Amphibian and Reptile Species of Special Concern in California

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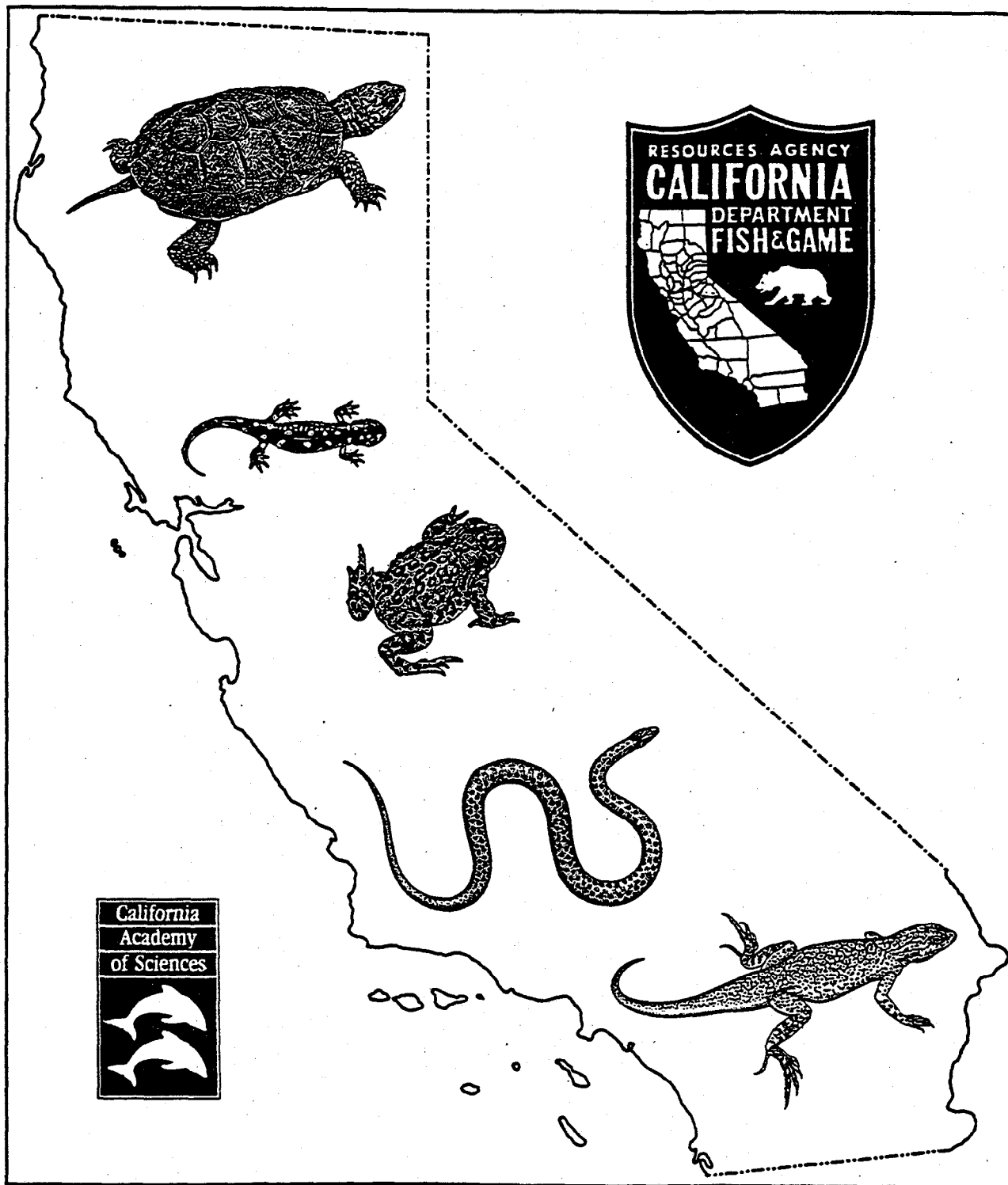**Some of the authors of this publication are also working on these related projects:**

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AMPHIBIAN AND REPTILE SPECIES
OF
SPECIAL CONCERN IN CALIFORNIA

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AMPHIBIAN AND REPTILE SPECIES
OF
SPECIAL CONCERN IN CALIFORNIA

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The California Department of Fish and Game commissioned this study as part of the Inland Fisheries Division Endangered Species Project. Specific recommendations from this study and in this report are made as options by the authors for the Department to consider. These recommendations do not necessarily represent the findings, opinions, or policies of the Department.

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Abstract: Data on 80 amphibian and reptile taxa native to the State of California were reviewed. All taxa potentially candidates for State or Federal "Threatened" or "Endangered" species listing were examined. Review of available data revealed that 48 of these 80 taxa warranted listing at some level. Data for review were assembled from individuals having field experience with each taxon, available literature, museum records, unpublished field notes, field surveys, and archival records. Review was directed at determining if available data could establish whether threats existed, identifying the nature of those threats, suggesting directions that individuals or agencies involved in management of these taxa could take to minimize those threats, and providing a recommendation of the appropriate status for each taxon or portions of each taxon based on these collective data. Status was identified as one of four categories the State of California currently recognizes: Endangered, Threatened, Special Concern, and no official status. Status was prioritized on the basis of the presence, complexity, and imminence of existing or potential threats to each taxon as well as their distributions, both geographic and within California.

Of the 48 taxa that warranted having their status reconsidered (11 salamanders, 14 anurans, 2 turtles, 12 lizards, and 9 snakes), Endangered status is justified for 14, Threatened status is justified for 16, and Special Concern status is justified for 25. Seven taxa (5 anurans, 1 turtle, and 1 snake) are recommended for listing in at least two status categories because threats to these taxa vary significantly across their range within California. Anurans and turtles are the most imperilled groups. Populations over significant portions of the geographic ranges of 10 of the 14 anurans considered (71%) deserve Endangered status, 5 of 14 (36%) deserve Threatened status, and 5 of 14 (36%) deserve Special Concern status; populations of both turtle species considered deserve either Endangered or Threatened status. Remaining major groups, ranked from most to least imperilled, are: salamanders (1 Endangered, 3 Threatened, 7 Special Concern), lizards (5 Threatened, 7 Special Concern), and snakes (1 Endangered, 2 Threatened, 6 Special Concern).

Species occurring in aquatic habitats are at greatest risk. Of the taxa that use aquatic habitats, Endangered status is justified for most populations of 13 of the 20 taxa considered (65%), Threatened status is justified for most populations of 9 taxa (45%), and Special

Concern status is justified for most populations of 6 taxa (30%). In contrast, of taxa that use terrestrial habitats, Endangered status is justified for 2 of 28 taxa considered (7%), Threatened status is justified for most populations of 7 taxa (25%), and Special Concern status is justified for most populations of 19 taxa (68%). Aquatic habitats are threatened by alteration of their physical or biotic structure as a function of several types of human use of water and adjacent land. Excessive numbers of livestock that are area-confined; stream channelization; construction of hydroelectric, recreational, or water storage reservoirs of significant size; removal of ground and surface water near or beyond recharge or volume capacities; and the introduction of a suite of exotic species with which the native aquatic fauna frequently cannot coexist are the uses that most severely affect aquatic habitats and their contained species. The most imperilled aquatic habitats in California that harbor one or more of the taxa recommended for listing are springs, seeps, and bogs; rain (or vernal) pools; marshes; and small headwater streams. In California, taxa occurring in terrestrial habitats are generally less imperilled because most terrestrial habitats in the state have a much greater total area than most aquatic habitats. Yet, aside from outright destruction and development, several widespread activities and land uses continue to alter the structure and vegetation of most terrestrial habitats in a manner unfavorable to the survival of their contained taxa. Among such uses, most significant are the impact of the variety of vehicles used off-highway or off-road; livestock that are area-confined; and urbanization. The most imperilled terrestrial habitats in California that harbor one or more of the taxa recommended for listing are dunes, grasslands dominated by perennial grasses, and the saltbush scrub vegetative association in the San Joaquin Valley.

The need to list 48 amphibian and reptile taxa led to several pivotal recommendations. Current levels of funding and support for sensitive or potentially sensitive amphibians and reptiles and issues related to these species are, at minimum, two orders of magnitude smaller than that needed to support an agenda with some chance of improving the survival of these species. The historical inertia of an archaic view of, and funding system for, non-game species is a primary underpinning of the extreme funding shortfall. Many specific recommendations can be made to help alleviate the precarious conditions of imperilled taxa, but such recommendations will be ineffectual without broad-based public support. Education of the public at all levels that amphibians and reptiles are just as indispensable a part of California ecosystems as are species traditionally viewed as economically important are necessary to reverse the funding shortfall. In particular, recognition that amphibians and reptiles, as well as other non-game organisms, have value commensurate with the mineral and the renewable natural resource wealth of ecosystems, a view currently held by few, should be common knowledge and the object of unwavering public support. Such support is essential to effectively implement recommendations, the most important of which include: increased attention to aquatic ecosystems, and in particular, to maximizing their quality and quantity; increased attention to minimizing or eliminating the impacts of off-road use of vehicles of all types; increased attention to minimizing, eliminating, or mitigating the impacts of all forms of livestock; increased attention to prohibiting the translocation or introduction of exotic species; and increased attention to the preservation of entire hydrographic units. Finally, it needs emphasis that all these problems are directly or indirectly rooted in the absolute human population size and its continued growth in California. As a consequence, any solutions to minimize impacts on amphibians and reptiles that do not consider the present human population and its changing size will be no more than temporary solutions.

Preface

The intent of this document was to consider amphibians and reptiles in California that were not provided legal protection other than, for some, the limited protection afforded species with Special Concern status, but that might require reconsideration of their status for various reasons. Just the nature of assembling data for such a synthesis is complex. Vast differences in the current state of knowledge among taxa and the fact that most data needed to interpret the status of each were broadly scattered across varied sources contributed to this complexity. Very early during the process of data assimilation, it became apparent that too few data were available for some amphibians and reptiles to provide comprehensive reviews of their status. We have, nevertheless, reviewed available data on those taxa, if for no other reason than that the gaps in current knowledge need emphasis. The combination of limited data on many species; the continuing rapid, human-induced changes in many California environments; and the continual appearance of new data indicated that the most useful form that this document could take is one that could be readily modified. In particular, it should facilitate incorporating new data, an essential element of future reviews. We have attempted to structure the document with this idea in mind. We hope that it will induce students of the California herpetofauna to fill the essential data gaps so that those exercising stewardship over habitats in which these amphibians and reptiles occur can refine their management plans, and that consultants, legislators, planners, and others will be better advised or give sound advice where it relates to the biology and ecology of these organisms.

MRJ
MPH
30 November 1993

AMPHIBIAN AND REPTILE SPECIES

OF

SPECIAL CONCERN IN CALIFORNIA

Introduction

The human population in California (since 1957 the most populous state in the nation) experienced especially rapid growth during the 1960s and 1970s, and continues to grow beyond the 30 million mark (U.S. Department of Commerce 1990). Continued growth increasingly impacts the abundant natural resources found in California (California Department of Forestry and Fire Protection 1988), among them, the 130-odd species of native amphibians and reptiles (Jennings 1987a). The most compelling symptom that human population growth has significantly impacted native amphibians and reptiles in California is that the U.S. Fish and Wildlife Service (USFWS), in combination with the California Fish and Game Commission (the Commission), now list 8 amphibians and 14 reptiles as either "Endangered" or "Threatened", and at least 20 additional taxa are proposed for listing (Jennings 1987a, U.S. Fish and Wildlife Service 1991). State listing of those taxa fall under the purview of the California Endangered Species Act (CESA) of 1984 [Section 2050 et. seq., California Fish and Game Code]. An outgrowth of the California Endangered Species Act passed in 1970 (Mallette and Nicola 1980), CESA requires the California Department of Fish and Game (CDFG) to: 1) review the status of CDFG-listed taxa (which includes those on USFWS lists and any taxa CDFG officially recommended for listing) every five years, and 2) prepare annually a report summarizing the status of all State-listed Endangered, Threatened, and Candidate taxa (California Department of Fish and Game 1990). CESA-required reviews are one important way that recommendations can lead to directed action concerning each taxon. They are intended to determine if conditions that led to a taxon's listing are still present, and to ensure that listing reflects the most current status of each taxon accurately (California Department of Fish and Game 1990). With the lag time needed to begin implementing CESA, CDFG produced its first annual report based on the aforementioned requirement in 1986 (California Department of Fish and Game 1987) and four additional reports have been produced since that time (California Department of Fish and Game 1988, 1989, 1990, 1991). However, these reports only partly fulfilled the CESA review requirement because each summarizes only CESA-recognized Threatened, Endangered, and Candidate taxa (California Department of Fish and Game 1990; see also Section 2079 of the California Fish and Game Code). Nevertheless, each annual report advocated the broader intent of CESA review by cautioning that other unlisted taxa which might deserve official "Candidate" status were not included (see Sections 2062, 2067, and 2068 of the California Fish and Game Code). Further, CDFG has been hampered in recent years in its ability to effectively address, much less review, many taxa not officially designated by the Commission because the CDFG designation, Species of Special Concern, has no legal definition, and therefore is not expressedly included in the review requirement. Moreover, severe funding limitations have restricted the number of taxa that CDFG could address, and the highest priority taxa, the critically Threatened or Endangered species, absorbed the funding base. This is especially true of the nongame project within the Inland Fisheries Division, the branch of CDFG responsible for amphibians and reptiles, the funding levels of which have consistently represented less than 1.0% of the total CDFG budget (Appendix I).

Despite these problems, CDFG has made significant strides in attempting to address unlisted or "third-category taxa" since 1971, when the Department implemented the elements that led to its current non-game program (Mallette and Nicola 1980). In the early 1970s, CDFG gave third-category taxa two labels, "Status-Undetermined" or "Depleted"

(e.g., see Bury 1972a), in an attempt to refine their statuses. The 1970, California Species Preservation Act had defined CDFG's mandate to address third-category taxa. However, this Act, which directed CDFG to inventory all threatened fish and wildlife taxa, develop criteria for officially designated Rare and Endangered species, and provide a biennial report on the status of these animals (Mallette and Nicola 1980), was repealed when CESA was adopted in 1984. The adoption of CESA enabled the Commission to add or remove species from the lists of Endangered and Threatened taxa, but neither provided a vehicle for the addition of species nor for the review of Candidate species; CESA simply states that species could be added or removed from either list if the Commission finds that action is warranted upon receipt of sufficient scientific information (CESA, Article 2, Section 2070). Sufficient scientific information is never addressed in CESA in the context of either adding species to the lists of Threatened or Endangered species, or evaluating Candidate or potential Candidate species. CESA addresses scientific information only in the context of projects that may impact Endangered or Threatened species, requiring CDFG to base its written finding of the review of such projects on the best scientific information (CESA, Article 4, Section 2090). The steps that led to filling the current void CESA created began in 1978, before CESA's inception, when CDFG first used the label "Species of Special Concern" for third-category taxa (see Remsen 1978). The intent of the Special Concern category was that since such species lacked legal protection other than bag restrictions, giving them consideration wherever possible might help avert costly recovery efforts that would otherwise be required to save such species. CDFG provided the vehicle to address third-category species that had been treated under the California Species Preservation Act by initiating a series of reports that reviewed the members of vertebrate groups that could be included under the Special Concern heading before CESA actually repealed that Act in 1984. Three such reports have been published (birds: Remsen 1978; mammals: Williams 1986; and fishes: Moyle et al. 1989). In light of the lack of a CESA-designated vehicle for review, these higher taxon-oriented reports have gained greater importance because they summarize the status of all third-category species (i.e., those not yet officially listed as Candidate, Threatened, or Endangered, and including those acknowledged as Species of Special Concern) through the provision of the best scientific information for their review. The latter is the substance of these higher taxon-oriented reviews. This document, which addresses amphibians and reptiles, represents the fourth such review.

We have attempted to review amphibians and reptiles of Special Concern in California within CESA's mandate to add species to the lists of Endangered and Threatened species upon the receipt of sufficient scientific information by providing a well-defined structure for the recommendations we propose, and future, more refined, reviews. As a result, we have examined 80 taxa, including both those previously acknowledged as Special Concern (Jennings 1983, 1987a), and any other unlisted taxa that were suggested by at least one independent source (State or Federal resource agencies, museum personnel, university faculty, wildlife biologists, or other individuals) for consideration as Special Concern. State or Federally Endangered and Threatened taxa that might deserve a downgrade in status to Special Concern were not addressed since those taxa remain within the purview of the five-year reviews conducted by the State, but we did consider the possibility that some taxa currently recognized as Special Concern might require a downgrade in status.

Methods

Determination of which taxa should be included for review was the first step in this study. The CDFG (Inland Fisheries Division) had originally conducted an informal survey of herpetologists and other interested individuals in the early to mid-1970s to assemble data on taxa that might need protection. Stewart (1971), Bury (1972a), and Bury and Stewart (1973) reported some of the conclusions of that survey, but much data have remained

unreported. We reviewed those data and all available, reports, surveys, and CDFG files (including the Natural Diversity Data Base) for relevant information regarding the amphibian and reptile species we had under consideration (see Appendix II for species list).

A working list of 80 taxa for potential consideration was assembled from the most current state lists (Jennings 1983, 1987a) and data from the aforementioned files and surveys (Appendix II). The list and a questionnaire (Appendix III) was then sent to 127 individuals familiar with various aspects of the California herpetofauna (Appendix IV). Another 90 individuals were contacted (by letter or in person) to inquire on specifics about selected taxa (Appendix IV). Many respondents expressed a need to elaborate on the information they provided, so we conducted personal interviews whenever possible. Collectively, these different sources of data were used to generate the list of candidate taxa that warranted having their statuses reconsidered.

We also conducted field reconnaissance in specific regions of California to help assess the presence or absence of candidate taxa. During reconnaissance, standard techniques were used to aid detection of different groups, including light-assisted nocturnal examination of breeding or refuge habitats for amphibians (Stebbins 1985), baited traps for turtles (Iverson 1979, Feuer 1980), and night driving for some lizards and snakes (Klauber 1939). Additionally, electroshocking (Reynolds 1983) was used to help detect certain amphibians. Efforts were made to collect voucher specimens and tissue samples of amphibians and reptiles, particularly from regions where collections were poorly represented. Whenever possible, we searched for field evidence of threats to candidate taxa. Regions covered during field reconnaissance included: 1) the foothills of the central and southern Sierra Nevada Mountains (1-5 October 1988; 20-22 July 1990), 2) the upper Mojave River drainage (18-20 March 1989; 6 July 1990), 3) the coastal plain and coastal ranges of southern California (21-24 March 1989; 14-20 May 1990; 14-16 August 1989; 29 September-1 October 1989; 17-18 November 1989; 24 December 1989; 24 June-6 July 1990), 4) the Coast Range slope of the San Joaquin Valley and the central coast (13-14 and 21 May 1989), 5) the Colorado River Basin (9-14 August 1989; 3-4 July 1990), 6) northeastern California from the vicinity of Mt. Shasta eastward to the Warner Mountains and southward to Lassen Volcanic National Park and the northern half of Plumas County (7-14 September 1990), and 7) the Trinity Mountains and north coastal region of California from Mendocino to Del Norte Counties (30 October-4 November 1990; 18-27 April 1991). We also conducted 15 shorter surveys (2-3 days) in a number of areas on the north and central coast and the Sierra Nevada Mountains between August 1988 and September 1991. Additionally, a few data were gathered during a 26 August 1991 visit to Tule Lake National Wildlife Refuge in Siskiyou County, while this report was in draft form. Data gathered during field reconnaissance were systematically recorded in field notebooks, and specimens taken as vouchers were deposited in the herpetology collections of the California Academy of Sciences.

Historical assessments of past distributions of candidate taxa were made from a combination of museum specimens and the field notes of present and former naturalists (in addition to the surveys and interviews described above) as well as over 25 years of our own personal field experience in California. Museum collections examined for field notes and relevant specimens were: AMNH, ANSP, CAS, CAS-SU, CPSU, CSUC, CSUS, HSU, LACM, MCZ, MVZ, SBMNH, SDSNH, SSU, UCD, UCSB, UMMZ, and USNM (see Table 1 for explanation of institutional codes). Legal proceedings prevented us from reviewing records at San Jose State University. Additional records were sent to us from ASU, CPSLO, CRCM, CU, KU, and UIM; specimen loans were requested from these institutions for verification of important locality records.

Table 1. Museum collections examined or queried for specimens and information.
Museum symbolic codes follow Leviton et al. (1985); asterisked (*)codes are not in
Leviton et al. (1985).
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Code	Museum, Location
AMNH	American Museum of Natural History, New York, New York.
ANSP	Academy of Natural Sciences, Philadelphia, Pennsylvania.
ASU	Arizona State University, Tempe, Arizona.
CAS	California Academy of Sciences, San Francisco, California.
CAS-SU	California Academy of Sciences-Stanford University Collection, San Francisco, California.
CPSLO*	California State Polytechnic University, San Luis Obispo, California.
CRCM	Charles R. Conner Museum, Washington State University, Pullman, Washington.
CSPU	California State Polytechnic University, Pomona, California.
CSUC*	Chico State University, Chico, California.
CSUS*	California State University Stanislaus, Turlock, California.
CU	Cornell University, Ithaca, New York.
FRC*	Feather River College, Quincy, California.
HSU	Humboldt State University, Arcata, California.
KU	University of Kansas, Lawrence, Kansas.
LACM	Natural History Museum of Los Angeles County, Los Angeles, California.
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.
MVZ	Museum of Vertebrate Zoology, University of California, Berkeley, California.
SBMNH	Santa Barbara Museum of Natural History, Santa Barbara, California.
SDSNH	San Diego Natural History Museum, San Diego, California.
SSU	Sacramento State University, Sacramento, California.
UCD*	University of California, Davis, California.
UCSB*	University of California, Santa Barbara, California.
UIM	University of Idaho, Moscow, Idaho
UMMZ	Museum of Zoology, University of Michigan, Ann Arbor, Michigan.
USNM	National Museum of Natural History, Washington, D.C.

Data from the aforementioned sources were organized into accounts for each species that included seven sections:

1) Description - This section provides a description of the taxon sufficient to characterize its physical appearance; it is not intended to be comprehensive. Included are data on body size (provided as a standard length measurement of the range in adult body sizes, taken as snout-vent length (SVL) for lizards, salamanders, and some snakes; total length (TL) for some snakes; snout-urostyle length (SUL) for frogs; and carapace length (CL) for turtles), the characteristic colors and patterns found on most body surfaces (including eye color), and to varying degrees, the characteristic shapes of the body or selected body parts (sometimes simply indicated by the higher-order group [usually the genus] to which a taxon belongs).

2) Taxonomic remarks - This section indicates the current systematic status of the taxon, noting any recent or pending changes in status. Because the use of genetic data has become indispensable for characterizing geographic variation and detecting cryptic species,

this section also indicates what genetic data are available for the taxon and, where possible, their potential systematic significance.

3) Distribution - This section describes the known geographic and elevational range of the taxon. A map identifies the historic and current range of the taxon in California, as far as is known. The elevational range of the taxon in California is provided only in those cases where it differs from that within the entire geographic range of the taxon.

Data for distribution maps are based on a total of 27,051 museum specimens, the identification of which were verified by one or both of us; and 2,085 sight records, the allocations of which were supported by one or more of the following types of evidence: a) living animals or preserved specimens, b) photographs, c) published evidence (such as peer-reviewed scientific papers), d) field notes, and e) personal interviews of the individual(s) who made the original observation(s). In a few cases, we had independent justification for not discarding records despite a lack of supporting evidence, such records are denoted on distribution maps with question marks. Circles versus square symbols differentiate verified museum records and verified sightings on the distribution maps. Solid versus open symbols differentiate locations where taxa are believed to be extant versus those likely to be extinct. The determination of extant versus extinct localities are either based on personal observations or interviews with individuals familiar with the area (and the taxa in question). In most cases, taxa are presumed to be extirpated from a given site if the habitat has been greatly modified by agriculture, roads, water projects, or urbanization, or repeated visits to historic sites revealed no organisms over a 10-year period. Data used to generate these distribution maps will be filed with the Natural Diversity Data Base (NDDB), California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814.

Wherever possible, an indication of the degree to which the geographic range of a taxon had been reduced was provided. For some taxa, it was possible to calculate the reduction in geographic range based on the known loss of selected populations, the known-loss of suitable habitat, or both. In a few cases, a map wheel could be used to measure the amount (in km or km$_2$) of stream or terrestrial habitat for the taxon on large-scale (1:7,920- 1:26,400) AAA and United States National Forest maps based on our distribution maps. The percentage of reduction in geographic range was calculated by summing the amount of habitat with extirpated populations and dividing it by the amount of habitat with extant and extirpated populations.

4) Life history - This section provides a synoptic summary of the life history of the taxon based on the primary literature. Aspects of behavior, reproduction, and the physiological ecology of each taxon that help evaluate the relative vulnerability of a taxon are emphasized. Except where so stated, data are restricted to populations from California.

5) Habitat - This section characterizes the physical and, to the degree possible, the biotic habitat requirements of each taxon. Where known, emphasis is placed on characterizing nesting and oviposition sites; aestivation, hibernation, and refuge sites; and any partitioning of habitat that may occur among the different life stages of a taxon. The habitat utilization patterns of a taxon that will help evaluate its relative vulnerability are emphasized.

6) Status - This section indicates the state-level status recommended for a taxon (or portion of a taxon) and its justification. The collective data allowed assignment of taxa (or portions of a taxon) to one of three categories:

      a) Taxa for which **Endangered** status is justified.
      b) Taxa for which **Threatened** status is justified.
      c) Taxa for which **Special Concern** status is justified.

Determination of whether Endangered or Threatened status was justified was based on the state-level definitions in the California Fish and Game Code (see Appendix V). For determining Special Concern status, we followed the criteria indicated in Williams (1986) and Moyle et al. (1989). The primary factor leading to our recommending the state-level listing of a taxon was the presence, complexity, and imminence of existing and potential threats to the survival of that taxon. We made every attempt to evaluate threats to each taxon within a holistic framework, one as encompassing as possible with regard to the biology and ecology of each taxon. Particular attention was given to how ecologically specialized a taxon might be. Consideration of ecological specialization meant that, in general, taxa occurring in geographically restricted (rare) habitats, taxa occurring in a single habitat type, or taxa occupying a higher trophic position in food webs were considered at greater risk than taxa occurring in geographically widespread (common) habitats, taxa occurring in more than one habitat type, and taxa occupying a lower trophic position in food webs. However, taxa with life cycles tied to more than one habitat type were considered at greater risk than those whose entire life cycle could be completed within a single habitat type. Because threats to some taxa were judged to vary significantly across their geographic ranges, more than one and as many as three status listings have been recommended for some taxa[1]. In addition to the presence, complexity, and imminence of threats to each taxon, we gave consideration, whenever possible, to three aspects of each taxon's abundance and distribution, its endemicity, the size of its geographic range, and its abundance across its geographic range. Endemicity refers to whether the organism's known geographic range occurs entirely within California, and thus, in the absence of human-assisted translocation, is found nowhere else in the world. Beyond the fact that endemic taxa were accorded greater importance simply because of the fact that this report focuses on the political subdivision of California, such taxa were given greater attention because the recommendations we made addressed the entire known geographic range of these taxa. For similar reasons, near endemics, taxa with known geographic ranges occurring almost entirely within California, were accorded greater importance than taxa with known geographic ranges that are more widespread outside of California. Endemic or not, taxa with smaller known geographic ranges were accorded greater importance than those with larger known geographic ranges because the former were considered to be at greater risk from regional-scale catastrophic events. The local abundance of individual taxa was also considered. In particular, taxa known to consist of numerically smaller local populations (demes) or complexes of subpopulations (metapopulations) were considered at greater risk than those known to consist of numerically larger or continuous ones.

In establishing the recommended listing of a taxon, a concerted effort was made to use criteria that might be universally applicable. Nevertheless, some criteria (e.g., the linkage of a taxon's life cycle to various habitat types) may not be universally applicable without caveats. Yet, all criteria used here could be applied unambiguously to the set of taxa reviewed; using them to evaluate other taxa in the same manner should be done cautiously.

Taxa that were reviewed, but that were judged to require no special status during the time that data for this report were being gathered are listed in Table 2.

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[1]We are cognizant that the California Fish and Game Code does not address multiple status listings for a taxon. Nevertheless, multiple listings are not specifically excluded by the Code, and a Federal precedent exists for their use.

Table 2. Taxa judged not to warrant any state-level status at this time. The habitat column refers to whether a taxon has one or more life stage in an aquatic habitat (A) or whether its life stages use exclusively terrestrial habitats (T). Lack of current data for taxa marked with an asterisk "*" indicates a particular need for some kind of monitoring.

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Taxon	Habitat Category
California giant salamander, *Dicamptodon ensatus*[1]	A
Oregon giant salamander, *Dicamptodon tenebrosus*[1]	A
Red-bellied newt, *Taricha rivularis**	A
Channel Islands slender salamander, *Batrachoseps pacificus pacificus*	T
Fair-view slender salamander, *Batrachoseps* sp.[2]	T
Guadalupe slender salamander, *Batrachoseps* sp.[2]	T
Hell Hollow slender salamander, *Batrachoseps* sp.[2]	T
Kern Plateau slender salamander, *Batrachoseps* sp.[2]	T
San Gabriel slender salamander, *Batrachoseps* sp.[2]	T
Dunn's salamander, *Plethodon dunni*	T
Great Basin spadefoot, *Scaphiopus intermontanus**	A
Great Plains toad, *Bufo cognatus*	A
Arizona toad, *Bufo microscaphus microscaphus*	A
Red-spotted toad, *Bufo punctatus*	A
California treefrog, *Pseudacris cadaverina**	A
Peninsular leaf-toed gecko, *Phyllodactylus xanti nocticolus*	T
Baja collared lizard, *Crotaphytus insularis vestigium**	T
Long-nosed rock lizard, *Petrosaurus mearnsi mearnsi**	T
Pigmy short-horned lizard, *Phrynosoma douglassii douglassii**	T
Western chuckwalla, *Sauromalus obesus obesus*	T
Yellow-backed spiny lizard, *Sceloporus magister uniformis*	T
Granite spiny lizard, *Sceloporus orcutti*	T
Granite night lizard, *Xantusia henshawi henshawi*	T
Southwestern blind snake, *Leptotyphlops humilis humilis*	T
Desert rosy boa, *Lichanura trivirgata gracia**	T
Coastal rosy boa, *Lichanura trivirgata roseofusca**	T
Sharp-tailed snake, *Contia tenuis*	T
Sierra mountain kingsnake, *Lampropeltis zonata multicincta*	T
Coast mountain kingsnake, *Lampropeltis zonata multifasciata*	T
St. Helena mountain kingsnake, *Lampropeltis zonata zonata*	T
Sonoran lyre snake, *Trimorphodon biscutatus lambda*	T
California lyre snake, *Trimorphodon biscutatus vandenburghi*	T
Western diamondback rattlesnake, *Crotalus atrox**	T

[1]Systematics follow Good (1989).
[2]Description of this taxon is pending (D. Wake, pers. comm.).

7) Management recommendations - This section provides the recommendations that need to be implemented to have some possibility of reversing the threats that are currently impacting a taxon. Gaps in current data needed to refine present management alternatives are also presented in this section.

Scientific and vernacular names and current taxonomy follows Jennings (1987a) unless otherwise indicated. Controversies or departures from current taxonomy are noted in the taxonomic remarks sections of each species account. For the three taxa reviewed that await

description (two salamanders and one snake), a description section was omitted to protect the priority of publication of the describers. Only enough data on these three taxa were included so that they can be properly addressed once their descriptions appear.

Results

Of the 80 taxa reviewed, 33[2] were judged not to warrant listing at this time (Table 2). While a number of these taxa have declined or disappeared from some areas, these taxa are abundant and widespread enough at this writing that even current levels of environmental alteration do not significantly threaten their survival. Though we do not review these taxa, we identify several among them that bear watching because they are likely to encounter problems in the future (Table 2).

The remaining 48 taxa were found to warrant a reconsideration in status. One additional species, the desert tortoise *(Xerobates agassizii),* was originally considered with the remaining taxa discussed here, but was listed as Endangered by the Commission and Threatened by the USFWS (U.S. Fish and Wildlife Service 1990) in the course of assembling our review, so we will not address it here. Those desiring information parallel to that presented here for the desert tortoise should refer to Dodd (1981, 1986), Luckenbach (1982), Berry (1984), and U.S. Fish and Wildlife Service (1990). Accounts of the 48 taxa that warrant a reconsideration in status follow.

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[2]The actual number is 33 instead of 32 due to *Dicamptodon ensatus* being split into two taxa in California by Good (1989) after our questionnaire was compiled and mailed.

SALAMANDERS

CALIFORNIA TIGER SALAMANDER
Ambystoma californiense Gray 1853

Description: A large (75-125 mm SVL) terrestrial salamander with several white or pale yellow spots or bars on a jet-black field (Stebbins 1985, Barry and Shaffer 1994; pers. observ.). Undersurfaces are highly variable in pattern, ranging from nearly uniform white or pale yellow to variegated white or pale yellow and black (pers. observ.). The relatively small, but protruding eyes have black irises (pers. observ.).

Taxonomic Remarks: Although the California tiger salamander had been regarded for many years as one of several subspecies within the *Ambystoma tigrinum* complex (e.g., Dunn 1940, Gehlbach 1967, Frost 1985, Stebbins 1985), the most recent genetic work indicates that populations of the California tiger salamander seem to be consistently differentiated from the most proximate western populations within the complex (Jones 1989), which supports the older systematic allocation of this form as a full species (e.g., Storer 1925, Bishop 1943). Genetic variation within *A. californiense* consists of several well-differentiated geographically segregated clusters (Shaffer et al. 1993). Additionally, several novel tiger salamander populations both outside and inside the known historical range of *A. californiense* have been discovered (e.g., Mullen and Stebbins 1978; Shaffer and Stanley 1992; J. Brode, R. Hansen, B. Shaffer, and T. Taylor, pers. comm.). None of these *Ambystoma* populations are closely related to *A. californiense* (B. Shaffer, pers. comm.), and many of them may represent accidental introductions associated with the fishbait trade (Espinosa et al. 1970, Glaser 1970, Bury and Luckenbach 1976, Stebbins 1985).

Distribution: This species ranges from the vicinity of Petaluma, Sonoma County and Dunnigan, Colusa-Yolo County line (Storer 1925) with an isolated outpost north of the Sutter Buttes at Gray Lodge, Butte County (Hayes and Cliff 1982) in the Central Valley, south to vernal pools in northwest Tulare County, and in the Coast Range south to ponds and vernal pools between Buellton and Lompoc in the Santa Ynez drainage, Santa Barbara County (Figure 1). The known elevational range of this species extends from 3 m to 1054 m (Shaffer and Fisher 1991). Potential habitat along the west side of the Sacramento Valley may exist north of Yolo County to the vicinity of Coming (e.g., see specimen CSUC 1460), but surveys in this area have failed to reveal extant populations (Shaffer et al. 1993).

Life History: This species engages in nocturnal breeding migrations over distances of 1000 m or more that are likely highly stereotyped (e.g., see Myers 1930a, Twitty 1941). Movement occurs from subterranean refuge sites (small mammal burrows) to breeding sites (relatively long-lasting rain pools) following relatively warm late winter and spring rains (November-February; Voigt 1989, Shaffer and Fisher 1991, Barry and Shaffer 1994). Some evidence exists to indicate that males precede females during the breeding migration (Shaffer et al. 1993). Eggs are deposited singly or in small groups of 2-4, submerged in the relatively shallow water of rain pools (Storer 1925). A minimum of ca. 10 weeks is required to complete development through metamorphosis (P. Anderson 1968, Feaver 1971). Larvae generally weigh about 10 g at metamorphosis, although they may remain in water and grow to much larger sizes; sexually mature larvae, as occur in other ambystomatid salamanders, are unknown, but during 1993, the first observations of oversummering larvae were made (Shaffer et al. 1993). It needs emphasis that the latter pattern is unusual, and the temporary pools occupied by the California tiger salamander generally dry up during the hot summer months (Storer 1925). Larvae are often cryptic (S.
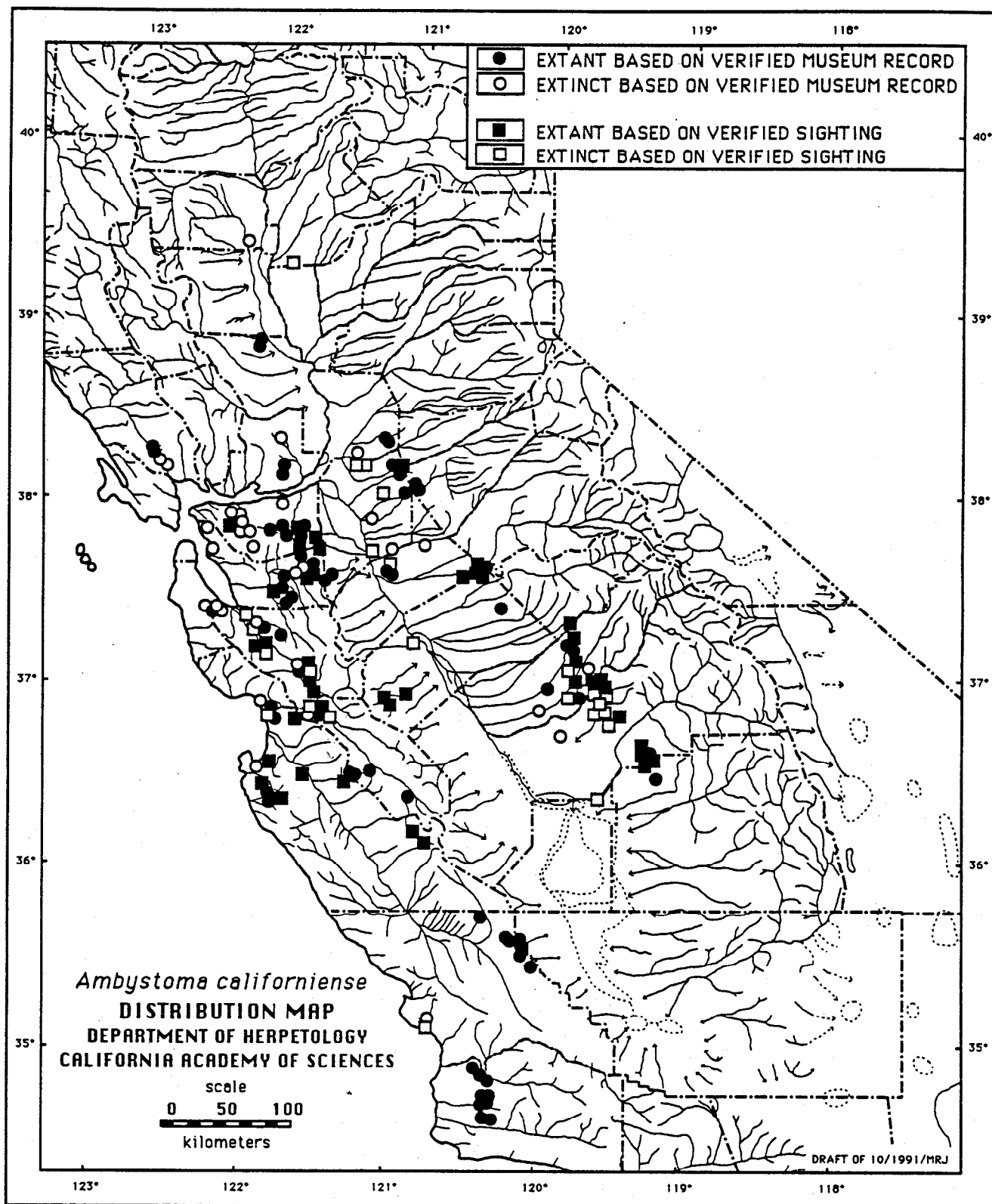
Figure 1. Historic and current distribution of the California tiger salamander (*Ambystoma californiense*) in central and northern California based on 383 locations from 769 museum records and 158 records from other sources.

Sweet, pers. comm.) and they exhibit short bursts of swimming activity when threatened (Shaffer et al. 1991, Austin and Shaffer 1992). However, the water of temporary pools they occupy may be turbid, so larvae are often difficult to detect visually (pers. observ.). Following metamorphosis, juveniles emigrate in mass at night from the drying breeding site after spending a few hours or days near the pond margin (Zeiner et al. 1988; S. Morey, pers. comm.). Juveniles have been found to migrate up to 1.6 km from breeding sites to refuge sites (Austin and Shaffer 1992). Except where refuge sites have been unearthed or disturbed (Storer 1925; Myers, ms.; N. Euless, pers. comm.) or under conditions of aseasonal rainfall (Holland et al. 1990), California tiger salamanders have not been observed outside of the wet-season interval (Morey and Guinn 1992, Barry and Shaffer 1994). During years of low rainfall, California tiger salamanders may not reproduce (K. Baldwin, B. Shaffer, and S. Sweet, pers. comm.). Preliminary data suggest that most individuals require 2 years to become sexually mature, but some individuals may be slower to mature (Shaffer et al. 1993).

Habitat: The California tiger salamander is a lowland species restricted to the grasslands and lowest foothill regions of Central and Northern California, which is where its breeding habitat (long-lasting rain pools) occurs (Shaffer and Stanley 1992). Permanent lowland aquatic sites are claimed to be used for breeding (Stebbins 1985; Zeiner et al. 1988; P. Moyle, pers. comm.), but use of such sites is unlikely unless they lack fish predators (Shaffer and Stanley 1992, Shaffer et al. 1993), so this species should be viewed as capable of breeding almost exclusively in temporary pools until data to the contrary show otherwise. Dry-season refuge sites within a reasonable distance of breeding sites (up to 1.6 km: Austin and Shaffer 1992) are likely a necessary habitat requirement since this species is absent from sites with seemingly suitable breeding habitat where surrounding hardpan soils are lacking in small mammal burrows; if the burrowing ability of California tiger salamanders is similar to that of its eastern congener (see Semlitsch 1983), they are probably poor burrowers. Although the range in types of burrows that California tiger salamanders regularly use needs study, those of the California ground squirrel *(Spermophilus beecheyi)* may be favored in some areas (Shaffer et al. 1993; J. Medeiros and S. Morey, pers. comm.), Botta's pocket gopher *(Thomomys bottae)* burrows are also known to be used (Shaffer et al. 1993, Barry and Shaffer 1994) as are certain man-made structures (e.g., wet basements, underground pipes, and septic tank drains: Zeiner et al. 1988; Myers, ms; S. Sweet, pers. comm.; pers. observ.).

Status: Threatened; this unique California endemic is the most vulnerable of the group of amphibians that breed in rain pools because its long developmental interval appears to restrict its ability to reach metamorphosis in only those rain pools that are the longest lasting, and as a consequence, often the largest in size. Moreover, the apparently stereotyped migrations to breeding sites are probably linked to use of sites over many years (e.g., Twitty 1941) and considerable longevity, which is likely the result of highly variable annual rainfall that does not consistently provide suitable environmental conditions for breeding or metamorphosis. Loss of rain (vernal) pools (Jain 1976, Stone 1990), and specifically, the degradation of complexes of long-lasting pools that are critical breeding [= core] habitat is a significant threat to the California tiger salamander, especially with the continued fragmentation of known breeding sites. Introduction of exotic and transplanted predatory fishes (including mosquitofish *[Gambusia affinis])* to rain pools for mosquito (Culicidae) control, a practice still engaged in by mosquito abatement agencies in California, or other purposes can eliminate an entire cohort of developing embryos or larvae (Zeiner et al. 1988; J. Medeiros and S. Morey, pers. comm.; see also Collins et al. 1988 and Shaffer et al. 1993). Shaffer and Fisher (1991), Shaffer and Stanley (1992), and Shaffer et al. (1993) identified a strong inverse correlation between the occurrence of California tiger salamanders and fishes, emphasizing that California tiger salamanders were very rarely found in any pond with fish. These data strongly suggest that California tiger

salamanders cannot survive in the presence of fish predators, perhaps because fishes are not recognized as predators, a condition in need of experimental investigation. Shaffer et al. (1993) also found the presence of California tiger salamanders inversely correlated with that of bullfrogs *(Rana catesbeiana),* a condition that Shaffer and Fisher (1991) found only in unvegetated ponds, which suggests that California tiger salamanders perhaps gain a protective advantage when some vegetation structure is present. Some California tiger salamander populations also may have been eliminated by the widespread introduction of the Louisiana red swamp crayfish *(Procambarus clarkii).* Historically, loss of populations in the Palo Alto area of San Mateo County was linked to groundwater pumping that lowered the water table and dried up springs, ponds, and wells (Myers, ms.). Loss of refuge habitat adjacent to breeding sites due to land use changes (e.g., grazing land to agriculture conversions, suburban housing development, or even converting grazing land to irrigated pasture) and poisoning of burrowing mammals are also significant threats (Barry and Shaffer 1994; J. Medeiros and H. Basey, pers. comm.). Further, artificial barriers that prevent or seriously impede migration (e.g., heavily travelled berms or roads, or solid road dividers) may have significantly affected California tiger salamander populations in certain areas (S. Morey, pers. comm.; see also Shaffer and Fisher 1991, Shaffer and Stanley 1992, Shaffer et al. 1993, Barry and Shaffer 1994). Decreased larval production or breeding during the years after 1986 suggests that the 1986-1990 drought may have negatively impacted California tiger salamander populations (Jones and Stokes 1988). Based on the data of Shaffer et al. (1993), California tiger salamanders were not found at 58% of the historical locations (see Shaffer et al. (1993) for a definition) and 55% of the ponds they sampled, leading to the conclusion that California tiger salamanders have disappeared from about 55% of their historic range in California.

Management Recommendations: Particular effort should be made to protect the vicinity of large rain pool complexes that are known core breeding sites in order to maintain the integrity of the breeding-refuge site ensembles that California tiger salamanders use (see Shaffer et al. 1993). Shaffer et al. (1993) also found a low level of gene flow between extant California tiger salamander populations, even those in close spatial proximity. As they emphasize, this suggests that each population is a genetically independent entity, and this warrants strong consideration for conservation to be resolved at a local population-level of protection. Because the large rain pools that salamanders use are also the only habitat for a number of plant species and invertebrates that are listed or proposed for listing (Jain 1976; Jain and Moyle 1984; Reiner 1992; T. Griggs, pers. comm.; see also Shaffer et al. 1993), ample justification exists for protection of these unique habitats beyond simply the presence of California tiger salamanders. The range of variation in physical characteristics of rain pools that allow California tiger salamanders to reproduce and metamorphose successfully is not well understood, but is currently under continued study (Shaffer and Stanley 1992, Shaffer et al. 1993). The latter urgently needs study for effective recommendations to be made about habitat management and protection for this species. Also poorly understood is the variation in distance between the breeding and refuge sites. Even minor habitat modifications that traverse the area between the breeding and refuge sites (such as roads, berms, and certain types of pipelines or fences) can impede or even prevent breeding migrations, and should be avoided. If one or more roads must traverse such a route, amphibian tunnels that allow continued migration beneath the road should be part of the road design (Shaffer et al. 1989; Barry and Shaffer 1994; see also Langton 1989). Moreover, solid road dividers should not be used where migratory routes exist so as not to hinder California tiger salamanders that may migrate across the roadbed (Shaffer et al. 1989). Introduction of exotic or transplanted aquatic fauna to rain pools should be avoided; efforts should be made to develop novel integrative programs with agencies like Mosquito Abatement Districts to develop management methods that are non-destructive to native rainpool inhabitants like California tiger salamanders. Soil disturbance to depressions that seasonally become rain pools should be avoided. In particular, special

care should be taken to avoid puncturing or altering any potentially thin hard pan that has developed in the pool substrate over many years (e.g., caliche hard pan). Such disturbances could increase percolation rate and shorten the duration of pool life enough that California tiger salamanders could no longer metamorphose successfully in such pools.

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INYO MOUNTAINS SALAMANDER
Batrachoseps campi Marlow, Brode, and Wake 1979

</div>

Description: A robust (32.0-60.7 mm SVL), dark brown to black slender salamander with a relatively broad, rounded snout; large eyes (Papenfuss and Macey 1986); and patches of silvery iridophores concentrated on the upper eyelids, head, and the anterior body (Marlow et al. 1979), or forming a continuous network covering the entire dorsal surface (Yanev and Wake 1981). Sixteen to 18 costal grooves are present (Stebbins 1985). The distribution of iridophores often gives these salamanders a greenish or silvery green appearance (Yanev and Wake 1981). The iris color is undescribed.

Taxonomic Remarks: The Inyo Mountains salamander is a distinct species distinguished from all other species of *Batrachoseps* based on its large size, short tail, broad head, and distinctive coloration without a dorsal stripe (Marlow et al. 1979, Yanev and Wake 1981). Yanev (1980) and Yanev and Wake (1981) found *B. campi* genetically very distinctive from all other known species of *Batrachoseps,* but least differentiated from *B. wrighti* of Oregon.

Distribution: This California endemic is known only from 16 localities (Papenfuss and Macey 1986; J. Brode, pers. comm.) extending 32 km along the Inyo Mountains (Inyo County) between Waucoba Mountain and New York Butte, and 10.5-13.5 km east to west across the mountain range (Figure 2). Yanev and Wake (198 1) report the known elevational range of this species as extending from 550-600 m (Hunter Canyon) to 2590-2620 m (Upper Lead Canyon):

Life History: Almost nothing is known of the life history of this species although a report detailing the natural history and local distribution of *B. campi* is anticipated (K. Berry, in prep; see Yanev and Wake 198 1). Only the juvenile through the adult stage have been observed or collected (Marlow et al. 1979). The Inyo Mountains salamander appears to be nocturnal, taking shelter under moist rocks or in damp crevices during the daytime (Macey and Papenfuss 1991a). The species likely has direct development similar to other members of the genus *Batrachoseps* where the reproductive pattern is known. Nesting sites are likely to be moist subterranean localities within the talus slopes or fissures of the habitat where this species has been found. No data are available on the movement ecology or physiology of this species or on the potential differential use of habitat by various life stages.

Habitat: Currently, only the gross habitat requirements of *B. campi* are known. The original two known localities where this species was discovered each have permanent seepage springs with limited vegetation associated with talus rubble (Mat-low et al. 1979). Fissured limestone likely provides shelter for *B. campi* in the canyons where it is known to occur (Papenfuss and Macey 1986). Each of the sites where this species is known to occur has a narrow strip of riparian vegetation. Where habitat is suitable, cliffs, outcrops, or talus are in contact with spring flow and the flow passes through dense riparian vegetation (Papenfuss and Macey 1986, Macey and Papenfuss 1991a). The area estimated to be ideal habitat at each locality where this species is known to occur is very small, ranging from 0.17 ha to 4.34 ha (Giuliani 1977, Papenfuss and Macey 1986). This species may be more
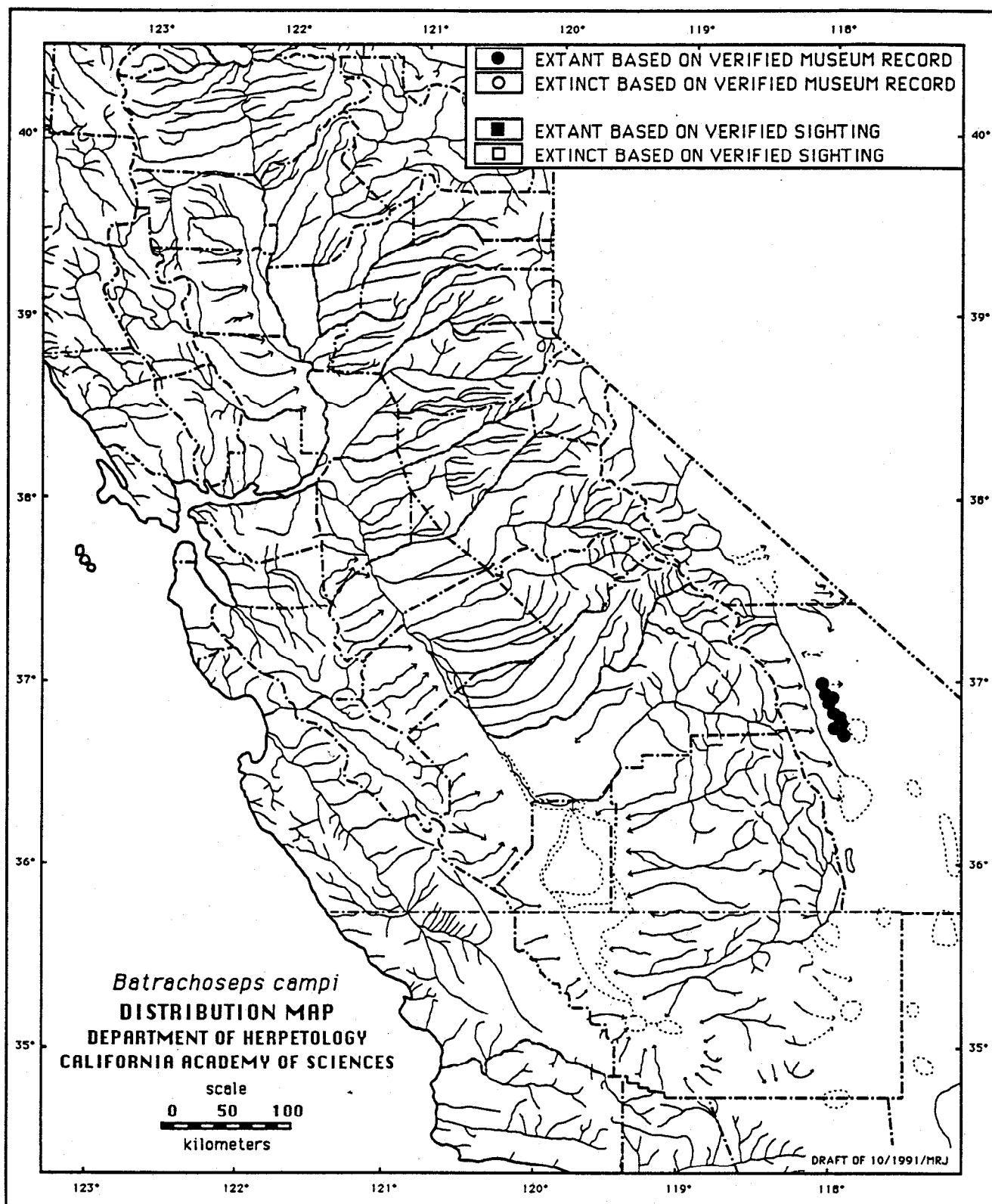
Figure 2. Historic and current distribution of the Inyo Mountains salamander (*Batrachoseps campi*) in central California based on 16 locations from 163 museum records and 29 records from other sources.

difficult to detect near the surface in non-spring situations, so it may be more widespread than current data indicate. Novel sampling techniques will be needed to verify this.

Status: Threatened; the relatively restricted distribution of this California endemic to limited habitat in the Inyo Mountains and the very small area of estimated ideal habitat may make this species especially vulnerable to habitat alteration. Much of its known habitat is associated with springs that can attract significant human *(Homo sapiens)*, horse *(Equus caballus)*, and burro *(E. asinus)* activity that is likely to imperil its survival. Its restricted geographic range also makes it particular susceptible to extinction from catastrophic climatic or geomorphologic events of regional scale.

Management Recommendations: A thorough understanding of the specific habitat requirements significant to the survival of this species are an absolute prerequisite to refining management efforts for this species. Until specific habitat data become available, efforts should be directed at protecting the habitat ensemble associated with the springs and other riparian areas where *B. campi* has been found, and in particular, efforts should be made to avoid any alterations that might modify the hydrology of these areas. The practice of opening and clearing springs with explosives for enhancement of upland species and other animals (see Marlow et al. 1979) should be prohibited within the known and suspected range of this species. Capping of springs has been identified as the major threat to the survival of *B. campi* (Macey and Papenfuss 1991a). A combination of water diversion from springs, disturbance of the substrate through mining, and damage to potentially sheltering riparian plants by feral burros and domestic cattle *(Bos taurus)* currently pose some degree of threat to every one of the 16 localities where this species is known to occur. Existing populations of *B. campi* would be better protected if the areas associated with the springs in which they occur were closed to vehicles and mining (see Marlow et al. 1979). Concerted efforts should be made to search for this species in other nearby springs when sufficient surface moisture is present to induce near-surface activity in this salamander. Protection of this species would be assisted through initiation of land use restriction measures in the Inyo Mountains, which would anticipate future finds of this species outside of its known range.

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RELICTUAL SLENDER SALAMANDER
Batrachoseps relictus Brame and Murray 1968

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Description: A moderate-sized (32.1-48.1 mm SVL), dark black slender salamander with a very dark brown dorsal band extending from the forelimbs to the base of the tail and gray-black undersurfaces (Brama and Murray 1968). Sixteen to 20 costal grooves are present (Stebbins 1985). The iris is dark brown or black (R. Hansen, pers. comm.).

Taxonomic Remarks: Brame and Murray (1968) included salamanders from four disjunct regions (the central Coast Ranges, the southern Sierra Nevada Mountains, Santa Cruz Island, and the San Pedro Mártir Mountains of Baja California) within *Batrachoseps relictus,* but Yanev (1980) restricted *relictus* to the Sierran populations. Yanev (1980) treats *relictus* as a subspecies of *B. pacificus,* but the geographic pattern of genetic variation across what is termed *B. relictus* here is poorly understood. Both the work of Yanev (1978) and unpublished data (D. Wake and R. Hansen, pers. comm.) suggest that *B. relictus,* as treated here, may represent several species.

Distribution: This California endemic complex of populations is currently known from the vicinity of Briceburg, Mariposa County south to the Kern River Canyon, Kern County (Figure 3), but the northern limits of the range remain poorly understood. Its known elevation range extends from 182 m to 2438 m (R. Hansen, pers. comm.).
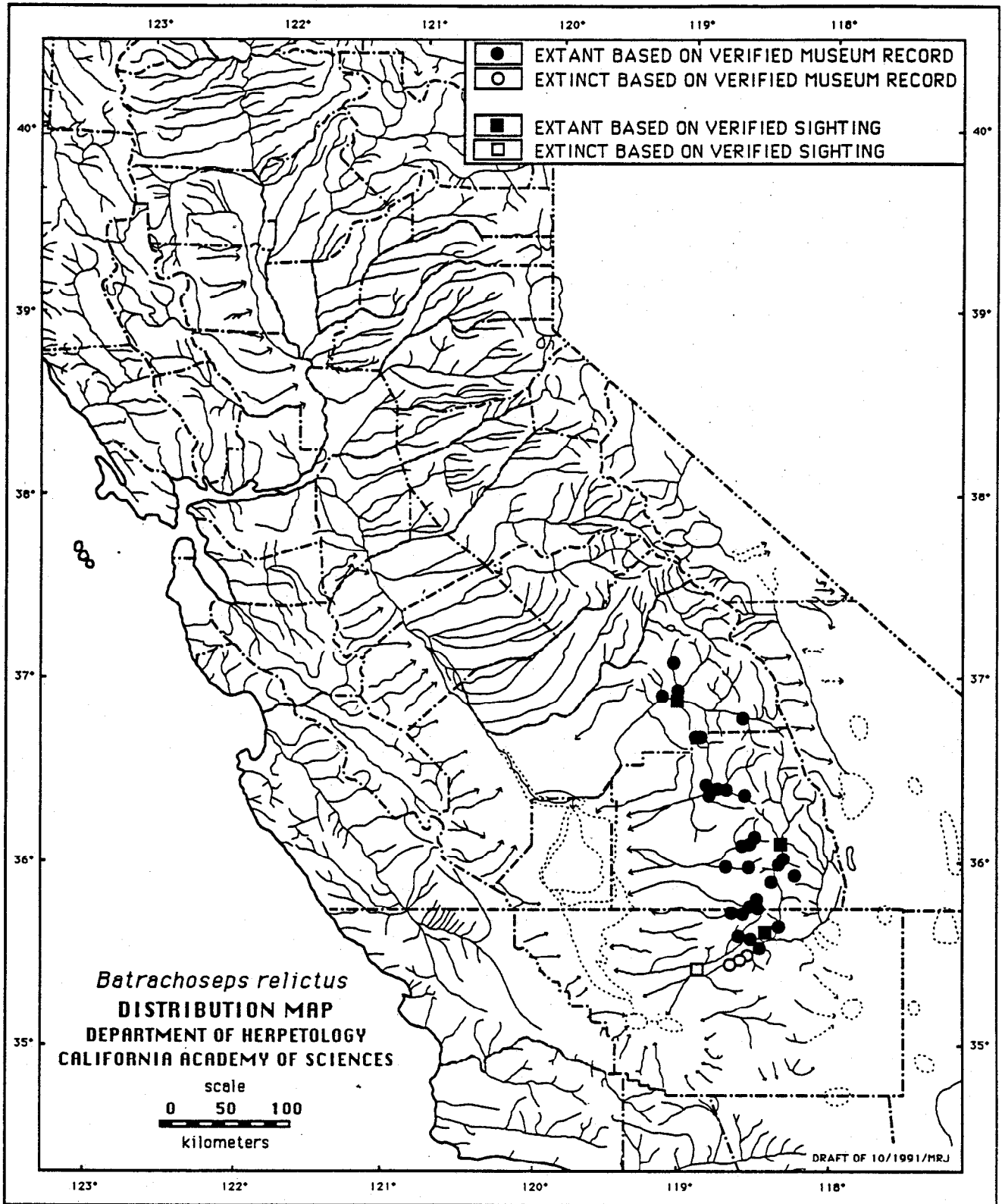
Figure 3. Historic and current distribution of the relictual slender salamander (*Batrachoseps relictus*) in central California based on 73 locations from 154 museum records and 19 records from other sources.

Life History: Virtually nothing is known of the life history of this taxon. As with other members of the genus, direct development is presumed. A probable communal nest of this taxon similar to the one described for the Breckenridge Mountain slender salamander (see subsequent account) has recently been discovered (R. Hansen, pers. comm.).

Habitat: Details of the habitat requirements of this taxon are poorly understood. It has been found under a range of surface objects ranging from rocks to bark and other tree debris. This taxon may be more difficult to detect near the surface in situations where movable surface objects are absent, so it may be more widespread than current data indicate. Novel sampling techniques will be needed to properly evaluate this possibility.

Status: Special Concern; The known range of this unique California endemic is relatively restricted (i.e., the southern Sierra Nevada) and lies within a region that has undergone extensive local development and changes in land use patterns over the last 20 years (Moyle 1973, California Department of Forestry and Fire Protection 1988). Despite extensive searches at suitable time intervals, no salamanders have been found at the type locality of *B. relictus* in Lower Kern River Canyon since 22 April 1970 (D. Wake, pers. comm.). Moreover, no salamanders have been found at eight sites in Kern Canyon where they were relatively common in the 1960s (R. Hansen, pers. comm.).

Management Recommendations: Systematic study of *B. relictus* to identify how many taxa are really present and the geographic range of each is the basic foundation needed prior to all other studies. Once taxa are identifiable, the habitat requirements of each need to be better understood before really effective management recommendations can be made. Much of the most basic data on the biology of this complex of populations are lacking. Phenological studies integrated with identifying the components of habitat structure essential to these salamanders are especially needed. In the absence of significant data, the recommendations made for *B. campi* apply to this species. Sites where *B. relictus* are known to occur should be protected from disturbance, especially alterations that may affect local hydrology. Particular attention should be paid to how more subtle (remote) effects may affect the local water table and soil moisture regimes, and such potential effects should be assessed for a significant radius around sites known to harbor *B. relictus.* What a significant radius is will have to be established through study of populations of *B. relictus* and the range of variation in local hydrologies. More specific recommendations will be possible after data from the suggested studies on *B. relictus* become available.

BRECKENRIDGE MOUNTAIN SLENDER SALAMANDER
Batrachoseps sp.

Taxonomic Remarks: Individuals representing this currently undescribed taxon were likely first found in 1977, although it was not recognized that this population represented a unique taxon until somewhat later on. Unpublished genetic data indicate that this taxon, which is being described by David B. Wake and Robert W. Hansen, is distinctive.

Distribution: This California endemic is known only from a single locality at approximately 1920 m near Squirrel Meadow on Breckenridge Mountain, Kern County (Figure 4).

Life History: Little is known of the life history of this species; only eggs and adults have been observed or collected. Robert W. Hansen (pers. comm.) found a probable communal oviposition site, approximately 150 eggs in a moist location under a large rock. Eggs and gravid females were observed in June. The eggs look similar to those of other *Batrachoseps,* so the species probably undergoes direct development.
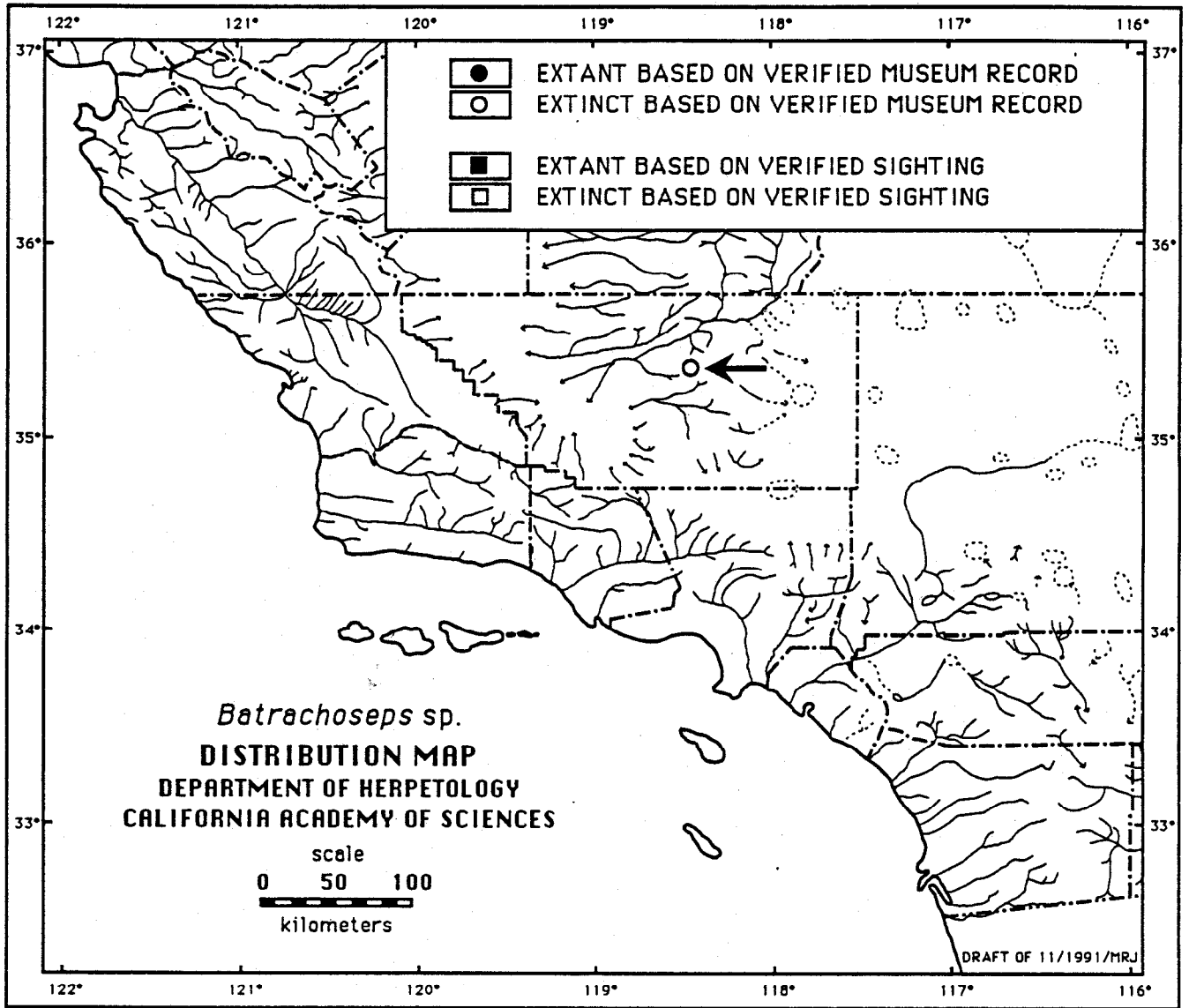
Figure 4. Historic and current distribution of the Breckenridge Mountain slender salamander (*Batrachoseps* sp.) in southern California based on 2 locations from 16 museum records and 52 records from other sources.

Habitat: All life stages of this taxon found thus far are restricted to a seep with a sandy loam substrate on a southeastern-facing slope. Rocks or rotting logs are used as cover during the interval of near-surface activity. This species may be much more difficult to detect near the surface in situations away from springs, so it may be more widespread than current data indicate. Novel sampling techniques will be needed to verify this possibility.

Status: Endangered; the highly restricted known distribution of this California endemic to the locality where it was discovered makes it especially vulnerable. Few observations of this taxon even exist. Larry Satterfield observed 26 individuals of what was presumably this taxon at the only known locality in 1977. On 13 June 1979, Robert W. Hansen observed 22 individuals and the communal nest described above. Between 1979-1983, the dirt road adjacent the locality where this taxon was found was judged too steep for logging trucks to negotiate the grade, so the Sequoia National Forest approved regrading and paving the road so that it was rerouted directly through a substantial portion of the bottom of the seep in which this taxon had been observed, considerably modifying its structure and hydrology. Additionally, the black oaks *(Quercus kelloggii)* that historically bordered this seep were cut (R. Hansen, pers. comm.). Following this alteration, Hansen has found only four adults of this taxon (all observed on 18 September 1983). More recent searches have failed to reveal this taxon.

Management Recommendations: What remains of the only seep on Breckenridge Mountain where this species has been found should be protected from further disturbance, including more remote effects that may influence local hydrology. Assuming a population can be relocated, data on the basic biology of this taxon need to be gathered. Efforts should also be made to search for this taxon in similar habitat nearby, particularly downslope from the only known locality on Breckenridge Mountain, where habitat is relatively inaccessible. In the absence of significant data, the recommendations made for *B. cuapi* and *B. relictus* apply to this species. More specific recommendations will be possible after data from the suggested studies on the Breckenridge Mountain slender salamander become available.

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YELLOW-BLOTCHED SALAMANDER
Ensatina eschscholtzii croceater (Cope 1869)

</center>

Description: A moderate-sized (48.0-78.0 mm SVL) salamander with reasonably large (averaging 3-4 mm in width and up to 7 mm in length), irregular, pale, lemon-yellow to yellowish cream blotches (yellow in juveniles) on a deep blackish brown to black ground color and a prominent constriction at the base of the tail (Stebbins 1949; R. Hansen, pers. comm.). A single large rectilinear, although often irregularly outlined, blotch that does not extend onto the upper eyelids occurs in each parotid area. Twelve to thirteen costal grooves are present. The iris is dark brown or black with few or no guanophores (Stebbins 1949).

Taxonomic Remarks: This taxon is one of a series of morphologically (Stebbins 1949) and genetically (Wake and Yanev 1986) differentiated forms of *Ensatina.* The only population of yellow-blotched salamander which has been sampled genetically is well differentiated from populations currently allocated to the most proximate other subspecies of *Ensatina* (see Wake and Yanev 1986). Wake and Yanev (1986) have concluded that their genetic data support Stebbins' (1949) interpretation that *Ensatina eschscholtzii croceater* is simply a morph within a cline now recognized *as E. eschscholtzii;* but data on the geographic pattern of genetic variation within *E. e. croceater* are not currently available. Such data are absolutely necessary to exclude the possibility that specific-level recognition for this taxon is justified.
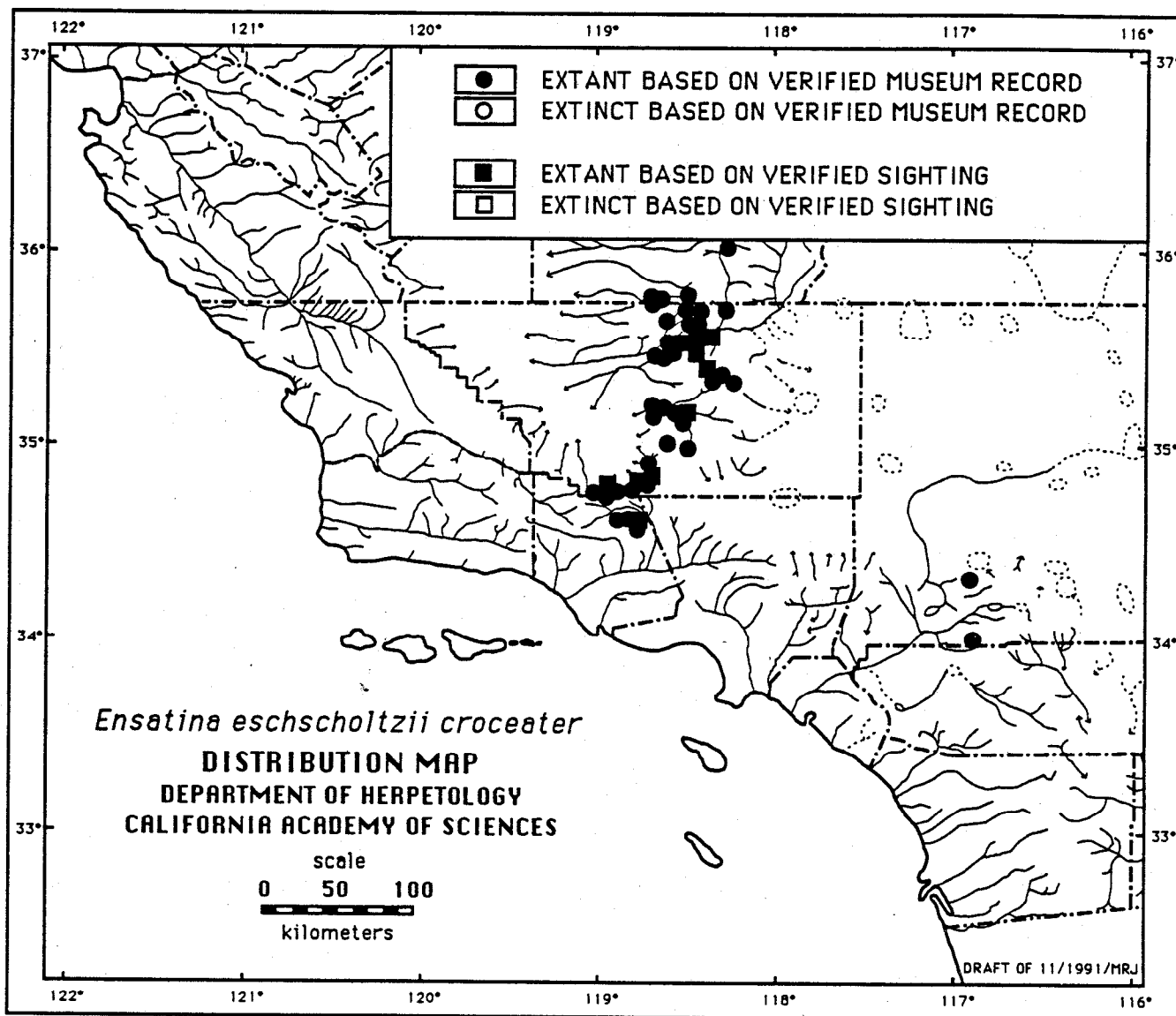
Figure 5. Historic and current distribution of the yellow-blotched salamander (*Ensatina eschscholtzii croceater*) in southern California based on 128 locations from 253 museum records and 35 records from other sources.

Distribution: The known range of this California endemic is restricted to Kern and Ventura counties, California, and extends from the Piute Mountains southwestward to the vicinity of Alamo Mountain (Figure 5). Its known elevation range is from 427 m to 2285 m (Piute Peak, Kern County).

Life History: Little is known of the life history of this nocturnal salamander and until very recently, it remained poorly represented in collections (see Stebbins 1949), probably because the region in which it occurs has been poorly searched relative to others areas in the state (R. Hansen and J. Boundy, pers. comm.; see also Stebbins 1949). If similar to other forms of *Ensatina* studied (see Stebbins 1954a), it likely deposits small clutches of terrestrial eggs that undergo direct development. Gravid females have been observed in April and May (R. Hansen and D. Holland, pers. comm.). This species may be much more difficult to detect near the surface than data would indicate, so it could be more widespread than even current data indicate. Novel sampling techniques will be needed to test whether this possibility is reasonable. No data are available on the movement ecology of this taxon or on the potential differential use of habitat by various life stages, although data on these aspects of the life history of *E. e. croceater* are anticipated to be similar to that described for *E. e. xanthoptica* (see Stebbins 1949). Longevity in the field is unknown, but captive adults have lived at least 3 years (Bowler 1977).

Habitat: Yellow-blotched salamanders occur in a reasonable broad range of vegetational associations from California black oak-, blue oak- *(Quercus douglasii),* and gray pine- *(Pinus subiniana)* dominated open woodlands to Jeffrey pine- *(P. jeffreyi),* ponderosa pine- *(P. ponderosa),* and white fir- *(Abies concolor)* dominated open forest. They are also frequent in canyons amongst litter and debris from canyon live oaks *(Q. chrysolepis),* and they extend onto slopes with California scrub oaks *(Q. dumosa)* and deerbrush *(Ceanothus* sp.). Ecologically, this taxon appears to be rather generalized; Stebbins (1949) suggested that the larger-blotched forms of *Ensatina* like the yellow-blotched salamander had a selective advantage other pattern variants of *Ensatina* over because they could be cryptic on both light and dark substrates instead of being cryptic on one substrate category. Woody debris is a key habitat component for other forms of *Ensatina* (Aubry et al. 1988; see Stebbins 1954a), and observations suggest a parallel pattern for *E. e. croceater (R.* Hansen, D. Holland, and S. Sweet, pers. comm.; see Block et al. 1988).

Status: Special Concern; this taxon is considerably more widespread and abundant than Stebbins (1949) originally realized largely because until recently most of its range had been poorly examined (R. Hansen, pers. comm.). Original concerns regarding exploitation of this salamander by the pet trade (J. Brode, pers. comm.) are less significant as it is now illegal to sell California amphibians and reptiles (Nicola 1981). Nevertheless, indications exist of considerable interest to modify land use practices and development in the Tehachapi Mountains that would threaten a significant portion of the range of the yellow-blotched salamander. The Tehachapi Mountains, Cummings Valley, and Bear Valley areas south of California Highway 58 have undergone significant development over the last 10 years (R. Hansen, pers. comm.). Moreover, the Tejon Ranch Company, probably the largest landowner in this region, has conducted extensive wood cutting operations for oak over the past decade (D. Holland and D. Jennings, pers. comm.), as well as opening up various areas of the ranch for hunting, camping, agriculture, mining, and potential investment (R. Hansen and D. Holland, pers. comm.; pers. observ.). Existing and planned development in these areas has focused largely on oak woodlands, perhaps the most important habitat used by yellow-blotched salamanders.

Management Recommendations: A better understanding of the local and geographic distribution of this taxon are needed. In particular, the habitat features that influence its local distribution are only vaguely understood and need study in the event that directed

management of this taxon becomes necessary. Surveys for this taxon should be a routine component of feasibility assessments addressing potential development in the area of its geographic range.
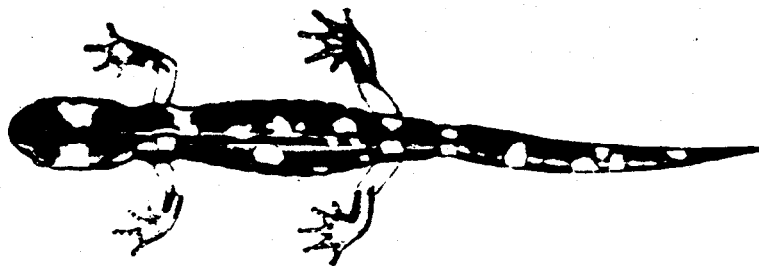

Plate 1. Adult yellow-blotched salamander (*Ensatina eschscholtzii croceater*) [from Stebbins 1954b).

LARGE-BLOTCHED SALAMANDER
Ensatina eschscholtzii klauberi Dunn 1929

Description: A moderate-sized (45.0-82.0 mm SVL) salamander with large (often 5-6 mm or more in greatest linear dimension), usually rectilinear orange blotches on a deep blackish brown to black ground color and a prominent constriction at the base of the tail (Stebbins 1949). Blotches are variable in size and arrangement, sometimes distributed in checkerboard fashion, often connected to form diagonal or transverse bands, or in varying combinations of spots and bands. Twelve to thirteen costal grooves are present. The iris is dark brown or black with few or no guanophores (Stebbins 1949).

Taxonomic Remarks: This taxon is one of a series of morphologically (Stebbins 1949) and genetically (Wake and Yanev 1986) differentiated forms of *Ensatina.* Only two populations of large-blotched salamanders have been sampled genetically, both of which are well-differentiated from populations currently allocated to other subspecies of *Ensatina* (see Wake and Yanev 1986, Wake et al. 1986). Further work on the geographic pattern of genetic and morphological variation in *Ensatina eschscholtzii klauberi* and its allies are needed to reveal whether specific-level recognition for this taxon is justified.

Distribution: The known range of this apparent California endemic is discontinuous from the San Jacinto Mountains in Riverside County to Cottonwood Creek, San Diego County, California (Figure 6). Its known elevational range extends from 518 m (Alpine, San Diego County) to 1646 m (Idyllwild, Riverside County). An old, single record reported as 120 km (75 mi) southeast of San Diego (Lockington 1880; this distance would actually place this record in the Sierra de Juarez) was thought to have come from from the Sierra San Pedro Mártir, Baja California (Dunn 1926, Slevin 1930), and Stebbins (1949) speculated they might occur there (see also Mahrdt 1975), but no further specimens attributed to localities outside of California have been found.

Life History: Little is known of the life history of this form of *Ensatina,* largely because little effort has been made to study it. Laurence Monroe Klauber found an adult female attending a group of 14 eggs on 25 July 1927 (Storer 1929). Like other forms of *Ensatina* studied (see Stebbins 1954a), development is presumed to be direct. Large-blotched salamanders are insectivorous and are known to eat a variety of ground- or litter-dwelling arthropods (Stebbins 1954a). Surface activity is restricted to the period of the year with sufficient surface moisture, usually November to April. Yet, *E. e. klauberi* has been found in logs that harbor a favorable microenvironment into July (Stebbins 1954a). Longevity in the field is unknown, but captive adults have lived over 4 years (Bowler 1977).

Habitat: Large-blotched salamanders occupy a reasonable broad range of habitats from canyon live oak- and Coulter pine *(Pinus coulteri)*-dominated woodland and yellow pine- and incense cedar *(Calocedrus decurrens)-* dominated coniferous forest to California scrub oak-, toyon *(Heteromeles arbutifolia)-,* and buckwheat *(Eriogonum fasciculatum)-* dominated shrubby assemblages. Ecologically, this taxon appears to be rather generalized; Stebbins (1949) suggested that-the larger-blotched forms of *Ensatina* such as the large-blotched salamander had a selective advantage over other pattern variants of *Ensatina* because they could be cryptic on both light and dark substrates instead of being cryptic on one substrate category. Oak logs and debris, especially that provided by coast live oak *(Quercus agrifolia)* and black oak may be favored (M. Long, D. Morafka, and D. Wake, pers. comm.; pers. observ.); woody debris has been identified as a key habitat component for other forms of *Ensatina* (Aubry et al. 1988; Block et al. 1988; see also Stebbins 1954a).

Status: Special Concern; this taxon is considerably more common than was historically believed. Its relatively broad habitat requirements and its occurrence in woodland habitats,
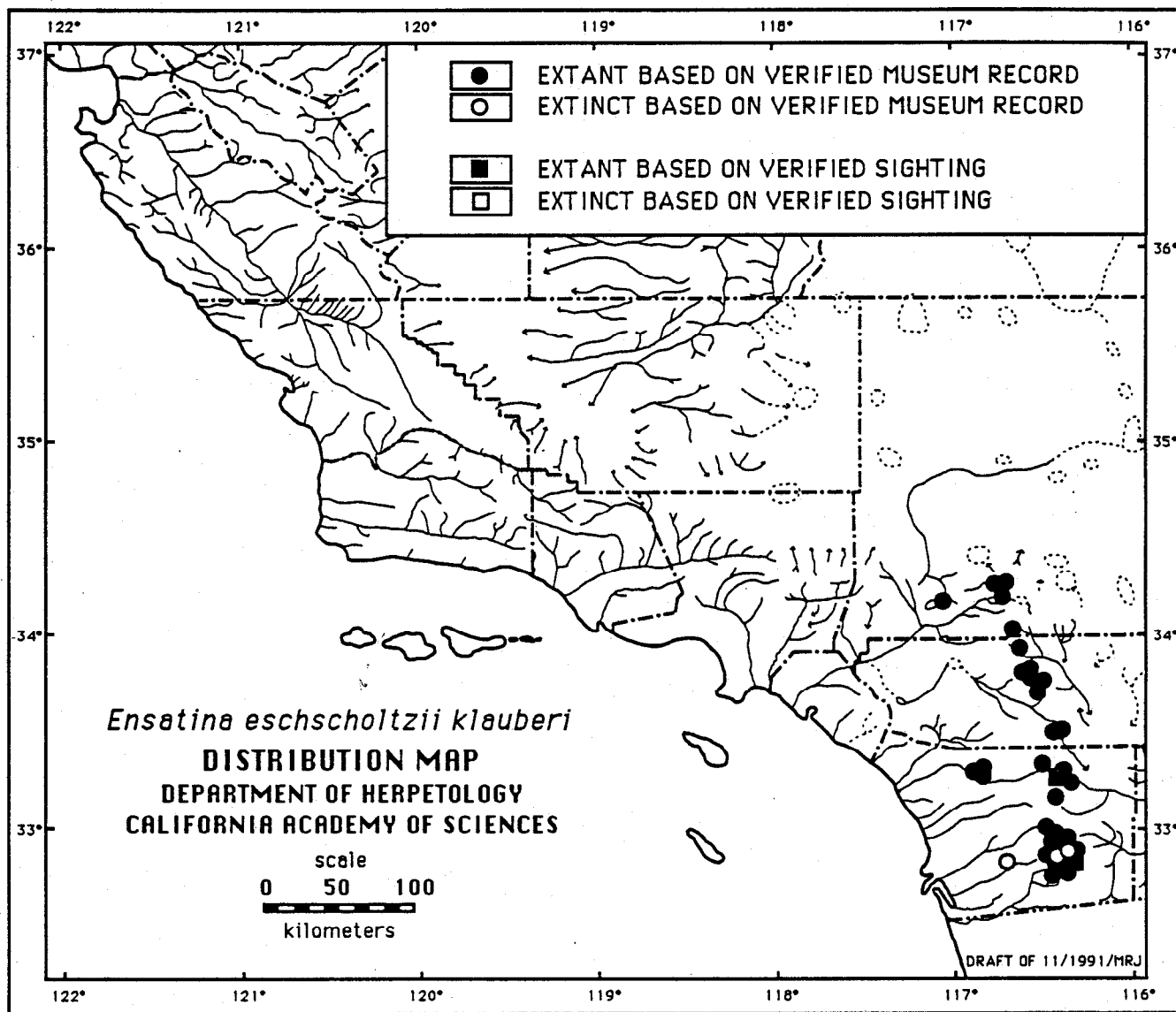
Figure 6. Historic and current distribution of the large-blotched salamander (*Ensatina eschscholtzii klauberi*) in southern California based on 133 locations from 639 museum records and 24 records from other sources.

including residential yards (J. Copp, pers. comm.), with a relatively undisturbed rocky granitic parent substrate that are less accessible may limit the potential threats to this species. Moreover, original concerns regarding exploitation of this salamander by the pet trade (J. Brode, pers. comm.) are less significant as it is now illegal to sell California amphibians and reptiles (Nicola 1981). Nevertheless, continued growth has resulted in a trend toward more intensive development of less accessible sandstone/woodland associations on steep slopes in montane Riverside and San Diego counties, particularly for improved pasture, drip-irrigated orchards and luxury homes, development that is often associated with more intensive substrate disturbance. Potential impacts to populations from mining exist in the Crystal Creek area of the San Bernardino Mountains (J. Brode, pers. comm.).

Management Recommendations: A better understanding of the local and geographic distribution of this taxon are needed. In particular, the habitat features that influence its local distribution are only vaguely understood and need study in the event that directed management of this taxon becomes necessary. Surveys for this taxon should be a routine component of feasibility assessments addressing potential development in the area of its geographic range.

MOUNT LYELL SALAMANDER
Hydromantes platycephalus (Camp 1916)

Description: A moderate-sized (44.0-70.0 mm SVL) salamander with a blotched rock-flake pattern resulting from flecks and patches of pale metallic gold, gray to whitish pigment on a brown to nearly black background color (Stebbins 1954b). Twelve costal grooves are present (Storer 1925), the feet are prominently webbed (Stebbins 1985), and the iris is bright yellow (Camp 1916a).

Taxonomic Remarks: This taxon is one of the three recognized species in the genus *Hydromantes* from California (Gorman 1988). The Mount Lyell salamander appears genetically distinct from other recognized species of *Hydromantes,* but only one population of *H. platycephalus* has been sampled genetically (Wake et al. 1978), so data on the geographic pattern of genetic variation within *H. platycephalus* are lacking.

Distribution: The known range of this California endemic extends from the Smith Lake area (El Dorado County) to the Franklin Pass area (Tulare County) in the Sierra Nevada Mountains (Figure 7). An isolated population is present on the Sierra Buttes, Sierra County (Stebbins 1985). Its known elevational range extends from 1260 m to 3635 m.

Life History: Mount Lyell salamanders are nocturnal (Adams 1942) and adapted to cool conditions; they are known to be active between -2.0°C and 11.5°C (mean = 5.6°C; Brattstrom 1963), which is the lowest temperature range under which any species of *Hydromantes* is known to be voluntarily active (Gorman 1988) and may be the lowest known for any North American salamander. They climb using the tail, a distinctive mode of locomotion that helps them move over the smooth, inclined surfaces of glacially polished rock, which is frequently encountered in their environment (Stebbins 1947). They are presumed to undergo direct development like other plethodontid salamanders; Gorman (1956) examined an 11 egg-bearing female *H. platycephalus* and concluded that they lay fertilized, but undeveloped eggs. Mount Lyell salamander are insectivorous with hatchlings and juveniles apparently restricted to eating smaller forms, such as globular springtails (Sminthuridae) and fungus gnats (Mycetophilidae: Adams 1938, 1942). The season of near-surface activity ranges from around May 1 to late August, after which individuals probably retreat to refugia in talus slopes and fissures with sufficient moisture.
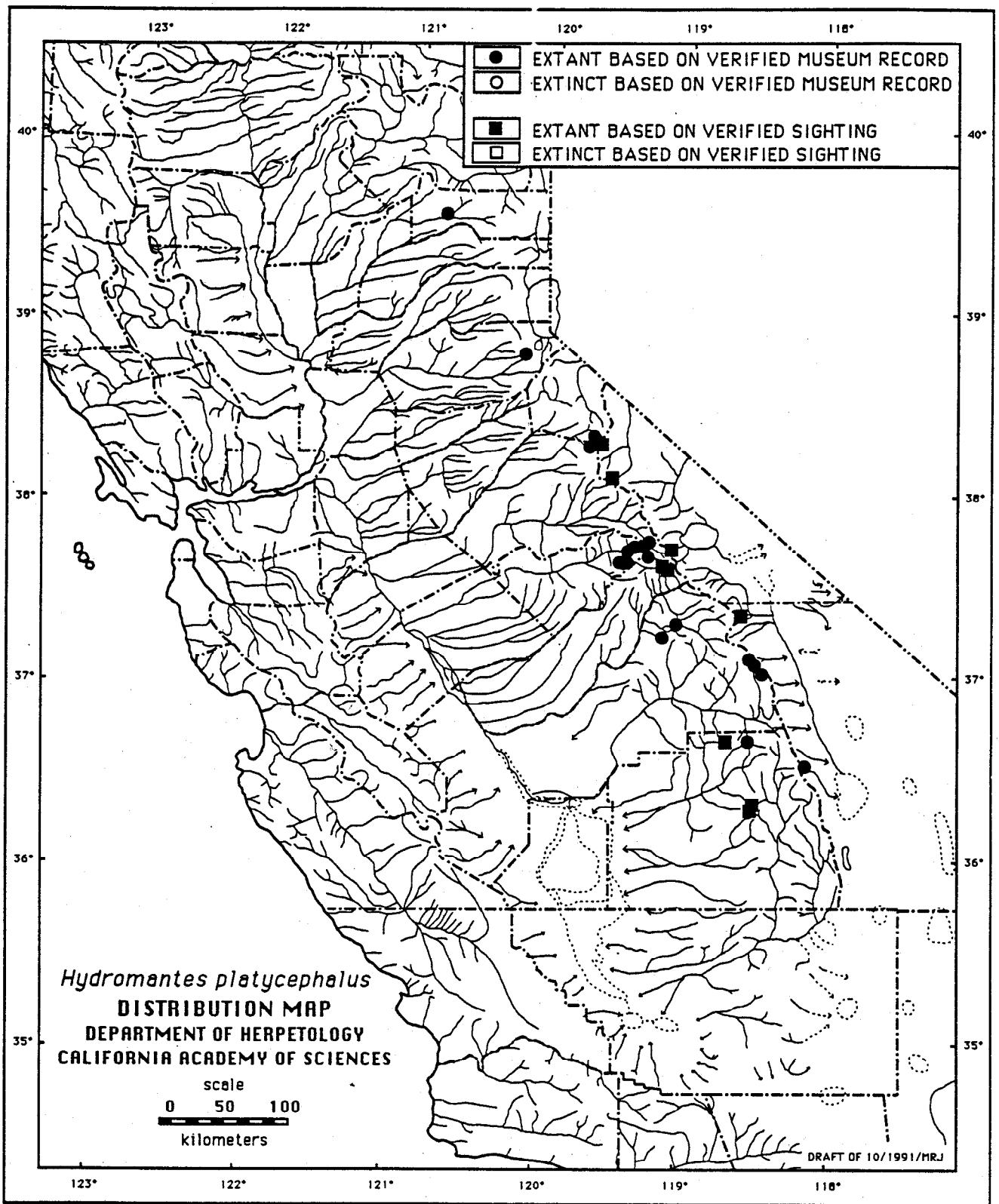
Figure 7. Historic and current distribution of the Mount Lyell salamander (*Hydromantes platycephalus*) in central and northern California based on 56 locations from 386 museum records and 13 records from other sources.

Habitat: *Hydromantes platycephalus* is largely restricted to alpine or subalpine vegetation associations (Adams 1938, 1942; Stebbins 1951), although scattered records of this species exist from somewhat lower elevations. Extensive outcrops of rock and scattered boulders are characteristic of the habitat of *H. platycephalus* (Stebbins 1985). Free surface water, such as a permanent stream, waterfall, seepage, or runoff from melting snow, is almost always present within a few meters, and usually within a few centimeters, of the sites where *H. platycephalus* is present as it has been described as being no more resistance to water loss than wet paper (Gorman 1988). This high elevation endemic is most frequently found beneath rocks on a moist-to-wet substrate of rock and soil with little humus (Gorman 1988), on north and east slopes (Zeiner et al. 1988). Woody vegetation (largely alpine willow *[Salix anglorum],* heather *[Phyllodoce breweri]* scrubby whitebark pine *[Pinus albicaulis]),* is typically sparse or absent altogether; but grasses, sedges, mosses, or lichens may be present.

Status: Special Concern; although this California endemic has the broadest geographic range of the known species of *Hydromantes,* within that range, *H. platycephalus* may be very patchily distributed (Zeiner et al. 1988) with local populations of 6-60 individuals (Gorman 1988). Past observations indicate that large aggregations of adults may be susceptible to human intrusion during favorable years (Gorman 1988; H. Basey, pers. comm.). Until its microhabitat requirements are better understood, a conservative approach of giving it this designation is strongly recommended based on its potentially very patchy distribution that may be especially susceptible to local extirpation events. That listing may be modified as knowledge of its range and habitat requirements are acquired.

Management Recommendations: A much better understanding of the specific habitat requirements significant to the survival of this species are an absolute prerequisite to refining management efforts. Until specific habitat data become available, efforts should be directed at protecting the habitat ensemble associated with the rocky habitats where *H. platycephalus* has been found. In particular, efforts should be made to avoid any alterations that might result in alteration of the physical or hydrological structure of these areas. Wherever possible, talus slopes should be protected from intrusion. Disruption of exfoliated rocky shelves or granite fissures known to harbor salamanders should be avoided. Limiting or excluding climbing activity or the use of rock-altering climbing gear in areas where these salamanders are known to exist should be encouraged until the distribution of this salamander and how it responds to different habitat disturbances is better understood.

OWENS VALLEY WEB-TOED SALAMANDER
Hydromantes sp.

Taxonomic Remarks: This recently discovered, currently undescribed taxon appears to be a member of the genus *Hydromantes* (Jennings 1987a, Gorman 1988, Macey and Papenfuss 1991a). Individuals of this taxon that have been found appear to be morphologically (colorwise) distinct from *H. platycephalus* (J. Brode, pers. comm.).

Distribution: Preliminary data indicate that this taxon is endemic to California, and probably restricted to Mono and Inyo counties on the east slope of the Sierra Nevada Mountains (Macey and Papenfuss 1991a; Figure 8).

Life History: The life history of this taxon is unknown, but is presumed to be nocturnal with a pattern similar to that described for *H. platycephalus* (Macey and Papenfuss 1991a).
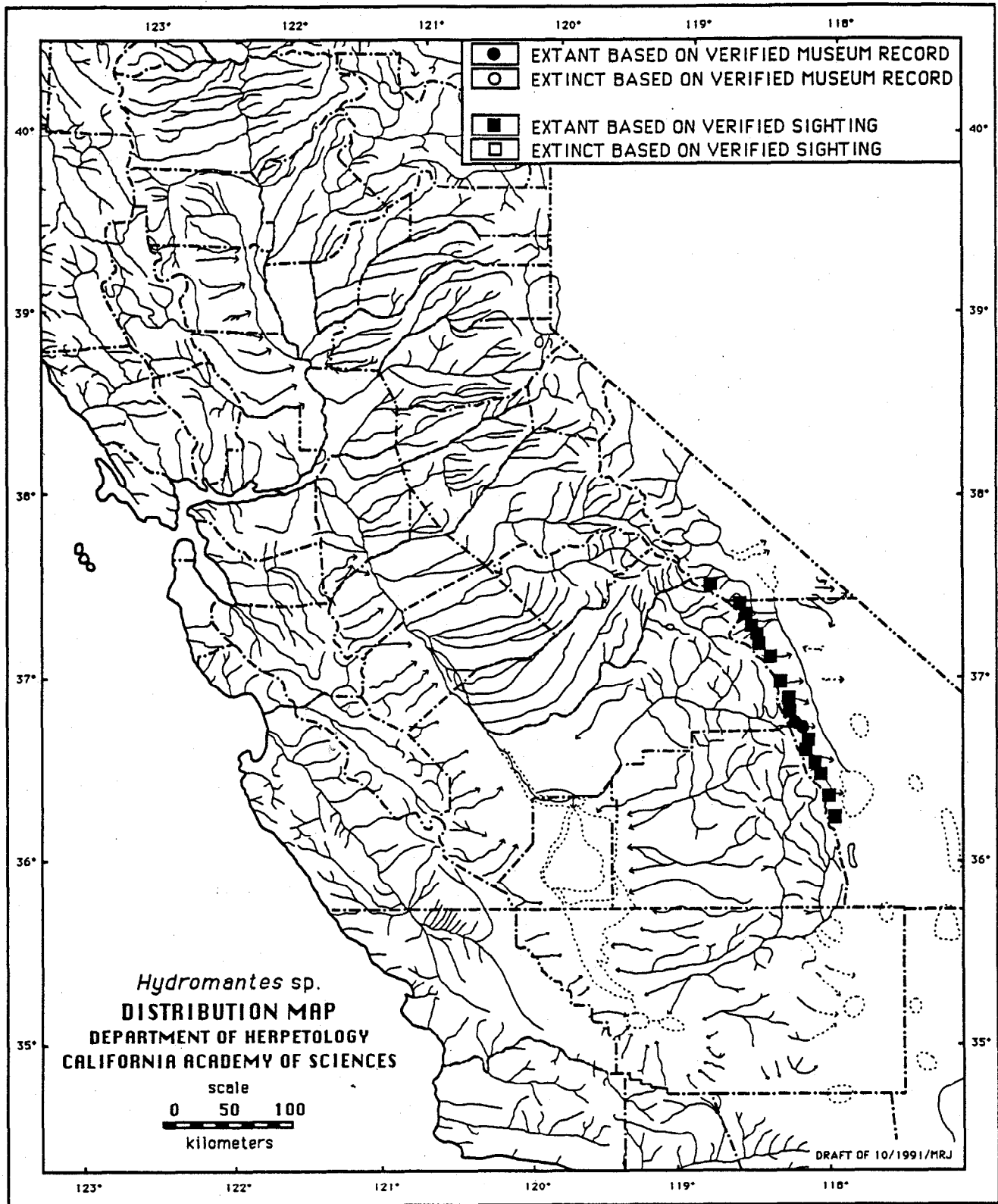
Figure 8. Historic and current distribution of the Owens Valley web-toed salamander (*Hydromantes* sp.) in central California based on 16 locations from 163 museum records and 29 records from other sources.

Habitat: This taxon is known to occur in localized talus adjacent to very moist riparian areas in the vicinity of permanent springs and mountain streams (Macey and Papenfuss 1991a). It can be found under woody debris or rocks in areas with moist soil. A more precise understanding of the habitat features of localities where the Owens Valley web-toed salamander has been found awaits its formal description.

Status: Special Concern; although not yet described, this taxon is likely to be restricted to the east slope of the Sierra Nevada in California. A conservative approach of listing this species at this level is strongly recommended based on its relatively restricted known range, small numbers of adults (≤ 8) observed in each population, and lack of knowledge of its habitat requirements. That listing may be modified as knowledge of its range and habitat requirements are acquired.

Management Recommendations: Efforts should be made to protect areas known to serve as habitat for this species on the east slope of the Sierra Nevada. In particular, activities that result in disturbance of the mesic, rocky talus or the seep hydrology where this salamander occurs should be prohibited. Recommendations made for *H. platycephalus* probably apply equally well to this species. Knowledge of habitat requirements must be greatly improved before recommendations can be refined.

DEL NORTE SALAMANDER
Plethodon elongatus elongatus Van Denburgh 1916

Description: A moderate-sized (51.0-75.0 mm SVL) black or dark brown salamander often with a reddish dorsal stripe (Brodie 1969, 1970). Undersurfaces are black except for a light gray throat that is often mottled. White and yellow iridophores are scattered over the body, but particularly concentrated on the sides of the head and body, the upper surfaces of the limbs, and the throat (Brodie and Storm 1971). Seventeen to 20 costal grooves are present (Stebbins 1985). The iris is dark brown with few or no iridophores (Brodie 1969, 1970).

Taxonomic Remarks: Genetically, *Plethodon elongatus* is well differentiated from its close relatives (Feder et al. 1978, Highton and Larson 1979), but no data exist on how populations within California may vary. Some authors include *P. stormi* in this taxon (e.g., Bury 1973a, Stebbins 1985), but genetic data appear to justify specific recognition for both taxa (Highton and Larson 1979). A much better understanding of the genetic pattern of geographic variation within *P. elongatus* is needed, especially in view of the fact geographically correlated differences in external morphology seem to exist. In particular, *P. elongatus* in coastal California are smaller and darker, have immaculate sides, and have the dorsal stripe nearly obscured in adults; *P. elongatus* from inland locations are larger and lighter-colored with a persistent dorsal stripe and scattered white spots on the sides (Nussbaum et al. 1983).

Distribution: The known distribution of the Del Norte salamander extends from the vicinity of Port Orford, Curry County, Oregon to central Humboldt County, California. In California, it ranges from the Oregon border adjacent Del Norte and eastern Siskiyou counties south to Humboldt County (Figure 9). Its known elevational range extends from near sea level to ca. 1097 m.

Life History: Similar to other plethodontid salamanders, this species lays terrestrial eggs and has direct development. Females oviposit in spring and brood eggs in a terrestrial nest during the summer (Nussbaum et al. 1983). A nest in a small cavity in a redwood *(Sequoia sempervirens)* post found on 27 July 1958 contained 10 eggs in a grape-like

Plethodon elongatus elongatus
DISTRIBUTION MAP
DEPARTMENT OF HERPETOLOGY
CALIFORNIA ACADEMY OF SCIENCES

scale

0   50   100

kilometers

● EXTANT BASED ON VERIFIED MUSEUM RECORD
○ EXTINCT BASED ON VERIFIED MUSEUM RECORD

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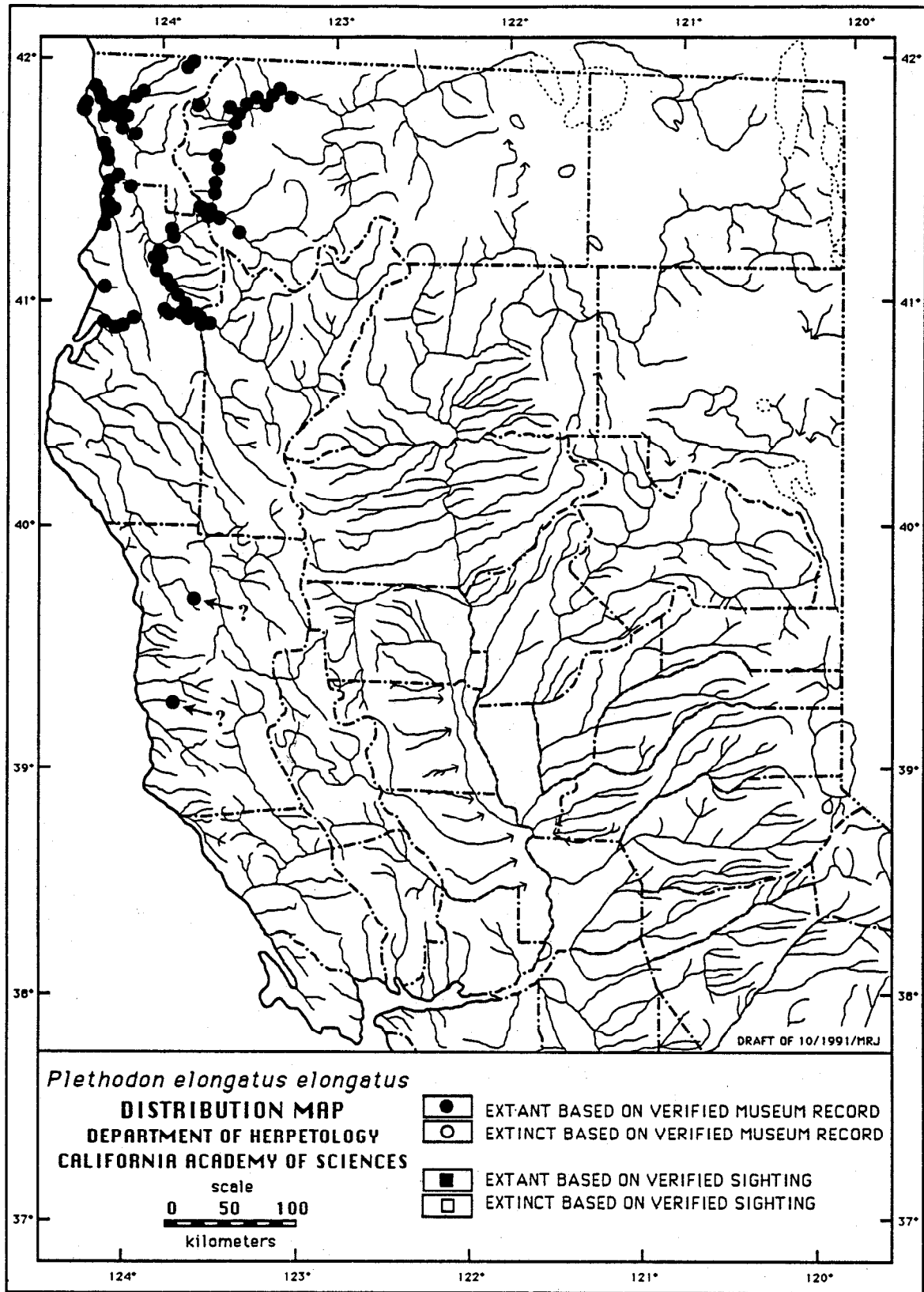
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Figure 9. Historic and current distribution of the Del Norte salamander (*Plethodon elongatus elongatus*) in northern California based on 216 locations from 1297 museum records.

cluster (Livezey 1959). Eighteen mature gravid females from Siskiyou County, California contained 3-11 large eggs (Nussbaum et al. 1983). Stebbins (1951) reported gravid females obtained at Orick and near Willow Creek, Humboldt County, California on 15 February and 16 November to contain 10 and 11 eggs. On 17 November 1988, two females carrying spermatophores (= sperm packets) were also found at a site in this vicinity (Welsh and Lind 1992). Limited data indicate that *P. elongatus* eats mostly springtails (Collembola) and larval and adult beetles (Coleoptera: Bury and Johnson 1965) as well as termites (Isoptera), ants (Formicidae), and orbatid mites (H. Welsh, pers. comm.). During a 3-year study of *P. elongatus* in the Klamath Mountains of northwestern California, Welsh and Lind (1992) found this salamander to be a very sedentary species; 80% of adult recaptures moved < 7.5 m over 3 years. The greatest distance traveled by any salamander was 36 m (straight line) in 6 months. Welsh and Lind (1992) also reported that growth rates for females (averaged 1.1 mm/yr) less than half that for males (averaged 2.4 mm/yr). This species seems to be more frequently encountered near the surface following winter rains.

Habitat: The Del Norte salamander is largely restricted to the redwood and north coast forests of northwestern California and southwestern Oregon (Stebbins 1951). Relatively recent work has identified *P. elongatus* as most abundant in old-growth forest (Bury 1983, Raphael 1988, Welsh 1990, Welsh 1993) with intermediate levels of moisture (Welsh and Lind 1988), particularly in association with talus slopes (Bury 1973a, Herrington 1988, Diller and Wallace 1994) and outcrops of fractured metamorphic rock (Welsh and Lind 1988), which is consistent with *P. elongatus* being tolerant to intermediate levels of water loss relative to other salamanders (Ray 1958). The relative abundance of the hardwood understory in general and specifically that of tanbark oak *(Lithocarpus densiflora)* have been positively correlated with the relative abundance of *P. elongatus* (Raphael 1987, 1988; but see also Diller and Wallace 1994 for data from more mesic sites). However, what other hardwoods might be important to *P. elongatus* and how hardwoods are important'to the life history of *P. elongatus* needs study. Welsh and Lind (1991) and Welsh (1993) found the best-fit multivariate model describing the habitat characteristics of *P. elongatus* to be one where its distribution was positively correlated with seeps and a rocky substrate, and negatively correlated with the volume of downed hardwood logs and the weight of small downed logs. Their findings indicate that greater attention and study should be devoted to the presence of seeps with regard to understanding the distribution of *P. elongatus.*

Status: Special Concern; this species has a relatively restricted distribution in California (the extreme northwest portion of the state) and its range outside California is limited. Although still somewhat abundant along a narrow coastal strip of mesic habitats in northern California (Diller and Wallace 1994), inland populations have relatively specialized habitat requirements (mostly old-growth situations associated with a fractured rocky substrate) that make *P. elongatus* is vulnerable. Currently, timber harvest is the most significant activity within the range of *P. elongatus* that threatens remaining old-growth stands.

Management Recommendations: In the absence of data needed to understand whether inland populations of *P. elongatus* at low densities in non-old-growth stands can survive long-term, preservation of old-growth stands is imperative to ensure the survival of a significant proportion of *P. elongatus* populations. Efforts should be focused on protecting talus slopes and outcrops of fractured metamorphic rock from alteration, especially those in association with seeps in old-growth stands. Impacts to old-growth canopy and to the hydrology of seeps should especially be avoided. In particular, any type of alteration that modifies natural grade and canopy cover, such as logging, should be minimized or prohibited in the vicinity of such habitats (Corn and Bury 1989). Based on the data of Welsh and Lind (1991) and Welsh (1993), a better understanding of the relative importance of seeps to the distribution of *P. elongatus* is needed. An understanding of the

recolonization potential of *P. elongatus* under different alteration regimes in both coastal and inland locations is also needed.
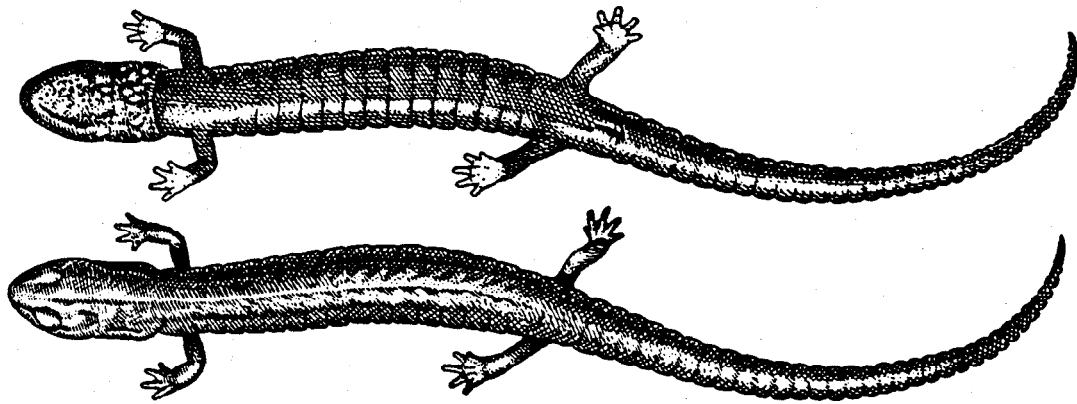
Plate 2. Adult Del Norte salamander (*Plethodon elongatus elongatus*) [from Stebbins 1951].

SOUTHERN SEEP SALAMANDER
Rhyacotriton variegatus Stebbins and Lowe 1951

Description: The southern seep salamander is a moderate-sized (ca. 40.0-51.4 mm SVL)
olive or pale olive salamander with strongly black to brown spots, and some fine white
guanophores dorsally (Stebbins and Lowe 1951, Good and Wake 1992). Undersurfaces
range from greenish yellow to yellow, usually heavily flecked and spotted with dark
melanic blotches of variable size (Fitch 1936; Stebbins and Lowe 1951; Good and Wake
1992; pers. observ.). The iris is blackish-brown with metallic, light-colored markings
(Stebbins and Lowe 1951).

Taxonomic Remarks: *Rhyacotriton variegatus* had been previously recognized as part
of a single, wide-ranging species, *R. olympicus* (e.g., Stebbins and Lowe 1951, J.
Anderson 1968, Stebbins 1985), but Good et al. (1987) identified considerable genetic
variation within this species, which ultimately led to the partitioning of the latter into four
species, including *R. variegatus* (Good and Wake 1992). Information presented in this
account is restricted to *R. variegatus,* the only one of the four species found in California.

Distribution: This species ranges from the vicinity of Point Arena, Mendocino County,
California (Stebbins 1955) to the Little Nestucca River on the northwest coast of Oregon
(Good et al. 1987, Good and Wake 1992). In California, this taxon ranges from
Mendocino County to the Oregon border (Figure 10). Its known elevational range extends
from near sea level to ca. 1200 m (Nussbaum et al. 1983).

Life History: The life histories of seep salamanders *(Rhyacotriton* spp.) are poorly
known and even fewer data apply *R. variegatus* in California. Males found in California
indicated reproductive readiness in mid-February, but females with ovarian eggs
approaching full size on 1 October and ovarian eggs visible through the body wall in June
(Welsh and Lind 1992) suggest that oviposition may occur as early as the fall (Stebbins and
Lowe 1951). The only field description of a seep salamander oviposition site is that
assumed to belong to *R. kezeri* (Nussbaum 1969); large (4.5 mm dia), pigmentless eggs
found in December were loosely placed in cracks in saturated sandstone. If oviposition is
similar to that observed for *R. olympicus* (see Noble and Richards 1932), communal
deposition of singly laid eggs in concealed locations may be typical. Based on data from
Fall Creek (Lincoln County), Oregon, the embryonic and larval interval combined is
extremely long (ca. 4.0-4.5 years), and reproductive maturity may require 6-7 years or
more (Nussbaum and Tait 1977). Adults are active at air and water temperatures lower
than those known for any other aquatic salamander, between 5° and 10°C (Stebbins and
Lowe 1951; Stebbins 1955; Brattstrom 1963; see also Nussbaum and Tait 1977), and have
among the lowest critical thermal maxima (28.3°C: Brattstrom 1963) of any salamander
known. *Rhyacotriton variegatus* may also be the most desiccation intolerant salamander
found in California (see Ray 1958), which is likely related to a high degree of dependence
of seep salamanders on cutaneous respiration for oxygen exchange (Whitford and
Hutchinson 1966). Adults of *R. variegatus* eat mostly amphipods (Amphipoda),
springtails, and the larvae of insects (Insecta) found in moist habitats (Bury and Martin
1967). Recent data collected by Welsh and Lind (1992) suggests that *R. variegatus is*
highly sedentary. Welsh and Lind (1992) note, however, that caution is needed in the
interpretation of the degree to which *R. variegatus* is sedentary because movement of
salamanders beyond their sample area could not be determined. Their data also indicate that
larvae are more vagile than adults, suggesting that larval dispersal is the most likely means
of connectivity between populations. Welsh and Lind (1992) emphasize that such a
scenario requires interconnecting aquatic habitats, which may be an infrequent rainy season
phenomenon in the drier interior portions of the range of *R. variegatus* in California. Much
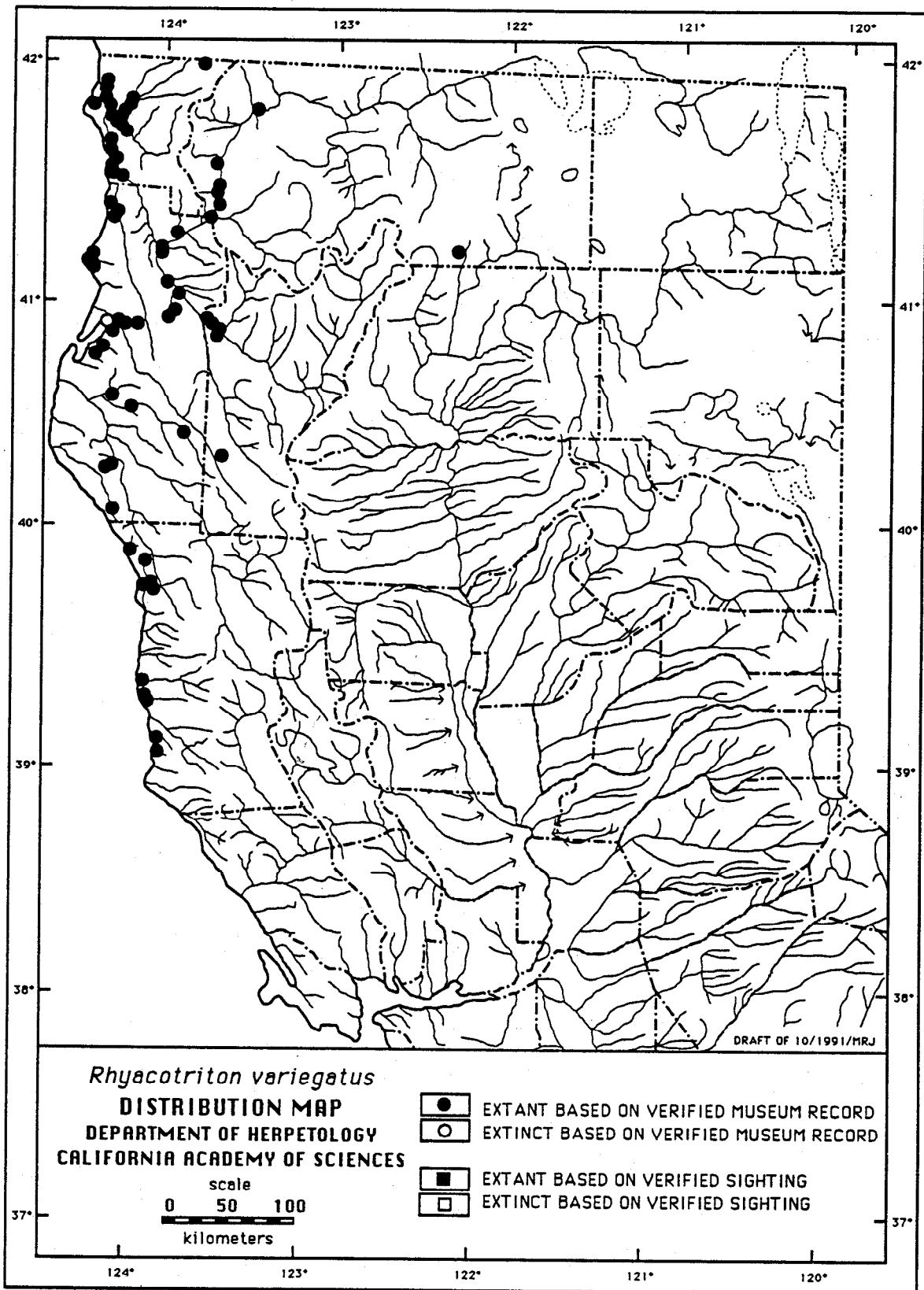of the movement ecology of *R. variegatus* remains to be understood.

Figure 10. Historic and current distribution of the southern seep salamander (*Rhyacotriton variegatus*) in northern California based on 111 locations from 567 museum records.

Habitat: Cold, permanent seeps and small streams with a rocky substrate appear to be the preferred habitats (Fitch 1936, Stebbins and Lowe 1951, Stebbins 1955). Relatively recent work has linked this species to seeps, small streams, and waterfalls in wet or mesic, coastal old-growth habitats (Bury 1983; Welsh and Lind 1988; Corn and Bury 1989; Good and Wake 1992; Welsh 1993; see also Raphael 1988), an association that is likely influenced by the fact that old-growth provides the hydric and thermal environment more favorable (cooler and wetter) to the survival of *R. variegatus* for longer intervals than similar habitats in non old-growth situations (Welsh 1990). *Rhyacotriton variegatus* larvae may be found in somewhat larger streams (especially in the splash zone of waterfalls: D. Good, pers. comm.), but their abundance in seeps has led to the suggestion that predators, like the larvae of Pacific giant salamanders *(Dicamptodon ensatus* and *D. tenebrosus),* may largely exclude them from the former habitats (Stebbins 1955; see also Nussbaum 1969). The greater frequency of *R. variegatus* in seeps may also reflect the greater facility; and thus bias, with which seeps versus streams are sampled as well as the lack of systematic sampling for *R. variegatus* in streams, so the reasons for the apparent restriction of *R. variegatus* to seeps needs study in order to refine current understanding of the habitat requirements for this species. Adults and metamorphosed individuals have been found in concealed locations within a few meters of the seep habitat that displays surface flow; such locations typically have shallow free water or a saturated substrate (Stebbins and Lowe 1951).

Status: Threatened; The relatively narrow hydric and thermal requirements of *R. variegatus* make it particularly vulnerable, and are probably the reason this species is closely associated with seep habitats in coastal old-growth. Moreover, the apparently relatively long interval to reproductive maturity probably makes replacement of disturbed *R. variegatus* populations relatively slow. Until the variation in hydric and thermal requirements that appears to restrict this species to seep and small stream habitats are better understood, one must take the conservative approach that coastal old-growth seeps and small streams are the only habitats that can support viable populations of this species. Recent estimates place the amount of coastal old-growth redwood forests in California, which comprise a significant portion of coastal old-growth forests in California, at 12% of their historic extent (Fox 1988), over half of which is found on private or unreserved public lands, and therefore susceptible to significant timber harvest. Moreover, how *R. variegatus* is distributed through the remaining suitable habitat is poorly understood.

Management Recommendations: Efforts should be focused on protecting the remaining seep and small stream habitats that occur within coastal old-growth forests from alteration. Impacts to the hydrology of seeps and old-growth canopy should especially be avoided. In particular, logging activities or any type of construction that modifies natural grade should be minimized or prohibited in the vicinity of such habitats (Corn and Bury 1989). One of the biggest gaps in current understanding of the life history of *R. variegatus* is a better understanding of the movement ecology of larvae and post-metamorphs over diel and seasonal intervals. Until studies improve the understanding of its movement ecology, a significant impediment will exist to refining habitat-oriented management recommendations for California populations of *R. variegatus.* In particular, efforts should be made to determine whether the low densities of *R. variegatus* that occur outside of old-growth seeps and small streams do not simply represent individuals dispersing or moving from foci of suitable habitat or non-viable relict populations. Better survey and inventory methods for this cryptozooic species are especially needed.
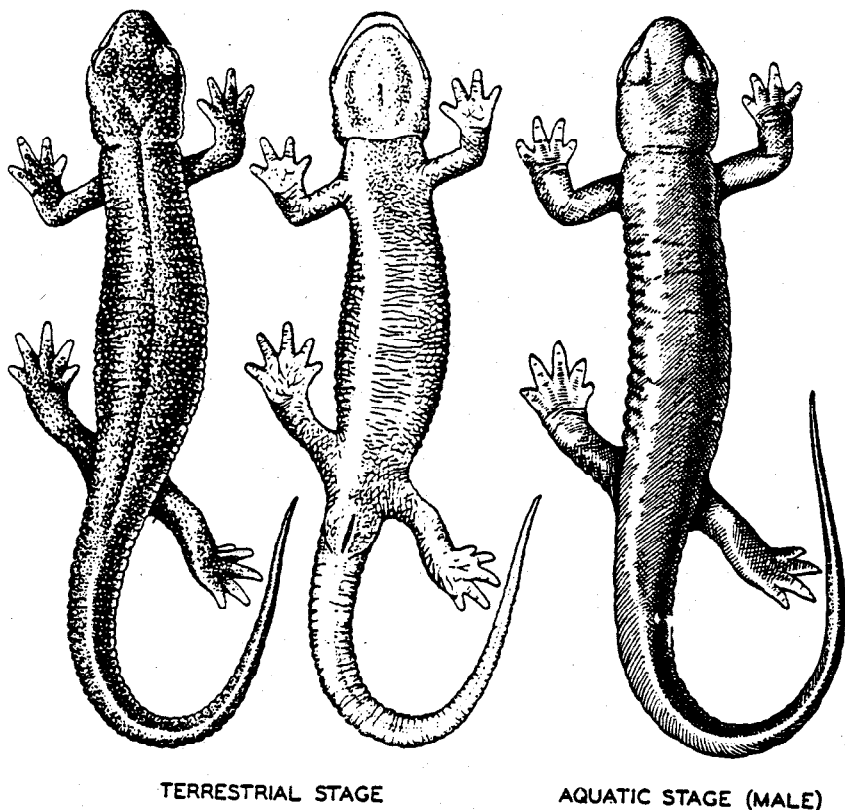
TERRESTRIAL STAGE   AQUATIC STAGE (MALE)

Plate 3. Larval, juvenile, and adult Coast Range newt (*Taricha torosa torosa*) [from Stebbins 1951].

COAST RANGE NEWT
Taricha torosa torosa (Rathke <u>in</u> Eschscholtz 1833)

Description: A moderate-sized (50.0-87.0 mm SVL) dark brown salamander with bright yellow-orange to orange undersurfaces (Riemer 1958); thick, relatively textured skin that becomes markedly rough-glandular during its terrestrial phase, but reverts to a relatively smooth condition during its aquatic phase (Nussbaum and Brodie 1981). Each iris has areas of dense gold iridophores interrupted by a prominent brown, horizontal eyestripe that broadens toward the outer edges of the iris (Riemer 1958).

Taxonomic Remarks: Genetic variation in *Taricha torosa torosa* is known from only 6 populations in central California, the southernmost two of which showed considerable genetic divergence from the northern four (Hedgecock and Ayala 1974, Hedgecock 1977). This coupled with apparent significant differences in timing of reproduction of *T. t. torosa* from Monterey County south may indicate that more than one taxon is currently concealed within *T. t. torosa.*

Distribution: Historically distributed in coastal drainages from the vicinity of Sherwoods (central Mendocino County) in the North Coast Ranges, south to Boulder Creek, San Diego County (Figure 11). Nevertheless, populations in southern California appear to be highly fragmented, even historically. The records of Slevin (1928) for Baja California are thought to be erroneous (Stebbins 1951). The known elevation range of this species extends from near sea level to ca. 1830 m (Stebbins 1985).

Life History: A frequently conspicuous diurnal salamander that, if the behavior of the related red-bellied newt *(T. rivularis)* can be considered an appropriate indicator (Hedgecock 1978), probably engages in stereotyped, sometimes long-distance (i.e., > 1 km) migrations to breeding sites. In spring, males congregate at breeding sites first (Ritter 1897), followed by females some days to weeks later (Smith 1941). In a relatively stereotyped courtship, females pick up sperm packets (spermatophores) deposited by males (Smith 1941), internal fertilization occurs, and females deposit 3-6 egg spheriodal masses each containing 7-47 eggs over a period of several days on rocks, stems, or root masses (Ritter 1897; Brame 1956,1968; Riemer 1958; pers. observ.). Eggs apparently hatch after 4-6 weeks (Kats et al. 1994). In central California, breeding appears to occur in two waves, the first in January or February and the second in March or April (Twitty 1942, Stebbins 1951, Miller and Robbins 1954), although Coast Range newts may enter ponds as early as December (Riemer 1958). Larvae take approximately 3-6 months to reach metamorphosis (pers. observ.) and subsist largely on aquatic invertebrates and also conspecifics (Ritter 1897). Adult newts eat a wide variety of aquatic and terrestrial invertebrates (earthworms, insects, snails, beetles, butterflies, and stoneflies; Stebbins 1972, Hanson et al. 1994), as well as egg masses and larvae (Kats et al. 1992), and carrion (Hanson et al. 1994). If *T. t. torosa* is similar to the related *T. rivularis,* adults are probably long-lived (i.e., > 20 yrs) and may not reproduce every year (Hedgecock 1978). The Coast Range newt is one of a group of related newts thought to possess warning (aposematic) coloration (Brodie 1977). Whether or not the bright ventral coloration of the post-metamorphic Coast Range newt is aposematic, its skin and eggs are endowed with toxic glands (Buchwald et al. 1964, Brodie et al. 1974) that appear to have the ability to repel at least some predators *(e.g., Thamnophis elegans,* Hubbard 1903) and can be presented to predators in distinctive postures (Brodie 1977). The Coast Range newt seems to have greater opportunity to display any distinctive coloration or noxious skin gland because its morphology (it possesses thicker skin and a significantly larger bladder capacity than most other salamanders), its behavior (it maintains more frequent body contact with the substrate than other salamanders), and its physiology (it has a higher temperature tolerance than most other salamanders) make it more resistant to desiccation than most other
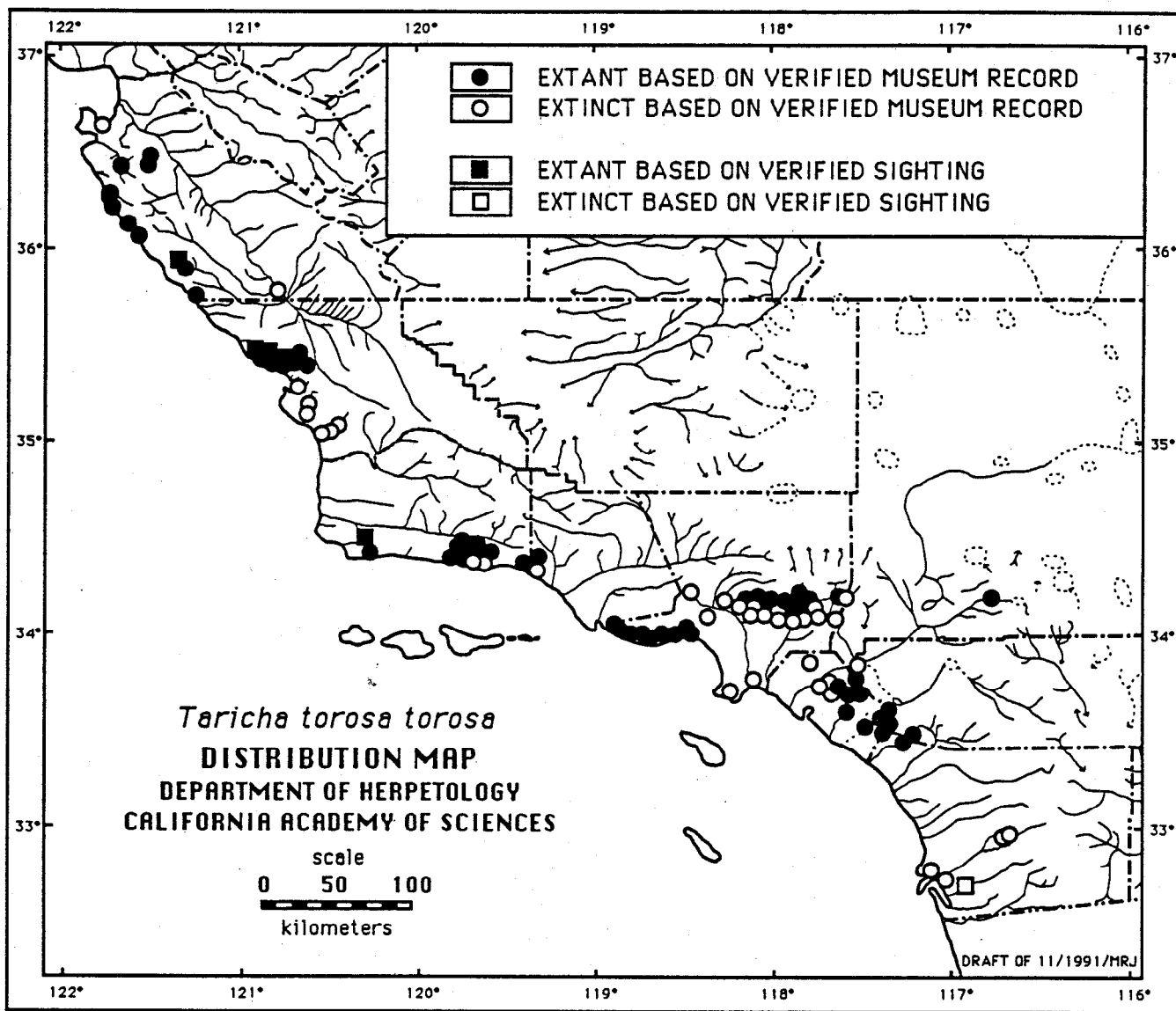
Figure 11. Historic and current distribution of the Coast Range newt (*Taricha torosa torosa*) in southern California based on 374 locations from 1,690 museum records and 29 records from other sources.

salamanders (Cohen 1952, McFarland 1955, Brattstrom 1963, Brown and Brown 1980). Larval *T. t. torosa* may be a seasonally very significant food resource for newborn individuals of certain species of garter snakes *(Thamnophis* sp.), including the federally endangered San Francisco garter snake, *Thamnophis sirtalis tetrataenia* (S. Barry, pers. comm.). Although the movement ecology of the related *T. rivularis* has been well-studied (Twitty et al. 1967a, 1967b), that of *T. t. torosa* is essentially unknown (Twitty 1959).

Habitat: Coast Range newts frequent terrestrial habitats, but breed in ponds, reservoirs, and slow-moving streams (Stebbins 1954b, 1985). Lack of data on the movement ecology of this species prevents a complete characterization of the microhabitats used.

Status: Special Concern--southern California populations only from south of the Salinas River in Monterey County; if the sizes of local populations (demes) of the related *T. granulosa* (pers. observ.) and *T. rivularis* (Hedgecock 1978) consisting of many thousands of individuals can be considered a suitable indicator, historically, *T. t. torosa* may have been one of the most abundant, if not the most abundant amphibian through much of its range. Only in the small coastal drainages of the Santa Ynez Mountains of Santa Barbara County were populations probably historically always relatively small (estimated at between 50 to 100 adults; S. Sweet, pers. comm.). This species has been depleted by large-scale historical commercial exploitation coupled with the loss and degradation of stream habitats, especially in Los Angeles, Orange, Riverside, and San Diego counties. Our own observations indicated that the breeding habitat of *T. t. torosa* has, at best, been severely degraded over much of its range, largely due to a shift in sedimentation dynamics that has resulted in greater filling and less frequent scouring of pools to allow them to retain their characteristic structure (Coming 1975 as modified and cited in Faber et al. 1989).

Management Recommendations: The movement ecology, age structure, and longevity of *T. t. torosa* must be better understood before really effective management recommendations can be made. Meanwhile, efforts should be made to preserve historic sites where *T. t. torosa* has been known to breed. Until a better understanding of its movement ecology is obtained, it is unclear how much terrestrial habitat will be needed to ensure long-term survival of *T. t. torosa* populations, but until that time, the decision to preserve terrestrial habitat associated with the breeding sites for this species should conservatively preserve the largest terrestrial areas possible. A thorough study of the geographic pattern of genetic variation within *T. t. torosa* is needed to determine whether more than one taxon is represented because if more than one taxon is present, each taxon will not only have a more restricted geographic range, but each will require more intensive life history study to determine if significant differences in their ecologies exist.

Plate 4. Larval and adult tailed frog (*Ascaphus truei*) [from Stebbins 1951].

ANURANS

TAILED FROG
Ascaphus truei Stejneger 1899

Description: A small (35.0-45.0 mm SUL) olive, brown, gray, or reddish frog, often with a pale yellow or greenish triangle extending between the eyes and snout, and a dark eyestripe (Mittleman and Myers 1949, Metter 1964a). The undersurfaces are white to yellowish white. The eyes are brown with gold iridophores on both the upper and lower portions of the iris, but a greater density of iridophores is present on the upper iris (Metter 1964a).

Taxonomic Remarks: *Ascaphus truei* is probably the most distinctive species of North American frog, and it is currently regarded as the only species within the genus *Ascaphus.* However, indications of potential geographic polymorphism in the karyotypes of *A. truei* (Green et al. 1980) and larval and postmetamorphic morphology (Mittleman and Myers 1949; Metter 1964a; J. Applegarth, pers. comm.) suggest that the geographic pattern of genetic variation within *A. truei* should be examined with the idea of identifying potentially cryptic taxa, particularly in view of the fact that a number of isolates between which there is little or no gene flow occur throughout its geographic range (Metter and Pauken 1969; see also Daugherty 1980).

Distribution: The known range of the tailed frog extends from extreme northern Mendocino County, California in the United States north to Bute Inlet, British Columbia in Canada; disjunct population systems also occur in Idaho, western Montana, and extreme southeastern British Columbia; extreme eastern Oregon; extreme eastern Washington (Metter 1968a); and the McCloud River system in the Shasta region of California (Bury et al. 1969). In California, the distribution extends from coastal Mendocino County (Salt 1952, Welsh 1985) north to the Oregon border (Grinnell and Camp 1917, Mittleman and Myers 1949) with the disjunct population system in the Shasta region (Figure 12). The known elevational range of the tailed frog extends from near sea level (Mill Creek, Humboldt County) to 1981 m (Pony Mountain, Trinity County: Bury 1968).

Life History: Most data in this summary of the life history of *A. truei* comes from outside of California. *Ascaphus truei* has one of the most distinctive life histories of any North American frog. Adults are nocturnal and have been observed to be active between April and October, and may reproduce during most months over that interval (Gaige 1920, Stebbins 1985). Amplexus is pelvic, males use their small tail as a penis in sperm transfer (Slater 1931, Wemz 1969), females can store sperm (Metter 1964b), and fertilization is internal (Metter 1964a). The unpigmented, heavily yolked eggs are among the largest of any North American frog (ca. 4.0 mm average diameter; Wright and Wright 1949) and are deposited in rosary-like strings of 33-98 eggs on the undersurfaces of submerged rocks (Nussbaum et al. 1983, Adams 1993). Embryos have the narrowest range of thermal tolerance (5°-18°C) and the lowest critical thermal maximum of any North American frog (Brown 1975a). The rate of oxygen consumption during development is also very low (Brown 1977). This suite of features gives *A. truei* the slowest rate of embryonic development among North American frogs. Tadpoles, which have the lower lip expanded into a distinctive sucker-like disk (Gaige 1920, Gradwell 1973), normally attach themselves to rocks in turbulent water (Altig and Brodie 1972), where they feed on diatoms, filamentous green algae, desmids, and conifer pollen for up to 9 months of the year (Metter 1964a, Brown 1990). Tadpoles exhibit a diel cycle that involves movement to high positions on rocks at night, presumably for feeding purposes (Altig and Brodie 1972). They also actively avoid water temperatures above 22°C and die at water temperatures
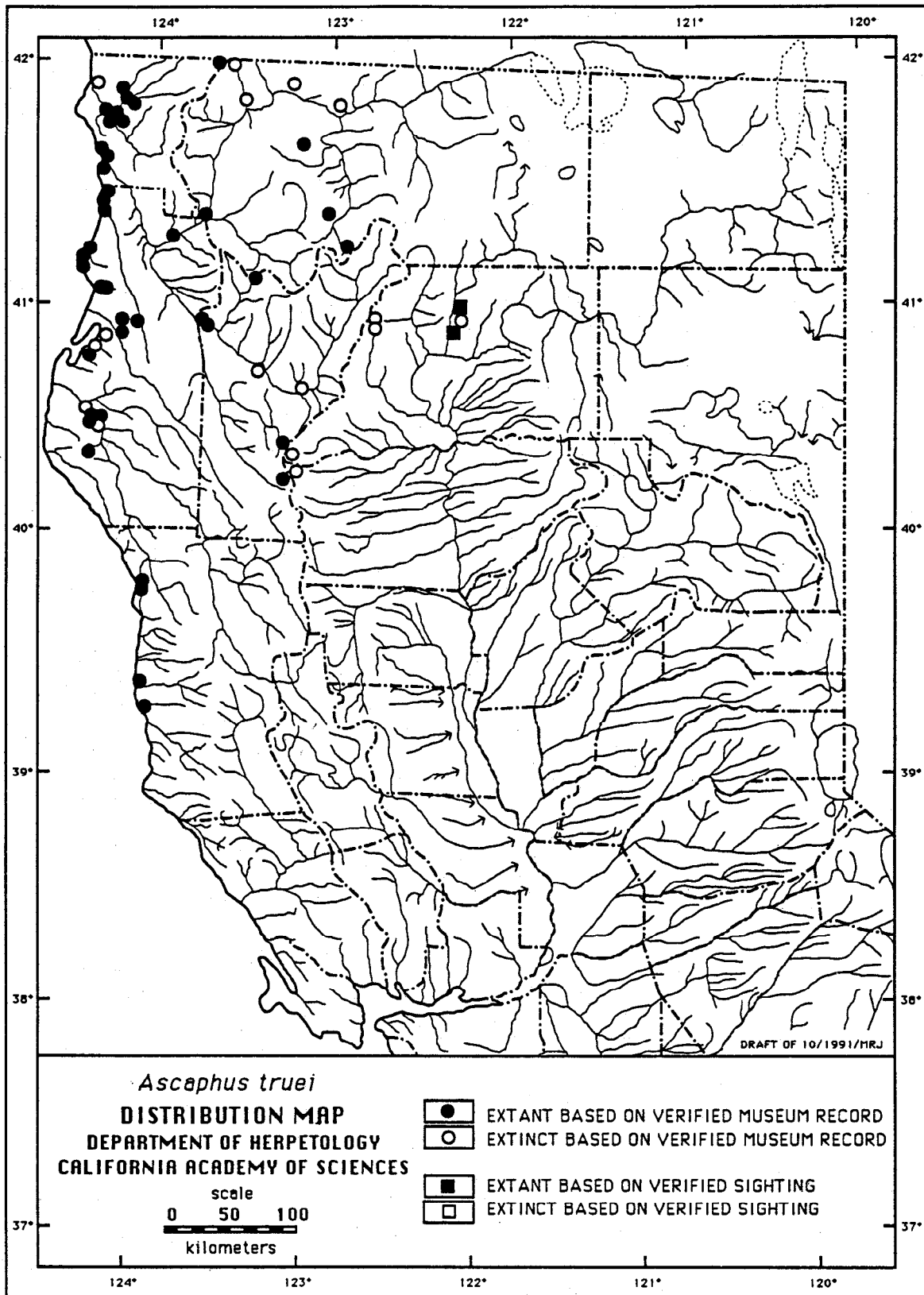
Figure 12. Historic and current distribution of the tailed frog (*Ascaphus truei*) in northern California based on 88 locations from 283 museum records and 2 records from other sources.

> 30°C (de Vlaming and Bury 1970). Preference for low temperatures and hibernation during winter months are probably two reasons why larval development is slow (Brown 1989), and the time required to reach metamorphosis requires at least 2-3 years (Ricker and Logier 1935; Metter 1964b, 1967), and has been recently postulated to take as long as 4 years (Brown 1990). Adults also appear sensitive to elevated temperatures (Metter 1966, Landreth and Ferguson 1967, Welsh 1990) with lethal thermal maxima at 23-24°C (Claussen 1973a). In western Montana, the minimum age at which *A. truei* first reproduce has been estimated at 7 years, males and females are estimated to first reproduce in their 8th and 9th years, respectively, and adults may have an average lifespan of 15-20 years (Daugherty and Sheldon 1982a). Following metamorphosis, pre-reproductive *A. truei* from Montana exhibited limited movement, and adults, who were highly philopatric, moved even less (Daugherty and Sheldon 1982b), probably spending the majority of their time immersed in water (e.g., Claussen 1973b). Nevertheless, occasional observations of *A. truei* some distance from streams (Slater 1934; Bury and Corn 1988a, 1988b) indicate that it is able to resist desiccation like other terrestrial anurans (Claussen 1973b) and that some variation in its movement ecology may exist across its geographic range. Pacific giant salamanders *(Dicamptodon ensatus* and *D. tenebrosus),* foothill yellow-legged frogs *(Rana boylii),* and Oregon garter snakes *(Thamnophis hydrophilus)* coexist with *A. truei in* streams in California (Myers 1931, Bury 1968), and may prey on tailed frog larvae (Metter 1963; Bury 1968; Welsh and Lind, pers. comm.). Adults and juveniles of *A. truei* eat mostly amphipods, springtails, and the larvae of insects found in moist habitats (Bury 1970).

Habitat: The habitat of *A. truei* is best characterized as permanent streams of low temperature to which many aspects of its life history can be correlated (Bury 1968). Intermittent streams with all the other proper environmental factors are unsuitable habitats (Brown 1990). Tailed frogs have been recorded in forested assemblages dominated by Douglas fir *(Pseudotsuga menziesii),* redwood, Sitka spruce *(Picea sitchensis),* Ponderosa pine, and western hemlock *(Tsuga hererophylla).* Although not correlated with any specific forest assemblage, recent work has established that tailed frogs are either recorded more frequently or solely in mature and old-growth stands (Bury 1983; Bury and Corn 1988a, 1988b; Raphael 1988; Welsh and Lind 1988; Corn and Bury 1989; Welsh 1990; Welsh 1993), which possess the habitat structure most likely to create the low temperature and clear water conditions that the life stages of *A. truei* require (Welsh 1990; Welsh 1993). In California, tailed frogs are largely restricted to coastal forests with ≥ 100 cm annual precipitation (Bury 1968).

Status: Threatened in upper Sacramento River system; Special Concern elsewhere in the state; the highly specialized features of tailed frog biology (e.g., the low temperature requirements of various life stages coupled to densely forested streams) that result in long periods of development and long intervals to replace adults make this species vulnerable (Bury and Corn 1988b). Noble and Putnam (1931) and Metter (1964a) noted that *A. truei* disappeared with the removal of timber through harvesting or fire, presumably because of the increased temperatures that result when the stream is exposed (Gray and Edington 1969, Brown and Krygier 1970). Further support for the latter emerged recently when significantly different densities of tailed frogs were encountered in small streams with different temperatures because of differential removal of forest cover during the 1980 Mount Saint Helens eruption (Hawkins et al. 1988). Deforestation appears to be somewhat less detrimental along the immediate coast (Corn and Bury 1989), presumably because the maritime climate maintains a more favorable (cooler) temperature regime (Bury 1968), but the demography of *A. truei* in coastal situations needs study. For the aforementioned reason, populations of *A. truei* occupying interior locations in the upper Sacramento River system are considered at greater risk than those occupying coastal drainage systems in California. Flooding also appears to have the ability to significantly modify the structure of

A. truei populations (Metter 1968b), so modification of the historical flooding regime may influence whether this species survives locally.

Management Recommendations: The temperature requirements of *A. truei* makes it essential that stream systems be managed in a manner that will maintain the low temperature regimes essential to the survival of *A. truei.* To date, most data have focused on the critical thermal maxima of various life stages; more attention needs to be paid to the seasonal variance in stream temperatures in the habitats where *A. truei* occurs. Monitoring temperature variation in streams where *A. truei* occurs should be an essential part of any management plan directed at this species. This is particularly important where any sort of alteration likely to increase stream temperatures may occur. Foremost among this class of alterations within the range of *A. truei* in California is timber harvest. Where timber harvest must occur, a no-harvest band of a specified minimum width (e.g., two tree heights (based on mature trees) on each bank (see Fritschen et al. 1971)) along the stream corridor should be implemented (Mahoney and Erman 1984, Bury and Corn 1988b). Since timber harvest can also increase siltation load (Cordone and Kelly 1961, Newbold et al. 1980, Murphy and Hall 1981, Everest et al. 1985, Corn and Bury 1989), such a policy may also help decrease the silt load that has frequently been observed in timber harvest situations. The effect of the latter, especially on the developmental stages of *A. truei,* needs study. Road crossings of stream corridors should be designed in a manner that will minimize modification of the riparian corridor and the creation of migration barriers to tadpoles and metamorphosed *A. truei.* Although many significant aspects of the life history of *A. truei* are reasonably well known, an understanding of its movement ecology is not. The movement ecology of *A. truei* needs to be well understood to better gauge the terrestrial habitat needs of the species.

COLORADO RIVER TOAD
Bufo alvarius Girard <u>in</u> Baird 1859

Description: A large (110-187 mm SUL) olive brown to black toad with distinctive, large, oval to sausage-shaped glands located on some of the upper surfaces of all limbs (Fouquette 1970). One to four white warts (tubercles) occur just behind the angle of the mouth (Wright and Wright 1949, Fouquette 1970). The iris is dark brown or black with a few guanophores (pers. observ.).

Taxonomic Remarks: This large toad is unquestionably a distinct species, as indicated by data on eggs (Savage and Schuierer 1961), parotoid venom (Porter and Porter 1967), and skin secretions (Erspamer et al. 1967). The geographic pattern of genetic variation within *B. alvarius* is unknown and needs study.

Distribution: The known range of the Colorado River toad extends from southeastern California into lowland Arizona and extreme southwestern New Mexico in the United States and southward into the states of Sonora and northern Sinaloa, Mexico (Fouquette 1968, 1970). Colorado River toads are documented to occur up the Colorado River from Fort Yuma (Fouquette 1968) to the Blythe-Ehrenberg region (Vitt and Ohmart 1978), and historically, likely extended up the Colorado River bottomlands to extreme southern Nevada near Fort Mojave (Cooper 1869, Meams 1907, Storer 1925). In California, *B. alvarius* was historically present along the channel of the lower Colorado River and in the southern Imperial Valley (Figure 13). This toad ranges in elevation from near sea level to 1615 m (Cole 1962).

Life History: Colorado River toads generally appear just before summer showers, and congregate and breed in temporary pools after the rains begin (notes of J. J. Thomber in Ruthven 1907). Seven to eight thousand eggs are laid in long strings (Wright and Wright 1949) and are claimed to be distinctive in lacking an outer jelly envelope and any partitions between individual eggs (Savage and Schuierer 1961), although recent observations on other toads indicates this assertion needs re-evaluation (see Sweet 1991). Details of the larval period are lacking, but the interval is believed not to exceed 1 month (notes of John James Thomber in Ruthven 1907), and tadpoles metamorphose at a very small size (< 15 mm SUL; C. Schwalbe, pers. comm.). Adults may be long-lived; individuals are known to have survived over 9 years in captivity (Bowler 1977). *Bufo alvarius* has a rather catholic diet that includes other anurans (Gates 1957, Cole 1962). The skin toxins and parotoid poison of *B. alvarius* protect it from some predators (e.g., striped skunk *[Mephitis mephitis];* Hanson and Vial 1956), but others (e.g., raccoon *[Procyon lotor])* can avoid the toxins to prey on these toads (Wright 1966).

Habitat: Data on the habitat requirements of *B. alvarius* are scant. Although temporary pools and irrigation ditches are the habitat in which Colorado River toads have been observed to breed (Blair and Pettus 1954, Savage and Schuierer 1961, Stebbins 1985), an understanding of the range of conditions under which they may breed is not known.

Status: Endangered; in California, we did not observe Colorado River toads during our surveys, and no collections or observations of this species have been made since 31 July 1955 (Jennings 1987a) despite a 5 April-2 May 1991 search by CDFG personnel (Ring and Robbins 1991a). However, a single toad was taken in a can trap on a 30-ha barren dredged spoil on the Arizona side of the Colorado River in 1980 (Anderson and Ohmart 1982) and another was found on 8 September 1986 at the Cibola National Wildlife Refuge, which is adjacent to the dredge spoil site (J. Rorabaugh, pers. comm.). Both locations are approximately 37 river km south of Blythe. Additionally, sightings of 5-10 toads were made along agricultural borders on the Colorado Indian Reservation (in Arizona) during the
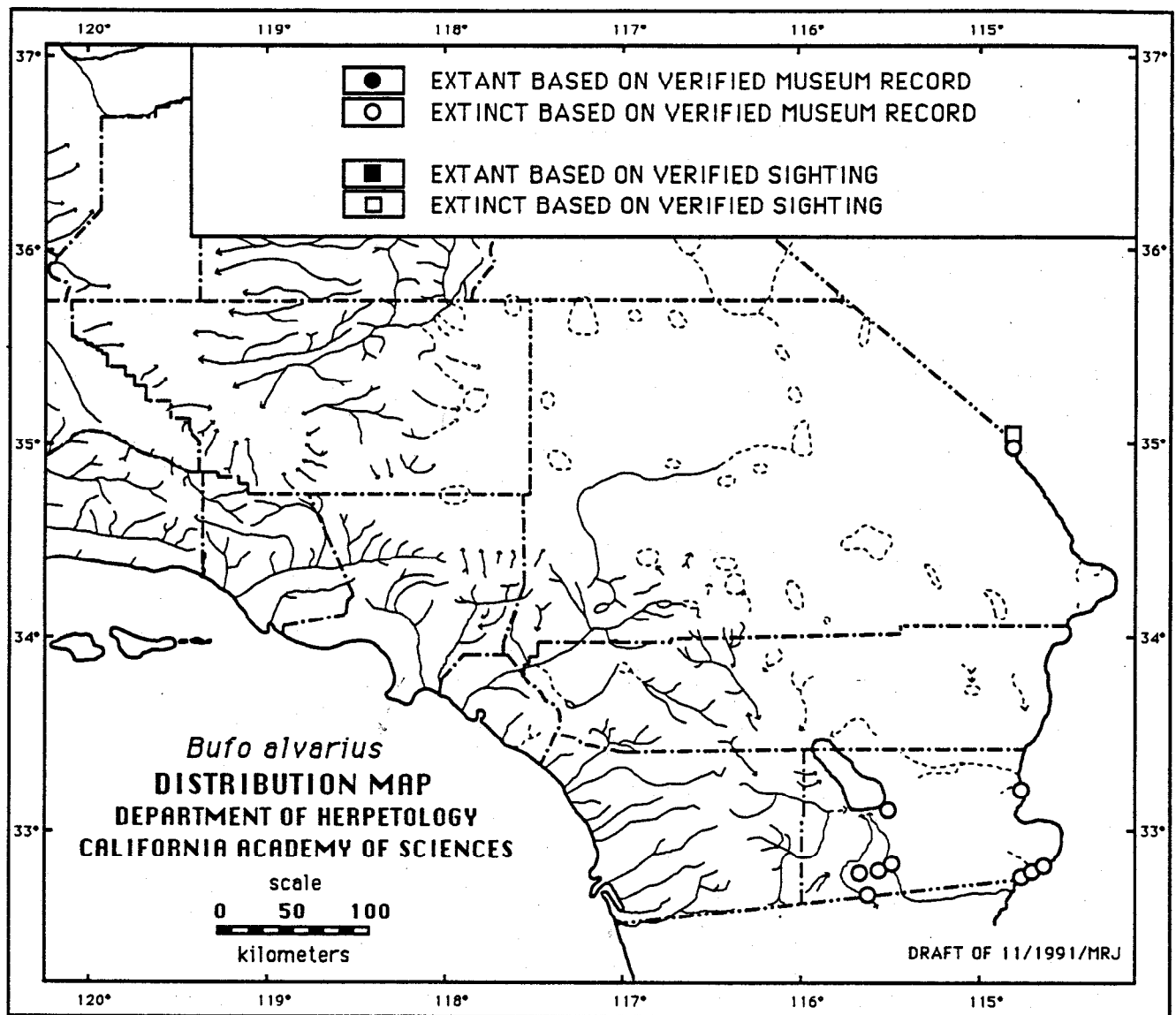
Figure 13. Historic and current distribution of the Colorado River toad (*Bufo alvarius*) in southern California based on 15 locations from 34 museum records and 2 records from other sources.

1970s (B. Loudermilk, pers. comm.). The species may have been extirpated over most its range in California because of habitat destruction (due to changing farming practices) and the extensive use of pesticides after World War II (Jennings 1987a). Moreover, although it has a relatively large range outside of California, some investigators have suggested that *B. alvarius* is imperilled throughout much of its range (B. Brattstrom, R. Ruibal, and C. Schwalbe, pers. comm.).

Management Recommendations: The severe habitat alteration that has taken place in the lower Colorado River region (e.g., see Ohmart et al. 1988) has undoubtedly impacted this species, but the lack of data on its habitat requirements hampers understanding how Colorado River toads may have declined in the region. Detailed information on the habitat requirements of this species are urgently needed to identify the range of conditions under which this species will thrive. A study needed to identify those conditions will probably have to be conducted outside of *B. alvarius'* range in California. An understanding of the microhabitats these toads use for refugia is unknown, and the latter need to be identified and coupled to knowledge of breeding habitat requirements so that a coherent picture of the toad's overall habitat requirements is available to guide land use managers.

Recently, law enforcement officers confiscated several shipments of *B. alvarius* that were in route to California. One Arizona raid resulted in the confiscation of 62 Colorado River toads (Banks 1994). These toads were intended to be used in the drug culture trade where individuals try to become intoxicated from licking the skin of toads (Leavitt 1989), or by smoking dried venom extracted [=milked] from the parotoid glands (Gallagher 1994, Richards 1994). The problem is extensive enough that some states have passed laws against toad licking (Landsberg 1990). The venom of toads is currently classified as controlled substance (Richards 1994). Any *B. alvarius* taken in drug raids should not be released into the wild.

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YOSEMITE TOAD
Bufo canorus Camp 1916

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Description: A moderate-sized (30.0-71.0 mm SUL) toad with rounded to slightly oval parotoid glands that displays a remarkable sexual dichromism (Karlstrom 1962). Females have black spots or blotches edged in white or cream that are set against a gray, tan, or brown ground color. Females also have prominent black spots or bars on the legs. In contrast, males have a nearly uniformly colored yellow-green to drab olive to darker greenish brown dorsum. A pencil-thin middorsal stripe is present in both juvenile males and females, but this stripe is lost more rapidly in males than females as they grow in size, resulting in younger adult females retaining a stripe fragment, whereas males of the same age generally lose the stripe entirely (D. Martin, pers. comm.). Iris color is dark brown with gold iridophores, the latter being especially dense on the upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: The Yosemite toad, long recognized as a distinct species (Camp 1916b), has not been confused with any other taxon (Karlstrom 1962). Feder (1977) found *B. canorus* to be distinctive based on electrophoretic data and based on her limited geographic sampling, also found some genetic variation within *B. canorus.* More comprehensive sampling is needed to assess genetic variation that may display geographic patterns. Yosemite toads are thought to hybridize with western toads *(B. boreas)* in the northern part of their range (Karlstrom 1962, Morton and Sokolski 1978), but no indication exists that western toads will threaten Yosemite toads through genetic swamping. Karlstrom and Livezey (1955) reported geographic variation in the pigmentation and size of *B. canorus* eggs, but the significance of this variation has not been investigated.
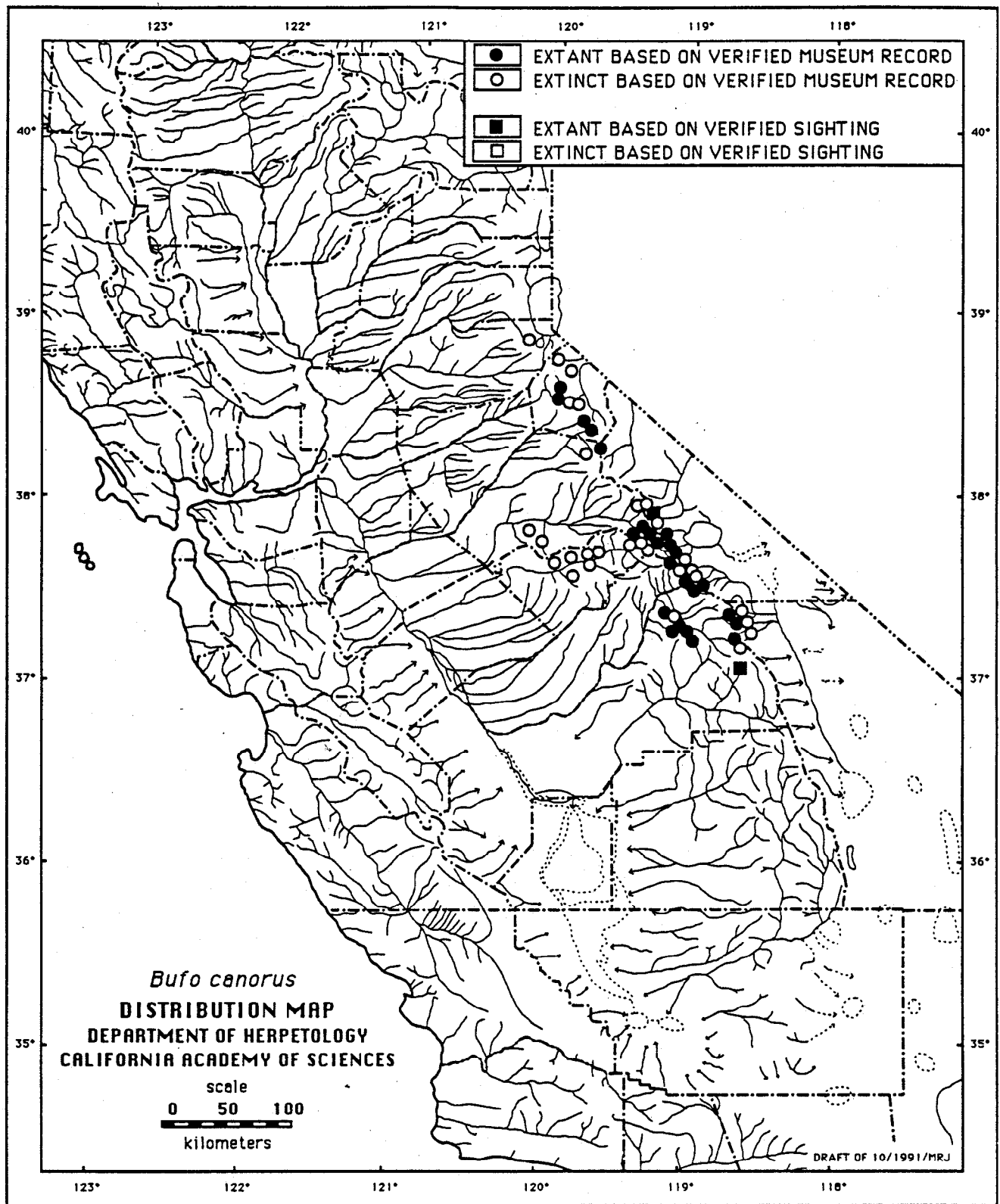
Figure 14. Historic and current distribution of the Yosemite toad (*Bufo canorus*) in central California based on 144 locations from 945 museum records and 14 records from other sources.

Distribution: This California endemic ranges in the Sierra Nevada from the Blue Lakes region north of Ebbetts Pass (Alpine County) south to 5 km south of Kaiser Pass in the Evolution Lake/Darwin Canyon area (Fresno County; Figure 14). Mullally and Powell (1958) reported two specimens collected from the vicinity of Heather and Grass Lakes (El Dorado County; see also Stebbins 1985), but these appear to represent misidentified high elevation isolates of *B. boreas* that have some *B. canorus*-like color dimorphism (D. Martin, pers. comm.). Its known elevational range extends from ca. 1950 m (Aspen Valley, Tuolumne County) to ca. 3450 m (Mount Dana, Tuolumne County: Karlstrom 1962).

Life History: *Bufo canorus* is a largely diurnal toad that emerges from winter hibernation as soon as snow-melt pools form near their winter refuge sites (Karlstrom 1962, Kagarise Sherman 1980). The timing of emergence varies with elevation and season, but known dates of emergence range from early May to mid-June (Kagarise Sherman 1980). Males form breeding choruses and breeding occurs soon after emergence. Large eggs (relative to other toads; 2.1 mm average diameter), brownish black or jet black over the upper three-fourths and gray or tannish gray on the lower fourth, are deposited in strings of single or double strands, or in a radiating network or cluster four or five eggs deep (Karlstrom and Livezey 1955). Females are estimated to deposit between 1,000 and 1,500 eggs (Kagarise Sherman 1980). Eggs strings are typically wound around short emergents in shallow (I 7.5 cm deep), still water with a flocculent or silty bottom (Karlstrom 1962). Following breeding, adults feed in subalpine meadows until entering hibernation (Kagarise Sherman 1980) and may be active after dark when the nights are warm during midsummer (A. McCready, pers. comm.). Larvae hatch in 3-6 days, depending on temperature, and typically metamorphose 40-50 days after fertilization. Based on observing immature tadpoles well into September, Mullally (1956) thought that *B. canorus* might overwinter as tadpoles, but corroboration for overwintering tadpoles has not been found (see Karlstrom 1962; Kagarise Sherman 1980; D. Martin, pers. comm.). Like many species of toad tadpoles, those of *B. canorus* are black and tend to aggregate (Brattstrom 1962). During daylight hours, *B. canorus* tadpoles tend to remain in warmer (average 23.3°C: Cunningham 1963), shallow water, but at night, they move to deeper water (Mullally 1953). Yosemite toad tadpoles tolerate higher temperatures as development advances and tadpoles with limb buds have critical thermal maxima ranging from 36°C to 38°C (Karlstrom 1962). At metamorphosis, juveniles are around 10 mm (SUL). Although some individuals may attain the minimum reproductive size at 30 mm (SUL) in 2 years, most probably require longer to become sexually mature. Both sexes grow slowly and males begin breeding at 3-5 years of age, whereas females begin breeding at 4-6 years of age (Kagarise Sherman 1980, Kagarise Sherman and Morton 1984). Females probably do not breed each year once they are sexually mature (Morton 198 1). A number of predators, such as the mountain yellow-legged frog *(Rana muscosa:* Mullally 1953), dragonfly naiads (species unspecified: Cunningham 1963; D. Martin, pers. comm.), and possibly larval long-toed salamanders *(Ambystoma macrodactylum:* A. McCready, pers. comm.), probably occasionally prey on the young life stages of Yosemite toads. However, garter snakes, particularly the western terrestrial garter snake *(Thamnophis elegans),* likely prey on significant enough numbers of Yosemite toad larvae and metamorphs (Karlstrom 1962; D. Martin, pers. comm.) that they may be seasonally important prey in the diet of these snakes (Jennings et al. 1992). California gulls *(Larus californicus)* and Clark's nutcrackers *(Nucifraga columbiana)* have been observed to kill breeding toads (Kagarise Sherman 1980; Mulder et al. 1978; Kagarise Sherman and Morton 1993; M. Morton, pers. comm.), and American robins *(Turdus migratorius)* have eaten tadpoles (C. Kagarise Sherman, pers. comm.). Desiccation of pools before metamorphosis is a major cause of mortality (Zeiner et al. 1988; Kagarise Sherman and Morton 1993; R. Hansen, D. Martin, and M. Morton, pers. comm.).

Habitat: The Yosemite toad is a high-elevation endemic that seems to prefer relatively open montane meadows, although forest cover around meadows is also used (Karlstrom 1962, Kagarise Sherman and Morton 1984). Yosemite toads are found in high montane and subalpine associations in meadows surrounded by forests of lodgepole pine (Pinus *contorta)* or whitebark pines. Suitable breeding sites are generally found at the edges of meadows or slow, flowing runoff streams. Short emergent sedges *(Carex* spp.) or rushes (Juncus spp.) often dominate such sites. Overwintering sites are rodent burrows. Burrows of Belding's ground squirrels *(Spermophilus beldingi)* and yellow-bellied marmots *(Marmota flaviventris)* may be preferred for over-wintering because their greater depth probably make such overwintering sites less susceptible to freezing (Kagarise Sherman 1980). However, the burrows of meadow voles *(Microtus montanus)* and mountain pocket gophers *(Thomomys monticola)* are probably also used. Burrows of all four species are probably used as temporary refuge sites during the summer season (Mullally and Cunningham 1956a).

Status: Endangered; despite the fact that many populations of *B. canorus* occur in areas that are among the least physically disturbed in California, this species has declined or disappeared from more than 50% of the sites from which it has been recorded. Abundant populations Kagarise Sherman (1980) and Martin L. Morton (pers. comm.) studied have either disappeared or exist at very low densities (Kagarise Sherman and Morton 1993). Other observations (D. Bradford, L. Cory, R. Hansen, and D. Martin, pers. comm.) suggest similar patterns elsewhere within the range of the Yosemite toad. Some population declines can be attributed to the effects of extended drought and the grazing of livestock in breeding and rearing sites (R. Hansen, D. Martin, A. McCready, and M. Morton, pers. comm.). Attempts to link these declines to acidification from atmospheric deposition and inorganic aluminum have not been successful; some acidification has been identified, but it is above the levels that can induce significant mortality in the life stages of Yosemite toads (Bradford et al. 1991, 1992, 1994). Non-localized declines imply an atmospheric causal agent. In the light of overwhelming recent evidence of ozone depletion (Watson et al. 1988) and concomitant increases in ultraviolet radiation (UV) reported from alpine regions (Blumthaler and Ambach 1990), an unexamined, but potentially important atmospheric causal agent in such declines is increased levels of ambient UV (see also Blaustein et al. 1994). Increases in ambient UV may explain the immuno-suppressive effects hypothesized to have occurred in the decline of high-elevation toad populations in Colorado where individuals died presumably as consequences of the bacterial pathogen, *Aeromonas hydrophila* (Carey 1993). Differential mortality in egg masses at breeding sites associated with differential exposure to the sun (D. Martin, pers. comm.) may be explained by differences in exposure to UV (see also Blaustein et al. (1994) for data with closely related *B. boreas).* Some investigators also believe that introduced fishes may be responsible for declines in *B. canorus* (E. Karlstrom and D. Martin, pers. comm.). Despite the generalized dogma about the unpalatability of larval *Bufo* (e.g., see Voris and Bacon 1966), the palatability of *B. canorus* to various predators, especially fishes, has not been examined.

Management Recommendations: Systematic population monitoring of *Bufo canorus,* already begun on a localized scale by a few investigators (C. Kagarise Sherman, D. Martin, and M. Morton, pers. comm.), urgently needs implementation on a larger scale. Population monitoring especially needs to be coupled to experiments designed to establish whether an atmospheric causal agent, like UV, is involved. Experiments should also address whether an interaction between an atmospheric effect and immune-system function may be causal (see Carey 1993). Although the life history of *B. canorus* is reasonably well known, the pattern of local extinction and recolonization is not. This aspect of Yosemite toad biology is in urgent need of study because it can provide insight into the probability of survival of local populations.

ARROYO TOAD
Bufo microscaphus californicus Camp 1915

Description: A moderate-sized (55.0-74.0 mm SUL), light-olive green to gray to tannish brown toad with small, oval parotoid glands, a light-colored, "v" shaped stripe between the eyelids, and usually lacking a middorsal stripe (Camp 1915; S. Sweet, pers. comm.; pers. observ.). Undersurfaces are creamy to dirty white, but never blotched, mottled, or spotted with dark markings. The iris is dark brown with scattered gold iridophores on upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: Long treated as a subspecies of *B. microscaphus* (Price and Sullivan 1988), it is becoming increasingly clear that *B. m. californicus* is morphologically differentiated enough from Arizona populations of *B. m. microscaphus* that species recognition is justified (Frost and Hillis 1990) even though limited genetic data show little differentiation (S. Sweet, pers. comm.), as do advertisement and release calls (Sullivan 1992). Genetic data indicating what variation may exist across the geographic range of *B. m. californicus* are currently not available but are presently under study (E. Gergus, pers. comm.).

Distribution: *Bufo microscaphus californicus* historically extended from the upper Salinas River system in the vicinity of Santa Margarita (San Luis Obispo County), California (Miller and Miller 1936) southward to the Rio Santo Domingo system in Baja California, Mexico (Tevis 1944). Its known elevational range extended from near sea level to ca. 2440 m (La Grulla Meadow, Baja California: Welsh 1988). In California, its distribution extended from the Salinas River system south through the Los Angeles Basin (Myers 1930b, Sanders 1950) and the coastal drainages of Grange and Riverside counties to the San Diego River system (Figure 15). The arroyo toad has been recorded at six locations on the desert slope (Patton and Myers 1992): the Mojave River, Little Rock Creek, Whitewater River, San Felipe Creek, Vallecito Creek, and Pinto Canyon.

Life History: Until the work of Samuel S. Sweet begun in 1980, the life history of *B. m. californicus* was known from only a handful of scattered observations (e.g., Sanders 1950, Stebbins 1951, Cunningham 1962). Most of the life history data in this account were synopsized from the data of Sweet (1991, 1993), conducted mostly on the Los Padres National Forest. Adults are entirely nocturnal and mainly active between the first substantial rains (January-February) and mid-summer (early August). Males emerge from stream terrace overwintering sites, precede females to the breeding pools, and call nightly from late March to late June, with local variation depending on elevation and seasonal variation in climate (Sweet 1991, 1993). Calling males display relatively high site fidelity and generally position themselves in an exposed location along the edge of the breeding pool, which is typically occupied by one to three males calling on any particular night (Sweet 1991). Males stop calling when they are disturbed or air temperatures fall below 13-14°C (Myers 1930b; pers. observ.). Females must forage for several weeks in order to produce a clutch of eggs; wide variation exists in the time required for individual females to complete this process due to variations in rainfall and stream flows from year to year, which seasonally results in available females mating over a several-month interval (Sweet 1991, 1993). Breeding may occur at any time between early April and early July (Myers 1930b; Cunningham 1962; Sweet 1991, 1993; pers. observ.). Female arroyo toads lay 2,000-10,000 (mean = 4,750) small (ca. 1.5 mm average diameter), darkly pigmented eggs in two long (3.0-10.7 m) strings in the shallow (mean = 3.1 cm) water of the male's calling site (Sweet 1991). Embryonic development requires ca. 5 days, but larvae cannot swim effectively until they are nearly 2 weeks old. Arroyo toad larvae have a black dorsal coloration similar to the larvae of other toads when they first hatch, but they become progressively lighter and more cryptically colored after about 3 weeks of age, making them
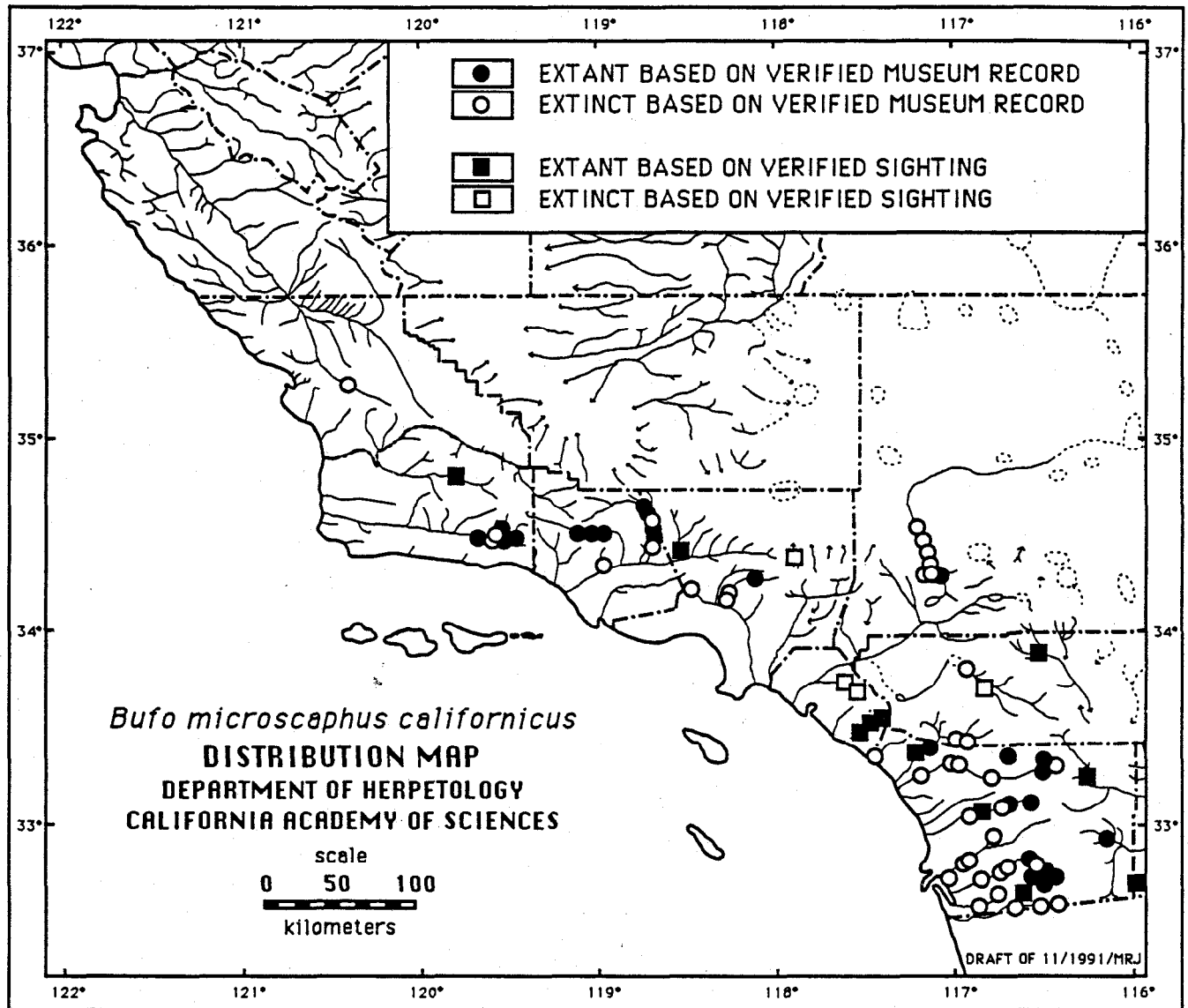
Figure 15. Historic and current distribution of the arroyo toad (*Bufo microscaphus californicus*) in southern California based on 157 locations from 1159 museum records and 32 records from other sources.

nearly invisible on a sandy substrate (Sweet 1991). This crypsis, their typically solitary behavior, and their inability to recognize fish predators suggests that arroyo toad larvae (like the larvae of many other native anurans in the western United States; see discussion in Hayes and Jennings 1986) are probably palatable, which makes them vulnerable to predation by exotic fishes and invertebrates such as crayfish *(Procambarus clarkii* and *Pacifasticus* spp). Arroyo toad larvae are also highly specialized when compared to the larvae of other California anurans; they are the only ones that feed by sifting the substrate for organic detritus and interstitial algae, bacteria, protozoans, and fungi (Sweet 1991). Larvae require 65 to 85 days to reach metamorphosis. Prior to metamorphosis, arroyo toad larvae stop feeding and assemble on the edges of open sand or gravel bars. Larvae need about 4 days to metamorphose, during which time their movements are impaired. Recently metamorphosed toads remain on the saturated margins of sand or gravel bars for about a week, then move to the somewhat drier areas of the bars for up to 8 weeks, depending on the variation in the physical environment of the bars (Sweet 1991, 1993; see also Linsdale 1932). Juveniles ≤ 22 mm (SUL) are highly cryptic on a mixed rocky-sandy substrate, diurnal, and actively select damp substrates with temperatures of 32-35°C; but they cannot burrow and avoid shade, dry substrates, and temperatures over ca. 42°C. During this interval, juveniles grow rapidly and feed mostly on ants (Sweet 1991). Around 20-25 mm SUL, juvenile toads begin to display burrowing capabilities, become nocturnal, and shift to a diet of small beetles. Sandy areas needed for burrowing are often limited on gravel-based bars, so juveniles in this size range may disperse to bordering willow *(Salix* spp.) areas at night (Sweet 1991). As juveniles approach 30 mm in size, they disperse into willow areas bordering the breeding pools regardless of substrate on the bars, and apparently burrow 10-18 cm into pockets of sandy substrate where they remain inactive for the next 6-8 months (Sweet 1993). Arroyo toads appear to require 2 years to reach reproductive maturity, although males can mature in a single year under favorable rainfall conditions (Sweet 1993). Adults return to stream terraces in mid-summer after breeding, where they construct relatively deep burrows and remain inactive through fall and winter (Sweet 1991). Data on longevity are largely unknown; some populations of arroyo toads have been identified as being not particularly long-lived (ca. 5 years; see Sweet 1991, 1993), a situation that may vary with local conditions. Much of the movement and physiological ecology of adults and juveniles is poorly understood, but recent data collected by Sweet (1993) show many subadults and some adult males moving alongstream frequently > 0.8 km in distance and > 1.0 km in a few cases.

Recruitment failures because of embryonic or larval mortality may be frequent. When stream levels are stable, most arroyo toad eggs hatch and little predation on eggs or larvae occurs (Sweet 1991, 1993). However, streamflow alteration by humans (e.g., suction dredge mining) can eliminate an entire cohort (Sweet 1993). Survivorship is high in pools lacking exotic fishes or with shallow refuge areas for larvae, but poor where introduced green sunfish *(Lepomis cyanellus),* juvenile bass *(Micropterus* spp.), fathead minnows *(Pimephales promelas),* bullfrogs, and red swamp crayfish occur (see Sweet 1993). Native garter snakes *(Thamnophis* spp.) and selected aquatic hemipterans (especially *Abedus indentatus)* are known to prey on arroyo toad larvae, but these predators do not seem abundant enough to be consistently significant (Sweet 1993). Direct human impact (through trampling, illegal road maintenance, and fires) and birds (especially killdeer *[Charadrius vociferus])* were identified as the principal agents of the catastrophic metamorphic and young juvenile mortality that most extant populations of arroyo toads sustained during 1991-1993 (Sweet 1993). Drought can also markedly affect cohort size by influencing the number of toads that breed. During 1989 and 1990 at the end of the 4-year drought, only 20 and 7 pairs of toads bred, respectively, at sites examined on the Los Padres National Forest, whereas in 1991, 166 pairs bred with above average rainfall totals (Sweet 1991). This improving trend continued in 1992 with above average rainfall totals resulting in the breeding of 263 pairs (Sweet 1993).

Habitat: Arroyo toads have perhaps the most specialized habitat requirements of any amphibian found in California. Adults require overflow pools adjacent to the inflow channel of 3rd- to greater-order streams that are free of predatory fishes in which to breed (Sweet 1991; pers. observ.). Exposed pools (i.e.; with little marginal woody vegetation) that are shallow, sand- or gravel-based and have a low current velocity are strongly favored (Sweet 1991). Pools with a minimum of silt are necessary for arroyo toad larvae to feed and grow rapidly (see Sweet 1993). Such breeding pools must occur in the vicinity (ca. 10-100 m) of juvenile and adult habitat, which consists of a shoreline or central bar and stable, sandy terraces. Shoreline or central bars dampened through capillarity and possessing some emergent vegetation (e.g., *Veronica)* seem preferred because they possess the thermal and refuge conditions that juvenile arroyo toads need to survive and grow rapidly (Sweet 1991). Inability of small juvenile toads (< 20 mm SUL) to burrow makes them vulnerable to desiccation; under hot, windy conditions, small juveniles must shelter in holes in drying algal mats or available small damp refuges and depressions. Stable, sandy terraces should possess a moderately well-developed, but scattered shrub and tree vegetation overstory (Sweet 1991), and typically have mulefat *(Baccharis viminea),* California sycamore *(Plutanus racemosa),* Fremont's cottonwood *(Populus fremontii),* or coast live oak present (Myers 1930b; Cunningham 1962; S. Sweet, pers. comm.; pers. observ.). The understory is generally barren or contains dead leaves or a few scattered grasses and rodent burrows (see also Linsdale 1932). Gravel or cobbles may be a part of such terraces, but fine sand seems to be the essential because adults and juveniles burrow or overwinter on terraces (Cunningham 1962, Sweet 1991).

Status: Endangered; the species has disappeared from 76% of its total historic range in the United States [= California]. Populations have disappeared entirely from the northern, central, and eastern parts of its range; the extreme habitat specialization of arroyo toads coupled with the fact that most factors that undoubtedly contributed to the extirpation of most populations still impact or threaten the few (less than 25) remaining small (30-100 adults) populations (Sweet 1991, 1993) probably make this taxon the most vulnerable in California Coupled requirements of relatively large, streamside flats with scattered vegetation (juvenile-adult habitat) adjacent to shallow pools with open sand or gravel bars place significant constraints on where arroyo toads may occur. Development and alteration of streamside flats (particularly by changing the natural hydrologic regime) may have been the crucial factors contributing to the extirpation of historic populations. One or more of excessive human use (campgrounds), manipulation of the hydrologic regime, urban development, placer mining (especially by suction dredges), off-road vehicle use, introduction of exotic predators, and cattle grazing threaten all known remaining populations (see examples in Sweet 1993). Additionally, natural disturbances such as forest fires and four consecutive years of drought have almost eliminated several already stressed populations (Sweet 1991, 1993; pers. observ.). The poor recruitment identified in the Los Padres National Forest is creating an aging population of breeding adults to which, based on existing levels of recruitment, few or no adults will be added until 1993 or 1994. Exactly what happens hinges mostly on the mortality of adult toads because those available to breed in 1992-1993 will be the mostly survivors from the 1991 breeding population. The current situation may become more precarious than realized if the short adult lifespan implied by the comparative size data Sweet (1991, 1993) presents are borne out. Whatever occurs, a population bottleneck in 1992-1994 is unavoidable; whether the bottleneck will cause local extinctions cannot be predicted precisely, but existing indications make this a likely possibility given the present human activities at some sites (see management update in Sweet 1993). Additionally, in the small populations of breeding adult arroyo toads, local chance effects, such as interference with successful breeding by male western toads *(Bufo boreas),* are more likely (e.g., see Awbrey 1972).

Management Recommendations: Greater protection of the habitat ensemble of overflow pools and streamside flats where extant populations of *B. m. californicus* exist is extremely urgent because of the precarious condition of existing populations (Sweet 1991, 1993). The stream conditions that create sandy, streamside flats in combination with appropriate shallow pools and adjacent open sand or gravel need detailed study to understand how stream hydrology can be maintained or manipulated to maintain or create habitat for *B. m. californicus.* Since it is likely that unfavorable habitat conditions impinging on the arroyo toad result from broad-scale manipulation of hydrologic basins and regimes, conditions now at least 2 decades old in most cases, habitat restoration will probably require radical solutions that will necessitate major changes in current patterns of hydrologic manipulation and land use policies. Such changes may require time intervals equal to or longer than those under which current pattern of hydrologic manipulation have existed simply to begin to be effective. Disturbance or development of streamside flats in the vicinity of known populations of *B. m. californicus* should be eliminated. Manipulations of the hydrologic: regime that scour overflow pools during the interval between breeding and metamorphosis of any year's cohort of *B. m. californicus* should he avoided. Land use conditions that contribute to siltation of streams during the breeding interval should also be avoided. Isolation of existing *B. m. californicus* populations from the exotic aquatic fauna should be maximized; translocation of the exotic aquatic fauna should be prohibited. Rangewide surveys are needed to determine if undetected populations stilt exist and focal surveys are needed for monitoring existing populations.

NORTHERN RED-LEGGED FROG
Rana aurora aurora Baird and Girard 1852

Description: A moderate-sized (42.0-101.0 mm SWL) brown, reddish brown to greenish gray frog with marked dorsolateral folds and a dorsal pattern of either small, irregular dark brown to black spots; small dark spots with light centers; or a fine dark reticulum (Dunlap 1955, Dumas 1966). A distinct, but irregular pattern of contrasting light and dark markings is consistently present in the groin; the light markings range from offwhite to sun yellow to red to green (Dunlap 1955; pers. observ.). Some red coloration, variable in intensity and extent, is present on undersurfaces. The latter ranges from bright red on the undersurfaces of the limbs, along the sides of the body, and the abdomen to a very pale red on the undersurfaces of only the hind limbs (Dunlap 1955; pers. observ.). Each iris is dark brown with gold iridophores that are particularly dense on the upper and, to a lesser extent, the lower portions of the iris (pers. observ.).

Taxonomic Remarks: Recent. work on vocal sac variation suggests that the red-legged frog *(Rana aurora)* may actually represent two species that approximate the previously recognized subspecies (Hayes and Krempels 1986). Populations with at least some individuals that exhibit features intermediate between northern *(R. a. aurora)* and California red-legged frogs *(R. a. draytonii)* occur between northern Humboldt County and Pt. Reyes National Seashore, Marin County, but further study is needed to understand the relationships among red-legged frogs and the distribution of red-legged frogs with different morphologies. For the purpose of this report, the intermediate populations are lumped with the northern red-legged frog with regard to listing status because of the greater ecological and morphological similarity of individuals in these populations to northern red-legged frogs; impacts on these populations are likely to be more similar to those affecting northern red-legged frogs.

Limited data indicate that northern red-legged frogs exhibit some degree of genetic differentiation from California red-legged frogs (Hayes and Miyamote 1984; Green 1985a, 1986b) and elsewhere:, similar data may be concealed because samples identified simply as
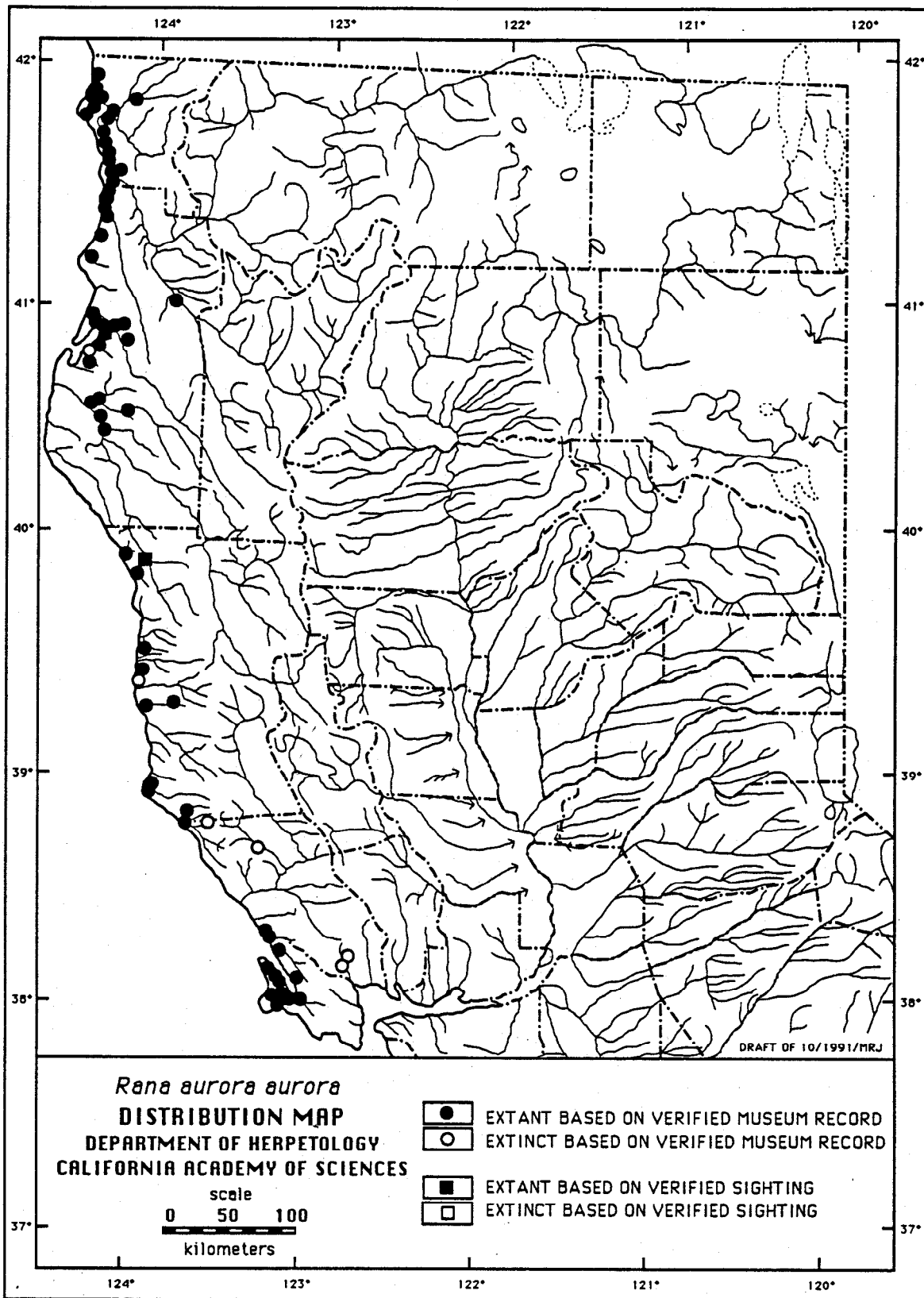
Figure 16. Historic and current distribution of the northern red-legged frog (*Rana aurora aurora*) and intergrades with the California red-legged frog (*Rana a. draytonii*) in northern California based on 96 locations from 286 museum records and 6 records from other sources.

red-legged frogs were lumped (Case 1976, 1978b). Because various studies have obtained material from geographically disparate localities within the range of red-legged frogs and analyses and standards are non-parallel, it is impossible to interpret the variation observed across these different studies. Genetic data are urgently needed to better understand the variation across the geographic range of both northern red-legged frogs and red-legged frogs in general to identify the distribution of taxa that may need recognition.

Distribution: The northern red-legged frog is known to occur from northern Humboldt County, California northward to Sullivan Bay, British Columbia (Stebbins 1985). Additionally, frogs that exhibit primarily features associated with the northern red-legged frog appear to extend southward into coastal California to the latitude of Pt. Reyes National Seashore, Marin County. The known elevational range of the northern red-legged frog and associated intermediate populations extends from near sea level to 1160 m (Salt Creek Falls, Lane County, Oregon; Dunlap 1955). In California, the northern red-legged frog and populations intermediate between northern and California red-legged frogs extend from Marin County north to the Oregon state line (Figure 16). The elevational range of the northern red-legged frog and intermediate populations in California is from near sea level to ca. 300 m.

Life History: Life history data on northern red-legged frogs, with rare exceptions (e.g., see Twedt 1993), come from populations outside California. Northern red-legged frogs have the lowest embryonic critical thermal maximum known (21°C) for any North American ranid frog (Licht 1971), which is probably the reason that oviposition is restricted to a time-window early in the year (January-March: Storm 1960, Licht 1969b, Brown 1975b). Males are observed at breeding sites for as much as a month before females appear at water temperatures as low as 2°C, and can be under skim ice (Licht 1969b). Moreover, males may typically call from underwater (Storm 1960, Licht 1969b, Calef 1973a). Male northern red-legged frogs are particularly tenacious in amplexus (Twedt 1993) and the female behavior needed to obtain release from the amplectic male is distinctive and highly stereotyped (Licht 1969a). Large (3.0 mm average diameter: Livezey and Wright 1945), pigmented eggs are laid in a rounded, submerged egg mass that contains 194-1081 eggs and is attached to a vegetation brace (Storm 1960, Licht 1974, Brown 1975b). After oviposition takes place, adult *R. a. aurora* vanish from the breeding site (Twedt 1993; R. Storm, pers. comm.) and disperse into moist areas of dense, thick vegetation, where they can be observed through late spring and summer (Twedt 1993; pers. observ.). The time required for *R. a. aurora* embryos to develop to hatching can vary from less than 1 week (at 20°C) to over 8 weeks (at 4.5°C), but embryos typically require around 4-5 weeks at field water temperatures of 6-9°C (Storm 1960, Licht 1971). At hatching, young larvae are 11-12 mm total length (Storm 1960, Brown 1975b). Larvae are often cryptic and may display a preference for a light- and dark- striped substrate which is correlated with their developing in a habitat with a striped light and shade mosaic (Wiens 1970). Larvae are algal grazers, and can significantly reduce the standing crop of epiphytic algae under certain conditions (Dickman 1968). Larval development to metamorphosis seems to require ca. 3.5 months (Licht 1974, Brown 1975b), but an understanding of the variation in the length of the larval developmental interval is lacking.

Males can become sexually mature the breeding season following metamorphosis, at ca. 45 mm SUL (Licht 1974; pers. observ.), but most probably do not reproduce until their second breeding season following metamorphosis. Females do not appear to become sexually mature until at least the second breeding season following metamorphosis, at ca. 60 mm SUL (Licht 1974; pers. observ.), but most probably do not reproduce until their third breeding season following metamorphosis. Longevity of adults in the field is unknown, but data from captives indicate that adults can live in excess of 10 years (Cowan 1941). Postmetamorphic *R. a. aurora* are largely insectivorous, with larger frogs being

capable of eating larger prey (Licht 1986a). Different predators typically prey on the various life stages of the northern red-legged frog, but most mortality occurs during the larval, metamorphic, and recent post-metamorphic stages (Licht 1974). Throughout the range of *R. a. aurora,* the northwestern salamander *(Ambystoma gracile)* and the rough-skinned newt *(Taricha granulosa)* are probably among the most important predators of larval northern red-legged frogs (Calef 1973b, Licht 1974), whereas certain species of garter snakes are probably among the most important predators on metamorphic and recent post-metamorphic life stages (Fitch 1941, Licht 1974). In each case, these predators may be seasonally dependent, even if not for a long interval, on the particular life stage of *R. a. aurora* for food. Postmetamorphic *R. a. aurora* appear to depend largely on crypsis for concealment, remaining immobile until a predator, such as a garter snake, approaches too closely, whereupon they depend on their leaping ability to move out of the range of the predator and take up a new cryptic, immobile position (Gregory 1979, Licht 1986b). Recent field studies by Twedt (1993) show that introduced bullfrogs eat postmetamorphic northern red-legged frogs where the two coexist. The movement ecology of adult northern red-legged frogs is essentially unknown.

Habitat: Northern red-legged frog breeding habitat typically consists of permanent or temporary water bordered by dense grassy or shrubby vegetation (Storm 1960, Licht 1969b, Calef 1973a, Brown 1975b, Twedt 1993). If temporary, standing water is typically available for the life stages of *R. a. aurora* for a period of 4-6 months (see Storm 1960; pers. observ.). Habitat used by post-metamorphic frogs consists of patches of dense grassy or shrubby vegetation (Stebbins 1951, Storm 1960, Twedt 1993), such as willow thickets and dense sedge swales, that maintain significant substrate moisture (pers. observ.). Bury and Corn (1988a) found a high frequency of juvenile *R. aurora* in a mature Douglas fir forest stand having moderate moisture levels in the State of Washington, but the context of this observation is unclear. In northwestern California, the dense undergrowth created by sword ferns *(Polystichum munitum)* and sedges along streamside flats within coastal redwood forest is often used by adult and subadult northern red-legged frogs (see Twedt 1993). Habitat associated with beaver *(Castor canadenis)* dams seems to provide all the aforementioned conditions and may be particularly favorable for northern red-legged frogs because they frequently occur in such habitat (see Stebbins 1951 and Brown 1975b; pers. observ.).

Status: Special Concern; this taxon has been identified as declining in British Columbia, Oregon, and Washington (see summary in Hayes and Jennings 1986). Although surveys for this taxon have not been systematically conducted in California, many of the coastal watersheds in the region where it occurs have sustained significant alteration related to timber harvest (California Department of Forestry and Fire Protection 1988) and urban development. Bullfrogs and selected exotic predatory fishes now occur in a significant number of northwest coastal drainages where *R. a. aurora* are infrequently observed (pers. observ.; see also Twedt 1993). Habitat degradation because of local coastal development and grazing may have also contributed to the apparent decline of this taxon in California.

Management Recommendations: Systematic surveys of this taxon in California are urgently needed. Although a general idea of the impacts and problems with *R. a. aurora* exists, data are unavailable to indicate how serious impacts on this taxon are or what trends may be evolving. How disconnected the dense grassy or shrubby habitat for postmetamorphs can be from the aquatic breeding habitat before the habitat can no longer support this taxon is unknown; this aspect especially needs the type of study that will link it to the movement ecology of this taxon. Additionally, the significant populations of *R. a. aurora* that remain in California are associated with the freshwater marsh portions of the lagoons of coastal drainages. Although salinity tolerance of *R. a. aurora* is unknown, it is likely to be similar to that reported for *R. a. draytonii* (see Jennings and Hayes 1989), so

changes in the salinity gradients in coastal lagoons that could significantly impact the survivorship of *R. a. aurora* in a manner similar to that reported for *R. a. draytonii* (see Jennings and Hayes 1989) need study. Finally, because it is likely that many of the conditions that impact *R. a. aurora,* allowing for differences in their respective life histories, also impact *R. a. draytonii,* the account for the California red-legged frog should be read to gain a broader perspective on other potential impacts.

CALIFORNIA RED-LEGGED FROG
Rana aurora draytonii Baird and Girard 1852

Description: A large (85.0-138.0 mm SUL) brown to reddish brown frog with prominent dorsolateral folds and diffuse moderate-sized dark brown to black spots that sometimes have light centers (Storer 1925; pers. observ.). Distribution of red or red-orange pigment is highly variable, but usually restricted to the belly and the undersurfaces of the thighs, legs, and feet. Some individuals have red pigment extending over all undersurfaces and upper surfaces of the body; other individuals lack red pigment entirely or have it restricted to the feet (pers. observ.). The groin has a distinct black region with a complex arrangement of light blotches that range from white to pale yellow in color. The posterior thigh is a nearly uniform brown color with 3-12 distinct white to lemon-yellow spots. The iris is dark brown with iridophores on the upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: See the northern red-legged frog *(Rana aurora aurora)* account for pertinent remarks. The California red-legged frog *(R. a. draytonii)* is a morphologically (larger body size, males have paired vocal sacs), behaviorally (males always call in air, adults do not leave the site of oviposition), and probably genetically distinct form (Hayes and Miyamoto 1984; Green 1985a; pers. observ.). Comprehensive study of the geographic pattern of morphological, behavioral, and genetic variation, some of which is underway, is needed to determine whether the California red-legged frog represents a distinct species.

Distribution: The historic range of this frog extends through Pacific slope drainages from the vicinity of Redding (Shasta County: Storer 1925) inland and at least to Point Reyes (Marin County: pers. observ.), California (coastally) southward to the Santo Domingo River drainage in Baja California, Mexico (Linsdale 1932). Historically, it also occurred in a few desert slope drainages in southern California (Jennings and Hayes 1994). Populations in central southern Nevada are introduced (Linsdale 1940, Green 1985b). In California, it occurs from Shasta County south to the Mexican border (Figure 17). The records for Santa Cruz Island have been shown to represent an introduction (Jennings 1988a). Its known elevational range extends from near sea level to around 1500 m, although some of the populations toward the upper limit of the range of this species may represent translocations (unpubl. data).

Life History: California red-legged frogs breed early in the year (late November-late April: Storer 1925; Hayes and Jennings 1986; S. Sweet, pers. comm.; pers. observ.), undoubtedly because they have a low embryonic critical thermal maximum (see Hayes and Jennings 1986) that restricts them to using a time-window with a high probability of ensuring embryonic survival. Males appear at breeding sites from 2-4 weeks before females (Storer 1925). At breeding sites, males typically call in small, mobile groups of 3-7 individuals that attract females (pers. observ.). Females move toward male calling groups and amplex a male. Following amplexus, females move to the site of oviposition and attach egg masses containing ca. 2,000 to 6,000 moderate-sized (2.0-2.8 mm in diameter), dark reddish brown eggs to an emergent vegetation brace (Storer 1925; pers.
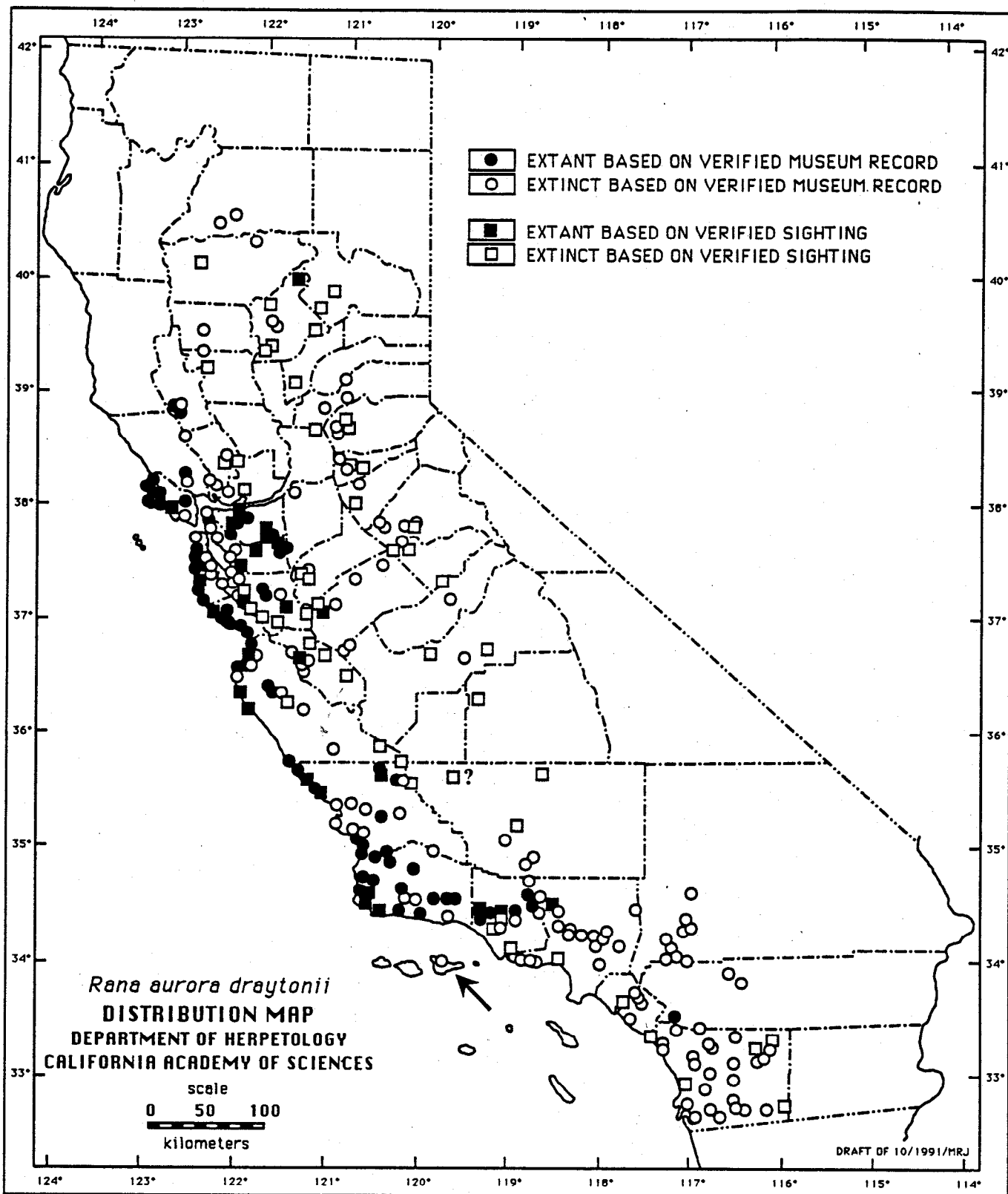
Figure 17. Historic and current distribution of the California red-legged frog (*Rana aurora draytonii*) in California based on 762 locations from 1229 museum records and 291 records from other sources.

observ.). Embryos hatch 6-14 days after fertilization, and larvae require 4-5 months to attain metamorphosis (Storer 1925). Larvae are thought to be algal grazers, but the foraging ecology of larval *R. a. draytonii* is unknown. Larvae are infrequently observed in the field because they spent most of their time concealed in submergent vegetation or organic debris (pers. observ.). Larvae, which are not known to overwinter, typically metamorphose between July and September (Storer 1925; pers. observ.). Postmetamorphs grow rapidly, and sexually maturity can be attained at 2 years of age by males and 3 years of age by females (Jennings and Hayes 1985), but both sexes may not reproduce until 3 and 4 years of age, respectively (pers. observ.). Females attain a significantly larger body size than males (138 mm vs. 116 mm SUL: Hayes and Miyamoto 1984). No data are available on the longevity of California red-legged frogs.

Unlike northern red-legged frogs, adult California red-legged frogs do not appear to move large distances from their aquatic habitat, although they are known to make pronounced seasonal movements within their local aquatic and terrestrial habitats. Adult *R. a. draytonii* move seasonally between the site of oviposition and the foraging habitat occupied in spring and summer (Jennings and Hayes 1989; pers. observ.), but a few data indicate that they move into terrestrial riparian thickets during the fall (Rathbun et al. 1993). It is also known that during periods of high water flow, California red-legged frogs are rarely observed (S. Sweet, pers. comm.; pers. observ.). Where frogs go during this interval is not well understood, but at least some individuals have been observed concealed in pockets or small mammal burrows beneath banks stabilized by shrubby riparian growth (pers. observ.). Nevertheless, much of the movement ecology of *R. a. draytonii* remains poorly understood.

Postmetamorphs have a highly variable animal food diet (Hayes and Tennant 1986). Most prey that can be swallowed that are not distasteful are eaten, with larger frogs capable of taking larger prey. Frogs (Anura) and small mammal prey may contribute significantly to the diet of adults and subadults (Arnold and Halliday 1986, Hayes and Tennant 1986). Adult frogs appear to use vibrations transmitted along willow branch runways to detect approaching small mammal prey (see Hayes and Tennant 1986; pers. observ.).

In general, adult frogs are quite wary. Highly nocturnal (Storer 1925, Hayes and Tennant 1986), adults appear to face frequent attempts at predation by wading birds (e.g., black-crowned night herons *[Nycticorax nycticorax],* bitterns *[Botaurus lentiginosus]),* judging from the number of dorsal puncture-like wounds observed on frogs (pers. observ.). Moreover, adult frogs also seem to use vibrations transmitted along willow branches or vegetation upon which they are resting to detect the approach of certain predators (e.g., raccoons). In contrast, juveniles (< 60-65 mm SUL) are much less wary, are frequently active diurnally, and spend much of the daytime hours basking in the warm, surface-water layer associated with floating and submerged vegetation (see Hayes and Tennant 1986), where they can fall prey to predators such as San Francisco garter snakes (Wharton 1989) and two-striped garter snakes *(Thamnophis hammondii:* Cunningham 1959a). California red-legged frogs are seasonal prey in the diet of the San Francisco garter snake (Wharton 1989).

Habitat: Habitat of California red-legged frogs is characterized by dense, shrubby riparian vegetation associated with deep ($\leq$ 0.7 m), still or slow-moving water (Jennings 1988b, Hayes and Jennings 1988). The shrubby riparian vegetation that structurally seems to be most suitable for California red-legged frogs is that provided by arroyo willow *(Salix lasiolepis);* cattails *(Typha* sp.) and bulrushes *(Scirpus* sp.) also provide suitable habitat (Jennings 1988b). Although California red-legged frogs can occur in ephemeral or permanent streams or ponds, populations probably cannot be maintained in ephemeral

streams in which all surface water disappears. Water should have a salinity of ≤ 4.5 ‰ to ensure the survival of embryonic stages (Jennings and Hayes 1989). Juvenile frogs seem to favor open, shallow aquatic habitats with dense submergents (pers. observ.).

Status: Endangered in the Central Valley hydrographic basin (includes the Sacramento, San Joaquin, Kings, Kaweah, and Kern River systems) and in southern California from the Santa Clara River system south to the Mexican border; Threatened throughout the remainder of its range in California; once the abundant species of large ranid frog throughout most of lowland California, this species has sustained large reductions both in geographic range and in the size of local populations. Historically, California red-legged frogs were heavily commercially exploited for food, a situation that led to their becoming severely depleted by the turn of the century (Jennings and Hayes 1985). Continued exploitation of depleted populations and the prior and subsequent establishment of a diverse exotic aquatic predator fauna that includes bullfrogs, crayfish, and a diverse array of fishes likely contributed to the decline of the California red-legged frog (Hayes and Jennings 1986), although it is not understood which exotic aquatic predator or predators may have been most significant (Hayes and Jennings 1988). Further, habitat alterations that are unfavorable to California red-legged frogs and favorable to most of the exotic aquatic predators are confounded with potential direct effects of predation by such exotics (Hayes and Jennings 1986). The tone of these suggestions is not new. Nearly 20 years ago, Robert L. Livezey (in litt., 3 February 1972 to Leonard Fisk, then Senior Fishery Biologist with CDFG charged with investigating the state of non-game amphibians and reptiles) attempted to draw attention to the fact that he believed that the California red-legged frog has suffered a drastic reduction over the previous 15 to 20 years because of bullfrogs and expanding human activities. Regardless of the exact cause, our surveys for California red-legged frogs at over 95% of the historical localities in the Central Valley hydrographic basin over the last 10 years indicate that this species has probably disappeared from over 99% of its former range within that region. The few remaining populations are threatened by proposed reservoir construction, off-road vehicle use, and continued habitat degradation due to the cumulative effects of abusive land use practices, especially with regard to livestock grazing (pers. observ.; see Kauffman et al. 1983; Kauffman and Krueger 1984; Bohn and Buckhouse 1986) and development of groundwater resources (see Groeneveld and Griepentrog 1985). The only locality within the Central Valley hydrographic basin that supports California red-legged frogs that receives some degree of protection, the Corral Hollow Ecological Reserve, is currently threatened by siltation promoted by an off-road vehicle park and livestock grazing practices upstream. Similarly, between the Santa Clara River system and the Mexican border, extant populations of California red-legged frogs are known from only four relatively small areas. These combined areas represent no more than 1% of the area historically occupied by California red-legged frogs within that region. Additionally, no more than 10% of the localities where California red-legged frogs were recorded within the Salinas River hydrographic basin and inner Coast Ranges between the Salinas basin and the San Joaquin south of the Pacheco Creek drainage still have *R. a. draytonii.*

Significant numbers of California red-legged frogs occur only in the relatively small coastal drainages between Point Reyes (Marin County) and Santa Barbara (Santa Barbara County). The drainages within this region are characterized by more suitable habitat and a less frequent occurrence of exotic aquatic predators than elsewhere. Yet, even the California red-legged frogs within this region are threatened by an exotic aquatic predator fauna that is still slowly expanding its range, continuing habitat degradation because of abusive grazing practices, and decreased water quality because of increases salinities related to decreased freshwater flows because of increased human use and recent decreases in annual rainfall potentially related to global climate changes.

Management Recommendations: Riparian habitats where California red-legged frogs still occur need a greater degree of protection. In particular, emphasis needs to be placed on retaining the dense riparian vegetation associated with deep water habitats used by this taxon. Additionally, the water quality standards (e.g., low salinity levels: Jennings and Hayes 1989) and water flow regimes of such sites need to be maintained. This taxon is suspected of being particularly sensitive to changes in water quality due to a variety of factors (e.g., various herbicides and pesticides, sulfate ions) that have not been examined specifically for their effects on the developmental stages of this taxon; these urgently need study. The local hydrology of sites where California red-legged frogs still occur should be carefully monitored. Impacts such as additional withdrawals of surface and groundwater that modify existing flow regimes and can change water quality should especially be avoided. Particular efforts need to be made to reduce or eliminate habitat modification that results from overgrazing because grazing and similar land use practices are especially effective at reducing or eliminating the dense riparian cover required by California red-legged frogs. Despite the fact that the total protection of entire local hydrographic basins has been suggested (Moyle 1973, Hayes and Jennings 1988), that suggestion remains unimplemented. That approach may ultimately be the only way to protect some of the remaining populations of this taxon.

FOOTHILL YELLOW-LEGGED FROG
Rana boylii Baird 1854

Description: A moderate-sized (37.2-82.0 mm SUL) highly variably colored frog, but usually dark to light gray, brown, green, or yellow with a somewhat mottled appearance often with considerable amounts of brick or reddish pigment, and rough, tubercled skin (Zweifel 1955; unpubl. data). A light band is present between the eyelids that often appears as a pale triangle between the eyelids and the nose. Undersurfaces of the legs and lower belly are yellow or orangish-yellow, the latter color usually present on the largest individuals (pers. observ.). The iris is silvery gray with a horizontal, black countershading stripe (pers. observ.).

Taxonomic Remarks: Since the work of Zweifel (1955), this frog has been recognized as a distinctive species. An understanding of the genetic and karyologic variation within *R. boylii* is limited to 13 populations in central and northern California and one population in Oregon (Houser and Sutton 1969; Haertel et al. 1974; Case 1976, 1978a, 1978b; Green 1986a, 1986b). Available data indicate complex genetic variation within *R. boylii,* but data are both difficult to interpret because of some lumping of nearby populations (Case 1978b) and too few to identify any geographic patterns to genetic variation conclusively. A sound understanding of the geographic pattern of genetic variation in *R. boylii,* with the intent of distinguishing potentially cryptic taxa, is needed.

Distribution: Historically, this species was known to occur in most Pacific drainages from the Santiam River system in Oregon (Mehama, Marion County) to the San Gabriel River system (Los Angeles County) in California (Storer 1923, 1925; Fitch 1938; Marr 1943; Zweifel 1955). Its known elevational range extends from near sea level to ca. 2040 m (lower end of La Grulla Meadow, Baja California, Mexico; Stebbins 1985). No desert slope populations are known, but an isolated outpost has been reported from the Sierra San Pedro Mártir, Baja California, Mexico (Loomis 1965). In California, *R. boylii* was historically distributed throughout the foothill portions of most drainages from the Oregon border to the San Gabriel River (Figure 18). Its known elevation range in California extends from near sea level to 1940 m (Snow Mountain, Trinity County: Hemphill 1952).
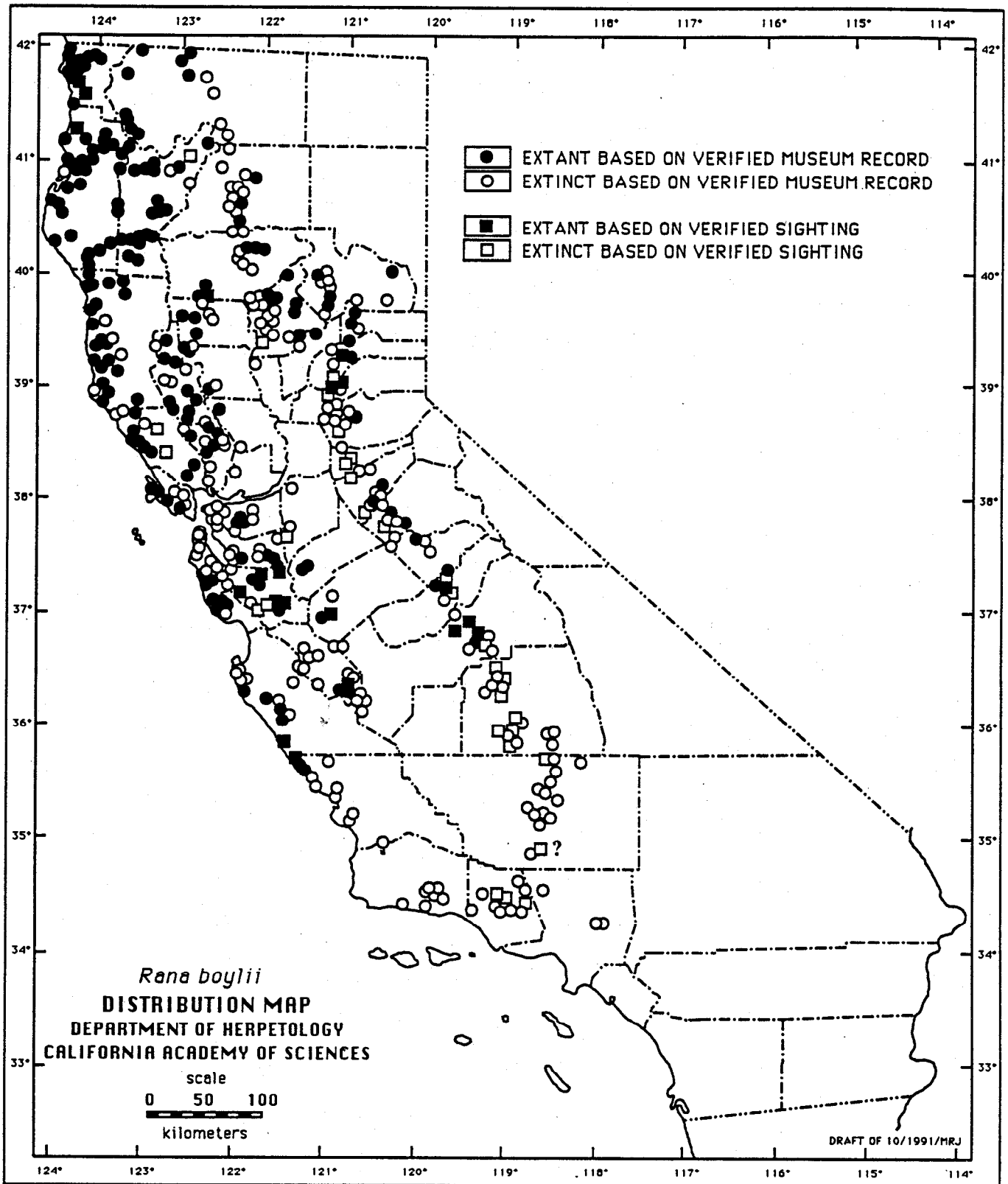
Figure 18. Historic and current distribution of the foothill yellow-legged frog (*Rana boylii*) in California based on 937 locations from 3195 museum records and 164 records from other sources.

Life History: *Rana boylii* is one of the most poorly known ranid frog species in California; no detailed study of its life history has ever been undertaken (although at least two investigators are currently gathering life history data on this species: H. Welsh, and A. Lind, pers. comm.). This species is a stream-dwelling form that deposits masses of 300-1200 eggs on the downstream side of cobbles and boulders over which a relatively thin, gentle flow of water exists (Storer 1925, Fitch 1936., Zweifel 1955). The timing of oviposition typically follows the period of high flow discharge resulting from winter rainfall and snowmelt, which results in oviposition usually occurring between late March and early June (Storer 1925; Grinnell et al. 1930; Wright and Wright 1949; unpubl. data). The embryos have a critical thermal maximum (CTM) of c 26°C (Zweifel 1955), but the precise embryonic CTM for this species is not known. Tadpoles display more dorsoventral flattening, have a more muscular tail fin, and have a larger number of tooth rows than most other ranid frogs native to the western United States, features thought to assist the larvae of this species in its flowing stream environment (Zweifel 1955). Tadpoles are infrequently observed because they are cryptic against the substrates of rocky pools and riffles in which they occur (pers. observ.). Tadpoles seem to be capable of growing much more rapidly on epiphytic diatoms than other types of algae, and have been observed to preferentially graze on this algal type (S. Kupferberg, pers. comm.). Such preferentially grazing has been observed to enhance the productivity of other algae (S. Kupferberg, pers. comm.) in a manner similar to that described for fishes (Power 1990). After oviposition, a minimum of roughly 15 weeks is needed to attain metamorphosis, which typically occurs between July and September (Storer 1925, Jennings 1988b). Upon metamorphosis, juveniles show a marked differential movement in an upstream direction (Twitty et al. 1967b) very similar to the compensating mechanism displayed by stream insects that are subject to downstream drift. Two years are thought to be required to reach adult size (Storer 1925), but no data are available on longevity. Postmetamorphs probably eat both aquatic and terrestrial insects, but few dietary data exist for this species (see Storer 1925, Fitch 1936). Red-sided *(Thamnophis sirtalis),* western terrestrial, and Oregon garter snakes have been reported as feeding on the post-hatching stages of *R. boylii* (Fitch 1941, Zweifel 1955, Lind 1990), whereas Evenden (1948) recorded *Taricha granulosa* predation on the eggs of *R. boylii*. The Oregon garter snake has been observed to feed more frequently on tadpoles than metamorphosed individuals (pers. observ.), whereas the other three garter snakes are recorded to feed more frequently on metamorphosed individuals. The diel and seasonal movement ecology and behavior of adults is essentially unknown.

Habitat: *Rana boylii* requires shallow, flowing water, apparently preferentially in small to moderate-sized streams situations with at least some cobble-sized substrate (Hayes and Jennings 1988, Jennings 1988b). This type of habitat is probably best suited to oviposition (see Storer 1925, Fitch 1936, Zweifel 1955) and likely provides significant refuge habitat for larvae and postmetamorphs (Hayes and Jennings 1988, Jennings 1988b). Foothill yellow-legged frogs have been found in stream situations lacking a cobble or larger-sized substrate gram (Fitch 1938, Zweifel 1955), but it is not clear whether such habitats are regularly utilized (Hayes and Jennings 1988). Foothill yellow-legged frogs are infrequent or absent in habitats where introduced aquatic predators (i.e., various fishes and bullfrogs) are present (Hayes and Jennings 1986, 1988; Kupferberg 1994), probably because their aquatic developmental stages are susceptible to such predators (Grinnell and Storer 1924).

Status: Endangered in central and southern California south of the Salinas River, Monterey County; foothill yellow-legged frogs have not been observed in or south of the Transverse Ranges since before 1978 (H, DeLisle, M. Long, G. Stewart, and S. Sweet, pers. comm.; pers. observ.). The last verifiable records from this region were a series of specimens collected 17 April 1970 on Piru Creek 10 miles north of Temescal Ranger Station, Ventura County (LACM 106062). and upstream from Piru Gorge (currently under

Pyramid Lake), Los Angeles County (California State University Northridge, uncat.; P. McMonagle, pers. comm.). High water conditions estimated to be of 500-year frequency, which occurred over much of southern California during the spring of 1969, are believed to be largely responsible for the apparent extirpation of this taxon in that region (Sweet 1983). The last reliable observation (unverified by specimens or photographs) of a foothill yellow-legged frog in the region occurred at 1-2 km south of Frenchman's Flat along Piru Creek (Los Angeles County) on 6 July 1977 (H. DeLisle, pers. comm.).

Threatened in the west slope drainages of the Sierra Nevada and southern Cascade Mountains east of the Sacramento-San Joaquin River axis; foothill yellow-legged frogs have not been observed for nearly 20 years at least 19 historical localities on the west slope of the southern Sierra Nevada (J. Brode, R. Hansen, D. Holland, and D. Wake, pers. comm.; pers. observ.), and localities at which this species is extant on the western slope of the northern Sierra Nevada and the extreme southern Cascades appear widely scattered.

Special Concern in the Coast Ranges north of the Salinas River; *Rana boylii* still occurs at many localities in coastal drainages north of the Salinas River system in California, some of which harbor significant numbers of frogs (E. Ely, A. Lind, and H. Welsh pers. comm.; pers. observ.). Nevertheless, even in this area, *R. boylii* is at risk due to the exotic predatory aquatic fauna that is still increasing its range in this region (Kupferberg 1993; S. Kupferberg and M. Power, pers. comm.), poorly timed water releases from upstream reservoirs that scour egg masses from their oviposition substrates (e.g., Trinity River system during the spring of 1991: H. Welsh and A. Lind, pers. comm.), and decreased waterflows that can force adult frogs to move into permanent pools where they may be more susceptible to predation (see Hayes and Jennings 1988). Additionally, aseasonally (late), forceful storms in most years since 1987 that are though to be responsible for scouring salmonid redds (M. McCain, pers. comm.) may have had similar effects on *R. boylii* egg masses (H. Welsh and A. Lind, pers. comm.). Aseasonal storms and decreases in annual rainfall that result in decreased waterflows may be linked to local and global anthropogenically influenced climatic changes.

Management Recommendations: A life history study that details the habitat requirements of *R. boylii,* especially for the larvae and early postmetamorphic stages, is urgently needed. Such a study would greatly facilitate refining the management recommendations made here. Until data indicate otherwise, habitat critical to the survival of *R. boylii* should be identified in part by the presence of oviposition habitat having riffle areas with a substrate of cobble-sized or larger rocks. Since such habitats are dynamic in stream systems based largely on the ability of the existing flow regime to differentially sort the loose substrate, particular attention should be paid to maintaining a flow regime that ensures the presence of suitable habitat for *R. boylii.* Moreover, an understanding of the variation in flow and shear conditions that egg masses and larvae will tolerate before they are damaged is needed, as well as a more precise understanding of the critical thermal maxima of the embryonic stages. Management should avoid water releases that create excess flow and shear conditions during the time interval that egg masses and the more fragile younger larval stages are present. *Rana boylii* egg masses are known to accumulate suspended particulates (Storer 1925), but how much silt deposition they can withstand and still survive is not known. Tolerance to silt deposition needs study because increased silt loads due to vegetation removal, such as logging and livestock grazing, are a frequent occurrence within the range of *R. boylii.*

CASCADE FROG
Rana cascadae Slater 1939

Description: A moderate-sized (50-75 mm SUL) brown, red-brown, or slightly greenish brown frog with prominent dorsolateral folds and a distinct light jaw stripe (Slater 1939a, Dunlap 1955, Dumas 1966). Individuals are usually spotted with a few to over 50 inky black, distinct-edged dorsal spots; rarely, individuals are entirely unspotted (Slater 1939a; pers. observ.). A diffuse light and dark reticulum is present in the groin (Dunlap 1955). Undersurfaces are yellow to cream without any dark pigment, the yellower areas largely confined to the posterior belly and the undersurfaces of the lower limbs. The iris is brown with some gold iridophores on the upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: *Rana cascadae* is a morphologically (Slater 1939a) and genetically (Case 1978b; Green 1986a, 1986b) distinct species. Although not universally recognized as such for a number of years following its description in 1939 (e.g., Stebbins 1951), Dunlap (1955) first confirmed its distinctiveness based on morphology, which was later reaffirmed by genetic data (Case 1978b; Green 1986a, 1986b). Data on genetic variation within *R. cascadae* is based on 6 populations in California (Case 1976, 1978a, 1978b) and 7 populations in Oregon and Washington (Haertel et al. 1974; Green 1986a, 1986b). Available allozyme data indicate some potentially significant genetic variation within *R. cascadae* (Case 1976, 1978b), but the data are both difficult to interpret because of lumping of adjacent populations (Case 1978b, Green 1986a) and are too few to identify any geographic patterns of genetic variation conclusively.

Distribution: Historically, *R. cascadae* was discontinuously distributed along the Cascade Mountain axis between northern Washington (Stebbins 1985) and northern California (Bury 1973b) and extended southward to the extreme northern end of the Sierra Nevada (Hayes and Cliff 1982). A disjunct population system also occurs in the Olympic Mountains in Washington (Stebbins 1985). The known elevation range of *R. cascadae* extends from near sea level to 2500 m (Emerald Lake, Lassen National Park, Shasta County). In California, *R. cascadae* was distributed from the Shasta-Trinity region eastward toward the Modoc Plateau and southward to the Lassen region and the upper Feather River system (Figure 19). Notably, numerous specimens identified as western spotted frog *(R. pretiosa)* from localities in eastern Siskiyou County are actually *R. cascadae,* so the historical range of *R. cascadae* in California shown here is more extensive than that shown by most current authorities (e.g., Altig and Dumas 1971, Stebbins 1985). The known elevational range of *R. cascadae* in California extends from 270 m (Anderson Fork, Butte County: Hayes and Cliff 1982) to 2500 m (Emerald Lake, Lassen National Park, Shasta County: Grinnell et al. 1930 as *R. pretiosa).*

Life History: Data on the life history of the Cascade frog are based almost entirely on studies conducted in Oregon, so inferences regarding the details of its life history in California should be viewed with caution. *Rana cascadae,* exclusively diurnal in its activity, appears soon after melting ice and snow creates some open water on the edges of ponds or ponded streams where this species hibernates in the mud bottom (Briggs 1976, 1987; pers. observ.)., Males appear hours to a few days in advance of females and intercept females as they appear (pers. observ.). The first female or first few females to deposit an egg mass seem to oviposit in the warmest melt-water available, whereas subsequent females appear to cue on the position, perhaps by olfaction, of previously laid egg masses. This results in most egg masses being aggregated (Sype 1975, Briggs 1987). Masses are globular, contain 400-600 eggs, are laid in shallow water, and are not attached to a vegetation brace. The aggregation of egg masses frequently results in their being stacked so that after their jelly swells, a significant number of the uppermost eggs are above the water line and can freeze (Sype 1975). Oviposition occurs some time in the interval of
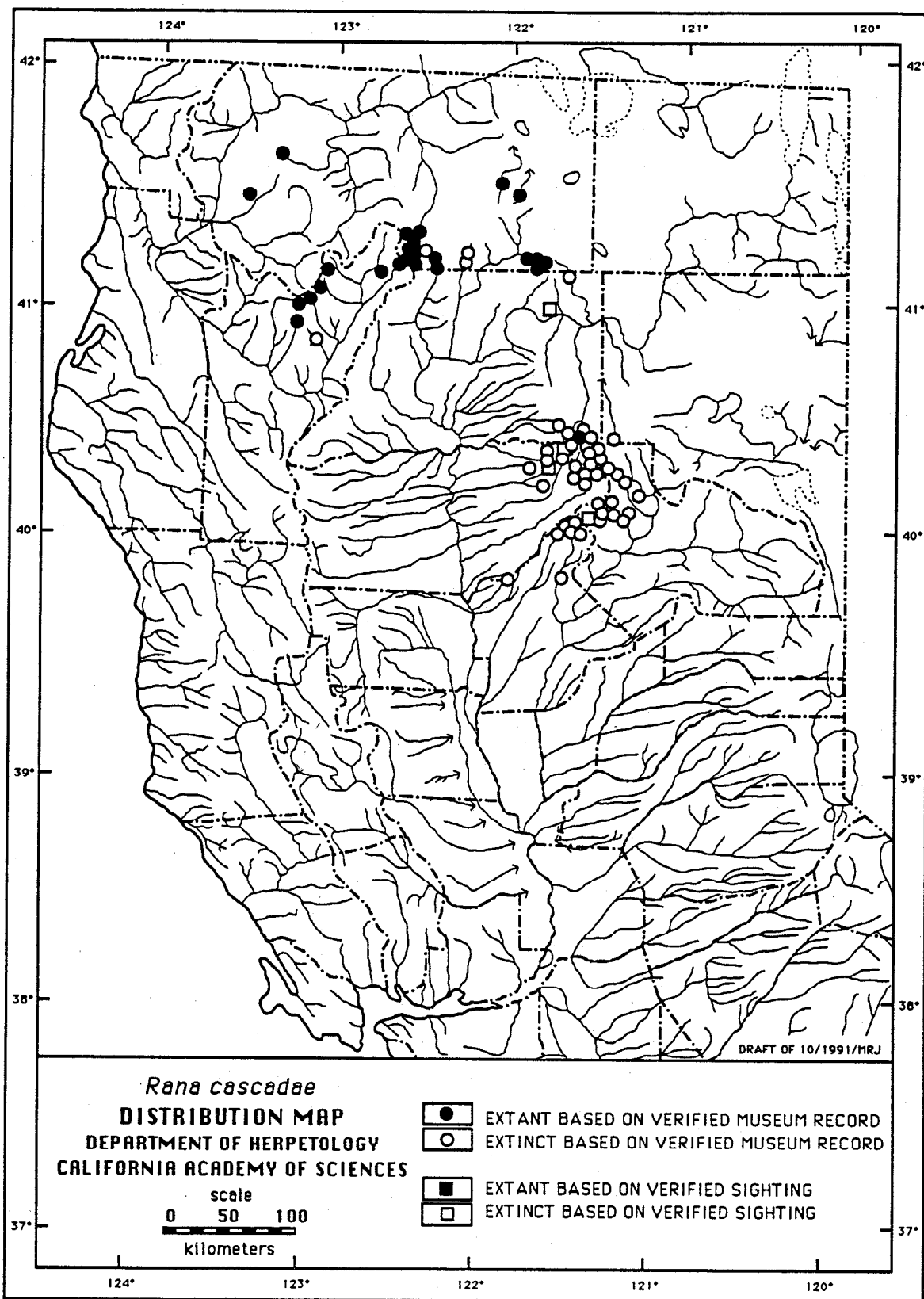
Figure 19. Historic and current distribution of the Cascade frog (*Rana cascadae*) in northern California based on 132 locations from 533 museum records and 6 records from other sources.

March-July depending on climatic conditions and elevation (Nussbaum et al. 1983); oviposition at any one locality, however, is completed in just a few days (T. Rodgers, pers. comm.; pers. observ.). Most embryos will die if water temperatures warm to $\geq 28°C$ (Sype 1975). After hatching, *R. cascadae* larvae are almost never found alone, but form spatially loose social aggregations of generally < 100 individuals composed primarily of kin (O'Hara and Blaustein 1985, Blaustein and O'Hara 1987). *Rana cascadae* larvae voluntarily select a high water temperature (27.3 ± 0.6°C; Wollmuth et al. 1987), presumably to optimize conditions for growth and development. The length of the larval period is also highly temperature dependent, but probably ranges from 1 to over 2 months in the field (Nussbaum et al. 1983, Briggs 1987). Upon entering metamorphosis, larvae voluntarily select the highest environmental temperatures (28.8 ± 0.4°C) during their developmental history since all postmetamorphic life stages voluntarily select temperatures < 17°C (Wollmuth et al. 1987). At a pond located at 1285 m elevation in Oregon, males and females first exhibited signs of sexual maturity at 35 mm and 52 mm SUL, respectively (Briggs and Storm 1970). Based on growth rates of marked individuals, males could mature by 2 years of age and females by 4 years of age. However, both sexes may not reproduce until they are one or two years older than the minimum ages at maturity. Longevity in *R. cascadae* is unknown, but the species is probably long-lived (> 5 years).

Habitat: *Rana cascadae* occurs and reproduces in both ephemeral and permanent ponds or streams (Zweifel 1955; Nussbaum et al. 1983; Briggs 1987; pers. observ.), but probably cannot survive in ephemeral situations where at least some of the substrate does not remain saturated. Oviposition habitat is open, shallow water (Briggs 1987) that remains unshaded during the hours of strong sunlight (pers. observ.). Aquatic sites in which *R. cascadae* is found are relatively oligotrophic (Briggs and Storm 1970, Nussbaum et al. 1983), so a certain level of water quality is undoubtedly important to its survival. However, what its tolerance limits to various water quality parameters are (except temperature; see life history section) are unknown. Cascade frogs typically occur in waters lacking predatory fish and indications exist that a shift away from the use of more permanent aquatic sites, in a manner similar to that described for California red-legged frogs (Hayes and Jennings 1988), may have been induced in part by fish plants (see Liss and Larson 1991). Hibernation occurs underwater or in saturated ground (Briggs 1987), presumably because frogs cannot survive the level of water loss sustained if a dry terrestrial hibernation site were used.

Status: Special Concern in the Trinity Alps and Shasta region and the headwaters of the Sacramento and McCloud River systems; Endangered elsewhere in the state (i.e., from the Pit River system south); our field surveys from Butte County northward through the Lassen National Park region to the Modoc Plateau area of eastern Siskiyou County failed to reveal any Cascades frogs at localities where they were historically known to occur. Only two adults of this taxon were recently found in each of two different years at the same location in Lassen Volcanic National Park following extensive searches during the summers of 1991-1993 (Fellers and Drost 1993; G. Fellers, pers. comm.). All available indications are that *R. cascadae* is exceedingly rare in this region, which is in sharp contrast to its historic abundance (Grinnell et al. 1930 [as *R. pretiosa*]; Badaracco 1960). Collections (MVZ 136125-136127, 136131-136136, 136138-136143, 148944-148988, 175949-175954; n = 68) indicate that this species was abundant at several locations within Lassen National Park in the mid-1970s (see also Case 1976, 1978a; Fellers and Drost 1993). Our field surveys for *R. cascadae* during 1990 indicated that it was moderately to extremely abundant in lake and ponded stream situations where few or no fishes were present from the upper McCloud River system (Colby Meadows) westward into the Trinity Alps at localities where it had been historically recorded.

Management Recommendations: Comprehensive genetic data are needed to identify potential cryptic taxa within *R. cascadae.* In California, the Trinity Alps-Shasta region

population system may be sufficiently differentiated from populations in, the Oregon Cascades to justify species recognition. Judging from the large number of misidentifications of *R. cascadae* in museum collections alone, its distribution in California is still poorly understood. Comprehensive surveys for this taxon in California are urgently needed. Surveys should focus on how far west along the Trinity Alps ridge system this species extends, on its pattern of occurrence in the Siskiyou-Klamath region of western Siskiyou County, and on its pattern of occurrence west and northwest of Mt. Shasta. How adversely this species may have been affected by the planting of trout in high elevation lakes is poorly understood, but some effort should be focused at understanding both the current and historical bases of this problem. An attempt should be made to work toward a policy of discontinuing fish plants and encouraging management alternatives that will eliminate exotic or transplanted fishes where populations of *R. cascadae* still exist, As a start, fishless lakes should be clearly identified and no such lakes should be planted. Termination of fish stocking or elimination of exotic fish should be considered on a case-by-case basis. Water quality variables and the tolerance limits of the various life stages of *R. cascadae* to those variables especially need study, as well as the effects of varying levels of UV radiation on developing eggs (see Blaustein et al. 1994). Although dispersal abilities of *R. cascadae* seem to be poor (O'Hara 1981), the movement ecology of *R. cascadae,* particularly with respect to its ability for recolonization following local extirpation, is essentially unknown. That knowledge is essential to the proper management of local areas where this taxon occurs.

MOUNTAIN YELLOW-LEGGED FROG
Rana muscosa Camp 1917

Description: A moderate-sized (ca. 40-80 mm SUL), highly variably colored frog with a dorsal pattern ranging from discrete dark spots that can be few and large, smaller and more numerous ones with a mixture of size and shapes, irregular lichen-like patches, or a poorly defined reticulum (Zweifel 1955). Color is highly variable, usually a mix of brown and yellow, but often with gray, red, or green-brown; some individuals may be dark brown with little pattern (pers. observ.). The posterior half of the upper lip is weakly light-colored. Dorsolateral folds are present, but not usually prominent (Stebbins 1985). The throat is white or yellow, sometimes with mottling of dark pigment (Zweifel 1955). The belly and undersurfaces of the high limbs are yellow, which ranges in hue from pale lemon yellow to an intense sun yellow. The iris is gold with a horizontal, black countershading stripe (pers. observ.).

Taxonomic Remarks: *Rana muscosa* has been regarded as a distinct species since the work of Zweifel (1955), who differentiated it primarily on morphological grounds. Subsequent genetic work (Houser and Sutton 1969; Haertel et al. 1974; Case 1976, 1978b; Green 1986a, 1986b) has confirmed its distinctiveness. Allozyme data, based on 16 populations, show a complex pattern of genetic variation (Case 1976, 1978b; Green 1986b), but the data are difficult to interpret because of lumping of populations along political boundaries and because sample sizes from most populations are too small to allow conclusive identification of a pattern. Comprehensive genetic data, particularly among disjunct population systems within *R. muscosa* are needed to help identify genetic variation, particularly since morphological differences have been noted between frogs collected from the Sierra Nevada and frogs collected from southern California (Camp 1917, Zweifel 1955).

Distribution: This near endemic to California is distributed more or less continuously in the Sierra Nevada from the vicinity of La Porte (southern Plumas County) southward to Taylor and French Joe Meadows (southern Tulare County; Zweifel 1955; Figure 20). It extends out of California into Nevada only in the vicinity of Lake Tahoe (Zweifel 1955, Jennings 1984a). Disjunct populations occur north and south of the ends of the main body of its geographic range. The northernmost populations includes a population cluster from the vicinity of Butts Creek (Plumas County; CSUC 1132-1133) to the upper reaches of the Butte Creek drainage (Butte County: Zweifel 1955). In southern California, a single specimen collected on 13 September 1952 at the USFS campground (2013 m elevation) on Breckenridge Mountain, Kern County (MVZ 63389) has been tentatively identified by us as *R. muscosa.* Additional populations of *R. muscosa* occur in isolated clusters in the San Gabriel, San Bernardino, and San Jacinto Mountains (Zweifel 1955), and an isolated outpost occurs in Pauma Creek flowing through Doane Meadow on Mt. Palomar in northern San Diego County (Klauber 1929; Figure 21). Its known elevation range extends from ca. 1370 m (San Antonio Creek, Calaveras County: Zweifel 1955) to > 3650 m near Desolation Lake (Fresno County: Mullally and Cunningham 1956b) in the Sierra Nevada. In southern California, its historical elevational range extended from 370 m (Eaton Canyon, Los Angeles County; M. Long, pers. comm.) to > 2290 m near Bluff Lake (San Bernardino County: Zweifel 1955).

Life History: *Rana muscosa* is a diurnal frog that emerges from overwintering sites immediately following snowmelt (D. Bradford, pers. comm.). Oviposition typically occurs in shallow water (Mullally 1959), with the egg mass unattached, and clustering of eggs masses occurs frequently (H. Basey, S. Morey, and Jay Wright, pers. comm.); however, in stream situations, the egg mass may be attached (Zweifel 1955). Clutch size and the time required for embryonic development are unknown. Larvae maintain a

Figure 20. Historic and current distribution of the mountain yellow-legged frog (*Rana muscosa*) in central and and northern California based on 530 locations from 2270 museum records and 161 records from other sources. The distribution of *R. muscosa* in southern California is presented in Figure 21.
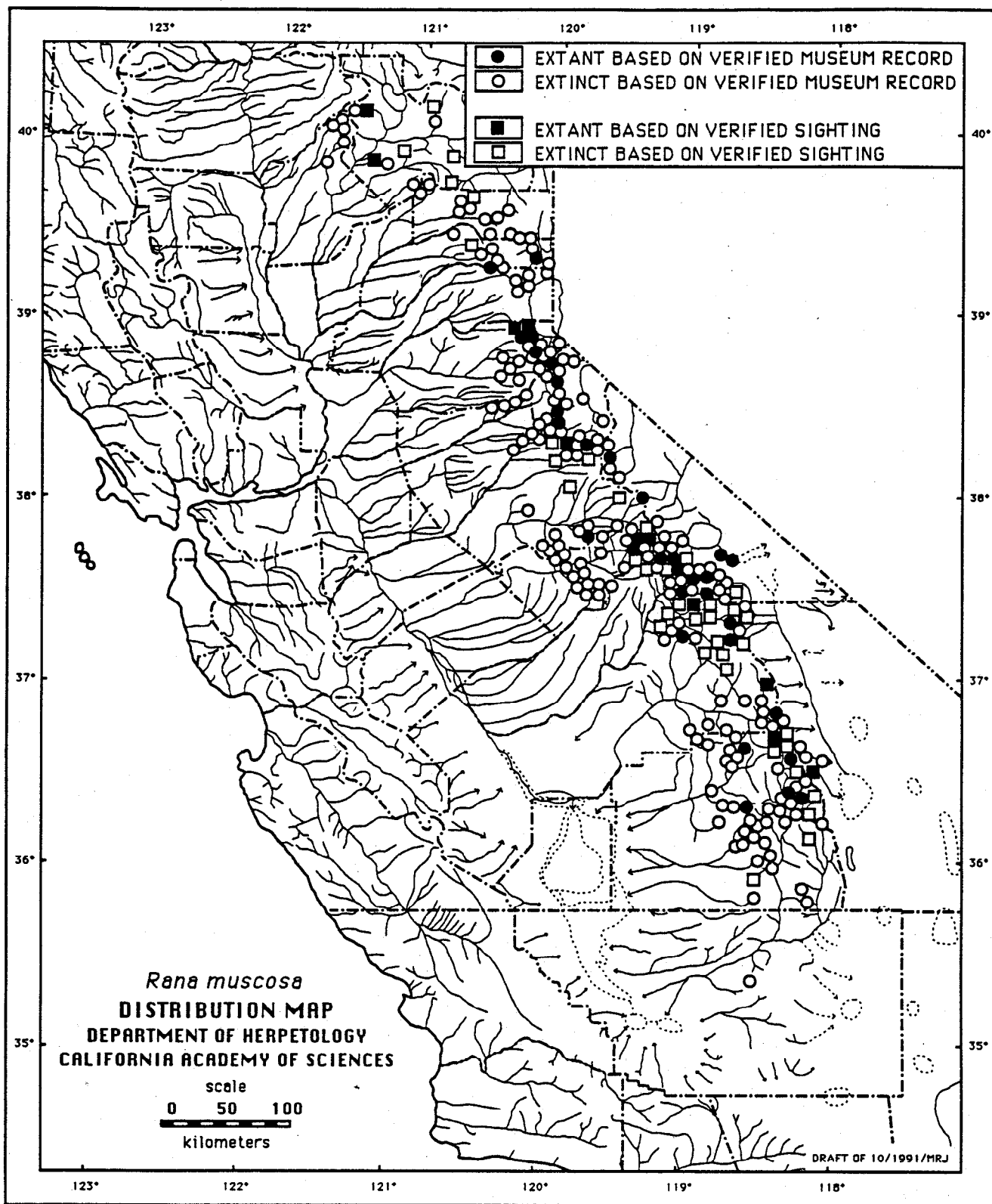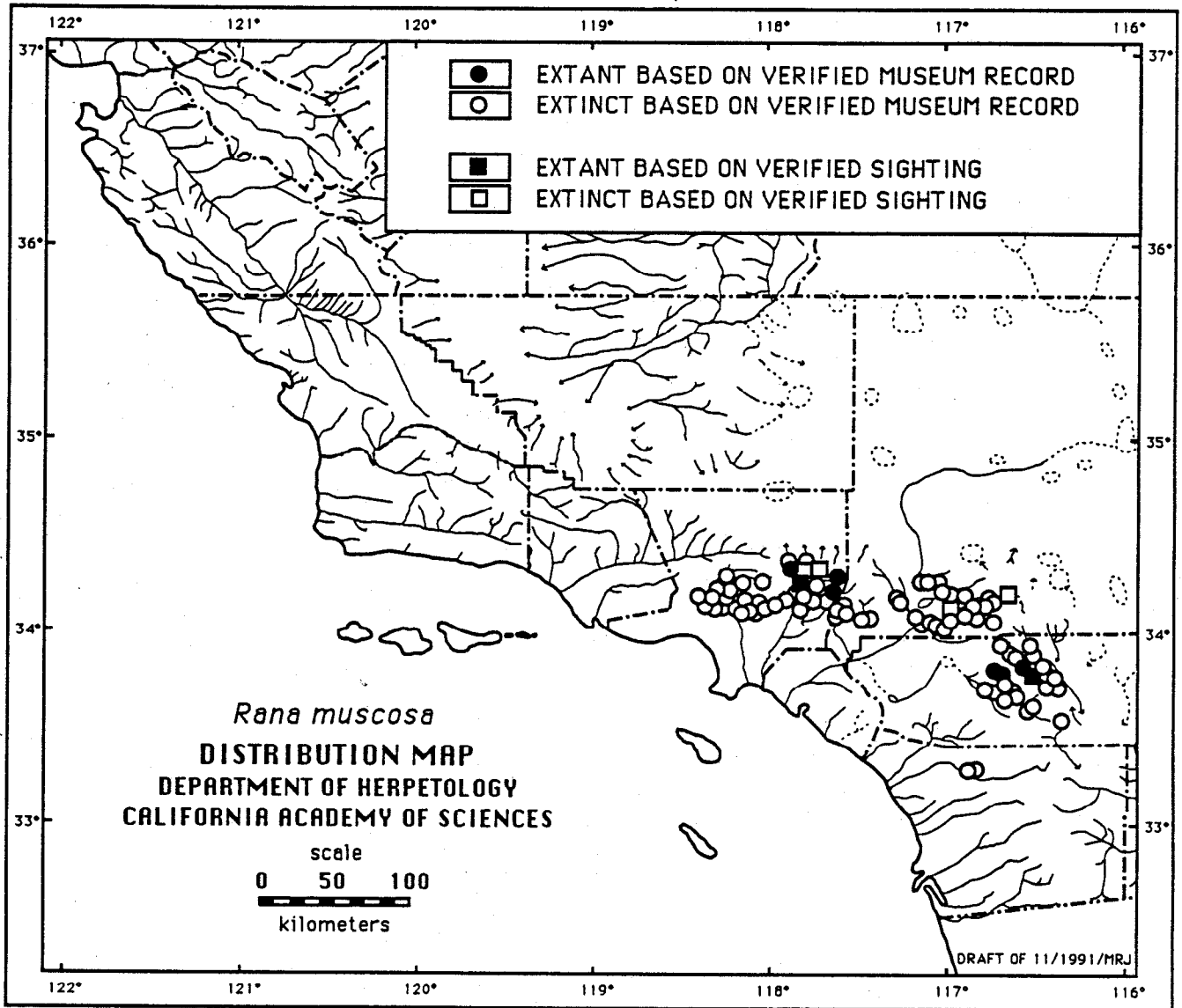
Figure 21. Historic and current distribution of the mountain yellow-legged frog (*Rana muscosa*) in southern California based on 166 locations from 651 museum records and 28 records from other sources. The distribution of *R. muscosa* in central and northern California is presented in Figure 20.

relatively high body temperature by selecting warmer microhabitats (Bradford 1984). Before spring overturn, larvae remain in warmer water below the thermocline; after spring overturn, they move to warm shallows on a daily basis, taking advantage of daily changes in water temperatures. Larvae may form diurnal aggregations in shallow water that may number in the hundreds, and voluntarily elevate their body temperatures to as high as 27°C (Bradford 1984). Despite such behavior, larvae apparently must overwinter up to two times for 6-9 month intervals (Cory 1962a, Bradford 1983) before attaining metamorphosis because the active season is short and the aquatic habitat maintains warm temperatures for only brief intervals (Mullally and Cunningham 1956b). Overwintering results in larvae dying when the aquatic habitat becomes ephemeral in some years (Mullally 1959). Larvae have the ability to survive anoxic conditions when shallow lakes freeze to the bottom for months (Bradford 1983). The time required to develop from fertilization to metamorphosis is believed to vary between 1 and 2.5 years. Data on the time required to reach reproductive maturity and longevity of adults is unknown. During the active season, postmetamorphs tend to maximize body temperature at nearly all times of day by basking in the sun, moving between water and land (depending on which is warmer), and concentrating in the warmer shallows along the shoreline (Bradford 1984). Postmetamorphs appear to be susceptible to winterkill in shallow lakes that undergo oxygen depletion because they are less tolerant of low oxygen tension than larvae (Bradford 1983). Frogs apparently must hibernate in water, probably because they can tolerate only limited dehydration (see Hillman 1980).

Postmetamorphic diet is dominated by beetles, flies (Diptera), ants, bees (Apoidea), wasps (Hymenoptera), and true bugs (Hemiptera: Long 1970). Larger frogs take more aquatic true bugs probably because of their more aquatic behavior. Coyotes *(Canis latrans),* Brewer's blackbirds *(Euphagus cyanocephalus),* and western terrestrial garter snakes are known to prey on the larvae and postmetamorphs of *R. muscosa* (Moore 1929, Mullally and Cunningham 1956b, Bradford 1991), but these life stages of *R. muscosa* are probably a regular seasonal component of the diet only for the western terrestrial garter snake (see Jennings et al. 1992). Mass mortality leading to a local extinction event was induced by unknown circumstances, although some of the affected frogs harbored pathogenic bacteria (Bradford 1991). *Rana muscosa* is apparently intolerant of introduced predatory fishes, since they rarely occur with such fishes where these have been introduced (Cory 1962b, 1963; Bradford 1989; Bradford et al. 1993, in press). Data on the movement ecology and recolonization capabilities of *R. muscosa* are lacking.

Habitat: *Rana muscosa* inhabits ponds, tams, lakes, and streams at moderate to high elevations (Mullally and Cunningham 1956b). It seems to be absent from the smallest creeks probably because these have insufficient depth for adequate refuge and overwintering. Although *R. muscosa* can occur in low numbers along a variety of shorelines, it appears to prefer open stream and lake margins that gently slope up to a depth of ca. 5-8 cm. Such shorelines are probably essential for oviposition and important for thermoregulation of larvae and postmetamorphs; additionally, this kind of shoreline configuration probably provides a refuge from predation if fishes occur in adjacent deeper water. *Rana muscosa* seems to be most successful where predatory fish are absent (Bradford 1989; Bradford et al. 1993, in press).

Status: Endangered in southern California; *R. muscosa* has probably been extirpated from > 99% of its historic range in southern California. No *R. muscosa* have been observed in the San Bernardino Mountains since the 1970s. In the San Gabriel Mountains small populations of frogs exist only in the upper reaches of Little Rock Creek, Devils Canyon, and the East Fork of the San Gabriel River (Jennings and Hayes 1994; unpubl. data). A visit to the Doane Meadow locality on Mt. Palomar found the pond overrun with bullfrogs and exotic fishes; *R. muscosa* and *R. aurora draytonii* have not been seen there

since the mid-1970s (T. Knefler and L. Grismer, pers. comm.). The only *R. muscosa* known to still occur in southern California (to our knowledge) can be found in four small tributaries of the upper reaches of the San Jacinto River system in the San Jacinto Mountains, and four small streams in the San Gabriel Mountains. Field surveys indicate that the entire remaining populations in the San Gabriel and San Jacinto Mountains probably numbers less than 100 adult frogs. Regardless of the precise number, *R. muscosa* in southern California is represented by a precariously small remnant.

Threatened in the Sierra Nevada; it is unclear from how much of its historic range in the Sierra Nevada *R. muscosa* has disappeared, but several indications suggest that the extent of disappearance is significant (Bradford et al. (in press); J. Boundy, D. Bradford, L. Cory, R. Hansen, D. Martin, and M. Morton, pers. comm.; unpubl. data). Introduced fishes have apparently eliminated *R. muscosa* from many lakes and streams (Grinnell and Storer 1924; Bradford 1989; Bradford et al. 1993, in press). However, *R. muscosa* was abundant at many sites at least until the 1960s (Zweifel 1955, Cory et al. 1970). Only a few *R. muscosa* have been observed at the extreme northern end of the range (Butte-Plumas counties) since the 1970s (unpubl. data). A significant number of local populations have also apparently become extinct in the central and southern Sierra Nevada since the 1960s (Bradford et al. (in press); L. Cory, R. Hansen, and D. Martin, pers. comm.). Some of these sites are unlikely to be recolonized because they are isolated from the nearest extant populations by aquatic habitats populated by exotic fishes (Bradford 1991, Bradford et al. 1993). Recent studies of the potential effects of acidification and inorganic aluminum indicate that neither of these factors is the likely explanation for the observed declines in the Sierra Nevada (Bradford et al. 1991, 1992, 1994).

Management Recommendations: A range-wide survey for extant populations of *R. muscosa* is needed to determine more precisely to what extent this taxon has disappeared. Such a survey should be conducted over several years to validate the accuracy of survey methods and to provide an indication of the degree of recolonization. Much of the basic life history of *R. muscosa* remains poorly understood, but for management, an understanding of its movement ecology, recolonization potential, and determination of whether the same oviposition sites are repeatedly used (as in *R. cascadae)* are especially needed. The policy of planting trout *(Oncorhynchus aguabonita, O. mykiss,* and *Salmo trutta),* charr *(Salvelinus fontinalis),* and other fishes in currently fishless high elevation lakes should be discontinued. In addition, a thorough inventory of Sierran sites supporting *R. muscosa* should be conducted. Such an inventory should be capable of identifying fish-linked recruitment failures. Where the inventory suggests fish-induced demographic changes, termination of stocking or eradication of exotics should be considered on a case-by-case basis. An economic argument for the retention of trout stocking in high elevation Sierran lakes is not justified based on backcountry use levels of these areas (P. Moyle, pers. comm.). Some recent declines are puzzling because the presence of pathogens suggests that a primary causative agent exists that makes frogs susceptible to pathogens and predators (see Bradford 1991). As with *Bufo canorus* and *R. cascadae,* the possibility exists that unexplained declines in *R. muscosa* are linked to non-acidification-mediated atmospheric effects (D. Bradford, pers. comm.); this alternative needs investigation (see Management Recommendations section of the Yosemite toad *(B. canorus)* account).
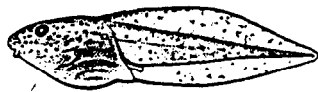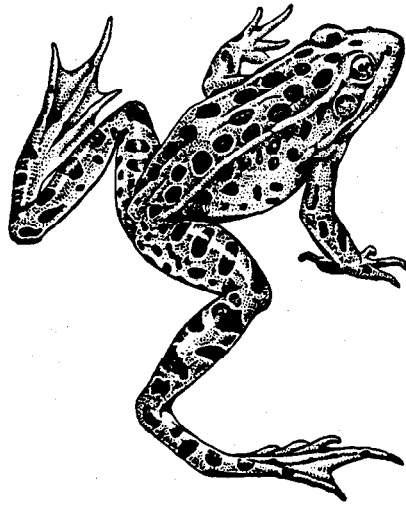
Plate 5. Larval and adult northern leopard frog (*Rana pipiens*) [from Stebbins 1951].

NORTHERN LEOPARD FROG
Rana pipiens Schreber 1782

Description: A moderate-sized (50-100 mm SUL) frog with moderate, to moderately large, dark brown spots, each edged with a narrow, halo of white, or pale yellow pigment (Pace 1974). Prominent, continuous dorsolateral folds are present. Dorsal ground color is highly variable, but typically includes a significant amount of green, the remaining areas being tan or beige (Stebbins 1985). Undersurfaces are cream, sometimes with a yellow taint, but without dark pigment or mottling of any kind. The iris is brown with some gold iridophores on the upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: Historically, this taxon was regarded as a highly variable species that included all taxa now regarded as part of the *R. pipiens* complex (Hillis 1988). The work of Pace (1974) conclusively separated *R. pipiens,* and later work helped define the geographic limits of this taxon (e.g., Dunlap and Kruse 1976, Lynch 1978). More recent genetic work (Hillis et al. 1983; see also discussion in Hillis 1988) has affirmed the specific status of this taxon. Genetic data on *R. pipiens,* which are limited to segments of its geographic range, have been used largely to differentiate *R. pipiens* from its close congeners rather than address the geographic pattern of genetic variation within the taxon (e.g., Kruse and Dunlap 1976, Platz 1976, Dunlap 1978). Studies are needed to determine whether a significant geographic pattern to genetic variation exists on a range-wide basis.

Distribution: Improved understanding and the relatively recent partitioning of the complex of species regarded as leopard frogs (Hillis et al. 1983, Hillis 1988) has still left the nominal species, *Rana pipiens,* as one of the most broadly distributed frogs in North America, with over 98% of its geographic range occurring outside California. The northern leopard frog extends northward to Great Slave Lake, southern MacKenzie District, Canada, eastward to southern Labrador and Newfoundland, Canada, and southward to Virginia, Nebraska, New Mexico, and northeastern Arizona (Stebbins 1985). Its known elevational range extends from near sea level to 3350 m (Stebbins 1985). In California, native populations of the northern leopard frog whose origin is largely unquestioned are historically recorded from only Modoc and Lassen counties (Figure 22). The origin of leopard frogs in the upper Owens Valley has been questioned (Bury and Luckenbach 1976), but no data dispute a native origin (see Macey and Papenfuss 1991b; pers. observ.), the treatment followed here. In California, its known elevational range extends from 1216 m (MVZ 71684: 1.6 km west of Big Pine, Inyo County) to 1503 m (CAS-SU 15230-15232: Pictograph Springs in Rattlesnake Creek above Big Sage Reservoir, Modoc County). Frogs in the vicinity of Lake Tahoe have been treated as native (Stebbins 1966, 1985), but historical evidence indicates that at least some of these are introduced populations (Bryant 1917, Storer 1925, Jennings 1984a). Leopard frogs that represent this taxon have been introduced at various sites elsewhere within the state (Storer 1925, Bury and Luckenbach 1976, Stebbins 1985), but no evidence exists that any of these introductions have resulted in large naturalized populations that continue to exist today (G. Hansen, and Jay Wright, pers. comm.; pers. observ.). The leopard frog historically present in the lower Colorado River, once labelled *R. pipiens* (Storer 1925, Ruibal 1959), is actually *R. yavapaiensis* (Platz and Frost 1984, Clarkson and Rorabaugh 1989).

Life History: No data are available on the life history of *R. pipiens* in California (e.g., see Storer 1925). This life history summary is a composite assembled from studies conducted at broadly scattered localities throughout the geographic range of *R. pipiens* outside California. Caution should be used to interpret the degree to which these studies reflect the behavior of *R. pipiens* that still occur in California. *Rana pipiens* emerges from underwater overwintering sites that consist of small pits the frogs apparently excavate in the bottom mud (Emery et al. 1972). Breeding seems to be initiated in spring when the
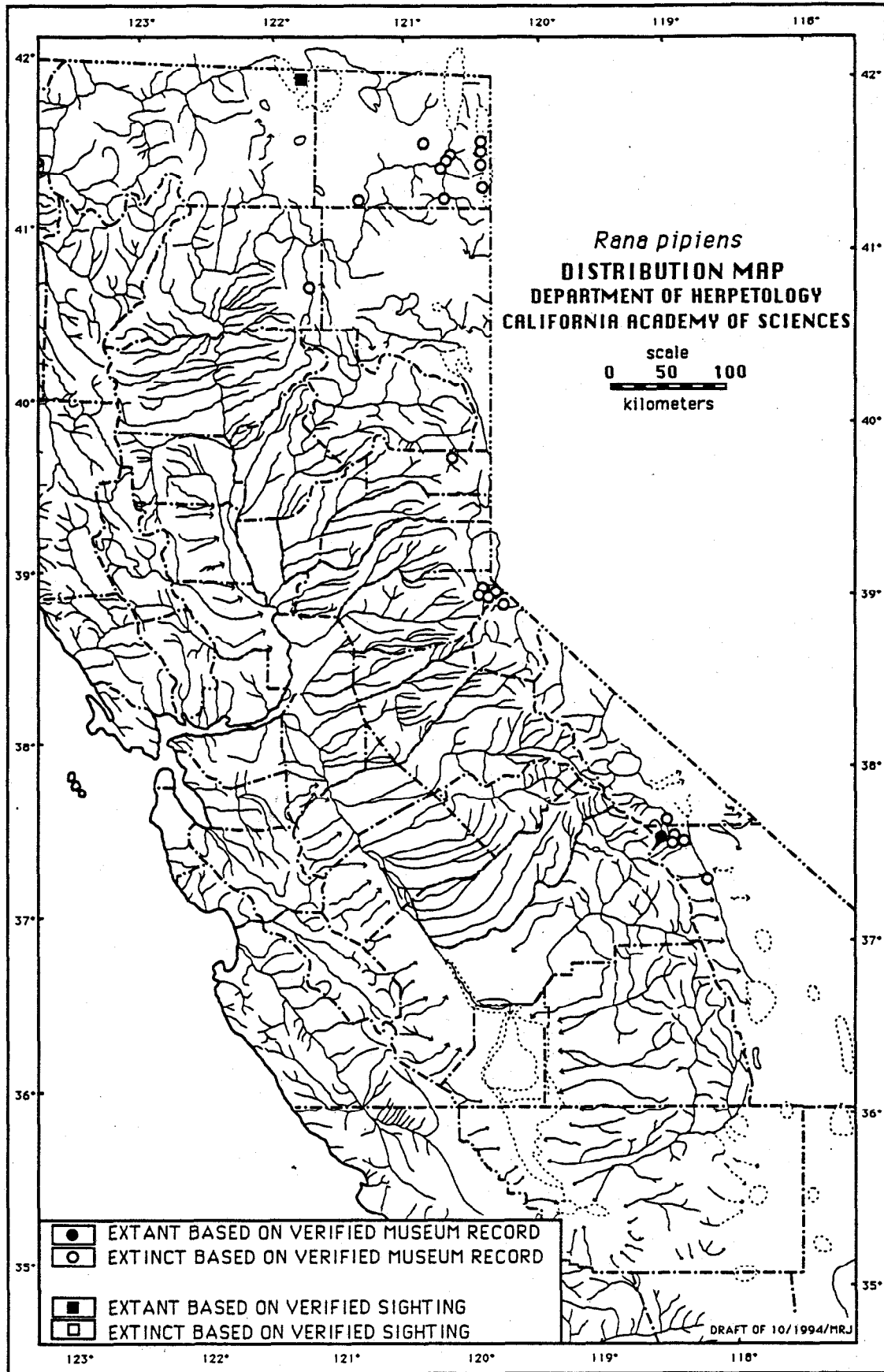
Figure 22. Historic and current distribution of presumed native populations of the northern leopard frog (*Rana pipiens*) in central and northern California based on 43 locations from 267 museum records and 2 records from other sources. Museum records based on known introductions are not plotted.

probability of minimum temperatures attaining the level of a hard freeze becomes very low (see Corn and Livo 1989). Males appear at breeding sites prior to females (Merrell 1977). When females begin to appear, males achieve an axillary (pectoral) amplexus (Noble and Aronson 1942), and females move to the site of egg deposition. Embryos hatch in 8-15 days (Hupf 1977) and larvae require 3-6 months before metamorphosing (Merrell 1977). Newly metamorphosed leopard frogs can move from natal ponds significant distances (800 m in 2-3 days; Dole 1971). Subadult frogs show a consistently higher degree of movement than adults (Dole 1965b, 1971). Males can mature at 1 year of age, but most probably become mature at 2, whereas females mature at 2 or 3 years of age (Rittschof 1975, Merrell 1977, Hine et al. 1981). Some indication exists that frogs at higher latitudes require longer to mature. Adults show a high degree of site fidelity, both intra- and inter-seasonally, although they will move under conditions that adversely modify their local habitat (e.g., lack of precipitation; Dole 1965a, 1965b). Adults frequently return to small pockets (called forms) at the base of dense graminoid or forb vegetation that has been molded into a resting location where frogs sit (Dole 1965a). Frogs may establish their adult home range as far as 5 km from their natal ponds (Dole 1971). Home ranges of adults may vary from < 20 m^2 to > 600 m^2 depending on local variation in habitat (Dole 1965b). Maximum longevity is unknown, but adults probably live 4-5 years (Rittschof 1975, Merrell 1977). Leopard frogs consume largely arthropods, with larger individuals capturing a higher frequency of larger, more mobile prey species (Linzey 1967).

Habitat: Leopard frogs require an aquatic habitat in which to overwinter (Emery et al. 1972) and lay eggs (Corn and Livo 1989). Emergent or submergent vegetation may be necessary both for oviposition and refuge during the breeding interval, but the degree to which leopard frogs require vegetation in the aquatic habitat where they deposit eggs has not been quantified nor experimentally evaluated. A dense, relatively tall, grass- or forb-dominated habitat with a moist substrate for foraging during the active season must occur in the vicinity of the aquatic habitat used for oviposition and overwintering (Dole 1965a, 1965b; Rittschof 1975; Merrell, 1977). A moist substrate is an essential aspect of *R. pipiens* habitat since they are relatively susceptible to water loss (Thorson 1955, 1956; Dole 1967; Gillis 1979). The degree to which the two required habitats must be juxtaposed to support a leopard frog population is poorly understood. Similarly, no understanding exists of the size of dense grass or forb habitat patches needed to sustain a leopard frog population (probably variable with habitat; see Dole 1965b) or inter-patch distances that will prevent recolonization of patches having sustained local extirpation.

Status: Endangered; no individuals of this taxon were encountered during our field surveys in California, and we know of only two recent sight records of this taxon from this region. A single adult leopard frog was observed beneath the outfall pipe moving water from the Lost River to the upper sump at the Tule Lake National Wildlife Refuge (Siskiyou County) during the summer of 1990 (R. Grove, pers. comm.), and 8-10 juveniles were observed in a marsh near Pine Creek, about 16 km northwest of Bishop (Inyo County), during the fall of 1994 (J. Brode, pers. comm.). Most of the habitat in the Pit River-Modoc Plateau area and the Owens Valley where this species occurred historically has been severely altered largely because of agricultural grazing practices. The dense tall-grass thickets and shelves bordering riparian zones that are essential habitat for this species are either no longer present or so fragmented that the habitat can no longer support populations of this taxon. Moreover, bullfrogs have become well-established along the riparian corridors where *R. pipiens* was historically present. Although the interaction between these two taxa is poorly understood, bullfrogs may have a negative effect on leopard frogs. Other members of the introduced predatory aquatic fauna that have been established alongside bullfrogs (e.g., red swamp crayfish, various exotic fishes) are likely to have negatively affected this species. Outside California, populations of *R. pipiens* from various

areas have been identified as being at risk. In the early 1970s widespread declines in the northern United States were attributed to overharvesting (Johnson 1975) coupled with other still unexplained factors (Hine et al. 1981). High elevation populations of this taxon in Colorado appear to be going extinct (Corn and Fogelman 1984). Like *Bufo canorus, Rana cascadae,* and *R. muscosa,* non-acidification atmospheric effects need investigation as a major cause for these declines.

Management Recommendations: Comprehensive surveys to determine the current distribution and status of *R. pipiens* in California are needed. We did not examine many aquatic habitats in the Siskiyou-Modoc-Lassen region that have some probability of harboring this species. Urgency is needed in addressing this taxon because four sequential years of drought in California (1986-1990) have exacerbated the already severe damage caused by grazing to potential *R. pipiens* habitat in this region. Special efforts should be made to implement programs that protect habitat for this species were populations of *R. pipiens* are detected. Particular attention should be paid to protecting juxtaposed grassy shelves and aquatic oviposition and overwintering habitat. Management should attempt to isolate this taxon from the introduced aquatic fauna; in particular, introduction of members of that fauna should be avoided. If significant populations of *R. pipiens* are found in California, some effort should be put into a local life history study to determine whether California leopard frogs behave in a manner consistent with what is known over the rest of their geographic range. Other studies should place some emphasis on assessing the patch sizes of habitat needed to sustain local populations long-term and evaluating the factors influencing recolonization potential when a local population become extinct.

SPOTTED FROG
Rana pretiosa Baird and Girard 1853

Description: A moderate-sized (60-110 mm SUL) brown frog with prominent dorsolateral folds and a highly variable pattern of dark spots ranging from large, "runny" ragged spots reminiscent of ink absorbed by a blotter, to diffuse-edged spots often with light centers (Dunlap 1955, Dumas 1966; pers. observ.). Undersurfaces are washed with reddish-orange, orange, or yellow in a manner that seems painted on (Dunlap 1955, Turner 1959a). Lower legs are relatively short (Dunlap 1955). The iris is brown with gold iridophores that are especially concentrated in the upper portions of the iris (pers. observ.).

Taxonomic Remarks: *Rana pretiosa* has been recognized as a distinctive taxon since the work of Dunlap (1955), but it is clearly a morphologically highly variable taxon with a broad geographic range that has made allocation of some populations difficult (Dunlap 1977). Allozyme data on *R. pretiosa* based on small samples from four populations in Idaho (Green 1986b), two populations in Montana (Case 1976, 1978b), and three populations in Oregon (Green 1986b), suggest considerable genetic variation. Current work now underway strongly suggests that at least three morphologically or genetically differentiated taxa are presently contained within *R. pretiosa* (D. Green, pers. comm.). Moreover, it has been recognized for some time that the variation in bright color pigments that different populations of *R. pretiosa* exhibit on their undersurfaces are geographically segregated (Nussbaum et al. 1983).

Distribution: As currently understood, this taxon is one of the most widely distributed frogs in the western United States. It ranges from southeastern Alaska westward to British Columbia and Alberta, Canada, southward to Montana, Wyoming, and Utah, and westward into Nevada, California, and Oregon (Turner and Dumas 1972). Its known elevational range extends from sea level to ca. 3050 m in western Wyoming (Stebbins 1985). In California, *R. pretiosa* is known from only 7 records (representing 5 localities) in Siskiyou and Modoc counties in the northeastern portion of the state (Figure 23). Its known elevational range in California extends from ca. 1000 m (Fall River Mills, Shasta County: USNM 38806) to ca. 1450 m (Pine Creek near New Pine Creek (town), Modoc County; J. Brode, pers. comm.).

Life History: No ecological or life history data exist for *R. pretiosa* from California. The life history summary presented here is a composite from studies conducted largely in British Columbia, Canada (Licht 1969b, 1971, 1974, 1986a, 1986b); Utah (Morris and Tanner 1969); and Wyoming (Turner 1958, 1959b, 1960). Caution should be used to interpret the degree to which these studies reflect the behavior of *R. pretiosa* in California, especially in view of the fact that this taxon may soon be partitioned (D. Green, pers. comm.). Whatever partitioning occurs, we anticipate that California populations will be ecologically and morphologically most similar to the *R. pretiosa* studied by Licht (1969b, 1971, 1974, 1986a, 1986b) along the Little Campbell River in British Columbia.

In southwestern British Columbia, *R. pretiosa* emerges from unspecified, but probably aquatic overwintering sites when air temperatures have attained at least 5.0°C; the first individuals appearing from late February to early March (from Licht 1969b). Males appear at breeding sites before females and form small aggregations in shallow-water areas that have emergent vegetation. The first females that appear are amplexed by males and they lay their eggs in shallow water that has reached at least 5°C in a manner that when the jelly becomes swollen, a significant portion of the eggs mass (often over half) is exposed to the air (Licht 1969b, 1971). Subsequent females oviposit on or immediately adjacent to the first egg mass laid, suggesting that they have to cue on the presence of an egg mass to deposit their own eggs (Licht 1969b). Egg masses of *R. pretiosa* contain a complement of
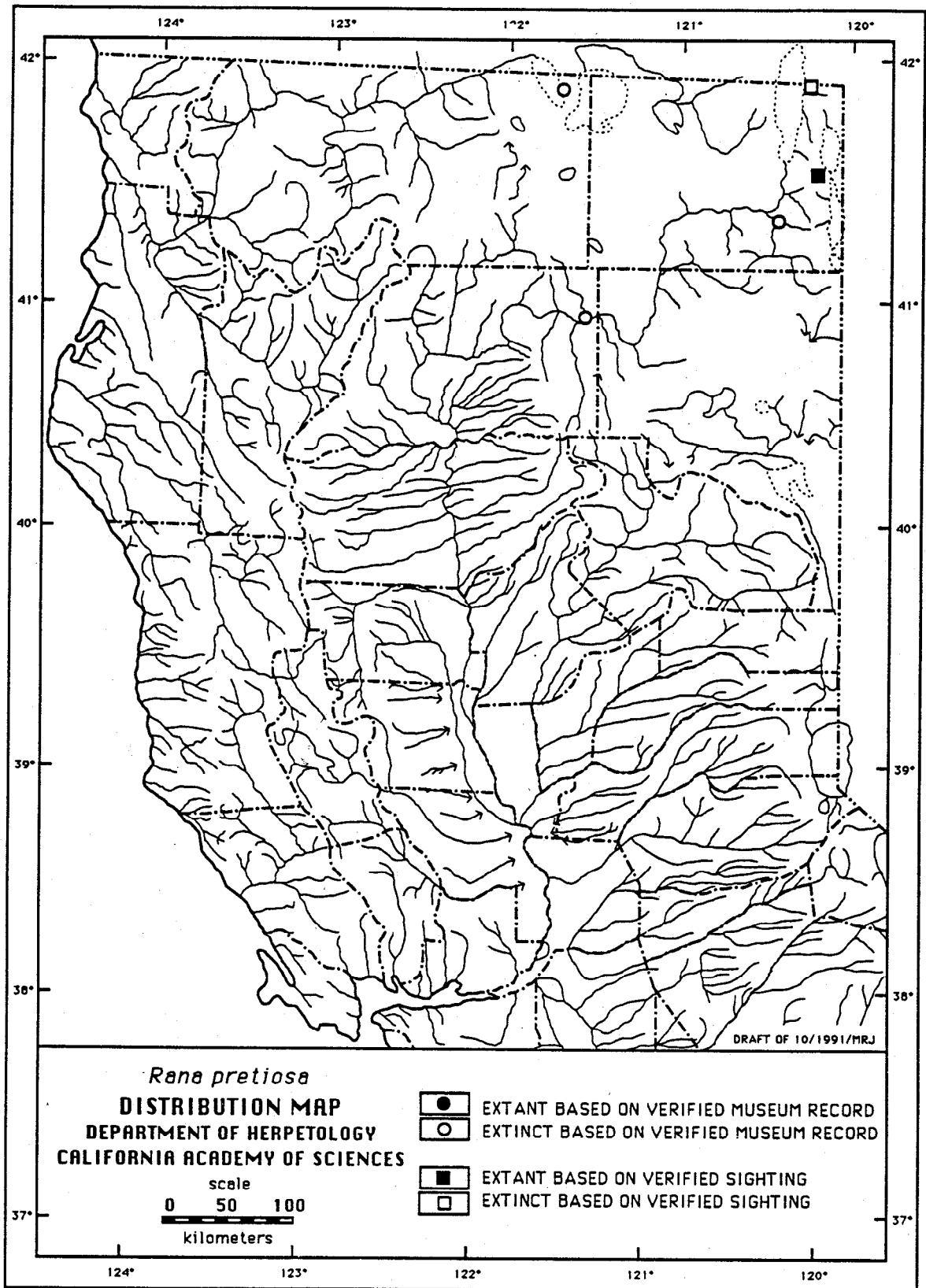
Figure 23. Historic and current distribution of the spotted frog (*Rana pretiosa*) in northern California based on 5 locations from 5 museum records and 2 records from other sources.

250-900+ moderate-sized (2.3 mm average diameter) eggs (Licht 1974). The thermal tolerance of *R. pretiosa* embryos ranges between 6°C and 28°C (Licht 1971). The pattern of oviposition often results in relatively high pre-hatching mortality (ca. ≥ 30%), largely because exposed embryos are susceptible to desiccation or freezing (Licht 1974). Larval mortality is greater and typically results in < 1% survival of eggs laid in any one season. Larvae require around 4 months to attain metamorphosis (Licht 1974). In British Columbia, *R. pretiosa* were sexually mature the third year after metamorphosis, but the time required to reach sexual maturity increases with altitude (see Turner 1960) and probably latitude, so *R. pretiosa* may mature at a younger age. In Wyoming, *R. pretiosa* were estimated to live in excess of 10 years (Turner 1960), but this pattern of longevity is probably related to the slow growth rates these frogs experience; populations at lower elevations or somewhat warmer clines may not live as long. Adult males have a somewhat lower survivorship than adult females, probably because of their increased exposure to predators during the breeding interval (Turner 1960, Licht 1974). Spotted frogs can engage in significant seasonal movements, primarily associated with movements between hibernacula and breeding sites in springs or movements out of drying aquatic habitats in late summer (Turner 1960); the magnitude of such movements is probably largely dependent on the local variation in habitat structure. Leeches *(Batrachobdella picta)* are significant predators on *R. pretiosa* eggs (Licht 1969b), and common garter snakes and great blue herons *(Ardea herodias)* are significant predators on tadpoles and postmetamorphs (Licht 1974). Postmetamorphic *R. pretiosa* nearly always escape predation by diving and submerging in the nearest water, from which they seldom leave (Licht 1986b). Postmetamorphic *R. pretiosa* are largely insectivorous, although larger frogs do eat smaller vertebrates (e.g., Pacific treefrogs, *Pseudacris regilla;* and juvenile northern red-legged frogs; Licht 1986a).

Habitat: The habitat requirements of *R. pretiosa* are poorly understood. Spotted frogs require shallow-water oviposition sites that may be in permanent or temporary water (Licht 1969b, 1971). If in temporary water, permanent water must occur in the vicinity for postmetamorphs, to survive. Historically, many oviposition sites were probably in overflow areas of large (≥ third order) streams flooded by high water during winter or spring months. Current indications that *R. pretiosa* typically uses temporary water for breeding may simply be an indication that most permanent sites are unsuitable because of introduced exotic aquatic predators not tolerated by the larval stages of *R. pretiosa* (see Hayes and Jennings 1986). Oviposition habitat is open (Licht 1971) and probably cannot be shaded because of the thermal requirements of the embryonic stages. Low emergent vegetation is probably also an important component of *R. pretiosa* habitat that is a significant element of the refuge habitat of postmetamorph juveniles and adult males (Licht 1969b; pers. observ.). Spotted frogs probably also require permanent water in which to overwinter, but the microhabitat characteristics of their overwintering site are unknown.

Status: Endangered; we found no individuals of this taxon during a concerted field effort on the Modoc Plateau, Pit River drainage, and in the Warner Mountains at sites where this taxon was historically present, and we know of only one recent sight record of this taxon in California. A single subadult frog was found beneath a woodpile at the Modoc National Forest Fire Station in Cedarville, Modoc County, on 24 September 1989 (G. Martinsen, pers. comm.). Virtually all frogs we encountered in museum collections allocated to this taxon from California are actually *R. cascadae*. The frogs found in California may be most closely related to the red- or orange-ventered *R. preriosa* populations in western Oregon and Washington. If this is the case, then the situation with *R. pretiosa* in California would be even more urgent because it may represent a species with an even more restricted range. Furthermore, accumulating evidence indicates that populations most likely related to those in California (e.g., western Oregon and Washington) have been largely extirpated over the past 50 years (McAllister and Leonard 1990, 1991; McAllister et al. 1993; unpubl. data).

Management Recommendations: Proper systematic characterization of *R. pretiosa* throughout its geographic range to determine what taxa may be represented in California is a top priority. Thorough field surveys for *R. pretiosa* are equally important. This taxon is most likely to exist in California in situations that are highly isolated from the widely distributed exotic predatory aquatic fauna and that have been least mechanically altered due to livestock grazing. Where populations of this taxon are identified, management should attempt to keep these populations isolated from exotic aquatic predators. Grazing should be excluded from such sites, but where this is impossible, levels of grazing should be managed to keep mechanical alteration of *R. pretiosa* habitat at an absolute minimum. If systematic studies identify more than one taxon within *R. pretiosa*, existing ecological studies will have to be linked to the proper taxon and studies will be needed to fill gaps in knowledge, especially those that characterize the difference in habitat utilization patterns between different taxa. Studies of the movement ecology and the ability of *R. pretiosa* or its contained taxa to recolonize are especially needed to establish better management guidelines.

Plate 6. Adult spotted frog (*Rana pretiosa*) [from Stebbins 1954b].

LOWLAND LEOPARD FROG
Rana yavapaiensis Platz and Frost 1984

Description: A moderate-sized (46-87 mm SUL) frog with prominent, light dorsolateral folds that are interrupted on the lower back and inset medially in the sacral region (Platz 1988). Background dorsal color is variable, but usually light gray-green to gray-brown, a low percentage of individuals are green; dorsal spots are irregularly elliptical, dark brown or black each surrounded by a narrow, light-colored halo; lemon yellow is present in the axillary region, the groin, and the posterior venter; remaining undersurfaces are cream to dirty white, sometimes with darker markings on the throat (Platz 1976; Platz and Frost 1984; M. Sredl, pers. comm.; pers. observ.). The iris is dark brown with some gold iridophores on the upper and lower portions of the iris (pers. observ.).

Taxonomic Remarks: This species is a genetically (Platz 1976, Hillis et al. 1983) and morphologically (Platz and Frost 1984) distinct member of the *Rana pipiens* complex that is most closely related to the Mexican species *Rana magnaocularis* (Hillis et al. 1983). Although this form has been recognized as distinct for over 15 years (Platz 1976), Platz and Frost (1984) did not formally describe it until 1984. The omission of *R. yavapaiensis* from Collins (1990) is apparently an oversight as this frog is a valid taxon (Frost 1985, Platz 1988).

Distribution: Historically, *R. yavapaiensis* was discontinuously distributed northward to Overton (Clark County), Nevada, and near St. George (Washington County), Utah; westward to San Felipe Creek (Imperial County), California; eastward to extreme western New Mexico; and southward into Sonora, Mexico (Platz and Frost 1984, Platz 1988). Its distributional range extended from near sea level to 1700 m (Platz 1988). In California, the known range extends discontinuously from San Felipe Creek near its junction with Carrizo Creek eastward through the Imperial Valley to the entire lower Colorado River (Jennings and Hayes 1994; Figure 24).

Life History: The life history of the lowland leopard frog is not well understood. In San Felipe Creek, Ruibal (1959) observed the initiation of breeding during the first 2 weeks of January in each of 3 years (1957-1959), and breeding adults were collected during 26-27 December 1938 (MVZ 27893-27897). Storer (1925) found an egg mass presumed to be that of this taxon in a pool 3.2 km east of Dixieland (Imperial County) on 28 March 1923. Oviposition is recorded for March-April and October in Maricopa and Yavapai counties, Arizona, suggesting that two breeding episodes are possible annually (Platz and Platz 1973, Collins and Lewis 1979, Frost and Platz 1983) and that cooler water temperatures may be necessary for reproduction. Salinities $\geq$ 5‰ are lethal to developing eggs, and those $\geq$ 13‰ are lethal to adults (Ruibal 1959), both of which are conditions likely to restrict the availability of sites where *R. yavapaiensis* can exist within its range in California; salinities in several of the few, widely scattered aquatic habitats in southeastern California are known to exceed these lethal limits seasonally. Larvae of this species can overwinter, and most individuals that overwinter are thought to result from fall breeding episodes (Collins and Lewis 1979). Other data on the development, growth, and phenology of the lowland leopard frog are currently lacking, but several individuals in Arizona are currently studying the ecology of this taxon (M. Sredl, pers. comm.).

Habitat: A detailed understanding of the habitat requirements of *R. yavapaiensis* is lacking, but this species apparently inhabited slackwater aquatic habitats dominated by bulrushes, cattails, and riparian grasses near or under an overstory of Fremont's cottonwoods and willows (Storer 1925, Stebbins 1951, Glaser 1970, Jennings and Hayes 1994; see also Lowe 1985, Jones 1988a [as *R. pipiens*]). Lowland leopard frogs were
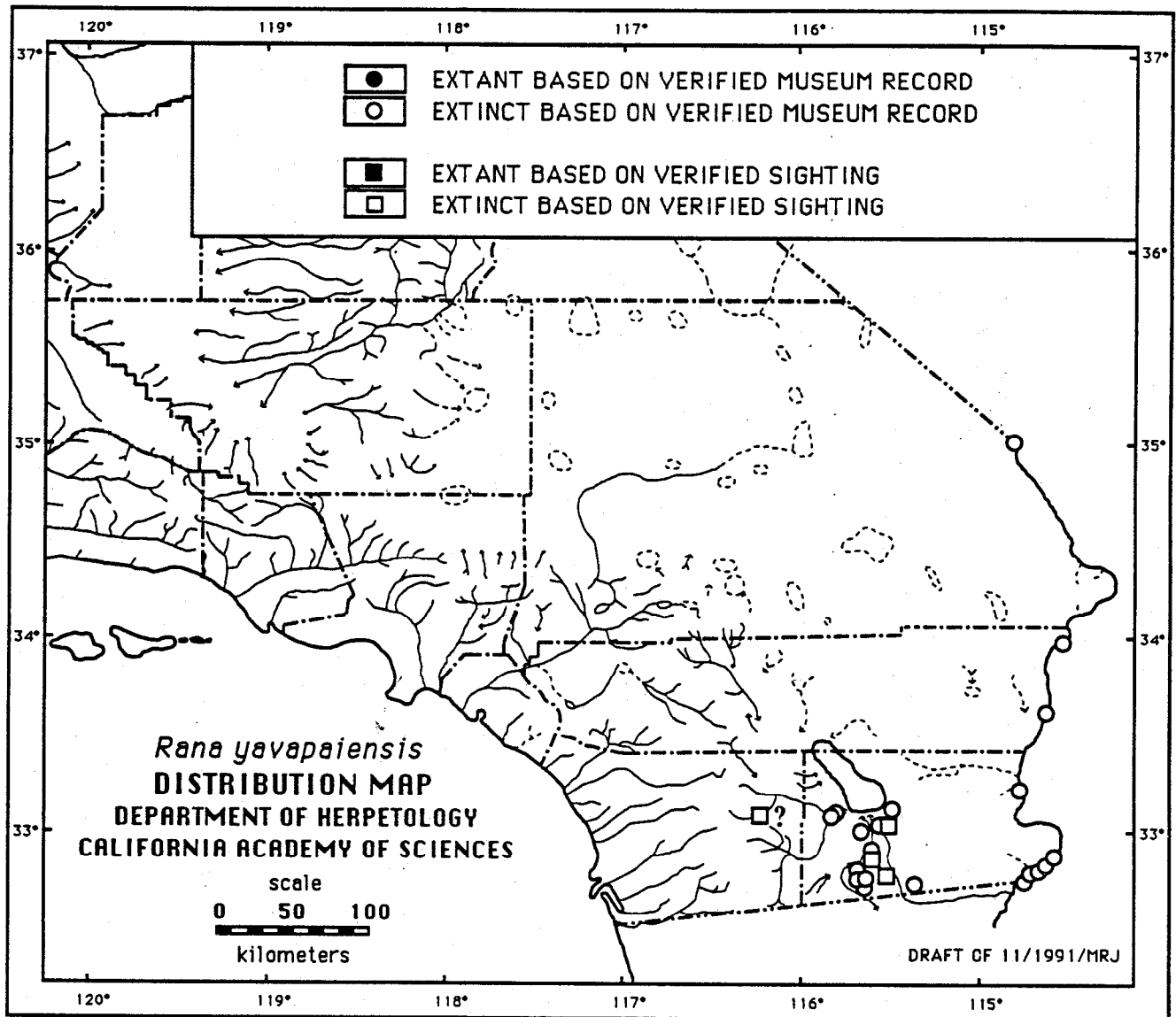
Figure 24. Historic distribution of the lowland leopard frog (*Rana yavapaiensis*) in southern California based on 28 locations from 116 museum records and 5 records from other sources.

also seen in canals, roadside ditches, and ponds in the Imperial Valley during the first quarter of this century (Storer 1925, Klauber 1934), but the context of its occurrence in those areas is not well understood because that era was a period of extensive habitat alteration. Lowland leopard frogs may have simply been transitory in those areas.

Status: Endangered; *Rana yavapaiensis* has been considered at risk in California for some time. Concern over this species was expressed nearly 20 years ago in a 7 February 1972 letter from Rudolfo Ruibal to Leonard Fisk (CDFG files), which indicated that this species was rare in California and should be protected. The habitat of the site at which Ruibal studied *Rana yavapaiensis* in the 1950s has been altered in a manner that makes it unsuitable for this species (B. McGurty, pers. comm.; see also Black 1980). Although this species has a reasonably broad range outside of California, scattered data indicate that this species has disappeared from > 50% of its historic range and is imperilled elsewhere, largely because of habitat changes associated with agriculture, livestock grazing, development, reservoir construction, and the introduction of exotic predatory fishes, crayfishes, and frogs (Clarkson and Rorabaugh 1989; M. Sredl, pers. comm.). In California, the most recent records of this species are from an irrigation ditch east of Calexico on 12-13 April 1965 (SSU 519-520). More recent surveys have failed to reveal this species in California (Vitt and Ohmart 1978, Clarkson and Rorabaugh 1989, Jennings and Hayes 1994), although an unverified sighting of a "leopard frog" exists from Sentenac Ciénega in May of 1988 (C. Fagan, pers. comm.). All post-1980 leopard frog records in the lower Colorado River have turned out to be the Rio Grande leopard frog *(Rana berlandieri),* which has recently established itself in the Imperial and lower Colorado River valleys (Platz et al. 1990, Jennings and Hayes 1994); although leopard frogs of uncertain taxonomic status at an isolated series of springs in extreme southern Nevada (near Lake Mead along the Colorado River) are currently under study (R. Jennings and D. Bradford, pers. comm.). *Rana yavapaiensis* is still present at at least two locations close to the Colorado River in Arizona (Clarkson and Rorabaugh 1989).

Management Recommendations: Although *R. yavapaiensis* has not been recorded from California since 1965, surveys conducted that had some possibility of detecting it were either of a general nature (the survey was not exclusively focused on lowland leopard frogs) or limited in their scope, so we cannot dismiss it as extinct within the state (e.g., see Scott and Jennings 1989). Intensive surveys repeated over several years at localities known to have historically harbored this species as well as other localities with potential habitat are needed to really ascertain its current status in California. If any populations are found, management efforts will have to emphasize maintenance of the quality and quantity of aquatic habitat where frogs occur and promote isolation from the exotic aquatic fauna now widespread in the region of the lower Colorado River (see Ohmart et al. 1988). The continued spread of introduced *R. berlandieri* populations within the historic range of *R. yavapaiensis* also needs to be documented and monitored.

COUCH'S SPADEFOOT
Scaphiopus couchii Baird 1854

Description: A moderate-sized (45.0-82.0 mm SUL), highly variably colored toad with a distinctive, black, cornified, teardrop-shaped spade on each hindfoot (Stebbins 1985). The dorsal color pattern is highly variable; it may be a reticulated (green with black markings), mottled (black, green and yellow, or brown), or solid green pattern with black flecks (Wasserman 1970), often overlain with distinctive cream-colored, hourglass-shaped spots (pers. observ.). Hindlimbs are short, and undersurfaces are cream to dirty white. Constricted pupils have a vertical, fusiform shape and the iris is brown and liberally marked with gold iridophores (pers. observ.).
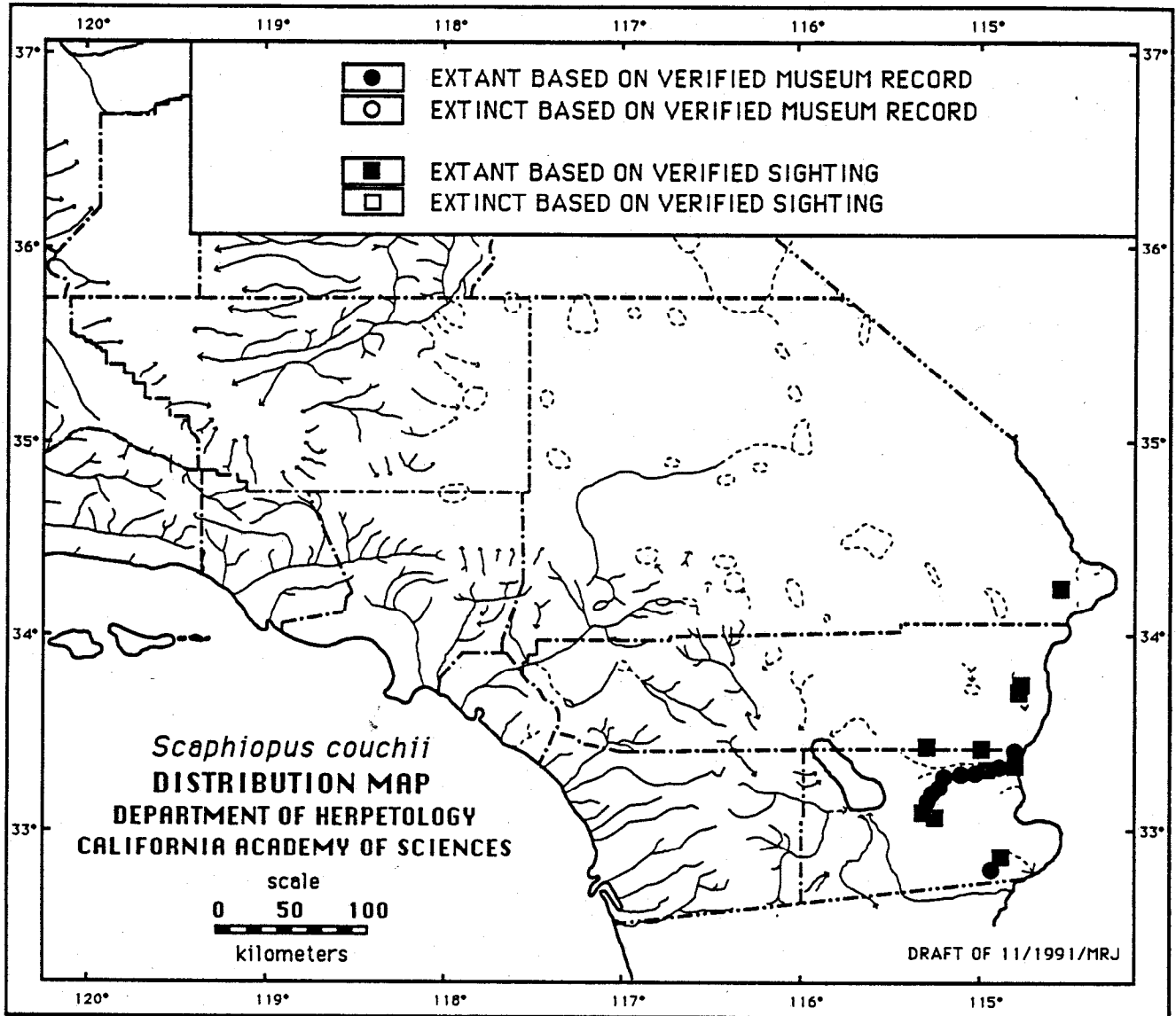
Figure 25. Historic and current distribution of Couch's spadefoot (*Scaphiopus couchii*) in southern California based on 30 locations from 24 museum records and 23 records from other sources.

Taxonomic Remarks: *Scaphiopus couchii* has been considered a distinct species since its description (Baird 1854), and has rarely been confused with other spadefoots. However, it is a wide-ranging, morphologically variable species, and no attempt has been made to identify potentially significant morphological or genetic variation across its geographic range.

Distribution: Couch's spadefoot has a broad geographic range that extends from extreme southeastern California eastward through Arizona, New Mexico, Texas, and Oklahoma, and southward into San Luis Potosí, Nayarit, and the southern tip of Baja California, Mexico (Wasserman 1970, Stebbins 1985). An isolated population cluster occurs in the vicinity of Petrified Forest National Monument, southeast of La Junta, Otero County, Colorado (Hammerson 1982). Its known elevational range extends from near sea level to ca. 1710 m (Stebbins 1985). In California, it is known only from the western side of the Colorado River from Chemehuevi Wash (ca. 9.32 km north of Vidal Junction), San Bernardino County, southward to the vicinity of Ogilby, Imperial County (Mayhew 1962, Tinkham 1962; Figure 25). In California, its known elevation range extends from ca. 210 m (near Palo Verde, Imperial County; pers. observ.) to 335 m (at Imperial Gables, Imperial County: Dimmitt 1977).

Life History: Couch's spadefoot is almost completely terrestrial, entering water only to reproduce (Bentley 1966, Mayhew 1968). A significant portion of current knowledge about the life history of *S. couchii* is based on studies done on Arizona populations. Couch's spadefoots remain dormant for 8-10 months in soil-filled "winter" burrows 20-90 cm deep (Shoemaker et al. 1969, Dimmitt 1975, Dimmitt and Ruibal 1980a). Surface activity is restricted to short periods following warm summer rains, during which Couch's spadefoot may appear suddenly in large numbers (Dimmitt and Ruibal 1980a). Low frequency sound (probably < 100 Hz) caused by falling rain, rather than rain *per se,* has been identified as the primary cue that *S. couchii* use to emerge, although low soil temperatures ($\leq 15°C$) appear to inhibit emergence notwithstanding a sound cue. Emergence coincides with the initiation of warm, late summer rains; the typical climatic pattern encountered throughout the range of *S. couchii,* but found in California only along the Colorado River. Woodward (1982) found that mating occurs only on the first night following the formation of temporary ponds. Females deposit 300-700 eggs which are attached in small clumps to vegetation or other solid objects (Stebbins 1954b). Couch's spadefoot is well-suited to breeding in the relatively warm, short-lived rainpools that form as a result of these summer rains. Early cleavage embryos have a higher lethal thermal minimum (ca. 15°C) and maximum (34°C) than most anurans known (Hubbs and Armstrong 1961, Ballinger and McKinney 1966, Zweifel 1968), and by Gosner (1960) stage 12, embryos tolerate even higher temperatures (lethal maximum temperature ca. 40°C) until they hatch (Zweifel 1977). Couch's spadefoot displays one of the most rapid rates of development known; at water temperatures > 30°C, it can hatch in considerably less than 1 day (Zweifel 1968) and can attain metamorphosis in as little as 7 days (Mayhew 1965a). Larvae also display high levels of temperature tolerance (39.0-42.5°C), the variation dependent on earlier temperature exposure (Brown 1969). Larvae often maximize their growth by cannibalizing conspecifics (Mayhew 1968). Postmetamorphic growth rates and longevity are unknown, but the unpredictability of the breeding habit may select for longevity.

Scaphiopus couchii displays a suite of features that make it well suited to the lengthy periods it spends in subterranean dormancy (Bentley 1966). During dormancy, it tolerates high water losses and high body fluid solute concentrations (McClanahan 1967, 1972; see also Hillman 1976, 1980), and displays a remarkably low level of oxygen consumption (Seymour 1973). Moreover, S. *couchii* displays a remarkable feeding ability; it can consume up to 55% of its body weight at one feeding (Dimmitt and Ruibal 1980b).

Coupled with a high assimilation efficiency (Dimmitt and Ruibal 1980b), this feeding ability allows it to potentially consume in one night the energy reserves for more than 1 year. Alate termites which constitute the major portion of the diet of *S. couchii* (Whitaker et al. 1977), emerge with the same summer rains that elicit emergence in *S. couchii* (Dimmitt and Ruibal 1980b). Alate termites have the highest lipid content by live weight of > 200 insect species reported in the literature (Past 1964, Basalingappa 1970), and they are more digestible (less sclerotized) than most insects, so they probably represent a significant proportion of the energy intake of *S. couchii*. The movement ecology and potential for colonization of *S. couchii* is unknown.

Habitat: Couch's spadefoot requires temporary desert rainpools with water temperatures $\geq 15°C$ (Zweifel 1968) in which to breed that last at least 7 days in order to metamorphose successfully (Mayhew 1965a). Subterranean refuge sites (with a loose-enough substrate to permit burial) must occur in the vicinity of rainpool depressions where reproduction takes place. An insect food base that probably includes alate termites must be available, which implies that minimal primary production must be available to sustain this food base.

Status: Special Concern; *S. couchii* has a very small range in California and seems to be declining in other states where it is found (J. Platz, pers. comm.). In fact, ponds created by road maintenance along Hwy 78 in eastern Imperial County have actually created breeding habitat for this toad (Dimmitt 1977). Its apparent tolerance for agricultural habitat modification appears to have allowed it to persist throughout most of its historical range in California. Despite an ability to tolerate certain types of disturbance, its subterranean refuge sites may be susceptible to disturbance from off-road vehicles that create noise similar to rainfall, inducing emergence under highly unfavorable (hot, dry) conditions that would be almost certainly fatal to adults (Brattstrom and Bondello 1979). The breeding sites of this species are potentially vulnerable to disturbance that alters the percolation characteristics of the substrate in a manner that makes pools too short-lived for larvae to attain metamorphosis.

Management Recommendations: Better morphological and genetic characterization of *S. couchii* is needed to determine whether more than one taxon is represented by this species, as well as identifying which taxon may be represented in California. While the energetics of *S. couchii* are reasonably well known, it is not clear at what level trends toward increasing xerification may ultimately affect this species. In particular, it is thought that *S. couchii* may be able to accumulate enough reserves to survive two rainless summers, but how frequently this may occur or how much more depletion of its energy reserves *S. couchii* may be able to tolerate is unknown. Such data and that on its movement ecology and colonization abilities are especially needed to formulate sound management guidelines. Rigorous field testing of the noise effects of off-road vehicles is needed to assess the potential importance of this impact. *Scaphiopus couchii* utilizes a significant number of pools that were created as the result of highway or railroad construction, but many of these pools are subject to washing out, getting leaky because of disturbance of the underlying substrate, or being eliminated by culverts (S. Morey, pers. comm.). Data on the contribution of these artificial pools when compared to natural pools of various sizes (such as at the base of the Algodones Dunes) is significant for the long-term management of this species. The substrate characteristics of pools suitable for this species, particularly with regard to percolation, need study.

WESTERN SPADEFOOT
Scaphiopus hammondii Baird 1859

Description: A moderate-sized (37.0-62.0 mm SUL) greenish, grayish, or brownish toad irregularly marked with dark orange- or reddish-tipped tubercles; having faint hourglass markings on the back consisting of four irregular, light-colored stripes; and possessing a distinctive, black, cornified, teardrop-shaped spade on each hindfoot (Storer 1925, Stebbins 1985). Hindlimbs are short, and undersurfaces are cream to dirty white. Constricted pupils have a vertical, fusiform shape, and the iris is pale gold because of a prominent reticulum of gold iridophores on a brown ground color (pers. observ.).

Taxonomic Remarks: For many years, *Scaphiopus hammondii* were regarded as having a broad geographic range from California to western Texas and Oklahoma with a hiatus across the Colorado River (Storer 1925; Stebbins 1951, 1966). However, Brown (1976) identified morphological, vocalization, and reproductive differences between eastern (Arizona eastward) and western (California) populations, justifying species recognition for each. Since the work of Brown (1976), the name *S. hammondii* has been applied exclusively to California populations. Genetic variation across the range of *S. hammondii* has not been studied.

Distribution: This near endemic to California ranges from the vicinity of Redding, Shasta County, southward into northwestern Baja California, Mexico (Stebbins 1985). Its known elevational range extends from near sea level to 1363 m (Zeiner et al. 1988). In California, the known range of *S. hammondii* is entirely west of the Sierran-desert range axis (Myers 1944; Figure 26).

Life History: *Scaphiopus hammondii* is almost completely terrestrial, entering water only to breed (see Dimmitt and Ruibal 1980a). Western spadefoots become surface active following relatively warm ($\geq$ 10.0-12.8°C) rains in late winter-spring and fall, emerging from burrows in loose soil to a depth of at least 1 m (Stebbins 1972; A. McCready, pers. comm.), but surface activity may occur in any month between October and April if enough rain has fallen (Morey and Guinn 1992; S. Morey, pers. comm.). Amount of rain may be a better predictor of surface activity than temperature (S. Morey, pers. comm.), but the cue or combination of cues that induces emergence in *S. hammondii* remains poorly understood. Western spadefoots can form large (> 1000 individuals), highly vocal, breeding aggregations (pers. observ.), although choruses are often much smaller (A. McCready, pers. comm.). Females deposit eggs in irregular small cylindrical clusters of 10-42 attached to plant stems or pieces of detritus in temporary rain pools, or sometimes pools in ephemeral streamcourses (Storer 1925; Stebbins 1985; pers. observ.). The critical thermal minimum of early embryos is 9°C (Brown 1967), so oviposition does not occur until temperatures permit some warming of rainpools in late winter (pers. observ.). Depending on the temperature regime and annual rainfall, oviposition may occur between late February and late May (Storer 1925, Burgess 1950, Feaver 1971, Stebbins 1985).

Eggs hatch in 0.6-6 days, depending on temperature (Brown 1967), and larval development can be completed in 3-11 weeks (Burgess 1950; Feaver 1971; S. Morey and K. Baldwin, pers. comm.), the variation depending on food resources and temperature. No data are available to indicate how long *S. hammondii* needs to reach sexual maturity, but considering the relatively long period of subterranean dormancy (8-9 months; pers. observ.), individuals probably require at least 2 years to mature. Adults have a moderate stomach capacity (they can eat roughly 11% of their body mass at a single feeding; Dimmitt and Ruibal 1980b) and can probably acquire enough energy to survive the long annual dormancy interval in a few weeks. Known food items taken include crickets (Gryllacrididae), butterflies, beetles, flies, ants, and earthworms (Morey and Gullin 1992).
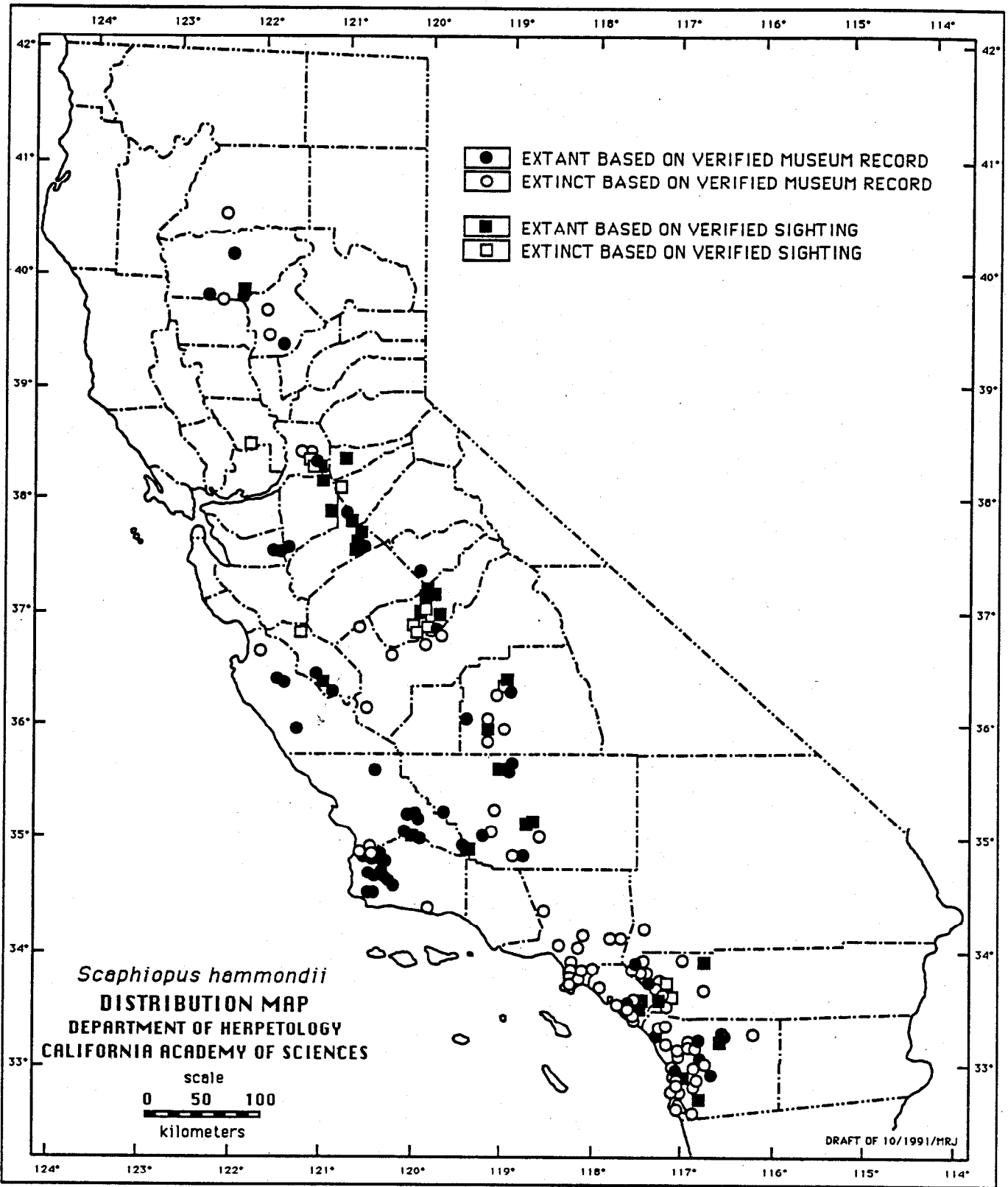
Figure 26. Historic and current distribution of the western spadefoot (*Scaphiopus hammondii*) in California based on 346 locations from 742 museum records and 90 records from other sources.

California tiger salamanders, garter snakes, great blue herons, and raccoons are probably the most important predators of larval and post-metamorphic *S. hammondii* (Childs 1953, Feaver 1971). No data are available on the movement ecology or colonization abilities of *S. hammondii.*

Habitat: Western spadefoots require temporary rainpools with water temperatures of $\geq$ 9°C and < 30°C (Brown 1966, 1967) in which to reproduce and that last $\geq$ 3 weeks (Feaver 1971) in order to metamorphose successfully. Rainpools in which western spadefoots reproduce and from which they are able to metamorphose successfully lack fishes, bullfrogs, and crayfishes; many indications exist that S. *hammondii* cannot recruit successfully in the presence of exotic predators, primarily introduced fishes, but also bullfrogs and crayfishes (K. Baldwin, S. Morey, B. Shaffer, pers. comm.; pers. observ.). Soil characteristics of burrow refuge sites that western spadefoots use have not been studied, but if they are similar to those of *S. multiplicatus,* the soil may become fairly compact and hard during the season of summer aestivation (Ruibal et al. 1969).

Status: Threatened; concern over the decline of *S. hammondii* is not new. Nearly 20 years ago, both Robert L. Livezey and Rudolfo Ruibal (in litt. 3 and 7 February 1972 to Leonard Fisk) believed that this taxon had sustained drastic reductions over the previous 15-20 years in the Central Valley and southern California. Current data indicate that in southern California (from the Santa Clara River Valley, Los Angeles and Ventura counties, southward), > 80% of habitat once known to be occupied by S. *hammondii* has been developed or converted to uses that are undoubtedly incompatible with its successful reproduction and recruitment. In northern and central California, loss of habitat has been less severe, but nevertheless significant; it is estimated that > 30% of the habitat once known to be occupied by *S. hammondii* has been developed or converted to uses incompatible with the survival of this taxon. Regions severely affected include the lower two-thirds of the Salinas River system, and much of the areas east of Sacramento, Fresno, and Bakersfield. Moreover, in many ares of the Central Valley, remaining suitable rainpool or vernal pool habitat, which is concentrated on valley terraces along the edges of the Valley Floor, has been disappearing in a fragmented fashion, which may present a significant threat to the metapopulation structure of *S. hammondii.* The continued placement of mosquitofish by mosquito abatement programs in vernal pools threatens some populations (S. Morey, pers. comm.; pers. observ.). Emigration of juvenile and adult bullfrogs into rainpool breeding sites may also pose a threat to some populations (Hayes and Warner 1985; Morey and Gullin 1992; A. McCready and S. Morey, pers. comm.).

Management Recommendations: Effort should be made to protect significant areas of rainpool habitat from alteration. Currently, rainpool habitats that harbor *S. hammondii* are protected in only a handfull of relatively small preserves, mostly under the jurisdiction of The Nature Conservancy (e.g., Santa Rosa Plateau, Riverside County; Pixley Vernal Pools Preserve, Tulare County). The biggest gap in current understanding of S. *hammondii* relates to its population structure and how habitat fragmentation may affect its likely metapopulation structure. Such an understanding is critical to determining the spatial population array that will allow *S. hammondii* to survive long-term. Much of the basic life history of *S. hammondii* remains poorly understood. In particular, variation in postmetamorphic survivorship, longevity, and movements must be understood in order to refine the direction of management. Finally, the features of suitable habitat remain poorly understood. It has often been assumed that *S. hammondii* requires loose soil for subterranean dormancy, but it has also been observed to occupy small mammal burrows (Stebbins 1951). Whether it uses the latter only as temporary refuges during its season of surface activity is unknown, but a better understanding of its pattern of utilization of subterranean refuges will allow refining of our current understanding of suitable habitat. Indications exist that western spadefoots can easily burrow into moist soils that would be

probably impossible to burrow into when they are dry (A. McCready, pers. comm.), but detailed study of the soil texture characteristics that may limit *S. hammondii* is needed for its management.

Plate 7. Adult and larval western spadefoot (*Scaphiopus hammondii*) [from Stebbins 1966].

TURTLES

WESTERN POND TURTLE
Clemmys marmorata (Baird and Girard 1852)

Description: A moderate-sized (120-210 mm CL), drab brown or khaki-colored turtle lacking prominent markings on its carapace (Holland 1991a). At close range, the carapace can frequently be observed to have a fine, vermiform reticulum of light and dark markings (pers. observ.). Males frequently develop a light, unmottled throat and lower facial area as they become sexually mature, markings that become even more prominent (contrasting) with increasing age; females typically retain the mottled or darker-colored throat and facial area juveniles possess into adulthood (Holland 1991a). The belly or plastron is variously marked with varying degrees of dark and light markings; turtles sometimes have an entirely dark or an entirely light plastron (pers. observ.). The iris is straw-colored with a brown eyestripe extending through the eye (D. Holland, pers. comm.).

Taxonomic Remarks: The western pond turtle is a distinct taxon that has not been confused with any other turtle. Seeliger (1945) described northern and southern subspecies that show some morphological differentiation and were envisioned as intergrading over a relatively broad range in central California. The pattern of geographic variation in this turtle, currently the focus of intensive study based on morphological and genetic data, suggests that more than one historical unit may be represented within its range in California (D. Holland, pers. comm.). Distribution of those units corresponds roughly to currently recognized subspecific taxa (Holland 1992).

Distribution: Historically, the western pond turtle had a relatively continuous distribution in most Pacific slope drainages from Klickitat County, Washington along the Columbia River (Slater 1962) to Arroyo Santo Domingo, northern Baja California, Mexico. Western pond turtles were also present at a cluster of nearby localities in Pierce and Thurston counties at the southern end of Puget Sound in Washington State (Slater 1939b). A single specimen reported from the Snake River above Shoshone [Falls] (Jerome County), Idaho (Slater 1962; CAS-SU 8624) is thought to be an error (D. Holland, pers. comm.; unpubl. data). Records also exist for the Carson, Humboldt, and Truckee drainages in Nevada (Cooper 1861, LaRivers 1942, Banta 1963a, Hattori 1982), but whether these records represent historical remnants, recent introductions (see LaRivers 1962, p. 20), or a combination of introductions and historical remnants is not known (D. Holland, pers. comm.). The known elevational range of the western pond turtle extends from near sea level to ca. 1430 m (Jose Basin Creek, Fresno County; D. Holland, pers. comm.). It has been recorded from somewhat higher elevations (e.g., Laurel Lake [2042 m]), but turtles are known to have been introduced at all such sites. In California, it was historically present in most Pacific slope drainages between the Oregon and Mexican borders (Figure 27). *Clemmys marmorata* is known from only two drainages on the desert slope in California: the Mojave River (San Bernardino County: Stebbins 1985) and Andreas Canyon (Riverside County; pers. observ.).

Life History: *Clemmys marmorata* is an aquatic turtle that usually leaves the aquatic site to reproduce, to aestivate, and to overwinter. Recent fieldwork has demonstrated that western pond turtles may overwinter on land or in water, or may remain active in water during the winter season; this pattern may vary considerably with latitude and habitat type, and remains poorly understood (Holland 1985a, 1991a; Rathbun et al. 1993). Western pond turtles markedly increase their level of activity when water temperatures near the surface consistently reach at least 15°C (D. Holland, pers. comm.). Thus, along the central and southern coast of California, western pond turtles may be active year-round (Holland
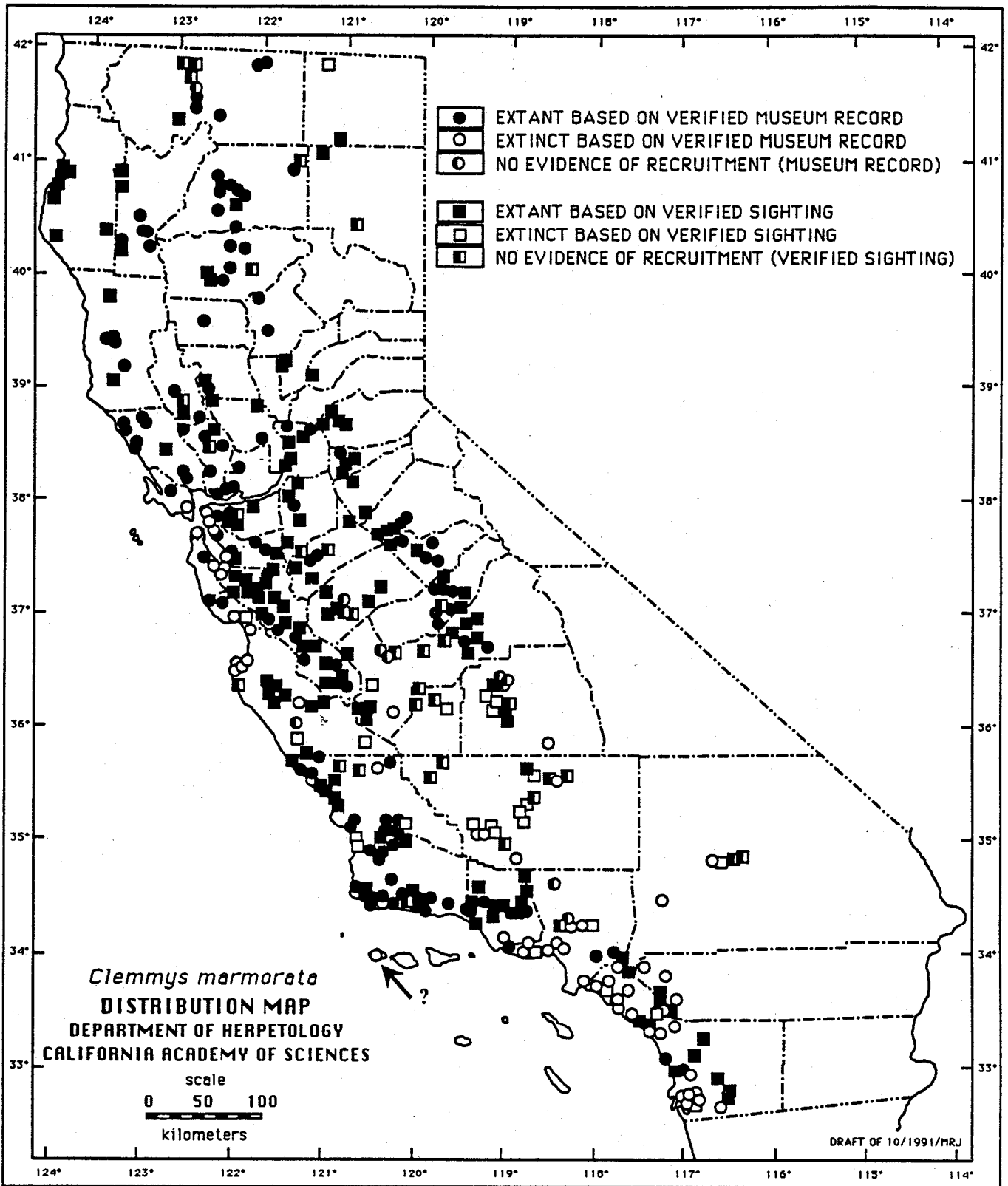
Figure 27. Historic and current distribution of the western pond turtle (*Clemmys marmorata*) in California based on 715 locations from 615 museum records and 322 records from other sources.

1985a, 1991a; Zeiner et al. 1988; Rathbun et al. 1993), whereas at interior localities or at higher latitudes in California, *C. marmorata* typically become active in March or April, and disappear to overwintering sites in October or November (Holland 1991a). The most prominent part of western pond turtle behavior is the activities they perform to thermoregulate, which vary with ambient temperature based on time of day and season. Turtles frequently perform aerial basking on logs or other objects out of the water when water temperatures are low and air temperatures are greater than water temperatures (Bury 1972b, Holland 1985a). Temperature preferenda of western pond turtles are not well understood, but they generally seem to avoid water at temperatures of > 39-40°C (D. Holland, pers. comm.). When air temperatures become too warm and almost invariably when they exceed 40°C, as they may later in the day and later in the season (especially at interior localities), western pond turtles water bask by lying in the warmer surface water layer with their heads out of water (Bury 1972b, Holland 1985a). Mats of submergent vegetation, such as pondweed *(Potamogeton* spp.) and ditch grass *(Ruppia maritima),* are favored water basking locations because these mats trap surface water thus maintaining even higher surface water temperatures, and turtles require less energy to maintain their position in the surface layer when such a vegetation structure is present (Holland 1985a; pers. observ.). Mating, which has been rarely observed, typically occurs in late April or early May, but may occur year-round (Holland 1985a, 1991b). Females emigrate from the aquatic site to an upland location that may be a considerable distance (400 m or more) from the aquatic site to nest, but is often less, and deposit from 1-13 eggs that have a thin, but hard (calcified) outer shell in a shallow (ca. 10-12 cm deep) nest excavated by the female (Holland 1991a; Rathbun et al. 1992, 1993). Females may lay more than one clutch a year (Rathbun et al. 1993). Most oviposition occurs during May and June, although some individuals may deposit eggs as early as late April and as late as early August (Storer 1930; Buskirk 1992; Rathbun et al. 1992, 1993; D. Holland, pers. comm.). The young may hatch and overwinter in the nest because hatchling-sized turtles have almost never been observed in an aquatic site during the fall (Holland 1985a). Only a few records exist of hatchling emergence in the early fall in southern and central California (Buskirk 1992; D. Holland, pers. comm.). Most hatchling turtles are thought to emerge from the nest and move to the aquatic site in the spring (see data in Buskirk 1992). Neonates or hatchlings spend much of their time feeding in shallow water that typically has a relatively dense vegetation of submergents or short emergents (D. Holland, pers. comm.). Nekton, the zooplankton fauna that can occur at high densities in the water column in standing water, are an important food of hatchlings and young juveniles (Holland 1985b, 1991a), and these age groups may not grow as rapidly where this food resource is lacking. Much variation exists in the rates at which western pond turtles grow, with turtles presumably growing more slowly at higher latitudes and altitudes. In most areas, hatchlings (ca. 25 mm CL) typically double their length the first year and grow relatively rapidly over the next 4-5 years (Storer 1930; Holland 1985a; D. Holland, pers. comm.). Age and size at reproductive maturity varies with latitude. In California, reproductive maturity occurs at between 7 and 11 years of age, and approximately 110-120 mm CL, with turtles maturing at a larger size and a more advanced age as one moves north, and males generally maturing at a slightly smaller sizes and younger ages than females (D. Holland, pers. comm.). Data on longevity are lacking, but western pond turtles are thought to be long-lived since the minimum age of a recaptured individual was 42 years from a population studied in northern California (Trinity County: B. Bury and D. Holland, pers. comm.). Western pond turtles are dietary generalists and highly opportunistic (Holland 1991a), and will consume almost anything that they are able to catch and overpower. The relatively slow pursuit of western pond turtles results in their diet being dominated by relatively slow-moving aquatic invertebrates (e.g., the larvae of many aquatic insects) and carrion, although aquatic vegetation may be eaten (Holland 1985a, Bury 1986, Baldwin and Stanford 1987), especially by females having recently laid eggs (D. Holland, pers. comm.). The movement ecology of *C. marmorata* is partly known for only very restricted circumstances. In a pond

situation, movement away from water except to nest was rare (Rathbun et al. 1993). In a stream situation, turtles were highly variable in their movements. Some individuals would nest, aestivate, or overwinter only a few meters away from the watercourse, whereas others move considerable distances (e.g., 350 m) to overwinter (Rathbun et al. 1992, 1993).Turtles will move significant distances (at least 2 km) if the local aquatic habitat changes (e.g., disappears), and adult turtles can tolerate at least 7 days without water (D. Holland, pers. comm.), but dispersal abilities of juveniles and the recolonization potential of western pond turtles following extirpation of a local population are unknown.

Habitat: Western pond turtles require some slack- or slow-water aquatic habitat. Western pond turtles are uncommon in high gradient streams probably because water temperatures, current velocity, food resources, or any combination thereof may limit their local distribution (Holland 1991a). Habitat quality seems to vary with the availability of aerial and aquatic basking sites (Holland 1991a); western pond turtles often reach higher densities where many aerial and aquatic basking sites are available. Hatchlings (i.e. individuals through their first year of activity) require shallow water habitat with relatively dense submergent or short emergent vegetation in which to forage (D. Holland, pers. comm.). Such situations probably increase the probability that the nekton hatchlings require will be abundant Western pond turtles also require an upland oviposition site in the vicinity of the aquatic site (Holland 1991b). Suitable oviposition sites must have the proper thermal and hydric environment for incubation of the eggs. The porcelain-thin shelled eggs of *C. marmorata* are suited to development in a dry nest; an excessively moist nest has a high probability of failing (Feldman 1982, Holland 1991b). Nests are typically dug in a substrate with a high clay or silt fraction since the female moistens the site where she will excavate the nest prior to nesting (Holland 1991b). Nests also are typically located on a slope that is unshaded (Rathbun et al. 1993) that may be at least in part south-facing, probably to ensure that substrate temperatures will be high enough to incubate the eggs (pers. observ.). How close the aquatic site is to the nesting site probably depends largely on the availability of suitable nesting sites adjacent to aquatic sites where western pond turtles are known to occur because the array of features that make a nesting site suitable may significantly limit the availability of such sites. The nesting site can be up to 402 m from the aquatic site (Storer 1930), but the majority of nest located to date are within 200 m (D. Holland, pers. comm.). However, at localities with less gradient, soil moisture gradients and soil type may cause nesting sites to be located at a significantly greater distance than where the majority are located. Slope of the nest sites range up to 60°, but most nests are on slopes < 25°.

Status: Endangered from the Salinas River south coastally, and from the Mokelumne River south (inland) in the San Joaquin hydrographic basin; Threatened for the rest of California; the recent report on *C. marmorata* in southern California (Brattstrom and Messer 1988) indicates that few viable populations remain in this region (see also Brattstrom 1988). Even more recent fieldwork indicates that only 6-8 viable populations of *C. marmorata* remain south of the Santa Clara River system (including the desert slope) in California (Holland, 1991a). The situation in most of the Santa Joaquin Valley, Salinas and Pajaro drainages, and a significant number of coastal drainages between San Francisco Bay and the Santa Clara River is only a little better. Four years of drought (1986-1990) have exacerbated the negative effects of habitat alteration accumulated over many years over much of this region from changes in land and water use, and abusive grazing practices (Holland 1991a). In particular, most western pond turtle populations examined in this region appear to show an age (size) structure increasingly biased toward adults, indicating little or no recruitment is taking place. Many localities that harbor turtles populations seem to be affected because the nesting habitat is being impacted or altered during the incubation interval on an annual basis by some type of agriculture or the activity of livestock (D. Holland, pers. comm.; pers. observ.). These impacts probably create annual nesting

failures, leading to the increasingly adult-biased populations. Additionally, some introduced exotic aquatic predators or competitors likely extract a significant toll on turtle populations. Bullfrogs prey on hatchling or juvenile turtles (Moyle 1973; Holland 1991a; H. Basey, P. Lahanas, and S. Wray, pers. comm.), and may be responsible for significant mortality because they occupy shallow-water habitats in which the youngest age groups of turtles are frequently observed (pers. observ.). Bass (*Micropterus* spp.) are also known to prey on the smallest juveniles (Holland 1991a), and sunfishes (*Lepomis* spp.), although they are not large enough to prey on hatchling western pond turtles, probably compete with them for food since they are known to be able to keep available nekton at very low levels, stunting their own growth (see Swingle and Smith 1940). Increases in local raccoon activity because of local human disturbances or translocations by animal control agencies (S. Sweet, pers. comm.), introduced red foxes (*Vulpes vulpes* spp.), and translocated black bear (*Ursus americanus)* populations may have all contributed to increased predation on nests or post-hatching stages over historic background levels (D. Holland, pers. comm.). It also needs mention that historically, western pond turtles were heavily exploited for food in the Central Valley and that numbers of this species represent but a fraction of their historic levels (for example, the number of western pond turtles that existed in the southern San Joaquin Valley has been estimated at 3.35 million; Holland 1991a). The status of western pond turtles north of San Francisco Bay may be somewhat better, but trends similar to those observed in southern California have been noted in most populations examined within this region (D. Holland, pers. comm.). Moreover, the western pond turtle populations in some areas of northern California (e.g., the drainages entering Clear Lake, and portions of the Klamath River system in California) are in equally serious or worse condition than those in southern California (D. Holland, pers. comm.). Recent surveys indicate that western pond turtles are also seriously threatened throughout most of their range outside California. The state of Washington has fewer than six known populations, the most significant of which have been threatened by disease (Holland 1991b; D. Holland, pers. comm.). Recent observations also suggest the potential occurrence of a similar disease syndrome in one northern California population (D. Holland, pers. comm.). In the Willamette Valley in Oregon, western pond turtles appear to have declined to a level that represents roughly 1% of historic levels (Holland 1991a). Surveys in Oregon also indicate that western pond turtles are frequently caught on baited hooks and are subsequently released carrying a hook that can significantly impair or entirely prevent normal feeding (Mader 1988; T. DeLorenzo, pers. comm.; pers. observ.). Based on the weight loss observed in such turtles, a high likelihood exists that most of the individuals caught in this manner ultimately perish if released without removal of the hook. In Baja California, most historic populations have been extirpated and only a few populations remain at remote localities (Holland 1991a).

Management Recommendations: The systematic status of the various historical units that are represented by *C. marmorata* in California must be determined to establish whether different units need to be treated separately. The most significant gaps in current understanding of the ecology of what is currently called *C. marmorata* are variation in nesting location that accompanies variation in habitat, movement responses to habitat change, the pattern of movements in the absence of change, and recolonization ability in structurally different habitats. Current lack of knowledge of the first of these four has led to the recent recommendation that at least 500 m from the aquatic site known to harbor western pond turtles are needed to adequately protect nesting habitat (Rathbun et al. 1992).

Most critical for existing populations where declining trends have some opportunity of being reversed are protection of suitable nesting habitat associated with the sites where those populations exist, and reduction of mortality in the younger age (size) groups of turtles. Since nesting sites are located in areas that have some probability of having had historical use over many years, in order for the former suggestion to be effective, corridors

broad enough not to impede either the movement of adult females to and from the nesting location nor the movement of hatchlings from the nest to the aquatic site should be fenced in a manner to allow turtle movement and to ensure that nests will not be trampled during incubation. For the latter to be effective, every effort should be made to isolate such systems from the exotic aquatic fauna that may prey on or compete with western pond turtles, and in particular, discourage human translocation of such organisms within the state. Efforts should also be made to minimize mortality from terrestrial predators of nests and post-hatching stages. Regulation of fishing with baited hooks in those areas that harbor significant turtle populations should be implemented. Finally, more attention needs to be paid to the appearance of symptoms and mortality linked to upper respiratory disease syndrome, as this may be an unrecognized cause of mortality that may be linked to environmentally immuno-induced suppressive problems (see #5 under Recommendations).
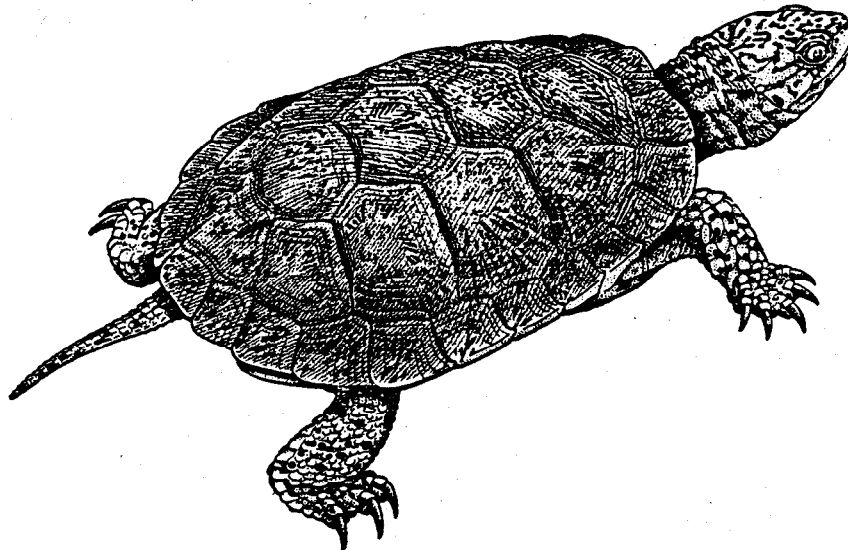

Plate 8. Adult western pond turtle (*Clemmys marmorata*) [from Stebbins 1954b].

SONORAN MUD TURTLE
Kinosternon sonoriense sonoriense (LeConte 1854)

Description: A small to moderate-sized (80-160 mm CL), drab brown or olive-colored turtle with darkly-marked seams on the carapace, webbed feet, a short tail, heavily mottled head, and barbels on the throat (Stebbins 1985). The plastron has well-developed hinges and is yellow to brown in color with darkly-marked seams (Iverson 1976). The iris is dark brown with a black eyestripe extending through the eye (pers. observ.).

Taxonomic Remarks: This taxon has long been recognized as a distinct species (Iverson 1976) within which two subspecies are currently recognized: *Kinosternon sonoriense longifemorale,* restricted to the drainage of the Río Sonoyta (Mexico), and *K. s. sonoriense,* which is distributed throughout the remainder of the range (Iverson 1981). The geographic pattern of genetic variation within *K. sonoriense* has not been examined.

Distribution: Historically, *K. sonoriense* occurred in the lower Colorado system in southeastern California, northward to southern Nevada, eastward through Arizona into New Mexico, and southward into Sonora and western Chihuahua, Mexico (Iverson 1976, 1981). A record from "Utah" attributed to *K. sonoriense* (Yarrow 1882) is based on an incorrectly labeled specimen (Iverson 1978). Its known elevational range extended from 43 m to 2040 m (Iverson 1981). In California, Sonoran mud turtles were historically present along the lower Colorado River from as far as north as the Nevada boundary (Cooper 1870, La Rivers 1942) downstream to past Palo Verde, Riverside County (Van Denburgh 1922b) and the Mexican border (Mearns 1907; Figure 28). Its known elevational range in California extended from 43 m along the Colorado River near Yuma (Imperial County: Iverson 1981) to 155 m along the Colorado River near Fort Mojave at the Nevada boundary (Cooper 1870). Two post-1920 records of Sonoran mud turtles exist from along canals in the Imperial Valley, Imperial County (SDSNH 17897, 33866), these specimens are undoubtedly based on individuals dispersing along human-created waterways.

Life History: Most ecological data on *K. sonoriense* are based on studies conducted in Arizona and New Mexico (Hulse 1976, Rosen 1987). Sonoran mud turtles seem to be active all year, although they may not feed during the colder winter months (Hulse 1982). *Kinosternon sonoriense* are active day and night, and are mostly nocturnal at low elevations during the warmer months (Hulse 1974a, Rosen 1987). Adults are known to mate during March and April, and females lay clutches of 1-10, large (average = 31.0 mm long x 14.3 mm wide) eggs in the interval from May to September (Hulse 1982, Rosen 1987). Where females locate their nests is not known. Females generally produce two or more clutches of eggs between July and September if sufficient food resources are available (Hulse 1982). Males take from 2-6 years and females take 6 years to mature after hatching (Hulse 1976, 1982). Size at sexual maturity is ca. 75 mm CL for males and is primarily age dependent in females, with newly mature females ranging from about 90 mm to over 130 mm CL (Hulse 1982; Rosen pers. comm.). The oldest Sonoran mud turtles that have been reliably aged in Arizona populations were females 12 and 13 years of age (Hulse 1976), so the species may be long-lived.

Juveniles and adults eat mostly mollusks, feeding on other plants and animals opportunistically (Hulse 1974a). Sonoran mud turtles in suboptimal habitat display a more generalized diet, lower growth rates, and smaller clutch sizes, and mature at smaller sizes than individuals that occur in optimal habitats probably because they lack the opportunity to consume more energy-rich benthic invertebrates (Hulse 1976, 1982). *Kinosternon sonoriense* often gives off a peculiar musky odor when it is handled (pers. observ.) whose function is unknown, but may be a deterrent to some predators. Known predators of *K.*
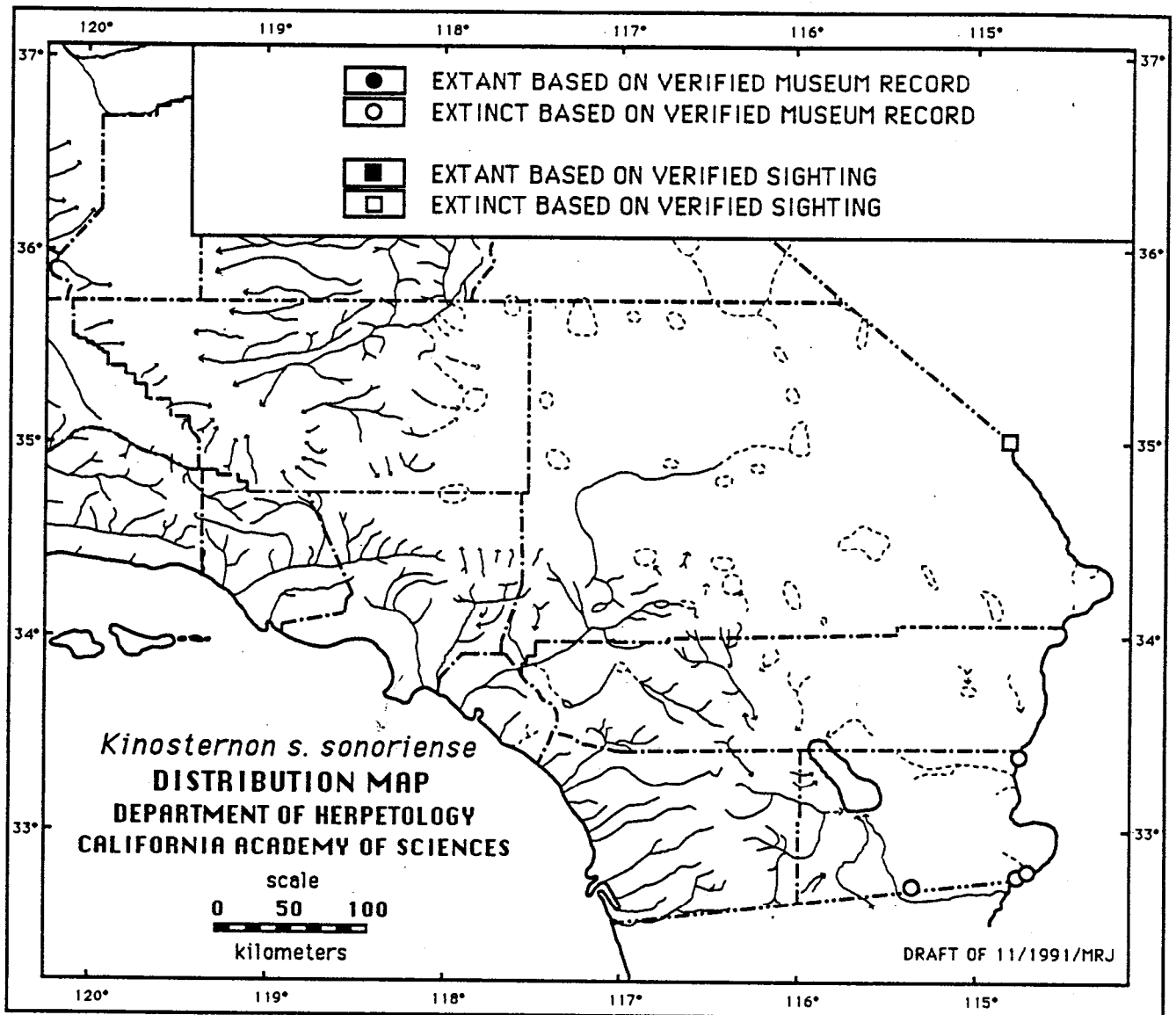
Figure 28. Historic and current distribution of the Sonoran mud turtle (*Kinosternon sonoriense sonoriense*) in southern California based on 5 locations from 4 museum records and 1 record from another source.

sonoriense include bald eagles (*Haliaeetus leucocephalus*), raccoons, humans, and black bears (W. Eakle and A. Hulse, pers. comm.). *Kinosternon sonoriense* also seems to be susceptible to introduced aquatic predators, such as bullfrogs and Louisiana red swamp crayfish (P. Rosen, pers. comm.). Available data suggest that Sonoran mud turtles are sedentary (P. Rosen, pers. comm.). They are very rarely seen moving overland on roads or elsewhere; however, no systematic studies on the movement ecology and colonization abilities of this turtle have been undertaken.

Habitat: *Kinosternon sonoriense* is largely restricted to permanent slackwater habitats along intermittent or perennial streams with abundant submergent vegetation and benthic invertebrates (Hulse 1974a, 1974b, 1976; Iverson, pers. comm.). Although adults in southern Arizona have been observed in open sandy creeks whose flow consists entirely of tertiary-treated wastewater (pers. observ.), Sonoran mud turtles normally occur in ponds and along slow-moving watercourses lined with willows, Fremont's cottonwood, sycamore (*Platanus* sp.), mesquite (*Prosopis* spp.), blue paloverde (*Cercidium floridum*), yellow paloverde *(C. microphyllum),* or other native vegetation (Rosen 1987; see also Jennings 1987b). Optimal habitats are spring runs, quiet pools in streams, or oxbows or other ponds that contain abundant mollusks (J. Iverson and P. Rosen, pers. comm.). In such habitats, population densities can exceed 750-825 turtles/ha (Hulse 1982; P. Rosen, pers. comm.); Sonoran mud turtles are reported at such densities from selected quiet portions of the Salt River (W. Minckley, pers. comm.). Permanent or nearly permanent water must be present to support this taxon (P. Rosen, pers. comm.). Sonoran mud turtles appear to be rare in introduced salt cedar (*Tamarix* spp.)-dominated habitats in some parts of their range (e.g., Ohmart et al. 1988) for reasons that are not clear, but which may be related to available food resources.

Status: Endangered; once presumably common in overflow channels of the lower Colorado River (Van Denburgh 1922b, Dill 1944), this turtle has apparently disappeared with the widespread riparian habitat changes that have occurred along the Colorado River and the introduction of a suite of exotic aquatic predators (Jennings 1983, 1987a; Ohmart et al. 1988). A Sonoran mud turtle observed on 31 March 1962 in a canal about 1.6 km southwest of Laguna Dam on the Arizona side of the Colorado River (Funk 1974) is the last verifiable record known. A search for mud turtles along the Colorado River from 5 April-2 May 1991 with fyke traps revealed no aquatic turtles other than introduced Texas spiny softshells (*Trionyx spiniferus emory*i; King and Robbins 1991a). The impact that introduced softshell turtles may have had on Sonoran mud turtles is unknown. The Sonoran mud turtle also appears to be undergoing declines over much of its range in Arizona and Mexico (J. Iverson, pers. comm.).

Management Recommendations: Intensive surveys should be coordinated as joint efforts with Arizona agencies and conducted in remaining suitable habitat along the lower Colorado River (such as near Yuma or at the mouth of the Bill Williams River [Topock Marsh]) to determine if the Sonoran mud turtle is still part of the regional herpetofauna If any populations are located, steps need to be taken to protect the riparian and aquatic habitat where they are found from further degradation and life history studies of these populations should be initiated. Additionally, efforts should be made to isolate these populations from the introduced exotic aquatic fauna that may prey on Sonoran mud turtles. Sonoran mud turtles are apparently highly susceptible to habitat loss resulting from the construction of reservoirs, the manipulation of hydrologic regimes, and the widespread invasion of salt cedar, but which of these factors is really detrimental to Sonoran mud turtles and its underlying mechanism is not known. Sonoran mud turtles are easily caught on baited hooks (Dill 1944; pers. observ.); when released by cutting the line, they probably have a low survivorship (see the western pond turtle (*Clemmys marmorata*) account). Human manipulation of daily fluctuations in flows in the main Colorado River seems to have

altered the normal pattern of burrow and crevice use by mud turtles (P. Rosen, pers. comm.) and may alternately flood and dry potential nesting sites. An understanding of the nesting ecology and the seasonal activity patterns of this species is urgently needed to gain insight into how alteration of hydrologic regimes and concomitant habitat change may affect this species.
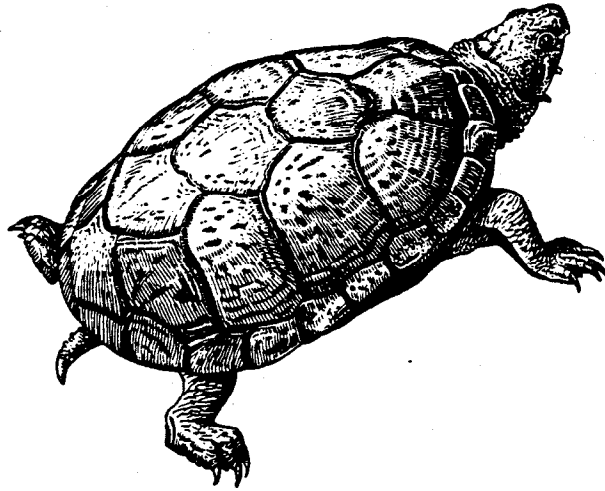
Plate 9. Adult Sonoran mud turtle (*Kinosternon sonoriense*) [from Stebbins 1954b].

LIZARDS

CALIFORNIA LEGLESS LIZARD
Anniella pulchra Gray 1852

Description: A small (95-170 mm SVL), slender limbless lizard with a shovel-shaped snout; a counter-sunk lower jaw; smooth, polished scales; and a blunt tail (Stebbins 1985). Dorsal coloration is highly variable, ranging from metallic silver, to beige, to dark brown, to jet black, with a dark vertebral line and several lateral stripes (Hunt 1983) that decrease in number as individuals mature (pers. observ.). Ventral coloration varies from pale yellow-white to bright yellow (Klauber 1932a; L. Hunt, pers. comm.). The iris is black (Klauber 1940).

Taxonomic Remarks: The name change to *A. nigra* proposed for this species (Hunt 1983) has not been followed because of its destabilizing effect on nomenclature (Murphy and Smith 1985, 1991; Jennings 1987a). Ongoing morphological and genetic studies of this taxon indicate that no evidence exists for its partitioning into subspecies (Hunt 1984; L. Hunt and S. Sweet, pers. comm.) along the lines various authors have proposed (Grinnell and Camp 1917, Miller 1943, Hunt 1983, Bury 1985, Stebbins 1985). However, genetic data that compare 11 populations in central (n = 9) and southern (n = 2) California indicate allozyme and karyotypic differences suggesting more than one species-level taxon may be concealed within what is currently recognized as *A. pulchra* (Bezy and Wright 1971, Bezy et al. 1977; Rainey as cited in Bury 1985). More comprehensive data are needed to characterize the geographic pattern of genetic variation and resolve the systematic status of potential units contained within *A. pulchra.*

Distribution: *Anniella pulchra* is a near-endemic to California, ranging from the vicinity of Antioch (Contra Costa County), California south through the Coast, Transverse, and Peninsular ranges; parts of the San Joaquin Valley; and the western edge of the Sierra Nevada Mountains and Mojave Desert to El Consuelo (Baja California Norte), Mexico (Hunt 1983). This lizard is also known from the East and South Los Coronados and Todos Santos Islands off the coast of Baja California (Stebbins 1985). The known elevational range extends from near sea level on the Monterey Peninsula (Monterey County: Bury 1985) to ca. 1800 m in the Sierra Nevada foothills (Hunt 1983). In California, its range extends from Contra Costa County to the Mexican border (Figure 29). Scattered desert slope records are known from Lancaster in Antelope Valley (Los Angeles County: Mullen 1989), Morongo Valley (San Bernardino County), Whitewater (Riverside County: Stebbins 1985), and in the San Felipe Creek drainage (San Diego County: Klauber 1932a). An old record from Redwood Canyon (Marin County: Rivers 1902, Stebbins 1985) is not verifiable, and may be based on a mislabeled specimen that has since been lost (L. Hunt, pers. comm.). This lizard has been inadvertently introduced into parts of the southern Sierra Nevada foothills through nursery and tree-planting operations (H. Basey, pers. comm.).

Life History: Most ecological and life history data on *A. pulchra* are the result of a field study Miller (1944) conducted during 1939 and 1940 in the dunes of the Monterey Peninsula (Monterey County) and Antioch (Contra Costa County), California. Legless lizards are fossorial animals that construct burrows in loose soil with a high sand fraction (Miller 1944, Stebbins 1954b). Several morphological and physiological traits facilitate efficient burrowing and allow them to live subsurface for extended intervals (Coe and Kunkel 1906, Bury and Balgooyen 1976, Kamel and Gatten 1983, Fusari 1984, Gans et al. 1992). Legless lizards appear to be active mostly during the morning and evening at which time they may rest just beneath the surface of the sunlight-warmed substrate (Miller
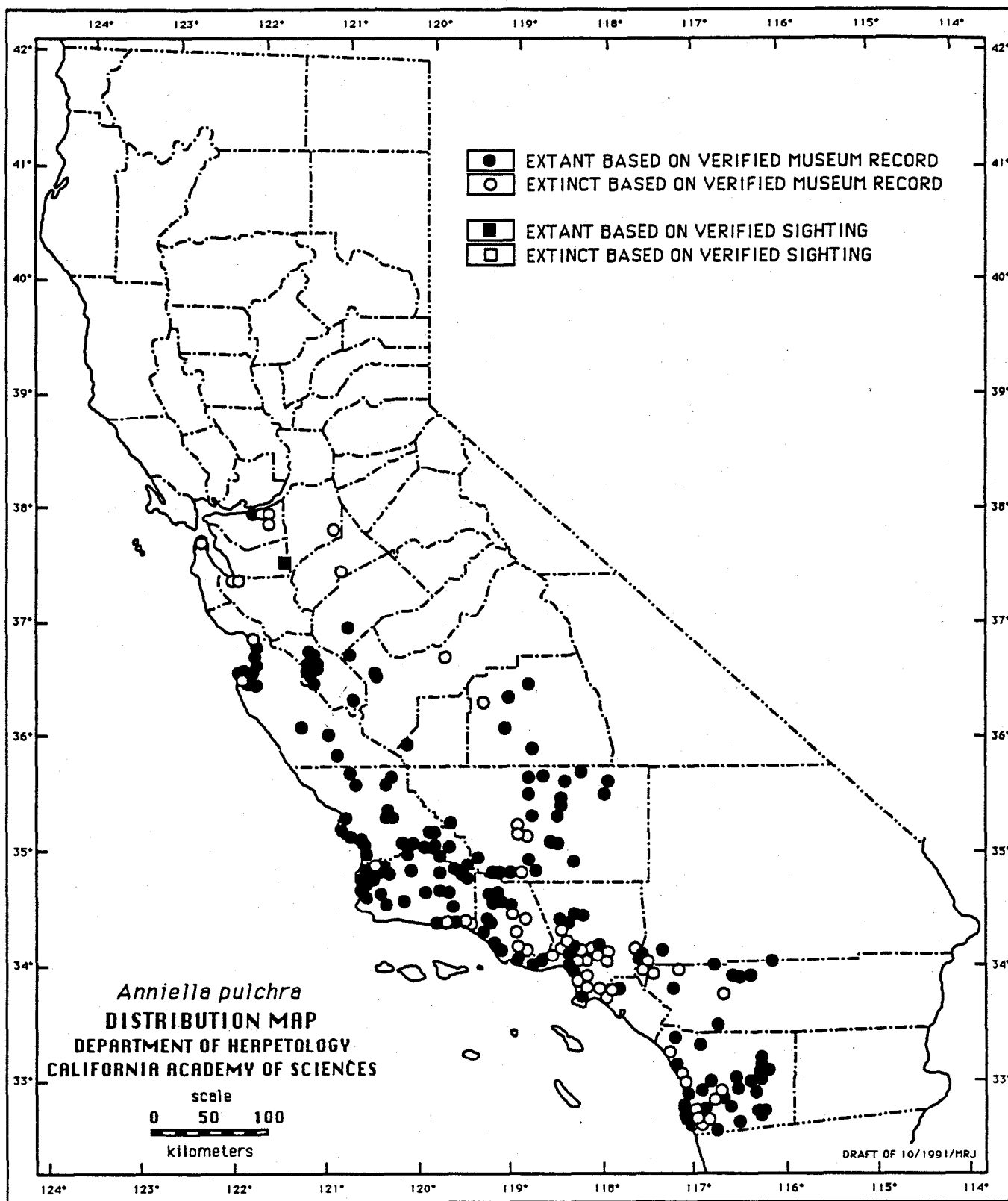
Figure 29. Historic and current distribution of the California legless lizard (*Anniella pulchra*) in California based on 490 locations from 2095 museum records and 7 records from other sources.

1944, Stebbins 1954b, Bury and Balgooyen 1976, Bury 1985), but they have also been observed on the surface at night, especially when substrate temperatures remain warm (probably > 21°C) for extended intervals (Miller 1944, Gorman 1957; pers. observ.). Adult and juvenile lizards are insectivorous and subsist largely on larval insects (especially microlepidopterans and beetles), adult beetles, termites, and spiders (Araneida; L. Hunt, pers. comm.); prey are typically ambushed from a concealed location beneath the leaf litter or substrate (Coe and Kunkel 1906, Miller 1944).

Laboratory experiments have shown that legless lizards have a relatively low thermal preferendum (generally 21-28°C; Bury and Balgooyen 1976) and a relatively low critical thermal maximum (34°C; Brattstrom 1965) when compared to other California lizards. These data are consistent with the range of temperatures at which legless lizards are encountered in the field (7.8-28.3°C, average = 21.0°C; Gorman 1957; Brattstrom 1965; L. Hunt, pers. comm.). The preference for low temperatures allows legless lizards to be active on relatively cool days (Miller 1944), and is consistent with the behavior of fossorial lizards not known to bask directly in sunlight. High ambient and substrate temperatures probably limit the daily pattern of activity of legless lizards in the field (Miller 1944). California legless lizards from coastal areas and the southern portions of its range may display some activity nearly year-round (see Banta and Morafka 1968), whereas lizards from the Sierra Nevada foothills and other inland locations are thought to hibernate during winter months (Zeiner et al. 1988).

Anniella pulchra is a live-bearing species that probably breeds in the interval between early spring and July (Goldberg and Miller 1985). Oviductal eggs are observed in females from July through October (Goldberg and Miller 1985) and litters of 1 to 4 (normally 2) young (ca 50 mm SVL) are born in the interval from September to November (Miller 1944), probably after a gestation period of about 4 months (Goldberg and Miller 1985). Young lizards grow rapidly (2.5-4.4 mm SVL/month) before reaching sexual maturity at ca. 90 mm SVL (males) and 121 mm SVL (females) typically in 2 to 3 years, respectively (Miller 1944, Goldberg and Miller 1985). Once they reach sexual maturity, females may not reproduce every year (Goldberg and Miller 1985), but insufficient data exist to identify biennial reproduction as the typical pattern for this species. Data on the longevity of this taxon in the field are lacking; sexually mature adults have been kept alive under laboratory conditions for almost 6 years (L. Hunt, pers. comm.).

Despite a small litter size, *A. pulchra* can attain high densities where habitat is suitable (S. Sweet, pers. comm.). California legless lizards seem to have high site fidelity, at least over the short term; marked lizards were recaptured < 10 m from their original capture points (average = 2.64 m; n = 10) after a period of 2 months (Miller 1944), but data on the movement ecology of *A. pulchra* are otherwise entirely lacking. The high incidence of tail injuries as indicated from the large percentage of scarred and broken tails seen on lizards found in the field and museum specimens suggests that fighting between adult males and encounters with natural predators are frequent (Bury 1985; pers. observ.); known predators include ringneck snakes *(Diadophis punctatus),* common kingsnakes *(Lampropeltis getulus),* deer mice *(Peromyscus maniculatus),* long-tailed weasels *(Mustela frenata),* domestic cats *(Felis sylvestris),* California thrashers *(Toxostoma redivivum),* American robins, and loggerhead shrikes *(Lanius ludovicianus;* Miller 1944; L. Hunt and S. Sweet, pers. comm.).

Habitat: California legless lizards occur primarily in areas with sandy or loose loamy soils under the sparse vegetation of beaches, chaparral, or pine-oak woodland; or sycamores, cottonwoods, or oaks that grow on stream terraces (Gorman 1957, Cunningham 1959b, Banta and Morafka 1968, Stebbins 1985). The sandy loam soils of stabilized dunes on which bush lupine *(Lupinus arboreus),* mock heather *(Eriogonum*

parvilfolium), mock aster *(Ericameria ericoides),* and other native coastal shrubs occur seems especially favorable habitat (Grinnell and Camp 1917, Miller 1944, Smith 1946, Bury 1985). Legless lizards also occur in desert scrub at the western edge of the Mojave Desert (Klauber 1932a). They are often found under, or in the close vicinity of, surface objects such as logs, rocks, old boards (Miller 1944, Gorman 1957, Banta and Morafka 1968) and the compacted debris of woodrat *(Neotoma* spp.) nests (S. Sweet, pers. comm.). Rocky soils or areas disturbed by agriculture, sand mining, or other human uses apparently lack legless lizards (Miller 1944, Bury 1972a, Hunt 1983, Stebbins 1985).

Soil moisture is essential for legless lizards. Preference for substrates with a higher moisture content has been identified in the laboratory and legless lizards die if they are unable to reach a moist substrate (Burt 1931, Miller 1944, Bury and Balgooyen 1976). Soil moisture is crucial for conserving energy at high temperatures (Fusari 1984) and also allows shedding to occur (Miller 1944). Legless lizards are though to be soil moisture-limited at the edges of portions of their geographic range (Miller 1944, Bury and Balgooyen 1976).

Status: Special Concern; its specialization for a fossorial existence in substrates with a high sand fraction renders *Anniella pulchra* vulnerable. Lack of comparable observational or sample data is the primary difficulty with evaluating the status of this cryptozooic lizard. Although key aspects of its habitat requirements are partly understood, that knowledge is insufficient to allow confident within-habitat evaluation of the distribution of this taxon. Nevertheless, some indications exist that various conditions place this species at risk. High confidence exists that legless lizards cannot survive in urbanized, agricultural, or other areas where a loose substrate in which to burrow has been removed or radically altered (e.g., the substrate severely disturbed by plowing or bulldozing). On this basis, *A. pulchra* has probably disappeared from ca. 20% of the area within its known historic range. A suite of other factors, including livestock grazing, off-road vehicle activities, sand mining, beach erosion, excessive recreational use of coastal dunes, and the introduction of exotic plant species (e.g., ice plants [*Carpobrotus edulis* and *Mesembryanthemum crystallinum*], Marram grass [*Ammophila arenaria*], veldt grass [*Ehrharta calycina*] and eucalyptus trees [*Eucalyptus* spp.]; Bury 1972a, 1985; Vivrette and Muller 1977; L. Hunt, pers. comm.) are likely to alter the substrate so that *A. pulchra* can no longer survive there. These factors decrease soil moisture or alter the conformation of the substrate, each of which may act singly or in concert to limit the food base or make the substrate physically unsuitable for *A. pulchra* to survive in. Exotic plants may be especially insidious because they support only a limited arthropod food base (Nagano et al. 1981) for *A. pulchra,* likely because they replace the native vegetation (Vivrette and Muller 1977, Powell 1978), which supports more significant arthropod populations. Some exotics, like *C. edulis,* also build up the salt concentration in the soil (Kloot 1983) that may create habitat unsuitable for legless lizards (Bury 1985) either because *A. pulchra* has difficulty osmoregulating in such a substrate, or indirectly, by limiting the arthropod food base. Legless lizards may also be susceptible to pesticide poisoning because of their insectivorous diet (Honegger 1975). Some areas in which legless lizards are known to occur are protected within several private and public reserves in central and southern California (e.g., Asilomar State Beach, Camp Joseph H. Pendleton Marine Corps Base, Carrizo Plain Preserve [The Nature Conservancy], Morro Bay State Park, Point Dume State Beach, Vandenberg Air Force Base), but these areas are becoming progressively smaller fragments because of losses of adjoining habitats due to development, road construction, poor land use practices (such as burning or clearing vacant lots), continued erosion of coastal beaches (due to the loss of sand supplies caused by water diversion projects and breakwaters), and the spread of exotic plants. The latter is especially true in State Beaches and other coastal reserves where much of the native vegetation has already been greatly reduced or replaced by exotic species. Over 45 years ago, Miller (1944) suggested that the increased presence of feral

house cats in parks and coastal areas may contribute to reducing legless lizard populations; that suggestion, while likely, has never been evaluated.

Management Recommendations: Detailed life history studies of legless lizards in various parts of California need to be undertaken in order to more precisely determine the habitat requirements of this animal. Information is especially needed on natural fluctuations in numbers and what constitutes a viable population size, as well as dispersion and colonization abilities. Management of this species needs to dovetail with ongoing biochemical studies on the taxonomy of this lizard, to determine if more than one taxon of legless lizard exists in California, so that the protection of each taxon can be individually addressed. Efforts should be made to enhance coastal beach habitat for legless lizards only after more precise ecological data become available on this species. Habitat restoration projects will have to be conducted to minimize impacts to existing legless lizard populations and other taxa that co-exist with them. The effects of removing exotic vegetation and restoring native plant communities in coastal dune habitats harboring legless lizards are in need of controlled experimental studies.

BELDING'S ORANGE-THROATED WHIPTAIL
Cnemidophorus hyperythrus beldingi (Stejneger 1894)

Description: A moderate-sized (50.0-94.0 mm SVL) gray, reddish brown, dark brown, or black lizard with five to seven pale yellow or tan stripes (Walker and Taylor 1968, Stebbins 1985, Rowland 1992). The top of the head has a single, fused frontoparietal scale (Rowland 1992), and is yellow-brown to olive gray. Undersurfaces are yellowish white, often with gray or bluish slate on the belly; adults have varying degrees of red-orange wash (Stebbins 1985) that may occur on all undersurfaces (Rowland 1992). The latter is especially prominent on the throat and chest in breeding males. The iris is brown (pers. observ.). In hatchlings and juveniles, the tail is a highly visible bright blue (Rowland 1992).

Taxonomic Remarks: This taxon is morphologically distinct (Walker and Taylor 1968), and has never been confused with any other taxon. No attempts have been made to characterize genetic variation across the geographic range of *C. h. beldingi*. An understanding of that variation is needed to elucidate potential geographic patterns to genetic variation.

Distribution: *Cnemidophorus h. beldingi* ranges from Corona del Mar (Orange County: LACM 14747) and near Colton (San Bernardino County), California southward to Loreto, Baja California, Mexico (Stebbins 1985). The upper elevational limit of this taxon, which probably occurs in Baja California, is not known, but the lower limit extends down to near sea level (Corona del Mar, Grange County). In California, *C. h. beldingi* ranges from the southern edges of Orange and San Bernardino counties southward to the Mexican border (Figure 30). In California, the known range of *C. h. beldingi* is located on the coastal slope of the Peninsular Ranges-and extends from near sea level to ca. 1040 m (northeast of Aguanga, Riverside County).

Life History: Data on the life history of *C. h. beldingi* are relatively limited. The studies of Bostic (1964, 1965a, 1965b, 1966a, 1966b, 1966c) and Rowland (1992) in California, and Karasov and Anderson (1984) in Mexico, include essentially all the ecological data known for this species. Orange-throated whiptails typically emerge from hibernation in February or March (Rowland 1992), but some lizards may be active in every month of the year whenever it is sufficiently warm (Bostic 1966a; see also Brattstrom 1990 and Rowland 1992). *Cnemidophorus h. beldingi* typically emerges from overwintering sites
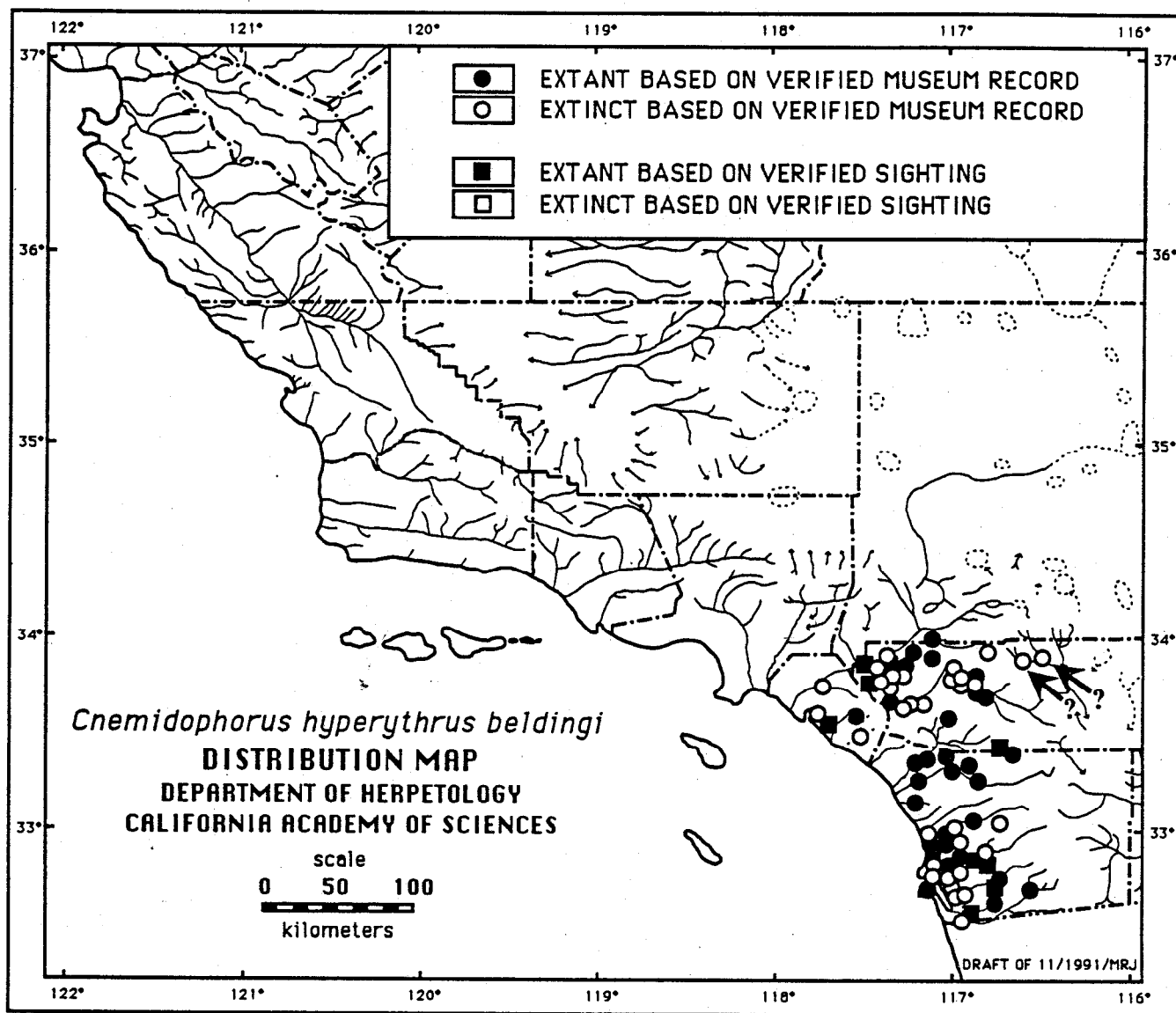
Figure 30. Historic and current distribution of Belding's orange-throated whiptail (*Cnemidophorus hyperythrus beldingi*) in southern California based on 131 locations from 389 museum records and 14 records from other sources.

that consist of relatively short (7-30 cm long), J-shaped burrows with a small (3-19 cm^3) terminal chamber on a south-facing slope having open bare ground (Bostic 1964, 1966a). Orange-throated whiptails are typically active across a relatively high temperature range (36.3°C-41.0°C) and usually emerge only after soil temperatures have reached at least 28°C (Bostic 1966b; see also Rowland 1992). The daily activity cycle of this diurnal lizard is largely unimodal early in the season, but shifts to a bimodal pattern as midday near-surface temperatures become unfavorably hot during the summer months (Bostic 1966a, Rowland 1992). May matings are probably typical, although copulation in the field has been observed as late as July (Atsatt 1913). Females deposit two or three moderate-sized, leathery-shelled eggs in June or July in an unknown location (Bostic 1966c). Hatchlings are first observed in the field from the second week of August through the first week of September (Bostic 1966c, Rowland 1992). Orange-throated whiptails can become sexually mature in 1 year, but most individuals, especially females, require 2 years to become sexually mature (Bostic 1964). Longevity of *C. h. beldingi* is unknown. Perhaps the most distinctive aspect of the life history of *Cnemidophorus h. beldingi* is that it appears to be a dietary specialist, most (> 85%) of its prey being comprised of termites, specifically one subterranean species, *Reticulitermes hesperus* (Bostic 1966b); the degree of specialization may vary locally or geographically, because in Baja California, a considerably lesser percentage (ca. 40%) of termites were eaten (Karasov and Anderson 1984). Orange-throated whiptails appear to take other insects (mostly spiders, beetles, and grasshoppers [Orthoptera]) largely during late summer, when their staple prey (termites) migrate downward into the soil, and thus, are largely unavailable (Rowland 1992). Adults disappear into hibernation in the latter part of July through early September, whereas immature lizards begin to hibernate in the latter part of December (Bostic 1966a, Rowland 1992).

Habitat: The habitat characteristics of *C. h. beldingi* are poorly understood, largely because data are sparse. Historically, most populations occurred on the floodplains or terraces along streams (McGurfy 1980). This species appears to be tied to the presence of some perennial plants, probably because its major food resource, termites (Bostic 1966b), requires some kind of a perennial plant as a food base (Rowland 1992). California buckwheat *(Eriogonum fasciculatum),* California sagebrush *(Artemisia californica),* black sage *(Salvia mellifera),* white sage *(Salvia apiana),* and chamise *(Adenostema fasciculatum)*-redshank *(A. sparsifolium)* chaparral apparently fulfill the perennial plant requirement for *C. h. beldingi* (Bostic 1964; pers. observ.; see also Brattstrom 1990). Rowland (1992) found that adult orange-throated whiptails associated with California buckwheat and black sage at frequencies greater than which these species occurred in the habitat. Rowland also observed that all age groups of orange-throated whiptails tended to avoid open areas, but precisely how these aspects of its habitat requirements are linked to its overall life history remain poorly understood. Hibernation sites seem to occur on well-insolated, south-facing slopes (Bostic 1964, 1966a), so open slopes adjacent to terraces with woody perennials may represent the best available habitats. Oviposition sites remain to be discovered, but they probably also occur on well-insolated, south-facing slopes. Home ranges for this taxon have been reported to average between 363.6-445.0 m^2 (range: ca. 150 m^2-1400 m^2) for adults (Bostic 1964, 1965a; Rowland 1992).

Status: Threatened; Cooper et al. (1973) reviewed the status of *C. h. beldingi* in California in the course of an assessment of the Santa Margarita Ecological Reserve and environs, and concluded that this taxon was depleted, based on the definitions the California Department of Fish and Game used at that time. McGurty (1980) reviewed this taxon in California based on data that is now over 10 years old. His mapped data suggest that *C. h. beldingi* had been extirpated from ca. 60% of its historic range at the time of his survey. Based on comparing aerial photographs from roughly the time that McGurty did

his assessment (1980) to current aerials (i.e., 1990), we estimate that ca. 75% of the historic range of *C. h. beldingi* no longer supports this taxon. Most of the suitable habitat for *C. h. beldingi* occurs in floodplains and stream terraces, the most developed areas in southern California. Remaining populations of *C. h. beldingi* are highly fragmented because the lower floodplain of most coastal drainages, where most of the historical habitat for this species existed, has been developed, thus isolating the remaining populations in smaller floodplain and terraces at the higher elevations where this species is known to occur. Most of the latter are probably more susceptible to local extinction with little opportunity of recolonization because historically, the avenue for recolonization was likely via the larger populations on the lower floodplains and terraces. Further, *C. h. beldingi* is something of a habitat specialist that copes poorly with even minor modifications to local environments caused by humans. Furthermore, the four years of severe drought (1986-1990) may have reduced its insect food base, which may directly influence reproduction and have exacerbated the problem of small local populations staving off extinction. Finally, the likelihood that this whiptail is a dietary specialist on termites places it at some risk, particularly if it lacks other foods to switch to to a significant degree.

Management Recommendations: The life history of *C. h. beldingi* needs to be much better understood to refine any management recommendations. Life history data is currently being gathered and surveys are being conducted with state and federal (military) funding on orange-throated whiptails (Brattstrom 1990), but only limited results of these studies are available (see Rowland 1992). In particular, a better understanding is needed of how obligatory the termite diet of this species really is; of the relationship between this whiptail, perennial plants, and termites; of the nature and characteristics of oviposition sites; and of the movement ecology and colonization abilities of this species. Until these data are obtained, sites known to harbor this species should be surveyed on a site-by-site basis to identify the quality of existing populations and to take measures to provide some degree of protection for this species where it occurs in significant numbers. Additionally, Argentine ants *(Iridomyrmex humilis)* are an exotic pest species that displaces many native insects (see species account for the San Diego horned lizard [*Phrynosoma coronatum blainvilli*]), and may be influencing the food base of *C. h. beldingi.* The recommended life history studies of *C. h. beldingi* should be conducted with the idea of gaining an understanding of the potential negative effects of the exotic fauna and flora on this species.

PANAMINT ALLIGATOR LIZARD
Elgaria panamintina (Stebbins 1958)

Description: A large (90-150 mm SVL) alligator lizard with a light yellow or beige dorsum marked with seven or eight, relatively evenly spaced, brown crossbands between the head and the hindlimbs (Stebbins 1958). Crossbands extend onto the tail, but are much more contrasting in juveniles than adults. When unbroken, the tail is nearly twice the body length. Continuous or broken lines occur lengthwise down the center of scale rows on the light-colored venter (Stebbins 1985). The iris is pale yellow (Stebbins 1958).

Taxonomic Remarks: A distinctive alligator lizard that is considered a valid species (Stebbins 1958, Good 1988). Formerly a member of the genus *Gerrhonotus* (e.g., Stebbins 1958, 1985), recently revised alligator lizard systematics places this species in the genus *Elgaria* (Waddick and Smith 1974; Gauthier 1982; Good 1987a, 1987b, 1988). Genetic variation across the geographic range of *E. panamintina* has not been characterized, and genetic data on this species are based on a single individual (see Good 1988). An understanding of genetic variation is needed to determine whether any populations of *E. panamintina* are distinctive genetic units.

Distribution: This California endemic is known only from the vicinity of 15 isolated riparian localities below permanent springs in the Argus, Inyo, Nelson, Panamint, and White mountains of Inyo and Mono counties (Figure 31; see also Macey and Papenfuss 1991b). Its known elevational range extends from ca. 760 m to 2072 m.

Life History: Few data are available on the life history of *E. panamintina.* If similar to other alligator lizards whose life history is known, it probably has a relatively low preferred temperature range (Brattstrom 1965, Cunningham 1966a. Kingsbury 1994), it does not bask (*contra* Macey and Papenfuss 1991b), and it favors very dense cover, a habitat infrequently occupied by the easily observed, frequently abundant, basking lizard species (e.g., *Sceloporus occidentalis, Uta stansburiana).* Depending onelevation, Panamint alligator lizards emerge from hibernation in late winter or early spring, and seem to be active during the day and at dusk (Stebbins 1958, Dixon 1975). Based on pitfall capture dates, *E. panamintina* may be most active in May, June, and September, and less conspicuous due to aestivation or nocturnal activity during very hot periods (typically July-August; Banta 1963b), but these data are difficult to interpret, since the manner in which, and the frequency with which, traps were checked was not reported. A pair of captive Panamint alligator lizards were observed mating on 15 May (Banta and Leviton 1961) and a female obtained on 1 May 1959 contained 12 developing eggs (Banta 1963b), suggesting that the species lay eggs (Stebbins 1985) rather than being live-bearing. If reproduction is similar to that of the related *E. multicarinata,* which occurs nearby (see Macey and Papenfuss 1991b), the anticipated intervals for reproduction and oviposition would be spring and early summer, respectively (see Goldberg 1972), and if second clutches are laid, a second round of oviposition might occur in late summer (see Burrage 1965). Data on incubation time, growth, and feeding habits are lacking for the Panamint alligator lizard, but if similar to the southern alligator lizard, incubation of the eggs may take nearly 3 months (see Atsatt 1952 and Burrage 1965), sexual maturity probably requires at least 2 years (see Goldberg 1972), and terrestrial invertebrates likely dominate the diet (see Cunningham 1956).

No predators of *E. panamintana* are recorded, but several species known to eat other alligator lizards (e.g., coachwhip [*Masticophis flagellum*], striped whipsnake [*M. meniatus*], loggerhead shrike, red-tailed hawk [*Buteo jamaicensis*]: Fitch 1935) occur within the range of the Panamint alligator lizard, and may prey on it. Data on the movement ecology and colonization abilities of *E. panamintina* are lacking.
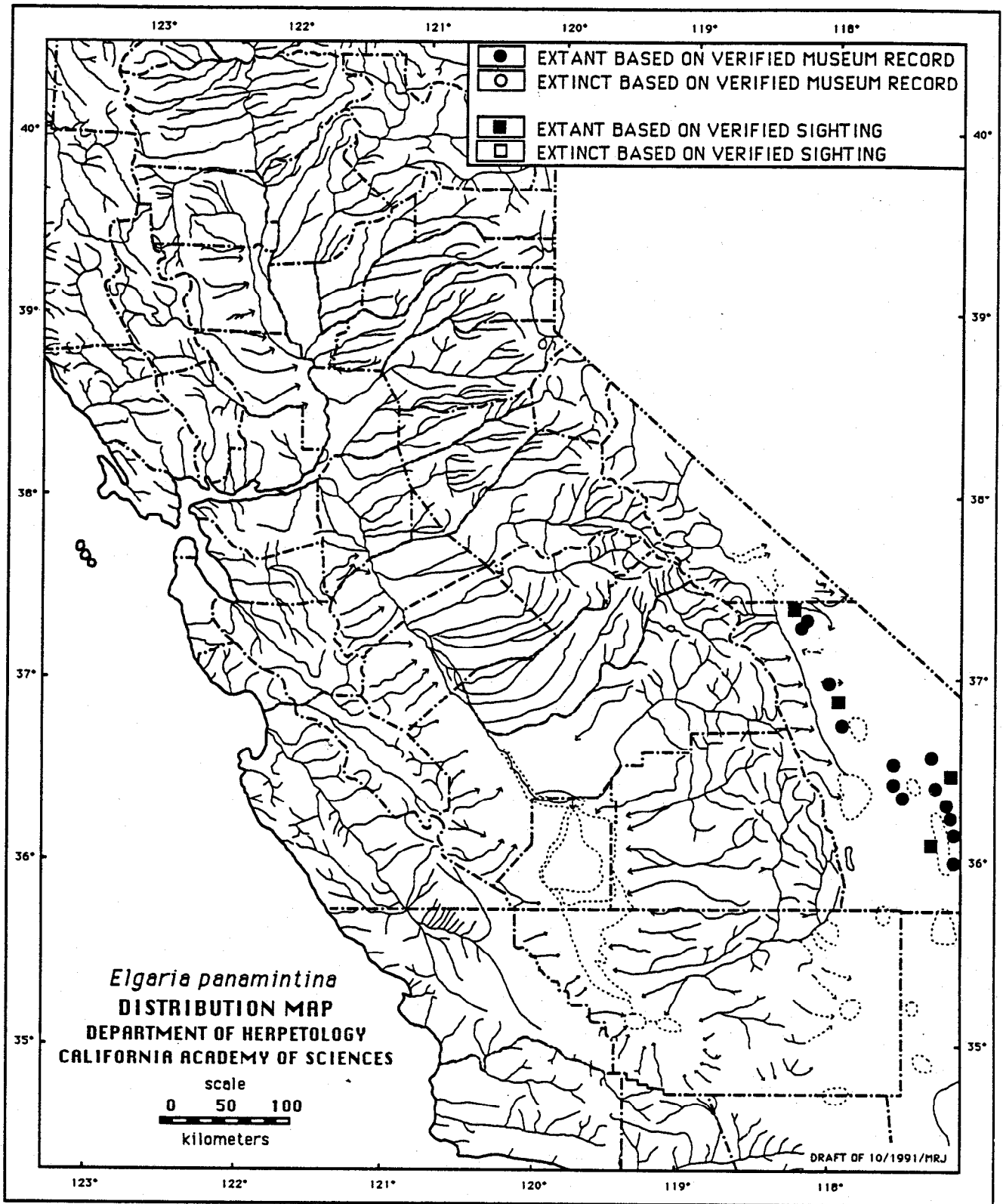
Figure 31. Historic and current distribution of the Panamint alligator lizard (*Elgaria panamintina*) in central California based on 19 locations from 25 museum records and 4 records from other sources.

Habitat: *Elgaria panamintina* is thought to be a relict species that occupies a now restricted habitat representative of a more mesic period (Good 1988). Panamint alligator lizards are confined mostly to narrow riparian strips associated with permanent springs in talus canyons composed of limestone, marble, and other metamorphic rocks (Stebbins 1958). These riparian zones are extremely limited in areal extent, being only a few meters wide and 0.75-3.1 km long and closely confined to canyon bottoms (Stebbins 1958, Banta 1963b). In most places, coyote bush *(Baccharis sergiloides),* virgins bower (*Clematis lugusticifolia),* and wild grape *(Vitis girdiana)* dominate the dense riparian growth (Stebbins 1958, Banta 1963b, Dixon 1975). At the edges of the riparian zones, more xeric-adapted vegetation (e.g., creosote bush [*Larrea divaricata*] and sagebrush [*Artemisia ludoviciana*]) predominates (Stebbins 1958, Banta 1963b). Although Panamint alligator lizards have been commonly observed in or under dense riparian thickets near damp soil (Stebbins 1958), they may forage in, or actually occupy, talus-covered slopes at some distance beyond the immediate influence of the riparian zone, where such areas shelter more mesic subsurface habitat, as suggested by the four specimens trapped in areas adjacent the riparian zone (see Banta 1963b).

Status: Threatened; all except two of the known populations of Panamint alligator lizard occur on private lands and are currently at risk because of habitat loss from mining, both feral and domestic livestock, and off-road vehicle activity in the restricted riparian habitats that shelter this species. Off-road activity in the Panamint-Inyo-White Mountain system has increased significantly over the last 10 years, so impacts to the Panamint alligator lizard are anticipated to increase.

Management Recommendations: A thorough understanding of the specific habitat requirements significant to the survival of this species are an absolute prerequisite to refining management efforts for this species. Until specific habitat data become available, efforts should be directed at protecting the habitat ensemble associated with the springs and other riparian areas where Panamint alligator lizards have been found. Since most known localities are on private land, particular efforts should be made to encourage landowners to manage for habitat preservation. Such guidance may not be well-received, so encouragement should emphasize the positive benefits that landowners would gain in their own operations if they choose to undertake such preservation. Habitat preservation should emphasize avoidance of alterations that might modify the hydrology of these areas. Many of the suggestions made here are similar to those that would help protect *B. campi* (see species account for the Inyo Mountains salamander), although we anticipate that the alligator lizard may be more tolerant of limited alteration. Minimizing mining-, feral livestock-, and off-road vehicle-associated disturbance of the vegetation or substrate in the riparian zones is particularly important. Concerted efforts should be made to search for the Panamint alligator lizard in nearby riparian areas where it has not yet been detected. Where possible, protection of this species would be assisted through initiation of land use restriction measures in the Inyo-Panamint-White Mountain system, which would anticipate future finds of this species outside of its known range.
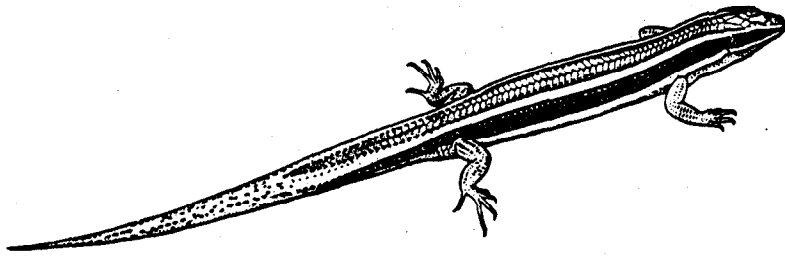
Plate 10. Adult western skink (*Eumeces skiltonianus*) [from Stebbins 1954b].

CORONADO SKINK
Eumeces skiltonianus interparietalis Tanner 1957

Description: A medium-sized (53-83 mm SVL) smooth-scaled lizard with relatively small limbs and four white or beige stripes on a brown dorsum (Stebbins 1985. Tanner 1988). The intervening middorsal and lateral dark stripes extend to or beyond the middle of the tail in adults (Tanner 1957). The tail has at least some blue coloration; the tail color is often brilliant blue in juveniles and adults having unbroken tails. This skink has a small interparietal scale enclosed posteriorly by the parietal scales (Tanner 1957). The iris is dark brown (pers. observ.).

Taxonomic Remarks: The Coronado skink is currently treated as a subspecies of the western skink (Tanner 1988), but the taxonomy of Pacific Coast skinks *(Eumeces skiltonianus-E. gilberti)* needs revision because of inconsistencies in many of the morphological characters used to distinguish taxa. Data on genetic variation across the geographic range of *Eumeces s. interparetalis* are lacking; available genetic data on this taxon are based on a single individual (Murphy et al. 1983). An understanding of that variation is needed to determine whether any populations of the Coronado skink are distinctive genetic units, and to resolve the relationship between the Coronado skink and other western skinks in the *skiltonianus* assemblage.

Distribution: The Coronado skink inhabits the coastal plain and Peninsular Ranges west of the deserts from approximately San Gorgonio Pass (Riverside County) southward to San Quentin (Baja California), Mexico (Tanner 1988). Isolated populations also occur on Santa Catalina, Los Coronados, and Todos Santos islands off the coast of southern California and Baja California (Zweifel 1952a, Stebbins 1985). The known elevational range of *E. s. interparetalis* extends from near sea level to about 2000 m (La Grulla, Baja California). In California, *E. s. interparetalis* ranges from near Banning (Riverside County: Tanner 1957) south to the Mexican border (Figure 32). The known elevational range of the Coronado skink in California extends from near sea level to about 1675 m (Strawberry Valley, Riverside County: Atsatt 1913). *Eumeces s. interparetalis* is described as intergrading with *E. s. skiltonianus* at the northern edge of its range (from near Escondido, San Diego County, north to Mt. San Jacinto, Riverside, County: Tanner 1957, 1988), but conclusive identification of this pattern awaits the systematic resolution of these taxa.

Life History: Few life history data are available for the Coronado skink and the following life history summary is based largely other subspecies of *E. skiltonianus.* Adults and juveniles are diurnal and are typically active from early spring through early fall, although activity is bimodal (early morning and late afternoon) during the summer months (Zweifel 1952a; see Tanner 1943, 1957). Coronado skinks are secretive lizards (pers. observ.), they may have a relatively low activity temperature (28.5°C-31.2°C, n = 2; Zweifel 1952a), and they likely prey upon many small invertebrates in leaf litter or dense vegetation at the edges of rocks and logs, but may selectively avoid ants (see Atsatt 1913, Tanner 1957; pers. observ.). Like other skinks, Coronado skinks are probably facile burrowers and undoubtedly construct similar tunnels under stones or other cover for refuge or use in hibernation or nesting. Breeding for closely related *E. s. skiltonianus* begins soon after spring emergence and females lay 2-6 eggs during June and July in nest chambers constructed in loose, moist soil under rocks, logs, or other cover (see Tanner 1957, Punzo 1982) Females may attend their eggs until they hatch (see Tanner 1943, 1957). Young *E. s. interparetalis* probably hatch in late summer, and sexual maturity may occur at 2 years of age., but most individuals probably do not reproduce until they are 3 years old; longevity of adults is probably 5 or 6 years (see Rodgers and Memmler 1943). Known predators include California mountain kingsnakes *(Lampropeltis zonata;* McGurty
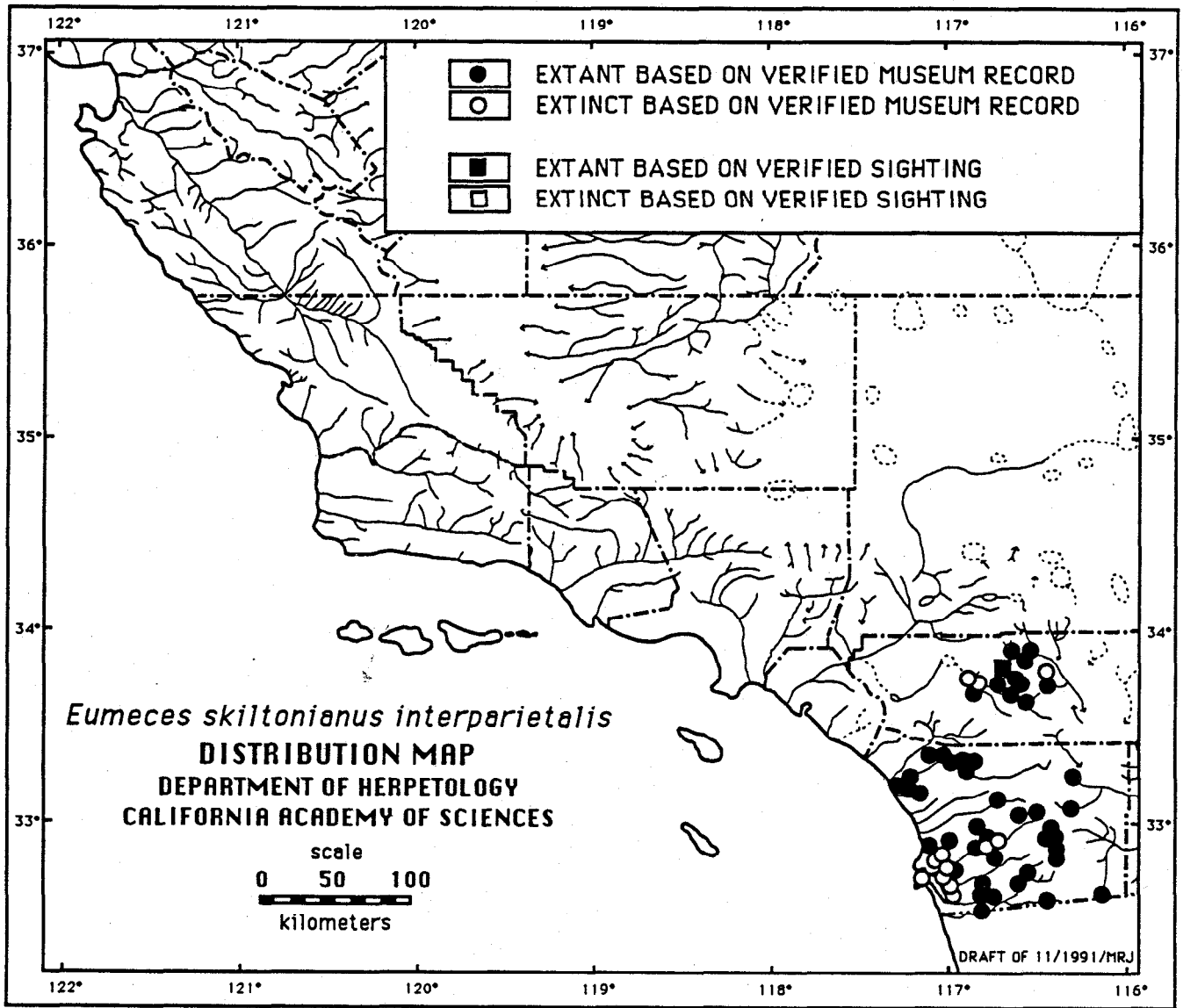
Figure 32. Historic and current distribution of the Coronado skink (*Eumeces skiltonianus interparietalis*) in southern California based on 104 locations from 245 museum records and 1 record from another source.

1988; see also Newton and Smith 1975), and western rattlesnakes *(Crotalus viridis,* Zweifel 1952a), but several birds and mammals probably also prey on Coronado skinks (see Tanner 1957; C. Fagan, pers. comm.). Brightly colored tails are postulated to be both an intraspecific age recognition device and a predator distraction device (Vitt et al. 1977). No data exist on movement ecology or the colonization abilities of *E. s. interparetalis.*

Habitat: The Coronado skink seems generalized in the sense that it occurs in a variety of plant associations ranging from coastal sage, chaparral, oak woodlands, pinon-juniper, and riparian woodlands to pine forests (Stebbins 1985), but within these associations it is often restricted to the more mesic pockets (Tanner 1957; Zeiner et al. 1988; see also Fowlie 1973). The latter often consist of open riparian or subriparian margins, but significant variation exists in the nature of the mesic habitats used (e.g., fog-bound islands; Zweifel 1952a).

Status: Special Concern; although the Coronado skink occurs in a number of vegetative associations, a large portion of the area of southern California with suitable habitat for this taxon has been developed or has undergone land use changes incompatible with its survival (e.g., see Brattstrom 1988). Large areas of habitat have been urbanized or converted into orchard crops (citrus [*Citrus* spp.] and avocado [*Persea americana*]). Although much of the physical habitat structure Coronado skinks require remains in many relatively recently planted steep-slope avocado orchards, the absence of skinks in such habitats suggests that something besides habitat structure may exclude this species; pesticide or herbicide use in orchards and on other agricultural crops may adversely affect this species. Human use of surface and underground water resources has made many of the more mesic pockets within various plant associations become increasingly dry, a situation that likely mitigates against the presence of Coronado skinks.

Management Recommendations: The systematic status of the Coronado skink relative to other western skinks needs clarification and any distinct genetic units need to be identified. A more refined understanding of the habitat requirements of the Coronado skink is especially needed. In particular, knowledge of what constitutes suitable refuge habitat and nest sites, focusing on key habitat parameters, is almost entirely lacking; these data are an absolutely prerequisite to providing sound management recommendations for this species. Also needed are data on local population dispersion, movement ecology, and the recolonization potential of this taxon. The effect of increased xerification on the local distribution of the Coronado skink, a situation likely to be significant in southern California, needs study. Current evaluation of the listing status of the Coronado skink suffers primarily from a generalized lack of data at most levels.

BANDED GILA MONSTER
Heloderma suspectum cinctum Bogert and Martín del Campo 1956

Description: A large (22-35 cm SVL), robust lizard with a short, stout tail and relatively short limbs with strongly curved claws (Stebbins 1985, Campbell and Lamar 1989). The back and sides are covered with beadlike scales colored in an orange, pink, or yellow and black-banded pattern that suggests Indian beadwork (Bogert and Martin del Campo 1956); belly scales are similarly colored, but squarish in shape (Stebbins 1985). The iris is dark brown or black (pers. observ.).

Taxonomic Remarks: *Heloderma suspectum cinctum* was described on the basis of morphological data (Bogert and Martín del Campo 1956); genetic data have never been used to verify this allocation. Moreover, no data exist on genetic variation within this taxon.
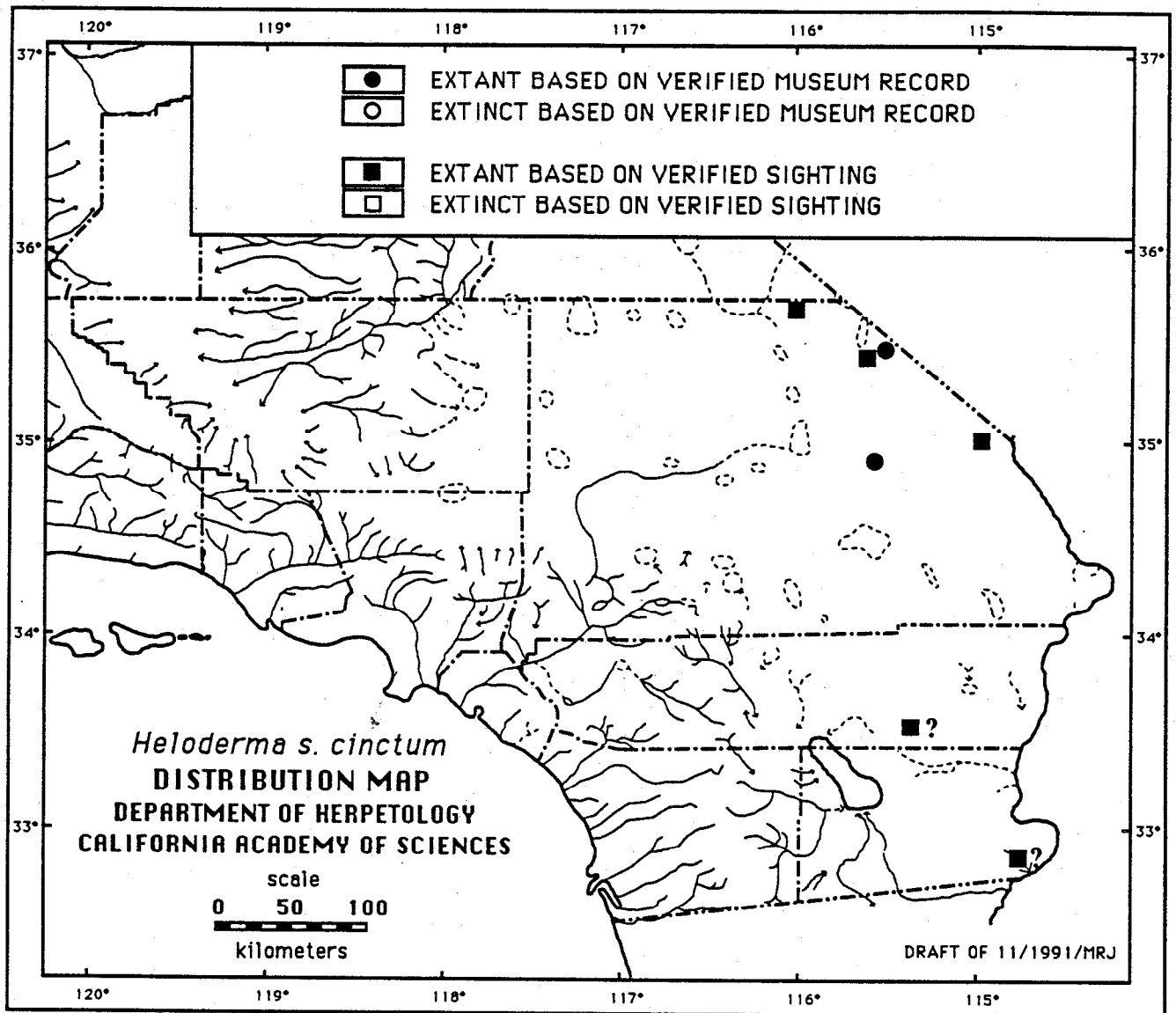
Figure 33. Historic and current distribution of the banded Gila monster (*Heloderma suspectum cinctum*) in southern California based on 9 locations from 3 museum records and 6 records from other sources.

Distribution: *Heloderma s. cinctum* ranges from the Vermillion Cliffs (Washington County), Utah (Woodbury 1931) southward through the lower Colorado River basin, which includes extreme southern Nevada (Bradley and Deacon 1966), southeastern California, and Arizona west of the Central Plateau to Yuma (Yuma County: DeLisle 1985). The known elevational range for *H. s. cinctum* extends from 45 m along lower Colorado River near Yuma to 1124 m at Congress (Yavapai County), Arizona (Bogert and Martín del Campo 1956). In California, *H. s. cinctum* is known from isolated records in the Clark, Kingston, Paiute, and Providence mountains of eastern San Bernardino County (DeLisle 1979, 1983, 1985; Ford 1981; Bicket 1982; Stebbins 1985: Figure 33). No specimens or photographs are available to verify other California records (i.e., 15.5 km east of Desert Center in the Chuckwalla Mountains [Riverside County: Tinkham 1971], and the Imperial Dam area [Imperial County: Funk 1966, DeLisle 1985]). In California, the known elevational range of *H. s. cinctum* extends from 45 m along the lower Colorado River to at least 1100 m in the Clark Mountains.

Life History: *Heloderma s. cinctum* is a relatively sedentary, venomous, largely diurnal lizard that often returns to the same overwintering sites year after year (Lowe et al. 1986). No life history studies of banded Gila monsters have been conducted in California. Much of this summary is based on recent work conducted in Utah (Beck 1990). Using it to interpret the behavior of *H. s. cinctum* in California should be done cautiously. *Heloderma s. cinctum* leaves overwintering sites located on elevated, rocky slopes during mid-March when temperatures consistently exceed 22°C and moves up to 1 km into less elevated, adjacent bajadas and valleys, where it occupies large (6-66 ha) home range areas during the spring-fall interval (Beck 1990). The banded Gila monster seems to spend most of its time (> 95%) underground in natural cavities or animal burrows (often not its own), and emerges only during the day, which is when foraging occurs (Jones 1983, Beck 1990). *Heloderma s. cinctum* feeds opportunistically, subsisting largely on eggs of birds (mourning dove [*Zenaida macroura*], Gambel's quail [*Lophortyx gambelii*]) and reptiles (desert tortoise), and rabbit (desert cottontail [*Sylvilagus audubonii*]) and ground squirrel (white-tailed antelope squirrel [*Ammospermophilus leucurus*]) young, which it finds while robbing nests over a broad area (Armberger 1948, Shaw 1948, Hensley 1949, Jones 1983, Vaughan 1987, Beck 1990; see also Barrett and Humphrey 1986). The venom is thought to be used solely for defensive purposes, rather than for subduing or predigesting prey (Lowe et al. 1986, Beck 1990). During the spring, banded Gila monsters may forage over significant distances (up to 1 km/day) to accumulate enough fat reserves (stored largely in the tail) for use during the rest of the year when food resources are scarce (Jones 1983, Beck 1990). Banded Gila monsters spend anywhere from a few minutes to 4-5 hours basking and foraging each day (Porzer 1982). The range of body temperatures at which Gila monsters are usually active is 22-37°C (Lowe et al. 1986, Beck 1990). As midday temperatures become warmer during April and May, surface activity shifts from a single midday interval to a bimodal pattern; most activity occurs during a 3-to-4 hour interval 1-2 hours after sunrise, but a less frequent, often shorter interval occurs in late afternoon (Porzer 1982, Jones 1983). Banded Gila monsters are frequently observed out of their burrows on warm cloudy days, but lizards out after dusk are usually hatchlings, or individuals that are starved, displaced by floods, or incapacitated from recent fights (Lowe et al. 1986). As temperatures cool during September, banded Gila monsters revert to a unimodal pattern of surface activity (Beck 1990). When air temperatures consistently drop below 25°C, lizards return to winter denning sites (Lowe et al. 1986).

In Arizona, banded Gila monsters normally breed from late April through early June (Lowe et al. 1986). Breeding adults can occupy the same burrow at this time and probably mate underground. Males appear to be territorial during the spring and early summer, often fighting rival males in bouts of up to several hours of intermittent combat (Beck 1990). Females lay 2-12 (average = 5), leathery, oblong (average = 59.8 mm long x 30.6 mm

wide), white eggs from mid-July to mid-August (Lowe et al. 1986). Eggs hatch from late April to early June after an incubation period of about 10 months, thus developing young overwinter in the nest. Hatchling *H. s. cinctum* average ca. 120 mm SVL (Bogert and Martín del Campo 1956) and grow rapidly until they attain approximately 260 mm SVL (minimum adult size), after which growth rates probably slow to 7-10 mm SVL/year (see Tinkham 1971). Adults grow more slowly (ca. 4-7 mm/year) until they reach 300 mm SVL, after which growth slows to < 2 mm/year (Beck 1990). Based on captive animals, sexual maturity is probably reached after about 4 years (DeLisle 1985). If the large sizes of adults found in the wild (up to 360 mm SVL) are an indication of extreme age (see Bogart and Martín del Campo 1956), then Gila monsters are extraordinarily long-lived; captives have been maintained in zoos for over 40 years (Jennings 1984b). These lizards have relatively few natural predators because of their large size, secretive habits, and venomous bite, but Harris hawks *(Parabuteo unicinctus)* and coyotes are known to prey on Gila monsters (DeLisle 1985).

Habitat: *Heloderma s. cinctum* occurs in several desert plant associations, but seem most common in the paloverde *(Cercidium* spp.)-saguaro *(Curnegia gigantea)* desertscrub association. However, Gila monsters can also occur in mesquite-grassland, creosote bush, and singleleaf pinyon *(Pinus monophylla)*-western juniper *(Juniperus occidentalis)* vegetation types (Bogert and Martín del Campo 1956, Ford 1981, Lowe et al. 1986, Beck 1990). In Arizona, they are absent in agriculturally-modified habitats and riparian zones (Lowe et al. 1986), but in California, *H. s. cinctum* has been recorded from willow-, mesquite-, salt cedar-, and mulefat-dominated rocky canyons (Bicket 1982), several of which could be construed as "desert riparian". Banded Gila monsters are quite capable of digging (Lowe et al. 1986), but they depend largely on natural crevices, desert pack rat *(Neotoma lepida)* nests, or animal burrows (e.g., desert tortoise burrows) for shelter (Beck 1990). Significant differences exist between winter and summer homesites; banded Gila monsters winter at more elevated locations on rocky slopes, in rocky outcrops or below cliffs (often with other reptiles such as rattlesnakes and desert tortoises), whereas summer ranges are located in adjacent lower valleys or bajadas (Porzer 1982, Beck 1990). Preferred shelters normally face to the east, southeast, or south (Beck 1990). Habitat requirements appear similar for both juveniles and adults (Porzer 1982, Jones 1983). Data on nest sites are lacking.

Status: Special Concern; in California, this lizard is largely restricted to only a few isolated mountain ranges in the Mojave Desert, most of which are owned by the United States Bureau of Land Management or private mining companies. Known areas from which this species is recorded appear to be secure from immediate development. Banded Gila monsters are protected by the California Department of Fish and Game and it is illegal to pursue or possess this lizard without a special permit. However, a black market may exist for this species and some animals are still taken from the wild and sold as pets or for breeding purposes (unpubl. data). Banded Gila monsters are often killed by automobiles (DeLisle 1985) and sometimes by domestic dogs *(Canis familiaris:* Bogert and Martín del Campo 1956).

Management Recommendations: Directed field surveys for this taxon need to be conducted in the Mojave Desert to determine the true extent of its distribution in California. Historical locality records for this lizard in Riverside and Imperial counties need verification. Data regarding the basic biology of this taxon in California are especially needed. Notably, ecological studies to determine essential habitat requirements, namely refuge sites, nesting sites, and home ranges are needed in order to make sensible management recommendations. Telemetry is likely to be necessary to conduct studies of this taxon in California.

SAN DIEGO HORNED LIZARD
Phrynosoma coronatum blainvillii Gray 1839

Description: A large (65-110 mm SVL), dorsoventrally flattened lizard with five (four large, lateral, sometimes curved, and one moderate-sized, median) backwardly projecting head spines; a large shelf above each eye terminating a backwardly projecting, spine-like, scale (postrical); large, convex, smooth scales on the forehead (frontals); and two parallel rows of pointed scales fringing each side the side of the body (Reeve 1952, Jennings 1988c). No stripes radiate from the eyes (Stebbins 1985). The dorsal color is highly variable, but typically gray, tan, reddish-brown, or whitish, and usually resembles the prevailing soil color (Jennings 1988c). The venter is yellow to white with discrete, dark spots. The iris is black (pers. observ.).

Taxonomic Remarks: Wide disagreement has existed as to the allocation of horned lizards in the *coronatum-blainvillii* complex and their associated forms. Van Denburgh (1922a), Klauber (1936), Smith (1946), and Tinkham (1951) recognized two species *(P. blainvillii* and *P. coronatum)* each with several subspecies, while Linsdale (1932), Tevis (1944), Reeve (1952), and Murray (1955) argued for a single species *(P. coronatum).* Jennings (1988c) followed the latter arrangement based on the evolutionary arguments of Savage (1960, 1967) and Murphy (1983), but felt that *P. c. blainvillii* was a valid taxon. Taxonomy of this difficult group is currently being revised (R. Montanucci, pers. comm.). Genetic data on this taxon are based on only a few individuals from Baja California (Murphy 1983); characterization of genetic variation throughout the geographic range of *P. c. blainvillii* has never been attempted.

Distribution: *Phrynosoma c. blainvillii* was historically distributed from the Transverse Ranges in Kern, Los Angeles, Santa Barbara, and Ventura counties southward throughout the Peninsular Ranges of southern California to Baja California, Mexico as far south as San Vicente (Jennings 1988c). The known elevational range of this taxon is from ca. 10 m at the El Segundo dunes (Los Angeles County: Von Bloeker 1942) to approximately 2130 m at Tahquitz Meadow on Mt. San Jacinto (Riverside County: LACM 19890). In California, this taxon ranges from the Transverse Ranges to the Mexican border west of the deserts, although it occurs at scattered sites along the extreme western desert slope of the Peninsular Ranges (Jennings 1988c: Figure 34). In 1894, an attempted introduction of this taxon at Smugglers (= Pyramid) Cove, San Clemente Island (Los Angeles County: Mearns 1907) failed (Jennings 1988c). *Phrynosoma c. blainvillii* is thought to intergrade with *P. c. frontale* in extreme southern Kern County and northern Santa Barbara, Ventura, and Los Angeles counties (Reeve 1952, Montanucci 1968, Jennings 1988c).

Life History: *Phryosoma c. blainvillii* emerges from hibernation in late March (Pequegnat 1951, Howard 1974) and is surface active mostly during April-July, after which time most adults aestivate (Jennings 1987c, Hager 1992). San Diego horned lizards then reappear again briefly in August disappearing into overwintering sites from late August through early October, the variation depending on elevation (Klauber 1939, Howard 1974, Hager 1992) and perhaps local conditions. *Phrynosoma c. blainvillii* displays a distinctive sequence with regards to its daily diurnal activity. Frequently just before sunrise (when surface temperatures are > 19°C), San Diego horned lizards emerge from their burial sites in the substrate (sometimes with just the head exposed) and later move into a position where the first rays of the sun will allow them to bask (Heath 1965, Hager 1992). As temperatures warm, San Diego horned lizards thermoregulate by either shifting the orientation of their bodies relative to the sun or moving in and out of the shade; ultimately, an optimum body temperature range of 20.8-39.0°C (average = 34.9°C) is reached (Brattstrom 1965, Heath 1965). By late morning, body temperatures are elevated enough to allow the horned lizards to feed or engage in territorial and sexual behavior.
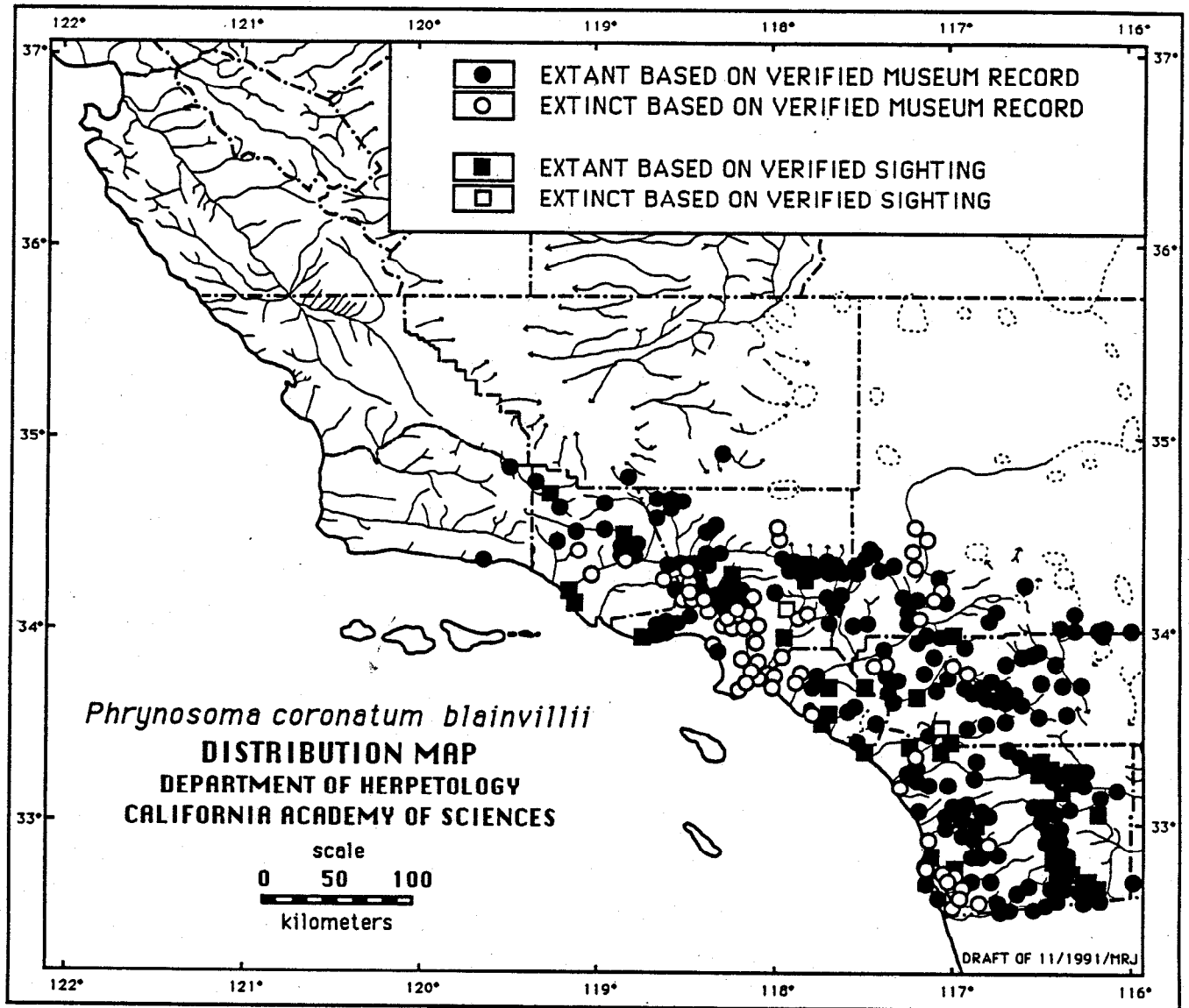
Figure 34. Historic and current distribution of the San Diego horned lizard (*Phrynosoma coronatum blainvillii*) in southern California based on 610 locations from 1054 museum records and 109 records from other sources.

During the warmest part of the day, *P. c. blainvillii* covers itself with loose soil by literally "swimming" into the substrate (Stebbins 1954b). San Diego horned lizards often display high site fidelity because effective temperature regulation requires familiarity with their surroundings (Heath 1965). In the later afternoon, individuals re-emerge from the substrate and resume full activities. The sequence of morning behavior is repeated in reversed order prior to when individuals rebury themselves in the substrate for the night. San Diego horned lizards do not voluntarily expose themselves to temperatures over 40°C for extended periods (Cowles and Bogert 1944, Brattstrom 1965; contra to Hager 1992), the condition that probably limits the distribution of this taxon primarily to areas west of the deserts in southern California (Heath 1965).

San Diego horned lizards are oviparous and lay one clutch of 6-17 (average = 11-12) eggs each year from May through early July (Stebbins 1954b, Howard 1974, Goldberg 1983); no data exist suggesting that this taxon can produce more than one clutch per year. Incubation requires approximately 2 months and hatchlings first appear in late July and early August (Shaw 1952, Howard 1974, Hager 1992). Male and female *P. c. blainvillii* require 2 to 3 years to reach the minimum size for sexual maturity (ca. 73 mm SVL for males, ca. 76 mm SVL for females; Stebbins 1954b, Howard 1974; Pianka and Parker 1975, Goldberg 1983). Data on longevity in the wild are lacking, but adults are thought to be long-lived (> 8 yr: see Baur 1986). No data are available on density or colonization abilities. Hager (1992) presented limited information on the home range and movement ecology for *P. c. blainvillii* in western San Bernardino and Riverside counties, but resightings are so few that home ranges are likely to be severely underestimated and interpretation of the significance of movement patterns is equivocal.

San Diego horned lizards have an insectivorous diet that consists mostly of native harvester ants *(Pogonmyrmex* spp.: Ingles 1929, Pianka and Parker 1975) and do not appear to eat exotic Argentine ants (pers. observ.; see also Montanucci 1989) that have been introduced to the western United States and have replaced native ants over much of central and southern California (Ward 1987). Ants can make up over 90% of the diet items of *P. c. blainvillii* (Pianka and Parker 1975), but the diet of this taxon may vary considerably with locality since it is an opportunistic feeder that will eat other insects (especially termites, beetles, flies, wasps, and grasshoppers) when the latter are abundant (Stebbins 1954b, Miller and Stebbins 1964). Known predators of *P. c. blainvillii* include the Southern Pacific rattlesnake *(Crotalus viridis helleri),* striped racer *(Masticophis lateralis),* burrowing owl *(Athene cunicularia),* greater roadrunner *(Geococcyx californianus),* loggerhead shrike, American kestrel *(Falco sparverius),* prairie falcon *(Falco mexicanus),* badger *(Taxidea taxus),* and gray fox *(Urocyon cinereoargenteus;* Bryant 1916, Von Bloeker 1942, Klauber 1972, Eakle 1984), but a variety of other predators probably take San Diego horned lizards. The defense this taxon typically uses against an approaching predator is to depend on its cryptic appearance by remaining motionless and to make a rapid run for the nearest cover only if disturbed or touched (pers. observ.). Captured lizards will puff themselves up with air, presumably to appear larger and less wieldy to a predator (see Tollestrup 1981), and may squirt blood from a sinus located in the eyelid of each eye if roughly handled (Bryant 1911, Burleson 1942).

Habitat: The San Diego horned lizard is found in a wide variety of habitats including coastal sage, annual grassland, chaparral, oak woodland, riparian woodland, and coniferous forest (Grinnell and Grinnell 1907, Klauber 1939, Stebbins 1954b). The key elements of such habitats are loose, fine soils with a high sand fraction; an abundance of native ants or other insects; and open areas with limited overstory for basking and low, but relatively dense shrubs for refuge (pers. observ.). Historically, the San Diego horned lizard was most abundant in riparian and coastal sage habitats on the old alluvial fans of the southern California coastal plain (Grinnell and Grinnell 1907, Bryant 1911, Van Denburgh

1922a). In the foothill and mountain habitats covered with dense brush or other vegetation, San Diego horned lizards are largely restricted to areas with pockets of open microhabitat, a habitat structure that can be created by natural events such as fire and floods or human-created disturbances such as livestock grazing, fire breaks, and roads. Juvenile and adult *P. c. blainvillii* utilize the same general habitat, but oviposition and hibernation sites are unknown. This taxon is unable to survive in habitats altered through urbanization, agriculture, off-road vehicle use, or flood control structures (Grinnell and Grinnell 1907, Goldberg 1983, Jennings 1987c; pers. observ.).

Status: Threatened; the relatively specialized diet and habitat requirements, a high degree of site fidelity, and a defensive behavior based on crypsis make the San Diego horned lizard vulnerable. San Diego horned lizards seem to have disappeared from about 45% of its range in southern California; few populations are extant on the coastal plain where it was once common (Stewart in Bury 1972a; Hayes and Guyer 1981). This taxon was heavily exploited for the curio trade at the turn of the century (Tower 1902, Klauber 1939, Jennings 1987c), and later, by biological supply companies and the pet trade before commercial collecting was banned in 1981 (B. Brattstrom, J. Copp, and D. Morafka, pers. comm.). These factors, coupled with extensive habitat loss from agriculture and urbanization, have been the main reasons cited for the decline of this taxon (e.g., Jennings 1987c). Most surviving populations currently inhabit upland sites with limited optimal habitat (S. Goldberg and B. McGurty, pers. comm.). Many such sites occur on U. S. Forest Service lands that are marginally suitable. Under these conditions, populations of the San Diego horned lizard have become increasingly fragmented and have sustained the added stress of a combination of other factors that include fires, off-road vehicles, livestock grazing, pets (especially domestic cats), and various types of development. Perhaps the most insidious threat to the San Diego horned lizard is the progressive elimination of its food base by exotic ants that have invaded upland habitats. Argentine ants build nests in disturbed soils (such as around building foundations, roads, and landfills) and expand into adjacent areas, eliminating native ant colonies (Ward 1987; see also Nagano et al. 1981), as development continues. The defensive behavior of initially remaining immobile rather than fleeing makes San Diego horned lizards particularly vulnerable to capture by humans and domestic pets (Hayes and Guyer 1981), and to being killed by approaching vehicles. San Diego horned lizards do poorly in captivity without special care (Montanucci 1989), so captives have a low survivorship and few individuals, if any, are returned to the wild (B. McGurty, pers. comm.).

Management Recommendations: Comprehensive surveys that identify the best remaining habitat and largest extant populations of this taxon are needed in order to determine which areas should be protected from human disturbance as well as the many other factors that negatively affect San Diego horned lizards. Limited surveys and studies of the San Diego horned lizard are currently underway (Brattstrom 1990), but data are lacking to provide an understanding of the completion level of those surveys or the significance of the results (see Hager 1992). Existing surveys notwithstanding, much more extensivesurveys and studies of this taxon are needed. In particular, a more precise understanding of the negative effects of exotic organisms (especially ants and domestic cats) on horned lizard populations is urgently needed. Additionally, an understanding of the susceptibility of San Diego horned lizards to land-use practices potentially detrimental to its survival, such as livestock grazing, off-road vehicle use, and prescribed burning, is needed for management purposes. Proper management of this taxon also requires detailed studies of its movement ecology and colonization abilities. Although systematic revision of this taxon and its relatives based on morphology is currently underway, parallel studies using novel biochemical techniques are also needed to clarify the systematic status of *P. c. blainvillii*. In the absence of data from such studies, the vulnerability of San Diego horned lizards indicates that maximizing isolation from all aforementioned potentially negative

impacts is the best management option. That approach may be relaxed as new data from these studies becomes available.

CALIFORNIA HORNED LIZARD
Phrynosoma coronatum frontale Van Denburgh 1894

Description: A large (65-105 mm SVL), dorsoventrally flattened lizard with five (four large, lateral, sometimes curved, and one moderate-sized, median) backwardly projecting head spines; a large shelf above each eye terminating a backwardly projecting, spine-like, scale (postrictal); small, pointed rugose scales on the forehead (frontals); and two parallel rows of pointed scales fringing each side the side of the body (Reeve 1952, Jennings 1988c). No stripes radiate from the eyes (Stebbins 1985). The dorsal color is highly variable, but typically gray, tan, reddish-brown, or whitish, and usually resembles the prevailing soil color (Jennings 1988c). The venter is yellow to white with discrete, dark spots. The iris is black (pers. observ.).

Taxonomic Remarks: See taxonomic remarks under the *P. c. blainvillii* account. Characterization of genetic variation throughout the geographic range of *P. c. frontale* has never been attempted, and no other genetic data are available for this taxon.

Distribution: This California endemic originally had a spotty distribution from Kennett (now under Lake Shasta, Shasta County) southward along the edges of the Sacramento Valley into much of the South Coast Ranges, San Joaquin Valley, and Sierra Nevada foothills to northern Los Angeles, Santa Barbara and Ventura counties; California (Jennings 1988c; Figure 35). A disjunct locality at Grasshopper Flat near Medicine Lake (Siskiyou County) has been recorded (Banta 1962) as have several fine-scaled populations in the Shandon-Cuyama Valley region, Santa Barbara and San Luis Obispo counties, which have been mistakenly identified in Stebbins (1985) as *P. platyrhinos calidiarum* (S. Sweet, pers. comm.; pers. observ.). *Phrynosoma c. frontale* intergrades with *P. c. blainvillii* in southern Kern County and much of northern Santa Barbara, Ventura, and Los Angeles counties. The known elevational range for this taxon extends from near sea level at Monterey, Pacific Grove, and Seaside (Monterey County: Reeve 1952) to ca. 1980 m at Breckenridge on Breckenridge Mountain (Kern County: Van Denburgh 1922a).

Life History: Based on limited data, California horned lizards appear to have a life history very similar to the related San Diego horned lizard (see *P. c. blainvillii* account for comparison). *Phrynosoma c. frontale* have been observed to be active between April and October with activity being more conspicuous in April and May (Banta and Morafka 1968, Tollestrup 1981). Captive California horned lizards have been observed to copulate in late April and early May (Banta and Morafka 1968) while courtship activities have been noted in wild California horned lizards during April (Tollestrup 1981). Hatchlings first appear in July and August (Banta and Morafka 1968). Longevity in the wild is unknown, but captive *P. c. frontale* have been-maintained for over 8 years (Baur 1986). California horned lizards are recorded as preying on beetles and ants (Grinnell and Storer 1924), but probably take many other insects which ate seasonally abundant (Stebbins 1954b). Blunt-nosed leopard lizards *(Gambelia silus)* have been observed preying on California horned lizards (Montanucci 1965) at some sites, but not others (Tollestrup 1979). At sites where leopard lizards are not known predators, *P. c. frontale* may display aggressively at the latter and can displace it from basking sites (Tollestrup 1981). As for *P. c. blainvillii,* ejection of blood from its eyes is reported (Bryant 1911, Van Denburgh 1922a), probably as a defensive mechanism against potential predators.
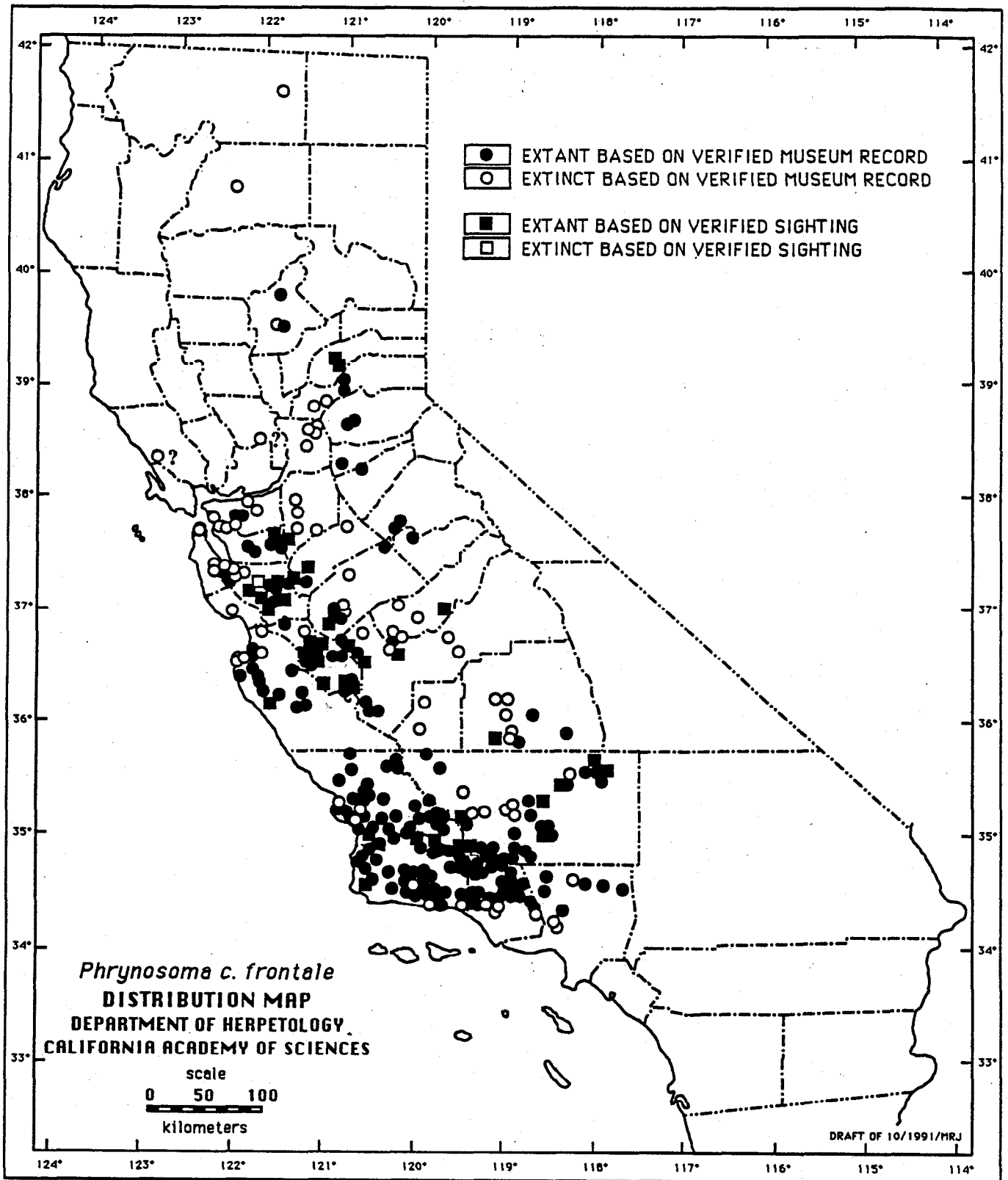
Figure 35. Historic and current distribution of the California horned lizard (*Phrynosoma coronatum frontale*) in California based on 640 locations from 979 museum records and 118 records from other sources.

Habitat: The California horned lizard seems to occur in several habitat types, ranging from areas with an exposed gravelly-sandy substrate containing scattered shrubs (e.g., California buckwheat; pers. observ.), to clearings in riparian woodlands (Stebbins 1954b), to dry uniform chamise chaparral (Banta and Morafka 1968) to annual grassland with scattered perennial seepweed *(Suaeda fruticosa:* Tollestrup 1981) or saltbush *(Atriplex polycarpa:* see Montanucci 1968; Tollestrup 1981) Montanucci (1968) indicates that *P. c. frontale* reaches it maximum abundance in sandy loam areas and on alkali flats, the latter often dominated by iodine bush *(Allenrolfea occidentalis).* The California horned lizard could apparently survive in vineyards, at least in the manner in which these were tended historically, because the typically sandy soil was suitable, the substrate was infrequently disturbed (Montanucci 1968), and probably because horned lizards could take refuge in the areas around the trunks of the perennial vines (see also *P. c. blainvillii* account). However, this is probably not the case today given the manner in which vineyards are currently tended because *P. c. frontale* is virtually never observed under such conditions. Historically, this taxon was identified as most abundant in relict lake sand dunes and old alluvial fans bordering the San Joaquin Valley (Bryant 1911, Van Denburgh 1922a). Zeiner et al. (1988) report that coast horned lizards utilize small mammal burrows or burrowed into loose soils under surface objects during extended periods of inactivity or hibernation, but data on over-wintering sites are fragmentary, and the general characteristics of overwintering sites are not well understood. Data on oviposition sites are unavailable.

Status: Threatened; *P. c. frontale* has disappeared from approximately 35% of its range in central and northern California and extant populations are becoming increasingly fragmented with continued development of the region. In the Central Valley, the conversion of a large percentage of the historical habitat of the California horned lizard from relict lake sand dunes and alluvial fans to agriculture (see Grinnell and Storer 1924), and to a lesser extent other development such as pipelines, canals, and roads, has resulted in the disappearance of this taxon from many areas. This activity continues and has been significantly extended into the surrounding foothills over the last 20 years as technological advances have allowed farmers to cultivate crops such as wheat *(Triticum aestivum),* grapes *(Vitis* spp.), and fruit orchards on increasingly steeper slopes previously only used for livestock grazing. Because the California horned lizard is probably long-lived, individuals may continue to be observed for some years along the fringes of agricultural developments. However, this lizard seems inevitably to disappear after several generations if the edge habitat is altered, or its food resources are reduced due to pesticides or habitat takeover by Argentine ants. Today, *P. c. frontale* remains abundant only in localized areas along the South Coast Ranges (e.g., Pinnacles National Monument, San Benito County), and in isolated sections of natural habitat remaining on the valley floor (e.g., Pixley Vernal Pools Preserve, Tulare County). The California horned lizard continues to be threatened by development in other parts of its range, especially near fast-growing hubs such as Bakersfield, Fresno, Modesto, and Sacramento. As more people move into the Sierra Nevada foothills below 1200 m, a trend that has been more pronounced in the last 15 years as more individuals have attempted to find a rural setting in which to settle, *P. c. frontale,* which has already relatively scattered populations in this region, can be expected to be more impacted there. The negative effects of human disturbance are not limited to the immediate vicinity of land disturbance or human habitation, sometimes effects are manifest at considerable distances (e.g., domestic cats have been observed to eliminate horned lizards within a several km^2 area from a cat's home base [G. Hanley, pers. comm.]).

Management Recommendations: Management recommendations for this taxon are parallel to those for *P. c. blainvillii* (see the previous species account). Comprehensive surveys of historical localities in the northern and Sierran slope portions of the range of this taxon urgently need to be conducted in April and May over several years to determine what

populations are still extant. Greater effort needs to be directed at preservation of remaining native plant community fragments, especially in the San Joaquin drainage basin, that contain habitat that has never undergone significant substrate disturbance.
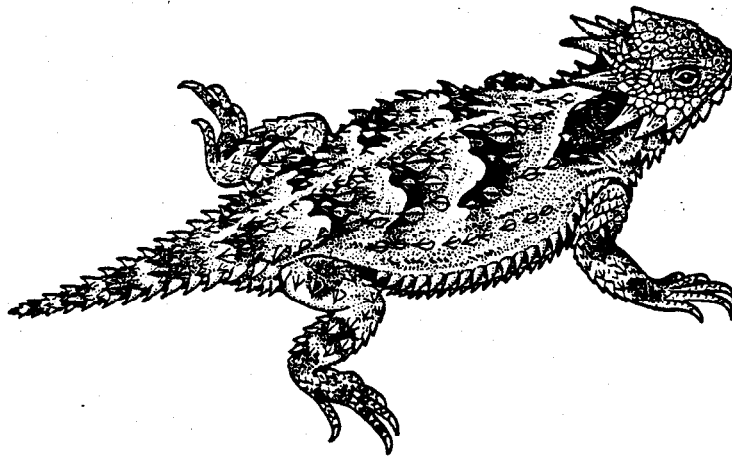
Plate 11. Adult coast horned lizard (*Phrynosoma coronatum*) [from Stebbins 1954b].

FLAT-TAILED HORNED LIZARD
Phrynosoma mcallii (Hallowell 1852)

Description: A moderated-sized (50.0-82.0 mm SVL), gray, tan, reddish-brown, or whitish horned lizard with a narrow middorsal stripe from the head to the base of the tail and a prominently dorsoventrally flattened tail (Funk 1981). The two largest (occipital) head spines are very long (3-4 times longer than their basal width) and do not contact each other at the base. Three shorter, lateral (temporal) spines are present on each side of the head. The undersurfaces are white without any markings or spots whatsoever. The iris color has not been described.

Taxonomic Remarks: The flat-tailed horned lizard is morphologically distinctive, it has not been confused with any other species of horned lizard, and it has not been partitioned infraspecifically (Funk 1981). No attempts have been made to characterize genetic variation across the geographic range of *P. mcallii.* An understanding of that variation is needed to determine whether a geographic pattern to genetic variation exists in this species.

Distribution: *Phrynosoma mcallii* occurs throughout most of the Colorado Desert, it extends from the north end of the Coachella Valley (Riverside County), California southward into northeastern Baja California, Mexico (Klauber 1932b), and eastward through southwestern tip of Arizona into Sonora, Mexico (Funk 1981). Its known elevational range extends from 52 m below sea level at Frink, Imperial County, California to ca. 300 m on Superstition Mountain (Imperial County: Funk 1981). In California, its range extends from central Riverside County southeast through most of Imperial County to the Mexican border (Figure 36). Flat-tailed horned lizards also enter extreme eastern San Diego County (Klauber 1932b).

Life History: *Phrynosoma mcallii* is a distinctive lizard with behavioral, morphological, and physiological features that allow it to survive in hot, dry environments with a sandy substrate. Its concealed tympanum; markedly dorso-ventrally flattened tail; distinctively pointed and sharply keeled scales just below its knees and just above its heels; and pale, reflective coloration are all features that facilitate its existence in hot, dry, sandy environments (Klauber 1939, Norris 1949; see also Stebbins 1944). *Phrynosoma mcallii* adults are obligate hibernators that. overwinter at 2.5-20 cm of depth in loose sand (Cowles 1941, Mayhew 1965b, Muth and Fisher 1992). While overwintering, flat tailed horned lizards have the ability to metabolize at a low rate during intervals when the temperature of the substrate in which they are located is relatively high. This feature of their physiology appears to be the result of overwintering sites often attaining high temperatures, and minimizes the probability that *P. mcallii* will deplete its stored energy reserves before spring emergence (Mayhew 1965b). Adult flat-tailed horned lizards emerge from overwintering sites relatively late in the spring season (April: Howard 1974; but see also Muth and Fisher 1992 who found lizards emerging in February and March in Imperial County); they emerge when substrate temperatures at a depth of 5 cm reach their voluntary minimum, which is relatively high (29.3°C: Cowles and Bogert 1044, Muth and Fisher 1992). Flat-tailed horned lizards display several behavioral and physiological traits that allow them to cope with the high temperatures regularly attained by the sandy substrate in which they live. They voluntarily maintain a higher body temperature when active (average = 37.8°C; n = 473) than most lizards (Mayhew in Pianka and Parker 1975; see also Brattstrom 1965), they orient relative to both the sun and the substrate depending on the temperature variation of each (Cowles and Bogert 1944, Heath 1965), and when sand surface temperatures reach or exceed 41°C, they avoid overheating by submerging themselves into the cooler subsurface sand by wriggling violently (Klauber 1930, Norris 1949). Female flat-tailed horned lizards lay clutches of 3-10 eggs in May (Norris 1949, Stebbins 1954b, Howard 1974), and may deposit a second clutch in favorable years
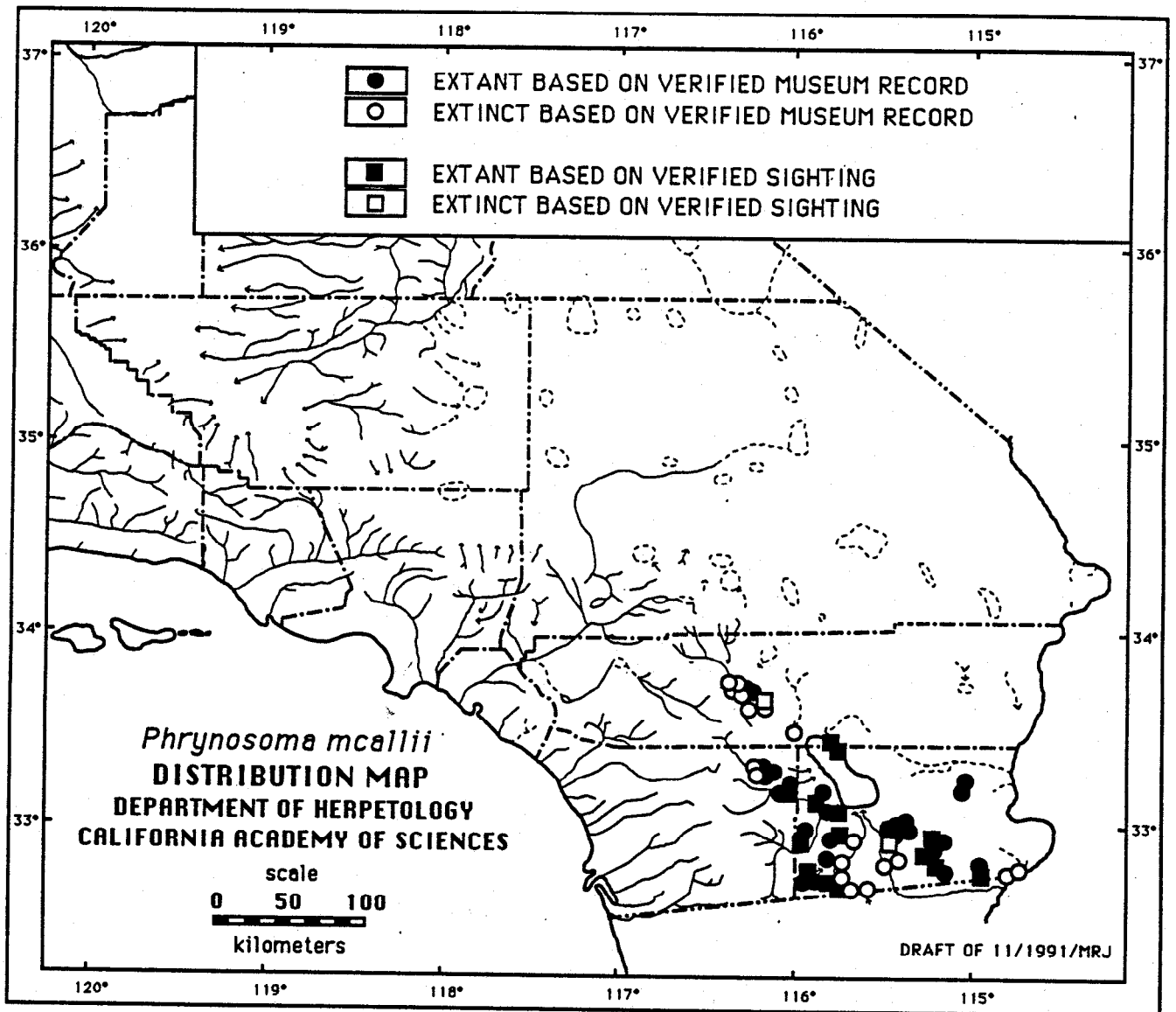
Figure 36. Historic and current distribution of the flat-tailed horned lizard (*Phrynosoma mcallii*) in southern California based on 149 locations from 200 museum records and 38 records from other sources.

(Turner and Medica 1982). Adults do not aestivate (Muth and Fisher 1992); the interpretation that adults aestivate (Howard 1974) was based on a biased sample from museums with no post-July collections of adults. The earliest clutches hatch in July, and hatchlings (34-38 mm SVL) emerge through September (Howard 1974, Turner and Medica 1982, Muth and Fisher 1992). Juveniles from early clutches can grow rapidly, reaching 54-64 mm SVL by October, and may reproduce in their first season after hibernation, where juveniles from late clutches likely have to wait until their second season to reproduce (Howard 1974, Muth and Fisher 1992). Females are probably not sexually mature until around 12 months of age (Muth and Fisher 1992; *contra* the Turner and Medica (1982) finding of 20 months of age). Longevity for the flat-tailed horned lizard is unknown. *Phrynosoma mcallii* is a dietary specialist that consumes mostly ants (Norris. 1949, Pianka and Parker 1975; Turner and Medica 1982). In the one study where ants were identified, the majority (> 80%) of ants consumed were three species of harvesters *(Veromessor pergandei, Pogonomyrmex californicus,* and *P. magnacanthus)* and *Conomyrma* sp. (Turner and Medica 1982). Juveniles of *P. mcallii* are known to be preyed upon by sidewinders *(Crotalus cerastes:* Funk 1965), while all age classes are subject to predation by round-tailed ground squirrels *(Spermophilus tereticaudus),* loggerhead shrikes, American kestrels, common ravens *(Corvus corax),* coyotes, and kit foxes *(Vulpes macrotis:* Muth and Fisher 1992, Duncan et al. 1994). Flat-tailed horned lizards are also killed by off-road vehicles and automobiles on paved roads (Muth and Fisher 1992; pers. observ.). *Phrynosoma mcallii* typically escapes its predators by initially fleeing a short distance, invariably diving into the sand, and subsequently remaining immobile (Klauber 1939, Norris 1949). According to Turner and Medica (1982), adult males occupied home ranges averaging nearly 1,287 m^2, whereas females occupied home ranges averaging less than half that size (509 m2). More recently, estimates obtained with radio telemetry indicate home ranges over an order of magnitude larger (averaging 17,894 m^2 for adult males and 19,703 m^2 for females; Muth and Fisher 1992). The large discrepancy probably results from the fact that the Turner and Medica (1982) data seriously underestimate home range size because of the much lower number of captures.

Habitat: *Phrynosoma mcallii* is a specialized sand-dweller that has not been observed outside of areas with a shifting sand substrate (Norris 1949), areas in which it is known to forage (Turner and Medica 1982), and overwinter (Mayhew 1965b). It requires fine, wind-blown (aeolian) sand deposits and has been recorded in several vegetative associations where such a substrate is present, including those where creosote bush, burro weed *(Franseria dumosa),* bur-sage *(Ambrosia dumosa),* and indigobush *(Psorothamnus emoryi)* are abundant (Norris 1949, Turner and Medica 1982, Muth and Fisher 1992). It seems to be more abundant in associations where plants large enough to form nuclei for sand accumulations are present (Norris 1949), and a strong, positive correlation (r = 0.93) between the abundance of *P. mcallii* and the total density of perennial plants has been identified (Turner and Medica 1982). Muth and Fisher (1992) related the preference of flat-tailed horned lizard for bur-sage and indigobush to the fact that both species are low growing, densely branched shrubs with multiple branching at the crown, a growth habit that permits it to accumulate more sand at the base than co-occurring single-stemmed species, and provide more shade than other co-occurring multi-stemmed species (e.g., creosote bush). These relationships may be a function of vegetation being important for oviposition sites, which have never been identified, but are likely to be located next to clumps of vegetation because the vegetation tend to stabilize shifting sand, which may be important to the stability of a nest site. High lizard abundance has also been generally associated with high abundances of harvester ants (Turner and Medica 1982).

Status: Threatened; historically, this lizard was never a common species (Klauber 1939, Norris 1949), but the observations of Wilbur W. Mayhew in the early 1960s first gave rise

to concerns that this species might be declining. Stewart (1971) and others repeating Mayhew's earlier concern regarding the status of *P. mcallii* because of increased use and development of desert areas in Riverside and Imperial counties in the late 1960s and early 1970s led to the Office of Endangered Species (United States Fish and Wildlife Service) designating *P. mcallii* as a species that should be reviewed (Turner et al. 1980; see also Johnson and Spicer 1985). This action ultimately led to the Bureau of Land Management supporting investigations of the status of *P. mcallii* in California (Turner and Medica 1982; see also Turner et al. 1980 and Rado 1981). Based on their surveys, Turner and Medica (1982) concluded that *P. mcallii* was not endangered, but they noted that, "While *P. mcalli[i]* still exists comfortably in parts of its geographic range, it is rapidly disappearing in others. For example, areas developed in Riverside County and in the south-central portion of Imperial County are no longer inhabited by *P. mcalli[i]....Perhaps* the most dramatic change in apparent abundance of *P. mcalli[i]* has occurred along the 11-km stretch of California Highway 78 west of the Algodones Dunes....over 500 *P. mcalli[i]* were captured or observed dead along this road between 1961 and 1964. But our research in 1978 and 1979 showed *P. mcalli[i]* to be uncommon in this area." Turner and Medica (1982) also indicated that an exhaustive analysis of how present and projected land used in southeastern California showed that about 52% of the estimated geographic range of *P. mcallii* in California (ca. 7,000 km^2) was within areas subjected to one or more use-oriented activities (e.g., agriculture; sand and gravel quarries; off-road-vehicle "parks"; approved oil, gas, and geothermal leases). On 20 January 1986, Barbara A. Carlson and Wilbur W. Mayhew submitted a well-supported petition to the California Fish and Game Commission to have *P. mcallii* listed as Endangered (see Carlson and Mayhew 1986). The significant data in that petition consisted of a resampling of sites that Turner and Medica (1982) had discussed; the data presented by Carlson and Mayhew indicate a significant reduction in the relative abundances of *P. mcallii* from the data presented by Turner and Medica (1982). As required by Section 2074.6 of the Fish and Game Code, Betsy C. Bolster and Kimberly A. Nicol (California Fish and Game staff) rewrote the Carlson-Mayhew document as a status report and suggested that *P. mcallii* be listed as Threatened (see Bolster and Nicol 1989). Based on aerial photographs, our current assessment is that about 70% of the range of *P. mcallii* is impacted by one or more of the uses discussed by Rado (1981), and that flat-tailed horned lizards have been eliminated entirely from roughly 30% of this historic range. These data coupled with the trends indicated by the aforementioned reports strongly justify listing this species as Threatened. The defensive behavior of *P. mcallii* making it particular susceptible to injury by off-road vehicles (Muth and Fisher 1992; see also Collins 1988) and the fact that off-road vehicle use continues at high levels over much of the region where this taxon occurs (Bury and Luckenbach 1983, Turner et al. 1984) make *P. mcallii* especially susceptible to mortality from this source, whether it be accidental or the result of clandestine activity. The new home range data of Muth and Fisher (1992) also indicate that *P. mcallii* may be much more susceptible to habitat disturbance than previously thought.

Management Recommendations: While the life history of *P. mcallii* is understood in a general way, understanding of its movement ecology, its recolonization potential, and the variation in its nesting sites are essential to future management recommendations. Current understanding of the population dynamics and recolonization potential of *P. mcallii* is too poor to ignore taking significant action now. Two-year life history studies by Muth and Fisher (1992) have assisted in understanding part of the aforementioned aspects of the life history of *P. mcallii,* but they need to be continued for at least another 10 years to determine long-term trends for this taxon. In addition, surveys discussed by Carlson and Mayhew (1986) on the permanent plots established by Turner and Medica (1982) need to be continued on a yearly basis and their geographic scope extended. The recent petition to list this species as threatened was rejected by the Commission based on insufficient

information (Muth and Fisher 1992). Efforts should be made to regularly collect the data upon which a sufficient-data Commission decision can be based. A more precise understanding of how this species responds to off-road vehicles is especially needed. The dynamics of aeolian sand habitats and adjacent habitats needs to be better understood so that these areas can be appropriately managed to ensure the survival of the flat-tailed horned lizards.

COLORADO DESERT FRINGE-TOED LIZARD
Uma notata notata Baird 1858

Description: A moderate-sized (69.0-121 mm SVL), pale-colored lizard with a dorsal reticulum of black-bordered pale spots with red centers (ocelli: Norris 1958, Stebbins 1985). Ocelli tend to form broken lines that extend the length of the body. Undersurfaces are white except for "chevron-like" diagonal dark lines on the throat, dark bars on the tail, and a single dark spot or bar on each side of the belly (Stebbins 1954b). The side of the belly around each dark spot or bar has a permanent orange or pinkish stripe, colors which may be more vivid during the breeding season (Norris 1958). The iris is black.

Taxonomic Remarks: The taxonomic status of *Uma notata notata* is controversial. Heifetz (1941) differentiated this taxon morphologically from the remaining two of the three members of the genus *Uma* in California *(U. inornata* and *U. scoparia)* based on characters that seem to be variable at a population level (Norris 1958, Mayhew 1964a). These data lent support to the earlier suggestion that all three California taxa represent one species (Stebbins 1954b). Based on behavioral data, Carpenter (1963) regarded two of the three taxa, *U. notata* and *U. inornata,* as subspecies of the former, but accorded *U. scoparia* specific rank. This pattern of allocation creates a historical unit, the *U. notata* and *U. inornata* cluster, that is nonsense (a paraphyletic group) based on genetic data (Adest 1977). The low level of geneticdifferentiation between the three California taxa (Adest 1977) seems to support the suggestion that all three taxa should be considered one species (e.g., Collins 1990). However, the genetic comparison was based on a small number of allozymes and only one sample of each of the three currently recognized members of the genus *Uma* in California. Moreover, morphological and genetic analyses have not been coupled, so it is impossible make a sound systematic determination with such non-parallel data. Comprehensive assessment of genetic variation across the range of *U. notata* and potentially conspecific populations now recognized under other names is needed. Such an assessment should be coupled to a morphological analysis of those same populations. This analysis is of some significance because the potentially conspecific population system currently recognized under the name *U. inornata* is presently listed as being Federally Endangered.

Distribution: This taxon is thought to be distributed from northeast of Borrego Springs (northeast San Diego County) westward to the Colorado River and southward into Baja California (Mexico) at a latitude roughly due west of the mouth of the Colorado River. Heifetz (1941) allocated populations of *Uma* in the Gila drainage (Arizona) to this taxon, but Norris (1958) restricted *U. n. notata* to populations west of the Colorado River. Its known elevational ranges extends from below sea level at -74 m (at the edge of the Salton Sea, Imperial County: Norris 1958) to ca. 180 m (northeast of Borrego Springs, San Diego County). In California, its range extends from northeastern San Diego County through the southern two-thirds of Imperial County to the Colorado River (Pough 1977: Figure 37). We caution that because of the difficulties with this taxon noted above, the distribution we provide here is based entirely on the most recent assessment by previous workers. Verification of the distribution of this taxon will require the systematic analysis we have indicated.
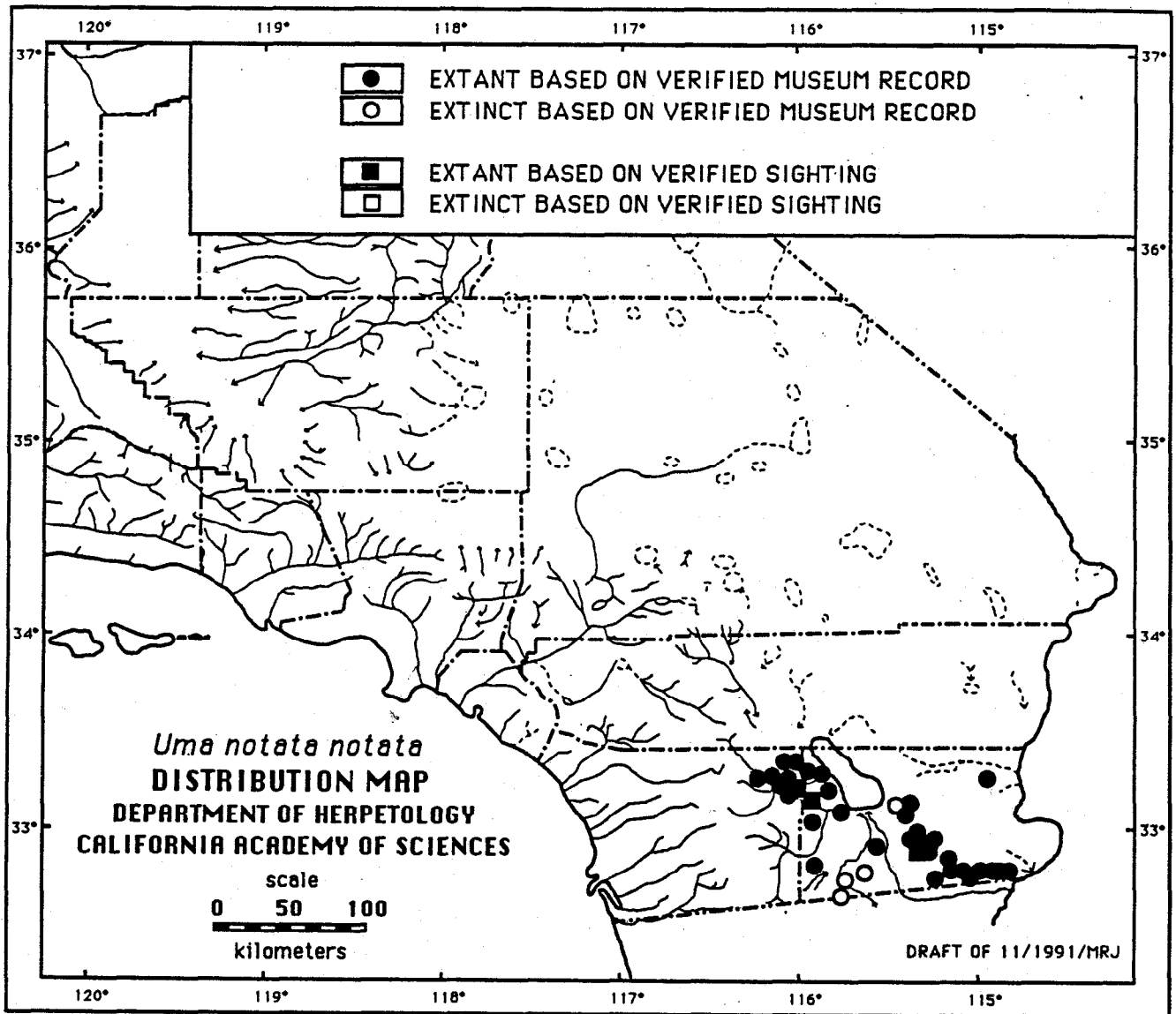
Figure 37. Historic and current distribution of the Colorado Desert fringe-toed lizard (*Uma notata notata*) in southern California based on 143 locations from 451 museum records and 7 records from other sources.

Life History: *Uma n. notata* is a distinctive lizard that is behavioral, morphologically, and physiologically specialized for living in hot, dry, sandy habitats. Its dorso-ventrally flattened body shape, concealed eardrum (tympanum), fringed toes, distinctive pointed and keeled scales below the knee and above the heel, nasal valves, and pale dorsal coloration are all features that facilitate its survival as a sand-dwelling lizard (Stebbins 1944, Norris 1958, Pough 1970; see also Stebbins 1948). Experiments have shown that the fringed toes, the namesake from which the genus to which *Uma* derives its common name, significantly assist movement on shifting sand (Carothers 1986). Adults of *U. n. notata* overwinter at moderate depths (ca. 30 cm) in sand (Cowles 1941), but smaller individuals may remain active throughout the year (Deavers 1972). Colorado Desert fringe-toed lizards do not emerge until substrate temperatures reach at least 26°C (Cowles and Bogert 1944), which typically results in their emerging for overwintering sites in late March or early April. *Uma n. notata* displays several behavioral and physiological traits that allow them to cope with the high temperatures regularly attained by the sandy substrate in which they live. They voluntarily maintain a higher body temperature when active (39.9°C) than most lizards (Deavers 1972); they orient relative to both the sun and the substrate depending on the temperature variation of each (Cowles and Bogert 1944); when sand surface temperatures reach or exceed 43°C, they submerge themselves into the cooler subsurface sand by wriggling violently to avoid overheating (Stebbins 1944, Norris 1958); and they exhibit other physiological features that allow them to cope with this extreme environment (Pough 1969a, Deavers 1972). In addition, *U. n. notata* displays coupled behavioral and morphological features that assist in undersand breathing (Pough 1969b). Adults probably typically mate in May, and females typically deposit clutches containing two eggs from late May to early August (Mayhew 1966). Females may lay more than one clutch per year, but adults are sensitive to food levels and will not reproduce if they do not obtain adequate food (Mayhew 1966). Since insect productivity is directly related to annual rainfall, lizards probably have a significantly depressed reproductive output in years with low rainfall. The known predators of *U. n. notata* are badgers, glossy snakes *(Arizona elegans),* sidewinders, coachwhips, loggerhead shrikes, roadrunners, and coyotes (Stebbins 1944). *Uma n. notata* employs an escape behavior similar to its thermoregulatory behavior, it initially flees from a predator to a reasonably safe distance and then buries itself in the sand (Stebbins 1944).

Habitat: *Uma n. notata* is a habitat specialist that is totally restricted to habitats of aeolian sand (Norris 1958). Aeolian sand in which *U. n. notata* can be found has a grain size typically no coarser than 0.375 mm in diameter (averages 0.205 mm in diameter). As with *U. inornata* (Turner et al. 1984), increased sand penetrability (i.e., how easy the sand is to burrow into), is probably an important factor constraining the local distribution of *U. n. notata* The dominant plant in the associations in which *U. n. notata* is found include the following perennial shrubs: burro weed, creosote bush, croton *(Croton wigginsii),* desert buckwheat *(Eriogonum deserticola),* honey mesquite *(Prosopis glandulosa),* mormon tea *(Ephedra californica),* and the composite *(Helianthus tephrodes),* none of which occur in very high density, giving the habitat an open sparse appearance (Stebbins 1944, Norris 1958, Mayhew 1966). Burrowing in sand on the lee side of desert shrubs has been noted by several authors (Stebbins 1944, Norris 1958), a selection that may be influenced by the differences in penetrability and grain size of the sand in those locations (see Turner et al. 1984). The location of oviposition sites is unknown, but they may be located at the base of perennial plants (see the flat-tailed horned lizard *(Phrynosoma mcallii)* account).

Status: Special Concern; although this species has a reasonably broad range in California, it is vulnerable because of its specialization for fragile sandy habitats that have been heavily impacted by off-road vehicles in the last 20 years (Busack and Bury 1974, Bury and Luckenbach 1983, Luckenbach and Bury 1983, Maes 1990). Although probably not as vulnerable as *P. mcallii,* most of the comments made under the status section for that

species also apply to *U. n. notata.* The escape behavior of *U. n. notata* makes its vulnerable to injury from off-road vehicles, which continue to be used at high levels over the range of *U. n. notata* (Maes 1990, King and Robbins 1991b). As demonstrated for *U. inornata,* the surface stabilization and sand depletion that occur as a result of the placement of windbreaks (e.g., rows of salt cedar: Turner et al. 1984) and probably other structures, an increasing phenomenon over the range of *U. n. notata,* threatens to continue to decrease the amount of habitat available for this taxon.

Management Recommendations: Much of the ecology of *U. n. notata* is reasonably well-known, but several key aspects are not. In particular, the location of oviposition sites and the variation in their location, the movement and recolonization abilities of this taxon, and a better understanding of variation in habitat suitability with the vegetation association and the specific species consumed in the diet. Additionally, regular annual surveys conducted at fixed locations and at identical diel and seasonal intervals are needed to track long-term trends in this species (see Maes 1990). Sweeps surveys to estimate sand lizard track densities (see England and Nelson 1977) need further evaluation as a survey method. Long-term data are particularly important to couple to any measurements of habitat change for management purposes. Emphasis on preservation of large, unobstructed expanses of aeolian sand habitat is needed. The dynamics and variation in the natural maintenance of such habitats is poorly understood, and urgently needs study before definitive management recommendations regarding the size of areas needed for long-term persistence of this taxon.

MOJAVE FRINGE-TOED LIZARD
Uma scoparia Cope 1894

Description: A moderate-sized (69.0-112.0 mm SVL), pale-colored lizard with a dorsal reticulum of black-bordered spots with red centers (ocelli: Norris 1958, Stebbins 1985). Ocelli are irregularly arranged over the back. Undersurfaces are white except for crescent-shaped dark marking on the throat, dark bars on the tail, and a single, prominent dark spot on each side of the belly (Norris 1958). During breeding, a yellow-green ventral wash develops that becomes pink on the side of the body (Stebbins 1985). The iris is black.

Taxonomic Remarks: Remarks made regarding the taxonomic status of *Uma notata notata* generally also apply to *Uma scoparia.* It needs emphasis that determination of the systematic status of *U. scoparia* cannot be made without a comprehensive assessment of genetic variation across its range coupled to a morphological analysis of those same populations.

Distribution: The known distribution of this near-endemic to California extends from extreme southern Inyo County (Norris 1958) through most of San Bernardino County and barely into the northeast comer of Los Angeles County southward and eastward through the eastern half of Riverside County to the vicinity of Blythe (Figure 38). A single record exists for Parker, Yuma County, Arizona (Pough 1974). Its known elevational range extends from below sea level to ca. 1000 m in the vicinity of Kelso (San Bernardino County).

Life History: Many of the generalized comments that apply to the genus made in the *U. n. notata* account also apply to this species. *Uma scoparia* is sand-dwelling specialist that inhabits similar environments utilized by *U. notata* (Stebbins 1944, Norris 1958). Lizards emerge from hibernation sites in late March or early April (Mayhew 1964b). Adults begin to exhibit breeding colors during April and breeding continues through July (Norris 1958). Males actively defend territories against other rival males in addition to courting females. Females also maintain territories, but they do not show any aggression against other individuals (Kauffman 1982). Home ranges for adult males are estimated to average 0.10 ha, while home ranges for adult females averaged 0.034 ha and overlapped the territories of adult males (Kauffman 1982). Females deposit from 2-5 (average = 2-3) eggs in sandy hills or hummocks during the months of May through July (Stebbins 1954b, Kauffman 1982). Some adult females produce more than one clutch of eggs a year. Hatchlings first appear by September (Miller and Stebbins 1964), and grow rapidly over the next 2 years. Most males and females teach sexual maturity (70 mm and 65-70 mm SVL, respectively) two summers after hatching. Juveniles do not defend territories until they become subadults. Juveniles eat largely arthropods and only a small amount of plant material; in contrast, adult *U. scoparia* consumed more plant material than arthropods (Minnich and Shoemaker 1970, 1972). Foods consumed by these opportunistic feeders include dried seeds, grasses, ants, beetles, scorpions (Scorpionida), and occasionally conspecifics (Miller and Stebbins 1964, Minnich and Shoemaker 1970, 1972). Both juveniles and adults have daily activity patterns that are temperature dependent. From April to May, lizards are active during the mid-day. From May to September, they move about in the mornings and late afternoons, but retreat underground when temperatures are high (Miller and Stebbins 1964). Hibernation occurs from November to February (Mayhew 1964b). Known predators are the same animals listed for *U. n. notata* (see previous account), plus the burrowing owl (Miller and Stebbins 1964) and leopard lizard *(Crotaphytus wislizenii:* Gracie and Murphy 1986).

Habitat: The habitat characteristics of *U. scoparia* are essentially identical to those for *U. n. notata* except that some of the vegetation associates will differ because the range of the
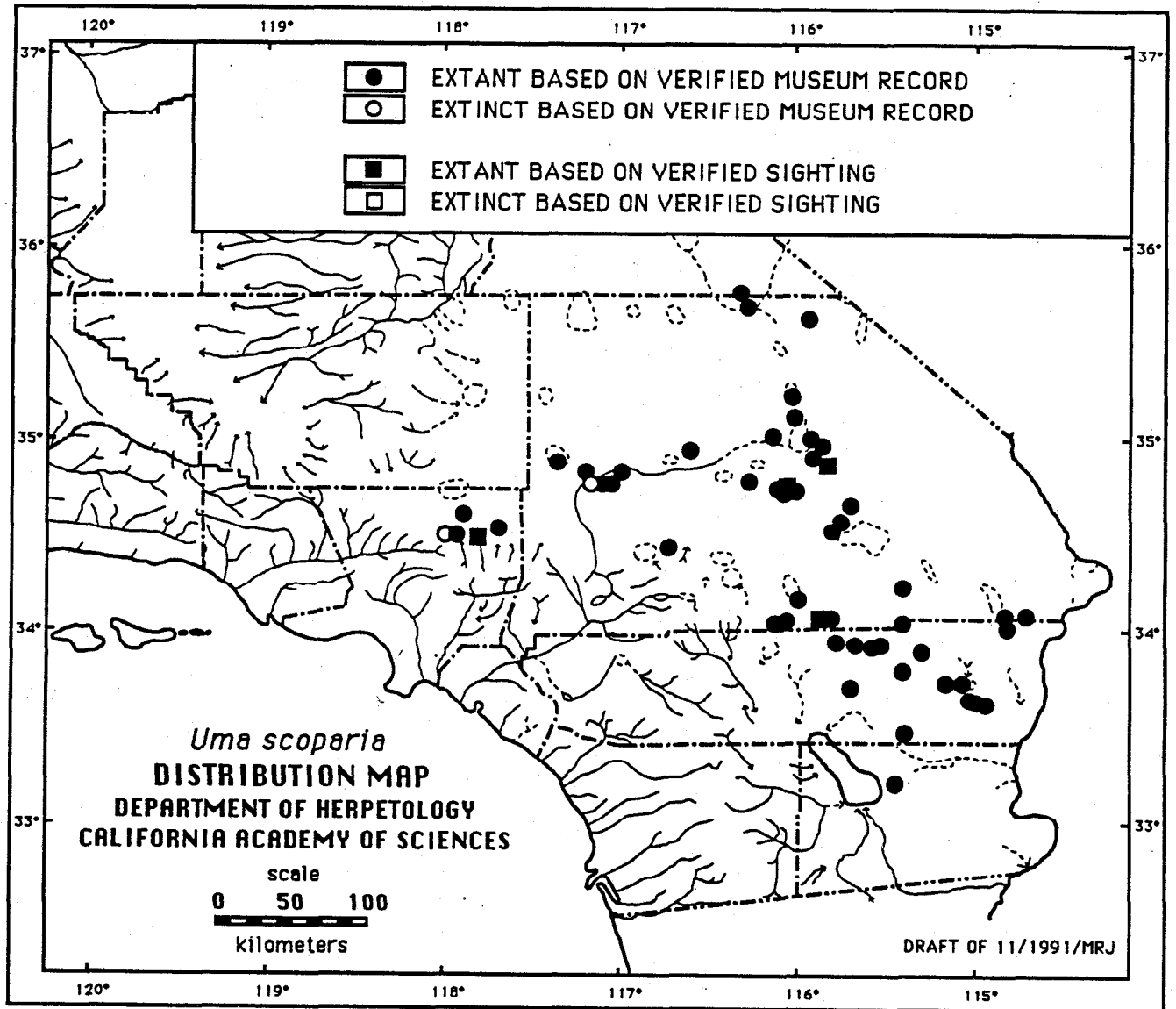
Figure 38. Historic and current distribution of the Mojave Desert fringe-toed lizard (*Uma scoparia*) in southern California based on 140 locations from 599 museum records and 8 records from other sources.

former is largely the Mojave desert region in California. The habitat section of the *U. n. notata* account should be referred to. Throughout most of its range, *U. scoparia* is found in creosote bush scrub (Kauffman 1982).

Status: Special Concern; most of the comments made for *U. n. notata* also apply to this species, although the importance of major impacts differ somewhat. Off-road vehicles seems to be the more important impact over most of the range of *U. scoparia,* whereas the influence of development is currently really significant in the western Mojave desert Several towns in the western Mojave (e.g., Hesperia, Lancaster, Palmdale, and Victorville) have sustained extraordinary levels of growth (up to over an order of magnitude) over the last 15 years. This level of growth has not only fragmented desert habitat, but markedly increased the local use of adjacent desert areas. The increase in landfills associated with such growth has resulted in a marked increase in selected generalized predators (e.g., common ravens; see King and Robbins 1991b and Camp et al. 1993), which are implicated in recruitment declines in other species such as desert tortoises (U.S. Fish and Wildlife Service 1990). Such predators may have similar negative effects on the Mojave fringe-toed lizard (King and Robbins 1991b).

Management Recommendations: Most of the comments made for *U. n. notata,* except that regarding oviposition sites, also apply to this species. The ability of fragments of sandy desert habitat to sustain populations of the Mojave fringe-toed lizard over the long-term needs to be determined. It is unclear what sort of use and what intensity of use desert habitats can sustain and still maintain Mojave fringe-toed lizards; Additionally, it needs to be determined whether the generalized predators currently on the increase have any significant effect on the recruitment or survivorship of Mojave fringe-toed lizards.

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SANDSTONE NIGHT LIZARD
Xantusia henshawi gracilis Grismer and Galvan 1986

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Description: A medium-sized (50-70 mm SVL), narrow-waisted, soft-skinned lizard with fine, granular scales; a flattened head; an enlarged temporal scale; gular folds; lidless eyes; and vertical elliptical pupils (Grismer and Galvan 1986). The dorsoventrally flattened, slender body is covered with a dense pattern of reduced dark brown spots on a light colored background (Grismer and Galvan 1986). The venter is white with minute amounts of black peppering present only on forepart of the body (Grismer and Galvan 1986). The iris is dark brown with dense iridiophores split by a vertical eye stripe (pers. observ.).

Taxonomic Remarks: This recently described night lizard is considered morphologically (Grismer and Galvan 1986) and biochemically distinct (Bezy and Sites 1987) from the granite night lizard *(X. h. henshawi).* Analysis of genetic variation across its highly restricted known geographic range has not yet been attempted.

Distribution: The known range of this California endemic is confined to the Truckhaven Rocks, a 1.3-km wide x 3-km long outcrop in the eastern part of Anza-Borrego State Park (Figure 39). The known elevational range of the sandstone night lizard extends from 240 m to 305 m.

Life History: Virtually nothing is known of sandstone night lizard life history. The morphology of *X. h. gracilis* is thought to facilitate survival in sandstone and mudstone habitat, a rocky substrate that undergoes constant local erosion (Grismer and Galvan 1986). These authors speculate that it may be excluded by other saxicolous lizards (e.g.
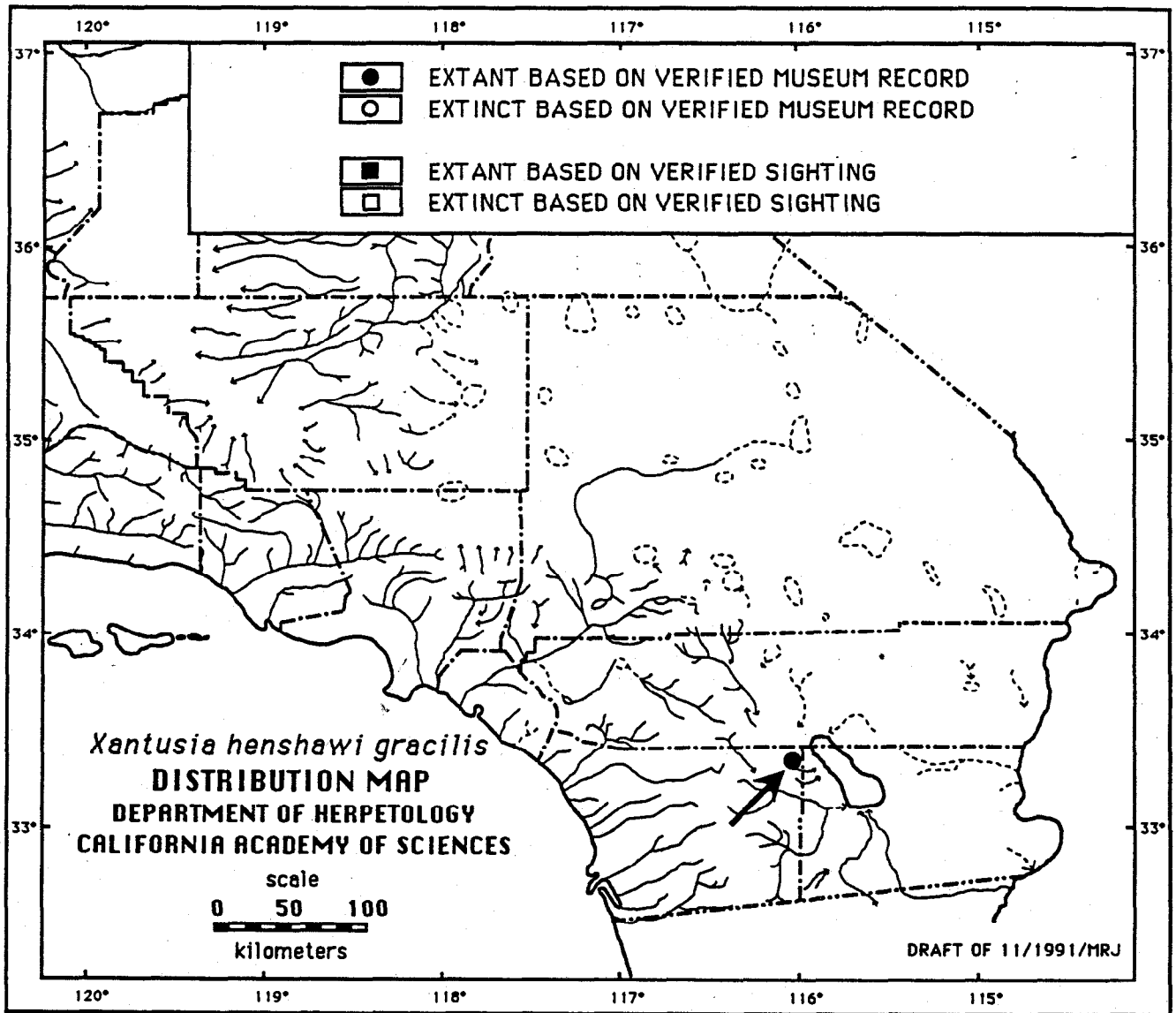
Figure 39. Historic and current distribution of the sandstone night lizard (*Xantusia henshawi gracilis*) in southern California based on 1 location from 28 museum records.

Phyllodactylus xanti) that occur in less erosive, rocky habitats, but the other saxicolous species may simply do poorly in that habitat type whether or not *X. h. gracilis* is present.

If similar in life history to the related granite night lizard *(X. h. henshawi),* it bears one or two live young annually (Brattstrom 1951, Lee 1975), it has a low metabolic rate (Mautz 1979), it is active over a relatively low range of temperatures (Lee 1975), it has an insectivorous diet (Brattstrom 1952), and it is probably relatively sedentary (see summary in Bezy 1988). Based on four captive specimens, *X. h. gracilis* may be more nocturnal than the relatively diurnal or crepuscular *X. h. henshawi* (compare Grismer and Galvan 1986, with Lee 1974, and Mautz and Case 1974).

Habitat: The sandstone night lizard is entirely confined to a substrate of eroded sandstone and mudstone (or siltstone) in Truckhaven Rocks (Grismer and Galvan 1986). It is found in fissures or under slabs of exfoliating sandstone and rodent burrows in compacted sandstone and mudstone. This taxon seems to be locally abundant rather than evenly distributed within its habitat (Grismer and Galvan 1986). The physical characteristics of the refuge sites it prefers have not been examined.

Status: Special Concern; because of its highly restricted geographic range, this taxon is susceptible to local-scale catastrophic effects. Proximity to an access road and the relatively fragile nature of its sandstone or mudstone substrate makes this lizard vulnerable to illegal collection and habitat destruction.

Management Recommendations: Human access to the sandstone habitats where these lizards are found should be restricted. Specifically, the access road to the Truckhaven Rocks and adjacent calcite mine area should be closed and the nearby parking should be relocated further from the habitat this lizard occupies. Limiting access should simplify enforcement for Anza-Borrego State Park personnel. Further, field surveys for other possible populations of this taxon should be conducted in habitat identified as potentially suitable in the southern part of the Santa Rosa Mountains. The basic life history of this taxon needs study.

SIERRA NIGHT LIZARD
Xantusia vigilis sierrae Bezy 1967

Description: A small (40-51 mm SVL), slim velvet-skinned lizard with fine, granular scales; gular folds; lidless eyes; and vertical elliptical pupils (Stebbins 1985). A broad, postorbital light stripe is present on either side of the head; 40 to 44 scale rows are present across the back; the spotting on the back forms an interconnected, dark network; and 10 to 12 femoral pores are present on the hindlimbs (Bezy 1967a, 1967b, 1982). The head tends to be longer and broader than in other desert night lizards in California (Bezy 1967b). The iris is dark brown with fine iridophores split by a vertical eye stripe (pers. observ.).

Taxonomic Remarks: A rock-dwelling night lizard that is morphologically differentiated from *Xantusia v. vigilis* typically found in yucca *(Yucca* spp.) woodlands (Bezy 1967a, 1982).

Distribution: This California endemic is found only on the western edge of the Greenhorn Mountains within a few dozen kilometer radius of Granite Station, Kern County (Figure 40). The known elevational range of this taxon falls between 450 m and 500 m. *Xantusia v. sierrae* may intergrade with *X. v. vigilis* in the Greenhorn Mountains along the eastern edge of its range (Bezy 1967a; B. Bezy, pers. comm.).
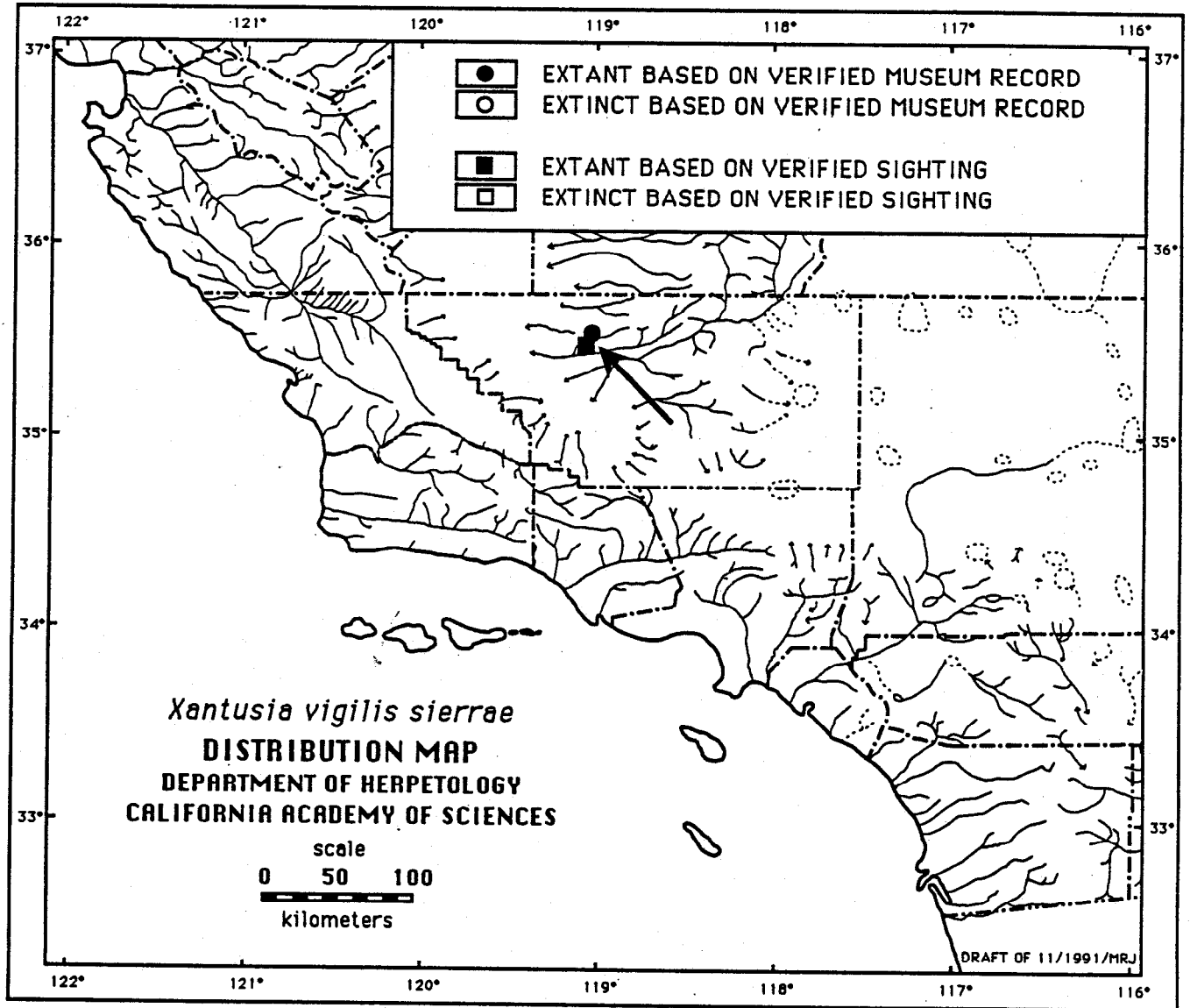
Figure 40. Historic and current distribution of the Sierra night lizard (*Xantusia vigilis sierrae*) in southern California based on 9 locations from 82 museum records and 4 records from other sources.

Life History: *Xantusia v. sierrae* exhibits a morphology somewhat convergent with the granite night lizard, a highly specialized rock-crevice dweller (Bezy 1988), but virtually nothing is known of its life history. If the life history of the Sierra night lizard is similar to that of other night lizards on mainland California; Sierra night lizards are sedentary, they exhibit a low metabolic rate, they are active over a low range of temperatures, they grow slowly for their size (2-3 years to reach sexual maturity), they bear live young, and they are probably long-lived (see Miller 1951; Brattstrom 1951, 1965; Zweifel and Lowe 1966; Bezy 1988; Mautz 1979). If reproduction and diet in the Sierra night lizard is similar to the related *X. v. vigilis,* it likely bears one or two young annually (see Miller 1954, Zweifel and Lowe 1966), and have an ant-dominated insectivorous diet (see Brattstrom 1952). If similar to the granite night lizard in its pattern of activity, the Sierra night lizard is probably largely diurnal and crepuscular (see Mautz and Case 1974; see also Bezy 1988).

Habitat: All Sierra night lizards have been found under exfoliating granite caps and flakes in outcrops of Cretaceous age. *Xantusia v. sierrae* seems to prefer larger (8-15 cm thick, 61-92 cm long) horizontal caps rather than thinner spalls or flakes, which are numerous on vertical surfaces (Bezy 1967a). Outcrops are often represented by small groups of boulders within areas of clay soils having an open grassland or oak woodland vegetation. For reasons that are unclear, but perhaps related to predator access, single boulders or isolated groups of two to three boulders appear to harbor more Sierra night lizards than larger piles of boulders (Bezy 1967a). Woody plant dominants associated with outcrops where Sierra night lizards have been found include blue oak, elderberry *(Sambucus mexicana)* and California buckeye *(Aesculus californica).*

Status: Special Concern; because of its tiny geographic range, this taxon is highly susceptible to even local-scale catastrophic effects. The preferred habitat of the Sierran night lizard is easily destroyed by humans prying off caps or flakes in an effort to obtain the lizards (Zeiner et al. 1988; see also Klauber 1926). Since the natural formation time for caps or flakes is much longer than that needed to destroy them, much of this sort of activity could eliminate the preferred habitat of this taxon rather rapidly. Increased development of the foothill area where this taxon occurs for homes and ranchettes has the potential to seriously negatively impact this species. If the Sierra night lizard is really localized in the smaller, more isolated groups of boulders within a grassland matrix, then existing lizard populations risk becoming increasingly isolated with current patterns of development and thus, are even more susceptible to local-scale catastrophic events.

Management Recommendations: A thorough survey of likely habitat for this lizard needs to be undertaken to determine its current distribution and the amount of suitable habitat still intact. An ecological study of this lizard is also needed to understand its movements and natural population fluctuations. Because the entire range of this taxon is currently under private ownership, efforts should be made to explore the possibility of purchasing and preserving a major portion of the granite rock outcrops in the vicinity of Granite Station for this taxon.

Plate 12. Adult desert night lizard (*Xantusia vigilis*) [from Stebbins 1954b].

SNAKES

BAJA CALIFORNIA RAT SNAKE
Elaphe rosaliae (Mocquard 1899)

Description: A large (85-150 cm TL), slender colubrid snake with a long head, large eyes, and smooth scales, the latter of which each contain two apical pits (Price 1990a, 1990b). The dorsum is uniform olive or reddish brown without dark markings on a cream-colored background (Ottley and Jacobsen 1983). Yellowish or greenish coloration extends from the lower sides of the body to the venter (Price 1990b). The iris is yellow-green (Ottley and Jacobsen 1983).

Taxonomic Remarks: Dowling and Price (1988) have placed this snake in its own genus *(Bogertophis)* based on immunological data, hut complications with the data set and the mode of analysis indicate that it is best to regard this species as a member of the rat snake genus, *Elaphe,* until further data become available (L. Grismer and John Wright, pers. comm.). No attempts have been made to characterize genetic variation across the geographic range of *E. rosaliae.* An understanding of that variation is needed to determine whether genetically differentiated populations exist within *E. rosaliae.* The difficulty with obtaining the requisite material for such a study make it likely that novel techniques, such as extracting DNA from preserved specimens, will he needed to address this problem.

Distribution: The Baja California rat snake ranges from extreme southern Imperial County southward into Baja California to Cabo San Lucas (Price 1990a). Over at least the northern half of its range, it is known from widely disjunct locations (Ottley and Jacobsen 1983, Price 1990b). Its known elevational range extends from near sea level to ca. 300 m. In the United States, *E. rosaliae* is known from only one road-killed specimen [SDSNH 64416] taken 26 May 1984 on Interstate Highway 8, 3.84 km east of Mountain Spring (Imperial County), California (Figure 41). Although Stebbins (1985) and others believe this locality to be genuine (L. Grismer and G. Pregill, pers. comm.), some have questioned the validity of this record (S. Barry, J. Copp. and C. Fagan, pers. comm.).

Life History: The life history of *E. rosaliae* is virtually unknown (Price 1990b). The species seems to be nocturnal or crepuscular and may be surface active during daylight hours under suitable conditions (Ottley and Jacobsen 1983). Nothing is known about reproduction or growth except that clutches with an unspecified number of eggs have been laid in captivity (Price: 1990b). The few data on diet and behavior are based on captive specimens and are difficult to interpret in the absence of data on this snake under field conditions. If similar to other rat snakes, it Climbs easily (Wright and Wright 1957) and adults are probably long-lived (see Bowler 1977). No data on movement, colonization abilities, or the potential predators of this taxon exist.

Habitat: *Elaphe rosdiae* is largely confined to mesic and dry desert habitats (rocky arroyos and washes) in the immediate vicinity of small springs (Ottley and Jacobsen 1983, Stebbins 1985) but individuals have also been observed on hillsides and dry mesas away from water sources (L. Grismer, pers. comm.). The habitat components critical to this snake have not been identified precisely, but it may require some of kind of shrub or tree with a moderately dense crown in which to take refuge because it has been taken in native fan palms *(Washingtonia* spp.), date palms *(Phoenix dactylifera),* mesquite, palo blanco *(Lysiloma candida),* palo verde, and creosote hush associations in the past (Price 1990b). The locations of oviposition sites are unknown.
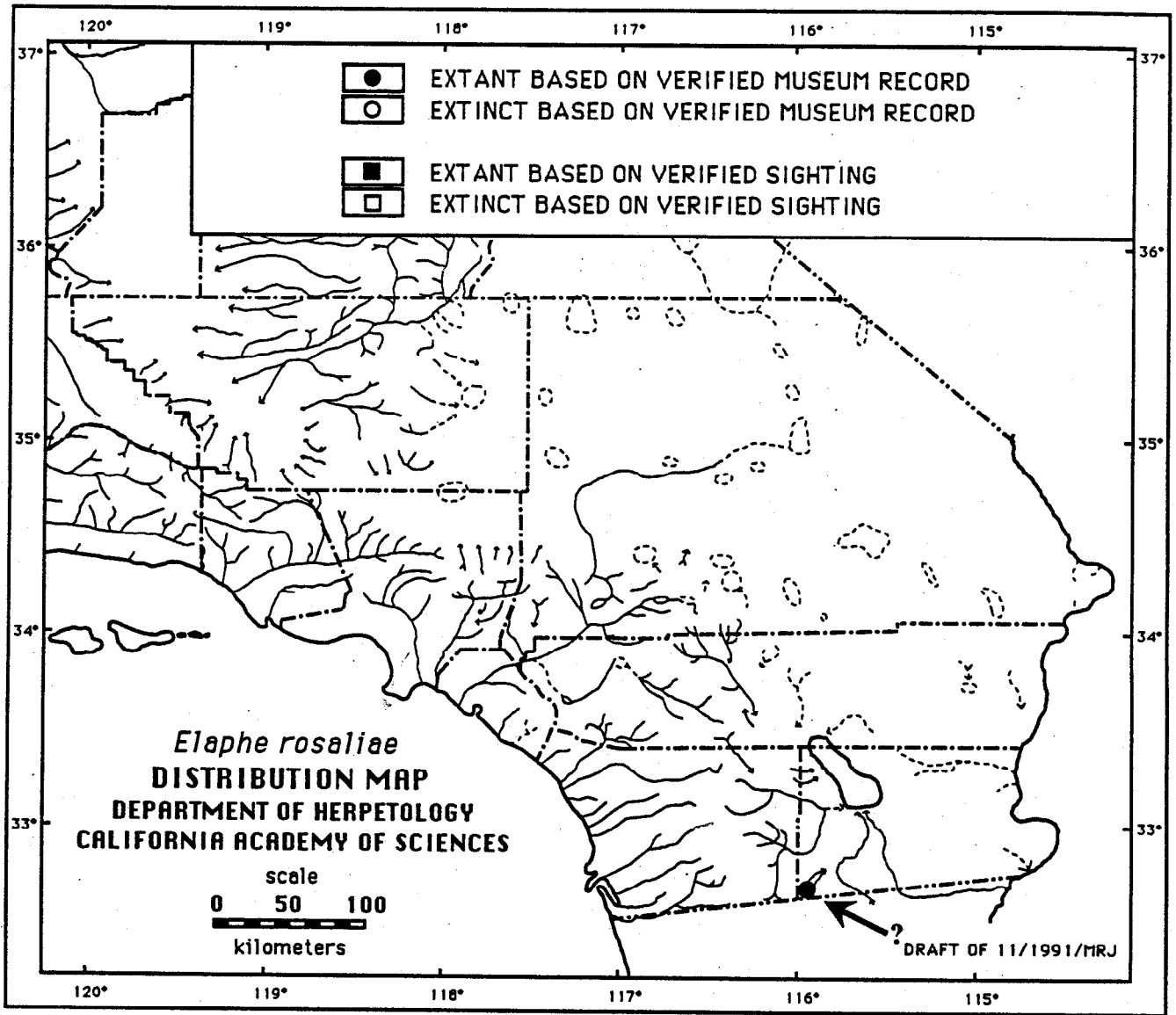
Figure 41. Historic and current distribution of the Baja California rat snake (*Elaphe rosaliae*) in southern California based on 1 location from 1 museum record.

Status: Special Concern; this snake is an infrequently observed species avidly sought after by amateur, scientific, and professional collectors alike. Because of the uncertain status of the single record from California, it should remain protected until further information regarding its distribution within the state becomes available.

Management Recommendations: Intensive surveys of habitats with shrubs or trees having a moderately significant crown in Imperial and San Diego counties are needed to determine whether this snake is really part of the herpetofauna of California. If populations are discovered, the local habitat needs to be protected from modification and potential collecting, and some kind of monitoring for this taxon should be initiated.

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RED DIAMOND RATTLESNAKE
Crotalus ruber ruber Cope 1892

</div>

Description: A large (75-163 cm), heavy-bodied rattlesnake with a tan, pink, brick-red, or reddish-colored dorsal color, and obscure, usually light-edged brick or pinkish diamond-shaped blotches (Klauber 1937, Gloyd 1940, Stebbins 1985). The tail base is prominently "coontail" marked with broadly spaced, but relatively narrow, distinct black rings contrasting with the rest of the body color (pers. observ.). The belly is white to pale yellow, and the undersurface of the tail is pinkish buff (Wright and Wright 1957; pers. observ.). The iris is brown (Wright and Wright 1957).

Taxonomic Remarks: This morphologically distinctive rattlesnake has rarely been confused since Cope (1892) described it. No attempts have been made to characterize genetic variation across the geographic range of *Crotalus ruber ruber.* An understanding of that variation is needed to determine whether genetically differentiated populations exist within *C. r. ruber.* The difficulty with obtaining the requisite material for such a study make it likely that novel techniques, such as extracting DNA from preserved material, will be necessary to address this problem.

Distribution: The known range of *Crotalus r. ruber* extends from near Pioneertown and Morongo Valley (San Bernardino County) southward on both sides (coastal and desert slopes) of the Peninsular Ranges (including the Santa Ana Mountains: Peguegnat 1951) to Loreto, Baja California, Mexico (Stebbins 1985). Its known elevational range extends from near sea level to about 1520 m (slopes of Palomar Mountain), although *C. r. ruber* is most frequently encountered below 1200 m (Klauber 1972). In California, the red diamond rattlesnake ranges southward from San Bernardino County to the Mexican border (Figure 42).

 Life History: Despite its size and proximity to one of the largest urban sprawls in the world, red diamond rattlesnakes are among the more poorly known species of rattlesnakes. No intensivestudy of the life history of this species has even been undertaken; all of what is known of the life history of this species is based on scattered bits of information from various sources. Behaviorally, *C. r. ruber* is a retiring, secretive species with a reputation for being more docile than other rattlesnake species found in California (Klauber 1972). Sixteen-year census records from San Diego County (Klauber 1939) show that at least some red diamond rattlesnakes are active year-round, although a peak in the numbers of this species observed occurs in April and May, probably because movements associated with mating activities make these snakes more conspicuous at that time. Mating may take place as early as March (Perkins 1938). Females carry developing young for ca. 140-150 days (Wright and Wright 1957). Three to 20 young 300-350 mm TL are born live typically between late July and September (Klauber 1937, Wright and Wright 1957). Nothing is known about the rate of growth or the age at which red diamond rattlesnakes become
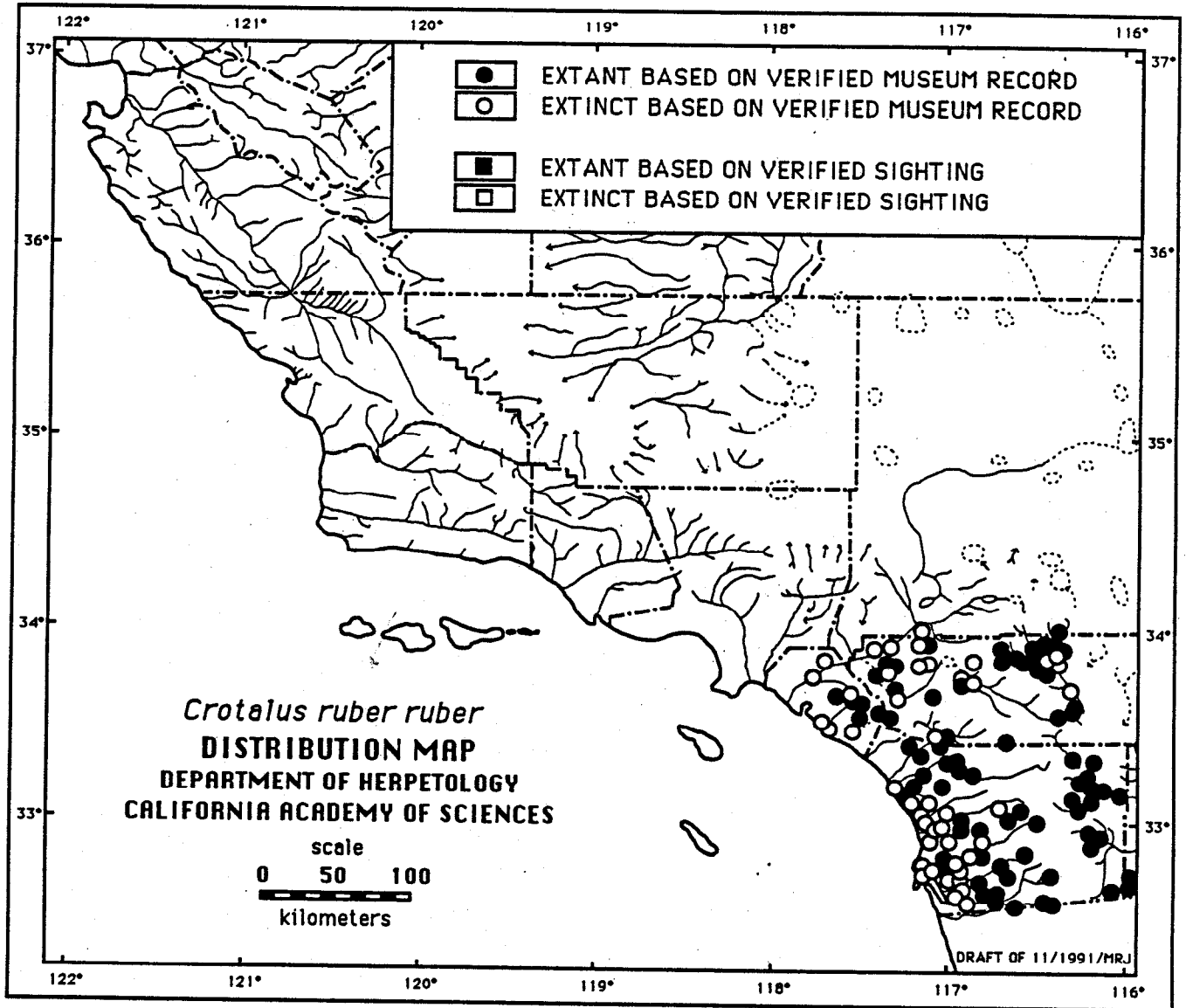
Figure 42. Historic and current distribution of the red-diamond rattlesnake (*Crotalus ruber ruber*) in southern California based on 345 locations from 577 museum records and 18 records from other sources.

sexually mature, but 733 mm TL is the size of the smallest gravid female Klauber (1937) found. Nothing is known about longevity in wild *C. r. ruber,* but a captive lived over 14 years (Bowler 1977), so the species may be relatively long-lived. Red diamond rattlesnakes eat mostly squirrels (e.g., white-tailed antelope ground squirrels, California ground squirrels) and rabbits (e.g., desert cottontails, brush rabbits *[S. bachmani])* as adults, but lizards (e.g., western whiptails *[Cnemidophorus tigris])* are also significant in the diet of juveniles (Tevis 1943, Klauber 1972). Although *C. r. ruber* frequently takes live prey, it may also eat relatively fresh carrion (Cunningham 1959a, Patten and Banta 1980). Red-tailed hawks *(Buteo jamaicensis)* are known predators of red diamond rattlesnakes (Huey in Klauber 1972). No data on the movement ecology or the colonization abilities of *C. r. ruber* exist.

Habitat: Although red diamond rattlesnakes are recorded from a number of vegetative associations, they seem to occur more frequently in habitats with heavy brush associated with large rocks or boulders (Klauber 1972). *Crotalus r. ruber* is frequently observed in chamise- and red shank-dominated associations, probably because these associations best fulfill the aforementioned structural habitat requirements. Such associations likely provide better refuges or food resources for red diamond rattlesnakes than other habitats, but how this is facilitated is not well understood. Red diamond rattlesnakes are also found in coastal sage scrub and desert slope scrub associations.

Status: Special Concern; this taxon has a relatively restricted range in California, and a significant portion of the habitat that was historically prime red diamond rattlesnake habitat has been developed over the last 20 years. Particularly significant has been the rate of development in northern San Diego County and southwestern Riverside County during the 1970s and 1980s. A combination of urban development and the trend toward increasing drip irrigation of orchards, such as avocados, on steeper, rocky slopes has significantly intruded into the habitat that *C. r. ruber* historically used. Systematic evaluation of habitat loss has not been quantified in detail, but we estimate that this snake has lost at least 20% of the suitable habitat within its range due to these types of development. Moreover, the general negative regard humans have for rattlesnakes has probably accelerated the local extirpation of this relatively shy, retiring species where development is occurring, especially since adult snakes over 1.3 m (TL) have become increasingly rare since the early 1960s (J. Copp and D. Morafka, pers. comm.).

Management Recommendations: A better understanding of the life history of this poorly known rattlesnake is needed before more refined management recommendations can be made. It is unlikely that such an understanding will be obtained without resorting to telemetry because field survey efforts without telemetry are likely to be extremely time costly. Especially needed is a better understanding of the habitat parameters critical to red diamond rattlesnakes, and how these are important to its ecology. Until more detailed habitat data become available, shrubby vegetative associations in areas with large rocks or boulders should be routinely surveyed for this taxon at appropriate diel and seasonal intervals and assessments of the quality of the habitat for this species should be done on a case-by-case basis. Efforts to protect and minimize disturbance to areas that are identified as likely containing high densities of this snake should be implemented.
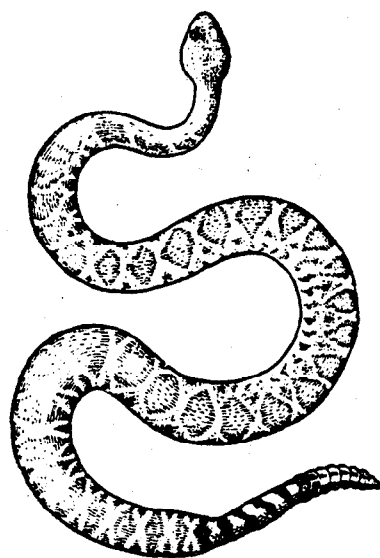
Plate 13. Adult red diamond rattlesnake (*Crotalus ruber ruber*) [from Stebbins 1954b].

SAN BERNARDINO MOUNTAIN KINGSNAKE
Lampropeltis zonata parvirubra Zweifel 1952

Description: A medium-sized (55-111 cm TL) snake with a distinctive sequence of red, black, and white rings (tricolor dyads: Savage and Slowinski 1990; these are similar, but yet different from the triads of Zweifel 1952b) in which relatively narrow white rings are always bordered by black rings, and red coloration, which can occur as rings or bands, borders alternate black rings (Zweifel 1952b; pers. observ.). The number of tricolor dyads on the body (except the tail) ranges from 35 to 48, and between 4% and 100% of the red rings between body dyads are complete (Zweifel 1952b). The snout is jet black and the iris is very dark brown (B. McGurty, pers. comm.).

Taxonomic Remarks: This taxon has not been reexamined since Zweifel (1952b) described the races of *Lampropeltis zonata.* Diagnosis of *L. z. parvirubra* is problematic because allocation of individuals to this taxon requires using a combination of several characters simultaneously that individually overlap considerably in variation with other races of *L. zonata.* Biochemical analyses coupled to more extensive morphological analyses are needed to better understand the systematic status of this taxon. Since individuals of *L. z. parvirubra* are difficult to obtain (captive snakes notwithstanding), novel techniques such as DNA extraction from preserved specimens will almost certainly be needed to help resolve this problem. Interpretation of this taxon as a full species (Collins 1991) is unjustified and awaits the aforementioned analyses.

Distribution: This California endemic is restricted to the San Gabriel, San Bernardino, and San Jacinto mountains of southern California (Figure 43). The known elevational range of this taxon extends from ca. 370 m (Eaton Canyon, Los Angeles County) to ca. 2470 m (Mount San Jacinto, Riverside County: Zweifel 1952b).

Life History: *Lampropeltis z. parvirubra* is an infrequently observed, secretive, cryptozooic snake, the life history of which, as a result, is virtually unknown. Its life history is probably similar to what is known for *L. z. pulchra,* the other race of mountain kingsnake in southern California, and the account for *L. z. pulchra* should be referred to in order to gain a general idea of the life history of this taxon. Cunningham (1959a) reported on a female *L. z. parvirubra* from Skyforest (San Bernardino County) that laid 3 eggs on July 18, and Zweifel (1952b) mentioned that 8 young were hatched from a female *L. z. parvirubra* from Seven Oaks (San Bernardino County) at the San Diego Zoo, but the latter observation did not indicate the original clutch size, so it is unclear whether the latter was the same as the number of young that hatched. The San Bernardino mountain kingsnake may be primarily saurophagous (Newton and Smith 1975); DeLisle in McGurty (1988) indicates that 7 specimens of *L. z. parvirubra* had eaten sagebrush lizards *(Sceloporus graciosus)* and 3 others had taken western skinks (see also Cunningham 1959a). Cunningham (1955) found an individual in the decaying cavity of a black oak, suggesting that this taxon will climb when the appropriate habitat structure is available. No data are available on longevity, but Bowler (1977) reported on a captive individual nearly 12 years old. No data exist on the movement ecology or colonization abilities of this taxon.

Habitat: *Lampropeltis z. parvirubra* occurs in well-illuminated canyons with rocky outcrops or rocky talus in association with bigcone spruce *(Psuedotsuga macrocarpa)* and various canyon chaparral species at lower elevations, and with black oak, incense cedar, Jeffrey pine, and ponderosa pine at higher elevations (Zweifel 1952b, Cunningham 1955, Newton and Smith 1975). The rocky outcrops or talus likely provide hibernation and refuge sites as well as the food resources for this probably largely lizard-eating snake (see *L. z. pulchra* account). Where oviposition sites are generally located is not known, but
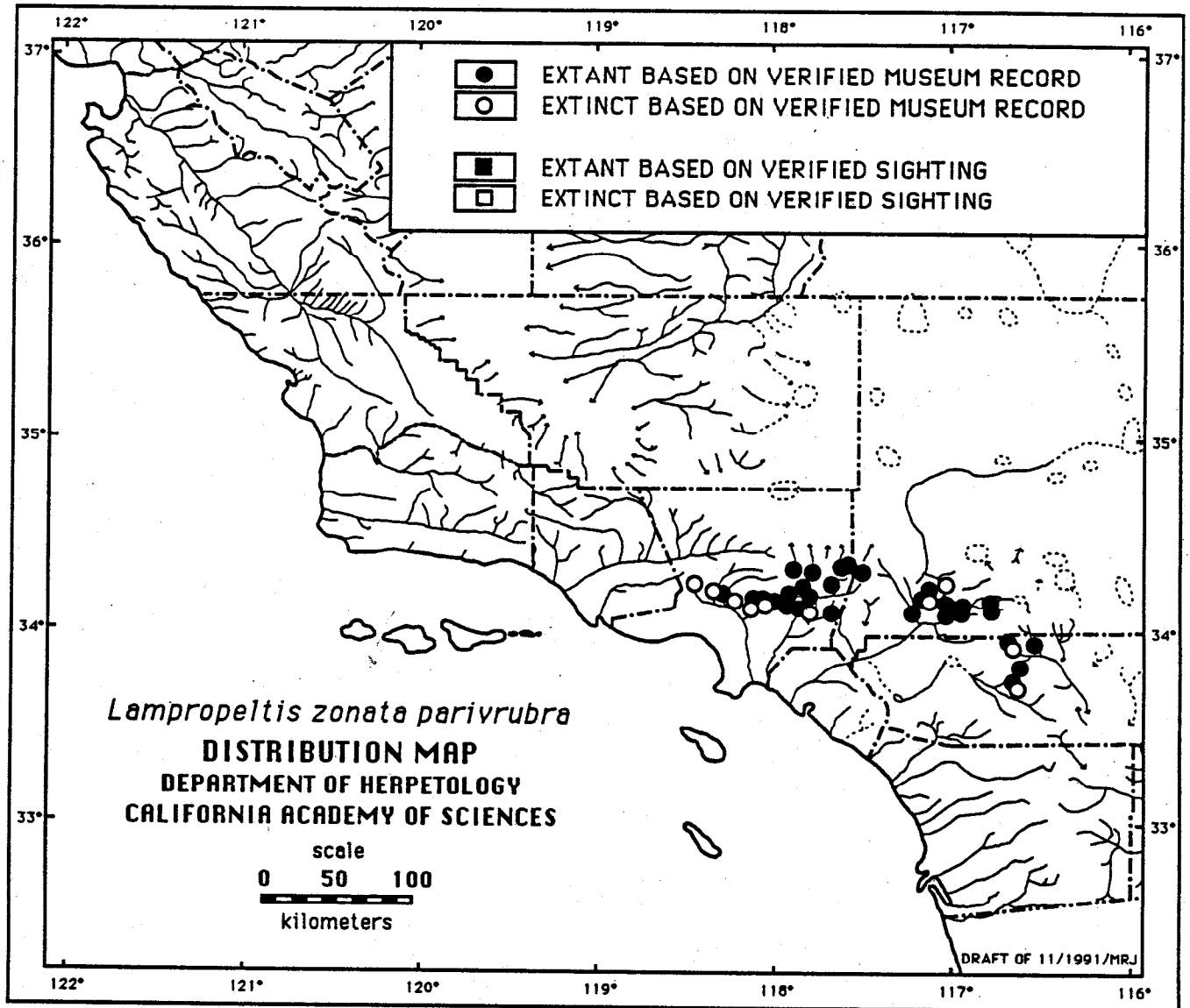
Figure 43. Historic and current distribution of the San Bernardino mountain kingsnake (*Lampropeltis zonata parvirubra*) in southern California based on 88 locations from 131 museum records.

rocky outcrops and talus areas may also provide suitable oviposition sites. Basic understanding of habitat utilization patterns are lacking.

Status: Special Concern; this taxon continues to be highly prized among collectors (S. Barry, R. Fisher, and B. McGurty, pers. comm.), despite regulations limiting collecting and laws preventing the sale of native reptiles in the state (Nicola 1981; California Fish and Game Commission 1990). Over 10 years ago, this taxon brought prices as high as $250.00 a specimen and the current black market trade of this taxon continues with high demand (especially in Europe) bringing much inflated prices (B. McGurty, pers. comm.; see also Newton and Smith 1975). One of the reasons this taxon is in high demand is because collectors are desirous of having examples of each of the various color morphs known from southern California (e.g., the "San Gabriel phase", the "San Jacinto phase", etc.: S. Barry, J. Brode, and John Wright, pers. comm.). Moreover, sharply increased public use levels of the Angeles (San Gabriel Mountains) and San Bernardino (San Bernardino Mountains and Mount San Jacinto) National Forests over the past 25 years have undoubtedly put increased collecting pressure on this species (Newton and Smith 1975).

Management Recommendations: Better systematic characterization of this taxon is needed, an issue that, as suggested previously, will require a considerable investment because novel biochemical techniques will almost certainly be needed. This species is sufficiently cryptozooic and secretive that the best and least costly way to gain some understanding of its life history and habitat utilization patterns is to employ telemetry. Perhaps once telemetry has adequately characterized this species behavior can field surveys be effectively done, but we believe that attempts to field survey this taxon without the assistance of a telemetric study will be very time costly and probably produce only limited data.

SAN DIEGO MOUNTAIN KINGSNAKE
Lampropeltis zonata pulchra Zweifel 1952

Description: A medium-sized (53-108 cm TL) snake with a distinctive sequence of red, black, and white rings (tricolor dyads: Savage and Slowinski 1990; these are similar, but yet different from the triads of Zweifel 1952b) in which relatively narrow white rings are always bordered by black rings, and red coloration, which can occur as rings or bands, borders alternate black rings (Zweifel 1952b; pers. observ.). Occasional aberrant patterns can be found in which rings are lacking (see Figure 2 in McGurty 1988). The number of tricolor dyads on the body (except the tail) ranges from 27 to 38, and between 15% and 100% of the red rings between body dyads are complete (Zweifel 1952b). The snout is jet black and the iris is very dark brown (B. McGurty, pers. comm.).

Taxonomic Remarks: The taxonomic remarks made for *Lampropeltis zonata parvirubra* also apply to this taxon.

Distribution: This California endemic occurs in the Santa Monica Mountains (Los Angeles County); Santa Ana Mountains (Grange and Riverside Counties); Santa Rosa Mountains (Riverside County); and Corte Madera, Cuyamaca, Hot Springs, Laguna, and Palomar Mountains (San Diego County: McGurty 1988;. Figure 44). Its elevation range extends from near sea level to ca. 1800 m (Palomar Mountain, San Diego County). Two early specimens (SDSNH 9930, USNM 13889) and three post-1960 records (B. McGurty, pers. comm.) from western San Diego County suggest the possibility of native populations of this taxon near the coast; However, the latter records have remained unverified and the
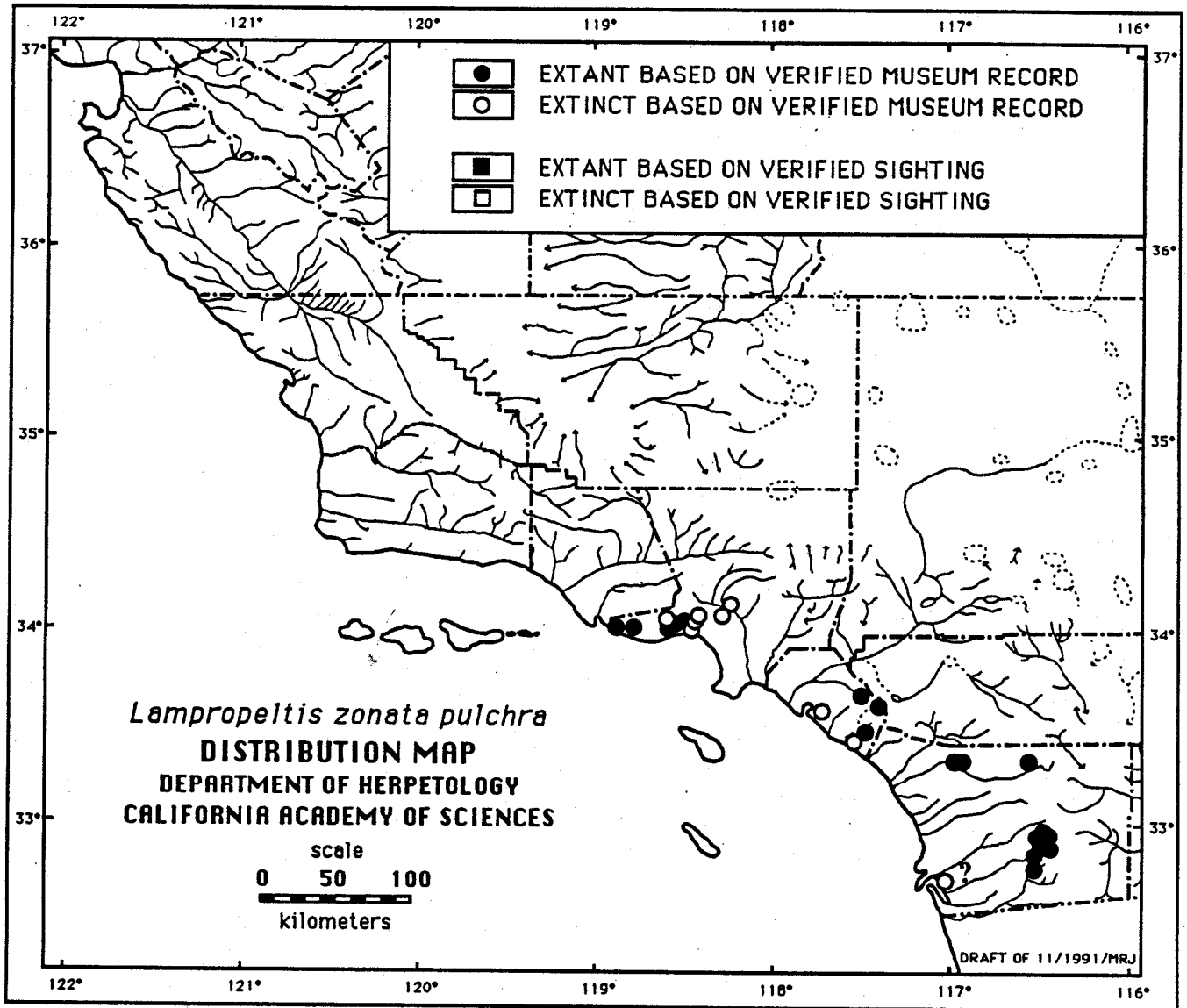
Figure 44. Historic and current distribution of the San Diego mountain kingsnake (*Lampropeltis zonata pulchra*) in southern California based on 48 locations from 73 museum records and 1 record from another source.

former may represent mislabeled specimens or escaped or released pets (B. McGurty, pers. comm.).

Life History: *Lampropeltis z. pulchra* is an infrequently observed, secretive, cryptozooic snake, the life history of which is still only partly understood. The San Diego mountain kingsnake typically emerges from overwintering sites in March and may remain near-surface active through November, but it is particularly conspicuous near the surface from roughly mid-March to mid-May (Klauber 1931, McGurty 1988), during which time it is active during the warmer daylight hours (pers. observ.). Later in the season, it may be active after dark, which is probably related to the fact that, like most snakes, it has a relatively low temperature preferendum and a relatively low critical thermal maximum (42.5°C: data provided for *L. zonata,* subspecies not specified; Brattstrom 1965). Based on wild-caught captive individuals, mating probably takes place in May and eggs are usually laid in June or early July (McGurty 1988; pers. observ.). Females lay 4-9 moderate-sized (averages 36 mm long x 16 mm wide), bone white, leathery-shelled eggs that if similar to eggs incubated in captivity, require at least 2 months to develop before hatching (McGurty 1988). Hatchlings are usually first observed between late August and early October (pers. observ.). The time required to reach reproductive maturity in the field is unknown, but captive *L. z. pulchra* required 4-5 years to reach sexual maturity (McGurty 1988). If captive longevity records for other races of this species are any indication (see Bowler 1977), San Diego mountain kingsnakes may be relatively long-lived. Indications exist that *L. z. pulchra* may be highly philopatric, consistently using local patches of suitable habitat (McGurty 1988), but the movement patterns of this taxon are largely unknown. This taxon is also probably primarily saurophagous, and only western fence lizards and western skinks have been recorded as having been eaten by San Diego mountain kingsnakes, but prey similar to other subspecies of *L. zonata* are probably also taken (Newton and Smith 1975, McGurty 1988).

Habitat: In the interior mountain ranges, *Lampropeltis z. pulchra* occurs primarily in associations of ponderosa, Jeffrey, and Coulter pine, and black oak, and is infrequently found below the coniferous forest associations (Zweifel 1952b, McGurty 1988; pers. observ.). At lower elevations and in coastal ranges, it occurs below the edge of mixed oak-coniferous forest in riparian woodlands, usually in canyon bottoms, that have western sycamore *(Platanus racemosa),* Fremont's cottonwood, coast live oak, willows, wild rose *(Rosa* spp.), and blackberries. It may be found in narrow riparian woodlands in association with chaparral and coastal sage vegetation types (pers. observ.; see McGurty 1988). Rocks or rocky outcrops appear to be an important element of *L. z. pulchra* habitat (McGurty 1988), probably because they provide suitable refuge sites and they harbor the necessary food resources. Such locations may also provide overwintering sites.

Status: Special Concern; this snake continues to be highly prized among collectors (S. Barry, R. Fisher, and B. McGurty, pers. comm.) despite prohibitions on collecting or selling it in California (Nicola 1981, California Fish and Game Commission 1990). The only individuals that can be possessed are those that were in possession of their owners prior to when the prohibition on collection regulations were implemented. Currently, this taxon is mentioned for sale in some reptile fancier lists at $250.00 per snake (pers. observ.); such a demand undoubtedly fuels a black market trade for this taxon among collectors. In addition, McGurty (1988) provided data for a single locality in San Diego County suggesting a local decline in *L. z. pulchra* that he attributes to overcollecting of this taxon. Since no obvious habitat change has occurred at this site (B. McGurty, pers. comm.), the interpretation McGurty provided may be correct. McGurty (1988) also cites the destruction of local habitat by overzealous collectors (the dismantling of outcrops and the shredding of logs and stumps), especially in San Diego County, as reasons for this taxon's decline (see also Newton and Smith 1975). Rock-chipping for this taxon as well

as for selected lizards was a problem that was recognized over 15 years ago, and continues to be a problem in certain local areas despite the fact that altering habitat in this way is prohibited under current regulations by both State and Federal land management and resource agencies. Illegal fuelwood harvesting also adds to the problem of habitat alteration (McGurty 1988).

Management Recommendations: All the comments made under the *L. z. parvirubra* account also apply here. In addition, systematic monitoring of habitat is needed to ensure that clandestine alteration (rock-chipping and removal of wood) is minimized. It is imperative to couple a systematic program of public education to make monitoring effective.
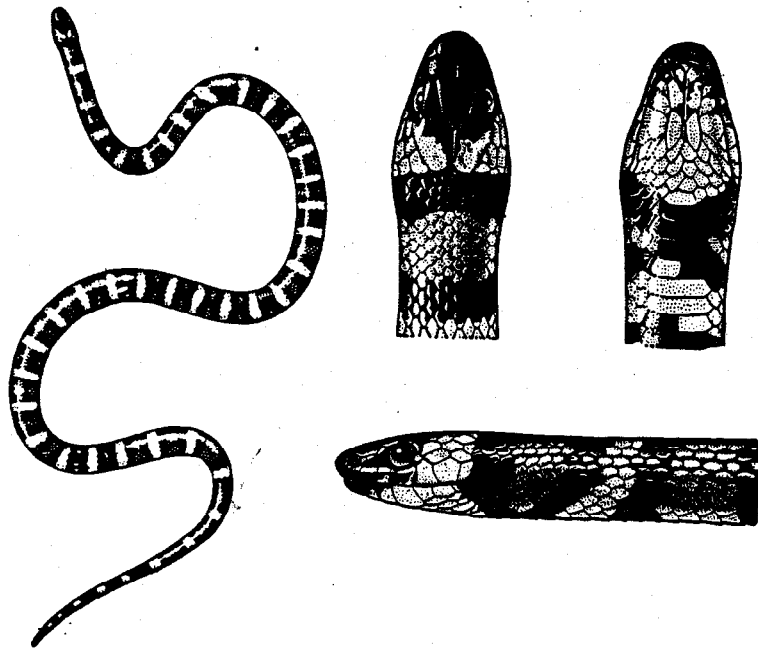

Plate 14. Adult California kingsnake (*Lampropeltis zonata*) [from Stebbins 1954b].

SAN JOAQUIN COACHWHIP
Masticophis flagellum ruddocki Brattstrom and Warren 1953

Description: The San Joaquin coachwhip is a large-sized (90-155 cm SVL), smooth-scaled, large-eyed, slender snake with a buffy citrine, tan-yellow, or olive brown dorsal color without lengthwise stripes (Brattstrom and Warren 1953). The ventral color is straw yellow that acquires a pinkish or orangish cast under the tail and the top of the head is light brown (pers. observ.). The iris color has not been described.

Taxonomic Remarks: Brattstrom and Warren (1953) described this taxon on the basis of the general buffy citrine to olive dorsal color, an absence of dark neck bands, and a lower subcaudal scale count. Verification of the validity of this taxon on any other grounds has never been attempted (see Wilson 1970). Genetic variation within *Masticophis flagellum ruddocki* has not been examined and should be studied to evaluate the distinctiveness of this taxon. The difficulty in obtaining material for such study may require novel techniques, such as extracting DNA from preserved material. *Masticophis f. ruddocki* apparently intergrades with *M. f. piceus* in the lower Kern Canyon-Caliente-Tehachapi region of eastern Kern County (Brattstrom and Warren 1953; R. Hansen, pers. comm.).

Distribution: The known range of this California endemic extends from 13 km west of Arbuckle (Colusa County; SDSNH 26084] in the Sacramento Valley southward to the Grapevine in the Kern County portion of the San Joaquin Valley and westward into the inner South Coast Ranges (Figure 45). An isolated population occurs in the Sutter Buttes (Hayes and Cliff 1982). The known elevational range of the San Joaquin whipsnake extends from near ca. 20 m to around 900 m in the Temblor Range (Kern County: pers. observ.).

Life History: The life history of this taxon is virtually unknown. The summary presented here is based largely on *M. f. piceus* from the nearby desert areas of California. *Masticophis f. ruddcocki* is a swift (see Mosauer 1935), diurnal snake that maintains a high activity level when on the surface (Sullivan 1981). If similar to other *M. flagellum* subspecies, it voluntarily maintains a higher active body temperature than most other snakes (Cowles and Bogert 1944, Brattstrom 1965, Hammerson 1977) and will not emerge from burrow retreats either on a daily or seasonal basis until near-surface temperatures reach ca. 28°C (see discussion in Hammerson 1989). As a result, emergence tends to be relatively late in the season (usually April-early May) and later in the morning (ca. 1000-1100 hr), although some evidence exists that smaller (younger) individuals emerge earlier in the day and the season than larger (older) snakes. Emergence is preceded by a warming interval during which only the head and neck are extruded from the burrow (Hammerson 1977; pers. observ.). *Masticophis f. ruddocki* are typically active during the warmest part of the day; only later during the season (see Banta and Morafka 1968), when midday temperatures become intolerably warm does *M. f. ruddocki* become bimodal in its surface activity. Mating is thought to occur in May and oviposition probably occurs in June or early July. Oviposition sites have not been found, but are probably situated in the wall of a rodent burrow (see Wright and Wright 1957); clutch size probably ranges from 4 to 20 (see Stebbins 1985). Adults may disappear seasonally as early as the first part of August (pers. observ.), perhaps in response to a late-summer decline in food resources. *Masticophis f. ruddocki* seems to primarily eat lizards and rob the nests of birds and mammals, but it may also eat carrion (see Cowles 1946 and Cunningham 1959a); blunt-nosed leopard lizards (Montanucci 1965, Tollestrup 1979), western whiptails (R. Hansen, pers. comm.), side-blotched lizards *(Uta stansburiana:* pers. observ.), San Joaquin antelope ground squirrels *(Ammospermophilus nelsoni:* S. Sweet, pers. comm.) are known prey. Individual *M. f. ruddocki* probably have a relatively large home range (R.
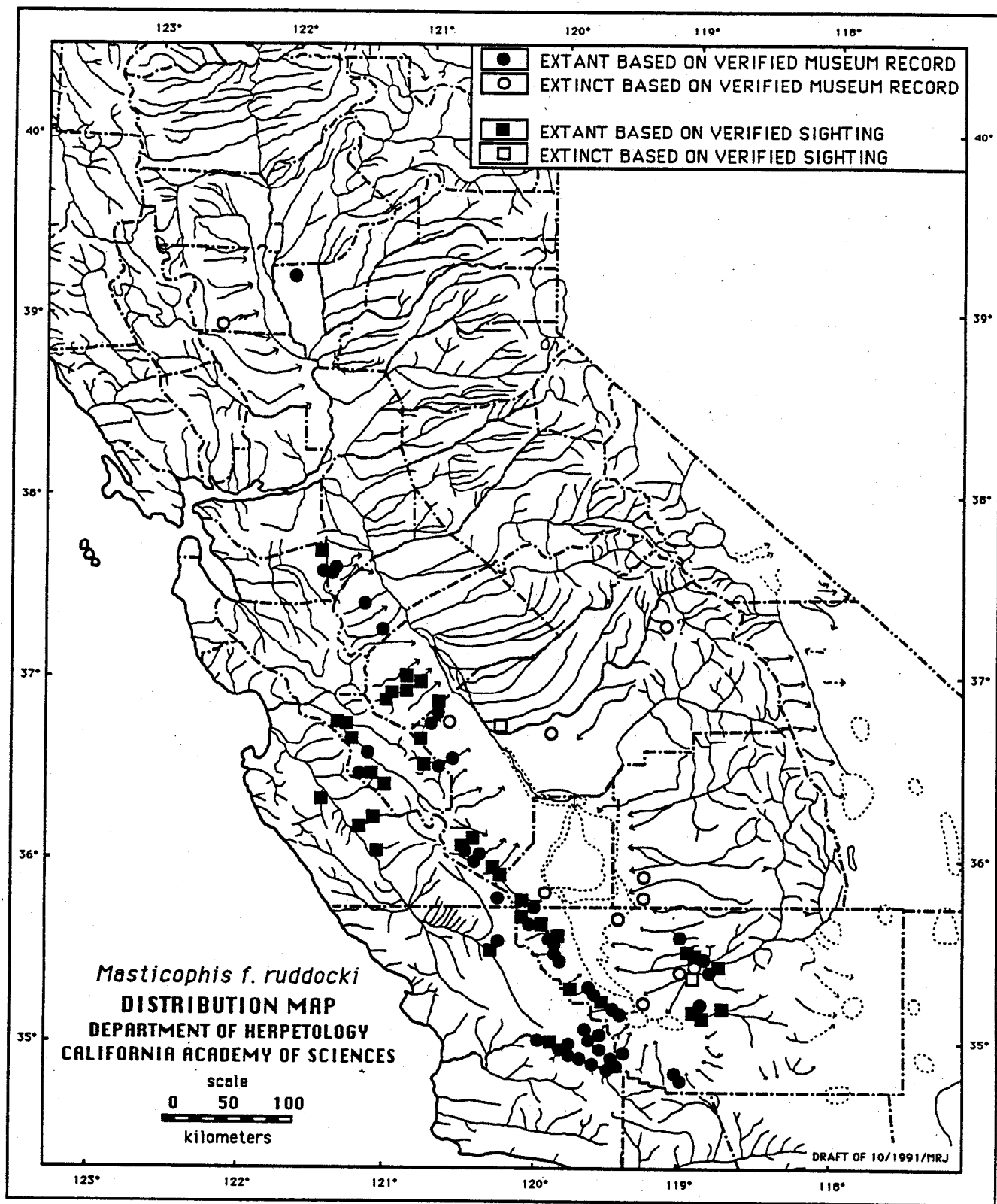
Figure 45. Historic and current distribution of the San Joaquin coachwhip (*Masticophis flagellum ruddocki*) in central and northern California based on 186 locations from 102 museum records and 98 records from other sources.

Hansen, pers. comm.), but movement data for this taxon are lacking. Subterranean overwintering sites are probably located in a burrow system (see Cowles 1941).

Habitat: *Masticophis f. ruddocki* occurs in open, dry, vegetative associations with little or no tree cover (Morafka and Banta 1976). In the western San Joaquin Valley, it occurs in valley grassland and saltbush scrub associations (Montanucci 1965, Banta and Morafka 1968, Tollestrup 1979, Sullivan 1981; pers. observ.) and is known to climb bushes such as *Atriplex* for viewing prey and potential predators (see Cunningham 1955). *Masticophis f. ruddocki* probably requires one or more mammal associates because it uses burrows for refuge and probably for oviposition sites, and may sometimes be dependent on mammals for food. Although this snake probably has a high degree of dependence on mammals, the species it may be dependent upon and the nature of such relationships are vague.

Status: Threatened; beyond simply having a relatively restricted geographic range, much of the area within the historic range of *M. f. ruddocki* has undergone extensive land use changes over the last 15 years. Most significant is the first-time conversion of large areas of valley grassland or shadscale scrub association to row crop agriculture in the San Joaquin Valley, particularly cotton *(Gossypium* sp.), grapes, kiwi fruit *(Actinidia chinensis),* and various vegetables. This type of conversion not only eliminates the food base that *M. f. ruddocki* typically depends upon, but it eliminates the burrow mammal associates that this taxon needs for the creation of refuge sites. Further, urban development has also expanded in selected areas in the inner Coast Ranges where this species was historically common. Land-use conversion coupled with 4 years of drought (1986-1990) that have reduced the available lizard food base for *M. f. ruddocki* in many areas may have also contributed significantly to the depletion and fragmentation of populations of this taxon.

Management Recommendations: The life history of *M. f. ruddocki* needs intensive study to better establish its habitat utilization patterns, its dependence on mammal associates, and the patch sizes of habitat it needs to maintain populations over the long-term. Until the life history is better understood (especially of size of home ranges and long-term patterns of movement), the largest open habitat patches of suitable habitat in valley grassland, saltbush, and shadscale scrub associations should be protected or preserved to ensure this taxon's survival. A few large segments of protected habitat in which *M. f. ruddocki* occurs currently exist (e.g., The Nature Conservancy's Carrizo Plain Preserve), but at the rate that land-use conversion has eliminated this taxon's habitat in the San Joaquin Valley and inner Coast Ranges over the past 15 years, more large segments are needed in order to preserve even a small remnant of the historical habitat for this taxon.

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SANTA CRUZ GOPHER SNAKE
Pituophis melanoleucus pumilus Klauber 1946

</div>

Description: A medium-sized (70-110 cm), yellow or cream-colored snake with black, brown, or reddish dorsal blotches, and smaller secondary dorsal blotches (Klauber 1946). Undersurfaces are nacreous white or cream often becoming somewhat yellow on the throat and ventral surfaces of the neck and tail with three rows of dark spots along the sides of the body. The iris is dark brown (pers. observ.).

Taxonomic Remarks: *Pituophis melanoleucus pumilus* is a dwarf subspecies of gopher snake that can be distinguished from other subspecies of *P. melanoleucus* in California based on the presence of ≥ 29 dorsal scales rows at the mid-body. It is thought to be most closely related to one of the two adjacent mainland forms, *P. m. annectens* and *P. m. catenifer* (Klauber 1946). Although it is considered a valid taxon (Sweet and Parker 1990),
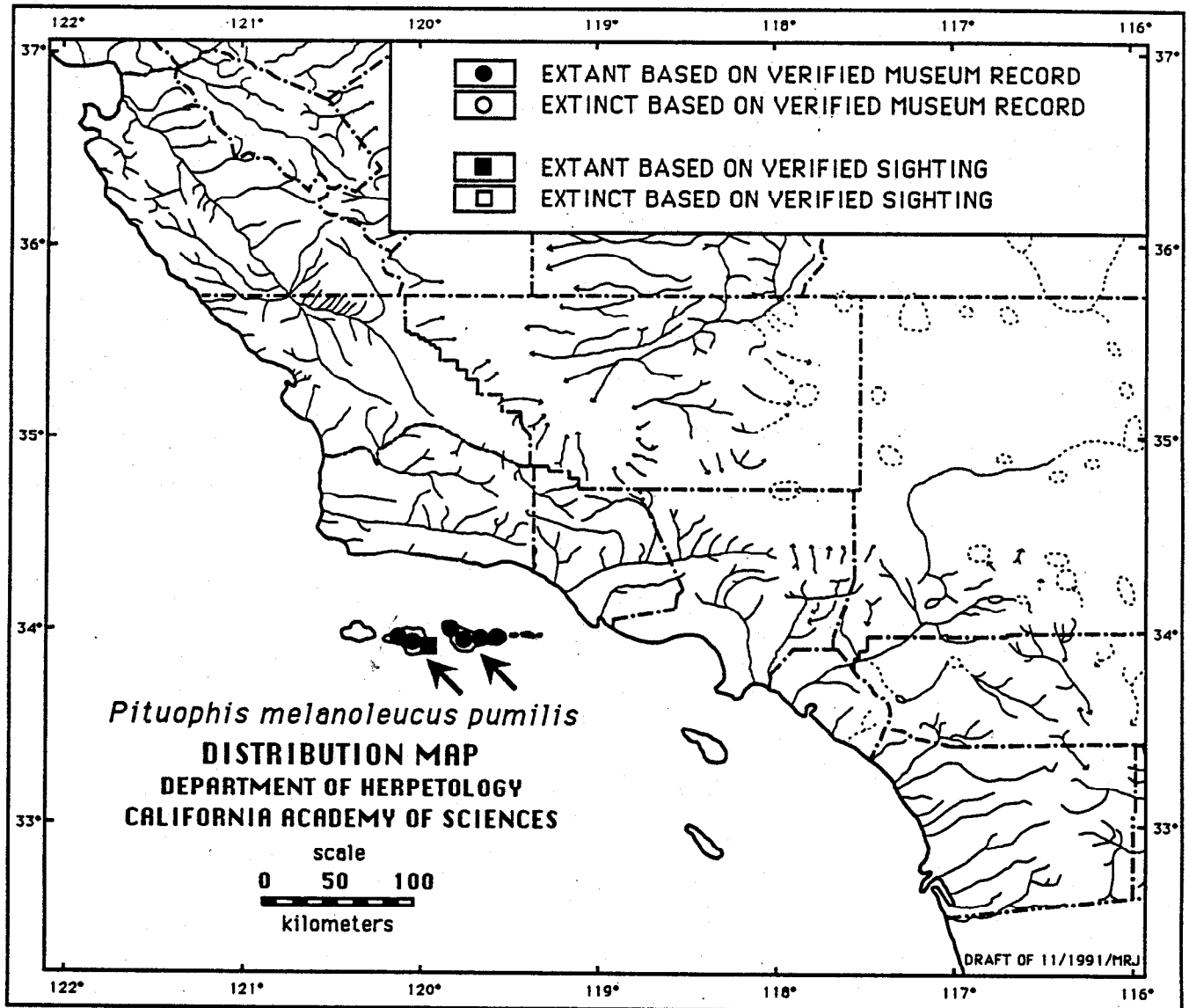
Figure 46. Historic and current distribution of the Santa Cruz gopher snake (*Pituophis melanoleucus pumilis*) in southern California based on 26 locations from 39 museum records and 6 records from other sources.

verification of the validity of this taxon on other than morphological grounds has not been addressed (see Collins, ms). Genetic variation within *P. m. pumilus* has not been examined and should be studied to evaluate its distinctiveness. The scientific name of this taxon is often incorrectly spelled as *"P. m. pumilis"* in the literature (e.g., see Stebbins 1985 and Collins, ms).

Distribution: This California endemic has only been recorded on Santa Cruz and Santa Rosa (Orr 1968) islands off the coast of southern California (Wilcox 1980; Figure 46). The statement by Stebbins (1985) of this taxon occurring on San Miguel Island is based on an unverified sight record (P. Collins, pers. comm.). The known elevational range extends from near sea level to 640 m (on Santa Cruz Island).

Life History: Allowing for its smaller body size and the depauperate island fauna where it occurs (see Wenner and Johnson 1980), this island-dwelling gopher snake has a life history that is anticipated to be similar to gopher snakes found on the adjacent mainland (e.g., see Fitch 1949). In spring, juveniles and adults emerge from rodent burrows or rock fissures, where they hibernate during the colder months of fall and winter (P. Collins, pers. comm.). Adults probably reproduce in May with females depositing clutches from late June through July and hatchlings emerging in September and October (Van Denburgh 1898, Stebbins 1985; P. Collins, pers. comm.); the reproductive ecology of this taxon is currently being studied (R. Fisher, pers. comm.). Santa Cruz gopher snakes are probably surface active during the day whenever temperatures are high enough to elicit movement (see Rüthling 1915). Because the island fauna is depauperate, the prey base available to gopher snakes is limited. Potential prey are limited to southern alligator lizards *(Elgaria multicarinata),* western fence lizards, side-blotched lizards, deer mice *(Peromyscus maniculatus),* western harvest mice *(Reithrodontomys megalotis),* and a variety of land birds (Diamond and Jones 1980, Wenner and Johnson 1980, Laughrin 1982). Of these, adult Santa Cruz gopher snakes probably consume mice, adult lizards, and the eggs or nestlings of the birds that are small enough to eat, whereas juvenile gopher snakes probably take juvenile lizards, mouse pups, and possibly insects (e.g., Jerusalem crickets, *Stenopelmatus* sp.; Laughrin 1982). Island foxes *(Urocyon littoralis:* Laughrin 1977) occasionally eat *Pituophis m. pumilus* as do feral pigs *(Sus scrofa),* red-tailed hawks, and common ravens (Laughrin 1982; P. Collins, pers. comm.). A captive-born snake lived for 16.5 years in captivity (P. Collins, pers. comm.). Data are lacking on the growth or movement ecology of this taxon.

Habitat: *Pituophis m. pumilus,* like its mainland congeners, is a habitat generalist. It can be found in all vegetation associations on the two islands, but it is most common in open areas such as grasslands, dry streambeds, and oak and chaparral woodlands (Laughrin 1982). No data are available on either overwintering or oviposition sites.

Status: Special Concern; introduced ungulates, which destroy and modify the vegetative cover, and feral pigs, which eat snakes, continue to threaten the Santa Cruz gopher snake on both islands on which the latter occurs. Gopher snakes are rare on Santa Rosa Island, yet are still relatively common on Santa Cruz Island for reasons not well-understood (Laughrin 1982; Collins, ms.; P. Collins and R. Fisher, pers. comm.).

Management Recommendations: Exclusion fencing needs to continue as long as feral livestock threatened the native fauna (and flora) on any of the Channel Islands. Particular effort should be made to remove wild pigs from islands on which this taxon occurs because of the greater degree of destruction wild pigs can inflict on snake populations and habitat. Even after threat from the feral fauna has been alleviated, Santa Cruz gopher snake populations need study to gain a better understanding the natural history of these island populations. Emphasis should also be placed on reevaluating its taxonomic status via

genetic and morphometric techniques. Much basic data, including that on distribution, habitat affinities, abundance, reproductive biology, food habits, and factors affecting mortality are needed to improve management guidelines for this taxon.
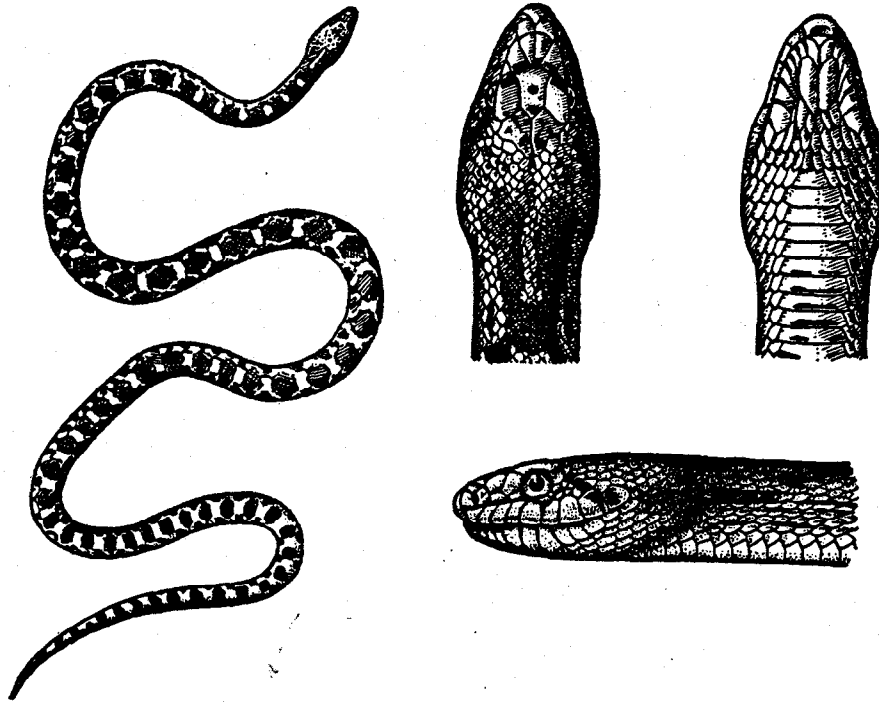

Plate 15. Adult gopher snake (*Pituophis melanoleucus*) [from Stebbins 1954b].

COAST PATCH-NOSED SNAKE
Salvadora hexalepis virgultea Bogert 1935

Description: A medium-sized (55-115 cm TL), slender snake with a yellow or beige, dark-bordered middorsal stripe one full scale row and the two half-scale rows on either side wide; and a broad, patch-like rostral scale (Bogert 1935, 1945; Stebbins 1985). Sides of the body are often dark brown, a color which covers all but the lowermost 1 or 2 dorsal scale rows. Undersurfaces are cream to white, but often washed with pink or orangish on the posterior belly and undersurface of the tail. The iris is black with a buffy-colored ring around the pupil (Wright and Wright 1957).

Taxonomic Remarks: Bogert (1935) defined this form as a subspecies of *Salvadora hexalepis* based on morphology. Alternative data sets have never been examined to affirm the validity of this taxon. Genetic data are needed both to affirm its validity and to identify potential variation across its geographic range. Potential difficulties with obtaining material for such a study, may require considering using novel techniques, such as extracting DNA from preserved material.

Distribution: The known range of this taxon is thought to extend from near Creston (San Luis Obispo County; UCSB 13697), California southward into Baja California (Figure 47). Its known elevation range extends from sea level to around 2130 m.

Life History: The life history of *S. h. virgultea* is among the most poorly known of the regularly surface-active snakes that occur in California. The limited number of records of this species may be largely a function of its bimodal activity period (peak in late morning and secondarily in late afternoon) less frequented by collectors or observers (S. Sweet, pers. comm.) coupled with a relatively cryptic appearance that results from lower light levels during the active period (pers. observ.). During the rest of the daylight hours, *S. h. virgultea* apparently remains immobile on the surface (S. Sweet, pers. comm.). *Salvadora h. virgultea* is an active, relatively swift-moving snake (see Mosauer 1935) that probably maintains a relatively high body temperature (see Brattstrom 1965, Cunningham 1966b, and Jacobson and Whitford 1971). Indications exist that its peak emergence interval corresponds roughly to the emergence interval of what is probably a major prey item, lizards of the genus *Cnemidophorus* (Cunningham 1959a; Jacobson and Whitford 1971; S. Sweet, pers. comm.), The modified rostral scale of this taxon and its congeners is thought to be a modification to aid unearthing reptile egg prey (Bogert 1939, Shaw and Campbell 1974), but whether coast patch-nosed snakes prey extensively on such eggs is not known. *Salvadora h. virgultea* is recorded as emerging from overwintering sites in March and disappearing to overwintering sites in October (Klauber 1939). but these census data probably conceal significant differences in seasonal patterns of activity between juveniles and adults. Additionally, a number of observations exist of juveniles emerging on warm days during the winter months (S. Sweet, pers. comm.). Although this taxon is presumed to lay eggs like other member of its genus, its eggs have never been described (Wright and Wright 1957). Other than the fact that it is a facile climber (Grinnell and Grinnell 1907), its movement ecology is unknown.

Habitat: Several authors have commented on this species association with brushy or shrubby vegetation, such as chaparral (Klauber 1924, Bogert 1935, Perkins 1938). If the assessment that *S. h. virgultea* adjusts its activity around that of its whiptail lizard prey, the link to shrubby associations may simply be a function that being the preferred habitat of its prey. Whatever the link, coast patch-nosed snakes seem to require at least a low shrub structure of minimum density since they are not found in habitats lacking this structural component. Coast patch-nosed snakes are presumed to take refuge and perhaps overwinter
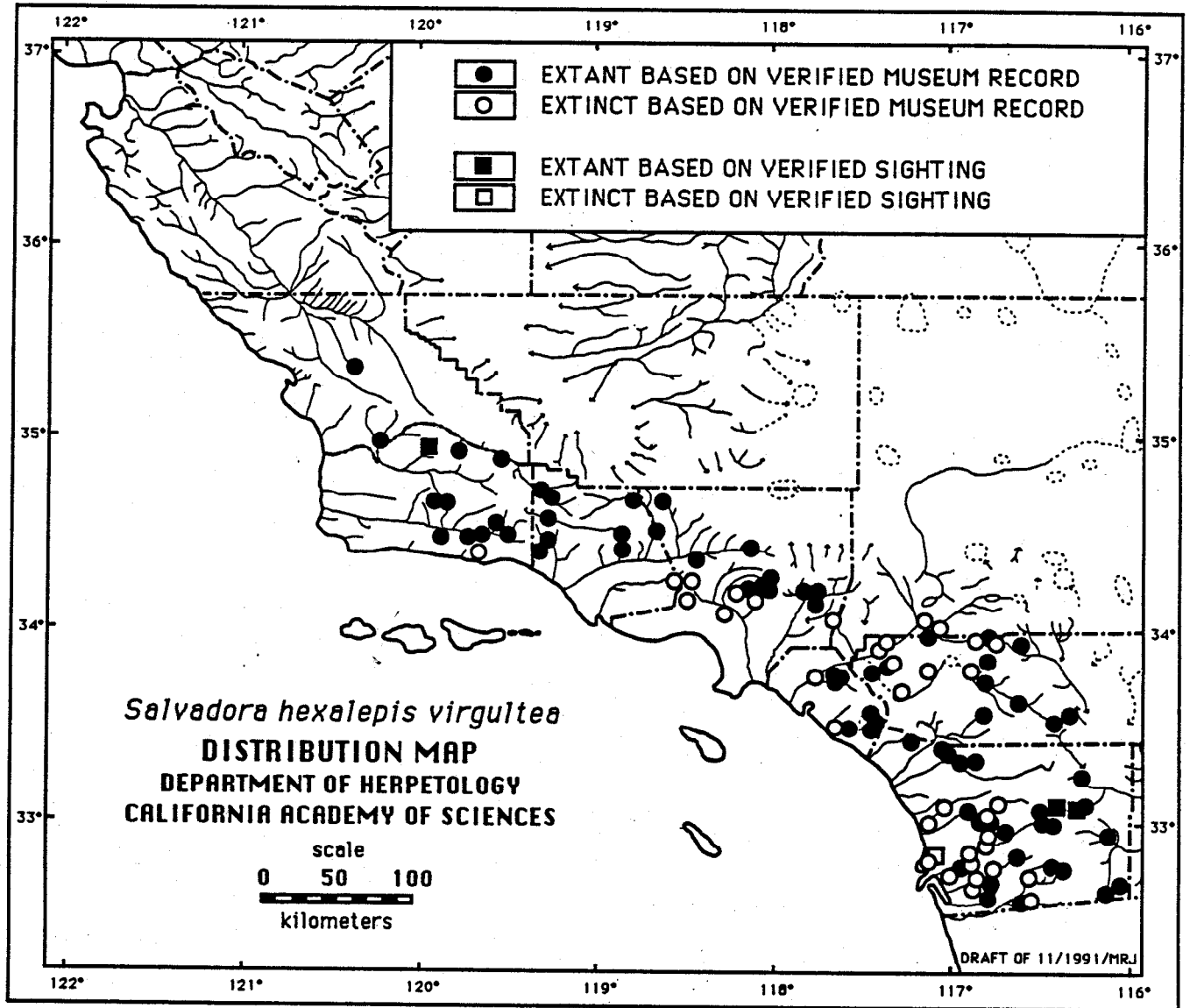
Figure 47. Historic and current distribution of the coast patch-nosed snake (*Salvadora hexalepis virgultea*) in southern California based on 168 locations from 198 museum records and 10 records from other sources.

in burrows or woodrat nests, so the presence of one or more burrow- or refuge-creating mammals may be necessary for this snake to be present.

Status: Special Concern; although available data indicate that the coast patch-nosed snake may have always been an uncommon taxon, the data may be strongly biased because the interval over which time this snake is active is infrequently sampled. Regardless of the bias, extensive areas in coastal southern California with a shrubby habitat structure have been converted through various land uses to habitats largely unsuitable to this species. Extensive conversion of chaparral to grassland began over 30 years ago in coastal southern California, largely to create grazing land for livestock, but later, also for fire control. Beginning at the same time and particularly in the last 20 years, large foothill tracts of shrub-dominated vegetation associations on the coastal slope have been converted to urban development and to a lesser extent, drip-irrigated orchards and row crops. It is conservatively estimated that at least 20% of the habitat historically available to this species is no longer suitable, but the actual figure maybe much higher.

Management Recommendations: Intensive life history study of this snake is needed, especially to better understand its pattern of activity and habitat use, and identify the habitat components that are critical to its survival. Based on the latter, surveys of existing habitat should be made that incorporate ground-truthing against aerial photointerpretation, and existing aerial surveys should be compared with historical aerial photographs to assist estimating the degree of habitat loss and where and how habitat has changed. Until more detailed habitat data become available, shrubby vegetative associations should be routinely surveyed for this taxon at appropriate diel and seasonal intervals and assessments of the quality of the habitat for this species should be done on a site-by-site basis.

TWO-STRIPED GARTER SNAKE
Thamnophis hammondii (Kennicott 1860)

Description: A medium-sized (60-101 cm TL), garter snake with a variable dorsal coloration of olive, brown, or brownish gray, and a single yellow-orange lateral stripe on each side of the body (Fitch 1940, Fox 1951, Larson 1984). These lateral stripes may be lacking on melanistic individuals, which are common in the northern third of the range of this species (Bellemin and Stewart 1977, Larson 1984). A nuchal spot may be present on the back of the neck when the middorsal stripe is absent (Stebbins 1985). The iris is a light tan color (pers. observ.).

Taxonomic Remarks: *Thamnophis hammondii* was recently removed from the *T. couchii* complex (Fox and Dessauer 1965, Rossman 1979, Lawson and Dessauer 1979, Fitch 1984) and elevated to species rank (Rossman and Stewart 1987; but see also Fitch 1940). Field observations indicating that *T. hammondii* is ecologically distinct from coexisting populations of *T. atratus, T. elegans,* and *T. sirtalis* along the central California coast support this conclusion (Fox 1951, Bellemin and Stewart 1977, Rossman and Stewart 1987, Boundy 1990). Some of these taxa have historically been confused with *T. hammondii* (e.g., Larson 1984). Lawson and Dessauer (1979) provide some genetic data on this taxon, but genetic variation across the seven populations sampled cannot be interpreted because the data are lumped. Even if the data had not been lumped, the small sample sizes make it unlikely that one could identify a geographic pattern. Recently, Boundy (1990) suggested that *T. hammondii* be split into two subspecies in California based on his morphometric analyses. This conclusion does not seem justified based on his small sample size of snakes from the northern half of their range. Moreover, the recent conclusions of McGuire and Grismer (1993) from their morphomettic analysis of several newly discovered populations of *T. digueti* indicates that *T. digueti* simply represents *T.*
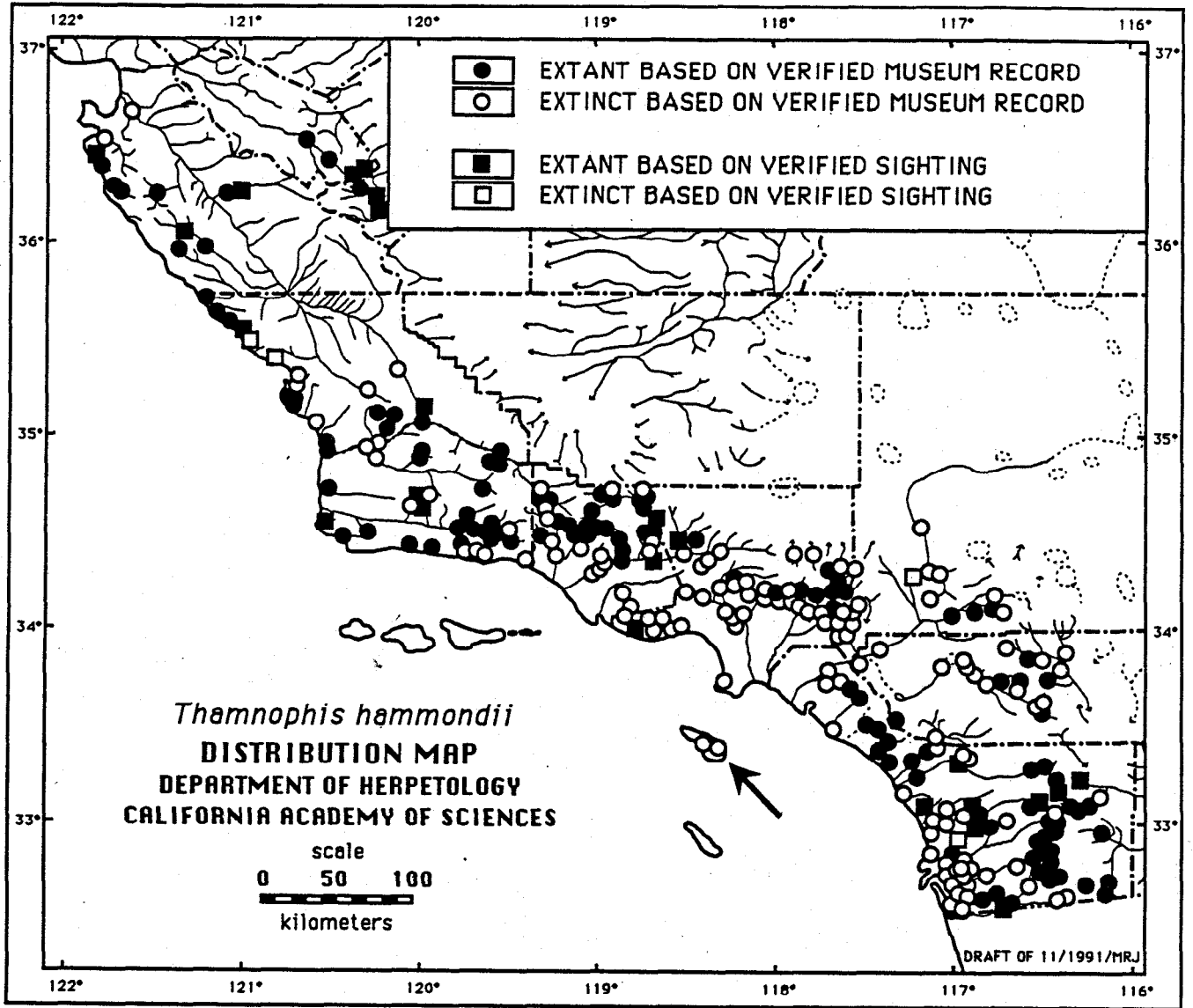
Figure 48. Historic and current distribution of the two-striped garter snake (*Thamnophis hammondii*) in central and southern California based on 509 locations from 1260 museum records and 100 records from other sources.

hammondii in central and southern Baja California, Mexico. More comprehensive genetic and morphometric data are needed to identify potential variation across the geographic range of this taxon.

Distribution: The known range of *T. hammondii* extends through the South Coast and Peninsular ranges west of the San Joaquin Valley and deserts from the vicinity of Salinas (Monterey County: Boundy 1990) and Cantua Creek (Fresno County: Ely 1992), south to La Presa, Baja California, Mexico (McGuire and Grismer 1993). The known elevational range of *T. hammondii* extends from sea level to around 2450 m at Tahquitz Valley on Mt. San Jacinto (Riverside County: Atsatt 1913). In California, *T. hammondii* occurs throughout most of the South Coast and Transverse ranges from Salinas Valley and the southeastern slope of the Diablo Range, south to the Mexican border (Figure 48). This species is also present on Santa Catalina Island (Los Angeles County), California (Brown 1980) and occurs in several perennial, desert slope streams (e.g., Mojave River [San Bernardino County], Whitewater River [Riverside County], and San Felipe Creek [San Diego County]; Perkins 1938, Fitch 1940, Stebbins 1985, Boundy 1990).

Life History: Despite the fact that *T. hammondii* was historically a relatively common snake, its life history is poorly known. In part, this is because this taxon has never been subject to intensive ecological study. *Thamnophis hammondii* is a highly aquatic snake; it is rarely found far from water, which it freely enters to forage or escape predators (Fitch 1940, 1941; Stebbins 1985). Individuals have also been recorded to climb trees or vegetation > 3 m above the surface of the water (Cunningham 1955), but the frequency of this behavior is unknown. Juveniles and adults emerge from hibernation in the spring although they may sometimes be observed foraging on warm winter days (Rüthling 1915, Rathbun et al. 1993). Two-striped garter snakes may have a lower thermal preferendum (18.6-31.8°C [average 22.6°C]: Cunningham 1966b) than measured for other garter snake species (see Brattstrom 1965), but the temperature data are difficult to interpret because the temporal and behavioral context of when temperatures were taken is frequently lacking. *Thamnophis hammondii* is often observed basking during the early morning and afternoon before foraging for prey (pers. observ.). Two-striped garter snakes mate in the spring (March) and bear from 1-25 live young during the fall (Bogert 1930; Cunningham 1959a; G. Stewart, pers. comm.). Neonates have been observed from late August through November (Rathbun et al. 1993). Evidence suggests that females can store sperm for up to 53 months (Stewart 1972), although they probably mate each year. Juveniles and adults feed primarily on fish *(Cottus* sp. and *Eucyclogobius newberryi:* Rathbun et al. 1993; *Gasterosteus aculeatus:* Bell and Haglund 1978, Bell 1982, Rathbun et al. 1993; *Oncorhynchus mykiss:* Fitch 1941), fish eggs (Fitch 1940), and the tadpoles and metamorphs of anurans; *Bufo microscaphus californicus, B. boreas halophilus, Pseudacris cadaverina, P. regilla, Rana aurora draytonii, R. boylii,* and *R. muscosa* have been recorded as prey (Grinnell and Grinnell 1907, Klauber 1931, Fitch 1940, Cunningham 1959a; G. Stewart, pers. comm.; pers. observ.). *Thamnophis hammondii* will prey on bullfrog metamorphs and larvae when other food resources are rare or absent (pers. observ.), which suggests that the life stages of bullfrogs are differentially avoided. Earthworms and larval California newts *(Taricha torosa)* may also be eaten (Fitch 1940, Von Bloeker 1942, Stebbins 1985). The two-striped garter snake probably does not reach sexual maturity until 2 or 3 years of age (pers. observ.). *Thamnophis hammondii* has been maintained in captivity for 7-10 years (Bowler 1977; G. Stewart, pers. comm.), but longevity in the field is unknown. Potential predators include: hawks, shrikes, herons, raccoons, coyotes, and probably introduced exotics such as largemouth bass, catfish, and feral pigs (see Springer 1977 and Schwalbe and Rosen 1988). Bullfrogs are known to eat all life stages of *T. hammondii (S.* Sweet, pers. comm.). Some data are available on the movement ecology of *T. hammondii.* Adult snakes display use of different areas and habitats in summer versus winter (Rathbun et al. 1993). During summer, snakes utilized

streamside sites and had home ranges that varied from approximately 80 m^2 to over 5,000 m^2 (mean = ca. 1500 m^2; n = 7). During winter, they occupied coastal sage scrub and grassland locations in uplands adjacent riparian areas, and had home ranges that varied from approximately 50 m^2 to nearly 9,000 m^2 (mean = ca. 3400 m^2; n = 3). Many aspects of the movement ecology of *T. hammondii,* especially with respect to their colonization abilities, are poorly understood.

Habitat: *Thamnophis hammondii* commonly inhabits perennial and intermittent streams having rocky beds bordered by willow thickets or other dense vegetation (Grinnell and Grinnell 1907; Fitch 1940, Fitch 1941). Two-striped garter snakes also inhabit large sandy riverbeds, such as the Santa Clara River (Ventura County), if a strip of riparian vegetation is present along the stream course (pers. observ.). This taxon also utilizes stock ponds and other artificially-created aquatic habitats (e.g., Lake Hemet [Riverside County]) if a dense riparian border of emergent vegetation and amphibian and fish prey are present. If flooding, overgrazing, burning, or mechanical alteration removes dense riparian vegetation, *T. hammondii* is infrequently found in such habitats (pers. observ.). Limited data indicate that small mammal burrows are used as overwintering sites (Rathbun et al. 1993). Data are lacking on the microhabitats required for bearing young.

Status: Threatened; *T. hammondii* has disappeared from approximately 40% of its historic range on the California mainland during the past century, and most of this has occurred since 1945. It can now be considered common only in eastern San Diego County. Much of this decline is attributed to habitat destruction from urbanization, large reservoirs, and the cement lining of stream channels in southern California for flood control. During the past decade, however, *T. hammondii* has also disappeared from numerous localities in Ventura, Santa Barbara, and San Luis Obispo counties where habitat was once considered to be relatively secure from development (S. Sweet and D. Holland, pers. comm.). The reasons for the rapid decline in the northern part of the range of *T. hammondii* are probably due to a combination of factors, which include: habitat modification resulting from livestock grazing; predation by introduced fishes, bullfrogs, and feral pigs; and loss of the prey food base, particularly amphibians (see accounts on *Rana aurora draytonii, R. boylii,* and *R. muscosa* for pertinent comments, as well as the information presented in Jennings et al. 1992 for *T. elegans)* and fishes, recently exacerbated by the severe drought that occurred over much of southern California between 1986 and 1990. A significant portion of the riparian habitat that still harbors *T. hammondii* is degraded, and could rapidly become unsuitable if present trends towards drier climatic conditions for southern California continue; those conditions are exacerbated by current levels of livestock grazing. Additionally, many areas in the Angeles, Cleveland, Los Padres, and San Bernardino National Forests have sustained significant increases in recreational use since 1970; such trends increase the probability of human contact and the frequency of incidental take contributes to depleting local populations. Hikers, fishermen, and off-road vehicle enthusiasts who mistakenly believe that garter snakes consume large numbers of trout often kill *T. hammondii* (Fitch 1940, Fitch 1941; G. Stewart, pers. comm.; pers. observ.; see also Von Bloeker 1942).

On Santa Catalina Island, individuals from a small melanistic population consisting of < 30 snakes that inhabited a 2.9-km section of stream and a 4-ha reservoir in Cottonwood Canyon has not been seen since 1977 (Brown 1980; G. Stewart, pers. comm.), although a single pregnant female was collected in nearby Middle Canyon on 12 May 1985 (SBMNH 1181). The decline of this isolated population is attributed to the filling of the reservoir with alluvium during the 1982 floods coupled with later drought, predation by feral pigs and introduced bullfrogs, and loss of vegetative cover due to overgrazing. This population of *T. hammondii* should be listed as Endangered.

Management Recommendations: Detailed field surveys to determine the presence of extant populations of *T. hammondii* in southern California are urgently needed to assess the quality of habitat and the numbers of garter snakes remaining in this region. Studies on the ecology of this taxon are especially needed to determine the importance of various food resources for recruitment and reproduction, as well as to indicate the seasonal movements and colonization abilities of garter snakes in natural and human-modified habitats. Land-use managers should consider limiting public access to riparian habitats which harbor significant populations of *T. hammondii.*

SOUTH COAST GARTER SNAKE
Thamnophis sirtalis sp.

Taxonomic Remarks: Recent comparison of *Thamnophis sirtalis* from southern California with individuals from populations north of the Tehachapi Mountains and Carpinteria (Santa Barbara County) indicate that individuals from southern California represent a distinct taxon (J. Boundy and S. Sweet, pers. comm.). Description of this taxon is pending (J. Boundy, pers. comm.).

Distribution: This California endemic is known only from scattered localities along the southern California coastal plain; apparently from the Santa Clara River Valley (Ventura County: SDSNH 4376; UCSB uncat.; S. Sweet, pers. comm.), south to the vicinity of San Pasqual (San Diego County: Klauber 1929; Figure 49). Verified sightings and museum specimens indicate that this taxon historically occurred from near sea level (Ballona Creek and Playa del Rey Marsh, Los Angeles County: Von Bloeker 1942) to ca. 832 m (Lake Henshaw, San Diego County: R. Fisher, pers. comm.).

Life History: Little is known about the life history of this taxon. Because *T. sirtalis* is found over most of North America in a wide variety of habitats except for far northern latitudes and southwestern deserts (Fitch 1981), the 14 known subspecies exhibit a wide variation in habits and life history traits (see Fitch 1965 for a summary). The few data on the South Coast garter snake are interpreted in the context of similarities to other *T. sirtalis* taxa.

The South Coast garter snake is live-bearing, it breeds in the spring and gives birth to 12-20 young during August (Cunningham 1959a), although the birthing interval probably extends from late summer to early fall. If the pattern of growth is similar to other *T. sirtalis,* juvenile snakes typically mature after 2-3 years for males and females, respectively. Other California *T. sirtalis* are known to feed principally on amphibians *(Pseudacris regilla:* Fitch 1941, Cunningham 1959a, White and Kolb 1974; *Bufo boreas:* Fitch 1941; 1949), although fish, small mammals, and insects are also taken (Cunningham 1959a, Fitch 1949, White and Kolb 1974). Thus, the South Coast garter snake may have a similar diet, as small fishes, tadpoles, and insects have been identified as prey items (Grinnell and Grinnell 1907). Snakes are active during the spring through fall (March-October), although occasional individuals can be found abroad during the cold winter months (December-January) on exceptionally warm days (Rüthling 1915). The South Coast garter snake was historically reported as locally common (Grinnell and Grinnell 1907, Bogert 1930, Von Bloeker 1942), but is unknown if overwintering aggregations existed as reported elsewhere (Gregory 1982). *Thamnophis sirtalis* has survived in captivity for over 10 years (Bowler 1977), but longevity of the South Coast garter snake in the field is unknown. Potential predators include kingsnakes, hawks, shrikes, herons, raccoons, coyotes, and probably introduced exotics such as largemouth bass, catfish, and bullfrogs (see Fitch 1965 and Schwalbe and Rosen 1988). Data on movement ecology and colonization abilities are lacking.
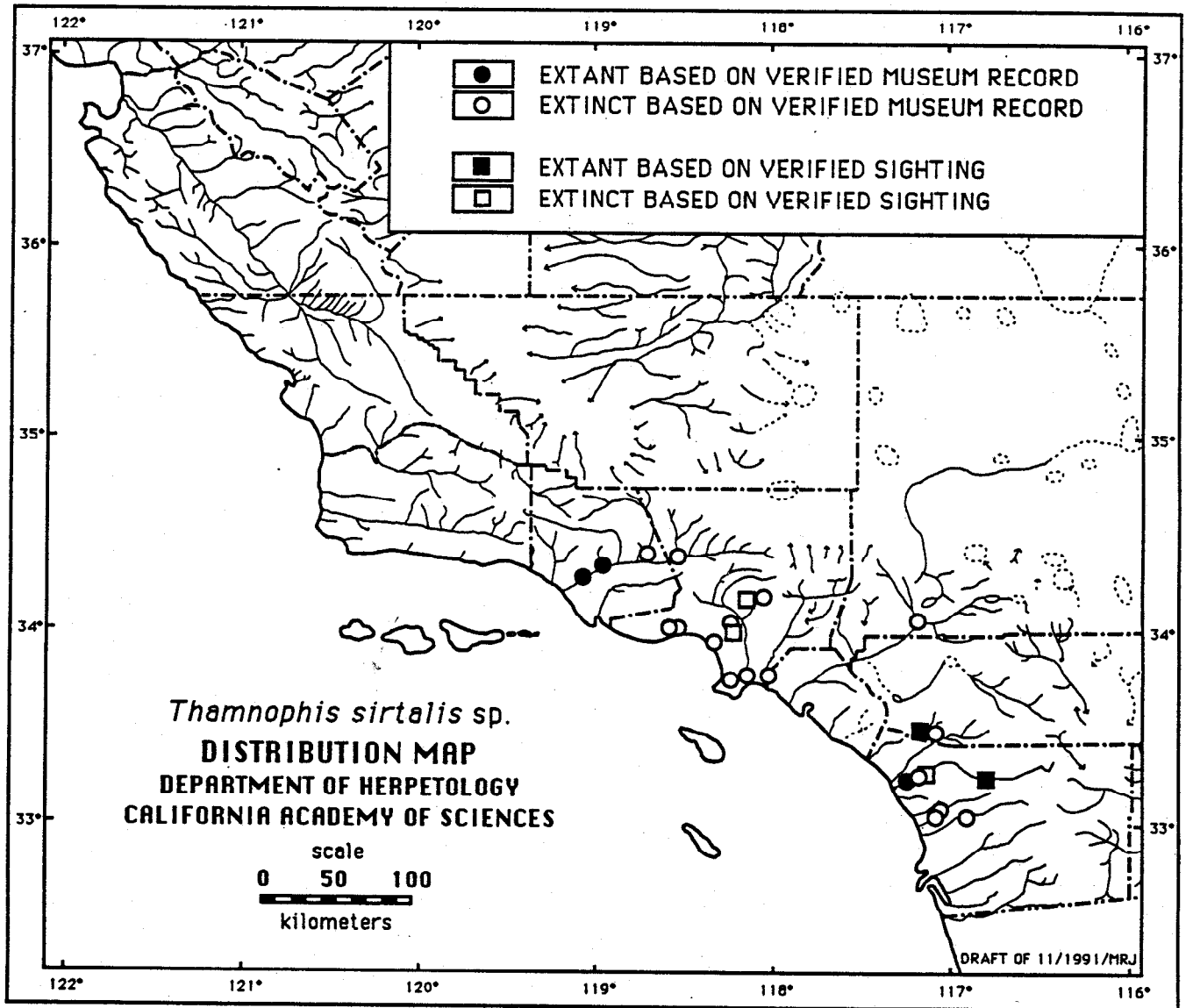
Figure 49. Historic and current distribution of the South Coast garter snake (*Thamnophis sirtalis* sp.) in southern California based on 23 locations from 81 museum records and 7 records from other sources.

Habitat: The South Coast garter snake appears restricted to marsh and upland habitats near permanent water that have good strips of riparian vegetation (Grinnell and Grinnell 1907; S. Sweet, pers. comm.), probably because such sites provide the right combination of prey and refuge sites. Historical records of this taxon also exist for meadow-like habitats adjacent to marshlands (Van Bloeker 1942). Data are lacking on the microhabitats required for bearing young.

Status: Endangered; of the 24 known historic localities for this taxon, 18 (75%) no longer support snakes. Extensive urbanization and flood control projects have destroyed most sites; some more isolated locations, such as in the Santa Monica Mountains, appear to have lost snakes following heavy floods or extended droughts (DeLisle et al. 1986). Habitat loss through agriculture, urbanization, and flood control projects, as well as the presence of many introduced aquatic predators threatens the six remaining localities where this snake still exists. This taxon can be notorious difficult to find in some areas (Klauber 1929; S. Sweet, pers. comm.).

Management Recommendations: Thorough monitoring to determine where this taxon remains in riparian habitats in southern California are urgently needed to evaluate the quality of habitat and the number of snakes that remain. Baseline monitoring should be conducted over several years to ensure that local populations have not been missed, and also extended to identify population trends. Studies on the ecology of this snake are also needed to identify the importance of various prey resources for recruitment and reproduction, and the seasonal movement patterns and the colonization abilities of snakes in remnant habitats.

Discussion

General aspects of the 48 taxa reviewed are summarized in Tables 3, 4, and 5. Of the 48 taxa recommended for state-level status, anurans (frogs and toads) are the numerically best represented group with 14, followed by lizards (12), salamanders (11), snakes (9), and turtles (2). These groups are not equally represented in the California fauna, so the proportion of taxa recommended for listing is a function of the total number taxa in each group in California less the number already listed (at State or Federal levels) provides a better indication of the relative impacts on each group. Based on the latter, turtles have the greatest proportion of taxa being recommended for listing (100%), followed by anurans (70%), salamanders (46%), lizards (35%), and snakes (22%).

An uneven distribution exists in the the number of taxa being recommended for listing at different levels among amphibian and reptile groups (Table 6). In the most critical category (Endangered), anurans and turtles are overrepresented; whereas salamanders, lizards, and snakes are underrepresented (see Table 3). Conversely, in the least critical category (Species of Special Concern), anurans and turtles are underrepresented, whereas salamanders, lizards, and snakes are over-represented (see Table 5). Despite bias because of greater confidence in the data available for the more visible groups (anurans, lizards, and turtles) when compared to the less visible ones (salamanders and snakes), this analysis allows a conclusion that turtles or anurans are more imperilled than lizards, salamanders, or snakes. That conclusion is not likely related to taxonomic group *per se* because some taxa deviate from the modal critical category their taxonomic group exhibits (e.g., *Thamnophis hammondii* among snakes, *Ambystoma californiense* among salamanders).

Partitioning taxa into aquatic and terrestrial categories indicates a more generalized explanation: Taxa with aquatic life stages are more imperilled than those with an exclusively terrestrial life history (Table 6). Among the 20 taxa with at least one aquatic life stage, 13 (60%) are proposed for listing in the most critical category (Endangered), whereas only 2 of the 28 taxa (7%) with a terrestrial life history is proposed for the same category. This comparison may be more extreme than this somewhat arbitrary analysis indicates because one of the two "terrestrial" taxa proposed for Endangered status may be highly dependent on local hydrology for its survival (see species account for the Breckenridge Mountain slender salamander). In contrast, only 6 of the 20 (30%) taxa with at least one aquatic life stage are proposed for allocation to the least critical category (Species of Special Concern), whereas 19 of the 28 taxa (68%) with a terrestrial life history are proposed for that same category. This pattern should not be surprising. Today, most aquatic habitats in California are rarer (i.e., smaller in area) than most terrestrial habitats, a difference often reflected on a scale of one or more orders of magnitude. Overall rarity of aquatic habitats now seen in California is couched in a long history of change in which xerification or loss of aquatic habitat has been and continues to be the dominant pattern (see Anderson and Ohmart 1982, 1985; Anonymous 1991; Brady et al. 1985; L. Bryant 1985; Buckhouse et al. 1985; Ferren and Gevirtz 1990; Harris et al. 1985; Heede 1985; Jones 1988b; Kauffman and Krueger 1984; Kauffman et al. 1983; Marlow and Pogacnik 1985; Ohmart et al. 1988; Szaro and Debano 1985). The large number of critically imperilled taxa associated with aquatic habitats simply underscores the alarming, but long-standing pattern of degradation and reduction of aquatic habitats in California, a pattern that 4 years of recent drought has severely exacerbated.

Degradation and reduction of aquatic habitats in California is a statewide phenomenon, but several regions of the State deserve mention because the current species composition reflects acute degradation and habitat loss. In southern California (south of the Santa Clara River), the aquatic amphibian and reptile fauna is severely depleted; four taxa *(Bufo alvarius, Kinosternon sonoriense, Rana boylii,* and *R. yavapaiensis)* may be extinct and

Table 3. Summary of third category amphibian and reptile species in California for which State listing as Endangered is recommended.

Common Name	Scientific Name	Endemic To California?**	Very Small Range	Small Range	Moderate-Sized Range	Moderately Broad Range	Broad Range	Vernal Pool Habitat Specialist	Breeding Habitat Limited	Refuge Habitat Limited	Habitat Restricted	Old-Growth Specialist	Stream Habitat Specialist	Sandy Habitat Specialist	Dietary Specialist	Seasonal Movements Between Habitats	Large Home Range	Behaviorally Vulnerable	Exotic Predators	Overcollecting Or Black Market Trade	Land Use Conversion	Modification Of Hydrology	Modification Of Seep Hydrology	Removal Of Old-Growth Forest	Removal Of Live Or Dead Oak Tree Material	Off-Road Vehicles	Unidentified, But Causing Widespread Declines
Breckenridge Mtn. slender salamander	*Batrachoseps* sp.	Y	X	--	--	--	--	--	X	X	X	--	--	--	--	--	--	--	--	?	X	--	X	--	X	--	--
Colorado River toad	*Bufo alvarius*	N	--	X	x	--	--	--	?	?	X	--	X	--	--	--	--	--	X	--	X	X	--	--	--	--	--
Yosemite toad	*Bufo canorus*	Y	--	--	X	--	--	--	X	X	X	--	--	--	--	X	--	?	--	--	--	X	--	--	--	--	X
Arroyo toad	*Bufo microscaphus californicus*	N	--	X	x	--	--	--	X	X	X	--	X	--	--	X	--	X	X	--	X	X	--	--	--	X	--
California red-legged frog***	*Rana aurora draytonii*	N	--	x	--	X	--	--	X	X	X	--	--	--	--	--	--	X	X	--	X	X	--	--	--	X	--
Foothill yellow-legged frog***	*Rana boylii*	N	--	--	x	X	--	--	X	--	X	--	X	--	--	--	--	X	X	--	X	X	--	--	--	?	--
Cascade frog***	*Rana cascadae*	N	--	X	--	x	--	--	X	X	X	--	--	--	--	--	--	?	X	--	--	X	--	--	--	--	X
Mountain yellow-legged frog***	*Rana muscosa*	N	--	--	X	--	--	--	X	X	X	--	--	--	--	--	--	?	X	--	--	X	--	--	--	X	X
Northern leopard frog	*Rana pipiens*	N	--	X	--	--	x	--	X	X	X	--	--	--	--	--	?	--	--	--	X	X	--	--	--	--	X
Spotted frog	*Rana pretiosa*	N	--	X	--	--	x	--	X	X	X	--	--	--	--	--	--	X	X	--	X	X	--	--	--	--	--
Lowland leopard frog	*Rana yavapaiensis*	N	--	X	--	x	--	--	X	X	X	--	--	--	--	--	--	--	X	--	X	X	--	--	--	--	--
Western pond turtle***	*Clemmys marmorata*	N	--	--	x	X	--	--	X	X	X	--	--	--	--	?	?	X	X	X	X	X	--	--	--	--	--
Sonoran mud turtle	*Kinosternon sonoriense sonoriense*	N	--	X	--	x	--	--	?	X	X	--	X	--	X	?	?	--	X	--	--	X	--	--	--	--	--
Two-striped garter snake***	*Thamnophis hammondii*	N	--	x	X	--	--	--	--	--	X	--	X	--	X	--	--	--	X	--	X	X	--	--	--	X	--
South Coast garter snake	*Thamnophis sirtalis* sp.	Y	--	X	--	--	--	--	--	X	X	--	--	--	--	--	--	--	X	--	X	X	--	--	--	X	--

*A lower case "x" identifies the size of the geographic range of the taxon outside California.
**Y = Yes; N = No.
***This taxon has also been proposed for Threatened or Special Concern status in parts of its geographic range (see Tables 4 and 5).

Table 4. Summary of third category amphibian and reptile species in California for which State listing as Threatened is recommended.

Common Name	Scientific Name	Geographic Range*						Vulnerable Aspects											Current Major Impacts								
		Endemic To California?**	Very Small Range	Small Range	Moderate-Sized Range	Moderately Broad Range	Broad Range	Vernal Pool Habitat Specialist	Breeding Habitat Limited	Refuge Habitat Limited	Habitat Restricted	Old-Growth Specialist	Stream Habitat Specialist	Sandy Habitat Specialist	Dietary Specialist	Seasonal Movements Between Habitats	Large Home Range	Behaviorally Vulnerable	Exotic Predators	Overcollecting Or Black Market Trade	Land Use Conversion	Modification Of Hydrology	Modification Of Seep Hydrology	Removal Of Old-Growth Forest	Removal Of Live Or Dead Oak Tree Material	Off-Road Vehicles	Unidentified, But Causing Widespread Declines
California tiger salamander	*Ambystoma californiense*	Y	--	--	X	--	--	X	X	X	X	--	--	--	--	X	--	X	X	--	X	X	--	--	--	--	--
Inyo Mountains salamander	*Batrachoseps campi*	Y	--	X	--	--	--	--	X	X	X	--	--	--	--	--	--	--	--	--	--	--	X	X	--	?	--
Southern seep salamander	*Rhyacotriton variegatus*	N	--	--	B	--	--	--	X	X	X	X	--	--	--	--	--	?	--	--	--	--	--	X	X	X	--	--
Tailed frog***	*Ascaphus truei*	N	--	--	X	x	--	--	X	?	X	X	X	--	--	?	--	X	--	--	--	--	--	X	X	X	--	--
California red-legged frog***	*Rana aurora draytonii*	N	--	x	--	X	--	--	X	X	X	--	--	--	--	--	--	X	X	--	X	X	--	--	--	X	--
Foothill yellow-legged frog***	*Rana boylii*	N	--	--	x	X	--	--	X	--	X	--	X	--	--	--	--	X	X	--	X	X	--	--	--	?	--
Mountain yellow-legged frog***	*Rana muscosa*	N	X	--	X	--	--	--	X	X	X	--	--	--	--	--	--	?	X	--	--	X	--	--	--	--	X
Western spadefoot	*Scaphiopus hammondii*	N	--	x	--	X	--	X	X	X	X	--	--	--	--	X	--	X	X	--	X	X	--	--	--	--	--
Western pond turtle***	*Clemmys marmorata*	N	--	--	--	x	X	--	X	X	X	--	--	--	--	?	?	X	X	X	X	--	--	--	--	--	--
Belding's orange-throated whiptail	*Cnemidophorus hyperythrus beldingi*	N	--	--	X	x	--	--	?	--	X	--	--	--	X	--	--	--	--	X	--	--	--	--	--	?	--
Panamint alligator lizard	*Elgaria panamintina*	Y	--	X	--	--	--	X	X	X	--	X	--	--	--	--	--	--	--	X	X	--	--	--	--	?	--
San Diego horned lizard	*Phrynosoma coronatum blainvillii*	N	--	x	X	--	--	--	--	--	--	--	--	--	X	--	?	X	X	--	X	--	--	--	--	X	--
California horned lizard	*Phrynosoma coronatum frontale*	Y	--	--	X	--	--	--	--	--	--	--	--	--	X	--	?	X	X	--	X	--	--	--	--	X	--
Flat-tailed horned lizard	*Phrynosoma mcallii*	N	--	X	x	--	--	?	--	X	--	--	--	X	X	--	X	X	--	X	--	--	--	--	--	X	--
San Joaquin coachwhip	*Masticophis flagellum ruddocki*	Y	--	--	X	--	--	--	--	--	X	--	--	--	--	--	?	--	--	X	--	--	--	--	--	X	--
Two-striped garter snake***	*Thamnophis hammondii*	N	--	x	X	--	--	--	--	--	X	--	X	--	X	--	--	X	--	X	X	--	--	--	--	X	--

*A lower case "x" identifies the size of the geographic range of the taxon outside California; a "B" is used where the size of the geographic range inside California is subequal to that outside California.

**Y = Yes; N = No.

***This taxon has also been proposed for Special Concern or Endangered status in parts of its geographic range (see Tables 3 and 5).

Table 5. Summary of third category amphibian and reptile species in California for which Special Concern status is recommended.

Common Name	Scientific Name	Geographic Range*						Vulnerable Aspects											Current Major Impacts								
		Endemic To California?**	Very Small Range	Small Range	Moderate-Sized Range	Moderately Broad Range	Broad Range	Vernal Pool Habitat Specialist	Breeding Habitat Limited	Refuge Habitat Limited	Habitat Restricted	Old-Growth Specialist	Stream Habitat Specialist	Sandy Habitat Specialist	Dietary Specialist	Seasonal Movements Between Habitats	Large Home Range	Behaviorally Vulnerable	Exotic Predators	Overcollecting Or Black Market Trade	Land Use Conversion	Modification Of Hydrology	Modification Of Seep Hydrology	Removal Of Old-Growth Forest	Removal Of Live Or Dead Oak Tree Material	Off-Road Vehicles	Unidentified, But Causing Widespread Declines
Relictual slender salamander	*Batrachoseps relictus*	Y		X							?												X		X		
Yellow-blotched salamander	*Ensatina eschscholtzii croceater*	Y		X						?	?									?					X		
Large-blotched salamander	*Ensatina eschscholtzii klauberi*	Y		X						?	?									X					X		
Mount Lyell salamander	*Hydromantes platycephalus*	Y			X					?	?												X				
Owens Valley web-toed salamander	*Hydromantes* sp.	Y		X						?	?												X				
Del Norte salamander	*Plethodon elongatus elongatus*	N		X	x					?		X												X			
Coast Range newt***	*Taricha torosa torosa*	Y			X				?										?	X	X						
Tailed frog****	*Ascaphus truei*	N		X	x				X	?	X	X	X			?		X			X			X		X	
Northern red-legged frog	*Rana aurora aurora*	N			X		x		X	X	X							X	X		X	X		X			
Foothill yellow-legged frog****	*Rana boylii*	N			x	X			X		X		X					X	X		X	X					?
Cascade frog****	*Rana cascadae*	N		X		x			X	X	X							?	X		X						X
Couch's spadefoot	*Scaphiopus couchii*	N	X				x	X	X						?			X			?					X	
California legless lizard	*Anniella pulchra*	N			X	x				?	X			X				X	X		X					?	
Coronado skink	*Eumeces skiltonianus interparietalis*	N		B					?	?	X								?		X				X	X	
Banded Gila monster	*Heloderma suspectum cinctum*	N		X		x									X		X			X	X					?	

*A lower case "x" identifies the size of the geographic range of the taxon outside California; a "B" is used where the size of the geographic range within California is subequal to that outside California.

**Y = Yes; N = No.

***Only for a portion of its geographic range (see species accounts for details).

****This taxon has also been proposed for Threatened or Endangered status in parts of its geographic range (see Tables 3 and 4).

Table 5. Summary of third category amphibian and reptile species in California for which Special Concern status is recommended (continued).

Common Name	Scientific Name	Geographic Range*						Vulnerable Aspects											Current Major Impacts								
		Endemic To California?**	Very Small Range	Small Range	Moderate-Sized Range	Moderately Broad Range	Broad Range	Vernal Pool Habitat Specialist	Breeding Habitat Limited	Refuge Habitat Limited	Habitat Restricted	Old Growth Specialist	Stream Habitat Specialist	Sandy Habitat Specialist	Dietary Specialist	Seasonal Movements Between Habitats	Large Home Range	Behaviorally Vulnerable	Exotic Predators	Overcollecting Or Black Market Trade	Land Use Conversion	Modification Of Hydrology	Modification Of Seep Hydrology	Removal Of Old-Growth Forest	Removal Of Live Or Dead Oak Tree Material	Off-Road Vehicles	Unidentified, But Causing Widespread Declines
Colorado Desert fringe-toed lizard	*Uma notata notata*	N	--	X	x	--	--	--	--	--	X	--	--	X	--	--	--	?	--	--	X	--	--	--	--	X	--
Mojave fringe-toed lizard	*Uma scoparia*	N	x	X	--	--	--	--	--	--	X	--	--	X	--	--	--	?	--	--	X	--	--	--	--	X	--
Sandstone night lizard	*Xantusia henshawi gracilis*	Y	X	--	--	--	--	--	--	X	X	X	--	--	--	--	--	--	--	?	--	--	--	--	--	--	--
Sierra night lizard	*Xantusia vigilis sierrae*	Y	X	--	--	--	--	--	--	X	X	X	--	--	--	--	--	--	--	?	?	--	--	--	--	--	--
Baja California rat snake	*Elaphe rosaliae*	N	X	--	--	x	--	--	--	--	X	--	--	--	--	--	?	--	--	X	--	--	--	--	--	--	--
Red diamond rattlesnake	*Crotalus ruber ruber*	N	--	X	x	--	--	--	--	--	X	--	--	--	--	--	?	--	--	--	X	--	--	--	--	--	--
San Bernardino mountain kingsnake	*Lampropeltis zonata parvirubra*	Y	--	X	--	--	--	--	--	X	X	--	--	--	--	--	--	--	X	X	--	--	--	--	X	--	--
San Diego mountain kingsnake	*Lampropeltis zonata pulchra*	Y	--	X	--	--	--	--	--	X	X	--	--	--	--	--	--	--	X	X	--	--	--	--	X	--	--
Santa Cruz gopher snake	*Pituophis melanoleucus pumilus*	Y	X	--	--	--	--	--	--	--	X	--	--	--	--	--	--	X	--	--	--	--	--	--	--	--	--
Coast patch-nosed snake	*Salvadora hexalepis virgultea*	N	--	x	X	--	--	--	--	--	?	--	--	--	--	?	--	X	--	--	X	--	--	--	--	--	--

*A lower case "x" identifies the size of the geographic range of the taxon outside California.
**Y = Yes; N = No.

Table 6. Taxonomic and ecological groupings of amphibian and reptile taxa across recommended listing categories.

Group	Total[a] (N)	Endangered (E) (N_e)	%E (N_e/N) x 100	Threatened (T) (N_t)	%T (N_t/N) x 100	Special Concern (SC) (N_{sc})	%SC (N_{sc}/N) x 100
Amphibians	25	11	44	8	32	11	44
Anurans	14	10	71	5	36	4	40
Salamanders	11	1	9	3	27	7	63
Reptiles	23	3	13	8	35	13	57
Lizards	12	0	0	5	42	7	58
Snakes	9	2	22	2	22	6	67
Turtles	2	2	100	1	50	0	0
Aquatic Taxa[b]	20	13	65	9	45	6	30
Terrestrial Taxa[b]	28	2	7	7	25	19	68

[a] Total indicated the total number of taxa recommended for listing in the indicated group. The sum of the totals for each listing category sometimes do not match the total in each group because some taxa are listed in more than one category.

[b] Taxa were placed in the aquatic grouping if one or more life stages of that taxon was dependent on significant accumulations of free water. Thus, all anurans, the two turtles, Ambystoma californiense, Rhyacotriton variegatus, Taricha torosa, and Thamnophis hammondii were placed in the aquatic group, and all plethodontid salamanders, lizards, and snakes were placed in the terrestrial group.

fragmented populations are all that remain of seven others *(B. microscaphus californicus, Clemmys marmorata, R. aurora draytonii, R. muscosa, Scaphiopus hammondii, Thamnophis hammondii,* and *T. sirtalis sp.).* Even taxa that were generally historically abundant (e.g., *Taricha torosa torosa)* are now observed in limited numbers. In the San Joaquin Valley, three aquatic taxa *(C. marmorata; R. a. draytonii,* and *R. boylii)* have highly fragmented distributions restricted to segments of the bordering foothills, and two others *(Ambystoma californiense* and *S. hammondii)* remain largely in the less-disturbed rainpool habitats that have become increasingly isolated along the edges of the valley. In northeastern California, two frogs *(R. pipiens* and *R. pretiosa),* if present, are extremely rare. Finally, aquatic taxa from high elevations along the Cascade-Sierra axis *(B. canorus, R. cascadae,* and *R. muscosa)* have displayed apparent widespread reductions in geographic range that are especially alarming.

Aquatic habitats in California dominate the picture of species in severe decline, but several taxa associated with specialized and often rather fragile terrestrial or terrestrial-aquatic interface habitats also deserve special mention. Four taxa often, and, for some, uniformly, associated with deposits of wind-blown sand *(Anniella pulchra, Phrynosoma mcallii, Uma notata notata,* and *U. scoparia)* are at varying degrees of risk because of alterations to this habitat type. Three taxa *(Ascaphus truei, Plethodon elongatus,* and *Rhyacotriton variegatus)* closely associated with old-growth coniferous forests are increasingly at risk due to the removal of this habitat type at rates faster than it can renew itself. Finally, two taxa often associated with saltbush scrub or annual grassland associations *(Masticophis flagellum ruddocki* and *P. coronatum frontale)* are at risk because these habitat types are now greatly reduced and fragmented.

Recommendations

Patterns revealed in this analysis led to making the following recommendations. The facts that such a large number of amphibian and reptile taxa (48) deserve some kind of listing, and that proposed listings are exclusively upgrades (no downgrades[3]) is reflective of a grave situation with far-reaching environmental consequences. Because issues raised in the proposed listing of many taxa are complex and linked, ranking the recommendations associated with such listings was difficult. Nevertheless, some recommendations are more encompassing; these (hereafter "primary") are provided first. Linkage between primary and most subsequent recommendations is complex enough to prevent logically ranking recommendations in a more refined way. As a consequence, grouped primary and secondary recommendations are numbered solely because presentation must be sequential. This numbering should not be interpreted as an importance ranking. Finally, some of the recommendations made here have appeared in individual species accounts in a taxon-specific context; these recommendations reappear here in a generalized context since they may apply not only to more than one taxon, but to other taxa not discussed here in future situations.

Primary Recommendations:

1) Funding - As treated here, funding refers to any monies available to address amphibian and reptile taxa that are listed, candidates or potential candidates for listing, or the problems associated with such taxa. Current levels of funding are conservatively

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[3]At this writing, no data addressing any of the taxa the State of California lists as Endangered or Threatened has indicated that a downgrade in status was justified.   Such evaluations were outside the purview of this report (see page 8).

estimated at two orders of magnitude or more below the level needed to reverse existing trends. As a consequence, two issues are evident: a) existing agency machinery is highly unlikely to be able to generate funding at the level needed to reverse existing trends; and b) because of the great cost, generation of funding levels necessary to reverse existing trends must be broad-based, and thus draw on agency-, public-, and private-sector funding. The latter result is unlikely to be achieved without radical changes in current attitudes towards land use and land ownership. In particular, private ownership of land now allows landowners enough latitude to engage in short- or long-term abuse of land incompatible with the survival of most amphibians and reptiles. Moreover, the full realization of changes to achieve this kind of funding base are unlikely to be implemented without a significant transitory period, especially in the context of the current weak economic situation. Details of the pertinent arguments related to the current funding base are addressed in Appendix I.

2) Education - Education of the public at all levels as to the significance of amphibians and reptiles is essential for several interrelated reasons. First, recognition that the failure of selected amphibians and reptiles to maintain populations is not simply a detriment to those species, it is indicative of a decline in environmental quality that increasingly affects humans in a negative manner, so humans should recognize it as such. Second, amphibians and reptiles are an essential part of the natural heritage of California, having evolved in tandem with the diverse physical and biotic environments found in the state. Nonetheless, a remarkable amount of disinformation exists about the native California herpetofauna. This is in part a consequence of the fact that some exotics are so well established (e.g., bullfrogs) that many people perceive those species to be native and are ignorant of the problems exotics create. Third, understanding of the significance of amphibians and reptiles must be broad-based if the funding needed to maintain programs addressing their study, their survival, and education of the public about them is to continue (see also Gibbons 1988 for pertinent comments). Broad-based means that concerted educational efforts should provide age-appropriate information to individuals ranging from pre-school to adults. Scattered evidence indicates that serious deficiencies in the latter area are a major reason that much of the public is ignorant regarding amphibians and reptiles. The connection between declines among amphibians and reptiles and various aspects of environmental quality are not perceived or poorly understood by many people. Thus, the public is refractory to providing or supporting the funding needed to address these species. Education must provide the primary vehicle for changes in attitude in land use from one of ownership incompatible with sensitive taxon survival to one of stewardship compatible with sensitive taxon survival. Fourth, education related to sensitive taxa has tended to have a narrow focus, addressing mostly biological assessments to which technological solutions most strongly influenced by economic concerns are applied (see especially Kellert 1985). Aesthetic, educational, historical, and recreational values of sensitive species are often ignored (Kellert 1985, Rolston 1981). Education should provide exposure to the full range of values these taxa provide.

Secondary Recommendations:

1) Protection of aquatic systems - The gravity of the situation facing the aquatic species treated here indicates that a much more concerted effort should be directed at aquatic systems. Especially needed are efforts in the areas of: a) modification of aquatic habitat structure, b) water quality, and c) exotic biota. To be effective, these efforts must be integrated, not independent.

Perhaps the most pervasive problem concerning aquatic systems is their continued modification with still only limited attention to the natural or historical dynamics of these systems with regard to sediment distribution and vegetation structure (see Harris et al.

1985, Heede 1985, Platts et al. 1985, Schultze and Wilcox 1985, Stabler 1985). Future engineering solutions should focus on integrating into existing hydrological patterns without significantly modifying them or working towards restoring the historicalpatterns, rather than attempting solutions that force changes upon existing patterns. Further, the inability of many aquatic systems to support the imperilled aquatic amphibians and reptiles we discuss is often testimony either to the inadequacy of current local, regional, and state water quality standards; or their enforcement; or both. Finally, exotic biota that threaten, or that are suspected of threatening much of the native aquatic biota continue to expand their range in California. Limiting the expansion of exotics requires efforts on several fronts including: a) development of species-specific control measures that will not affect non-target species; b) education that emphasizes the overwhelming discrepancy between the many disadvantages exotics have versus the very limited advantages, if any, they provide; and c) reducing the translocation and future importation of exotics into California to the maximum extent possible. Special attention should be devoted to bullfrogs, which are one of the foremost among problem exotics that influence amphibians and reptiles (see Schwalbe and Rosen 1988). Bullfrogs should be deleted from the CDFG list of game species, the bag limits on them should be removed, and programs directed at the selective removal and elimination of bullfrogs should be encouraged. The latter measures should be coupled to a broad-based education program that details bullfrog identification procedures and life history characteristics and contrasts them to those of the native frogs. Equal effort should be devoted to the eliminating the translocation of exotic fishes, regardless of their game species status. Particularly, efforts should be made to reduce or even eliminate the translocation of mosquitofish, which continues to occur for claimed public health reasons that frequently lack a scientific basis. Studies are needed to determine the level at which mosquitofish exert their negative effects. Alternatives to using exotics should be developed in conjunction with agencies that have historically promoted the translocation of exotic fishes.

Perhaps most significantly, special efforts should be directed at the protection of entire hydrographic basins or drainages, or at measures that will ultimately lead to protection of entire drainages. Failure to at least initiate measures that will lead to protection of entire drainages guarantees that the current patterns of degradation will eliminate most of the remaining populations of imperilled aquatic species within the next two decades.

2) Systematic studies - Many of the taxa discussed herein lack systematic study on them adequate to understand the historical units that may be contained within them. Several currently recognized taxa (e.g., California newt) almost undoubtedly represent more than one taxon. For taxa such as the fringe-toed lizards *(Uma* spp.), systematic study is imperative because it remains vague whether the Federally listed *U. inornata* is conspecific with the two *Uma* taxa we discuss. For fringe-toed lizards as with other taxa, understanding precisely what populations comprise discrete taxonomic units is tantamount to listing or otherwise addressing imperilled populations. If the taxonomic units that may be imperilled are not precisely defined, what populations require protection or directed management efforts will remain vague.

3) Movement studies - The species accounts cumulatively reflect the fact that movement ecology is the least understood aspect of life histories (see the life history section of the respective accounts). As treated here, movement ecology is a broad heading that encompasses the diel, seasonal, inter-seasonal, and inter-generational movements that individuals or populations of a species makes. They include, but are not limited to, movements between foraging and refuge sites, overwintering and summering sites, and breeding and non-breeding sites. Movement data are sparse largely because they are time costly to obtain. Ironically, movement data are among the most crucial to obtain to formulate management recommendations because they allow precise identification of

habitats that a species uses, sometimes only temporarily, but which are essential to its survival. The thorough telemetry study of Muth and Fisher (1992) that showed that the home ranges of *Phrynosoma mcallii* were up to over an order of magnitude larger than had been identified in previous studies elegantly demonstrates that the quality of movement data obtained is related to the effort expended. Perhapsthe most significant finding of the latter study was that the number of points needed to confidently establish the size of the home range is several times as many as was previously believed to be adequate. This study alone makes the quality of existing movement data on most species suspect (e.g., the recent studies of Hager (1992) and Rowland (1992), and older studies of Bostic (1964), Kauffman (1982), and Turner and Medica (1982)). Inter-seasonal (*fide* Muth and Fisher 1992) and inter-generational movement data are lacking for all taxa we discuss, and even rudimentary movement data are available for only a few taxa. Efforts to obtain significant movement data on all taxa treated here should be a primary focus of future work

4) Treatment of taxa potentially extirpated within the state - Several of the taxa reviewed here have some probability of having been extirpated within California (e.g., Colorado River toad, lowland leopard frog, and Sonoran mud turtle). It needs emphasis, however, that no taxon for which this condition is suspect has been surveyed enough to be confident of this assertion. Assertions of extirpation are necessarily based on negative evidence. The accumulation of such evidence only increases confidence in the assertion that extirpation has occurred. As a consequence, concluding that extirpation has occurred should be treated conservatively in the extreme. Guidelines need to be established to determine just how extirpation should be evaluated, if at all. Because extirpation is based on negative evidence, it absolutely should not be used as the basis for delisting taxa.

5) Attention to complex, synergistic, or additive environmental effects. The rapid pace of change in current local, regional, or global environments has resulted in new or previously unrecognized complex impacts on their contained species. While only a few of these novel effects are mentioned here, a general awareness should exist that the likelihood of novel effects is increased at the current rapid pace of often complex changes. One symptom of a potentially serious, but as of yet undetermined, effect is the apparent decline of high elevation populations of amphibians as the result of an unidentified impact that may be atmospheric in nature. Recent surveys and studies attempting to show that acidification is the cause of such declines have failed to reveal data in support of this hypothesis in California (Landers et al. 1987; Bradford et al. 1991, 1992, 1994). In the absence of evidence for acidification, increased levels of ambient mid-range (UV-B) ultraviolet radiation (Blumthaler and Ambach 1990) as a consequence of the widely publicized pattern of depletion of stratospheric ozone (Watson et al. 1988) is a potentially grave atmospheric effect that should be addressed (see Blaustein et al. 1994). Even if no direct effect of UV-B is found in California, indirect effects should be considered because supratypical UV-B levels are thought to be capable of depressing immune system function, which could increase the susceptibility of organisms to pathogens or parasites (see Carey 1993).

Numerous other complex effects are possible; only a few more important ones will be mentioned. First, recent climatic trends perhaps indicative of global warming resulted in severe drought in California over the interval 1986-1990 (see especially Knox 1991). Terrestrial plethodontid salamanders (e.g., *Batrachoseps* spp., *Ensatina eschscholtzii,* and *Hydromantes* spp.), which are dependent on soil moisture to maintain activity (Cohen 1952), may have had their activity altered or their survivorship influenced in unknown ways by the severe drought. If a major underlying theme can be attributed to the general pattern of habitat change in California even before the 1986-1990 drought, it was increased xerification on local and regional scales. Human diversion and use of water initiated or assisted, often imperceptibly on a short time-scale, the drying of many previously more mesic habitats. Drought accentuated the process of xerification, which became apparent in

places where previously it had been barely perceptible. Drought-accentuated xerification may influence some aquatic amphibians (e.g., *Rana boylii* and *R. cascadae)* that have apparently disappeared from the southern portions of their geographic ranges in California. Understanding of how local xerification may haveinfluenced both aquatic and terrestrial amphibians needs study. Second, a frequently unrecognized, but potentially important influence, on amphibian and reptile populations is the temporary or permanent change in the concentration of predators as the result of human activity. For example, local increases in common raven *(Corvus corax)* populations associated with excessive depredation of young desert tortoises in the Mojave Desert has been linked to local increases in alternative food resources (garbage dumps and landfills) as a consequence of local increases in the human population (U.S. Fish and Wildlife Service 1990; but see also Camp et al. 1993). Similar human-induced concentrations of generalized predators (e.g., American crows *[C. brachyrhynchos],* common ravens, Virginia opossums *[Didelphis virginiana],* and raccoons) that increase predation over historic background levels may be occurring elsewhere and may be responsible for declines now observed in several of the species discussed herein. Moreover, such effects are likely additive to or synergistic with the problems posed by exotics. Such human-induced effects should be watched for, and steps should be taken to discourage them, wherever possible. Third, ways in which other elements of the native fauna may benefit native amphibians and reptiles are often unrecognized or need study. For example, dam-constructing beaver create slackwater habitat that benefit a number of taxa including amphibians (e.g., *Rana aurora aurora),* and removal of beaver has been linked to unfavorable erosional downcutting in some stream systems (Apple 1985, Parker et al. 1985). Care should be taken however, to differentiate between native and introduced populations of beaver in California since the latter may have undetermined undesirable impacts. Furthermore, the often limited burrowing capabilities of amphibians and reptiles may be the cause of their frequent association with burrowing mammals (besides the latter simply being prey items in the case of snakes). Determination of how dependent on burrowing mammals many amphibians and reptiles are for refuge sites needs study. Fourth, more subtle human-induced changes in habitats often go unrecognized for years. One example of this is the increase and proliferation in campsites in wilderness areas over the past 20 years (see Cole 1993). The effects local habitat degradation caused by these impacts has on amphibian and reptile populations is unknown. Yet, these effects need to be quantified because they may be more insidious as negative long-term trends will be more difficult to identify than for other factors.

6) Livestock management and grazing - Problems that result from grazing practices and livestock management undoubtedly rank among the most important in California; the effects are often cumulative over many years and are amplified by interactions with other factors. While the impacts of grazing have focused appropriately on riparian and aquatic systems (Buckhouse et al. 1981, L. Bryant 1985, Jones 1988b, Kauffman and Krueger 1984, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985, Szaro et al. 1985), impacts to the terrestrial herpetofauna are also recognized (Jones 1979). Perhaps the greatest problem with grazing and livestock management is that, in California, much of it occurs on private land, where non-abusive management practices must be largely voluntarily applied by landowners. As a result, most landowners implement management practices that are economically the most favorable in the short-term, practices which are invariably the least favorable to the amphibian and reptile fauna in the long-term (e.g., see species account for the California red-legged frog). Recent economic hardship assisted by the severity of multi-year drought conditions has worsened this pattern. In particular, drought conditions have accentuated the cumulative effects of many years of abusive grazing practices. Significant reversal of the existing patterns of livestock management on private land require a broad-based education effort (see #2 primary recommendation) that emphasizes the greater long-term gain of applying beneficent grazing practices over practices that result in only short-term gain, but cumulative loss. This must be coupled to

encouraging practices that allow recovery of rangelands (e.g., partial riparian exclosures (Szaro et al. 1985) and timing of grazing (Marlow and Pogacnik 1985)).

7) Patterns of timber harvest - Although problems associated with timber harvest relate largely to the coniferous forests of coastal and montane California, some also apply to the diverse oak woodlands in lowland and submontane areas of the state. Education and programs that encourage some diversity of downed woody material (in particular, that ensure a continuous supply of that material of different ages), that help maintain a significant broad-leaf (especially oak) litter layer, that help maintain significant riparian corridors, and that limit the size of tree patches harvested should be promoted. These measures help provide nest and refuge sites for, encourage the food base for, or reduce hydrological and other impacts to, amphibians and reptiles that occupy timbered areas (Bury 1983; Bury and Corn 1988a, 1988b; M. Bryant 1985; Murphy and Hall 1981; Newbold et al. 1980; Raphael 1987; Welsh and Lind 1988; Welsh 1990).

8) Long-term studies - Long-term studies are costly, but are the only way to identify population trends that may signal deteriorating environmental conditions (Morrison 1988), and are the only way to obtain demographic information on amphibian and reptile taxa that are long-lived (e.g., *Clemmys marmorata).* These demographic data are essential to their effective management. Long-term is a taxon-relative designation. To be useful, a long-term study should at least exceed the average longevity of adults of a taxon. Where the average longevity is not known, it should extend over a period long enough that confidence is high that at least 80% of the adult population has turned over (i.e., replaced itself). In the absence of long-term data, deteriorating environmental conditions will be manifest in a frequently abrupt manner. Intermittent surveys over long time intervals will often reveal only absences of taxa once present, and an inability to refine management alternatives for long-lived species will persist.

9) Loss of biological information - Under current State and Federal statutes, development and other land use changes require that biological assessments be undertaken only when one or more listed species are suspected of being at risk. Although generalized biological inventories are often undertaken, neither vouchers nor photographs of amphibian and reptile species identified to be present are taken for historical record. As a result, if the development or land use change takes place, nothing is available to voucher the historical biological composition of a given site. The biological composition of a given site, including its amphibian and reptile fauna, is as much a part of the heritage of California as its archaeological heritage. Under Sections 106 and 110 of the National Historic Preservation Act, Federal agencies and, by default, State agencies must require a pre-development survey for archaeological sites. Where archaeological remains are found, but the site is of too minor archaeological significance to be secured in permanence, qualified professionals salvage the remains. A parallel, state-level statute should be instituted to "salvage" biological data in the form of some kind of vouchering for sites that ultimately undergo development. Such vouchers, including materials secured for frozen tissue collections, should be deposited in one of the four major, in-state repositories designed for that purpose (i.e., CAS, LACM, MVZ, SDSNH; Table 1). Cost of the biological survey as well as the maintenance cost of vouchers in the repository institution should simply be a part of the cost of development of a site.

Acknowledgments

Plate 16. Larval and adult California red-legged frog (*Rana aurora draytonii*) [from Stebbins 1951].

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APPENDIX I

The budget of the California Department of Fish and Game (CDFG)
As Applied to Amphibians and Reptiles

Constraints on the non-game portion of the budget applied directly or indirectly to amphibians and reptiles (in the sense treated in the discussion) are a function of the total CDFG budget. However, interpretation from budget changes is difficult because non-game monies applied to these taxa do not represent a tracked budget category (Appendix Table I) and are drawn from different budget categories (J. Brode and B. Bolster, pers. comm.). Moreover, non-parallel shifts have occurred in the amounts applied to amphibians and reptiles among different budget categories (J. Brode and B. Bolster, pers. comm.). Nevertheless, several considerations based on an understanding of the total budget and changes in tracked budget categories are possible.

First, although the total CDFG budget has increased roughly six-fold since 1970 (see Appendix Table 1), many indications exist that the funding base is deteriorating. These include the fact that since 1978 the total CDFG budget has represented a declining fraction of the total state budget, and has not kept pace with inflation.

Second, except for a decrease in the total CDFG budget between the years 1977-78 and 1978-79, the total budget increased by absolute amounts varying from $76,000 (between 1986-87 and 1987-88) to $16.7 million (between 1984-85 and 1985-86) through 1990 (Appendix Table 1). Most alarming is the fact that for the most recent budget year (1990-1991), the total CDFG budget has decreased by $109,000 over the previous fiscal year.

Third, the Nongame Inland Fisheries budget, which historically contributed the largest segment of amphibian and reptile monies, increased from a small fraction of the total budget (0.17%) in 1970-1971 to fluctuating around 1.0% of total budget in the late 1970s and early 1980s (peaking at 1.3% in 1985-86). In 1990-91, this budget dropped to an all-time low of 0.07% of the total budget and the decrease of $803,000 over the previous fiscal year was the largest ever. It needs emphasis that this only partly reflects what has occurred in the most recent years with nongame monies applied to amphibians and reptiles. Since 1986, two additional budget categories (Nongame Heritage and Total Nongame Monies Spent; see Appendix Table I) have been tracked from which significant monies have been applied to these groups. The Total Nongame Monies Spent category is further complicated because it represents CDFG budget monies combined with monies from outside the total CDFG budget, thus this category cannot be treated as a fraction of the total budget. Nevertheless, the data indicate consistent annual declines in the Total Nongame Monies Spent category since 1987-88 with the greatest decline (2.5 million dollars) occurring between the two most recent fiscal years for which data exist (Appendix Table 1). The Nongame Heritage category did increase in 1990-1, but by an amount ($692,000) more than exceeded by the decrease in the Nongame Inland Fisheries budget.

Although factors contributing to the deteriorating budgetary situation are complex and are beyond the scope of this report to unravel, a number of significant factors contribute. These include:

a) The annual CDFG budget, like the state and federal budgets, is based in part on projections of growth. Expectations of increased income levels exist whether or not growth occurs. Lack of growth contraindicating annual projections have contributed to a funding shortfall and resulted in deficit spending.

Appendix Table I. The annual budget of the California Department of Fish and Game 1970-1991. Data in dollar amounts were extracted from the official Governor's Budget Reports (1973-1993). All figures are based on actual monies spent. The Nongame Inland Fisheries budget is shown separately because it includes expenditures on amphibian and reptiles as well as nongame fishes. Annual totals exclude administrative expenses.

ITEM	1970-71	(%)	1971-72	(%)	1972-73	(%)	1973-74	(%)
Total Budget	21,631,707	(100.00)	23,147,296	(100.00)	25,513,307	(100.00)	28,434,562	(100.00)
Enforcement	6,563,560	(30.34)	6,723,301	(29.05)	7,407,526	(29.03)	8,204,202	(28.85)
Wildlife Management	4,169,987	(19.28)	4,466,447	(19.30)	4,841,465	(18.98)	5,288,030	(18.60)
Inland Fisheries	4,396,463	(20.32)	4,892,026	(21.13)	5,422,149	(21.25)	6,292,484	(22.13)
Anadromous Fisheries	2,494,079	(11.53)	2,816,195	(12.17)	3,112,160	(12.20)	3,336,579	(11.73)
Marine Resources	2,485,855	(11.49)	2,756,481	(11.91)	3,004,266	(11.76)	3,261,501	(11.47)
Environmental Services	1,521,763	(7.03)	1,492,846	(6.45)	1,725,741	(6.76)	2,051,766	(7.22)
Administration	(1,915,470)	(-----)	(1,919,455)	(-----)	(2,066,599)	(-----)	(2,221,057)	(-----)
Nongame Heritage	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Total Nongame Monies Spent	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Nongame Inland Fisheries	36,807	(0.17)	110,166	(0.48)	156,505	(0.61)	190,387	(0.91)

ITEM	1974-75	(%)	1975-76	(%)	1976-77	(%)	1977-78	(%)
Total Budget	32,796,462	(100.00)	36,098,138	(100.00)	39,009,722	(100.00)	43,566,205	(100.00)
Enforcement	9,746,528	(29.72)	10,291,408	(28.51)	11,235,154	(28.80)	13,915,804	(31.94)
Wildlife Management	5,695,628	(17.37)	6,965,253	(19.30)	7,305,207	(18.73)	7,372,003	(16.92)
Inland Fisheries	6,871,652	(20.95)	7,452,483	(20.65)	8,484,157	(21.75)	9,232,987	(21.19)
Anadromous Fisheries	4,340,203	(13.23)	4,396,488	(12.18)	5,040,603	(12.92)	5,083,662	(11.67)
Marine Resources	3,744,456	(11.42)	4,311,351	(11.94)	4,371,450	(11.21)	4,619,431	(10.60)
Environmental Services	2,397,995	(7.31)	2,681,155	(7.43)	2,573,151	(6.60)	3,342,318	(7.67)
Administration	(2,714,019)	(-----)	(2,875,165)	(-----)	(3,068,482)	(-----)	(3,301,561)	(-----)
Nongame Heritage	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Total Nongame Monies Spent	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Nongame Inland Fisheries	299,629	(0.91)	313,693	(0.87)	405,778	(1.04)	479,329	(1.10)

Appendix Table I. The annual budget of the California Department of Fish and Game 1970-1991 (continued). Data in dollar amounts were extracted from the official Governor's Budget Reports (1973-1993). All figures are based on actual monies spent. The Nongame Inland Fisheries budget is shown separately because it includes expenditures on amphibian and reptiles as well as nongame fishes. Annual totals exclude administrative expenses.

ITEM	1978-79	(%)	1979-80	(%)	1980-81	(%)	1981-82	(%)
Total Budget	43,480,197	(100.00)	50,220,500	(100.00)	60,194,000	(100.00)	65,788,000	(100.00)
Enforcement	13,960,639	(32.11)	15,415,782	(30.70)	19,089,000	(31.71)	20,078,000	(30.52)
Wildlife Management	7,552,850	(17.37)	9,021,127	(17.96)	10,893,000	(18.10)	11,621,000	(17.66)
Inland Fisheries	8,883,956	(20.43)	9,356,608	(18.63)	10,600,000	(17.61)	12,232,000	(18.59)
Anadromous Fisheries	5,170,479	(11.89)	7,485,578	(14.91)	8,851,000	(14.70)	12,032,000	(18.29)
Marine Resources	4,763,001	(10.95)	5,079,053	(10.11)	5,972,000	(9.92)	4,807,000	(7.31)
Environmental Services	3,149,272	(7.24)	3,862,352	(7.69)	4,789,000	(7.96)	5,018,000	(7.63)
Administration	(3,480,727)	(-----)	(3,680,248)	(-----)	(2,104,000)	(-----)	(8,700,000)	(-----)
Nongame Heritage	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Total Nongame Monies Spent	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Nongame Inland Fisheries	487,320	(1.12)	506,364	(1.01)	545,364	(0.91)	394,000	(0.60)

ITEM	1982-83	(%)	1983-84	(%)	1984-85	(%)	1985-86	(%)
Total Budget	66,980,000	(100.00)	71,156,000	(100.00)	82,490,000	(100.00)	99,251,000	(100.00)
Enforcement	20,592,000	(30.74)	20,985,000	(29.49)	25,065,000	(30.39)	25,908,000	(26.10)
Wildlife Management	12,329,000	(18.41)	12,596,000	(17.70)	16,378,000	(19.85)	25,434,000	(25.63)
Inland Fisheries	11,983,000	(17.89)	13,782,000	(19.37)	13,966,000	(16.93)	13,740,000	(13.84)
Anadromous Fisheries	11,993,000	(17.91)	12,943,000	(18.19)	15,290,000	(18.54)	21,847,000	(22.01)
Marine Resources	5,231,000	(7.81)	5,442,000	(7.65)	6,245,000	(7.57)	6,712,000	(6.76)
Environmental Services	4,852,000	(7.24)	5,408,000	(7.60)	5,546,000	(6.72)	5,610,000	(5.65)
Administration	(8,960,000)	(-----)	(11,298,000)	(-----)	(11,310,000)	(-----)	(12,852,000)	(-----)
Nongame Heritage	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Total Nongame Monies Spent	-----	(-----)	-----	(-----)	-----	(-----)	-----	(-----)
Nongame Inland Fisheries	631,000	(0.94)	447,000	(0.63)	450,000	(0.55)	1,268,000	(1.28)

Appendix Table I. The annual budget of the California Department of Fish and Game 1970-1991 (continued). Data in dollar amounts were extracted from the official Governor's Budget Reports (1973-1993). All figures are based on actual monies spent. The Nongame Inland Fisheries budget is shown separately because it includes expenditures on amphibian and reptiles as well as nongame fishes. Annual totals exclude administrative expenses.

ITEM	1986-87	(%)	1987-88	(%)	1988-89	(%)	1989-90	(%)
Total Budget	103,244,000	(100.00)	103,320,000	(100.00)	113,106,000	(100.00)	118,798,000	(100.00)
Enforcement	26,746,000	(25.91)	29,864,000	(28.90)	26,989,000	(23.86)	28,614,000	(24.09)
Wildlife Management	16,482,000	(15.96)	14,783,000	(14.31)	16,783,000	(14.84)	19,469,000	(16.39)
Inland Fisheries	17,587,000	(17.03)	19,764,000	(19.13)	22,726,000	(20.09)	23,330,000	(19.64)
Anadromous Fisheries	19,806,000	(19.18)	14,388,000	(13.93)	15,611,000	(13.80)	17,791,000	(14.98)
Marine Resources	7,171,000	(6.95)	8,167,000	(7.90)	7,804,000	(6.90)	9,886,000	(8.32)
Environmental Services	8,772,000	(8.50)	8,789,000	(8.51)	7,246,000	(6.41)	7,756,000	(6.53)
Administration	(15,462,000)	(-----)	(18,947,000)	(-----)	(21,425,000)	(-----)	(22,283,000)	(-----)
Nongame Heritage	6,680,000	(6.47)	7,565,000	(7.32)	11,239,000	(9.94)	8,118,000	(6.83)
Total Nongame Monies Spent	(10,401,000)	(-----)	(17,596,000)	(-----)	(16,488,000)	(-----)	(15,570,000)	(-----)
Nongame Inland Fisheries	484,000	(0.47)	423,000	(0.41)	590,000	(0.52)	882,000	(0.74)

ITEM	1990-91	(%)
Total Budget	118,689,000	(100.00)
Enforcement	29,602,000	(24.94)
Wildlife Management	16,086,000	(13.55)
Inland Fisheries	17,487,000	(14.73)
Anadromous Fisheries	23,953,000	(20.18)
Marine Resources	9,579,000	(8.07)
Environmental Services	10,226,000	(8.62)
Administration	(22,669,000)	(-----)
Nongame Heritage	8,810,000	(7.42)
Total Nongame Monies Spent	(13,061,000)	(-----)
Nongame Inland Fisheries	79,000	(0.07)

b) Total nongame monies available is partly dependent on voluntary contributions, such as the check-off system on the state-tax form and personalized license plate monies. The increasingly severe economic climate, exacerbated by multi-year drought, has led to a decline in voluntary contributions. Moreover, competition resulting from an increase in the number of voluntary check-off items on the state tax form has resulted in a greater partitioning of voluntary contributions from a largely unchanging base. Finally, a decline in confidence in governmental agencies has assisted in curtailing contributions.

c) Total nongame monies available is partly dependent on a funding base linked to game species, largely from monies that result from licensing for hunting and fishing. Changes in this funding base in the last 10 years have declined for two key reasons: A change in attitude about the environment has resulted in a decline in numbers of individuals that hunt or fish, and declines in populations of game species has resulted in hunters or fishermen decreasing their level of these activities within the state, with avid sportsmen increasingly leaving the state to hunt or fish.

d) Total non-game monies available is partly dependent on a funding base linked, like the total CDFG budget, to the state general fund, also a declining funding base. Environmental deterioration in California, exacerbated by the recent, severe multi-year drought, increasingly contributes to a demographic transition in which a greater number of individuals of moderate-to-high income levels leave the state than enter it. Such a transition is helping to slowly erode the state income tax base. Environmental deterioration also contributes to numerous obvious and subtle hidden costs that increasingly burden the general fund from different directions, leaving an ever-smaller segment for CDFG, and consequently, the non-game contribution.

The current economic crisis in California will undoubtedly slow any attempts at reversal of the deteriorating budgetary situation. Yet, several recommendations can be made that will ultimately achieve a reversal, benefiting the entire budgetary base for CDFG, and as a consequence, the non-game segment applied to amphibians and reptiles. These are:

a) Eliminate the pattern of annual budget estimation based on projections of growth, and as a result the anticipation of increased funding that leads to deficit spending. The realization must be arrived at that an adequate level of environmental quality and the general of quality of life in California requires a population cap. As a consequence, the state funding base can not longer be expected to increase as a function of the population. If any increases in the CDFG budget occur, they will have to result from funding innovations that are largely population-independent.

b) To the greatest extent possible, the nongame portion of the CDFG budget, and perhaps the entire budget, should be decoupled from the vagaries of the political and social climate. It should be recognized that the health of humans and game and non-game species alike are inextricably linked to environmental quality. This linkage should be reflected in a budget that represents a significant, but fixed proportion of the state budget, whatever that might be. Such an emphasis would reflect the responsibility of the entire human population of the state for maintenance of environmental quality. Voluntary contributions and license-generated funding should ultimately be viewed as supplemental, and should add to, rather than be necessary to fill out, various segments of the CDFG budget.

c) Game species should not be favored over non-game species within the new budget construct. Based on numbers alone, although awareness continues to increase, nongame species are currently highly de-emphasized. If emphasis on a taxon occurs, it should reflect environmental sensitivity or the degree to which that taxon controls greater energy

flow in an ecosystem or is a keystone taxon. Ultimately, the artificial dichotomy of game and nongame species should be eliminated.

d) Novel sources of funding should be linked to CDFG's responsibility in the management of all animal taxa, such as the potentially significant funding that could be generated as the result of recouping lost biological data (see secondary recommendation #9 in discussion).

Implementation of the aforementioned reforms will, no doubt, result in a long, likely tortuous transitory period. Yet, if implemented, they will result in significantly decrease costs that are currently the result of ignorance of the linkage between environmental quality, human welfare, and the array of other species (both game and nongame). Among the most important is that currently, a full one quarter of the CDFG budget is allocated to enforcement. If the human population of the state takes greater responsibility by paying for a significant, but fixed CDFG budget, the enforcement segment of the budget, as awareness increases, will be guaranteed to decrease to a much lower level. Many other positive feedbacks of this effect are possible.

APPENDIX II

The working list of taxa submitted with the questionnaire (see Appendix III). This list includes all taxa suggested as possible candidates for special status or potential listing as threatened or endangered.

List of Species for Consideration as Special Concern

Species are listed according to Jennings (1987. Special Publication, Southwestern Herpetologists Society (3):1-48). Species currently listed as being of "Special Concern" by the State of California are denoted by an asterisk (*).

Ambystomatidae:
____1) California tiger salamander   *Ambystoma californiense**

Dicamptodontidae:
____2) Pacific giant salamander   *Dicamptodon ensatus*
____3) Olympic salamander   *Rhyacotriton olympicus variegatus*

Salamandridae:
____4) Red-bellied newt   *Taricha rivularis*

Plethodontidae:
____5) Inyo Mountains salamander   *Batrachoseps campi**
____6) Channel Islands slender salamander   *Batrachoseps pacificus pacificus**
____7) Relictual slender salamander   *Batrachoseps pacificus relictus*
____8) Breckenridge Mt. slender salamander   *Batrachoseps* sp.
____9) Fairview slender salamander   *Batrachoseps* sp.
___10) Guadalupe slender salamander   *Batrachoseps* sp.
___11) Hell Hollow slender salamander   *Batrachoseps* sp.
___12) Kern Plateau slender salamander   *Batrachoseps* sp.
___13) San Gabriel slender salamander   *Batrachoseps* sp.
___14) Yellow-blotched salamander   *Ensatina eschscholtzii croceater**
___15) Large-blotched salamander   *Ensatina eschscholtzii klauberi*
___16) Mount Lyell salamander   *Hydromantes platycephalus**
___17) Owens Valley web-toed salamander   *Hydromantes* sp.
___18) Dunn's salamander   *Plethodon dunni**
___19) Del Norte salamander   *Plethodon elongatus elongatus**

Ascaphidae:
___20) Tailed frog   *Ascaphus truei*

Pelobatidae:
___21) Couch's spadefoot   *Scaphiopus couchii*
___22) Western spadefoot   *Scaphiopus hammondii**
___23) Great Basin spadefoot   *Scaphiopus intermontanus*

Bufonidae:
___24) Colorado River toad   *Bufo alvarius**
___25) Yosemite toad   *Bufo canorus**
___26) Great Plains toad   *Bufo cognatus*
___27) Arizona toad   *Bufo microscaphus microscaphus**
___28) Arroyo toad   *Bufo microscaphus californicus**
___29) Red-spotted toad   *Bufo punctatus*

Appendix II. List of Species for Consideration as Special Concern (continued).

Hylidae:
___30) California treefrog   *Pseudacris (=Hyla) cadaverina**

Ranidae:
___31) Northern red-legged frog   *Rana aurora aurora**
___32) California red-legged frog   *Rana aurora draytonii**
___33) Foothill yellow-legged frog   *Rana boylii**
___34) Cascade frog   *Rana cascadae*
___35) Mountain yellow-legged frog   *Rana muscosa*
___36) Northern leopard frog   *Rana pipiens*
___37) Spotted frog   *Rana pretiosa**
___38) Lowland leopard frog   *Rana yavapaiensis*

Kinosternidae:
___39) Sonoran mud turtle   *Kinosternon sonoriense sonoriense*

Emydidae:
___40) Southwestern pond turtle   *Clemmys marmorata pallida**

Testudinidae:
___41) Desert tortoise   *Xerobates (=Gopherus) agassizii**

Gekkonidae:
___42) Peninsular leaf-toed gecko   *Phyllodactylus xanti nocticolus**

Iguanidae:
___43) Baja collared lizard   *Crotaphytus insularis vestigium*
___44) Long-nosed rock lizard   *Petrosarus mearnsi mearnsi*
___45) San Diego horned lizard   *Phrynosoma coronatum blainvillii**
___46) California horned lizard   *Phrynosoma coronatum frontale*
___47) Pigmy short-horned lizard   *Phrynosoma douglassii douglassii*
___48) Flat-tailed horned lizard   *Phrynosoma mcallii**
___49) Western chuckwalla   *Sauromalus obesus obesus**
___50) Yellow-backed spiny lizard   *Sceloporus magister uniformis*
___51) Granite spiny lizard   *Sceloporus orcutti*
___52) Colorado Desert fringe-toed lizard   *Uma notata notata**
___53) Mojave fringe-toed lizard   *Uma scoparia*

Xantusiidae:
___54) Granite night lizard   *Xantusia henshawi henshawi**
___55) Sandstone night lizard   *Xantusia henshawi gracilis**
___56) Sierra night lizard   *Xantusia vigilis sierrae**

Teiidae:
___57) Belding's orange-throated whiptail   *Cnemidophorus hyperythrus beldingi**

Anguidae:
___58) Panamint alligator lizard   *Elgaria panamintina**

Anniellidae:
___59) Silvery legless lizard   *Aniella pulchra pulchra**
___60) Black legless lizard   *Aniella pulchra nigra**

Appendix II. List of Species for Consideration as Special Concern (continued).

Helodermatidae:
___61) Banded Gila monster   *Heloderma suspectum cinctum**

Leptotyphlopidae:
___62) Southwestern blind snake   *Leptotyphlops humilis humilis*

Boidae:
___63) Desert rosy boa   *Lichanura trivirgata gracia**
___64) Coastal rosy boa   *Lichanura trivirgata roseofusca**

Colubridae:
___65) Sharp-tailed snake   *Contia tenuis*
___66) Baja California rat snake   *Elaphe rosaliae*
___67) Sierra mountain kingsnake   *Lampropeltis zonata multicincta**
___68) Coast mountain kingsnake   *Lampropeltis zonata multifasciata**
___69) San Bernardino mountain kingsnake   *Lampropeltis zonata parvirubra**
___70) San Diego mountain kingsnake   *Lampropeltis zonata pulchra**
___71) St. Helena mountain kingsnake   *Lampropeltis zonata zonata**
___72) San Joaquin whipsnake   *Masticophis flagellum ruddocki**
___73) Santa Cruz gopher snake   *Pituophis melanoleucus pumilus**
___74) Coast patch-nosed snake   *Salvadora hexalepis virgultea*
___75) Hammond's two-striped garter snake   *Thamnophis hammondii hammondii*
___76) South Coast garter snake   *Thamnophis sirtalis* sp.
___77) Sonoran lyre snake   *Trimorphodon biscutatus lambda*
___78) California lyre snake   *Trimorphodon biscutatus vandenburgi**

Viperidae:
___79) Western diamondback   *Crotalus atrox*
___80) Red diamond rattlesnake   *Crotalus ruber ruber*

APPENDIX III

Copy of Cover Letter and Questionnaire:

10 October 1988

Dear   :

      We are currently reviewing the status of third category amphibian and reptile taxa (i.e., species of special concern) for the State of California. As one who has either, or both of, current or past field experience with one or more of the taxa being considered, we would like the benefit of your ideas and opinions. We cannot overemphasize that our ability to refine the quality of this review will remain limited without input from you; being among a handful of people with direct experience with, or knowledge of, each of these species. These last two decades have seen significant advances in increasing environmental awareness, yet the understanding of many California amphibians and reptiles, particularly with respect to their basic ecology and their importance in local communities and ecosystems, remains limited. With widespread habitat modification, your contribution to the understanding of these species, in particular where that contribution could benefit management, is urgent. It is especially so if we are to have some expectation that most species will be present for future generations to appreciate and study. We firmly believe that we can increase the objectivity of our recommendations and information by distilling information from a maximum number of sources, so we encourage you to take the time to respond carefully to this questionnaire as promptly as your schedule will allow.

      Find enclosed a preliminary list of species under consideration [see Appendix II]. We emphasize the preliminary nature of this list because data collected in this review are likely to change list composition and one of the objectives of this review is to provide recommendations for changes in status of respective taxa. The array of possible recommendations for changes in status within the scope of our review are: 1) no change from a species' current status, 2) an upgrade from no listing to special concern or from special concern to either threatened or endangered, and 3) a downgrade either from special concern to no listing or from threatened or endangered to special concern. It is because of the aforementioned changes in status that the list contains a number of species that are not special concern according to the current state listing. The preliminary list does not include currently listed threatened or endangered species since we anticipate few or no downgrades to a special concern status. Still, for the sake of completeness, we consider downgrades possible and you should refer to the most current state listing of threatened and endangered species if presenting data supporting a downgrade. We also welcome suggestions of additional species that based on the data you have, you feel should be listed.

      In reviewing the status of third category amphibian and reptile taxa for California, we have several objectives. These objectives are: 1) to identify and characterize the range of extant populations of each taxon; 2) to provide some indication of whether the current range differs significantly from the historic range; 3) to suggest the reasons for change, if any, between the current and historic ranges; 4) to provide some indication of the habitat variables crucial to each taxon; 5) to suggest how management should be implemented to the greatest benefit of each taxon; 6) to indicate gaps in knowledge for each taxon in each of the categories indicated previously; and 7) to recommend a status change as discussed above. The questions we ask are directed at addressing these objectives.

Appendix III (continued)

We realize that some of you may have concerns as to the release of data that might be used by individuals to collect animals from extant populations of reviewed taxa or as to the release of data not yet published. We wish to provide assurances that the details of any data released to us in confidence will not be revealed, but that we will be making interpretations, drawing conclusions, and making summary recommendations based, in part, on these data. Because one of the purposes behind this review is to help fill gaps in the data possessed by the California Department of Fish and Game-The Nature Conservancy Natural Heritage Data Base for California, we will be sending information to the Data Base from those contributions that are willing to have their data released through us. If you do not wish us to release your information to the Data Base, we would hope that you will provide it to them yourself, preferably as soon as possible. Regulatory agencies often query the Data Base for listed species that occur within large-scale development projects. If the Data Base lacks such information for special concern amphibians and reptiles, a greater probability will exist that even more of the remaining habitat for such species will be eliminated. Thus, it is important that the Data Base be provided with current information.

We want to thank you in advance for taking the time to response to this questionnaire. Only with your contributions can this review be truly realized. Please return your questionnaire to Mark Jennings at the Davis address. We look forward to hearing from you soon.

Sincerely,

Mark R. Jennings
Research Associate
California Academy of Sciences
1830 Sharon Ave
Davis, CA 95616-9420
Telephone: (916) 753-2727

Marc P. Haves
Department of Biology
P.O. Box 249118
University of Miami
Coral Gables, FL 33124-9118
Telephone: (305) 665-2291
              (305) 667-2761

Encl: questionnaire

Appendix. III (continued).

QUESTIONNAIRE

AMPHIBIAN AND REPTILE SPECIES
OF SPECIAL CONCERN IN CALIFORNIA

1) Verify that your name and address as indicated in our cover letter to you is correct. In addition, please provide us with the nine-digit zip code for your area (if you have not already done so and one exists), your phone number(s) (include your area code), and some minimum series of hours during the week at which time it would be convenient for us to contact you should the need arise. It is essential that we have this information in order to help organize the array of information provided by the many contributors in a sensible fashion. It will be particularly important where we need to have you elaborate on the data you provide or follow-up on sources of information.

2) Check off and number the taxa on which you will be providing data on the enclosed list. If you have reason to include taxa not on that list, please add them. However, **please restrict your list to taxa that you feel should have special concern status,** whether or not these taxa currently have that status. **Please also restrict your list to taxa with which either you have had direct field experience or your own experience indicates that said taxa have disappeared at localities where evidence of their historical occurrence exists.** In the event you feel the data you have to provide is too voluminous to handle in the questionnaire format we have provided, and you would be willing to arrange a meeting with us to discuss those data, please indicate so and we will contact you.

3) For each taxon you have listed, list any localities for which you are providing data alphabetically by county and locality specifics. **Please be as specific as you can;** we will do randomized update checks of some localities in the course of fieldwork associated with this review. For each locality, wherever possible, provide the time of day and time interval (search effort) involved in the sighting, any specific sampling methods that may have been used (if applicable), the number of individuals observed or captured, whether individuals of the observed taxon were adults, juveniles, or some other life stage (if this could be distinguished), and a statement of condition of the habitat relative to said taxon. If a locality or localities were visited in a haphazard fashion not linked to any particular sampling regime, state so. Finally, indicate for each sighting whether museum specimens, photographs, or other individuals that were with you at the time of the sighting are available to corroborate the record. We do not include this to discourage listing of sight records you may have, rather it is simply better if the records you provide have some way in which they can be corroborated.

4) Available evidence indicates that some taxa for which you will be reporting data have gone locally extinct. Since one important objective of our review is to establish historical trends, we are particularly interested in you indicating whether or not a particular record or sighting is **the most recent one** you know of or have for a particular locality. Please be as specific as possible with dates; day, month, and year is best, when available.

Appendix III (continued)

5) If the data you report is suggestive of decline for a particular taxon, please indicate what is (are) the likely factor(s) causal in decline. **Please be as specific as possible.** If you indicate that habitat alteration appears to be causal, specify what type of habitat alteration (e.g., removal of riparian vegetation). Further, if a specific type of removal of riparian vegetation was done, state so. Also try to focus, if possible, on the aspect of alteration that may be negatively affecting the taxa you discuss. If data, from whatever source or aspect or aspect exist to support your contention, provide the support or state the source. We are equally interested how habitat alteration may be physiologically as well as ecologically stressing said taxa, so your suggestions and opinions are also important. **Remember, if no data are available at whatever level, state so, but we still want your suggestions as to the most likely factors that may be negatively affecting the taxa you discuss.**

6) For each taxon you discuss, indicate the elements of habitat variation that appear to be crucial to its survival. Partition habitat elements into those important for mating, nesting or oviposition, hibernation, and refuges for developmental stages, juveniles, or adults, if these differ or are applicable in each case. If data are unavailable to understand either the elements of habitat variation crucial to a taxon's survival or to allow the partition of those elements with respect to the aspects of the life history listed above, state so. Please indicate the data source for the information you state, whether it be your own opinions, observations, systematically collected data, or literature. If the latter, please indicate one or two of the **most recent** references that apply.

7) Most of you reporting data have some kind of local or regional domain in which you may come into contact with individuals knowledgeable about amphibians and reptiles that are, or should be, of special concern or reports (i.e., the so-called "gray literature" including county surveys, environmental impact statements, biological surveys of military bases, national, state, and regional parks or monuments, and other regional reports) that may contain information important to our review. Please list for us any such individuals or reports as you may know of and provide us with a minimum of information as to how we might contact these individuals or gain access to the reports or records. We have some knowledge of such data, but nevertheless, it is best to treat us as naive with respect to the aforementioned information. That will insure we miss fewer potential sources of data that should have been examined. Again, if you feel the information you have to provide is too voluminous, state so and we will contact you regarding this information.

8) Although we have asked you to indicate above if no data exist in certain areas for discussed taxa, we feel the gaps in data may exceed the areas we have indicated. If you have any particular strong feelings as to gaps in data for certain taxa that were not covered by our inquiry, or broader studies that include these taxa that are imperative to be done to better understand them, please elaborate on these gaps and needed studies here.

9) Please recommend a status change according to the categories provided in our cover letter for each taxon you discussed. Also provide some indication of how strongly you feel about your recommendation based on available data.

10) We are attempting to be as thorough as possible, but we, may have omitted covering areas that are important to this review. Thus, we ask you to please indicate to us any areas that we have overlooked that you feel are important. Do not hesitate to provide any strongly held opinions about what we should add, delete, or change, or in general, as to what this review should provide.

APPENDIX IV

Individuals Who Were Mailed Questionnaires:

Benjamin H. Banta, James E. Berrian, Sean J. Barry, Harold E. Basey, Elinor S. Benes, Kristen H. Berry, Robert L. Bezy, Charles M. Bogert, Raymond J. Bogiatto, Michael C. Bondello, Jeffrey Boundy, David F. Bradford, Arden H. Brame, Jr. II, Bayard H. Brattstrom, John M. Brode, Edmund D. Brodie, Jr., Charles W. Brown, Charles J. Brown, Jr., R. Bruce Bury, Janalee P. Caldwell, Mark L. Caywood, Henry E. Childs, Jr., Frank S. Cliff, Arthur L. Cohen, Nathan W. Cohen, James P. Collins, Paul W. Collins, Lawrence Cory, Harold F. DeLisle, Mark A. Dimmitt, James R. Dixon, C. Kenneth Dodd, Jr., James W. Dole, Stan Elam, F. Edward Ely, Richard E. Etheridge, Colin D. S. Fagan, Gary M. Fellers, Timothy J. Ford, Martin J. Fouquette, Jr., Thomas H. Fritts, Anthony J. Gaudin, Derham Giuliani, Stephen R. Goldberg, Ronald Gonzales, David A. Good, David M. Graber, Joe Gorman, Harry W. Greene, L. Lee Grismer, Donald E. Hahn, George H. Hanley, George E. Hansen, Robert W. Hansen, Lester E. Harris, Jr., David M. Hillis, Dan C. Holland, Warren J. Houck, Jeffrey M. Howland, Arthur C. Hulse, Donald Hunsaker II, Lawrence E. Hunt, John B. Iverson, David L. Jameson, Cynthia Kagarise Sherman, John P. Karges, Roger Lederer, Robert L. Livezey, Michael C. Long, Roger A. Luckenbach, David L. Martin, Paul E. Maslin, Wilbur W. Mayhew, Samuel M. McGinnis, Brian M. McGurty, Joseph C. Medeiros, Philip A. Medica, Richard R. Montanucci, David J. Morafka, Steven R. Morey, Martin L. Morton, Robert W. Murphy, Thomas F. Newman, Velma Nile, Kenneth S. Norris, Ronald A. Nussbaum, Richard O'Grady, Robert D. Ohmart, John R. Ottley, Theodore J. Papenfuss, James E. Platz, Edwin P. Pister, Gregory K. Pregill, Theodore A. Rado, Martin G. Raphael, Thomas L. Rodgers, Aryan I. Roest, Douglas A. Rossman, Martin B. Ruggles, Rudolfo Ruibal, Stephen B. Ruth, Robert B. Sanders, Alan A. Schoenherr, Cecil R. Schwalbe, Norman J. Scott, Jr., H. Bradley Shaffer, Wade C. Sherbrooke, Robert C. Stebbins, Glenn R. Stewart, Brian K. Sullivan, Samuel S. Sweet, Lloyd P. Tevis, Jr., Kristine Tollstrup, Walter Tordoff III, Frederick B. Turner, Velma J. Vance, Jens V. Vindum, Laurie J. Vitt, David B. Wake, Hartwell H. Welsh, Jr., Daniel C. Wilhoft, J. W. (Jay) Wright, John W. Wright, R. Peter Yingling, Gary Zahm, and Richard G. Zweifel.

Other Individuals Who Were Contacted For Information:

Kevin S. Baldwin, Gerald Barden, Richard D. Beland, Gary Bell, Albin R. Bills, Peter Bloom, Norris Bloomfield, Betsy C. Bolster, William L. Brisby, Philip R. Brown, Slader G. Buck, Robin A. Butler, Sheila Byrne, Beverly Clark, Joseph F. Copp, Stephen P. Corn, James Cornett, Kenneth S. Croker, William R. Dawson, James E. Deacon, Al Denmston, William A. Dill, Mark Dodero, George Drewry, Wade L. Eakle, Todd C. Esque, Roger Farschon, Sheri Fedorchak, Robert N. Fisher, William E. Frost, Michael M. Fuller, Robyn Garcia, Richard E. Genelly, John D. Goodman, David M. Graber, Michael P. Hamilton, Thomas E. Harvey, Charles P. Hawkins, John Hendrickson, Arthur C. Hulse, Randy D. Jennings, Mark C. Jorgensen, Ernest L. Karlstrom, Steve Klett, F. Thomas Knefler, Mike Krause, Pete N. Lahanas, Robert C. Lewis, Eric Lichtwardt, Leslie E. Long, William E. Loudermilk, Charles H. Lowe, Jr., Greg Martinsen, William J. Mautz, Michael E. McCain, Clinton W. McCarthy, Alan M. McCready, Roy W. McDiarmid, Darline A. McGriff, Pat McMonagle, William L. Minckley, Peter B. Moyle, Stephen J. Myers, Kimberly A. Nicol, Mary E. Rasmussen, Galen B. Rathbun, Stephen M. Reilly, James C. Rorabaugh, Philip C. Rosen, Ronald Ruppert, Nancy H. Sandburg, Georgina M. Sato, Nancy Sirski, Joseph P. Skorupa, Todd M. Steiner, Jerry J. Smith, Michael J. Sredl, George Sturdinski, Camm C. Swift, Thomas L. Taylor, Brian K. Twedt, Robert Van De Hoek, Jared Verner, Elden H. Vestal, Dana L. Waters, William O. Wirtz II, Annemarie Woessner, Karen Worcester, Ronald J. Woychak, and Richard L. Zembal.

APPENDIX V

Definitions of "Endangered" and "Threatened" Species
Based on the 1991 Fish and Game Code of the State of California

CHAPTER 1.5. ENDANGERED SPECIES

Section 2062. "Endangered species" defined.

"Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. Any species determined by the commission as "endangered" on or before January 1, 1985, is an "endangered species."

Section 2067. "Threatened species" defined.

"Threatened species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter. Any animal determined by the commission as "rare" on or before January 1, 1985, is a "threatened species."