

**Monitoring Reptile and Amphibians and Biodiversity:
Nature Reserve of Orange County**

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Annual Report

Reptile and Amphibian Autecology Study

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1. Introduction and background.

The herpetofauna of coastal southern California is very diverse (Stebbins, 1985) due to a variety of factors including topography, history, and climate. This herpetofauna consists of over 70 species, of which 24 are considered sensitive at the state or federal levels (Fisher and Case, 1997; Jennings and Hayes, 1994). Much of the remaining open space in coastal southern California is highly fragmented and the future of the herpetofaunal diversity in southern California will depend on an understanding of the distribution and abundance of these species within this fragmented landscape. Protection within fragments may depend on taking the following measures: restricting access to the public, adaptive management, control of exotics, and many other factors. These types of management decisions should be based on sound scientific research to ensure that mistakes are not made, which can result in a loss of biological resources. The Nature Reserve of Orange County is a large reserve of high quality habitat for reptiles and amphibians. As such, it plays an important role in maintaining populations of the herpetofauna (herps) in Orange County, as it is one of the few protected areas directly on the coastline.

We began an autecological study of the herpetofauna of the Nature Reserve of Orange County to identify what reptile and amphibian species were present, when they were active, and in what habitats they were associated. One goal was to identify any immediate management needs regarding the maintenance of the diversity of this herpetofauna and in particular sensitive species. The various study sites within the Nature Reserve of Orange County have come on line over the past five years and are at different stages of producing sampling data. Table 1 outlines the study sites across Orange County, with Figure 2 showing their relative positions to one another. Three additional sites will be referenced which are in Orange County, but are not part of the Nature Reserve of Orange County, they are Chino Hills, Starr Ranch, and Unocal. Additional descriptive information about each site can be found in Appendix A.

2. Materials and methods.

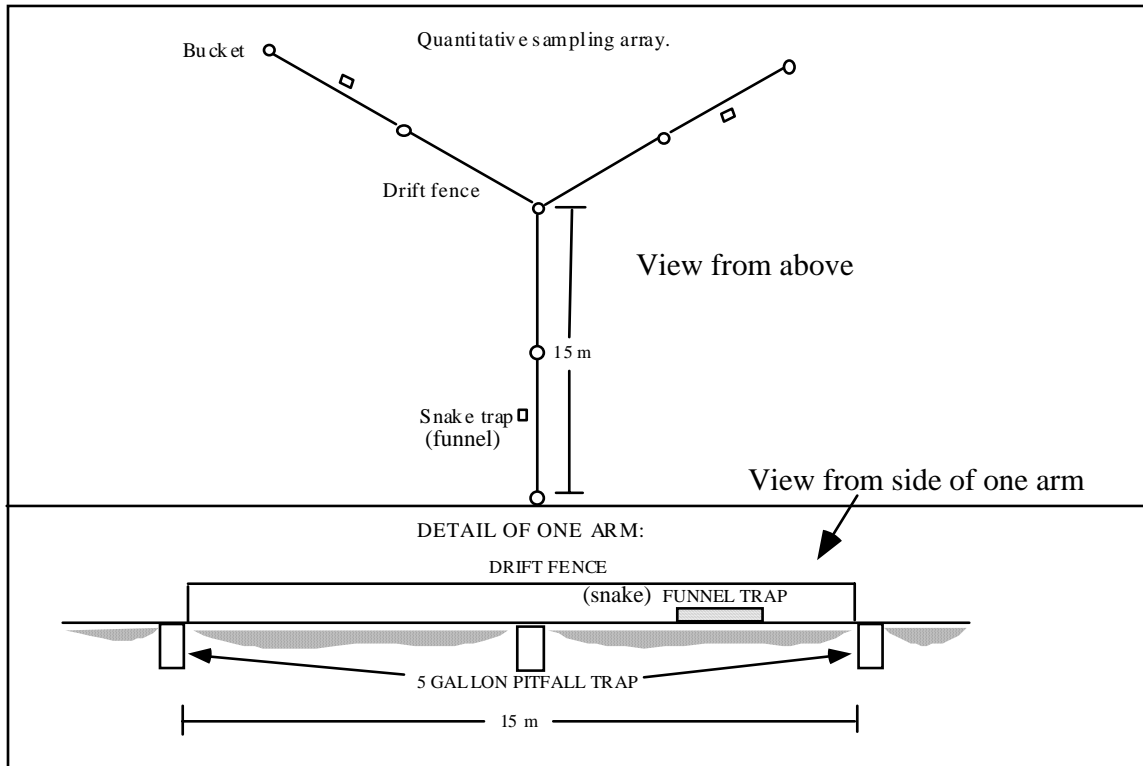
In 1995, we began an intensive study of the diversity and autecology of the herpetofauna of the California portion of the California Floristic Province, including several sites within the Nature Reserve of Orange County. The Limestone Canyon study site was constructed first and consisted of 17 pit-fall drift-fence arrays. The design of the pit-fall array is diagrammed in Figure 1. Study arrays were distributed across the various habitats, currently present, which

include coastal sage scrub, chaparral, grassland, and oak woodland. Each array consisted of seven 5 gallon buckets as pit fall traps, connected by shade cloth drift-fences (15 meter arms), in the shape of a Y (Figure 1). A hardware cloth funnel trap was placed at each of the three arms for capturing large snakes and lizards. In spring of 1997, we also added 0.3 X 0.3 meter plywood board along each array arm for the purposes of detecting tracks of California Legless Lizards (*Anniella pulchra*). Sampling was conducted at each study site for 10 consecutive days every 6 weeks, for a total of 50 to 60 days a year. This sampling regime was spread evenly across all seasons. The traps were kept closed between the sampling periods.

The animals captured were individually marked (except for slender salamanders) either by toe-clipping or scale-clipping (snakes) and then released. We processed the reptiles and amphibians in the field and released other trapped animals. Processing included marking, weighing, and measuring the body length; we kept the toe-clips and tail tips from snakes in ethanol for future molecular systematic work. The vegetation was recorded in the vicinity of each array following established protocols of the California Native Plant Society, and various local landscape features were also recorded and entered into a GIS database.

The results and discussion that follow are based on the results of our surveys as well as our knowledge of species that we did not capture in traps. In addition, we present a series of management recommendations based on these results. These analyses should help to determine what factors may be important in controlling diversity and abundance of small terrestrial vertebrates within the Nature Reserve of Orange County and thus where to focus management resources.

Figure 1. Terrestrial survey protocol and designs for arrangement of pitfall and funnel traps with drift fences. Figures are not drawn to scale.



3. Results: Diversity and distribution of reptiles and amphibians in the Nature Reserve of Orange County

To date, 35 species and over 6,200 specimens of reptiles and amphibians have been documented from the Nature Reserve of Orange County and associated Orange County sites (Table 1). These 35 species represent four families of amphibians and eleven families of reptiles.

Primarily because of habitat loss, 24 southern California reptile and amphibian species are listed or have become candidates for federal endangered species status or are currently listed as California Species of Special Concern by California Department of Fish and Game (Fisher and Case, 1997). Ten species of reptiles and amphibians are listed as "Covered" within the NCCP/HCP area, with an additional seven species marked as "Species of Interest". Nine of the ten covered species have been documented within the Nature Reserve and the associated Orange County sites. The nine species include two species of salamanders, the Arboreal Salamander (*Aneides lugubris*), the Black-bellied Slender Salamander (*Batrachoseps nigriventris*), a toad, the Western Spadefoot Toad (*Spea hammondi*), three species of lizards, the Orange Throated Whiptail (*Cnemidophorus hyperythrus*), the Coastal Western Whiptail (*Cnemidophorus tigris*),

and the Western Skink (*Eumeces skiltonianus*), along with three snake species, the Coastal Rosy Boa (*Charina trivirgata*), the Western Ringneck Snake (*Diadophis punctatus*) and the Red Diamond Rattlesnake (*Crotalus ruber*). The only covered species yet to be documented is the Arroyo Toad (*Bufo microscaphus*). Of the seven species of interest, only three have been confirmed by this study within the same area. These are the Coastal Horned Lizard (*Phrynosoma coronatum*), the Two-striped Garter Snake (*Thamnophis hammondi*), and the Coast Patch-Nosed Snake (*Salvadora hexalepis*). The Pacific Pond Turtle (*Clemmys marmorata*) is present in some creek channels. We would not expect to capture it in our traps, but might observe it on the roads when they move seasonally to nesting sites.

Across the Nature Reserve of Orange County study sites the species diversity varies from 2 to 14 species across all the arrays, and from 9 to 26 species per study site. The arrays that currently only show 2 documented species have only recently started operation and will most likely increase in species diversity as the sampling effort continues. The 17 older arrays of Limestone Canyon have the highest diversity with an average of 10.6 species per array. Limestone Canyon is closely followed the Edison Easement study site, which averages 10.2 species per array. With the exception of the two new study sites at Aliso – Woods Canyon and the San Joaquin Hills West, the remaining study sites range from nearly 7 to 9 species per array on average. Aliso – Woods Canyons and San Joaquin Hills West show relatively low diversity per array, but as noted before, this will most likely change over time. Species diversity at each array and for a site as a whole continues to increase over time as more of the rare elements are detected.

4. Status of sensitive species.

Below we detail the status of the different sensitive species within the Nature Reserve of Orange County. Five of the ten NCCP covered species were each captured at five of the ten Nature Reserve of Orange County study site. None of the NCCP species of interest occurred at more than four of the study sites. The Western Fence Lizard is the most abundant and widespread species we collected in the Reserve. We were able to identify patterns of body size segregation, seasonal activity, and periods of hatchling emergence in these species. In addition, we suggest specific management recommendations that the Reserve could implement to maintain populations of these sensitive species.

Covered by the NCCP

A. Arboreal Salamander (*Aneides lugubris*)

Status: No State or Federal Listing

The Arboreal Salamander had previously only been represented by one individual documented at the Limestone Canyon study area. With the addition of the San Joaquin Hills West study site in 1999, the Arboreal Salamander is now known from two sites in the Nature Reserve of Orange County. The documentation of this species within such a short period of time after having opened the San Joaquin Hills West site is promising that there are good populations at this site. There is also a recent sighting of the Arboreal Salamander at the Peters Canyon site by Mike Reeder.

B. Black-bellied Slender Salamander (*Batrachoseps nigriventris*)

Status: No State of Federal Listing

Black-bellied Slender Salamanders are believed to be present at three sites within the Nature Reserve of Orange County. Difficulty identifying this species, separate from the Pacific Slender Salamander (*Batrachoseps pacificus*), may require genetic testing to verify the identity of this species. Before the recent addition of the two sites of Aliso – Woods Canyons and the San Joaquin Hills West, Black-bellied Slender Salamanders had only been found at Limestone Canyon. The specimens from Aliso – Woods Canyon and San Joaquin Hills have greatly increased the representation of this species in the Nature Reserve of Orange County.

C. Arroyo Toad (*Bufo microscaphus californicus*)

Status: Federally Listed as Endangered

Arroyo Toads are the only NCCP covered species yet to be detected in the Nature Reserve of Orange County. Several sites are within their historic range and it may be likely that this species will eventually be confirmed in the Reserve.

D. Western Spadefoot Toad (*Spea hammondi*)

Status: Cal. State Species of Concern/Federal Candidate Species

The Western Spadefoot toad has been in decline throughout its range primarily due to habitat loss from the destruction of vernal pools (Fisher and Shaffer, 1996). This species has survived habitat loss in certain areas by utilizing cattle tanks, road ruts, and other artificial temporary aquatic habitats. We found this species to be very uncommon at the Edison and San Joaquin Hills West sites, each with just one or two arrays of occurrence. It was absent from the

remaining sites with the exception of Weir Canyon, where it was documented in three arrays. The addition of upland breeding pools would greatly help this species remain viable in the reserve.

E. Orange-Throated Whiptail (*Cnemidophorus hyperythrus*)

Status: Cal. State Species of Concern/Federal Candidate Species

This species has been of federal concern for many years, although much of the biology of this species is still unknown (Jennings and Hayes, 1994). Widespread in Baja California, the species only occurs in coastal southern California in the United States. It was the fourth most common lizard that we recorded within the Nature Reserve of Orange County, and its distribution within the reserves was nearly ubiquitous, only missing from the two newest sites and UC Irvine, all within the coastal reserve. The Orange-Throated Whiptail was very rare in Limestone Canyon, represented by only one specimen. The activity data for the Orange-Throated Whiptail indicate that there is good evidence of reproduction and recruitment at most of the sites where they have been documented, with the exception of Limestone Canyon. Thus we conclude that the Orange-Throated Whiptail does not currently appear at risk of extinction within the Nature Reserve of Orange County, but certain edge populations should be monitored for trends that might change due to various edge effects (including feral cats, exotic plants, etc.). The highest densities we found of Orange-throated whiptails were from Peter's Canyon (Table 3).

F. Coastal Western Whiptail (*Cnemidophorus tigris multiscutatus*)

Status: Federal Candidate Species

The Coastal western whiptail has only recently received federal attention, and the status of most populations is unknown. We found it at seven of the ten Nature Reserve of Orange County survey sites. One concern, based on the activity level of these lizards during spring, is that the lizards are often very active on dirt and paved roads. To avoid population declines along roads within the Reserve system, signs warning drivers and mountain bikers to be particularly careful in the reserve should be posted. In addition, accidental deaths should be quantified. Our activity data (Figure 3) will help identify the months when these lizards are most likely to be on roads.

G. Western Skink (*Eumeces skiltonianus*)

Status: Federal Candidate Species

This subspecies has only recently received federal interest, and although the species is widespread, the subspecies is not very well known (Jennings and Hayes, 1994). This species was the most widespread of the NCCP covered species, and occurred at all but one study site within the entire Nature Reserve of Orange County. The data indicate that their activity patterns are similar to those seen in the Horned Lizards, and much earlier in the season than the Orange-throated and Coastal Western Whiptails. The abundance of Coronado Skinks was highest at the UC Irvine site, where it was approximately twice that of the other sites combined. Long-term maintenance of this species in the reserve may be dependent on appropriate management practices, and the protection of this area from the invading Argentine Ant. This ant appears to be negatively affecting these lizards in coastal sites. If it were to invade this area, it could put this species at risk.

H. Coastal Rosy Boa (*Charina trivirgata*)

Status: Federal Candidate Species

The Coastal Rosy Boa is a species that is very slow moving and easy to identify. We found this species only at Weir Canyon, although we know it is more widespread in Orange County. Their long-term persistence is at risk for two reasons. First, is the fragmentation due to the roads. These species will often lay on roads at night to obtain heat, and are easily run over. The second reason might be exposure to people. This snake is a very popular pet, due to its mild temper. Any snakes found by hikers are at risk of poaching. Over the next 50 years these snakes might literally be collected out of the Reserve unintentionally by naturalists, and visitors. Since the number of people using the reserve is likely to increase, they will always be at risk of poaching. A more thorough posting of the fines for collecting in the Reserve might help to limit poaching, as visitation increases.

I. San Diego/San Bernardino Ring-necked Snake (*Diadophis punctatus*)

Status: Federal Candidate Species

The Ring-Necked Snake was found once at each Orange Hills, Rattlesnake Reservoir, and Weir Canyon, and repeated times at UC Irvine, Aliso – Woods Canyons, and Limestone Canyon. This species is very secretive most of the year, although often in spring they may be foraging during the day. They tend to prefer areas with increased moisture levels,

including riparian zones. Any additional sightings for this species should be noted in order to better understand its limited distribution within the Nature Reserve of Orange County.

J. Red diamond rattlesnake (*Crotalus ruber*)

Status: Federal Candidate Species

The Red diamond rattlesnake was widespread throughout southern California historically, and still appears to be widespread inland. We have found that several of our coastal sites now lack this species, although historic records document its past occurrence. The apparent decline of *Crotalus ruber* in the coastal area may be related to the fragmentation of the habitat by roads. This species can obtain a large size (2 meters), and is often observed as a road kill where it still occurs. There is a sufficient amount of good habitat within the Nature Reserve of Orange County for this species. The Red Diamond Rattlesnake has observed it seven of the ten sites. We found this species to be most often observed in the Weir Canyon. If portions of the reserve could be insulated from roads, then this species might be able to develop a core area with little human activity.

Species of Interest

A. Red-Legged Frog (*Rana aurora*)

Status: Federally Listed as Threatened

The Red-legged frog has not been detected to date in the Nature Reserve of Orange County. Several sites, Limestone Canyon, Aliso – Woods Canyon, and Weir Canyon are within their known historic range.

B. California Legless Lizard (*Anniella pulchra*)

Status: Cal. State Species of Concern/Federal Candidate Species

The Legless Lizards were never collected in buckets. Boards were placed along the fences so that we could detect their distinctive undulating trails, but to date none have been observed. This species appears to prefer very sandy areas in general, and may be present in some of the washes we are currently not trapping.

C. Coastal Banded Gecko (*Coleonyx variegatus abbotti*)

Status: Federal Candidate Species

This species is thought to have declined in southern California due to the destruction of coastal sage scrub. The Coastal Banded Gecko has not been recorded at our study sites within the Nature Reserve of Orange County. Within the sites where they occur, the species is typically very rare, and at 3 of the sites it is known from only one array each. Within Orange County, only one Coastal Banded Gecko has been documented by our study in the past five years. It occurred at Starr Ranch.

D. Coast Horned Lizard (*Phrynosoma coronatum*)

Status: Cal. State Species of Concern/Federal Candidate Species

The Coastal horned lizard has been a species of concern at the state and federal level for numerous years. It historically was very common throughout southern California, especially in coastal dune systems (Fisher and Case, 1997; Jennings and Hayes, 1994). There has been a marked decline in this species for several decades, although the causes have been unknown. This species was found in similar abundance in both the Limestone Canyon and Weir Canyon sites. It was more rare in the San Joaquin Hills West area. Preliminary data shows an unusually large number of Coast Horned Lizards in the Agua Chinon site, but these numbers are biased by the fact that this site has only just recently opened and has not yet been surveyed over the winter season. We found that these lizards occurred primarily in coastal sage scrub and chaparral within the Reserve, usually on ridgelines. They appeared to prefer chamise chaparral in many situations. This species tends to occur along dirt roadsides, especially near thick vegetation, therefore signs should be posted along roadsides warning of the presence of these lizards. In addition, bike trails should avoid areas where they are known to occur.

E. Two-striped garter snake (*Thamnophis hammondi*)

Status: Cal. State Species of Concern/Federal Candidate Species

The Two-striped garter snake is typically associated with freshwater wetlands, including vernal pools, creeks, rivers, marshes, and ponds (Jennings and Hayes, 1994). To date, only one Two-striped Garter snake has been collected in any of the Nature Reserve of Orange County herpetofaunal study sites, Limestone Canyon. Its preferred food is treefrogs or toads and these occur in all but a few of the study sites in relative abundance. Intensive surveys of Aliso – Woods Canyons and San Joaquin Hills West might detect the presence of this species, as well as the Edison Easement.

F. Coastal Patch-Nosed Snake (*Salvadora hexalepis virgulata*)

Status: Federal Candidate Species

The Coastal Patch-Nosed Snake was recorded most commonly at Peter's Canyon, but also at Limestone Canyon, and the Weir Canyon. This species probably historically occurred throughout the reserve, in particular, in areas with coastal sage scrub and chaparral. This species is an active forager, and is often run over on roads as they cross. We have found road kills in other study sites, and as traffic increases in certain areas, these species may be negatively impacted. This is another species that will benefit from having a section of the reserve without roads, bikes, and little human impact.

G. Western Pond Turtle (*Clemmys marmorata*)

Status: Federally Candidate Species/Cal. State Species of Special Concern

Western Pond Turtles have not been documented at any of the ten study sites within the Nature Reserve of Orange County. The Western Pond Turtle are still present at some upstream creek channels, or sloughs at these sites, especially in Aliso – Woods Canyons. We would not expect to capture it in our traps, but might observe it on the roads when they move seasonally to nesting sites as has occurred at the Chino Hills study site.

5. Species presence patterns for reptiles and amphibians at the Nature Reserve of Orange County lands.

We have calculated the average capture rate per array per day for each of the ten different study sites of the Nature Reserve of Orange County lands, by four taxonomic categories (amphibians, turtles, lizards and snakes). The capture rate plotted was the total number of captures for a taxa at a site, divided by the number of arrays at the site, and the number of days that a site has been sampled. This acts to scale the capture rates, accounting for the fact that different sites have both varied numbers of arrays and sample days. Such a calculation allows for a more even comparison of capture rates and species presence at a site. The number is further manipulated by multiplying by 1000 sample days, resulting in the average number of captures per 1000 sample days per array at each site.

Mathematically:

$$CR = [n_i / (a_s \times d_p)] \times 1000$$

where

CR = mean capture rate for each taxa at a site

n_i = number of individuals of a species

a_s = number of arrays per site

d_p = number of days site has been sampled

The numbers generated by this process are presented in Table 3 and Table 5. Table 3 reflects the data for the overall species likely to occur within the southern California area. Table 5 has been narrowed down to show the NCCP covered species and species of interest.

These tables also show that several species are missing from the reserve. We are surprised by the fact that we have not recorded the Longnosed Snake (*Rhinocheilus lecontei*) or the Glossy Snake (*Arizona elegans*) at any of the study sites. Both species were previously known from the area. We have never recorded Legless Lizards (*Anniella pulchra*) in Orange County, yet museum records exist. The two new sites in the Coastal Reserve may detect them.

6. Recommendations for management and monitoring small vertebrates at the Nature Reserve of Orange County.

We present our **PRELIMINARY** recommendations for the following 3 categories: diversity differences within the reserve, management activities, and identification of movement corridors. We have been able to identify several regions that are important for the maintenance of diversity of reptiles and amphibians within Nature Reserve of Orange County lands. We have also identified several management activities that could benefit several species. These were discussed under the species accounts presented above and some are repeated herein. An attempt was made to determine what habitat linkages and corridors could possibly connect Nature Reserve of Orange County lands to other habitat fragments to the east and south. Some of these habitat linkages and corridors may be non-functional, but could through modification, become useful for the movement of reptiles and amphibians into the reserve.

Diversity differences within the Reserve:

We have found that 11 of the 35 species observed occur at ten or more Nature Reserve of Orange County or other Orange County sites (Table 2). We found that an additional 11 species occur at five or more of the study sites (Table 2). Each site is important for the long-term persistence of a series of species, which are indicated by their highest abundance in that site. These are shown below, and are taken from Table 2 and Table 3.

A. UC Irvine: Despite its overall low species diversity, this site does represent a large portion of the documented Western Skinks from Orange County. With 118 Western Skink to its credit, it accounts for nearly one third of the Western skinks to date for the ten study sites in Orange County. This species appears to be sensitive to Argentine ant invasions, and at sites where there are many ants their recruitment is low. At UC Irvine, we observe almost all adults.

B. Agua Chinon: Highest proportional rate of Coast Horned Lizards. While this site only show seven animals when compared to Limestone Canyon's 74 captures in Table 2, this needs to be viewed as relative. Agua Chinon has only a fraction of the arrays and sample days of Limestone Canyon. Table 3 helps to clarify this by showing a relative capture rate. Viewing the data under these corrections, Agua Chinon would appear to produce Coast Horned Lizards at nearly twice the rate of Limestone Canyon .

C. Limestone Canyon and Weir Canyon: Highest rates of species diversity of the ten study sites within the Nature Reserve of Orange County, both at 24 species. These sites also rank as first and second highest for diversity in the NCCP covered or species of interest, Limestone with 10 and Weir at 9.

D. San Joaquin Hills West: A relative new comer, but still showing high species diversity. With only 34 sample days, San Joaquin Hills West has produced 19 different species. Notable when compared to other sites that have been open for nearly three times as long. It includes species that are rare in the county, such as Black-headed Snakes and Yellow Bellied Racers.

Specific management activities for species and diversity:

Exotic Species:

- **Argentine ants:** We have found these exotic ants to be wide spread in southern California. These ants are known to displace native ant species in San Diego (Suarez et al., in press), and possibly cause effects at higher trophic levels if the spread within the Reserve. The California Horned Lizard is an ant specialist that prefers native ants to the exotics (Suarez, pers. comm.). Within the Nature Reserve of Orange County the ants appear limited by moisture, and have not widely invaded natural habitats (Suarez et al., unpub. data). These ants may also play a role in disrupting and depressing the arthropod community within natural areas (Suarez, pers. comm.), and therefore might affect many species. The ants may benefit from additional runoff into the Reserve. Increased moisture level associated with irrigation would play a role in their invasion. The dead humus from exotic plants, irrigation from adjacent landscaping, and the silt runoff from construction might also help raise moisture levels in the Reserve to benefit the ants.
- **Red Imported Fire Ants:** These ants may become a problem in the future and monitoring has begun for its presence.
- **House/feral cats:** These are a problem at most wildland/urban boundaries, and we know from previous and on-going studies that they are killers of lizards, small mammals and birds (Crooks, pers. comm.). We have some data from the San Diego County that they might be major predators of California Horned Lizards. When initial horned lizard radio-tracking studies were performed at Torrey Pines Extension (in San Diego County), the first two lizards were attacked, by what we suspect were cats. The presence of coyotes within the Nature Reserve of Orange County should minimize the ability of feral cats to invade. Any residents within the reserve should keep their cats indoors for their safety, and to restrict their incidental killing of native wildlife.

Physical modifications:

- **Pond creation:** The Pacific Treefrogs, Western Toads, and Western Spadefoot Toads may benefit from additional habitat and habitat improvement. We have not searched exhaustively for breeding pools, but if there are some present then maybe they can be enhanced if necessary to benefit these species. Enhancement could be done to ensure they hold water through the breeding season, by increasing their depth. Pool creation should also be done in strategic locations to maximize the ability of the pools to hold water. These pools might benefit some invertebrates in addition to the frog/toad species. The ridgelines in flat areas would be appropriate for pool creation for spadefoot populations.

Enforcement:

The following two items that may need increased enforcement within Nature Reserve of Orange County.

- **Bikes on the trails:** We have personal observations of animals killed and maimed by bikes in natural areas and will present them as evidence for the need to keep mountain bikes out of the majority of the Nature Reserve of Orange County. These observations include dead alligator lizards at several places smashed on bike trails, a dying Southern Pacific Rattlesnake (*Crotalus viridis*), that was almost a meter in length, hit by a bike at an open space in Chula Vista, and a Red Racer (*Masticophis flagellum*) dragging the rear third of its body along a bike trail at Lake Perris State Park. These incidental mortalities might be avoided by posting signs at the base of trails that indicate a fine exists for cycling, and informing the public of the risk to the species along the trail from bikes.

- **Poaching:** Signage should be put around reserves indicating that it is illegal to collect from the property. Trails should avoid areas where we identify horned lizards or other species sensitive to poaching.

Education:

- **Information on rattlesnakes:** We think it would be advantageous to include more information fliers/billboards on the Rattlesnake at Nature Reserve of Orange County as they have at other Regional Parks. This information could indicate safety issues, and give some statistics on bites in the park relative to other injuries. Have there ever been reported snakebites? We know that the snakes are widespread in the Reserve (Table 1), and prefer to crawl on the trails, therefore it is inevitable that people will see them. The Reserve could have checklist for where snakes have recently been seen (and when), and there should be information that

differentiates the Southern Pacific Rattlesnake from the Red Diamond Rattlesnake. This could help to identify any locations where physical barriers could be used to keep Rattlesnakes out of public facilities.

Identification of corridors for Reptiles and Amphibians:

The majority of the reptiles and amphibians of the Nature Reserve of Orange County are upland species. They will require some form of upland habitat linkage to maintain geneflow, and reinvasion if extinction in the reserve takes place. The Tree Frog, Western Toad and Pacific Pond Turtle might utilize a riparian corridor connecting to populations in the east and south. Of the upland species, several may be viable without any connection outside of the Nature Reserve of Orange County, if the adjacent lands do not become more developed. A few species might go extinct over time without a habitat linkage to eastern populations, these include the Coastal Horned Lizard, Red Racer, Long-nosed Snake, Red Diamond Rattlesnake, and the Coastal Patch-nosed Snake. There are two main identifiable habitat linkages that may or may not be functional for reptiles and amphibians that would connect the Nature Reserve of Orange County to the larger habitats to the east and south.

7. Conclusion.

We have documented significant diversity in reptiles and amphibians within Orange County and have high capture rates for some species. Management to enhance reserves identifies, as are species that may need additional surveys beyond our effort. A big gap in sampling includes adding another fragment or two on the coast, which could be Buck Gully or the area near Sand Canyon Reservoir. Also Shady Canyon represents an east facing coastal canyon, a habitat from which we have no data as of yet.

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Appendix

Nature Reserve of Orange County

Site Data

Table 1 Summary of study sites within the Nature Reserve of Orange County.

Site Name	NCCP Coastal and Central Reserve Status	Start Date	Number of Arrays	Total Sample Days
Agua Chinon	Edge	Dec-99	7	30
Aliso - Woods Canyons*	Core	Feb-00	17	30
Edison	Edge/Fragment	Jul-98	5	90
Limestone Canyon (1-17)	Core	Aug-95	17	230
Limestone Canyon (18-19)	Core	Sep-99	2	40
Orange Hills	Fragment	Jul-98	5	100
Peter's Canyon	Fragment	Aug-98	5	100
Rattlesnake Reservoir	Edge	Aug-98	5	104
San Joaquin Hills West*	Core	Feb-00	21	34
UC Irvine*	Fragment	Apr-96	5	200
Weir Canyon	Core	Aug-98	12	104

* Site within the coastal subregion.

Table 2 All Orange County sites are displayed, along with the actual number of individual captures per species. Not all sites listed are within the Nature Reserve of Orange County. All of the sites are sorted by overall species diversity for the site. The species list is also sorted to show which species are more prevalent.

		UC Irvine	Agua Chimon	Unocal**	Orange Hills	Rattlesnake Reservoir	Aliso - Woods Canyon	Edison	Peter's Canyon	San Joaquin Hills West	Chino Hills**	Limestone Canyon	Weir Canyon	Starr Ranch**	Totals Across Sites	Number of Sites
Num of Arrays		5	7	3	5	5	17	5	5	21	19	19	12	17		
Num of Sample Days		200	30	110	100	104	30	90	100	34	102	230(40)*	104	254		
Arroyo Toad	<i>Bufo microscaphus</i>															
Red-Legged Frog	<i>Rana aurora</i>															
Bullfrog	<i>Rana catesbeiana</i>															
African Clawed Frog	<i>Xenopus laevis</i>															
California Treefrog	<i>Hyla cadaverina</i>													3	3	1
California Newt	<i>Taricha torosa</i>													1	1	1
Arboreal Salamander	<i>Aneides lugubris</i>									1		1			2	2
Monterey Salamander	<i>Ensatina eschscholtzii</i>											1		4	5	2
Western Spadefoot Toad	<i>Spea hammondi</i>							2							19	4
Black-bellied Slender Salamander	<i>Batrachoseps nigriventris</i>			2			27		1	4	1	10			29	7
Pacific Treefrog	<i>Hyla regilla</i>			6		4	10	4	5	6	4	6	1	19	65	10
Western Toad	<i>Bufo boreas</i>		3	3		18	56	34	4	112	135	26	100	14	505	11
Pacific Slender Salamander	<i>Batrachoseps pacificus</i>	12		1	2	4	18	1	11	28	1	54	21	39	192	12
Western Pond Turtle	<i>Clemmys marmorata</i>										1				1	1
Slider	<i>Trachemys sp.</i>															
California Legless Lizard	<i>Anniella pulchra</i>															
Coastal Banded Gecko	<i>Coleonyx variegatus</i>													1	1	1
Granite Spiny Lizard	<i>Sceloporus orcutti</i>													4	4	1
Gilbert Skink	<i>Eumeces gilberti</i>		1									14	1		16	3
Coast Horned Lizard	<i>Phrynosoma coronatum</i>		7							2	6	74	17	1	107	6
Orange-Throated Whiptail	<i>Cnemidophorus hyperythrus</i>		12		41	139		52	162			1	38	25	470	8
Western Whiptail	<i>Cnemidophorus tigris</i>			2	1		1	26		13	43	74	24	92	276	9
Side-Blotched Lizard	<i>Uta stansburiana</i>	14	30	120	3	14		35	49		37	63	6	45	416	11
Western Skink	<i>Eumeces skiltonianus</i>	118	1	37	20		8	13	9	50	103	49	40	81	529	12
Southern Alligator Lizard	<i>Elgaria multicarinatus</i>	141	13	21	10	6	38	17	12	11	95	158	12	244	778	13
Western Fence Lizard	<i>Sceloporus occidentalis</i>	274	39	97	42	45	63	50	47	57	289	628	84	406	2121	13
California Glossy Snake	<i>Arizona elegans</i>															
Speckled Rattlesnake	<i>Crotalus mitchellii</i>															
California Mountain Kingsnake	<i>Lampropeltis zonata</i>															
Long-nosed Snake	<i>Rhinocheilus lecontei</i>															
Common Garter Snake	<i>Thamnophis sirtalis</i>															
Coastal Rosy Boa	<i>Charina trivirgata</i>													1	1	1
Two-striped Garter Snake	<i>Thamnophis hammondi</i>											1			1	1
Lyre Snake	<i>Trimorphodon biscutatus</i>													1	1	1
Night Snake	<i>Hypsiglena torquata</i>												1	4	5	2
Coachwhip/Red Racer	<i>Masticophis flagellum</i>	5									3				8	2
Coast Patch-Nosed Snake	<i>Salvadora hexalepis</i>								2		1	5	3	2	13	5
California Black-Headed Snake	<i>Tantilla planiceps</i>				1					1	5		2	1	10	5
Western Yellow-Bellied Racer	<i>Coluber constrictor</i>			1			1			2	2	3		1	10	6
Western Ringneck Snake	<i>Diadophis punctatus</i>	3			1	1	2				8	11	1	9	36	8
Western Blind Snake	<i>Leptotyphlops humilis</i>				1	1	5		1	1	14	2	7		32	8
Red Diamond Rattlesnake	<i>Crotalus ruber</i>				1	1	2	1	1	2	1	3	2	2	14	9
Southern Pacific Rattlesnake	<i>Crotalus viridis</i>					1	3	3	14	9	32	13	4	18	97	9
Striped Racer	<i>Masticophis lateralis</i>		3		8	6		6	7	7	35	46	13	80	211	10
San Diego Gopher Snake	<i>Pituophis melanoleucas</i>	17			2	2	1	1	10	32	18	8	19		112	11
California Kingsnake	<i>Lampropeltis getulus</i>	7		3	3	3	3	4	2	4	10	7	2	18	66	12
Total Captures per Site		591	111	291	137	246	238	254	328	324	866	1268	402	1161	6217	13
Total Species		9	10	10	13	14	15	15	16	19	23	24	24	26	35	

* At Limestone Canyon, arrays 1-17 have been sampled 230 days. Arrays 18 and 19 are new and have only been sampled for 40 days.

** These sites are not part of the Coastal and Central Reserve, but are in Orange County.

Table 3 All Orange County sites are displayed, along with the average number of captures per 1000 sample nights per array across an entire site. Not all sites listed are within the Nature Reserve of Orange County. As in Table 2, all of the sites are sorted by overall species diversity for the site, and the species list is sorted to show which species are more prevalent. These calculation allows for a more direct comparison of capture rates, taking into account both the number of arrays at each site and the length of time that a site has been in operation.

		UC Irvine	Agua Chinton	Unocal**	Orange Hills	Rattlesnake Reservoir	Aliso - Woods Canyon	Edison	Peter's Canyon	San Jaquin Hills West	Chino Hills**	Limestone Canyon	Weir Canyon	Starr Ranch**
	Num of Arrays	5	7	3	5	5	17	5	5	21	19	19	12	17
	Num of Sample Days	200	30	110	100	104	30	90	100	34	102	230(40)*	104	254
Arroyo Toad	<i>Bufo microscaphus</i>													
Red-Legged Frog	<i>Rana aurora</i>													
Bullfrog	<i>Rana catesbeiana</i>													
African Clawed Frog	<i>Xenopus laevis</i>													
California Treefrog	<i>Hyla cadaverina</i>													0.7
California Newt	<i>Taricha torosa</i>													0.2
Arboreal Salamander	<i>Aneides lugubris</i>									1.4		0.2		
Monterey Salamander	<i>Ensatina eschscholtzii</i>											0.2		0.9
Western Spadefoot Toad	<i>Spea hammondi</i>							4.4		4.2	3.1		6.4	
Black-bellied Slender Salamander	<i>Batrachoseps nigriventris</i>			6.1			52.9		2.0	5.6	0.5	2.3		6.7
Pacific Treefrog	<i>Hyla regilla</i>			18.2		7.7	19.6	8.9	10.0	8.4	2.1	1.4	0.8	4.4
Western Toad	<i>Bufo boreas</i>		14.3	9.1		34.6	109.8	75.6	8.0	156.9	69.7	5.9	80.1	3.2
Pacific Slender Salamander	<i>Batrachoseps pacificus</i>	12.0		3.0	4.0	7.7	35.3	2.2	22.0	39.2	0.5		16.8	9.0
Western Pond Turtle	<i>Clemmys marmorata</i>										0.5			
Slider	<i>Trachemys sp.</i>													
California Legless Lizard	<i>Anniella pulchra</i>													0.2
Coastal Banded Gecko	<i>Coleonyx variegatus</i>													
Granite Spiny Lizard	<i>Sceloporus orcutti</i>													3.2
Gilbert Skink	<i>Eumeces gilberti</i>		4.8									5.4	0.8	
Coast Horned Lizard	<i>Phrynosoma coronatum</i>		33.3							2.8	3.1	16.9	13.6	0.2
Orange-Throated Whiptail	<i>Cnemidophorus hyperythrus</i>		57.1		82.0	267.3		115.6	324.0			0.2	30.4	5.8
Western Whiptail	<i>Cnemidophorus tigris</i>		9.5		2.0		2.0	57.8		18.2	22.2	16.9	19.2	21.3
Side-Blotched Lizard	<i>Uta stansburiana</i>	14.0	142.9	363.6	6.0	26.9		77.8	96.0		19.1	14.4	4.8	10.4
Western Skink	<i>Eumeces skiltonianus</i>	118.0	4.8	109.1	40.0		15.7	28.9	18.0	70.0	53.1	16.6	32.1	18.8
Southern Alligator Lizard	<i>Elgaria multicarinatus</i>	141.0	61.9	63.6	20.0	11.5	74.5	37.8	24.0	15.4	49.0	42.7	9.6	56.5
Western Fence Lizard	<i>Sceloporus occidentalis</i>	274.0	185.7	293.9	84.0	86.5	123.5	111.1	94.0	79.8	149.1	154.6	67.3	94.0
California Glossy Snake	<i>Arizona elegans</i>													
Speckled Rattlesnake	<i>Crotalus mitchellii</i>													
California Mountain Kingsnake	<i>Lampropeltis zonata</i>													
Long-nosed Snake	<i>Rhinocheilus lecontei</i>													
Common Garter Snake	<i>Thamnophis sirtalis</i>													
Coastal Rosy Boa	<i>Charina trivirgata</i>													0.8
Two-striped Garter Snake	<i>Thamnophis hammondi</i>											0.2		
Lyre Snake	<i>Trimorphodon biscutatus</i>													0.2
Night Snake	<i>Hypsiglena torquata</i>												0.8	0.9
Coachwhip/Red Racer	<i>Masticophis flagellum</i>	5.0									1.0			
Coast Patch-Nosed Snake	<i>Salvadora hexalepis</i>							4.0			0.5	1.1	2.4	0.5
California Black-Headed Snake	<i>Tantilla planiceps</i>				2.0					1.4	2.6		1.6	0.2
Western Yellow-Bellied Racer	<i>Coluber constrictor</i>			3.0			2.0			2.8	1.0	0.7		0.2
Western Ringneck Snake	<i>Diadophis punctatus</i>	3.0			2.0	1.9	3.9				4.1	2.5	0.8	2.1
Western Blind Snake	<i>Leptotyphlops humilis</i>				2.0	1.9	9.8		2.0	1.4	7.2	0.5	5.6	
Red Diamond Rattlesnake	<i>Crotalus ruber</i>					1.9	2.0	4.4	2.0	1.4	1.0	0.2	2.4	0.5
Southern Pacific Rattlesnake	<i>Crotalus viridis</i>					1.9	5.9	6.7	28.0	12.6	14.4	4.1	3.2	4.2
Striped Racer	<i>Masticophis lateralis</i>		14.3		16.0	11.5		13.3	14.0	9.8	18.1	12.7	10.4	18.5
San Diego Gopher Snake	<i>Pituophis melanoleucas</i>	17.0			4.0	3.8	3.9	2.2	2.0	14.0	15.0	5.2	6.4	4.4
California Kingsnake	<i>Lampropeltis getulus</i>	7.0		9.1	6.0	5.8	3.9	8.9	4.0	5.6	4.6	1.6	1.6	4.2
Average capture/1000 days/array cross the site		591.0	528.6	878.8	274.0	473.1	464.7	564.4	654.0	453.8	442.2	319.5	322.1	268.9
Total Species		9	10	10	13	14	15	15	16	19	23	24	24	26

* At Limestone Canyon, arrays 1-17 have been sampled 230 days. Arrays 18 and 19 are new and have only been sampled for 40 days.

** These sites are not part of the Coastal and Central Reserve, but are in Orange County.

Table 4 All Nature Reserve of Orange County sites are shown with the number of specimens documented for each species, including a column calculating the total number of individuals of each species across the reserve. The final column shows the number of study sites where each species was documented.

		<i>U/C Irvine</i>	Rattlesnake Reservoir	Agua Chinon	Orange Hills	Peter's Canyon	<i>Aliso - Woods Canyons</i>	Edison	<i>San Joaquin Hills West</i>	Weir Canyon	Limestone Canyon	Total Captures Across Sites	Number of Sites
	Num of Arrays	5	5	7	5	5	17	5	21	12	19		
	Num of Sample Days	200	104	30	100	100	30	90	34	104	230(40)*		
Covered Species													
Arboreal Salamander	<i>Aneides lugubris</i>								1		1	2	2
Black-bellied Slender Salamander	<i>Batrachoseps nigriventris</i>						27		4		10	41	3
Arroyo Toad	<i>Bufo microscaphus</i>												
Western Spadefoot Toad	<i>Scaphiopus hammondi</i>							2	3	8		13	3
Orange Throated Whiptail	<i>Cnemidophorus hyperythrus</i>		139	12	41	162		52		38	1	445	7
Western Whiptail	<i>Cnemidophorus tigris</i>			2	1		1	26	13	24	74	141	7
Western Skink	<i>Eumeces skiltonianus</i>	118		1	20	9	8	13	50	40	49	308	9
Coastal Rosy Boa	<i>Lichanura trivirgata</i>									1		1	1
Western Ringneck Snake	<i>Diadophis punctatus</i>	3	1		1		2			1	11	19	6
Red Diamond Rattlesnake	<i>Crotalus ruber</i>		1			1	1	2	1	3	1	10	7
Species of Interest													
Red-Legged Frog	<i>Rana aurora</i>												
California Legless Lizard	<i>Anniella pulchra</i>												
Coastal Banded Gecko	<i>Coleonyx variegatus</i>												
Coast Horned Lizard	<i>Phrynosoma coronatum</i>			7					2	17	74	100	4
Two-striped Garter Snake	<i>Thamnophis hammondi</i>										1	1	1
Coast Patch-Nosed Snake	<i>Salvadora hexalepis</i>					2				3	5	10	3
Western Pond Turtle	<i>Clemmys marmorata</i>												
Total Species		2	3	4	4	4	5	5	7	9	10	12	10

* At Limestone Canyon, arrays 1-17 have been sampled 230 days. Arrays 18 and 19 are new and have only been sampled for 40 days.

Italics - Sites in italics are in the coastal subregion.