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Monitoring Reptiles and Amphibians at Long-Term Biodiversity Monitoring Stations: The Puente-Chino Hills

Final Report

Prepared for:

Mountains Recreation and Conservation Authority – Judi Tamasi
Puente Hills Landfill Native Habitat Preservation Authority – Andrea Gullo
California State Parks – Alissa Ing

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
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Monitoring Reptiles and Amphibians at Long-Term Biodiversity Monitoring Stations: The Puente-Chino Hills

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1. INTRODUCTION

The herpetofauna of coastal southern California are very diverse due to a variety of factors including topography, history, and climate (Stebbins 1985). These herpetofauna consist of over 70 species, 24 of which are considered sensitive at the state or federal levels (Jennings & Hayes 1994; Fisher & Case 1997). 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 Puente-Chino Hills represent a 50 km stretch of habitat for reptiles and amphibians. As such, they play an important role in maintaining populations of the herpetofauna (herps) in Los Angeles, Orange, Riverside, and San Bernardino Counties.

In 1995, we began an intensive autecological study of the herpetofauna of southern California, from the Los Angeles basin to the Mexican border, focused to identify what reptile and amphibian species are present, what habitats they are associated with, and when they are active. The Puente-Chino Hills study is a continuation of this larger ongoing project and began in the spring of 1998 and continued through the fall of 2000. The goals of this study were to 1) determine the distribution and diversity of herpetofauna species across the Puente-Chino Hills and 2) identify any immediate management needs regarding the maintenance of the diversity of the herpetofauna community, with particular focus on sensitive species.

2. STUDY AREA

The Puente-Chino Hills represent a continuous series of undeveloped open spaces consisting of both private and public lands, extending west from CA Route 91 in Orange and Riverside Counties to Interstate Route 605 in Los Angeles County, California. This 50 km long stretch of hills is entirely surrounded by urbanization with two exceptions: the eastern end is linked to the Santa Ana Mountains (Cleveland National Forest) by the Coal Canyon Biological Corridor and the western end is physically linked to the San Gabriel Mountains (Angeles National Forest) by the San Gabriel River.

Due to the extreme separation of the western end from a core area, the Puente-Chino Hills, at a regional scale, more closely resemble a peninsula of habitat extending from the Santa Ana Mountains into the urban matrix of the Los Angeles Basin. On a local scale, however, the open space connecting Chino Hills State Park with the Whittier Hills does represent a potential animal movement corridor.

The Puente-Chino Hills are widest at Chino Hills State Park, where they stretch almost 9 km across Orange, Riverside, and San Bernardino Counties. Further west, at Harbor Blvd., they narrow to a 1.5km wide area of open space. From Harbor Boulevard to Colima Road, the average width of the corridor is approximately 1 km. In the Whittier

Hills, the width of open space widens to almost 3 km. The western end of the hills is bordered by Workman Mill Road in the vicinity of Interstate Route 605.

3. METHODS

Reptile and amphibian species were surveyed utilizing the pitfall drift-fence array design. Each array consisted of seven 5-gallon buckets placed in the ground and serving as pitfall traps, connected by three 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. We also added a 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 six 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.

Captured animals were individually marked (except for slender salamanders) either by toe- 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.

Thirty-eight arrays were distributed among five sites across the various habitat types throughout the Puente-Chino Hills (Figure 2), including coastal sage scrub, chaparral, grassland, and oak and walnut woodland. Nineteen of the arrays were located in the Puente Hills and were distributed across four separate sites (Table 1); the Torch Operating Company property (Figure 3), the Pathfinder Homeowners Association property (Figure 4), Powder Canyon Open Space (Figure 5), and the Whittier Hills (comprised of Sycamore Canyon and Hellman Wilderness Park) (Figure 6). Sampling at these sites began in April 1998 (Table 1). An additional nineteen arrays were located in Chino Hills State Park (Chino Hills study site) and consisted of three groupings of arrays: Lower Aliso and Santa Ana Canyons (arrays 1-6; Figure 7); Telegraph Canyon (arrays 7-16; Figure 8); Sonome Canyon (arrays 17-19; Figure 9). Sampling at these arrays began in June 1998 (Table 1).

To compare species diversity among sites, we attempted to evaluate several measures of species richness and species heterogeneity. The species richness method is simply calculated by tallying the total number of species detected at a particular site. The rarefaction method standardizes all samples to a common size, thus eliminating the problem of comparing sites with different sample sizes. The species heterogeneity method combines two separate ideas: species richness and evenness. This method addresses the relative abundance of a species within a community (i.e. two sites may have the same number of species (richness) but one of the sites may have a dominant species that accounts for 90% of all individuals captured (evenness)). Thus, evenness measures attempt to quantify unequal representation of each species against a hypothetical community in which all species are equally common.

We calculated three types of heterogeneity measures: Simpson's Index, Shannon-Wiener Function, and Brillouin Index. These nonparametric measures make no assumptions about the shape of species abundance curves. Simpson's Index (1-D) ranges from 0 (low diversity) to almost 1 (high diversity) and is based on the assumption that diversity is inversely related to the probability that two individuals picked at random belong to the same species. Therefore, a community in which there is a high probability of picking two individuals of the same species at random would have low diversity. Alternatively, a community that has a high number of species (high diversity) would have a low probability of picking two individuals of the same species at random (Krebs 1989). The Shannon-Wiener Function (H') is based on the likelihood of correctly predicting the species of the next individual collected. Therefore, this function is a measure of uncertainty; the larger the value of H', the greater the uncertainty. In a community with high diversity, there would be greater uncertainty in correctly predicting the species of the next individual collected (since there are more species to collect). Alternatively, in a community with low diversity, there would be less uncertainty in correctly predicting the species of the next individual collected (since there are less species to collect). This measure increases with the number of species in the community, but rarely exceeds 5 (Krebs 1989). Generally, the Shannon-Wiener Function should be used on communities in which the total number of species is known. For most communities this is extremely difficult, therefore the Brillouin Index may be more appropriate. This index is nearly identical to the Shannon-Wiener Function.

Each of these three measures of heterogeneity has an associated evenness measure with them, which ranges from 0 (low) to 1 (high). Generally, each of these measures is scaled relative to its maximal value when each species in the sample is represented by the same number of individuals. Therefore, maximum diversity is obtained when all abundances are equal to each other. A higher evenness indicates that species in the community are more equally abundant. Alternatively, a lower evenness indicates that there are a few common species and many uncommon ones. One problem with all measures of evenness is they assume that the total number of species in the community is known. To address this problem, we plotted the number of species captured over the entire length of the study against the number of sampling periods that each site was surveyed.

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 Puente-Chino Hills and thus where to focus management resources.

4. RESULTS AND DISCUSSION

Across the Puente-Chino Hills, we captured 1699 specimens of reptiles and amphibians, which consisted of 23 species (Table 2). These 23 species represent four families of amphibians and seven families of reptiles. Species richness varied from 10 to 22 species per study site (Table 2) and from 5 to 13 species across all the arrays (Tables 3 and 4). Twenty-two species were detected at the Chino Hills site, 10 species at Torch, 12 species at Pathfinder, 11 species at Powder Canyon, and 14 species at Whittier Hills (Table 2).

Across the Puente-Chino Hills, the most common species detected were the Western Fence Lizard (*Sceloporus occidentalis*) (631 individuals at 38 arrays) and the Southern Alligator Lizard (*Elgaria multicarinatus*) (308 individuals at 37 arrays). The most common amphibian species detected was the Western Toad (*Bufo boreas*) (148 individuals at 22 arrays). The most common snake species were the Striped Racer (*Masticophis lateralis*) (97 individuals at 32 arrays) and San Diego Gopher Snake (*Pituophis catenifer*) (67 individuals at 29 arrays) (Tables 3 and 4).

For each site we plotted the cumulative number of species detected at the conclusion of each sampling period (Figures 10-14). For example, 17 species were captured during the first sampling period at the Chino Hills site (Figure 10). The next sampling period (period 2) yielded one additional species that was not captured during the first sampling period, bringing the total number of species captured at the Chino Hills site to 18. The purpose of these graphs is to illustrate the number of species captured as a function of sampling effort. These performance curves give an indication of how adequately sampled a site is given the total number of species detected over time. However, these graphs should be interpreted with caution, as the number of species detected is only a function of where the arrays were within a particular site. Sampling different habitats within a site may yield additional species.

The Chino Hills site, surveyed for 15 sampling periods, yielded 22 species by the sixth sampling period (Figure 10). All the Puente Hills sites were sampled 13 times. The Torch site yielded 10 species by the eleventh sampling period (Figure 11); the Pathfinder site yielded 12 species by the twelfth sampling period (Figure 12); the Powder Canyon site yielded 11 species by the eleventh sampling period (Figure 13); and the Whittier Hills site yielded 14 species by the sixth sampling period (Figure 14).

Table 5 summarizes the species diversity indices for each site. An important consideration is that the number of species detected may be a function of the size of the patch (i.e. the degree of habitat fragmentation), the number of different habitat types sampled at a particular site, and the number of sampling arrays at each site. Species richness was highest at the Chino Hills (22 species) and Whittier Hills (14 species) sites. The rarefaction index, which accounts for differences in sample sizes, showed a declining trend in diversity westward with an increase at the Whittier Hills site. The three heterogeneity measures showed a general decline in diversity westward. Diversity was always highest in Chino Hills and lowest in Whittier Hills. Between these sites, two of the heterogeneity measures (Shannon-Wiener and Brillouin's Index) revealed a small decline in diversity with westward orientation.

As with the measures of heterogeneity, the evenness measures were higher at the Chino Hills site and lower at the Whittier Hills site. Between these sites, evenness peaked at the Torch and Powder Canyon sites and declined at the Pathfinder site. The Chino Hills and Torch sites showed the highest levels of evenness, implying that species are more equally abundant than sites further west. The Whittier Hills site showed the lowest evenness, implying that species there are less equally abundant (there are a few abundant, or dominant, species and many less abundant species). Figures 15 and 16 give a graphical representation of a site with high evenness (Torch; Figure 15) and low evenness (Whittier Hills; Figure 16). Figure 15 depicts the relative abundance of species at the Torch site, which had the highest level of evenness. Relative abundance is calculated by dividing the number of individuals of a species by the total number of individuals captured at that site. From the graph, it is evident that the Torch site has species that are more equally common than species at the Whittier Hills site. This is determined by comparing the relative abundance of all species captured at each site (relative abundance is calculated by dividing the number of individuals of a species captured by the total number of individuals captured). Species at the Torch site have a more equal relative abundance than species at the Whittier Hills site, thus a higher evenness value. In fact, the two most common species captured at the Torch site (species 1 and 2 in figure 15) accounted for less than 50% of the total captures, whereas the two most common species captured at the Whittier Hills site (Figure 16) accounted for over 75% of the total captures.

This trend may be due to the loss of sensitive species from the east (Chino Hills) to west (Whittier Hills). Although the Whittier Hills has a high level of species richness relative to other sites to the east (aside from Chino Hills State Park), many of the sensitive species common in the Chino Hills are absent. The number of sensitive species declined from seven in the Chino Hills site (arrays 1-6) to four in the Whittier Hills site (Figure 17). No Western Spadefoot Toads (*Spea hammondii*) or Western Pond Turtles (*Clemmys marmorata*) were found west of Lower Aliso Canyon (Chino Hills arrays 1-6); no Coast Horned Lizards (*Phrynosoma coronatum*) or Coast Patch-nosed Snakes (*Salvadora hexalepis*) were found west of Chino Hills State Park; and no Red Diamond Rattlesnakes (*Crotalus ruber*) were found west of Powder Canyon. Alternatively, some sensitive species, particularly salamanders, were more common in the western sections (Figure 17). No Black-bellied Slender Salamanders (*Batrachoseps nigriventris*) were found in Lower Aliso Canyon, but were detected at all sites west (with the exception of the Torch site) and no Arboreal Salamanders (*Aneides lugubris*) were found east of Powder Canyon.

When analyzing the western limit for all species detected in this study, the same trends were apparent. No Coachwhips (*Masticophis flagellum*), Western Spadefoot Toads (*Spea hammondii*), California Black-headed Snakes (*Tantilla planiceps*) or Western Pond Turtles (*Clemmys marmorata*) were found west of Lower Aliso Canyon. No Coast Horned Lizards (*Phrynosoma coronatum*), Yellow-bellied Racers (*Coluber constrictor*) or Patch-nosed Snakes (*Salvadora hexalepis*) were found west of Chino Hills State Park. And no Side-blotched Lizards (*Uta stansburiana*), Western Skinks (*Eumeces skiltonianus*) or Red Diamond Rattlesnakes (*Crotalus ruber*) were found west of Powder Canyon (Figure 18).

4.1 Status of Sensitive Species

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). Eleven species of reptiles and amphibians are listed as "Covered" within the Nature Conservancy's Natural Heritage System, with an additional seven species marked as "Species of Interest", neither of which are recognized at the state level. Nine of the eleven covered species have been documented within the study area and the associated sites. The nine species include two species of salamander (the Arboreal Salamander (*Aneides lugubris*) and the Black-bellied Slender Salamander (*Batrachoseps nigriventris*)), a toad (the Western Spadefoot Toad (*Spea hammondii*)), three species of lizards (the Orange-throated Whiptail (*Cnemidophorus hyperythrus*), the Coastal Western Whiptail (*Cnemidophorus tigris*), and the Western Skink (*Eumeces skiltonianus*)), and three snake species (the Western Ringneck Snake (*Diadophis punctatus*), the California Red-sided Garter Snake (*Thamnophis sirtalis infernalis*), and the Red Diamond Rattlesnake (*Crotalus ruber*)). The only covered species yet to be documented are the Arroyo Toad (*Bufo microscaphus*) and the Coastal Rosy Boa (*Charina trivirgata*). 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 Coast Patch-nosed Snake (*Salvadora hexalepis*) and the Pacific Pond Turtle (*Clemmys marmorata*), all detected at arrays in Chino Hills State Park.

Below we detail the status of the different sensitive species within the Puente-Chino Hills. In addition, we suggest specific management recommendations that could be implemented to maintain populations of these sensitive species.

<u>Arboreal Salamander (*Aneides lugubris*)</u>

Status: No State or Federal Listing

> The Arboreal Salamander was detected at two sites within the study area: the Whittier Hills and Powder Canyon (Table 2). It is primarily associated with oak and sycamore woodlands and chaparral. The documentation of this species within such a short period of time after having opened these sites (it was first detected during sampling period 6 at the Whittier Hills site and sampling period 11 at the Powder Canyon site) is a good indication that there are good populations present.

<u>Arroyo Toad (*Bufo californicus*)</u>

Status: CA State Species of Concern/Federal Candidate Species

> Arroyo Toads are one of several species of interest yet to be detected in the study area. Several sites are within their historic range; however Jennings and Hayes (1994) suggest that this species may be extirpated from the Santa Ana River drainage system.

<u>Black-bellied Slender Salamander (*Batrachoseps nigriventris*)</u>

Status: No State or Federal Listing

> Black-bellied Slender Salamanders were detected at all of the sites within the study area with the exception of the Torch property. Powder Canyon contained the highest number of individuals captured (Table 2). Difficulty identifying this species, separate from the Garden Slender Salamander (*Batrachoseps major*), may require genetic testing to verify the identity of this species.

<u>California Legless Lizard (*Anniella pulchra*)</u>

Status: CA State Species of Concern/Federal Candidate Species

The Legless Lizard was never collected in buckets. Boards were placed along the fences so that we could better 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 currently are not trapping.

California Red-sided (Common) Garter Snake (*Thamnophis sirtalis infernalis*)

Status: No State or Federal Listing

The California Red-sided Garter Snake has been documented in the Santa Ana River Basin, upstream of the Chino Hills study site. This snake has declined throughout its range in southern California to a point that is near extinction. Intensive searches in Prado Basin would likely detect the presence of this species.

Coast Horned Lizard (*Phrynosoma coronatum*)

Status: CA State Species of Special Concern

The Coast Horned Lizard has been a species of concern at the state and federal level for numerous years. Historically, it 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. We found that these lizards occurred primarily in coastal sage scrub within the Puente-Chino Hills and were usually detected on ridgelines. All Coast Horned Lizards detected in this study were from the Chino Hills site (Table 3). This is also one of several species whose densities decrease with western orientation. 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. The Coast Horned Lizard is known to be negatively impacted by the introduced Argentine ant. Management efforts should be taken to reduce irrigation, which helps to support the Argentine ant, in areas likely to support this lizard.

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 Puente-Chino Hills. Typically, the species is very rare within the sites where they do occur. Our research has shown that at the three sites where they were detected, they were only captured at one array. Additional sampling may detect this species in the future.

Coastal Patch-nosed Snake (*Salvadora hexalepis virgultea*)

Status: Federal Candidate Species

The Coastal Patch-nosed Snake was recorded from only one array within Chino Hills State Park (Table 3). This species probably historically occurred throughout the Puente-Chino Hills, particularly in areas with coastal sage scrub and chaparral. This species is an active forager, and is often run over by vehicles as they attempt to cross roads. We have found road kills in other study sites;

therefore as traffic increases in certain areas these species may be negatively impacted. This is another species that will benefit from having portions of the Puente-Chino Hills free from the impacts of roads and trails, bikes, and human activity.

Coastal Rosy Boa (*Charina trivirgata*)
Status: Federal Candidate Species

The Coastal Rosy Boa is another species of interest yet to be detected in the Puente-Chino Hills. It is very slow moving and easy to identify. Their long-term persistence is at risk for two reasons. First is the fragmentation due to the roads. These species will often lie 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. These snakes might literally be collected out of their habitat unintentionally by naturalists and visitors. Since the number of people using the open space is likely to increase, they will always be at risk to poaching. A more thorough posting of the fines for collecting in the Puente-Chino Hills might help to limit poaching as visitation increases. This species is most likely to occur in the Coal Canyon area of Chino Hills State Park.

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 three of the five survey sites (Chino Hills, Pathfinder, and Whittier Hills) (Table 2). 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 bisecting open space across the Puente-Chino Hills, signs warning drivers and mountain bikers to be particularly careful should be posted. In addition, accidental deaths should be quantified.

Western Spadefoot Toad (*Spea hammondii*)
Status: CA 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). It primarily prefers grassland, shrub, and chaparral habitats but may occur in oak woodlands. 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 throughout the study area with the exception of the Chino Hills site. Here we detected 8 individuals at a single array in lower Aliso Canyon (Table 3). The addition of upland breeding pools would greatly help this species remain viable throughout the Puente-Chino Hills.

Western Skink (*Eumeces skiltonianus*)
Status: Federal Candidate Species

The local subspecies, the Coronado Skink, 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 widespread and occurred at all but one study site (Whittier Hills) within the entire study area (Table 2). This is one of several species in which densities decrease with western orientation. At the Chino Hills site we captured 112 individuals and numbers decreased rapidly until the western most site, Whittier Hills, where we captured no Western Skinks (Table 2). Long-term maintenance of this species in the Puente-Chino Hills 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.

San Diego/San Bernardino Ring-necked Snake (*Diadophis punctatus*)
Status: Federal Candidate Species
The Ring-necked Snake was found at three of the five sites (Chino Hills, Torch, and Whittier Hills) (Table 2). 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 Puente-Chino Hills.

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 where historic records document its past occurrence now lack this species. 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 road mortality where it still occurs. There is a sufficient amount of optimal habitat within the Puente-Chino Hills for this species. The Red Diamond Rattlesnake was observed at three of the five sites (Chino Hills, Torch, and Powder Canyon). This is one of several species that densities decrease with western orientation. If portions of habitat at the western end of the Puente-Chino Hills could be insulated from roads and human activity, this species might be able to increase in distribution and relative abundance.

Two-striped Garter Snake (*Thamnophis hammondii*)
Status: CA 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, the only Two-striped Garter Snakes in the Puente-Chino Hills have been detected in the Santa Ana River and Prado Basin. This species prefers treefrogs and toads, which only occur in a few of the study sites. Intensive surveys of Sycamore and Powder Canyons might detect the presence of this species.

Western Pond Turtle (*Clemmys marmorata*)

Status: CA State Species of Special Concern/Federal Candidate Species

Although not captured in an array, the Western Pond Turtle was documented at the Chino Hills study site, adjacent to the Santa Ana River. We would not expect to capture this species in our traps, however it may be observed crossing roads when they move seasonally to nesting sites. The Western Pond Turtle could still be present at some upstream creek channels, or sloughs at these sites

Red-legged Frog (*Rana aurora draytonii*)
Status: Federally Listed as Threatened

The Red-legged frog was not detected to date in the study area. Historically, this species was documented from Carbon, Tonner, and other canyons throughout the Puente-Chino Hills.

5. CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

We present our recommendations for the following three categories: management activities, identification of movement corridors, and future monitoring strategies. We have been able to identify several regions that are important for the maintenance of diversity of reptiles and amphibians within the Puente-Chino Hills. 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 the Puente-Chino Hills to other habitat fragments to the east and south. Some of these habitat linkages and corridors may be non-functional but could, through restoration, become useful for the movement of reptiles and amphibians between other large portions of habitat.

5.1 Specific Management Activities for Species and Diversity

5.1.1 *Exotic Species*

Argentine ants
We have found these exotic ants to be widespread in southern California. These ants are known to displace native ant species in San Diego (Suarez et al. 1988) and may possibly cause effects at higher trophic levels if they spread throughout the corridor. The California Horned Lizard is an ant specialist that prefers native ants to the exotics (Suarez, pers. comm.). Within the study area, 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. Increased moisture level associated with irrigation plays an important 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 to benefit the ants.

The Argentine ant is uncommon within Chino Hills State Park primarily due to the large continuous area and lack of artificially increased moisture levels typically associated with the urban edge. The ants were sampled for three times between the winters of 1999 and

2000. During this period only 2 Argentine ants out of 3,646 total ants were detected. In contrast, in the Puente Hills west of Pathfinder, we captured 16,588 Argentine ants out of a total of 17,205 ants within the same time frame. With such large numbers of Argentine ants present in the western portion of the Puente-Chino Hills, urban/wildland interfaces should be managed to incorporate drought tolerant vegetation and/or any means that utilizes less irrigation.

Red imported fire ants
These ants may become a problem in the future and we are continuing to monitor for its presence.

House/feral cats
House/feral cats are a problem at most wildland/urban interfaces, as they are recreational predators of native lizards, small mammals, and birds (Crooks and Soulé 1999). We have some data from San Diego County that suggest they might be major predators of Coast 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 movement of coyotes within the Puente-Chino Hills should minimize the ability of feral cats to invade a particular area. Any residents bordering open space should keep their cats indoors for their safety and restrict their incidental killing of native wildlife.

5.1.2 *Physical Modifications*

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 they may be enhanced 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 and toad species. The ridgelines in flat areas would be appropriate for pool creation for Spadefoot populations.

5.1.3 *Enforcement*

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 Puente-Chino Hills. These observations include dead Alligator Lizards at several places (smashed on bike trails), a dying Southern Pacific Rattlesnake 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 public areas 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.

5.1.4 *Education*

We think it would be advantageous to include more information fliers/billboards on rattlesnakes within the Puente-Chino Hills. This information could indicate safety issues and give some statistics on bites in the park relative to other injuries. We know that the snakes are widespread in the Puente-Chino Hills (Table 2) and prefer to crawl on the trails; therefore it is inevitable that people will see them. We suggest the development of a checklist identifying where and when snakes have recently been seen. Additionally, information that differentiates the Southern Pacific Rattlesnake from the Red Diamond Rattlesnake should be presented to the public, particularly at trailheads. This could help to identify any locations where physical barriers could be used to keep rattlesnakes out of public facilities.

5.2 Identification of Corridors for Reptiles and Amphibians

The majority of the reptiles and amphibians of the Puente-Chino Hills are upland species. They will require some form of upland habitat linkage to maintain gene flow, and reinvasion if localized extinctions in the corridor take place. The Tree Frog, Western Toad, and Pacific Pond Turtle might utilize a riparian corridor connecting to populations in the east and south, principally in the Prado Basin and Santa Ana Mountains. Of the upland species, several may be viable without any connection outside of the Puente-Chino Hills, if the adjacent lands do not become more developed. A few species might go extinct over time without a habitat linkage to other populations. These include the Coastal Horned Lizard, Red Racer, Red Diamond Rattlesnake, and the Coastal Patch-nosed Snake.

5.3 Future Monitoring Strategies

Given the fact that we have documented additional species in the past two to four sampling periods, we recommend that monitoring continue for an additional one to two years. This will accomplish two goals. First, we will be more likely to detect rare species occurring at the sites. For example, several of the last species detected at the Puente Hills sites are species that we have identified as sensitive to habitat fragmentation. These species include the Arboreal Salamander *(Aneides lugubris)* (Powder Canyon site) and the Red Diamond Rattlesnake (*Crotalus ruber*) (Torch site). Generally, a plateau in the performance curves indicates that additional species are not being detected at a site. Given the fact that the tail end of the graphs for the Puente Hills sites do not plateau, continued monitoring would increase the likelihood of capturing rare and less abundant species that have already been detected to the east in Chino Hills. Additionally, continued monitoring may detect species of amphibians that may be more abundant during wetter years, as the past three years have been relatively dry. Secondly, continued monitoring will allow us to detect trends in the herpetofauna population in the Puente-Chino Hills. Our regional autecological study has accumulated over five years of data. By surveying over this period of time, we are able to document trends in population sizes. Since herpetofauna populations are not as stable as populations of larger taxa (i.e. birds and large mammals) it is necessary to sample over longer periods of time in order to detect any changes in the population (Gibbs et al. 1998). Therefore, continued monitoring will allow us to collect enough information on fluctuations in these communities, thus allowing us to make more specific management recommendations.

Finally, we have identified additional sites that would warrant sampling. These sites include: the portion of habitat surrounding the Los Angeles County landfill, the former Chevron and Unocal properties on the east and west sides of Colima Road, and the ridgelines between Hacienda Boulevard and Powder Canyon (Skyline Trail). Information on these sites would fill in gaps in survey sites, thus giving us a more complete understanding of herpetofauna distribution and diversity across the Puente-Chino Hills.

6. ACKNOWLEDGEMENTS

We would like to thank and the Mountains Recreation and Conservation Authority, the Puente Hills Landfill Native Habitat Preservation Authority and Chino Hills State Park for funding. Specifically, we would like to thank Judi Tamasi, Andrea Gullo, Ken Hughs and Geary Hund for there dedication and patience to get this project completed. Also a special thanks to the USGS WERC San Diego Field Station staff for their contributions in the field.

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Table 1. Summary of study sites within the Puente-Chino Hills.

Site Name	*Start Date*	*End Date*	*Number of Arrays*	*Total Sampling Days*
Torch Property	4/21/1998	11/8/2000	4	120
Pathfinder	4/21/1998	11/14/2000	3	130
Powder Canyon	4/21/1998	11/14/2000	4	130
Whittier Hills	4/21/1998	11/17/2000	8	130
Chino Hills State Park	6/3/1998	6/15/2001	19	147

Table 2. Number of individuals captured per site.

Common Name	*Scientific Name*	*CHSP*	*Torch*	*Pathfinder*	*Powder Canyon*	*Whittier Hills*	*Total Individuals*
Arboreal Salamander	*Aneides lugubris*				1	1	2
Pacific Treefrog	*Hyla regilla*	5				1	6
Garden Slender Salamander	*Batrachoseps major*	2		2	2	2	8
Western Spadefoot Toad	*Spea hammondii*	8					8
Black-bellied Slender Salamander	*Batrachoseps nigriventris*	4		3	13	3	23
Western Toad	*Bufo boreas*	140				8	148
Coast Horned Lizard	*Phrynosoma coronatum*	7					7
Side-blotched Lizard	*Uta stansburiana*	50	4	2			56
Western Whiptail	*Cnemidophorus tigris*	51		14		12	77
Western Skink	*Eumeces skiltonianus*	112	8	1	5		126
Southern Alligator Lizard	*Elgaria multicarinatus*	146	20	22	47	73	308
Western Fence Lizard	*Sceloporus occidentalis*	327	18	62	65	159	631
Coast Patch-nosed Snake	*Salvadora hexalepis*	1					1
Western Yellow-bellied Racer	*Coluber constrictor*	3					3
Coachwhip/Red Racer	*Masticophis flagellum*	3					3
Red Diamond Rattlesnake	*Crotalus ruber*	2	1		1		4
California Black-headed Snake	*Tantilla planiceps*	6					6
Western Ringneck Snake	*Diadophis punctatus*	8	3			1	12
California Kingsnake	*Lampropeltis getulus*	17	1	1	1	2	22
Western Blind Snake	*Leptotyphlops humilis*	20		2		5	27
Southern Pacific Rattlesnake	*Crotalus viridis*	27	4	2	12	12	57
San Diego Gopher Snake	*Pituophis catenifer*	31	7	14	6	9	67
Striped Racer	*Masticophis lateralis*	41	10	11	15	20	97
	Total Individuals	1011	76	136	168	308	1699
	Total Species	22	10	12	11	14	23

Table 3. Number of individuals captured at Chino Hills State Park arrays.

		Array Number																			*Total*
Common Name	*Scientific Name*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*Individuals*
Garden Slender Salamander	*Batrachoseps major*						1												1		2
Black-bellied Slender Salamande	*Batrachoseps nigriventris*										1						3				4
Pacific Treefrog	*Hyla regilla*					5															5
Western Spadefoot Toad	*Spea hammondii*						8														8
Western Toad	*Bufo boreas*	2	9	4	15	52	11	11	7	2	3	1	1	3	9	5	5				140
Coast Horned Lizard	*Phrynosoma coronatum*			1														5	1		7
Side-blotched Lizard	*Uta stansburiana*	14	4		6	17	6	1					2								50
Western Whiptail	*Cnemidophorus tigris*		2		8	13	18						1	5				4			51
Western Skink	*Eumeces skiltonianus*	5	13	4	41	6	6	4		3		1	5	5	9	3	3	3	1		112
Southern Alligator Lizard	*Elgaria multicarinatus*	1	8	3	4	4		20	11	17	3	10	10	1	13	11	20	2	4	4	146
Western Fence Lizard	*Sceloporus occidentalis*	27	15	41	18	24	11	11	15	18	24	13	7	3	18	18	16	15	19	14	327
Coast Patch-nosed Snake	*Salvadora hexalepis*																	1			1
Red Diamond Rattlesnake	*Crotalus ruber*		1			1															2
Western Yellow-bellied Racer	*Coluber constrictor*					2												1			3
Coachwhip/Red Racer	*Masticophis flagellum*	1		1	1																3
Western Ringneck Snake	*Diadophis punctatus*				2	2	2														6
California Black-headed Snake	*Tantilla planiceps*							1					2			1	2			2	8
California Kingsnake	*Lampropeltis getula*				3	6	3	2	1	1									1		17
Western Blind Snake	*Leptotyphlops humilis*		4		6	3							4	3							20
Southern Pacific Rattlesnake	*Crotalus viridis*	1							11	2	1		1		4	5			1	1	27
San Diego Gopher Snake	*Pituophis catenifer*	2	2	2		4	1		1	1	2	3	2		4		3	3	1		31
Striped Racer	*Masticophis lateralis*	3	4	1				1	4	4	1	1	5	4		3		5	4	1	41
	Total Individuals	56	62	57	104	139	67	51	50	48	35	29	40	24	57	46	52	39	33	22	1011
	Total Species	9	10	7	10	13	9	8	7	7	6	5	10	6	6	7	7	9	8	5	22

Table 4. Number of individuals captured at Torch, Pathfinder, Powder Canyon, and Whittier Hills arrays.

		Array Number																							
		Torch					Pathfinder				Powder Canyon					Whittier Hills									*Total*
Common Name	*Scientific Name*	*1*	*2*	*3*	*4*	*Total*	*5*	*6*	*7*	*Total*	*8*	*9*	*10*	*11*	*Total*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*Total*	*Individuals*
Pacific Treefrog	*Hyla regilla*																						1	1	1
Arboreal Salamander	*Aneides lugubris*												1		1	1								1	2
Garden Slender Salamander	*Batrachoseps major*						1	1		2		1	1		2		*					2	*	2	6
Western Toad	*Bufo boreas*																1	1			1	3	2	8	8
Black-bellied Slender Salamander	*Batrachoseps nigriventris*						1		2	3	3	6	3	1	13	1			1			1		3	19
Side-blotched Lizard	*Uta stanburiana*	1		1	2	4	1		1	2															6
Western Skink	*Eumeces skiltonianus*	3	1	4		8		1		1	1	3		1	5										14
Western Whiptail	*Cnemidophorus tigris*						7		7	14						2	2	4		3	1			12	26
Southern Alligator Lizard	*Elgaria multicarinatus*	1	9	4	6	20	9	8	5	22	9	14	17	7	47	9	4	4	9	12	14	10	11	73	162
Western Fence Lizard	*Sceloporus occidentalis*	4	3	4	7	18	18	26	18	62	30	14	7	14	65	19	19	11	17	37	26	17	13	159	304
Red Diamond Rattlesnake	*Crotalus ruber*	1				1						1			1										2
Western Ringneck Snake	*Diadophis punctatus*		1	1	1	3													1					1	4
California Kingsnake	*Lampropeltis getula*		1			1			1	1	1				1			1			1			2	5
Western Blind Snake	*Leptotyphlops humilis*								2	2									2	1	2			5	7
Southern Pacific Rattlesnake	*Crotalus viridis*	1		2	1	4			2	2	2	7	1	2	12	2	3	3	1	1	1		1	12	30
San Diego Gopher Snake	*Pituophis catenifer*	2	2	1	2	7	2	3	9	14	1	1		4	6	1	1	3	1		3			9	36
Striped Racer	*Masticophis lateralis*	2	5	2	1	10	3	5	3	11	5	7	1	2	15	2	5		4	1	5	1	2	20	56
	Total Individuals	15	22	19	20	76	42	44	50	136	52	54	31	31	168	37	35	27	36	55	54	34	30	308	688
	Total Species	8	7	8	7	10	8	6	10	12	8	9	7	7	11	8	8	7	8	6	9	6	7	14	17

** = Batrachoseps captured; unable to identify to species*

Table 5. Species diversity indices for each site

Index Name	*Chino Hills*	*Torch*	*Pathfinder*	*Powder Canyon*	*Whittier Hills*
Total number of individuals	1011	76	136	168	308
Total number of species	22	10	12	11	14
Rarefaction (n=50)	11.67	9.26	8.89	8.09	8.40
Simpson's Diversity	0.835	0.841	0.742	0.755	0.670
Shannon-Wiener Diversity	3.169	2.838	2.494	2.444	2.228
Brillouin's Diversity	3.104	2.565	2.309	2.299	2.123
Maximum Possible Diversity[1]					
Simpson's	0.955	0.912	0.923	0.914	0.932
evenness	0.874	0.923	0.804	0.826	0.719
Shannon-Wiener	4.459	3.322	3.585	3.459	3.807
evenness	0.711	0.854	0.696	0.706	0.585
Brillouin	4.377	3.009	3.347	3.273	3.663
evenness	0.709	0.852	0.690	0.702	0.580

[1] = each evenness measure below is calculated by determining the maximum diversity value (obtained when all abundances are set equal to each other), which is listed above each evenness value. Therefore, the maximum diversity values for Simpson's, Shannon-Wiener, and Brilloins Index are estimated; the true values are presented in their respective rows above.

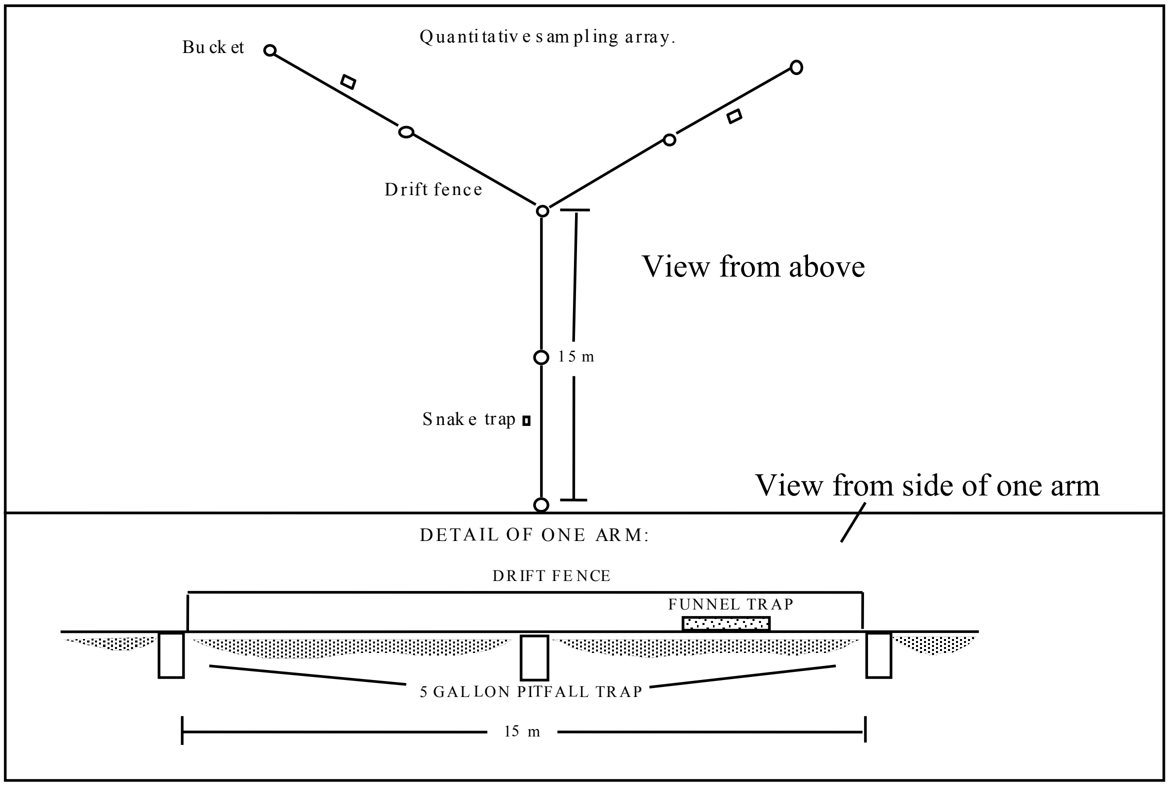

Figure 1. Terrestrial survey protocol and designs for arrangement of pitfall and funnel traps with drift fences. Figures are not drawn to scale.

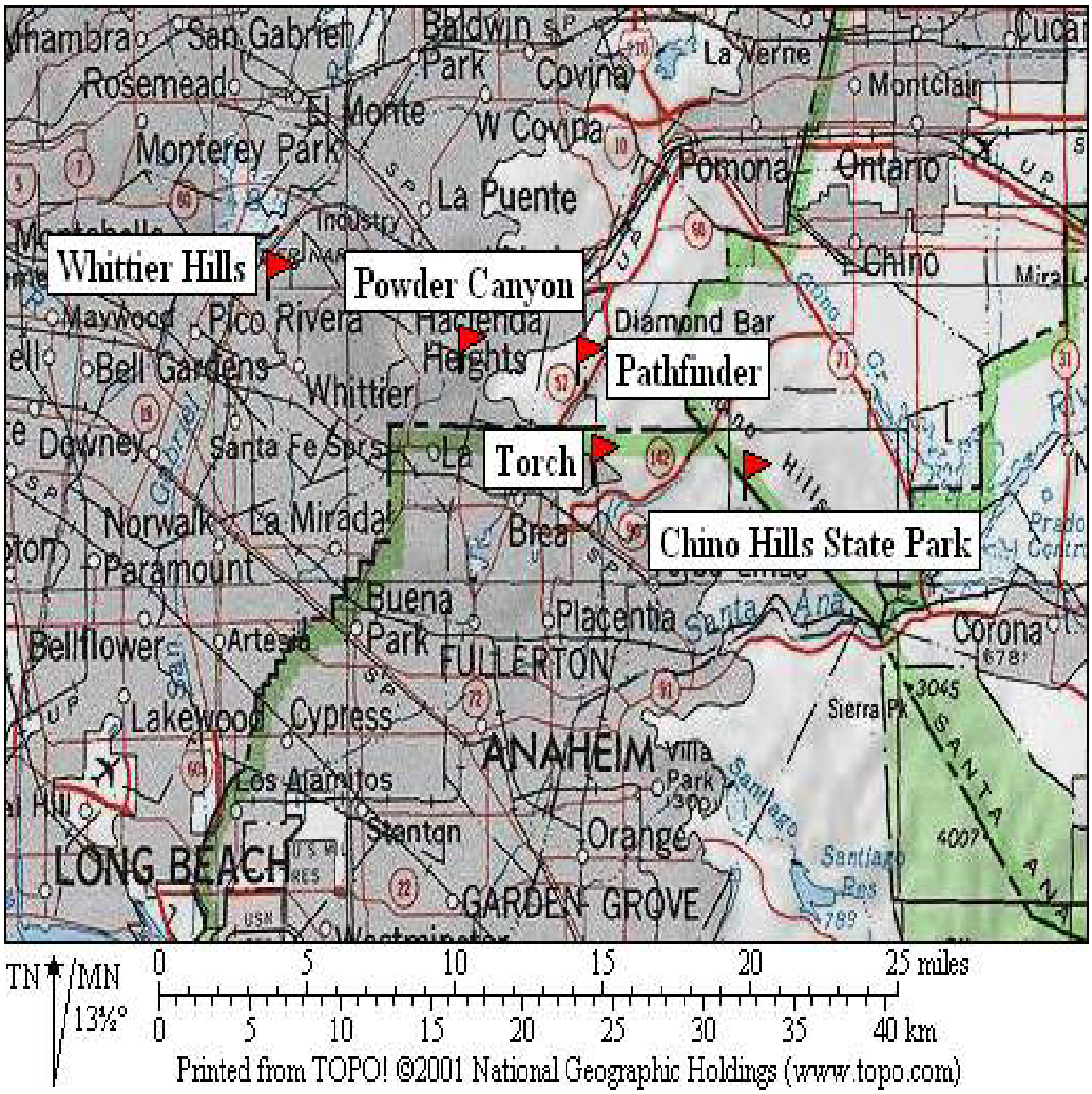

Figure 2. Locations of study sites within the Puente-Chino Hills.

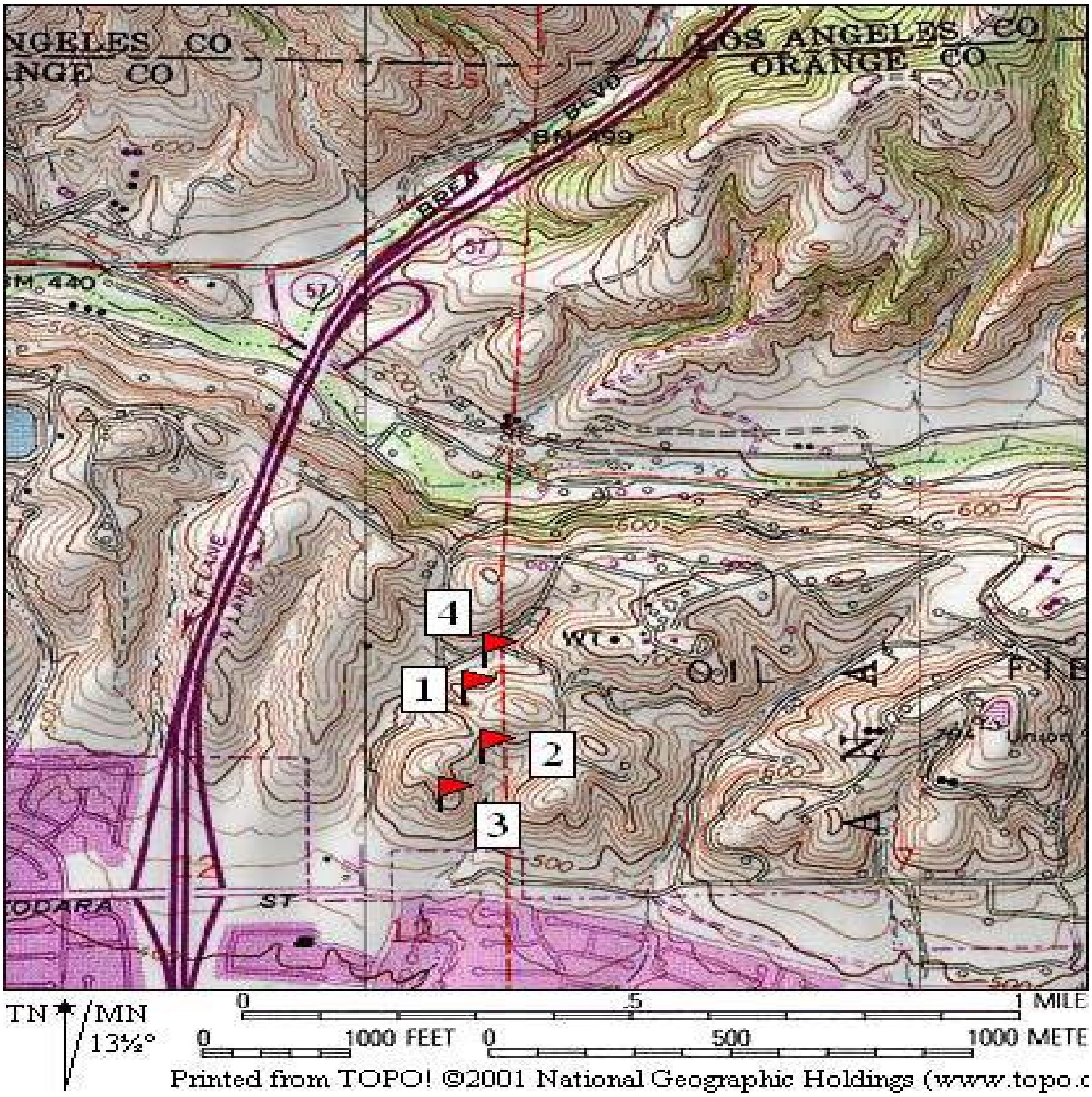

Figure 3. Locations of herpetofauna sampling arrays at the Torch site.

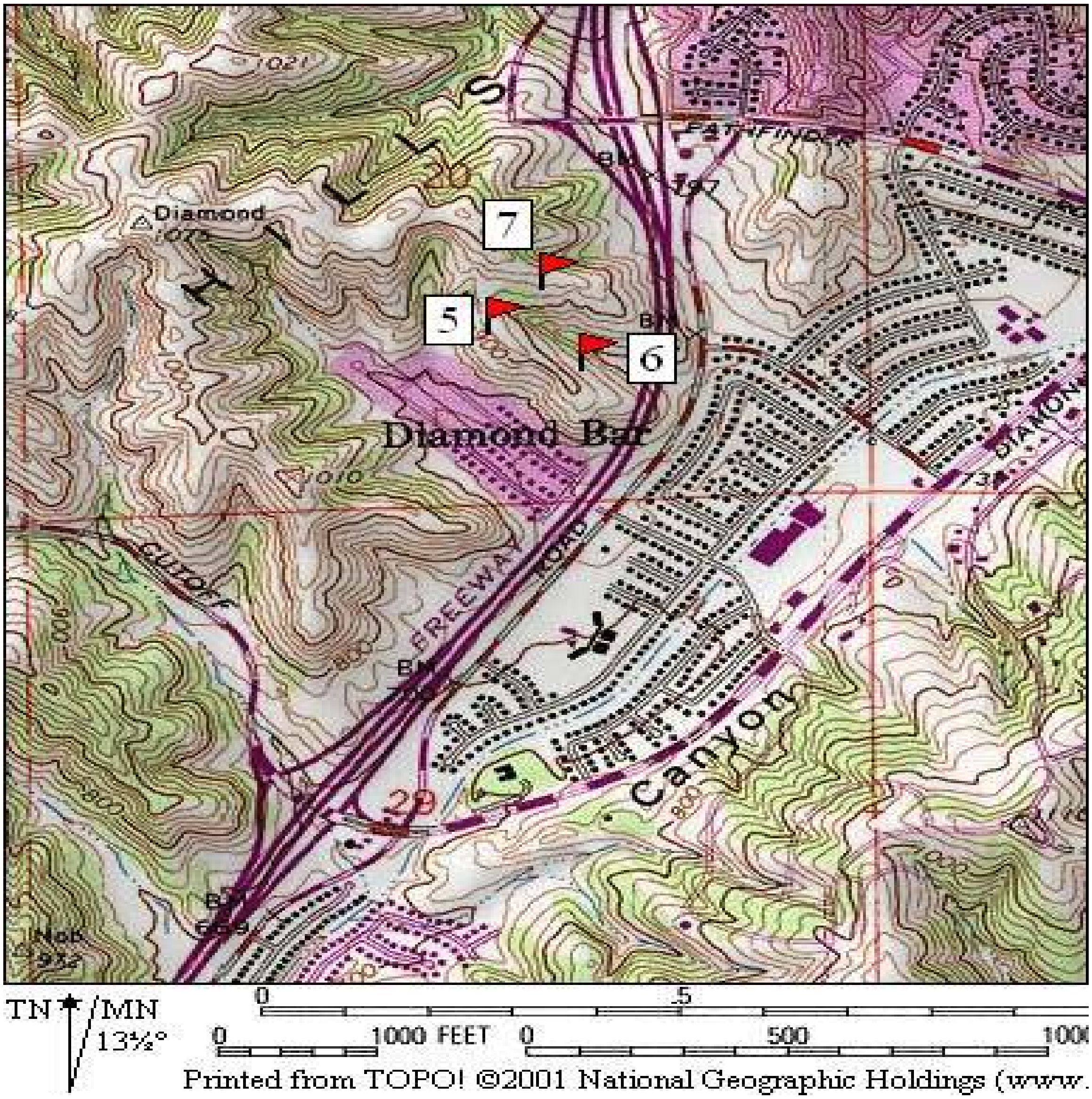

Figure 4. Locations of herpetofauna sampling arrays at the Pathfinder site.

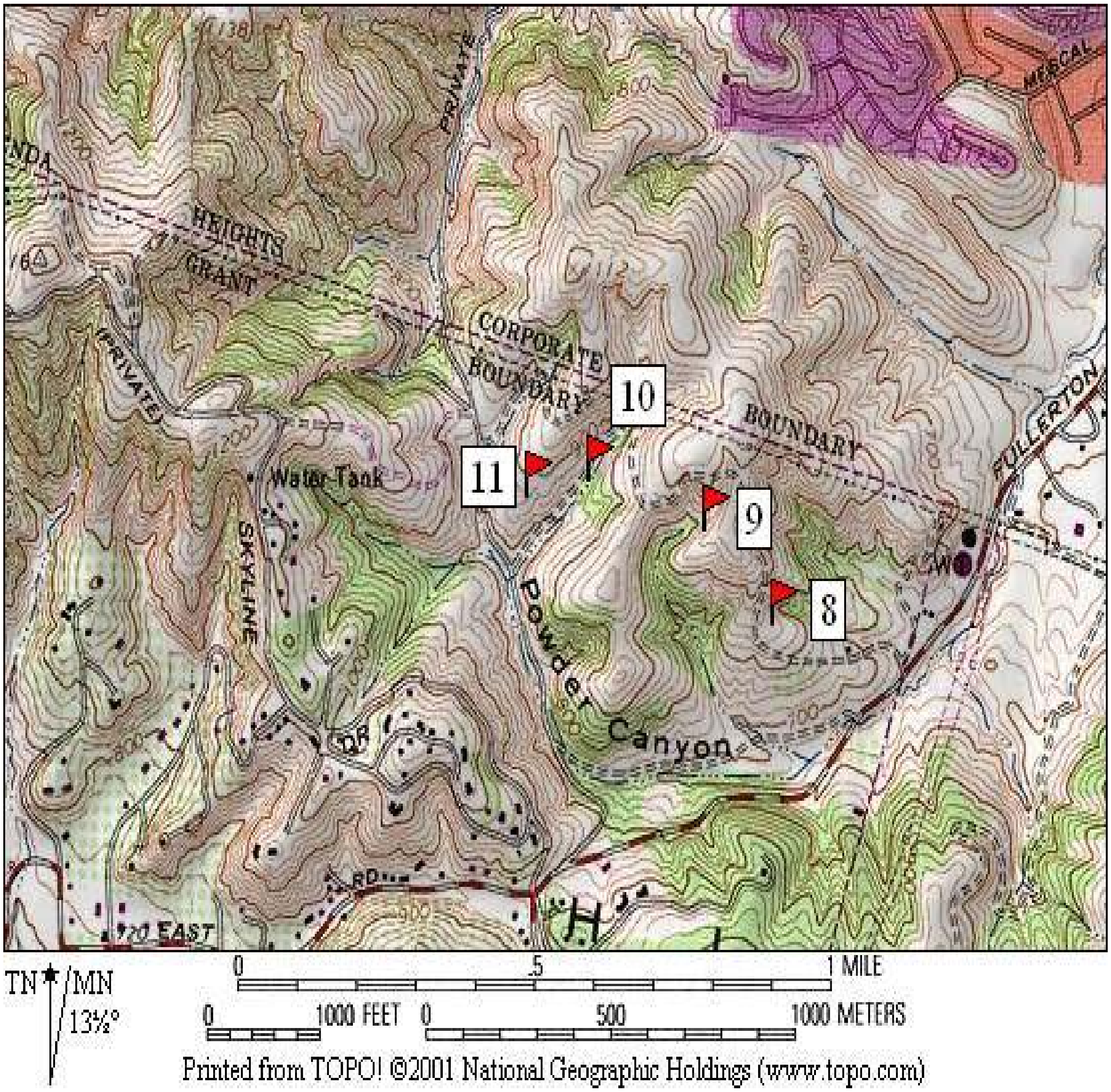

Figure 5. Locations of herpetofauna sampling arrays at the Powder Canyon site.

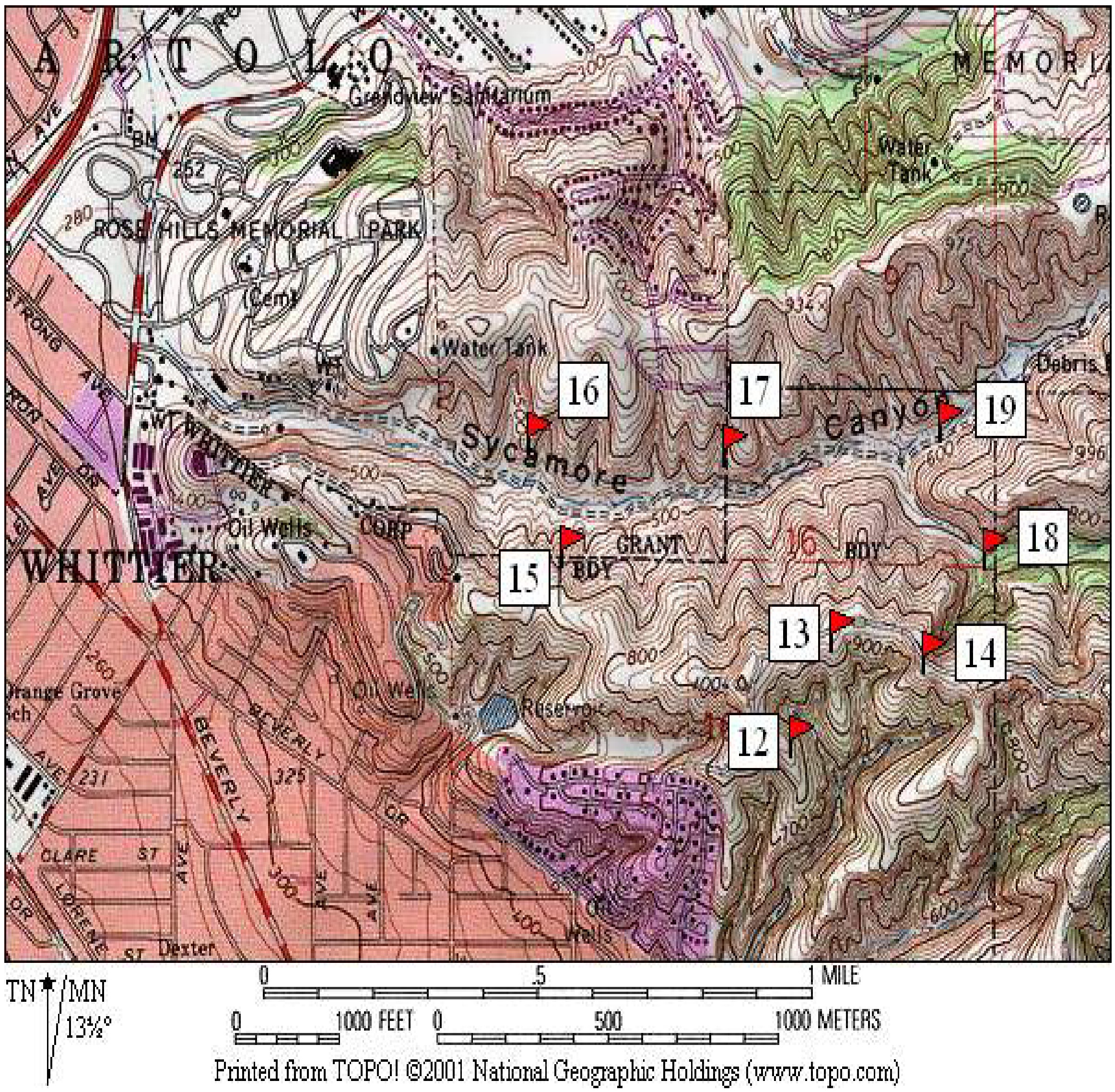

Figure 6. Locations of herpetofauna sampling arrays at the Whittier Hills site.

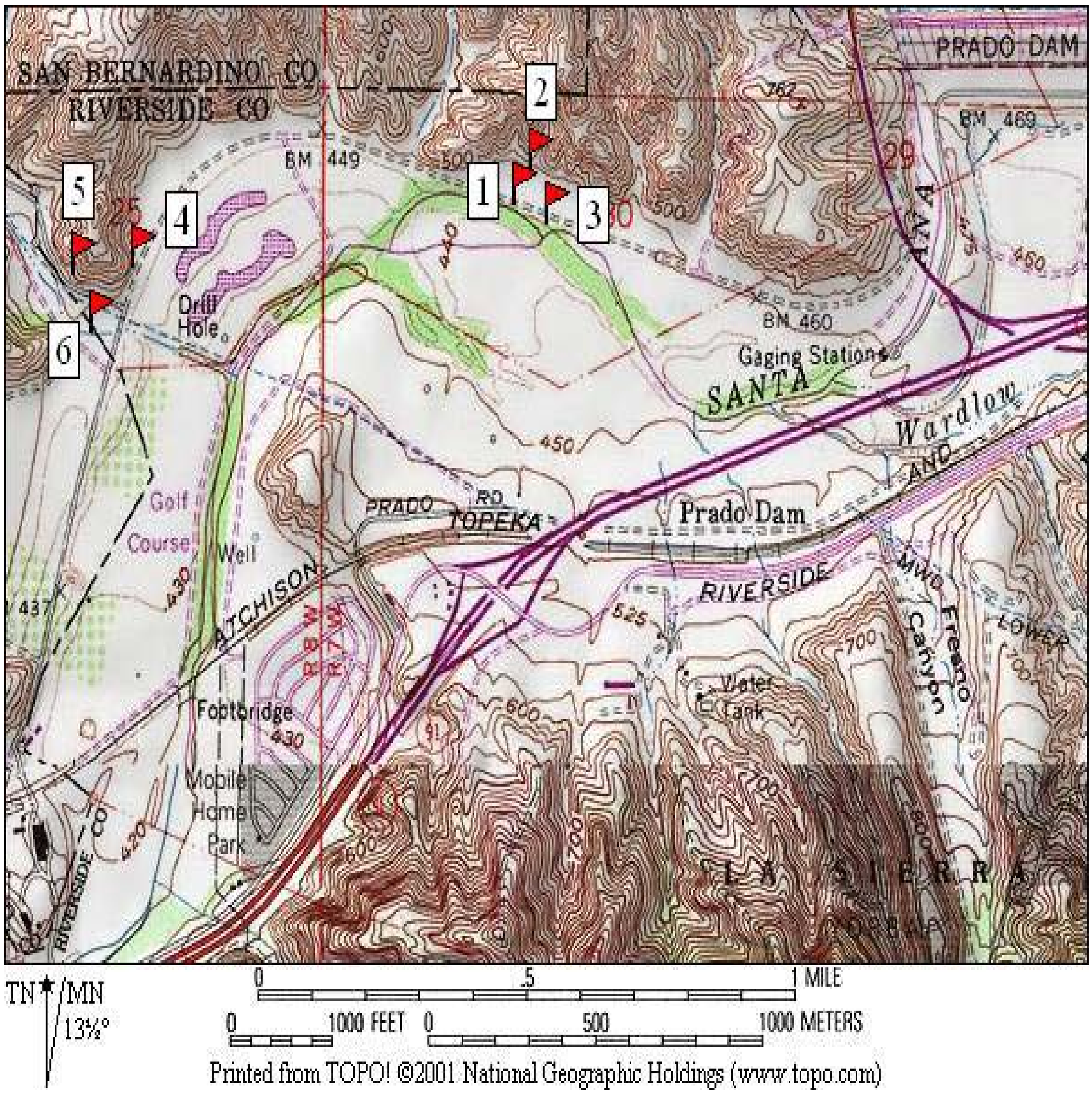

Figure 7. Locations of herpetfauna sampling arrays 1-6 at the Chino Hills site.

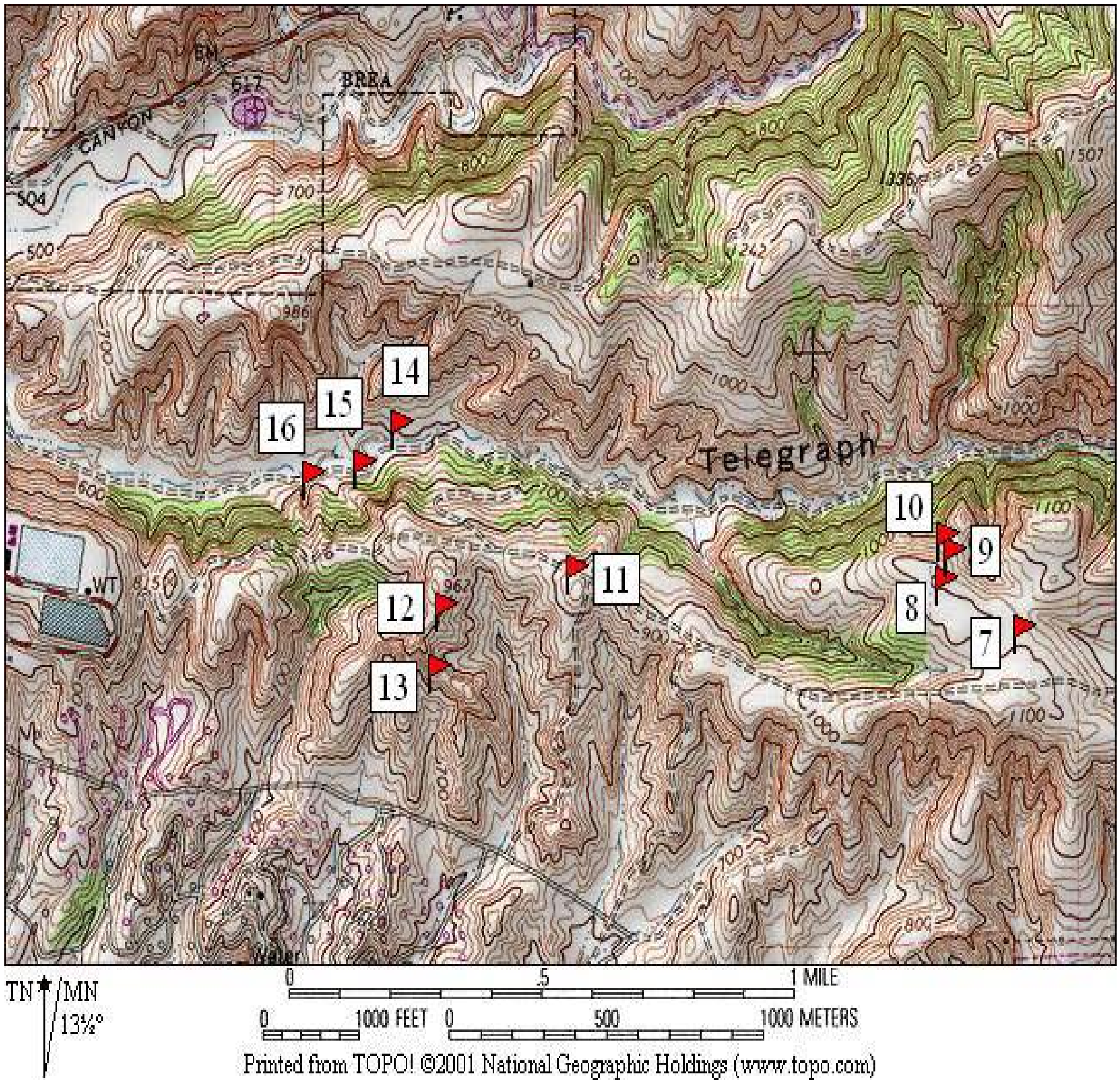

Figure 8. Locations of herpetofauna sampling arrays 7-16 at the Chino Hills site.

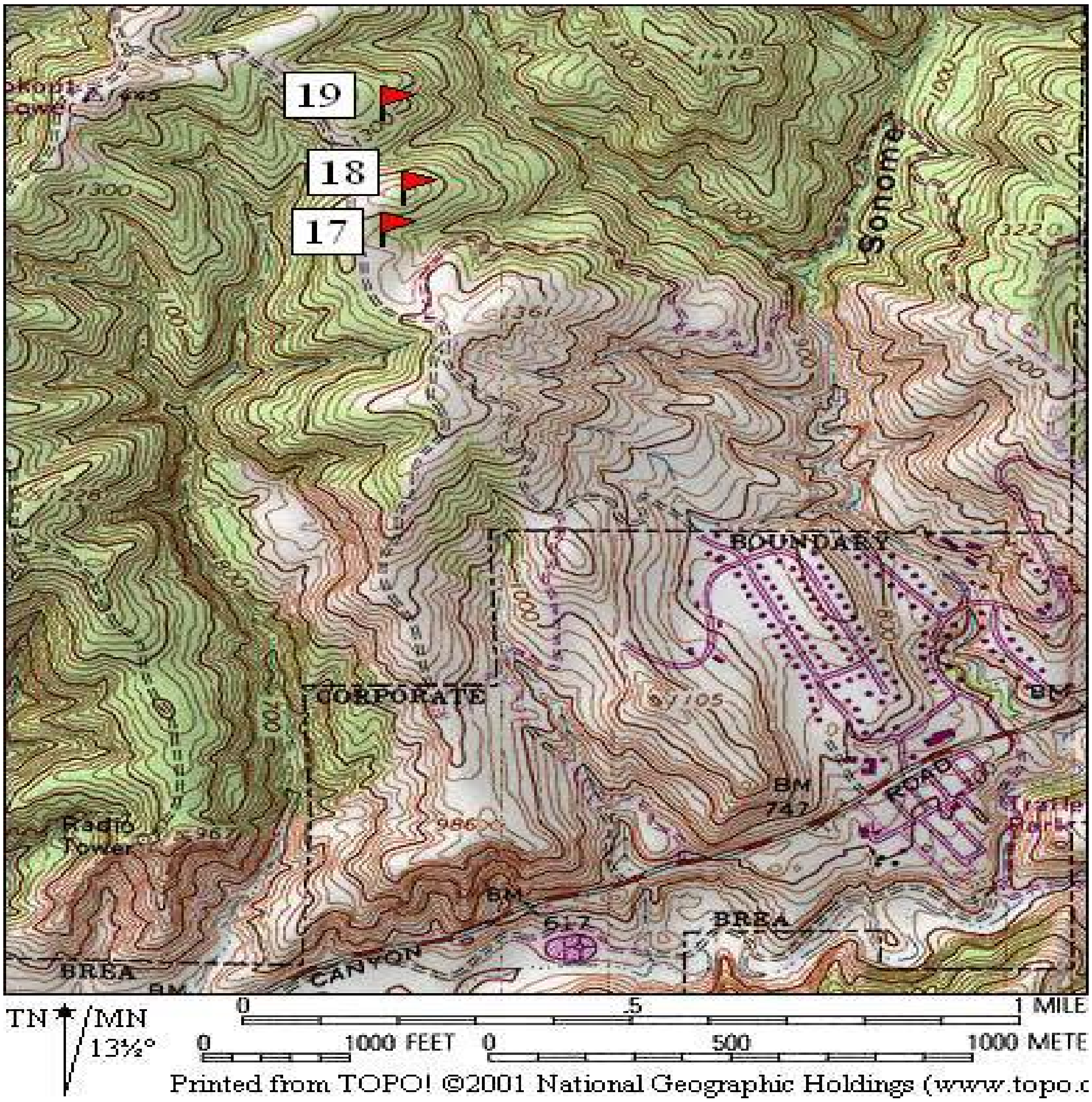

Figure 9. Locations of herpetofauna sampling arrays 17-19 at the Chino Hills site.

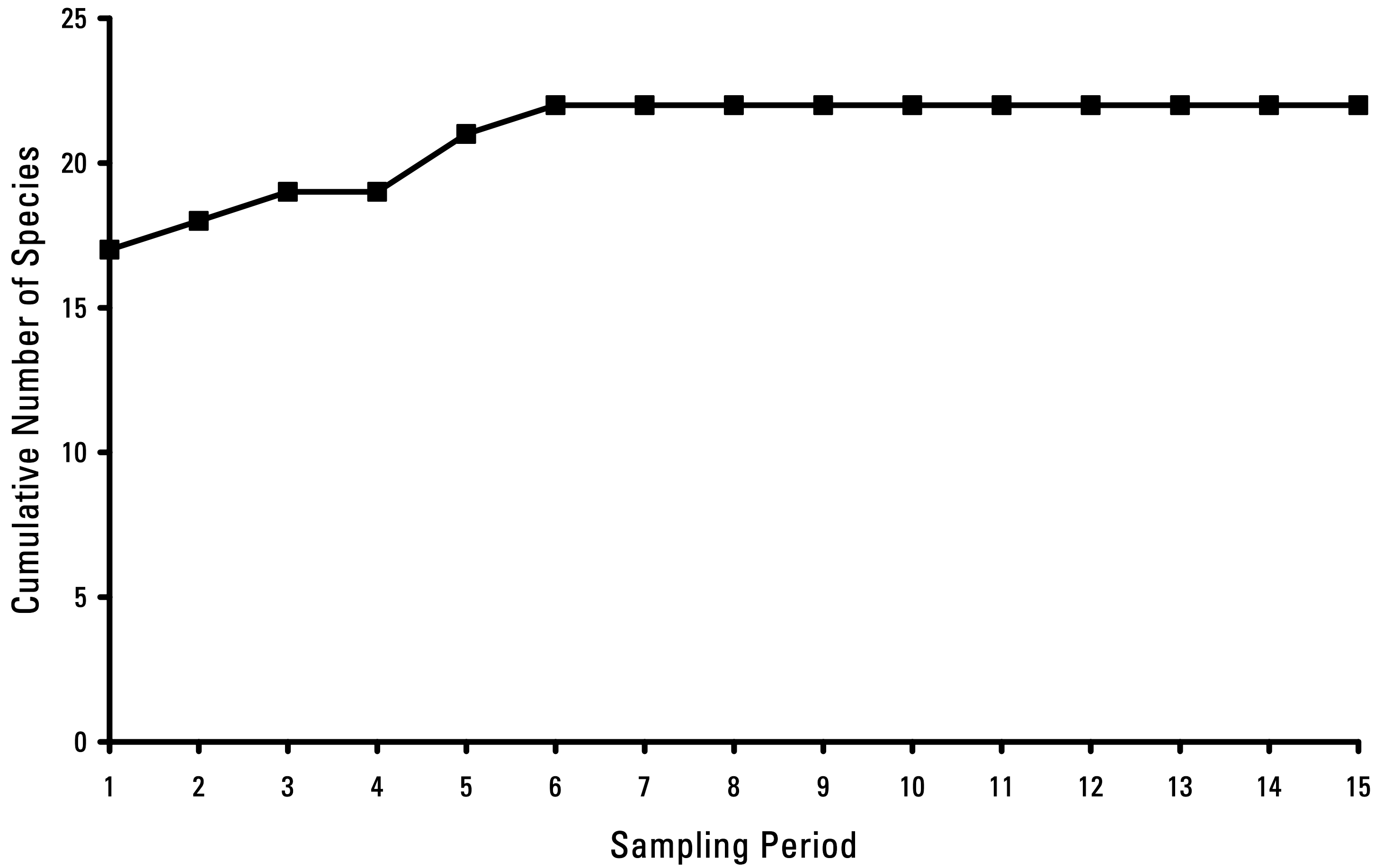

Figure 10. Performance curve of cumulative number of species vs. sampling period for the Chino Hills site

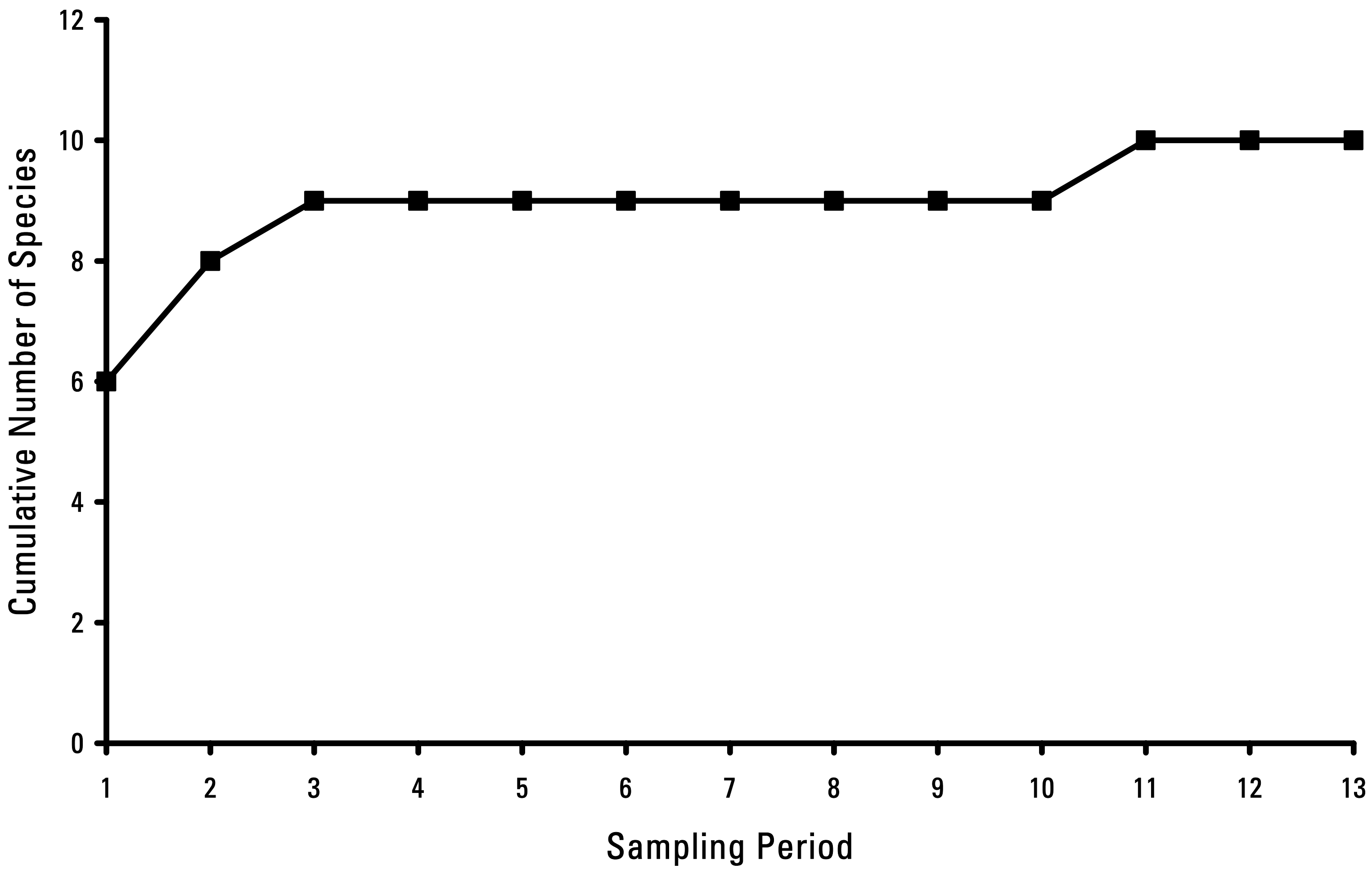

Figure 11. Performance curve of cumulative number of species vs. sampling period for the Torch site.

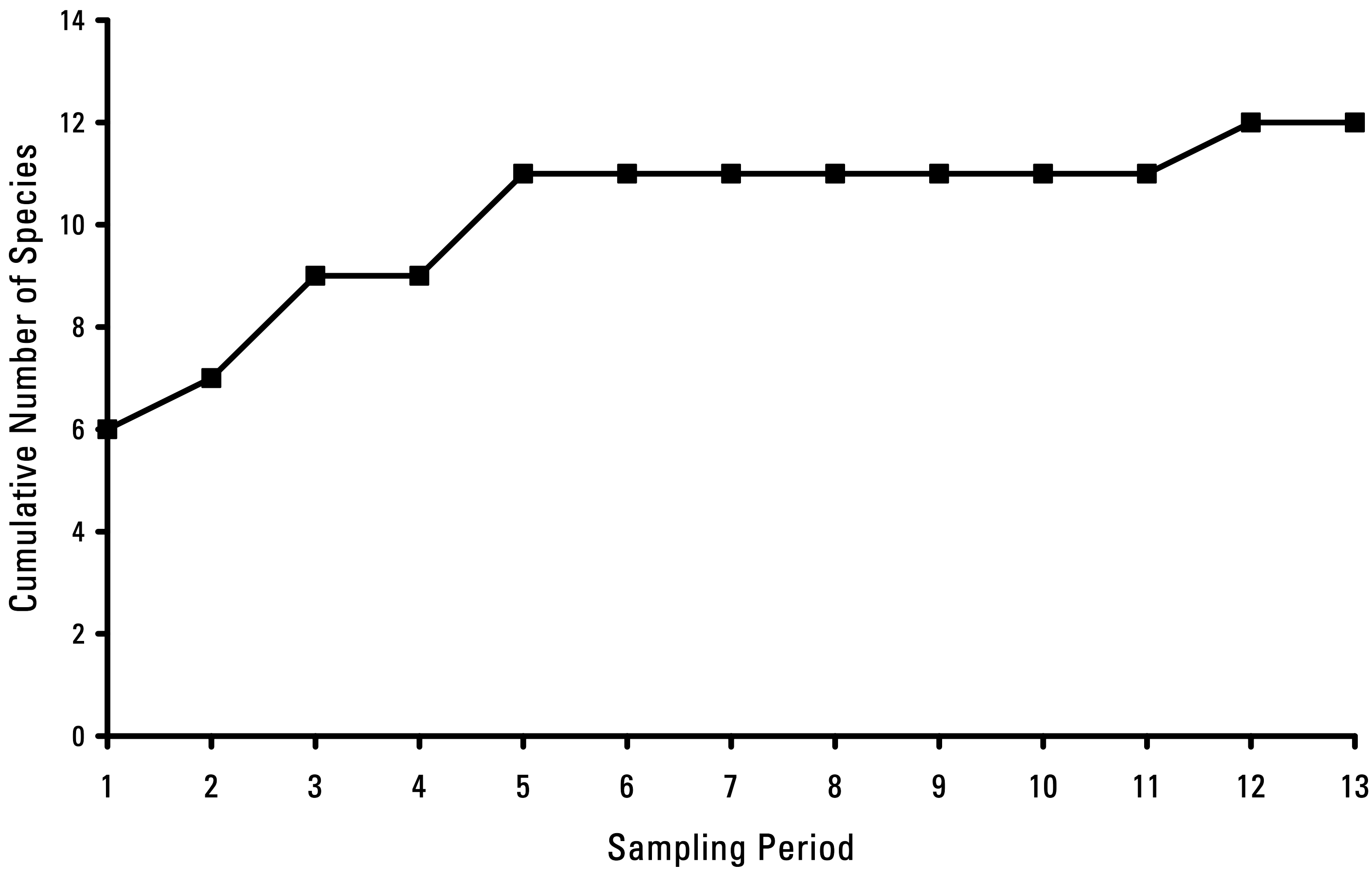

Figure 12. Performance curve of cumulative number of species vs. sampling period for the Pathfinder site.

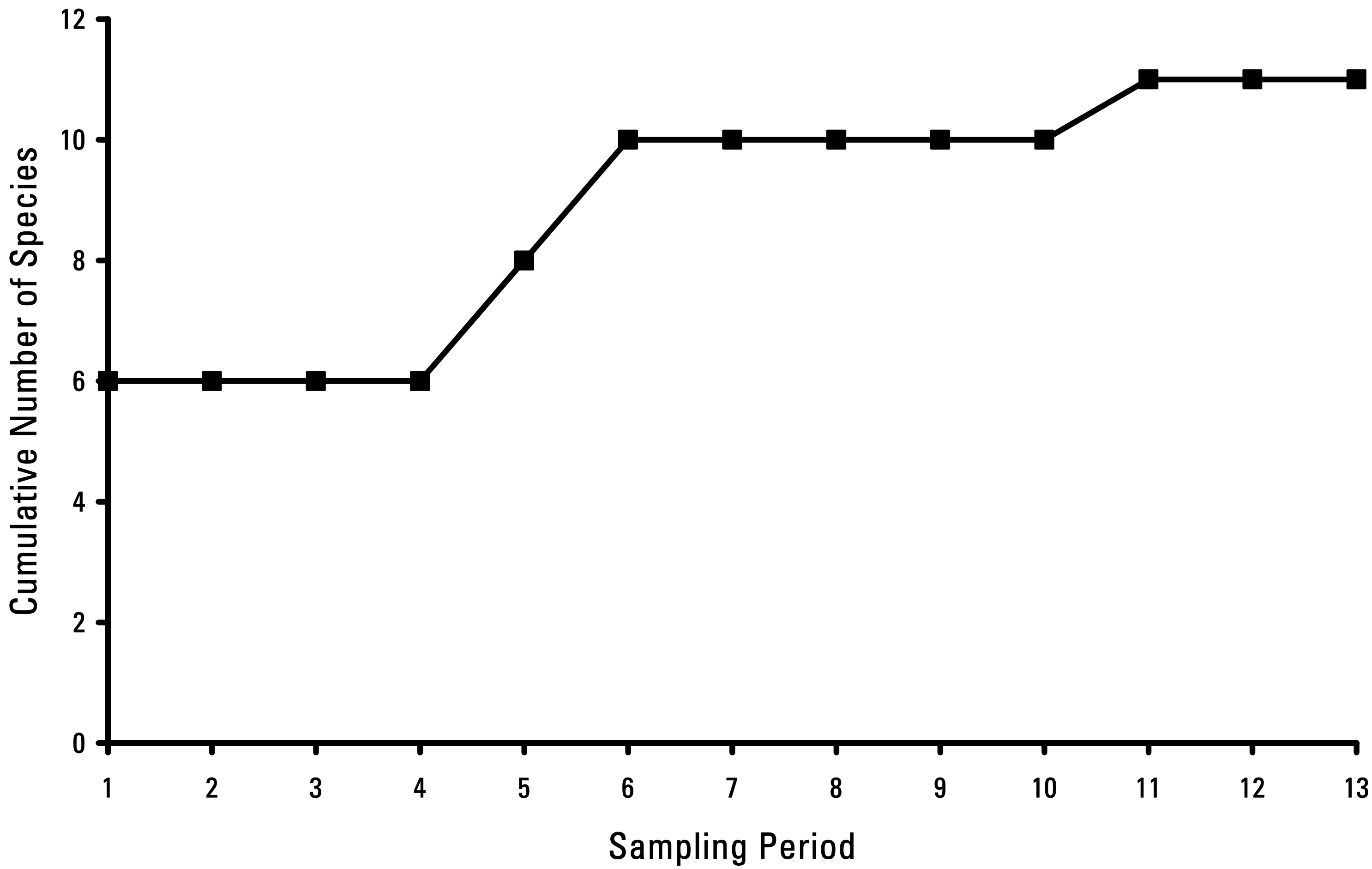

Figure 13. Performance curve of cumulative number of species vs. sampling period for Powder Canyon site.

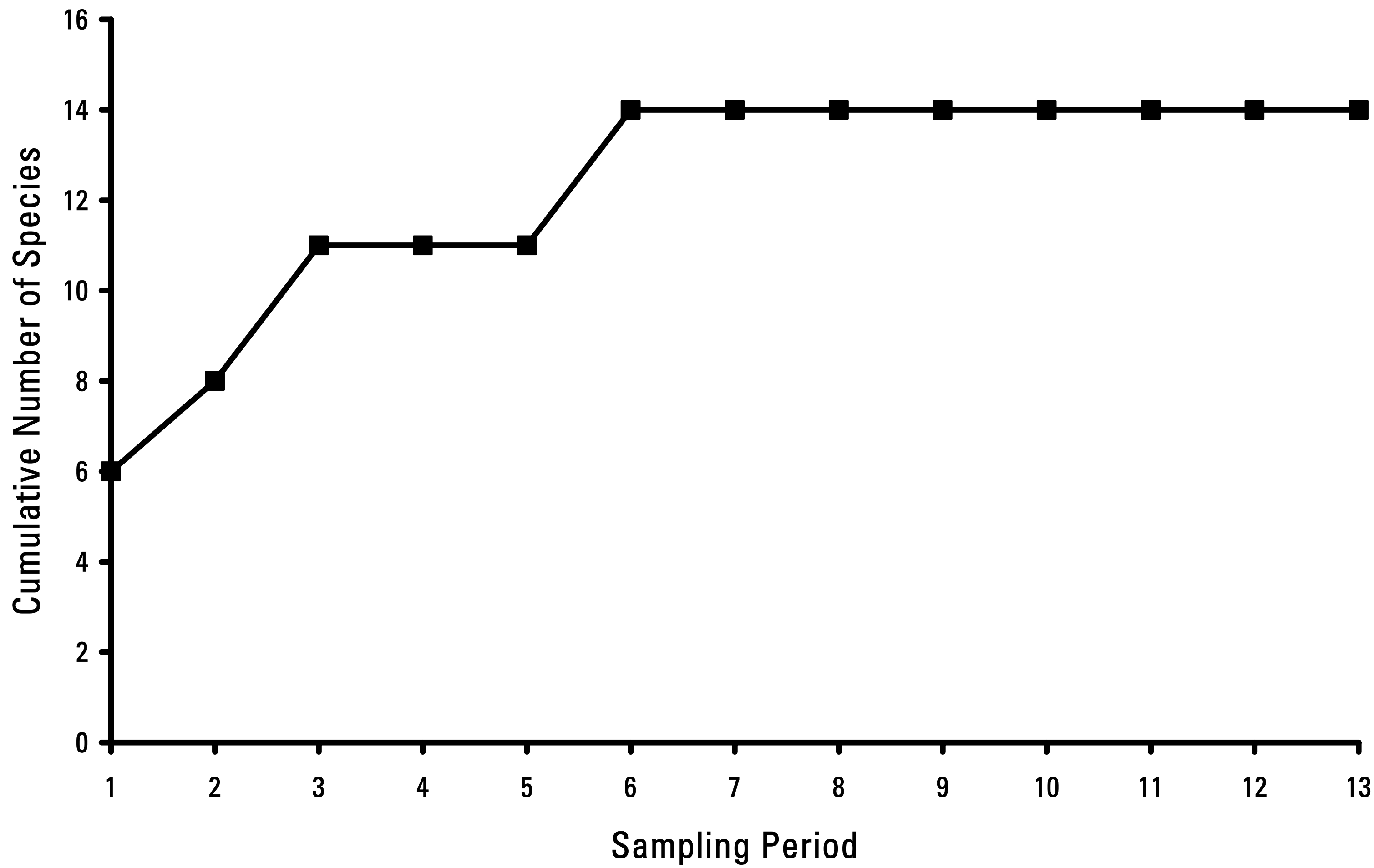

Figure 14. Performance curve of cumulative number of species vs. sampling period for the Whittier Hills Site.

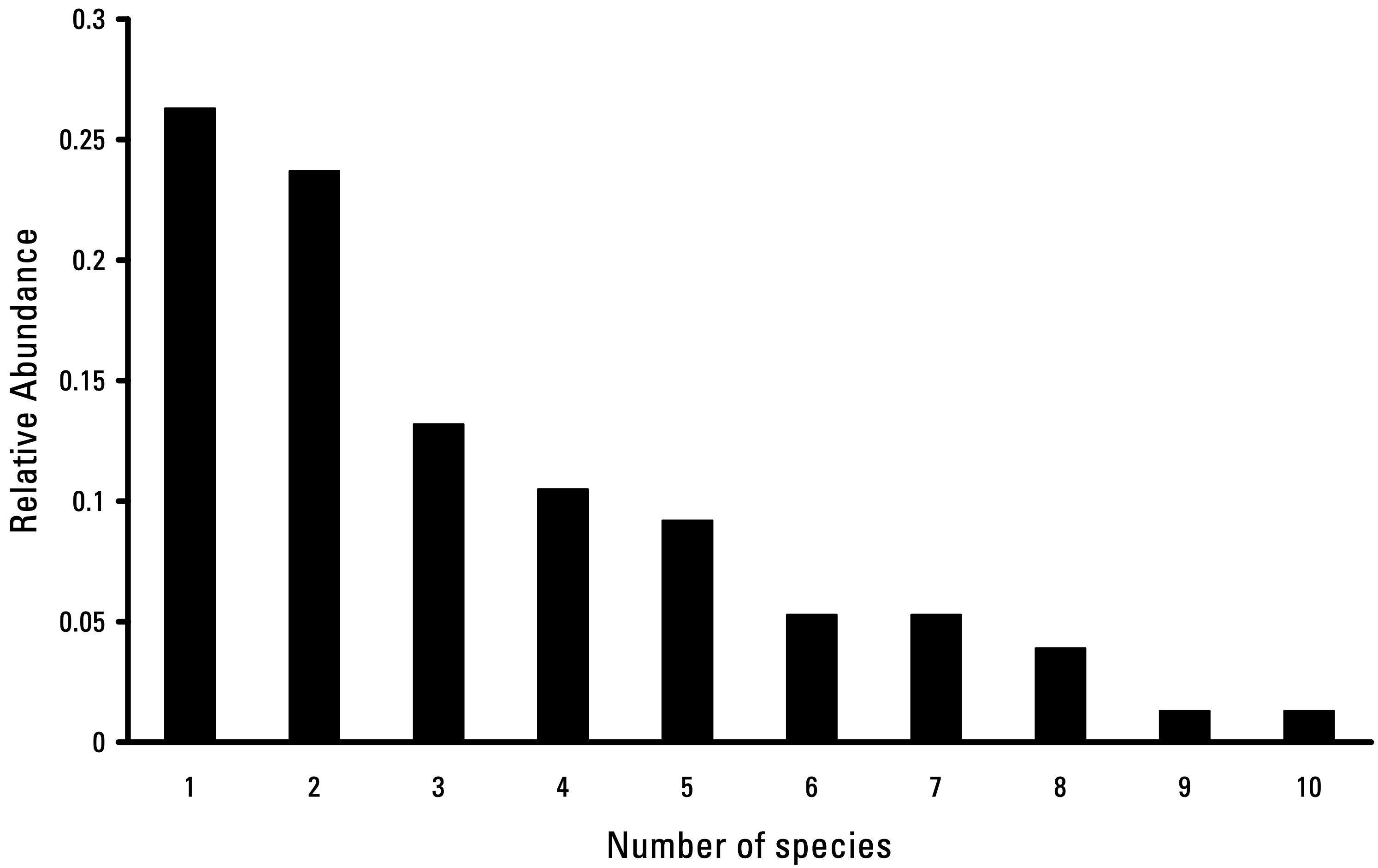

Figure 15. Relative abundance (evenness) of species detected at the Torch site.

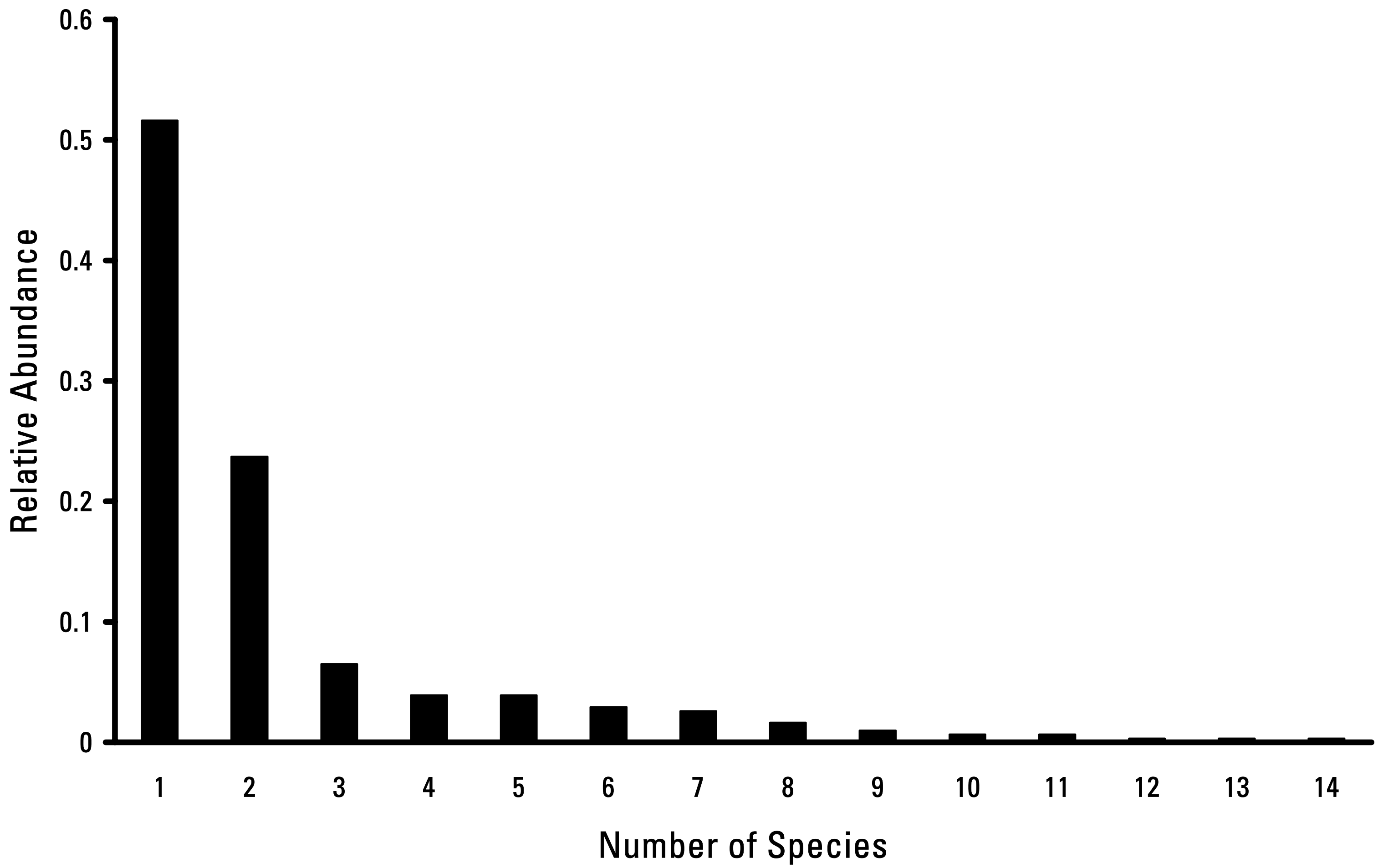

Figure 16. Relative abundance (evenness) of species detected at the Whittier Hills site.

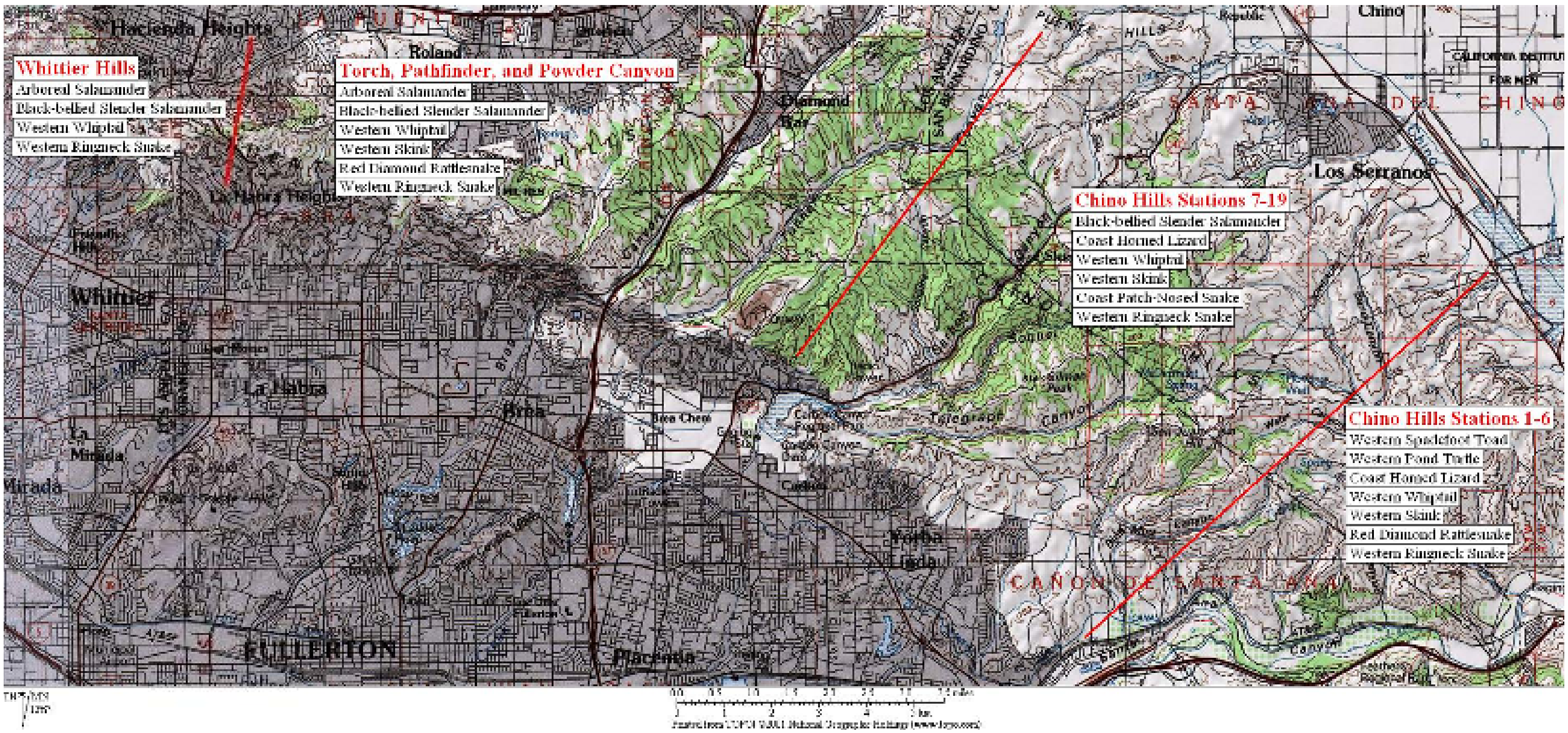

Figure 17. Distribution of sensitive species across the Puente-Chino Hills (see Section 4: Status of sensitive species). Seven sensitive species were detected in the Chino Hills Stations 1-6 section, two of which (Western Spadefoot Toad and Western Pond Turtle) were not detected in western sections; six sensitive species were detected in the Chino Hills Stations 7-19 section, two of which (Coast Horned Lizard and Coast Patch-nosed Snake) were not detected in western sections; six sensitive species were detected in the Torch, Pathfinder, and Powder Canyon section, one of which (Red Diamond Rattlesnake) was not detected in the Whittier Hills section; four sensitive species were detected in the Whittier Hills section.

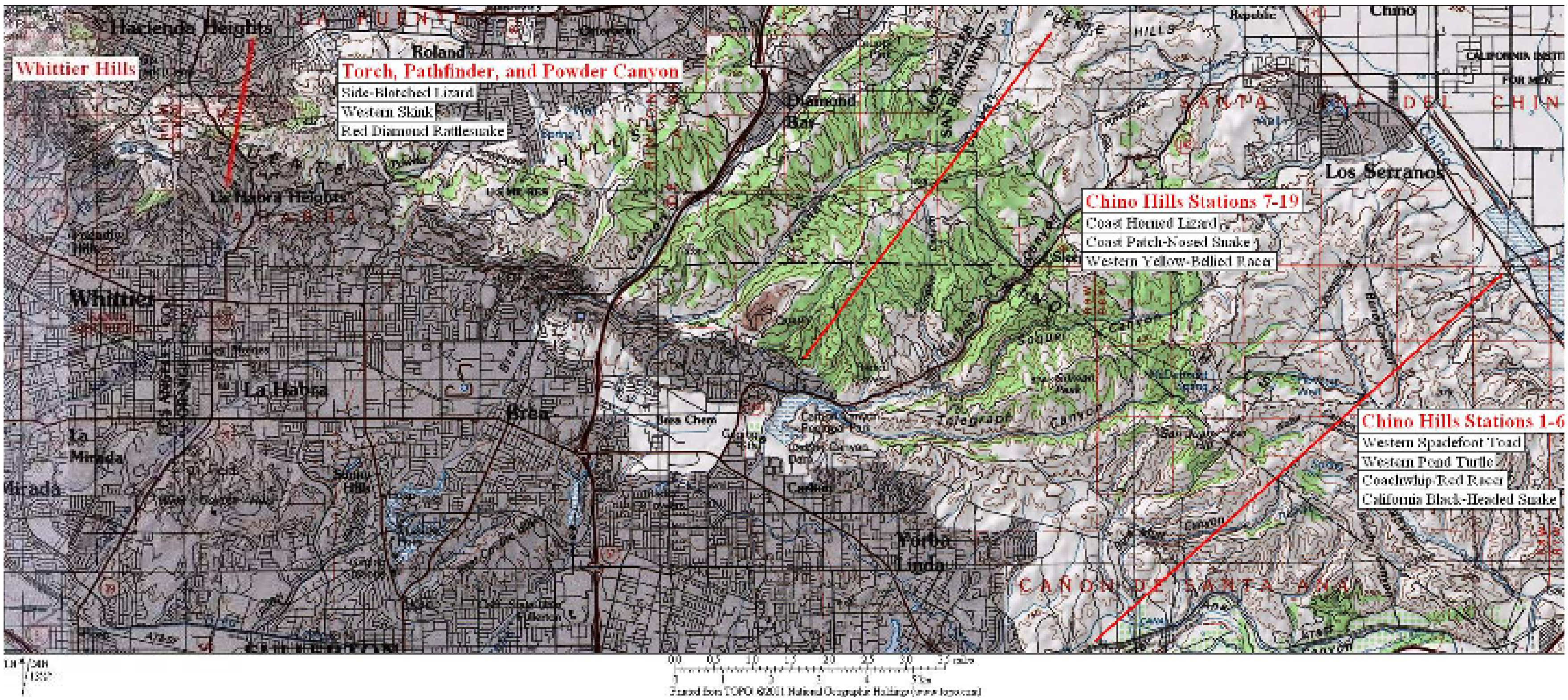

Figure 18. Western limit of species detected at herpetofauna arrays across the Puente-Chino Hills. The western limit is defined as the westernmost section that a species was detected in. All species listed under a particular section were also detected in eastern sections (except for the Coast Patched-nosed snake, which was only detected in the Chino Hills Stations 7-19 section).

Appendix 1. Site data for Chino Hills

Site Name: Chino Hills
County: Orange, Riverside, and San Bernardino
Responsible Parties: California State Parks
Contact: Geary Hund
Phone: (909)940-5617

Description: Elevation 110-415 meters. The arrays at this site are located in coastal sage scrub, chaparral, grassland, oak and walnut woodland, and wash areas. Several of the areas being sampled are near urban development and a golf course.

Start dates for Sample Periods:

6/3/1998	3/30/1999	5/10/2000
8/4/1998	6/15/1999	8/3/2000
10/6/1998	9/8/1999	10/16/2000
12/9/1998	11/16/1999	3/22/2001
1/20/1999	3/22/2000	5/8/2001

Number of Sample Days: 147

Location:

Array	*Lat. (N) dec.*	*Lon. (W) dec.*	*Elevation (m)*	*Datum*
1	33.8862164	117.6571776	114	NAD 83
2	33.8869706	117.6565799	146	NAD 83
3	33.8858978	117.6561024	144	NAD 83
4	33.8849642	117.6694502	140	NAD 83
5	33.8848445	117.6714212	126	NAD 83
6	33.8836914	117.6709525	150	NAD 83
7	33.9099952	117.7855465	352	NAD 83
8	33.9109764	117.7882757	354	NAD 83
9	33.9116218	117.7879728	355	NAD 83
10	33.911943	117.7882114	358	NAD 83
11	33.9112195	117.8009506	255	NAD 83
12	33.9103783	117.8054601	283	NAD 83
13	33.9090483	117.8056549	264	NAD 83
14	33.9144359	117.8069309	172	NAD 83
15	33.9135732	117.8082626	187	NAD 83
16	33.9133561	117.8100191	179	NAD 83
17	33.9393046	117.8160851	396	NAD 83
18	33.9403828	117.8157007	402	NAD 83
19	33.9422832	117.816063	411	NAD 83

Appendix 2. Site dat for the Torch, Pathfinder, Powder Canyon, and Whittier Hills sites.

Site Name: Puente Hills
County: Los Angeles and Orange
Responsible Parties: Puente Hills Native Habitat Authority
Contact: Ken Hughs
Phone: (310) 454-1395 ext 140

Description: Elevation 130-300 meters. The arrays making up this study are divided into separate locations; Torch Operating Systems property, property near CA 57 and Pathfinder, Powder Canyon Open Space, and the Whittier Hills (consisting of Sycamore Canyon and Hellman Wilderness Park). Habitat being sampled include oak and walnut woodland, coastal sage scrub, grassland, and chaparral.

Start dates for Sample Periods:

4/21/1998	2/9/1999	11/10/1999
6/23/1998	5/5/1999	2/8/2000
8/26/1998	7/7/1999	4/24/2000
10/27/1998	9/8/1999	7/19/2000
		11/28/2000

Number of Sample Days: 130

Location:

Array	*Lat. (N) dec.*	*Lon. (W) dec.*	*Elevation (m)*	*Datum*
1	33.9299	117.87364	196	NAD 83
2	33.92837	117.87323	164	NAD 83
3	33.92727	117.87429	174	NAD 83
4	33.93089	117.87323	189	NAD 83
5	33.9792712	117.8454247	269	NAD 83
6	33.9785471	117.8436125	269	NAD 83
7	33.9802262	117.8443454	271	NAD 83
8	33.9664494	117.9214288	250	NAD 83
9	33.9681106	117.923472	273	NAD 83
10	33.9690131	117.9268786	294	NAD 83
11	33.9688638	117.9288275	266	NAD 83
12	33.9964205	118.0351262	242	NAD 83
13	33.9985256	118.0339055	268	NAD 83
14	33.9980853	118.0310091	273	NAD 83
15	34.0001542	118.042463	196	NAD 83
16	34.0026266	118.0435104	131	NAD 83
17	34.0023314	118.03729	161	NAD 83
18	34.0001077	118.0291478	205	NAD 83
19	34.0027749	118.030495	200	NAD 83

Addendum to Monitoring Reptiles and Amphibians at Long-Term Biodiversity Monitoring Stations. This addendum is in response to questions posed by the MRCA.

1. Clarify the negative effects of bike traffic herpetofauna diversity

Page 14, paragraph 1: states "the need to keep mountain bikes out of the majority of the Puente-Chino Hills" by presenting anecdotal evidence of herpetofauna mortality from bikes. Certainly bike-related mortality, like road mortality, can be an additive on a population and has the potential to negatively impact herpetofauna diversity. The sentence should be reworded to state: We have personal observations of animals killed and maimed by bikes in natural areas and will present them as evidence for the consideration of limiting mountain bike activity through areas containing sensitive herpetofauna species. We can finish the paragraph by stating: "Careful consideration should be given in recreation plans to monitoring potential increases in mountain bike activity throughout the Puente-Chino Hills".

2a. The number of species sampled in the western part of the hills seems to be increasing. Is this an indication that sampling in the western part of the hills is not as complete as in the eastern part of the hills.

2b. Should additional sampling be carried out in the western end of the hills, and is it premature to say certain species are not found past certain points in the hills when sampling in the western end of the hills seems to be incomplete?

Figures 12 and 13: the cumulative number of species captured is largely a function of the amount of time sampled, the capture rate of individuals, and (to some extent) the habitat quality. Certainly, sampling for longer time periods will ensure that the majority of species occurring in an area are accounted for, particularly if the capture rate for one area is greater than the capture rate in another area. For example, two areas may have the same number of species, but one of the areas may have a considerably higher capture rate than the other. Thus, it would take considerably longer to detect all of the species at the location with the lower capture rate than it would for the location with the higher capture rate. Another factor to consider includes the detection of species, which may vary across seasons, particularly those species which are more likely to be detected during wet periods. However, for the purposes of this study there were species that were detected in the eastern portion of the study area that weren't detected in the western portion, so detection (as it relates to seasonality) is probably not too much of a concern.

In regards to the cumulative number of species increasing at the western arrays, the Whittier Hills cluster (the westernmost group of arrays) showed the same trend as the Chino Hills cluster (the easternmost group of array); arrays at the Chino Hills and Whittier Hills sites recorded no additional species between sample periods 6-13 (Figures 10 and 14). For the other 3 sites (Torch, Pathfinder, and Powder), new species were still detected during the 11th, 11th, and 12th, sample periods, respectively (Figures 11, 12, and 13). This is not a function of there being incomplete sampling; rather it is a function of time spent sampling. Again, the longer a site is sampled, the more likely you are at detecting a greater number of species. One factor to consider, however, is the coverage of an area. For example, the Chino Hills cluster contained 19 arrays, thus there is more opportunity to capture the majority of species occurring in that area because those arrays are sampling a wider variety of habitats. Thus, species may be detected more quickly based on the coverage of that site. For a site such as Pathfinder, which contained 3 arrays, detecting all of the species in that area may take longer, since only 3 arrays are present.

In response, we are not sure what is meant by sampling being “complete”. Assuming it is referring to the sampling effort; sampling is not considered complete until the cumulative species curve plateaus. Certainly, additional sampling at all sites may yield additional species that are either cryptic or occur at low densities, although it seems as if the concern was directed toward those sites at the western portion of the hills. However, the Chino Hills and Whittier sites showed identical species accumulation curves, indicating that sampling is likely to be “complete” at those sites, one of which (Whittier) represents the western-most portion of the hills. The other 3 sites did have additional species documented late into the period of the study, but the fact that they were sampled for the same number of sampling periods at the other sites does not mean that sampling at those sites was incomplete. In fact, sampling at any site may be incomplete and the fact that a species accumulation curve plateaus is not an indication that every single species occurring in an area has been accounted for. However, for the purposes of this study, the fact is that certain species were not detected in western portions of the hills when given equal sampling effort.

Finally, it is not premature to say that certain species were not found in the western end of the hills. This does not mean that they do not occur there; there are other locations that were not sampled that may harbor certain species (see Species of Interest section, page 7). It is important to distinguish between a species not being detected in the western end of the hills versus a species not being present in the western end of the hills. To determine if a species was not present in the western portions of the hills would require more intensive coverage and longer survey efforts to capture variability in population trends and environmental conditions. However, this study did not document certain species at certain locations given the fact that all arrays were sampled with equal intensity. This information certainly provides support for future management within the Puente-Chino Hills in that: 1) if habitat blocks in the eastern portion (i.e. Chino Hills State Park) become more fragmented, areas of concern can be identified so sensitive species become less abundant (as in the western portion of the hills) and 2) restoration goals relative to specific habitat types can be identified for the western portion of the hills where sensitive species may be less abundant.

In conclusion, additional sampling anywhere would likely detect additional species that were not detected in this study. But this is dependant on the detection of that species; i.e. it would take considerably longer time to find a lizard species in Powder Canyon if there were 2 individuals in the entire park versus if there were 2,000 lizards in the entire park.

3. What species are associated with which habitats in Puente-Chino Hills? (This is provided for some species of interest.) To what extent can you answer this given the data? (Scope says: veg. and topological aspect data will be combined with similar data in parallel study to determine baseline habitat affiliations between herp species in so Cal. Study will provide information on geographic and habitat-related variation in community composition for representative taxa in study area.)

We were unable to obtain GIS data layers for vegetation communities across the Puente-Chino Hills. Any help that you could provide us with in this effort would be appreciated.

As far as combining this data with similar data, as of now nothing has been published. However, we are providing you with 3 papers that are similar to what was envisioned the data collected in this study could be part of (this study was not complete by the time that these manuscripts were sent for review):

Case, T.J. and R.N. Fisher. 2001. Measuring and predicting species presence: coastal sage scrub case study. Pages 47-71 *in* C.T. Hunsaker, M.F. Goodchild, , M.A. Friedl, and T.J. Case, editors. Spatial uncertainty in ecology: implications for remote sensing and GIS applications. Springer-Verlag, Berlin, Germany.

Laakkonen, J., R.N. Fisher, and T.J. Case. 2001. Effect of land cover, habitat fragmentation, and ant colonies on the distribution and abundance of shrews in southern California. Journal of Animal Ecology 70:776-788.

Fisher, R.N., A.V. Suarez, , and T.J. Case. 2002. Spatial patterns in the abundance of the coastal horned lizard. Conservation Biology 16:205-215.

4. Can you address what are the priority species that are most susceptible/sensitive to fragmentation and edge effects? (Is the answer the ones listed as Species of Interest, A-Q? It appears you addressed somewhat which species dropped out.) It is possible to do some prioritizing of best acquisition goals? (Proposal section C says: create a list of priority species that may be most sensitive to fragmentation and edge effects then by utilizing the GIS recent and historic vegetation layers prioritize which fragments would be the best acquisition and management goals.)

Question 1: Addressed in Species of Interest section, page 7. There are other species that may have been identified through aquatic surveys, but the lack of rainfall during this study precluded any surveys of this type. This would be an immediate action item for future monitoring, should we receive above-average rainfalls in the upcoming months/years.

Question 2: Can be determined from GIS layers data; we do not have the layers available at this time.