Ecology of the Island Night Lizard, *Xantusia riversiana*, on San Nicolas Island, California

Gary M. Fellers
Biological Resources Division, USGS
Point Reyes National Seashore, CA 94956

Charles A. Drost
Biological Resources Division, USGS
Colorado Plateau Research Station, Box 5614, Flagstaff, AZ 86011

William J. Mautz
Department of Biology
University of Hawaii at Hilo, Hilo, HA 96720

Thomas Murphey
Biological Resources Division, USGS
P.O. Box 70, San Simeon, CA 93452

December 18, 1998

Abstract

We used both pitfall traps and artificial cover boards to sample island night lizards on San Nicolas Island. Using the combination of techniques, we surveyed for lizards in 15 habitat types. The total trapping effort was 29,241 trap days using pitfall traps (with a capture of 438 island night lizards) and 7,805 board checks (662 lizards). Data on sex ratios, activity periods, and habitat preference were similar to findings previously reported for Santa Barbara Island (Fellers and Drost, 1991b) and San Clemente Island (Mautz, 1993). Using recapture data spanning more than 10 years, we were able to obtain more accurate estimates of age for the largest lizards than has been previously possible. We found that island night lizards were remarkably long-lived, with the oldest individuals reaching an age of 30 years.

The distribution of island night lizards on San Nicolas Island is quite patchy. Lizards are largely absent from the western portions of the island, aside from some large populations occupying cobble / driftwood associations along some of the beaches. On the eastern parts of the island, island night lizards are more numerous and widespread that previous, limited studies have suggested. We estimate that there is a population of approximately 15,300 lizards on San Nicolas Island. This number is much lower, relative to the island's size, than on either of the other two islands where island night lizards occur. For example, Fellers and Drost (1991b) estimated an island-wide population of approximately 17,600 lizards for Santa Barbara Island, an island about 1/20th the size of San Nicolas. Similarly, although he did not attempt to project island-wide population size, Mautz (1982, 1993) found high densities of night lizards in very extensive habitats on San Clemente Island that suggest much higher lizard numbers on that island.

Based on these findings, we make specific management recommendations. These recommendations address issues related to the protection of island night lizard habitat, stabilization of erosion, revegetation, control of cats and rats, monitoring of lizards, and the incidental creation of undesirable, artificial habitats.

Introduction

The island night lizard (*Xantusia riversiana*) is a medium-sized lizard (adults 70 - 100 mm snout-vent length, SVL), endemic to the Channel Islands off the coast of southern California. They occur on San Nicolas, Santa Barbara, and San Clemente Islands and are also on one small islet (Sutil Island) immediately adjacent to Santa Barbara Island (Bezy et al., 1980). The U.S. Navy manages both San Clemente and San Nicolas Islands. Santa Barbara Island is part of Channel Islands National Park and is managed by the National Park Service.

Island night lizards are the most morphologically distinctive of the endemic vertebrates on the Channel Islands, indicating a long period of isolation from the mainland (Bezy et al., 1980). Owing to several features of their morphology, island night lizards are sometimes placed in the monotypic genus (Savage, 1957) or subgenus (Bezy et al., 1980), *Klauberina*.

In 1977, the U.S. Fish and Wildlife Service listed the island night lizard as a threatened species (Federal Register, 1977) because of its restricted range and apparently low population levels on two of the islands. Population levels had been reported to be relatively high on San Clemente Island, but night lizard populations were described as being " . . . critically reduced on San Nicolas and Santa Barbara Islands due to habitat alterations caused by farming, fire, grazing by introduced animals, and invasion by exotic plants which have occurred on one or both islands" (Federal Register, 1977).

Island night lizards have been the subject of numerous studies, though only a few of these have provided much information on its ecology or natural history (Fellers and Drost, 1991a). Many of the earlier studies dealt primarily with taxonomy (Baird, 1859; Bezy, 1972; Cochran, 1961; Crother et al., 1986; Klauber, 1931; Savage, 1951, 1957). Distribution and zoogeography have been discussed by Savage (1967), Bezy (1988) and Crother et al. (1986). Other research has included studies of physiology (Brattstrom, 1965; Mautz, 1979, 1993), parasites (e.g., Read and Amrein, 1952) and reproduction (Brattstrom, 1951; Goldberg and Bezy, 1974; Goldberg and Bursey, 1990).

Prior to 1990, most of the data on island night lizards were rather general and were gathered during only brief visits to the islands. Van Denburgh (1922) reported that island night lizards were found under stones and pieces of wood. Savage (1963) stated that lizards were found "under trash or any other object." The food habits of island night lizards have been examined by Brattstrom (1952), Knowlton (1949), Savage (1963) and Schwenkmeyer (1949).

These studies, which included only four lizards from Santa Barbara Island, found that lizards fed on a wide variety of animal taxa as well as a great deal of plant material (e.g., seeds, grasses and plant fragments).

Fellers and Drost (1991b) published a monograph on the species, which provides extensive data on its ecology on Santa Barbara Island. They trapped all the major habitats on the island (using both pitfall traps and Sherman small mammal traps) and found lizards most commonly in habitats providing dense vegetative cover (thickets of boxthorn and prickly pear) and in certain types of rock habitat. Lizard densities (lizards / ha) in the favored habitats on Santa Barbara Island ranged from 1,665 (rock), 2,476 (prickly pear), to 3,213 (boxthorn). Unfortunately, these habitats were all quite restricted and totaled a little more than 6 ha.

Island night lizards on Santa Barbara Island were unusual in being sedentary, having very small home ranges ($x = 17.2\ m^2$), and in being strictly diurnal. They are slow growing with some individuals living to at least 12 years old. Favorable habitat on that island has been reduced because of past farming and grazing, but, given the wide distribution of lizards on the island, exceptionally high densities in favored habitats, and current protection within a National Park, Fellers and Drost (1991b) and Fellers et al. (1988) judged that island night lizards on Santa Barbara Island were not threatened with extinction, as was previously thought (Federal Register, 1977).

Mautz (1993) provided data on island night lizards from San Clemente Island based on seven years of field work. He concluded that the rocky maritime desert scrub was the prime habitat for island night lizards and that population densities were as high as 1,458 lizards / ha. He also presented data on growth rates and movements of marked lizards. Of particular interest are the measurements of metabolic rates which demonstrated that island night lizards have a field metabolic rate which is about one third of that expected for a similar sized iguanid lizard.

Information on the ecology of island night lizards on San Nicolas Island has been very limited. Several authors had commented on activity, distribution, or presumed population size. There are no prior data from a long-term trapping program similar to that conducted on the other two Channel Islands where island night lizards are found.

The primary purpose of our study was to determine the population status and habitat preference of island night lizards on San Nicolas Island using the same techniques as Fellers and

Drost (1991b, 1993) on Santa Barbara Island. Field work was conducted on San Nicolas Island was initiated in 1992 - 1995. Additionally, we acquired an extensive data set from Tom Murphey, which was collected on San Nicolas Island during 1984 - 85. Data from these two studies were used to evaluate population density and distribution on an island-wide basis. A total of 810 lizards were captured a total of 1,363 times. The majority of these lizards were captured using either pitfall traps or cover boards. From 1984 – 1995 we accumulated a total of 1,969 pitfall trap days and 1,100 board checks.

Study Area

Our study was conducted on San Nicolas Island. Of the eight Channel Islands located off the coast of southern California, San Nicolas Island is the farthest from the mainland coast. It is approximately 98 km south-southwest of Point Mugu, the nearest point on the mainland, and 155 km south of Santa Barbara. San Nicolas is also the most isolated of the islands; the nearest other island is Santa Barbara Island, 45 km to the northeast. Santa Catalina and San Clemente are both about 80 km distant. San Nicolas is a medium-sized island for the Channel Islands group, with a land area of approximately 57 km^2.

The topography of San Nicolas Island is relatively simple. The island is a long, tilted mesa oriented in an east-west direction, ranging from 120 m elevation on the east and north, to 270 m on the south and west. The mesa drops off in steep slopes on all sides. Because southern edge of the escarpment is tilted up, the long, southern face of the island is particularly high and steep. A low terrace of 15 - 60 m elevation surrounds the base of the mesa, and slopes gently down to the island's shoreline. This low terrace is broadest at the west end, where is tapers out to form Vizcaino Point, the western tip of the island.

Geologically, the island is a broad anticline that rises up from the southeastern end of the island (Vedder and Norris 1963). There is a series of marine terraces that step up from the northern and western shoreline to the southern ridge and escarpment. San Nicolas Island is composed of sedimentary rock, with alternating layers of marine sandstone and siltstone (Vedder and Norris 1963). From a biogeographic standpoint, the most significant aspect of the geology of San Nicolas Island and the surrounding Southern California Bight are the deep basins separating San Nicolas from the other islands and from the mainland coast. San Nicolas Island

was completely submerged during periods of high ocean levels during the Pleistocene, and there has been no connection between the mainland and the island since submergence (Vedder and Howell 1980). Hence, the present flora and fauna has colonized the island by over water dispersal (e.g. Savage 1967).

The climate of San Nicolas Island has a Mediterranean character, with strong influences from the surrounding ocean. Like the surrounding islands and southern California mainland, most rainfall comes during the winter months. The scant annual precipitation totals (less than 30 cm) suggest quite arid conditions. However, summer temperatures are relatively low, and high relative humidity and frequent fog and low stratus clouds ameliorate the low rainfall total. For this reason, the island vegetation does not have the character of desert vegetation (Dunkle 1950). Characteristic of the weather on the island is the consistent high humidity, with the mean relative humidity at noon > 60% (Dunkle 1950; see also Fellers and Drost 1991b). Dunkle (1950) noted a mean annual temperature of 15.7 C (60.3 F) for San Nicolas, with an annual range in mean temperature of only 3.4 C (6.2 F). Mean high temperature on neighboring Santa Barbara Island ranged from 16.5 C in December to 23 C in August, while mean low temperature ranged from to 12 C in December to 17 C in September (over an eight year period, from 1981 through 1988; Fellers and Drost 1991b).

Halvorson et al. (1996) mapped vegetation communities on San Nicolas Island. They described twelve different communities, ranging from widespread happlopappus scrub (= goldenbush scrub) [*Haplopappus venetus* (= *Isocoma menziesii*)], coreopsis scrub, and grassland, to narrowly distributed vernal pool and *Lupinus* scrub. Of the major communities, grassland is dominated by non-native annual grasses (*Bromus* spp., and *Hordeum murinum* and *Avena barbata*), while the other communities have dominant native shrub components. For mapping purposes, they lump haplopappus scrub, annual iceplant, and minor scrub types into a general "coastal scrub" category. In their vegetation map, coreopsis scrub dominates the northern shore and slope of the island, the broad mesa is covered predominantly by coastal scrub and grassland, and the west slope and terrace is vegetated primarily with coastal scrub and inland dune. Most of the steep southern escarpment and shore is mapped as barren, with patches of coastal scrub.

Methods

We conducted visual reconnaissance of areas around the entire island. We characterized general habitat conditions, looked for prospective night lizard habitat (rock outcrops, boulders, and patches of vegetation such as prickly pear and boxthorn), and also actively searched for lizards. Searches for lizards consisted primarily of turning natural cover (e.g. rocks, small boulders) and artificial cover (e.g. wood and metal debris). We also looked for lizard sign (droppings, tracks, and bones) in suitable areas such as near cliffs and rock crevices.

Most lizards were captured using either pitfall traps or cover boards. Pitfall traps consisted of one-gallon plastic jars sunk level with the ground and covered with a 30 x 30 cm square of plywood (1.3 cm thick). Traps were made operational by removing the metal lid while leaving the plywood in place. Traps were installed in two different configurations. In most areas, traps were arranged in a linear fashion through suitable habitat. In dense or impenetrable habitats (e.g. cactus patches), traps were installed near the edge of the habitat. In a few areas initially surveyed in 1984, traps were arranged in a 5 x 5 grids with 2 m spacing between traps.

Cover boards consisted of 29 x 57 cm (11.5" x 22.25") pieces of Douglas fir (5 cm thick). The boards were put out in linear transects of 20 boards with a spacing of 5 m between boards for a total length of 95 m. Cover boards were checked once during each month that we conducted field work. When a cover board was turned, an attempt was made to capture any lizards under the wood. Because this was increasingly hard to do as the day warmed up, we generally checked boards early in the morning and typically with two people (one to turn the cover and one to catch lizards).

Lizards were also sampled on a regular basis under existing cover boards, typically plywood sheets (1.2 cm thick) which had been abandoned by the Navy. The size of this cover varied widely, ranging up to full size sheets of plywood, 2.4 x 1.2 m. Most of this cover had been in place for more than 10 years, and some of the greatest intervals between captures of marked lizards occurred at these sites. Existing cover boards were checked similarly to cover board transects, e.g. once a month and early in the day.

Sherman small mammal traps were set out in some local areas where it was difficult to install pitfall traps (e.g. steep slopes, rocky areas). Sherman traps are aluminum box traps with a spring-loaded door and are simply opened and placed on the ground in suitable areas. We also set out Sherman traps in 10 x 10 grids of 100 traps to sample small mammals. These traps were

set out in some habitats where lizards were known to occur, however, we did not catch any island night lizards in these traps.

The pitfall trap sites are listed in Table 1, cover board sites are listed in Table 2, and descriptions of how to locate each site is included in Appendix A. Figure 1 shows the distribution of pitfall trap and cover board sites around the island.

All captured lizards were weighed, measured, and examined to determine their sex and general condition. Lizards were weighed on a Pesola 10 g scale (with $\pm$ 0.05 g accuracy) or a 50 g scale ($\pm$ 0.25 g). The snout-vent length (SVL), tail length, length of any regenerating portion of the tail were measured to the nearest 1 mm. Lizards were marked by clipping a minimum of two toes, but never more than one toe per foot [see Fellers and Drost (1991b) for details].

Results

Weather

We summarized rainfall data over the period for which records were available (48 years, 1948 - 49 through 1995 - 96). San Nicolas Island has a pronounced pattern of winter rainfall, with most precipitation occurring in the months of November through March (Fig. 2). The wettest months are January (mean 5.0 cm), February (4.1), and March (3.5). The driest months are June (0.07) and July (0.03).

Because of the winter rainfall pattern in southern California, we analyzed precipitation in terms of "rainfall years" that encompass individual winter rainy seasons. These rainfall years extend from July of one year through June of the next. During the 1948 - 95 period, annual precipitation on San Nicolas Island averaged 20.65 $\pm$ 10.41 (SD) cm. The maximum annual rainfall during this period was 49.6 cm in 1977 - 78, and the minimum was 6.6 cm in 1960 - 61. The span of years encompassing our study (1982 - 95) was relatively wet (Fig. 3). The average annual rainfall for this 14-year period (26.5 $\pm$ 10.9 cm) was significantly greater than the average for the preceding 34 years (18.2 $\pm$ 9.2) for which we have records (t-test, $P = 0.025$). During the 1982 - 95 period, there was only one rainfall year when the rainfall total was much lower than average; this was 1989 - 90 when precipitation for the year was 10.0 cm. There were two very wet years: in 1982 - 83, rainfall total was 45.5 cm, and in 1994 - 95 it was 49.0 cm.

Capture rates

With the combination of pitfall traps and cover boards, we sampled a total of 15 habitat types. Table 3 shows the pitfall trapping effort, number of lizards captured, and capture rates for island night lizards captured from 1984 - 85, and from 1992 - 95. The total pitfall trapping effort was 29,241 trap days with a capture of 438 island night lizards. Table 4 summarizes the same information by habitat type. For cover boards, we accumulated 7,805 board checks with a total capture of 662 island night lizards. The most productive area for pitfall traps was a set of traps on Red-eye beach in the cobble / driftwood habitat. This habitat is limited to a narrow strand along only a few of the beaches around the island where cobbles afford shelter by being piled on top of one another. These few areas support remarkably dense populations of lizards and Red-eye Beach capture rates are nearly double the next best habitat on the island. The next best habitats are cholla, boxthorn, and prickly pear.

Table 5 shows similar data for the cover boards checked, number of lizards captured and capture rates. Table 6 summarizes the data by habitat type and Figures 3 and 4 show capture rates for pitfall traps and cover boards. Aside from a few miscellaneous boards, the most productive habitats were eucalyptus, cholla, boxthorn, haplopappus, and prickly pear. All the other habitats sampled with cover boards either had no lizards, or required twice as many visits to find a lizard.

Table 7 summarizes pitfall trapping data by month and Table 8 includes similar data for cover boards. The data from these two techniques were quite similar as can be seen in Figure 6. The only notable difference in capture rates is the higher rate sustained by the boards into the early fall.

Sex ratio

Determining the sex of lizards by judging the relative amount of swelling at the base of the tail (which is caused by the enlarged hemipenis in males) appeared to be more difficult on San Nicolas Island compared to the situation Fellers and Drost (1991b) found on Santa Barbara Island. Since it was more difficult to be confident that smaller lizards were properly sexed, we only used lizards $\geq$ 70 mm in evaluating the sex ratio. Within that more restricted group of lizards, there were 117 males and 136 females captured on San Nicolas Island. This results in a

1:1.2 ratio which is not significantly different from the expected 1:1 (binomial probability, P = 0.12).

Size distribution

Figure 7 shows the size distribution for male, female, and lizards of unknown sex. In general, we were able to determine the sex of lizards 70 mm and larger. All lizards below this size were categorized as undetermined. There was no significant difference in size distribution for male and female lizards.

Figures 8 – 10 show the size distribution for lizards in the three habitats (cobble / driftwood, cholla, and prickly pear) where the most lizards were captured. Though there were some differences for particular size classes, the overall distribution patterns were not significantly different among these three habitats. ($X^2 = 33.33$, df = 32, P = 0.402).

Condition Index

Lizard body mass was an exponential function of SVL. Excluding pregnant females, the cubic equation for mass-length (in mm) was: mass = $-0.34 + 0.000028(SVL)^3$ ($r^2 = 0.98$, $P < 0.001$, n = 694). Comparison of slopes between years resulted in significant differences ($F = 15.04$, $P < 0.001$). In 1984 and 1993, lizards were relatively heavy (Fig 11); in 1985 and 1995 they were relatively light; while lizards in 1992 and 1994 were somewhat intermediate.

Figure 12 shows condition indices for lizards based on both age and sex during the fall. The indices are remarkably similar across age and sex except for yearling lizards in 1984, which are in significantly better condition. Data for spring and fall sampling periods are not quite as extensive, but show a similar trend.

Longevity

Table 9 presents data on the age of all island night lizards with intervals between capture of greater than 1,000 days. These represent the lizards with the most useful information on longevity of this species. Known ages range from 2.8 years up to 11.3. Estimated total years of age is a combination of known years and calculations based on size-specific growth rates. The oldest lizard was estimated to have lived 32.9 years at the last capture.

Figure 13 shows the predicted age for lizards over a range of SVLs. This figure is based on the same data as Table 9 and provides a way to estimate the approximate age of an island night lizard on San Nicolas Island.

Habitat utilization

Island night lizards are generally distributed over the eastern half of San Nicolas Island, in areas where there is sufficient natural habitat (Fig. 14 and 15). On the eastern part of the island, they occur from the low beach terraces on the north and south sides to the highest elevations at the top of the mesa overlooking the southern escarpment. In contrast, island night lizards do not occur anywhere on the western half of the island, except for a few isolated populations in cobble /driftwood beach habitat at the west end and at the southern shore of the island. With the exception of these cobble / driftwood populations, intensive trapping and searching through all habitat types on the west half of the island has produced no evidence of island night lizards elsewhere. The absence of lizards from the western part of the island is apparently due to a combination of lack of suitable vegetative or rock cover for the species, and the largely sandy substrate that prevails throughout this area. We set out three sampling sites along the north shore of the island, in an effort to determine the westernmost extent of night lizard distribution. We caught night lizards at the eastern transect (Tranquility) and the middle site (Board 904), but caught no lizards along the length of the western transect (Corral Harbor). The substrate and associated vegetation change in the vicinity of these three sampling sites (as it does, generally, from the east to the west half of the island). Board 904 is along the east side of a small gully that separates clay soils on the east from sandy dune substrate on the west. Together with our data from other sampling sites on the eastern and western part of the island, this highlights the apparent unsuitability of sand substrates for island night lizards.

In the areas where island night lizards occur, lizard numbers vary greatly, depending on available habitat. Vegetated or barren dunes around the margins of the island and on the western mesa are devoid of lizards. Except for small numbers of apparent dispersing individuals, the broad grasslands that cover much of the eastern mesa support few or no lizards. Mixed shrub communities, whether on the low marine terrace on the north and south sides of the island, in some of the canyons, or on the top of the mesa, support moderate numbers of island night lizards. The most important elements of this mixed shrub association, in terms of island night lizard

habitat, appear to be haplopappus, island morning-glory (*Calystegia macrostegia*) Catalina tarweed (*Hemizonia clementina*), and possibly sagebrush (*Artemisia californica* and *A. nesiotica*). (see Appendix B for a summary of all common and scientific plant names.) Haplopappus and island morning glory are widely distributed and occur in many different habitats on San Nicolas, from stable dunes to canyons, open slopes, and the flats on the mesa top (Junak et al. 1995), and for this reason they may be particularly important to island night lizards in areas of the island that do not have more-favored lizard habitat (e.g. prickly pear and boxthorn).

Areas where the shrub cover is largely or entirely giant coreopsis (*Coreopsis gigantea*) have few or no lizards, but lizards do occur where coreopsis is associated with other species, such as haplopappus, or rock outcrops. Likewise, some other shrub and tree species on San Nicolas Island do not provide suitable habitat for island night lizards. Silver lupine (*Lupinus albifrons*) is common and widespread on the western part of the island, but we did not find lizards in association with it. This may be related to the sandy substrates inhabited by this bush lupine. Although our Eucalyptus boards support a dense population of lizards, the eucalyptus grove itself, with its dense ground cover of eucalyptus leaves and little else, does not appear to provide suitable habitat. Similarly, we have searched under rocks, deadfall, and debris in the introduced pine grove at the living compound, and have found no sign of lizards in that area.

As on the other islands where island night lizards occur (Santa Barbara Island, Fellers and Drost, 1991b; San Clemente Island, Mautz 1993), the habitats that support the highest densities of lizards are various cactus habitats and California boxthorn (*Lycium californicum*) thickets. On San Nicolas Island, lizards are found in stands of both prickly pear (*Opuntia littoralis* and *O. oricola*) and cholla (*O. prolifera*) cactus as well as the boxthorn shrubs.

Dense populations of night lizards found in cholla stands differs from the situation Fellers and Drost (1991b) found on Santa Barbara Island. Island night lizards on Santa Barbara Island are found in greater numbers in association with shrubby plant species as opposed to herbaceous species and the cover provided by the shrubby species appears to be an important component of night lizard habitat. However, one of the cholla sites on San Nicolas Island was associated with a sandstone outcrop, which provided many cracks and surface boulders for lizards to hide under. The other cholla sites had other dense, ground-level vegetation that also appeared to provide good cover for night lizards (see Habitat Descriptions). Cactus habitats are generally small and

widely scattered on San Nicolas Island, but even small patches support good numbers of lizards. Boxthorn, likewise, is rare on San Nicolas Island and occurs in small patches. However, where it does occur it supports moderate to high numbers of night lizards.

The kinds of rock habitat that support relatively high numbers of island night lizards on Santa Barbara Island (Fellers and Drost 1991b) and San Clemente Islands (Mautz 1993) are largely absent from San Nicolas Island. However, the cobble / driftwood habitat is a different kind of rock habitat that supports large numbers of night lizards on San Nicolas Island. Night lizards do not, as far as we know, use this beach habitat type on Santa Barbara Island. At the Red Eye Beach site on San Nicolas Island, this habitat supports numbers of island night lizards that rival or exceed the numbers found in cactus and boxthorn habitats.

Habitat Descriptions

The following section details the habitat categories that we used in describing our sampling sites for island night lizards on San Nicolas Island. In general, the categories are based on plant species that are dominant visually and in terms of overall cover. Preference is given to shrubby species as opposed to herbaceous species, as the cover provided by the shrubby species appears to be an important component of night lizard habitat. The categories are not botanical vegetation types (e.g. Halvorson et al. 1996), but rather are associations that, based on our current knowledge, are most meaningful in terms of island night lizard habitats. Plant names follow Junak (1992).

Cobble / Driftwood - This habitat is present along the central and west end of the cove at Red Eye, and along the strand north of Cormorant Rock, towards Rock Crusher. It consists of moderate-sized sandstone and limestone boulders (< 0.5 to 2 m across), with driftwood, beach-cast debris and sand-verbena (*Abronia maritima*), sea rocket (*Cakile maritima*) and other beach plants mixed in with, and bordering, the landward side of the cobble /driftwood beach. In our searches of this habitat, we found the highest numbers of lizards where large cobbles and boulders were stacked on top of each other, two or three or more deep. However, we also occasionally found night lizards under boulders resting directly on sand.

Boxthorn - Boxthorn is rare on San Nicolas Island. It occurs as small, continuous patches (10 -

20 m^2) or as clumps within grassland or mixed with other shrubs, and is primarily distributed on the beach terrace around the north, east, and south sides of the island. It is frequently associated with other shrubs that provide good night lizard habitat, including prickly pear and cholla cactus, and haplopappus. Mautz (1993) noted that scattered boxthorn mixed with cactus and other shrubs did not appear to support as many lizards as Fellers and Drost (1991b) reported for extensive, continuous boxthorn on Santa Barbara Island. This may be the case on San Nicolas Island, as well. Our NAVFAC grid consists of patches of boxthorn within grassland, and we caught only moderate (not high) numbers of lizards at that site.

Canyon - Canyons, particularly on San Nicolas Island, support a variety of plant associations, depending on aspect, steepness, and substrate. Some of them provide rock outcrops and boulder cover, while others have slopes of bare, eroding soil. For this reason, grouping areas into "canyon" habitat is decidedly artificial. However canyons frequently do have habitat conditions that support small populations of island night lizards. At our Desal Canyon site (named for the desalination plant along Beach Road), we found night lizards in association with prickly pear cactus, haplopappus, and rock cover. In surveys of "L" Canyon, we found evidence of night lizards along high rock outcrops. In other areas around the island where canyons support shrub species such as prickly pear, boxthorn and haplopappus, or have suitable fractured rock or boulder cover, they can be expected to support island night lizards.

Cholla - This habitat consists of patches of cholla cactus, with an understory of annual grasses and sometimes other shrubs, such as Catalina tarweed. It is present in scattered areas on the slopes and along gullies on the beach terrace around the east end of the island. Our sampling site along the mesa edge south of the east end of the airfield (SE cholla) is a large thicket of cholla over and around a low, fractured sandstone outcrop. This site supports a relatively dense population of lizards, which use sandstone cracks and surface boulders for cover, in addition to the cactus itself. In contrast, the Terrace cholla site is in grassland on the mesa, a short distance from the SE cholla site. It supports lower numbers of lizards, but they apparently get most of their cover from fallen cholla branches and joints, and perhaps from the dense grass and soil cracks.

Coreopsis - This habitat ranges from a dense, continuous canopy of giant coreopsis, with scant understory, to more open, scattered coreopsis associated with a variety of other shrubs, annual grasses, and other herbaceous species. Fellers and Drost (1991b) found very few island night lizards in coreopsis habitats, and even then, the lizards appeared to be associated with dense understory shrubs, rather than the coreopsis itself. This appears to be true on San Nicolas Island, as well. In areas that are predominantly dense coreopsis with little other cover, we caught few or no lizards. In the Coreopsis Grid at the east end of the island, located within this kind of dense coreopsis, the only night lizards we caught were at a large sandstone boulder at the edge of the grid. At other coreopsis-dominated sites, such as East NAVFAC and Ocean Coreopsis along the north side of the island, we caught night lizards in openings in the coreopsis canopy, with dense ground-level shrubs such as haplopappus and Australian saltbush. We also noted night lizards down in earth cracks at these same sites. Earth cracks are common in exposed areas of clay soils on the islands, and apparently provide important sources of cover for island night lizards (Fellers and Drost 1991b).

Grassland - We described areas as grassland where the dominant cover was grasses and associated herbaceous plants, with no shrubs or only very few, widely scattered shrubs. Grasslands cover broad areas of the mesa top, but shrubs encroach into the grasslands to varying degrees around canyons, the edges of the mesa, and the inland dunes on the west end of the island. We did not catch any lizards in our Grassland Grid, which is located in extensive grassland with no shrubs. At our other grassland sites (Monroe and Airstrip), there are scattered shrubs including haplopappus and boxthorn, and the airstrip site is near a small gully system. We caught a few small and medium-sized night lizards at these sites. The fact that we did not catch large lizards, and did not consistently recapture any lizards, suggests that the lizards we found at these sites were dispersing from nearby shrub habitats. One of our grassland sites (Central Stipa) has a large component of native bunchgrass [*Nassella* sp. (= *Stipa* sp.)]. Mautz (1993) found moderate numbers of island night lizards in Stipa grassland on San Clemente Island, but we did not find any night lizards at the Central Stipa site. This difference may be due to the presence of extensive clay soil crevices and rocks at Mautz's site, which the lizards used for cover. In addition, our Central Stipa site on San Nicolas Island is near the western boundary of where we found night lizards on the island, so generally low numbers, or other habitat factors,

may have led to the lack of night lizards at the site.

Haplopappus Grassland - We characterized areas as Haplopappus grassland where grasslands had a moderate amount of haplopappus mixed in. These areas consist of annual grasses (*Bromus* spp., *Avena* spp.) with scattered haplopappus and few or no other shrubby species. Two of the areas with the densest populations of lizards on the island - the Eucalyptus and Lighthouse sites - are in haplopappus grassland. However, both of these areas as well as Taxiway, which is also Haplopappus grassland, have numerous pieces of plywood and other artificial cover and would probably support relatively few night lizards without such debris..

Haplopappus Scrub - We based this habitat type on the widespread haplopappus scrub vegetation type noted on preliminary vegetation maps for San Nicolas Island, prepared by Bill Halvorson of U.S.G.S. Cooperative Parks Studies Unit at the University of Arizona. This haplopappus scrub type is comparable to the coastal scrub mapped by Halvorson et al. (1996). Haplopappus is dominant or co-dominant in this shrub - grass habitat, which occurs widely over both the eastern and western parts of the island. Other shrubby species vary, depending on location on the island. For example, at our Daytona East and Daytona West sites, the most common associated shrub species are silver lotus (*Lotus argophyllus*), San Nicolas Island lomatium (*Lomatium insulare*), and Trask's locoweed (*Astragalus traskiae*). At the SW Terrace and Tufts-Shannon sites, associated shrubs are silver lupine and silver beach weed. Island night lizards are present at the Daytona sites, but are absent from the SW Terrace and Tufts-Shannon sites. The substrate differs among these sites, with clay soils present at Daytona, caliche hardpan at SW Terrace, and sand and caliche rock at Tufts-Shannon.

Mixed Shrub - We categorized several sites as mixed shrub, where there was a varied association of shrubby species with no obviously dominant species. A good example of this is our Celery Canyon site, located on the terrace between Celery Canyon and Mineral Canyon, west of the Navy's equipment / "boneyard." This area is a moderately dense shrub association, with island morning glory, coreopsis, haplopappus, silver lotus, Australian saltbush, silver lupine, coyote brush, and sagebrush. The particular shrub species in this association vary depending on location

on the island - e.g. silver lupine is not generally found at the more eastern sites. We found night lizards at all of our mixed shrub sites.

Prickly Pear - Prickly pear patches are scattered on the north, east, and south sides of San Nicolas, mostly on slopes and along gullies. They range in size from barely 1 m^2 to 1,000 m^2 (at the head of "Dump Canyon" northeast of the residence / living compound). Important areas for prickly pear include the large gullies around and east of NAVFAC, gullies along Beach Road, and some of the canyons on the northern half of the mesa and the north slope (e.g. Celery Canyon and "Dump Canyon"). There are also some scattered, isolated patches on the southern escarpment (such as the large stand at our Theodolite site).

Prickly pear tends to form continuous stands, occasionally with vines (island morning glory and wild-cucumber, *Marah macrocarpus*) growing over it. Vegetation surrounding cactus patches is typically annual grass and other shrubs. Common shrub associates of cactus patches include haplopappus, coreopsis, island morning glory, and boxthorn. All of our pitfall traps and cover boards at prickly pear sites are within or directly adjacent to cactus.

Stabilized Dune (including Bush Lupine) - We sampled a variety of shrubby plant associations on the western half of the island. Some of these areas (such as Tufts Lupine and Magazine Road) are dominated by silver lupine, while others have a complex mix of species, including dune malacothrix (*Malacothrix incana*), Trask's locoweed, silver beach weed (*Ambrosia chamissonis*), and sea-fig (*Carpobrotus aequilaterus*). Some plant species that are associated with night lizards on other parts of island (such as island morning glory and haplopappus) are also common elements of these stable dune associations. However, the key component that ties these areas together, and apparently makes them unsuitable for island night lizards, is the deep, sandy substrate. Our results indicate that, even with suitable shrub or other cover (such as large boards), island night lizards cannot, or do not choose to, persist on dry sand substrates.

Population Estimate

We estimated population size and density for two areas on the island for which we had extensive capture data. These were the Eucalyptus and Lighthouse board sites. The Eucalyptus and Lighthouse boards are in sparse Haplopappus grassland along the top of the southern

escarpment. The primary cover used by island night lizards in these two areas are large pieces of plywood and other discarded lumber left by the Navy. Because of the combination of limited cover and our ability to search the area thoroughly (by turning all of the available cover), our samples approached a complete census of the lizards at these two sites. This is similar to the situation described by Mautz (1993) for his Harding site in maritime desert scrub (*Lycium* phase). After the first year of sampling this site, almost all of the lizards we captured in subsequent samples were recaptures (except for new young-of-year lizards present in September and October), indicating that we had close to an exhaustive survey of the local area.

We used a conservative, enumeration estimate of population size for both the Eucalyptus and Lighthouse sites (Krebs, 1966). This is also referred to as "minimum number alive." Not all lizards at the sites were captured at any given monthly sampling period. For example, lizard number 324 at the Eucalyptus site was first captured by Tom Murphey in September 1984. During intensive sampling between 1993 and 1995, we captured this individual in May, June and August of 1993; April, June, August, and October of 1994; and May and July of 1995. In enumerating population size, we assumed that this individual was present throughout the entire period from 1984 through July 1995, even though it was missed some months. We feel that this is a reasonable assumption, given the isolation of the Eucalyptus and Lighthouse sampling sites and the very small home ranges of island night lizards (see Fellers and Drost 1991b, Mautz 1993). In fact, for lizard 324, most of its captures were from two large boards on the site that are located side by side, and we never caught it outside of the Eucalyptus site.

The assumption of population closure also applies to recruitment (additions to the population from birth and immigration) and loss (mortality and emigration). Since we only included lizards in the enumerated total from their time of first capture until their time of last capture (i.e. we are not projecting beyond the span for which we have capture data for any given lizard), we are not violating this assumption. Our population estimate in this regard is conservative, since there were probably lizards at any given sampling period that we were not accounting for.

The core areas for which we calculated population size are small. At the Eucalyptus site, the area covered by boards and associated Haplopappus shrubs was measured at 36 m^2. At the Lighthouse site, the area covered by boards and low shrubs was 30 m^2. In 1994 and 1995, enumerated population size at the Eucalyptus site ranged from 8 - 10 lizards. (This only includes

the resident lizards in the area. It does not count the numbers of young-of-year lizards, which show up in the fall; for example, in the September 1995, we caught a total of 16 young lizards at the site, in addition to the resident adults). Eight to 10 lizards per 36 m^2 is equivalent to approximately 2,200 - 2,800 lizards per ha. Similarly, at the Lighthouse site, enumerated numbers in 1994 and 1995 ranged from 7 - 12 individuals, equivalent to 2,300 to 4,000 per ha.

Island-wide Population Estimate

High quality island night lizard habitat of the kind described by Fellers and Drost (1991b) and Mautz (1993) is very limited and patchy in distribution on San Nicolas Island. We developed a very rough estimate of island night lizard numbers on San Nicolas Island (Table 10) by combining measurements of area of different habitats with previously published estimates of night lizard population density in corresponding habitats (Fellers and Drost 1991b). Areas of different habitats were estimated from examination of 1:4800 true color aerial photographs (November 1991; Aelytek, Inc., Sunnyvale, CA). The small areas of cactus habitats were located and measured using a stereozoom dissecting microscope. Approximate areas of mixed shrub habitat were estimated from the aerial photographs, with reference to notes from field reconnaissance of the different areas.

Patches of prickly pear cactus are distributed along the north beach terrace and slope of the island from the vicinity of NAVFAC east to the east end. Scattered patches of prickly pear are also found in some of the canyons and gullies along the north side of the island, and in a few places along the southern escarpment (e.g. below the Theodolites installation). Prickly pear ranges in extent from single plants and small patches less than 1 - 2 m^2, to extensive pure stands. Size of patches that we measured from the aerial photographs ranged from 30 - 1,000 m^2 ("Dump Canyon," east of the residence area). Stands of cholla cactus are less extensive, mostly found on the slopes and gully edges around the east end of the island. The appearance of cholla stands on the aerial photographs was not distinctly different from that of prickly pear so, even though we knew the identity of many patches from field observations, we lumped cholla with prickly pear for the island population estimate.

Boxthorn is even rarer than the cactus habitats, and we could not measure it from the aerial photographs. It forms small, pure thickets at a few isolated sites (e.g. east of NAVFAC), or is found associated with prickly pear, cholla, and other shrubs at scattered locations on the

beach terrace and slopes on the north side of the island, and on the beach terrace along the southeastern shore (e.g. behind Daytona Beach). The area figure we use for boxthorn is a rough field estimate from the size of the main boxthorn stands we observed on the island.

Large numbers of island night lizards are found on San Nicolas in one additional habitat not described by Fellers and Drost (1991b) or Mautz (1993). This is the boulder beach habitat found at a few isolated sites around the west end of San Nicolas. Our estimates of lizard numbers in this habitat rival those of the best cactus and boxthorn habitats. The area we sampled at Red Eye beach measures approximately 500 m^2 (50 m x 10 m), and we estimate at least five times this much habitat over the remainder of the Red Eye beach area.

The last habitat type for which we estimated lizard numbers is the mixed shrub. The most important shrub species in this association (from the standpoint of night lizard habitat) are haplopappus, island morning glory, Australian saltbush, and occasional prickly pear and boxthorn. The mixed shrub and Haplopappus scrub habitats are quite variable over the extent of the island (see discussion under Habitat). Much of what Halvorson et al. (1996) mapped as this habitat does not support night lizards at all. Similarly, we could not distinguish good mixed shrub habitat (for island night lizards) from poor shrub habitat by visual inspection of the aerial photographs. Instead, our estimate of area for mixed shrub night lizard habitat is based on measurement of areas on the aerial photographs that we know, from field observations, to be good shrub habitats which support healthy numbers of island night lizards. (A good example of this is the diverse and relatively dense shrub community on the terrace between Celery Canyon and Mineral Canyon.) Our estimate of island night lizard numbers on San Nicolas Island is about 15,300 lizards (Table 10). Because of all the variables involved, this estimate is very crude, but it does present a conservative starting point for an island population estimate.

Other lizards

The southern alligator lizard [*Elgaria multicarinata* (= *Gerrhonotus multicarinatus*)] became established on San Nicolas Island some time before 1960 (Banta and Wilson 1976; see also Parks et al., in prep.). This species currently occurs in scattered areas of the south-central portion of the island. During this study, we found alligator lizards in locations ranging from the west end of Dutch Harbor on the south shore of the island, north to the area of the fire station at the junction of Monroe Drive and Owens Road, and from the grasslands south of the intersection

of Beach Road and Monroe Drive, west to the grasslands near the junction of Shannon Road and Jackson Highway.

We recorded alligator lizards at four of our trap areas: Central Stipa; Eucalyptus; Lighthouse; and Monroe. Numbers were low at all of these areas except for the Eucalyptus site (Table 11). Except for the Eucalyptus site, there was little or no overlap of alligator lizards and island night lizards: we only have two records of alligator lizards at the Lighthouse site, where night lizards are numerous; at the Monroe site, we captured a single night lizard, compared to the four alligator lizards captured; and at the Central Stipa site we did not catch any night lizards. At the Eucalyptus site, we evaluated the amount of overlap between island night lizards and alligator lizards at the 32 trap and board locations which make up the site. At five of the trap/board locations we found alligator lizards but no night lizards. At 13 trap/board locations we caught night lizards but no alligator lizards. At the remaining 14 traps and boards we caught both species.

The traps and boards at the Eucalyptus site are located in a range of microhabitat conditions. The traps and boards in and around the dense canopy of Eucalyptus and Lavatera in the upper part of the site are relatively cool and moist, while the down slope traps are in open short grass and scattered Haplopappus where it is warmer and drier. Comparing distribution of night lizards and alligator lizards in these microhabitats, numbers of night lizards were relatively higher (89 night lizards: 20 alligator lizards) in the warm locations while numbers of alligator lizards were relatively higher (19 night lizards: 12 alligator lizards) in the cool locations (Two-way test of independence; $G = 6.270$, $P = 0.043$).

We also evaluated relative numbers of night lizards and alligator lizards at the Eucalyptus site, in the early part of this study (1984 - 1985) compared to the later part (1992 - 1995). In 1984 - 85 (two trapping seasons), Tom Murphey caught 23 alligator lizards and 36 night lizards. In 1992 - 95 (four trapping seasons), we caught 34 alligator lizards and 118 night lizards.

Discussion

Weather

Annual rainfall, and its effects on vegetation and insect populations, appears to be the main aspect of weather that affects individuals and populations of island night lizards. Fellers and Drost (1991b) used regressions of lizard mass on body length as an index of relative condition, and found that lizards were heavier in 1982, a wet year, compared to 1981 which followed two very dry years. However, the years during which we were studying night lizards on San Nicolas Island were relatively wet. There were only two particularly dry years during this period: 1988 - 89 (16.0 cm); and 1989 - 90 (10.0 cm). Both of these years were outside of the times when we were actively trapping lizards.

Capture rates

Capture rates for island night lizards are difficult to compare to rates on other islands due to the dissimilarities in habitat. For example, Fellers and Drost (1991b) found the boxthorn was the prime habitat on Santa Barbara Island. It took an average of only 12.5 trap days to capture each lizard. This was clearly the best habitat on the island. On San Nicolas, boxthorn is quite limited. Often there is only one or a few bushes in an area, while on Santa Barbara Island, there were large areas totaling over 45,000 m^2. Such dense, extensive stands can clearly support much higher lizard populations than can single plants or small clusters.

On San Nicolas Island, the most extensive habitats which were both favorable for island night lizards and moderately extensive were cholla and prickly pear. Lizard densities in cholla could not be compared with anything on Santa Barbara Island since cholla was very restricted and was not sampled for lizards. The extent of prickly pear was much greater on Santa Barbara Island where most of the south-facing side of several canyons was covered with this cactus. On San Nicolas, there were scattered, modest patches in a number of areas on the lower terraces on the northern side of the island. Perhaps reflecting the more extensive nature of this favored habitat, capture rates on Santa Barbara Island were nearly double those on San Nicolas Island.

Though rock habitat is found on both Santa Barbara and San Nicolas Islands, suitable rock habitat (lots of fissures and loose rock) is far more restricted on the latter island and hence it is not surprising that the density of lizards was quite low there.

The cobble / driftwood habitat is not found on either of the other two islands which support island night lizards. While it is quite limited on San Nicolas Island, it is significant because of the remarkable densities of lizards that it supports and also because it occurs around the northwest part of the island and hence provides the only hospitable habitat for this lizard on that entire half of the island.

It is difficult to compare either boards with pitfall traps or board data with data from other islands since this is a relatively new technique not utilized by either Fellers and Drost (1991b) or Mautz (1993). On San Nicolas Island, the boards were mostly deployed in different habitat types than the pitfall traps. This was partially due to the fact that boards were deliberately placed in areas where lizard densities were expected to be low, and hence not be worth the effort to install pitfall traps. Aside from a small sample from one set of boards in the vicinity of Board 904, the most productive habitat sampled by cover boards was in a small eucalyptus grove near the Telemetry Building (182). These boards had been in place for more than 12 years, were associated with a thick layer of leaf litter, and were rarely disturbed by personnel on the island. Since eucalyptus is a non-native tree in the United States, we do not recommend that it be planted elsewhere on the island. On the other hand, since this one grove supports a significant, well-established population of lizards, the grove should not be removed until the trees become decadent or die of old age.

Differences in monthly capture rates between pitfall trapping and cover boards were extremely minimal except for the higher capture rate for boards in late summer and early fall (Aug – Sep, Fig. 6). This is the time of year when adult females are giving birth to their young. Some of the cover boards provided good habitat for both the adult and newly born young, and hence it was not surprising that they were found more frequently.

Both the trap and cover board data differ some from trapping data from Santa Barbara Island (Fellers and Drost, 1991b). On Santa Barbara Island, lizards were active a little earlier in the year with a peak in April. Comparisons during the late fall through early spring (October to March) are not possible because we did not visit San Nicolas Island during these periods of lower activity.

Sex Ratio and Size Distribution

There was no significant difference in sex ratio, which is similar to what has been found on the other two islands, . This is not surprising considering how skewed a sample ratio must be to become statistically significant. The ratio of 1:1.2 was within the range previously reported for this lizard, 1:1.1 for Santa Barbara Island (Fellers and Drost, 1991b), and 1:1.3 for San Clemente Island (Mautz, 1993). Additionally, apparent difference in sex ratios of lizards sampled from traps or cover boards can potentially reflect differences in activity between sexes rather than the underlying population sex ratio.

The size distributions are what one would expect from good, healthy populations. There are a substantial number of lizards across all size classes in all three of the best, natural habitats. This includes both young lizards, which indicate a good reproductive population, and the larger lizards, which indicate that there is good survival.

Condition Index

Fellers and Drost (1991b) found significant differences in night lizard condition index on Santa Barbara Island that appeared to relate to differences in annual rainfall. Mautz (1993) noted severe weight losses in adult lizards during a drought on San Clemente Island. Annual rainfall and its effects on plant growth and invertebrate populations probably affects night lizard populations in different ways. It seems likely that the rains of an El Ni☆o event will increase first year growth rate in the year of El Ni☆o (the neonates will show the fastest response to rain and vegetative growth); that adult body mass or condition index will rise in the subsequent year or two, lagging the neonate response; and that reproductive output will also peak in the year or two after a heavy El Ni☆o rain year.

This is similar to what was observed on San Clemente Island (Mautz, 1993) where neonatal growth rate (first year growth) was high in 1982 - 83 when a major El Ni☆o event occurred. Reproduction of island night lizards on San Clemente Island was also relatively high in 1983 and 1984.

Longevity

Fellers and Drost (1991b) presented data from Santa Barbara Island, which suggested that the largest island night lizard they captured (102.5 mm, SVL) could be as old as 13.4 years. Other lizards ranging up to 96 mm were estimated to be nearly 10 years of age. Mautz (1993) presented data that island night lizards on San Clemente were 12 and 13 years of age. Our data from San Nicolas Island indicate that at least a few lizards are likely to be well beyond 20 years and one lizard would be 32.9 years old if it grew at an average rate for the population. Ages of 20 and 30 years seem reasonable given the remarkably slow growth during capture intervals of more than a decade for five of the lizards used in these calculations.

Greater longevity of island night lizards on San Nicolas Island may be partially due to the fact that lizards there are notably larger than on the other two islands. For example, Fellers and Drost (1991b) captured exactly 900 island night lizards and only one was 100 mm SVL or longer (102.5). On San Nicolas Island, we captured 810 island night lizards and 68 were 100 mm or longer. There were three lizards over 115 with the largest being 117.0 mm. With the exceptionally low growth rates for island night lizards on all three islands, lizards which attain these large sizes will certainly attain a much greater age. It is not clear what the cause of this inter-island difference might be.

Records on lizard longevity have been compiled by Slavens (1998). Appendix C lists the records for lizards, which are known to have lived at least ten years. The oldest known *Xantusia* is a granite night lizard (*X. henshawi*) reported to have lived 14 years and an island night lizard reported at 13 years of age. Both of these lizards were captured in the wild and then kept in captivity for the reported length of time. The island night lizard was reported to be an adult when captured, and hence was much older than the known, reported age. These numbers would seem to be largely in accordance with the observations that we have made for lizards living in the wild.

While no members of the night lizard family have been documented to have lived more than 20 years, three species of skinks and two species of monitor lizards have exceeded this mark. The rather short record life span of 12 years for the very large Komodo monitor (*Varanus komodoensis*) in captivity seems low, probably due to the fact that these lizards are hard to keep in captivity. Auffenberg (1981) cited some records indicating ages in excess of 20 years and he estimated that they live upwards of 50 years in nature.

It is expected that the longevity of a species will increase with body mass (large lizard species will have longer lives) and that ecology, life history strategy, and phylogeny will stratify the body mass relationships. Within this generality, certain groups (e.g. xantusiids) have unusually long life span for their size. The record of 14 years for a granite night lizard is impressive, given its small size of 4 – 6 g. The desert night lizard (*X. vigilis*, 1 – 2 g) has ages of up to 9 years in nature, and island night lizards continue the body mass trend within the xantusiidae. Xenosaurid lizards are a lot like xantusiids in behavior / ecology and they too are long lived as are the fossorial amphisbaenia. It is interesting that skinks are notably long-lived. They have a diverse ecology that does not easily fit in a category of reclusive-secretive-fossorial like the amphisbaenids, especially since some of the skinks are rather large.

Habitat utilization

Unfortunately, the habitats described and mapped by Halvorson et al. (1996) appear to be of little use for describing and mapping island night lizard habitat. While suitable for island-wide community descriptions, Halvorson's habitats are too broadly defined and mapped on too coarse of a scale to reflect habitat characteristics including soil and rock substrates that are important to night lizards. For example, the broadly-defined coastal scrub habitat contains some of our sampling sites that have the highest concentrations of night lizards that we found on the island, such as the Eucalyptus and Lighthouse sites, and the Beach Boxthorn boards. On the other hand, it also contains many sites that have no lizards at all, such as the Tufts Baccharis and Tufts Lupine grids, and the Bunker, Thousand Springs, and Tufts-Shannon boards. Likewise, areas of boxthorn and prickly pear that are large enough to support hundreds of lizards (such as the Opuntia grid and the NAVFAC Prickly Pear traps) are much smaller than the minimum mapping units used in the vegetation map. For these reasons, useful descriptions of island night lizard habitat and population numbers must use a finer level of detail.

Figure 14 shows the distribution of the prime habitats for island night lizards. While it is not possible to map the exact edges for each area on a map of this scale, it does indicate where lizards were found in greatest densities at the time of our study. Over time, it would be expected that some of these habitats could change as the preferred vegetation either expands or contracts. These are the areas that demand the most careful management. Figure 15 shows those areas on San Nicolas Island which have moderate quality, low quality, or no lizard habitat. The areas of

moderate quality habitat warrant special attention since these are the areas where the Navy could easily enhance the existing habitat either by protecting it from erosion or other types of degradation or by a carefully designed restoration program.

Island night lizards can not be protected on San Nicolas Island by focusing only on the prime habitat. While the prime habitat areas are critically important, they are too limited to support a viable population on a long-term basis. Because of this, the moderate quality habitat is essential for the continued survival of island night lizards on the island.

Expected Habitat Changes

We expect that habitats on San Nicolas Island will change over time. In the absence of human activities that would interfere with natural processes on the island, we would expect there to be a trend toward increasing shrub cover in accordance with Halvorson et al. (1996). Specifically, there should be a trend toward such shrubs as haplopappus, bush lupine, coreopsis, and coyote brush (*Baccharis pilularis*) invading areas of non-native grassland. Of these species, increase in the dense, low-growing haplopappus, and possibly the coyote brush, should benefit island night lizards. The loss of grassland should not be a detriment, since this habitat supports almost no island night lizards aside from a few apparently dispersing individuals. In general, this trend would be a welcome change for an island, which has historically undergone significant disruption of the native flora and fauna.

Population Estimate

Because of limitations in measuring habitat area, variability of some of the habitats (especially the mixed shrub), and very approximate values for lizard density in different habitats, the numbers listed in Table 10 are only a very crude estimate of lizard population size on San Nicolas Island. However, the density values do highlight a number of important points. First, island night lizards are more numerous and widespread than previous, limited studies have suggested (Roger Wilson, pers. comm.). However, total lizard numbers on the island are much lower, relative to the island's size, than on either of the other two islands where island night lizards occur. Fellers and Drost (1991b) estimated 17,600 island night lizards on the much smaller Santa Barbara Island (about 1/20th the size of San Nicolas Island). Similarly, although he did not attempt to project island-wide population size, Mautz (1982, 1993) found high

densities of night lizards in very extensive habitats on San Clemente Island that suggest much higher lizard numbers on that island.

Finally, an important point illustrated by Table 10 is that the majority of island night lizards on San Nicolas appear to be spread out through relatively low quality habitat. By comparison, Fellers and Drost (1991b) found the majority of island night lizards on Santa Barbara Island in extensive, high quality habitat (boxthorn, prickly pear, rock). This further points out the scarcity of high quality island night lizard habitat on San Nicolas Island. The implications of this are not immediately clear. We do not know, for example, whether the mixed shrub habitats serve primarily as "sinks" for night lizards dispersing from dense populations in cactus and similar habitats, or whether stable, self-sustaining populations are maintained in purely mixed shrub habitats. It is likely that the extensive areas of mixed shrub are important in providing avenues for population interchange and mixing between the otherwise highly fragmented cactus and boxthorn areas. In any event, Table 10 and Figure 14 highlight the scarcity of high quality night lizard habitat on San Nicolas, and the urgent need to protect the scattered areas that are present on the island.

Other lizards

The alligator lizard is an introduced species on San Nicolas Island, and it is slowly spreading in its distribution. Banta and Wilson (1976) first reported on the occurrence of two specimens from San Nicolas Island, and these authors left open the possibility that the species was native to the island (or that it may have been introduced to San Nicolas prior to recorded history). However, careful searches by one of the authors (Murphey) in 1984 and1985 showed that the species was restricted to the local area (near Navy buildings and wood debris) where one of the first specimens was obtained. Our surveys over succeeding years have shown a slow increase in the distribution of the alligator lizard on San Nicolas. This pattern of occurrence and slow spread suggests a recent introduction of the species to the island in shipments of lumber or other materials brought from the mainland. Genetic analyses of island and mainland specimens also strongly suggest recent, artificial introduction of alligator lizards from the southern California mainland to San Nicolas (Parks et al., in prep.).

The alligator lizard is as large or larger than most island night lizards. Alligator lizards prey on a variety of invertebrates and small vertebrates (Nussbaum et al.1983), so there is some

concern about possible interactions with night lizards on San Nicolas Island, either as a competitor or a predator. For this reason, we analyzed our capture data for alligator lizards to assess possible adverse impacts on night lizards. Our data indicate that the two species tend to occur in different habitats, both in terms of general habitat types, and in terms of microhabitat preferences within a local area. We found a total of six alligator lizards in grassland habitats where night lizards rarely occur (and then probably only as transients). At the Eucalyptus site, where moderate numbers of alligator lizards and high numbers of night lizards occur, there was only partial overlap of the two species. Of 32 trap and board locations in our Eucalyptus sampling area, we found alligator lizards but no night lizards at five of the locations over the course of this study, and one or more night lizards but no alligator lizards at 13 locations. There was a significant difference in the distribution of the two lizards, with alligator lizards found more frequently in the cooler sites in and near the shade of Lavatera and Eucalyptus, and night lizards more numerous in the areas away from dense shade.

There were differences in the sampling scheme we used between the 1984 - 85 period and the 1992 - 1995 period. In particular, the 1984 - 85 sampling included both pitfall traps and boards, while the later sampling used only cover boards. This limits a rigorous comparison of numbers between the two periods. However, the apparent trend is toward higher numbers of night lizards, and relatively lower numbers of alligator lizards.

Based on these data, reflecting a 12-year span of time over which populations of night lizards and alligator lizards have been in contact, we see no indication of negative impacts of alligator lizards on island night lizards. The Eucalyptus site supports the most alligator lizards of any location we know of on the island, but also supports one of the densest concentrations of night lizards. There is a full range of age/size classes for island night lizards, and our data show no decrease in numbers of night lizards. To the contrary, comparison of 1984 - 85 data with 1992 - 95 data shows an apparent decrease in relative numbers of the alligator lizard. For these reasons, we do not recommend any management effort to control or eradicate alligator lizards on San Nicolas. Even though the species is apparently an artificial introduction to the island, it presents no evident harm to native species on San Nicolas, and management time and effort should instead be directed toward much more pressing problems, such as habitat restoration, erosion control, and removal of feral cats.

Management recommendations

Based on the results of this study, we make the following recommendations for protection and management of the island night lizard on San Nicolas Island:

1. Because of the restricted distribution and specific habitat needs of island night lizards on San Nicolas Island, any new projects that might alter or damage night lizard habitat need to be carefully reviewed and monitored. Habitats of concern include beach cobble / driftwood, prickly pear, cholla cactus, boxthorn, and mixed shrub habitats which contain prickly pear, cholla, island morning glory, Catalina tarweed, and haplopappus. Figure 14 shows the distribution of the prime lizard habitat (as of 1995) and Figure 15 shows areas that range from moderate to low to no lizard habitat present.

2. Habitat stabilization and restoration projects, including erosion control and revegetation, are badly needed in a number of areas around the island. These projects will benefit both plant and animal species native to San Nicolas. Halvorson et al. (1996) also note the need for active erosion control and vegetation restoration work in barren, eroding areas such as the south bluffs, and areas of the north bluffs. Consideration should be given to using prickly pear and boxthorn as components of the revegetation. Both species provide very good habitat for island night lizards, but are relatively neglected in propagation and restoration efforts. Boxthorn has suffered general decline on the Channel Islands (Philbrick 1972), and so is of concern itself, in addition to the habitat it provides for night lizards and other native animals.

3. Non-native cats and rats could be a serious threat to island night lizards. Rats are generalist predators known to prey on lizards in other island situations. Rats prefer the same dense, shrubby habitats that are best for island night lizards. On Anacapa Island in the northern Channel Islands, rats have reached high numbers between periods of active control. Rats prey on endemic island snails, lizards, and a wide variety of other native species. They may have been responsible for the extirpation of the endemic subspecies of deer mouse

on East Anacapa Island, which disappeared sometime during the last 40 years, subsequent to the introduction of rats. A concerted effort should be made to monitor for rats, and to eradicate them if and when they are found.

Cats are known predators of island night lizards. While we do not have detailed information on when cats were introduced to San Nicolas Island, we know that cats have been present during all years that we have conducted field work. While cats seem to be somewhat more abundant near human habitation, cats have been observed by us in nearly all parts of the island, including some of the best habitats for island night lizards. Animal Damage Control (ADC) personnel who worked on a cat control / eradication program on San Nicolas Island found the remains of island night lizards in the stomachs of several cats. While the current cat population is not likely to be a significant factor in reducing island night lizard populations, there is that potential if the cat population were left unchecked. A continued, concerted effort should be made to control cats, and to eradicate them if at all possible.

4. Monitoring of lizard populations should be continued on an intermittent basis. We recommend sampling every three to four years, using existing pitfall and cover board sites. This should provide adequate data for assessing changes in lizard numbers at individual sampling sites, and for tracking changes in distribution that may occur with continuing vegetation recovery on the island. It should be noted that if existing pitfalls are to be maintained for monitoring purposes, metal pitfall lids should be replaced with plastic lids.

5. Avoid creating artificial habitat for island night lizards with lumber, concrete, wooden pallets, boxes, sheet metal, and other materials. Subsequent removal of such materials would disrupt the local population of lizards which take up residence and could constitute "take" as defined by the U.S. Fish and Wildlife Service and hence require a formal consultation. To reduce the likelihood that lizards will occupy areas where materials are stored, we make the following recommendations for storage and handling of materials:

a) avoid storing materials on or near shrubby vegetation cover, particularly cactus and other low shrubs. Where possible, store material on bare asphalt, ground, or sand.

b) use pallets or other means of keeping lumber and other flat material up off of the ground.

c) avoid driving over or otherwise disturbing natural shrubby vegetation when using heavy equipment to handle and place materials.

d) avoid using rock riprap on slopes or in culverts since it can become night lizard habitat. If such materials are used, they should be made as permanent as possible, so that it is not necessary to disturb the rock and associated vegetation later.

e) where there is extensive artificial cover that harbors night lizards, consideration should be given to leaving the cover in place if it does not present a safety concern or other serious problem. If that is not possible or desirable, a quick survey of the cover and immediately surrounding area (by someone knowledgeable about night lizards and their habitat) may be sufficient to ensure that it is safe to remove the material.

Acknowledgments

We thank the Commanding Officer, Naval Air Weapons Station (NAWS), Point Mugu, for access to the island, and the support of members of the staff of NAWS Point Mugu. In particular, Tom Keeney of the Environmental Division provided the initial idea for this study, obtained funding to carry it out, and assisted and encouraged the work in numerous ways. Grace Smith of Environmental Division oversaw the latter part of the project, discussed project planning and application to natural resource management on San Nicolas, and gave invaluable assistance with the logistics of working on the island. Ron Dow, head of Environmental Division, supported the project and provided helpful discussion from his long experience with the natural resources of San Nicolas Island.

Mr. Charles Fisk of the NAWS Geophysics Branch provided island weather data and summaries. Todd Wills was biological technician for the project in 1993, and carried out much of the fieldwork that year. Student Conservation Association volunteers Joy Hosokawa, Tracy Miner, Leigh Ochikubo, and Adam Whelchel also provided valuable help with fieldwork.

Barbara Ball of the University of Arizona provided the base maps of San Nicolas Island used in some of the figures.

Literature Cited

Auffenberg, Walter. 1981. The Behavioral Ecology of the Komodo Monitor. University of Florida Presses. Gainsville, Florida.

Baird, S. F. 1859. Description of new genera and species of North American lizards in the museum of Smithsonian Institution. Proc. Acad. Nat. Sci. Philadelphia 1858:253-256.

Banta, B. H., and R. L. Wilson. 1976. On the occurrence of *Gerrhonotus multicarinatus* on San Nicolas Island, Ventura County, California. Bull. Maryland Herp. Soc. 12:99-100

Bezy, R. L. 1972. Karyotypic variation and evolution of the lizards in the family Xantusiidae. Contrib. Sci., Los Angeles Co. Mus. No. 277:1-29.

_____. 1988. The natural history of the night lizards, family Xantusiidae. Pp. 1-12. *In:* H. F. De Lisle, P. R. Brown, B. Kaufman, and B. M. McGurty (Eds.). Proceedings of the Conference on California Herpetology, Southwestern Herpetol. Soc.

Bezy, R. L., G. C. Gorman, G. A. Adest, and Y. J. Kim. 1980. Divergence in the island night lizard *Xantusia riversiana* (Sauria: Xantusiidae). Pp. 565-583. *In*: D. M. Power (Ed.), The California Islands: Proceedings of a Multidisciplinary Symposium. Santa Barbara Museum of Natural History, Santa Barbara, California.

Brattstrom, B. H. 1951. The number of young of *Xantusia*. Herpetologica 7:143-144.

_____. 1952. The food of the night lizards, genus *Xantusia*. Copeia 1952:168-172.

_____. 1965. Body temperatures of reptiles. Am. Midl. Nat. 73:376-422.

Cochran, P. M. 1961. Type specimens of reptiles and amphibians in the United States National Museum. Bull. U.S. Natl. Mus. 22:1-291.

Crother, B. I., M. M. Miyamoto, and W. F. Presch. 1986. Phylogeny and biogeography of the lizard family Xantusiidae. Syst. Zool. 35:37-45.

Dunkle, M. B. 1950. Plant ecology of the Channel Islands of California. University of Southern California Allan Hancock Pacific Expeditions 13(3): 247-386.

Federal Register. 1977. 42(155):40682.

Fellers, G. M., and C. A. Drost. 1982. *Xantusia riversiana* coloration. Herpetol. Rev. 13(3):95.

Fellers, G. M., and C. A. Drost. 1989. Fluorescent powder - a method for tracking reptiles. Herpetol. Rev. 20(4):91-92.

Fellers, G. M., and C. A. Drost. 1994. Sampling with Artificial Cover. Pp. 146-150. In: W. Ronald Heyer, Maureen A. Donnelly, Roy W. McDiarmid, Lee-Ann C. Hayek, and Mercedes S. Foster (eds.) Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press. xix+364 Pp.

Fellers, G. M., and C. A. Drost. 1991a. *Xantusia riversiana* species account. Catalog of American Amphibians and Reptiles. 518.1-518.4

Fellers, G. M., and C. A. Drost. 1991b. Ecology of the island night lizard, *Xantusia riversiana*, on Santa Barbara Island, California. Herpetological Monographs. 5: 28-78.

Fellers, Gary M., Charles A. Drost and Brian W. Arnold. 1988. Terrestrial Vertebrate Monitoring Handbook. Channel Islands National Park, Ventura, CA.

Goldberg, S. R., and R. L. Bezy. 1974. Reproduction in the island night lizard, *Xantusia riversiana*. Herpetologica 30:350-360.

Goldberg, S. R., Charles R. Bursey. 1990. Prevalence of *Eimeria noctisauris* (Apicomplexa: Eimeriidae) in the Island Night Lizard, *Xantusia riversiana* (Xantusiidae). J. Herpetol. 24(2):204-207.

Halvorson, W. L., D. B. Fenn, and W. R. Allardice. 1988. Soils and vegetation of Santa Barbara Island, Channel Islands National Park, California, USA. Environ. Mgmt. 12:109-118.

Halvorson, William L., Steve Junak, Cathy Schwemm, and Thomas Keeney. 1996. Plant communities of San Nicolas Island, California. Technical Report no. 55, U. S. Department of Interior, Cooperative Park Resources Studies Unit, University of Arizona, Tucson, AZ.

Heimlich, E. M., and M. G. Heimlich. 1947. A case of cannibalism in captive *Xantusia vigilis*. Herpetologica 3:149-150.

Junak, Steven A. 1992. An illustrated flora of San Nicolas Island, California. Report for Naval Air Weapons Center, Point Mugu. Santa Barbara Botanic Garden, Santa Barbara, CA.

Junak, Steve, William L. Halvorson, Cathy Schwemm, and Thomas Keeney. 1995. Sensitive plants of San Nicolas Island (Phase 1). Technical Report no. 51, U. S. Department of Interior, Cooperative Park Resources Studies Unit, University of Arizona, Tucson, AZ.

Klauber, L. M. 1931. A new species of *Xantusia* from Arizona, with a synopsis of the genus. Trans. San Diego Soc. Nat. Hist. 7:1-16.

Knowlton, G. F. 1949. Food of the island night lizard. Herpetologica 5(2):45-46.

Krebs, C. J. 1966. Demographic changes in fluctuating populations of *Microtus californicus*. Ecol. Monogr. 36: 239-273.

Mautz, W. J. 1979. The metabolism of reclusive lizards, the Xantusiidae. Copeia 1979:577-584.

Mautz, William J. 1982. The status of the island night lizard, *Xantusia* (=*Klauberina*) *riversiana* on San Clemente Island. Contract no. N00246-80M-7274 for United States Navy.

Mautz, William J. 1993. Ecology and energetics of the island night lizard, *Xantusia riversiana*, on San Clemente Island, California. Pp. 417-428. In: F.G. Hochberg (ed.), Third California Islands symposium: Recent advances in research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA. 661 pp.

Mautz, W. J., and T. J. Case. 1974. A diurnal activity cycle in the granite night lizard, *Xantusia henshawi*. Copeia 1974:243-251.

Nussbaum, R. A., E. D. Brodie, Jr., and R. M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University of Idaho Press, Moscow, Idaho.

Parks, D. H., M. J. Mahoney, and G. M. Fellers. *In prep*. Mitochondrial DNA sequence documents artificial introduction of two lizards (*Uta stansburiana* and *Elgaria multicarinata*) to the Channel Islands of California. Submitted to Molecular Ecology.

Philbrick, R. N. 1972. The plants of Santa Barbara Island, California. Madrono 21:329-393.

Read, D. O., and Y. U. Amrein. 1952. Some new oxyurid nematodes from Southern California. Parasitology 38:379-383.

Rose, B. 1982. Lizard home ranges: methodology and functions. J. Herpetol. 16:253-269.

Savage, J. M. 1951. Studies on the lizard family Xantusiidae, II: geographical variation in *Xantusia riversiana* from the Channel Islands of California. Washington Acad. Sci. 41:357-360.

Savage, J. M. 1957. Studies on the lizard family Xantusiidae, III: a new genus for *Xantusia riversiana* (Cope, 1883). Zoologica 42:83-86.

Savage, J. M. 1963. Studies on the lizard family Xantusiidae IV. The genera. Contrib. Sci., Los Angeles Co. Mus. 71:1-38.

Savage, J. M. 1967. Evolution of the insular herpetofaunas. Pp. 219-227. In R. N. Philbrick (Ed.), Proceedings of the Symposium on the Biology of the California Islands. Santa Barbara Botanic Garden, Santa Barbara, California.

Schwenkmeyer, R. C. 1949. Food habits of the island night lizard, *Xantusia riversiana* reticulata, from San Clemente Island. Nat. Hist. Misc., Chicago Acad. Sci. 38:1-3.

Slavens, Frank and Kate Slavens. 1998. Reptiles and Amphibians in Captivity – Longevity: Lizards. http://www.halcyon.com/slavens/lliz.html (information from 201 institutions, 256 private collections, 5 literature citations – 462 total reporting)

Van Denburgh, J. 1922. The reptiles of western North America. Occas. Papers, California Acad. Sci. 1:1-611.

Vedder, J. G., and D. G. Howell. 1980. Topographic evolution of the southern California borderland during late Cenozoic time. pp. 7-31 in: Power, Dennis M. (ed.), The California Islands: Proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, Calif.

Vedder, J. G., and R. M. Norris. 1963. Geology of San Nicolas Island. U.S. Geological Survey Professional Paper 369: 1-65. U.S. Government Printing Office, Washington, D.C.

Table 1. Pitfall Trap habitat types for island night lizard sampling on San Nicolas Island. Habitat designations are the broad community types defined by Halvorson et al. (1996), and the habitat categories we assigned to the sites in our field descriptions. Sites are listed alphabetically. See Appendix A for detailed locations of each site.

	Halvorson et al. Habitat	**Fellers et al. Habitat**
Cholla Transect (1101-1110)	Grassland	Cholla
Coreopsis Grid (601-625)	Coreopsis	Coreopsis
Daytona BBQ (501-525)	Coastal Scrub	Haplopappus / Boxthorn
Desal Canyon (940-950, 1951)	Coreopsis	Canyon
Eucalyptus Grid (1601-1625)	Barren / Coastal Scrub	Haplopappus Grassland
Grassland Grid (1301-1325)	Grassland	Grassland
Lupine Grid (1201-1225)	Coastal Scrub	Bush Lupine
NAVFAC Boxthorn (701-709)	Grassland	Boxthorn
NAVFAC Grid (911-935)	Grassland / Coreopsis	Boxthorn Grassland
NAVFAC PP (49-73)	Grassland / Coreopsis	Prickly Pear
NAVFAC Transect (1401-1415)	Coreopsis / Barren	Mixed Shrub
Opuntia Grid (1001-1025)	Coreopsis	Prickly Pear
Redeye Transect (1501-1510)	Beach	Cobble / Driftwood Beach
Tufts Baccharis (25-48)	Coastal Scrub	Baccharis / Lupine
Tufts Lupine (1-24)	Coastal Scrub	Bush Lupine

Table 2. Cover board habitat types for island night lizard sampling on San Nicolas Island. Habitat designations are the broad community types defined by Halvorson et al. (1996), and the habitat categories we assigned to the sites in our field descriptions. Sites are listed alphabetically. See Appendix A for detailed locations of each site.

	Halvorson et al. Habitat	**Fellers et al. Habitat**
Airstrip (201-220)	Coastal Scrub / Grassland	Grassland
Barber Pole (171-180)	Coreopsis	Prickly Pear
Beach Boxthorn (961-980)	Coastal Scrub	Boxthorn
Beach Cholla (181-189)	Coreopsis	Cholla
Beach PP (190-199)	Coreopsis	Prickly Pear
Board 904 (904)	Coastal Scrub	Mixed Shrub
Bunker (271-290)	Coastal Scrub	Baccharis grassland
Celery Canyon (881-902)	Coreopsis / Grassland	Mixed Shrub
Central Stipa (861-880)	Grassland / Coastal Scrub	Grassland
Chukar PP (161-170)	Coreopsis	Prickly Pear
Corral Harbor (821-840)	Coreopsis	Bush Lupine
Daytona East (351-370)	Coastal Scrub	Haplopappus Scrub
Daytona West (311-330)	Coastal Scrub	Haplopappus Scrub
East NAVFAC (801-820)	Coreopsis	Haplopappus Scrub
Eucalyptus (421-430 et al.)	Barren / Coastal Scrub	Haplopappus Grassland
Lighthouse (411-420 et al.)	Barren / Coastal Scrub	Haplopappus Grassland
Magazine Road (121-140)	Inland Dune / Coastal Scrub	Bush Lupine
Monroe (291-310)	Grassland	Grassland
Ocean Coreopsis (141-160)	Coreopsis	Coreopsis
Red-eye (231-250)	Inland Dune	Stable Dune
Red-eye Beach (2001-2050)	Beach	Cobble /Driftwood Beach
SE Cholla (221-230 et al.)	Grassland	Cholla
SW Terrace (251-270)	Coastal Scrub	Haplopappus Scrub
Taxiway (2074-2076)	Grassland	Haplopappus Grassland
Terrace Cholla (431-435)	Grassland	Cholla
Theodolite (441-452)	Coastal Scrub / Grassland	Prickly Pear
Thousand Springs (391-410)	Coastal Scrub	Bush Lupine
Tranquility (841-860 et al.)	Coastal Scrub	Mixed Shrub
Tufts-Shannon (371-390)	Coastal Scrub	Haplopappus Scrub
West End (101-120)	Coastal Scrub	Stable Dune

Table 3. Summary of pitfall trap capture rates for island night lizards in different sites on San Nicolas Island from 1984-85, and 1992-95. TD = trap days, where 1 trap day is equal to one trap open for 24 hours.

Traps	**TD**	**INL**	**TD / lizard**
Red-eye Transect	150	21	7.1
Cholla Transect	880	69	12.8
NAVFAC PP	3,388	160	21.2
Opuntia Grid	2,100	66	31.9
NAVFAC Boxthorn	541	15	36.1
NAVFAC Grid	3,348	34	98.0
Eucalyptus Grid	1,836	16	114.9
Daytona BBQ	5,400	36	149.3
Desal Canyon	685	4	172.4
NAVFAC Transect	1,170	6	196.1
Coreopsis Grid	5,059	6	833.3
Grassland Grid	1,600	0	-
Lupine Grid	1,500	0	-
Tufts Baccharis	792	0	-
Tufts Lupine	792	0	-
Totals	29,241	438	66.8

Table 4. Summary of pitfall traps capture rates for island night lizards in different habitats on San Nicolas Island from 1984-85, and 1992-95.

Traps	**TD**	**INL**	**TD / lizard**
Cobble / Driftwood	150	21	7.1
Cholla	880	69	12.8
Prickly pear	5,488	226	24.2
Boxthorn	541	16	33.8
Eucalyptus	1,836	16	114.8
Mixed scrub	9,918	76	130.5
Rocky canyon	685	4	171.3
Coreopsis	5,059	7	722.71
Bush lupine	2,292	0	-
Grassland	1,600	0	-
Baccharis	792	0	-
Totals	29,241	438	66.8

Table 5. Summary of cover board capture rates for island night lizards at different sites on San Nicolas Island from 1984-85, and 1992-95.

Boards	Board Checks	INL	Checks / lizard
Board 904	11	12	0.9
Taxiway	9	10	0.9
Eucalyptus	486	140	3.5
Lighthouse	787	206	3.8
Theodolite	240	54	4.4
SE Cholla	252	56	4.5
Beach Cholla	171	35	4.9
Beach Boxthorn	140	20	7.0
Beach PP	200	26	7.7
Terrace Cholla	105	10	10.5
Tranquility	231	17	13.6
Celery Canyon	220	15	14.7
Chukar PP	170	10	17.0
Ocean Coreopsis	360	20	18.0
East NAVFAC	220	12	18.4
Barber Pole	170	9	18.9
Airstrip	380	6	63.3
Daytona East	313	2	156.3
Daytona West	360	1	357.1
Monroe	420	1	416.7
Bunker	360	0	-
Central Stipa	220	0	-
Corral Harbor	220	0	
Magazine Road	340	0	-
SW Terrace	320	0	-
Thousand Springs	380	0	-
Tufts-Shannon	340	0	-
West End	380	0	-
Totals	7,805	662	11.8

Table 6. Summary of cover board capture rates for island night lizards in different habitats on San Nicolas Island from 1984-85, and 1992-95.

Boards	**Board Checks**	**INL**	**Checks / lizard**
Miscellaneous	20	22	0.9
Eucalyptus	486	140	3.5
Cholla	528	101	5.2
Boxthorn	140	20	7.0
Haplopappus	1,667	218	7.7
Prickly pear	780	99	7.9
Coreopsis / Lupine / Baccharis	220	15	14.7
Coreopsis	360	20	18.0
Mixed scrub	904	20	45.2
Grassland	798	7	114.0
Bush lupine	940	0	-
Stabilized dune	380	0	-
Baccharis	360	0	-
Stipa grassland	220	0	-
Totals	7,805	662	11.8

Table 7. Summary of pitfall trap capture rates for island night lizards in different months on San Nicolas Island from 1984 – 85, and 1992-95.

Traps	**TD**	**INL**	**INL / 100 TD**
Jan	0	0	0.00
Feb	0	0	0.00
Mar	0	0	0.00
Apr	1,444	28	1.94
May	2,020	52	2.57
Jun	2,151	26	1.21
Jul	4,784	110	2.30
Aug	8,637	66	0.76
Sep	7,934	98	1.24
Oct	2,271	37	1.63
Nov	0	0	0.00
Dec	0	0	0.00
Totals	29,241	417	

Table 8. Summary of cover board capture rates for island night lizards in different months on San Nicolas Island from 1984 – 85, and 1992-95.

Boards	**Board Checks**	**INL**	**INL / 100 Checks**
Jan	0	0	0.00
Feb	0	0	0.00
Mar	0	0	0.00
Apr	692	51	7.37
May	1,228	146	11.89
Jun	1,148	63	5.49
Jul	1,098	108	9.84
Aug	1,201	66	5.50
Sep	1,089	110	10.10
Oct	1,349	107	7.93
Nov	0	0	0.00
Dec	0	0	0.00
Totals	7,805	651	

Table 9. Known and estimated ages for selected island night lizards on San Nicolas Island from 1984 – 85, and 1992-95.

No	Sex	First Capture	Len. (mm)	Est. Age (yrs.)	Last Capture	Len. (mm)	Recap. Interval (yrs.)	Est. Total Years
324	F	09/26/84	109.0	22.1	07/01/95	115.0	10.8	32.9
1053	M	05/28/89	108.0	21.2	09/22/95	110.5	6.3	27.5
305	F	09/13/84	102.0	15.7	05/26/95	110.0	10.7	26.4
250	M	09/12/84	96.0	10.2	10/27/95	104.0	11.1	21.4
2225	F	08/19/92	100.0	13.9	10/27/95	102.0	3.2	17.1
141	F	07/19/84	83.0	3.7	10/27/95	99.0	11.3	15.0
14	U	06/28/84	63.0	1.9	08/23/94	102.0	10.2	12.1
1034	F	09/25/85	75.0	2.8	05/28/94	111.0	8.7	11.5
511	U	09/05/85	69.0	2.2	08/23/94	102.0	9.0	11.2
1022	F	09/24/85	78.0	3.1	09/09/93	96.5	8.0	11.1
354	F	07/16/85	61.0	1.8	05/28/94	98.0	8.9	10.7
420	F	07/29/85	55.0	1.5	06/28/94	101.5	8.9	10.4
502	U	09/04/85	49.0	1.2	08/23/94	103.0	9.0	10.2
503	F	09/04/85	91.0	5.7	06/23/88	95.0	2.8	8.5
1054	M	02/21/90	72.0	2.5	10/27/95	99.5	5.7	8.2
1102	M	02/22/90	71.0	2.4	09/18/93	88.5	3.6	6.0
2121	F	07/17/92	61.0	1.8	06/30/95	92.0	3.0	4.8
2122	U	07/17/92	43.0	0.9	04/30/95	70.0	2.8	3.7

Table 10. Population estimate of island night lizards on San Nicolas Island. Habitat areas were measured or estimated off aerial photographs of the island, or were measured in the field. Night lizard densities (per ha) in different habitats are based on Fellers and Drost (1991b), or are from this study (for the boulder beach habitat). The density for mixed shrub is the figure given by Fellers and Drost for coreopsis / tarweed.

Habitat	**Area (m^2)**	**INL / ha**	**Population size**
Cactus	4,740	2,500	1,190
Boxthorn	500	3,200	160
Boulder beach	2,500	4,000	1,000
Mixed shrub	650,000	200	13,000
	Total		15,350

Table 11. Table 11. Numbers of alligator lizards at different sampling sites on San Nicolas Island, between 1984 and 1995. The Eucalyptus and Lighthouse sites were sampled in all years of the study between 1984 and 1995. The Monroe site was established in 1992 and sampled thereafter, and the Central Stipa site was established in 1994, and sampled in 1994 and 1995.

Site	Habitat	Number of lizards
Central Stipa	Stipa-Avena grassland	2
Eucalyptus	Short grass / scattered Haplopappus, with Lavatera and Eucalyptus	58
Lighthouse	Short grass / scattered Haplopappus	2
Monroe	Avena-Bromus grassland	4

Figure 1. Distribution of pitfall traps and cover boards used for capturing island night lizards on San Nicolas Island from 1984-85, and 1992-95.

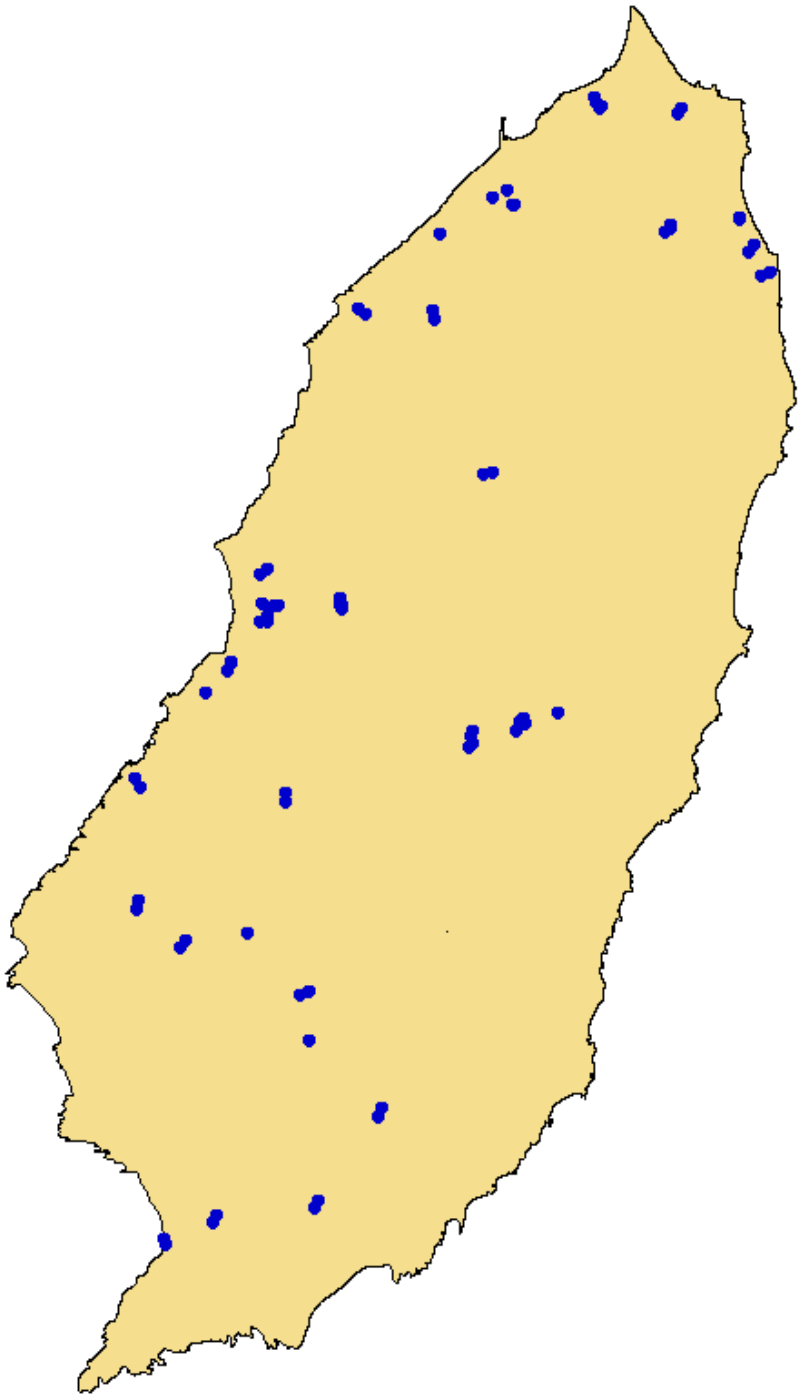


Figure 2. Mean monthly rainfall for San Nicolas Island from 1948 – 1995.

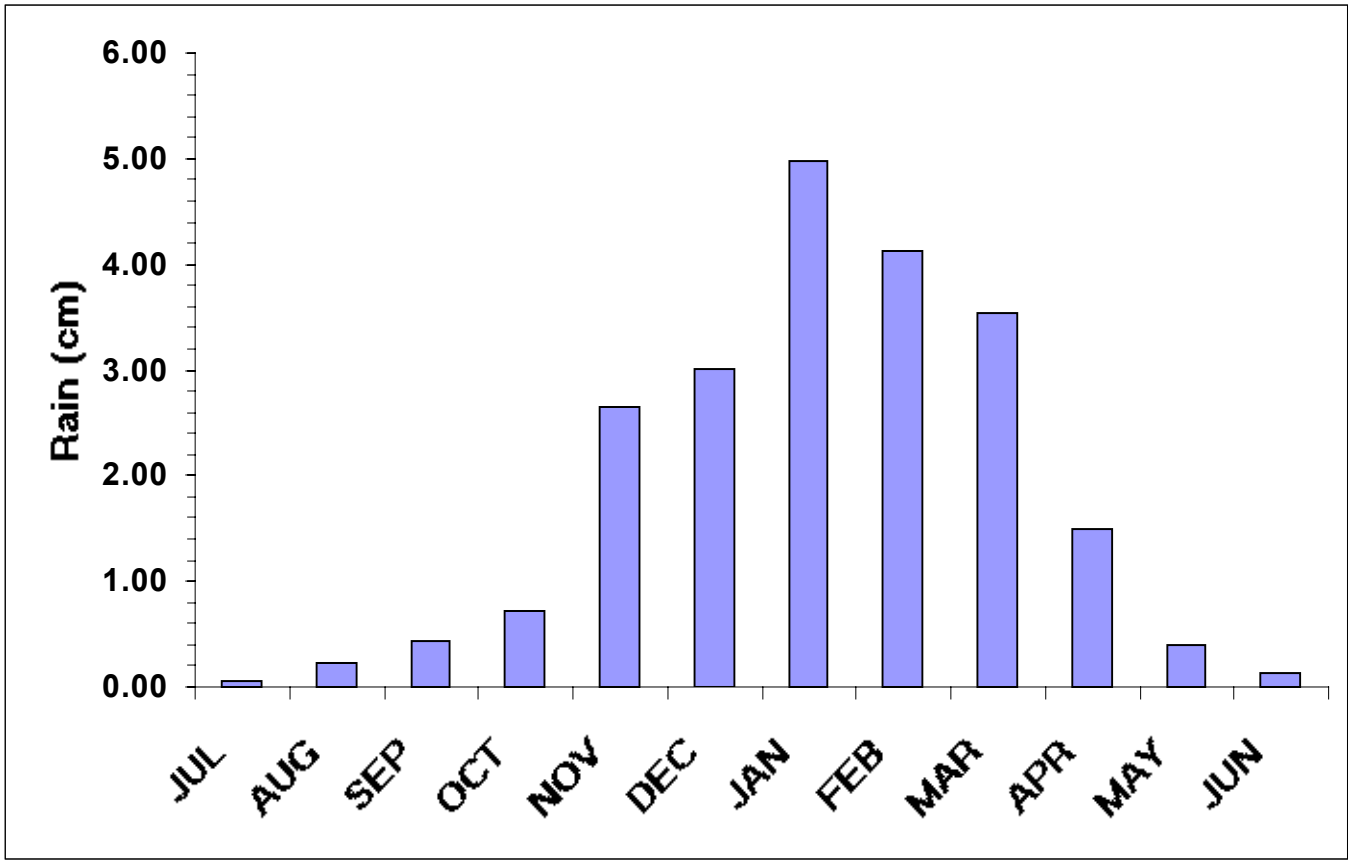


Figure 3. Annual rainfall for San Nicolas Island from 1981 – 95.

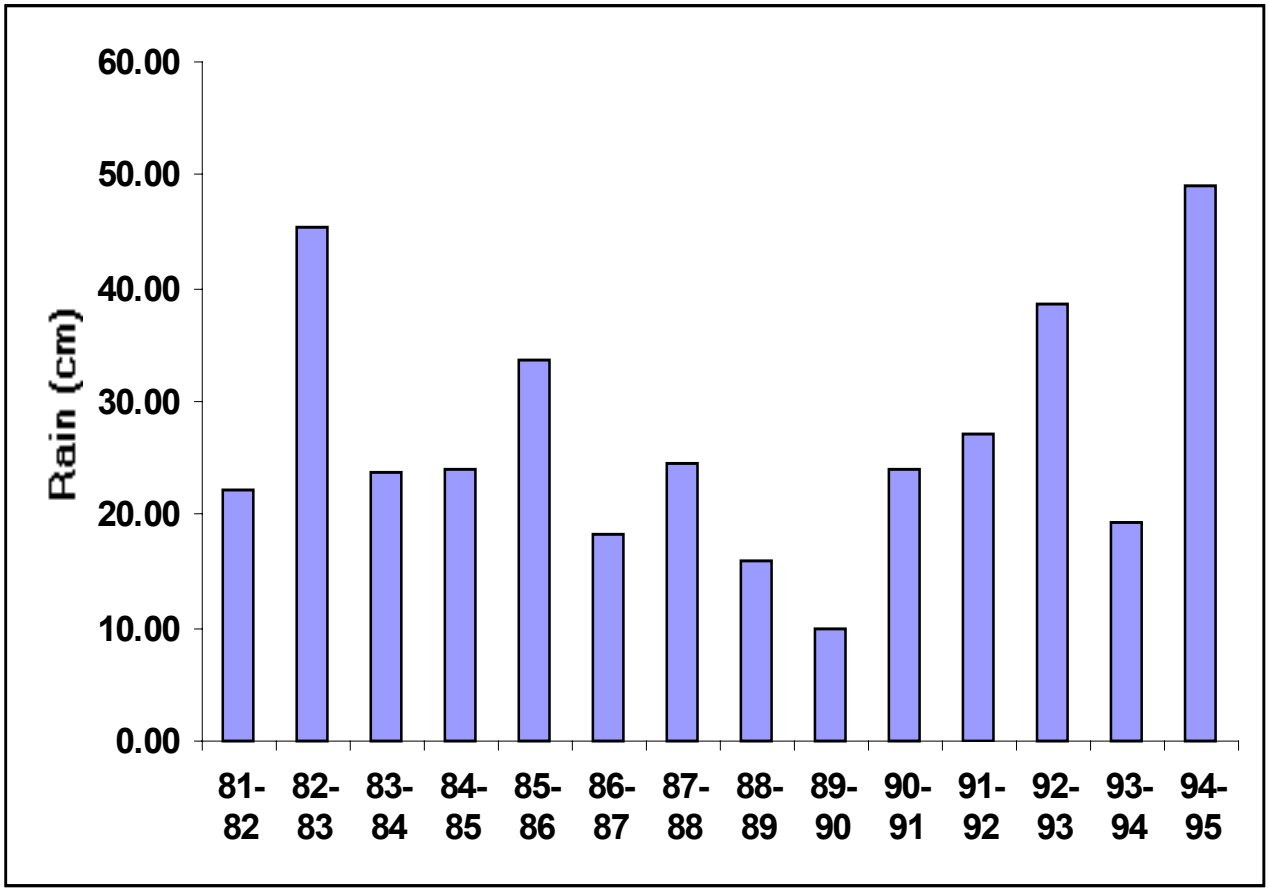


Figure 4. Pitfall trap success for island night lizards in different habitats on San Nicolas Island from 1984-85, and 1992-95.

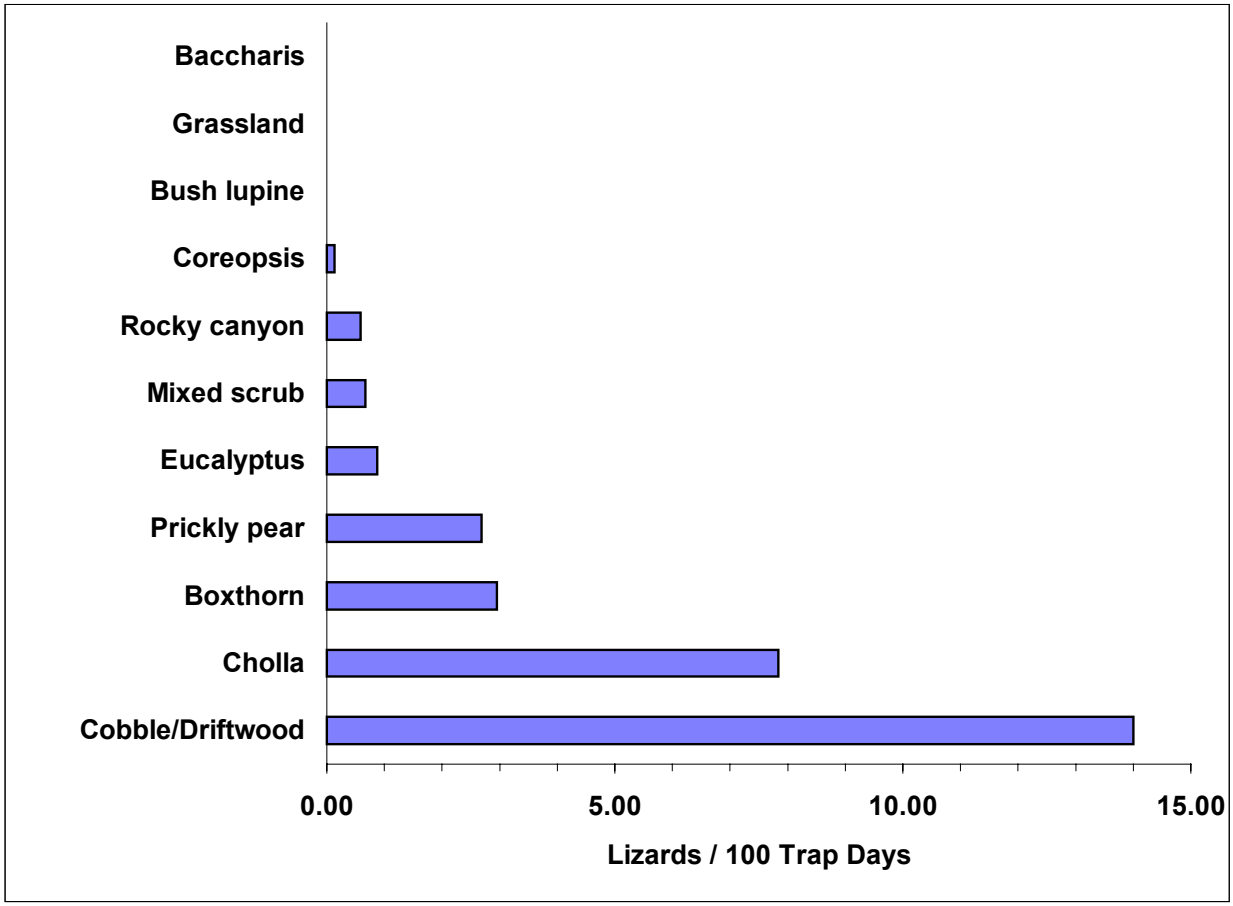


Figure 5. Cover board capture rates for island night lizards in different habitats on San Nicolas Island from 1984-85, and 1992-95.

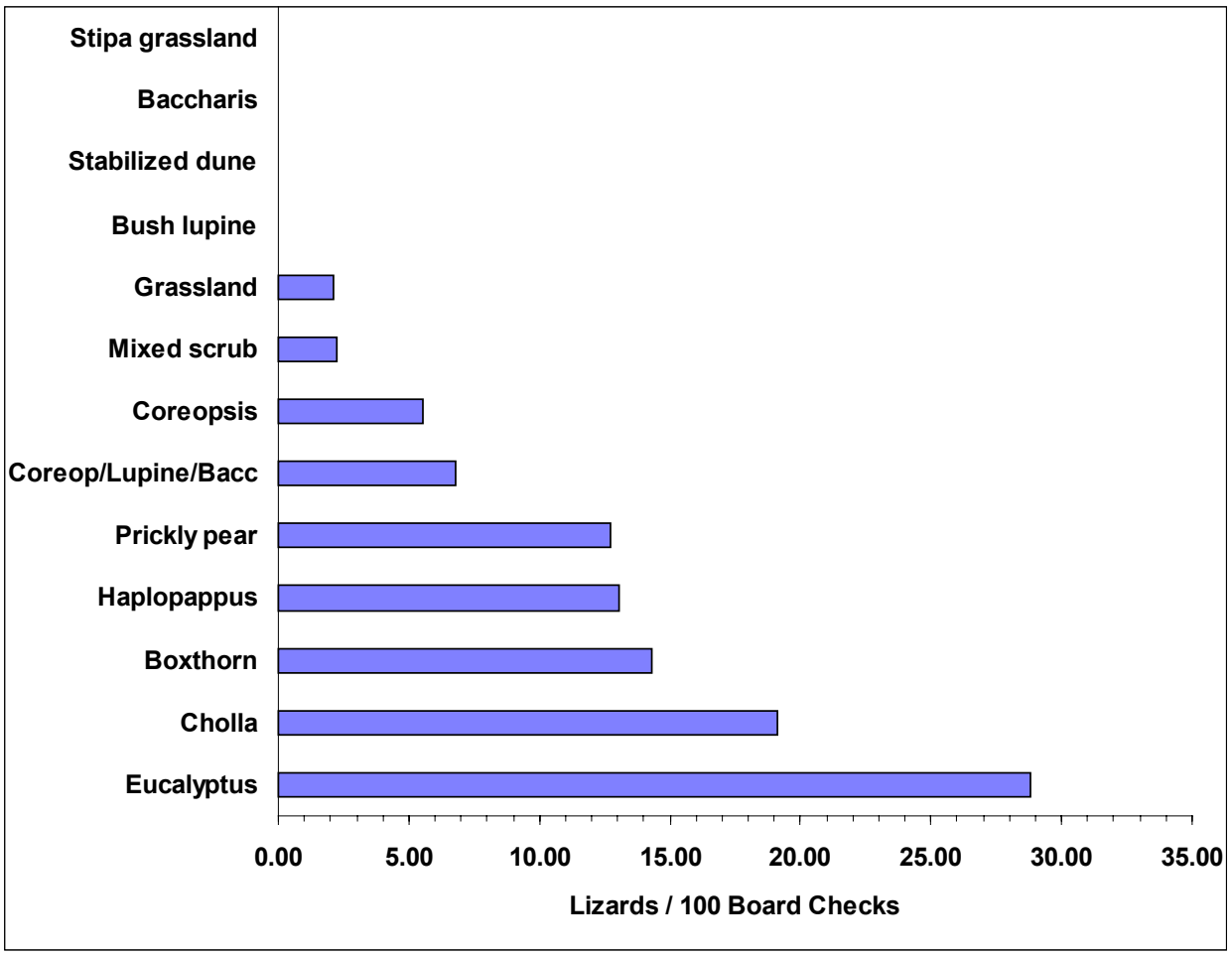


Figure 6. Summary of pitfall trap and cover board capture rates for island night lizards in different months on San Nicolas Island from 1984-85, and 1992-95.

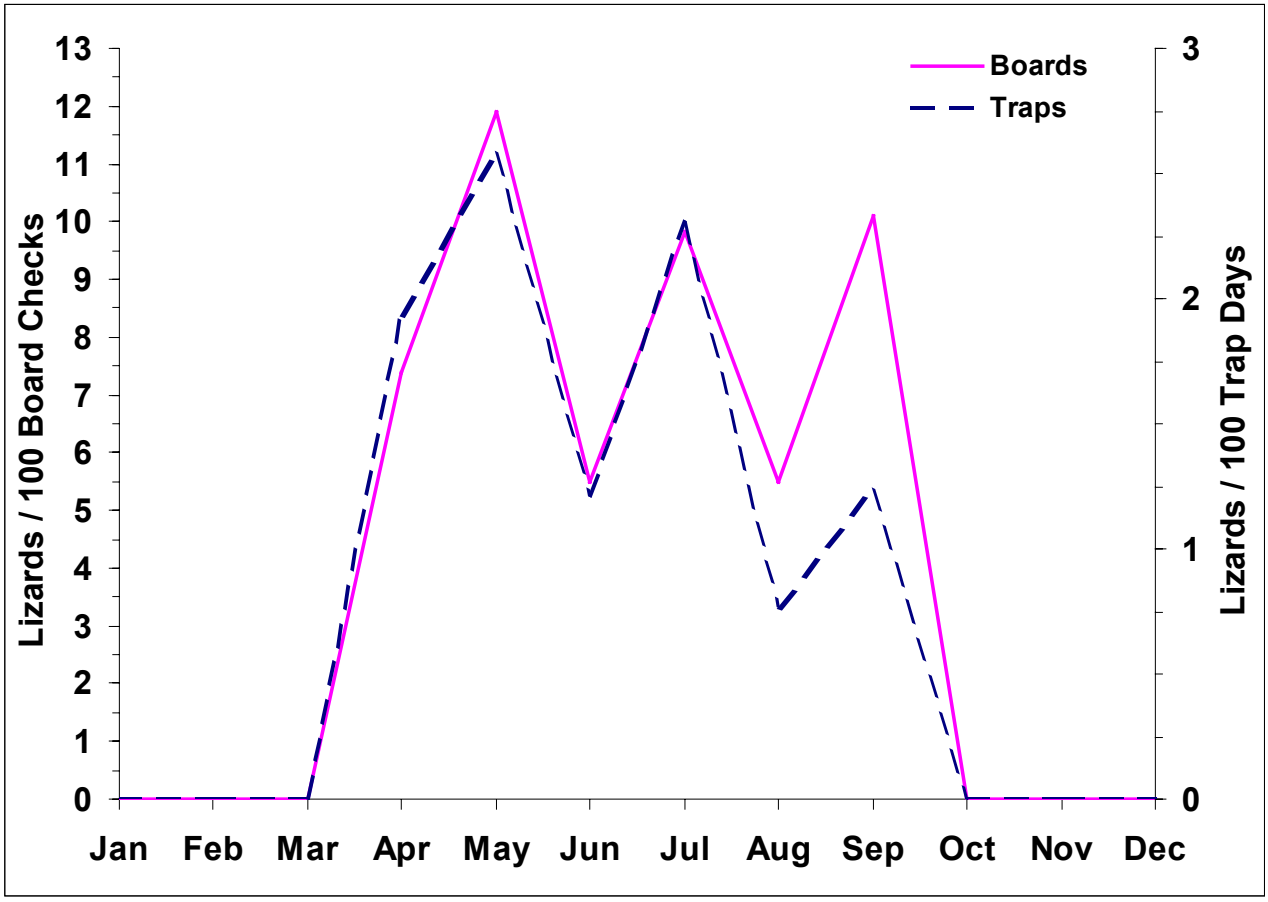


Figure 7. Size distribution for male, female, and unknown sex island night lizards on San Nicolas Island from 1984-85, and 1992-95.

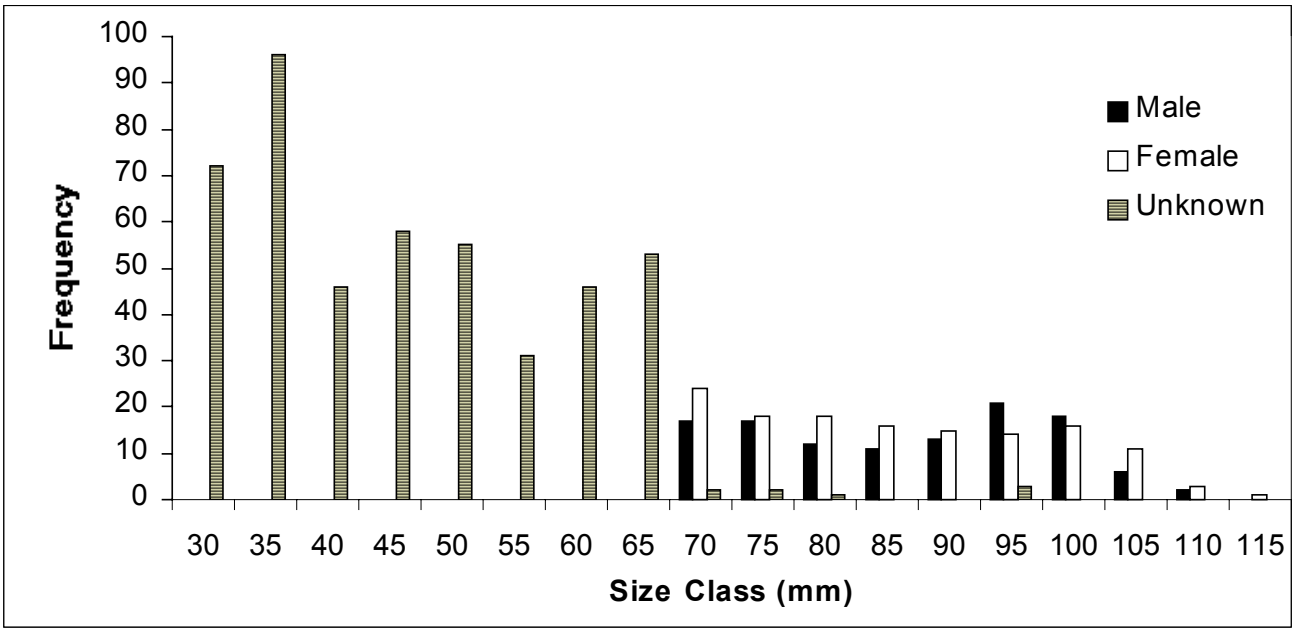


Figure 8. Size structure for island night lizards in cobble/driftwood habitat on San Nicolas Island from 1984-85, and 1992-95.

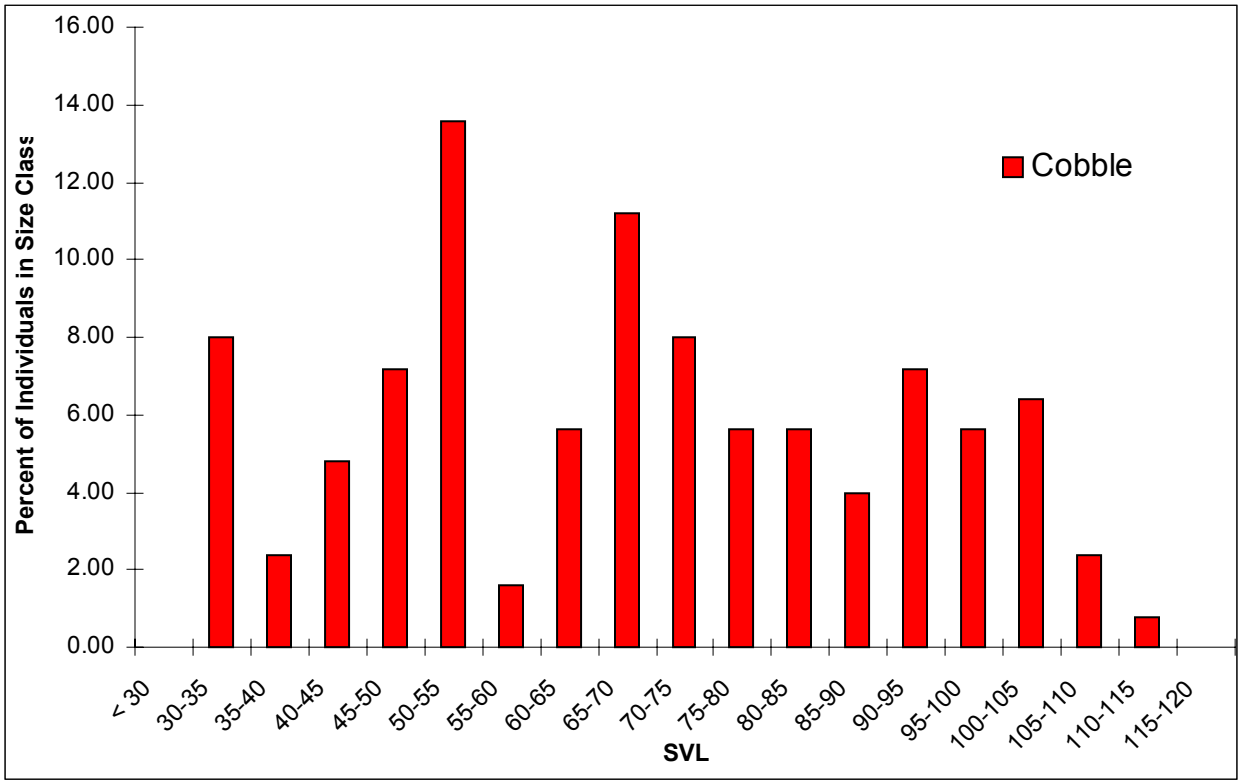


Figure 9. Size structure for island night lizards in cholla cactus habitat on San Nicolas Island from 1984-85, and 1992-95.

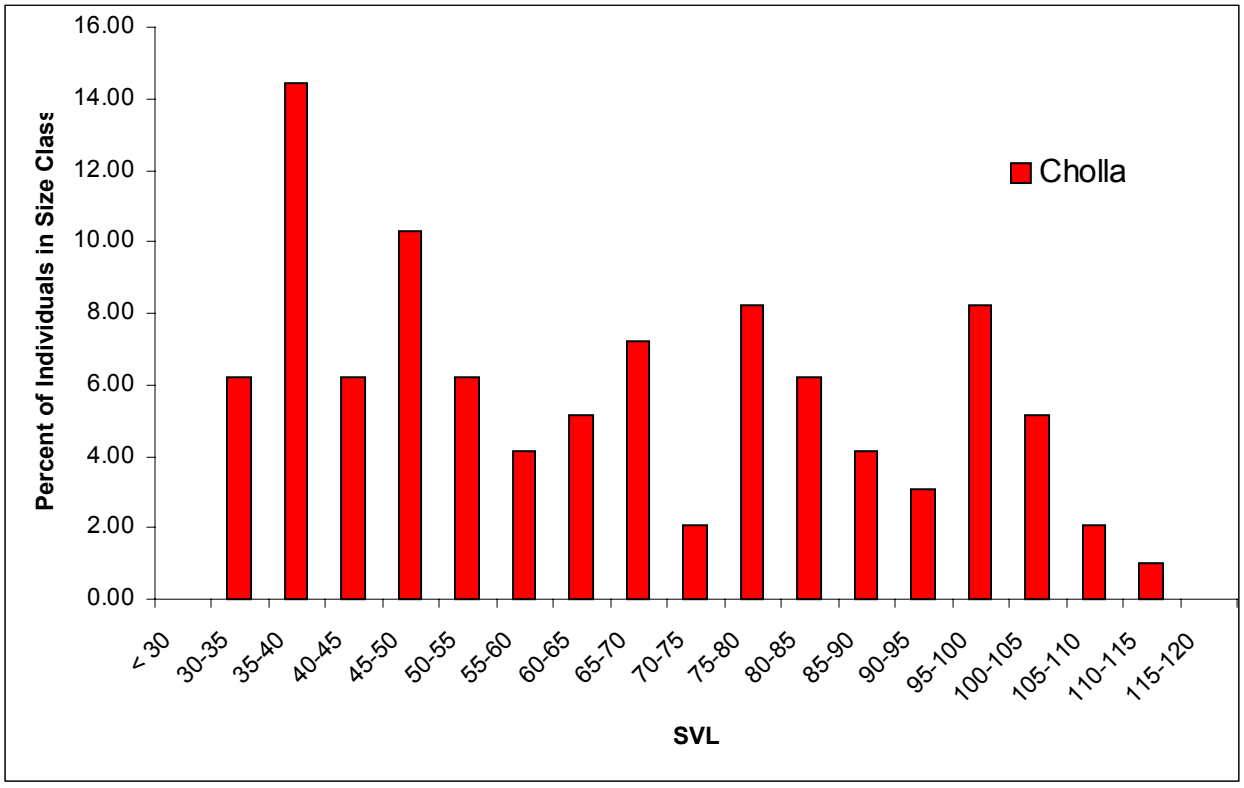


Figure 10. Size structure for island night lizards in prickly pear cactus habitat on San Nicolas Island from 1984-85, and 1992-95.

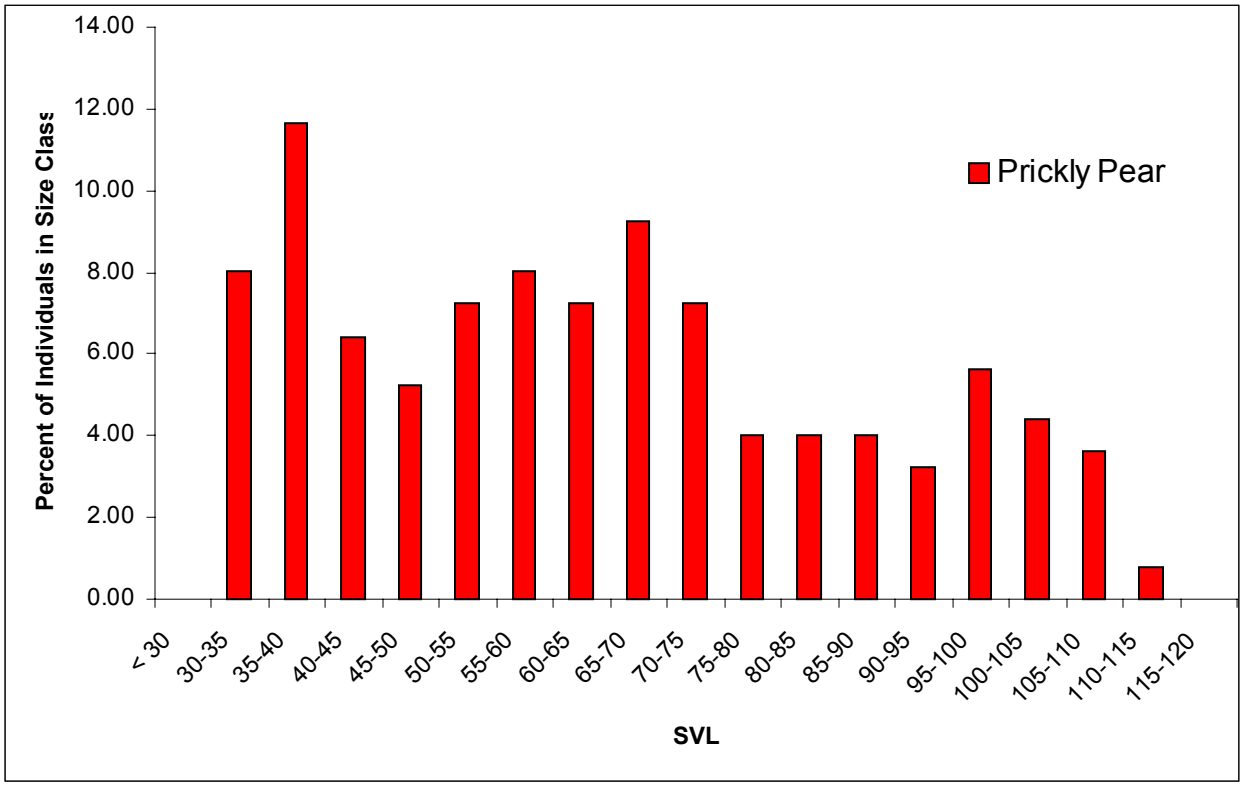


Figure 11. Condition index for island night lizards on San Nicolas Island from 1984-85, and 1992-95.

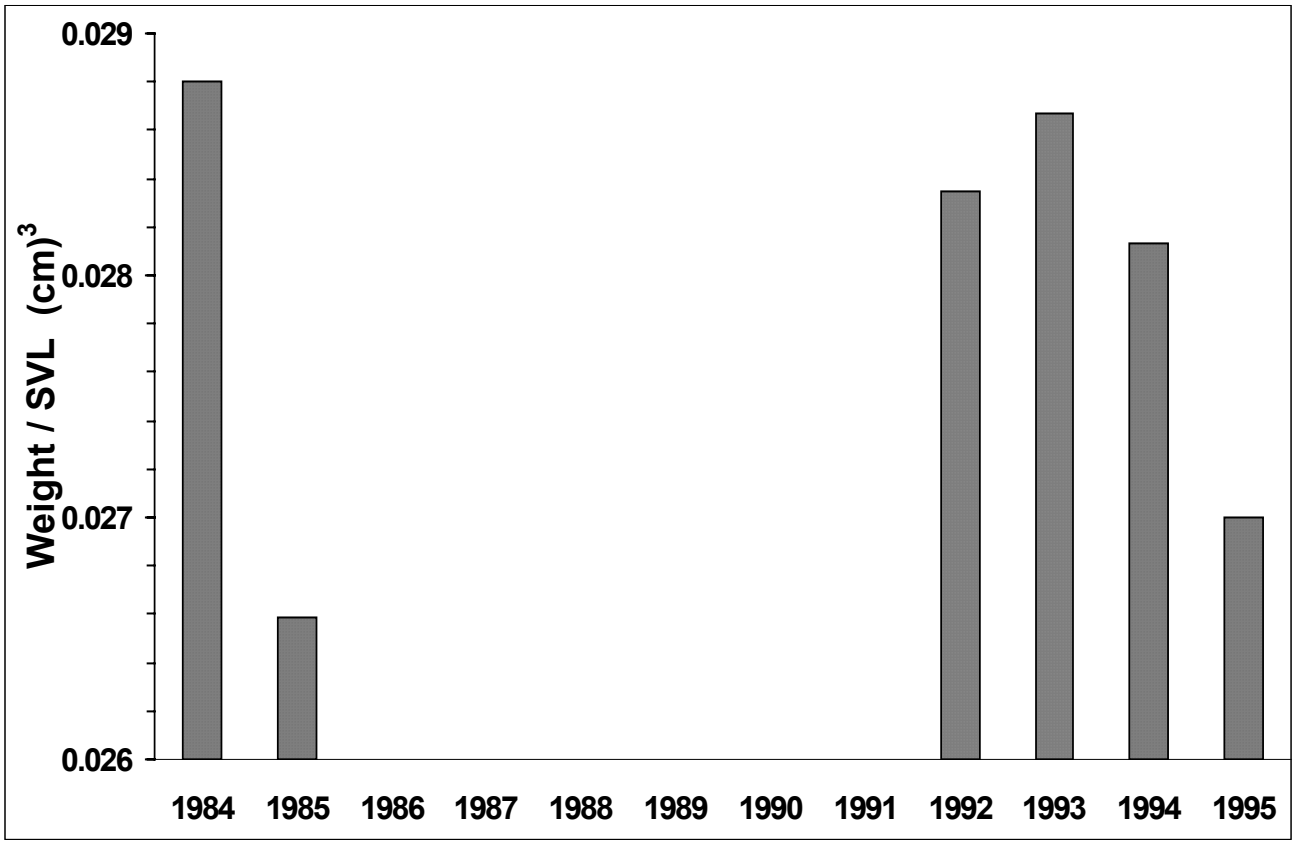


Figure 12. Condition index for island night lizards captured in the fall on San Nicolas Island from 1984 – 85, and 1992-95 for neonates (less than one year old), yearling, adult male, and adult female lizards.

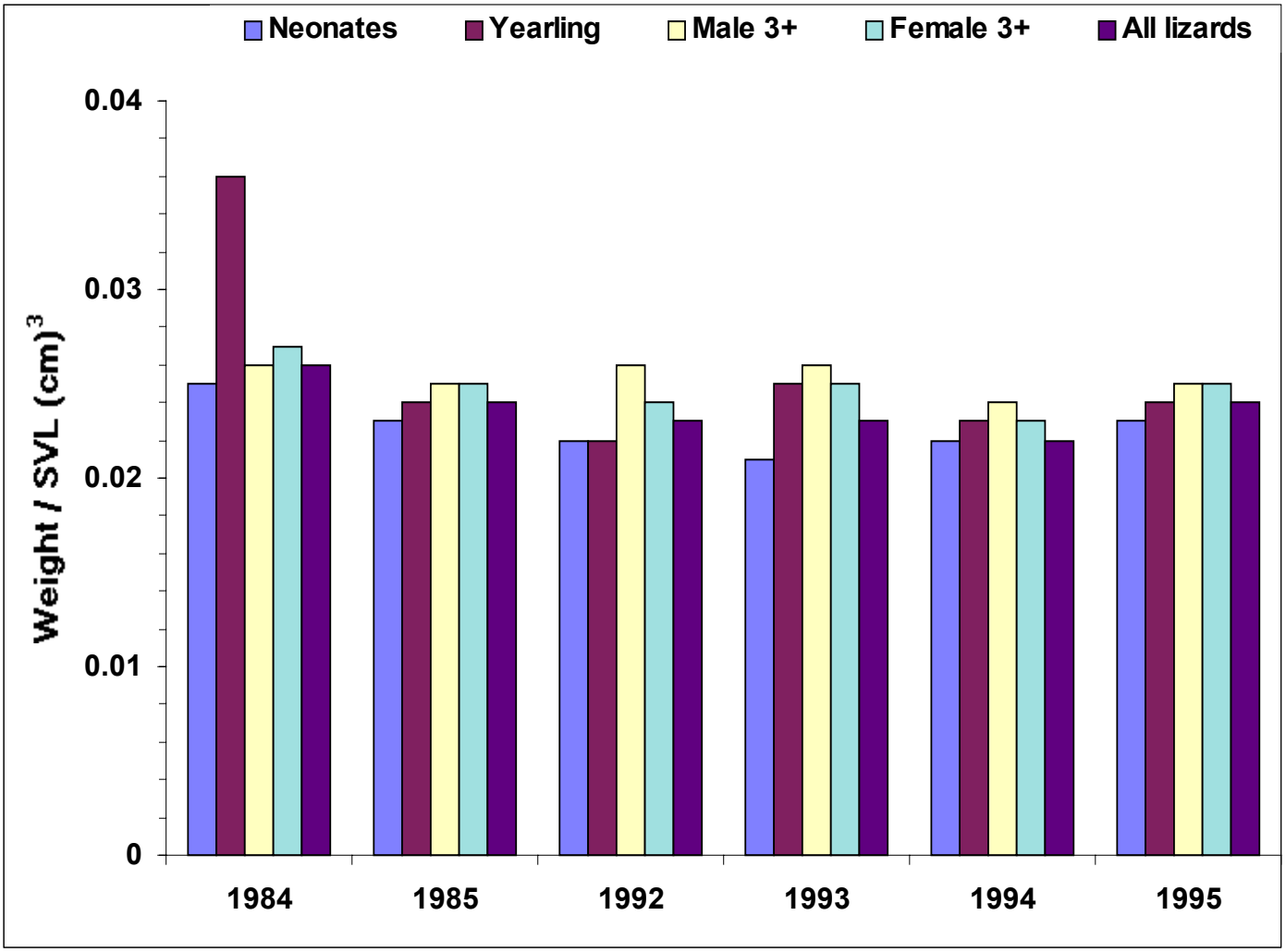


Figure 13. Estimated age of island night lizards at different SVL on San Nicolas Island from 1984-85, and 1992-95 (see Table 9).

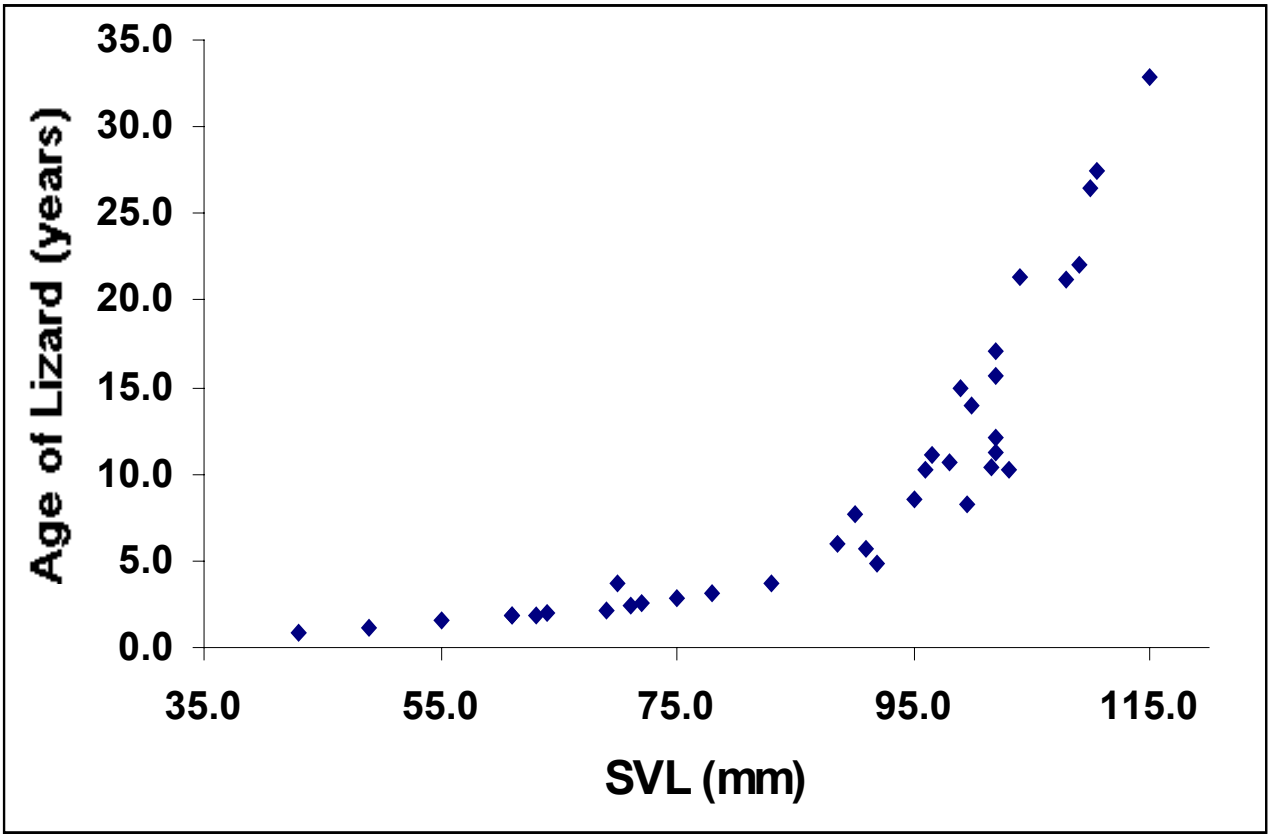


Figure 14. Distribution of 11 areas which represent prime habitat for island night lizards on San Nicolas Island. Each area is shown in yellow on the map. See Figure 15 for distribution of other, less suitable lizard habitats on San Nicolas Island.

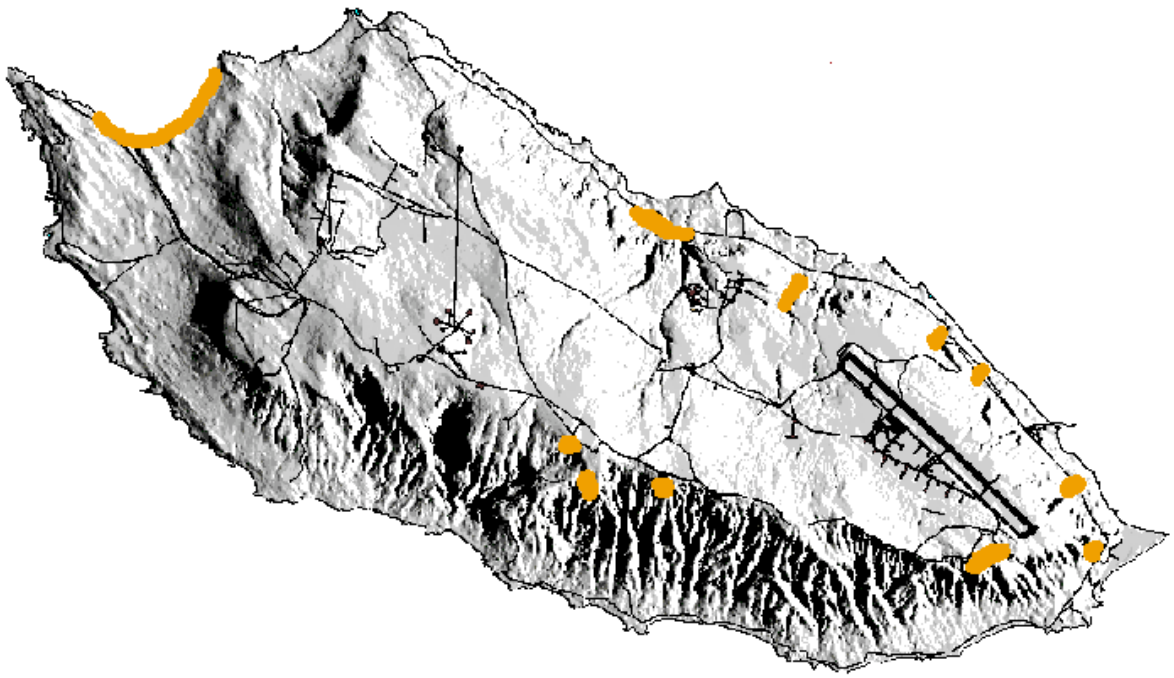
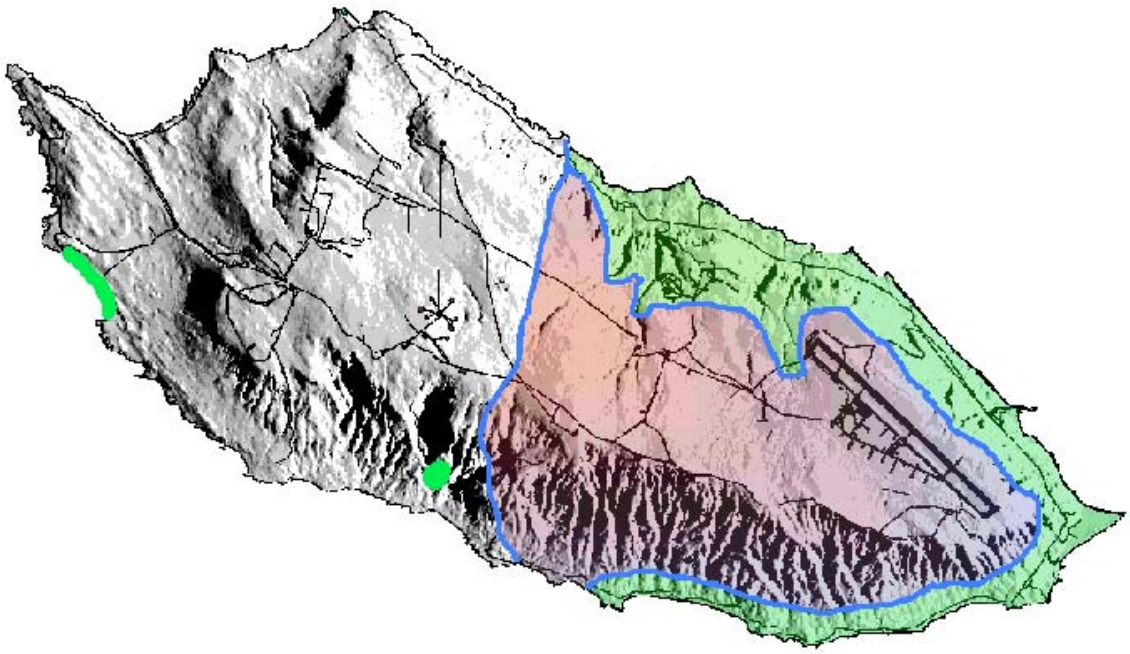


Figure 15. Distribution of areas on San Nicolas Island with moderate, low, and no island night lizard habitats. Moderate quality habitat (shown in green) includes the cobble / driftwood area along one beach (north of Cormorant Rock, towards Rock Crusher), an isolated area on the southern portion of the island, as well as the lower terrace all along the eastern half of the island. Low quality habitat (shown in dull red) is present on the other portions of the eastern half of the island. There are no island night lizards in nearly all of the western half of the island. See Figure 14 for the distribution of prime lizard habitat.



Appendix A. Trap and Cover Board Locations and Descriptions for San Nicolas Island, California. Notes in square brackets indicate alternate names that an area once had or the status of traps, e.g. if they have been removed and / or when they were installed.

Pitfall Traps

Tufts Lupine (traps 1-24): Bush Lupine Association [Tuffs Road Lupine; REMOVED]

Follow W leg of Tuffs Road 0.2 mi N from junction with Jackson Highway. Turn off of road (left) at inconspicuous gravel road, and park. From this junction, walk 35 m W (diagonally from junction of Tuffs Road and gravel road) to the first trap. Transect is oriented 320^{o} true, and consists of 2 rows of 12 traps.

Tufts Baccharis (traps 25-48): Baccharis / Lupine dune association [Tuffs Road Baccharis; REMOVED]

Begin along Tuffs Road 0.1 mi E of turn to Magazine Road (the "T" shaped road along the N side of Tuffs Road). This point on the road is S of the Missile Assembly Building (290C), along the W side of the crest of the small hill that slopes down to Magazine Road. Walk S 75 m to the first trap. From the first trap, it is 212^{o} to the westmost "golf ball" radar dome. The trap set consists of 2 rows of 12 traps, oriented 200^{o} true.

NAVFAC PP (traps 49-73): Prickly Pear / Haplopappus [NAVFAC Prickly Pear / Haplopappus]

Park in the NAVFAC parking lot and, from the edge of the road between the NAVFAC building and the broad gully, walk 100m SSE to the Prickly Pear patch along the W rim of the ravine. The first part of the transect winds around the cactus patch in a counterclockwise direction, beginning at the N corner and ending down in the gully on the far side. The second part of the transect begins at the next Prickly Pear patch, 75m to the S, and circles halfway around that patch in a counterclockwise direction.

Daytona BBQ (traps 501-525): Haplopappus scrub (Haplopappus / Lycium) Barge Landing / Daytona Beach Haplopappus]

Walk down Beach Road 350m W from the "Cat House" at the Barge Landing. This will bring you to a point 120m E of an old cinder block barbecue grill; traps are 50m N of the road.

Beach Rd. Coreopsis (601-625): Coreopsis [NAVFAC Coreopsis - abandoned because it is not near NAVFAC]

Follow Beach Road 0.6 mi S of its junction with the dirt road leading NW toward NAVFAC. Stop at a large Baccharis along the right (landward) side of the road. This is SE of L Canyon, and 0.2 mi N of jet fuel tanks 123, 124, and 125. The grid is on the landward side of the road; walk up the left (S) side of the gully 75 m to the first trap.

NAVFAC Boxthorn (701-709): Boxthorn [DEPLOYED in April 1994]

Park at the top of the rise just W of the "Chukar Crossing" sign E of NAVFAC. Walk between the telephone poles, which are 2 and 3 poles SE of the one with the Kestrel nest box. The first three traps are around a single boxthorn clump past the telephone lines. The next nine traps are around the SE side of a large boxthorn clump partially surrounded by morning glory, prickly pear and a large Myoporum (evergreen shrub).

NAVFAC Grid (911-935): Grassland / Boxthorn [grid established by Tom Murphy in 1984]

This grid is located on the E side of the gully that runs past the E side of NAVFAC (i.e. on the opposite side of the same gully where our NAVFAC Prickly Pear set of traps is). This is a 5 x 5 grid of traps, trap spacing 3 m, immediately adjacent to the gully approximately 75 m S of the NAVFAC road. Access is via a recent road scrape (beginning to grow over) that parallels the gully along the E side (fiber optic cable route).

Desal Canyon (940-950): Canyon [transect established by Tom Murphy in 1984]

These traps are located on the S-facing slope of "Desal Canyon," the large canyon that empties out at the desalination plant along Beach Road N of the Sand Spit. The trap line is divided into 2 sets (6 traps in the lower section, 5 traps in the upper) and trap spacing is

approximately 3 m. The first trap is at the upper end of a N - S trending berm on the S-facing slope of the lower canyon, where the canyon makes a left-hand turn toward the mesa approximately 75 m from the road. The next 5 traps are in a line going up-canyon along the canyon slope. The second part of the transect begins approximately 150 m up-canyon, on the left side of the canyon (as you walk up-canyon), at the upper edge of a very large Prickly Pear patch that spreads down the S-facing canyon slope. The other 4 traps proceed in a line up-canyon, up and over a small ridge.

Opuntia Grid (1001-1025): Prickly Pear [grid established by Tom Murphy in 1984].

This is a 5x5 grid of 25 traps, in a large, dense prickly pear thicket along the west side of the gully formed by Mineral Canyon, south of the NAVFAC road and about 200 m east of the NAVFAC building. Spacing between traps (which are now overgrown with prickly pear) is 3 m. This site is not shown in Figure 1, but is just east of the NAVFAC Boxthorn traps (701-709)

Cholla Transect (1101-1110): Cholla [transect established by Tom Murphy in 1984].

This transect of 10 traps is located along the base of a 2 m high sandstone outcrop, just below the SE Cholla board transect. Spacing between traps is 3 m. The site is southeast of Building 121 and southwest of the east end of the airstrip, at the edge of the bluff overlooking Daytona Beach. These traps are now overgrown with heavy cholla.

Lupine Grid (1201-1225): Bush Lupine Association [grid established by Tom Murphy in 1984; removed in 1988].

This 5x5 grid of 25 traps was located south of Tuffs Road and west of the intersection of Tuffs with Shannon Road. Spacing between traps was 3 m. Vegetation in the trap area is bush lupine and silver beach weed.

Grassland Grid (1301-1325): Grassland [grid established by Tom Murphy in 1984; removed in 1988].

This 5x5 grid of traps was located on the north side of the spur road between Owens Road and Harrington Road (north of Building 182, the Telemetry Building). Spacing

between traps was 3 m. Vegetation at the site consists of introduced annual grasses (*Avena*, *Bromus*), Australian saltbush, and associated annual plants. The traps were removed in 1988, and the location is not shown in Figure 1.

NAVFAC Transect (1401-1415): Mixed Shrub [transect established by Tom Murphy in 1984].

This transect is located on the terrace south of the NAVFAC building, west of the gully that runs past the NAVFAC building on the east side. It was originally established as a transect of 16 traps, starting at the base of the bluff at a prominent erosion scar south of NAVFAC (trap 1), and extending to the edge of the NAVFAC Prickly Pear group of traps (trap 16). Distance between the traps was 10 m, with stakes every 20 m. When the NAVFAC Prickly Pear group of traps was established in 1992, trap 16 was incorporated into it, and the remaining NAVFAC Transect traps re-numbered as 1401-1415. Vegetation in the area is mixed Haplopappus, Prickly Pear, other shrubs, and annual grass. Traps 1409-1414 removed Sept. 20, 1994. Board 1415 was buried by a landslide. Other traps were removed at a later date.

Redeye Transect (1501-1510): [transect established by Tom Murphy in 1984].

This transect is located at the back of Red Eye beach, west of the point where the dirt road turns to follow the shoreline in a northeasterly direction. The transect consists of 10 traps at 3 m intervals, and runs parallel to the shoreline. It is located between the boulders and cobbles that make up the beach on the ocean side, and piled driftwood, sand verbena, and other beach plants on the land side. This beach area is heavily disturbed by wave action during storms, and most or all of these traps have been washed away. We could not find any of them still in place during the 1992-95 surveys.

Eucalyptus Grid (1601-1625): [grid established by Tom Murphy in 1984].

This 5x5 trap grid is located south of, and down slope from, Building 182 (Telemetry). It is in the same location as the Eucalyptus boards (421-430), with the up slope rows of the grid located under the canopy of Eucalyptus and Lavatera at this site. Traps 21 and 22 at the up slope northwest corner of the grid were buried in August 1984, under dirt and

debris dumped from the top of the slope above. Except for the buried traps, these pitfalls have been removed. Traps 1601-1611, 1613-1618, and 1620-1622 were removed July 26, 1994.

Cover Boards

West End (boards 101-120): Stable Dune [Dizon's Ravine]

Follow the Jackson Highway 0.2 mi W of the turn to Red Eye Beach (i.e. at the fork in the road, go left 0.2 mi). Stop at the dirt road on the left (S), just past bunker 275. Walk 150 m along the dirt road to the conspicuous vertical white pipe, then walk another 20 m SE (toward the hilltop). Transect runs toward leftmost theodolite on the hill.

Magazine Road (boards 121-140): Stable Dune - Lupine

Transect parallels the W end of Magazine Road (the T-shaped road on the N side of Tuffs Road), just N of the crest of the dune ridge. To reach the beginning of the transect, walk 140 m W along the road from the intersection of the "T" (toward the bunkers), then turn and walk 40 m S.

Ocean Coreopsis (141-160): Coreopsis [North beach terrace]

Drive down the NAVFAC Road from the barracks / living compound area to the bottom of the hill and turn E on the dirt road leading toward Beach Road. Go 75 m down this dirt road to the yellow gate and park. The transect starts 65m at 320o magnetic from this gate (just past a lone, dead Coreopsis, at the head of a broad gully), and runs NW (toward the rightmost of the large stable dunes visible along the edge of the island). Spacing is 5m.

Chukar PP (161-170): Prickly Pear [NAVFAC Prickly Pear]

From the "Chukar Crossing" sign on the NAVFAC Road, transect is on the N (ocean) side of the road on the W side of the ravine, 55 m (N) from the 2 yellow upright pipes / posts. Spacing 3m.

Barber Pole (171-180): Prickly Pear [Beach Road Prickly Pear]

This group of boards is along Beach Road where it runs along Coast Guard Beach (NE side of the island) after the road comes down the hill from the airfield. Take Beach Road 0.25 mi SE from its junction with the dirt road to NAVFAC, to the 1st pair of black and

white "barber poles" on the ocean side of the road. Transect is in the gully on the SW (land) side of the road. The gully has 2 branches on the land side of the road, and the boards are on the S side of the wedge of land between the branches, 45 m W of the road.

Beach Cholla (181-189): Cholla ["Burma Shave" Cholla]

These boards are around a cholla stand on the N side of a large gully on the ocean side of Beach Road, 0.6 mi SE of the three storage tanks numbered 123, 124 and 125 (counting from the storage tanks, the site is 19 telephone poles down, just past a mud cut bank on either side of the road). Walk 40 m E from the road, through a small gully, to the cholla; the boards start on the near side of the cholla, and follow the edge of the stand in a clockwise direction.

Beach PP (190-199): Prickly Pear ["Burma Shave" Prickly Pear]

This transect is along the land side of the road, just SE of the preceding set of boards (i.e. between 0.6 and 0.65 mi SE of the storage tanks), and just N of a broad gully. There is a stand of Prickly Pear in a slight depression here, surrounded by Coreopsis, and the boards begin on the near side of this cactus stand, 10 m E of the road.

Airstrip (201-220): Avena / Bromus grassland [Airfield Grassland]

Site is N of NW end of the airfield; follow Beach Road 1.25 mi NE from its junction with Monroe Drive, then turn onto a dirt road that heads S toward the W end of the runway. Walk 90 m down this dirt road, then walk 18 m E to a broad, low Haplopappus, where the first board is located. The transect runs toward the ocean, just past the large Coreopsis near the edge of the terrace.

SE Cholla (221-231): Cholla [Field Station Cholla 1, board 232 overgrown and lost]

Walk SE from the Research Station (Bldg. 121) to the edge of the plateau above Daytona Beach and the barge landing. Transect runs E along the edge of the cholla patch, at the top of the slope.

Red-eye (231-250): Dune Association [Red Eye Dunes]

Site is NE of "slam" buildings, SE of small wooden shack along Red Eye Beach. From the Jackson Highway, go down the hill toward the west end. Turn onto the road to Red Eye Beach (this is the right fork in the road, onto a sand road beside a wood blockhouse with a "Danger / High Voltage" sign on it) and follow it for 0.45 mi. This will take you past a fallen wooden lattice structure, and 100 m beyond a second fork in the road - stay to the right at the fork. Stop at the 2 white concrete posts along the R side of the road. Walk 45 m W to the beginning of the transect.

SW Terrace (251-270): Haplopappus scrub [Building 165 Haplopappus]

Site is in Haplopappus scrub E of Building 165 complex. From the W end of the Jackson Highway, take the dirt road that leads S from Building 165 for 0.15 mi. Transect begins 30m E of a dip in the dirt road, at a small Baccharis pilularis. Transect runs 272o magnetic toward high point of caliche ridge.

Bunker (271-290): Baccharis grassland [Tuffs Road Baccharis Savanna]

From the W end of the Jackson Highway, turn N onto Tuffs Road and drive 0.5 mi. Turn right onto a dirt road just beyond a sharp curve in the road. Walk 225 m down this dirt road, past a bunker / magazine, and 30m beyond the last "Buried telephone cable" sign. Transect begins at a clump of Baccharis pilularis along the R side of the road, and heads SE toward the "golf ball" radar buildings.

Monroe (291-310): Avena grassland [East Grassland]

Transect begins just S of the junction of Beach Road and Monroe Drive. Start at yellow "Buried Telephone Cable" sign and proceed SW toward the tower on the ridge.

Daytona West (311-330): Haplopappus scrub Daytona Haplopappus 1]

This site is on the land side of the Daytona Beach Road at the yellow metal gate W of the barge landing. From the "Cat House", go W 1050 m (ca. 0.7 mi) to the gate. The transect begins 20 m N of the road and runs 320o magnetic toward a small sand hill.

Daytona East (351-370): Haplopappus scrub [Daytona Haplopappus 2]

This site is also on the land side of the Daytona Beach Road W of the barge landing. It is 700 m W of the Cat House (ca. 0.4 mi), and 10 m E of a culvert under the road, with concrete bag retaining walls. The transect begins 25 m N of the road and runs 300^{o} magnetic through a broad gully.

Tufts-Shannon (371-390): Haplopappus scrub [Shannon / Tuffs Haplopappus]

Site is N of the junction of Shannon and Tuffs Road. Transect begins 40m NE of the road junction, and runs toward the buildings at the W end of the barracks / compound area.

Thousand Springs (391-410): Bush Lupine

Take Shannon Road toward Thousand Springs, 1.1 mi from the junction of Shannon and Tuffs. This will take you just beyond (NW of) the pumping station. Stop at the 4 yellow posts along the NE side of the road, just past a concrete culvert under road. Transect is on the far side of the ravine that parallels the road, ca. 150 m W of the road; follow the small gully that runs under the road, then cross the ravine. The transect runs in a westerly direction.

Lighthouse (411-420, 453-485, 956-964): Haplopappus Grassland [Tower 68. Additional plywood deployed September(?) 1993 and June 26, 1994]

This is one of Tom Murphey's sites. Park at Building 112 along the N side of the Jackson Highway, and walk 35 m SSW from the SW corner of the building. The boards are set out around scraps of old plywood lying on the ground. Additional plywood is set out in arms radiating west, south, and east.

Eucalyptus (421-430, 490-500, 951): Eucalyptus - Lavatera – Haplopappus [Telemetry Building (182); <<Todd Wills' map shows 424-433 instead of 421-430>>]

Another of Tom Murphey's sites. Park at Building 182. From the shrubs and trash next to Building 183 (behind 182), go down slope (SE) 25 m. Boards are set out in a counterclockwise loop, beginning on the down slope edge of the eucalyptus and Lavatera.

Terrace Cholla (431-435): Cholla [Field Station Cholla 2]

Boards are around the edge of moderately dense cholla patch on the terrace just N of the Field Station Cholla 1 site (i.e. SE of the Field Station, near the bluff edge).

Theodolite (441-452): Prickly Pear

Follow the Theodolite Road (this is the old dirt road that leads down to the S side of the island from the SE corner of Building 148) to the boulders that barricade the road. Walk 350 m down the road to a large stand of Prickly Pear along the left side of the road. The boards start at the upper end of the stand and run downhill.

East NAVFAC (801-820): Haplopappus [DEPLOYED May 29, 1994]

Transect is East NAVFAC Road 0.4 mi W of Beach Road, just beyond (W of) a spur road that runs down to the ocean (East NAVFAC Road is the dirt/sand road connecting Beach Road and NAVFAC Road, on the N side of the island). From the spur road, walk 25 m W along the road, then 23 m S (landward) from the edge of the road. First board is at a bush lupine on a low prominence. Transect runs S, essentially perpendicular to the road.

Corral Harbor (821-840): Lupine [DEPLOYED May 29, 1994]

Transect is along West NAVFAC Road, where a spur road runs down to the ocean just W of the W end of Corral Harbor, 1.3 mi W of the NAVFAC Station (West NAVFAC Road is the dirt/sand road that runs towards Thousand Springs from the NAVFAC Station). Transect begins at a Coreopsis / Lupine clump on a sandhill approximately 25 m S of the road (i.e. on the land side), and runs in a SW direction, toward the theodolite on the bluff top.

Tranquility (841-860, 903): Mixed Scrub [DEPLOYED May 29, 1994]

Transect is located 0.3 mi W of NAVFAC just beyond an old section of standing fence line on the ocean side of the road. Transect is on the land side of the road; from the westmost of the 5 wooden fence posts, walk 29 m W along the road, then 10 m S of the

road. First board is by a boxthorn clump, just W of a small gully. Transect runs in a westerly direction, diagonally across the terrace toward the white-faced hill and slope break on the skyline. Board 903 is a large board (ca. 4 x 5 ft.) and is 10 m S of board 845 (perpendicular to transect).

Central Stipa (861-880): Stipa grassland [DEPLOYED May 29, 1994]

This transect is just N of the Jackson Highway, 50 m E of its intersection with Shannon Road. From the "Cable Route" sign on the N side of Jackson Highway, walk 24 m N (perpendicular to the road) to the first board (861) next to a Baccharis shrub. Boards 861-870 run approximately SE, to the right of the tall red and white radio tower. Board 871 is 70 m NE of board 870, toward the smaller red and white radio tower. Boards 871-880 run directly toward the tall red and white radio tower.

Celery Canyon (881-902): Coreopsis / Lupine / Baccharis scrub [DEPLOYED May 30, 1994]

This transect is between Celery Canyon and Mineral Canyon, and is reached from the Navy "boneyard"/ dump at the W end of the Public Works area (W of the gas station). Follow the trail from the bulldozer cut on the E side of the canyon, up to the W rim of the canyon via a small ridge that extends down into W side of the canyon (this is directly across from the bulldozer cut; note survey marker on W rim of canyon at this point). From the W rim, walk 38 m W to a large, broad coreopsis where the first board is located. Transect runs in a westerly direction, toward the 5th utility pole, counting from the ocean bluff. The transect crosses the old barbwire fence line at board 893, and ends 12 m from the 5th utility pole. Boards 901 and 902 are large boards located 10 m S and N, respectively, of board 893.

Board 904: Baccharis / Coreopsis / Haplopappus [DEPLOYED May 31, 1994]

Large board (ca. 4 x 6 ft.) located 0.55 mi. W of NAVFAC, at W end of Tranquility Beach cove (a large reef is just offshore at low tide). Board location is just E of a medium-sized gully separating Coreopsis-Baccharis-grass habitat (E of gully), and Bush Lupine association (W of gully). Board is 29 m S of the road, in a clump of Baccharis, Coreopsis, and Haplopappus.

Beach Boxthorn (961-980): Boxthorn [DEPLOYED October 26, 1994]

Located off the SE end of the Airstrip N of Beach Road, 0.6 mi from the Barge Landing parking area and 1.3 mi SW of the Desal Plant. Counting from the Barge Landing, the transect begins between telephone poles 5 and 6. The transect begins at a 5' cholla about 25 m N of the road and runs along the E side of the gully. The boards are not evenly spaced, but rather are placed adjacent to boxthorn. The last 10 boards circle a large boxthorn clump and a few outlying boxthorn bushes. These boards are not standard size. They consist of two pieces of 12" x 12" x 2" nailed together.

Taxiway (2074-2076): Haplopappus grassland: [DEPLOYED 2 & 3 August 1995].

These are three large pieces of scrap plywood along the road on the south side of the airstrip, about midway between the east and west ends of the airstrip (east of the terminal and associated buildings). They were set out as cover for several large night lizards that were found when Navy crews removed two large above-ground fuel tanks that had been located at the site. The vegetation at the site is moderately dense Haplopappus and annual grass.

Appendix B. Plant species referred to in the report, along with scientific names. See Junak (1992) for a complete overview of the flora of San Nicolas Island.

Australian saltbush	*Atriplex semibaccata*
California boxthorn	*Lycium californicum*
Catalina tarweed	*Hemizonia clementina*
Haplopappus (= Coastal goldenbush)	Haplopapp*us venetus* (=*Isocoma menziesii*)
Cholla	*Opuntia prolifera*
Coyote brush	*Baccharis pilularis*
Dune malacothrix	*Malacothrix incana*
Eucalyptus	*Eucalyptus globulus*
Giant coreopsis	*Coreopsis gigantea*
Island morning glory	*Calystegia macrostegia*
Needlegrass	*Nassella* sp.
Prickly pear	*Opuntia littoralis* and *O. oricola*
Sagebrush	*Artemisia* spp.
San Nicolas Island lomatium	*Lomatium insulare*
Sand-verbena	*Abronia maritima*
Sea-fig	*Carpobrotus aequilaterus*
Sea rocket	*Cakile maritima*
Silver beach weed	*Ambrosia chamissonis*
Silver lotus	*Lotus argophyllus*
Silver lupine	*Lupinus albifrons*
Trask's locoweed	*Astragalus traskiae*
Wild-cucumber	*Marah macrocarpus*

Appendix C. Summary longevity records for lizards known to have lived at least 10 years. (From Slavens, 1998)

XANTUSIIDAE

Lepidophyma flavimaculatum flavimaculatum (Mexican Night Lizard)
CHII 11 Years. Gender unknown, acquired 01/03/75 as an adult. Wild bred. Deceased.
CHII 9 Years, 11 Months. Gender unknown, acquired 11/06/76 as a juvenile. Captive bred.
Deceased. Born at CHII.

Lepidophyma tuxtlae (Night Lizard)
LIT.e 4 Years, 5 Months. Gender unknown, acquired date unknown. Wild bred. Deceased. At
HOUT in Snider 1992.

Xantusia henshawi ssp. (Granite Night Lizard)
LIT.e 14 Years, 4 Months. Gender unknown, acquired date unknown. Wild bred. Deceased.
At PHIP in Snider 1992.

Xantusia riversiana (Island Night Lizard)
LIT.e 13 Years, 11 Months. Male, acquired date unknown as an adult. Wild bred. Deceased.
At PHIP in Snider 1992.
LIT.a 5 Years, 4 Months. Male, acquired date unknown as an adult. Wild bred.
At PHIP, in
Bowler 1977.

Xantusia vigilis ssp. (Desert Night Lizard)

LIT.a 3 Years, 10 Months. Gender unknown, acquired date unknown as an adult. Wild bred.

Deceased. At ARIA, in Bowler 1977.

LACERTIDAE

Lacerta lepida ssp. (Ocellated Lizard)

PPDLa 14 Years, 5 Months. Gender unknown, acquired 08/07/71. Deceased. 1962 - 1976.

FORT 11 Years, 10 Months. Male, acquired 10/15/76. Wild bred. Died 09/01/88.

PPHC 10 Years, 3 Months. Male, acquired 09/15/77 as a juvenile. Captive bred. Deceased.

SCINCIDAE

Chalcides ocellatus ssp.

NATW ID # #30555E 14 Years. Male, acquired 09/16/55. Died 10/10/69.

Corucia zebrata (Prehensile-tailed Skink)

PHIP ID # 300286 20 Years, 4 Months. Male, acquired 08/25/73. Last reported 1994.

LOSC ID # 08582 15 Years, 2 Months. Female, acquired 10/21/79 as an adult. Wild bred.

Still living.

Egernia cunninghami ssp. (Cunningham's Skink)

TOPK ID # 20669B 23 Years, 6 Months. Male, acquired 06/02/69. Last reported 1993. Est.

another 2 yr. at accession.

LIT.d 16 Years. Gender unknown, acquired date unknown. At ZOOE, in Biegler 1966.

MELA 12 Years, 4 Months. Male, acquired 08/19/73. Deceased.

LIT.a 10 Years, 5 Months. Gender unknown, acquired date unknown as an adult.

Wild bred.
Deceased. At STLM, in Bowler 1977.

Egernia hosmeri (Hosmer's Skink)
LIT.e 17 Years, 7 Months. Gender unknown, acquired date unknown as an adult.
Wild bred.
Deceased. At PHIP in Snider 1992.

Egernia luctuosa (Mourning Skink)
NATW ID # 20497 18 Years, 2 Months. Female, acquired 07/03/48. Died 09/26/66.

Egernia major (Major Skink)
LIT.a 10 Years, 9 Months. Gender unknown, acquired date unknown as an adult.
Wild bred.
Deceased. At LINI, in Bowler 1977.

Egernia striolata (Tree Skink)
ZOOE ID # F#C100 14 Years, 7 Months. Gender unknown, acquired 05/13/80.
Still living.

Egernia whiti (White's Skink)
NATW ID # 20703 12 Years, 9 Months. Gender unknown, acquired 12/13/58. Died 09/27/71.

Eumeces algeriensis (Berber's Skink)
LIT.e 22 Years, 10 Months. Male, acquired date unknown as an adult. Wild bred. Deceased.
At DALT in Snider 1992.
PPHC 13 Years, 3 Months. Female, acquired 09/26/78 as an adult. Wild bred.
Last reported
1992.

Leiolopisma telfairi (Round Island Skink)
JERE 12 Years, 2 Months. Male, acquired 05/10/76 as an adult. Wild bred.
Died 07/17/88.

Tiliqua gerrardi (Pink-tongued Skink)
PPJGa 12 Years, 11 Months. Gender unknown, acquired date unknown as an adult. Wild
bred. Deceased.

Tiliqua gigas (New Guinea Blue-tongued Skink)
NATW ID # #300758 17 Years, 3 Months. Male, acquired 09/19/73 as an adult.
Wild bred.
Last reported 1991.
PPHC 14 Years, 2 Months. Male, acquired 10/21/77 as an adult. Wild bred.
Last reported
1992.

Tiliqua rugosus ssp. (Shingleback Skink)
LOSC ID # 07929 19 Years, 2 Months. Female, acquired 12/24/74 as an adult.
Wild bred.
Died 03/06/94.
BIRA 16 Years, 8 Months. Gender unknown, acquired 04/21/74. Last reported 1991.
LIT.a 14 Years, 6 Months. Gender unknown, acquired date unknown as an adult.
Wild bred.
Deceased. At COLO, in Bowler 1977.

Tiliqua rugosus rugosus (Shingleback Skink)
LIT.e 20 Years, 10 Months. Gender unknown, acquired date unknown. Wild bred.
Still living.
At TOPK in Snider 1992.

Tiliqua scincoides ssp. (Blue-tongued Skink)

FORT 19 Years, 7 Months. Female, acquired 05/17/71. Last reported 1991.

NATW ID # #32481 12 Years, 6 Months. Gender unknown, acquired 07/04/67. Died 01/20/80.

PPSRd 11 Years, 10 Months. Female, acquired 04/01/82 as an adult. Died 02/01/94.

Tiliqua scincoides intermedia (Northern Blue-tongued Skink)

CHII 12 Years, 9 Months. Gender unknown, acquired 03/09/73 as an adult. Wild bred. Died

01/04/86.

PPJZ 6 Years, 7 Months. Male, acquired 06/01/87 as a juvenile. Captive bred. Last reported

1994.

Tiliqua scincoides scincoides (Eastern Blue-tongued Skink)

GLAT 23 Years, 7 Months. Male, acquired 05/14/71 as an adult. Wild bred. Still living. Also

female same date.

DALT ID # 725109 20 Years. Male, acquired 12/20/72. Last reported 1993.

LOSC ID # 09878 15 Years, 2 Months. Male, acquired 10/03/79 as a juvenile. Captive bred.

Still living.

TEIIDAE

Tupinambis rufescens (Red Tegu)

LIT.a 10 Years, 7 Months. Male, acquired date unknown as an adult. Wild bred. Deceased. At

PHIP, in Bowler 1977.

Tupinambis teguixin (Common Tegu)

LIT.d 16 Years, 1 Month. Gender unknown, acquired date unknown. At ZOOE, in Biegler
1966.
PPKC 14 Years, 9 Months. Gender unknown, acquired 02/05/80 as an adult. Wild bred. Died
11/16/94.
NATW ID # #302455 12 Years, 10 Months. Male, acquired 04/15/75 as an adult. Wild bred.
Died 02/16/88.
LIT.a 11 Years, 11 Months. Male, acquired date unknown as an adult. Wild bred. Deceased.
At PHIP, in Bowler 1977.
CHII 10 Years, 6 Months. Gender unknown, acquired 07/12/76 as an adult. Wild bred. Died
02/07/87.

VARANIDAE

Varanus acanthurus brachyurus (Spiny-tailed Monitor)
LIT.a 10 Years. Female, acquired date unknown as an adult. Wild bred. At DALT, in Bowler
1977.

Varanus bengalensis ssp. (Bengal Monitor)
PPDBf ID # VBM1 11 Years, 2 Months. Male, acquired date unknown. Deceased.
LIT.a 10 Years. Gender unknown, acquired date unknown. Wild bred. Deceased. At STAN,
in Bowler 1977.

Varanus dumerili (Dumeril's Monitor)
BUFN ID # 80R54 10 Years, 7 Months. Male, acquired 11/07/80. Wild bred. Died 06/12/91.

Varanus exanthematicus ssp. (Savanna Monitor)
NATW ID # #300360 10 Years, 6 Months. Male, acquired 06/06/72. Died 12/07/82.

Varanus exanthematicus albigularis (Bosc's Monitor)
LIT.e 12 Years, 8 Months. Gender unknown, acquired date unknown. Deceased.
At LOUK in
Snider 1992.
LOUK 11 Years, 11 Months. Male, acquired 01/27/76 as an adult. Wild bred.
Last reported
1988.

Varanus giganteus (Perentie)
LIT.e 19 Years, 8 Months. Male, acquired date unknown as an adult. Wild
bred. Deceased. At
DALT in Snider 1992.
MELA 14 Years, 8 Months. Male, acquired 04/18/71. Deceased.

Varanus gouldi ssp. (Gould's Monitor)
LOSC 20 Years. Female, acquired 12/24/74 as an adult. Wild bred. Still living.
LIT.e 18 Years, 3 Months. Male, acquired date unknown as a juvenile. Wild
bred. Deceased.
At DALT in Snider 1992.

Varanus griseus ssp.
LIT.d 17 Years. Gender unknown, acquired date unknown. Deceased. Tel Aviv
Univ., in
Biegler 1966.

Varanus indicus ssp. (Mangrove Monitor)
LIT.e 17 Years, 5 Months. Male, acquired date unknown as a juvenile. Wild

bred. Still living.
At DALT in Snider 1992.
PPMK 10 Years. Male, acquired 12/23/84 as a juvenile. Captive bred. Still living. (2nd male
hatched same date).

Varanus komodoensis (Komodo Dragon / Ora)
LIT.d 12 Years, 4 Months. Gender unknown, acquired date unknown. At ZOOE, in Biegler
1966.
LIT.d 10 Years, 10 Months. Gender unknown, acquired date unknown. At ZOOE, in Biegler
1966.

Varanus mertensi (Merten's Water Monitor)
LIT.e 20 Years, 4 Months. Male, acquired date unknown as an adult. Wild bred. Deceased. At
DALT in Snider 1992.

Varanus niloticus ssp. (Nile Monitor)
LIT.c 15 Years. Gender unknown, acquired date unknown. Deceased. In Hughes 1988.
LIT.d 14 Years, 7 Months. Gender unknown, acquired date unknown. Deceased. At ZOOE, in
Biegler 1966.
CHII 10 Years, 6 Months. Gender unknown, acquired 06/05/81 as an adult. Wild bred. Last
reported 1992.

Varanus olivaceus (Gray's Monitor Lizard)
DALT ID # 825892 10 Years, 2 Months. Male, acquired 10/09/82 as an adult.

Wild bred.
Last reported 1993.

Varanus prasinus ssp. (Tree Monitor)
CHII 12 Years, 4 Months. Gender unknown, acquired 08/17/73. Died 12/21/85.

Varanus prasinus kordensis (New Guinea Green Tree Monitor)
LIT.e 14 Years, 3 Months. Male, acquired date unknown as an adult. Wild bred. Deceased. At
ATLG in Snider 1992.
OKLO 10 Years, 2 Months. Female, acquired 04/14/80. Died 07/07/90. On loan to ATLG.

Varanus prasinus prasinus (New Guinea Green Tree Monitor)
LIT.e 15 Years, 5 Months. Male, acquired date unknown as a juvenile. Wild bred. Deceased.
Mary Kuppersmith in Snider 1992.

Varanus salvator ssp. (Water Monitor)
LIT.e 15 Years, 8 Months. Female, acquired date unknown. Deceased. At METO in Snider
1992.
SEDK ID # CR-42 13 Years, 11 Months. Female, acquired 10/29/74 as an adult. Wild bred.
Deceased.
NATW ID # #301279 13 Years, 11 Months. Male, acquired 06/19/75 as an adult. Wild bred.
Died 05/25/89.
LIT.a 12 Years, 4 Months. Male, acquired date unknown as an adult. Wild bred. Deceased. At
SADC, in Bowler 1977.

CHII 11 Years, 8 Months. Gender unknown, acquired 07/08/65 as an adult. Wild bred. Died
04/01/77.

Varanus timorensis ssp. (Timor Monitor)
BUFN ID # 76R9 14 Years, 11 Months. Male, acquired 06/16/76. Died 06/02/91. Last reported 1994. Sold to R. Tremper Feb 91.
FORT 12 Years, 8 Months. Male, acquired 09/29/77. Wild bred. Died 06/14/90.

Varanus timorensis timorensis (Timor Monitor)
RION 11 Years, 9 Months. Male, acquired 03/07/79 as an adult. Wild bred.
Died 12/11/90.

Varanus varies (Lace Monitor)
MELA 14 Years, 8 Months. Male, acquired 04/24/71. Deceased.
CHII 13 Years, 6 Months. Gender unknown, acquired 07/21/73 as an adult. Wild bred. Died
02/03/87.

XENOSAURIDAE

Xenosaurus grandis sanmartinensis
San Martin Rock Lizard
LIT.e 12 Years, 9 Months. Male, acquired date unknown. Wild bred. Still living. At HOUT in
Snider 1992.

AMPHISBAENIDAE

Amphisbaena sp.
LIT.e 15 Years, 2 Months. Female, acquired date unknown as an adult. Wild

bred. Deceased.
At FORT in Snider 1992.

Amphisbaena alba (Worm Lizard)
OKLO 14 Years, 11 Months. Male, acquired 01/28/77. Last reported 1992.
LIT.a 13 Years, 4 Months. Female, acquired date unknown as an adult. Wild bred. At FORT,
in Bowler 1977.

Blanus cinereus
European Worm Lizard
PPBL 16 Years. Gender unknown, acquired date unknown. Wild bred. Last reported 1990.

Trogonophis wiegmanni (Wiegmann's Burrowing Lizard)
ZOOE ID # C125 14 Years. Gender unknown, acquired 12/16/80. Still living.

References and institution codes:

LIT.a: Bowler, Kevin. 1977. Longevity of Reptiles & Amphibians. 1977 SSAR.

LIT.b: Hughes, B. Longevity records of African captive amphibians and
reptiles.: part
1 Introduction and species list 1 Amphibians & Chelonians

LIT.c: Hughes, B. Longevity records of captive amphibians and reptiles: part
2 lizards and
amphisbaenians

LIT.d: Biegler, R. 1966. A survey of recent longevity records for reptiles

and amphibians in
zoos. IZY 6:487-493.

LIT.e: Snider, Andrew, and Kevin Bowler. 1992. Longevity of Reptiles and Amphibians in North American Collections, 2nd ed. 1992 S.S.A.R

ARIA: Howard Lawler, Curator of Small Animals
Arizona Sonora Desert Museum
2021 N. Kinney Road
Tucson, AZ 85743
Phone 602 883 1380

CHII: Ray Pawley, Curator of Reptiles
Chicago Zoological Park
300 Golf Road
Brookfield, IL 60513
Phone 708 485 0263

HOUT: Paul Freed, Section of Herpetology
Houston Zoological Gardens
1513 N. MacGregor
Houston, TX 77030
Phone 713 520 3226

PHIP: Curator of Reptiles
Philadelphia Zoological Gardens
34th St & Girrard Ave.
Philadelphia, PA 19104
Phone 215 243 1100