Use of Lizard Refugia to Indicate Ecosystem Health of Disturbed and Native Habitats in San Timoteo Nature Sanctuary

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USE OF LIZARD REFUGIA TO INDICATE ECOSYSTEM HEALTH OF DISTURBED AND NATIVE HABITATS IN SAN TIMOTEEO NATURE SANCTUARY

A Capstone Project
Submitted in Partial Fulfillment for Graduation with Honors Distinction and the Degree of Bachelor of Science

Rochelle Stiles

May 2012
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Thanks to all those who have supported me throughout my education and research. Photo of a western side-blotched lizard (*Uta stansburiana elegans*) by R.S.
ABSTRACT

An ever-growing human population has contributed to recurrent reductions in fragments of native coastal sage scrub (CSS) habitat left in areas surrounding Redlands, CA. This continuous pressure has allowed for invasions by nonnative vegetation, which undermine and radically alter plant and animal community structures. In less severe cases, a form of ecological restoration, land rehabilitation, can revive a piece of land to its pre-disturbance state, and measurements of ecosystem health indicators can determine the overall success of the rehabilitation. Lizards are one such example of an indicator and can be surveyed via refugia. Using this sampling technique, this project compared native-vegetation-dominated and nonnative-vegetation-dominated habitats of San Timoteo Nature Sanctuary (STNS) as well as documented the baseline abundance and diversity of lizards prior to the commencement of a rehabilitation project at this site. After weathering for four weeks, galvanized corrugated iron panels were surveyed from January to April 2012. Twenty-one western side-blotched lizards (*Uta stansburiana elegans*) were found to utilize the panels during dry, sunny days with temperatures between 10-30°C. Due to a low sample size, this study cannot conclude a difference in lizard utilization of native versus nonnative-vegetation-dominated habitat and suggests galvanized corrugated iron refugia may not be the most successful lizard survey method for CSS in STNS. The actual rehabilitation project will take place in subsequent years, and the ecosystem health indicator measurements of this subproject will contribute to a long-term monitoring program of the rehabilitation.
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INTRODUCTION

During the past two centuries in Redlands, California and surrounding areas, human land use has substantially altered native plant and animal communities (Judson, 1882). Human-related disturbances, such as agriculture, pollution, and development, have allowed nonnative plant species to invade and out-compete native vegetation (Cione et al., 2002; Burger et al., 2003; Seabloom et al., 2003). As a result of these invasions, ecosystems have changed in terms of species composition, nutrient cycling, resource availability, and disturbance regimes (Cione et al., 2002).

A scrubland native to the Mediterranean-climate region of California has specifically been reduced to 10-15% of its former extent. Coastal sage scrub (CSS) is characterized by 0.5-2.0 m tall, drought-tolerant deciduous shrubs. Stands of CSS in southern California have been known to remain unchanged for over 100 years in the absence of fire or anthropogenic disturbances (Weston, 1981). This seemingly permanent habitat, however, is being overwhelmingly converted to exotic grassland. This conversion can be extensive and difficult to reverse. In less severe cases, however, the alteration can be remedied using a form of ecological restoration: land rehabilitation.

Ecological restoration is the process of assisting the recovery of a piece of degraded, damaged, or destroyed land back to its historical or pre-disturbance condition. This process can mean renewing land productivity and ecosystem services and re-creating habitat for native species. In the case of a restored stream, the products may be clearer water, more native vegetation, erosion control, and more native animals that play a vital role in the food web. Restored land might also attract endangered, threatened, or special concern species. The overall
goal of restoration is to encourage the independent recovery of a disturbed site, which will provide resilience and self-sufficiency. Despite this commendable goal, ecological restoration is often times difficult to achieve. A form of restoration that focuses on restoring ecosystem processes, productivity, and services, rather than re-establishing both abiotic and biotic integrity, is land rehabilitation (Society for Ecological Restoration, 2004). This overall project seeks to rehabilitate in the relatively short term and perhaps someday, restore a piece of disturbed land.

The success of a rehabilitation project is difficult to measure qualitatively and rather should be determined quantitatively. Before a project is even implemented, a monitoring program should be initiated (Apfelbaum & Haney, 2010). Data from before, during, and after the rehabilitation can be compared to determine any changes that have occurred throughout the project. Data can also be compared to similar, less disturbed areas or reference sites. Reference sites can reveal what a piece of disturbed land might have become without the disturbance and with the physical constraints of a changing climate (Society for Ecological Restoration, 2004). Specifically in southern California, it may not be physically feasible for a piece of land to be restored to its pre-European settlement state, since climatic conditions have changed over the past 200 years. A restoration project can be deemed successful if external assistance is no longer required to keep an ecosystem intact and healthy (Society for Ecological Restoration, 2004).

Quantitative data for comparison of sites can be found using indicators of ecosystem health. Because healthy ecosystems require relatively stable food webs, lizard abundance can be a measure of environmental health. If lizards are abundant and diverse, it can be inferred that their arthropod prey are also abundant (Pianka & Vitt, 2003). Lizards are essentially an indirect way of measuring their prey, which drive many community and ecosystem processes, including decomposition, primary production, nutrient cycling, and plant succession (Burger et al., 2002).
Lizard abundances and diversity before, during, and after land rehabilitation can be compared to reveal the success of a project at providing habitat that can be utilized by lizard prey. Lizards are far fewer in number than arthropods and thus, are an easier and more efficient measure of ecosystem health. In addition, lizards have relatively small home ranges and thus can better represent a particular patch of vegetation than lizard predators with larger ranges (Perry & Garland, 2002).

Due to its nature as an ectotherm (i.e. an organism that receives body heat from external sources), the lizard is furthermore a useful research organism (Pianka & Vitt, 2003; Jones & Lovich, 2009). Ectotherms require basking to elevate their body temperatures and therefore, are often easy to locate and observe. Lizards also limit their energy consumption by relying on crypsis for camouflage (Bell & Pickett, 2009); rather than flat out running to escape predators, most tend to run a limited distance and freeze. This escape behavior makes lizards easy to study, since they move upon the researcher’s approach and remain motionless (Huey et al., 1983). In addition to being representative of their arthropod prey, lizards are also model organisms because their behavior is constrained by the need for external heat sources.

To collect quantifiable data on lizard abundance and diversity, transects, traps, and refugia sampling have commonly been used. My research this past summer focused on surveying Figure 1. Refugia surveys are a low impact alternative to transects and traps. Photo by R.S.
lizard populations using the Standardized Lizard Line (SLL) transect detailed by Shaw and Woodruff (2002). SLL transects involve slowly walking a specified line within the study site and taking note of lizards a given distance on either side of the line. This method of survey proved to be highly time intensive and biased based on the researcher’s ability to spot well-camouflaged, immobile lizards. A single transect may take 1-2 hours to complete and would only sample one site. On the other hand, refugia, or artificial shelters, placement can sample a variety of habitats with comparably less observer bias (Houze & Chandler, 2002; Moore, 2005; Sutherland, 2006; Lettink, 2007; Bell & Pickett, 2009), less cost (Ryan et al., 2002; Moore, 2005), less effort and maintenance (Kjoss & Litvaitis, 2000; Lettink, 2007), and relatively low impact (Fig. 1) (Sutton et al., 1999; Moore, 2005; Hoare et al., 2009). Since lizards are able to freely enter and exit, refugia result in far fewer cases of mortality due to heat stress and predation than traps (Grant et al., 1992; Hampton, 2007; Hoare et al, 2009). Furthermore, in addition to providing the benefit of a solar-heated refuge, refugia can increase the detectability of cryptic lizard species, making this data collection method time efficient (Lamb et al., 1998; Kjoss & Litvaitis, 2000; Moore, 2005; Hampton, 2007; Langham, 2011).

Based on its rehabilitation potential, the study site chosen was San Timoteo Nature Sanctuary (STNS) in San Bernardino County, CA. The San Timoteo Canyon runs 12 miles from east San Bernardino Valley to the Banning Pass and has historically been a corridor for many organisms, humans and wildlife alike. In the 200 acres of STNS, nonnative species are prevalent as a result of historic farming, sheep grazing, and bee keeping (www.redlandsconservancy.org/san_timoteo_nature_sanctuary, 2011). Running parallel to the site boundary, an active railway and highway provide present-day stressors. As it flows from Banning Pass to the Santa Ana River, a portion of the San Timoteo Creek also runs through STNS.
ridges are characterized by patches of remnant CSS, highly eroded slopes, and vast areas of largely nonnative *Bromus* and *Brassica* species (Fig. 2).

The most recent major disturbance to STNS was a result of past extensive flooding events. During 2006, the United States Army Corps of Engineers constructed 18 sediment basins and removed approximately one mile of creek vegetation. As part of mitigation to this habitat destruction, a conservation easement was given to the Redlands Conservancy in October 2010. The current effort of the Conservancy is to create an area on the hills sloping to the creek that can be utilized for passive recreation, habitat restoration research, and wildlife movement (www.redlandsconservancy.org/san_timoteo_nature_sanctuary, 2011). Based on its fragmented native vegetation and abundance of lizards, STNS is an ideal location for rehabilitation and research dealing with this indicator organism.

Figure 2. San Timoteo Nature Sanctuary ridges are characterized by coastal sage scrub remnants, highly eroded slopes, expanses of nonnative grasses and forbs, and bare ground. Photo by R.S.
OBJECTIVES

Based on lizards' ability to indicate ecosystem health, I hypothesized that lizard abundance and diversity will be greater in patches of habitat that are dominated by native vegetation rather than in nonnative-dominated patches. Using data collected from refugia surveys, I attempted to either support or disprove this hypothesis by meeting the following objectives:

(1) To develop a refugium lizard survey protocol that is less observer-biased than SLL transects.

(2) To measure the abundance and diversity of lizards utilizing refugia placed in nonnative-vegetation-dominated and native-vegetation-dominated habitats in STNS.

(3) To compare lizard abundance and diversity of the two habitat types to determine any effect nonnative vegetation may have on this ecosystem health indicator organism.

(4) To collect baseline measurements on STNS for the purpose of monitoring future rehabilitation efforts.

Figure 3. Pairing of nonnative-vegetation-dominated and native-vegetation-dominated (basketbrush) habitats in STNS. Photo by R.S.
EXPERIMENTAL METHODS

Survey sites were selected based on estimates of vegetation dominance and patch size. Nonnative sites were dominated almost entirely by annual grasses and forbs, e.g. *Bromus* and *Brassica* spp. Nonnative patch sizes had no less than approximately a 4.5 m radius, and refugia were placed within these sites at least 4.5 m away from any living native vegetation. Native sites were dominated by a variety of vegetation, including brittlebush (*Encelia farinosa*), California sagebrush (*Artemisia californica*), cane cholla (*Opuntia parryi*), basketbrush (*Rhus trilobata*), and fourwing saltbush (*Atriplex canescens*) (Table 1). Native patch sizes had no less than

Table 1. Dominant vegetation for native and nonnative paired sites chosen for lizard refugia placement in STNS.

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<td>Native-dominated-vegetation</td>
<td><em>Rhus trilobata</em></td>
<td><em>Atriplex canescens</em></td>
<td><em>Rhus trilobata,</em> <em>Penstemon sp., Artemisia dracunculus,</em> <em>Helichrysum sp., Solanaceae sp., Tetradymia axillaris</em></td>
<td><em>Opuntia parryi,</em> <em>Atriplex canescens,</em> <em>Artemisia californica,</em> <em>Encelia farinosa,</em> <em>Rhus ovata,</em> <em>Sambucus sp.</em></td>
<td><em>Atriplex canescens</em></td>
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<th>Site Pair</th>
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<tr>
<td>Native-dominated-vegetation</td>
<td><em>Encelia farinosa,</em> <em>Artemisia californica</em></td>
<td><em>Encelia farinosa</em></td>
<td><em>Encelia farinosa,</em> <em>Artemisia californica</em></td>
<td><em>Artemisia californica,</em> <em>Rhus avata,</em> <em>Eriogonum asciiclatum</em></td>
<td><em>Encelia farinosa,</em> <em>Opuntia parryi</em></td>
</tr>
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approximately a 3 m radius, and refugia were placed at least 1.5 m away from any nonnative vegetation. Each nonnative site was paired with a native site with similar elevation, aspect, and slope. The paired native site was never any more than a few ridges away from the nonnative site (Fig. 3).

Identification of lizard species was specified using *Lizards of the American Southwest: A Photography Field Guide* (Jones & Lovich, 2009). Lizard species seen at STNS prior to the surveying included the western side-blotch (*Uta stansburiana elegans*), northwestern fence (*Sceloporus occidentalis*), coastal whiptail (*Aspidoscelis tigris stejnegeri*), and Skilton’s skink (*plestiodon skiltonianus skiltonianus*). Data collection noted the number and species of lizards under each refugium, as well as recent weather and the current air temperature.

Numerous versions of refugia sampling have been utilized in previous studies; however, sampling variations can be reduced by consistency in design. Refugia can be made using galvanized corrugated iron, roofing felt, plywood, wooden boards, and carpet (Froglife, 1999). Langham points out that differences in refugium size and material can create variability in detection (2011). One of the most commonly used materials is galvanized corrugated iron due to its durability and effectiveness for attracting herpetofauna (Lamb *et al*., 1998; Sutherland, 2006; Hampton, 2007; Hoare *et al*., 2009; Langham, 2011; http://middlemarch-environmental.com/reptilesurvey, 2011). The specific galvanized corrugated iron panels used for this subproject were produced by Gibraltar Building Products and sold by Home Depot. The sizing was chosen based on recommendations offered by the Surry Amphibian and Reptile Group: height of 0.019 m, width of 0.66 m, and depth of 0.91 m. An eyebolt was attached on the edge, halfway down the longer side to allow for easy lifting in the field and to reduce the risk of bites associated with disturbed organisms (Landham, 2011). A file was used to reduce the
sharpness of the edges, and each refugium was marked with "Ecological Survey, University of Redlands, (909) 748-8736" in Super Permanent Sharpie to reduce removal (Fig. 3). Twenty refugia were made using these same specifications to reduce variability in sampling efforts.

Figure 4. Galvanized corrugated iron panels with dimensions: 0.019 x 0.66 x 0.91 m were used to survey lizards in STNS. Eyebolts were attached to reduce the risk of bites associated with lifting. Photo by R.S.

To better understand the difference between native-vegetation-dominated and nonnative-vegetation-dominated habitats, lizards utilizing placed refugia were compared in terms of abundance and diversity. Specifically, 10 refugia were placed in nonnative-dominated habitats and 10 in native-dominated habitats (Fig. 5). After allowing the refugia to weather for 4 weeks, surveying began the first week of January and continued through mid-April. Each refugium was
lifted approximately once each week during clear days with temperatures between 5-32°C (40-90°F). Sampling occurred for all within a 2-hour window.

At the beginning of the survey, lifting conditions were based on a previous study done by Hoare et al. (2009). This article recommended sampling during drier periods with air temperatures between 12-15°C (54-59°F) and argued that material under the refugia and time of day between 9:00 am – 5:00 pm were not significantly important factors. After a month of surveying with no success, alterations were made to the methods, since the recommended

Figure 5. Placement of refugia in San Timoteo Nature Sanctuary. Photo by Google Earth.
conditions did not seem to apply to STNS. As advised by McMartin (2012), the vegetation from underneath each cover was removed the last week of January. In addition, during the third week of February, 1 tsp. of cat food bait (Science Diet Light) was placed underneath each center. Each week, cat food was added if none was present or replaced to ensure freshness. The cat food wasn’t intended to attract lizards themselves, since the majority of common species in STNS are immobile hunters. Rather, the bait was intended to attract prey or merely to alter the microhabitats in hopes that organisms would begin to utilize the refugia.

RESULTS

Lizard abundances at native-vegetation-dominated and nonnative-vegetation-dominated sites did not significantly differ ($t = 1.42; df = 18; p = 0.173$). After 320 flips, 30 field hours, 80 miles of combined mountain biking and hiking, 21 lizards were recorded underneath refugia. Only one species has been found to utilize refugia in both types of habitats, the western side-blotched lizard (*Uta stansburiana elegans*) (Fig. 7), revealing an overall low diversity. Just 3 lizards were seen under 2 native-vegetation-dominated refugia, and 18 others were seen under refugia in 4 nonnative habitats (Fig. 6). All sightings were between the end of February and mid-April and during dry, sunny days with ambient temperatures 10-30°C (50-85°F).
Two other organisms were found underneath refugia, the field mouse and the San Diego gopher snake (*Pituophis catenifer annectens*). One mouse was recorded under the nonnative site 1 just once (third week of March), while 6 gopher snakes were found to utilize nonnative site 1 and nonnative site 3 (fourth week of March until mid-April). These nonnative sites are characterized by dense *Bromus* spp. grass that is at least 0.2 m tall.
During the course of the survey, other lizards were seen opportunistically throughout STNS. Beginning in January, northwestern fence and western side-blotched lizards were seen on the trail. Beginning in March, coastal whiptail and Skilton's skinks were also seen (Fig. 7). Lizards were seen near (within 3 m of) the following refugia but never underneath: nonnative site 3, native site 4, native site 5, and native site 6.

Figure 7. Lizards species encountered at STNS: (A) northwestern fence (*Sceloporus occidentalis*), (B) coastal whiptail (*Aspidoscelis tigris stejnegeri*), (C) western side-blotch (*Uta stansburiana elegans*), (D) skilton's skink (*Plestiodon skiltonianus skiltonianus*). Photos by R.S.
DISCUSSION

Objective Completion:

Objective (1) was to develop a refugium survey that was less observer-biased than SLL transects. This objective relied on the ability to create a successful lizard survey protocol detailing the two types of habitats, since refugia sampling is commonly known as less biased than SLL transects (Houze & Chandler, 2002; Moore, 2005; Sutherland, 2006; Lettink, 2007; Bell & Pickett, 2009). In addition, data were individual lizard count-based, and by limiting the area that must be surveyed to quite a small area (under each refugium), the survey was ultimately less biased and easier to replicate than SLL transects. In general, objective (1) was met. However, a follow up optimal conditions survey would clarify what weather conditions would result in a consistent abundance of lizards utilizing refugia. Such a survey would involve increasing replications of flips within a week’s time. Natural weather conditions over the week would result in abundance variations, which would point to the most optimal conditions for sampling.

Objective (2) was to measure the abundance and diversity of lizards utilizing refugia placed in native and nonnative-vegetation-dominated habitats. This objective depended on limiting physical variables between the different habitat types and recognizing weather condition variables. Physical variables (e.g. sunlight aspect, slope, and elevation) that affected organisms were limited by the pairing of each patch of native vegetation with the nearby patch of nonnative vegetation. Effects of weather conditions were limited by sampling each refugium many times and sampling all the refugia collectively during the same day and same time of day (Spitzer, 2011). A constraint of this methodology, the dormancy period of ectotherms, was encountered
during the survey season. Surveying is most successful from mid-March through mid-October (http://middlemarch-environmental.com/reptilesurvey). However, the mild Mediterranean climate of STNS allowed for refugia counts beginning at the end of February.

Objective (3) was to compare lizard abundance and diversity of the two habitat types to determine any effect nonnative vegetation may have on lizards. This objective depended on the use of statistical analysis to compare the individual lizard count data between the two habitat types: native and nonnative. Since two independent groups were compared for each pairing of sites, a two tail paired t-test was appropriate. This type of t-test meant that either the nonnative or the native site for each pairing could have a higher or lower abundance and diversity of lizards than the other. Since the differences between sightings of lizards at the two habitats types for the pairings were not significant, one cannot really suggest that the difference in vegetation may be affecting the lizard community of that particular habitat patch. Rather, other variables may account for the lack of significance: lizard home ranges might extended beyond the patch boundaries, lizards might be able to adapt to changes in prey communities within nonnative vegetation habitats, refugia surveys may not be a sufficient measure of lizard communities, and/or additional variables were not controlled for. In general, there does not seem to be a nonnative-vegetation effect on lizard abundance and diversity.

Objective (4) was to collect baseline measurements on STNS for the purpose of monitoring future rehabilitation efforts. This objective was accomplished by meeting the previous three objectives and by collecting data on native sites. However, in order to truly understand the patterns of lizard abundance and diversity in native and nonnative habitats, other survey materials or methods should be attempted, such as plywood refugia or pitfall traps. A more reliable survey method than galvanized corrugated iron refugia must be found in order to
track lizard abundance and diversity over the course of the overall rehabilitation project. Specifically, reliable data on native-dominated sites can then act as a goal for lizard communities that the rehabilitation seeks to achieve.

**General Survey Method Evaluation:**

Since lizards have been found near but never underneath certain refugia, this survey method may not be the most appropriate for STNS. Incentive and high densities of lizards are required (Hoare et al., 2009), and incentive may differ between native-vegetation-dominated and nonnative-vegetation-dominated habitats. The most commonly used nonnative sites were characterized by bare ground and hundreds of mammal burrows. A refugium in this habitat might have provided cover outside the burrows themselves. Native sites all had shrubs that might have provided the necessary cover. Moreover, some species may not require refugia (Hoare et al., 2009). In particular, species of the family Teiidae (whiptails) are active foragers, meaning they are constantly moving in search of prey (Jones & Lovich, 2009). Jorgensen et al. (1998) found refugia to attract fewer active foraging lizards. As Hampton (2007) also points out, artificial cover objects may not be as proficient at capturing these species relative to natural cover objects.

This study was justified in using refugia to survey, since other studies have found refugia to be a more effective survey method than pitfall traps, one of the most commonly utilized methods for lizard survey. Pitfall traps yielded no common geckos during a study conducted on South Island, New Zealand (Lettink, 2007), and the threatened sand skink (*Neoseps reynoldsi*) was better surveyed using cover boards than pitfall traps (Sutton et al. 1999). During a survey of
terrestrial lizards in a grazed coastal shrubland in New Zealand, pitfall traps produced samples dominated by skinks but few geckos. More than double as many captures were made using refugia compared to pitfall traps, and more new individuals were encountered under refugia rather than the traps (Lettink & Cree, 2007). These previous studies, however, are different from this study in terms of lizard species present and climate, and these successes may not be applicable to STNS.

Future research in STNS may attempt to survey via pitfall traps and drift fencing. Fencing is constructed out of a difficult-to-climb material and funnels organisms towards traps that are flush with the ground. Ryan et al. (2002) argues that drift fences are superior to coverboards and time-constrained searches for capturing both amphibian and reptile species and individuals in clearcut, mixed, and pine forests. The fences caught 97% of species seen and was responsible for the sole capture of 58% of species. Only the drift fence technique revealed herpetofaunal community differences among habitats. However, no single sampling method is likely to reveal every species in a particular region, but Ribeiro-Junior et al. (2008) argues that different techniques should not be used in different habitats if the objective is to collect comparative sample data. Furthermore, the choice of sampling method can reveal different patterns when comparing community structure among different habitat types.

Refugia Survey Method Evaluation:

Since refugia surveys have proven to be successful in other published literature (Grant et al., 2002; Hampton, 2007), materials other than galvanized corrugated iron might be better or worse for refugia sampling in STNS. Galvanized corrugated iron was originally chosen based on
the conclusions of Lamb et al. (1998) and Hampton (2007) that due to a thermal advantage, galvanized corrugated iron was a better material for sampling reptiles than plywood. However, iron might not appropriately retain moisture and desired temperatures in the hot, dry southern California climate. Refugia utilization is partly based on thermo-activity by reptiles, which varies depending on the air temperature. Galvanized corrugated iron refugia many only work better on milder days, while plywood might be more affective into the spring and summer. However, if several sheets are stacked and varying microhabitat temperatures are possible, galvanized corrugated iron may not limit herpetofauna on very warm or dry days (Hubbs, 2009).

Other research has used less common materials for refugia surveys. During the survey of terrestrial lizards in the grazed coastal shrubland in New Zealand, skinks utilized Onduline, corrugated iron, and concrete tiles without apparent preference (Lettink & Cree, 2007). Thus, Onduline and concrete tiles may not sufficiently survey lizard populations in STNS as well. Carpet can also be used but deteriorates more rapidly than galvanized corrugated iron or wood (Hubbs, 2009). Coverboards made of hardwoods have ranged in effectiveness at monitoring plethodontid salamanders in North America. Mean encounter rate of the most abundant salamander found under the coverboard has ranged from 2.4% (Monti et al., 2000) to 27% (Moore, 2005). Slight light variations in the refugia material, such as native versus nonnative wood, can have an affect on utilization (Moore, 2005).

Utilization Levels:

Additional factors may explain lizard utilization of refugia in STNS. A study on a rock-dwelling nocturnal gecko, Oedura lesueurii, suggests that refugia utilization depends on thermal
benefits, social interactions, and predator presence. Velvet geckos preferred refugia in full sun rather than full shade. Mature male geckos rarely co-inhabited with other males, and lizards avoided refugia with the scent of the natural predator. Specifically, subordinate males were forced to use cooler refugia when dominant males were present. Avoidance of predators was more important than the thermal benefit of the refugia. Lizards would utilize cooler, unscented covers over warmer, scented covers. Subordinate males also used scented covers or no covers when dominant males were present (Downes & Shine, 1998). This study shows that refugia utilization may not be solely dependent on the surrounding vegetation type. Conflicting priorities of at least one lizard species affected the individuals seen under the different refugia. Caution should be used when making conclusions about lizards seen under covers in native and nonnative-vegetation-dominated habitats.

Time, rainfall, ambient temperature, relative humidity may also affect refugia use (Hoare et al., 2009), and as suggested in the discussion of objective (1), the optimal sampling conditions might not have been found during this survey. Moore (2005) argues that one of the most probable explanations for the differences in encounter rates might be the weather prevailing before and at the time of sampling. In the case of salamanders, encounters under refugia do seem to increase with decreasing rainfall (Jaeger, 1980).

Food availability and seasonal behaviors (e.g. mating during the spring) may also affect usage (Hoare et al., 2009). Ryan et al. (2002) suggests that variation in seasonal activity patterns should be taken into account when determining the length of a monitoring program. These effects would mean future monitoring efforts in STNS should be conducted during the same season.
Refugia use is still a relatively new method for surveying (Hampton, 2007). This research shows that this technique still requires development and testing. If future refugia surveys do reveal consistent usage in the majority of sites, caution should be taken when drawing conclusions. Cover type and habitat have been found to influence the species captured, meaning that abundance differences between sites could be the result of native plants creating a different habitat structure rather than more abundant prey source (Hampton, 2007).

Rehabilitation Efforts:

Lizard abundance and diversity was hypothesized to differ between native and nonnative-vegetation dominated habitats because different vegetation attracts different arthropods. A more diverse plant community allows for more arthropod niches. A greater abundance and diversity of prey would suggest the same trend for the predator, namely lizards. Based on the only species observed to utilize refugia, vegetation does not seem to affect the abundance and diversity of western side-blotched lizards in STNS. This result may be due to the nature of this lizard species as a generalist forager (Jones & Lovich, 2009). If western side-blotched lizards can make a living off a variety of arthropods and solely require a form of shelter (e.g. shrub cover and burrows), the overall rehabilitation project may increase lizard abundance and diversity by planting any type of native CSS species in areas with limited current vegetation.
CONCLUSIONS / SIGNIFICANCE

Few primary sources exist on the use of refugium sampling in scientific research. The majority of sources act as how-to guides for individuals interested in sampling reptiles, and sources that do explain surveying within a specific location mostly have been done in regions other than the Southwest. Research in STNS will someday contribute to the short list of primary data available as well as to understanding the overall differences between habitat dominated by native CSS vegetation and nonnative annual grass and forb vegetation in southern California. Once these differences are described, land restoration will have a better chance of successfully mitigating losses of biodiversity and complexity caused by anthropogenic activities.

Furthermore, lizard diversity and abundance data from before, during, and after intervention can determine the overall success of this project at rehabilitating land and re-creating habitat. This subproject will be one of the first on ecosystem health indicators that will cover multiple years, and thus, data will act as the baseline for future comparison.

If restoration is successful, this project will help to preserve the native beauty of STNS for future generations of human life and wildlife. In the future, this piece of land may very well have some of the last intact CSS habitats in the area that can support the native species composition, importantly those species that are of special concern, threatened, or endangered. Preservation of these species will then assist in the return of ecosystem services and land productivity to STNS.
LITERATURE CITED


Spitzer, B. 2011. Personal communication with University of Redlands Assistant Professor of Biology.


