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Environmental Research, Assessment and Planning

Santa Cruz Long-toed Salamander Survey in Upper Moro Cojo Slough, Monterey County, CA

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FINAL REPORT

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May 1 1990

FIGURES and TABLES

1. INTRODUCTION

1.1. Site History

A development of approximately 298 single-family detached houses is proposed for the 74 acre Rolling Hills I site (formerly Villa Nueva). The original EIR was prepared by Earthmetrics Inc.(1988) to evaluate the impact of development on 5 separate parcels, including 'Villa Nueva'. The EIR was found to have deficiencies, and the scope of the proposed development was changed, so an Addendum was prepared by Coats Consulting (1989). The Addendum stated that due to the "potential degradation or loss of wetlands due to project development", "A qualified biologist should survey the sections of the Rolling Hills I site along Moro Cojo Slough during the winter breeding season to determine if this site supports a population of the Santa Cruz long-toed salamander."

1.2. Scope of Study

The primary purpose of this study was to determine if Santa Cruz Long-toed Salamanders (*Ambystoma macrodactylum croceum*); hereafter referred to as SCLTS) were present within the Rolling Hills I site and Watertek property. The State and Federal governments both list this subspecies as endangered. Though individuals have been previously reported from the lower Moro Cojo drainage, none have been reported from the upper drainage where development is proposed. Secondarily, this study attempted to determine whether two other locally rare amphibians were present: the California Tiger Salamander *(Ambystoma tigrinum californiense)* and the California Red-legged Frog *(Rana aurora draytoni)*. Both are State species of special concern and category II candidates for Federal listing under the Endangered Species Act. More detailed work to collect information on population sizes, exact distributions and positive identification of breeding sites was not attempted, as this would entail field efforts well beyond the scope of this study.

1.3. Site Description

The study site included the 74 acre Rolling Hills I site and the 25 acre Watertek property (Figure 1). The Rolling Hills parcel consists of grassy upland sloping eastward toward a low-lying extension of the Moro Cojo Slough. At its eastern border, grassland is replaced by willows *(Salix sp.)* occasional coast live oaks *(Quercus agrifolia)* and poison hemlock *(Conium sp)*. The Rolling Hills I parcel is higher than the designated 100-year floodplain of the Moro Cojo (FEMA, 1984), and differs greatly from the pickleweed *(Salicornia sp)*-vegetated drainage immediately to the east. Grass cover consists of non-native annuals, which is selectively maintained by continuous cattle grazing. The Watertek property consists of 3 treatment ponds totalling 15 acres, surrounded by approximately 10 acres of

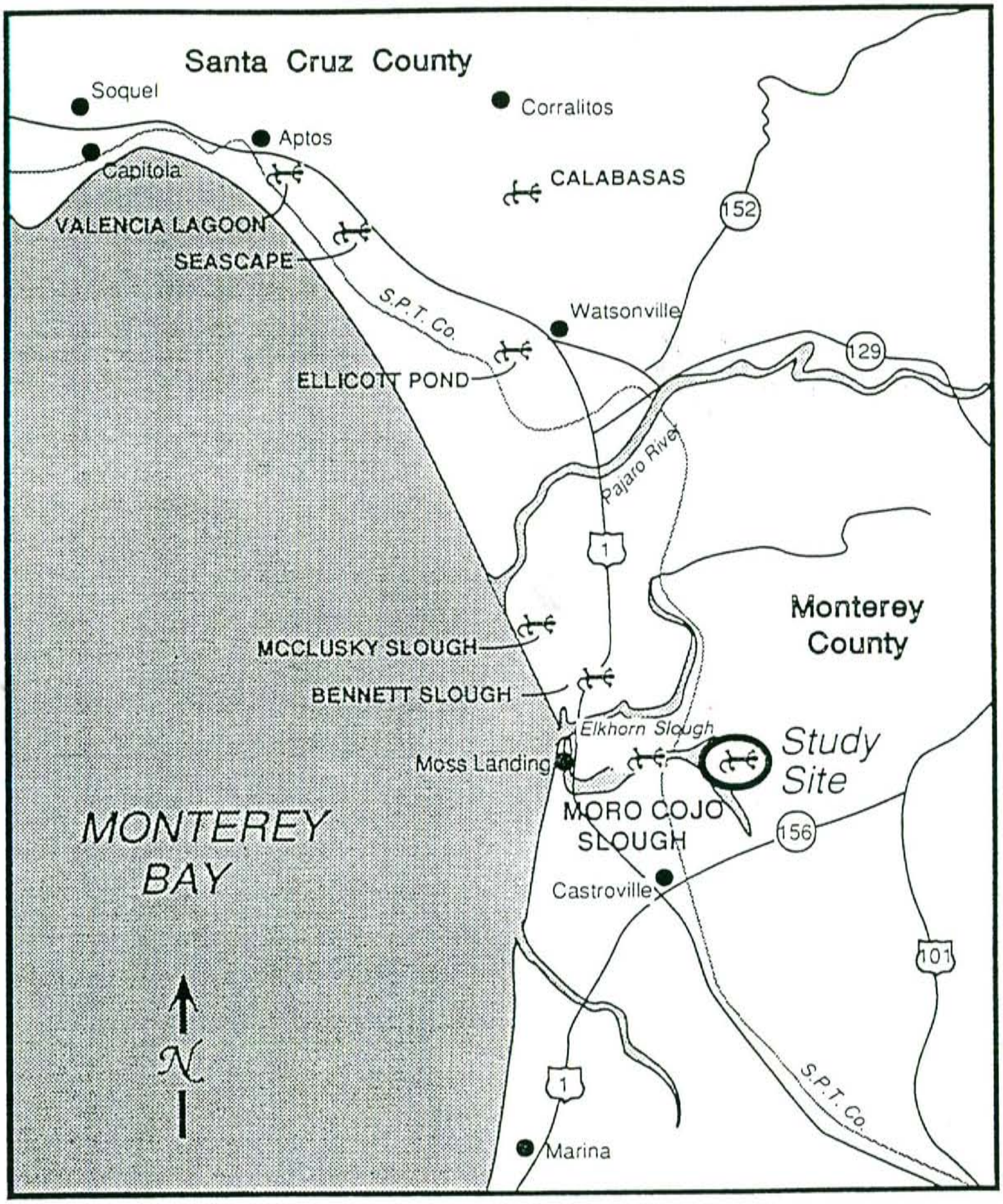


Figure 1: Regional map showing the study site and known locations of SCLTS populations.

spray irrigation fields and temporary wetlands continuous with the Moro Cojo drainage. The ponds and wetlands are within the Moro Cojo Slough 100-year floodplain (FEMA 1984). Dikes surrounding the ponds consist of bare earth berms which are heavily vegetated to the west by pines (*Pinus sp.*), and to the east by coyote bush *(Baccharis sp)* and poison hemlock. A low-lying temporary pond just south of the southernmost Watertek pond is heavily vegetated by cattails *(Typha sp.)* and tules *(Scirpus sp.)*. South and east of this temporary pond, foliage changes with rising elevation to willows, coyote bush, poison hemlock and ultimately, grassland.

1.4. Distribution, Status and Life History of the SCLTS

The SCLTS is one of five subspecies of long-toed salamanders which are widely distributed throughout the Pacific Northwest (Stebbins 1985). It is the southernmost of these subspecies, and is geographically isolated from the next closest population by more than 800 km. Its range is also the most limited of any subspecies. The SCLTS was first documented in 1954 at Valencia Lagoon, south Santa Cruz County, California (Russell and Anderson 1956). Since then, but prior to this study, seven SCLTS populations have been identified in southern Santa Cruz and northern Monterey Counties (Figure 2 in Ruth 1988b).

The SCLTS has been included on the Federal Endangered Species list since 1967, and was added to the State Endangered Species list in 1970. The establishment of two ecological reserves, as well as the protection afforded by its endangered status, have apparently succeeded in reducing immediate threats of extinction. However, SCLTS terrestrial and breeding habitat degradation continues to be a major concern, since known SCLTS populations typically occur in populated or agricultural areas.

SCLTS alternate between terrestrial retreats during the dry summer-fall seasons and breeding ponds during the rainy winter-spring seasons. They seek dark, moist cool terrestrial refuges such as leaf litter, mammal burrows, rotten logs. Oak woodland, coastal scrub and riparian vegetation are preferred SCLTS terrestrial habitats (Ruth 1988b). Adult SCLTS migrate annually to temporary pond habitats to breed and lay eggs (Reed, 1981). Migration is triggered primarily by rainfall, and occurs at night from November through March. Courtship and breeding take place in the pond; females attach 200-400 eggs to pond vegetation (Anderson, 1960). Hatching occurs in 2-4 weeks, followed by a 3- to 5-month larval stage. Metamorphosis to the juvenile stage occurs in response to drying of the breeding pond. Juvenile emigration from the pond site begins during the first fall rains and may continue through the winter (Ruth 1988a). Highly variable rainfall and other unknown factors make successful reproduction and juvenile recruitment equally variable from year to year. However, a relatively long life span (Bowler 1977) and high fecundity (Anderson 1960) contribute to the SCLTS's ability to withstand major fluctuation in annual reproductive success.

2. METHODS

2.1. Field Surveys

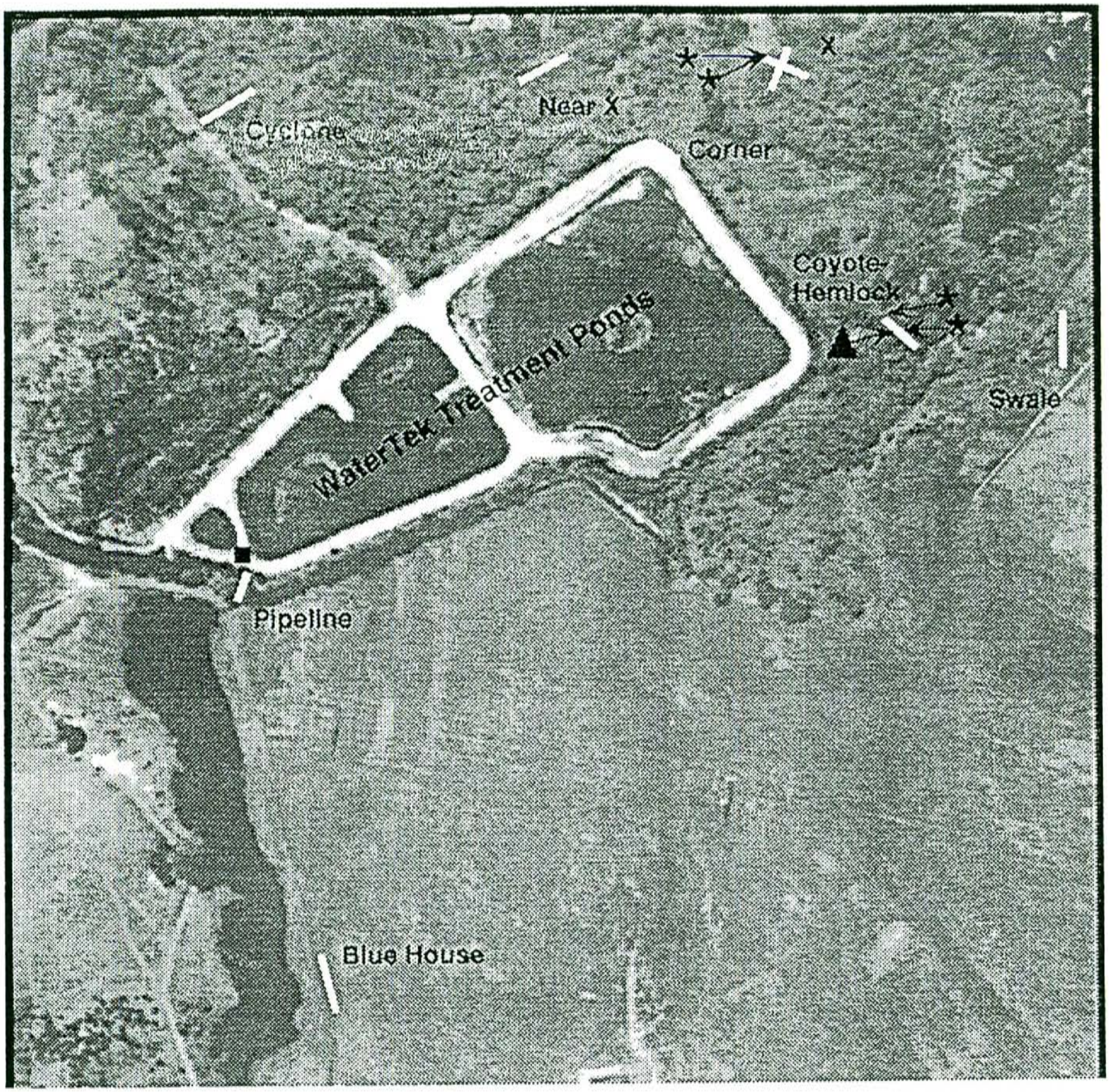
The potential breeding sites and migration corridors of SCLTS and tiger salamanders on the study site were surveyed between 1 January and 24 February 1990, following an initial reconnaissance of the study area in late November 1989. These surveys included 1) checks of strategically placed drift fences and pit traps, 2) spot checks under logs and old lumber, and 3) a night walk.

2.1.1. Drift Fences and Pit Traps

Twelve drift fences (Figure 2) were constructed on 23 December 1989 (6 fences outside Watertek property), 29 December 1989 (5 fences on Watertek property) and 20 January 1990 ("Last" Line on Watertek property). Fences averaging 26 m in length were placed across likely SCLTS and tiger salamander migration corridors so that migrating individuals would be deflected into open pit trap stations installed every 8 m (average) along the fence lines (Table 1). SCLTS were primarily targeted by fences in or near areas heavily vegetated by willows, coyote bush and poison hemlock. Tiger salamanders were targeted by fences installed in grassy upland areas.

Fence design was modeled after Ruth (1988a). Fences consisted of folded 30# tar paper 23 cm high, held upright by 76 cm -tall wood stakes. In areas likely to be subjected to heavy runoff during storms, fences were partially or wholly made of 46 cm-high, 0.3 cm mesh hardware cloth, and topped by aluminum flashing which was folded and splayed outward to prevent climbing over the fence. Both tar paper and hardware cloth were buried approximately 7 cm into the ground to prevent animals from passing under the fence.

Pit traps were installed as opposing pairs on either side of each fence. At the ends of some fences, large single traps were used in place of paired traps. Each paired set of traps or single end trap was labelled with a station number. In addition, each trap in a station pair was identified as an "in" trap (referring to the trap closest to the wetland area) or "out" trap


Near X
Cyclone
Corner
Coyote-
Hemlock
Swale
WaterTek Treatment Ponds
Pipeline
Blue House

(furthest from the wetland area) as appropriate. Distances between adjacent stations along each fence line are listed in Table 1.

Paired pit traps were made of plastic nursery pots (15 cm diameter x 18 cm deep). The six large (1.5 high x 2 cm wide) drain holes along the bottom edge of each pot were duct-taped to retain about 1 cm of standing water, with 1/4 cm at the top of each hole left open for drainage. Single end-traps were made of 19-liter plastic buckets which were punctured several times from the inside out about 2 cm above the bottom edge. Both small and large traps (i.e. nursery pots and 19-liter buckets) were equipped with 10 cm x 10 cm squares of foam rubber sponges (1 per small trap; 3 per large trap) to maintain a moist refuge in the traps after rain. Shade covers made of 20 cm or 30 cm plywood squares with 5 cm-high block legs were set over traps. Each small trap was closed between rains by inverting a 15 cm-diameter plastic drainage dish into the trap; large traps were closed by inverting 30 cm shade covers over the mouths of the traps and weighing them down with soil. In areas of heavy runoff, trap flooding was minimized by setting them into raised dirt mounds along affected fence lines. See Ruth (1988b) for further details of construction and installation.

Pit traps were opened the day before anticipated rain, and checked daily until closed 3 days after the last rainfall (Table 2). Fence lines were maintained continuously to insure that they were adequate barriers and holding areas for migrating salamanders.

2.1.2. Spot checks

Likely salamander refuges were checked opportunistically on days when pit traps were inspected. Logs and old lumber were briefly lifted to examine the ground beneath, then replaced in their original positions. In addition, sporadic checks were made of Castroville Rd. and Meridian Rd. bordering the study site to look for salamanders and frogs crossing the pavement and road kills.

2.1.3. Night walk

Potential Red-legged Frog breeding areas in the Watertek property were checked using headlamps and flashlights during a night walk on 24 February 1990 (2030-2230 hrs.) Four observers examined the 1 m-deep temporary pond filling the low-lying area between Coyote-Hemlock Line and Corner Line. The perimeters of the 3 Watertek settling ponds were also searched.

2.2. Handling of Captured Animals

Amphibians and reptiles captured in traps were identified to species and released live at the site. No animals were removed from the site or transferred to other locations within the site. Ambystomid salamanders were measured to obtain total length and snout-vent length, and photographed in the field as time and weather permitted. Snout-vent length was estimated by measuring the tip of the snout to the contraction at the base of the tail, as in Ruth (1988b). Sex of SCLTS was identified by shape and size of the vent, body size (of juveniles) and swollen appearance (of gravid females). Captured mammals were identified to genus; shrews were further identified to species. All live mammals were released at the site. Invertebrates were released from the traps daily.

2.3. Environmental Data

Amount of daily precipitation and minimum air temperatures were obtained for the period from 1 September 1989 to 28 February 1990 from the University of California Agricultural Extension Service. These data were recorded daily at 2400 h. from Castroville weather station #19, which is operated and maintained by the Department of Water Resources. Average annual rainfall totals near the study area were obtained from the local National Weather Service weather observer (C. Wilson, pers. comm.). Information regarding spraying of mosquito pesticides at the upper Moro Cojo Slough and Watertek property was obtained from the North Salinas Valley Mosquito Abatement District (A. Tregenza, pers. comm.).

3. RESULTS

3.1. Targeted Species

Four SCLTS and one Arizona Tiger Salamander *(Ambystoma tigrinum nebulosum)* were captured in pit traps during the 32 days traps were open between 1 January and 21 February 1990 (Table 2). In addition, one California Red-legged Frog (*Rana aurora draytoni*) was positively identified during a night survey on 24 February 1990, and two dead California Red-legged Frogs were found on 25 November 1989 two km northeast of the Watertek site on Meridian Road (S. Ruth, pers. obs.). No salamanders were found during opportunistic spot checks of likely salamander refugia and on the bordering roads. Opening and checking traps, spot checks of likely refugia and the night survey engaged 114 individual effort hours.

3.1.1. SCLTS

All SCLTS were captured at two fence lines in the southeast corner of the study area. At the Coyote-Hemlock line (Figure 2), a juvenile was captured at Station 1 (single end trap) on 13 January, and a gravid female was captured at Station 2 "out" (paired trap furthest from presumed breeding site) on 14 January. At X line, approximately 200 m east-southeast of

Coyote-Hemlock (Figure 2), another juvenile was captured at Station 31 "out" on 4 February; a second gravid female was captured in the same trap on 17 February. The two juveniles averaged 48 mm snout-vent length, 103.5 mm total length. The two gravid females averaged 54.5 mm snout-vent length, 113.5 mm total length (Table 3).
The SCLTS captures occurred within one day of maximum rainfall periods (> 1.3 cm, i.e. 0.5 inches per 24 hours) and high minimum air temperatures (> 3°C, i.e. 37 °F) recorded during the study (Table 2).

3.1.2. Arizona Tiger Salamander

One Arizona Tiger Salamander was captured at Coyote-Hemlock line Station 3 "in" trap on 7 February. Snout-vent length measured 115 mm; total length measured 180 mm. Sex was not identified.

3.1.3. Red-legged Frog

The Watertek sewage ponds and surrounding area were surveyed by headlamp and flashlight on 24 February, 2030-2230 h. The perimeters of all 3 ponds were examined, as well as the temporary pond between Coyote-Hemlock line and Corner line. One adult Red-legged Frog was positively identified (Ruth, pers. obs.) near the edge of the pond closest to Pipe line (see Figure 2).

2.4.4. Other Vertebrates

In addition to the species noted above, one Slender Salamander (*Batrachoseps sp.*), 33 Pacific Tree Frogs (*Hyla regilla*), and one juvenile Alligator Lizard (*Gerrhonotus multicarinatus*) were incidentally captured and released live from pit traps in the study area. Three mammal species were also captured in traps and released if live: five deer mice (*Peromyscus sp.*; 4 released), 4 voles (*Microtus sp.*; 2 released) and 15 Trowbridge's Shrews (*Sorex trowbridgii*;1 released).

4. DISCUSSION

4.1. Implications of Findings

This study is the first to identify the presence of the endangered SCLTS in the upper Moro Cojo Slough area east of Castroville Blvd. The capture of one non-native Arizona Tiger Salamander is also noteworthy, as it identifies a potentially major competitor to the California Tiger Salamander population known to occur in north Monterey County (Reed 1979; Ruth 1988, 1989 pers. obs). In addition, this work confirms the local presence of the California Red-legged Frog. Both the California Tiger Salamander and California Red-legged Frog are candidates to the Federal Endangered Species List.

Figure 3: Adult Santa Cruz Long-toed Salamander (Ambystoma macrodactylum croceum). Photo by Stephen B. Ruth.

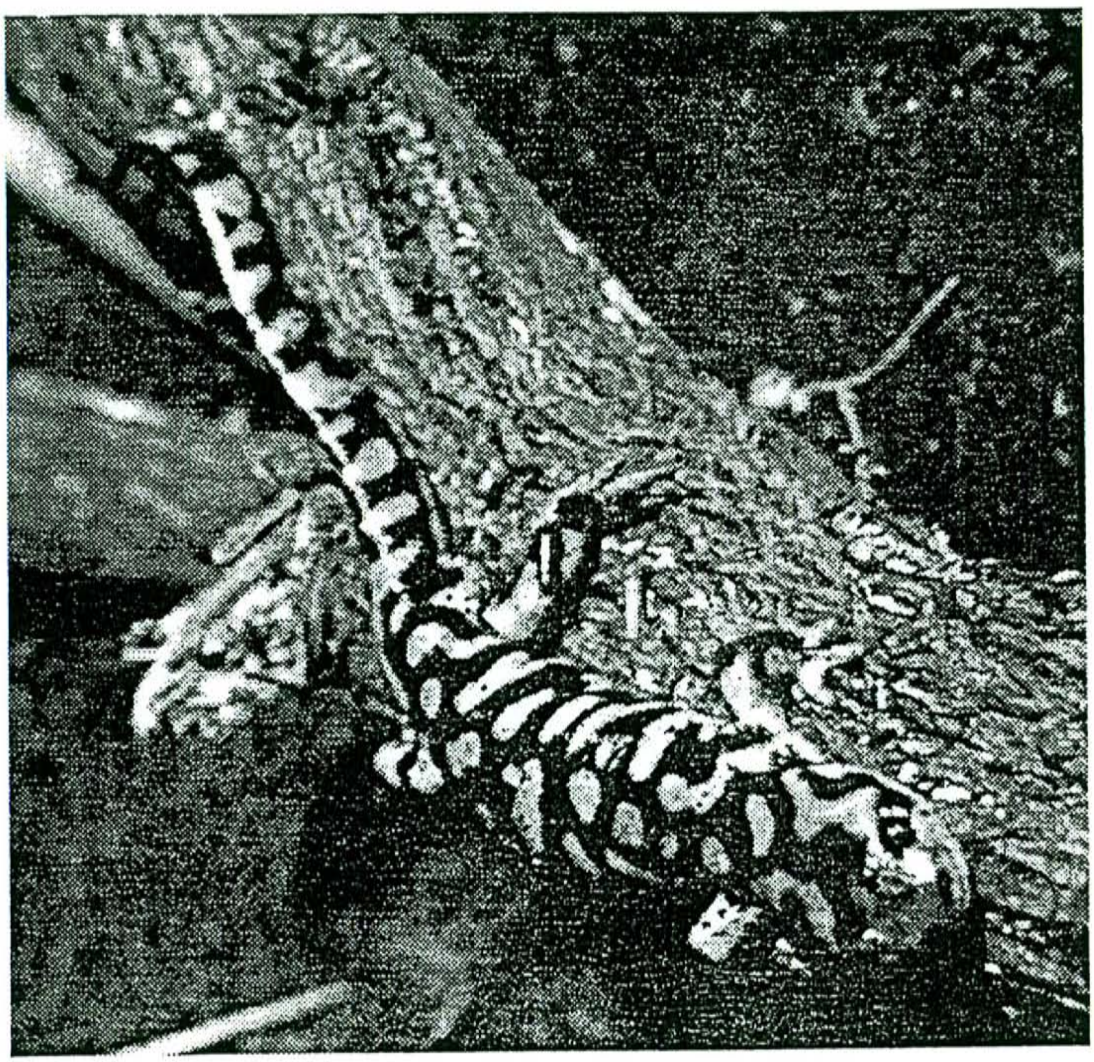


Figure 4: Tiger Salamander (*Ambystoma tigrinum nebulosum*) from study site.
Photo by Philip Bairrington.

4.1.1. SCLTS

The capture of gravid SCLTS confirms the existence of a reproductive population in the upper Moro Cojo, and suggests the presence of a breeding area in or near the capture sites. All SCLTS were captured within a 200 m range in the southeast corner of the study site, and on either side of a low-lying area which filled with water during the study period. As indicated by their captures in "out" traps, these individuals were apparently migrating from nearby upland slopes toward this low-lying area. However, the small number of SCLTS found and the lack of any information about SCLTS larvae in this area preclude further speculation.

The distance and habitat separating the present SCLTS capture site and the only other known SCLTS location in the Moro Cojo drainage (Reed 1979; Figure 1) suggest that reproducing individuals from the two sites use different breeding areas, though these may be sites used by a single Moro Cojo population. The maximum migration distance confirmed for an SCLTS is approximately 1.6 km (Ruth 1988b). The old SCLTS site is separated from the present capture site by more than 2 km of grassy upland area, or more than 5 km along a route following the Moro Cojo drainage channel. SCLTS apparently prefer to migrate between terrestrial and breeding sites through dense vegetation and along low-lying drainages rather than open grassland (Ruth 1988b). The well-travelled paved road (Castroville Blvd.) and extensive agricultural and pastureland which lie between the two known SCLTS sites probably restrict overland movements between these areas.

Though the small number of SCLTS captured preclude statistical analyses of migration patterns, the timing of captures support previously-identified correlations to high rainfall and air temperatures. All SCLTS were captured immediately following rains of at least 1.3 cm (0.5 in). These periods of high rainfall also coincided with minimum air temperatures generally greater than the average 2 °C (36°F) recorded for all days traps were checked. Anderson (1967) considered precipitation the only factor influencing SCLTS movement. However, more recent studies (Ruth and Tollestrup 1973; Reed 1979,1981; Ruth 1988b) indicate that minimum air temperature may secondarily influence migration. The small number of animals captured and the strong link between rainfall and warm air temperature occurring during this study confound any assessment of the relative importance of these two variables to SCLTS movement.

The small number of SCLTS captured was surprising; particularly in light of previously-discussed evidence that a likely breeding site is in or very near the SCLTS capture sites.

All previous drift-fencing studies near breeding habitat have captured many individuals (Talent and Talent 1980; Reed 1979,1981; Ruth 1988b; Ruth and Tollestrup 1973). Several factors may have contributed to the small number SCLTS captured. If a large SCLTS population does actually exist in the upper Moro Cojo drainage, the lack of SCLTS captures may have been due to 1) a migration which did not coincide with the study period, 2) a breeding site further from the study area than most SCLTS travelled 3) fence lines which did not cut across migratory corridors, and/or 4) migratory failure due to low rainfall. Each of these possibilities is briefly discussed below.

1) While it is possible that the breeding census was conducted too late and missed the breeding migration, this is unlikely. Though the study period encompassed only January and February, these months were by far the wettest of the 1989-1990 season (Sept = 0.8 in., Oct = 1.8 in., Nov = 1.0 in., Dec = 0 in., Jan = 3.3 in., Feb = 3.0 in., Mar = ca. 1 in.). Two local herpetologists (S. Ruth and R. Pontius pers. comm.) indicated that California Tiger Salamanders migrated later than usual this year. Their breeding migrations, like the SCLTS, are initiated by rainfall. It is therefore highly unlikely that most SCLTS migrated before or after the study period.
2) It is improbable that the breeding site of the two gravid females captured was outside the study area, unless SCLTS migrate much greater distances than presently thought. The temporary pond between Coyote-Hemlock and X line probably provides suitable SCLTS breeding habitat in some years.
3) Since all low-lying areas considered potential breeding areas near the capture sites were bordered by fence lines, any large population actively breeding in these areas would have been recorded in numbers larger than those found.
4) Total annual rainfall since the 1986-1987 season has averaged 12.6 in. locally, which also appears representative of the 1989-1990 season (1 July 1989-1 March 1990 = 10 in.). This is much lower than the 21.5 in. average annual rainfall for the previous decade (1976-1985). Since precipitation initiates SCLTS movement, it is very possible that the most recent four successive dry years have seriously limited SCLTS migration (though note that a study of the SCLTS Seascape population during the 1986-1987 dry year captured 1124 adults near the breeding pond; Ruth 1988b). Reed (1981) documented a 50% reduction in estimated SCLTS population size from a wet year (1977-1978) to a normal rainfall year (1978-1979) at Valencia Lagoon. Mortality of individuals utilizing the relatively exposed upland terrestrial habitat at the study site would be expected to be high during drought years due to the warmer and drier conditions.

As an alternative to the above explanations, it is possible that the four SCLTS captured accurately represent a very small local population which may not be self-sustaining. The well-documented presence of robust SCLTS populations in nearby areas (Reed 1981, Ruth 1988b) suggest that local environmental factors, rather than large-scale ones (e.g. Barinaga 1990), would be most likely to account for the low number of SCLTS in the upper Moro Cojo drainage. Though many factors may be limiting the number of SCLTS, the effects of 1) saline water, 2) mosquito fish *(Gambusia)*, 3) pesticide-laden run-off from nearby agricultural fields, 4) direct pesticide applications by the Mosquito Abatement District and 5) high nutrient and bacterial counts from livestock and Watertek pond overflows may be of special concern.

4.1.1.1. Salinity

In winter, the Moro Cojo drainage typically decreases in salinity from its mouth toward its inland reaches (ABA Consultants, 1988). However, even in the uppermost portions of the slough, some areas - e.g. the wetland immediately south of the southernmost Watertek pond - are apparently relatively saline (e.g. too saline in some years to support a viable population of mosquito fish; A. Tregenza, pers. comm.). Though virtually no information exists on the acceptable limits of pond salinity to SCLTS at different life stages, it appears to have adversely affected the Struve Pond SCLTS population from the late 1970's to the present (Rainey 1985a, 1985b; Ruth 1988b; Ruth pers. obs.). Licht et al. (1975) found that all adults from a relatively salt-tolerant Slender Salamander *(Batrachoseps)* population died when exposed to a salinity of 17ppt. Sensitive larval stages may be the most likely to encounter intolerable salinities as they remain in drying ponds during spring and summer prior to metamorphosis.

4.1.1.2. Mosquito Fish

Mosquito fish are stocked by the Mosquito Abatement District (A. Tregenza) in freshwater regions of the Moro Cojo (e.g. near Hwy 156, north of Castroville Blvd) and at least once annually in the Watertek ponds. Predation upon SCLTS by mosquito fish has not been observed. However, Ruth (1990, pers. comm.) has noted an inverse correlation between mosquito fish abundance and SCLTS abundance in the south Santa Cruz/north Monterey County area. The negative impact of other fish populations on amphibian larvae is well documented (Freytag 1984, Semlitsch 1988, Bradford 1989).

4.1.1.3. Pesticides

Twenty-six pesticides were in use on farmland adjacent to the Moro Cojo Slough, according to a review of pesticide use permits conducted by the CDFA Pesticide Branch (1988). Three of these - endosulfan, fenbutatin, and benomyl - were identified as the three most potentially hazardous pesticides to SCLTS used near any of the SCLTS sites in Monterey County, due to the high toxicities and long half-lives of these chemicals or their metabolites. Though the farmland sprayed is located on the west side of Castroville Blvd., i.e. outside the study area, the persistent nature of the 3 pesticides noted would potentially enable them to significantly impact SCLTS in the form of agricultural run-off. High levels of pesticides are found in the adjoining Elkhorn Slough and other regional watersheds (ABA Consultants, 1989). Assessment of SCLTS pesticide toxicity in the CDFA review was approximated by using known values for various freshwater fishes.

4.1.1.4. Mosquito Control Larvacides

Two mosquito larvacides are regularly applied to the Watertek property and the low-lying temporary ponds to the north and south. A light grade larvacidal oil called GB-1356 (manufactured by Golden Bear Co.) is applied to the open well pumps adjacent to the Watertek ponds about every 10 days (A. Tregenza, pers. comm.). Though the steep-sided wells are inaccessible to SCLTS, the water itself is exchanged with pond water. In addition, the ponds are generally sprayed once per month, spring through fall, with Baytex (manufactured by Wilbur Ellis Co.; active ingredient = fenthion). Baytex is also applied about once every three weeks to the temporary ponds south and north of the Watertek ponds between April and June, in concentrations of 2 oz per acre. Though the toxicity of these products to SCLTS is not known, their application to potential SCLTS breeding ponds precisely during the period when sensitive larvae are most likely to occur warrants more detailed study of their effects.

4.1.1.5. Livestock

Approximately 50 head of cattle and 10 horses inhabited grassland areas above several potential SCLTS breeding ponds throughout the study period. Possible resulting degradation of water quality would most likely affect those ponds nearest Horse Line, Blue House Line, Swale Line and Coyote-Hemlock Line. In addition, occasional past flooding of Watertek Ponds and run-off from saturated spray fields during unusually wet seasons (EIR 1988) may contribute to reduction of water quality of temporary ponds near Pipe Line, Corner Line, Coyote-Hemlock Line, Last Line, X Line and Near X Line. Tolerable levels of coliform and nitrates for SCLTS are unknown, though Reed (1979) documented an apparently healthy SCLTS population at Valencia Lagoon which contained fecal coliform levels greater than 200 colony/100 ml. Increased eutrophication due to nutrient loading may also potentially limit the viability of SCLTS populations by reducing oxygen levels in breeding ponds. The degradation of water quality could potentially reduce SCLTS breeding at ponds on the site.

4.1.2. Tiger Salamanders

The confirmed presence of the non-native Arizona Tiger Salamander *(Ambystoma tigrinum nebulosum)* is probably a result of its importation for use as live fish bait (Stebbins 1985). Its local distribution appears to overlap with that of the California Tiger Salamander, which has been found as larvae and adults associated with the Moro Cojo drainage just west of Castroville Blvd. (Reed 1979; Ruth 1988, 1989 pers. obs.). The potential impact of the Arizona subspecies to the native California population in this area is unknown, but could occur in several ways. Arizona Tiger Salamanders may mix with native tiger salamander populations (Stebbins 1985). As with other ambystomids, they are generalist feeders limited mainly by the size and power of potential prey. It is therefore likely that the diet of the two subspecies strongly overlaps. Competition for food, as well as breeding habitat and upland refugia may significantly affect the California subspecies. The presence of Arizona Tiger Salamanders may also directly impact SCLTS, as larval Arizona Tiger Salamanders are known to feed on larval SCLTS (Blau 1972).

Despite the installation of several fence lines in presumably desirable grass upland habitat, only one Arizona Tiger Salamander and no California Tiger Salamanders were captured. The surprising lack of both species may reflect the influence of one or several factors potentially impacting the SCLTS noted above. In addition, the potential impact of overgrazing in upland areas may have a greater impact on Tiger Salamanders, which utilize more mesic terrestrial habitats than SCLTS.

4.1.3. Red-legged Frog

The sighting of a single Red-legged Frog represents the first documented sighting of this species within the upper Moro Cojo drainage. Several Red-legged Frogs have been previously found on Meridian Road (Ruth pers. obs.). Red-legged Frog adults and larvae have also been found in a portion of the Elkhorn Slough drainage 3-4 km northwest of the study site (Reed 1979). In addition, larvae have been found approximately 5 km further north, in a creek bordering Strawberry Road (June 1989; S. Ruth, pers. obs.). Sightings of this species are particularly important in light of recent declines in abundance in several areas of California, perhaps due to habitat disturbance and the introduction of the bullfrog (Stebbins 1985). Although only one individual was sighted, the result of only one night of active searching, it is reasonable to expect that a larger population exists.

4.1.4. Other

No threatened or endangered mammal species were incidentally captured during the study. In particular, no Ornate Shrews *(Sorex ornata)* were caught, though this species is believed to occur in small numbers in this area.

Though the abundance of invertebrate species was not recorded, trap checks revealed consistently high numbers of isopods *(Armadillidium sp.)*. These are a major prey item of SCLTS. Anderson (1968) found that 50% of SCLTS stomachs contained isopods. These were also a major component of individual diets, as they comprised an average of 47% of the food items in SCLTS stomachs.

4.2. Study Limitations and Recommendations for Future Studies

The primary purpose of this study was to determine whether SCLTS occurred in the study area. This was achieved; however, the short duration of the study and the narrow focus of methods and results preclude any comprehensive assessment of population size or migratory movements, breeding location, or environmental influences (other than rainfall and temperature). Any future study should attempt to cover at least two winter seasons to increase the likelihood of sampling during a normal rainfall year. If the population size is greater that indicated by this study, marking of individuals would allow evaluation of the timing of migration and population size via mark-recapture analyses (Ruth 1988b, Reed, 1979). Radioactive wire implants and photo identification of individuals would greatly enhance what is known of local habitat use and individual behavior patterns on a diel and seasonal time scale (see Semlitsch 1983, Ruth 1988b). Dip-netting in potential breeding ponds for SCLTS, Red-legged Frog and Tiger Salamander larvae should be conducted to identify actual breeding sites, and to confirm the presence of potential predators such as mosquito fish.

Finally, the water quality of breeding ponds should be closely monitored for high salinity and pesticide concentrations as well as high nutrient and bacteria loading (see Rainey 1985a, 1985b; California Dept. of Food and Agriculture Report 1988; Reed 1979). Complimentary laboratory studies should be considered to provide some measure of the effects of mosquito fish predation on SCLTS as well as tolerances to salinity, pesticide, nutrient and bacteria levels at different life stages - particularly the sensitive egg, larval, and juvenile stages. Non-listed, common axolotls (e.g. *Ambystoma mexicanum*)would be suitable for such work, as they have similar life histories to the SCLTS in the aquatic phase, so responses to environmental changes would likely be similar.

It is possible that the SCLTS captured in this study and those previously documented in the lower Moro Cojo drainage (Reed 1979) represent remnants of a formerly much larger Moro Cojo population. In years of adequate rainfall, enough freshwater habitat exists in parts of the Moro Cojo system to support many more SCLTS than have been discovered to date. The most recent draft of the Santa Cruz Long-toed Salamander Recovery Plan (U.S. Fish and Wildlife Service 1986, withdrawn 1989) specifies that, in addition to maintenance of the relatively large populations previously documented at Valencia Lagoon and Ellicott Slough, three other sites should be secured and managed to support SCLTS populations of at least 2600 breeding individuals. With the exception of the recently-studied Seascape population (Ruth 1988b), the current status of known SCLTS populations is not well-documented. The discovery of gravid females in the Moro Cojo in January-February 1990 (this study) and the potential size of terrestrial and breeding habitat available to this population under favorable conditions make the Moro Cojo SCLTS population a potential candidate for one of the populations to be managed as part of the SCLTS Recovery Plan. However, the very low numbers of SCLTS actually documented and the many previously-discussed factors which may be negatively impacting this population emphasize the need for a comprehensive SCLTS habitat and population assessment. Such work is critical in determining whether the Moro Cojo Slough can be managed to support a self-sustaining SCLTS population. More thorough study of the SCLTS on the Rolling Hills I and Watertek site will also probably be required by the California Department of Fish and Game and the U.S. Fish and Wildlife Service prior to development or any other activity which could negatively impact this endangered species.

5. ACKNOWLEDGEMENTS & CREDITS

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Table 1. Summary of drift fence lengths, number of stations per fence, distances between fence stations and number of individual traps per fence at Moro Cojo study area, January-February 1990. Distances in meters.

Fence Name	Total Length	# Stations	Mean Distance between stations	Total # traps per fence (#pairs + #singles)
1. Coyote-Hemlock	35	4	11.7	6 (2pr +2)
2. Swale	18	3	9	4 (1pr + 2)
3. Cow Pond	26	3	13	4 (1pr + 2)
4. Blue House	28	4	9.3	6 (2pr + 2)
5. Horse (1 & 2)	63	7	12.6	10 (3pr + 4)
6. C-M	26	6	5.2	12 (6pr)
7. X	26	5	6.5	11 (5pr + 1)
8. Near X	10	3	5	6 (3pr)
9. Cyclone	31	6	6.2	11 (5pr + 1)
10. Corner	20	5	5	10 (5pr)
11. Pipeline	17	5	4.2	10 (5pr)
12. Last	11	3	5.5	6 (3pr)
TOTAL	311	54		96
MEAN	25.9	4.5	7.8	9

Table 2. Number of amphibians captured by drift fences in Moro Cojo study area in relation to daily total precipitation and minimum air temperature, 1 January - 21 February 1990.

	Total Captured	JANUARY* 1	2	3	4	11	12	13	14	15	16	17	18	19	20	30	31
Total Precipitation (inches)		1	0	0	0	0.2	0	0.6	0.7	0	0	0	0	0	0	0.3	0.2
Minimum Temperature (°F)		37	36	31	31	42	50	47	48	43	39	32	33	34	34	41	33
SCLTS	4							1	1								
Tiger Salamander	1																
Slender Salamander	1										1						
Tree Frog	33		4	2				4		1	2	1					2

contd.

*Dates include all days when traps were open.

Table 2. continued

	FEBRUARY*															
	1	2	3	4	5	6	7	8	9	15	16	17	18	19	20	21
Total Precipitation (inches)	0.1	0	0.7	0	0	0.2	0	0	0	0	1.7	0.2	0	0	0	0
Minimum Temperature (°F)	37	33	40	37	32	38	30	29	38	26	38	35	33	31	32	41
SCLTS				1								1				
Tiger Salamander							1									
Slender Salamander																
Tree Frog	2	2	1	2	1	2	2	2	2			1				

*Dates include all days when traps were open.

Table 3. Sex and length of Santa Cruz Long-toed Salamanders caught in Moro Cojo study area, 1 January-21 February 1990. A single individual was captured on each date. Lengths in mm.

Date	1/13/90	1/14/90	2/4/90	2/17/90
Sex	Juvenile	Female, gravid	Juvenile	Female, gravid
Snout-vent Length	49	53	47	56
Total Length	106	112	102	115