1st Annual Upland Ecology and Biology of CTS Workshop

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What is a CTS

- **Amphibian**
  - aquatic eggs, thin skin
- **Salamander**
  - four legs and a tail
- **Mole salamander**
  - Family Ambystomatidae
- **Tiger salamander**
  - large terrestrial salamanders and the only group to occupy grasslands

On land, mid-level predator of insects and other invertebrates. Top aquatic predator of vernal pool ecosystems.

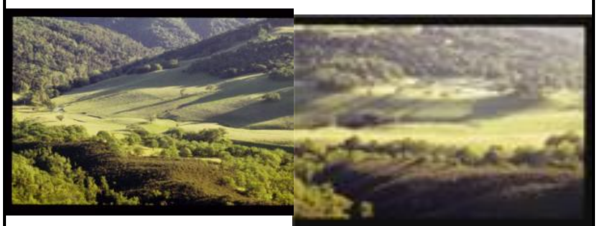
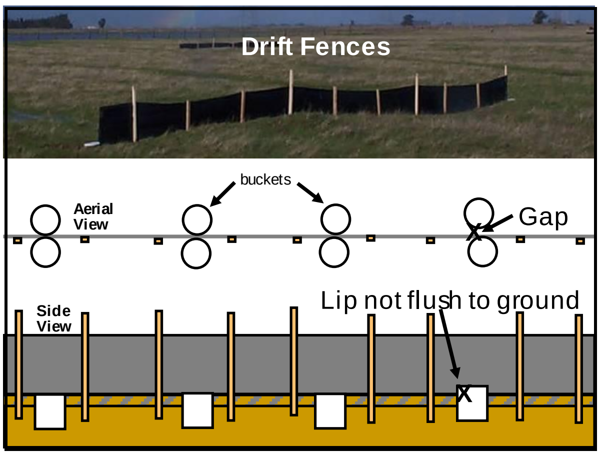


Figure 9. Southern trap line facing west.

Sue Orloff, Ibis Associates (2007)



Drift Fence Components

- Fence
  - non climbable material
    - aluminum flashing
    - silt fencing
    - shade cloth
    - wood paneling, fiberboard, screen
  - supporting elements
    - wooden stakes
    - rebar, other?
  - minimal requirements
    - 12 inches tall
    - 3 inches buried
- Pitfall Traps
  - plastic buckets
    - at least 2 gallons in size for protocol
  - bucket lids
    - permit info on traps
    - sunshade
  - other
    - foam/pvc tubes for moisture and shelter
    - escape ropes

Drift Fence Construction

- Fencing requirements
  - fencing equal to ≥90% of site perimeter
  - ≥ 50% of shoreline for potential breeding ponds
- Site selection for fencing
  - maximize capture potential
  - target areas near ponds
    - at least 10 ft from high water mark
  - avoid major mammal activity
- Site selection for pitfall traps
  - ≤10 meter (33 ft) between traps
  - avoid "wet" areas, ant hills
  - select higher spots

Protocol Sampling for CTS

- 1) Site assessment – assess upland and aquatic habitat onsite and in surrounding areas
- 2) If upland habitat only…
  - Two seasons of upland drift fence sampling
  - Traps opened for rain events Oct. 15 – Mar. 15
    - actual or predicted >70% chance
    - if it rains = traps open the next night too
    - after 20 nights, just sample during rain events
    - if CTS discovered, STOP and contact agencies
- 3) If potential breeding habitat present
  - One season upland sampling as above
  - Drift fences sampling potential breeding habitat
  - 2 seasons aquatic sampling for CTS larvae

FWS Reports

- Provide Complete Information
  - Dates and times sampled
  - Rainfall/temperature data for area during study period
  - Records of all animals captured
  - Photographs of representative specimens
  - Photographs of sampling apparatus
  - Records of all communications with FWS
  - For aquatic sampling calculations of the total effort expended/area covered each time

Trenham et al. 2000 Copeia – Summary of 8yrs of mark/recapture data

Upland Workshop Topics

- Survey methodology and regulations
- Review of CTS habitat, life cycle & identification
- Annual events, population biology
- Upland biology as we know it
- Studies and observations of movement and habitat use
- Threats
  - strategies for avoidance and minimization
  - strategies for land management

CTS Pre-Test

← Which is the CTS? →

- good features for a CTS breeding pond include?
- adult CTS spend ??% of the year in the water?
- where do they live on land?
- most CTS stay within 50 m of water?
- what time of year are breeding migrations?
- what is the best season for larval sampling?

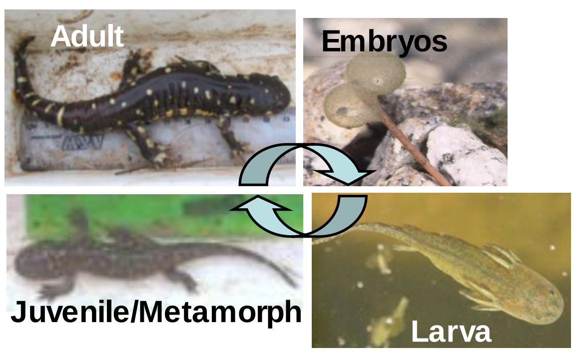
CTS Distribution

- extremely broad range
  - to >3000 ft in Coast Range
  - to 1000 ft in Sierra foothills
- habitat/climate differs
  10 to 30 in rainfall
- often generalizing based on studies from a few sites

Habitat Basics

- Aquatic Habitat
  - Ponds*
  - Vernal Pools*
  - Ditches
  - NOT streams
- Upland Habitat
  - Grassland*
  - Oak savanna*
  - Oak woodlands
  - Sometimes chaparral and shrublands
  - NOT forest

CTS Life Cycle and Morphology



Identification/Morphology

Get a field guide!

Identification/Morphology

- Breeding Adults
  - Males
    - Massively swollen vent
    - Tail fin
  - Females
    - No/minor swelling at vent
    - No prominent tail fin
    - Many visibly fat with eggs = gravid

Sex of non-breeding animals can be difficult/impossible to assign with confidence

Identification/Morphology

- Metamorphs
  - Muddy color patterns
  - Remnant gill stubs
  - 100 to 150 mm long
    - 4 – 6 inches
  - Fat
- Juveniles (after 1st summer)
  - Resemble adults, but smaller
  - Adults 6-10 inches

CTS Life Cycle

Breeding Migrations

Larvae in Ponds

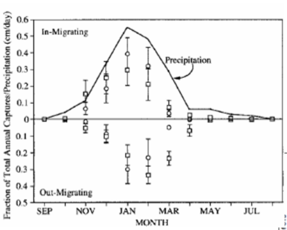
Metamorphosis

Juvenile Dispersal

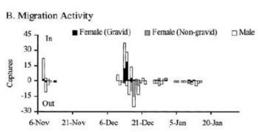
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

Pitfall Captures of Adults (at & not at ponds)

Cook et al. 2006 (Sonoma Co.)



Trenham et al. 2000 (Monterey Co.)



Orloff 2007 (Contra Costa Co.)

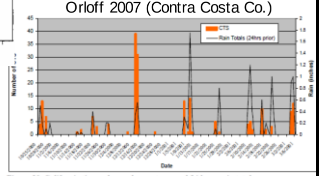
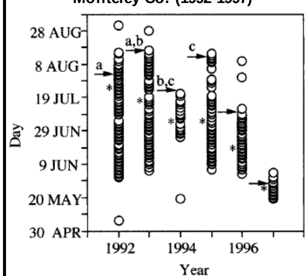


Figure 20. California tiger salamander captures and 24 hour rain totals – First year.

Dates of Metamorph Capture

Monterey Co. (1992-1997)



Trenham et al. 2000

Contra Costa Co. (1992-1993)

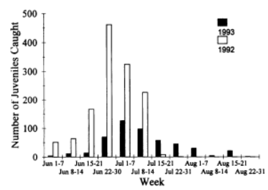
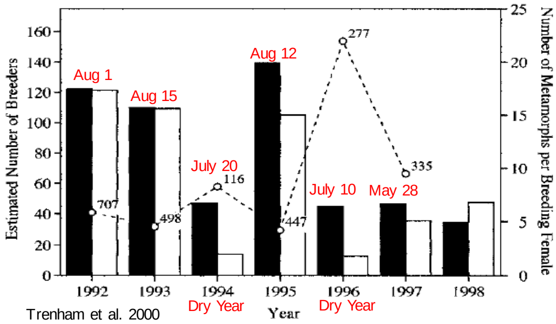


Fig. 3. Number of juvenile *Ambystoma californiense* caught by week in summer 1992 and summer 1993, Contra Costa County, California. Numbers of individuals include original captures and recaptures.

Loredo and Van Vuren 1996

Blomquist Pond Study

Breeding Adults: M=black; F=white
Metamorphs per Female = line



Trenham et al. 2000

Pond Size Influences Productivity

- Blom Pond, Monterey County
  - 116 to 707 metamorphs (average = 400)
- Loredo Study Pond, Contra Costa County
  - 1248, 481, and 3 metamorphs (average = 571)
- Jepson Prairie, Solano County
  - Olcott Lake ~2400 – ~3200 captured in 400 m fence
  - Round Pond ~200 – ~2700 captured in 100 m fence
- All other factors equal – larger pools support larger populations! – but hydroperiod is key!

Life Cycle and Morphology – Main Points

- Adults migrate to ponds during fall and winter rains
  - Present at ponds relatively briefly
- Embryos potentially detectable Nov-March
  - Eggs attached singly or in small groups
- Larv ae mainly detectable March-August
  - Too small to catch before March
  - Coloration extremely variable, but no stripes
- Metamorphosis begins in May
  - Metamorphs vary wildly in color and size
  - Some present in many ponds through summer

Demography – Key Life History Parameters

TABLE 4. PERCENTAGES OF KNOWN SURVIVORS IN EACH YEAR FOLLOWING MARKING, FOR COHORTS OF BREEDING ADULT *Ambystoma californiense* INITIALLY CAPTURED IN THE SAME YEAR.

Year first marked		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1992	Males	55.5	31.9	22.7	11.8	5.0	3.4
	Females	42.1	15.7	15.7	7.4	7.4	2.5
1993	Males	33.3	25.5	9.8	5.9	3.9	
	Females	13.6	12.1	6.1	3.0	1.5	
1994	Males	38.1	19.0	4.8	0.0		
	Females	33.3	16.7	16.7	16.7		
1995	Males	32.0	26.0	12.0			
	Females	14.5	14.5	10.8			
1996	Males	19.0	4.8				
	Females	11.0	11.0				
1997	Males	6.9					
	Females	0.0					

Annual probability of dying for adults = 25 – 40%

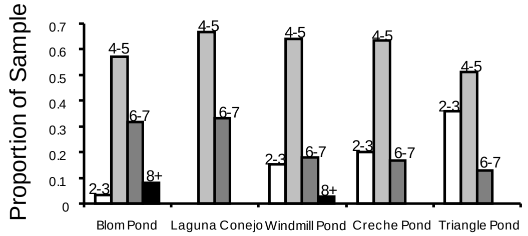
Higher first year after marking

Estimates above low due to 1) dispersal & 2) skipping breeding

Lifetime Breeding Events = 1.5 per female

Juvenile mortality rates are poorly understood – likely high

Age of Adults Varies Between Sites
-5 ponds in Carmel Valley-



Trenham (unpub. data)

- Modeled probability of extinction most sensitiv e to
  - 1) subadult survival
  - 2) adult survival
- This emphasizes importance of minimally disturbed upland habitat
- Trenham and Shaffer, 2005, Ecological Applications

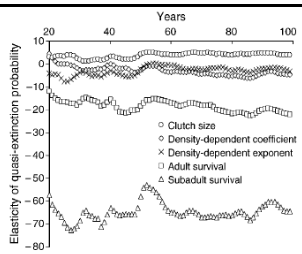


FIG. 5. Estimated elasticity values for cumulative quasi-extinction probabilities in response to perturbations of mean vital rates. Symbols represent elasticity in response to perturbation of various model parameters: subadult survival, adult survival, coefficient and exponent in larval density-dependent survival function, and number of eggs deposited per breeding female. Five adult females was the quasi-extinction threshold. The baseline model parameter values for this analysis were those indicated in Table 1. Elasticities for <20 years are not plotted because few extinctions occurred before this time, and as a result estimates of extinction probabilities and elasticities during this interval are highly variable and unreliable. Methods for elasticity analysis of density-dependent stochastic models are adapted from Morris and Doak (2002).

Demography – Main Points

- Capable of producing large numbers of offspring
  - Given the right conditions
- Some individuals can live 10+ years
  - Most don't ever make it to metamorphosis
- Population size is much more sensitive to upland survival than to larval survival

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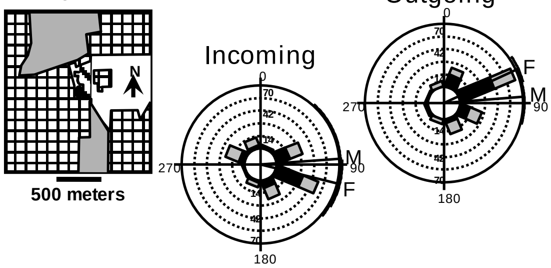
- Southwest Park Study – Urban CTS
  - drift fence around pond
  - most adults came from direction of remaining grassland



Trenham and Cook (2008)

CTS do not stay near ponds!
Sam Sweet – obs. 2km away

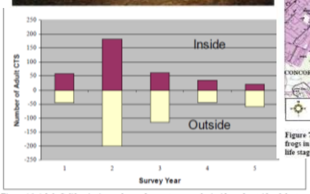


Figure 16. Adult California tiger salamander captures on the inside and outside of the trap line – Five survey years.

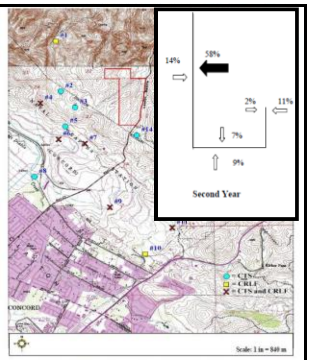
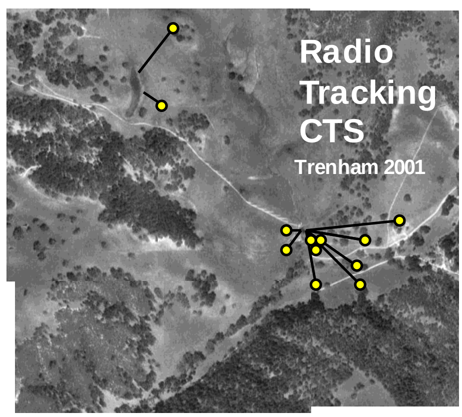


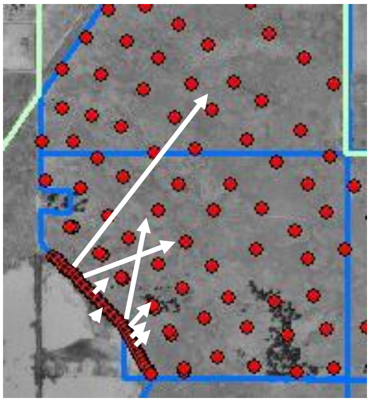
Figure 7. Known occurrence of California tiger salamanders and California red-legged frogs in the project vicinity (all locations are of aquatic habitats with occurrence of some life stage of CTS and/or CRLF).

Sue Orloff, Ibis Associates (2007)

In the uplands CTS depend on friends

FIBER-OPTIC VIDEO
Courtesy of Michael Van Hattem



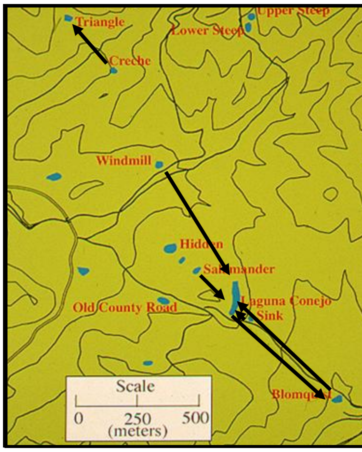


Jepson Prairie Solano County

CTS Study Area

2008 Radio Tracking

Adult males tracked after leaving pond

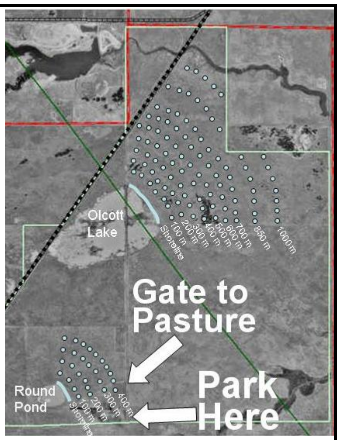


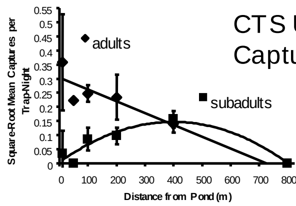
Landscape Ecology

- ~20% dispersed between ponds
- Most moved <600 m
- Estimated some disperse up to 1 to 2 km

• Trenham et al. (2001)

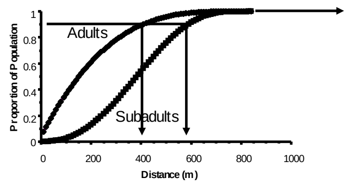
CTS Trapping Studies
2002-2010-?
Jepson Prairie (Solano Co.)





CTS Upland Trapping Captures vs Distance

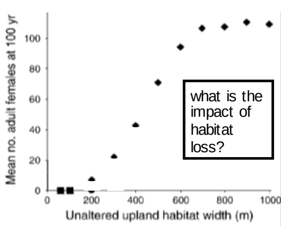
Predicted Upland Distributions

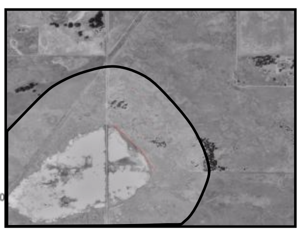


Trenham and Shaffer 2005

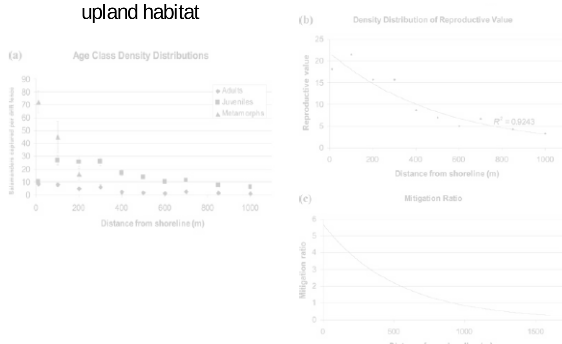
Population Viability Model Analysis for California Tiger Salamanders (Trenham and Shaffer 2005)

if reducing upland habitat reduces survival, populations will be smaller and more vulnerable to extinction

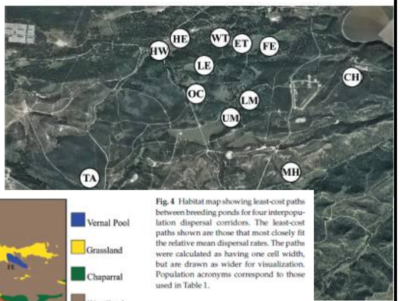




- Searcy and Shaffer (2008)
  - estimated "reproductive value" (adult > subadult > metamorph) of CTS at different distances to "value" upland habitat



Fort Ord Genetic Evaluation of Recent Migration History



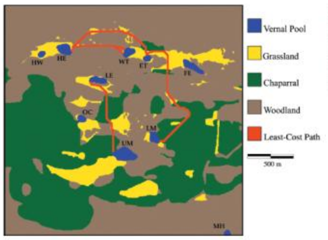


Fig. 4 Habitat map showing least-cost paths between breeding ponds for four interpopulation dispersal corridors. The least-cost paths shown are those that most closely fit the relative mean dispersal rates. The paths were calculated as having one cell width, but are drawn as wider for visualization. Population acronyms correspond to those used in Table 1.

Data suggest grassland and chaparral favored over woodland for migration

Wang et al. 2009

Upland Habitat Basics

- Major upland habitats
  - grassland
  - oak woodland (?)
  - chaparral/sage scrub
- Occupy mainly ground squirrel and gopher burrows
  - After metamorphosis, CTS are almost always underground
  - Emerge only at night, usually when raining
- Most do not remain near edge of pond
  - >1km is not rare
- Dispersal between ponds 1-2km estimated
  - 680m observed - ~800m genetically estimated

How many acres/hectares do CTS need?

- About how many hectares/acres are encompassed by a pond buffered by 1km?

$$AREA = \Pi r^2$$

- r = 1,000 m
- hectare = 10,000 m^2
- acre = 2.5 hectares

"Simple" Landscape Models Can Inform Conservation Planning Decisions

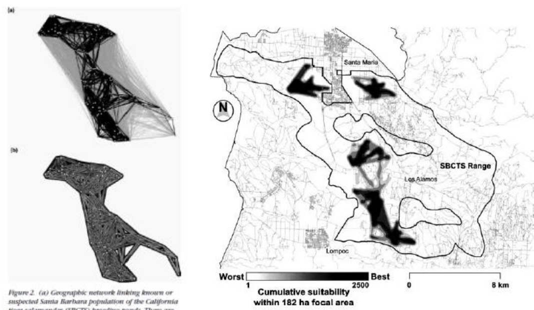


Figure 2. (a) Geographic network linking known or suspected Santa Barbara population of the California tiger salamander (SBCTS) breeding ponds. There are 3398 black links, < 8 km in length, of the total set of 14,280 potential linkages. (b) Geographic links buffered to become 100, 250, and 500-m wide assessment units. Open circles indicate known or suspected SBCTS breeding ponds (n = 120).

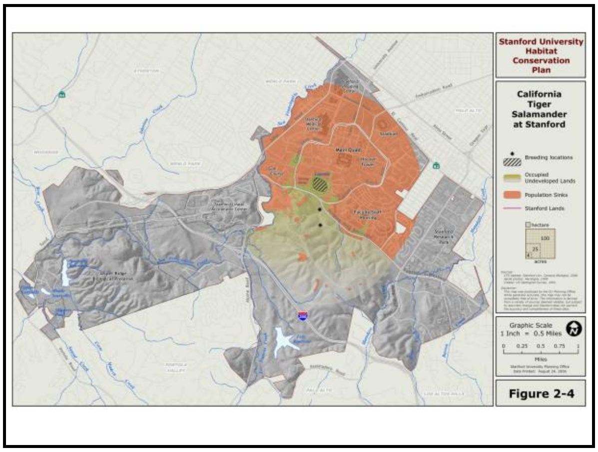
CR Pyke 2005 Conservation Biology

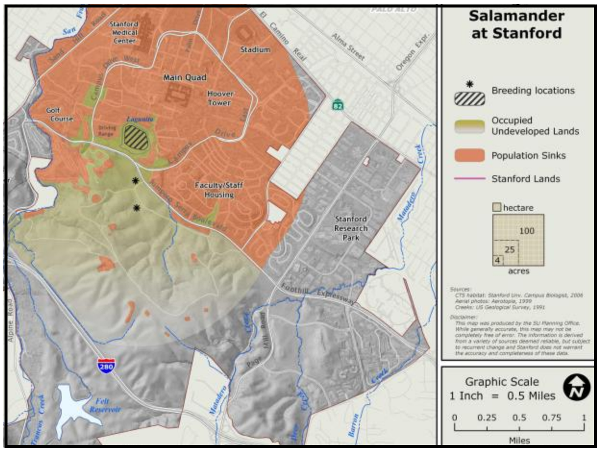
Managing Habitat for CTS

- Uplands
  - Maintain habitat connectivity
  - Maintain natural habitat near breeding ponds
  - Maintain burrowing mammal populations
  - May be able to enhance mammal habitat (e.g., creating mounds)
  - Effects of grazing unknown, but likely positive

Conservation Strategies

- Protect occupied landscapes
  - Ideally >>1000 acre blocks; minimally 100 acres
- Maintain/promote habitat connectivity
  - Minimize effects of new or improved roads
  - Potential barriers: aqueducts and canals, agricultural fields, landfills, other ideas?
- Other approaches
  - Creating/enhancing habitats
  - Compensation through conservation banks
  - Barriers or tunnels to keep them off roads


Stanford University Habitat Conservation Plan
California Tiger Salamander at Stanford
Breeding locations
Occupied Undeveloped Lands
Population Sinks
Stanford Lands
Graphic Scale
1 Inch = 0.5 Miles
Figure 2-4


Salamander at Stanford
Breeding locations
Occupied Undeveloped Lands
Population Sinks
Stanford Lands
hectare
100
25
4
acres
Main Quad
Hoover Tower
Stadium
Golf Course
Faculty/Staff Housing
Stanford Research Park
Graphic Scale
1 Inch = 0.5 Miles
0 0.25 0.5 0.75 1
Miles

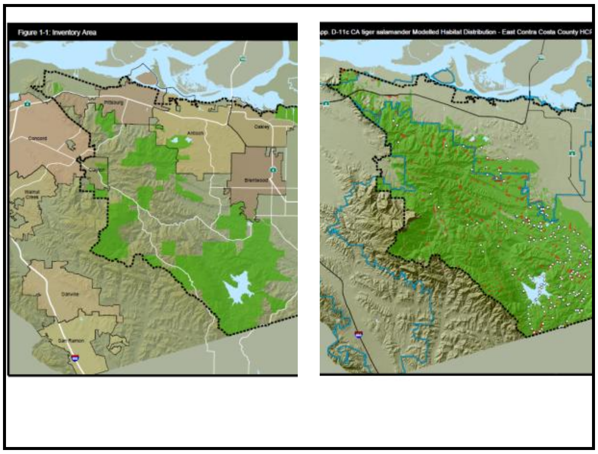
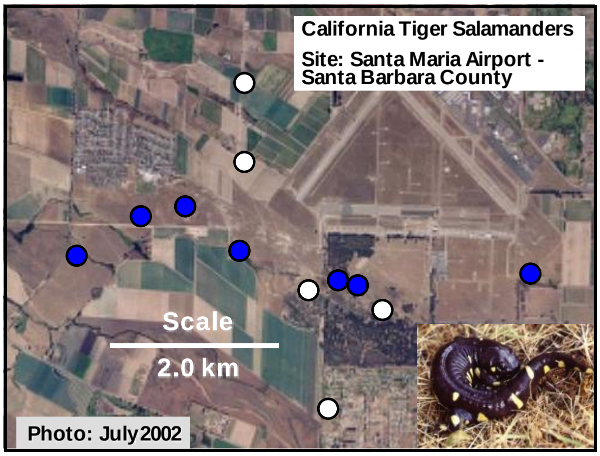
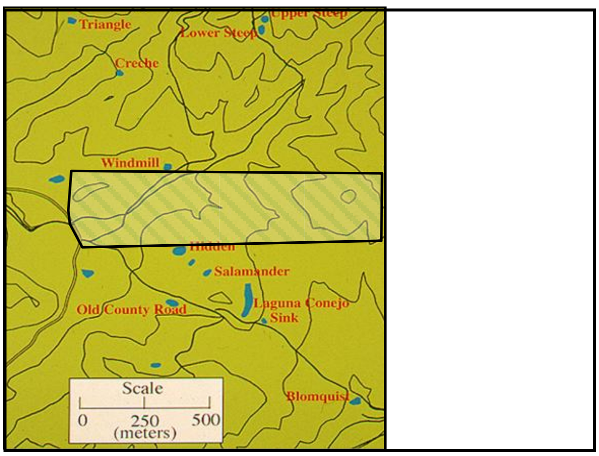


Figure 1-1: Inventory Area


California Tiger Salamanders
Site: Santa Maria Airport -
Santa Barbara County
Scale
2.0 km
Photo: July 2002


Triangle
Lower Steep
Upper Steep
Creche
Windmill
Hidden
Salamander
Old County Road
Laguna Conejo
Sink
Blomquist
Scale
0 250 500
(meters)