California Tiger Salamander Biology and Conservation

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Key Facts for Understanding CTS

- The CTS is primarily a terrestrial beast
  - lives mainly in small mammal burrows
  - observed to move >1km from ponds
- Breed in ponds – develop as aquatic larvae
  - ponds must hold water until at least May
- Larger ponds are better (but not permanent ponds)
- Large areas of contiguous or interconnected habitat is what's needed for its conservation
  - Habitat loss (and hybridization) are main threats
- CTS can persist with certain human land uses

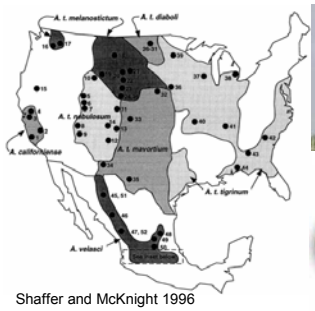
Workshop Topics

1) Tiger salamanders and how is the CTS unique
2) Range and habitat basics
3) Causes of decline
4) CTS life cycle and identification of different stages
5) Sampling methods and survey design
6) Habitats and ecology / predators and prey
7) Movements, upland distribution, and landscape ecology
8) Life history, demography, and population dynamics
9) Strategies for avoidance, minimization, conservation and recovery

What is a CTS

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

Pattern and Head Shape Differ From *Ambystoma tigrinum*

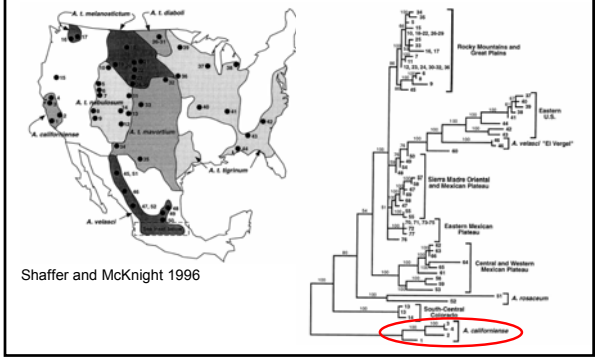


Shaffer and McKnight 1996
http://www2.eve.ucdavis.edu/shafferlab/

CTS larvae are smaller and are not known to become sexually mature larvae (paedomorphs)

CTS is Genetically Different

(est. 3-5 million years independent evolution)



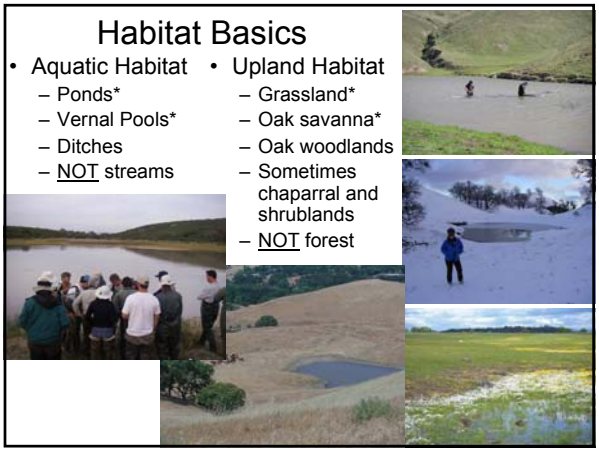
Shaffer and McKnight 1996

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

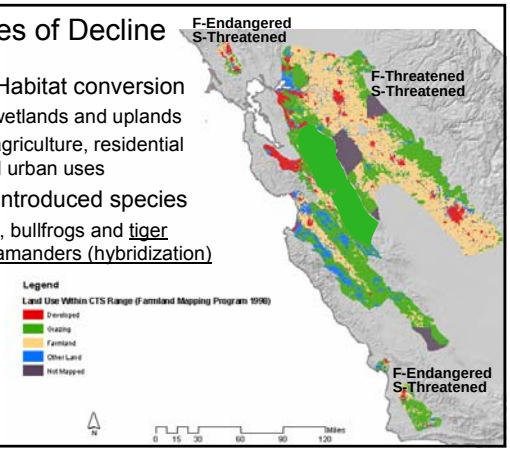
Habitat Basics

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



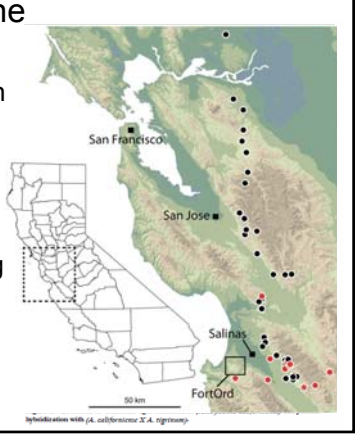
Causes of Decline

- #1 – Habitat conversion
  - of wetlands and uplands
  - to agriculture, residential and urban uses
- #2 – Introduced species
  - fish, bullfrogs and tiger salamanders (hybridization)



Cause of Decline *Hybrids*

- initial introduction
  - South of Salinas
  - 1940's
- discovered late 1990's
- situation evolving

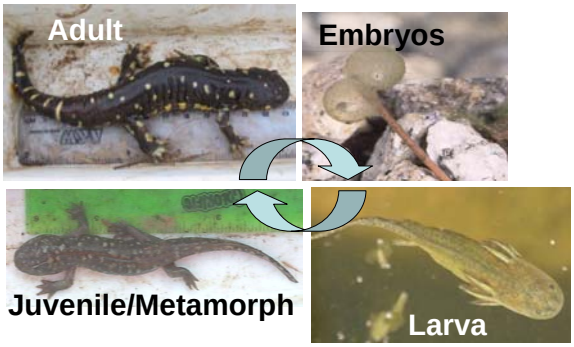


Cause of Decline - Hybrids

- Genetic test needed for conclusive ID
  - Adults with barring are suspicious
  - Giant larvae are suspect also (CTS larvae usually <6" total length)

Small Group Problem 1

CTS Life Cycle and Morphology



Identification/Morphology

Get a field guide!

CTS Life Cycle

Breeding Migrations

Larvae in Ponds----------

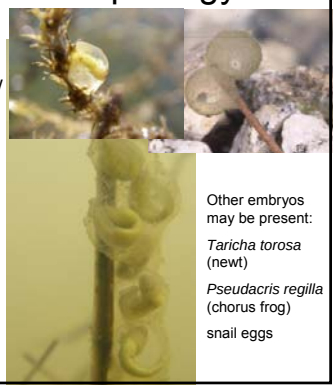
Metamorphosis----------

Juvenile Dispersal

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

Identification/Morphology

- Embryos
  - ovum 2-3mm diameter
  - whitish to grey to yellow
  - w/jelly 4.5-10mm
  - attached to vegetation or other materials
  - singly or small clusters
  - grape-like (each in its own separate membrane)
  - Detectable <u>mainly</u> Dec-Feb

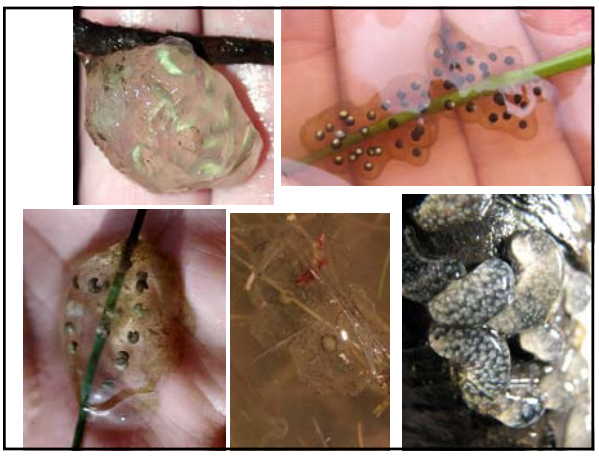


Other embryos may be present:

Taricha torosa (newt)

Pseudacris regilla (chorus frog)

snail eggs



Identification/Morphology

- Larvae
  - Fish-like
  - Feathery external gills
  - Four legs
  - Color variable
  - No stripes/organized pattern
  - 30 to 150 mm
    - 1 to 6 inches
  - Potentially detectable year-round
- other species may co-occur
  - hybrids; *Taricha torosa* (newt); *Pseudacris regilla* (chorus frog); *Ambystoma croeceum* (SC long-toed salamander)

CTS versus Hybrids

Photos: Dr. Maureen Ryan

Identification/Morphology

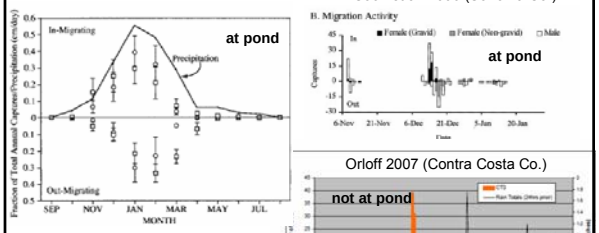
Adults
- NO nasolabial groove
- 6-10 inches long
- black to light brown backgound
- white to light yellow rounded spots
  - size/amount of spots varies
- similar species
  - Hybrids,
  - *Aneides lugubris*
  - *Aneidies flavipunctatus*
  - *Dicamptodon ensatus*

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

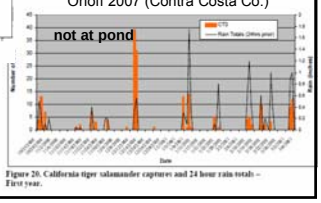
Pitfall Captures of Adults (at & not at ponds)

Cook et al. 2006 (Sonoma Co.)



Trenham et al. 2000 (Monterey Co.)

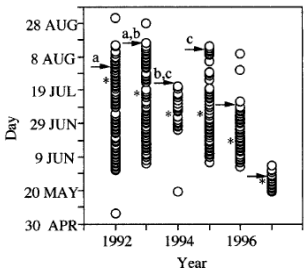
Orloff 2007 (Contra Costa Co.)



Activity differs by region!
Largely driven by rainfall

Dates of Metamorph Capture

Monterey Co. (1992-1997)



Trenham et al. 2000

Contra Costa Co. (1992-1993)

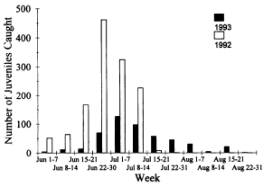


Fig. 3. Number of juvenile *Ambystoma californiense* caught by week in summer 1992 and summer 1995, Contra Costa County, California. Numbers of individuals include original captures and recaptures.

Loredo and Van Vuren 1996

Life Cycle and Morphology – Main Points

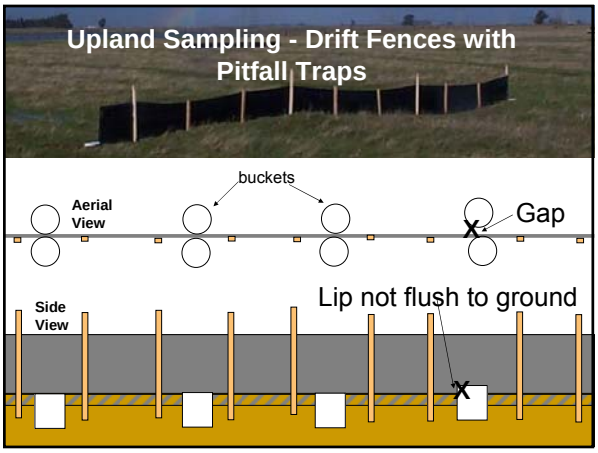
- Adults migrate to ponds during fall and winter rains
  - Present at ponds relatively briefly
- Embryos potentially detectable Nov-March
  - Eggs attached singly or in small groups
- Larvae mainly detectable March-August
  - Too small to catch before March
  - Coloration extremely variable, but no stripes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

Aquatic Sampling

- Dip nets
- Minnow Seine
- 1/8" mesh or smaller
- Move through the water quickly
- Neither works well in deep ponds

Figure 9. Southern trap line facing west.

Sue Orloff, Ibis Associates (2007)

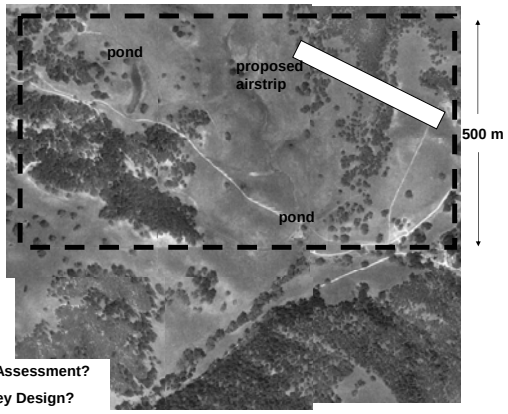


Alternate CTS Survey Methods

- Minnow traps
- Egg surveys
- Walking surveys

Sampling for CTS – CDFG/USFWS Guidance

- 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
  - ≥1 ft tall drift fence w/ pitfalls ≥ 90% site perimeter
  - Pitfall buckets <33 ft apart, ≥ 2 gallon buckets
  - Traps opened for rain events Oct. 15 – Mar. 15
- 3) If potential breeding habitat present
  - 2 seasons aquatic sampling for CTS larvae
    - Sample >10 days apart in March, April and May
    - Sample using dipnets and seines (if none detected in dipnets)
  - One season upland sampling as above
  - Drift fences around potential breeding habitat



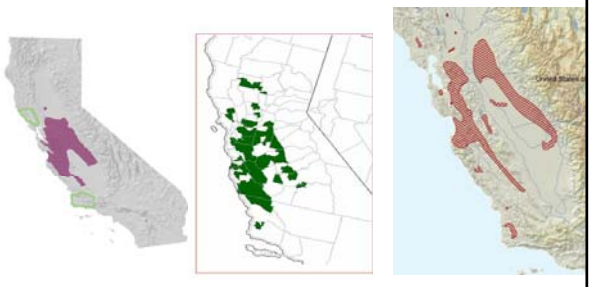
USFWS/CDFG Reports

- 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 USFWS
  - For aquatic sampling calculations of the total effort expended/area covered each time

Getting your own permit

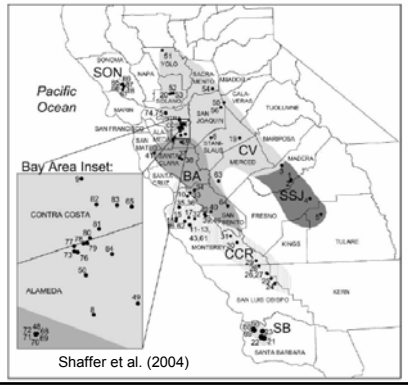
- Start early! It may take >1 year
  - talk to agency representatives throughout process
- FWS requirements
  - B.S. in biology (or equivalent experience)
  - Course work in herpetology (or eq. exp.)
  - Study/survey design experience (5surveys/40hrs)
  - Handling experience (>25, including >5 larve)
  - Familiarity with habitats
  - Familiarity with co-occurring amphibians
  - Ability to identify vegetative components of habitat

Approximate CTS Distribution
(check with agencies for latest range info)



CA Dept. of Fish and Game USGS ARMI Atlas IUCN

Regional Genetics



Shaffer et al. (2004)

Six "Clades"
Sonoma

Santa Barbara

Central Valley
Bay Area
S. San Joaquin
C. Coast Range

Small Group Problem 2

Aquatic Habitat – Important Issues

- Vernal pools/sag ponds (natural habitat)
  - Constructed ponds (more common today)
- Hydroperiod
  - Must persist into May (July or August better)
  - Permanent ponds often unsuitable due to predators
- Pool area and depth
  - Bigger pools = more metamorphs
  - Deeper pools = >hydroperiod
- Vegetation? Water quality?
  - Little is known

Aquatic Prey and Predators

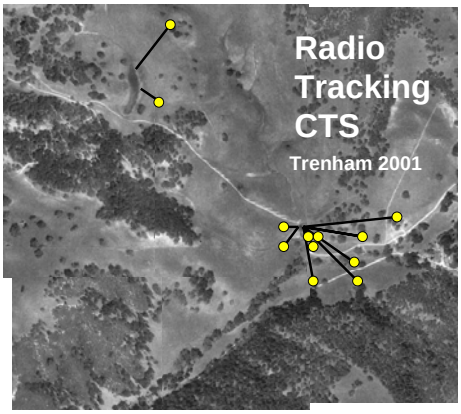
- Prey
  - Zooplankton
  - Crustaceans
  - Insect larvae
  - Chorus frog tadpoles
  - Newt larvae
  - CTS larvae
- Predators
  - Herons
  - Avocets
  - Terns
  - CTS larvae
  - Insect larvae*
  - Adult newts*
  - Fish*
  - Crayfish*
  - Bullfrogs*
  - *the problem with permanent ponds!

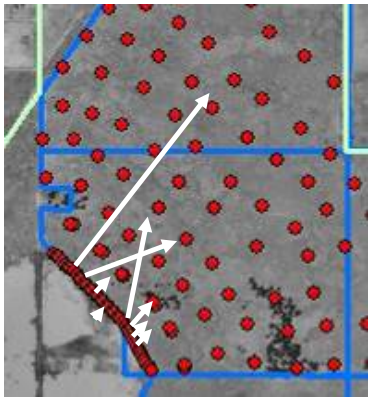
Pond Size Influences Productivity

- 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 – up to 3200 captured in 400 m fence
  - Round Pond ~200 – up to 2700 captured in 100 m fence
- All other factors equal – larger pools support larger populations! – <u>but hydroperiod is key!</u>

Habitat Basics

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



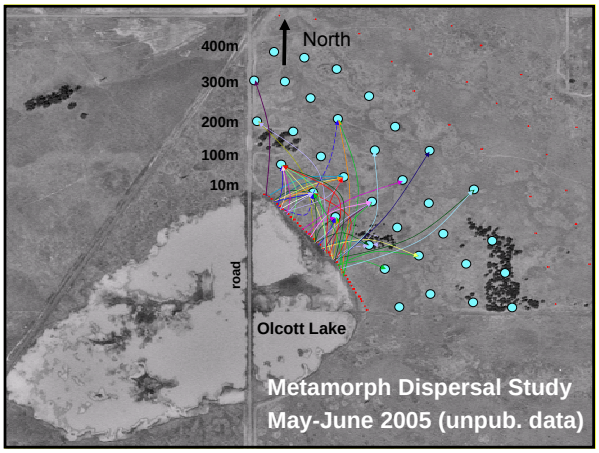


Jepson Prairie
Solano County

CTS Radio Tracking

Arrows = Adult males tracked after leaving pond in 2008

June/July 2010 metamorphs tracked to burrows and cracks up to 75 m from release points



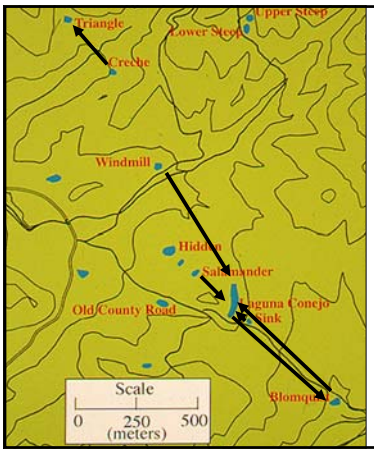
CTS and Small Mammal Burrows




FIBER-OPTIC VIDEO
courtesy of Michael Van Hattem

Upland Habitat Basics

- After metamorphosis, CTS are almost always underground
- Adults occupy mainly ground squirrel and gopher burrows
  - Emerge to move to pond or another burrow
  - Emerge only at night, usually when raining
- Metamorphs can survive in cracks
- Aestivation has not been observed
- Most do not remain near edge of pond

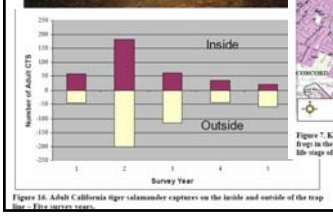


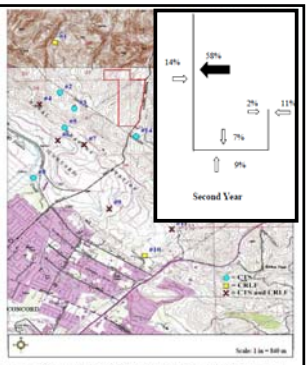
Landscape Ecology

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

• Trenham et al. 2001 Ecology

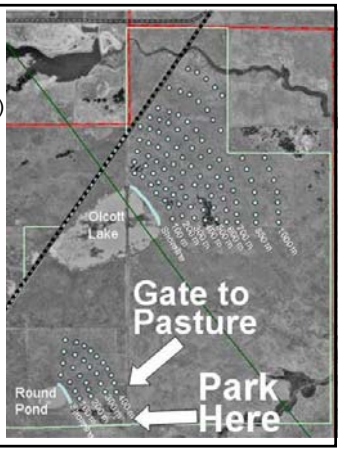
CTS do not stay near ponds!
Sam Sweet – obs. 2km away



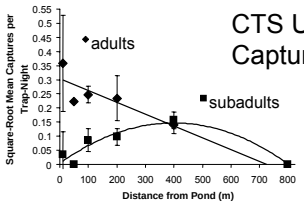


Sue Orloff, Ibis Associates (2007)

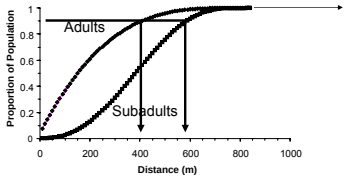
CTS Trapping Studies
2002-2012-?
Jepson Prairie (Solano Co.)



CTS Upland Trapping Captures vs Distance

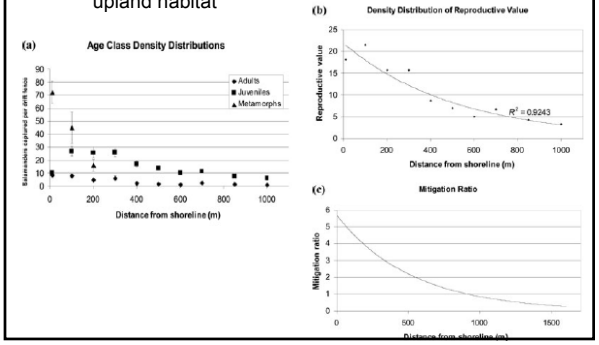


Predicted Upland Distributions

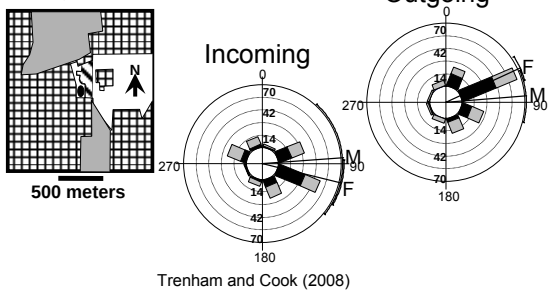


Trenham and Shaffer 2005

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

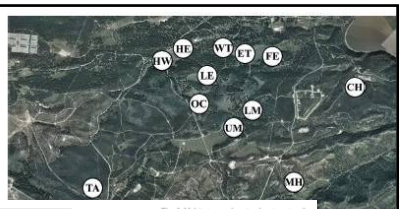


- Southwest Park Study – Urban CTS
  - drift fence around pond
  - most adults came from direction of remaining grassland



Trenham and Cook (2008)

Fort Ord Genetic Evaluation of Recent Migration History



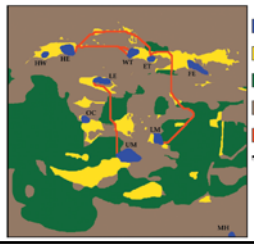


Fig. 4 Habitat map showing least-cost paths between breeding ponds for four interpopulation dispersal corridors. The least-cost paths shown are those that most closely fit the relative mean dispersal rates. The paths were calculated as having one cell width, but are drawn as wider for visualization.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

Data suggest grassland and chaparral favored over woodland for migration

Wang et al. 2009

More Upland Habitat Points

- Major upland habitats – for burrows/migration
  - grassland
  - oak woodland
  - chaparral/sage scrub
- Most do not remain near edge of pond
  - >1km is not rare
- Movement between ponds 1 - 2 km estimated
  - 680m observed - ~800m genetically estimated
  - introduced genes show large scale of movement over generations

Managing Habitat for CTS

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

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

~3,000,000 m^2
= ~300 ha
= ~750 acres

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

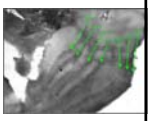
Estimates above low due to 1) dispersal & 2) skipping breeding

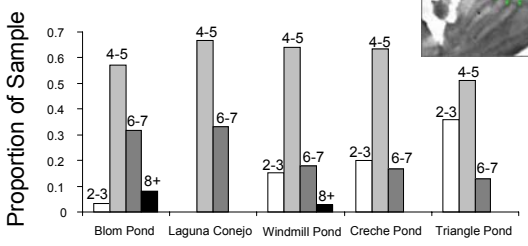
Lifetime Breeding Events = 1.5 per female

can produce 800 eggs per breeding event

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 sensitive to
  - 1) *subadult survival
  - 2) adult survival
- This emphasizes importance of minimally disturbed upland habitat
- Trenham and Shaffer, 2005, Ecological Applications

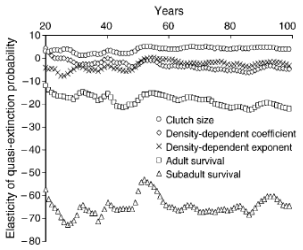


FIG. 5. Estimated elasticity values for cumulative quasi-extinction probabilities in response to perturbations of mean vital rates. Symbols represent elasticity in response to perturbation of various model parameters: subadult survival, adult survival, coefficient and exponent in larval density-dependent 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

- Female CTS can produce large numbers of eggs
  - but most breeders are at least 4 yrs old
  - and they don't breed every year
- Some individuals can live 10+ years
  - Most don't ever make it to metamorphosis
  - Protection against drought years
- Population size is much more sensitive to upland survival than to larval survival

Ideas for Avoidance and Minimization

- Habitat Management Issues: disking, mowing, burning, trenching, herbicides, mammal control, pond repair, road maintenance, irrigation, etc.
- Aquatic habitats
  - Avoid use of pesticides in area of pond
  - Disturb habitat only after pond has dried
- Upland habitats
  - Avoid mammal burrows wherever possible
    - Excavate burrow/relocate CTS
  - Limit activities to daylight hours
  - Limit activities to dry season
  - Disturb only part of site at a time over several years
  - Use drift fences to remove animals from site

Conservation Strategies

- Protect occupied landscapes (esp. rangeland!)
  - Ideally >>1000 acre blocks; minimally 100 acres
  - As large as possible given limitations
- 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/restoring habitats
  - Eliminate/reduce predators and hybrids
  - Compensation through conservation banks
  - ?Barriers or tunnels to keep them off roads
  - ?Salvage/translocation (disease is a BIG concern)

Group Problem Number 3

Managing Habitat for CTS

- Aquatic
  - Create additional ponds
  - Eliminate predators by drying
  - Modify/manage pond to make long lasting, but ephemeral
  - Maintain existing berms/remove excessive siltation
  - Allow livestock grazing (esp. vernal pools)

Managing Habitat for CTS

- Uplands
  - Maintain habitat connectivity for migration and dispersal
  - Maintain natural habitat esp. near breeding ponds
  - Maintain burrowing mammal populations
  - Effects of grazing unknown, but likely positive

CTS Basics – Final Review

- Aquatic Habitat – breeding
  - Ponds should be temporary but dry only after May
  - Bigger longer lasting ponds are better
- Upland Habitat – the rest of their lives
  - On land occupy small mammal burrows
  - 3-5 year subadult phase
  - Move hundreds of meters from ponds
- Landscape Considerations
  - More ponds = more security against local extinction
  - Ideally want ponds within <1-2 km of each other
- Weather/Rainfall
  - drives migrations and population dynamics

Additional Issues – Discussion Topics

- Monitoring CTS populations
- Metapopulation dynamics
- Geographic variability in habitat and climate
- Hybrids
- Mosquitofish
- Species range
- CNDDB records

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