

Pesticides Distributions and Population Declines of California, USA, Alpine Frogs, *Rana muscosa* and *Rana sierrae*

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Population Die-offs – *Rana muscosa* & *R. sierrae*

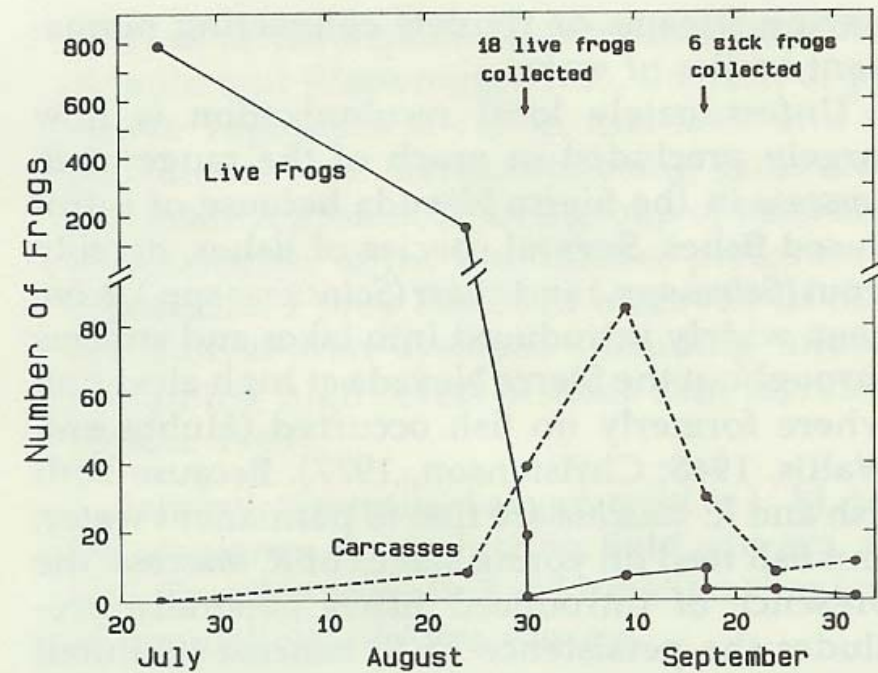


FIG. 1. Numbers of live frogs present and frog carcasses collected in Ridge Lake during summer, 1979.

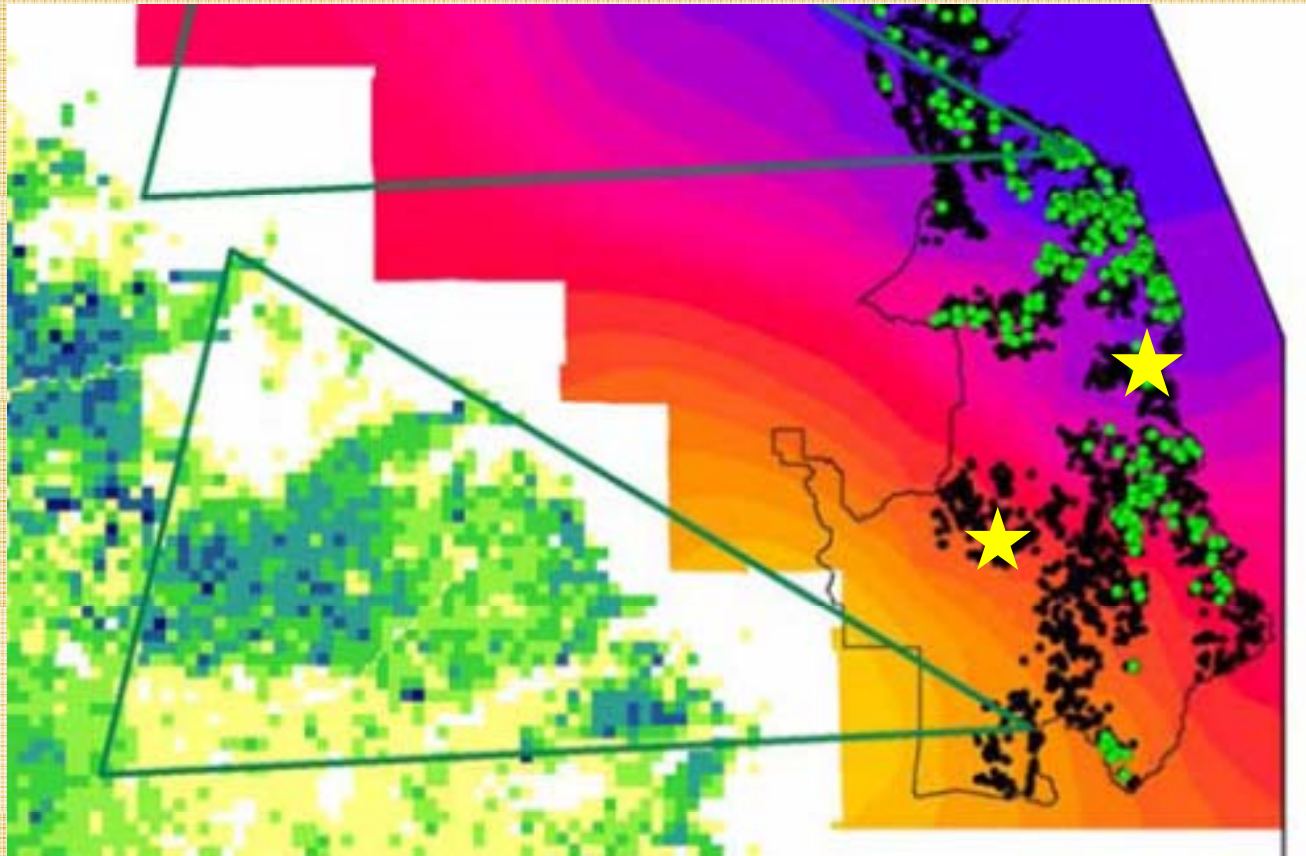
(Bradford 1991)

Absent at 94% of historic localities (Vredenburg et al. 2007)

Hypotheses for Cause of Declines

Cause	Evidence	Source
Introduced Fish	Yes	Knapp & Matthews 2000; Vredenburg et al. 2004
Chytridiomycosis	Yes	Briggs et al. 2005; Rachowicz et al. 2006
Acid Deposition	No	Bradford et al. 1994a, 1994b
Increased UV-B	No	Adams et al. 2005
Pesticides	???	Davidson & Knapp 2007; Fellers et al. 2004

From Davidson & Knapp 2007



3300 lakes in Sequoia/Kings Canyon
Color bands = Upwind pesticide use

★ = Fellers et al. 2004

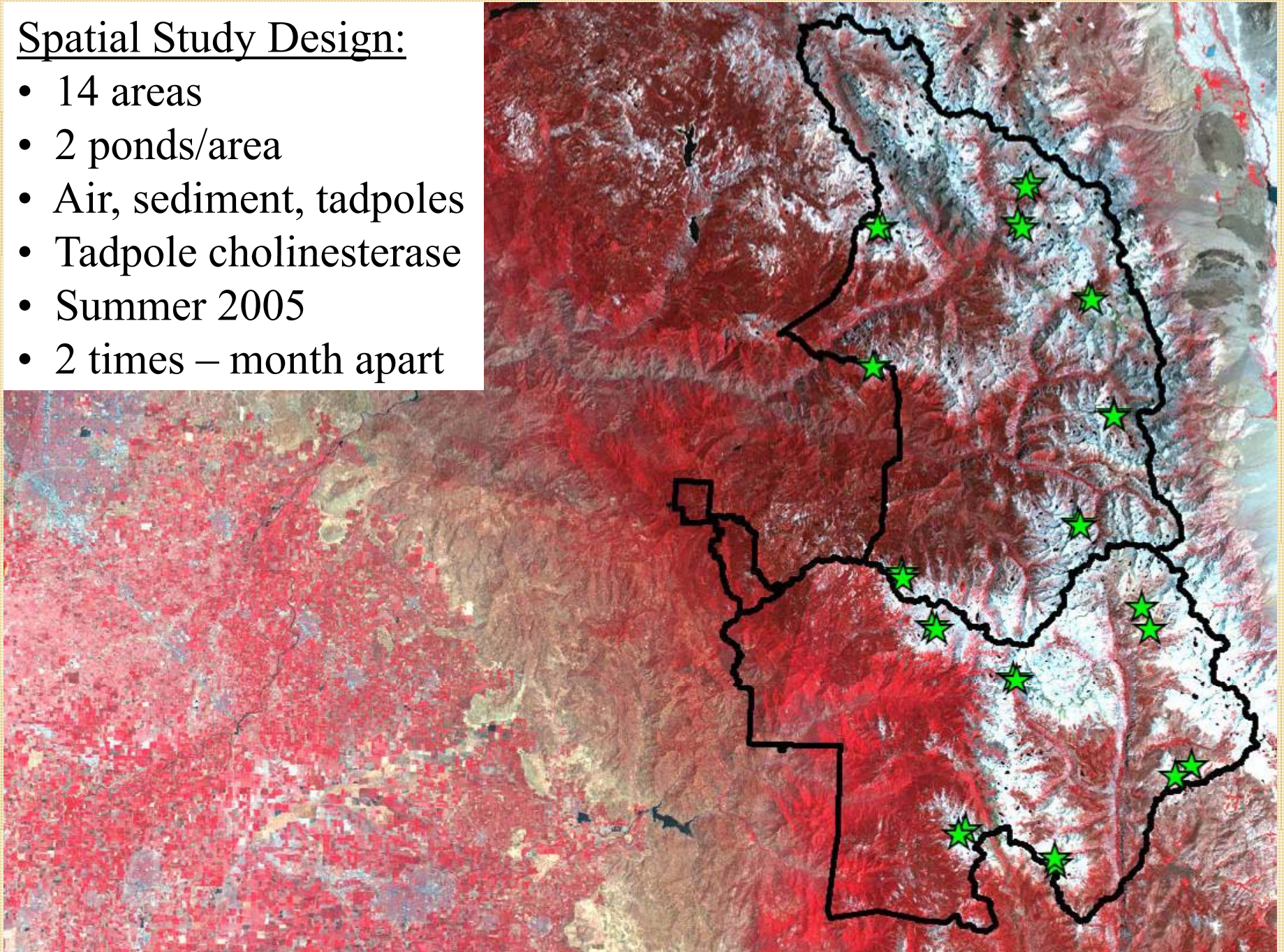
Green dots = Frogs present
Black dots = Frogs absent

Objectives

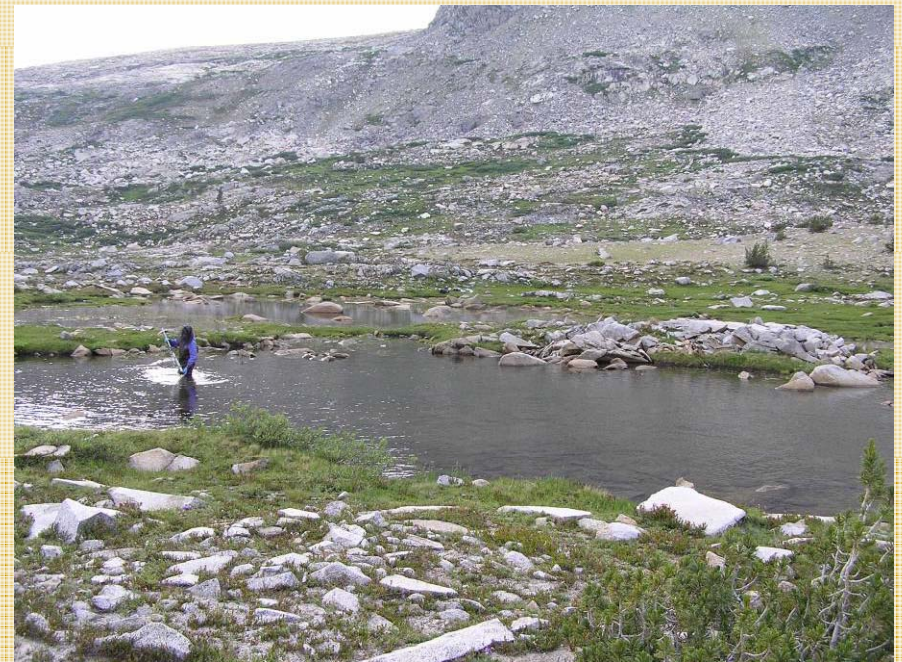
- Measure pesticide concentrations
 - Evaluate spatial pattern (e.g., distance from valley)
 - Temporal variation (not presented)
- Evaluate associations between concentrations and frog occurrence/die-offs
- Evaluate plausibility that alternative hypothesis, chytridiomycosis, alone could explain die-offs

Spatial Study Design:

- 14 areas
- 2 ponds/area
- Air, sediment, tadpoles
- Tadpole cholinesterase
- Summer 2005
- 2 times – month apart



Example 2005 Sample Sites



Logistics



Media: Air, Sediment, *Pseudacris* Tadpoles



Pesticides Used in Spatial Analysis

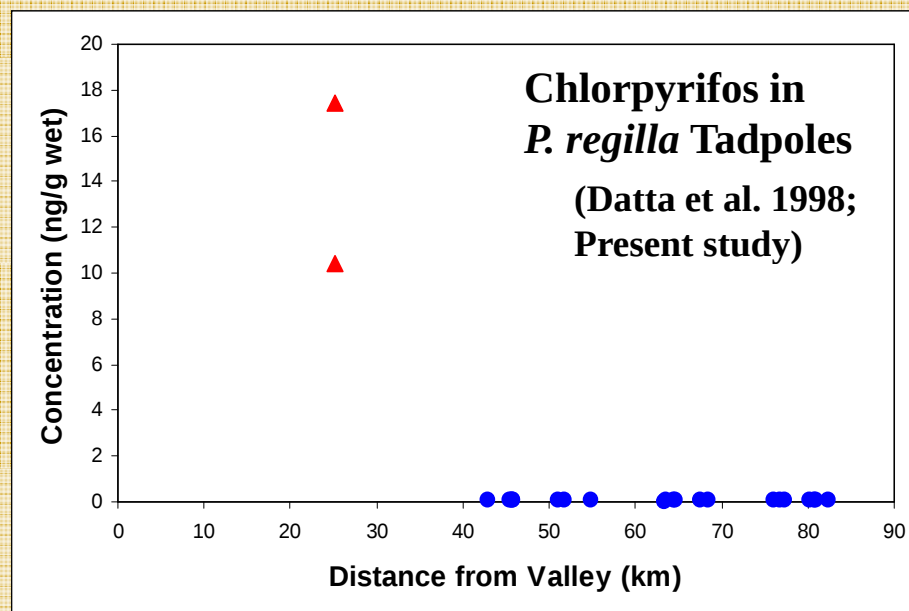
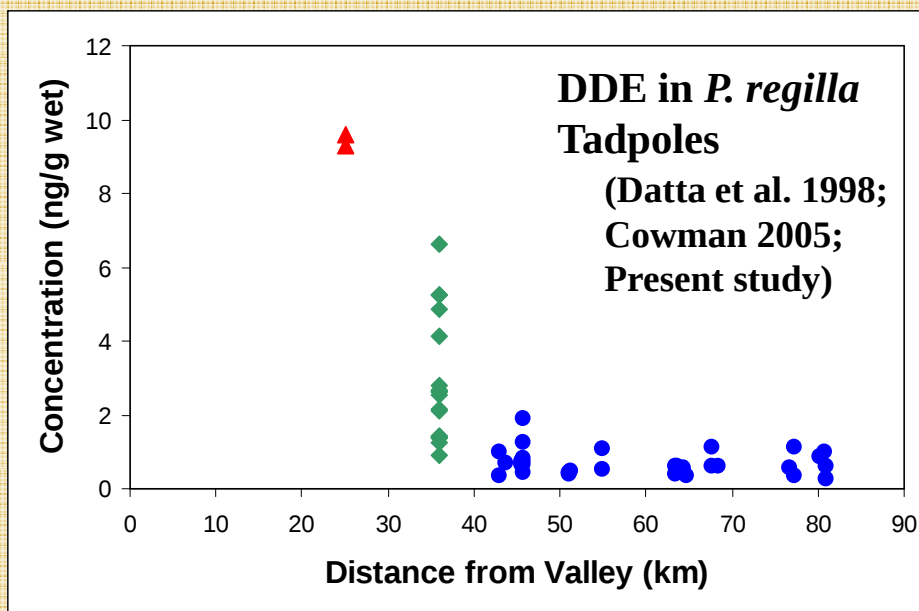
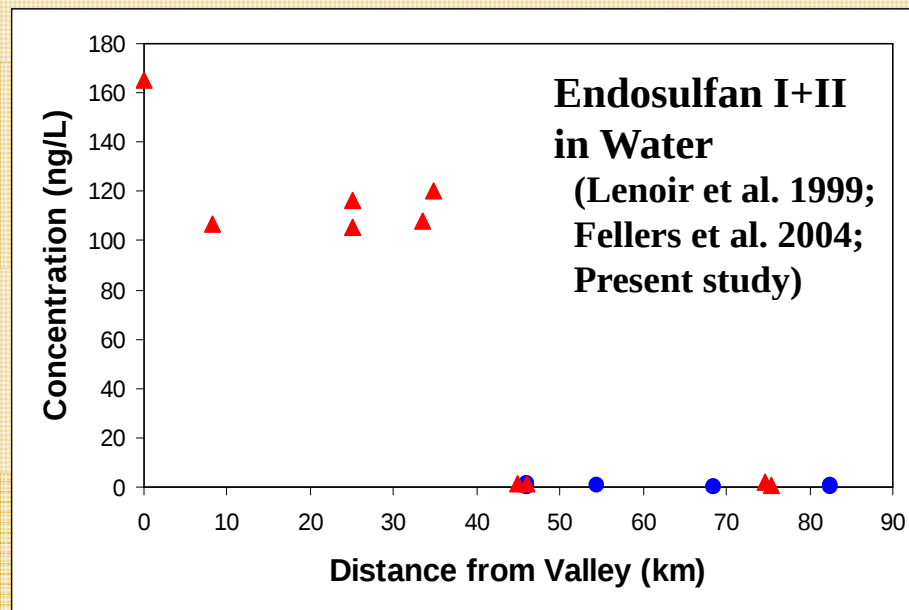
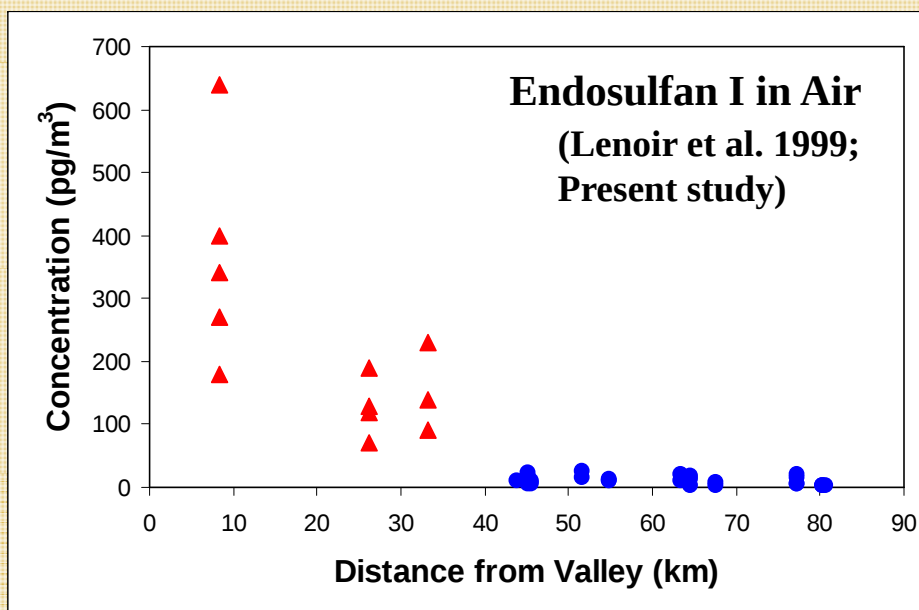
Pesticides	Air	Sediment	Tadpoles
Current Use:		X	X
Chlorpyrifos		X	X
Dacthal		X	X
Endosulfan I		X	X
Endosulfan II	X	X	X
Endo. Sulfate		X	X
Historic Use:		X	X
p,p'-DDE		X	X
Chlordane, trans		X	X
Nonachlor, cis		X	X
Nonachlor, trans		X	X

- Pesticides compounds: 48 targeted, 14 detected, 9 used
- Concentrations $< \sim 1$ ppb (dry basis)
- $< 10^{-3}$ below toxic levels

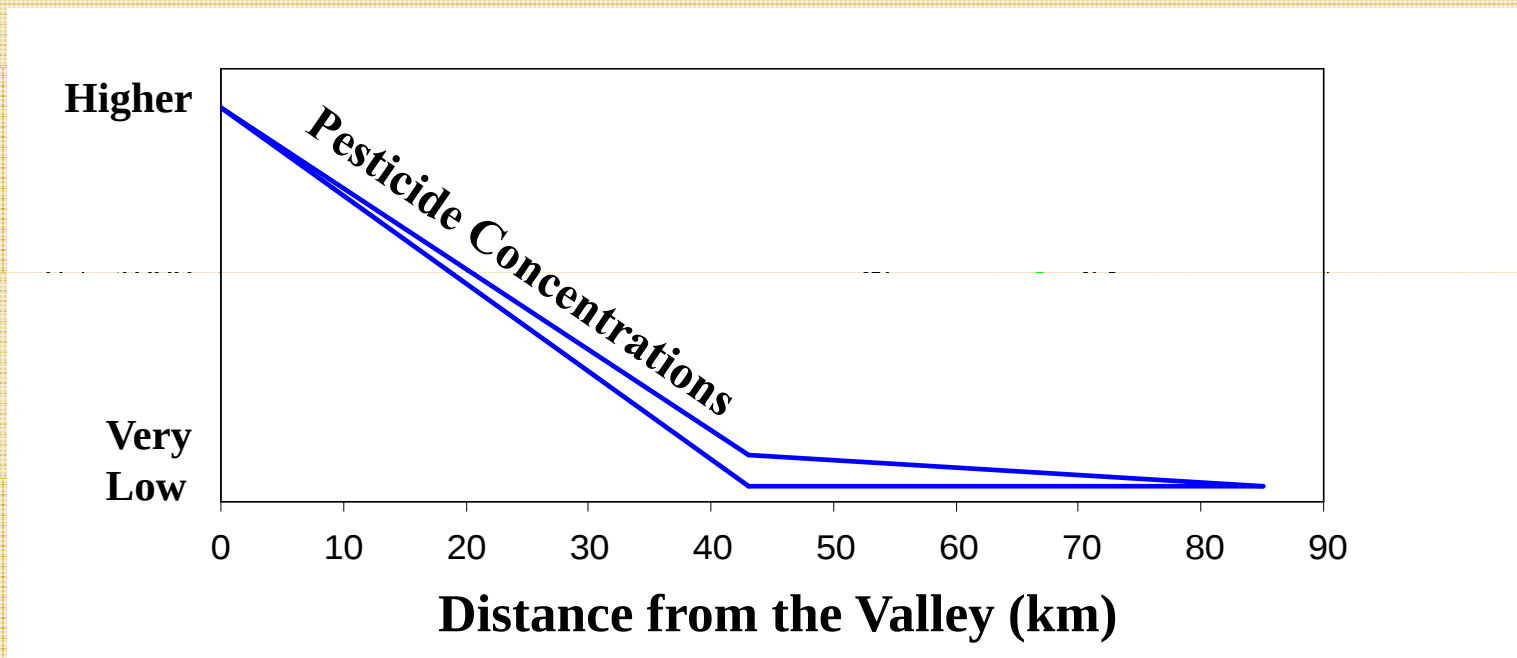
Concentrations vs. Linear Distance

	Early August				Early September		
	Air	Sed.	Tads		Air	Sed.	Tads
Chlorpyrifos		ns	ns			ns	
Dacthal		ns	ns			ns	ns
Endosulfan I		ns	ns				ns
Endosulfan II	ns	ns	ns		ns	ns	ns
Endo. Sulfate		ns	ns			Neg	ns
DDE		ns	ns			ns	ns
Chlordane		ns	ns			Neg	ns
Nonachlor, cis		ns	ns			Neg	ns
Nonachlor, trans		ns	ns			Neg	ns
All Pesticides (PCA)		ns	ns			ns	ns

Comparison to Studies Nearer Valley



General Pattern – Central Valley to Sierra Crest



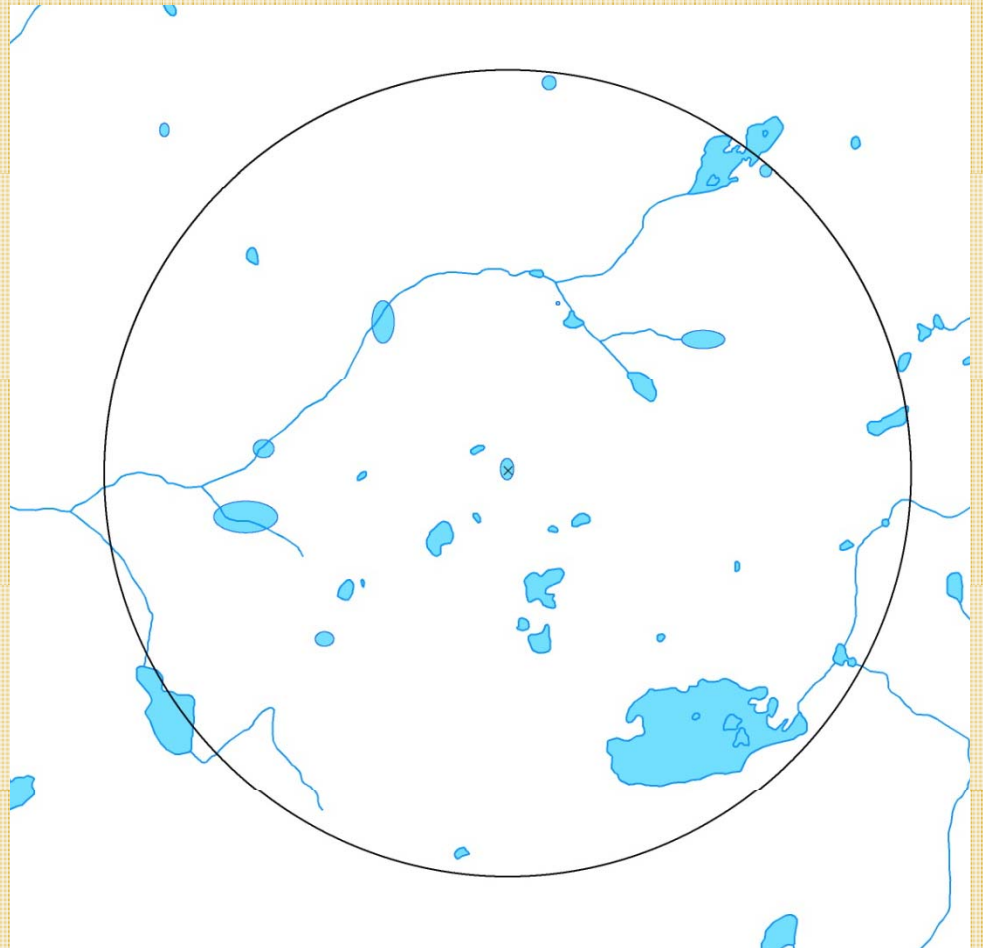
Is there an Association between Pesticide Concentrations and *Rana* Population Status?



Metric for *Rana* Population Status (1997-2002)

% Water Bodies Occupied

- Data from Knapp survey, 1997-2002
- Suitable habitat = no fish & depth ≥ 1.5 m
- Calculated % suitable sites occupied in 2 km radius

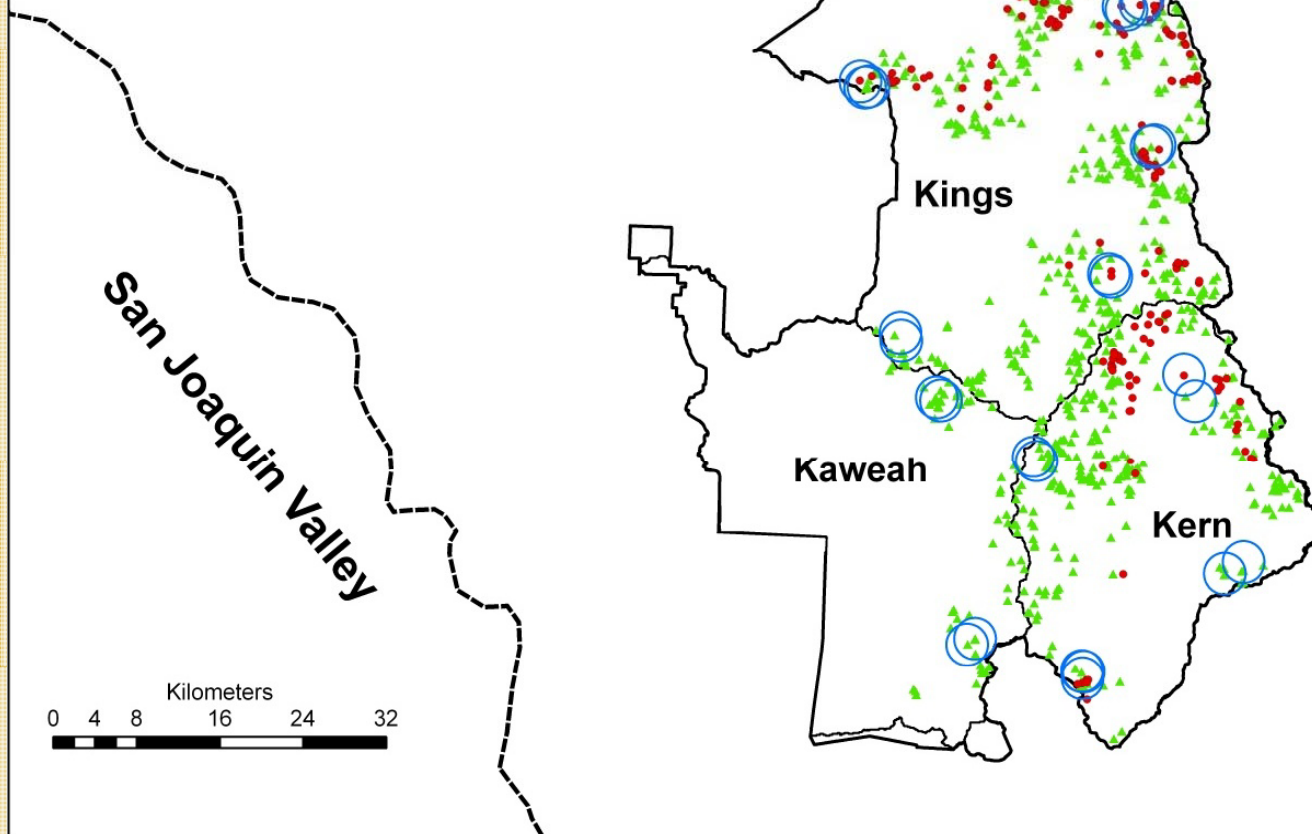


Rana Population Status (1997-2002)

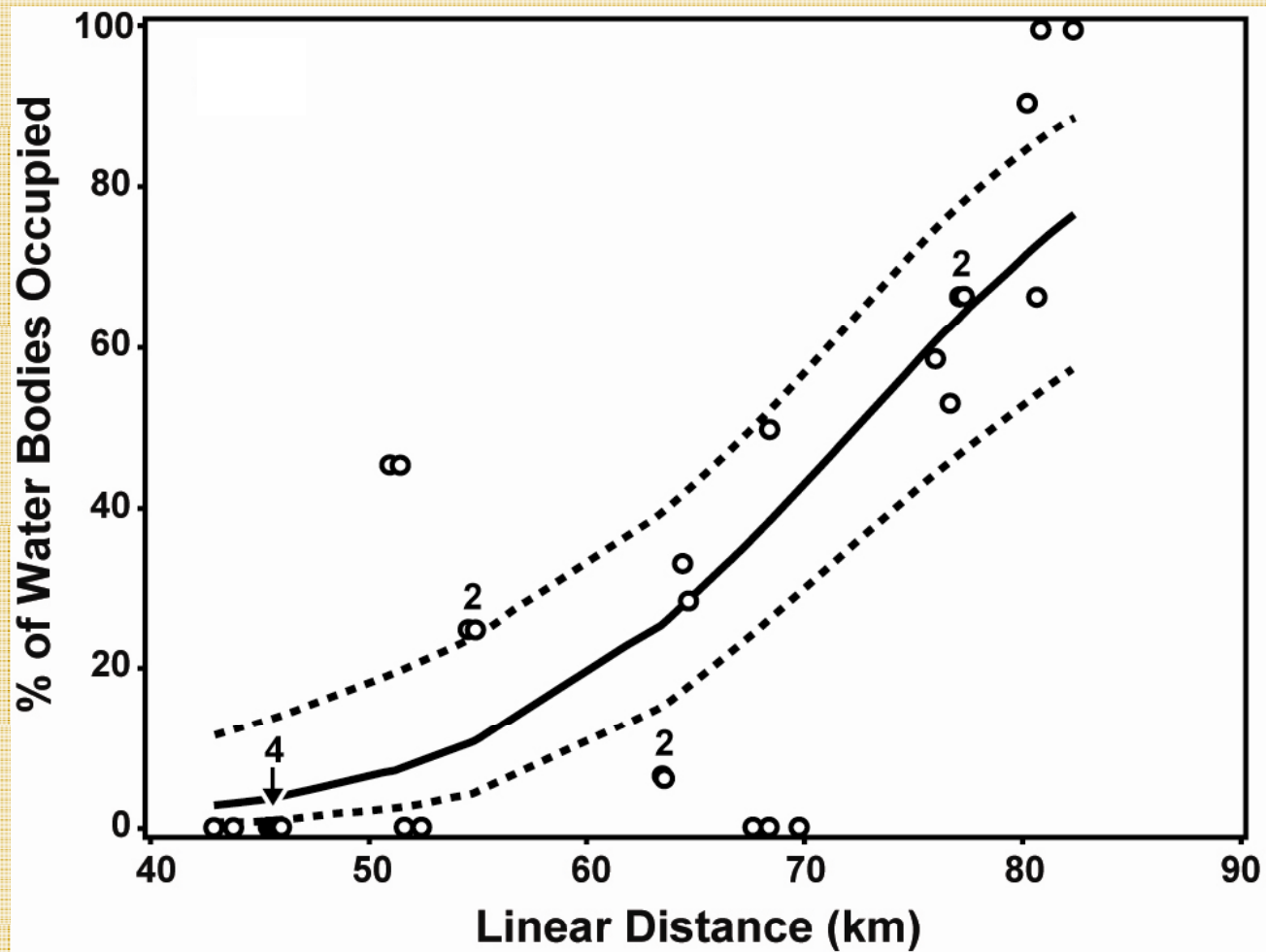
Data from Knapp survey,
1997-2002

Suitable habitat = no fish
& depth ≥ 1.5 m (n=1254)
Calculated % suitable sites
occupied in 2 km radius

Red = Site Occupied
Green = Site Unoccupied



Rana Occurrence vs. Distance from Valley, 1997-2002



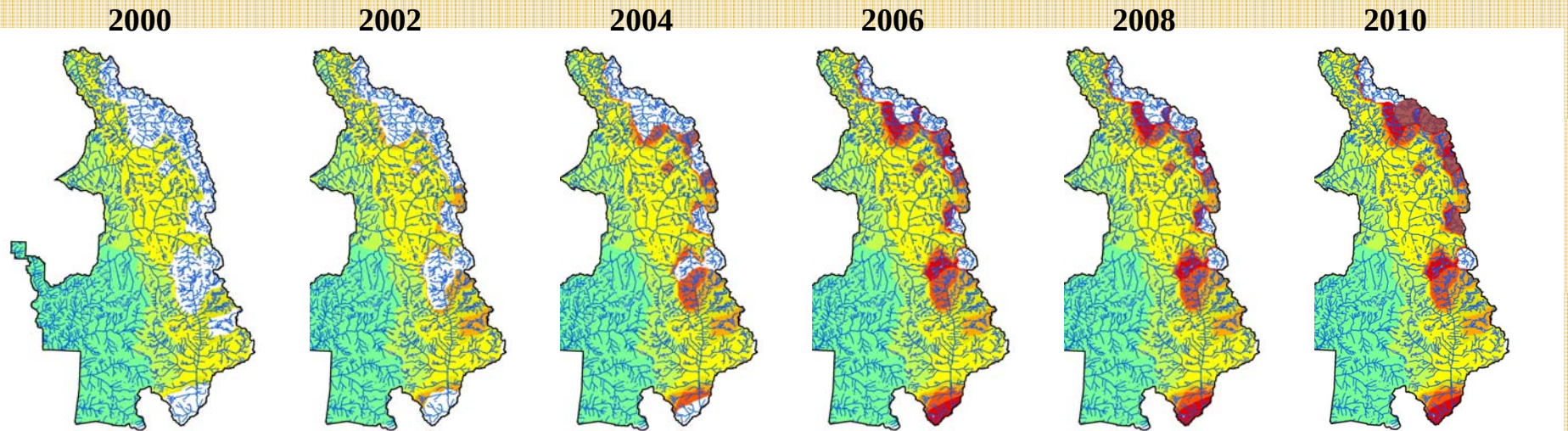
Rana Occurrence vs. Pesticide Metrics

(Stepwise Logistic Regression: Occurrence = Pesticide Metric + Distance)

	Early August				Early September		
	Air	Sedi- ment	Tad- poles		Air	Sedi- ment	Tad- poles
Chlorpyrifos		ns	ns			ns	
Dacthal		ns	ns			ns	ns
Endosulfan I		ns	ns				
Endosulfan II	ns	ns	ns		ns	ns	ns
Endo. Sulfate		ns	ns			ns	ns
DDE		ns	ns			ns	ns
Chlordane		ns	Pos			ns	Pos
Nonachlor, cis		ns	ns			ns	ns
Nonachlor, trans		ns	ns			ns	ns
All Pesticides (PCA)		ns	ns			ns	ns
Cholinesterase			ns				ns

SPREAD OF THE AMPHIBIAN CHYTRID FUNGUS

- Bd has spread across the range of the mountain yellow-legged frog during the past 30 years.
- Is now ubiquitous across much of Sierra Nevada, still spreading across SEKI.



- Following arrival of Bd in a frog population, infection prevalence and intensity increase rapidly to high levels, leading to high frog mortality.
- The resulting frog die-off typically results in population extirpation.

Conclusion – No Evidence for Pesticides as Cause of Frog Die-offs/Extirpations at High Elevation

- Pesticide concentrations in *Rana* habitat extremely low
 - Throughout study area, in all media
 - Year round (not presented)
 - Much below toxic levels
- Pesticide concentrations do not show much spatial structure in range of species
- No association between pesticide distributions and frog occurrence.
- Plausible alternative explanation for correlation between population metric and distance, i.e., west-to-east die-off caused by chytridiomycosis
- Concern about pesticides in region should be focused closer to Central Valley at lower elevations.

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