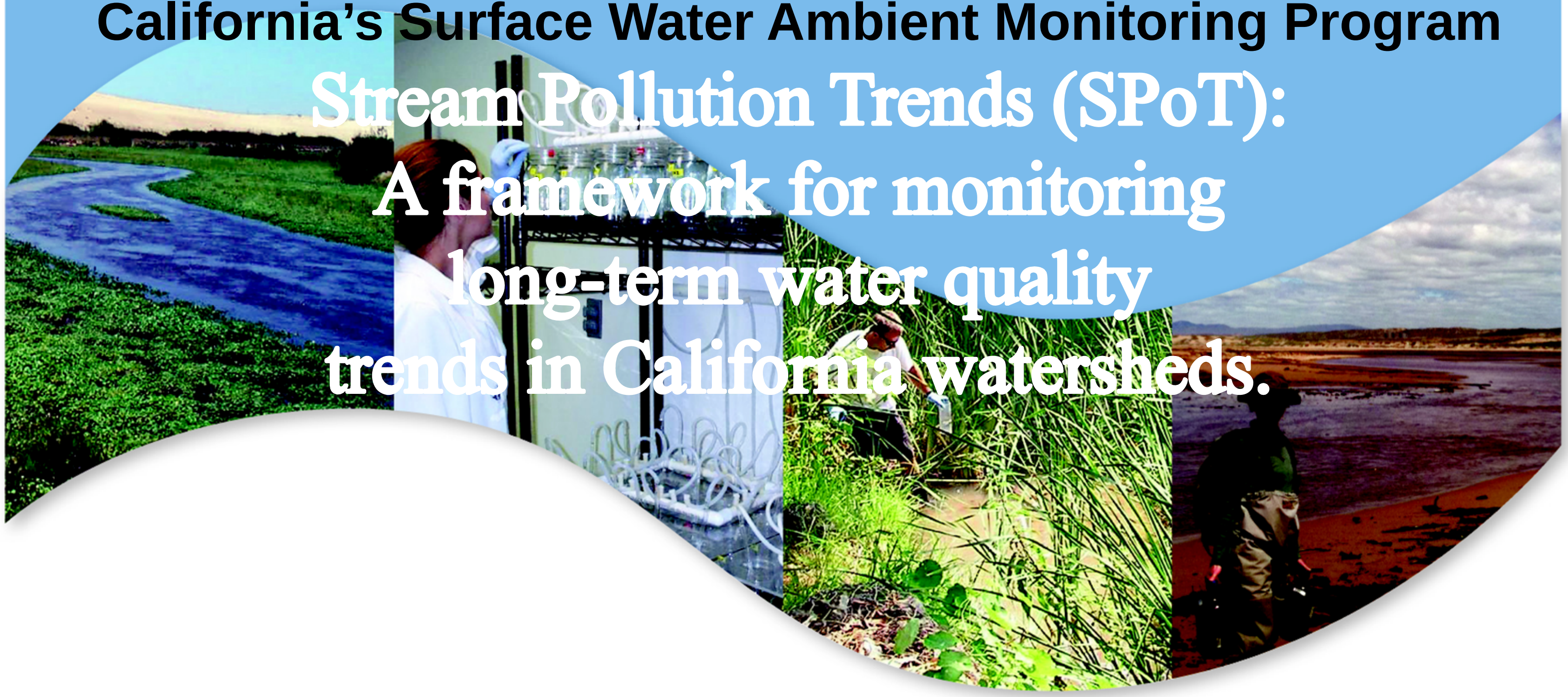
California’s Surface Water Ambient Monitoring Program

Stream Pollution Trends (SPoT): A framework for monitoring long-term water quality trends in California watersheds.



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Stream Pollution Trends (SPoT) Program

- Statewide monitoring program (2008)
- Part of SWRCB's Surface Water Ambient Monitoring Program (SWAMP)
- Sediment contaminants and toxicity

SPoT Program Goals

1. Determine long-term trends in stream contaminant concentrations statewide;

2. Relate water quality indicators to land-use characteristics; and

3. Establish a network of sites throughout the state to serve as a backbone for collaboration with local, regional, & federal monitoring programs.

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SPoT Design - Background

- Based on USGS NAWQA Integrator Site Design (Directed sampling)

- SPoT (and NAWQA) use integrator sites because both programs focus on understanding causes of water quality impairment - Connection with land-use

- To serve their purpose as integrator sites, SPoT sites are located at the base of drainage areas of interest.

- Trend detection is more likely to be successful on a site-specific basis.

- SPoT uses a statewide network of sites that provides statewide context for the findings of local and regional programs - targeted approach allows flexibility

SPoT Program Linkages

- SWAMP Linked Programs = Perennial Streams Assessment (PSA), Bioaccumulation Oversight Group (BOG), Regional Monitoring

- Non-SWAMP Linked Programs = Southern Cal. Stormwater Monitoring Council (SMC), Bay Area Stormwater Monitoring Agencies Assn (BASMAA), Ag Waiver monitoring Regions 3 and 5

- More Non-SWAMP linkages encouraged

- Regulatory Linkages = 303(d), 305(b), TMDL sources and causes

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SPoT Approach

- ❑ 100 base-of-the-watershed sites + 5 variability sites (~50% of major HUCs in California).
- ❑ Sediment sampling (once per year for majority of sites)
- ❑ Toxicity testing (10-day *Hyalella azteca*)

- ❑ Sediment chemistry (OC pesticides, OP pesticides Pyrethroids, Metals, Mercury, PAHs)
- ❑ Correlations between land use, contaminants, and toxicity – Trend analysis to follow with multi-year data

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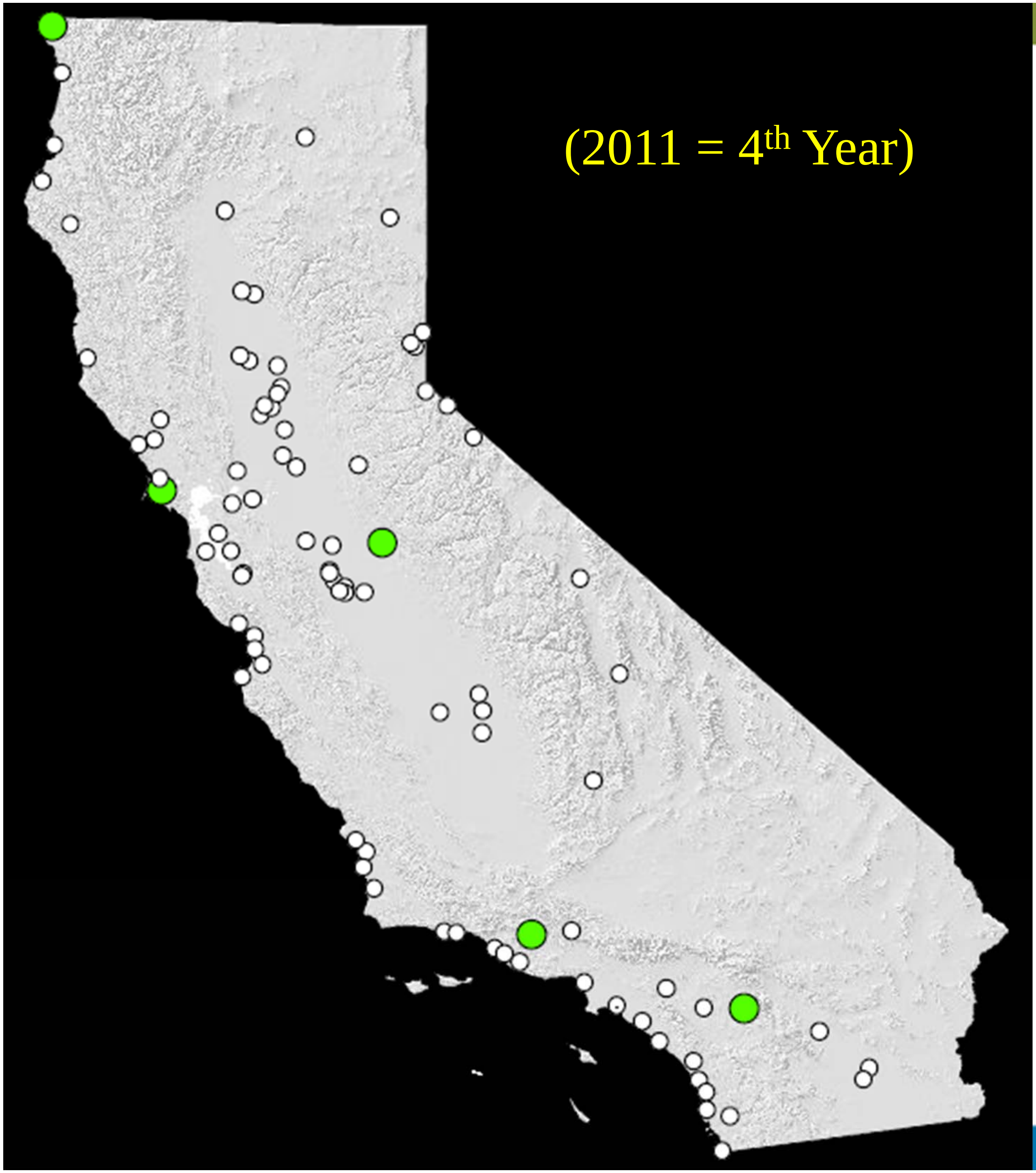

Sampling and Reference Sites:

- Smith River
- Lagunitas Creek
- Tuolumne River
- Sespe Creek
- San Jacinto River

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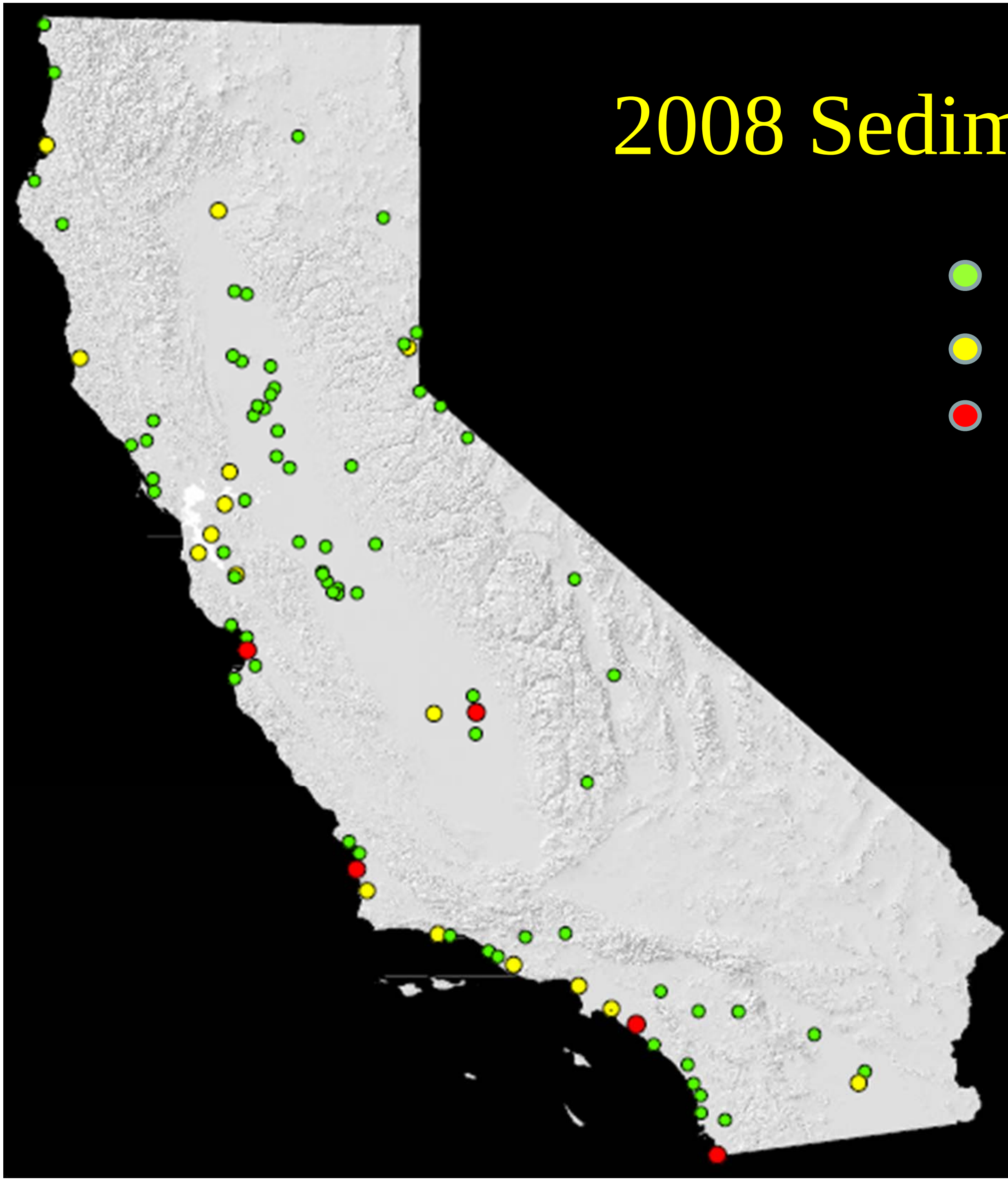
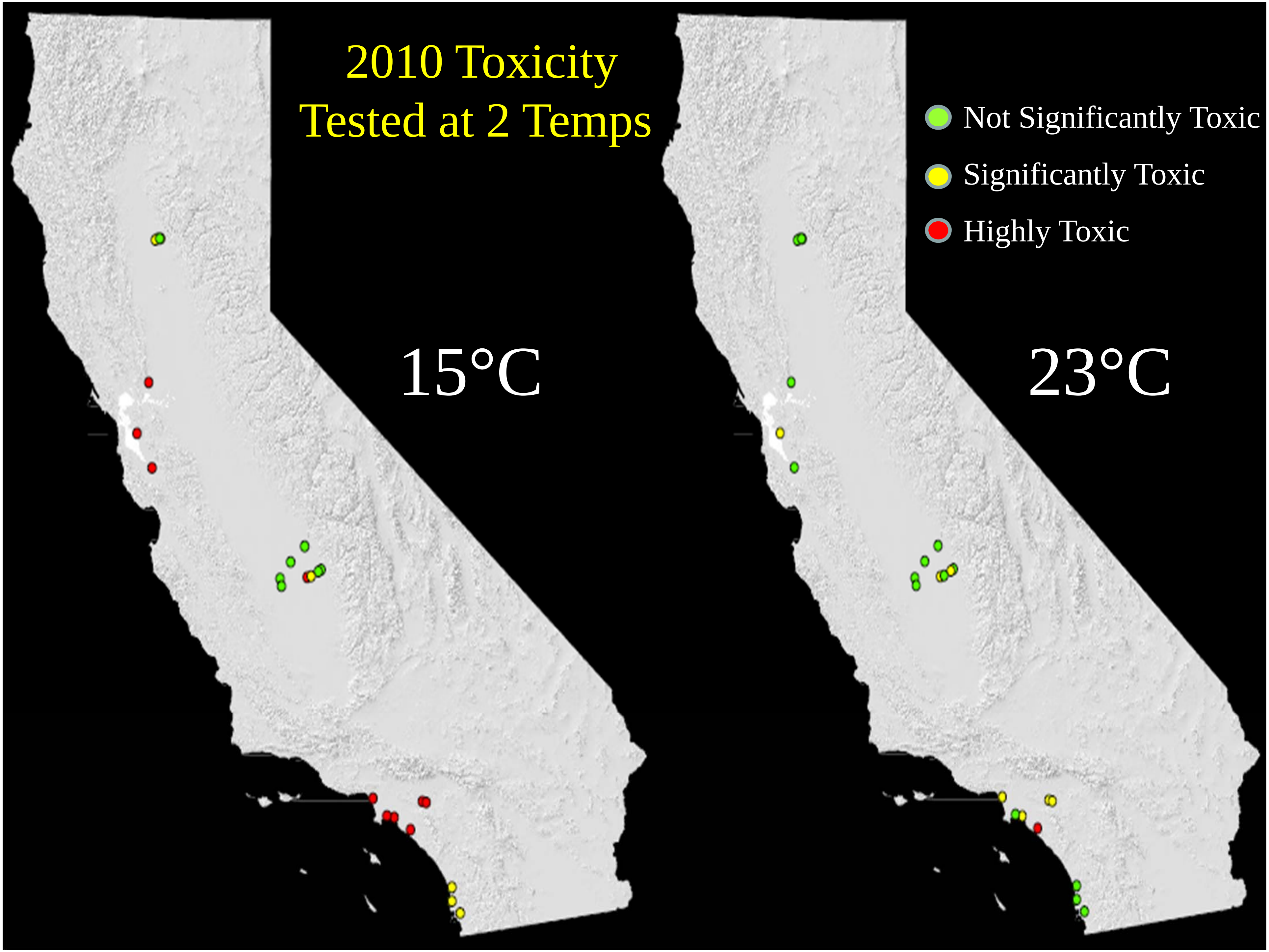
2008 Sediment Toxicity



- Not Significantly Toxic
- Significantly Toxic
- Highly Toxic

2008: 23% toxic
2009: 35% toxic
2010: 28% toxic

Tested at 23°C


2010 Toxicity
Tested at 2 Temps
15°C
23°C
Not Significantly Toxic
Significantly Toxic
Highly Toxic

2010

Station Code	15ºC Results: % of Control	15ºC Results: New SWAMP Qualifier	23ºC Results: % of Control	23ºC Results: New SWAMP Qualifier
204SLE030	22.22	Highly Toxic	86.49	Toxic
205GUA020	10.00	Highly Toxic	97.30	Non-toxic
207LAU020	22.22	Highly Toxic	95.95	Non-toxic
404BLNAxx	3.53	Highly Toxic	69.33	Toxic
405SGRA2x	1.18	Highly Toxic	69.33	Toxic
412LARWxx	21.18	Highly Toxic	94.67	Non-toxic
504BCHBID	90.43	Non-toxic	113.85	Non-toxic
504BCHNOR	84.04	Toxic	120.00	Non-toxic
504BCHRIV	74.47	Toxic	113.85	Non-toxic
504BCHROS	95.74	Non-toxic	115.38	Non-toxic
551LKI040	105.38	Non-toxic	105.41	Non-toxic
551LKI041	107.53	Non-toxic	108.11	Non-toxic
551LKI043	100.00	Non-toxic	105.41	Non-toxic
551LKI044	91.40	Non-toxic	105.41	Non-toxic
558PKC001	96.77	Non-toxic	106.76	Non-toxic
558PKC003	100.00	Non-toxic	74.32	Toxic
558PKC005	8.60	Highly Toxic	85.14	Toxic
558PKC010	91.40	Toxic	106.76	Non-toxic
801CCPT12	17.65	Highly Toxic	77.33	Toxic
801SARVRx	35.29	Highly Toxic	82.67	Toxic
801SDCxxx	1.18	Highly Toxic	16.00	Highly Toxic
904ESCOxx	64.71	Toxic	88.00	Non-toxic
906LPLPC6	40.00	Toxic	93.33	Non-toxic
907SDFVxx	85.88	Toxic	88.00	Non-toxic

	15ºC	23ºC
Non-Toxic:	**33%**	**67%**
Sig Toxic:	**67%**	**33%**
HighlyToxic:	**42%**	**4%**

2010 chemistry pending

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Paired t-test = $p < 0.001$

Statewide Ambient Temperatures

(Discreet daytime measurements; SWAMP database; n = 12,279)

Region	Average Temperature (°C)
1	13.1
2	14.5
3	16.6
4	19.4
5	16.5
6	11.3
7	21.9
8	11.6
9	17.8
Mean	**15.9**

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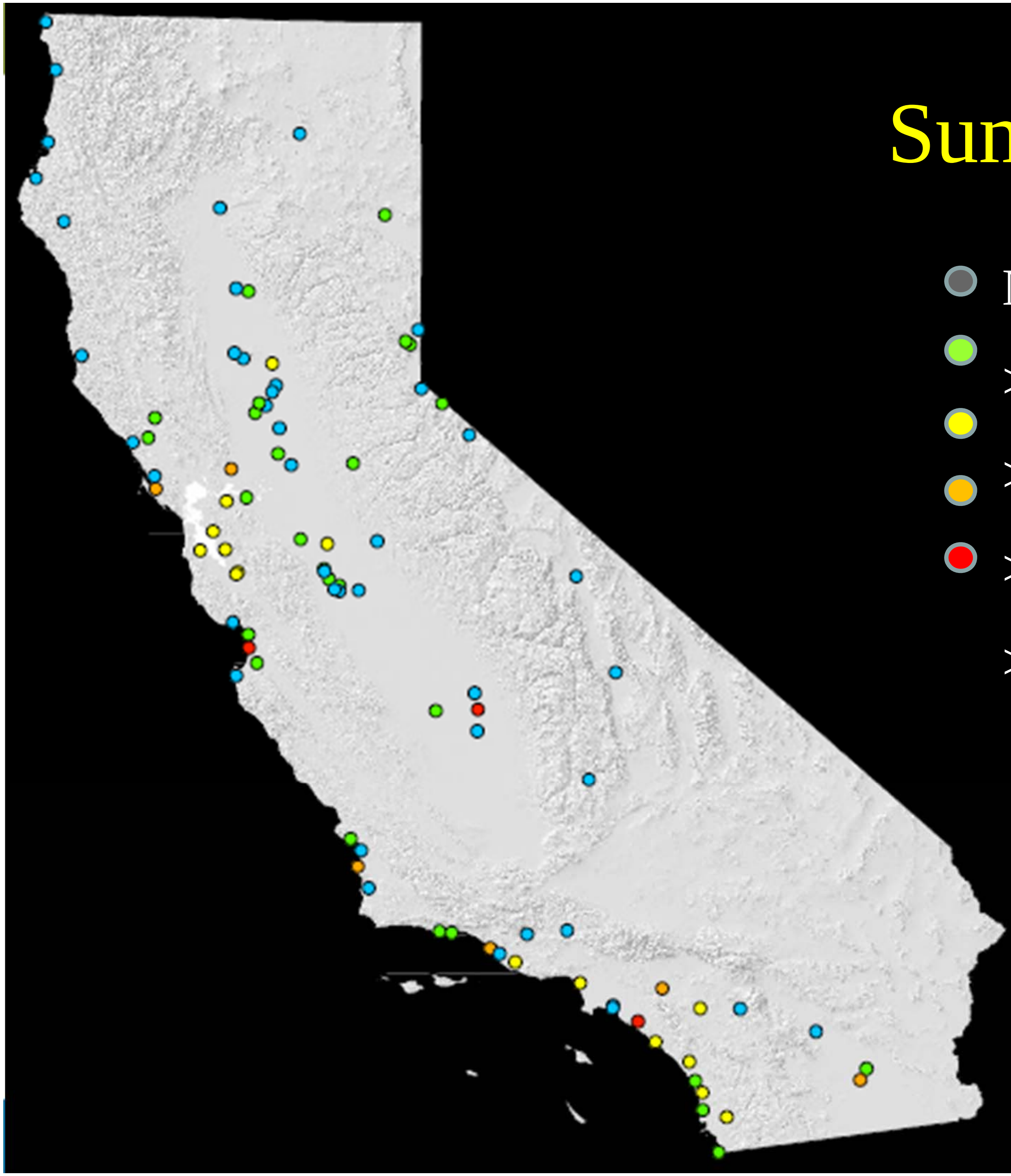
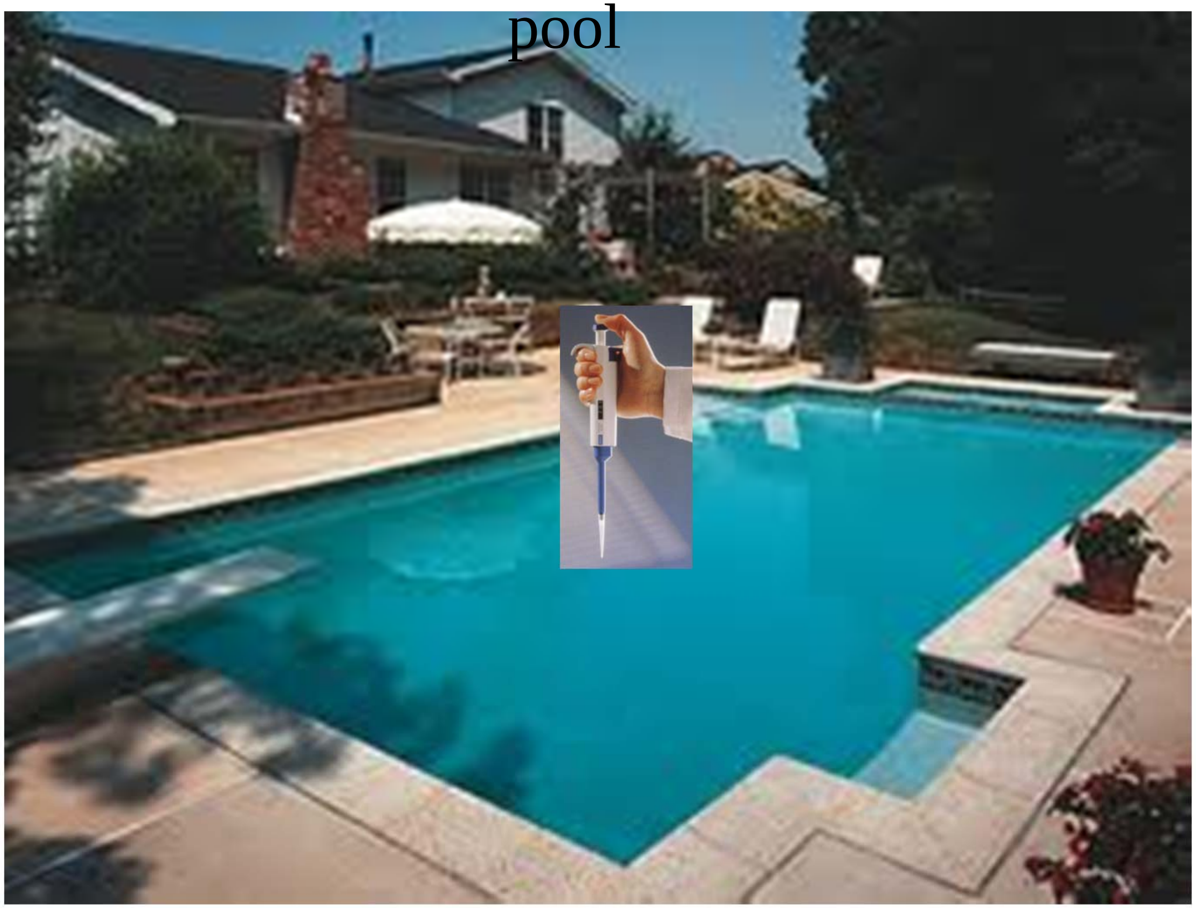
Sum Pyrethroids



Pyrethroids are toxic in the low parts per trillion range

1 part per billion = 1 ug/L $\simeq$ 1 drop of water in an olympic-size pool

1 part per trillion = 1 ng/L $\simeq$ 0.001 drop of water in an olympic-size pool



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Potential Underestimation of Impacts:

23°C vs 15°C testing

10d vs 28d test exposure w/ *H. azteca*

Importance of low detection limits for pyrethroids

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Evidence of pyrethroid-associated toxicity in nearshore marine habitats (Anderson et al., 2011)

- San Diego Harbor at Switzer Creek
- Upper Newport Bay at San Diego Creek
- Ballona Creek mouth
- Santa Maria River Estuary

Relationship Between Laboratory Toxicity and Field Impacts – Triad Data Sets w/ *H. azteca*

Colonization Experiments: Ingersoll et. al., 2005

Salinas River: Anderson et al. 2003a; 2006b

Santa Maria River: Anderson et al. 2006a

Santa Maria Estuary: Anderson et al. 2010

Central Valley Urban Creeks: Weston et al. 2005

Importance of physical habitat: Hall et al., 2007 and 2009

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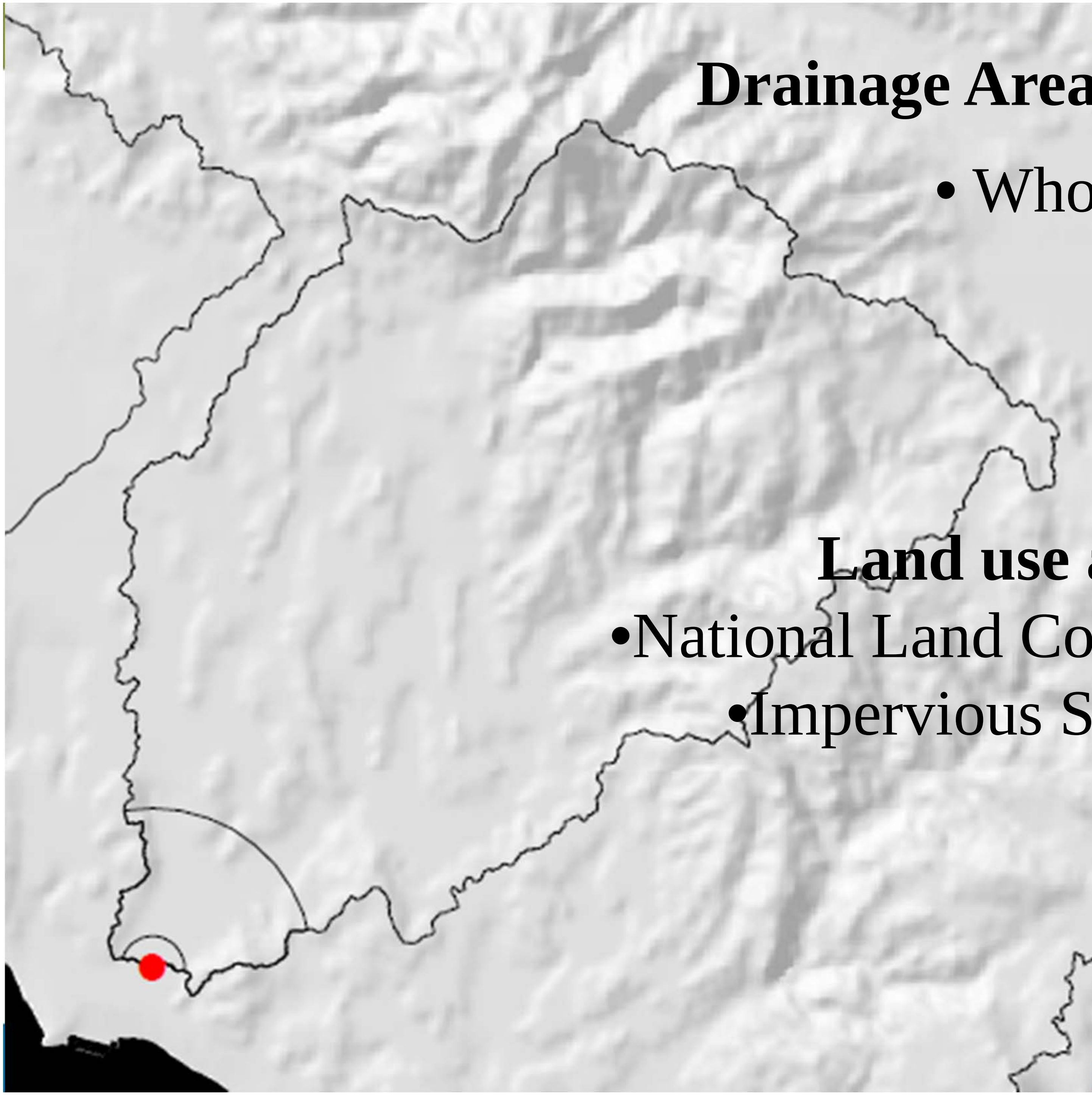

Drainage Area Delineation

- Whole Watershed
- 5 kilometer
- 1 kilometer

Land use at each scale

- National Land Cover Database
- Impervious Surface Cover

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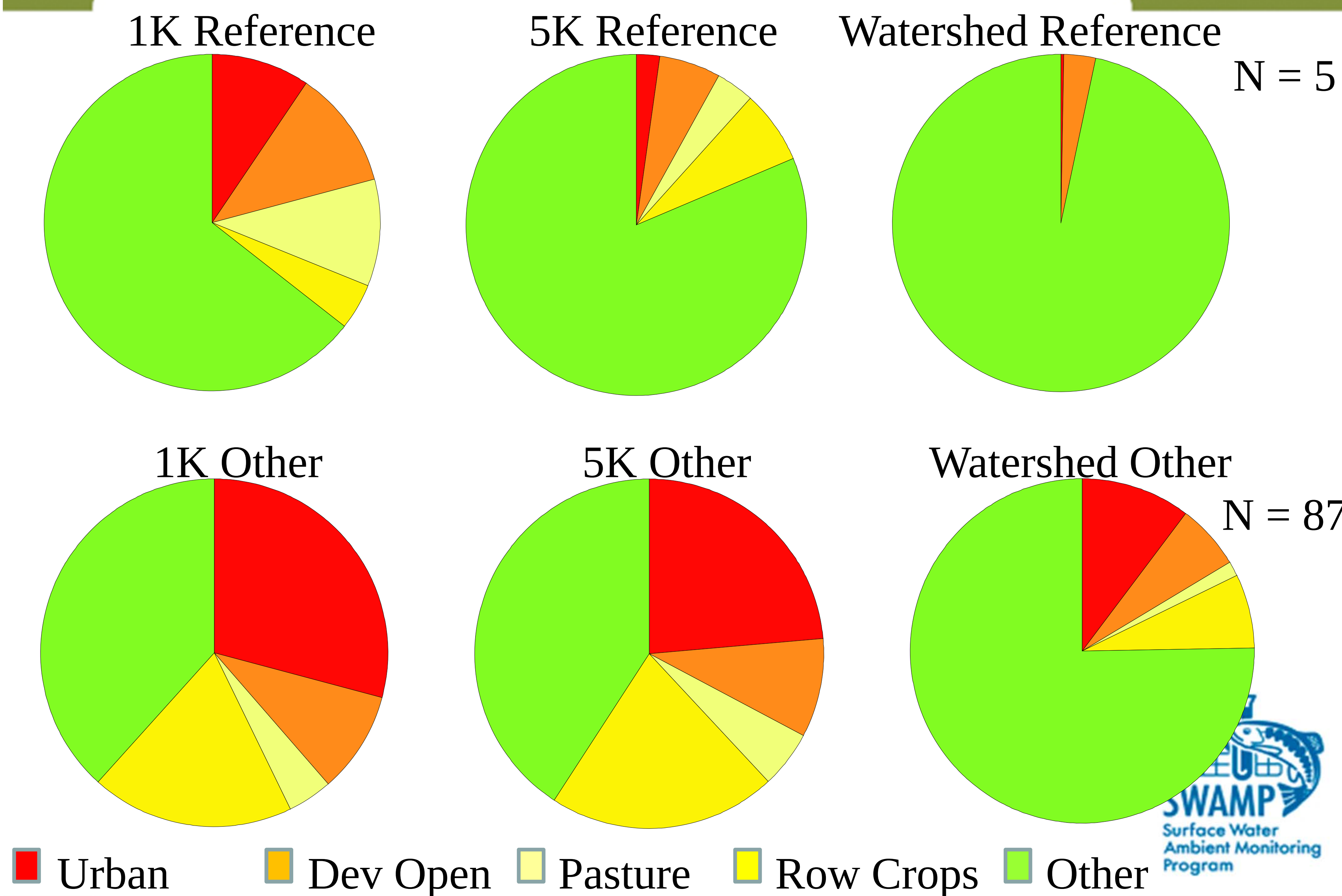
1K Reference
5K Reference
Watershed Reference
N = 5
1K Other
5K Other
Watershed Other
N = 87
Urban
Dev Open
Pasture
Row Crops
Other
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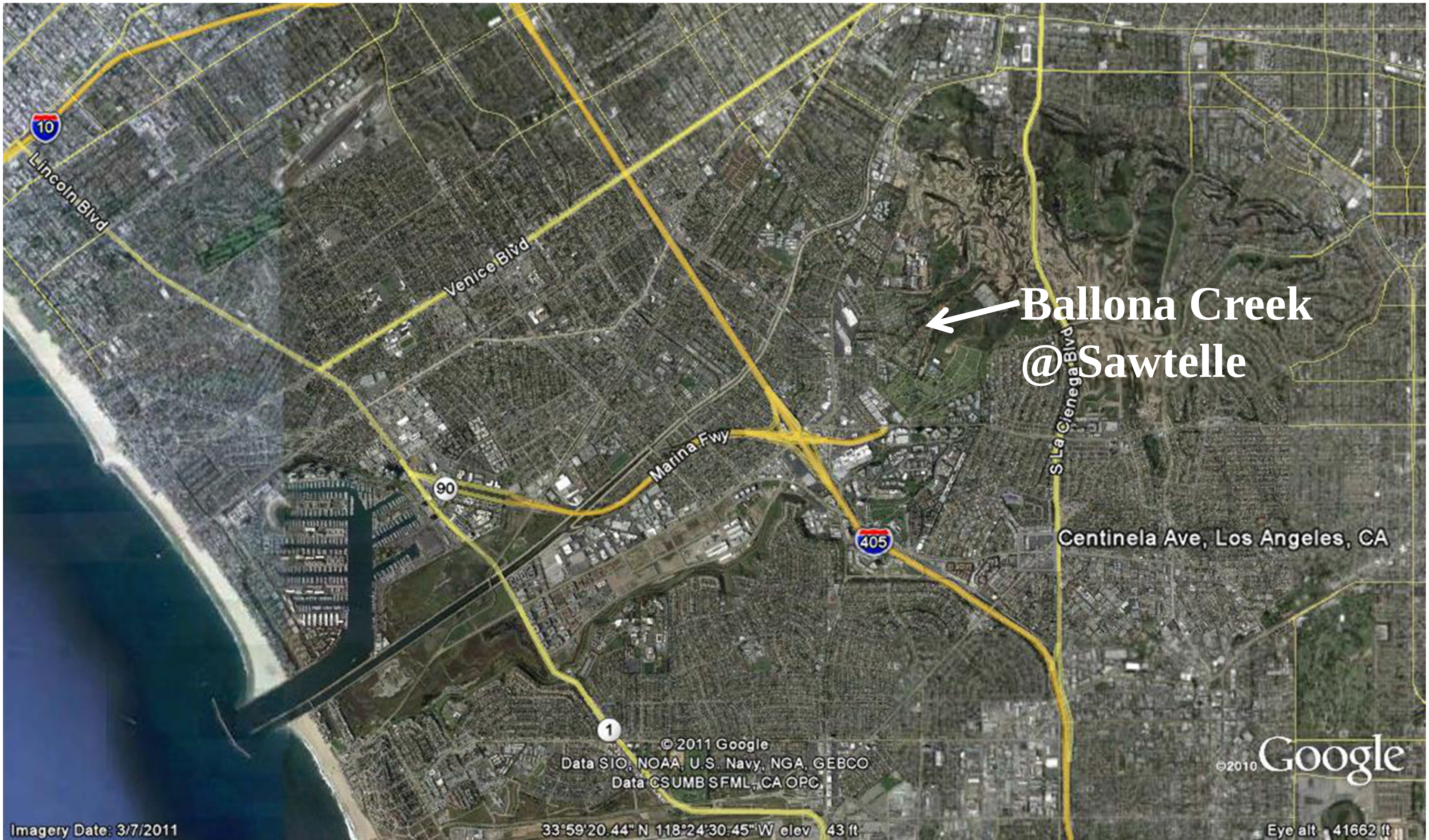

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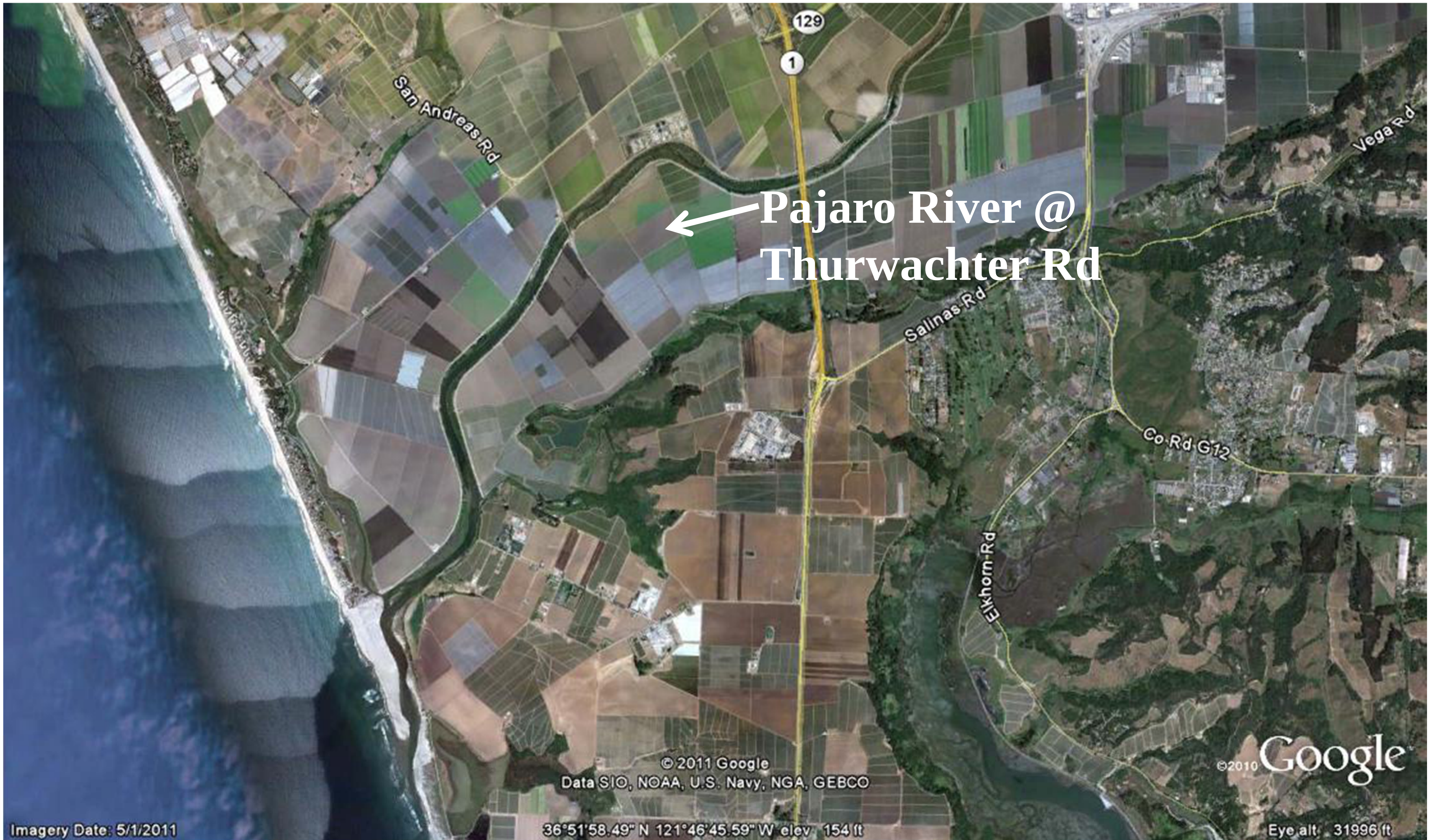

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Spearman MV Correlation

Variable	by Variable	Prob > ρ
Pyrethroids	Urban_WS	< .0001 *
Pyrethroids	Crops_WS	0.3055
Survival	Urban_1K	0.0083 *
Survival	Urban_5K	0.0002 *
Survival	Urban_WS	0.0339 *
Sum PCB	Urban_1K	< .0001 *
Sum PCB	Urban_5K	< .0001 *
Sum PCB	Urban_WS	< .0001 *
Sum DDT	Urban_1K	0.0012 *
Sum DDT	Urban_5K	< .0001 *
Sum DDT	Urban_WS	< .0001 *

On a statewide level, contaminants and toxicity correlate with urban areas.

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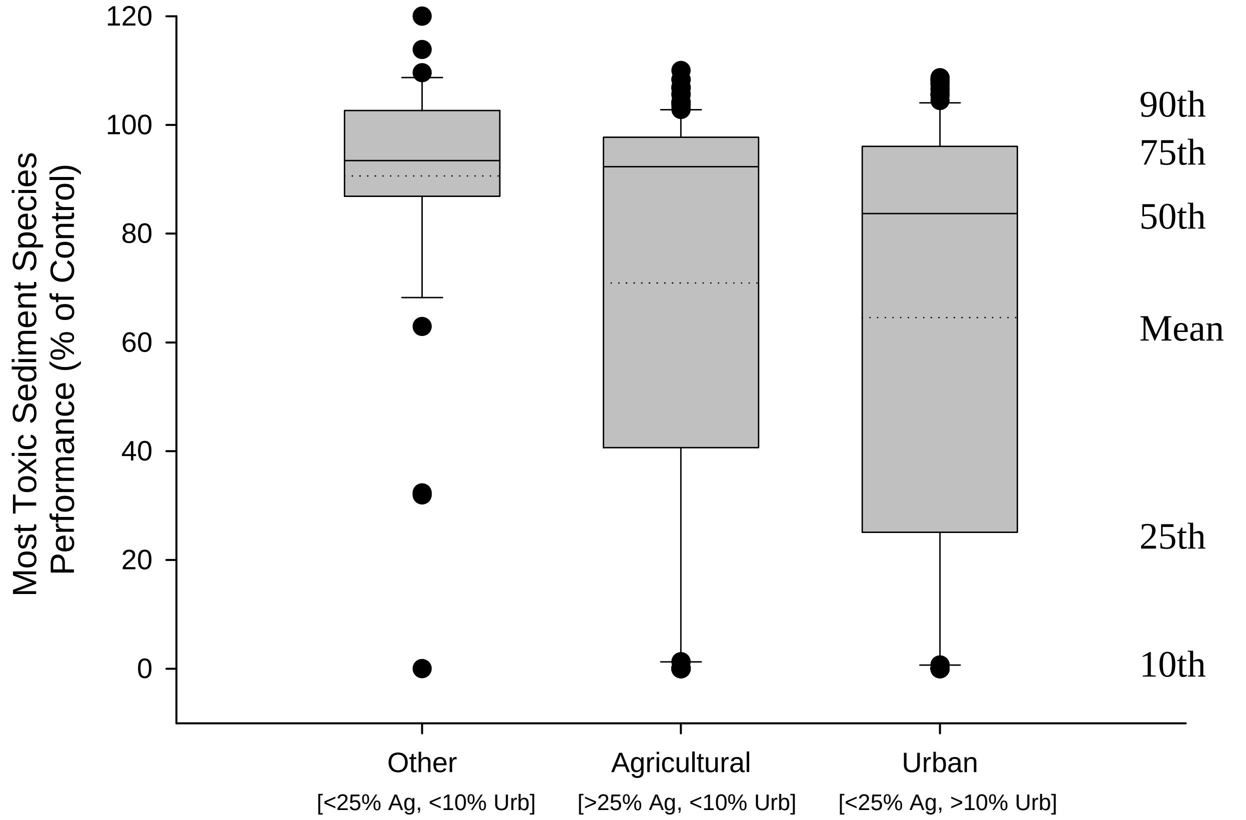
Statewide Monitoring Results – Sediment Toxicity*



*Anderson et al. 2011. Summary of toxicity in California surface waters 2001 – 2010. Surface Water Ambient Monitoring Program.

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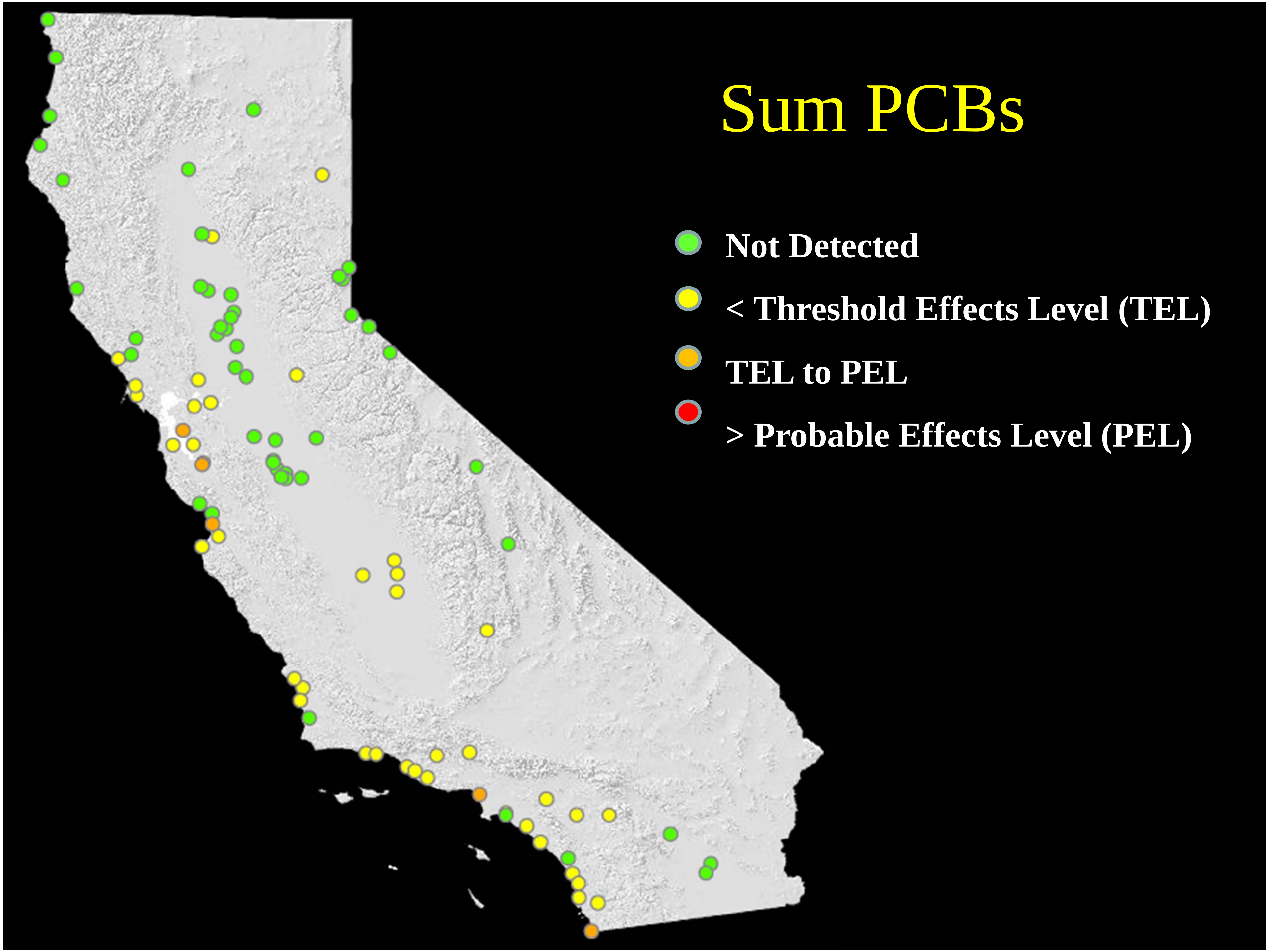
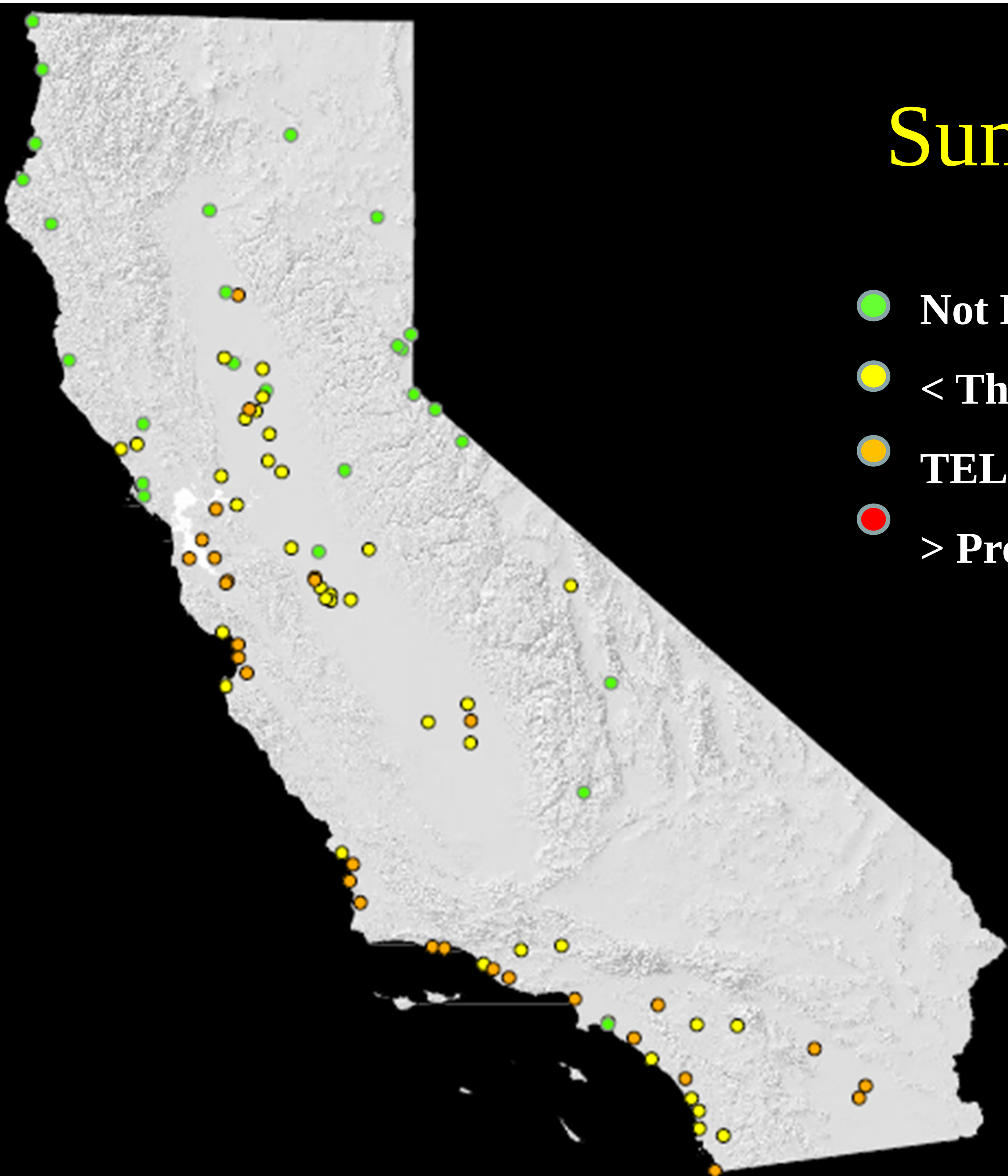

Sum PCBs
Not Detected
< Threshold Effects Level (TEL)
TEL to PEL
> Probable Effects Level (PEL)

Sum DDTs



- Not Detected
- < Threshold Effects Level (TEL)
- TEL to PEL
- > Probable Effects Level (PEL)

MacDonald *et* al. (2000)

Hyalella azteca sediment LC50s

Chemical	ng/g	ug/g oc	Endpoint	Alternate Species	Reference
Pyrethroids					
Bifenthrin	12.9	0.52	LC50		(Amweg et al., 2005)
Cyfluthrin	13.7	1.08	LC50		(Amweg et al., 2005)
Cyhalothrin	5.6	0.45	LC50		(Amweg et al., 2005)
Cypermethrin	14.87	0.38	LC50		(Maund et al., 2002) mean value
Deltamethrin	9.9	0.79	LC50		(Amweg et al., 2005)
Esfenvalerate	41.8	1.54	LC50		(Amweg et al., 2005)
Fenopropathrin		8.90	LC50		Yuping Ding in review
Permethrin	200.7	10.83	LC50		(Amweg et al., 2005)
Tefluthrin		2.90	LC50		Yuping Ding in review
Organochlorines					
Dieldrin		2000	Mean LC50		(USEPA, 2003a)
Endrin	4.4	147	LC50		(Nebeker et al., 1989)3% TOC
Endrin	6	53.6	LC50		(Nebeker et al., 1989)11.2% TOC
Total Chlordane	17.6		PEC		(Macdonald, 2000)
Total DDT	572		PEC		(Macdonald, 2000)
Total DDT	11000	367	LC50		(Nebeker et al., 1989)3% TOC
Total DDT	49700	473	LC50		(Nebeker et al., 1989)10.5% TOC
Total DDT		2580	LC50		Swartz et al. 1994
DDD		1300	LC50		predicted in Weston et al. 1994 (Amweg et al., 2005)
DDE		8300	LC50		predicted in Weston et al. 1994
Methoxychlor		85.8	LC51		Weston et al. 1994
alpha Endosulfan		51.7	LC52		Weston et al. 1994
Endosulfan sulfate		873	LC53		Weston et al. 1994
Organophosphates					
Chlorpyrifos	399	1.77	LC50		(Brown et al., 1997; Amweg and Weston, 2007)
PAHs					
Fluoranthene		1,077	LC50		(Suedel et al., 1993)
Fipronil					
Fipronil	306	9.3	LC50		(Ma, 2006)
Fipronil Sulfone	158	4.7	LC50		(Ma, 2006)
Fipronil Sulfide	435	14.0	LC50		(Ma, 2006)

Summary

- Sediment toxicity was observed at 23-35% of the statewide sites (at 23°C) over a three-year period.

- Testing at two temperatures indicates that toxicity is detected much more frequently at 15°C. Combined with toxic unit analysis, this implicates pyrethroids as a cause of observed biological effects at many sites.

- At the *statewide* level, urban land uses are most highly correlated with pollutant concentrations and toxicity.

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Stream Pollution Trends (SPoT) Monitoring Program

First Report

Field Year 2008

Statewide Perspective on Chemicals of Concern and Connections between Water Quality and Land Use

Hunt JW, Phillips B, Anderson B, Siegler K, Lamerdin C, Sigala M, Fairey R, Swenson S, Ichikawa G, Bonnema A, Crane D. 2011. Statewide perspective on chemicals of concern and connections between water quality and land use. Surface Water Ambient Monitoring Program – Stream Pollution Trends (SPoT) Program. California State Water Resources Control Board. Sacramento, CA.

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Acknowledgements

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