Pesticide prioritization with PUR data for surface water monitoring

Prioritization Workgroup (Xin Deng, Robert Budd, Michael Ensminger, April DaSilva, Yuzhou Luo)

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Surface Water Protection Program
DPR Environmental Monitoring Branch
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Overview

- Where, when, and what to sample?
- Early efforts
  - e.g., "*Assessment of acute aquatic toxicity of current-use pesticides in California, with monitoring recommendations*" (Starner, 2007)

Chemical	Toxicity	Use	Monitoring Priority
Malathion	very high	high	high
Diazinon	high	high	high
Carbaryl	very high	moderate	high
Thiram	high	moderate	high
Trifluralin	moderate	very high	high

Overview

- Where, when, and what to sample?
- Early efforts
- Prioritization workgroup
  - "*Establish computer programs to integrate and facilitate the automation of updating the agricultural and urban monitoring priority lists*" (workgroup charter, 2012)

Overview

- Where, when, and what to sample?
- Early efforts
- Prioritization workgroup
- Evolution
  - Phase 1 (use and toxicity), May 2013
  - Phase 2 (predicted/observed exposure), July 2014
  - Phase 3 (watershed), March 2015
  - Computer program

MONITORING

- Fumigant Regulatory Issues
- VOC Emissions
- Surface Water
- Ground Water
- Air
- Publications
- Air Monitoring Network

Monitoring Prioritization Methodology

Back to Surface Water Protection Program Publications

Models for prioritization of pesticides for monitoring in agricultural and urban environments.

2015

- NEW **Presentation 77, PPT** (13.1 mb). Yuzhou Luo. May 18, 2015. **Pesticide Prioritization Model for Surface Water Monitoring.**
- **Analysis Report, PDF** (763 kb). Yuzhou Luo and Xin Deng. March 19, 2015.**Methodology for Prioritizing Pesticides for Surface Water Monitoring in Agricultural and Urban Areas III: Watershed- Based Prioritization.**

2014

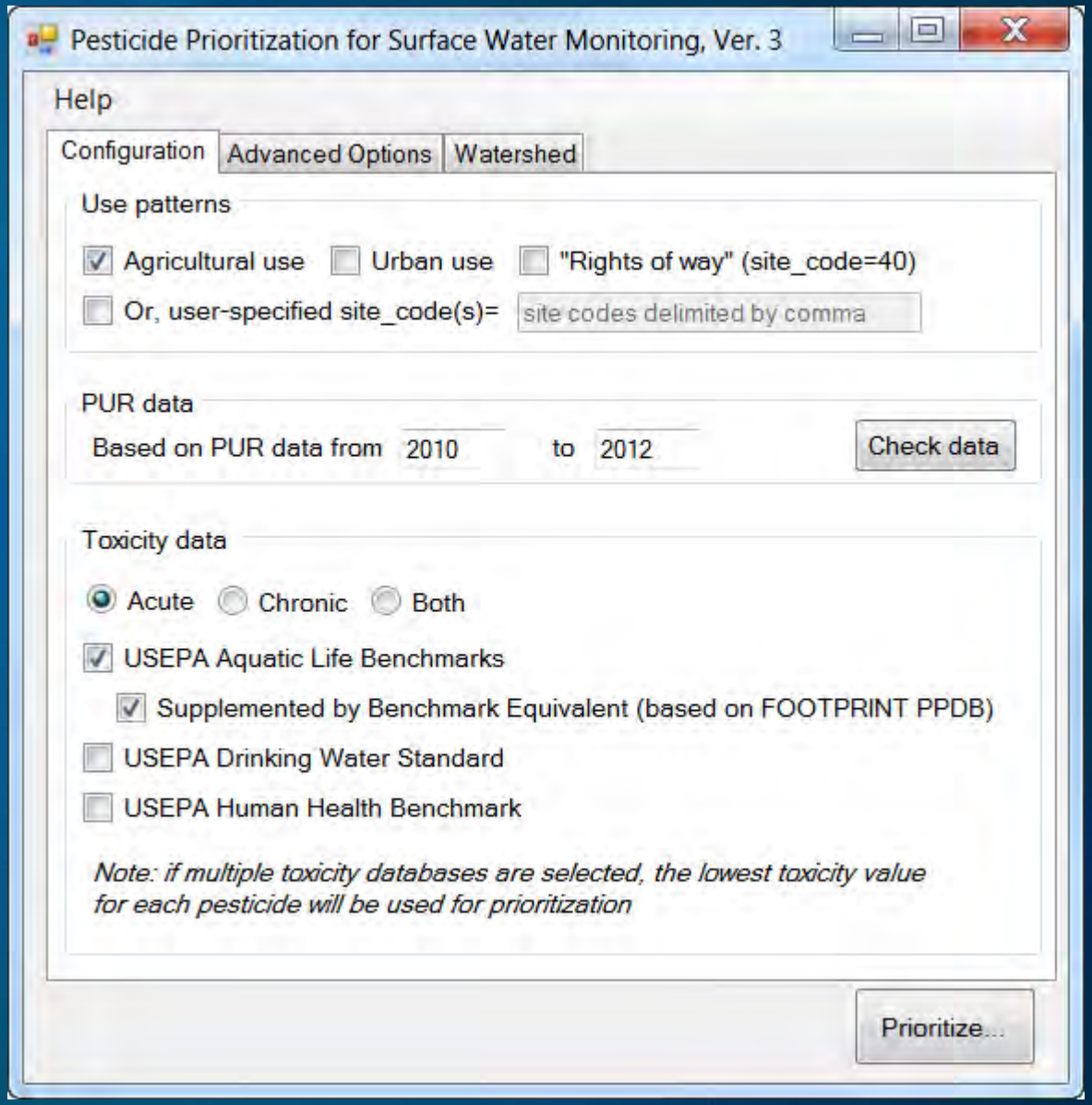
- **User Manual, PDF** (947 kb). Yuzhou Luo. **SWPP Monitoring Prioritization Model User Manual (Version 2.5).**
- **Presentation 69, PDF** (2.7 mb). Yuzhou Luo, Michael Ensminger, Robert Budd, Xin Deng, and April DaSilva. Aug 20, 2014. **Methodology for Prioritizing Pesticides for Surface Water Monitoring in Agricultural and Urban Areas.**
- **Analysis Memo, PDF** (536 kb). Yuzhou Luo, Michael Ensminger, Robert Budd, Xin Deng, and April DaSilva. July 2014. **Methodology for Prioritizing Pesticides for Surface Water Monitoring in Agricultural and Urban Areas II: Refined Priority List.**

2013

- **Analysis Report, PDF** (1.1 mb). Yuzhou Luo, Xin Deng, Robert Budd, Keith Starner, Michael Ensminger. 2013. May 28, 2013. **Methodology for Prioritizing Pesticides for Surface Water Monitoring in Agricultural and Urban Areas.**

http://www.cdpr.ca.gov/docs/emon/surfwtr/monitoring_methods.htm

GUI – basic configuration



Results

[Priority score]=
[use score]×[toxicity score]

Benchmark (ppb)
→ toxicity score (1~8)

Monitoring recommendation

Use (lb)
→ use score (1~5)

chem_code	CHEMNAME	use	usescore	benchmark	toxscore	finalscore	recom
253	CHLORPYRIFOS	1286319.6	5	0.05	6	30	True
1973	OXYFLUORFEN	649087.4	5	0.29	5	25	True
1601	PARAQUAT DICHLORIDE	824836.3	5	0.396	5	25	True
2297	LAMBDA-CYHALOTHRIN	54338.4	3	0.0035	7	21	True
367	MALATHION	428194.5	4	0.295	5	20	True
677	CHLOROTHALONIL	1045361.6	5	1.8	4	20	False
629	ZIRAM	829150.9	5	4.85	4	20	False
1929	PENDIMETHALIN	1948400.8	5	5.2	4	20	True
2008	PERMETHRIN	109106.6	3	0.0106	6	18	True
418	NALED	157512.2	3	0.07	6	18	False
2300	BIFENTHRIN	146639.8	3	0.075	6	18	True
45	ATRAZINE	26209.8	2	0.001	8	16	True
531	SIMAZINE	350724.5	4	2.24	4	16	True
231	DIURON	301054.7	4	2.4	4	16	True
383	METHOMYL	251223.9	4	2.5	4	16	True
597	TRIFLURALIN	482013.7	4	7.52	4	16	True
5133	S-METOLACHLOR	266233.7	4	8	4	16	True

Example: statewide, annual, agricultural uses, 2011-2013

Toxicity scores

- [priority score]=[toxicity score]*[use score]
- [toxicity score] =1 (lower toxicity) to 8 (higher toxicity)
- [toxicity score]=5-log[toxicity value]

Toxicity score	The lowest Benchmark value (TOX, ppb)
8 (higher)	<=0.001
7	(0.001, 0.01]
6	(0.01, 0.1]
5	(0.1, 1]
4	(1,10]
3	(10,100]
2	(100,1000]
1 (lower)	>1000

(Starner, 2007; 2008)

Use scores

- [priority score]=[toxicity score]*[use score]
- [use score]=1 (lower use) to 5 (higher use), dependent on user-defined regions and seasons

N=100

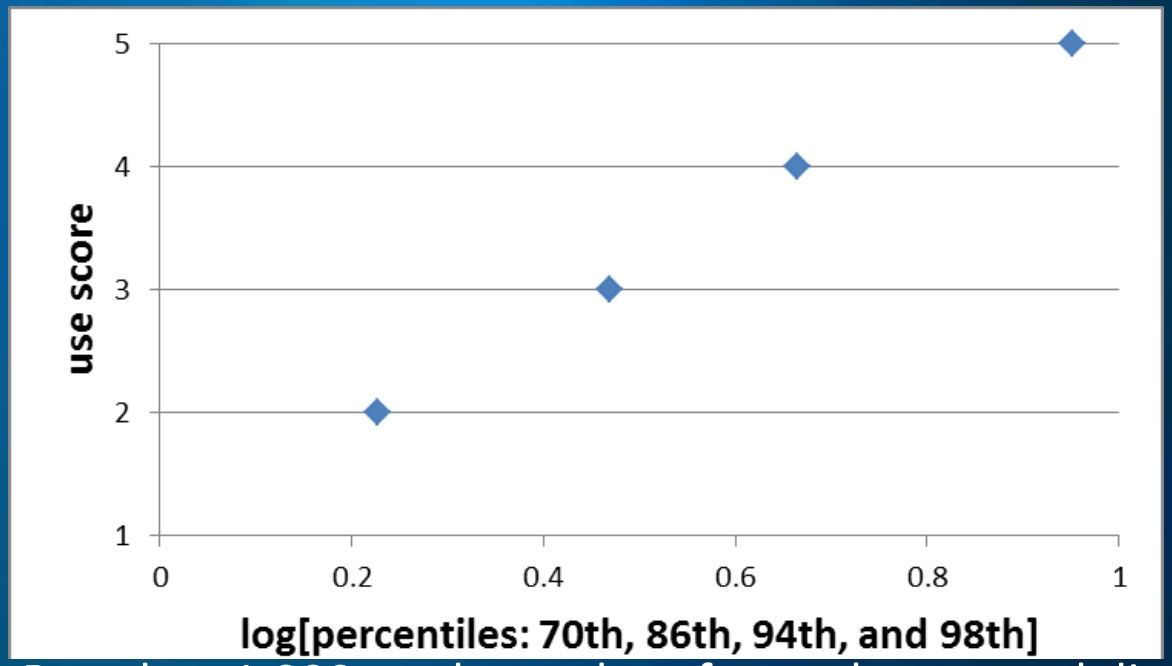
chem_code	chemname	use
970	POTASSIUM N-METHYLDITHIOCARBAMATE	6200902
5820	GLYPHOSATE, POTASSIUM SALT	3905396
1855	GLYPHOSATE, ISOPROPYLAMINE SALT	3232614
2629	KAOLIN	2237689
503	PROPANIL	2128464
1929	PENDIMETHALIN	1828874
253	CHLORPYRIFOS	1225664
677	CHLOROTHALONIL	994390
211	MANCOZEB	935848
629	ZIRAM	890609
1601	PARAQUAT DICHLORIDE	856215
1868	ORYZALIN	613030
1973	OXYFLUORFEN	580854
3946	GLUFOSINATE-AMMONIUM	504060
597	TRIFLURALIN	475117
367	MALATHION	463661
104	CAPTAN	418941
636	2,4-D	387744
531	SIMAZINE	375704

Percentage	Use score
2%	5 (higher)
4%	4
8%	3
16%	2
70%	1 (lower)

default values,
can be changed by users

Use scores

- [priority score]=[toxicity score]*[use score]
- [use score]=1 (lower use) to 5 (higher use)
- Use data generally follow log-normal distribution, so [use score] → log[use amount]



Based on 1,000 random values from a log-normal distribution location=0.0, scale=1.0, and threshold=0.0 (MINITAB v.16)

PUR data processing

- Temporally: monthly data
- Spatially
  - County-based (agriculture and urban)
  - Watershed-based
    - Standard watershed delineation, predefined by USGS 12-digit Hydrologic Unit Code (HUC12) (agriculture and urban)
    - User-defined watershed, by sections, 1x1 mi^2 (agriculture only)

County vs. watershed (HUC12)

Total (effective) pesticide use

- Simple sum
  - *Total USE*=USE(0)+USE(1)+…+USE(n), where “0” is the base HUC12 and 1~n are upstream HUC12’s
- With time of travel (T), from treated HUC12 to the site
  - *Total USE*=d_0×USE(0)+d_1×USE(1)+…+d_n×USE(n)
  - d_i=exp(-k×T_i)

Model application

- Example: Salinas River @ Del Monte, DPR site code 27_14, Ag. uses; April to September

Salinas River, Drainage Area = 11082 km^2

Pesticide	Use score	Tox score	Final score	Monitoring inclusion
Malathion	4	5	20	Yes
Permethrin	3	6	18	Yes
Chlorpyrifos	3	6	18	Yes
Methomyl	4	4	16	Yes
Diazinon	3	5	15	Yes
Paraquat dichloride	3	5	15	Pending[5]
Mancozeb	5	3	15	No[2]
λ-cyhalothrin	2	7	14	Yes
Naled	2	6	12	No[3]
Maneb	3	4	12	No[2]
Oxyfluorfen	2	5	10	Yes
Bensulide	5	2	10	Yes
Captan	3	3	9	No[2]
Cyprodinil	3	3	9	No[4]
Imidacloprid	3	3	9	Yes
Oxydemeton-methyl	3	3	9	Pending[5]

DPR Study #279 Protocol (Deng, 2015)
http://www.cdpr.ca.gov/docs/emon/pubs/protocol/study297_surface_water.pdf

Urban PUR downscaling

- Assumption: urban PUR data can be down-scaled by population density in a county
  - Urban use(HUC12) = f_1%*PUR(CO1)+f_2%*PUR(CO2)+…

- Approach

County (58) → US Census "County Subdivision" (397) → HUC12 (4,415)

Urban PUR downscaling

- Urban use(HUC12)=$\Sigma[f_j*PUR(j)]$
  - Example: HUC12=180701060606, "Coyote Creek – San Gabriel River"
  - USE(HUC12, urban)=

    3.4%*PUR(Los Angeles, urban)

    +3.0%*PUR(Orange, urban)

Model application

- Example, "MCC040" (South San Ramon Creek), urban receiving water, DPR site_code #01_15

- Results
  - Top-10 model-suggested: bifenthrin, fipronil, diuron, bromacil, permethrin, cyfluthrin, pendimethalin, cypermethrin, λ-cyhalothrin, deltamethrin
  - ALL of the top-10 have been included in the previous DPR monitoring (DPR Study #249, #264)

Spatially continuous mapping

- Objective: to compare statewide spatial distribution of one chemical (or one chemical group)

	Chemical	Location
Spatially continuous mapping	**One**	Multiple (4,415 HUC12)
Monitoring prioritization	Multiple	**One**

- Priority mapping index =
  - [USE, lb] / [TOX, ppb] / [FLOW, cfs], OR
  - [USE, lb] / [TOX, ppb] / [AREA, mi^2]

USE: PUR data aggregated by watershed,
adjusted by travel time, and
accumulated by drainage area

Model application

- Mapping for chlorpyrifos
- Results: priority mapping index in each HUC12
  - Excel format
  - JSON (JavaScript Object Notation) format

	A	B	C	D	E
1	FROM_NODE	HUC	HUCNAME	c253	c253acc
260	259	180101100601	Gill Creek-Russian River	4.686322	0.292451
261	260	180101100602	Sausal Creek-Russian River	22.3453	1.756
262	261	180101100603	Franz Creek	0	0
263	262	180101100604	Maacama Creek	1.804495	1.193915
264	263	180101100605	Brooks Creek-Russian River	0	1.638307
265	264	180101100701	Upper Laguna De Santa Rosa	0.049624	0.049624
266	265	180101100702	Upper Santa Rosa Creek	2.146451	2.146451
267	266	180101100703	Lower Santa Rosa Creek	0	1.536799
268	267	180101100704	Lower Laguna De Santa Rosa	5.560328	1.72843
269	268	180101100705	Windsor Creek	101.2231	101.2231
270	269	180101100706	Porter Creek-Mark West Creek	13.09921	14.65845
271	270	180101100801	East Austin Creek	0	0
272	271	180101100802	Ward Creek-Austin Creek	0	0
273	272	180101100901	Green Valley Creek	292.9369	292.9369
274	273	180101100902	Porter Creek-Russian River	105.6194	6.856086
275	274	180101100903	Dutch Bill Creek-Russian River	0	14.34443
276	275	180101100904	Willow Creek-Russian River	0	13.3787
277	276	180102010101	Headwaters Williamson River	0	0
278	277	180102010102	Haystack Draw-Williamson River	0	0
279	278	180102010103	Deep Creek-Williamson River	0	0
280	279	180102010104	Aspen Creek-Williamson River	0	0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{"name": "Gill Creek-Russian River", "value": 0.2924514},
{"name": "Sausal Creek-Russian River", "value": 1.756},
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{"name": "Maacama Creek", "value": 1.193915},
{"name": "Brooks Creek-Russian River", "value": 1.638307},
{"name": "Upper Laguna De Santa Rosa", "value": 0.04962377},
{"name": "Upper Santa Rosa Creek", "value": 2.146451},
{"name": "Lower Santa Rosa Creek", "value": 1.536799},
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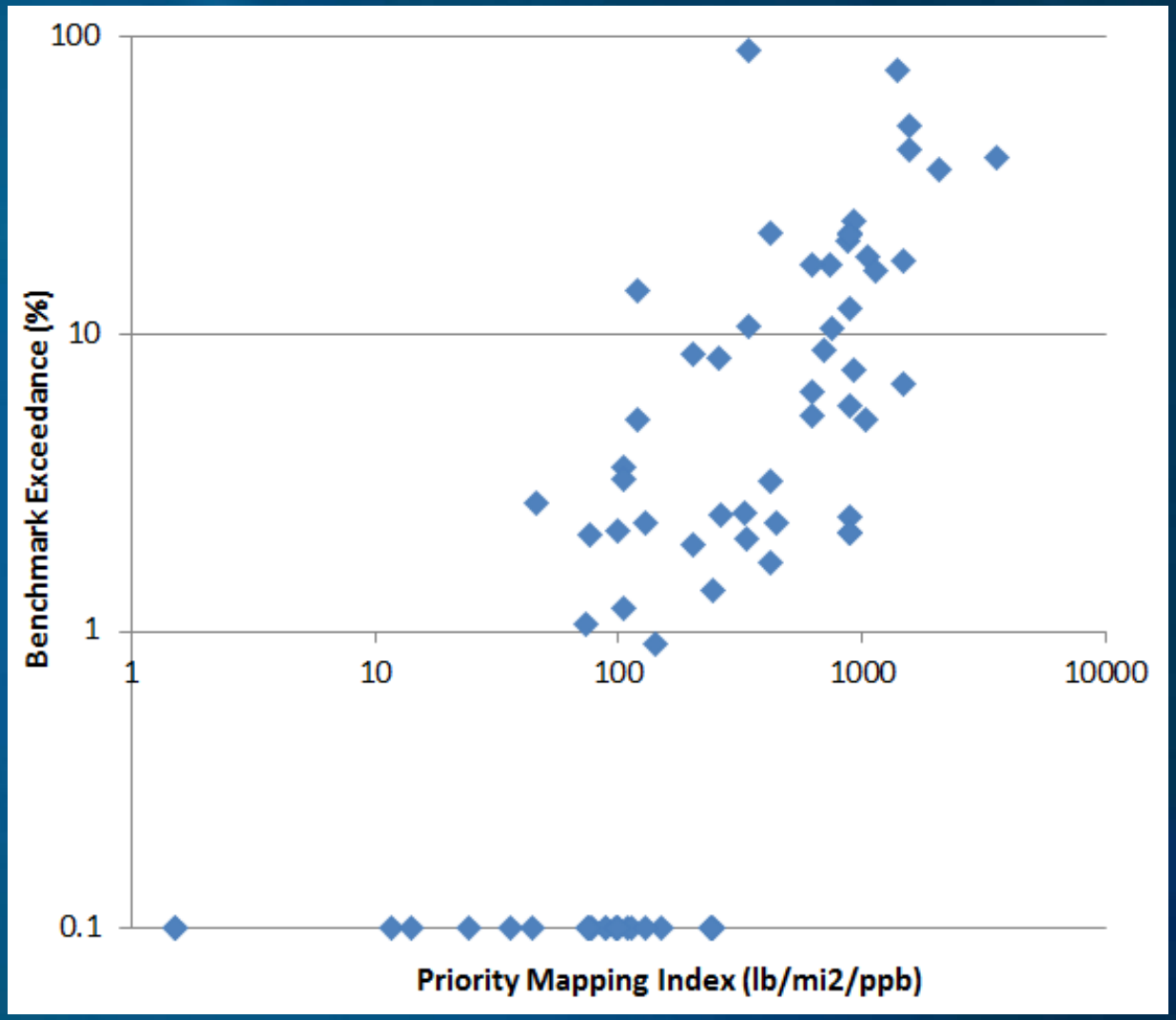
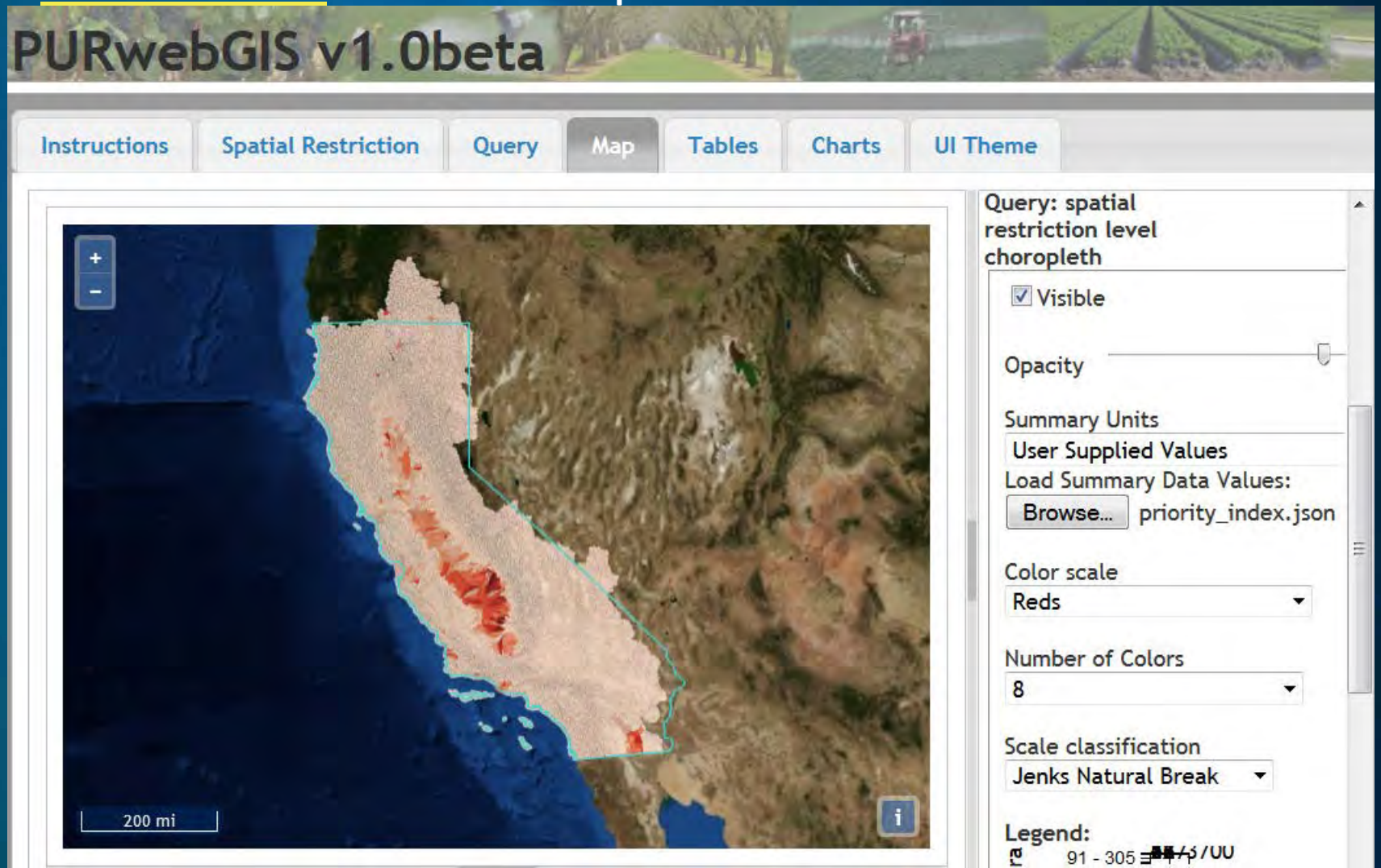
Data comparison



Priority mapping index vs. observed benchmark exceedance for chlorpyrifos in 74 monitoring sites throughout California. “No exceedance (0.0%)” is set as 0.1%.

Visualization

- PURwebGIS as an example



Thank you!

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