A New Approach to Modeling Potential Pesticide Aquatic Exposure in Urban Residential Environments: Application in a National Ecological Risk Assessment

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PYRETHROID WORKING GROUP

Introduction

A new urban pesticide exposure model scenario was parameterized to represent seven different US geographic regions (California, Northwest, North Central, Northeast, Mid-Atlantic, Southeast, and South Central) as part of a national aquatic ecological risk assessment. The scenario for the coupled SWMM/AGRO-2014 model, based on a high vulnerability urban residential watershed in Orange County California, was used to estimate potential pyrethroid exposure in aquatic ecosystems. For each region, 30-year hourly precipitation time series and local irrigation schedules were compiled. Detailed pyrethroid use survey data were used to define the conservative estimates of pyrethroid use extent, frequency, and seasonality for each regional parameterization. The regionally parameterized SWMM/AGRO-2014 model was applied to simulate expected environmental concentration (EEC) distributions for multiple pyrethroids across all seven regions. The region with the highest urban EECs was California, followed by the Southeast and South Central US. The risk of ecological effects resulting from these simulated pyrethroid EECs was found to be low.

Exposure Assessment Approach

Residential Scenario Development[1]

- An urban residential exposure modeling scenario was developed and validated based on a high density single family residential neighborhood (88th percentile nationally) in Aliso Viejo, Orange County, California.
- This residential scenario was then used to represent a high vulnerability urban setting that could be parameterized to represent different geographic locations across the United States.
- Six additional regions outside California were chosen to apply the new residential exposure modeling scenario (Fig. 1): Northwest, North Central, Northeast, Mid-Atlantic, Southeast, and South Central.
- Regional model parameterizations focused on climate, irrigation, and pyrethroid use.

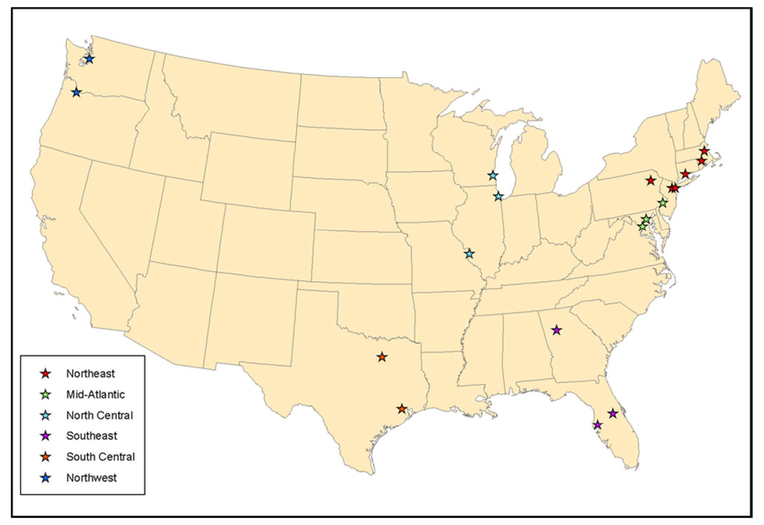

Figure 1. Locations where the CA-Based Residential Scenario was Applied.

1. Scenario development details provided in companion poster, Final Paper Number 220

Regional Parameterization, Climate and Irrigation

- For each geographic region, a 30-year time series of hourly precipitation and daily mean temperature was developed for a representative climate city (Table 1) obtained for the period of 1981 – 2010 from the National Climatic Data Center (NCDC).
- Monthly average evaporation data for each region was derived from EPA's SAMSON weather dataset, generally from the same climate stations used to derive the hourly precipitation time series. Regional pan factors were required to adjust the SAMSON evaporation data (Table1).

Region	Representative Climate City	Pan Factor
Northwest	Seattle	0.75
North Central	Chicago	0.77
Northeast	Boston	0.77
Mid-Atlantic	Philadelphia	0.75
Southeast	Orlando	0.77
South Central	Houston	0.73

Table 1. Climate Locations for each Geographic Region.

- In the development of the residential scenario for Aliso Viejo, California, lawn irrigation was found to be an important contributor to "dry weather" flows and a mechanism for off-target pyrethroid transport.
- Regional monthly irrigation schedules were developed using the following approach:
  - o Apply irrigation at an "excess" rate (Precipitation + Irrigation – Evapotranspiration (ET)) equivalent to what was found in California (an average excess of 2.14 inches per month)
  - o Calculate monthly irrigation in each region as: Irrigation = (2.14 + ET) - Precipitation
  - o Irrigation was not allowed to occur between the first and last freeze dates (grass is dormant).
  - o The number of irrigation events per month was calculated as the target monthly depth divided by a daily irrigation depth of 0.35 inches. The dates were spread evenly throughout the month.

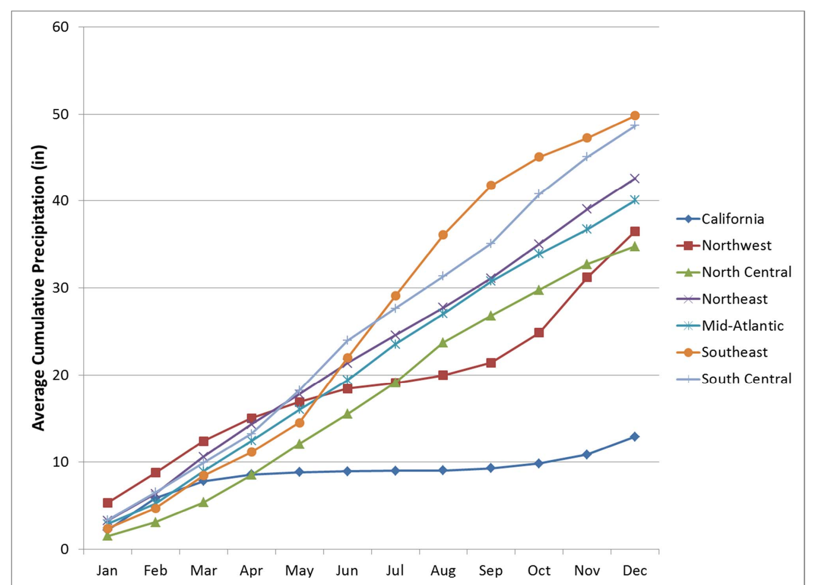

Figure 2. Cumulative Average Monthly Precipitation by Region.

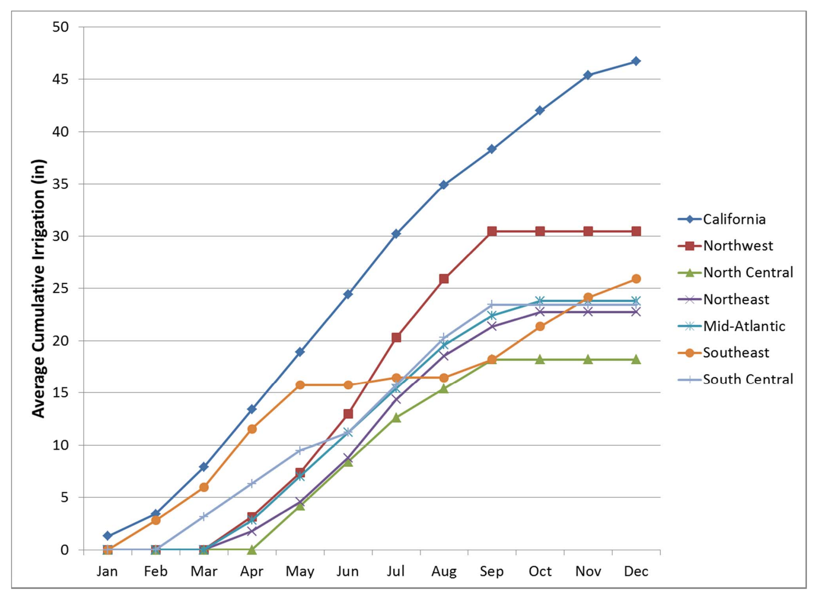

Figure 3. Cumulative Monthly Irrigation by Region.

Exposure Assessment Approach, Continued

Regional Parameterization, Pyrethroid Applications

- A recently completed survey characterized pyrethroid use across 6 geographically diverse regions of the US (Winchell, 2013).
- The primary survey objectives were:
  - o To supplement data from a previous California survey
  - o To understand any regional differentiation in pyrethroid use characteristics for parameterization of the urban residential exposure scenario.
  - o To understand relative significance of different pyrethroids to support active ingredient (AI) specific assessments in these regions.
- For each region, the analysis of the surveys quantified key application characteristics:
  - o The fraction of households receiving treatments
  - o The types of sites/surfaces receiving treatments (Fig. 4)
  - o The relative significance of different pyrethroid AIs for each use site
  - o The seasonal frequency of applications on different types of surfaces (Fig. 5)

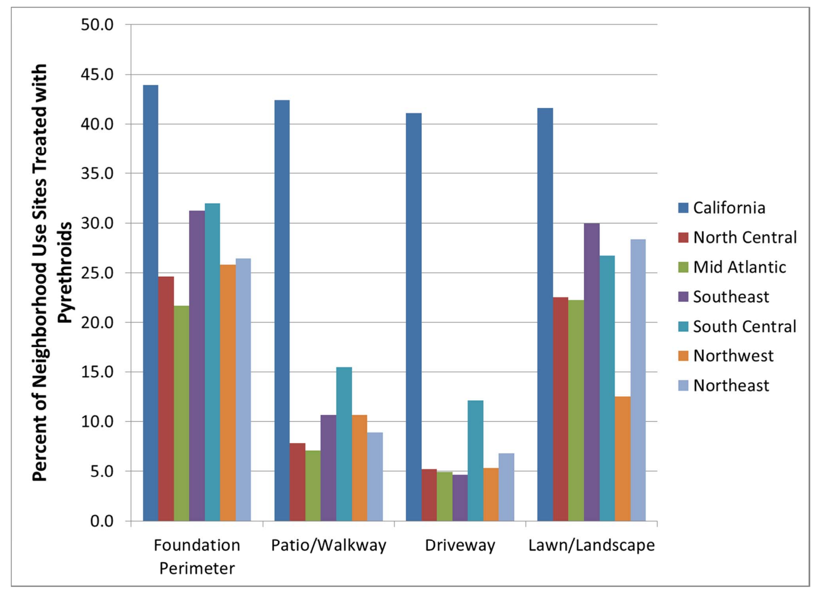

Figure 4. Fraction of Use Sites Treated with any Pyrethroid by Region.

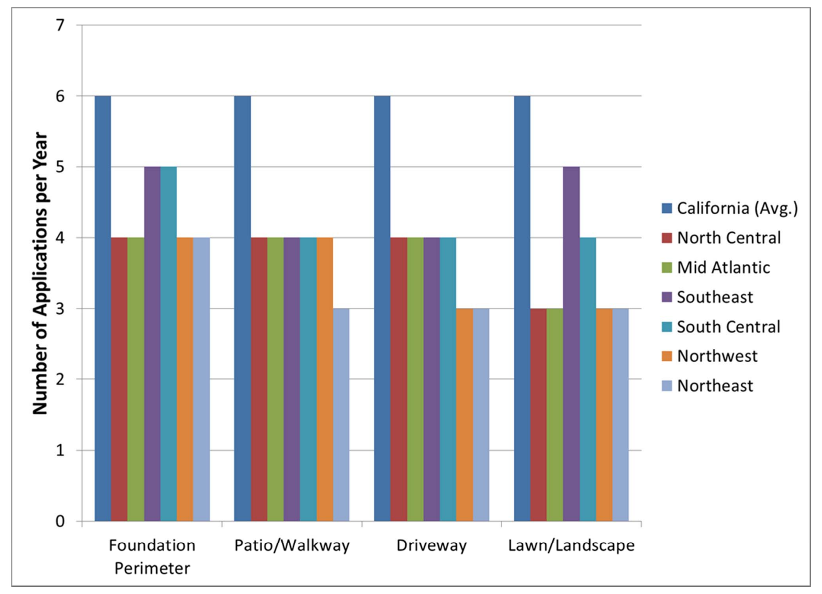

Figure 5. Annual Frequency of Applications by Use Sites and Region.

- Application rate was set at the maximum label rate.
- Per labels, applications were required to precede rainfall by a minimum of 48 hours.
- Current pyrethroid labels limit applications on hard surfaces to crack and crevice applications.
  - o Current label mitigations were simulated for each residential parameterization.
  - o For CA, historical broadcast treatment to hard surfaces was also simulated.

Estimated Environmental Concentrations

- Annual max Estimated Environmental Concentration (EEC) distributions for 7 different pyrethroids with residential uses were assessed for 7 geographic regions based on 30-year SWMM-AGRO simulations (Fig. 6).
- EECs are for a 1 ha, 2 m deep water body to allow comparison with agricultural assessments
- A conservative assumption that each individual pyrethroid active ingredient (AI) had 100% of the pyrethroid market share was made when estimating the extent of use.
- The variability in the EECs across AIs is due to:
  - o AI specific application rate
  - o AI specific environmental fate properties

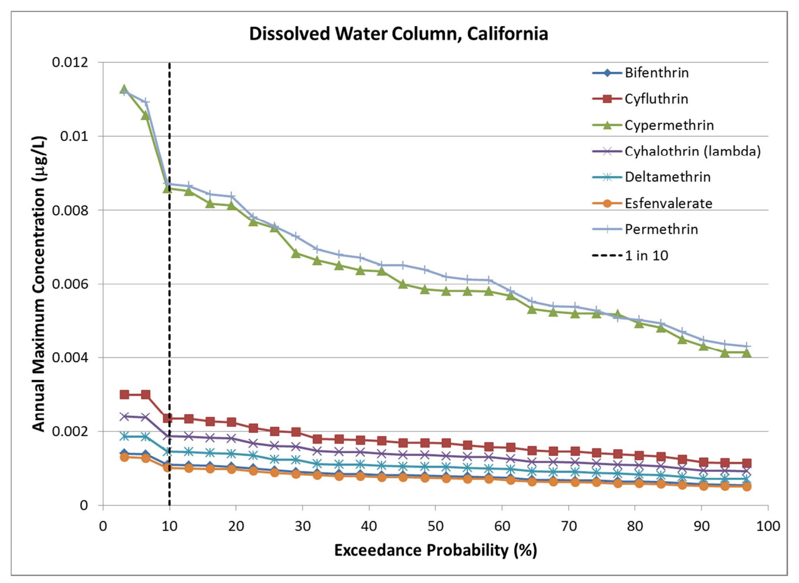

Figure 6. 24-hr Annual Maximum EEC Distributions, 7 Pyrethroids.

- For California, EECs were evaluated based on both historical and current labels (Fig. 7).
- Based on a conservative parameterization of the current label mitigations, annual maximum dissolved water column EECs showed an ~10x reduction compared to historic conditions.
- Factors not accounted for in the SWMM-AGRO model parameterization of current label mitigations include the effects of lower washoff rates observed from crack/crevice surfaces compared to smooth surfaces (Davidson et al., 2014).

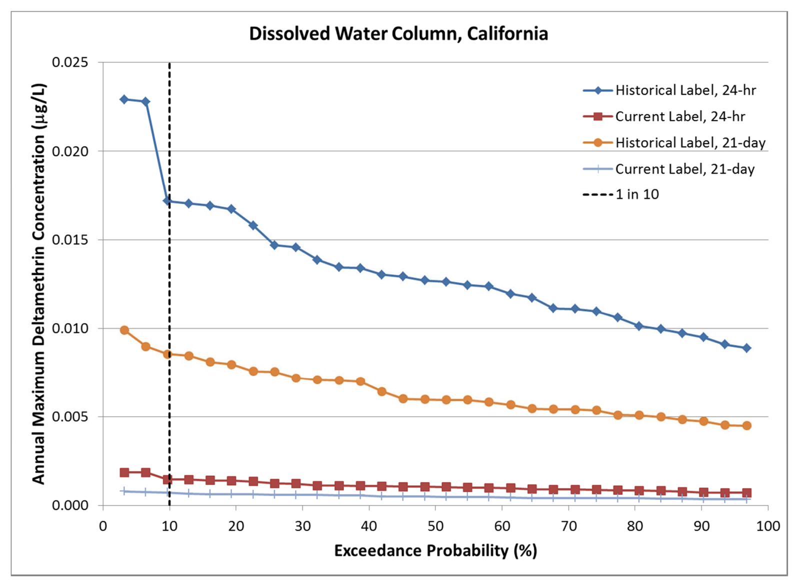

Figure 7. 24-hr Annual Maximum Deltamethrin EEC Distributions, Historical and Current Labels.

Ecological Effects of Residential Pyrethroid Use

Potential Ecological Exposure

- The EECs relevant to ecological effects (Fig. 8 and 9) are the acute (24-hr) and chronic (21-day) dissolved (bioavailable) water column concentrations, and the chronic (21-day) benthic layer pore water and sediment concentrations.
- For both water column and benthic pore water, EECs were higher for California compared to the other geographic regions assessed (Note: sediment concentration patterns match pore water).
- The variability in the EECs across the different regions is attributable to the differences in the extent of pyrethroid use and the variability in climate.

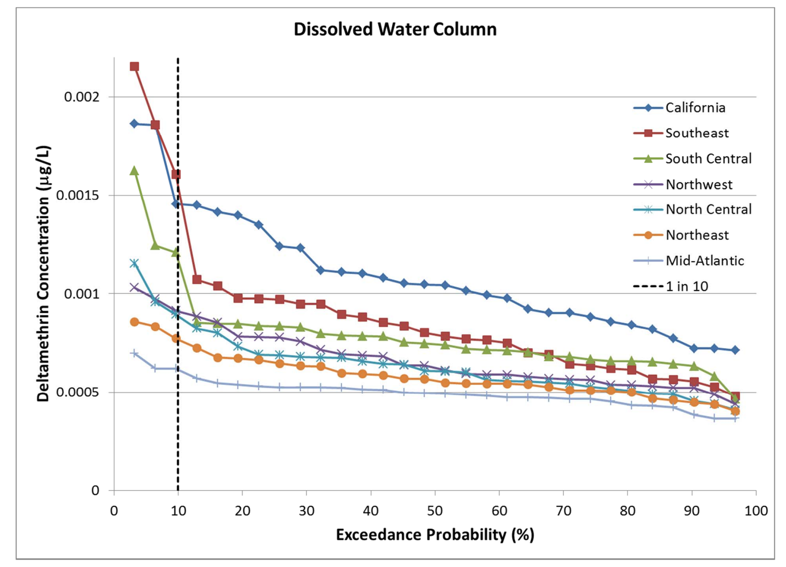

Figure 8. 24-hr Annual Maximum Water Column EEC Distributions, 7 Regions.

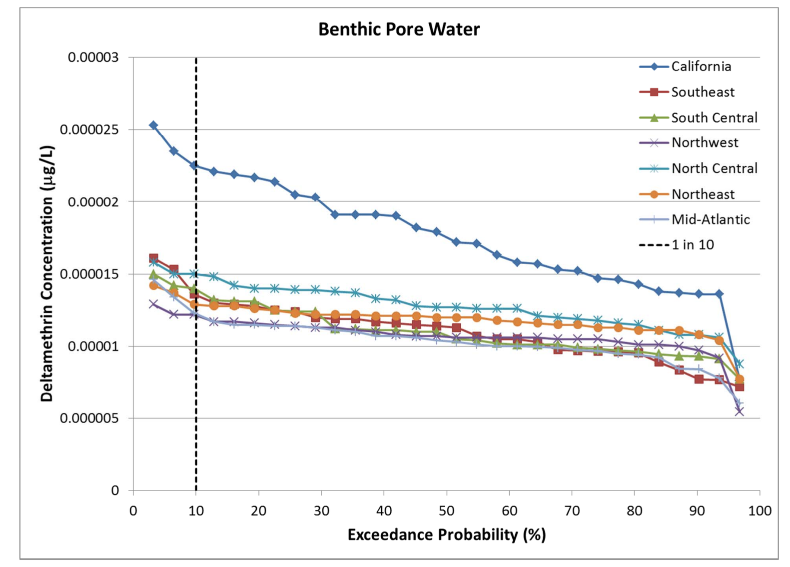

Figure 9. 21-day Annual Maximum Pore Water EEC Distributions, 7 Regions.

Potential Ecological Effects

- A comprehensive risk characterization was completed for deltamethrin by comparing EECs against toxicity endpoints for aquatic species.
- Risk quotients (RQs) were calculated using 90th percentile EECs from the **worst case** residential scenario and toxicity endpoints representing the most sensitive fraction of aquatic species

	Water Column (acute)[1]		Water Column (chronic)[2]		Pore Water[2]	Sediment[2]
	Invertebrates	Fish	Invertebrates	Fish	Invertebrates	Invertebrates
RQ	1.7	0.01	0.18	0.02	0.17	1
LOC	0.05/0.5[3]	0.05/0.5	1	1	1	1

1. Based on HC5 (5th percentile of species sensitivity distribution)
2. Based on No Observed Effect Concentration for most sensitive species
3. LOC for endangered/non-endangered species

Table 2.Summary of RQs for Worst Case Residential Scenario (California).

- RQs were found to be below the level of concern (LOC) for all species, with the exception of acute toxicity to aquatic invertebrates (Table 2).
- Joint Probability Curves (JPCs) were developed to determine the fraction of the most sensitive species (arthropods) potentially affected due to residential use of deltamethrin (Fig. 10).
- JPCs indicate that 1 year in 10, only 4% to 8% of arthropod species would potentially be affected by residential use of deltamethrin, even assuming deltamethrin has 100% of the pyrethroid market share.
- Mesocosm studies and bioassessments confirm that the estimated exposure concentrations would have minimal effect on aquatic biota.

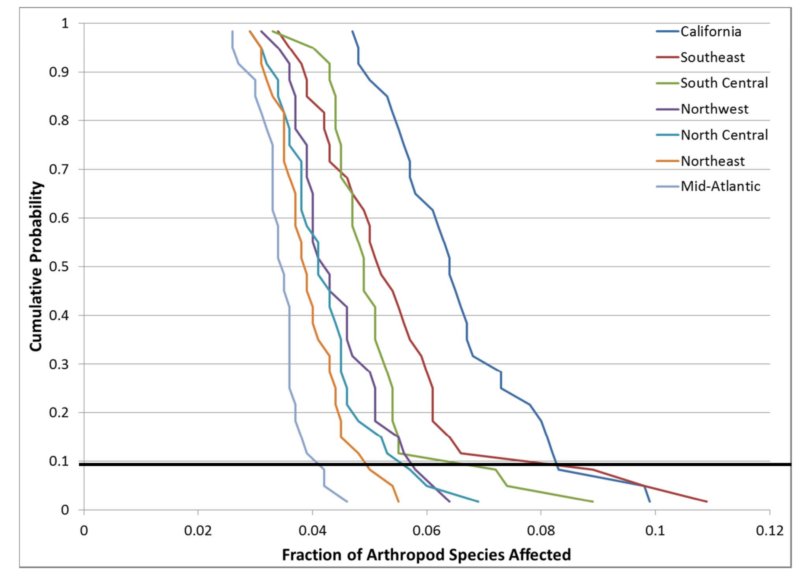

Figure 10. Joint Probability Curves for residential exposure scenarios in CA and 6 other regions.

Conclusions

- A new urban residential pyrethroid exposure scenario and modeling approach, calibrated to pyrethroid monitoring data, was applied as part of a national pyrethroid ecological risk assessment.
- The approach used the SWMM-AGRO model and a high vulnerability residential neighborhood in Orange County California that was parameterized to represent the climate and pyrethroid use characteristics from diverse geographical regions.
- The modeling approach has been applied to generate ecologically relevant EECs, based on many conservative assumptions, across seven different regions for seven pyrethroid AIs.
- The predicted EECs were used in a comprehensive ecological risk assessment for deltamethrin.
  - o The deltamethrin aquatic ecological risk assessment has shown that residential use according to current labels is unlikely to cause ecologically significant effects in aquatic systems.
  - o Additional data suggests all other pyrethroids will have risk conclusions similar to deltamethrin.

References

Davidson, P. C.; Jones, R. L.; Harbourt, C. M.; Hendley, P.; Goodwin, G. E.; Sliz, B. A. 2014. Major Transport Mechanisms of Pyrethroids in Residential Settings and Effects of Mitigation Measures. Environ. Toxicol. Chem. 33, 52-60.

Winchell, M.F. 2013. Pyrethroid Use Characteristics in Geographically Diverse Regions of the United States: Parameterization of Estimated Pyrethroid Treatment Extent and Frequency for Urban Exposure Modeling. PWG-ERA-02b. Stone Environmental Inc.