Using the Soil and Water Assessment Tool (SWAT) to Assess Pesticide Runoff from the Salinas River Watershed, California

Yina Xie,* Yuzhou Luo, Xuyang Zhang, Jennifer Teerlink, Nan Singhasemanon
Surface Water Protection Program, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA 95812

Overview

Here we present the preliminary work of using the Soil and Water Assessment Tool (SWAT) to assess pesticide runoff from the Salinas River Watershed in California. Results of watershed delineation, pesticide use analysis, and detections in surface waters are demonstrated. The development of the modeling approach is described.

The California Department of Pesticide Regulation's Surface Water Protection Program (CDPR/SWPP) relies on modeling tools for pesticide registration evaluation and post-use risk characterization. Linking pesticide uses and their associated risks in aquatic ecosystem, or "use-based modeling," is a critical component of SWPP's modeling efforts. The Surface Water Monitoring Prioritization Model (Luo, 2015) is an example of such efforts to prioritize pesticides based on use and toxicity data of pesticides at various spatial scales. However, a direct linkage between pesticide uses and in-stream concentrations has not been systematically investigated by SWPP. As such, the goal of this study is to develop a physically-based, spatially-distributed hydrologic/water quality model to establish the use-concentration relationship from field scale to watershed scale for large basins. The model will consist of various components, including hydrology, land management and pesticide applications, mitigation, and in-stream water quality routing.

The model will be used to:

- ❖ Predict the spatial-temporal distribution of pesticides in surface waters.
- ❖ Estimate the effectiveness of different mitigation measures.
- ❖ Identify vulnerable water bodies and the critical source areas of pesticide contaminations and informs monitoring, mitigation and regulatory efforts.
- ❖ Predict the efficacy of regulations and mitigation approaches at different watershed scales and through time.
- ❖ Evaluate pesticides of interest (e.g., pyrethroids, fipronil, neonicotinoids).

Pesticide monitoring studies in surface waters offer only a snapshot of what occurs in the environment under a specific set of parameter combination conditions. Physically-based, spatially-distributed hydrologic/water quality modeling is often used to supplement the limited number of monitoring observations and achieve an overarching picture of variability at the spatial-temporal scale (Gali et al., 2016). The Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) is a prominent watershed-scale model used to estimate pesticide loads and fate in water bodies based on various physical and hydrological characteristics across large basins. The SWAT model was originally developed by the US Department of Agriculture, Agricultural Research Service (USDA/ARS) and has evolved into a continuous-time, process-based, spatially-distributed model that is widely used to evaluate the influence of land management on water, sediment, and agrochemical loading and movements to water bodies for large rural basins (Gassman et al., 2007). The SWAT model has been used as an integrated hydrological/water quality model, and tested for the ability to evaluate pesticide loads and fate in water bodies (Holvoet et al., 2005).

The Salinas River Watershed

This study aims to develop an approach using the SWAT model for the Salinas River Watershed (SRW) in California (Figure 1).

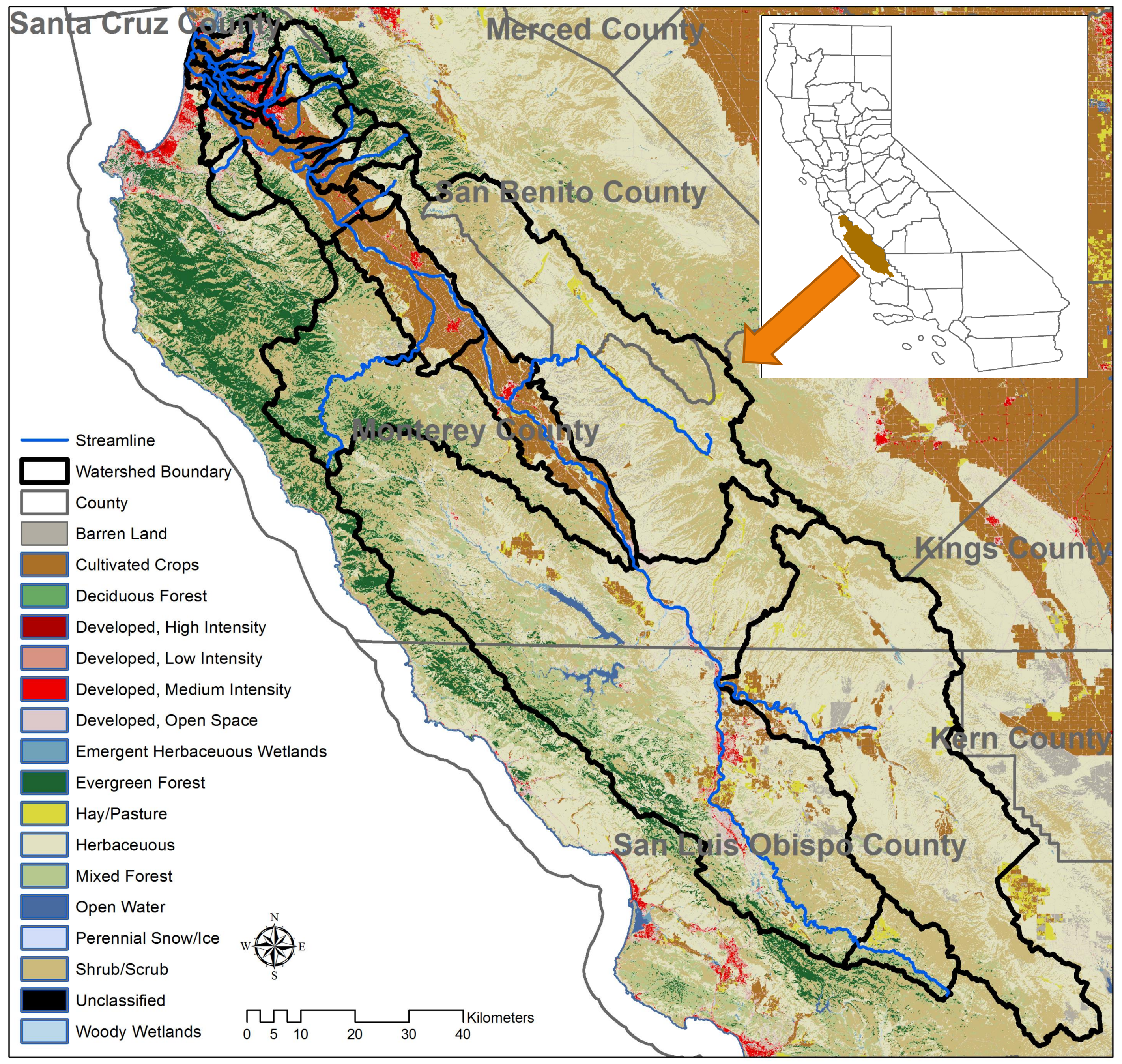

Figure 1. Salinas River Watershed (Basemap: NLCD 2011).

Spatial Pattern of Pesticide Use vs. Detection

Taking bifenthrin as an example, Figure 3 shows a snapshot of the spatial pattern of pesticide use vs. frequency of detection in surface waters in the lower part of SRW.

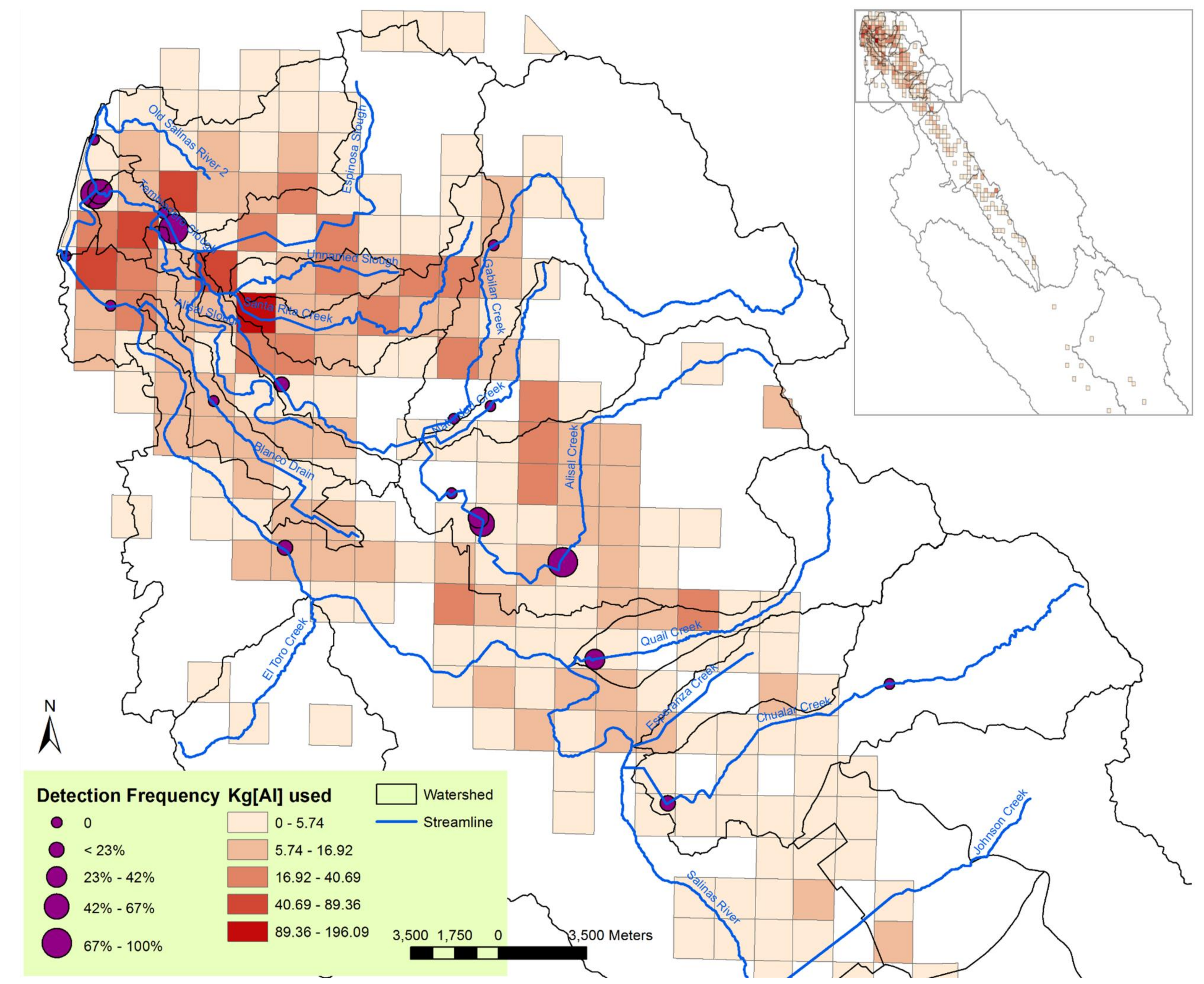

Figure 3. Spatial pattern of bifenthrin use vs. detection frequency in surface waters.
Kg[AI] used is the average annual bifenthrin use in 2000-2016 at the section (1 × 1 mile) level.
Detection frequency is computed from data reported in CDPR's Surface Water Monitoring Database.

Pesticide Use in the Watershed - Bifenthrin

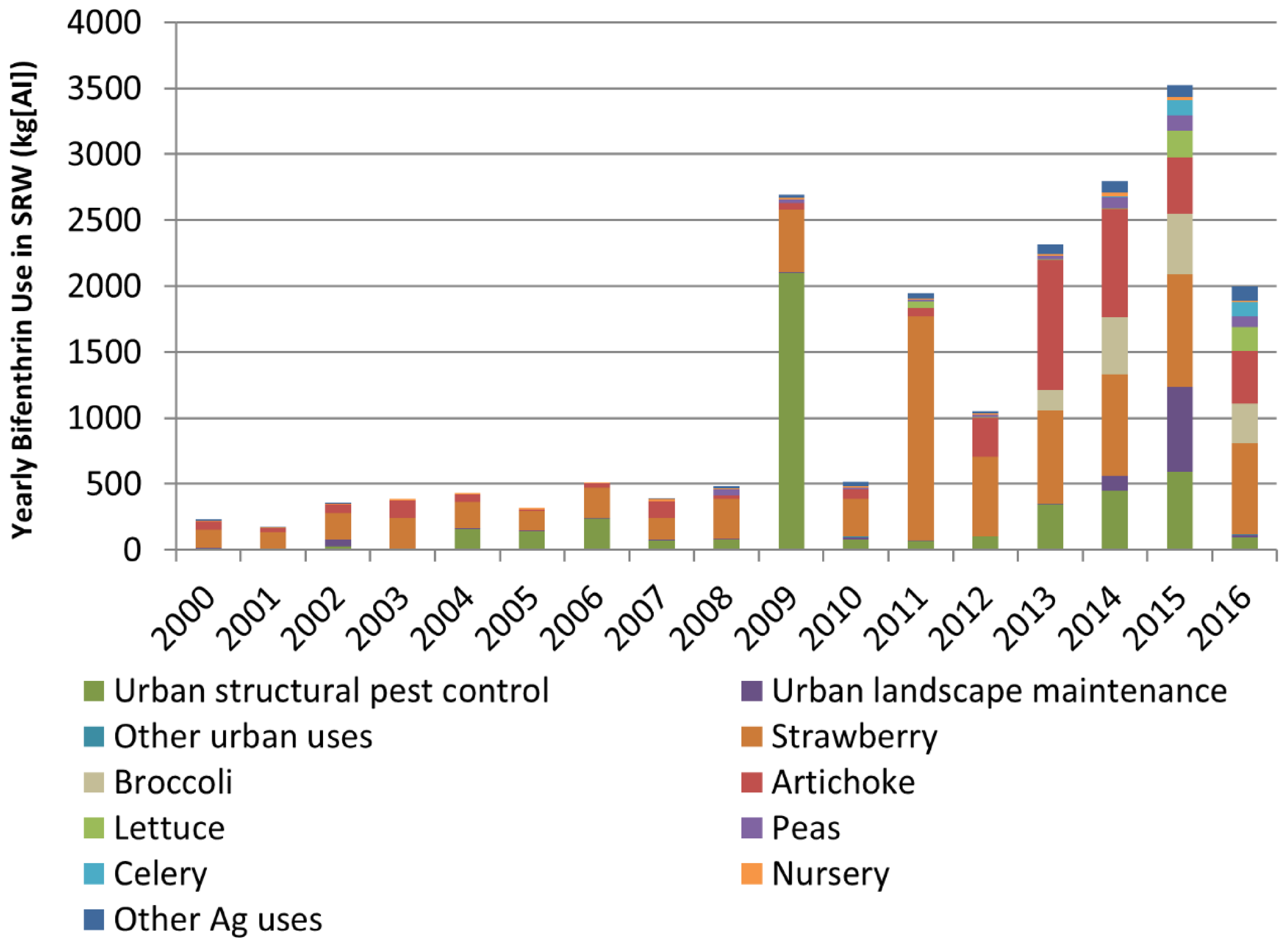

Figure 2. Kg bifenthrin used in SRW between 2000 and 2016 (Source: California Pesticide Use Reporting).

Future Development

The SWAT modeling approach under development will simulate the hydrological processes based on the meteorological and spatial data (e.g., hydrography, elevation, soil properties, and land use/land cover). For land management, the model will be configured to simulate crop growth, pesticide applications, and water management based on information from California's pesticide use reports and other relevant data sources. Monitoring data for hydrology, sediment and pesticide loadings and concentrations will be used for model calibration and validation. Figure 4 shows the SWAT model inputs and outputs for pesticide fate and transport modeling.

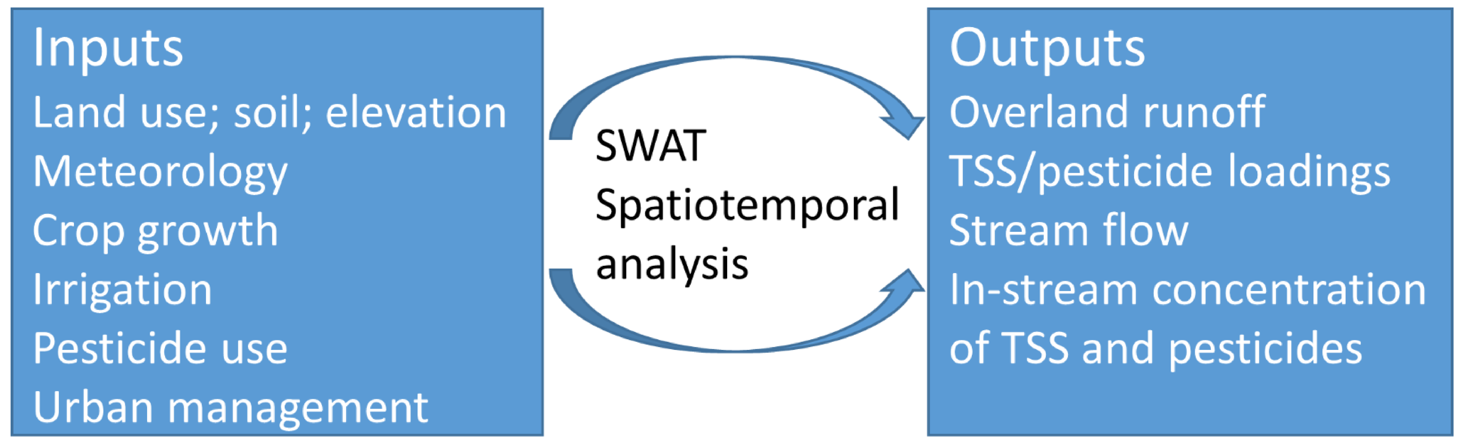

Figure 4. Diagram of SWAT model inputs and outputs for pesticide fate and transport modeling.

Contact

Yina Xie, PhD
Environmental Scientist
California Department of Pesticide Regulation
Email: Yina.Xie@cdpr.ca.gov

SETAC North America 39th Annual Meeting, Sacramento, CA, November 4-8, 2018

References

- Arnold, J.G.; Srinivasan, R.; Muttiah, R.S. and Williams, J.R. 1998. Large area hydrologic modeling and assessment part I: model development. *JAWRA Journal of the American Water Resources Association* 34(1): 73-89.
- Gali, R.K.; Cryer, S.A.; Poletika, N.N. and Dande, P.K. 2016. Modeling Pesticide Runoff from Small Watersheds Through Field-Scale Management Practices: Minnesota Watershed Case Study with Chlorpyrifos. *Air, Soil and Water Research* 9: 113.
- Gassman, P.W.; Reyes, M.R.; Green, C.H. and Arnold, J.G. 2007. The soil and water assessment tool: historical development, applications, and future research directions. *Transactions of the ASABE* 50(4): 1211-1250.
- Holvoet, K.; van Griensven, A.; Seuntjens, P. and Vanrolleghem, P. 2005. Sensitivity analysis for hydrology and pesticide supply towards the river in SWAT. *Physics and Chemistry of the Earth*, Parts A/B/C 30(8): 518-526.
- Luo, Y. 2015. SWPP *Monitoring Prioritization Model User Manual (Version 3)*. California Department of Pesticide Regulation, Sacramento, CA.

Databases:

- California Pesticide Use Reporting (PUR): https://www.cdpr.ca.gov/docs/pur/purmain.htm.
- CDPR Surface Water Monitoring Database (SURF): https://www.cdpr.ca.gov/docs/emon/surfwtr/surfdata.htm.
- NLCD 2011: National Land Cover Database 2016: https://www.mrlc.gov/index.php.