A Multi-Scale Probabilistic Approach for the Identification of Potential Pesticide Use Sites for Ecological Risk Assessments

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Highlight: The refined approach identifies uncertainty in potential pesticide use sites and can be leveraged for realistic, spatially resolved exposure and effects models

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Background

Ecological Risk Assessments (ERAs) examine overlap between chemical and receptor distribution in co-occurrence analysis and require spatial crop coverage data.

The EPA deterministic approach for ERAs utilizes 13 Use Data Layers (UDLs) to represent agricultural land. This approach is prone to error due to imperfect data and can result in overestimation.

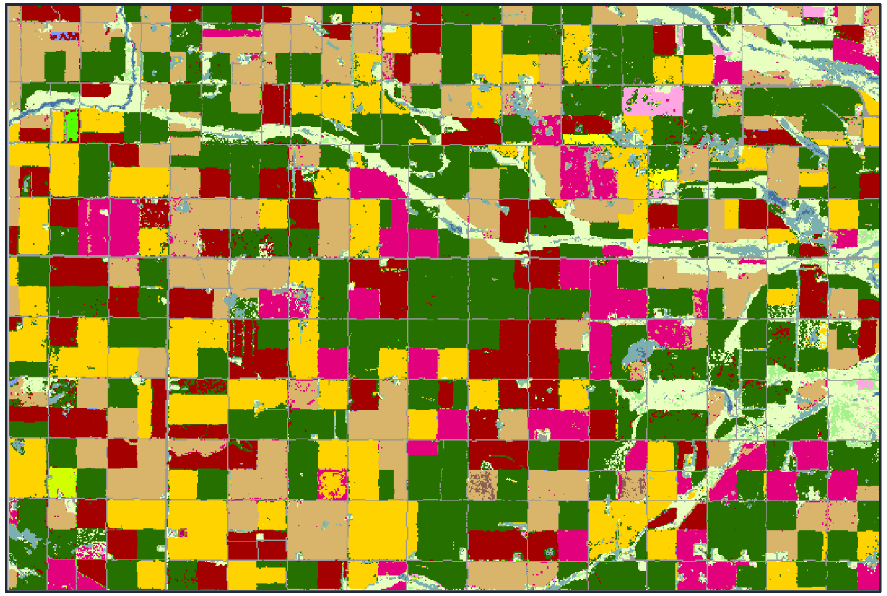
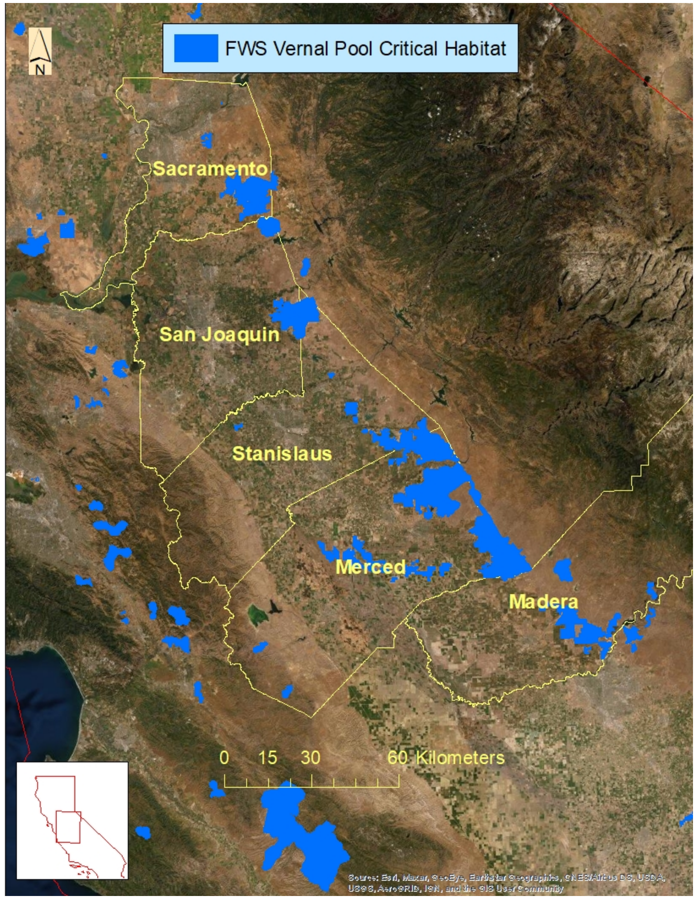


Photo Credit: USDA NASS, CropScape

While acceptable for initial screening, refined estimations of co-occurrence are desired, as well as identification of potential variability in coverage

Overview and Study Area

We expand upon a previously developed probabilistic approach[1,2] to include multiple crop types, and test a multi-scale repeated sampling method to define crop coverage at realistic field boundaries and capture variability in crop rotation schemes as well as potential area of application for 2017



Central Valley vernal pools provide critical habitat for 58 listed species, are near agricultural pesticide applications (bifenthrin)

Previous work in this region (Raimondo et al. 2019, Sinnathamby et al. 2020) identified focal species (*B. lynchi*) and exposure scenarios

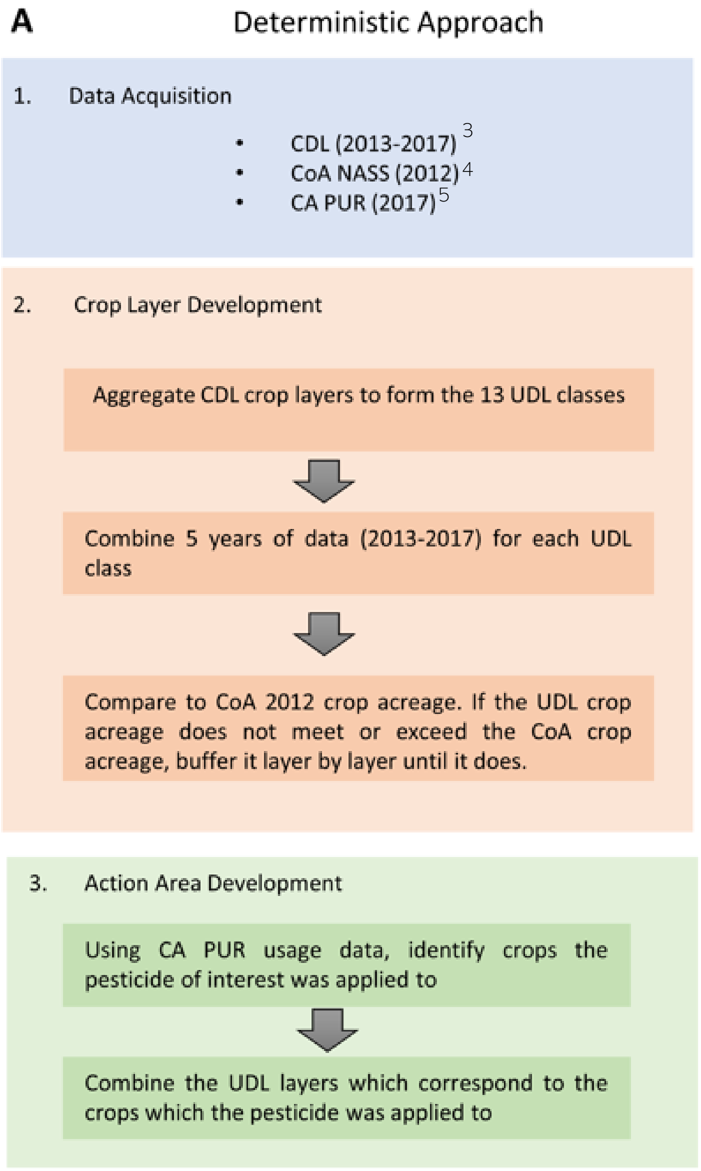
Photo Credit: US FWS Sacramento

Objectives

1. Demonstrate method for probability-based pixel-level estimates of potential pesticide use sites for multiple crops; original deterministic method conducted for comparison

2. Demonstrate a simulation approach to scaling pixel-level probabilities to field-level extent to improve realistic use and capture variability

1. Methods - Deterministic



Compile data sources

Aggregate CDL data, combine, buffer by CoA

Use CA PUR to identify pesticide crops

1. Methods - Probabilistic

B Probabilistic Approach[1]

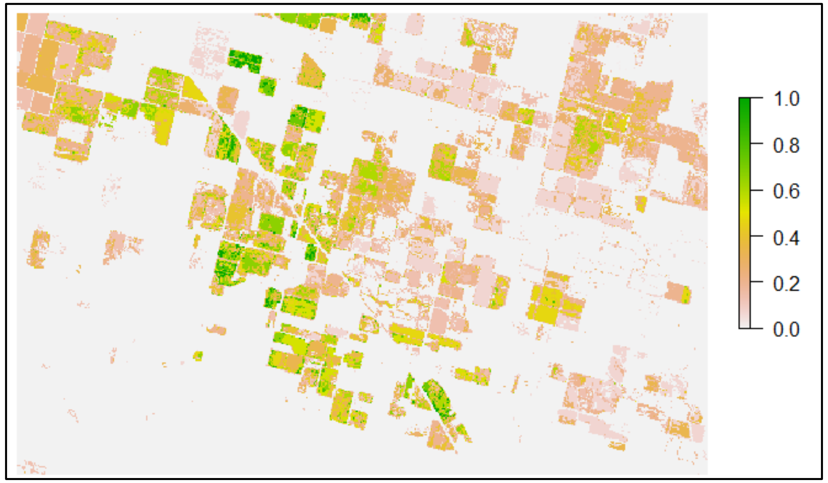
1. Data Acquisition
   - CDL (2013-2017)
   - NLCD (2011)[6]
   - CoA NASS (2012)
   - CA PUR (2017)

2. Crop Layer Development
   - Commission adjustment: Find the probability of a crop occurring, using CDL accuracy information and NLCD conditional probabilities to account for area wrongly-classified as the crop of interest
   - Omission adjustment: Use CoA crop acreage data to correct the probability values to account for area which should have been classified as the crop of interest but was not.
   - Find the weighted mean to combine the 5 years of crop data

3. Action Area Development
   - Using CA PUR usage data, identify crops the pesticide of interest was applied to
   - Calculate a final probability layer, whose values represent the probability that any one of the crops which the pesticide was applied to occurred

Compile data sources

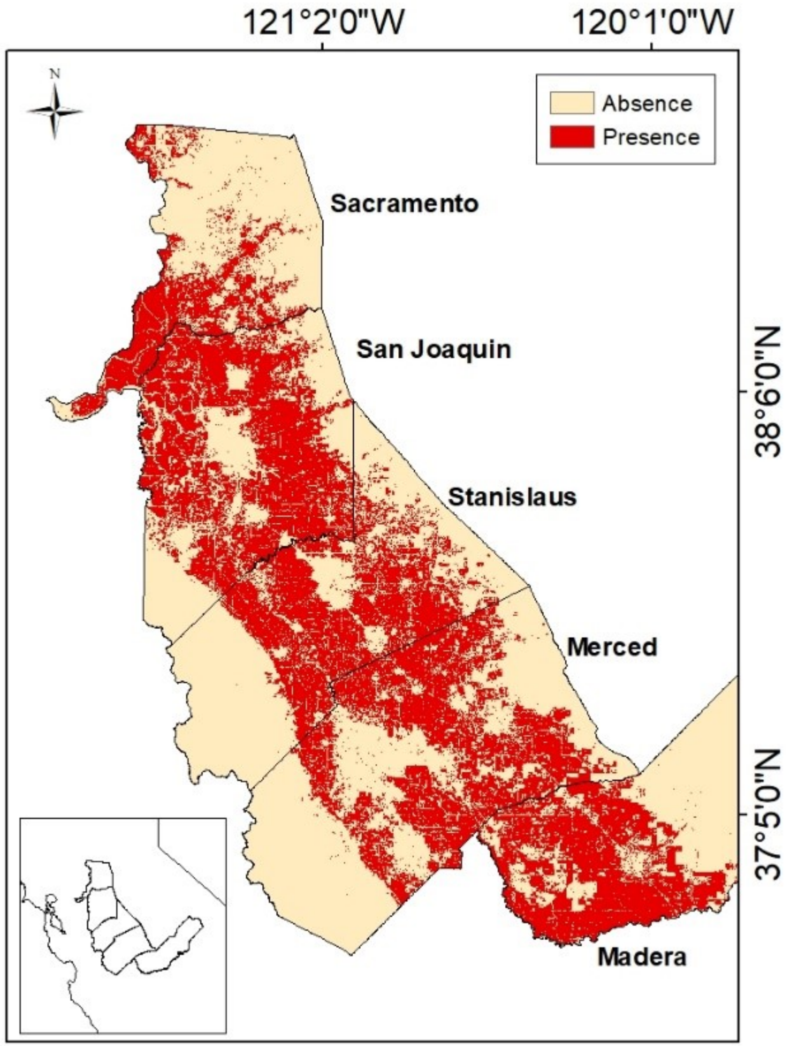
Using accuracy and error data from CDL & NLCD, find probability of crop occuring, correct using CoA



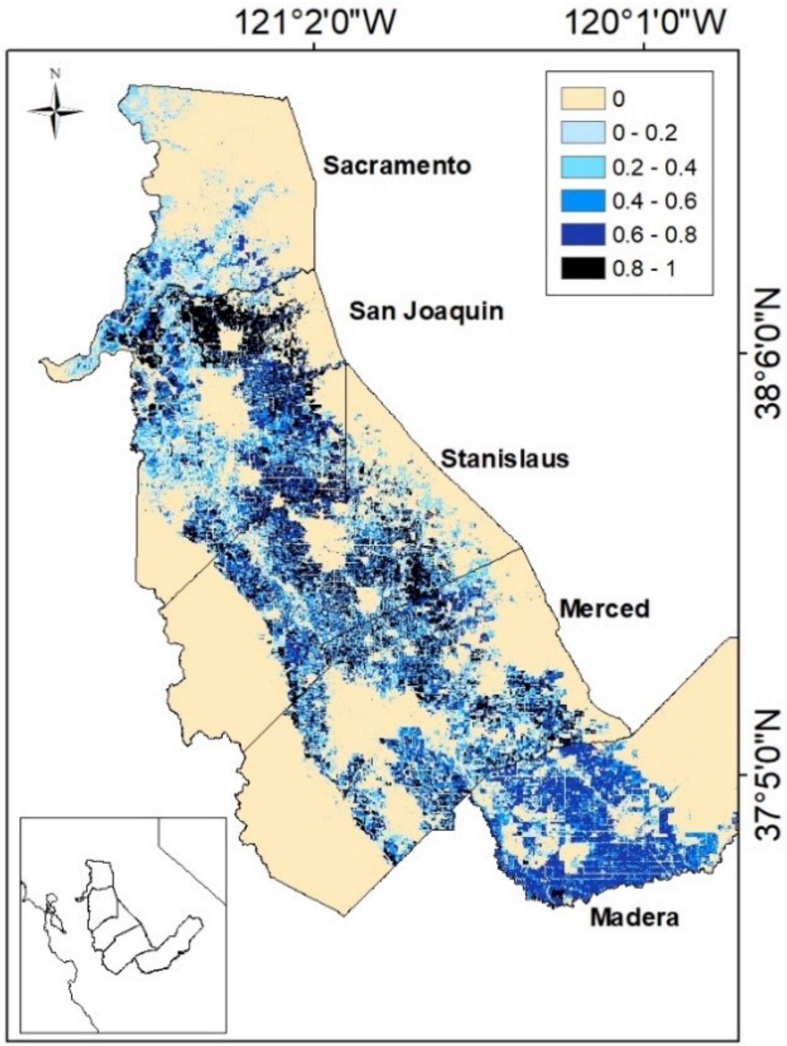
Final pixel layers for all bifenthrin crops, values represent probability that crop occurred

1. Results

Deterministic Potential Use Area



Probabilistic Potential Use Area



2. Methods – Spatial Scaling

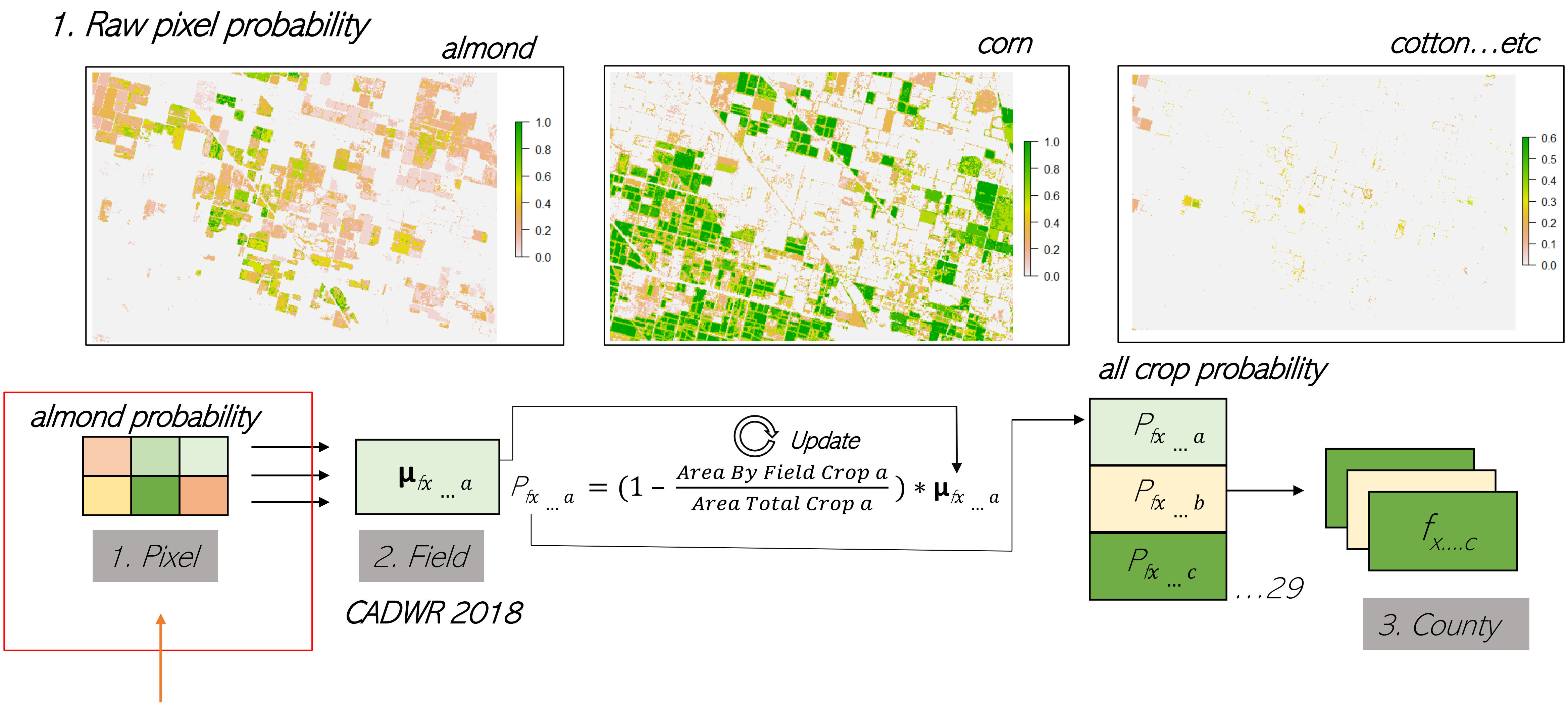
- ERAs typically evaluate co-occurrence of a species at the spatial scale of the fields to which pesticides are applied; need to scale up pixels to realistic boundaries

- Aggregated probabilistic layers may fail to capture variability in crop rotation schemes

- Spatial structure is an issue at pixel level (boundaries not respected) but desired at field level, as structure of field assignments (and therefore bifenthrin applications) needs to be maintained

- Estimates of pesticide loading from spatial crop coverage could be incorporated into exposure/effects models (PWC/SAM, etc.)

2. Methods – Spatial Scaling



2. Methods – Spatial Scaling

2. Field *almond* *corn* *cotton…etc*

almond probability

1. Pixel

$\mu_{fx\ldots a}$

2. Field

CADWR 2018

Update

$$P_{fx\ldots a} = \left(1 - \frac{\text{Area By Field Crop } a}{\text{Area Total Crop } a}\right) * \mu_{fx\ldots a}$$

all crop probability

$P_{fx\ldots a}$

$P_{fx\ldots b}$

$P_{fx\ldots c}$

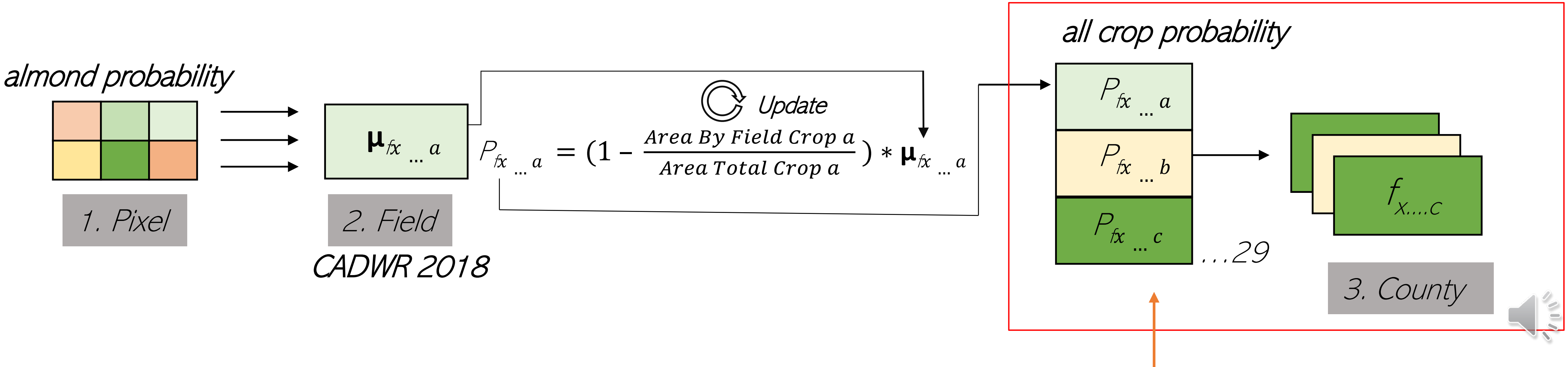
…29

$f_{x\ldots c}$

3. County

2. Methods – Spatial Scaling

3. County



$$\mu_{fx\ldots a}$$

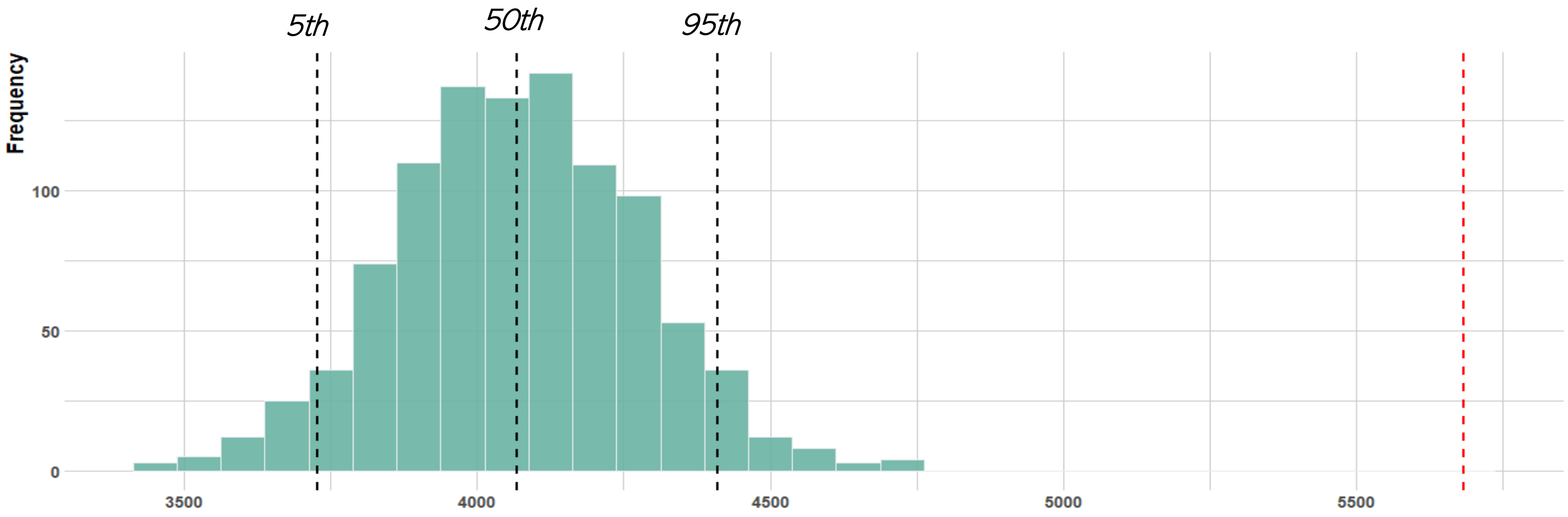
$$P_{fx\ldots a} = \left(1 - \frac{Area\ By\ Field\ Crop\ a}{Area\ Total\ Crop\ a}\right) * \mu_{fx\ldots a}$$

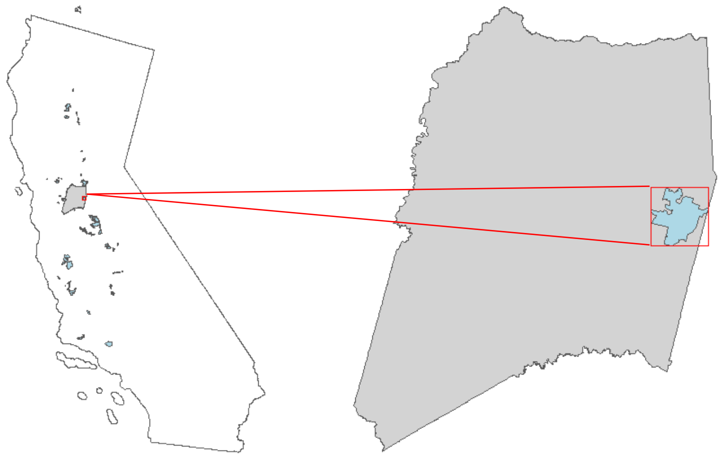
$$P_{fx\ldots a} \quad P_{fx\ldots b} \quad P_{fx\ldots c} \quad \rightarrow \quad f_{x\ldots c}$$

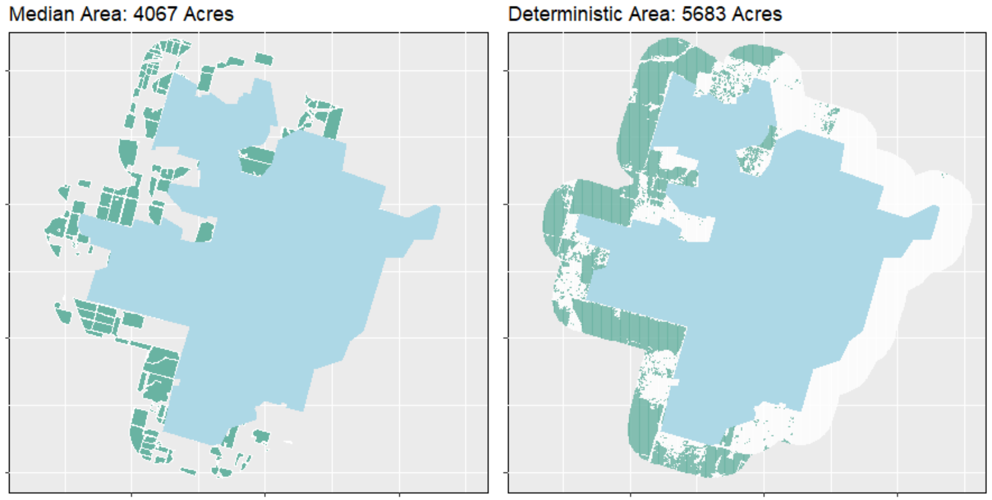
2. Results

County	Total Available Agricultural Acreage	Deterministic Area	Non-Zero Probability Field Area	Probabilistic Area (Probability-Weighted)	Field-corrected Probabilistic Area
Madera	1,378,353	340,621 (25%)	340,573 (25%)	187,618 (14%)	186,030 (13%)
Merced	1,266,690	479,098 (38%)	510,677 (40%)	246,856 (19%)	240, 266 (18%)
Sacramento	636,576	192,993 (30%)	165,641 (26%)	59,465 (9%)	40, 657 (6%)
San Joaquin	913,851	508,653 (56%)	508,422 (56%)	295,901 (32%)	275, 911 (30%)
Stanislaus	969,352	372,095 (38%)	395,576 (40%)	206,026 (21%)	198, 348 (20%)
Total Study Area	5,164,822	1,893,460 (37%)	1,920,889 (37%)	995,866 (19%)	941,212 (18%)

2. Results







1km Buffer

Conclusions/Future Work

- Improved ability to estimate potential pesticide use sites for multiple crop types
- Can be used for exposure/effects models to simulate variability in pesticide loading
- Could be expanded for additional pesticide types, used with additional SDMs
- Leveraged with methods for estimating toxic load for pollinators

References

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6. Homer, CG, Dewitz, JA, Yang, L, Jin, S, Danielson, P, Xian, G, Coulston, J, Herold, ND, Wickham, J, and Megown, K. 2015. Completion of the National Land Cover Database for the conterminous United States – representing a decade of land cover change information. Photogramm Eng Remote Sens, 81(5): 345-354. https://doi.org/10.1016/S0099-1112(15)30100-2