Spillover Effects of Pesticide Use: Externalities and Cross crop Benefits for Lygus Management in Cotton in the San Joaquin Valley (SJV) of California

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Selected Poster prepared for presentation at the 2023 Agricultural & Applied Economics Association Annual Meeting, Washington DC: July 23- 25, 2023

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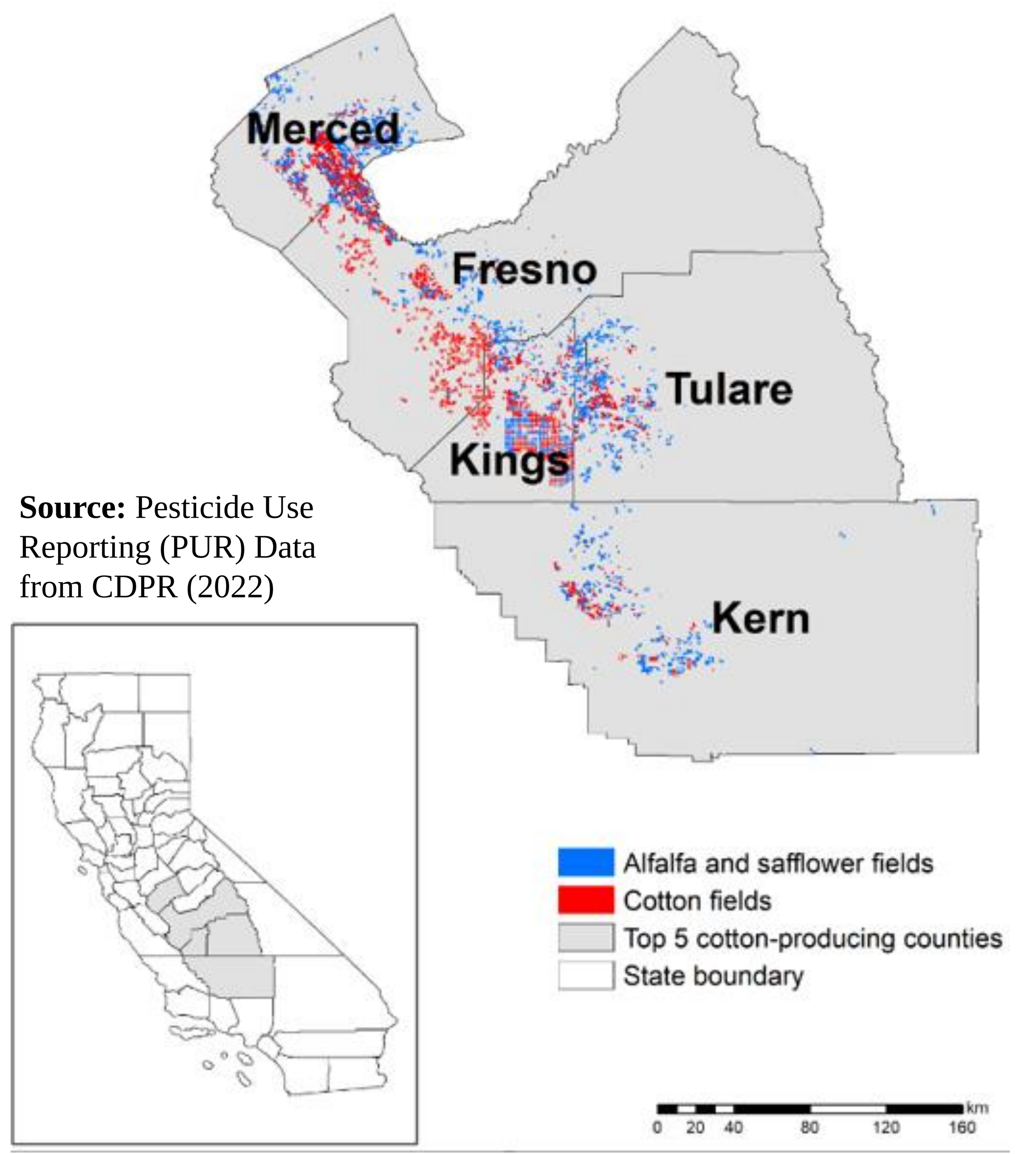
MOTIVATION

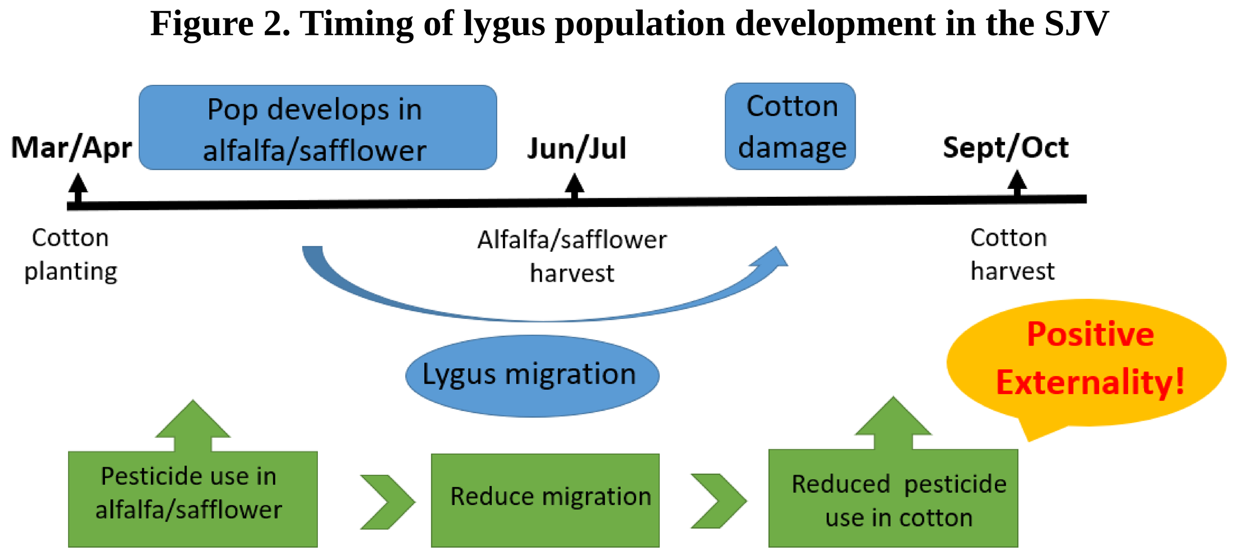
- ❖ Lygus bug is the most important pest of California cotton.
- ❖ In 2019, 83% of cotton acreage in California was infested with lygus (Cook and Threet 2020):
  - ➢ Economic loss: $33.6 million in 2019
  - ➢ $25.4M yield loss+$8.2M treatment cost
  - ➢ 91% of total cotton insect loss estimates
- ❖ The most important three host plants in the SJV
  - ➢ Alfalfa, cotton, and safflower.
  - ➢ Production of the three is geographically concentrated. (**Figure 1**)
- ❖ Cotton is less attractive to lygus than alfalfa and safflower
  - ➢ Populations often develop on alfalfa and safflower in early April to late July.
  - ➢ When alfalfa and safflower are harvested, adult lygus may then migrate into cotton (Sevacherian and Stern 1974). (**Figure 2**)
- ❖ One of the strategies to control lygus in cotton:
  - ➢ Apply pesticides to alfalfa and safflower in the early season to reduce lygus migrations into cotton (UC IPM 2013).
- ❖ Cotton growers may benefit from the **cross-crop spillover effect** of pesticide use if pesticide use in nearby alfalfa and safflower fields helps reduce lygus migrations into cotton.
  - ➢ An individual cotton grower may capture the ***cross-crop benefits*** of pesticide use by growing alfalfa and safflower and applying pesticides to these two crops earlier than to cotton.
  - ➢ Alfalfa and safflower growers may generate a ***positive externality*** for nearby cotton growers by reducing their need to apply pesticides to manage lygus.

Figure 1. Production distribution, the top five cotton-producing counties, 2019



Source: Pesticide Use Reporting (PUR) Data from CDPR (2022)

Figure 2. Timing of lygus population development in the SJV



Alfalfa is harvested multiple times in a year. Safflower is harvested once a year.

OBJECTIVE

❖Using monthly field-level data on pesticide use, assess the presence and extent of positive externalities and/or cross-crop benefits

1. Identify the cross-crop spillover effect of pesticide use
   - ❑ without separating fields operated by the same grower from fields operated by different growers.
2. Differentiate positive externalities from cross-crop benefits
   - ❑ separating fields by operator to see the extent to which these benefits are
     - ✓ cross-crop effects for growers of cotton who produce at least one of the other two crops
     - ✓ positive externalities of one grower's pesticide use decisions for another grower.
3. Examine the role of the timing of pesticide applications
   - ❑ reconduct exercise 1& 2
   - ❑ using the total number of applications by year
4. Estimate the economic values of positive externalities and cross-crop benefits through reduced pesticides costs in cotton.

CONTRIBUTION

This study makes two main contributions.

1. Incorporating the timing of pesticide applications into the analysis of cross-crop effects of pesticide use
   - ❑ The literature pays little attention to the timing of pesticide applications and tends to use cumulative measurements.
     - ✓ A few exceptions including Hall and Norgaard (1973), McKee et al. (2009), and Möhring et al. (2020)
   - ❑ Cumulative measurements do not account for the temporal variations in pesticide use.
   - ❑ Failing to consider the timing of pesticide applications may lead to erroneous conclusions on the presence and extent of externalities and cross-crop benefits.
2. Considering the spatial configuration of crop production and management
   - ❑ Very few identified the common management of different crops by the same grower.
     - ✓ Evaluate how common management affects growers' incentives to apply pesticides (e.g., Grogan and Goodhue 2012).
   - ❑ Owing to the paucity of information on crop management
     - ✓ Cannot distinguish externalities and cross-crop benefits/costs of pesticide use.

DATA & METHOD

Examine crop production and pesticide use in the top-five cotton-producing counties from 2010 to 2019

- ❖Pesticide Use Reporting (PUR) data from CDPR
  - ➢ Field level data
  - ➢ Pesticide applications with date, pounds, and acres treated & planted.
- ❖Field-level Geographic Information System (GIS) data on crop production from the Kern County CAC Office Spatial Data and CalAgPermits

- ❖Define variables
  - ➢ A focal field: the central field.
  - ➢ Nearby fields: within the central field's 3-km radius.
  - ➢ For each cotton field in each month, early pesticide applications to its nearby fields: earlier than to cotton
- ❖Employ **random-effects panel Tobit models**

$$\# \, pesticide \; application_{it} = f(pesticide, neighborhood, weather, profit \; indicators)$$

  - ➢ i: cotton field-year i in month
  - ➢ t: $month$
- ❖Using the marginal effect estimates from the regression models
  - ➢ Derive reduction in cotton pesticide costs

RESULTS

With the consideration of the timing of applications (using monthly data), we find

- ❖ Early pesticide applications to nearby alfalfa and safflower provided spillover benefits to cotton fields by decreasing the number of pesticide applications made to cotton.
- ❖ Alfalfa growers generated positive externalities for cotton growers by reducing their needs to apply pesticides .
- ❖ Some cotton growers captured the cross-crop benefits of growing alfalfa and safflower and applying pesticides that may help mitigate lygus movement into cotton fields.

By ignoring the timing of applications (using annual data), we detect

- ❖ There are overestimates of the magnitude of positive externalities and cross-crop benefits from pesticide use.

Table 1. Estimates of the marginal effects of early pesticide applications on the number of pesticide applications to cotton, with and without 1) timing component, 2) grower identification, 2010-2019

	With timing (Monthly)		**Without timing (Annual)**	
	Reg 1: all growers	**Reg 2: focal & other growers**	**Reg 1: all growers**	**Reg 2: focal &other growers**
Pesticide applications to nearby alfalfa fields that are operated by				
focal cotton grower		-0.014 ***		-0.014 ***
other growers		-0.002 ***		-0.004 ***
all growers	-0.004 ***		-0.008 ***	
Pesticide applications to nearby safflower fields that are operated by				
focal cotton grower		-0.016 ***		-0.042 ***
other growers		0.001		0.013
all growers	-0.002		0.009	
Pesticide applications to nearby cotton fields that are operated by				
focal cotton grower		0.030 ***		0.041 ***
other growers		-0.009 ***		-0.002 ***
all growers	-0.003 ***		0.005 ***	

CONCLUSION

❖Early pesticide applications to alfalfa and safflower can generate positive externalities for cotton production.

❖Some cotton growers captured cross-crop benefits by growing alfalfa and safflower and applying pesticides earlier than the applications they made to cotton.

❖On average, the annual reduction in cotton pesticide costs owing to pesticide use in alfalfa and safflower was about $2.44 million

❖Positive externality $0.57 million + Cross-crop benefits $1.87 million.

❖Annual pesticide cost reductions in cotton varied significantly by county, ranging from $0.06 million for Tulare County to $1.44 million for Kings County.

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