Incentives for Individual and Cooperative Management of a Mobile Pest:
The Olive Fruit Fly in California

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Broad Objectives

1. To understand sources of heterogeneity in pest management incentives

   – Between commercial producers of a host and

   – Between commercial and non-commercial owners of a host

2. To evaluate the viability and design of a cooperative pest management institution when heterogeneous agents are affected by an invasive species

Supporting Objectives

1. Identify biological sources of heterogeneity in management incentives

2. Build on (1) to formulate a bioeconomic model of pest control incentives at the grower level, including timing of the harvest

3. Aggregate up from (2) to estimate returns to cooperation across commercial producers and identify the effect of non-commercial hosts on those returns

Application:
Olive Fruit Fly in California

- IS detected in 1998, now established
- Fly is highly mobile (treatment externalities)
- Damages from infestation differ across commercial growers
  - Olive cultivars differ across industry sectors (table and oil) and vary in susceptibility to infestation
  - Industry sectors enforce different infestation thresholds
- Ornamental trees serve as a pest reservoir

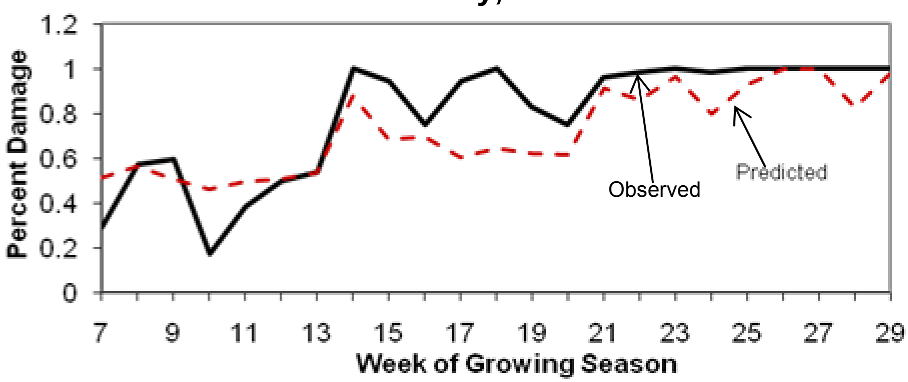
Application:
Olive Fruit Fly in California

- Single-host pest and single-pest host
- Damages fruit only, no effect on tree’s productivity
- Spread bounded
- Differing grower response by region
  - Glenn and Tehama Counties have active PCDs
  - Tulare County formed a PCD, but it is inactive (not funded)
  - Other olive-producing counties have not formed olive PCDs

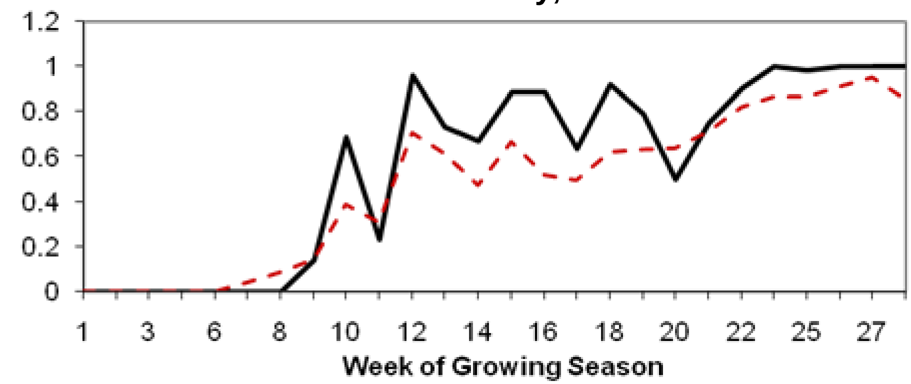
Objective 1:
Estimate a Pest Damage Function

- We use field infestation data and econometric methods to describe uncontrolled level of pest infestation across cultivars and locations
- Damage model reflects simultaneity in the pest population level and host susceptibility to infestation
- Predictions based on structural model reflect intra-seasonal variation in infestation rates across cultivars and locations

Butte County, Manzanillo



Ventura County, Mission



Objective 2:
Define Individual Management Incentives

- We build a dynamic programming model of grower pest control decisions over a single olive growing season

- A grower can reduce infestation by applying an insecticide or by changing the date of harvest
  - Delaying harvest allows fruit to grow (premium for table olives)
  - Larger fruit are more susceptible to infestation

- Stochasticity incorporated to reflect randomness in biological factors that affect olive size and fly population, as identified under objective (1)

Objective 2:
Define Individual Management Incentives

- With flexibility in harvest timing, 3 optimal approaches to pest management
  - Insecticide applied, change in harvest; insecticide applied, no change in harvest; change in harvest, no insecticide used

	SL-AQ	SL-SV	SL-MZ	BT-MZ	TL-MZ
Harvest Date	10/1	9/27	9/27	9/27	10/16
Avg. Treatment Dates	–	7/15-9/20	9/1-9/19	7/29-9/20	9/18-9/22
Avg. No. Treatments	–	15.8	4.2	13.4	1.7
Avg. Days b/w Treatments	–	4.3	4.6	4.0	2.0
Avg. Damage at Harvest (%)	–	1.0	1.0	1.0	1.0
Avg. Yield Loss at Harvest (%)	–	0.62	–	0.40	–
Avg. Price at Harvest ($/ac)	450	761.99	997.45	945.07	1,659.68
Avg. NPV ($/ac)	1,863.32	2,126.48	3,355.89	3,011.04	6,431.11

Objective 2:
Define Individual Management Incentives

- Abandonment driven by inability to simultaneously meet processor quality standards and CDPR spray frequency regulation
  - Assuming an application reduces damage by 95.5% over 7 days, average weather conditions

- CDPR limits applications to 1 every 5 days
  - 2 of 5 types of growers can satisfy CDPR and processor quality constraints simultaneously
  - For other 3 to meet both constraints, insecticide must
  - Reduce damage by 99-100% or remain effective for 10-12 days

Objective 3:
Examine Incentives for Cooperation

- Institution of interest is the Pest Control District (PCD), as defined by CDFA
  - Member initiated and funded (by 2/3 vote)
  - Defined by crop
  - Includes all commercial producers of the crop
  - Addresses infestation in ornamentals

- In the model, a region contains a mix of growers of 3 cultivars
  - With a PCD, assume that all growers apply insecticide at the same time; solve for treatment timing that maximizes weighted grower returns

Objective 3:
Examine Incentives for Cooperation

- Maximum WTP for a PCD ($/acre) =
  - □ Return with regional treatment (insecticide effective until pest population rebounds) less
  - □ Minimum private return (insecticide effective for 3 days)

	AQ	MZ	SV	ALL
Region 1 (All AQ)	0.00	□	□	0.00
Region 2 (All MZ)	□	74.06	□	74.06
Region 3 (All SV)	□	□	148.80	148.80
Region 4 (91% AQ, 6% MZ, 3% SV)	□58.83	56.30	□318.36	□59.71
Region 5 (7% AQ, 74% MZ, 19% SV)	□82.92	32.77	95.09	36.51
Region 6 (1% AQ, 95% MZ, 4% SV)	□60.12	55.65	□237.90	42.75
Region 7 (15% AQ, 48% MZ, 37% SV)	□93.70	22.00	129.98	44.60

Objective 3:
Examine Incentives for Cooperation

- Including ornamental trees in the model
  - Increases weighted returns, changes sign from − to + in 4 of 7
  - Driven by assumption that ornamentals reduce the efficacy of the insecticide more than do nearby untreated commercial trees

- Growers of AQ lose from PCD membership
  - Legal structure requires AQ growers to be members
  - Levy system requires AQ growers pay in disproportionately
    - Uniform levy per tree on a max. of 100 trees/ac
    - MZ and SV grown at 75 trees/ac, AQ at 600 trees/ac
    - At 7 cents per tree, MZ/SV pay $5.25 per ac, AQ pays $7; with 85% in MZ/SV (15% in AQ), MZ/SV pays 81%, AQ pays 19%

Conclusions:
Methodological Implications

- Effect of model components on estimated returns to PCD membership

1. Estimated damage function (Y) vs. logistic (N)
2. Flexible (Y) vs. fixed harvest date (N)
3. Inclusion of ornamentals (Y) vs. commercial only (N)

1/2/3	Regional Gain?
Y/Y/Y	5 of 7
N/Y/Y	2 of 7
Y/N/Y	4 of 7
Y/Y/N	2 of 7
N/N/N	0 of 7

Conclusions:
Policy Implications

- PCD membership requirement, levy structure may discourage cooperation
  - Consistent with debate in current olive PCDs

- Combined effect of regulation from two differing parties may engender abandonment
  - Downward cycle (Butte County)

- Better understanding of biological damage process may help identify efficacy of cultural control methods, including the timing of harvest

Conclusions:
Synthesis of Two PREISM Projects

- Current project: Olive fruit fly and California olives
- Earlier PREISM-funded project: Greenhouse whitefly and California strawberries
- Common themes
  - Heterogeneous economic actors and biological systems
  - Spatial-dynamic modeling of economic and biology
    - Structural biological system
  - Government regulation
  - Grower cooperation
- Fundamental challenges of economic modeling face bio-economic modeling.
- Bio-economic modeling requires addressing these decisions for
  - Economic relationships
  - Biological/physical relationships
  - Linkage(s) between the two
- Analyses of invasive species problems may face greater challenges than analysis of many other pest problems, due to less ex ante information

Synthesis of Two PREISM Projects: Modeling Choices

- Structural versus reduced-form analysis
  - System specification
  - GWF: Calibrated simulated population model vs. reduced form econometric model
  - OLF: model identification, structural model vs. reduced form econometric model
- Known and unknown relationships and values
  - OLF: population, fly development cycle? (Where do the flies go?)
  - GWF: fly development on strawberries vs. prior hosts? Why strawberries?
  - Nature of damage
    - Yield: OLF and GWF
    - Plant: GWF
  - Estimation of damage function
    - Cumulative and current pest populations: GWF
    - Time, temperature, location, variety, etc.: OLF

Synthesis of Two PREISM Projects: Time and Space

- Model scope determines damage function
  - Choose model scope based on economic question, biological information
- Definition of space
  - OLF: space = tree, unit of observation for damage = fruit, tree, unit modeled=tree
  - GWF: space=plant, unit of observation for damage=plant, unit modeled=plant, field
  - GWF: Region=point-space relationship between neighboring fields
  - OLF: Region=group of economic agents (no explicit cross-field spatial relationship)
  - Regions driven by what is known about pest movement
- Definition of time
  - OLF, GWF: unit of observation=week
  - OLF: period modeled= growing season
  - GWF: period modeled= growing season, multiple growing seasons
  - OLF: one-time harvest, cumulative damage
  - GWF: multiple harvests, current and cumulative damage

Synthesis of Two PREISM Projects: Conclusions re Common Themes

Recommendations to growers and policymakers

- Modeling: depend on the specification of growers' choice variables
  - Number of pesticide applications
  - Timing of pesticide applications
    - First application
    - Intervals
  - Harvest
    - Date
    - Number
    - Differences can be important
- Regulation: depend on the policies examined
  - OLF: Application intervals **and** processor quality requirements
  - GWF: Application intervals, number of applications, **and** date of first application
    - Costliness of each
- OLF, GWF: Heterogeneity matters considerably
  - In these cases, at least

Synthesis of Two PREISM Projects: Conclusions re Common Themes

Cooperation

- Scope and benefits driven by
  - Specification of choice variables
  - Spatial, temporal relationships
  - Economic considerations
  - Economic and biological heterogeneity
- Scope and benefits drive institutional choices
  - Existing institutions’ policy instruments, membership
  - Rules governing institutional formation
- Invasive species management/eradication issues evolve quickly
  - Analysis of *ex ante* rules governing institutional design and behavior is critical
  - Need to ensure flexibility while maintaining transparency