Economic Consequences
Pollinator Declines

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Benefits of Pollination Services

- Food and Forage Crops
- Ornamentals
- Medicines
- Aesthetics
- Genetic Diversity
- Ecosystem Resilience
Pollinator Dependency

- Plants vary in their need for animal pollination
  - Majority of world’s staple crops (cereals) are wind or self-pollinated
  - High value crops (fruits, vegetables, nuts, oil seeds) require animal pollination
- Animal pollinators impact plant production quantity and quality
Pollinator Dependency Ratio

- **Klein et al. 2007 – FAO Primary Crops**
- **Literature Review of Experimental Studies**
  - Bagged and un-bagged flowers on multiple plots
  - Compare differences in yield
- **Five classes of production dependence**
  - Essential (production reduced by >90%)
  - Great (production reduced by 40-90%)
  - Modest (production reduced by 10-40%)
  - Little (production reduced up to 10%)
  - None (no production reduction)
Global Pollinator Dependency

The percent of total production and the percent of total harvested acreage for pollinator-dependent crops are both increasing.
Status of Pollinators

• *Regional* declines in both managed and wild populations and loss of pollinator diversity
• Parasites (*Varoa destructor*) and pathogens
• Habitat destruction and degradation
  – nesting and foraging resources
• Agricultural intensification
  – Large monocultures
  – Increased use of chemicals
  – Competition for resources between managed and wild pollinators
Valuation of Pollination Services

• Changes in social welfare
  – Single market analysis
  – Multi-market analysis
• Lost value of crop production
  – Pollinator-dependent portion of production
• Replacement costs
  – Markets for managed animal pollinators
  – Markets for man-made alternatives
Research Methods: Model and Data

- Static multi-region, multi-sector CGE model
- Theoretically-derived system of equations
  - Household (region) expenditure minimization
  - Firm (sector) cost minimization
  - Nested CES preferences and production technology
  - Armington (1969) assumption of differentiated goods
  - Walrasian equilibrium (market clearance, zero profit, income-expenditure balance)
- Calibrated using Global Trade Analysis Project benchmark input-output database (2004 base year)
  - Aggregated 18 regions and 13 sectors
  - FAO primary crop price and production data
18 Global Regions
3 Americas, 4 Europe, 5 Africa, 5 Asia, 1 Oceania
13 Production Sectors

- Rice, Wheat & other Grains
- Vegetables, Fruit & Nuts
- Oil seeds
- Sugar cane & beet, and other crops
- Livestock
- Forestry

- Other agricultural sectors
- Processed food
- Fuels & Electricity
- Chemicals, Rubber & Plastics
- Manufactures
- Services
- Rest of economy
Research Methods: Scenarios

- Global and regional pollinator loss scenarios
- Pollinator declines implemented as exogeneous neutral shocks to pollinator-dependent crop sectors
  - value of production shares for all primary crops at risk using Klein et al.’s pollinator dependency ratios
  - “catastrophic” losses
- Prices and quantities adjust in all sectors and regions
- Changes in social welfare (equivalent variation)
- Changes in value of production (direct and indirect)
General Equilibrium Results
Global Pollinatoator Decline

- Global Welfare Effects
  - $143 billion loss (0.57%)

- Global Production Sector Effects
  - Crop Sectors: $24 billion loss (1.88%)
  - Non-Crop Sectors: $278 billion loss (0.36%)
  - All Sectors: $302 billion loss (0.39%)
  - Less than 8% of global loss (in dollars) occurs in crop sectors!
Distribution of Global Welfare Losses

- East Asia: 32%
- All of Africa: 6%
- Central America: 2%
- Northern America: 20%
- South America: 6%
- Central Asia: <1%
- Oceania: 3%
- Western Europe: 3%
- Southern Europe: 6%
- Northern Europe: 2%
- Eastern Europe: 3%
- Western Asia: 5%
- Southeast Asia: 3%
- South Asia: 8%

$143 billion
Distribution of Global Production Losses

- East Asia: 28%
- Northern America: 22%
- Southern Europe: 7%
- Northern Europe: 4%
- Eastern Europe: 3%
- Western Europe: 7%
- Western Asia: 3%
- Southeast Asia: 3%
- South Asia: 7%
- Central America: 3%
- South America: 5%
- Central Asia: 1%
- All of Africa: 4%
- Oceania: 3%

Total: $302 billion
Percent Change in Welfare Global Pollinator Decline
Percent Change in Value of Production Global Pollinator Decline
General Equilibrium Results

Regional Pollinator Decline

• Welfare Effects *(average)*
  – Own Region: $7.6 billion loss
  – Other Region: $140 million loss
  – World: $7.8 billion loss

• Production Sector Effects *(average)*
  – Crop Sectors: $3.8 billion loss
  – Non-Crop Sectors: $8.7 billion loss
  – All Sectors: $12.5 billion loss
Percent Change in Welfare
Regional Pollinator Declines

Own Region Declines

Other Region Declines
Percent Change in Value of Production Own Region Pollinator Decline
Why is Western Africa so vulnerable?

- Agriculturally-intensive economy (25% agriculture and processed foods)
- High pollinator dependency (10% veggies, fruits, nuts; 2% sugar and other crops)
- < 1% veggies, fruits, nuts, and oilseeds are imported
- Large producer of coffee and cocoa beans, 95% of which is exported
Comparison to Single-Market Results

Partial Equilibrium Analysis
• Global loss in crop production = $138 billion (11.3%)
• Welfare loss = $206 - $279 billion
• Several regions showing economic vulnerability including both developed and developing countries

General Equilibrium Analysis
• Global loss in total production = $302 billion (<1%)
  – Direct effect = $24 billion
  – Indirect effect = $278 billion
• Welfare loss = $143 billion
• Direct effects in some regions are positive
• Economic vulnerability focused in Western Africa
Summary of Key Results

• In dollars, indirect effects are greater than direct effects both globally and regionally (except waf)
• In percentages, direct effects are greater than indirect effects globally and in most regions
• Losses associated with regional pollinator declines are much smaller than global declines
• Some regions and sectors benefit from pollinator declines
• Western Africa regional economy is most at risk
• Partial equilibrium analyses may provide misleading results
Next Steps

• Input substitutions:
  – Bee colony rental including non-Apis species (formalize livestock sector)
  – Investment in conservation/fallow land for wild pollinators
  – Other forms of pollination (hand or mechanical)

• Output substitutions:
  – Conversion to less pollinator-dependent crops
  – Investment in and conversion to cultivars that don’t require pollination

• Long-run versus short-run mitigation
Demand for Pollination Services
(in honey bee colony equivalents)
Maximum Proportion of Pollination Services that could be met by Managed Colonies

Proportion Managed
- 0.01 - 0.10
- 0.11 - 0.35
- 0.36 - 0.70
- 0.71 - 1.00
A World Without Chocolate, Vanilla, and Strawberry?

QUESTIONS??