

Comanaging Fresh Produce Farms for Bird Conservation, Pest Control, and Food Safety

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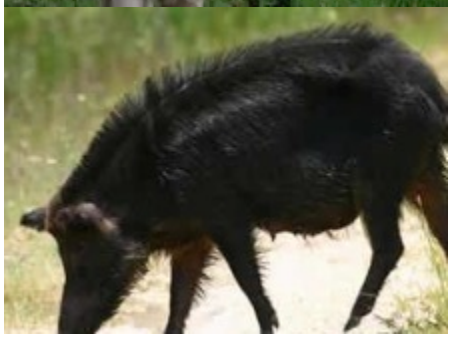
California's Central Coast



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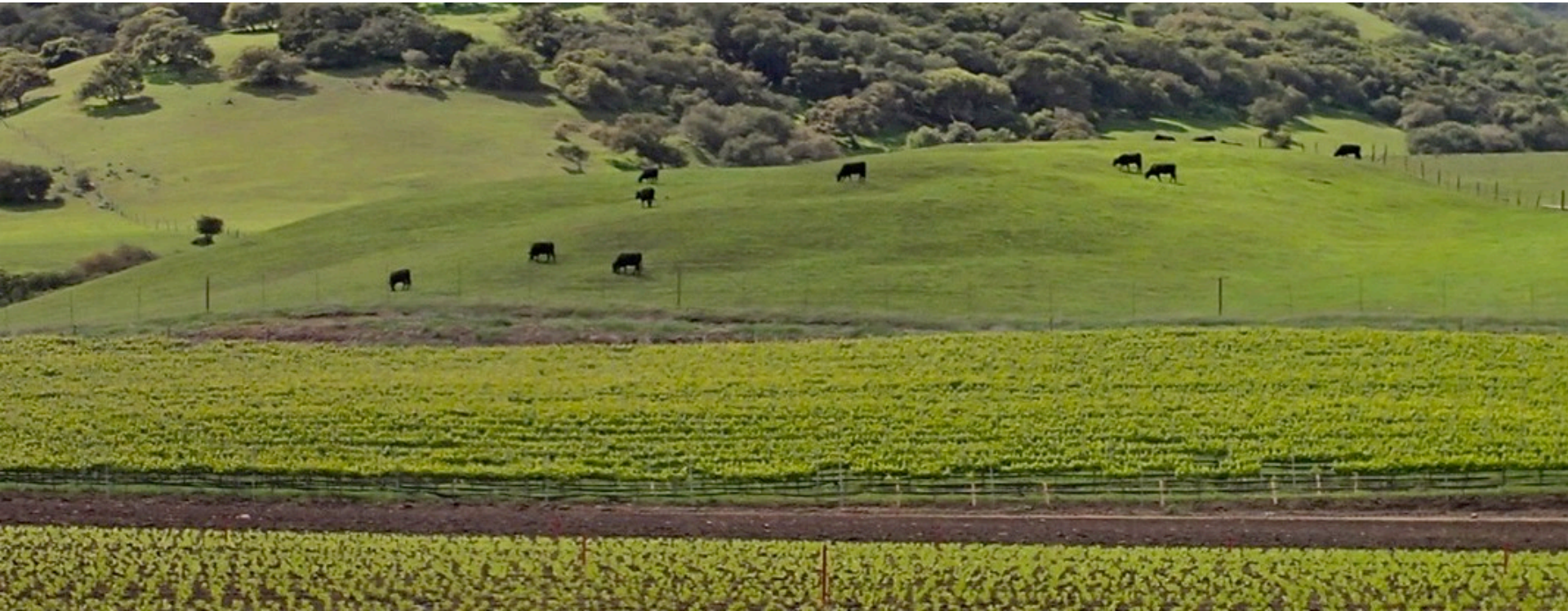
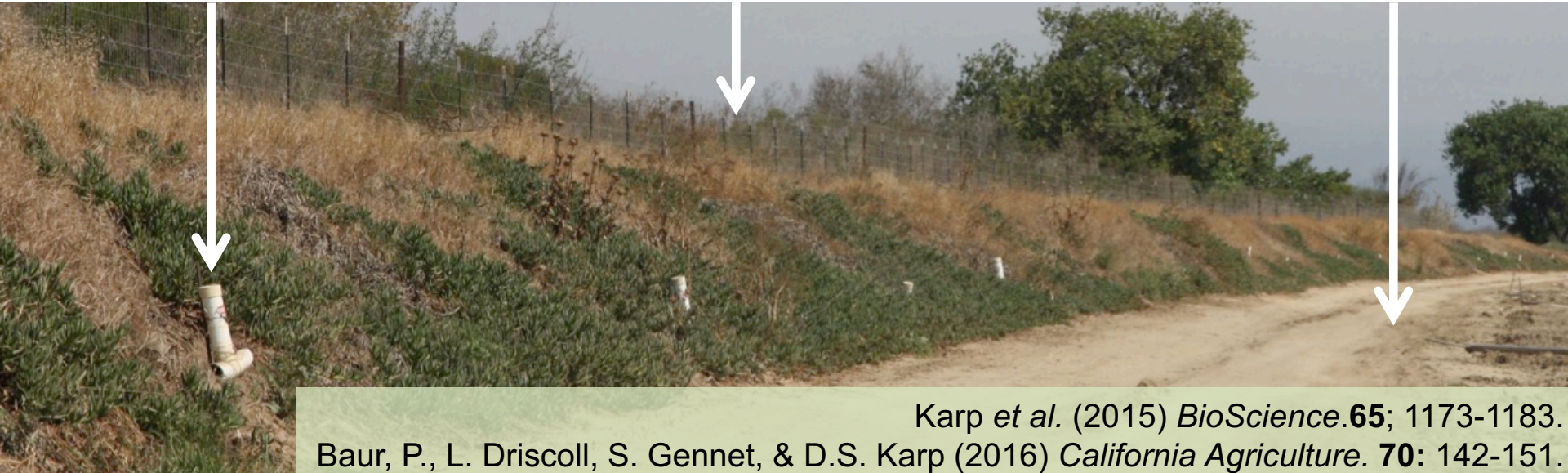


- **~13% of the remaining riparian habitat along the Salinas River was cleared between 2005 and 2009**
- **A survey from 2015 indicated that ~40% of California produce growers are still clearing vegetation**

Rodent traps

Wildlife fences

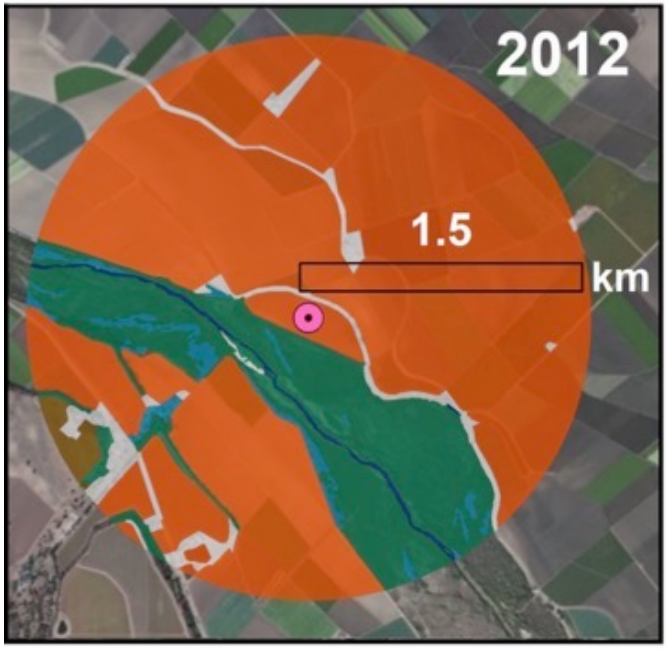
Vegetation removal



Karp *et al.* (2015) *BioScience*.**65**; 1173-1183.
Baur, P., L. Driscoll, S. Gennet, & D.S. Karp (2016) *California Agriculture.* **70:** 142-151.

Is habitat removal making our food safer?

- Enterohemorrhagic *E. coli* (EHEC) & *Salmonella* in leafy greens
  - 237,306 tests at 74 farms (2007-2013)
- Indicator *E. coli* in water (*e.g.*, wells & waterways)
  - 6,887 tests at 484 farms (2007- 2010)
- *Salmonella* in rodents
  - 792 tests at 9 farms (2007-2009)



Cropland
Grazeable Land
Riparian
Other natural
Unvegetated
Water

Is habitat removal making our food safer?

If anything, habitat removal would likely increase food-safety risks

Birds, Food Safety, and Effects on Crops

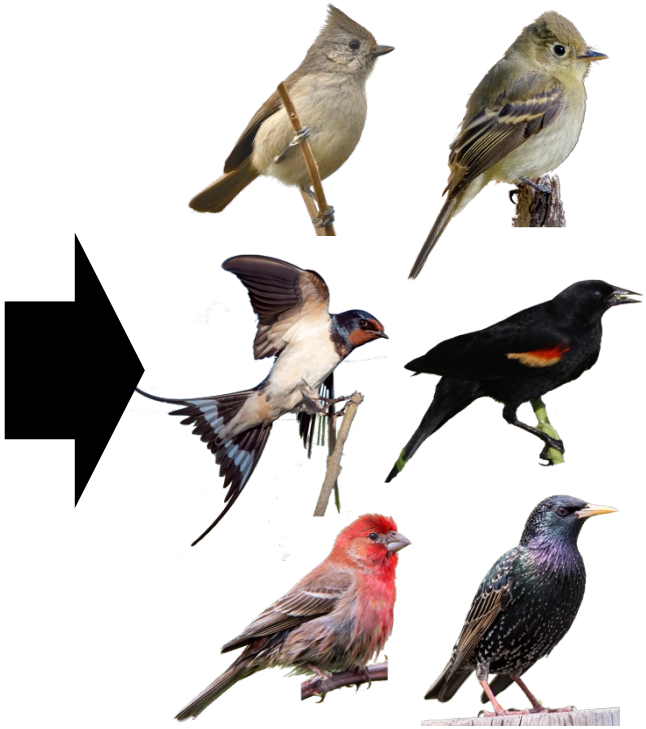
"The thing that worries me more actually are birds. . . you can't control birds and they constantly like flying over your field. They come and sit in the field. They carry Salmonella" – Grower A

Guiding Questions

1. Which bird species carry food-safety risk (if any)?
2. How does habitat (on and off the farm) affect food-safety risks from birds?
3. What are the implications for pest control and crop damage?

Non-crop Habitat

Bird Communities



Food Safety

Crop Damage

Guiding Questions

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Non-crop Habitat

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Holistic Risk Assessment

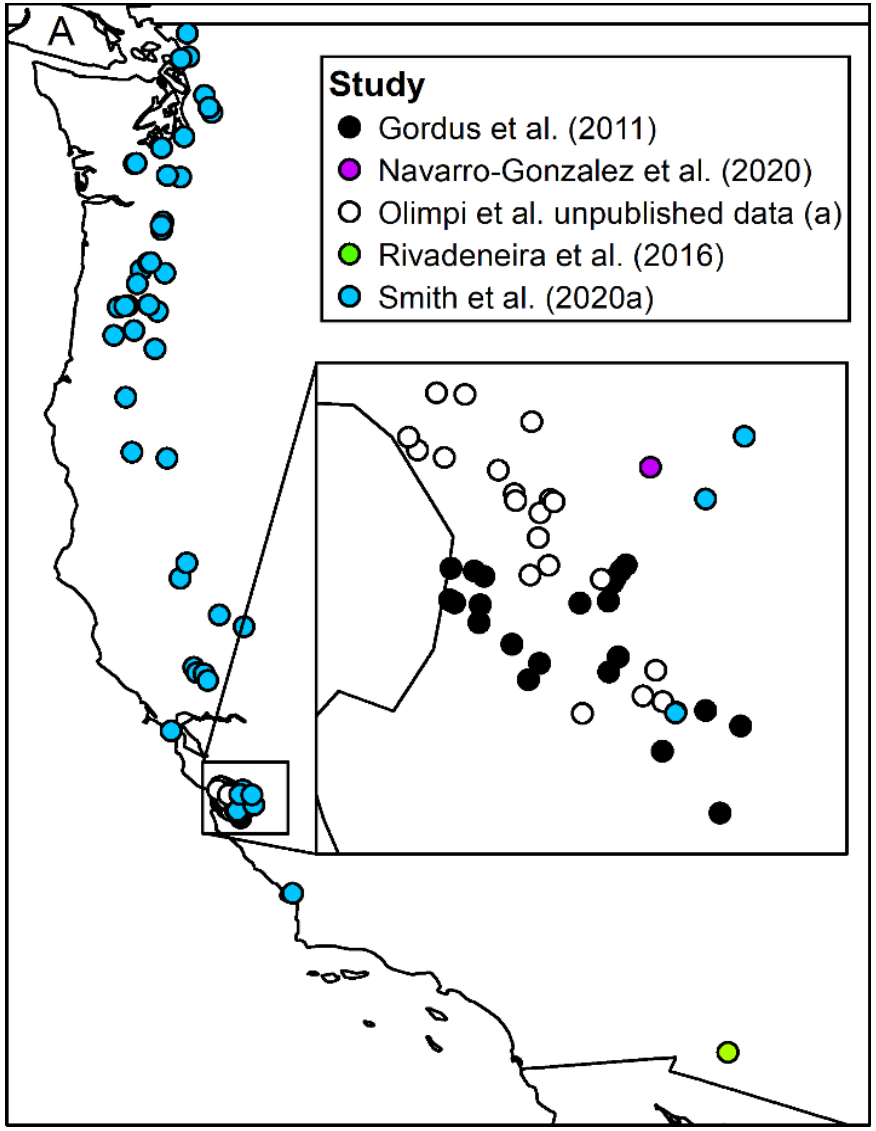
Does the species carry the pathogen?

- No → No extra risk
- Yes → Does contact occur?
  - No → No extra risk
  - Yes → Do bacteria survive for long periods?
    - No → No extra risk
    - Yes → Higher risk for spillover

Smith et al. (2020) *Biol. Rev.*

1. Which species carry the greatest risks?

- We compiled three datasets…
- Pathogen dataset
  - ~11,000 tests of STEC, *Salmonella,* & *Campylobacter*
  - ~90 produce farms
  - ~95 bird species
- Bird survey database
  - ~1500 point counts
  - ~350 sites
- Fecal database
  - ~460 feces
  - ~35 farms

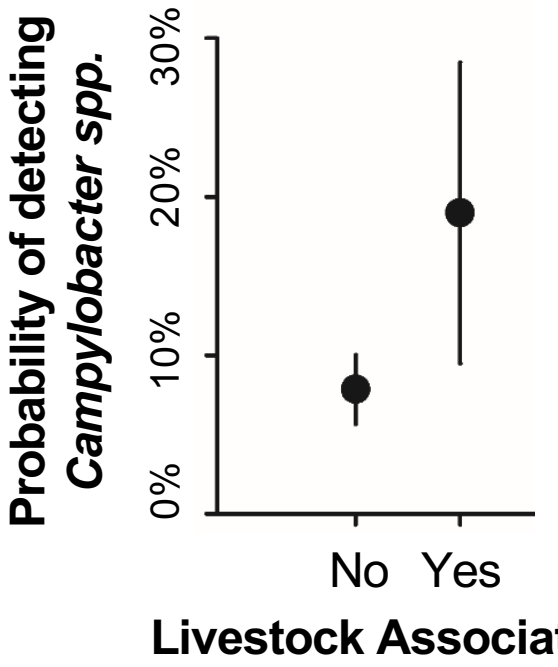


Smith *et al.* (2021) *Ecological Applications.*

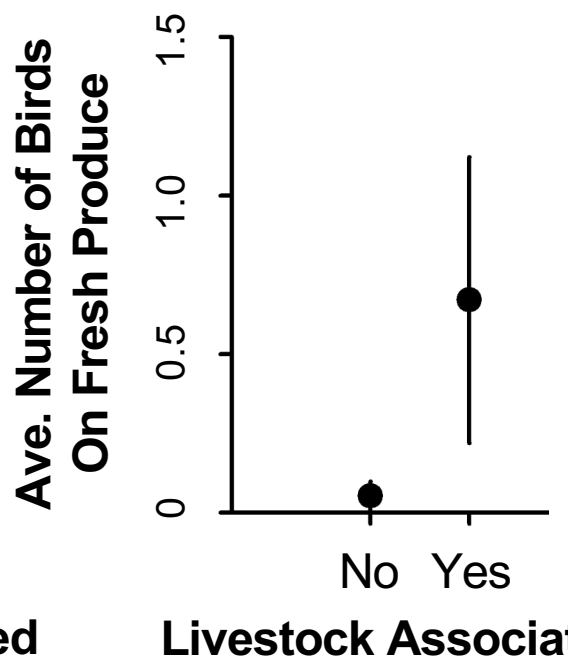
1. Which species carry the greatest risks?

- Positivity rates
  - STEC: 0.2%; *Salmonella*: 0.5%; *Campylobacter*: 8.0%
- Updated numbers with 554 more birds:
  - STEC: 0.2%; *Salmonella*: 0.4%; *Campylobacter*: 5.8%
- Livestock-associated species are more likely to…

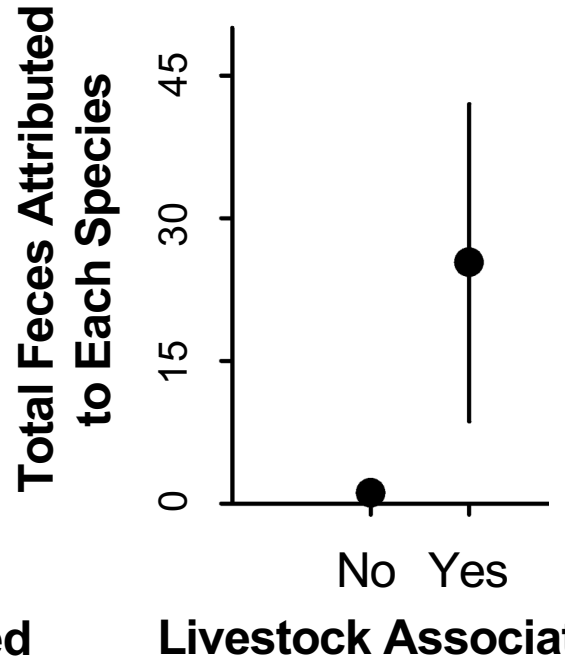
1. Carry pathogens



2. Contact produce



3. Defecate on crops



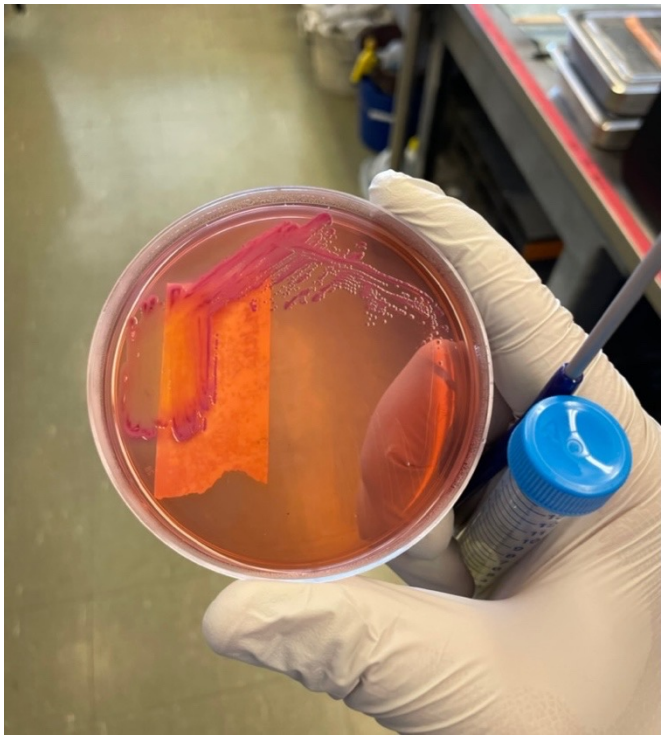
Smith *et al.* (2022) *Ecological Applications.*

1. Which species carry the greatest risks?

Grow *E. coli* in the lab

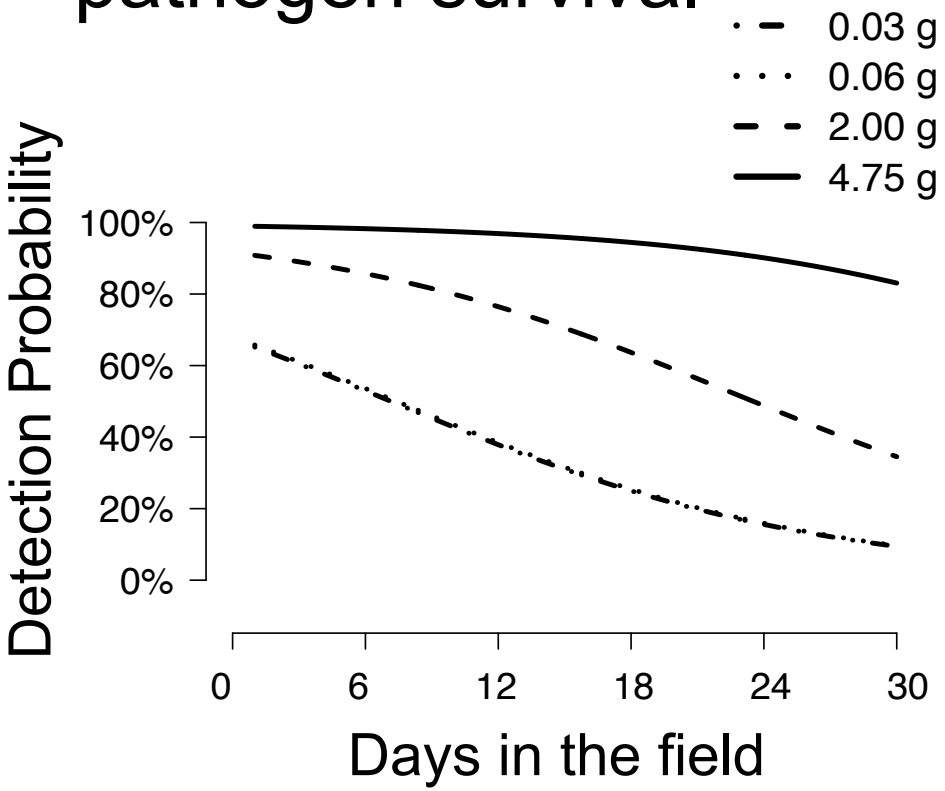
Collect bird feces & inoculate with *E. coli*

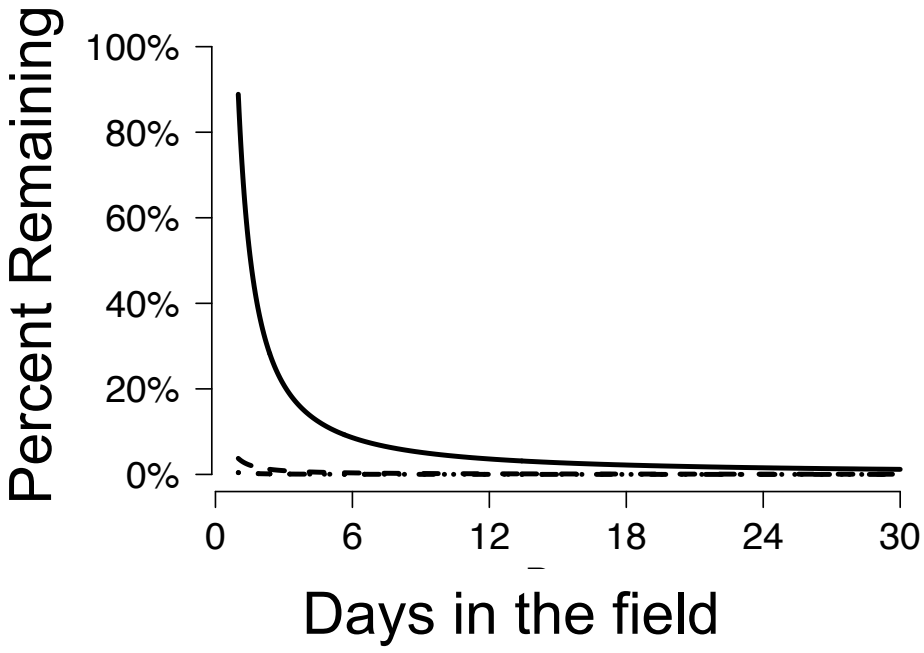
Deploy in field, collect at set times, and quantify fraction remaining



1. Which species carry the greatest risks?

- Survival is higher on lettuce (it is cooler and more humid)
- Size, not bird species identity, determined pathogen survival





1. Which species carry the greatest risks?

- Farmers are told to apply no-harvest buffers (often 1 m) around wildlife feces
- Across 108 bird fecal transects on lettuce farms, ~10% of 1m^2 quadrats had bird feces
  - ~50% on strawberry farms
- By our calculations, ignoring small feces (< 0.15 g) on soil would reduce affected area from 10% to 2.7% of farm fields

1. Which species carry the greatest risks?

To conclude…

- Higher-risk species: large, livestock-associated species that form big flocks
- Low-risk species: small, insect-eating species (including birds that use nest boxes!)

Guiding Questions

1. Which bird species carry food-safety risk (if any)?
2. **How does habitat (on and off the farm) affect food-safety risks from birds?**
3. What are the implications for pest control and crop damage?

Non-crop Habitat

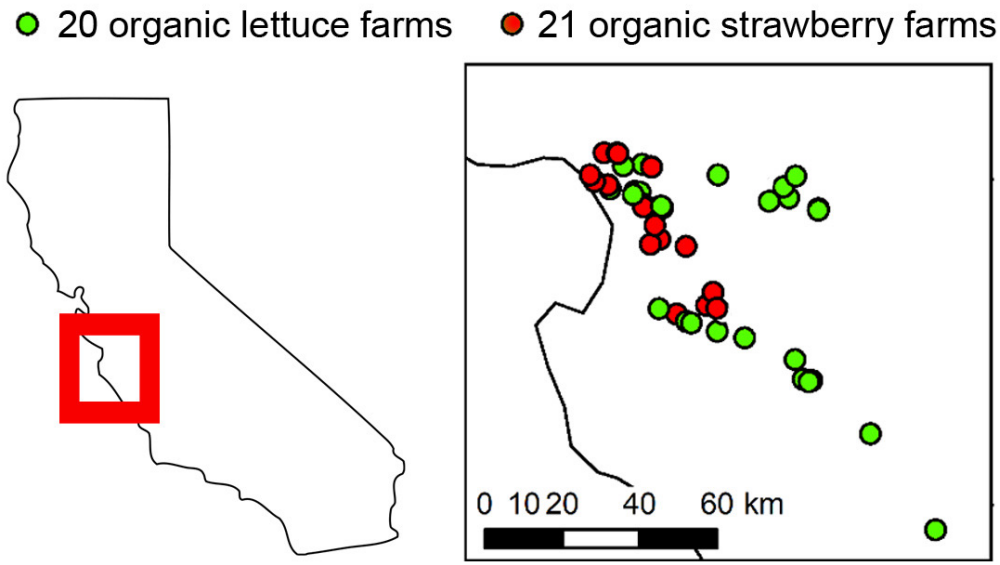
Bird Communities

Food Safety

Crop Damage

2. How does habitat affect risks from birds?

- ~20 organic strawberry farms and ~20 lettuce farms surveyed per year from 2018-2020
  - Local diversity (*e.g.*, # of crops, non-crop vegetation, etc).
  - Surrounding ungrazed seminatural habitat (within 1 km)
  - Surrounding grazed seminatural habitat (within 1 km)
- Strawberry study: fecal samples from captured birds
- Lettuce study: bird counts and feces collected from lettuce



Local Diversity

Ungrazed Habitat

Grazed Habitat

2. How does habitat affect risks from birds?

Strawberry Study:

- Feces contaminated 2 of >10,000 strawberries
- Positivity (out of 980 feces from captured birds)
  - STEC: 0.1%; *Salmonella*: 0%; *Campylobacter*: 3.6%

Birds were *less* likely to carry *Campylobacter* on farms with more surrounding habitat

2. How does habitat affect risks from birds?

Lettuce Study:

- Positivity (out of 601 feces from lettuce plants)
  - STEC: 0%; *Salmonella*: 0%; *Campylobacter*: 5.7%
- Potentially pathogenic feces: Positive for *Campylobacter* or possible *E. coli* virulence genes

Grazed habitats around produce fields carried higher food-safety risks from birds.

Ungrazed habitat did not.

2. How does habitat affect risks from birds?

Lettuce Study:

- What is driving these trends? Specifically, how do bird communities change across farm types?

Ungrazed seminatural habitats promote birds of higher conservation concern.

2. How does habitat affect risks from birds?

Lettuce Study:

- What is driving these trends? Specifically, how do bird communities change across farm types?

Big flocks of birds are *less* likely to occur on farms with more surrounding ungrazed seminatural habitats.

Guiding Questions

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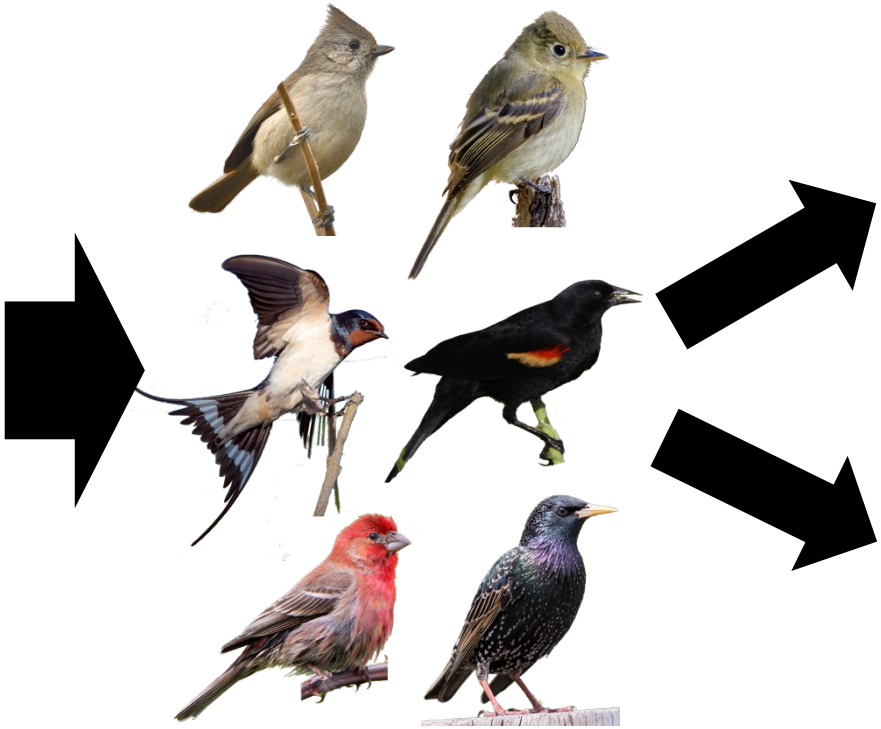
Non-crop Habitat

Bird Communities



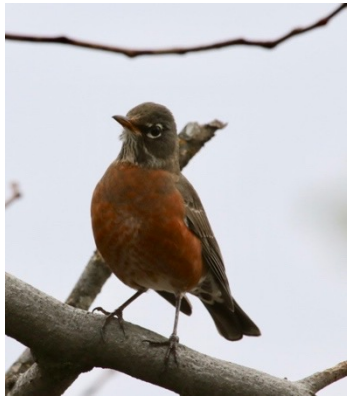
Food Safety

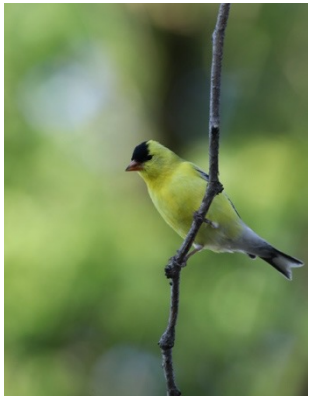
Crop Damage

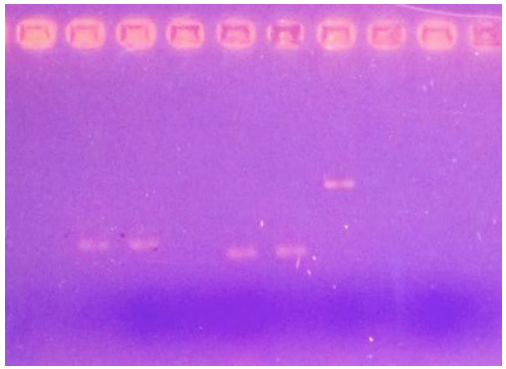
3. How does habitat affect crop damage?

~1000 fecal samples and ~50 species

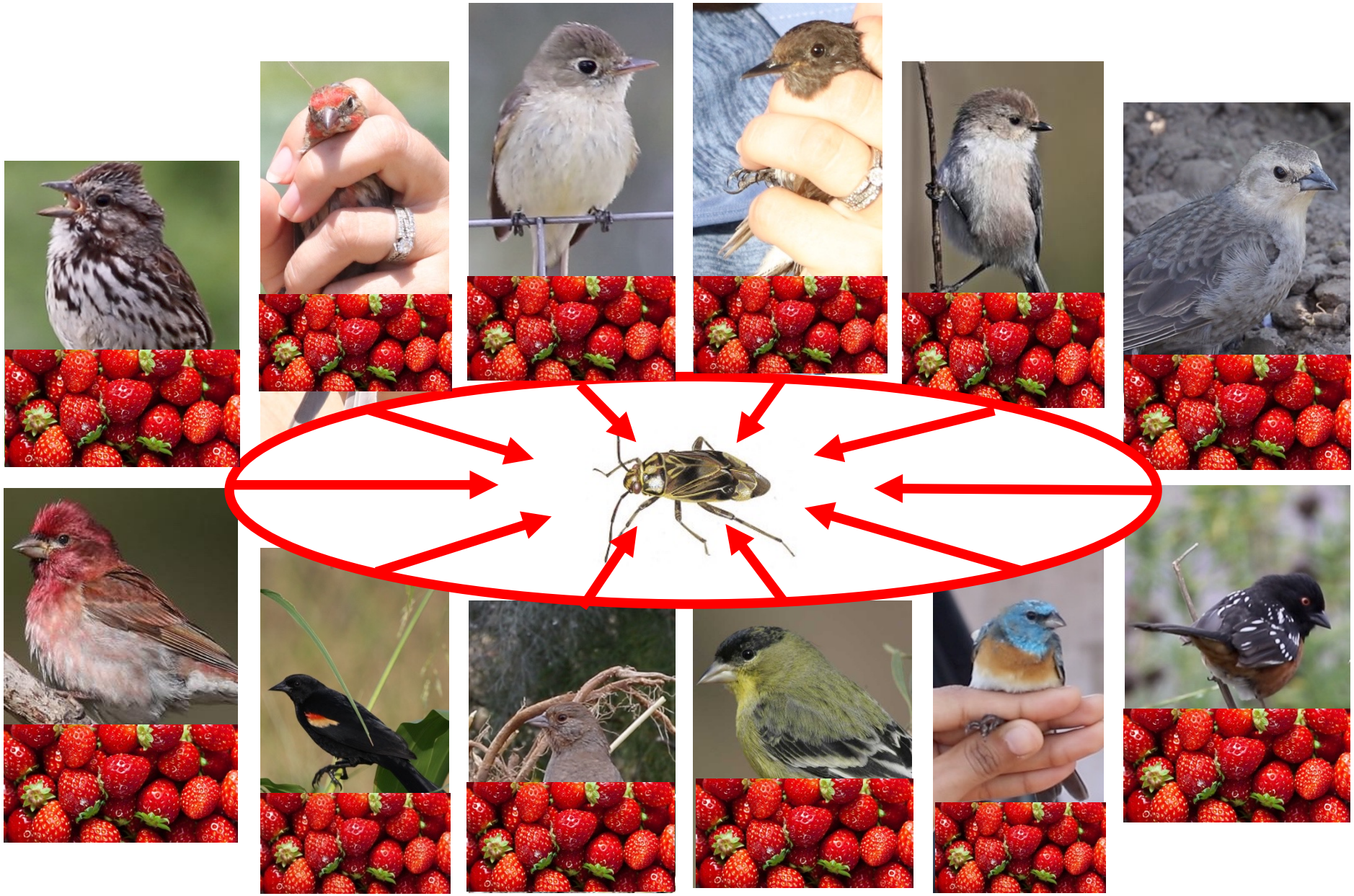
DNA sequencing of insects and plants







3. How does habitat affect crop damage?



3. How does habitat affect crop damage?

Surrounding Non-Crop Vegetation Reduces Overall Feeding Activity

3. How does habitat affect crop damage?

- Exclusion experiment across 14 farms
  - 3 pairs of cages and open frame controls per farm
- Monitored weekly for berry damage & insect abundance

- Insects damaged far more berries than birds
- The net effect of birds was slightly negative (~3.5% loss in yield)
- Likely due to bird damage and consuming beneficial insects

3. How does habitat affect crop damage?

Surrounding habitat mitigates costs associated with wild birds.

Conclusions

1. Pathogen prevalence in birds is low
   - Higher risk: large, livestock-associated, flocking birds
   - Lower risk: small, pest-eating birds that use nest boxes
2. No-harvest buffers near small feces may not be needed
3. Removing non-crop vegetation in California likely…
   - Harms species of conservation concern
   - Increases crop damage
   - Does **NOT** improve food safety

Acknowledgements

- Co-authors
- Growers and landowners
- The National Science Foundation, USDA, & CPS
- All of you for listening!