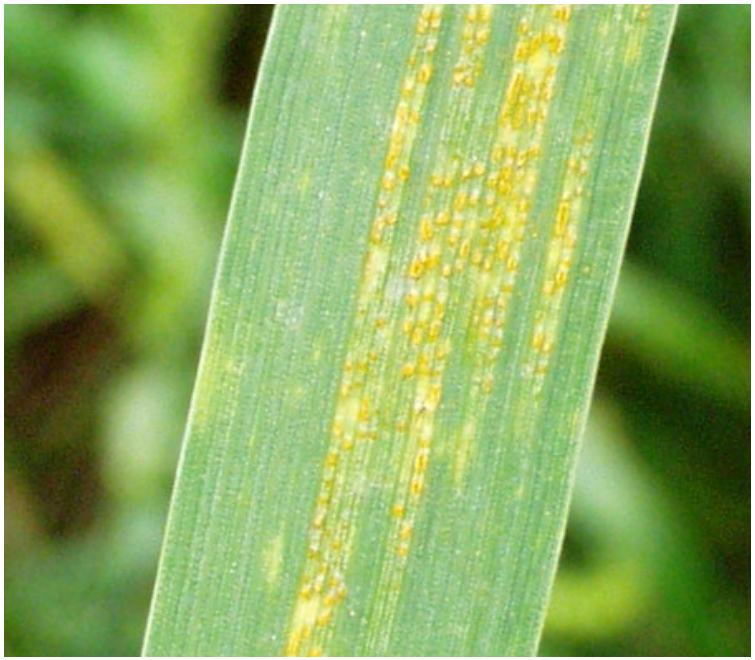
Anticipating and responding to biological complexity in the effects of climate change on agriculture

Karen Garrett, Kansas State University
Greg Forbes, CIP
Suresh Pande, ICRISAT
Serge Savary, IRRI
Adam Sparks, Kansas State University
Corinne Valdivia, University of Missouri
Casiana Vera Cruz, IRRI
Laetitia Willocquet, IRRI

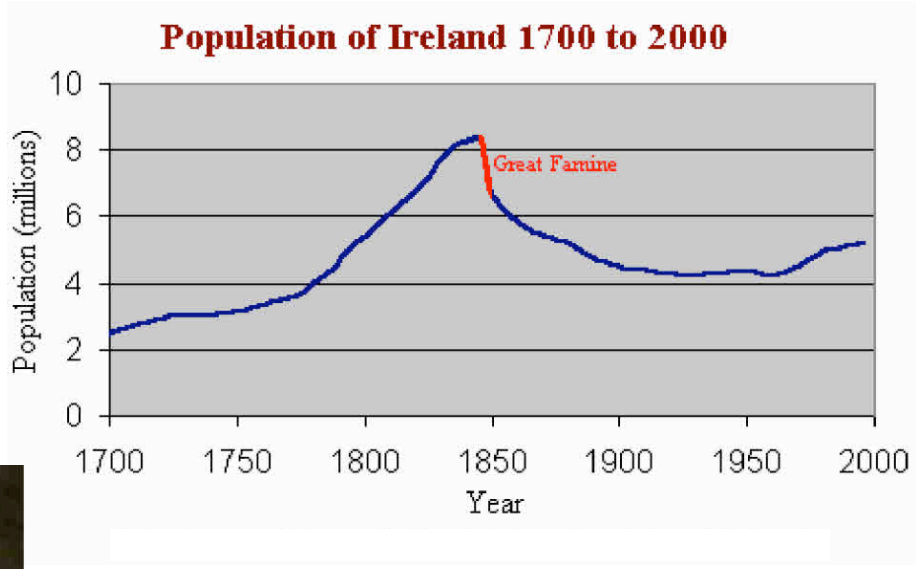


SANREM CRSP

Plant disease

- Caused by fungi, bacteria, viruses, nematodes
- Produces an estimated 10% crop yield loss overall (Savary et al. 2006)
- 42% loss due to disease and insect pests in the eight most important food and cash crops (Oerke et al. 1994)
- 65% of U.S. crop losses, $137 billion, due to introduced pathogens (Pimental et al. 2000)

Potato late blight and demographics, pre-1840



Biological complexity

- “It’s not just complicated, it’s complex”
  - Understanding emergent properties
  - The difference between a 5% increase in disease risk and a completely different disease complex
- Response to biological reductionism
  - Reductionism is common in plant pathology…
  - At the same time that we are mapping a pathogen genome, we often don’t know where the pathogen species occurs geographically
- Multi-species systems
  - Climate effects on pathogen/insect/plant species individually and on their interactions

Framework for evaluating complexity of climate change effects

- We have developed a series of queries (a checklist) as a tool for evaluation of complexity
- Evaluation might be in the context of a geographic area, a cropping (rotation) system, a particular crop species, or a particular pathogen species
  - Message to politicians: we need to understand the multi-scale biology of plant disease and insect pests better in order to manage them effectively - for both current scenarios and future scenarios

System questions (checklist)

1. Are interactions likely?
2. Are there feedback loops for management?
3. Are there population thresholds?
4. Are there indirect effects of global change?
5. How do communication/tool networks compare to epidemic/dispersal networks?

‘Simple’ effects of climate change on plant disease risk…

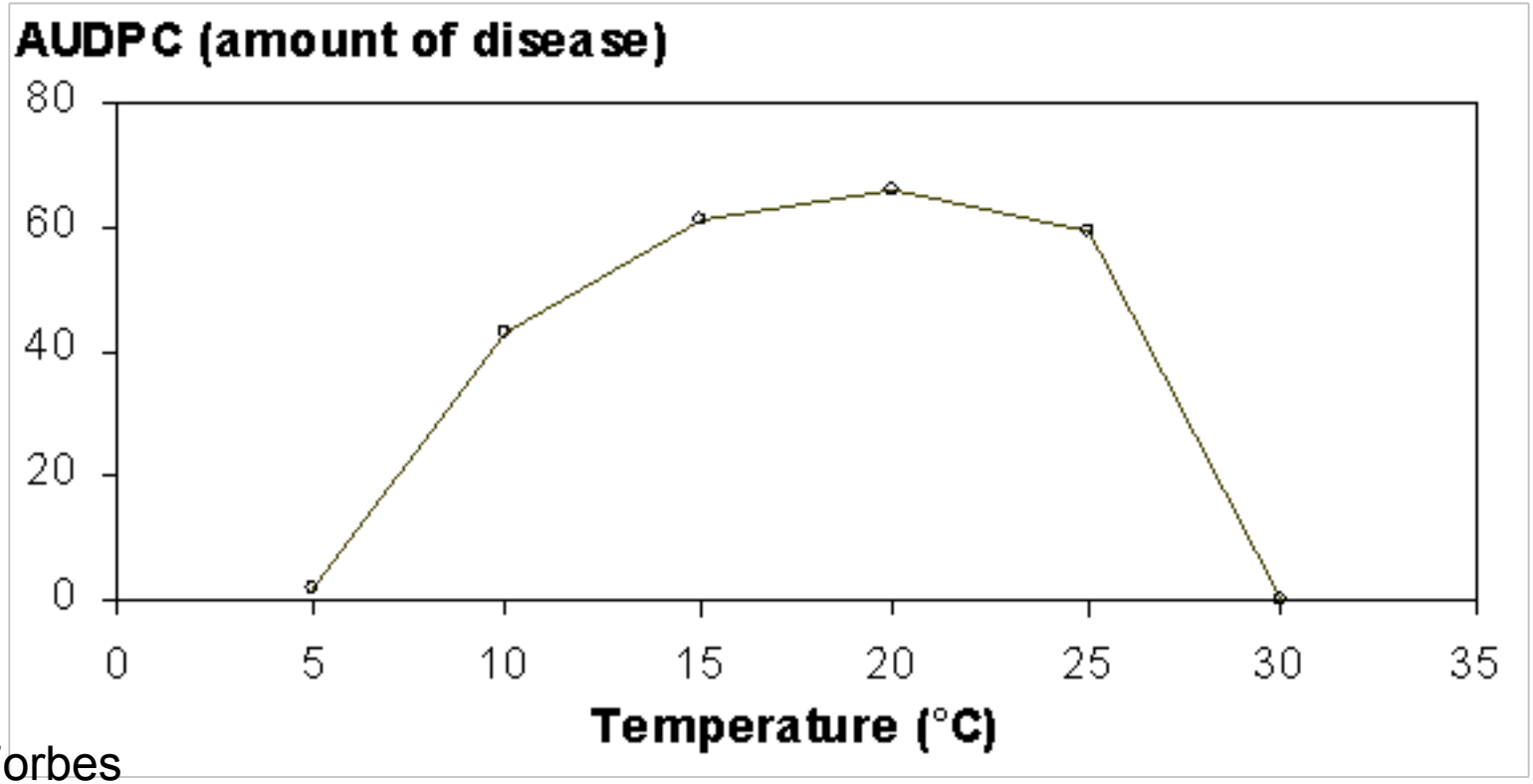
Soil Moisture Stress: Dry root rot (*Rhizoctonia bataticola*) of Chickpea

c/o Pande

Excessive Rains: Phytophthora blight (*Phytophthora drechsleri*) of Pigeonpea

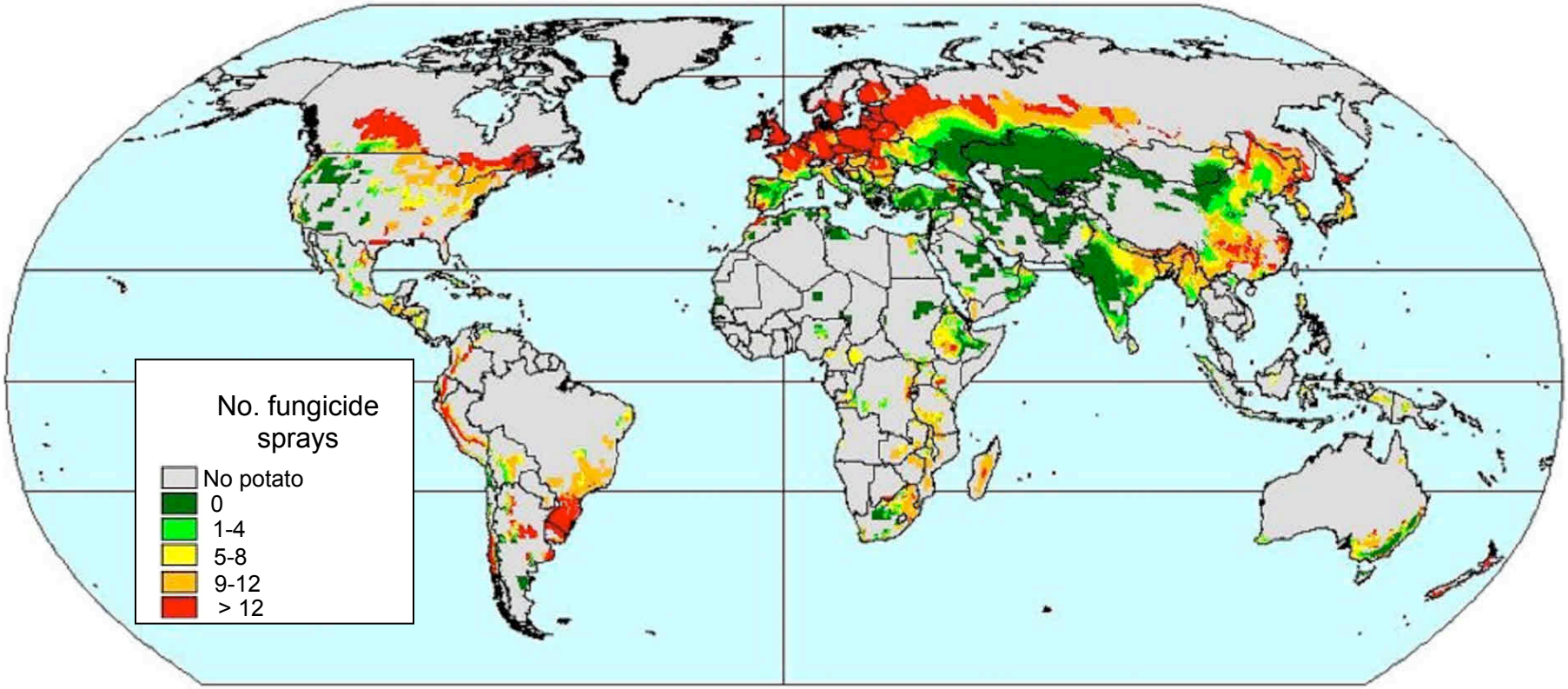
c/o Pande

Effect of temperature on potato late blight

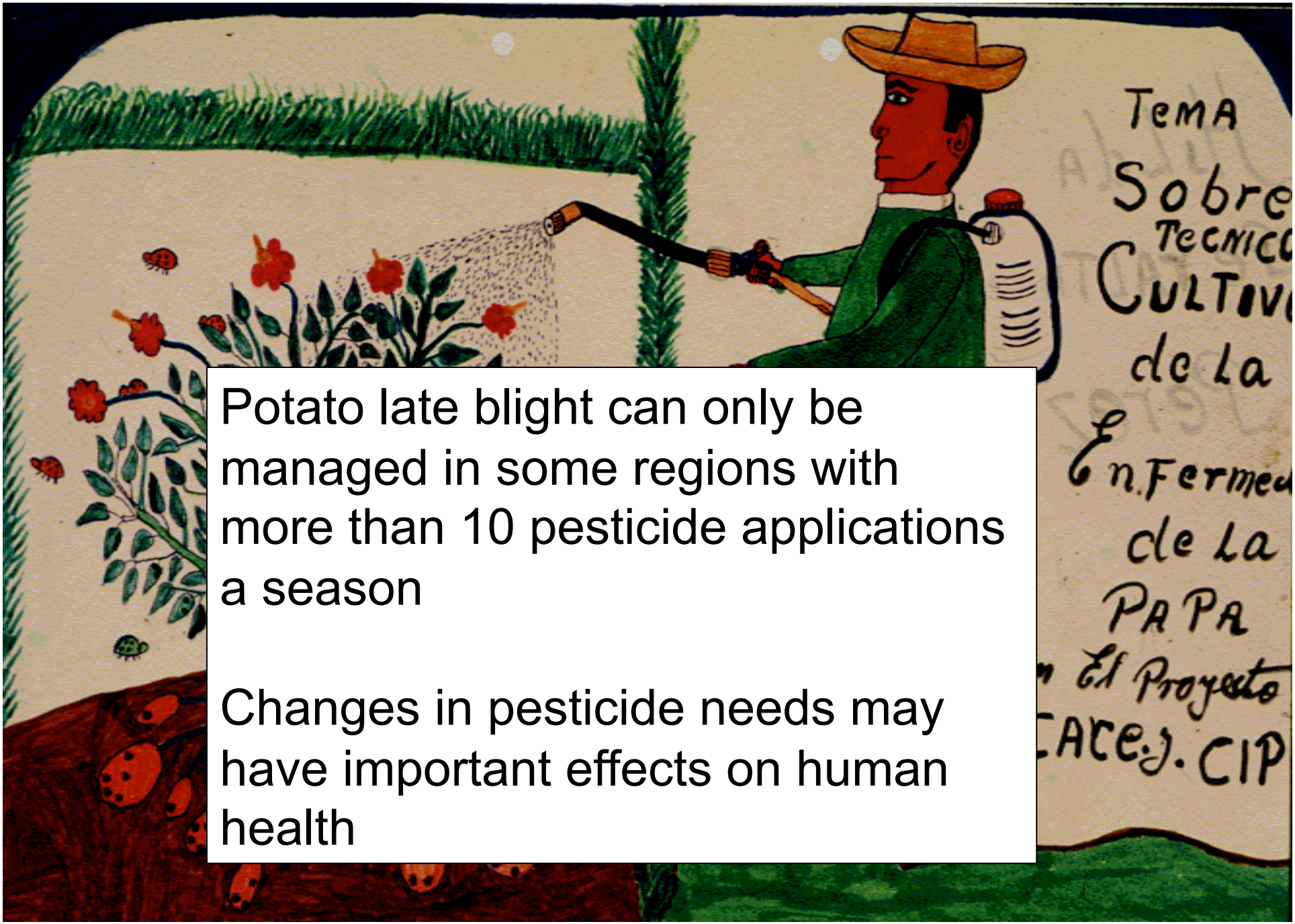


c/o Forbes

Estimated current pesticide needs for potato late blight management



Hijmans et al. 2000

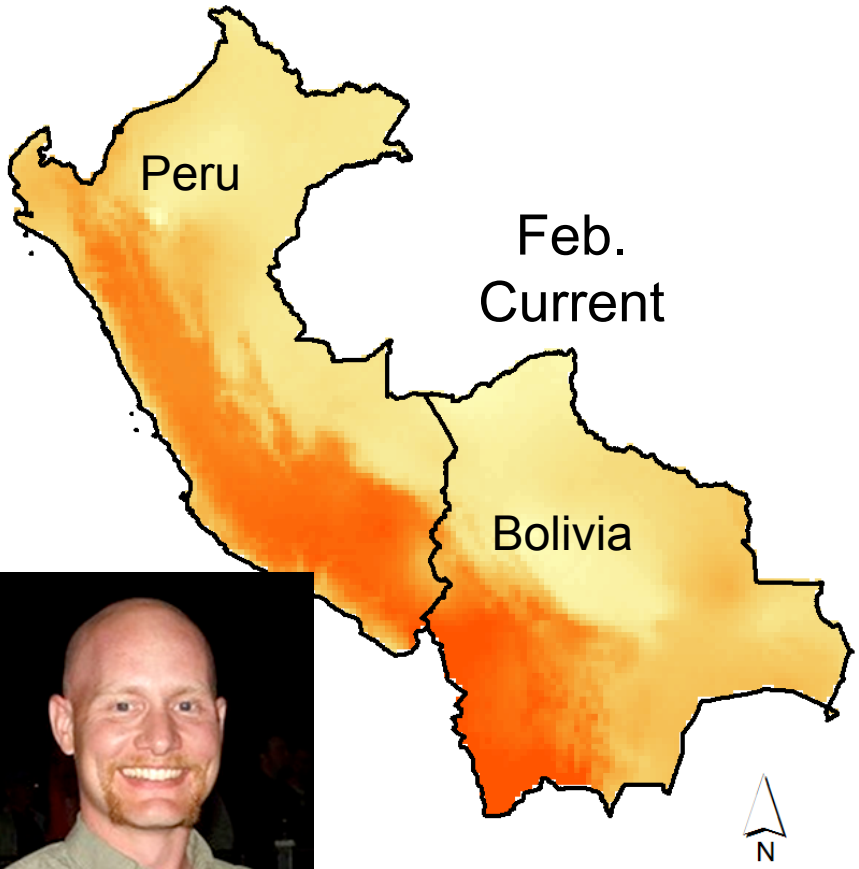


Potato late blight can only be managed in some regions with more than 10 pesticide applications a season

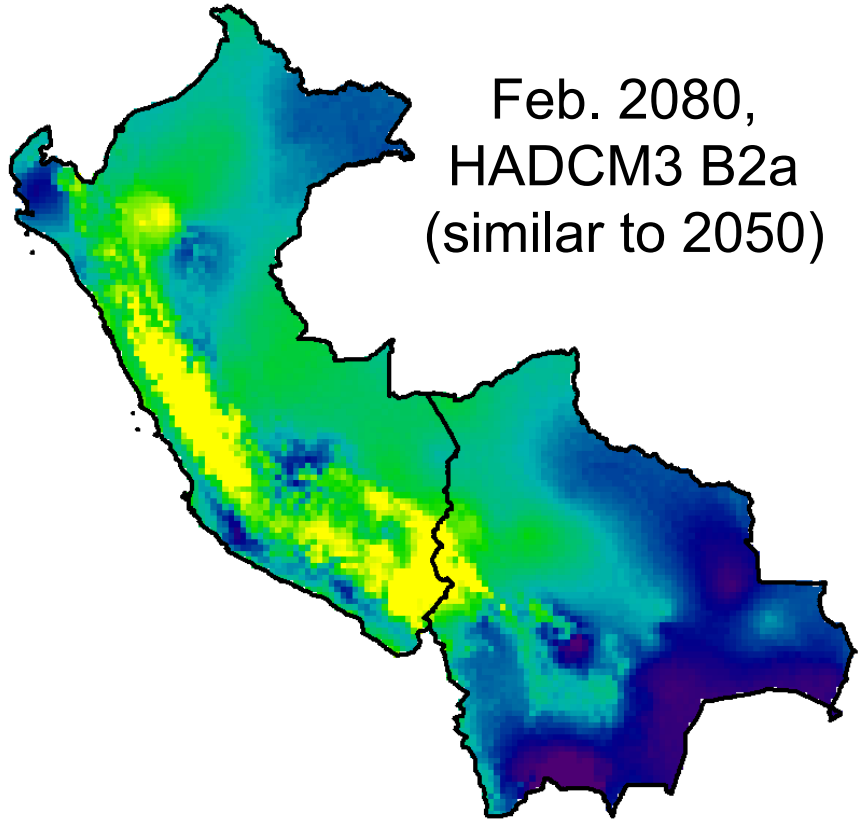
Changes in pesticide needs may have important effects on human health

Image c/o CIP and CARE farmer field schools and collaborators

Estimated Late Blight of Potato Disease Severity



Feb.
Current



Feb. 2080,
HADCM3 B2a
(similar to 2050)

c/o Adam Sparks

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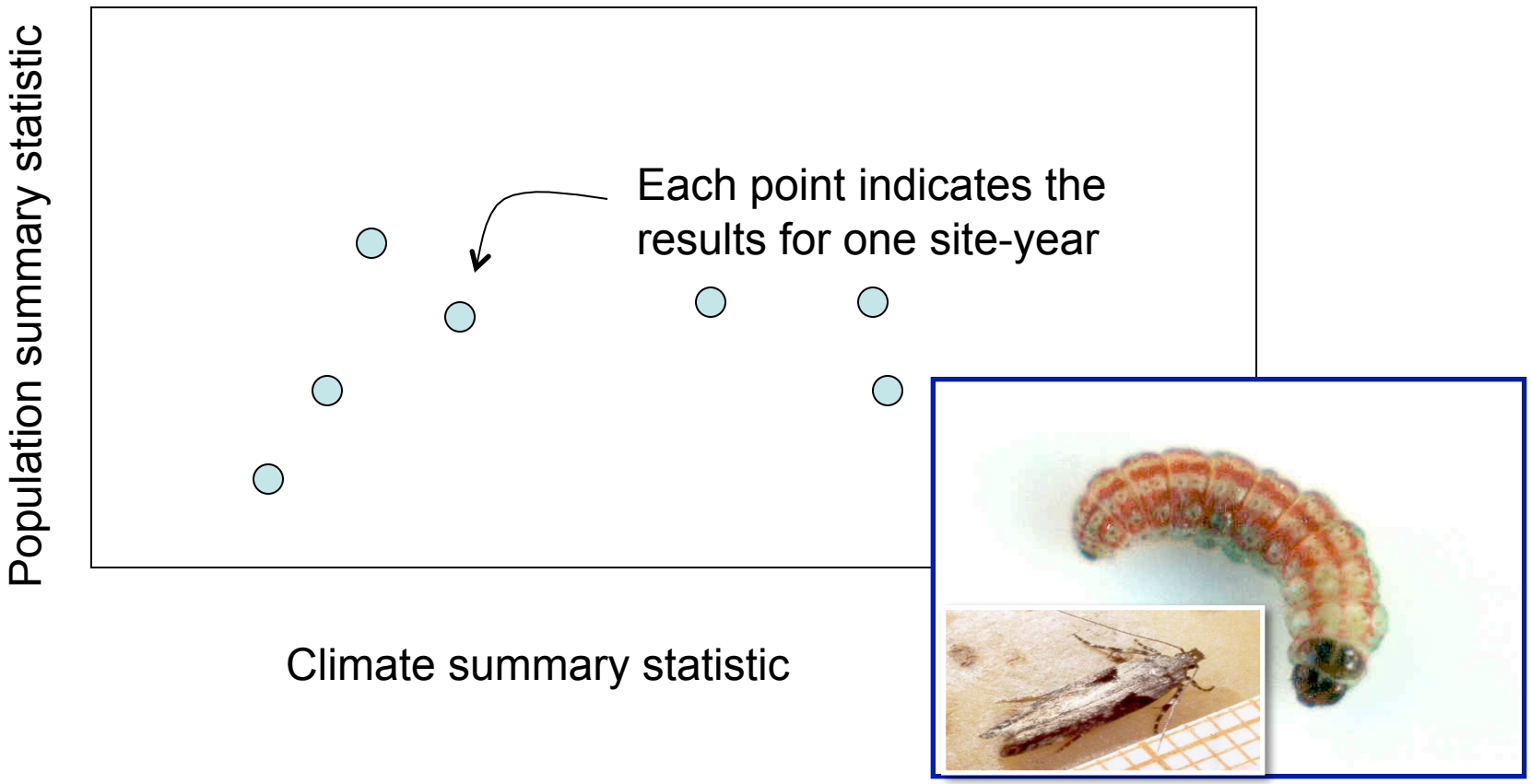
12.2

'Blight units' a measure of disease risk

Climate and populations of Andean potato weevil and potato tuber moth

We are currently preparing a summary model based on the SANREM students' field studies



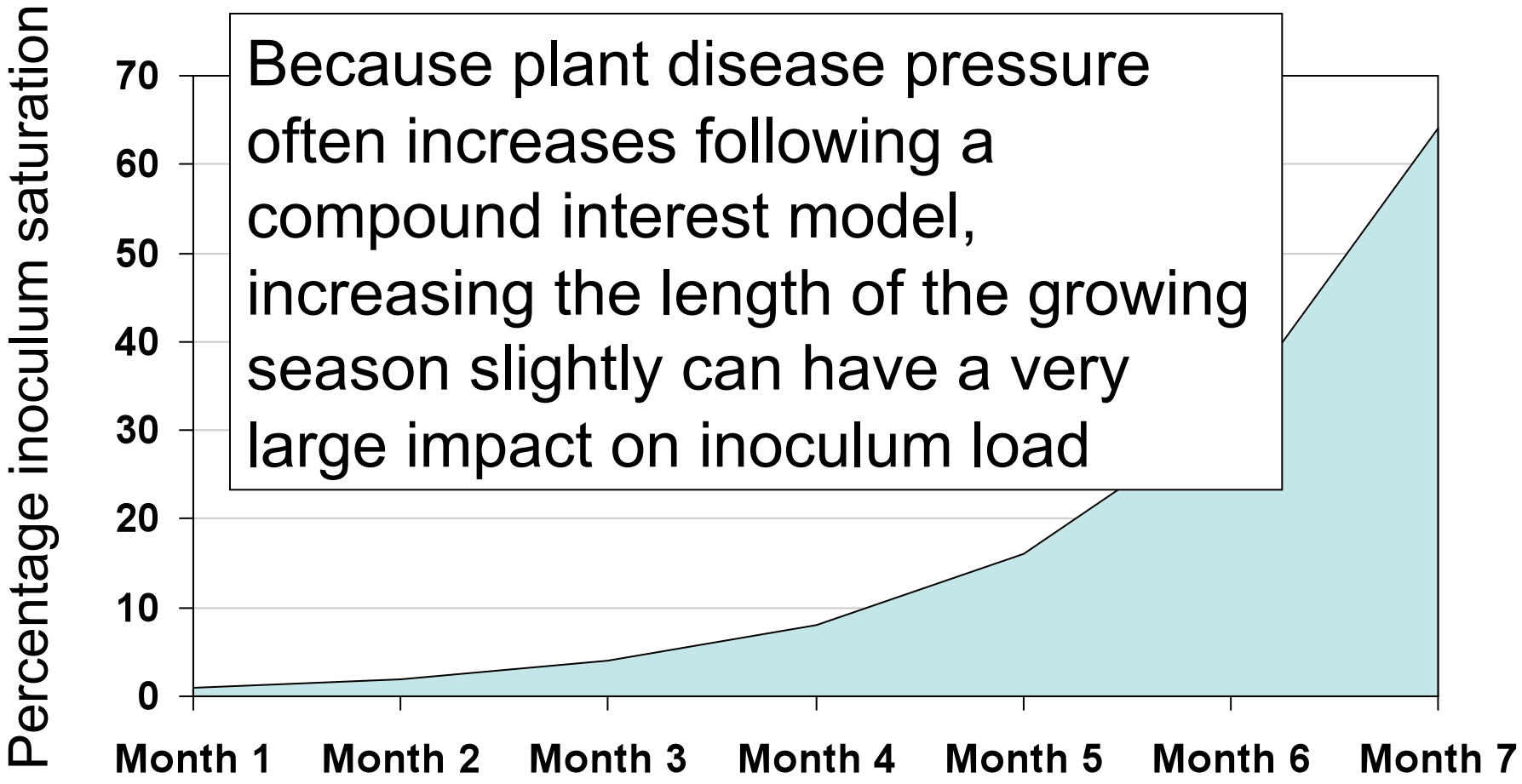
Disease resistance is generally the most desirable management tool

- The expression of disease resistance genes may also be a function of temperature

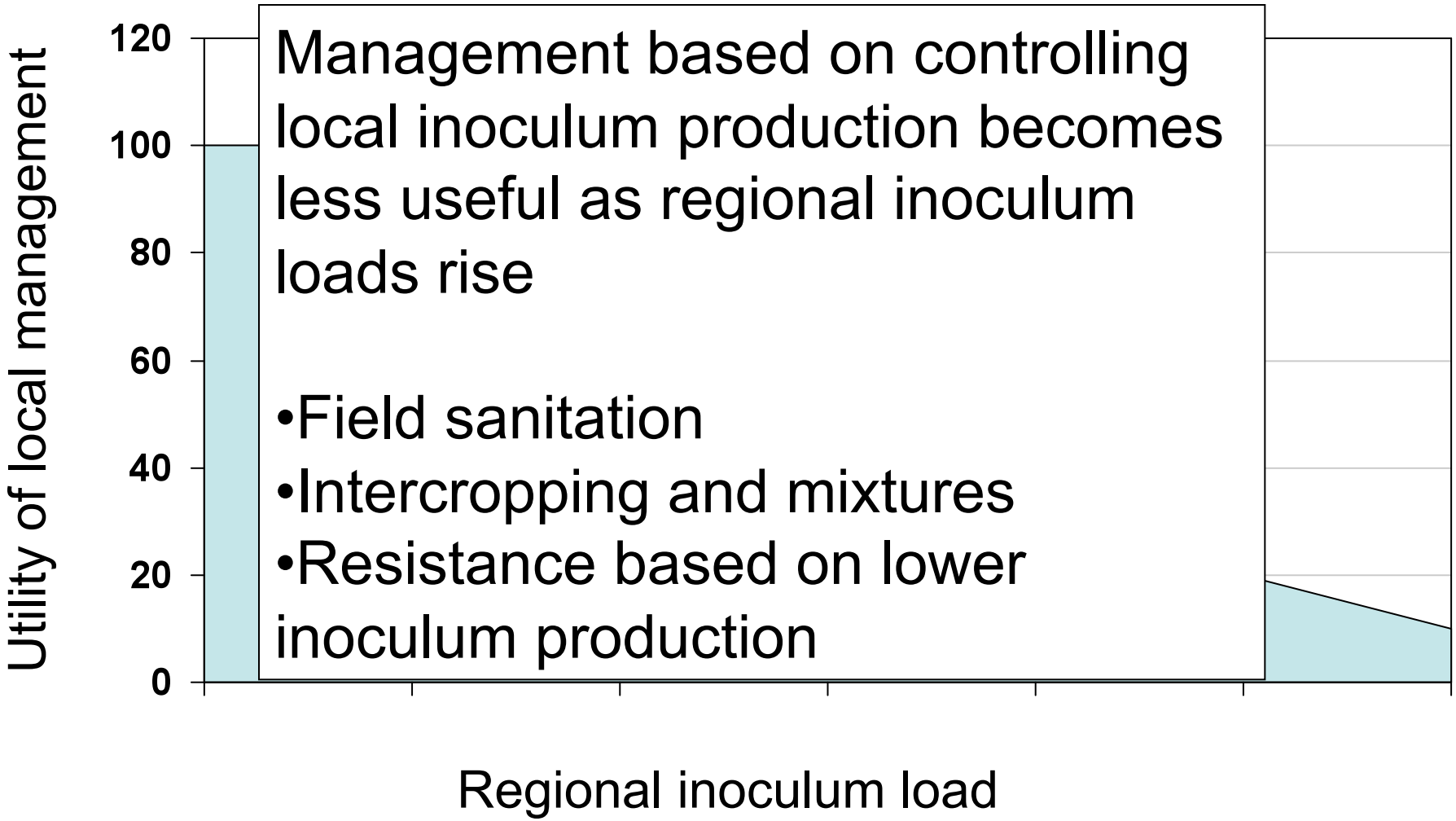
1. Are interactions likely?

- Range shifts and new combinations of pathogen and vector species
- New overlap of pathogen species can result in hybrid pathogens
- Other global change phenomena include increased movement of plant materials and so also plant diseases and pests

The local inoculum load builds during the period of disease conducive weather



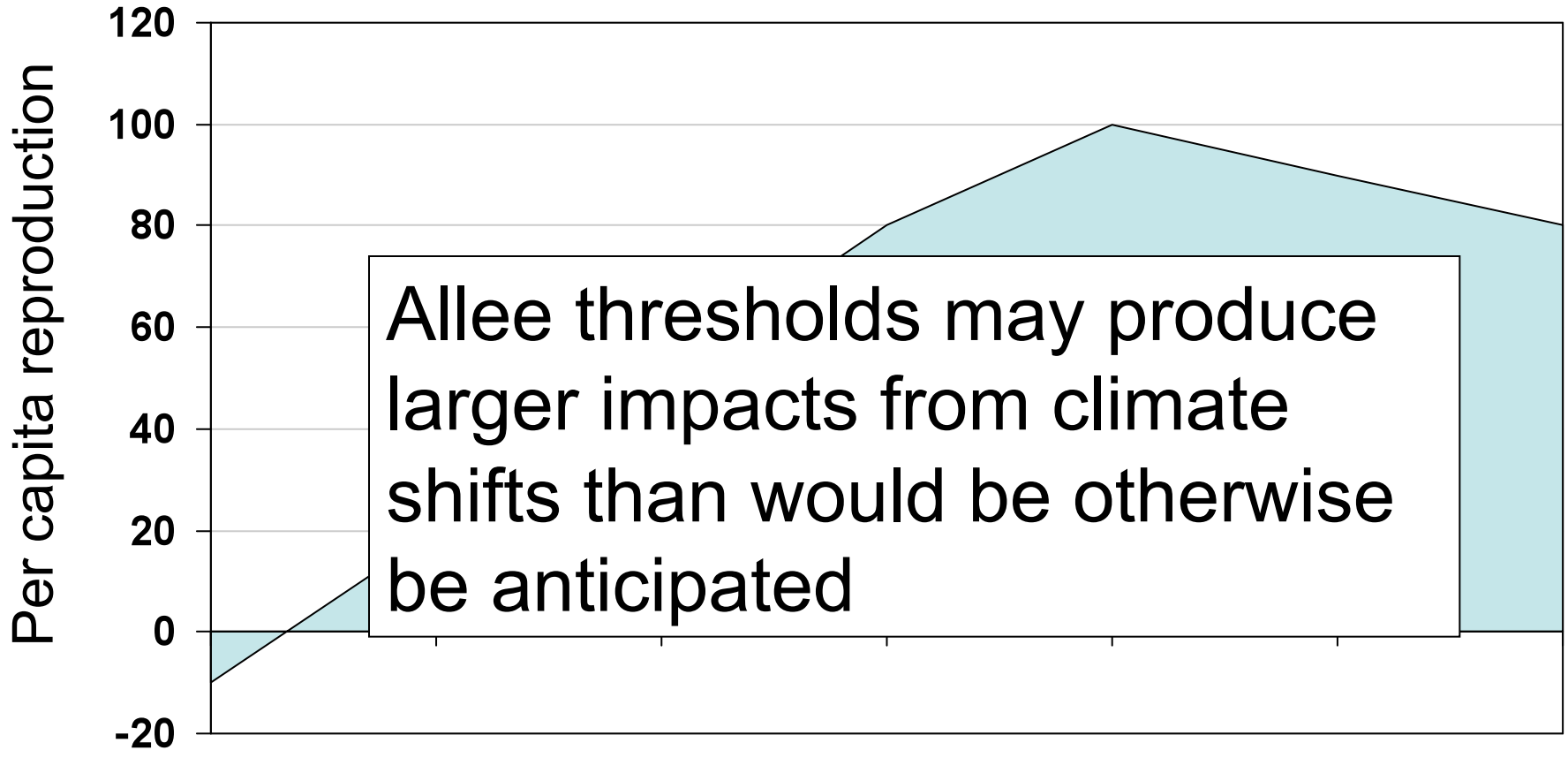
2. Are there feedback loops for management?



One of our interests is in the development of disease risk maps that incorporate geographic features such as host availability, integrated with climate features…

Margosian et al. 2009

3. Are there population thresholds?



Garrett and Bowden 2002

4. Are there indirect effects of global change?

'Orphan' crops such as quinoa, cassava, sweet potato, millets, and teff are of particular regional importance but receive relatively little research attention (Nelson et al., 2004).

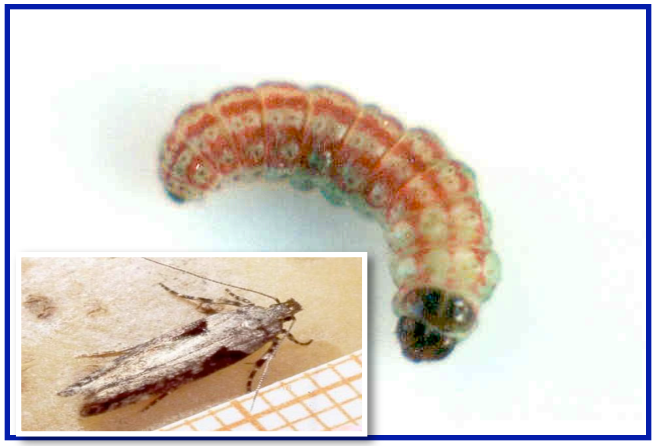
In tropical regions where food security is a particular concern, there may be greater climate variability and uncertainty combined with less investment in technologies to support crop production.

Quinoa variety trial in Bolivia

Photo: P. Motavalli

5. How do communication/tool networks compare to epidemic/dispersal networks?

- Biggest problems for management will be in scenarios where farmers have limited access to communication and tools and are confronted with a disease or pest that is new to them
- Ability to recover from shocks also depends on farmers' portfolios



The Human Factor: Farmer Knowledge

Subject	Level
Crops	High
Animals	High
Soil	High
Flora	High
Insects	Mod.
Pathogens	Low

c/o Greg Forbes

The plant health, human health and food security link

Pesticide poisoning epidemic

c/o Forbes

Conclusions

- We have developed a checklist for formulating strategies in response to climate change
- This checklist can also guide research prioritization, since good answers are not available for all important systems
  - The same research benefits current management strategies for potato late blight, Andean potato weevil, and potato tuber moth
- Tools for adaptation will include
  - Better strategies and implementation for networks of communication and tools (extension, etc.)
  - Availability of supporting resources such as crop germplasm as a source of new disease resistance genes

Tak!

Thanks for your attention

Contact information:

kgarrett@ksu.edu

For more information:

http://www.ksu.edu/pdecology/

Review of climate change and plant disease:
http://www.ksu.edu/pdecology/GarrettDendy2006ARP.pdf

Analysis of landscape connectivity:
http://www.ksu.edu/pdecology/Margosian2009.pdf