Climate Change Impacts on Insect Pests, Weeds, and Disease

Karen Garrett
Climate Change Impacts on Insect Pests, Weeds, and Disease

Karen Garrett
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Yield loss

Fig. 7. Average efficacy of pest control practices worldwide in reducing loss potential of pathogens, viruses, animal pests, and weeds, respectively (reduction rates calculated from estimates of monetary production losses in barley, cottonseed, maize, oilseed rape, potatoes, rice, soybean, cotton, sugar beet, tomatoes and wheat, in 2001–03).
What do we need to understand to adapt management to climate change?

• For growers
  – How to adapt early warning systems for within-season tactical decision making
  – How to construct longer-term (season or longer) support for decision making

• For plant breeders and pesticide developers
  – What diseases/weeds/pests to prioritize where

• For policy makers / donors
  – What the important problems are for investment in the future
  – How financial tools can buffer farmers from increased variability

• In natural systems and new biofuels systems
  – A lot… including the distribution of resistance genes
Plant Pathogens as Indicators of Climate Change

K.A. Garrett, M. Nita, E.D. De Wolf, L. Gomez and A.H. Sparks

Climate Change: Observed Impacts on Planet Earth
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A metamodeling framework for extending the application domain of process-based ecological models

A. H. Sparks, G. A. Forbes, R. J. Hijmans, and K. A. Garrett

Disease forecasting models based on weather exist for many important plant diseases, and can be rescaled for other purposes such as climate change scenario analysis.
Figure 2: Global potato late blight relative risk as predicted by ppm$_{Monthly}$ model using historic climate normals, 1961-1990 (1975 timeslice) for a susceptible genotype potato. Blight units are a predictor of biological risk based on weather and potato genotype resistance. Areas of highest risk appear in pink, areas of lowest risk appear in dark blue. White indicates limited potato production.
Figure 4: Global potato late blight relative risk as predicted by mm$_{Monthly}$ model using the A2 scenario model outputs for 2040-2060 (2050 timeslice) for a susceptible genotype potato. Blight units are a predictor of biological risk based on weather and potato genotype resistance. Areas of highest risk appear in pink, areas of lowest risk appear in dark blue. White indicates limited potato production.
Complexity in terms of the amount of information needed to adequately predict outcomes

- For example, predicting the effects of disease involves pathogen reproduction and dispersal, and multi-species interactions (in contrast to direct effects of weather on plant physiology)
Connectivity of the American Agricultural Landscape: Assessing the National Risk of Crop Pest and Disease Spread

MARGARET L. MARGOSIAN, KAREN A. GARRETT, J. M. SHAWN HUTCHINSON, AND KIMBERLY A. WITH

February 2009 / Vol. 59 No. 2 • BioScience  141
Maize

Threshold $\leq 100$

Red = connected areas for pests/disease that require at least low maize density to spread

Red = connected areas for pests/disease that require high maize density to spread
Consequences of Climate Change / CO$_2$ for Invasive Plants

**Introduction.** Warming polar regions will see increased traffic and new invasives.

**Colonization.** More frequent or severe storms provide opportunities for establishment of new invasives.

**Distribution.** Many invasives are range-limited by cold temperatures.

**Management.** Chemical control of invasive plants can be altered with rising CO$_2$ / climate.

Slide c/o L. Ziska, USDA
Does $\text{CO}_2$ preferentially select for invasive species within communities?

<table>
<thead>
<tr>
<th>Species</th>
<th>Community</th>
<th>Favored?</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow star thistle</td>
<td>California grassland</td>
<td>Yes.</td>
<td>Dukes, 2002</td>
</tr>
<tr>
<td>Honey mesquite</td>
<td>Texas prairie</td>
<td>Yes.</td>
<td>Polley et al. 1994</td>
</tr>
<tr>
<td>Japanese honeysuckle</td>
<td>Forest under-story</td>
<td>Yes.</td>
<td>Belote et al. 2003</td>
</tr>
<tr>
<td>Cherry laurel</td>
<td>Forest under-story</td>
<td>Yes.</td>
<td>Hattenschwiler &amp; Korner 2003</td>
</tr>
<tr>
<td>Red Brome</td>
<td>Desert</td>
<td>Yes.</td>
<td>Smith et al. 2000</td>
</tr>
</tbody>
</table>

Out of over 600+ Invasives in N. America alone.
Asian soybean rust....

Kudzu can serve as an alternative host for the pathogen. If warmer winters allow kudzu to move northward, what will the impact be on the spread of the disease?
Summary: Climate, CO$_2$ and Invasive weed biology

Rising CO$_2$ levels by themselves are likely to have a positive effect on the establishment and persistence of invasive species. (Cheatgrass and fire frequency)

Warmer seasonal temperatures and milder winters will extend the distribution of invasive weeds. (Kudzu and Ragweed)

Rising CO$_2$ can reduce the efficacy of herbicides (glyphosate) and management of invasive weeds. (Canada thistle and friends)
Climate change has favorable effects on insects

Body temperature is same as ambient unless absorbing sunlight

- rising winter temperatures reduce winter mortality
  - Decreased snow cover can increase mortality
- rising temperatures extend the growing season
  - Greater nutrient demands coincide with planting and fruiting of many crops
- rising temperatures accelerate insect life cycles
  - Greater generation numbers
  - Faster resistance to insecticides
- rising temperatures allow range expansion
  - Earlier migration and maturation
  - Greater winter survival
Increased CO$_2$ effects depend on insect-plant interaction

1. Increased carbon:nitrogen in plants makes for poorer forage for insects

2. Shift in plant defenses from nitrogen to carbon based
   • Fewer toxins, tougher leaves, more tannins/phenols

3. Deficiencies in micronutrients

4. Help for insects:
   • Nitrogen addition can make for better forage
   • Shift in plant defenses from nitrogen to carbon based
   • Consume more plant to make up for less nitrogen
Beetles and aphids generally perform better to the detriment of the plants.

Caterpillars generally eat more to compensate, but enhanced plant growth results in little net effect.

Slide c/o R. Srygley, USDA
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