Agricultural Outlook Forum
U.S. Department of Agriculture
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Climate Change Impacts on Insect Pests, Weeds, and Disease

Karen Garrett

Photo: Jin

Climate Change Impacts on Insect Pests, Weeds, and Disease

Karen Garrett

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Yield loss

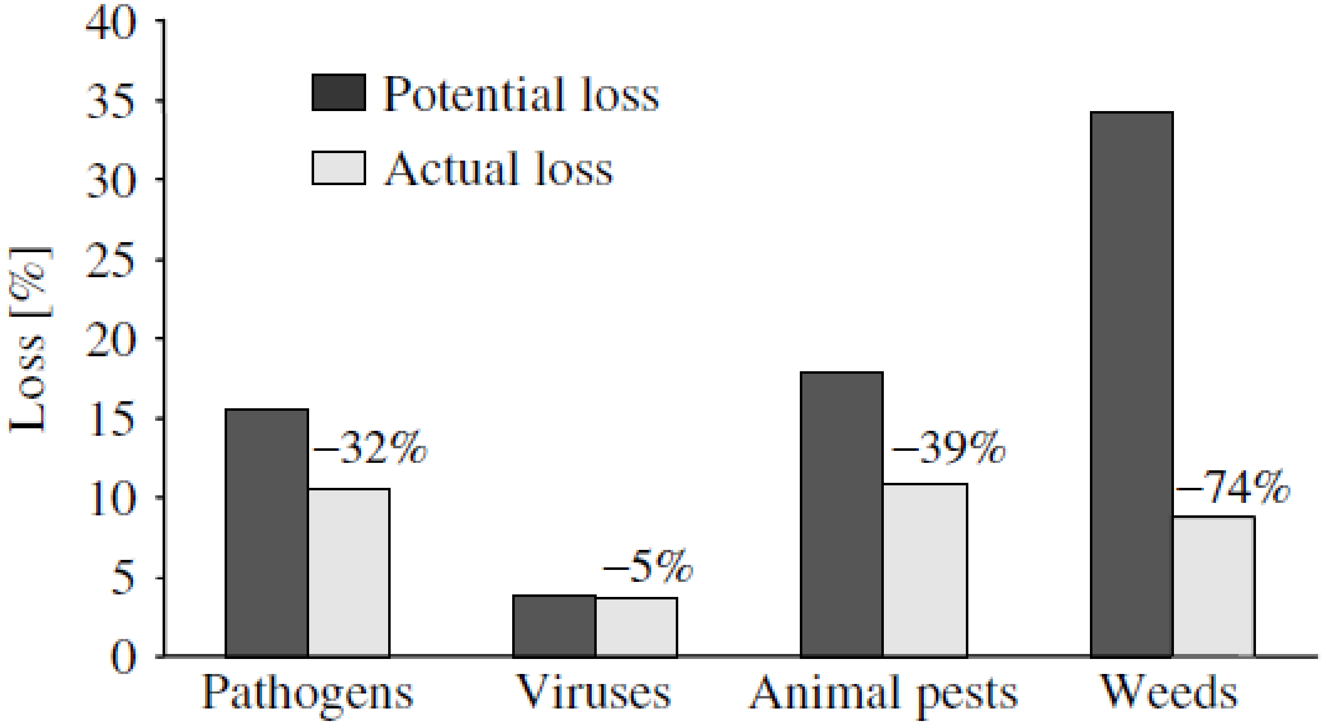


Fig. 7. Average efficacy of pest control practices worldwide in reducing loss potential of pathogens, viruses, animal pests, and weeds, respectively (reduction rates calculated from estimates of monetary production losses in barley, cottonseed, maize, oilseed rape, potatoes, rice, soybean, cotton, sugar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

Oerke 2006

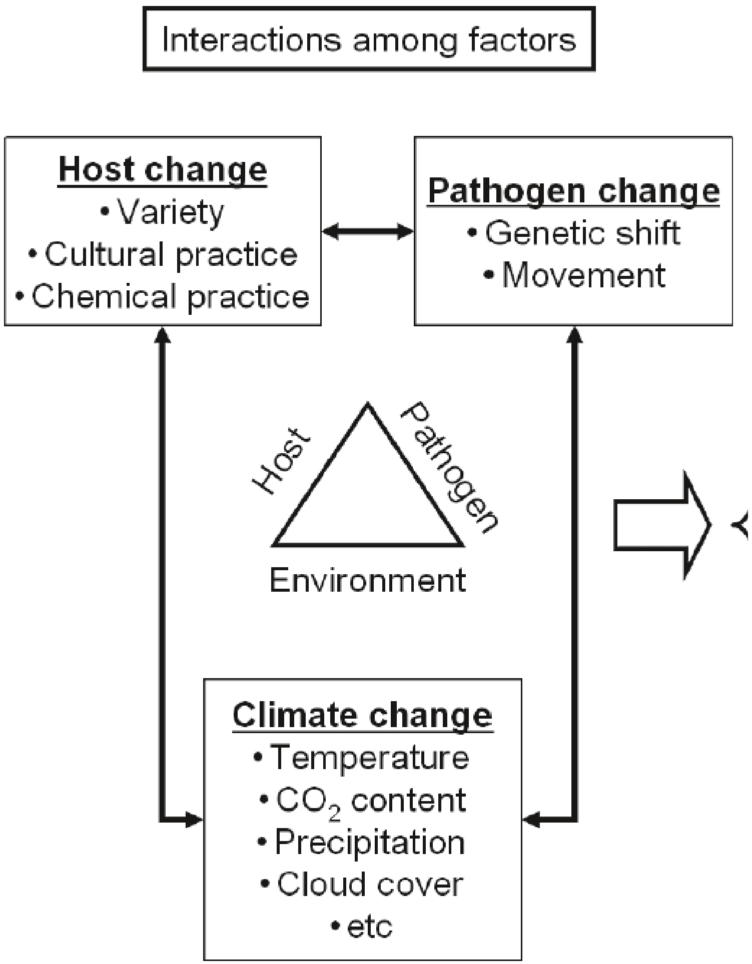
What do we need to understand to adapt management to climate change?

- 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

Climate Change: Observed Impacts on Planet Earth

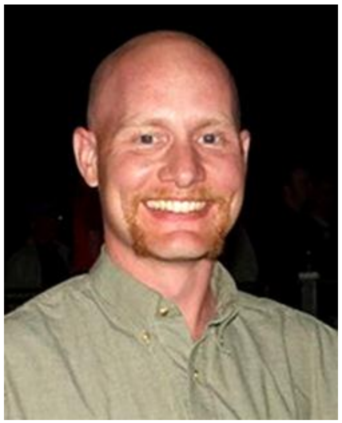
K.A. Garrett, M. Nita, E.D. De Wolf, L. Gomez and A.H. Sparks



esa 2011 ECOSPHERE

A metamodeling framework for extending the application domain of process-based ecological models

A. H. Sparks,[1,4] G. A. Forbes,[2] R. J. Hijmans,[3] and K. A. Garrett[1,†]



Adam Sparks

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

Estimated Potato Late Blight Risk

For current potato production regions

Adam Sparks, R. Hijmans, G. Forbes, K. Garrett

1961-1990

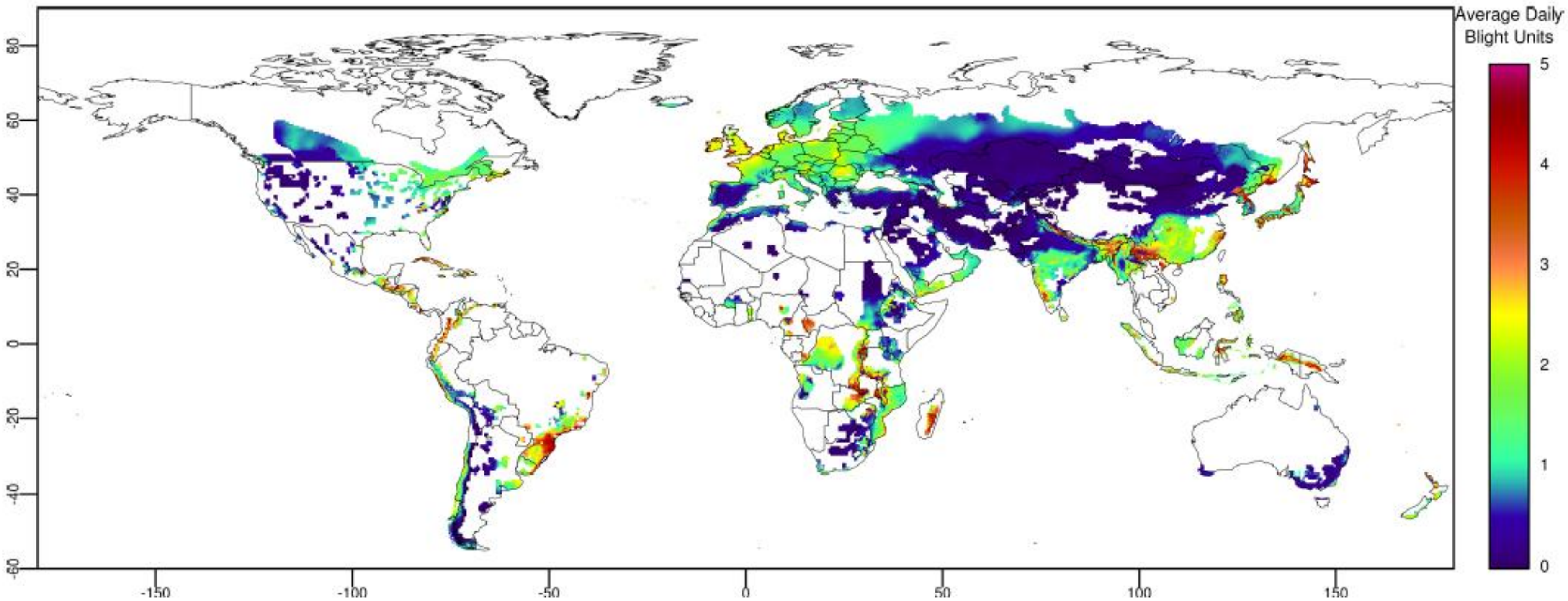


Figure 2: Global potato late blight relative risk as predicted by $mm_{Monthly}$ model using historic climate normals, 1961-1990 (1975 timeslice) for a susceptible genotype potato. Blight units are a predictor of biological risk based on weather and potato genotype resistance. Areas of highest risk appear in pink, areas of lowest risk appear in dark blue. White indicates limited potato production.

Estimated Potato Late Blight Risk

For current potato production regions

Adam Sparks, R. Hijmans, G. Forbes, K. Garrett

2040-2060 (A2 scenario)

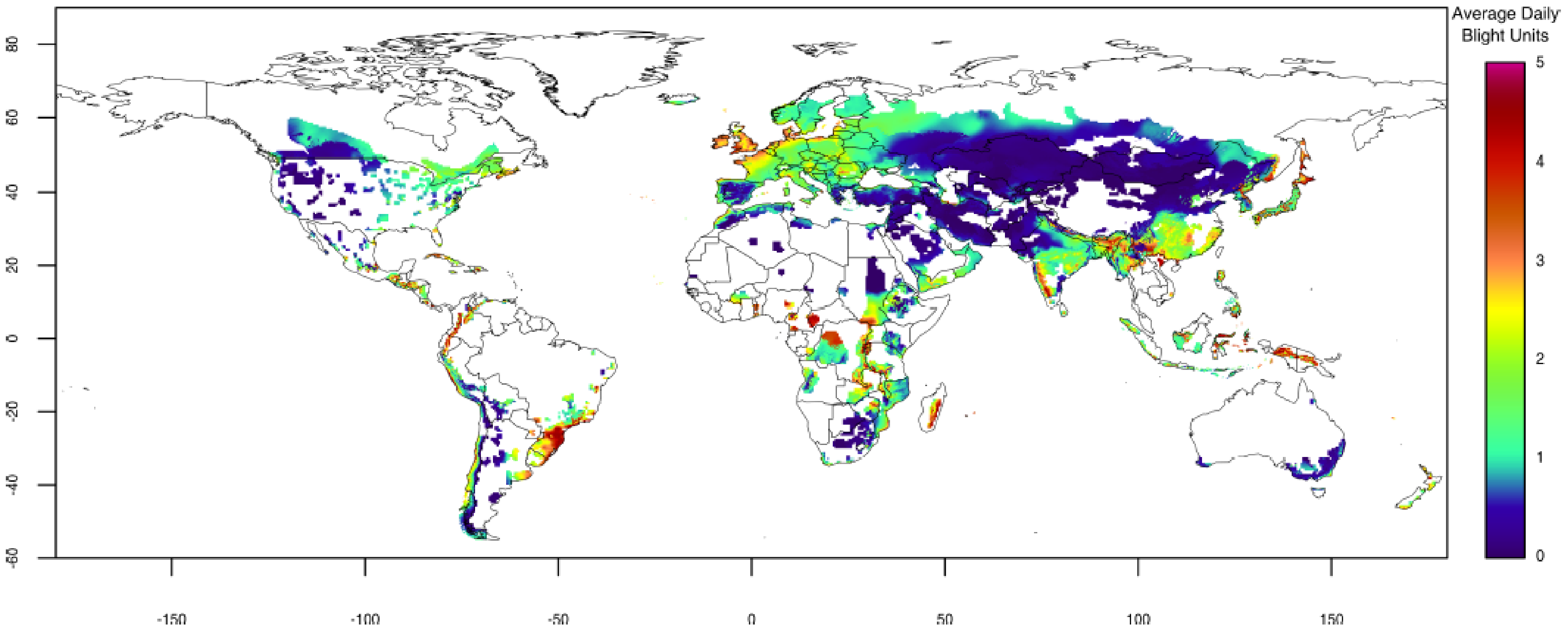


Figure 4: Global potato late blight relative risk as predicted by $mm_{Monthly}$ model using the A2 scenario model outputs for 2040-2060 (2050 timeslice) for a susceptible genotype potato. Blight units are a predictor of biological risk based on weather and potato genotype resistance. Areas of highest risk appear in pink, areas of lowest risk appear in dark blue. White indicates limited potato production.

Plant Pathology (2011) **60**, 15–30 Doi: 10.1111/j.1365-3059.2010.02409.x

REVIEW

Complexity in climate-change impacts: an analytical framework for effects mediated by plant disease

K. A. Garrett[a], G. A. Forbes[b], S. Savary[c], P. Skelsey[a], A. H. Sparks[a], C. Valdivia[d], A. H. C. van Bruggen[e], L. Willocquet[c], A. Djurle[f], E. Duveiller[g], H. Eckersten[f], S. Pande[h], C. Vera Cruz[c] and J. Yuen[f]

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

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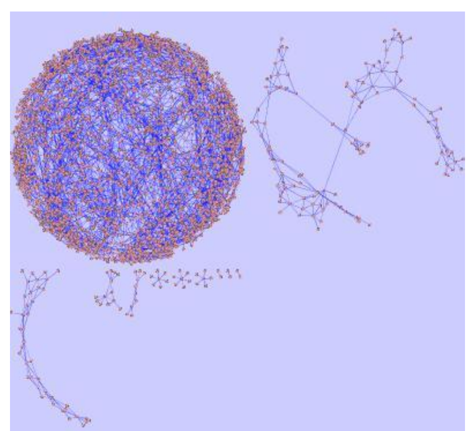
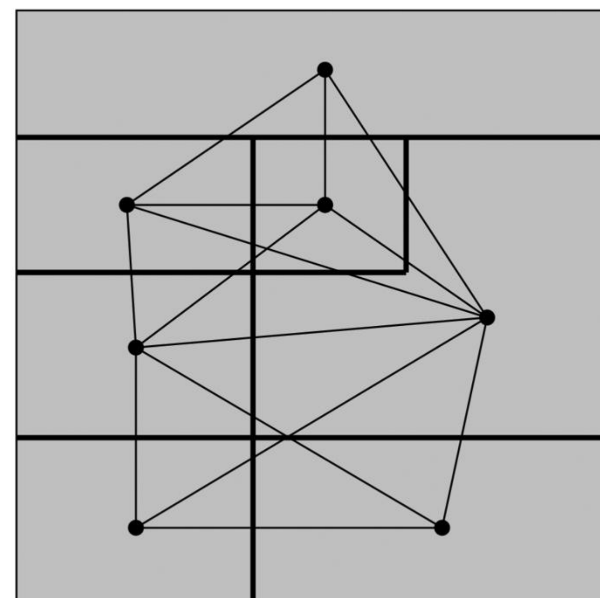
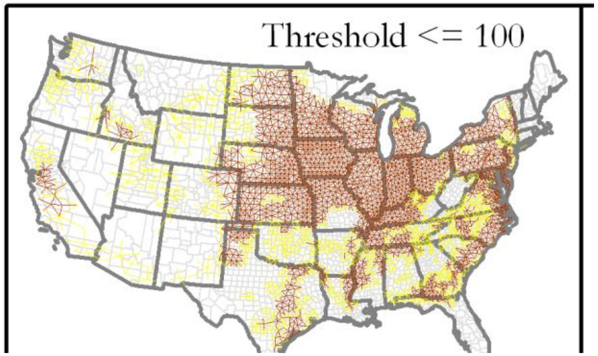




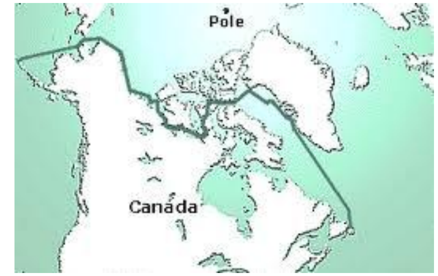
Maize



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 provides 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 CO_2 preferentially select for invasive species within communities?

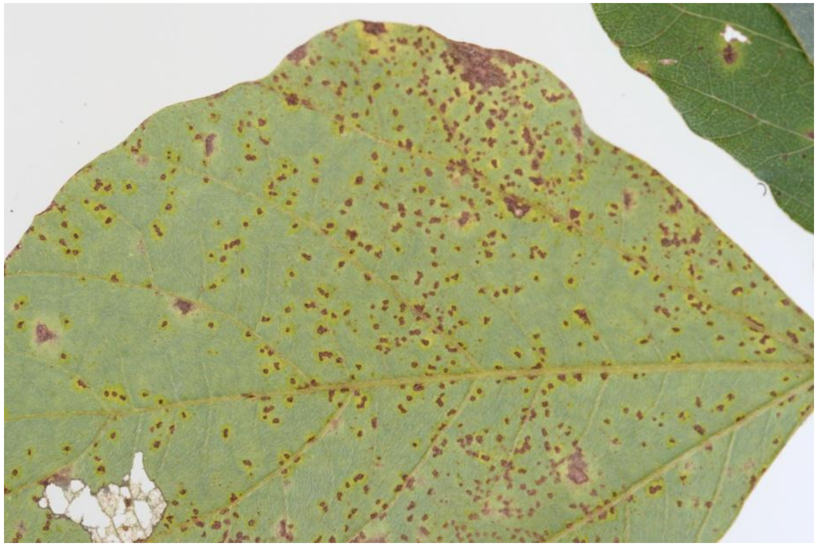
Species	Community	Favored?	Reference
Yellow star thistle	California grassland	Yes.	Dukes, 2002
Honey mesquite	Texas prairie	Yes.	Polley et al. 1994
Japanese honeysuckle	Forest under-story	Yes.	Belote et al. 2003
Cherry laurel	Forest under-story	Yes.	Hattenschwiler & Korner 2003
Red Brome	Desert	Yes.	Smith et al. 2000

Out of over 600+ Invasives in N. America alone.

Slide c/o L. Ziska ,USDA

Asian soybean rust….

Soybean



Kudzu

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?

Slide c/o L. Ziska ,USDA

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)

Slide c/o L. Ziska ,USDA

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

Slide c/o R. Srygley ,USDA

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*

Slide c/o R. Srygley ,USDA

Order	Herbivore Species	Host Species	Effect
Acarina	*Tetranychus urticae* (red spider mite)	*Trifolium repens*[1] (white clover) *Gossypium hirsutum*[2] (upland cotton) *Phaseolus vulgaris*[3] (kidney bean)	- - +
Coleoptera	*Popillia japonica* (Japanese beetle)	*Glycine max*[4] (soybean)	-
	Diabrotica virgifera (Western corn rootworm)	*Glycine max*[5] (soybean)	-
	Sitona lepidus (clover root weevil)	*Trifolium repens*[6] (white clover)	-
Diptera	*Pegomya nigritarsis* (leaf-mining fly)	*Rumex crispus* (invasive dock) *R. obtusifolius*[7] (invasive dock)	- -
	Chromatomyla syngenesiae (leaf-mining fly)	*Sonchus oleraceus*[8] (invasive sow thistle)	+
	Bemisia tabaci (sweet potato white fly)	*Gossypium*[9-11] (cotton)	Ø
Hemiptera	*Aulacorthum solani* (glasshouse potato aphid)	*Vicla faba*[12] (broad bean)	-
	Stiobion avenae (grain aphid)	*Triticum aestivum*[13] (spring wheat)	-
	Myzus persicae (green peach aphid)	*Poa annua*[14] (grass) *Brassica napus*[15] (oilseed rape)	- +
	Brevicoryne brassicae (cabbage aphid)	*Brassica napus*[15] (oilseed rape)	Ø
	Aphis glycines (soybean aphid)	*Glycine max*[5,16] (soybean)	-
Hymenoptera	*Aphidius matricariae* (green peach aphid parasitoid)	*Poa annua*[14] (grass)	Ø
Lepidoptera	*Pseudoplusia includens* (soybean looper)	*Glycine max*[17] (soybean)	-
	Trichoplusia ni (cabbage looper)	*Phaseolus lunata*[18] (lima bean)	Ø
	Spodoptera eridania (southern armyworm)	*Mentha piperita*[19] (peppermint)	Ø
	Spodoptera frugiperda (fall armyworm)	*Festuca arundinaceae*[20] (tall fescue)	Ø
	Pectinophora gossypiella (pink bollworm)	*Gossypium hirsutum*[21] (upland cotton)	Ø
	Helicoverpa armigera (cotton bollworm)	*Gossypium*[22] (cotton)	+

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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