Pesticide use and biodiversity

Glyphosate reduced Corn Belt milkweeds by over half, and monarch butterfly egg production by 81 percent.

Neonicotinoid insecticide seed treatments have largely replaced insecticide sprays in Bt maize.
HT crops and glyphosate-resistant weeds

Nationwide at least 10-15 million acres infested

Cumulative increased pesticide use through 2009:
~ 383 million lbs.
Source: Benbrook, 2009

Horseweed (Coneyza canadensis)
confirmed and suspected glyphosate-resistant weeds

- Gly-R common ragweed
- Gly-R giant ragweed
- Gly-R waterhemp

Black symbols: confirmed resistant cases; Blue: highly suspected
confirmed and suspected glyphosate-resistant weeds

2009

25 to 40% soybean fields gly-R C. Rag.

30 to 95% all fields have gly-R G. Rag.

5 to 20% all fields gly-R waterhemp

10 to 30% soybean fields gly-R C. Rag.

30 to 60% all fields gly-R C. Rag.

• Gly-R common ragweed
• Gly-R giant ragweed
• Gly-R waterhemp

Black symbols: confirmed resistant cases; Blue: highly suspected
Bryan Young, weed scientist at Southern Illinois University, estimates that glyphosate-resistant waterhemp has invaded 5-6 million acres in a wide swath across the state.

- Lawton, *Corn and Soybean Digest*, 2012
Multiple herbicide resistance -- Waterhemp

- Some are resistant to 3 herbicides
- Resistance to 2,4-D and isoxaflutole

“Glufosinate may soon be the only effective postemergence herbicide option for *A. tuberculatus* control in soybean, and this herbicide has several limitations.”

- Tranel et al., J. Ag Food Chem.
Glyphosate-resistant pigweed

“…Culpepper and other experts say the [glyphosate-resistant] palmer amaranth could be the worst threat to cotton since the boll weevil.”
FIGURE 3. No-Till Acreage Devoted to Corn in the United States

Source: Conservation Technology Information Center 2010.

- **Problem**: Herbicide-resistant weeds

- **Solutions**
  - New herbicide-resistant crops
  - Integrated weed management

- **Short-term**
  - Intensification of selection pressure
  - Increase in herbicide use
  - Sole use of herbicides
  - Reduction of selection pressure
  - Decrease in herbicide use
  - Use of multiple practices

- **Long-term**
  - Increase in resistant weeds
  - Increase in nontarget effects
  - Fewer control options
  - Reduction in the severity of resistant weeds
  - Environmental quality increases
  - Preservation of knowledge
Insect resistance to Bt crops

Insecticide use lower, but...

Resistance is developing in rootworm and several other insects

Regulatory failure by EPA, intransigence by Monsanto

Cross resistance in bollworm in China

Corn rootworm adult
GE encourages a simplified, unsustainable approach to agriculture

“Unfortunately, the knowledge infrastructure needed to practice IWM [Integrated Weed Management] in the future may be atrophying.”

“The current lack of integration of management tactics for insect pests of maize in the U.S. Corn Belt, due primarily to the escalating use of transgenic Bt hybrids, may eventually result in resistance evolution and/or other unforeseen consequences.” [emphasis added]
Adding complexity: Non-insecticide alternatives to Bt maize

Conventional breeding, including genomics…Conventional rootworm resistance

Organic production - ~18 time fewer corn borer eggs.
Source: Phelen et al.

Crop rotation – Wheat preceding corn reduces rootworm damage
Real solutions now: Cover crops...

Suppress weeds, provide habitat for biocontrol control organisms, reduce pathogens
Table 6. Mean corn yield over the years 2008–2010.

<table>
<thead>
<tr>
<th>Rotation system</th>
<th>Management strategy</th>
<th>GE (Mgha⁻¹)</th>
<th>Non-GE (Mgha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-year</td>
<td>GE</td>
<td>12.49</td>
<td>11.82</td>
</tr>
<tr>
<td>3-year</td>
<td>GE</td>
<td>12.59</td>
<td>12.43</td>
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<tr>
<td>4-year</td>
<td>GE</td>
<td>12.82</td>
<td>12.75</td>
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<tr>
<td>SE</td>
<td>GE</td>
<td>0.24</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Source: Gomez et al., *Renew. Ag. Food Systems*, 2012

Reduction in herbicide use by ~ 90% or more
Multifunctional agroecology in developing countries

Breeding, GE and genetic diversity

Large reserve of untapped diversity

Breeding continues to outperform GE

Wheat Fitch-Margoliash relatedness tree based on Roger’s measure of genetic distance.
- From Reif et al. 2005. Theoretical and Applied Genetics
Pleiotropy: Unintended effects

*era1* for drought tolerance also controls the function of many other proteins
– Including disease resistance

*Credit: Jorge Vivanco, Colorado State University*
Unintended pleiotropy - NUE

Engineering with the ALA gene causes reduced function of several crop disease-defense genes.
GE Pest Resistance…

✓ GE encourages biologically simplified farm landscapes, *leading to resistant pests*

✓ Research and policy needs to emphasis agricultural methods and systems that increase cropping system and landscape complexity, which reduces pest pressure: Agroecology