Agriculture & Climate Change:

MEETING THE CHALLENGES

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21st Century Agriculture: Intensification

- 2050 world population: 9+ billion
- Decreasing land area for cultivation
- Soil degradation
- Water: quantity & quality
- Nutrient availability & management
- Increasing production expenses
- Multifunction landscapes: ecosystem services
Agriculture Marches On:

- Industrial Revolution: Mechanization
  - Large areas – *Fast!*
- “Green Revolution”
  - Crop genetics focus – *Continues!*
- Information Revolution: Precision agriculture
  - Spatial & temporal variability
    - Yields & limiting factors
- *Traditional challenges to production still exist.....and......now*
Climate Change

- National Climate Assessment document
- Science literature *synthesis* update (2009-2012: 1400+ references)
- Foundation for risk analysis, future NCA
- Peer reviewed “Readable Desk Reference”
- Created *Community* of scientists
  - USDA- ARS
  - Universities & Industry
  - >55 contributors

- No Mitigation: see CAST Report:

Abiotic Effects....

- Changes of precipitation patterns
  - Some places drier, others wetter
  - Decreased snowfall & timing of snow melt
- Greater variability of precipitation
  - More short, intense events
  - Shift of timing of events
- More severe weather events
  - Hail, storms, wind, etc.
WATER

Not enough

Too much, too fast

Ground water & soil moisture recharge

Competition: urban & agriculture
Agroecosystem System Effects

• Soil
  • Water & wind erosion losses
  • Loss of nutrients, carbon
  • Soil biology functions affected

• Ecosystem Services
  • Watershed: ground water recharge & irrigation
  • Pollinator life cycles: Timing & shifts of populations
  • Biodiversity: wildlife
  • Carbon sequestration
  • Recreation
Biotic Effects

- Enhanced CO$_2$ fertilization
- Changing habitats

*Weeds, vines, invasive plants, Insects, Pathogens, Animals*

Overwintering vs die-off

Cheatgrass fire hazard?

C:N ratio + resistance?

C:N ratio + lodging?

Herbicide effectiveness??

Nutrient poor forage?
Beneficial Effects: Abiotic

- Reduced incidence of frost
- Increased concentrations of phenolic compounds
- Decreased water: Better Red Wine???

Too warm for pests & pathogens?
Increased Biotic Stresses

- **Insect pests**
  - Greater numbers, increased insecticide resistance
  - Geographic ranges increases & decreases
  - Imports from foreign sources

- **Pathogens**
  - Host-pathogen response changes (plants, insects, non-crop reservoirs)
  - Cultural control measures may be less reliable
  - Extreme events can spread

- **Weeds**
  - Increased vigor, herbicide resistance
  - Geographic range increases & decreases

*Effects on Production Costs???*
Livestock Production is Vulnerable

• Feed Grain & Forage
  – Quantity & **Quality Decrease**
  – **Production Cost Increase**

• Animal Heat & Humidity Stress
  – Reduces growth, reproduction, production (meat, dairy, eggs)
  -- Climate control costs increase

• Disease & Pests
  – Frequency, intensity, distribution
  – Abundance and/or distribution of competitors, predators, & parasites of vectors themselves
## Extreme Events*

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Location</th>
<th>Economic Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Missouri River Flooding</td>
<td>Upper Midwest (MT, ND, SD, IA, KS, MO)</td>
<td>$2.0 Billion</td>
</tr>
<tr>
<td>2011</td>
<td>Mississippi River Flooding</td>
<td>Lower Mississippi River (AR, TN, LA, MS, MO)</td>
<td>$1.9 Billion</td>
</tr>
<tr>
<td>2011</td>
<td>Heat/Drought</td>
<td>Southern Plains, Southwest</td>
<td>$10 Billion</td>
</tr>
<tr>
<td>2009</td>
<td>Drought</td>
<td>Southwest/Great Plains (CA, TX, GA, TN, NC, SC)</td>
<td>$5.3 Billion</td>
</tr>
<tr>
<td>2008</td>
<td>Flooding</td>
<td>Upper Midwest (IA, IL, IN, MO, MN, NE, WI)</td>
<td>$15.8 Billion</td>
</tr>
</tbody>
</table>

Currently, NCDC estimates that the cost of the 2012 drought that affected much of the U.S. had an economic impact of $12B. This estimate was not reviewed or available prior to publication of this report, however, and may change.

* Extreme events have been shown to be more probable than 40–50 years ago. However, one cannot attribute any single event to climate change alone.
Take Home Messages.....

- *Effects will continue:* Abiotic & Biotic
  - *Yield quantity & quality*
  - *Cost of production*

- *Effects to intensify:* beyond 20-30 years
- *Generations:* Future farming & climate different
- *Risk Management:* More climate & weather
- *Natural resources base:* soil, water, air
- *Ecosystem services:* pollinators, biodiversity
Adaptation

- Current practices can offset *some* effects over next 20-30 years: *but not all*
- Environment, economics, social systems: interactions affect *decision making & consequences*
- Decision criteria: farm-level costs/benefits, perception of risk, access to *actionable* information
- Roles for *Adaptation Planning & Adaptive Management*
- Develop climate friendly *crops & production systems*
- *Balanced research*: Genomics + Environment + Management

*Can enhanced rates of crop improvement be realized by a more integrated approach?*
A Framework for Research

- Address **Vulnerability** to climate change
  - Understand **Exposure**
    - *What parts of agriculture can be affected?*
  - Understand **Sensitivity**
    - *How much will agriculture be affected?*
  - Enhance **Adaptive Capacity**
    - *Strengthen how agriculture can adjust to moderate potential damages, take advantage of opportunities, cope with consequences*

(IPCC, 2001)
How do we enhance adaptive capacity?

- **Genomics x Environment x Management**

- **Genomics:** Variety

- **Environment:** Abiotic & biotic effects on agriculture & effects of agriculture on environment

- **Management:** Production practices Soil management
Soil Quality/Soil Health/ Soil Security: Nutrient Management

- Inorganic
- Organic
- Liquid
- Encapsulated/slow release
- Innoculants
- Paired Innoculant-crop combinations
- Other soil-biology oriented: biotic fertilizers

Promising signs for sustainability....
Mounting evidence points to benefits of managing soil biology component of soil health

Crop Genomics + Management Practices
- Nutrient Management Focus on Soil Biology

The Next Revolution for Agriculture?
A Challenge to Business as Usual for Science Community

G x E x M

Collaboration & development of communities are key…….

Can we “staff” challenges with multiple disciplines ~ Mayo Clinic?

What will success look like when we do this?
Climate Change & Agriculture: Challenge to Sustainability*

- Satisfy *human needs* for food, feed, and fiber, and contribute to biofuel
- Enhance *environmental quality* and the resources base
- Sustain *economic viability* of agriculture
- Enhance the *quality of life* for farmers, farm workers, and society as a whole

*NAS, 2010 definition by its goals*
Thank you

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