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

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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*

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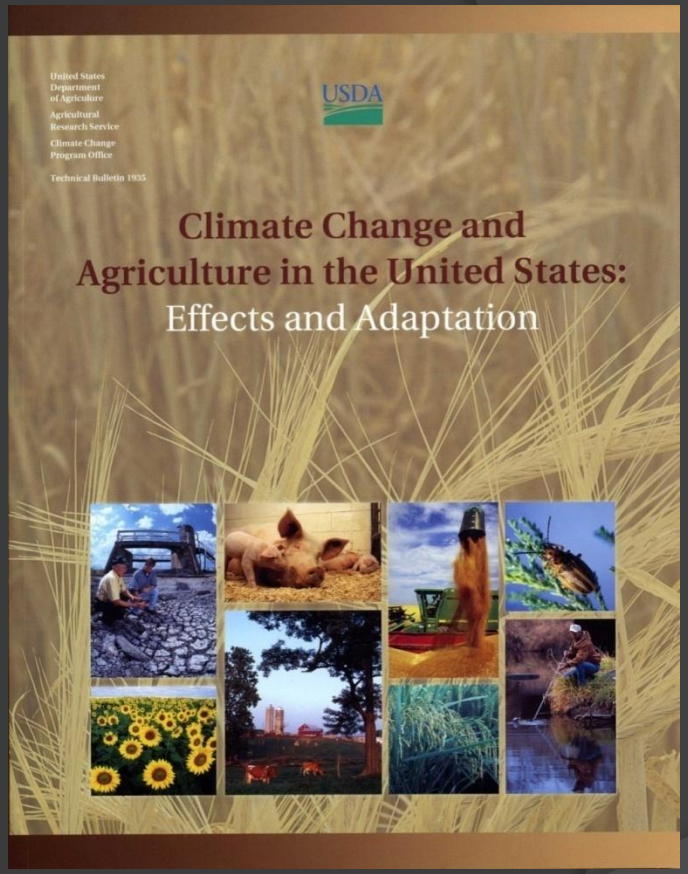
Climate Change

- 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:



http://www.usda.gov/oce/climate_change/effects_2012/effects_agriculture.htm

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.

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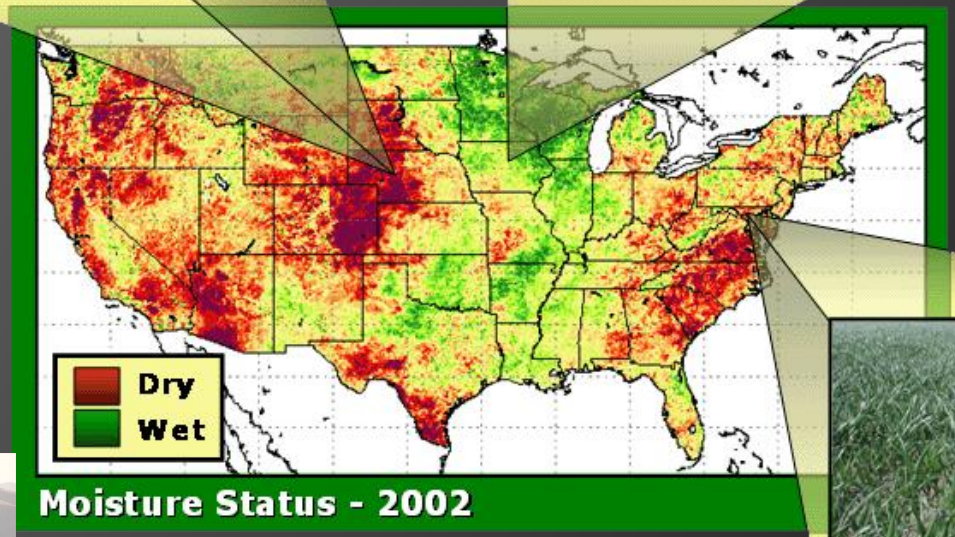
WATER

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

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Biotic Effects

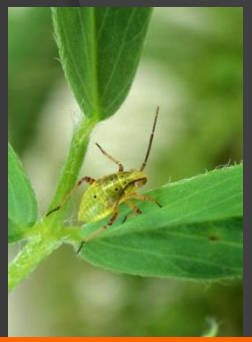
- **Enhanced CO_2 fertilization**
- Changing habitats

Weeds, vines, invasive plants, Insects Pathogens, Animals

Cheatgrass fire hazard?

C:N ratio + resistance?

C:N ratio + lodging?

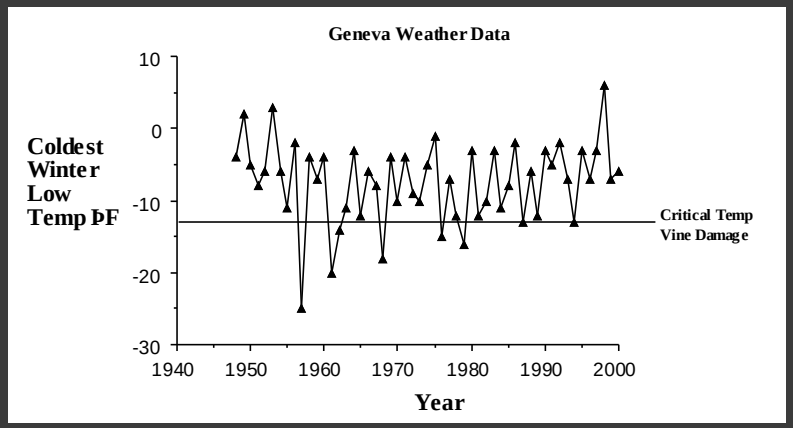


Herbicide effectiveness??

Overwintering vs die-off

Nutrient poor forage?

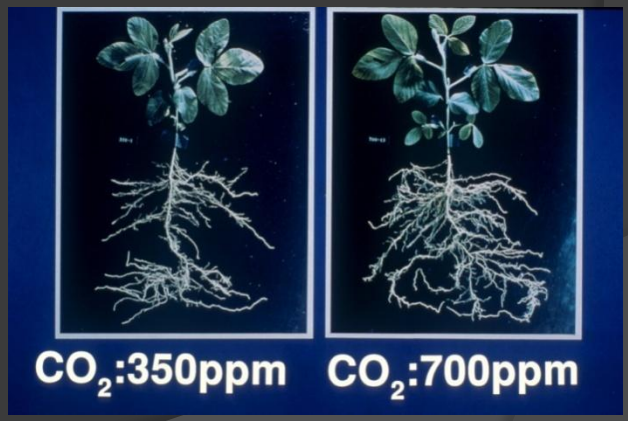
Beneficial Effects: Abiotic



Reduced incidence of frost

Too warm for pests & pathogens?

Increased concentrations of phenolic compounds



Decreased water: Better Red Wine????

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

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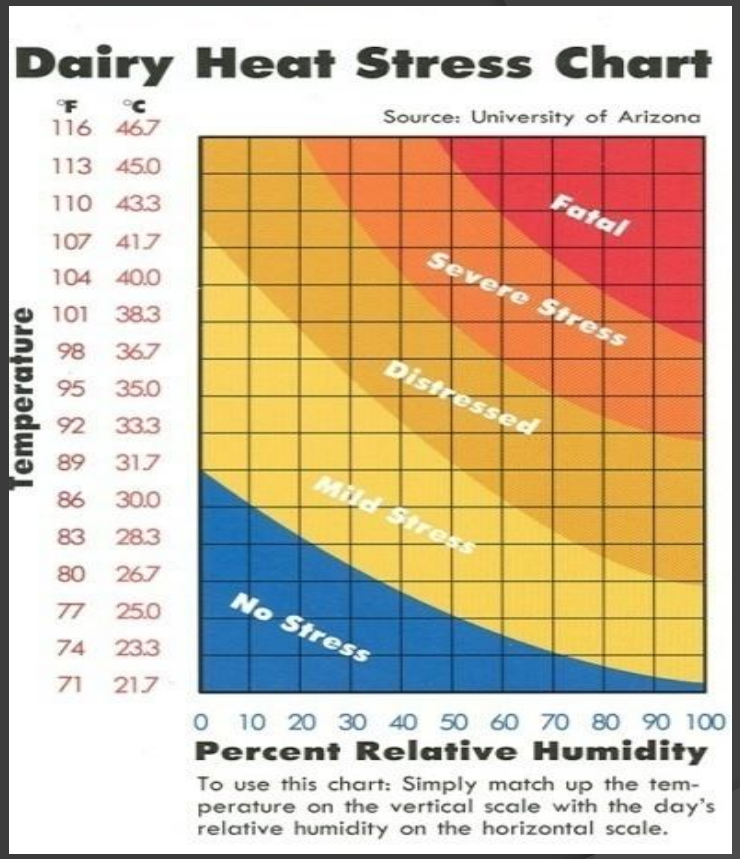
*Effects on Production **Costs**???*

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



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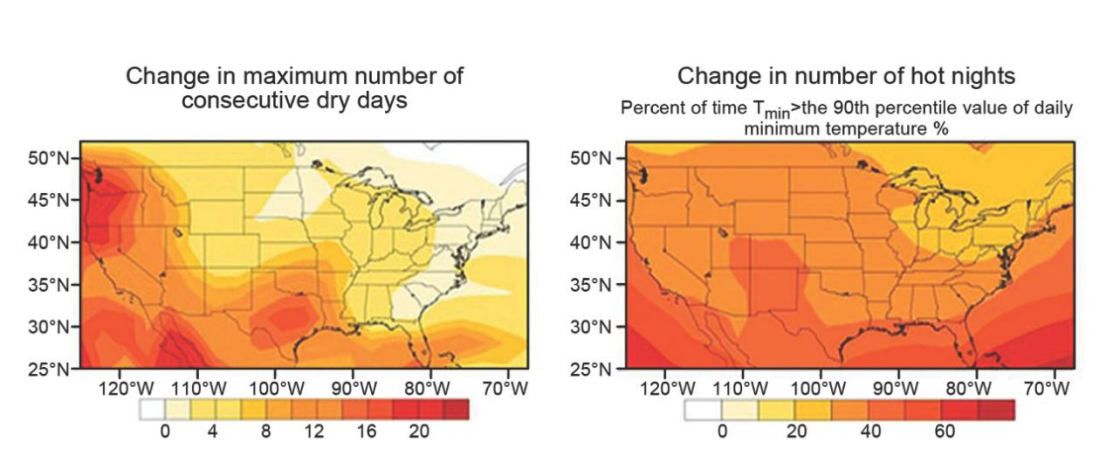
Extreme Events*



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

NCDC 2011

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

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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?

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HOW DO THIS?????
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)

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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

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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….

Why do these work?
How do these work?

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Soil Health: physical, chemical, biological

- *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?

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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?

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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

Metrics!

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* *Quantity & Quality*

*NAS, 2010 definition by its goals

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Thank you

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