Climate Change & Agriculture: Effects & Adaptation

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Agriculture Climate Change Science*

- *Mitigation* = reducing the impact of agriculture & associated activities on climate
  - Greenhouse gas management (N_2O, NH_4)
  - Carbon sequestration
- *Effects* = understanding the impact of climate change on agriculture
- *Adaptation* = enable sustainable agriculture under changing climate
  - *"Effects & Adaptation"*

*Will use US examples, however Principles apply globally…

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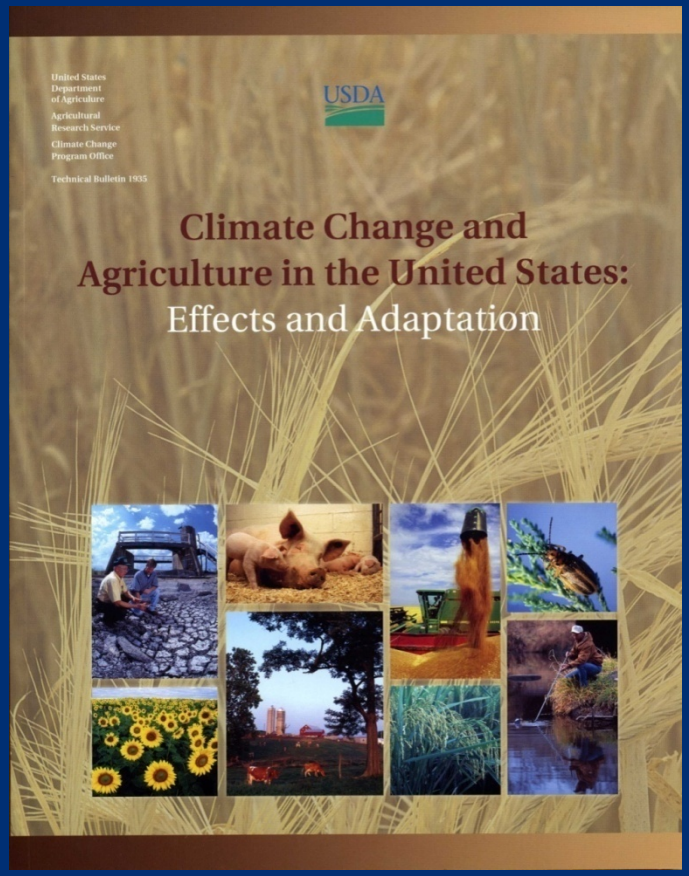
Climate Change & Agriculture: Effects & Adaptation

- Reference document for National Climate Assessment agriculture section
- Science synthesis update: 1400+ references)
- Foundation for risk analysis, future NCA
- Peer reviewed "Desk Reference"
- Created *Community* of scientists
  - USDA- ARS
  - Universities & Industry
  - >55 contributors



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

Will not address mitigation today: See CAST Document

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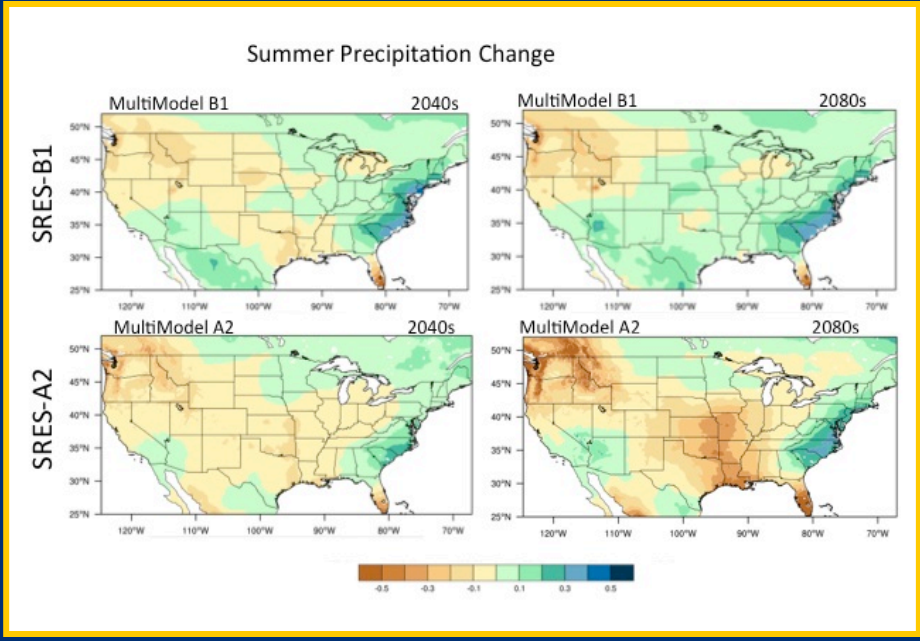
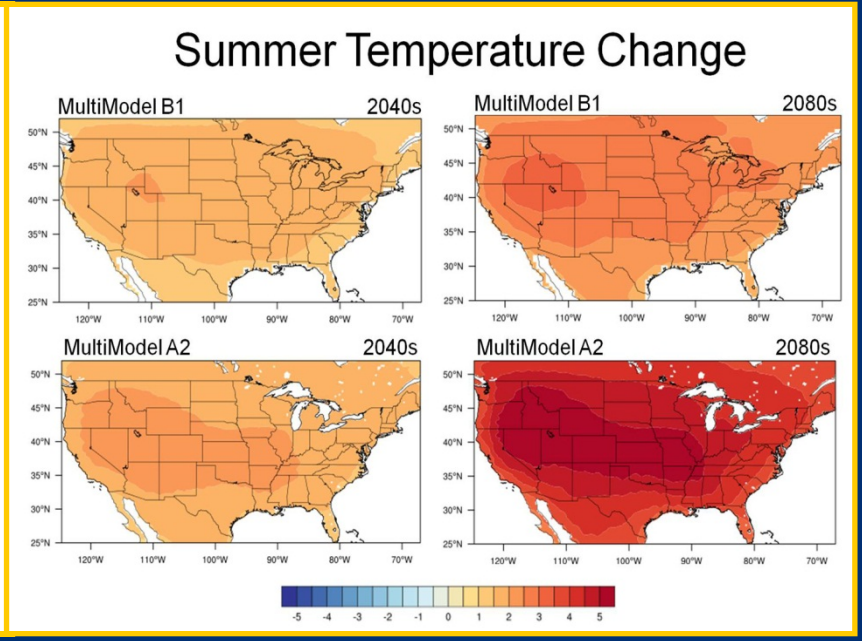
Changing Climate Conditions





- Temperature* increases: longer growing seasons, less frost, warmer nights
- Precipitation* changes: deficits, excesses, timing shifts, changing mix of rain/snow
- Increased intensity of precipitation events*: more flooding and more droughts
- Increasing carbon dioxide concentrations

**Variability Increasing*

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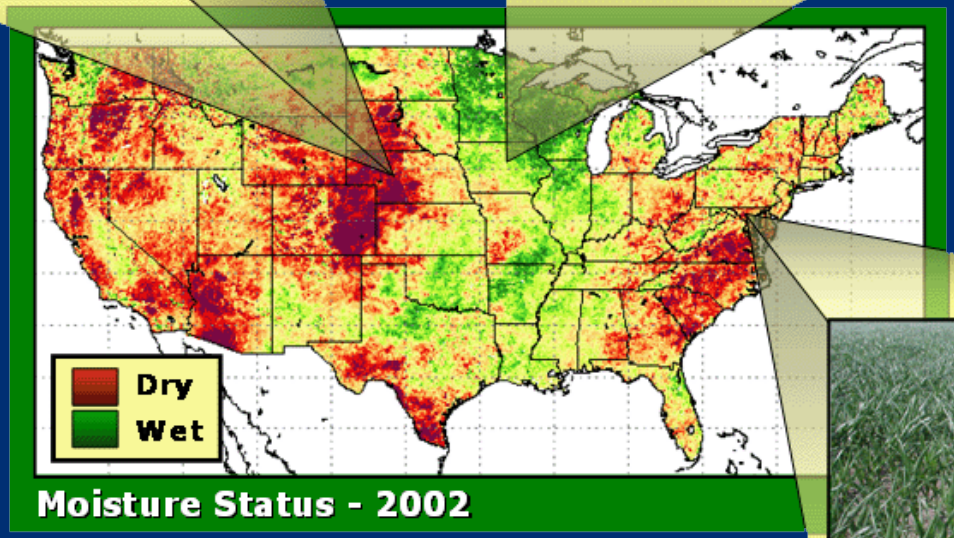
Water

Drought

Too much, too fast?



Ground water & soil moisture recharge??

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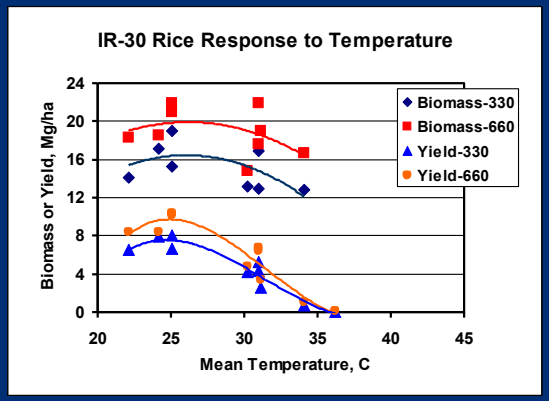
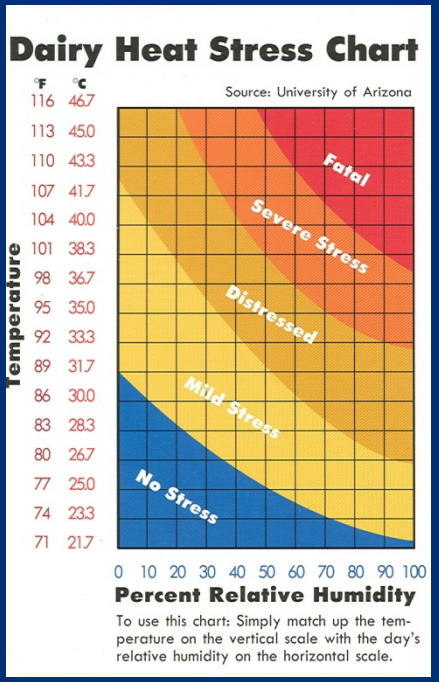
Abiotic Impacts

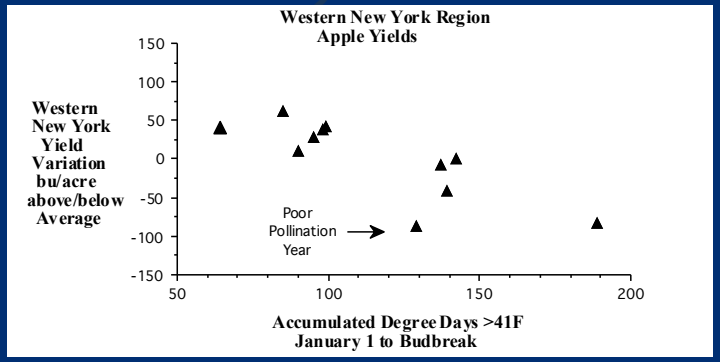


Plant stress: yield

Pollinators



Animal stress



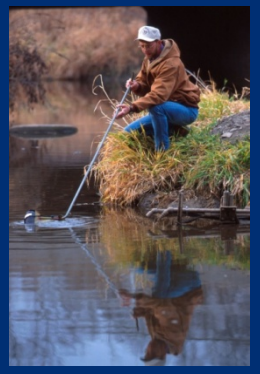
Pollination

Erosion

Air quality

Access to fields
Planting dates
Soil temperature

Food quality



Water quality

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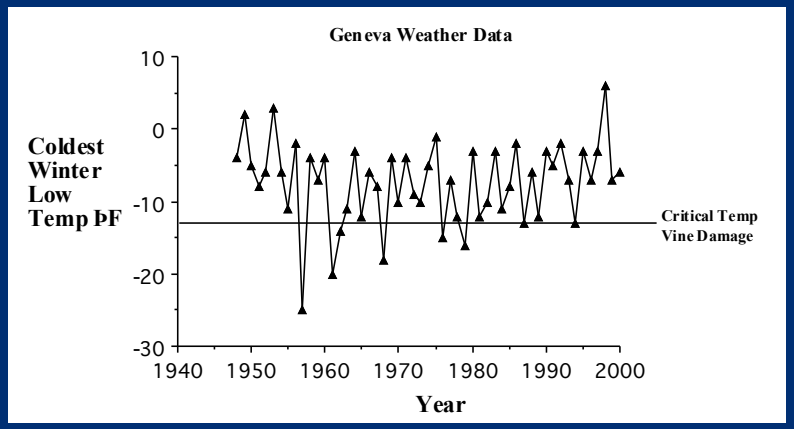
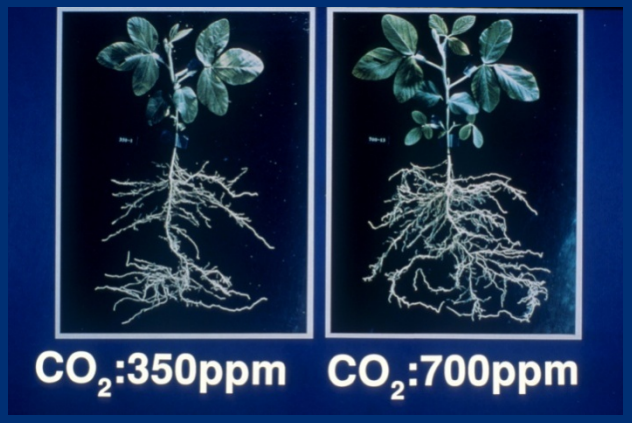
Beneficial Impacts



Reduced exposure to frost*

Longer growing seasons

Increased concentrations of phenolic compounds



Some pest species will "*move away*"

Biotic Impacts

- Changing habitats
- Enhanced CO_2 fertilization

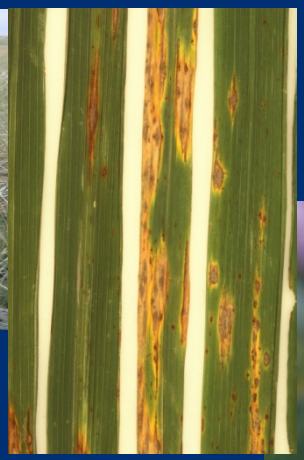
Some weeds, vines, invasives, insects, pathogens & animals will expand their temporal & spatial ranges & *vigor*

Cheatgrass fire hazard?

C:N ratio + lodging?

Herbicide effectiveness??

Nutrient poor forage?



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Effects and Sensitivity Vary by Commodity

- Corn: high nighttime temperatures, high temperatures during pollination, water stress
- Soybean: water stress, high temperatures
- Wheat and small grains: extreme events, frost during flowering, water stress
- Rice: temperature extremes during pollination, water management
- Cotton: high temperatures during boll fill
- Pasture and rangeland: water stress
- Fruit trees: chilling requirements not met, high temperatures during fruit development
- Specialty crops: water stress, high temperatures

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Increased Biotic Stresses Will Significantly Affect Agriculture

- Insect pests
  - Greater numbers & generations, 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

"Over-wintering"

Will affect the input COST of production….

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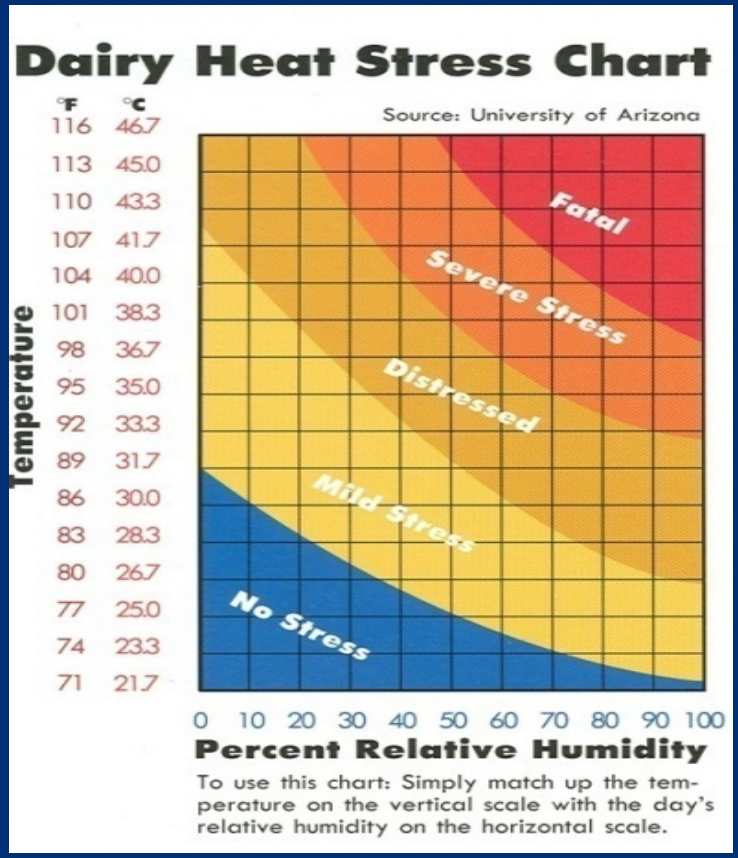
Livestock Production is Vulnerable

- 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



Responses of Agricultural Systems

- Changes in farmer behavior
  - More attention to climate *extremes (vs only means)*
- Changes in production, consumption, prices, & trade patterns
  - Domestic & global market response
  - U.S. impacts depend on global response
- Economic effects depend on domestic & global adaptive capacity
  - Impacts vary by region, by sector, & by group

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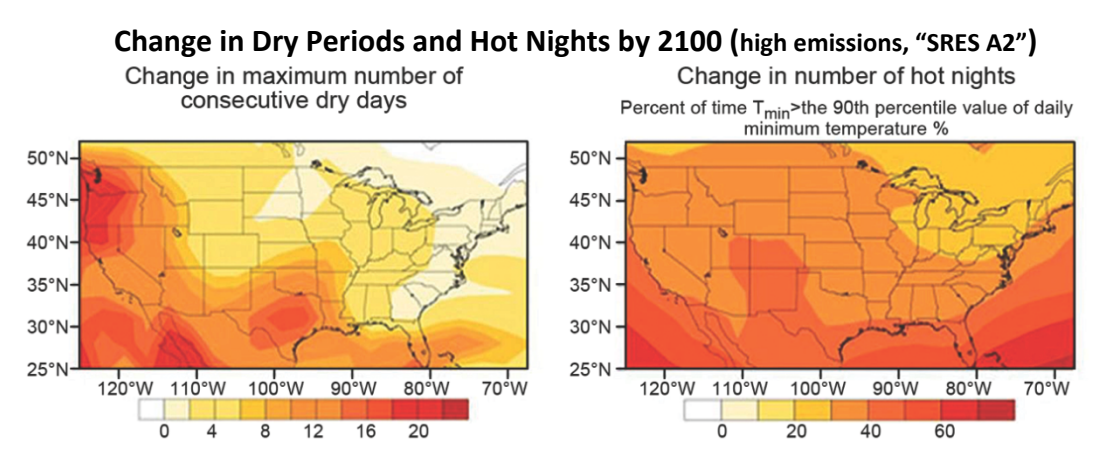
Extreme Events*



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.

Effects & Adaptation Take Home Messages…..

- *Effects to intensify:* beyond 20-30 years
- Effects will continue: Abiotic & Biotic
  - Yield Quantity & Quality
  - Cost of Production

- *Generations*: Future farming & climate different
- *Risk Management*: More climate & weather
- *Natural resources base:* soil, water, air
- *Ecosystem services:* pollinators, biodiversity

"Variability"
"Vegetative & Reproductive Stages"

Building Agricultural Resilience: Vulnerability

- Understand Potential *Exposures**
  - Focus on extremes as well as mean changes
- Understand *Sensitivities**
  - Define critical thresholds & interactions
- Enhance *Adaptive Capacity**
  - Resilient systems: *Climate-ready crops & production systems*

**Vulnerability = (exposure + sensitivity - adaptive capacity)*

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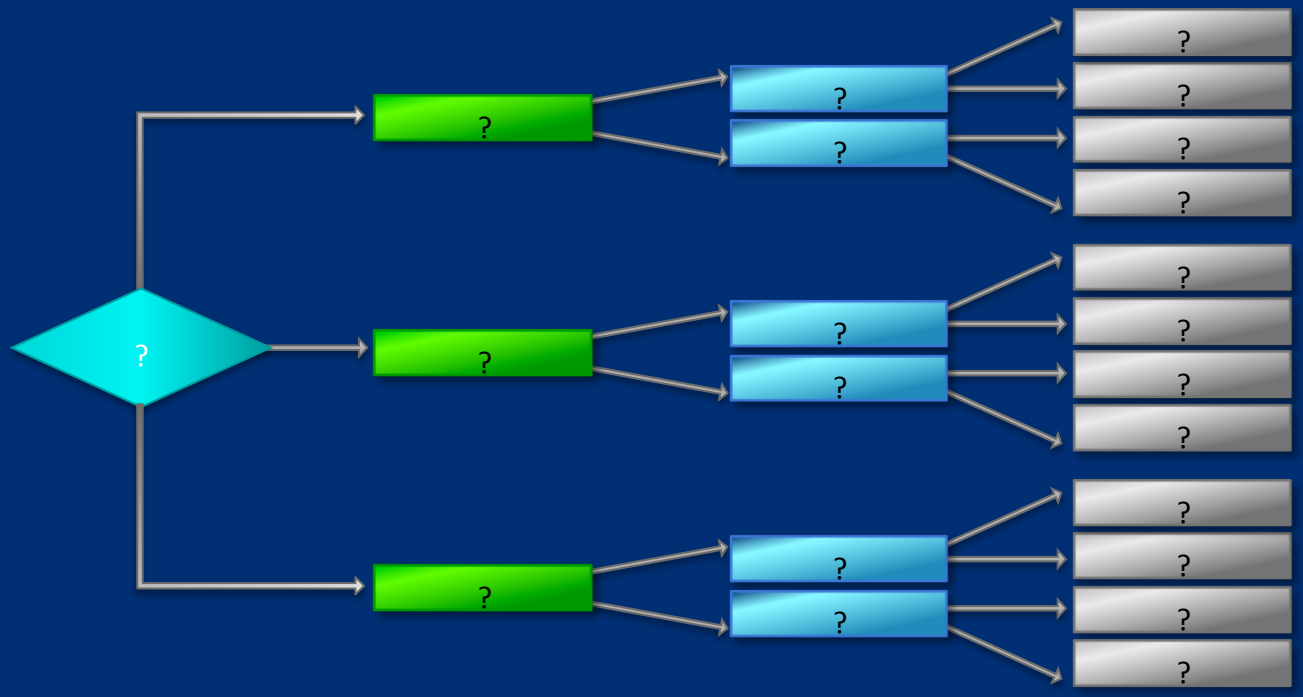
G x E x M

- *Over-emphasis on genetics as solution*
- *Genetics x Environment x Management*
  - Interactions
  - Cross/Trans Disciplinary
  - Matches producer decision-making
  - Yield gap focus
- Management: soils
- Systems: Add Post Production: *G x E x M x P*
- *Collaborations are essential*

Adaptation: Decision Support via Decision Trees?



Options…

What are the model, forecast, and data needs at each decision point?

Challenge to Agriculture: 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

** Quantity & Nutritional Quality*

*NAS, 2010 definition by its goals

http://www.usda.gov/oce/climate_change/effects.htm

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