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How will Climate Change Affect Agriculture? Impacts Over the Next 10-30 Years

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Impacts over the next 10-30 years

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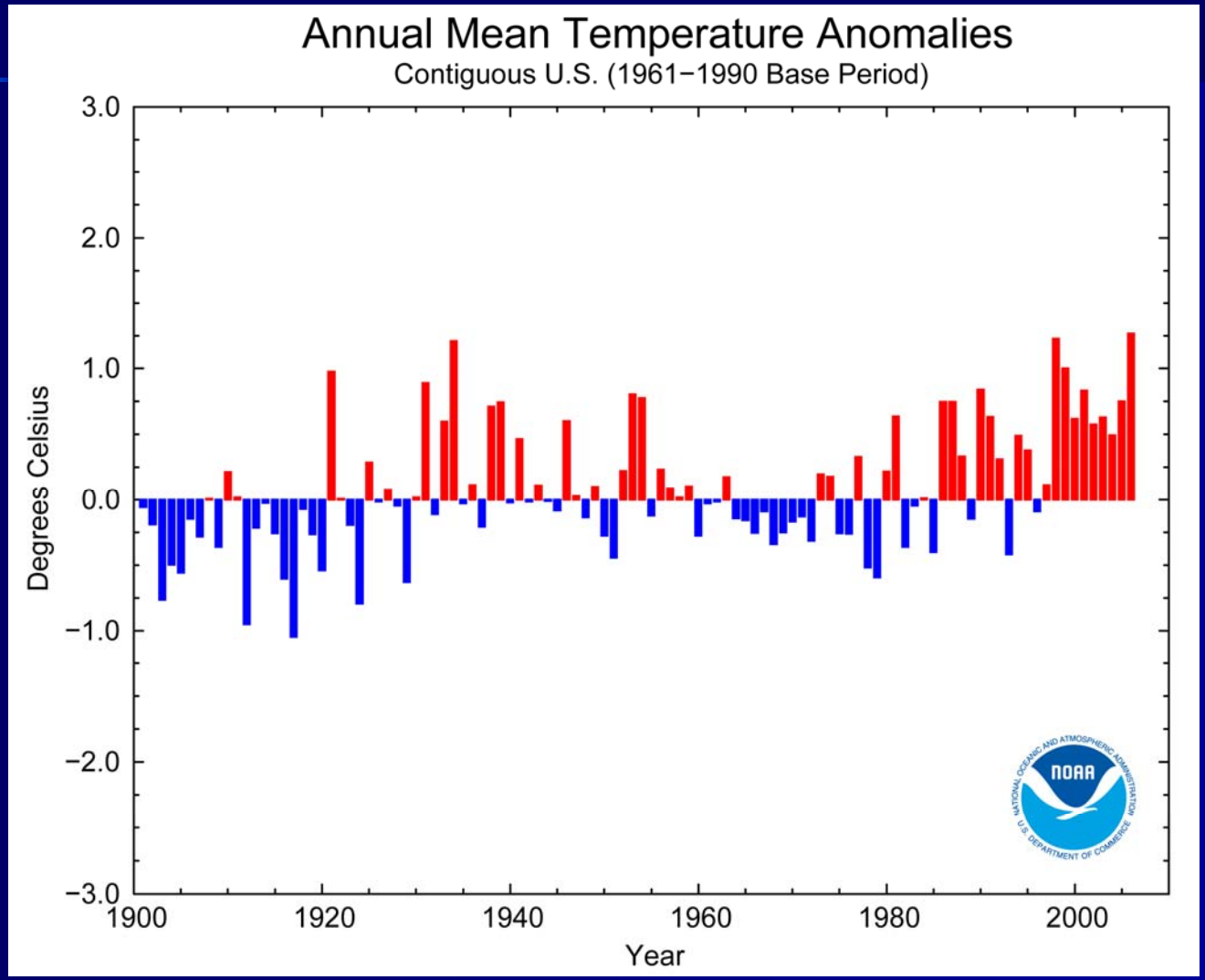
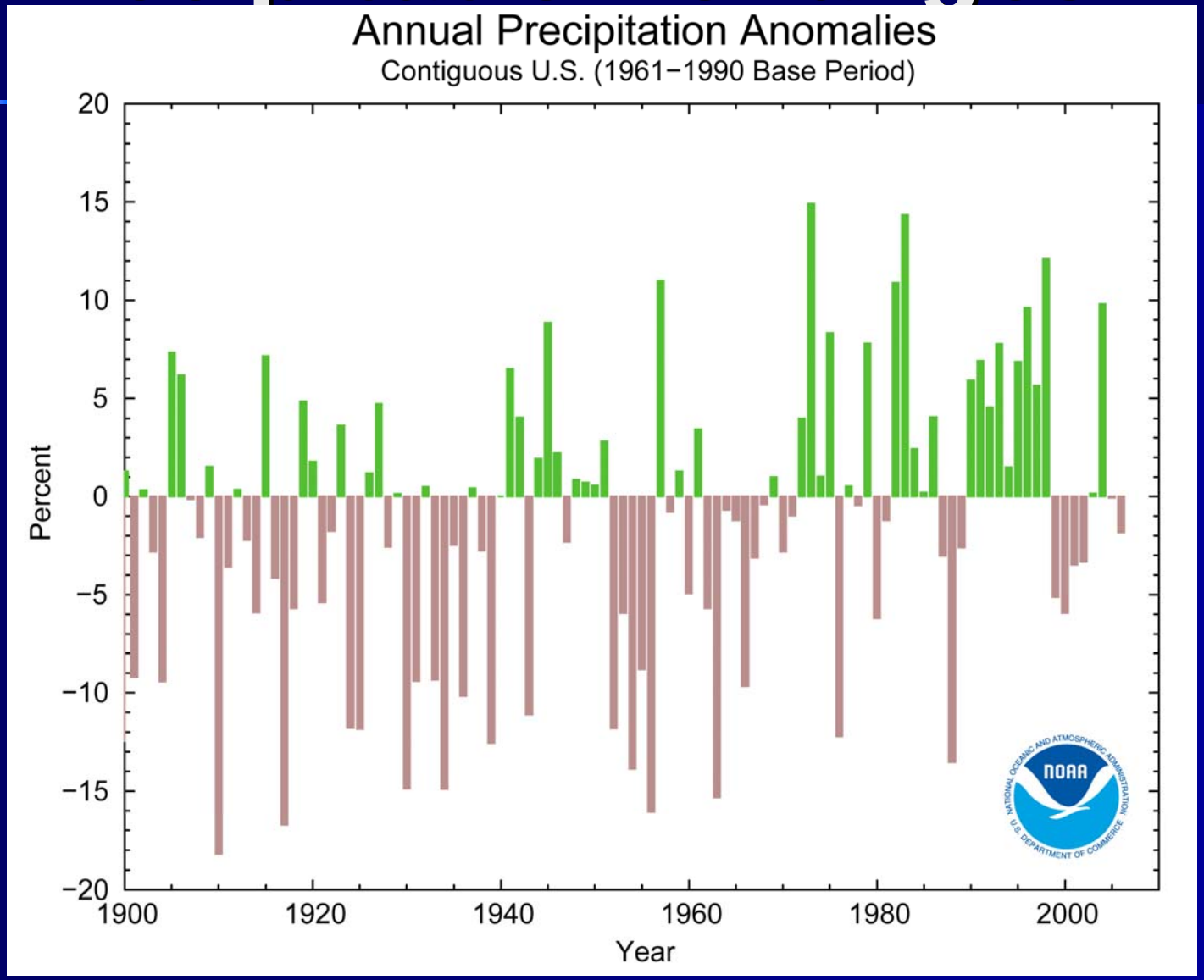
Climate Changes

- Increasing temperature of 1.2C (2.2F) over the next 30 years
- Increasing CO_2 of 60 ppm over the next 30 years
- Increasing variability in precipitation
- There will be increasing variation in temperature and precipitation within and among years

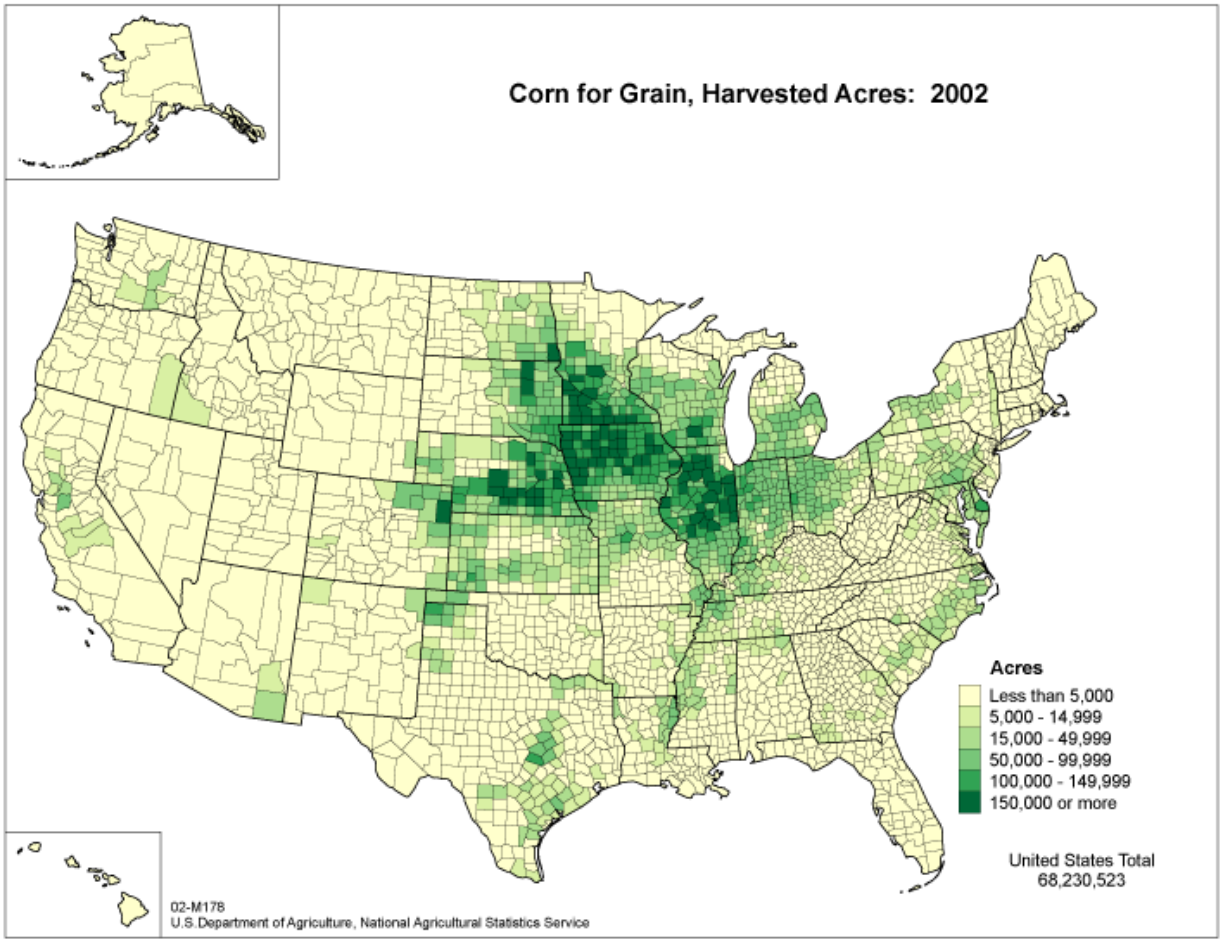
Temperature Changes



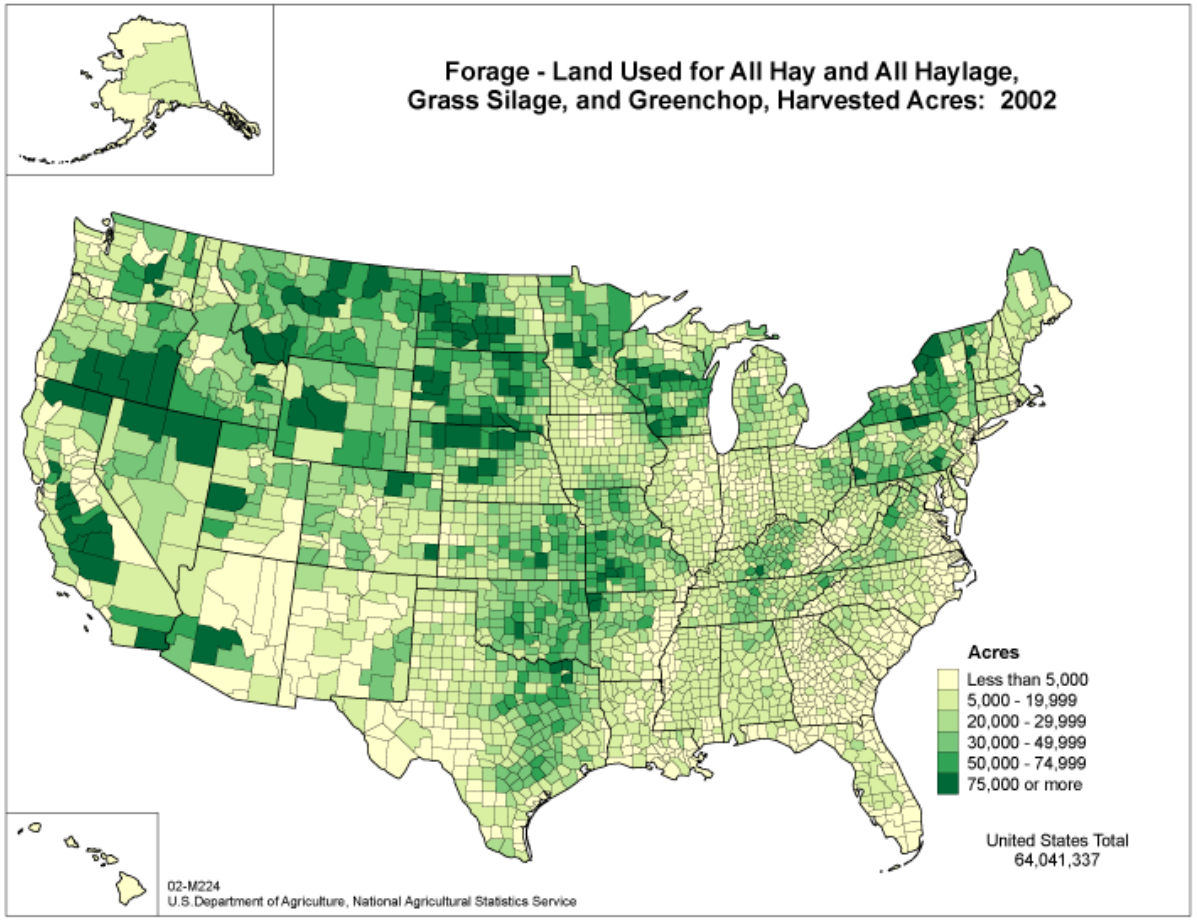
Precipitation Changes



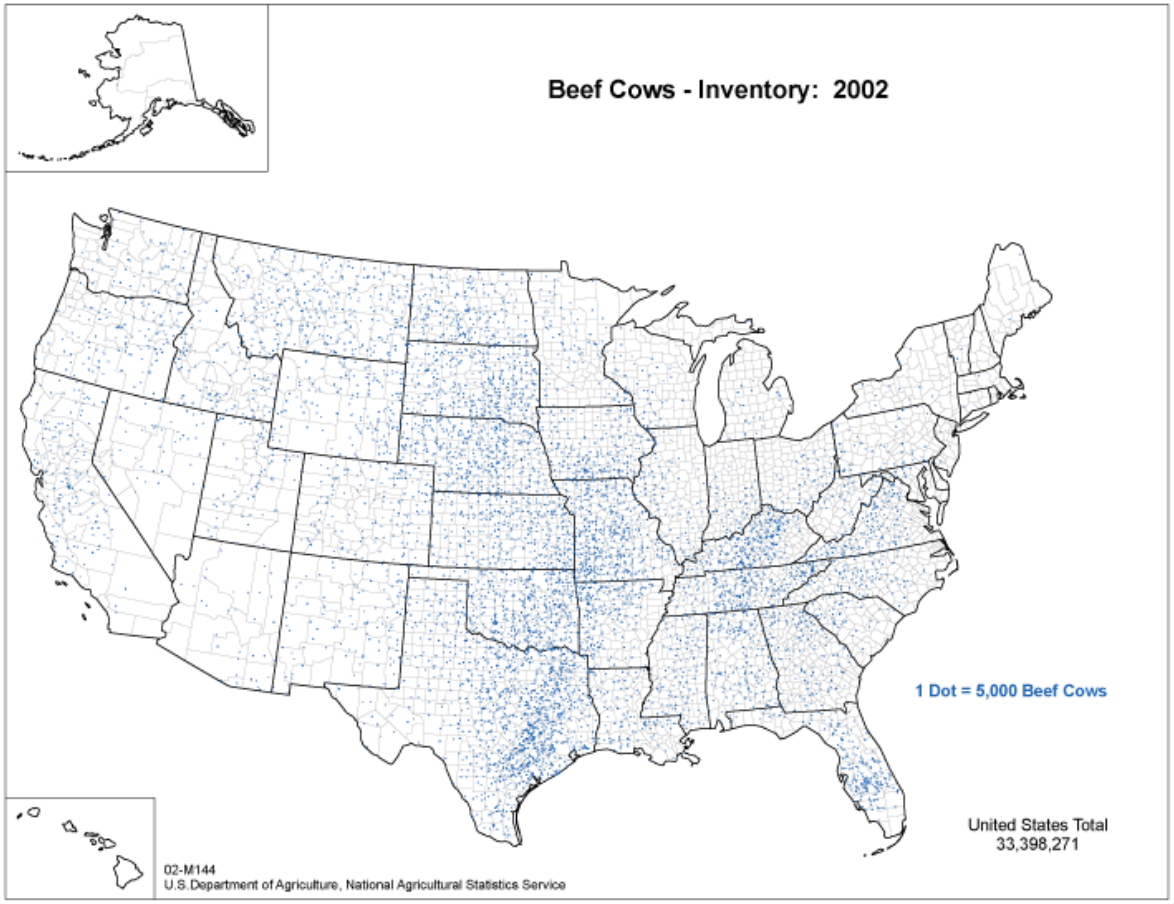
Corn Production in the US



Forage Production



Beef Cow Inventory



Temperature Responses

- Plants
- Animals

Plant Temperature Responses

- Variation among plants
- Variation among plant phenological stages
  - Germination
  - Vegetative Growth
  - Reproductive Growth
- Difference between air temperature and plant temperatures

Temperature

Crop	Optimum Temp (C)		Temp Range (C)		Failure Temp (C)
	Veg	Reprod	Veg	Reprod	
Maize	34		18-32	18-22	35
Soybean	30	26	25-37	22-24	39
Wheat	26	26	20-30	15	34
Rice	36	33	33	23-26	35-36
Cotton	37	30	34	25-26	35
Tomato	22	22		22-25	30

Temperature

Crop	Temp Range (C)	
	Veg	Reprod
Watermelon	18-35	25-27
Cucumber	12-30	20-25
Sweet Corn	12-30	20-25
Onion	7-30	20-25
Potato	5-25	16-25
Broccoli	5-25	16-18

Temperature Responses

- Occurrences of higher temperatures will cause faster phenological development
- Higher temperatures will affect reproductive development because of the sensitivity of pollen survival to temperature
- Yields will be impacted because of shorten reproductive periods

Climate Impacts

Crop	Yield Change
Maize	-4.0%
Soybean-Midwest	+2.5%
Soybean-South	-3.5%
Wheat	-6.7%
Rice	-12.0%
Sorghum	-9.4%
Cotton	-5.7%
Peanut	-5.4%
Bean	-8.6%

Forages

- Increased temperature will hasten development and increase the length of the growing season
- Impact on forage quality

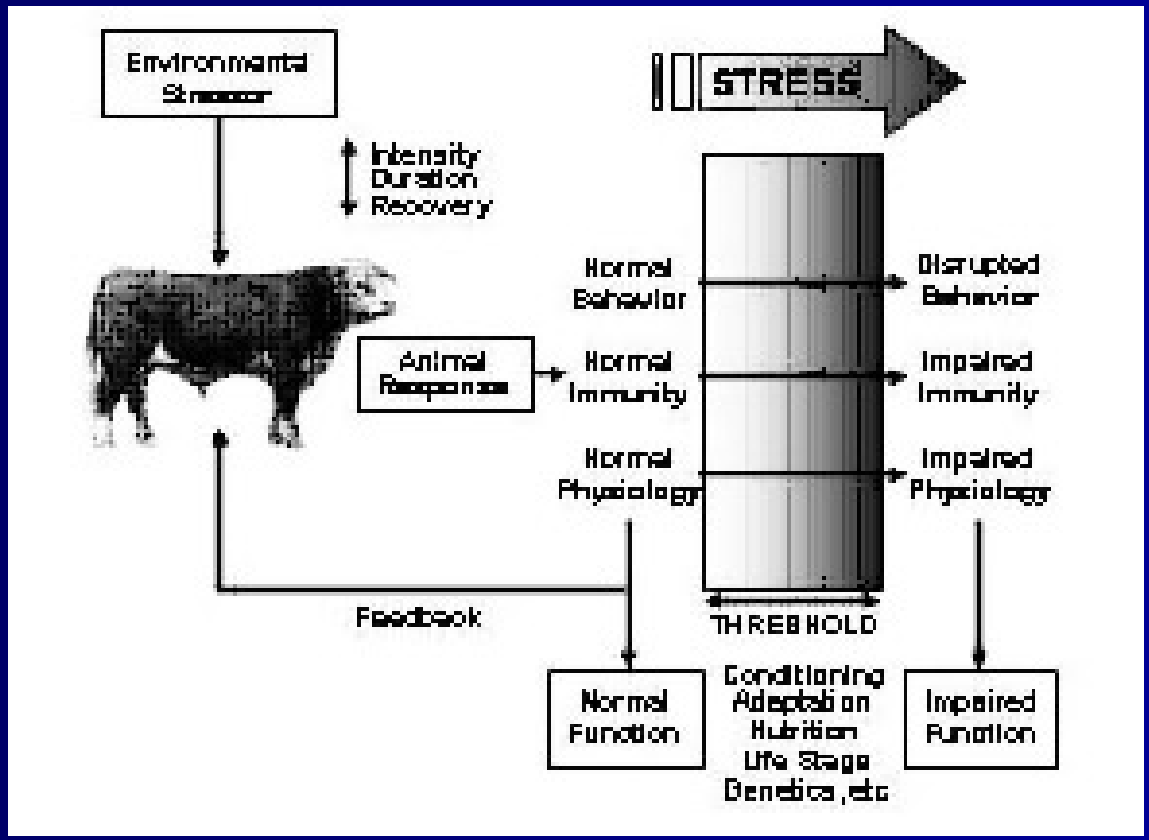
Fruits and Nuts

- Warmer temperatures will cause earlier bud break or flowering in the spring
- Warmer temperatures will cause faster development
- Warmer temperatures could impact chilling requirements for many plants
- Increase potential problems when warm temperatures cause early development and then turns cold

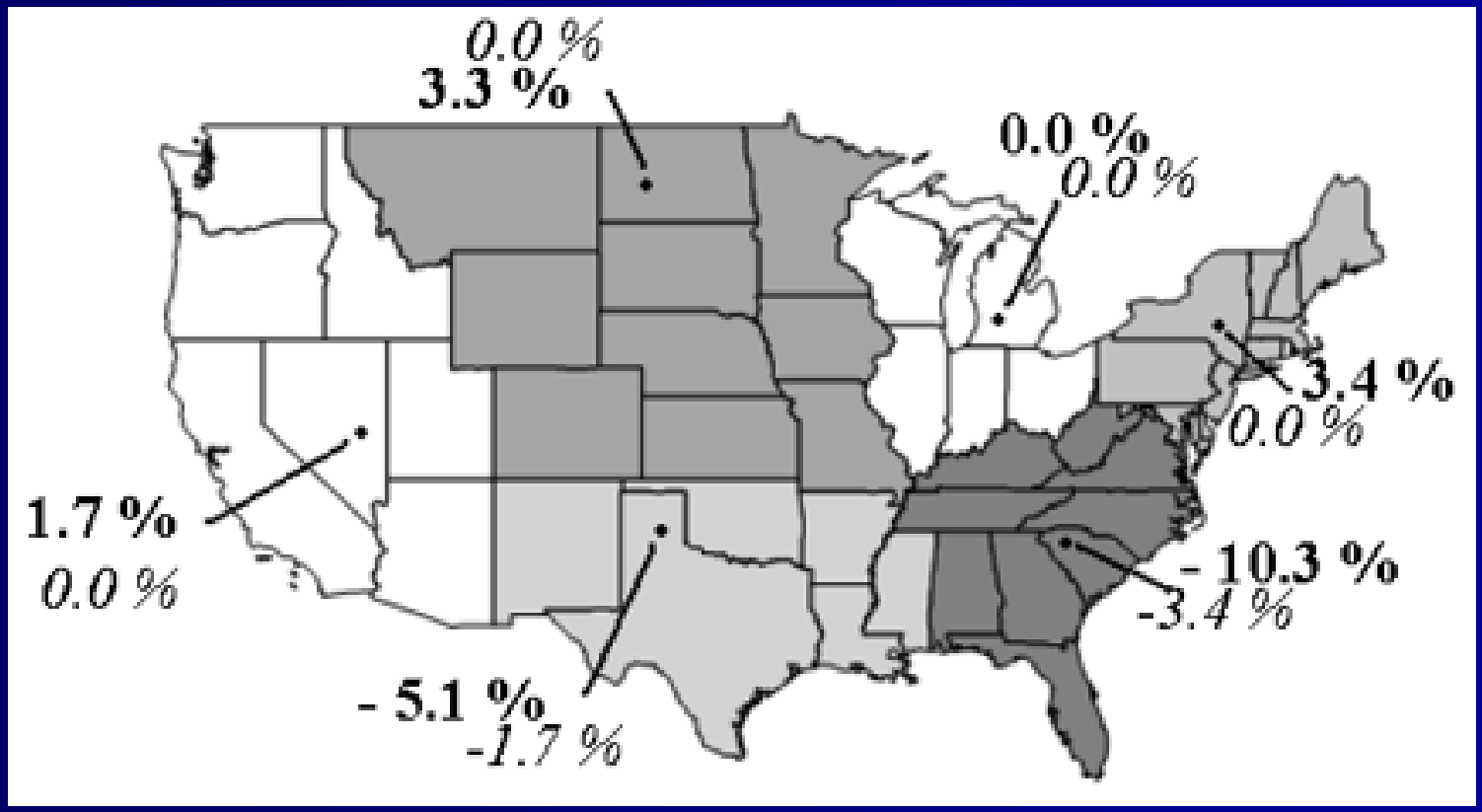
Animals

- Optimum temperature is a very narrow range (thermoneutral zone) is which animal does not need to alter behavior or physiological function to maintain core temperature
- Responses include panting, shivering, reduced feed intake, increased (cold) or decreased (warm) metabolic rates
- Any of these responses will impact productivity (meat, milk, or reproduction)

Temperature Response

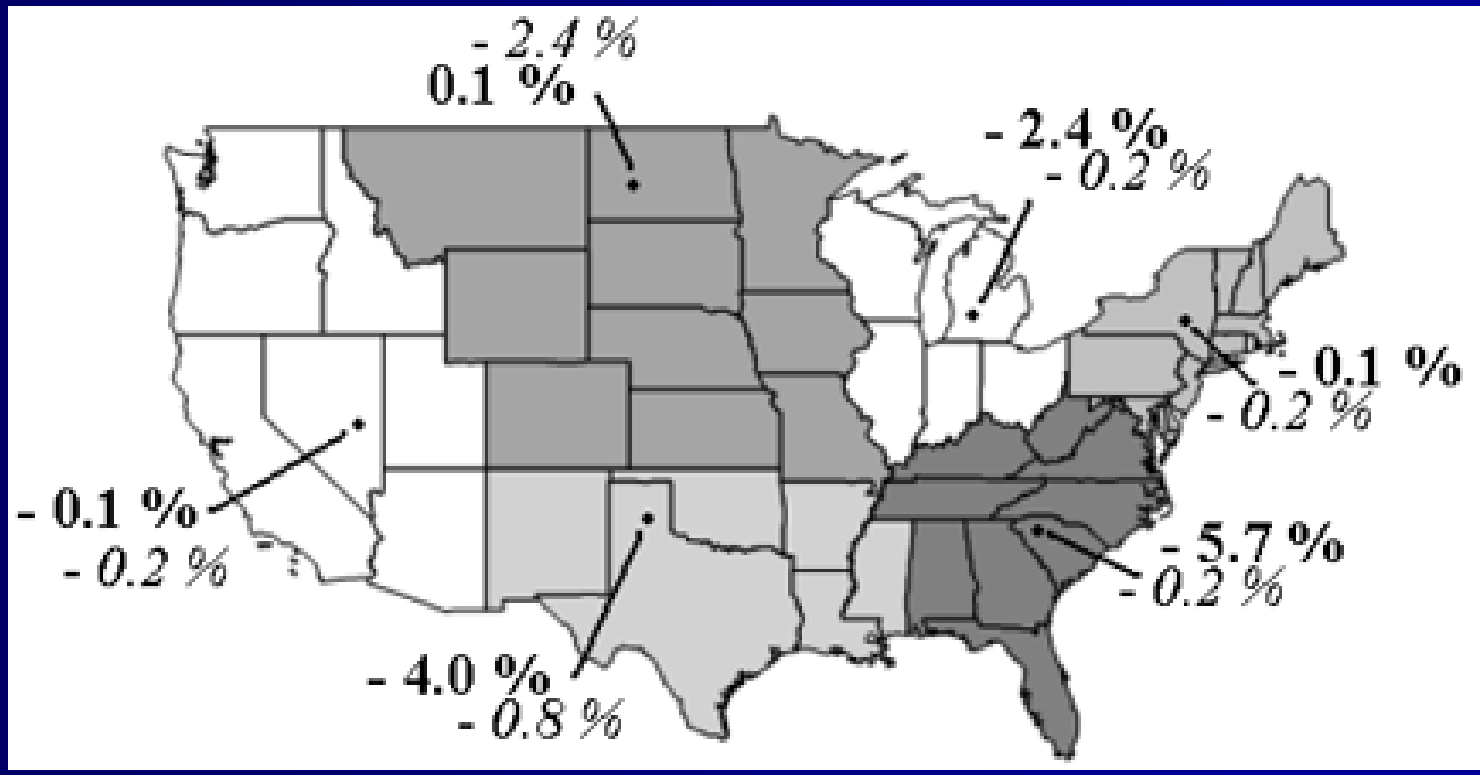


Impacts on Swine Production



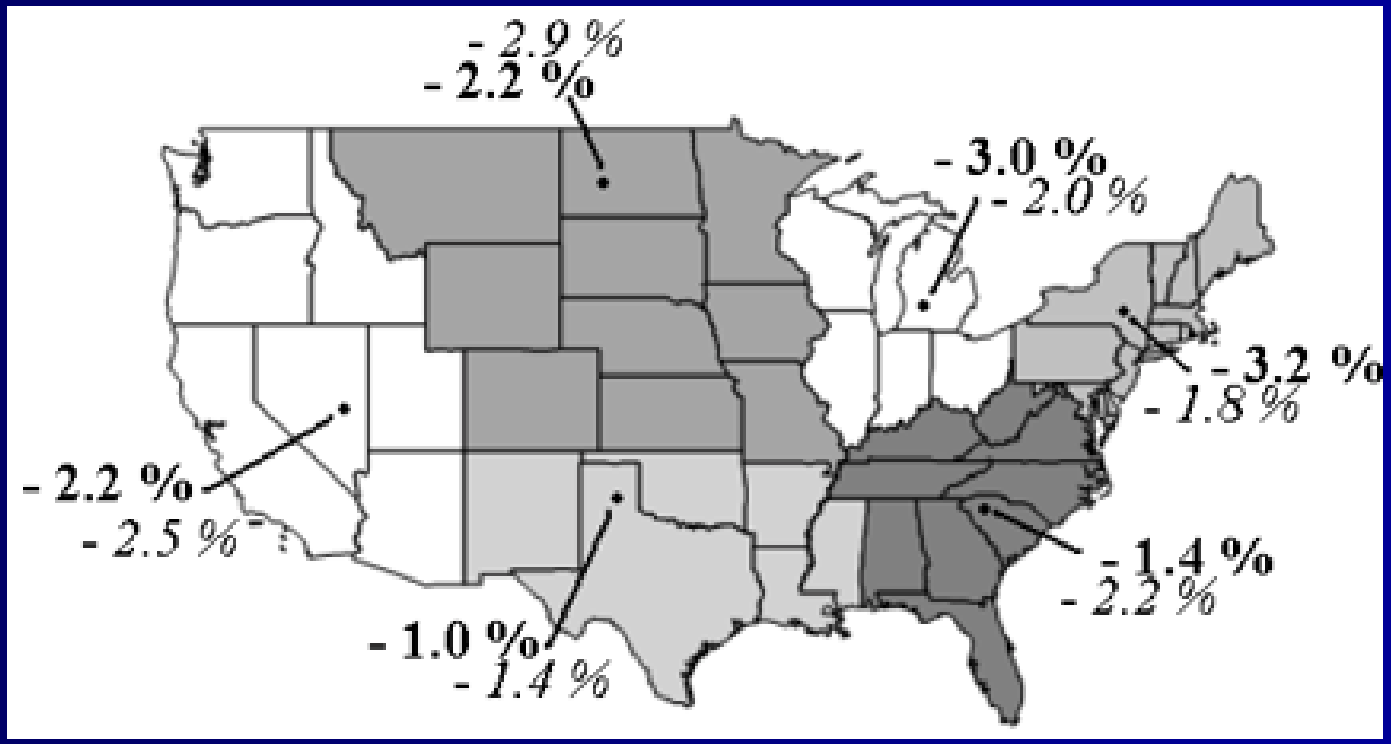
Days for swine to grow from 50 to 110 kg

Impacts on Beef Production



Changes in days to reach market weight

Impacts on Milk Production



Effects on milk production due to temperature increases

Temperature Effects on Reproduction

- Dairy cows reduced conception rate of 4.6% for Thermal/Humidity Index values above 70
- Beef cows reduced conception rate of 3.2% for Thermal/Humidity Index values above 70
- Beef cows 3.5% reduction in conception rate for each degree of temperature increase above 23.4C

Episodic Temperature Events

- High temperature episodes causes stress in animals which affects rate of gain, milk production
- Cold temperature episodes affect feed consumption and survival of young animals
- Temperature extremes lead to economic loss on order of Millions of dollars

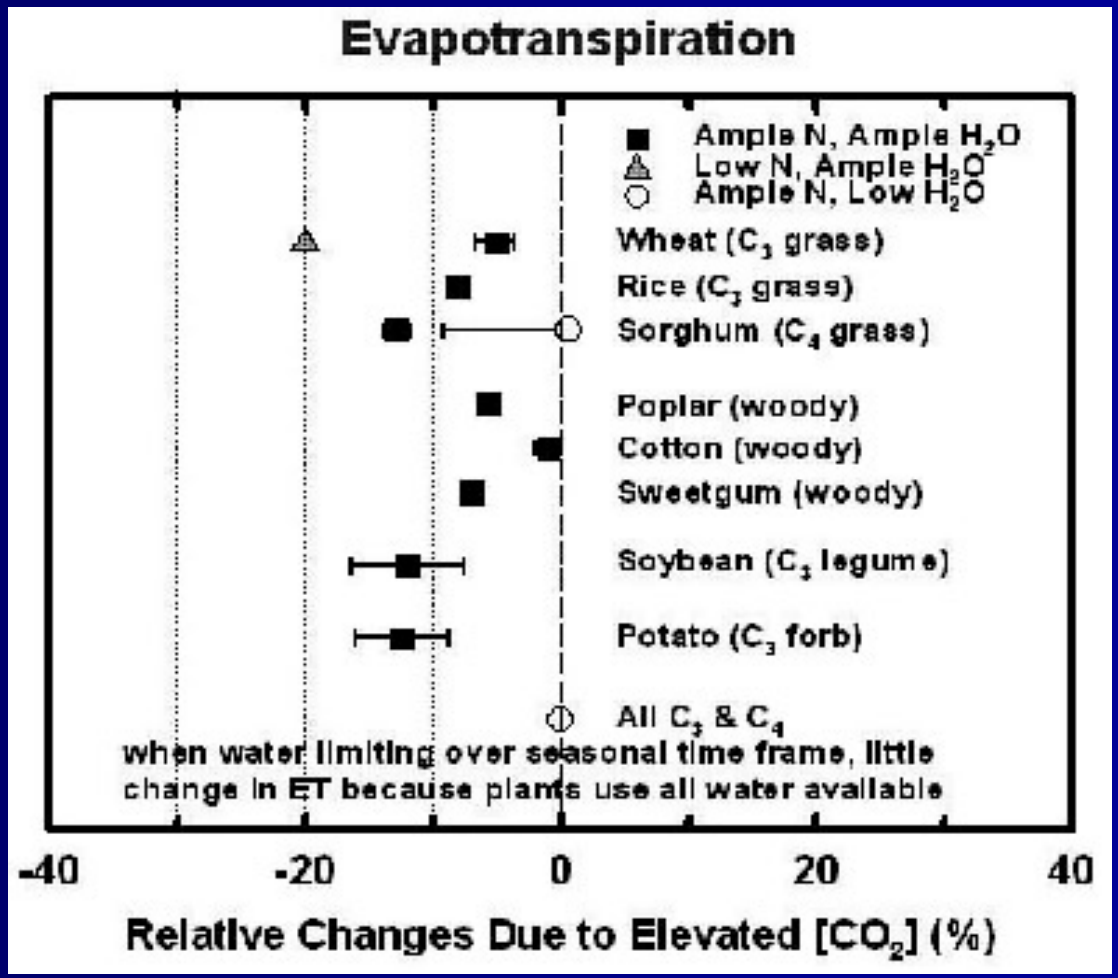
Carbon Dioxide Responses

- Increasing CO_2 will increase plant growth
- Difference between C3 and C4 plants
- Increasing CO_2 will increase water use efficiency because of increased growth per unit of water transpired

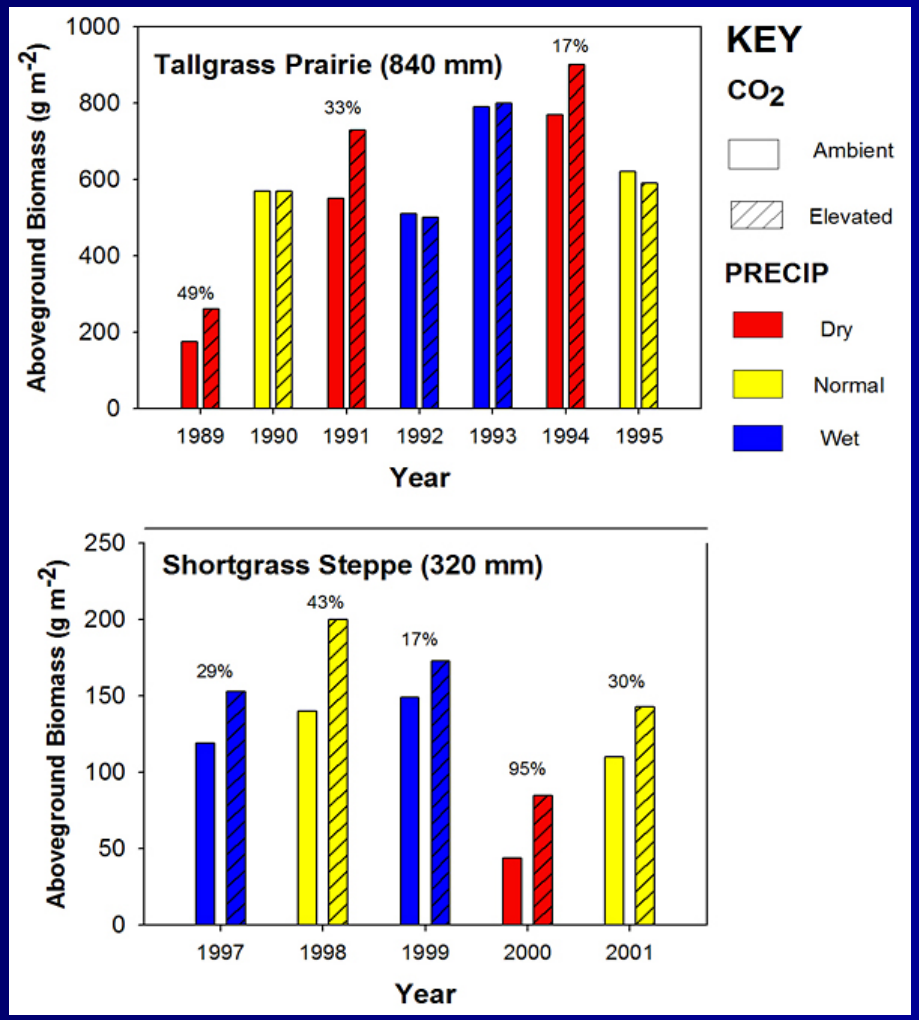
CO_2 Responses

Crop	Yield Change	ET Change
Corn	+1.0	
Soybean	+7.4	-2.1
Wheat	+6.8	-1.4
Rice	+6.4	-1.7
Sorghum	+1.0	-3.9
Cotton	+9.2	-1.4
Peanut	+6.7	
Bean	+6.1	

ET effect due to CO_2



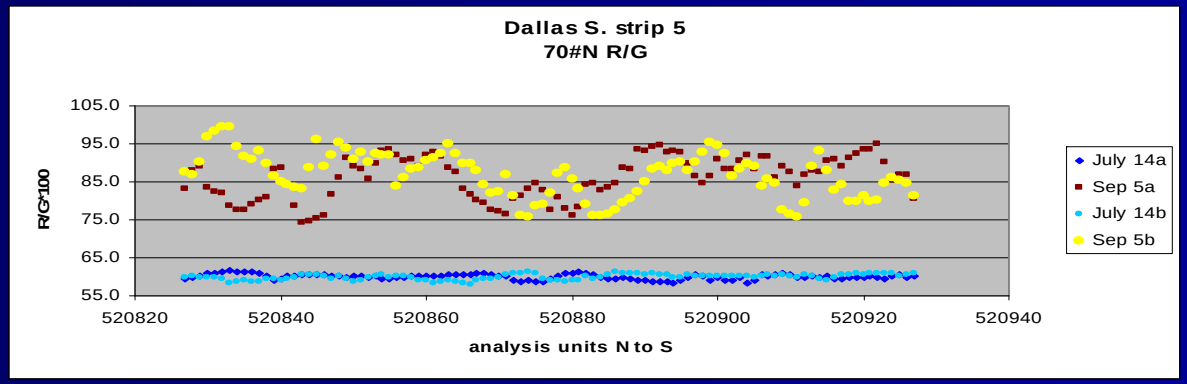
Rangeland Responses

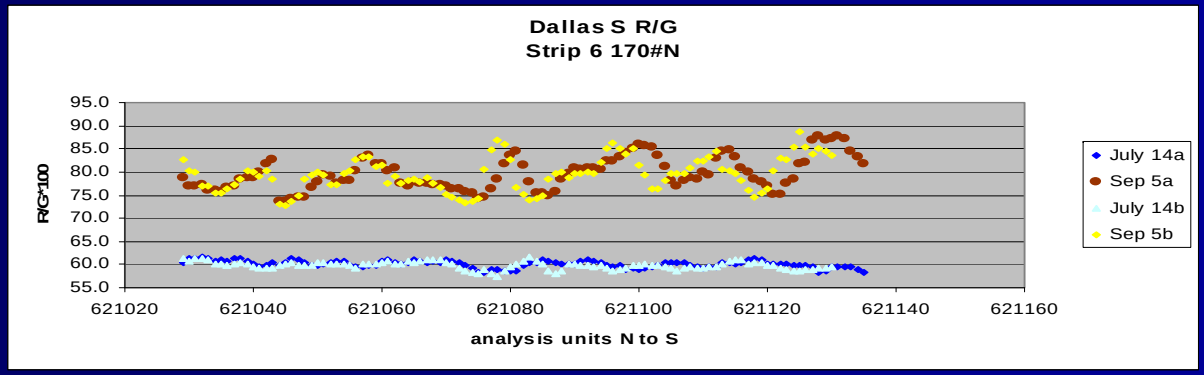


Precipitation

- Variable precipitation will increase potential soil deficits
- Decreased soil water availability will offset the positive impacts of CO_2 and exaggerate the effect of increasing temperatures

Field Scale Variation





Implications on Yield

- Yield patterns within fields are caused lack of soil water during the grain-filling period
- Yield variation in corn can be as large as 100 to 150 bu/A within a field due to soil water holding capacity

Forage Quality

Change	Examples of positive effects on forage quality	Examples of negative effects on forage quality
Life-form distributions	Decrease in proportion of woody shrubs and increase in grasses in areas with increased fire frequency.	Increase in the proportion of woody species because of elevated CO_2, increases in rainfall event sizes and longer intervals between rainfall events.
Species or functional group distributions	Possible increase in C_3 grasses relative to C_4 grasses at elevated CO_2.	Increase in the proportion of C_4 grasses relative to C_3 grasses at higher temperatures. Increase in abundance of perennial forb species or perennial grasses of low digestibility at elevated CO_2. Increase in poisonous or weedy plants.
Plant biochemical properties	Increase in non-structural carbohydrates at elevated CO_2. Increase in crude protein content of forage with reduced rainfall.	Decrease in crude protein content and digestibility of forage at elevated CO_2 or higher temperatures. No change or decrease in crude protein in regions with more summer rainfall.

Rangeland Responses

- Directional shifts in the composition of vegetation occur most consistently when global change treatments alter water availability
- Weedy and invasive plant species likely will be favored by CO_2 enrichment and other global changes because these species possess traits (rapid growth rate, prolific seed production) that permit a large growth response to CO_2
- CO_2 enrichment will likely accelerate the rate of successional change in species composition following overgrazing or other severe disturbances
- Rangeland vegetation will very likely be influenced more by management practices (land use) than by atmospheric and climatic change

Pest Response

- Weeds will be favored by increased CO_2
- Increased temperatures will change phenological development of weeds
- Increased spring, winter, and fall temperatures will allow for winter survival and earlier seasonal onset of insects and pathogens

Implications

- Temperature increases will alter phenological development of crops, increase potential sensitivity to temperature extremes in fruit crops
- Temperature increases will affect reproduction because of sensitivity of pollen to extreme temperatures
- Overall impact will be to decrease crop yield and forage quality
- Temperature increases will negatively impact animal production and reproduction

Implications

- Increasing CO_2 will positively impact plant growth and ultimately yield
- Increasing CO_2 will reduce crop water use which will be an advantage under water limitations
- Increasing CO_2 will offset some of the negative impacts of increasing temperature

Management Changes

- Producers can adapt to climate changes by altering crop management practices, e.g., planting date, crop selection, nutrient management
- Producers can adapt to climate changes in livestock through changes in management practices that reduce exposure to thermal stress