Production of Biofuels Feedstock on Agriculture Land and Grasslands

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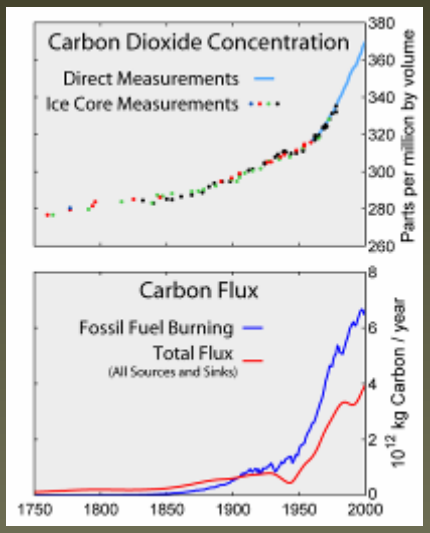
Important World Issues

Reliance on fossil fuels.

Increasing levels of greenhouse gases.



Increasing human population requiring an increase in the production of food and fiber.

Expectations for Agriculture

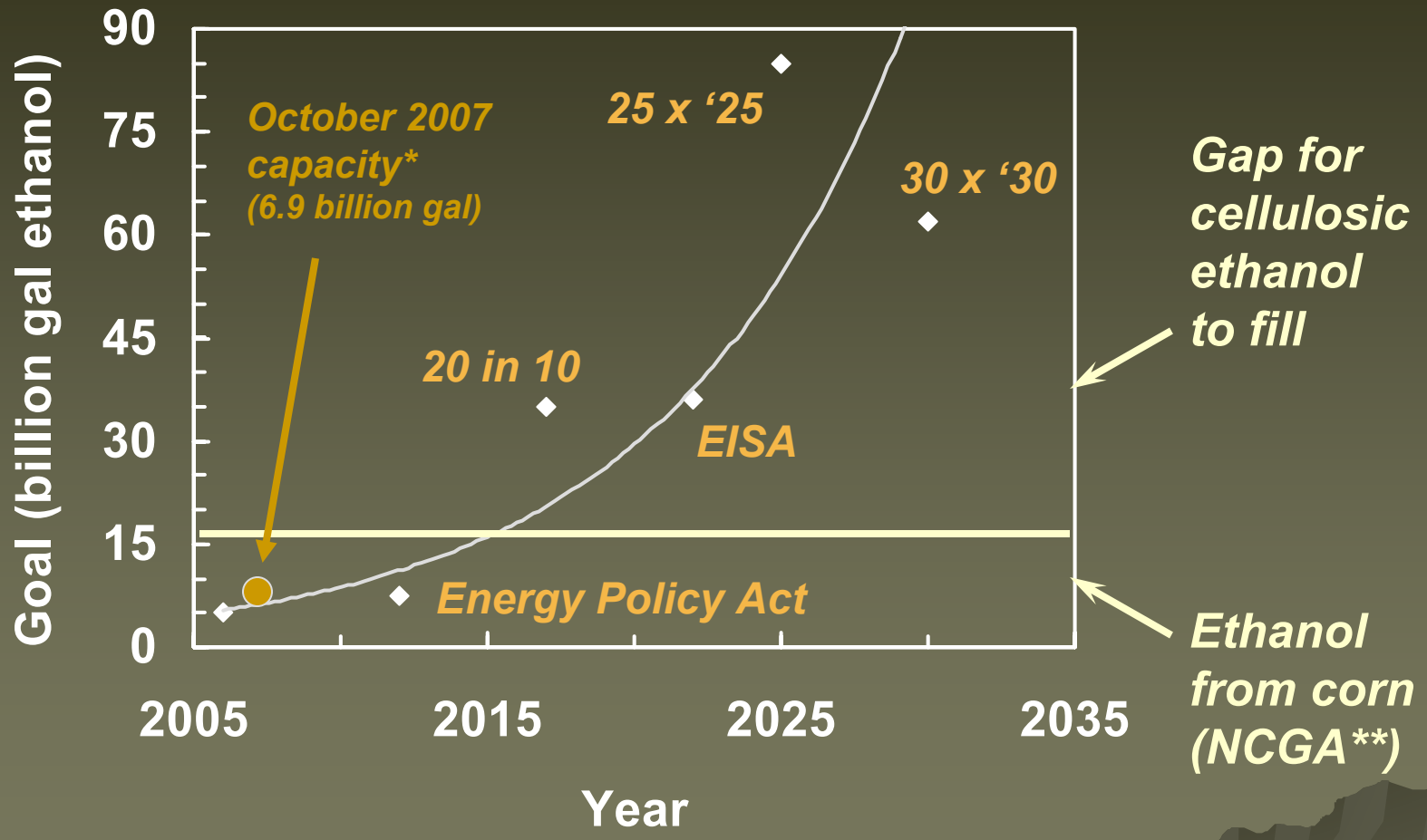
- Provide traditional outputs for an increasing world population
  - Food
  - Feed
  - Fiber
- Environmental services
  - Control erosion
  - Sequester C
  - Habitat
  - Water quality

Renewable energy feedstock*

  - 998 million tons (428 million ton from crop residues)

* Perlack et al., 2005; http://bioenergy.ornl.gov

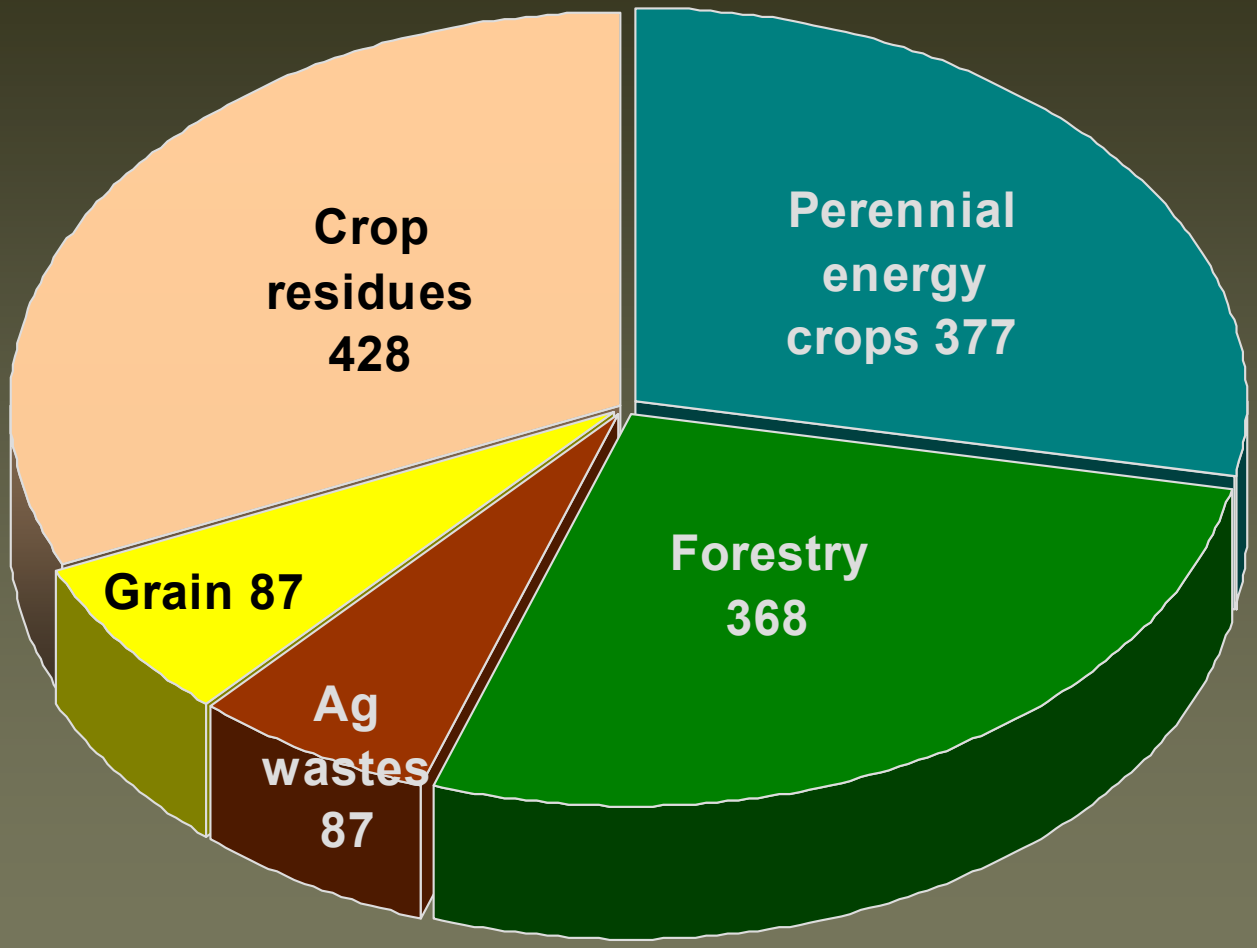
How will agriculture meet these demands?

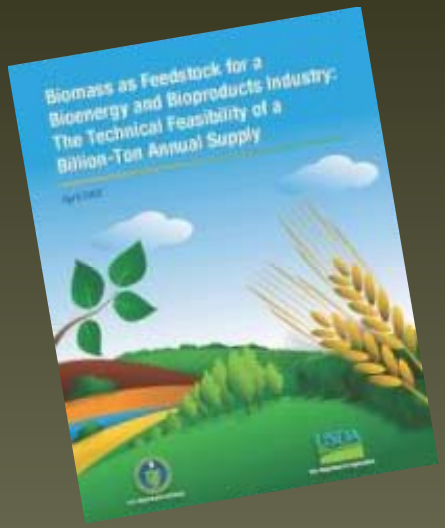


*RFA, http://www.ethanolrfa.org/industry/statistics/#C
**NCGA, http://www.ncga.com/ethanol/pdfs/2007/HowMuchEthanolCanComeFromCorn0207.pdf

Billion Ton Report

(1.366 billion tons/year)



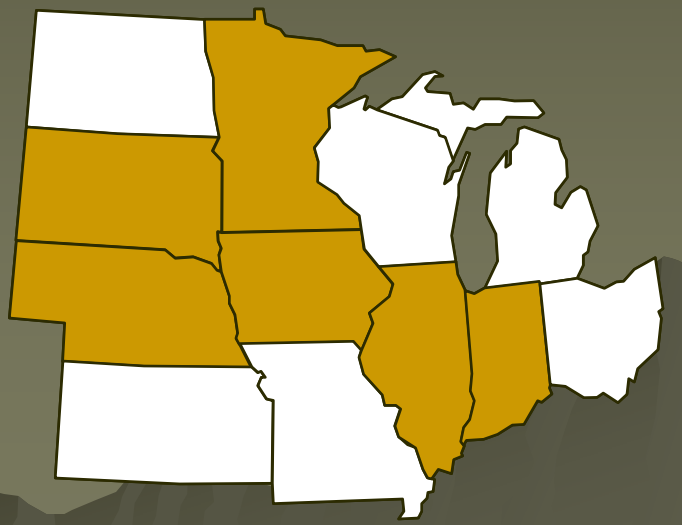


Estimated biomass (million tons/year) contribution by 2030

Perlack et al., 2005; http://bioenergy.ornl.gov

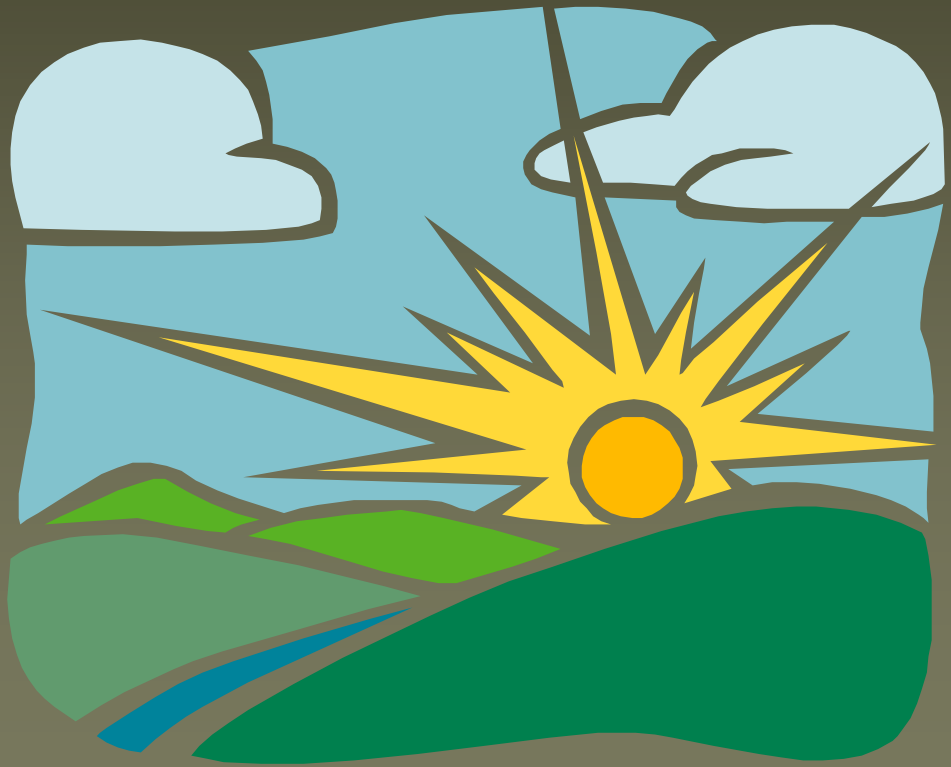
What is ONE BILLION tons?

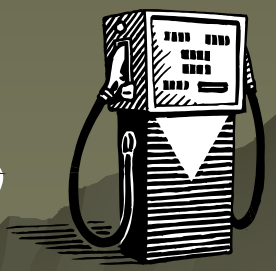
- Agricultural land (cropland plus hay and pasture)
  - 5 ton ac^{-1}
  - 200 million acres
    - 56% of North Central Region agricultural land
    - All of the agricultural land in Iowa, Illinois, Nebraska, Minnesota, Indiana, and South Dakota (Total = 195.5 million acres)



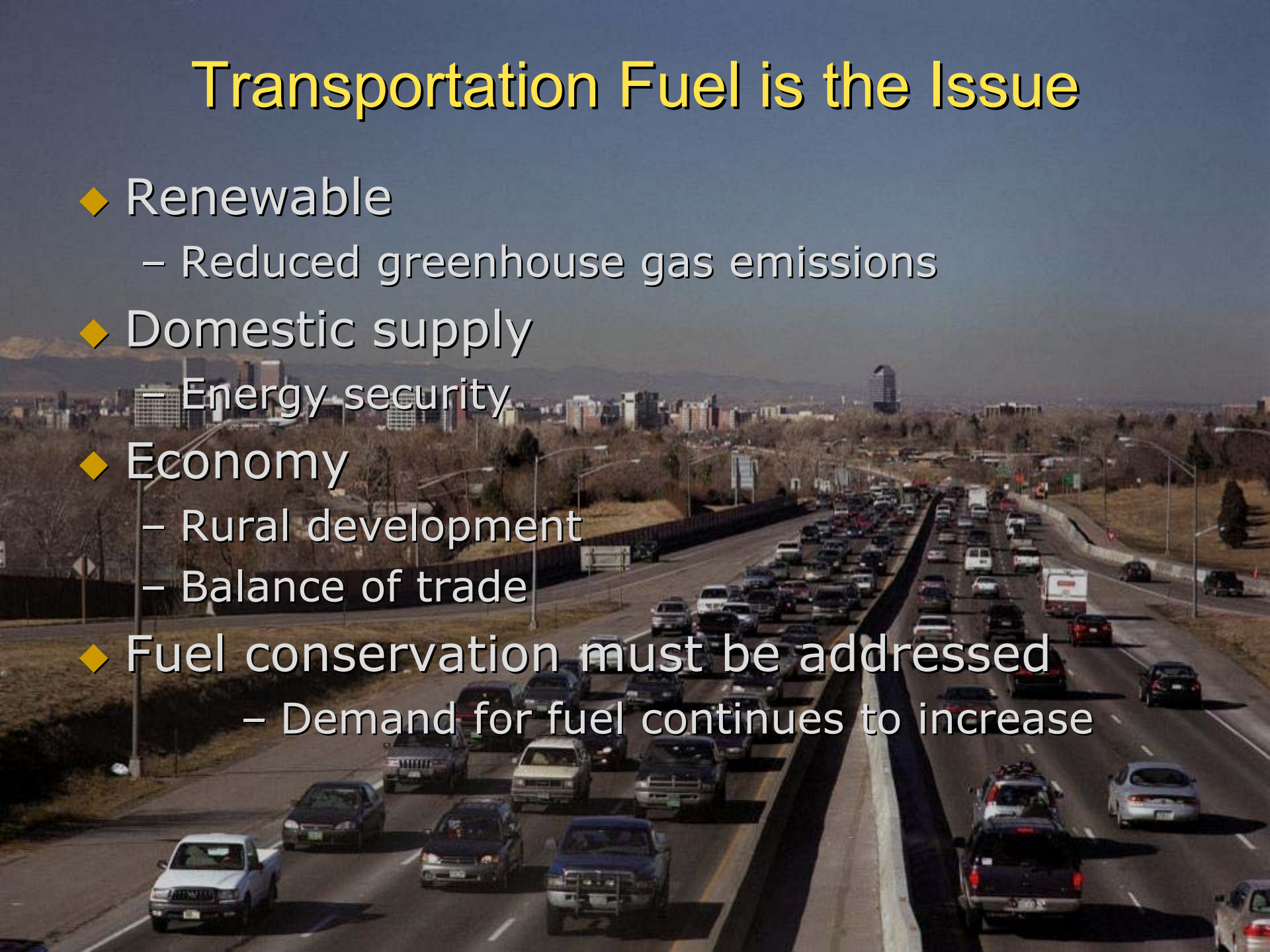
Energy Supply is Not the Problem

Collecting and delivering energy in a usable format is the issue.





Transportation Fuel is the Issue



- Renewable
  - Reduced greenhouse gas emissions
- Domestic supply
  - Energy security
- Economy
  - Rural development
  - Balance of trade
- Fuel conservation must be addressed
  - Demand for fuel continues to increase

Sustainability is Imperative

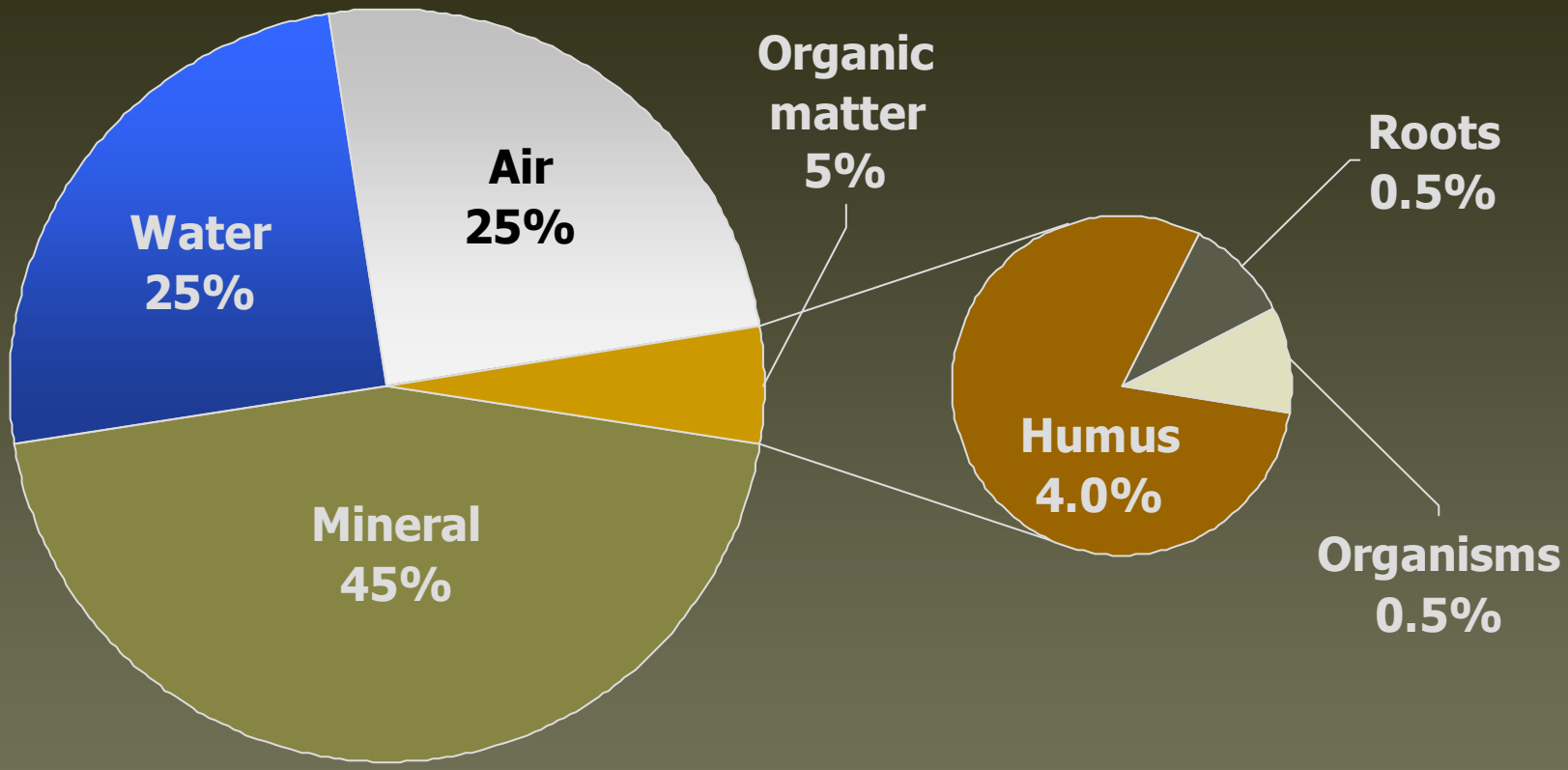
- Meet current needs in a manner that does not jeopardize the capacity of future generations to have their needs met.





How is Sustainability Measured?

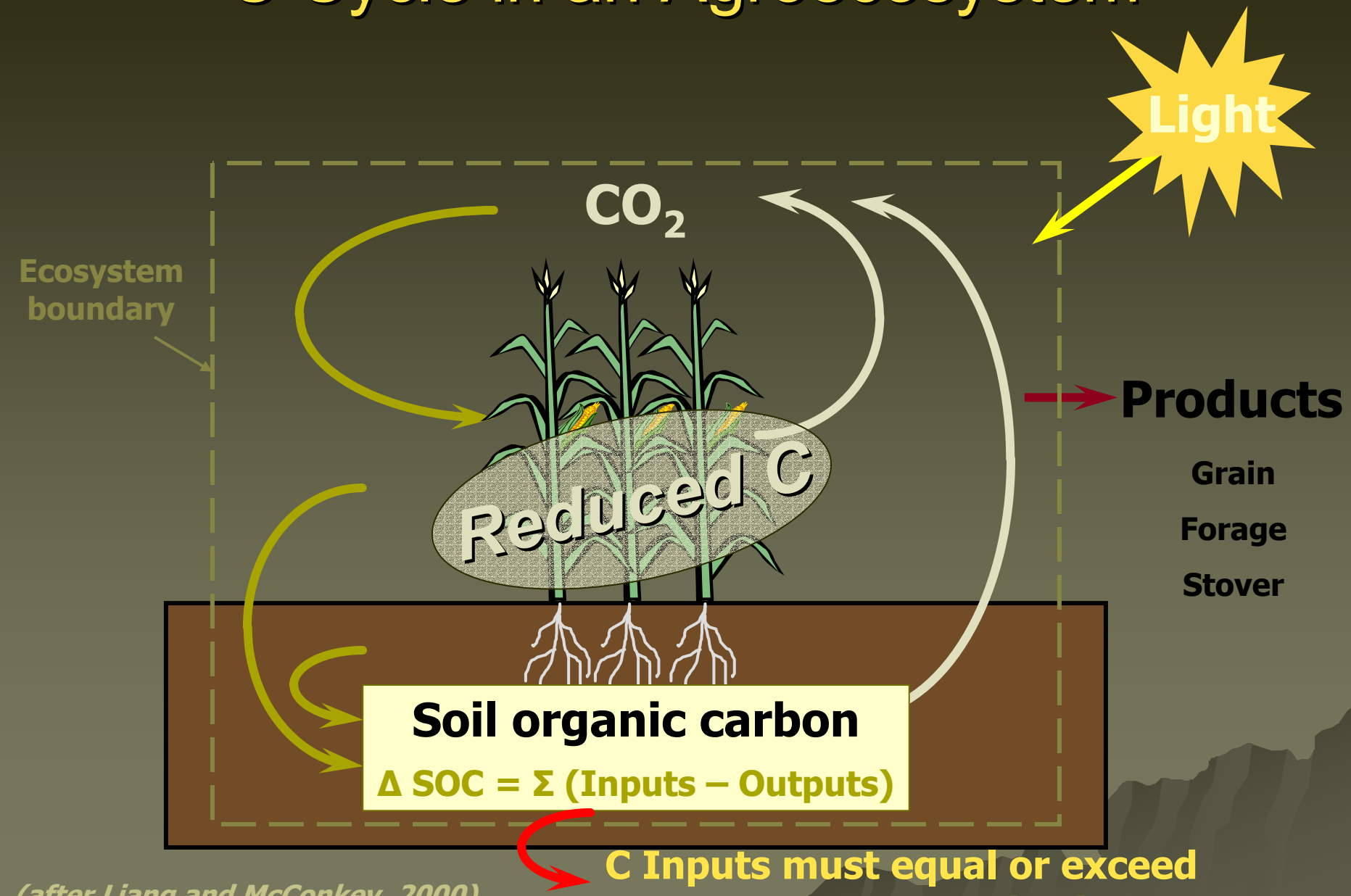
Soil Components and Sustainability



SOC - small fraction with large function – aggregation, aggregate stability, infiltration, water holding capacity, bulk density, soil tilth, nutrient availability & cycling, buffering capacity, etc.

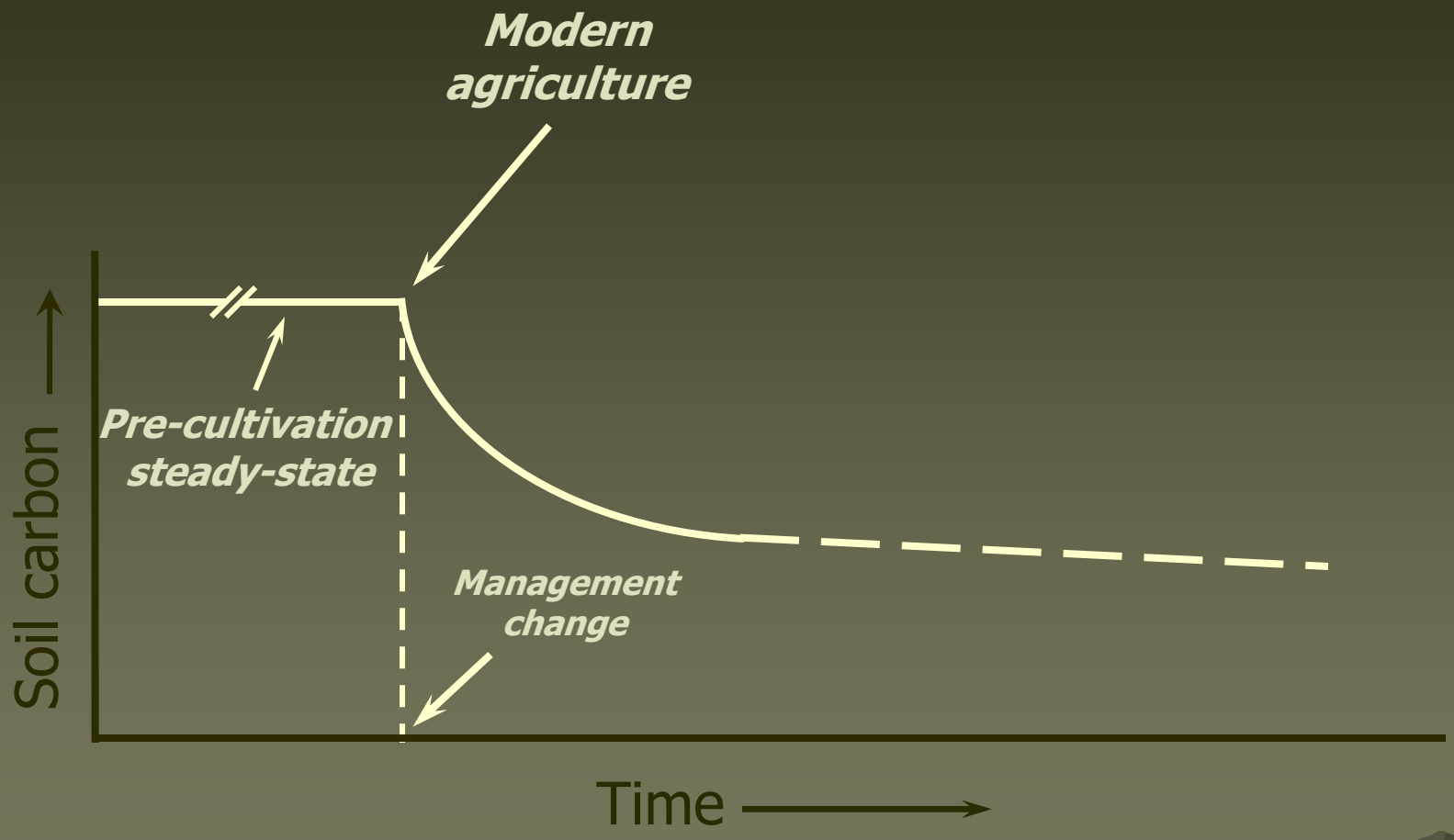
Δ SOC is the best available proxy for soil quality & sustainability

C Cycle in an Agroecosystem



(after Liang and McConkey, 2000)

Meeting Expectations Sustainably



Δ ***SOC = Σ (inputs – outputs)***

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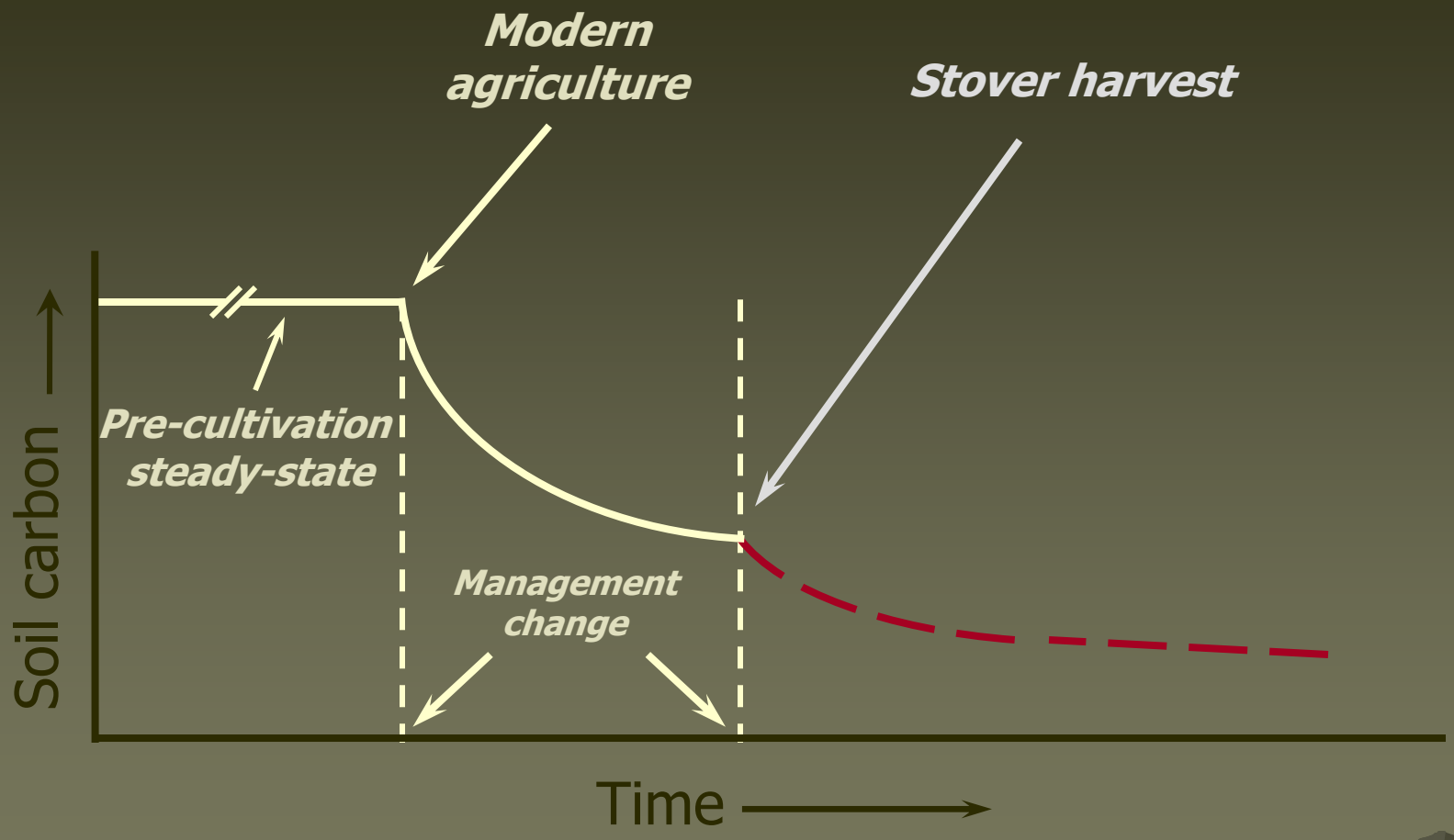

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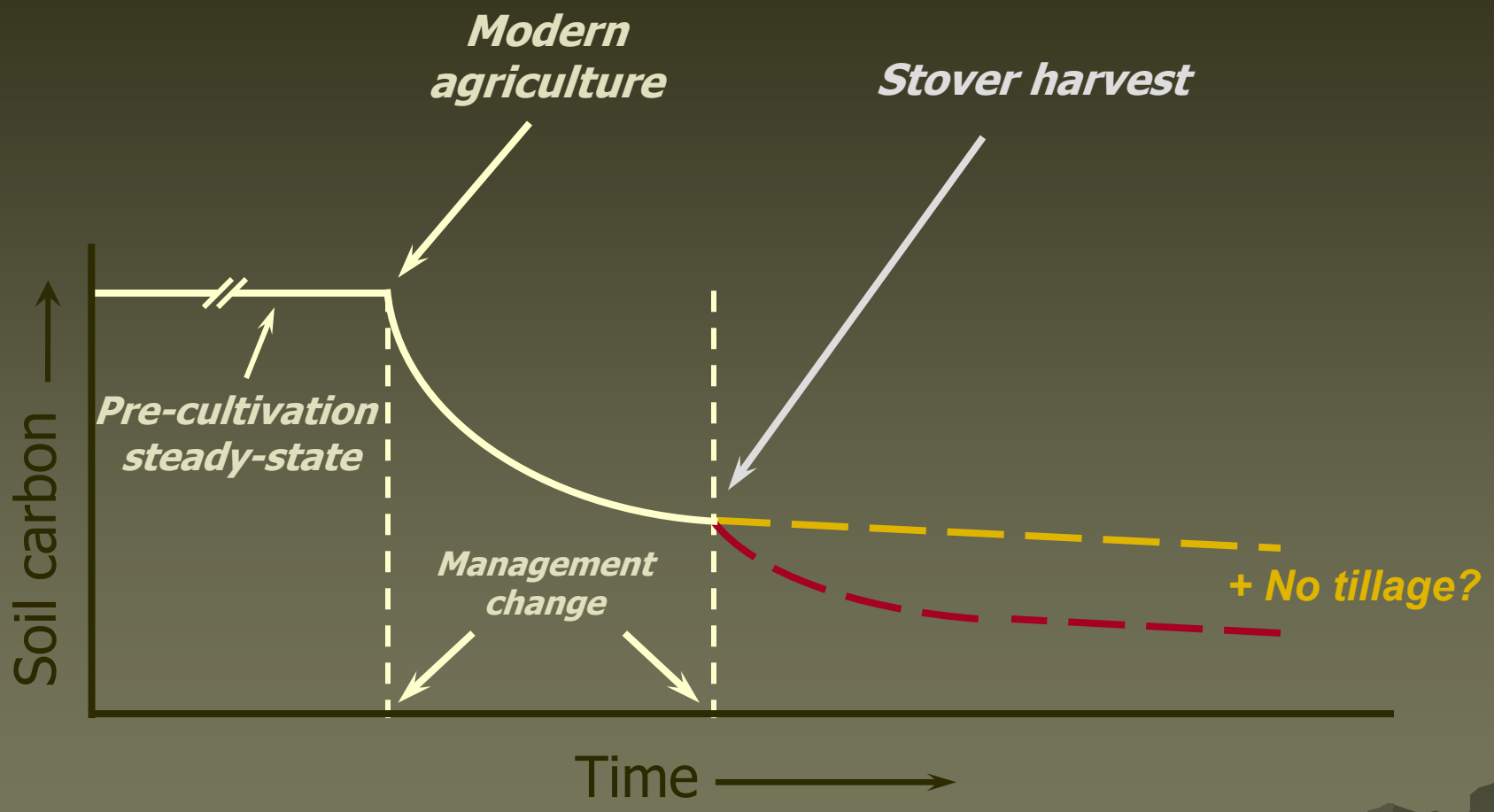

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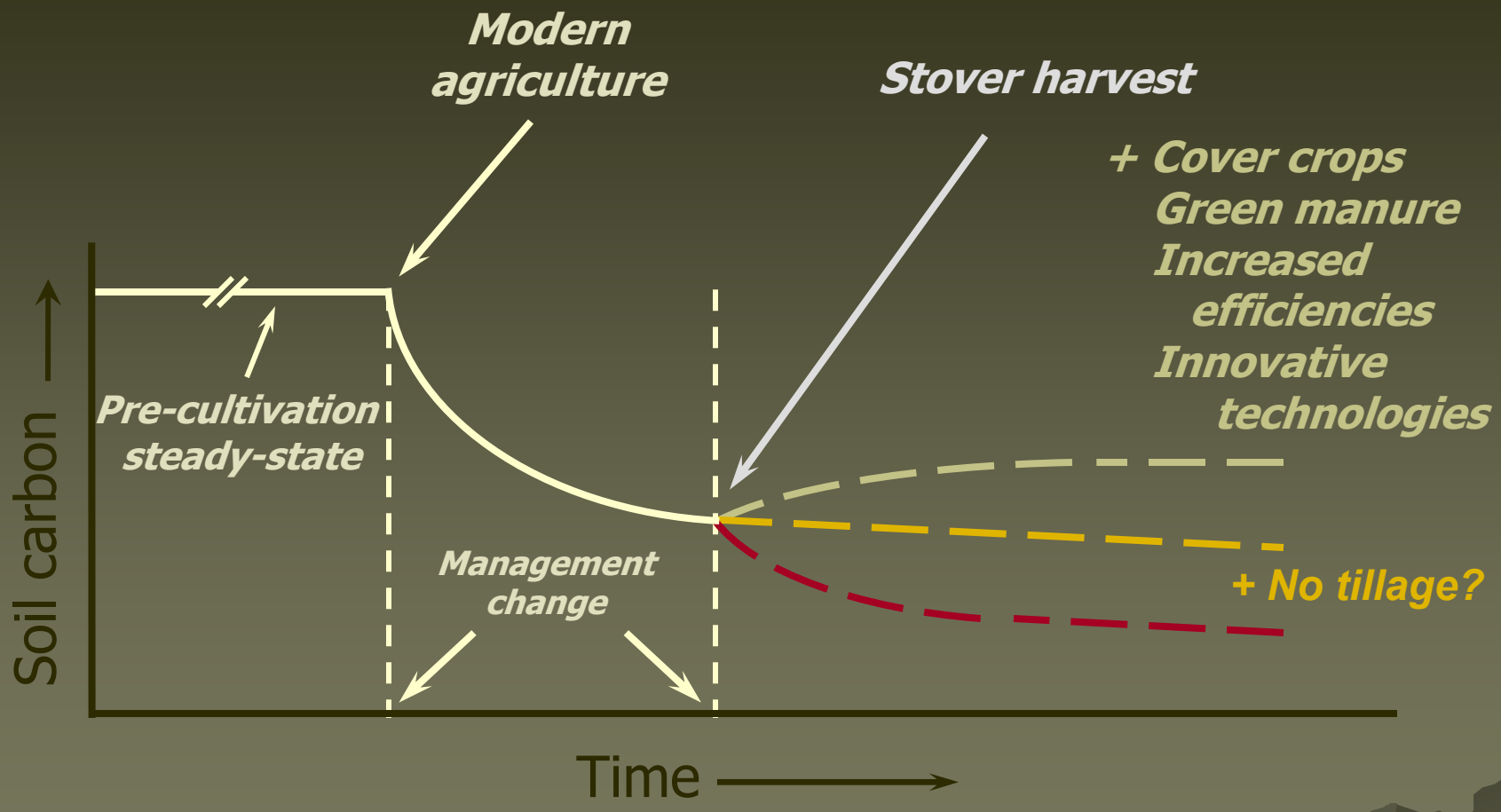
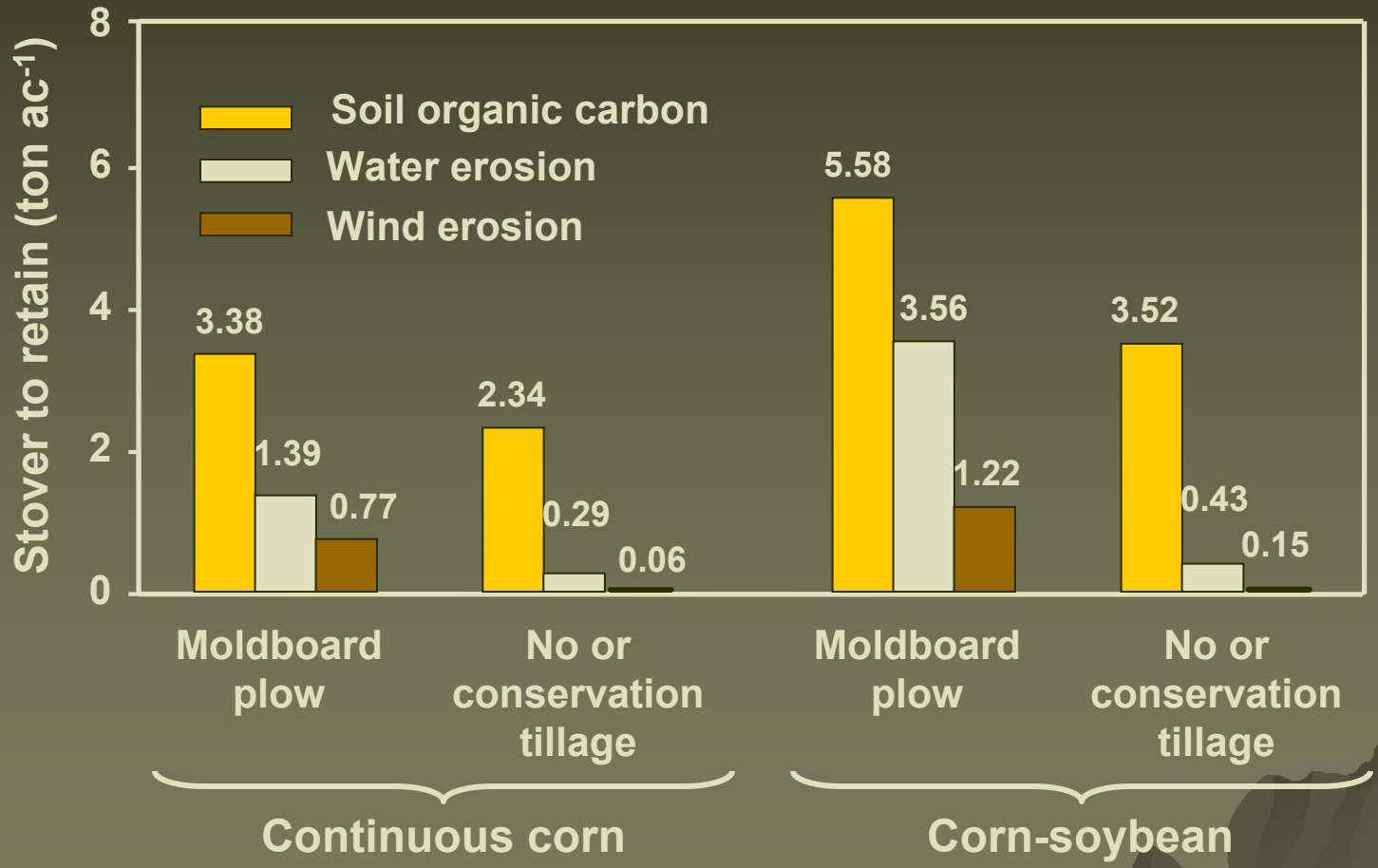


Δ ***SOC = Σ (inputs – outputs)***

SOC & Erosion Limit Crop Biomass Removal

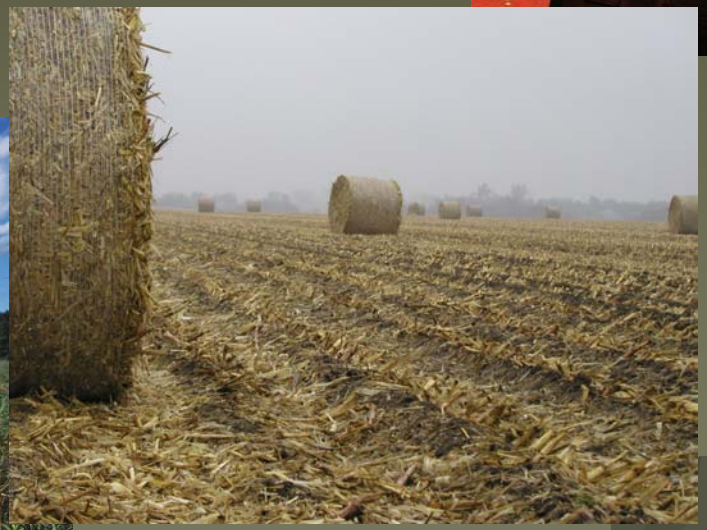
Common assumption: system is sustainable if retained crop residue reduces erosion losses to less than T



Wilhelm et al., 2007. Agron. J. 99:1665-1667.

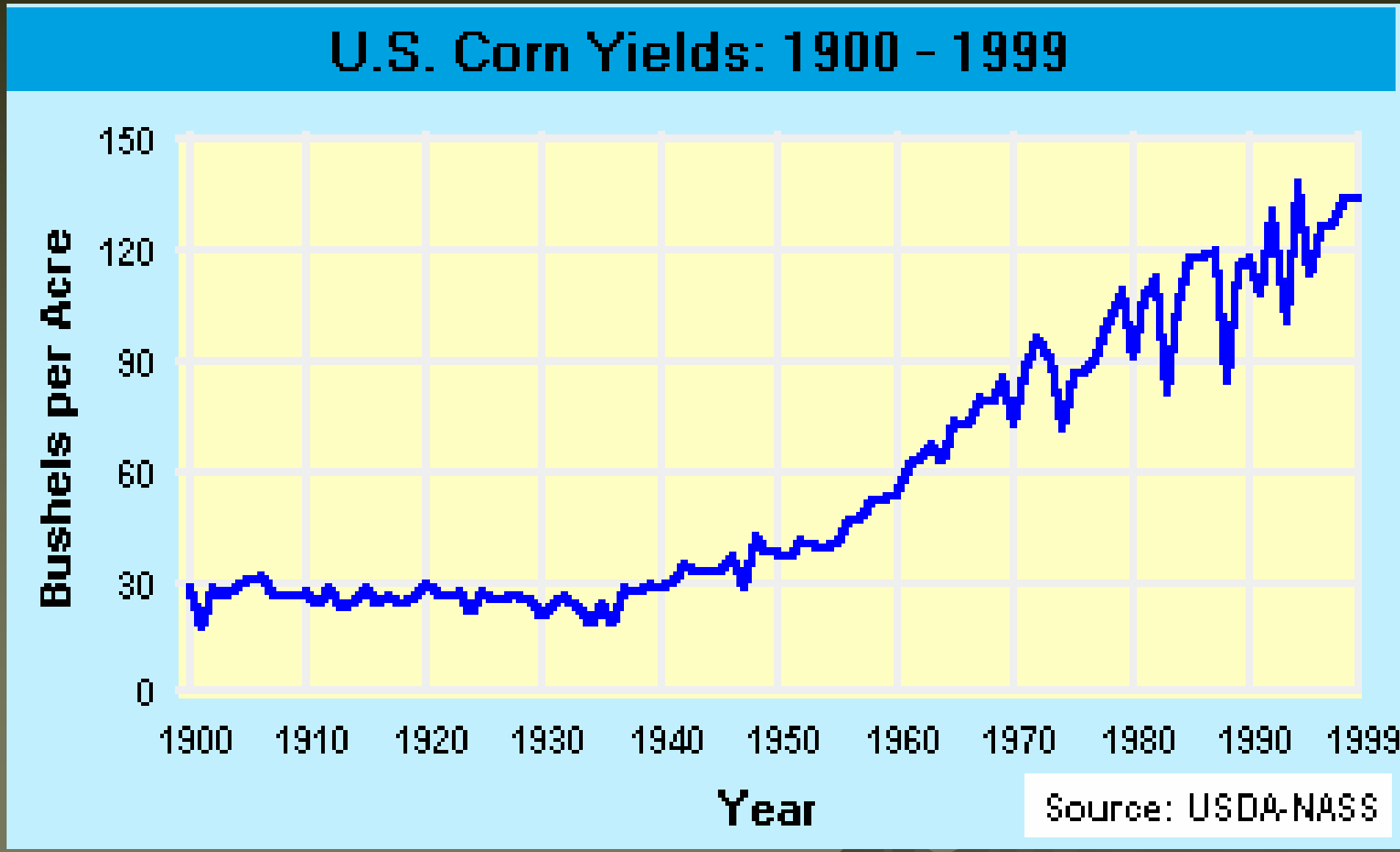
Biomass Sources From Agriculture

- Grain
- Crop residue
- Dedicated energy crops

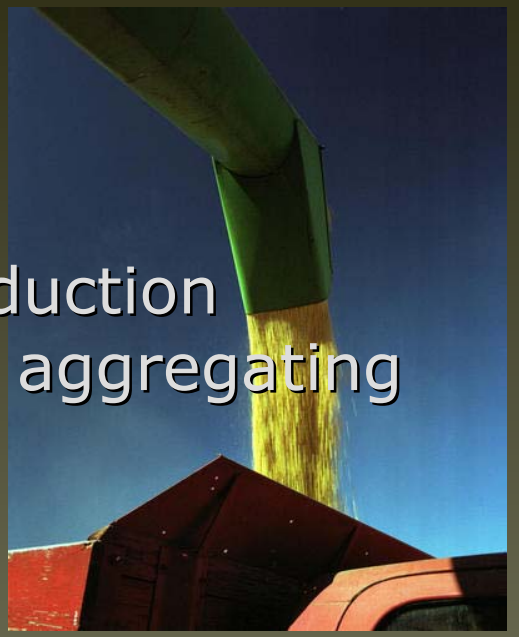


Grain

- Advantages
  - Current feedstock (largely corn)
  - Production, storage, transport, marketing, and conversion technology and expertise exist
- Liabilities
  - High market price increasing production area
    - Land use shift-marginal land returned to production
    - Less rotations, more monoculture, less landscape and species diversity
  - Demand met by increased yield per unit land
  - Improved genetics, improved practices

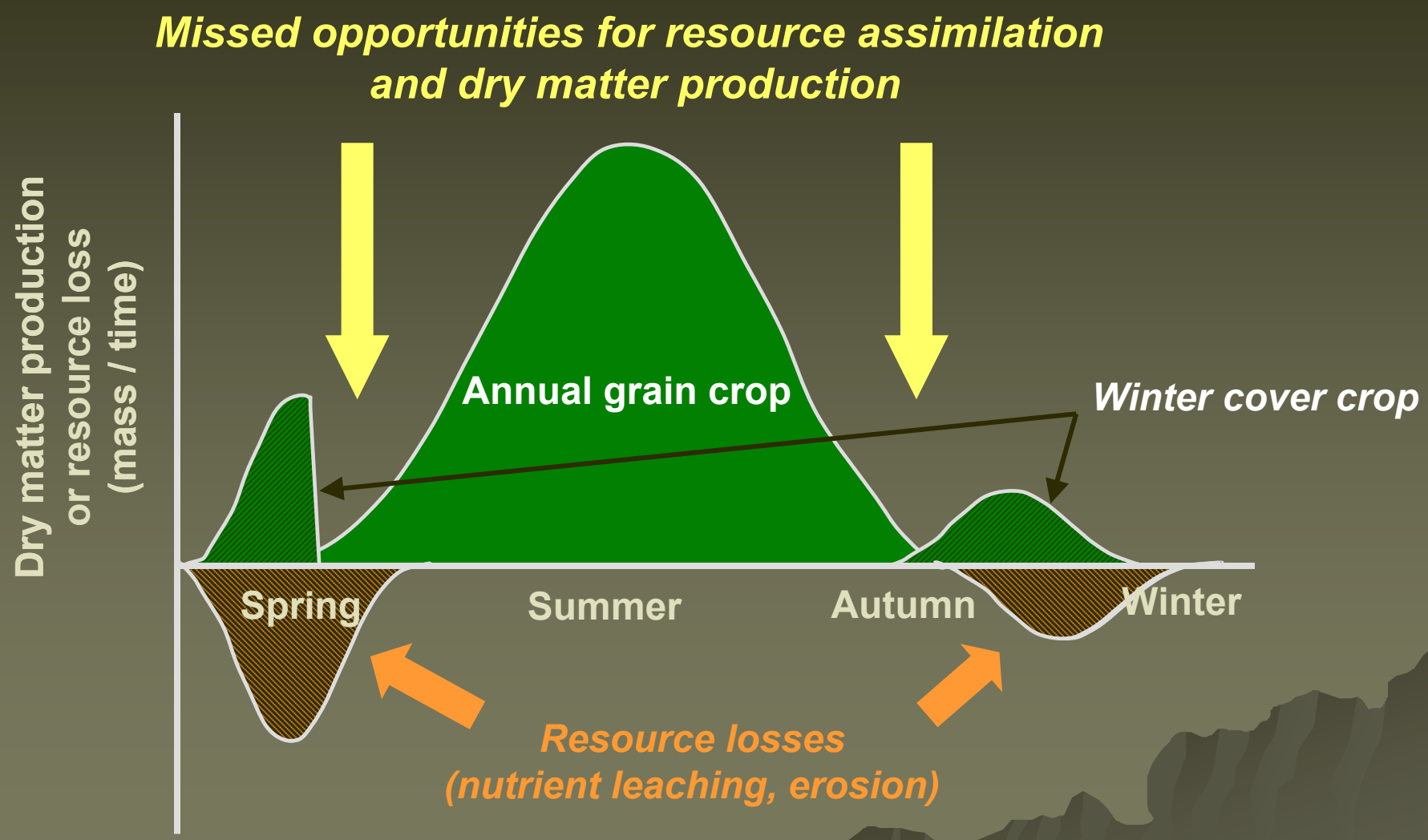

U.S. Corn Yields: 1900 - 1999
Bushels per Acre
150
120
90
60
30
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
1999
Year
Source: USDA-NASS

Grain



- Caveats
  - Technologies exist to improve production efficiencies (improve yield without aggregating environmental concerns)
  - Under-used practices
    - Cover crops, green manure crops
  - Innovative technologies

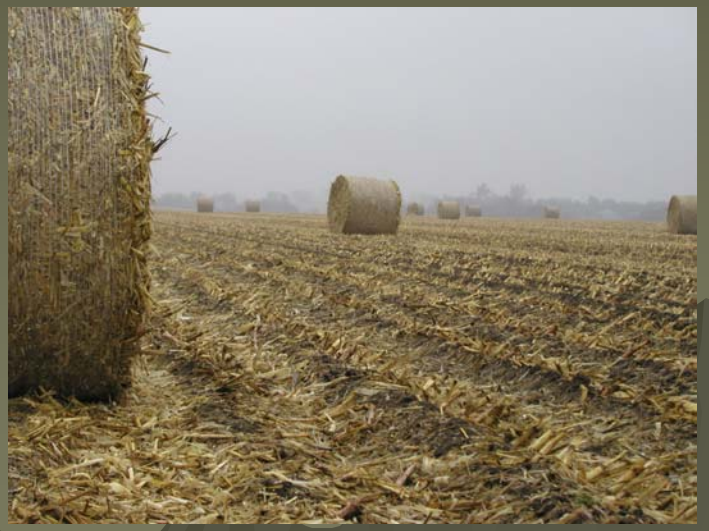
Cover Crop in Annual Cropping System



after A.H. Heggenstaller

Crop Residues

- Advantages
  - Production technology and expertise exist
  - Residue yield increases with grain yield
    - Harvest index
    - Cultural practices
    - Breeding emphasis shift to biomass
- Liabilities/Limitations
  - Currently important for:
    - Erosion control
    - SOC
    - Livestock feed
      - Increasing with supply of DDGS



Dedicated Energy Crops

- Annuals (triticale, sudangrass, tropical maize)
  - Advantages
    - Fit into existing crop rotation
    - Large production of biomass in one season
    - Adds to species diversity
    - C_3 and C_4 species
  - Disadvantages
    - Annual planting
    - Grower expertise lacking
    - Harvest technology
    - Biomass storage

Courtesy NRCS

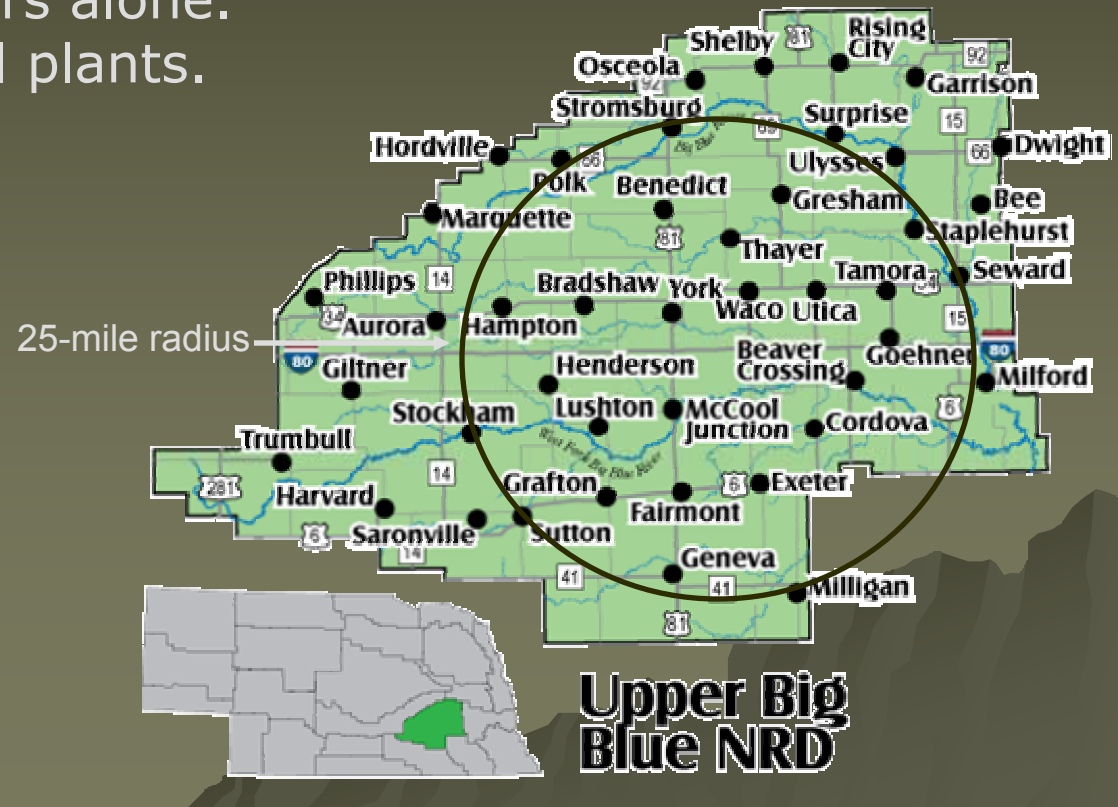
Dedicated Energy Crops

- Perennials (switchgrass, alfalfa, Miscanthus)
  - Advantages
    - Long rotation (multi-years of production)
      - Plant once, harvest for many years
    - Suited to more fragile or marginal lands
    - Fewer inputs (debatable)
      - Knowledge based on inefficient harvest systems (grazing)
      - Systems with low expected production (CRP)
  - Disadvantages
    - Grower expertise lacking
    - Harvest technology
    - Biomass storage
    - May become a monoculture to meet biomass demand (billion tons)

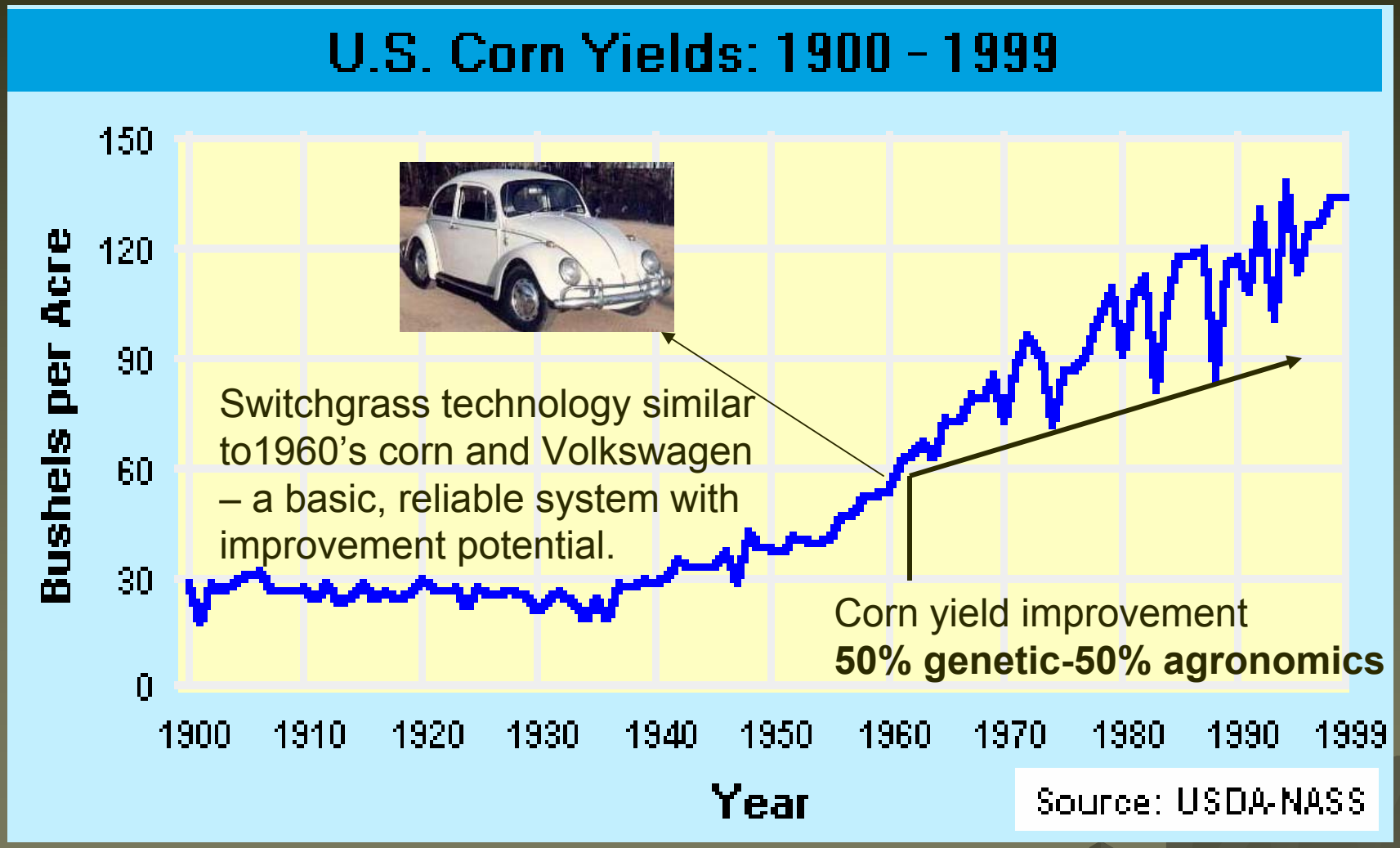
Dedicated Energy Crops
Where will they fit?

A 50-million gallon Ethanol Plant Will Require:

- 125,000 acres of switchgrass assuming 5 tons/acre and 80 gallons of ethanol/ton of switchgrass.
- The Upper Big Blue NRD has 1.83 million acres, 1 million irrigated acres, and 4,600 center pivots. This NRD could grow 128,800 acres of switchgrass in pivot corners alone.
- Has 4 existing corn ethanol plants.



Current switchgrass cultivars & agronomics equivalent to 1960's corn system



Improving biomass yields – hybrid cultivars

Strain	Yield T/A (Mg/ha)
Kanlow & Summer F1's	9.4 (21)
Kanlow	7.1 (16)
Summer	6.1 (14)

- Improved hybrid cultivars with modified cell walls could improve ethanol yields & reduce costs.

Over-arching Concerns

- Maximize capture and use of solar radiation and other inputs
- Create innovative cropping systems and technologies
- Continuously and adequately fund R&D to achieve bioenergy goals
- Coherent, coordinated energy policy
- Establish social environment of conservation


Multiple biomass feedstocks
Many technologies
Conservation
Reduced expectations
Asking, and answering, the right question