

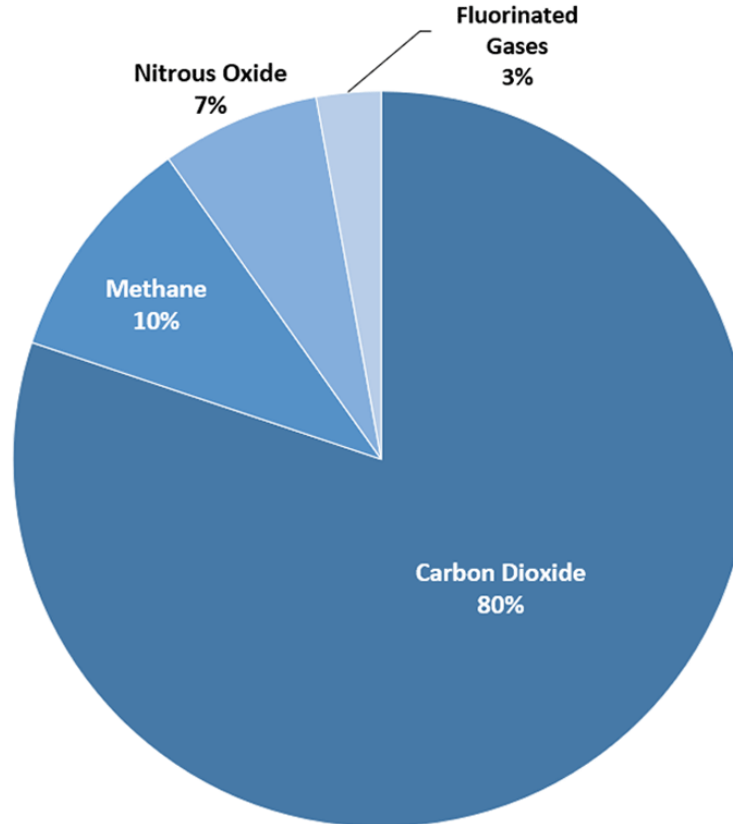


Measuring C: Carbon credits

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K·STATE
Research and Extension

Overview of U.S. Greenhouse Gas Emissions in 2019



U.S. Environmental Protection Agency (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019

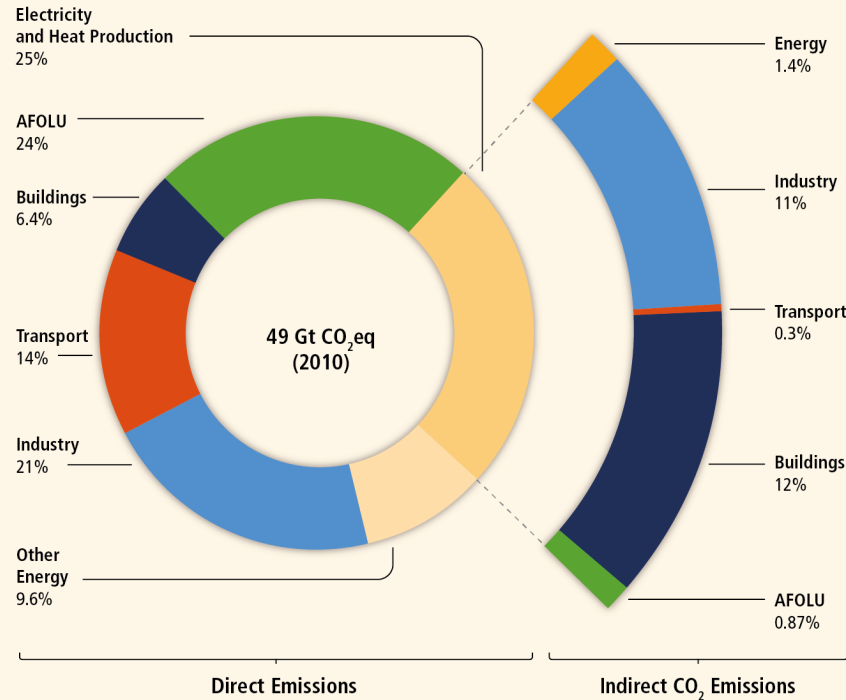
WHAT CAUSES GHG EMISSIONS TODAY?

- Anthropogenic GHGs come from many sources of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (HFCs, PFCs and SF_6).
- CO_2 makes the largest contribution to global GHG emissions; fluorinated gases (F-gases) contribute only a few %
- The largest source of CO_2 is combustion of fossil fuels (energy, engines, and in cooking and heating)
- One third comes from other activities like agriculture (mainly CH_4 and N_2O), deforestation (mainly CO_2), fossil fuel production (mainly CH_4) industrial processes (mainly CO_2 , N_2O and F-gases) and municipal waste and wastewater (mainly CH_4).

Many sources of GHGs

Agriculture, Forestry and
Other Land Use (AFOLU)

Greenhouse Gas Emissions by Economic Sectors



FUTURE PREDICTIONS

- GHG emissions are projected to grow in all sectors, except for net CO₂ emissions in the AFOLU sector
- Energy supply sector emissions are expected to continue to be the major source of GHG emissions
- While non-CO₂ GHG agricultural emissions (methane, nitrous oxides) are projected to increase, net CO₂ emissions from the AFOLU sector decline over time, with some models projecting a net sink towards the end of the century
- What this means: Ag and forestry have an opportunity and C trading markets are coming into existence

STRATEGIES

- The most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation, with large differences in their relative importance across regions.
- In agriculture, the most cost-effective mitigation options are cropland management, grazing land management, and restoration of organic soils (ex: Histosols in MN, WI, MI, and FL)

Outline

- C math
- C studies in Kansas
- C programs



(Not Kansas)

Backing way, way up:

- Where do soils come from? They are a product of the five soil forming factors, which are?
- 1.
- 2.
- 3.
- 4.
- 5.
- And 6.



**This means not all
soils are created equal**

- They can and do vary
- Across a landscape
- Even on the north side and south side of a hill



Climate as a soil forming factor

- Jenny (1941) reported the following relationships as rainfall increases (valid only for regions having average annual precipitation ranging from 15 - 35 in):
 - pH of soil decreases
 - Depth to secondary carbonates increases
 - OM values increase
 - Clay content increases
- Jenny (1941) also reported the following relationships as temperature increases:
 - Soil colors become less gray and more red
 - Bases are leached more
 - N and OM contents decrease
 - Clay contents increase

Paleoclimatic Sequence in Central US

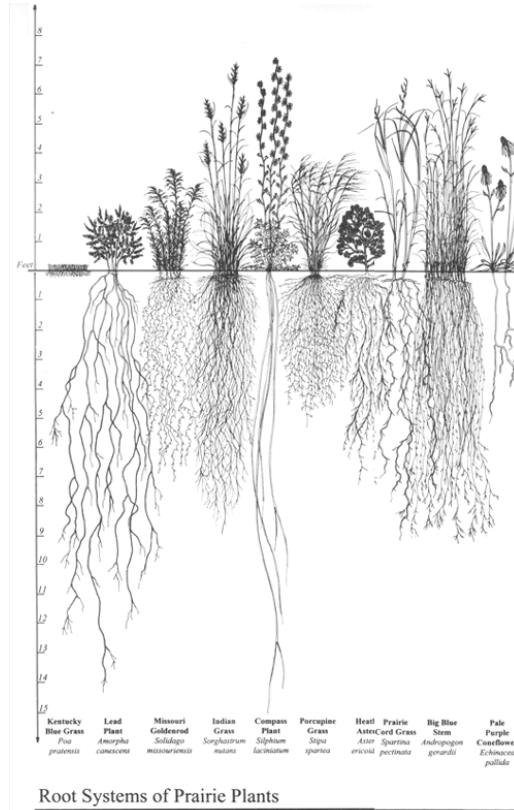
- > 1940 AD End of Dust Bowl marked beginning of slightly cooler period
- 1850 - 1940 AD Warmer, drier climate. Included period of dust bowl.
- 1430 - 1850 AD Very cool, moist period. Called "Little Ice Age" in Europe.
- 900 - 1300 AD Medieval Warm period. Norsemen occupied Greenland.
- 900 - 300 BC Cool period called "Iron Age Cold Epic"

Paleoclimatic Sequence in Central US

- 4500 - 6500 BP Warm dry period called "Hypsithermal." It was a period of great drought in U.S. Prairie expanded at the expense of forest.
- 6500 - 8500 BP Deciduous forest replaced coniferous forest.
- 8500 - 9500 BP Climate was cool and moist. Coniferous forest covered all of central U.S. Most of Kansas was covered by a prairie.
- 9500 - 11,000 BP End of Wisconsin glaciation (extended as far south as Des Moines)
- 12,000 - 10,000 BP Mass extinctions in the Great Plains. More than 1/2 of species of North American large animals became extinct.

And the point? The whooooooooole time our soils were forming.

Root Systems of Prairie Plants

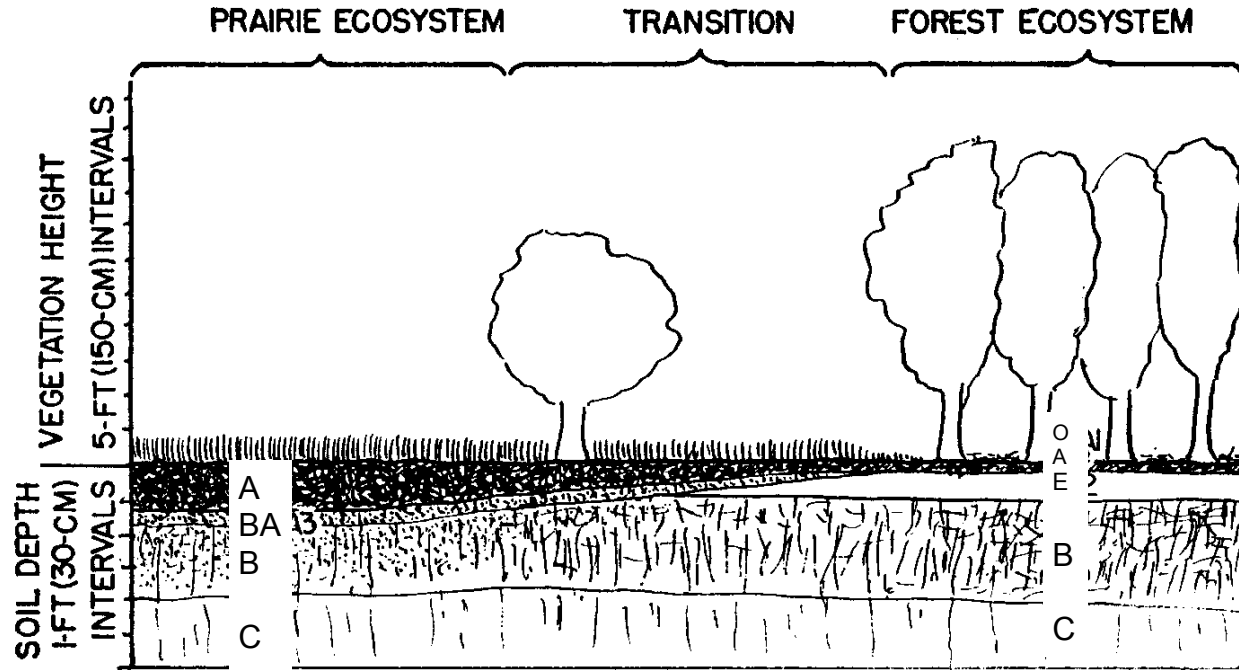


Root Systems of Deciduous Trees



From <http://imageweb-cdn.magnoliasoft.net/bridgeman/supersize/lal304195.jpg>

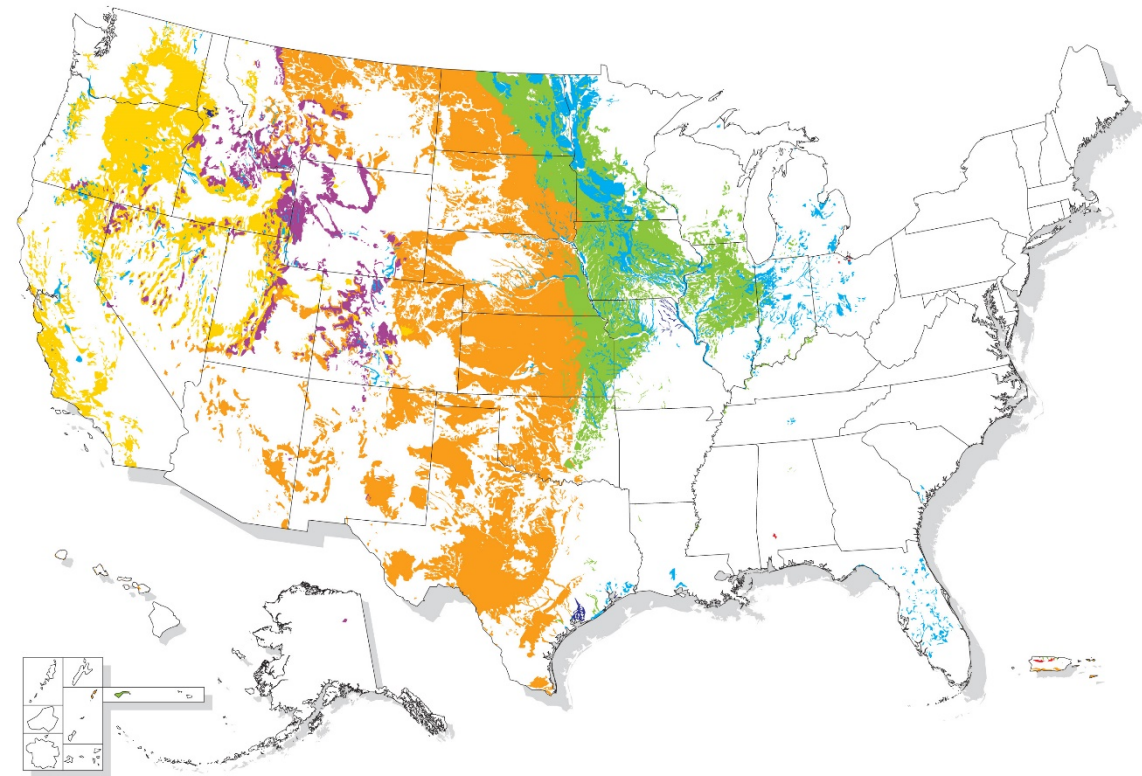
Vegetation and Soil Relationships at the Transition from Prairie to Forest



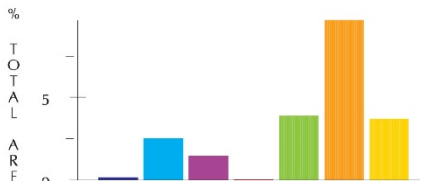
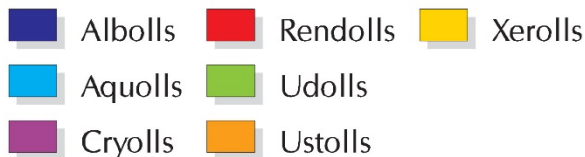
From Buol et al. (1980)

MOLLISOLS

- Mollis, Latin for “soft”
- Generally form under prairie



DOMINANT SUBORDERS



Carbon math

- Soil organic matter: What's all in it?
- How do we measure it?
- What values do we need to know?
- How can I compare two fields?

COMPARING SOILS



What's the different between the two photos? Hint: 150 years.



Photos: Ian Kenney

Cropland 40-60% eroded relative to adjacent pasture, NE KS

C: traded in tons per acre

- Or megagrams per hectare (Mg/ha)
- Need to know:
- Percent soil organic C (SOC)
- Bulk density (g/cm^3)
- And depth

Bulk density

- Excavate a known volume of soil and determine dry mass
- Volume of a cylinder:
 $\pi \cdot r^2 \cdot h$
- Where h is the length of the core
- r is half the diameter

Table 1. Average minimum bulk densities that restrict root penetration in soils of various textures.

Texture	Bulk Density g/cc
Coarse, medium, and fine sand	1.80
Loamy sand and sandy loam	1.75
Loam and sandy clay loam	1.70
Clay loam	1.65
Sandy clay	1.60
Silt and silt loam	1.55
Silty clay loam	1.50
Clay	1.40

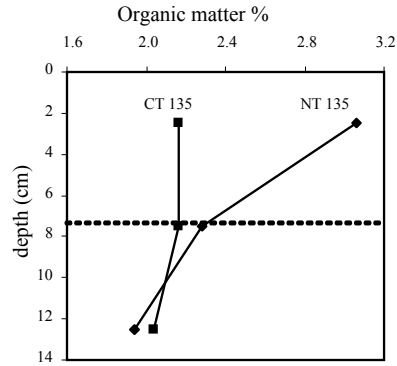
Converting C

- Soil organic matter contains C, N, S, H, O and lots of other elements
- On average, SOM is a little over half C by weight
- So the number 1.7 is used to convert
- $SOM = SOC * 1.7$

LONG-TERM SORGHUM

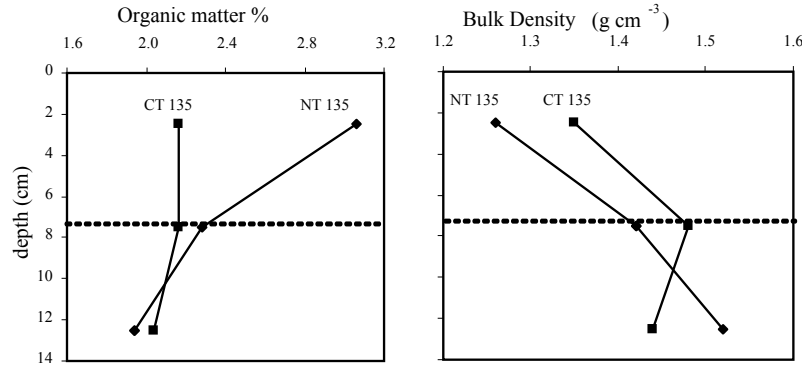
- Established 1982
- Soil sampled 2008
- Continuous grain sorghum, CT and NT, 4 N rates (0, 30, 60, 90, 120 lbs/ac)
- Sampled 0-2, 2-4, and 4-6 inch increments (sectioned cores)
- SOC determined with a LECO analyzer (if your soil contains carbonates, you'll have to get those removed)

Relationships: Organic matter is key



- Both soils received the same N rate for 30 years
- One tilled, other not tilled

Relationships: Organic matter is key



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TONS PER ACRE

- Or in this study I'm using metric which is Mg per ha and it's pretty close to tons per acre
- At the highest N rate:

Depth	NT	CT
0-2"	15.3	10.8
2-4"	11.4	10.8
4-6"	9.7	10.2
Sum:	36.4	31.8

MANAGEMENT PRACTICES

- For that same study, averaged across all the N rates, NT contained 34.9 Mg/ha SOC and CT contained 31.7 Mg/ha SOC
- So on the management list, practices that store more C in soil include:
- Reduced tillage disturbance
- More crop residue remaining on the surface
- Cover crops
- Good grazing management