

Climate Change / Carbon and Grazing

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Kamloops, BC

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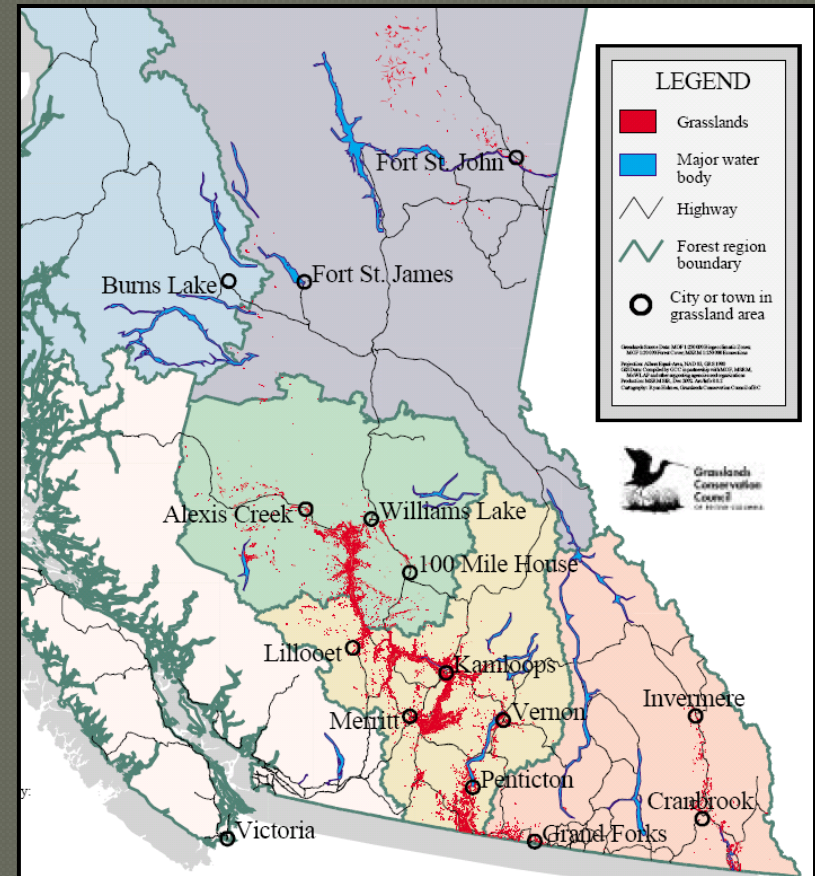
Outline

- ◉ Background on grasslands
- ◉ Carbon stocks and fluxes
- ◉ Soil carbon in a Kamloops grassland
- ◉ Soil processes 101
- ◉ Grassland afforestation scenario
- ◉ Summary



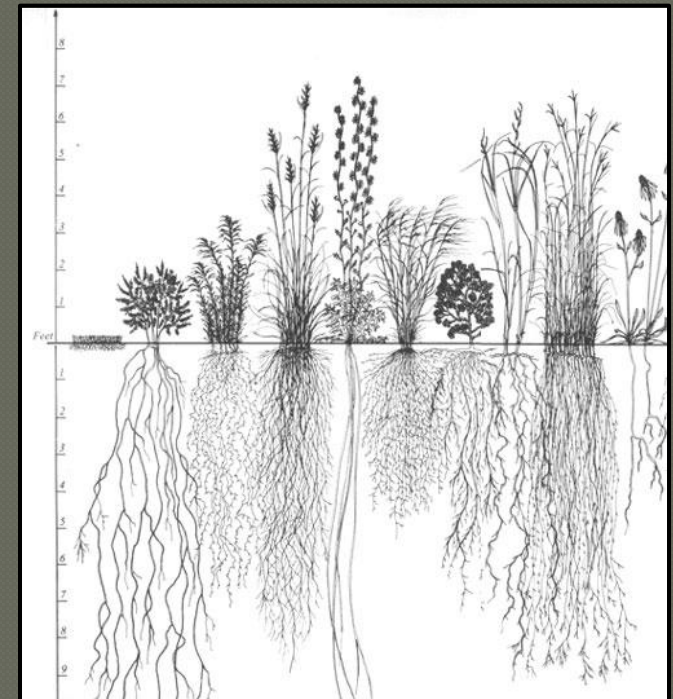
Grasslands of British Columbia

- 4 000 000 ha of open forest grazing
- 1 000 000 ha of grasslands
 - semi-arid (25 – 50 cm precip.)



Chernozem Soils Formed Under Grasses

- Source of organic matter is in direct contact with mineral particles
- High degree of mixing from soil biota
- Little leaching of nutrients due to low precipitation



Factors of soil
formation

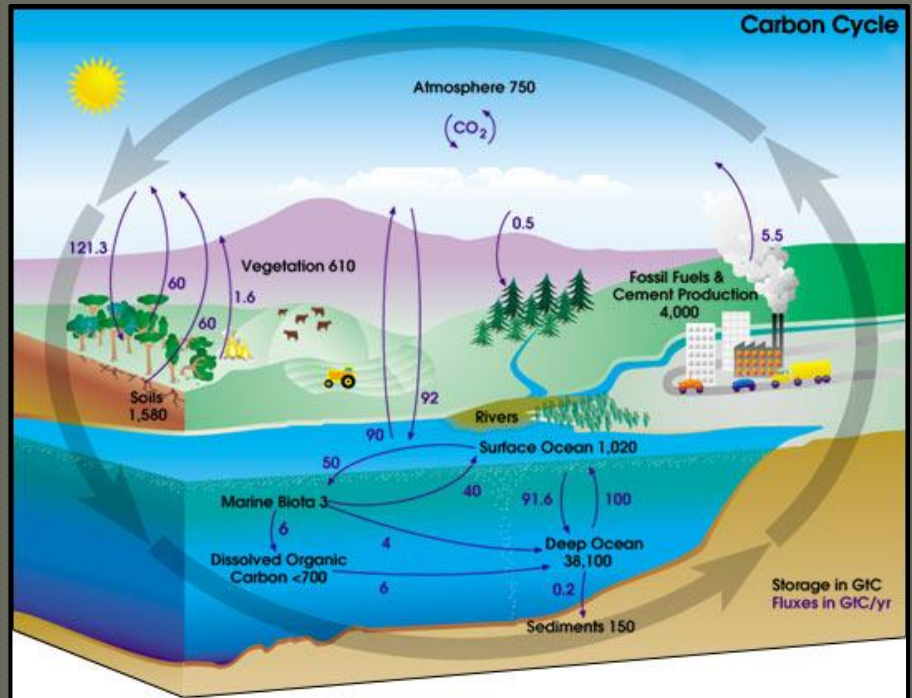
$$S = f(\text{cl, o, r, p, t....})$$

Global Carbon Stocks

Global Carbon Stocks

(Gt Carbon); Gt = 1 billion tonnes

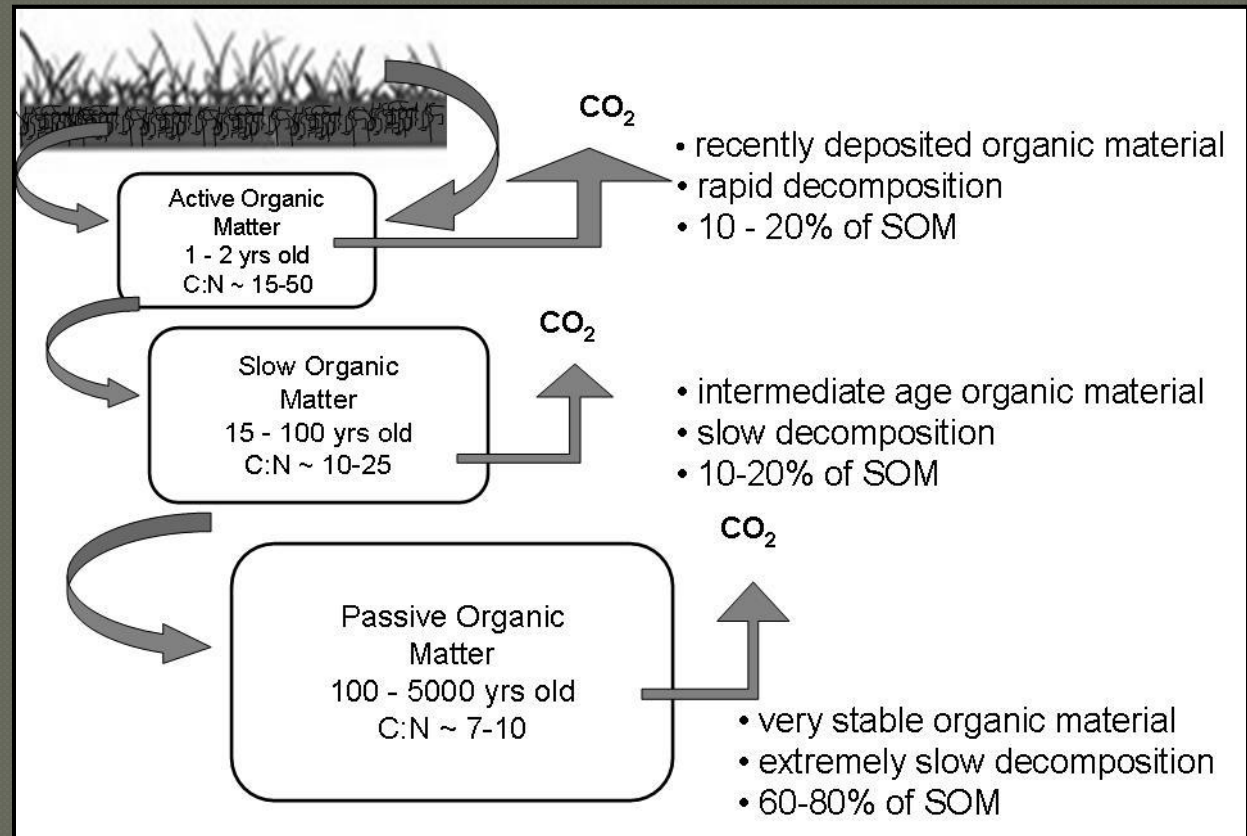
surface ocean	1020
vegetation	610
soil	1580
atmosphere	750
fossil fuels	4000



Soil Organic Matter (SOM) Pools

Includes ALL the organic components of the soil:

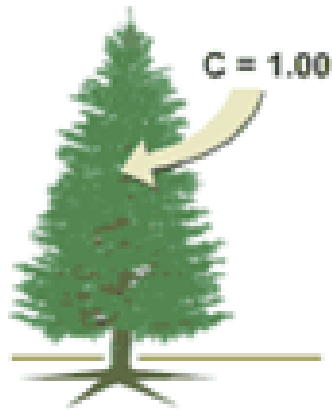
- living biomass
 - bacteria, fungi, nematodes, etc.
- detritus
 - plant litter
 - complex carbohydrates
- humus
 - humic and fulvic acids, humin



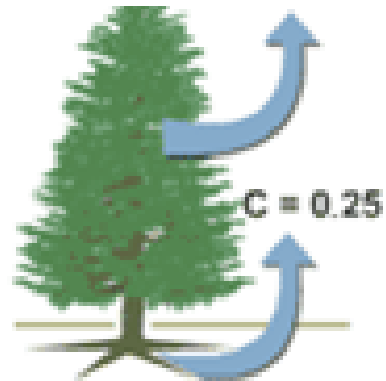
Inputs and Outputs

- In general, CO_2 is in equilibrium among the atmospheric and terrestrial pools

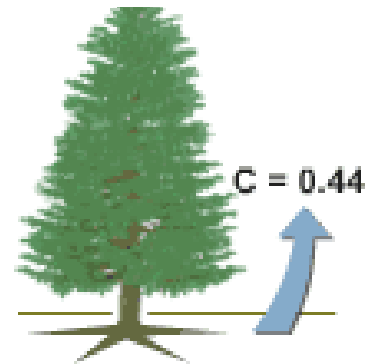
Photosynthesis



Autotrophic
Respiration



Heterotrophic
Respiration

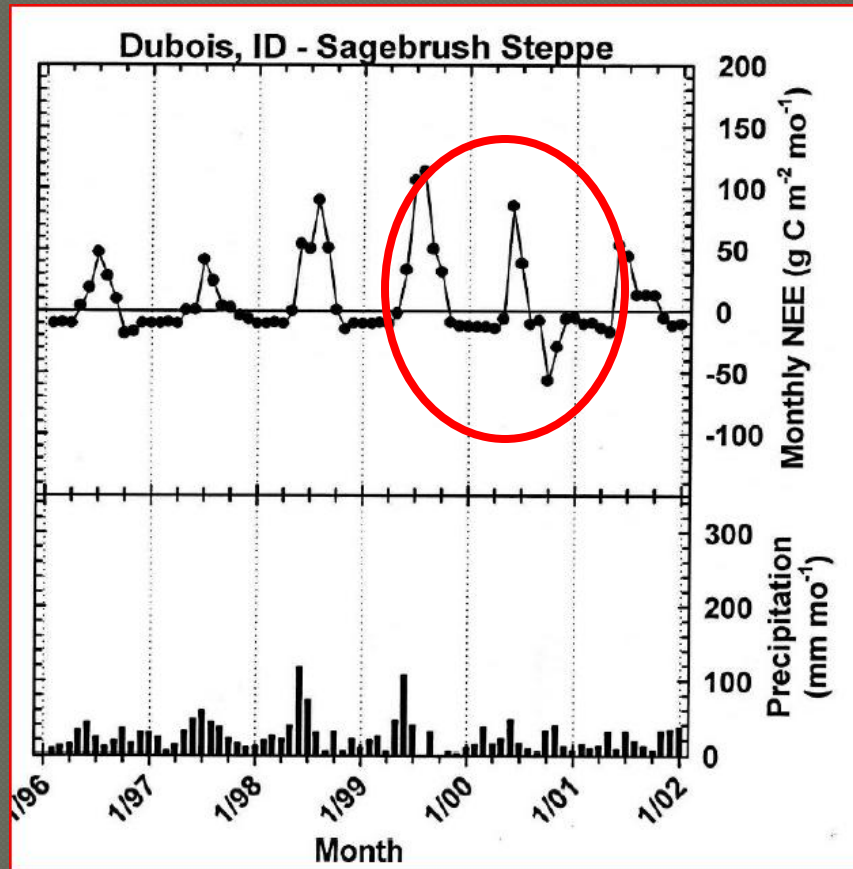


Inputs

Outputs

Variability of CO₂ Flux in Grasslands

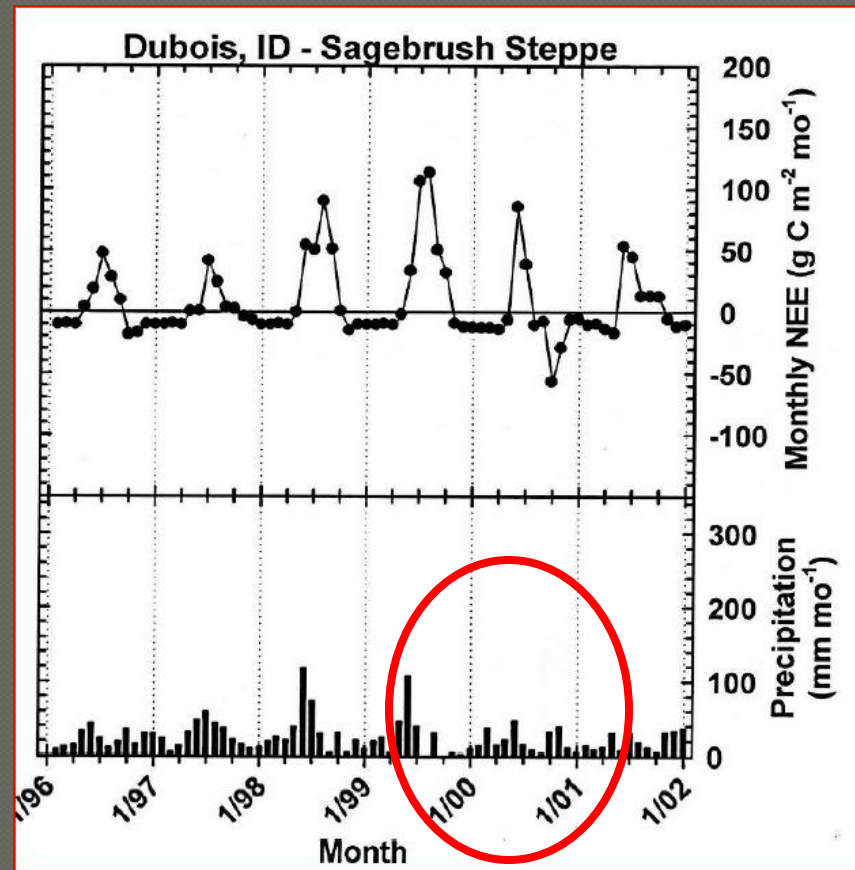
- Inter and intra year variability in Net Ecosystem Exchange (NEE) is large



Source: Svejcar et al. (2008)
Carbon Fluxes on North
American Rangelands.
Rangeland Ecology &
Management 61:465-474

Variability of CO₂ Flux in Grasslands

- The variability follows patterns of precipitation, which is the largest driver of Net Primary Productivity (NPP)



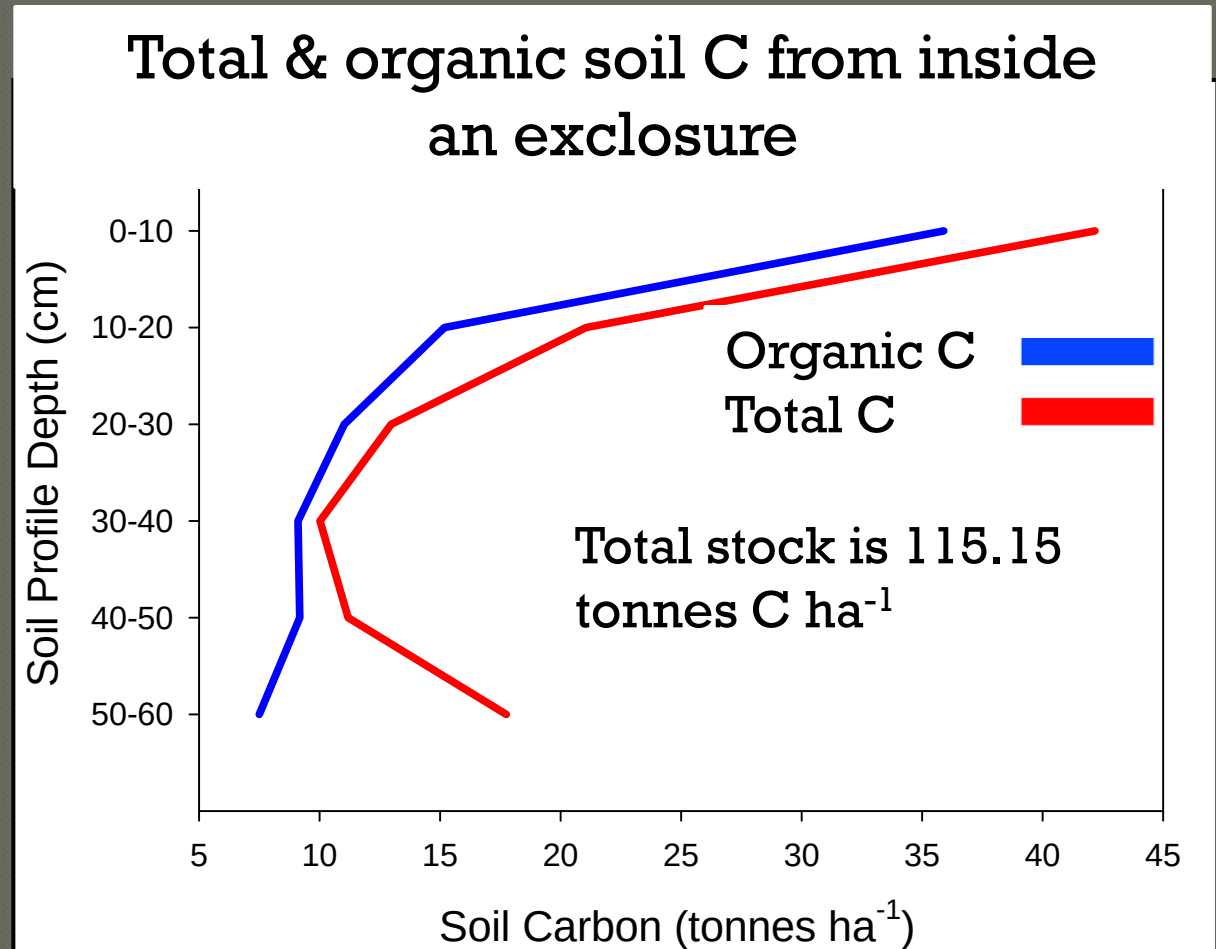
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Carbon Content of Grassland Soil Profile in Kamloops

- Samples taken from a soil pit in a dark brown chernozem (elev. 900-1000 m)
- The sharp increase in C content below 30 cm is inorganic carbon (e.g., CaCO_2)
- Soil organic C content decreases with depth



Carbon Content of a Kamloops Grassland Soil Profile

Total soil C from
IDF dk

0-30 cm 26

30-60 cm 9

35

Soil Carbon (Mg ha^{-1})

Outside

Inside

Total

Organic

Total

Organic

0-30 cm

63

56

76

62

30-60 cm

42

19

39

26

total

105

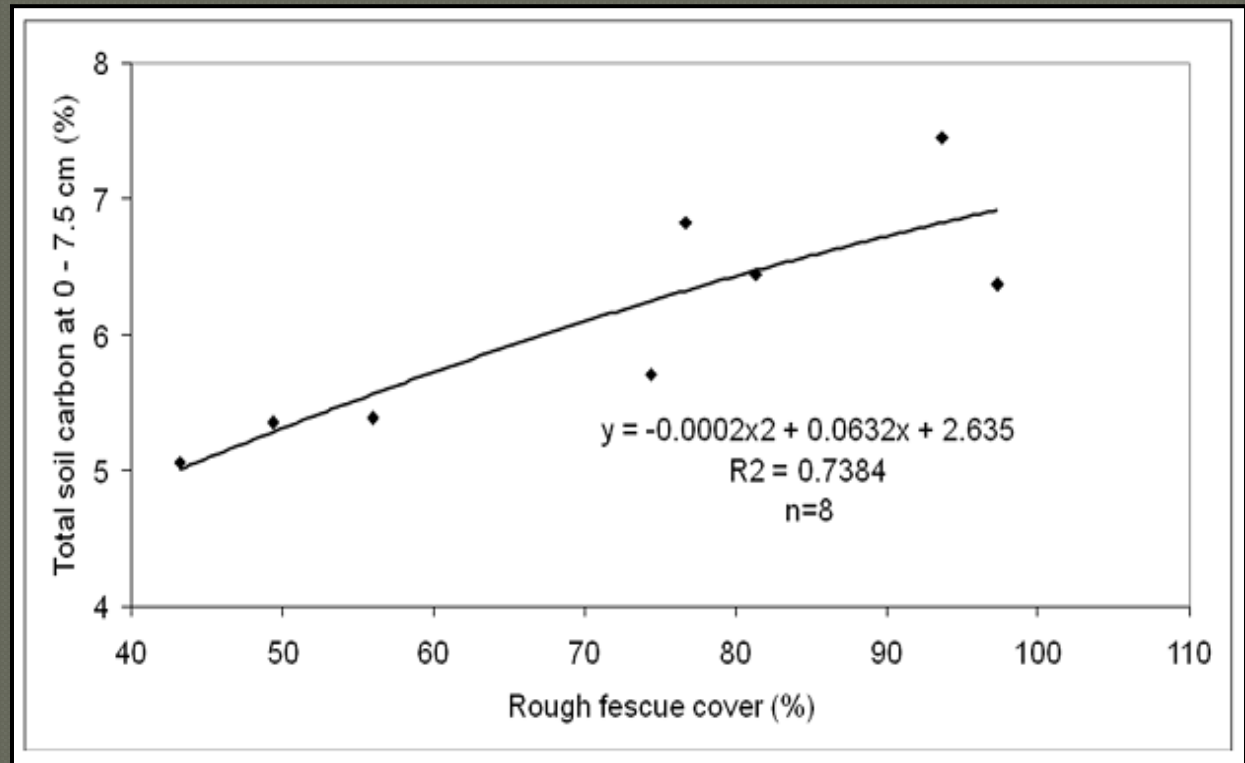
75

115

88

Potential to Sequester Carbon

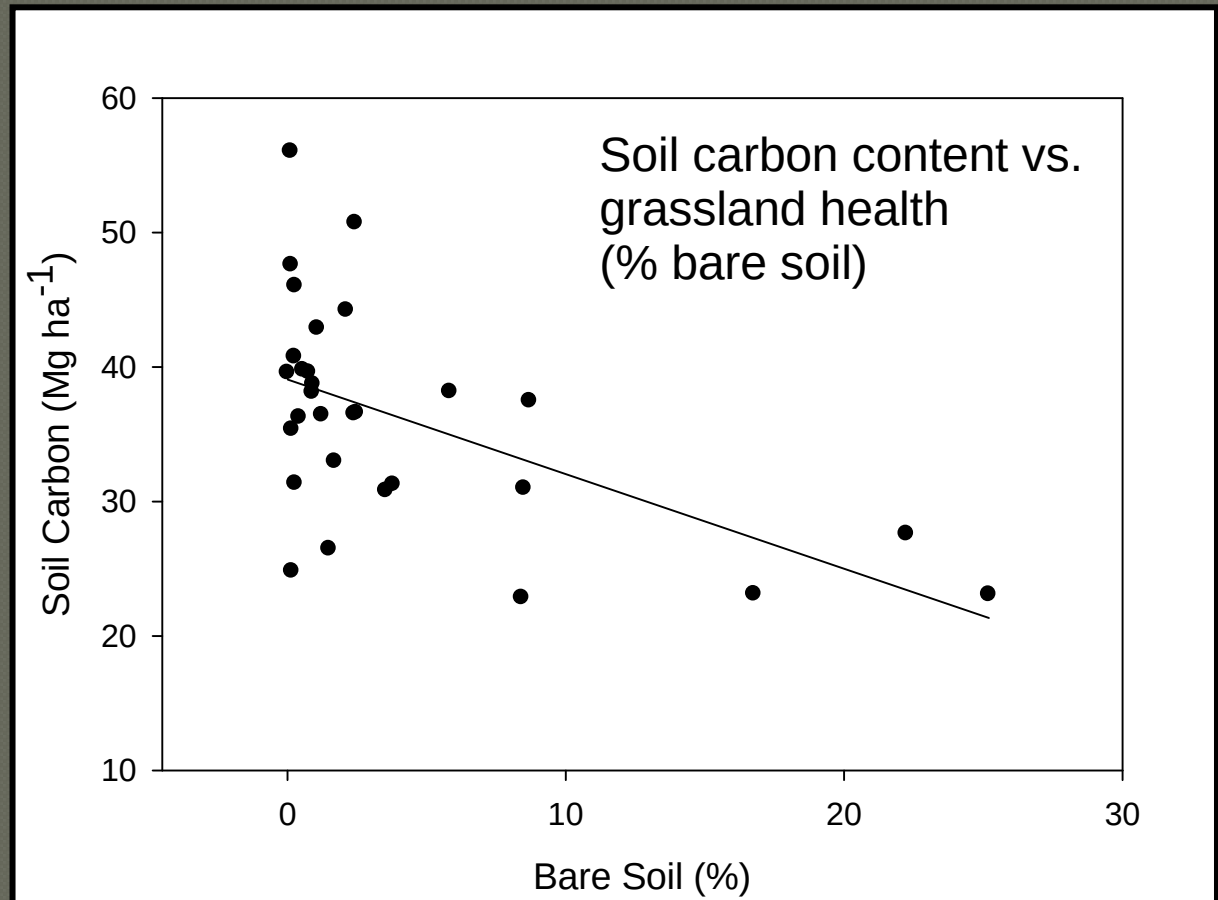
- Managing grasslands for late seral plant communities will remove CO₂ from the atmosphere
- Grasslands with high organic matter are more productive, retain more soil water, and protect against soil erosion



Source: Newman et al. (2008). Development of cost-effective health indicators for fescue grasslands of British Columbia. FSP Project Number: Y081045.

Potential to Sequester Carbon

- Managing grasslands for a healthy state (e.g., minimize bare soil) will remove CO₂ from the atmosphere
- The greatest potential to increase C sequestration is on our most degraded grasslands



Outline

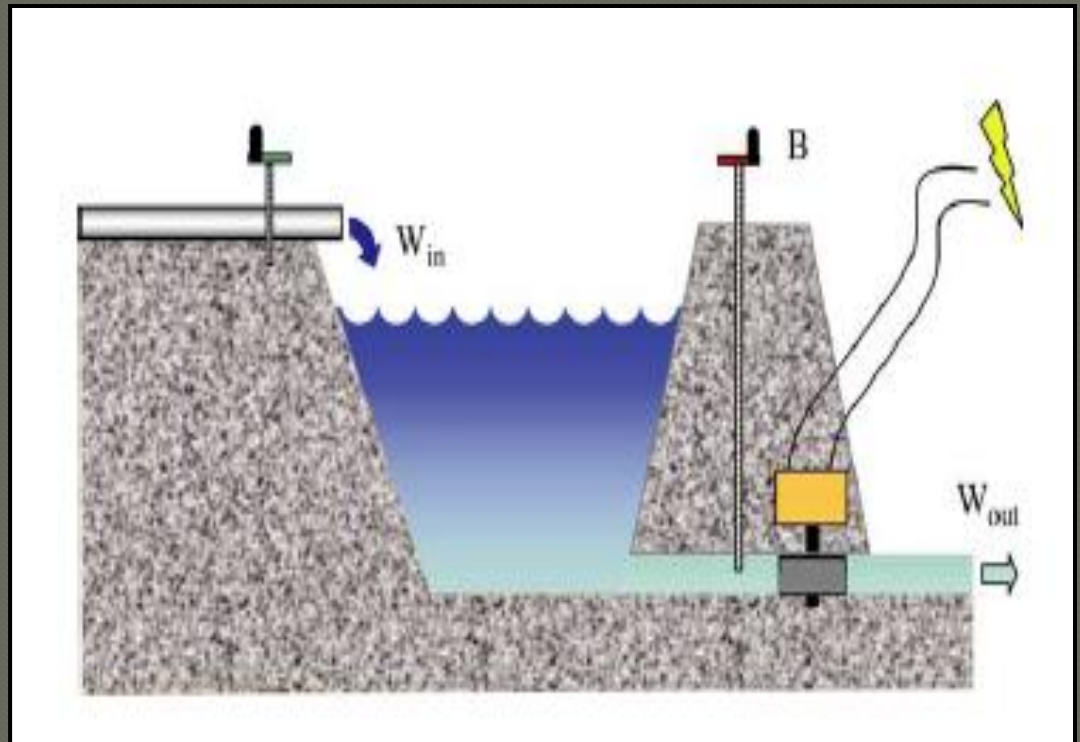
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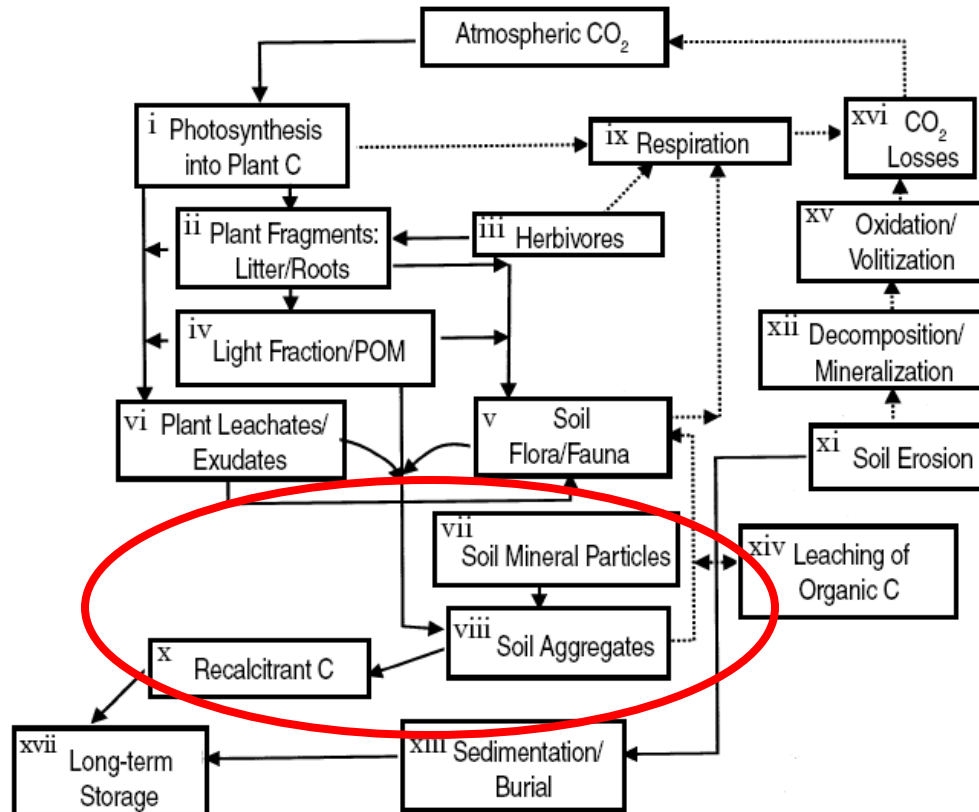
The soil carbon dilemma: Shall we hoard it or use it?

Henry Janzen, 2006

- Soil organic matter when decomposed provides nutrients and the energy for all biochemical reactions in the soil
- Soil organic matter when stored in the soil keeps CO_2 from entering the atmosphere, and provides integrity to soil physical properties



Processes of Soil Carbon Losses and Additions

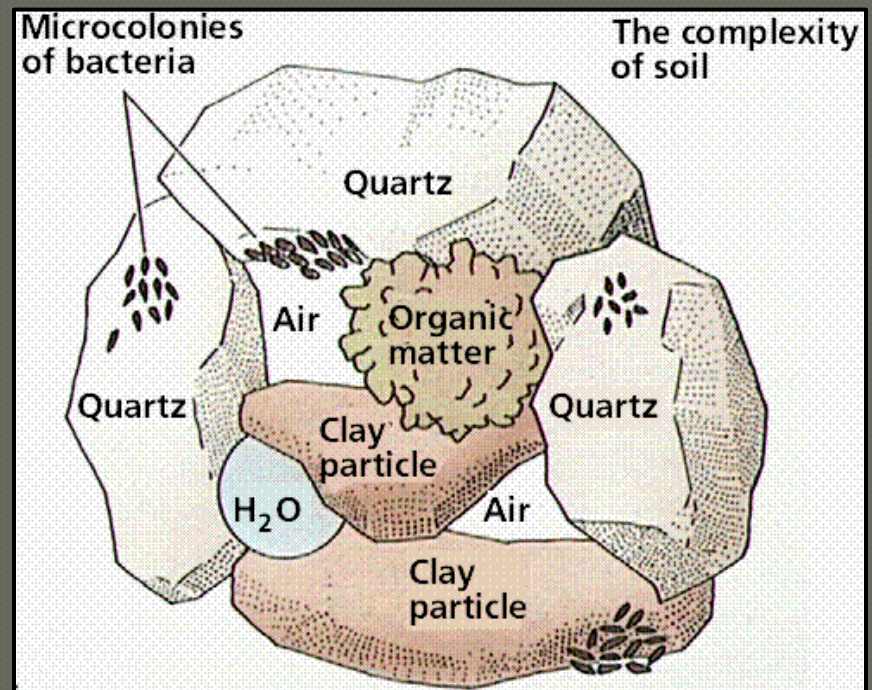


Source: Follett et al. (2001). The Potential of U.S. Grazing Lands to Sequester Soil Carbon

Figure 16.1. Pools and processes for the sequestration and loss of soil organic carbon.

Physically Protected Organic Matter (OM) – Soil Aggregates

- Biologically mediated mix of chemical and physical soil processes that bind clay, silt, and sand particles together
- Aggregates vary in size from about 2 μm – 2 mm, and are made up of particles of varying sizes
- OM is occluded within the nucleus of the aggregate becomes physically inaccessible to degrading microorganisms



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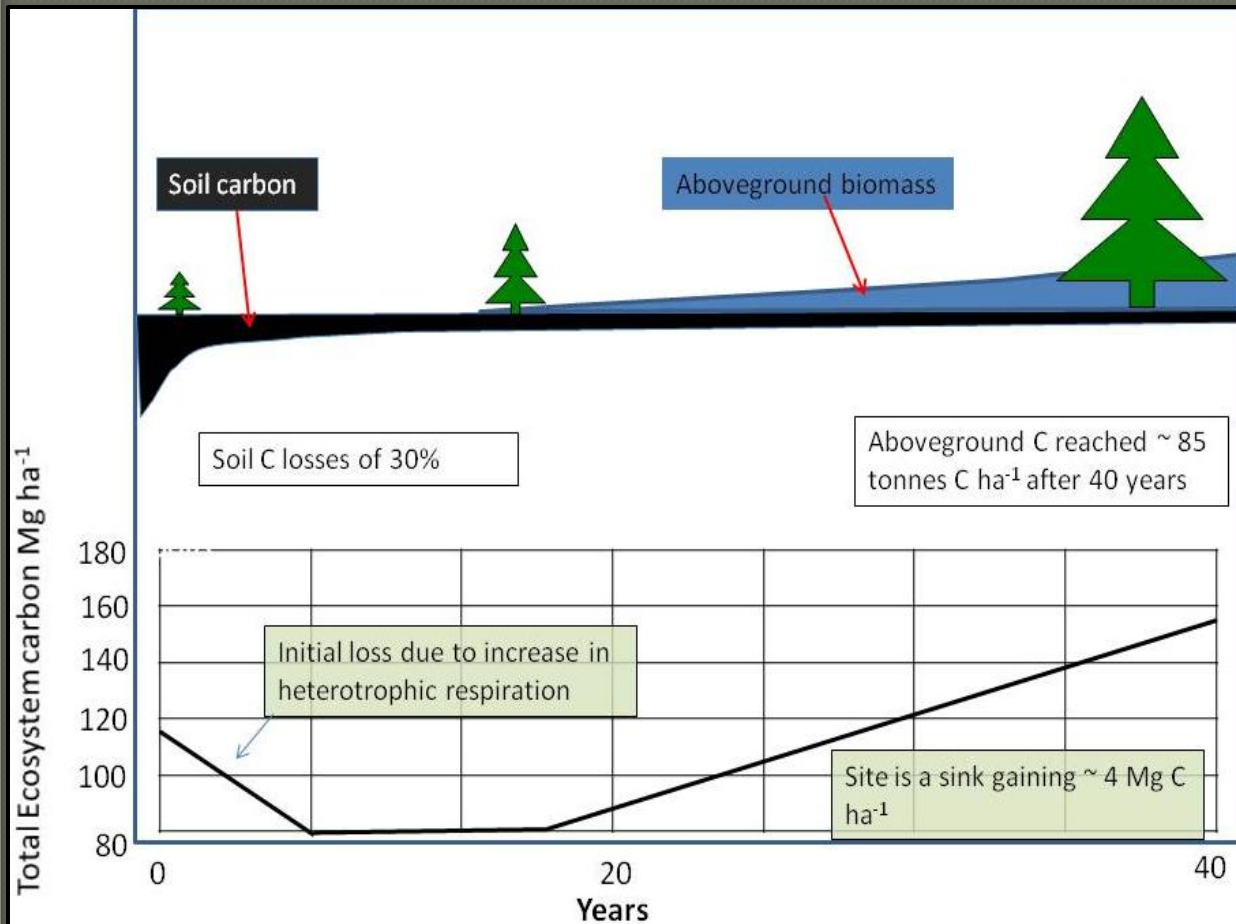
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Grassland Afforestation Scenario



Grassland Soil Carbon Accounting



- Site is estimated to be a C sink at 15-20 years
- There is little evidence of soil C accumulating following land conversion to forest from native grassland
- At 40 years the site has gained 85 Mg, yet lost 40 Mg from the more stable C pool

Uncertain sink in the trees

- How will a changing climate regime affect plant water-use efficiencies?
- What effect will forest litter have on the biochemical soil processes as opposed to grass litter. Will soil C levels increase, decrease, or stay the same?
- Is there risk involved when our C sequestration efforts are focused on above-ground pools that are susceptible to insects and fire?

Future Research

- Understand the rate of C accumulation in soils with respect to management
- Monitor soil processes with a changing climate
- Examine soil water dynamics in grasslands; drought tolerance of our native plants



Summary

- Not all organic matter\soil carbon can be treated equally
- Leaving more grass on the range, and maintaining later seral stages will increase soil organic matter
- Greatest potential for additional C storage in grasslands comes from the restoration of degraded areas
- Uncertain sink in the trees





Thank You!