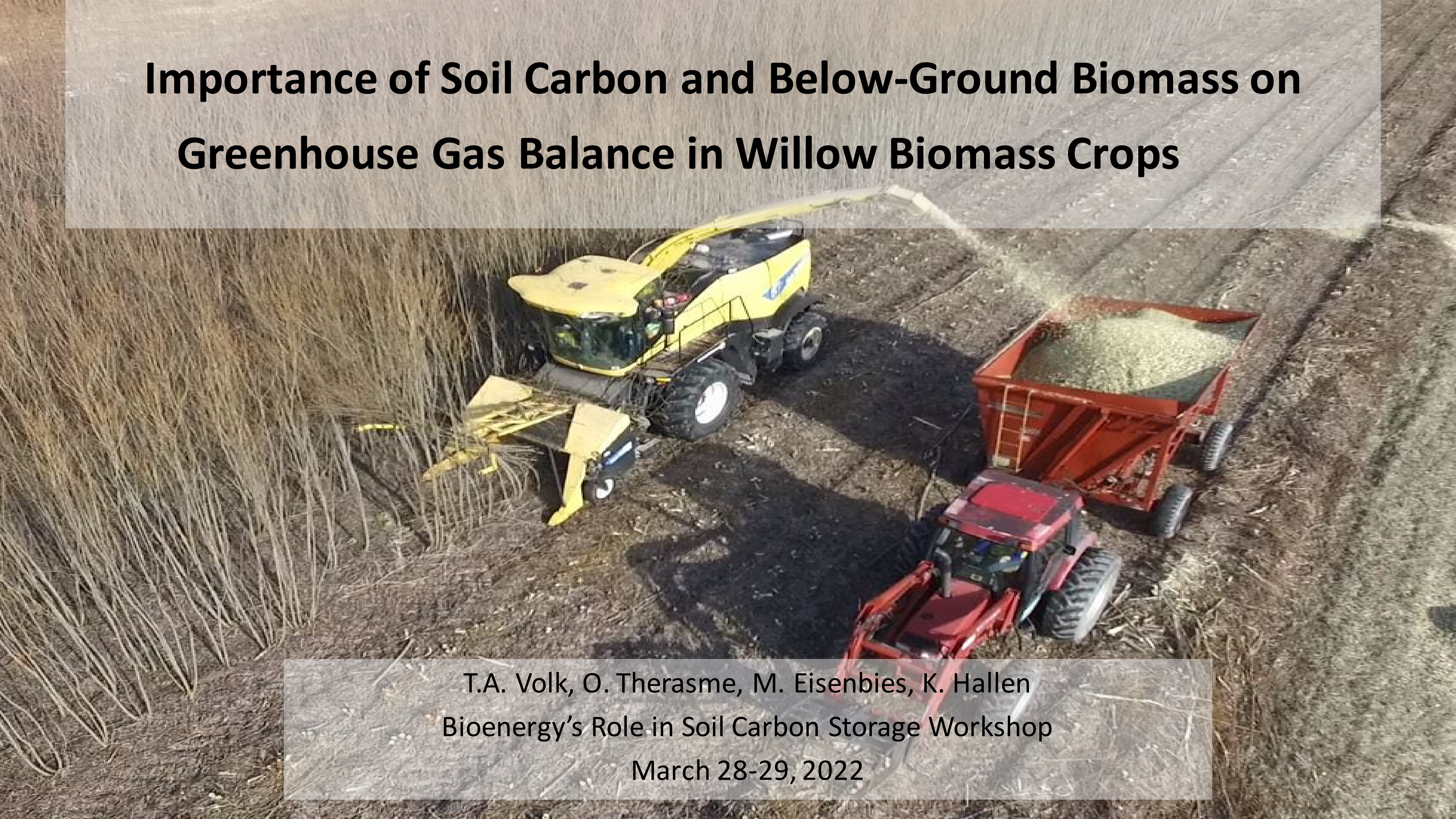
Importance of Soil Carbon and Below-Ground Biomass on Greenhouse Gas Balance in Willow Biomass Crops



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Bioenergy's Role in Soil Carbon Storage Workshop

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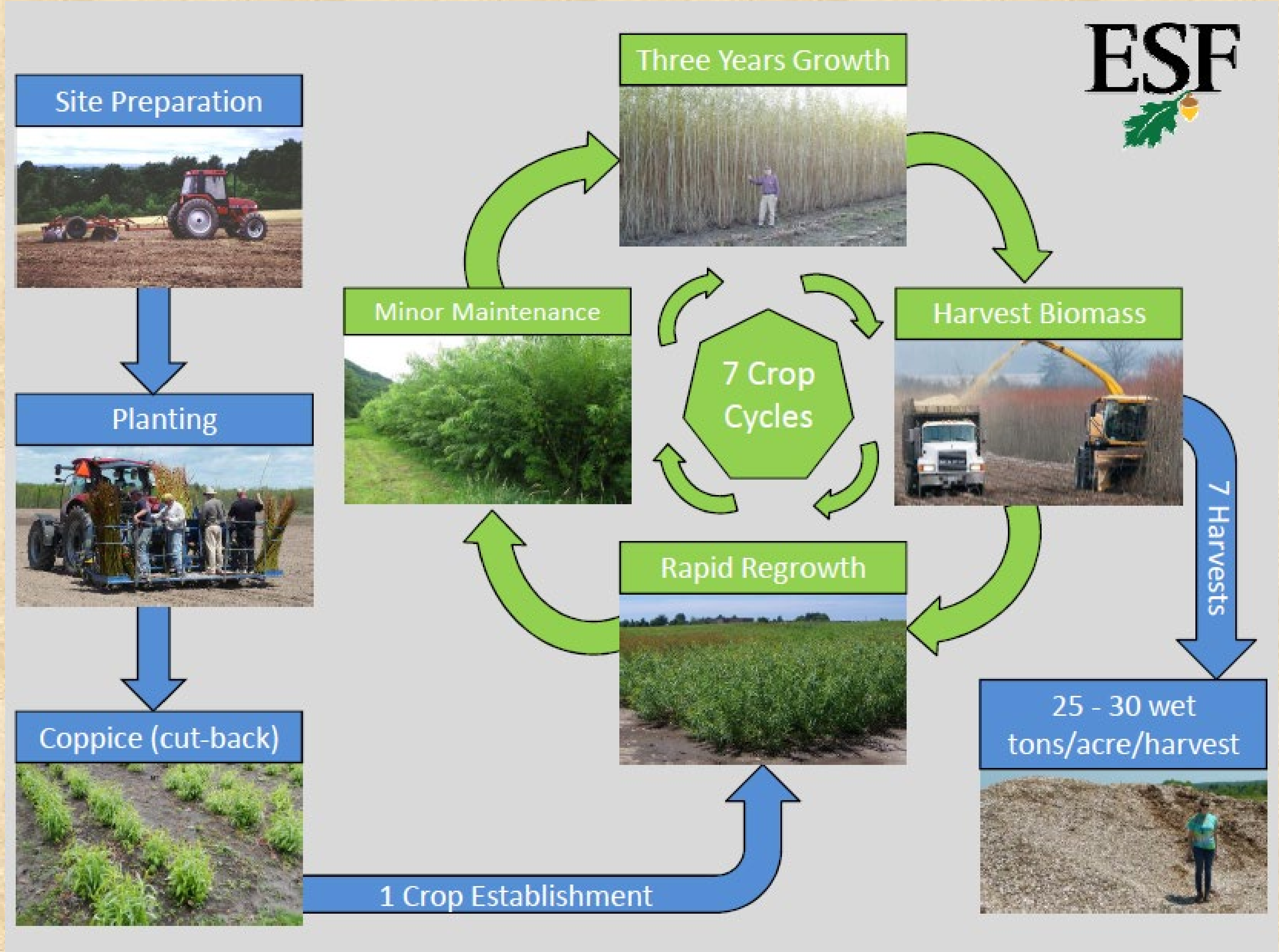
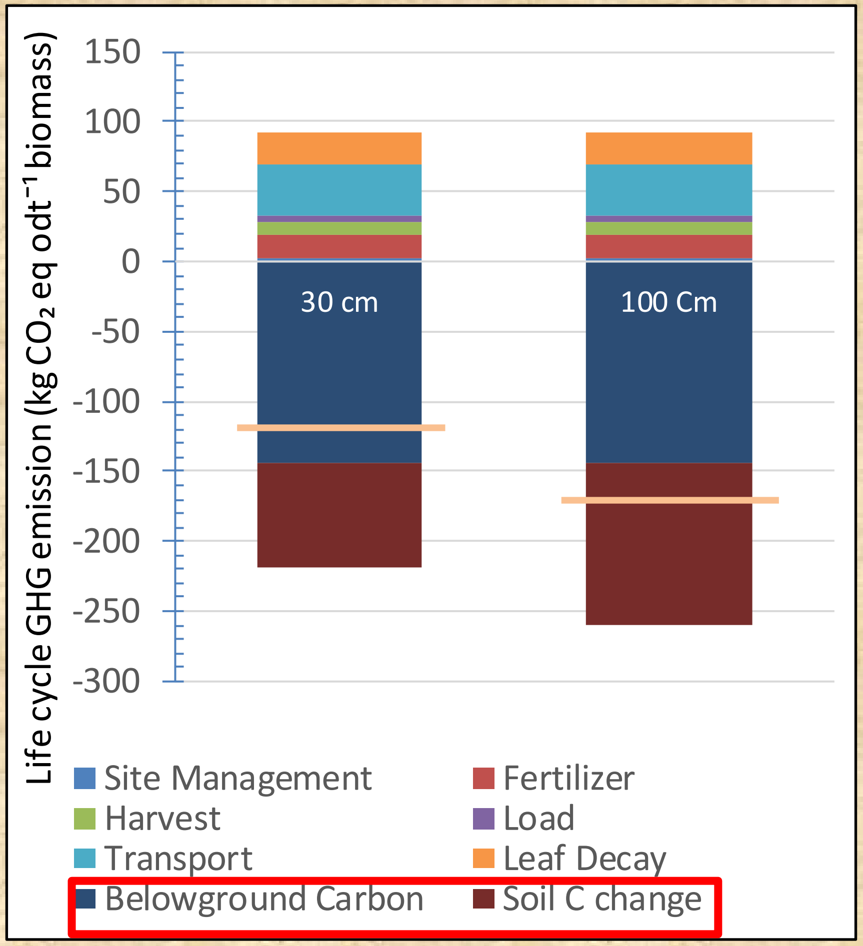
Key Points

- Changes in soil carbon and belowground biomass have a large impact on the overall GHG balance of SRWC systems
- Soil carbon and belowground biomass data is limited, often associated with short term studies, and does not include the spatial variation in large scale plantings
- To accurately assess GHG balance of these system there is a need for long term data for soil carbon and belowground biomass across a range of sites and cultivars
- Questions remain about soil and belowground carbon at end of the life cycle of the willow crop if it is removed

Willow Biomass - Crop Production Cycle



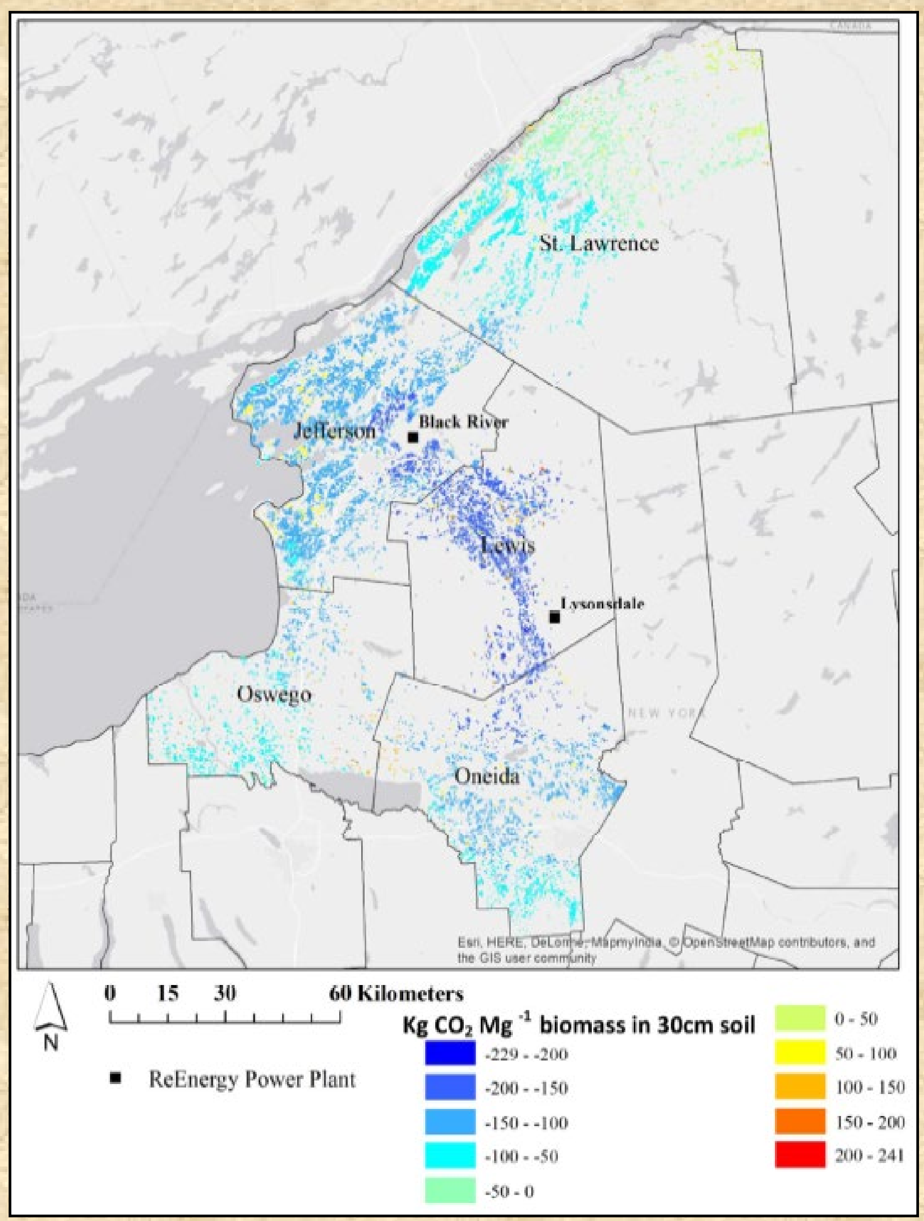
Importance of Soil and Belowground Carbon on Willow GHG Balance



GHG emissions from LCA for willow system are negative for cropland (Yang et al. 2020).

- LCA of willow from crop establishment to plant gate over seven 3-year rotations
- GHG balance of system is negative for cropland
  - -127 kg CO_{2eq} Mg^{-1} for 30 cm deep soils
  - -167 kg CO_{2eq} Mg^{-1} for 100 cm deep soils
- Soil and belowground carbon are key sinks
  - Soil carbon accounts for 34 – 45% of sequestered carbon in the system (74 to 114 kg CO_{2eq} Mg^{-1})
  - Belowground biomass accounts for 55 – 66% of sequestered carbon (148 kg CO_{2eq} Mg^{-1})
- GHG emissions on grassland are slightly positive (28 – 59 kg CO_{2eq} Mg^{-1}), but it is a very uncommon land use in the region

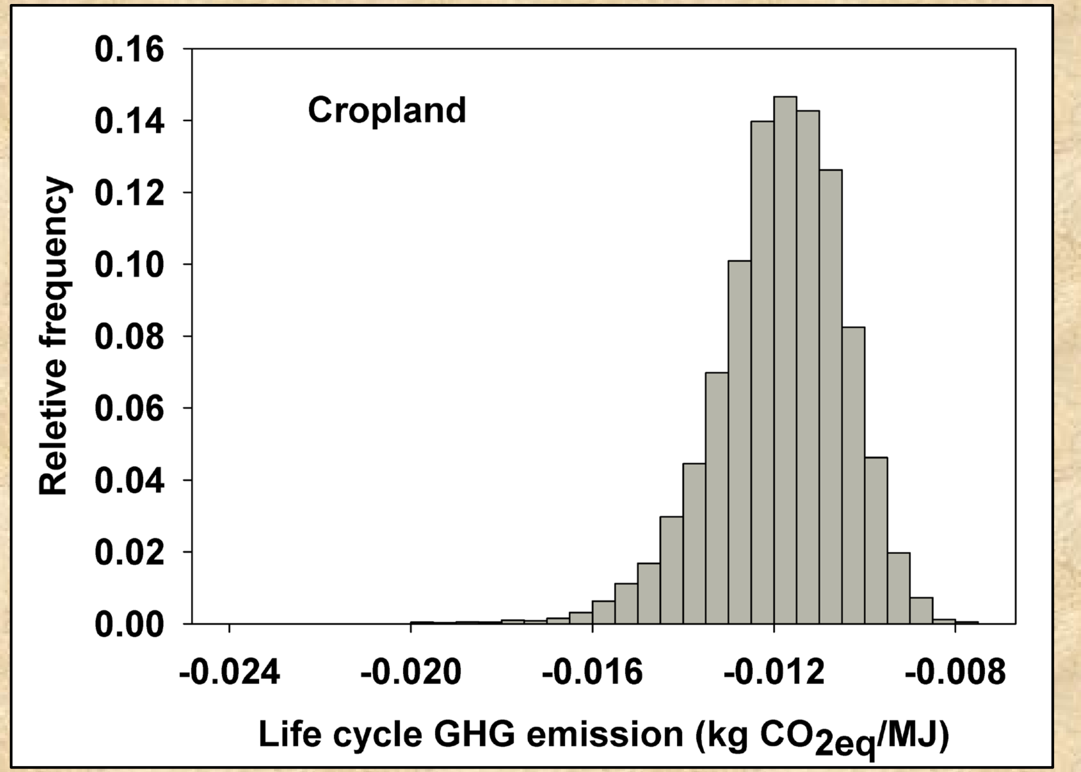
Spatial GHG Emissions

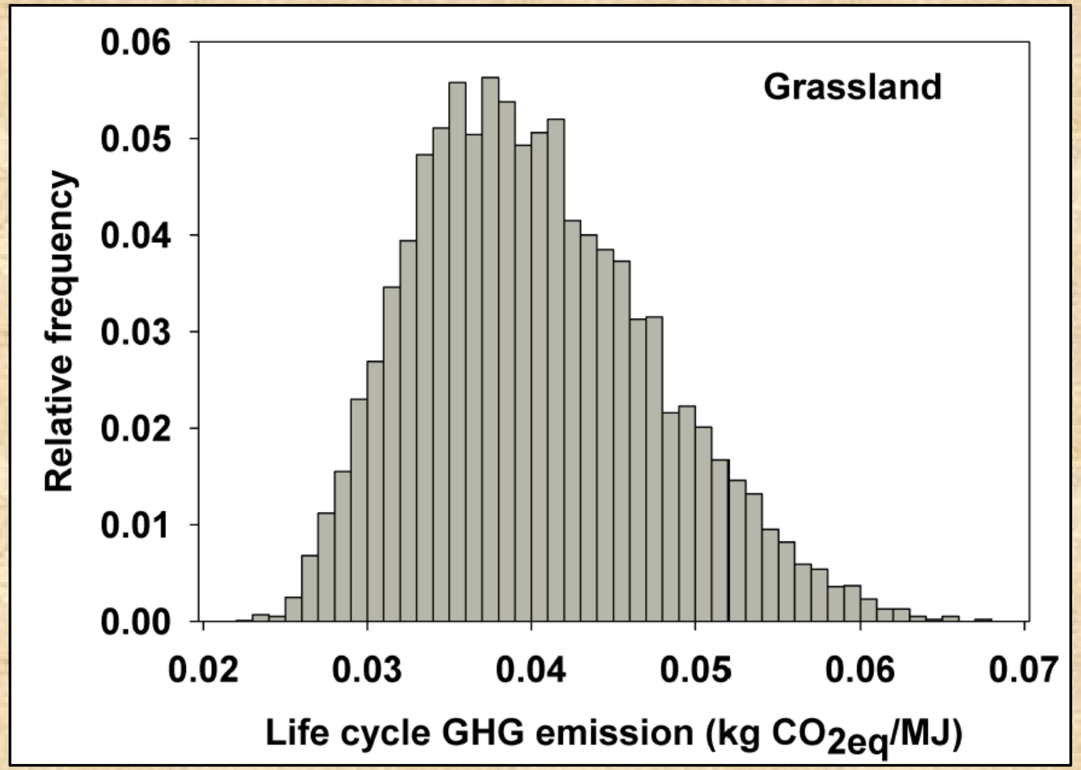


Life cycle GHG emissions from willow biomass crops across five counties in NY (Yang et al. 2020)

- Best summary of LUC and changes in soil carbon (Qin et al. 2016) indicates potential patterns
- Used county level modeling results for soil carbon changes in willow LCA (Dunn et al. 2017)
- Data, especially from North America, is very limited
- Very little data from plots >10 years old (Qui et al. 2016, Martani et al. 2020)
- Need data on long term changes in soil carbon

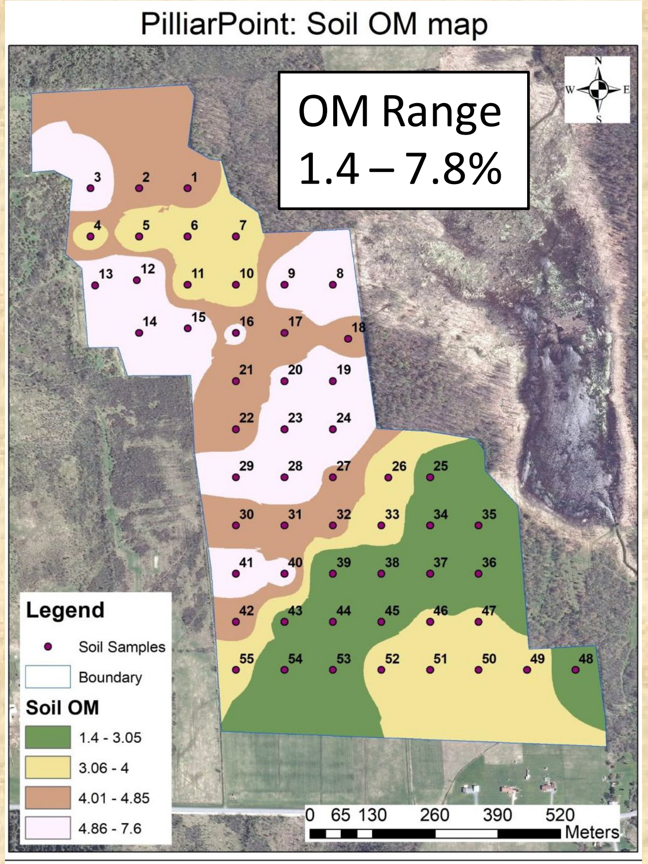
Land Use Change and Soil Carbon in Willow

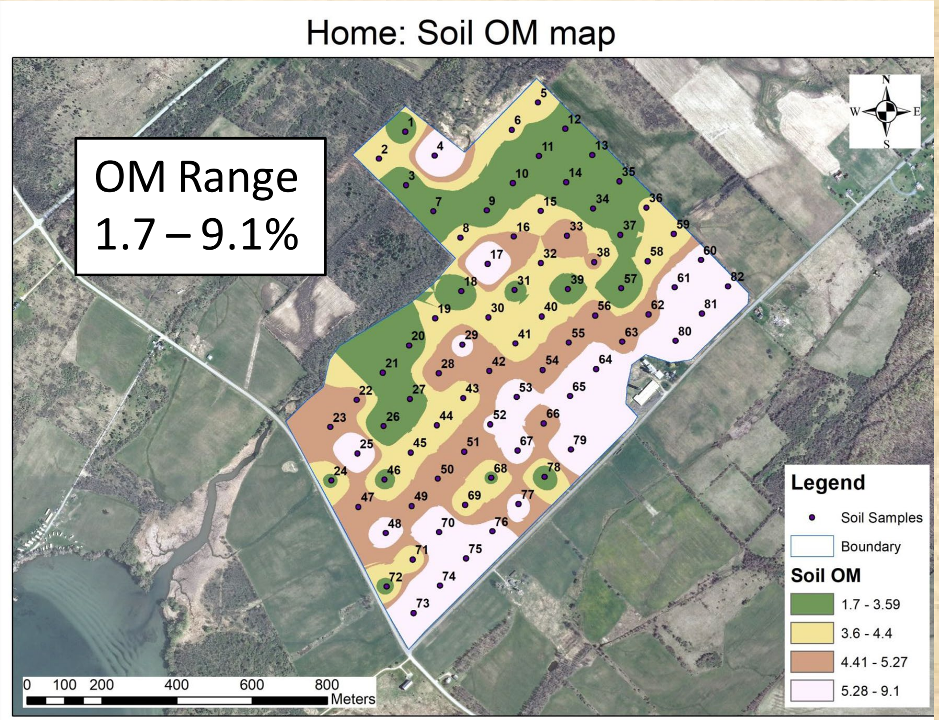




- For LCA of willow to ethanol the variation in final GHG emissions per MJ when just county level soil carbon data (across five counties) for two land uses scenarios is included can result in a 2x difference in life cycle GHG emissions (Therasme et al. 2021)

Field Level Variation



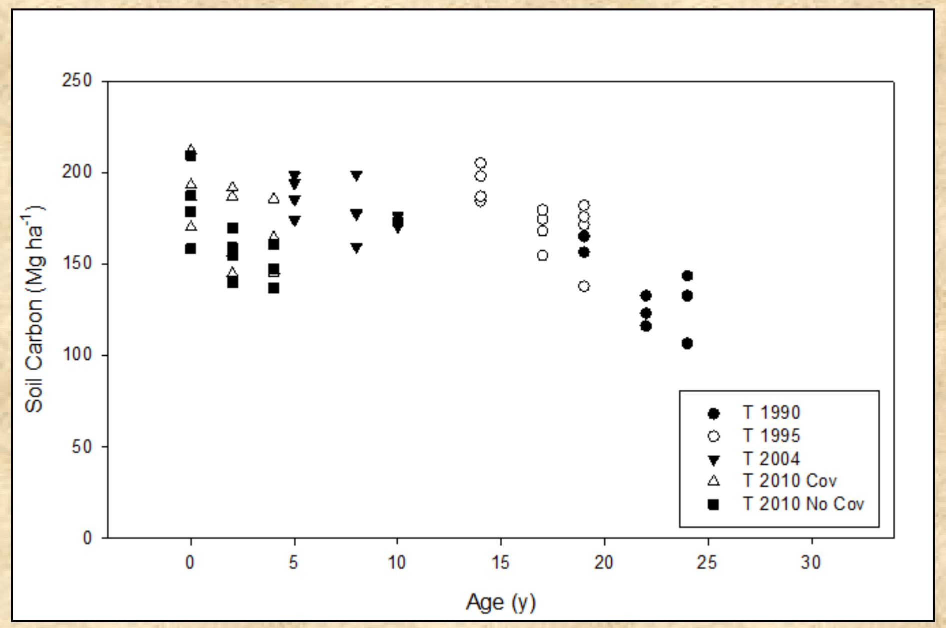


Organic matter content across two fields (60 – 80 acres) in NY at time of willow planting (2012). These fields are a part of a network of 1,200 acres established under USDA BCAP.

- Soils sampled when willow was established in 2012
- Wide range in organic matter content at time of willow planting
- How has soil carbon changed and played a role in willow growth?

Changes in Soil Carbon Under Willow

Soil C data to 45 cm depth under willow across a chronosequence (Pacaldo et al. 2013)



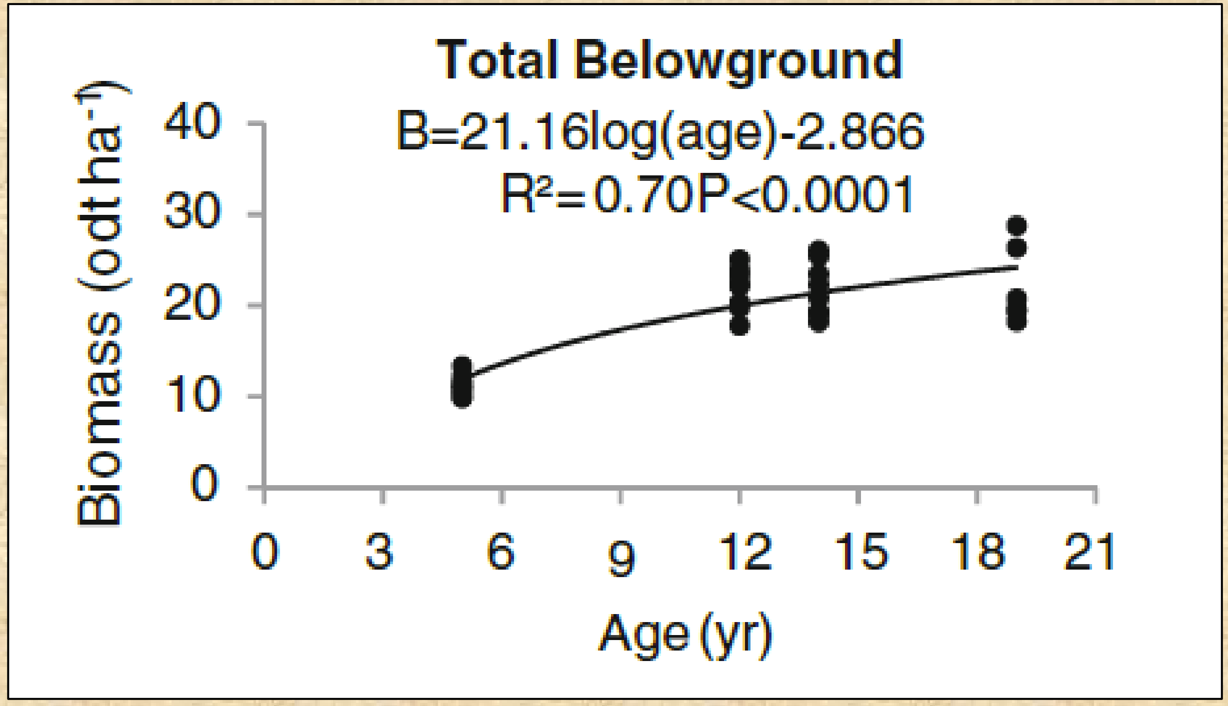
Soil C data to 45 cm depth under willow across a chronosequence with repeated sampling

- Short time frame for many projects is a limitation in assessing changes in soil carbon
- Data here limited to two sites and one cultivar in small plots

What About Belowground Biomass?

- Collection of belowground biomass data is time consuming
- Data only available for a limited number of sites and cultivars to date
- Changes over time not well understood

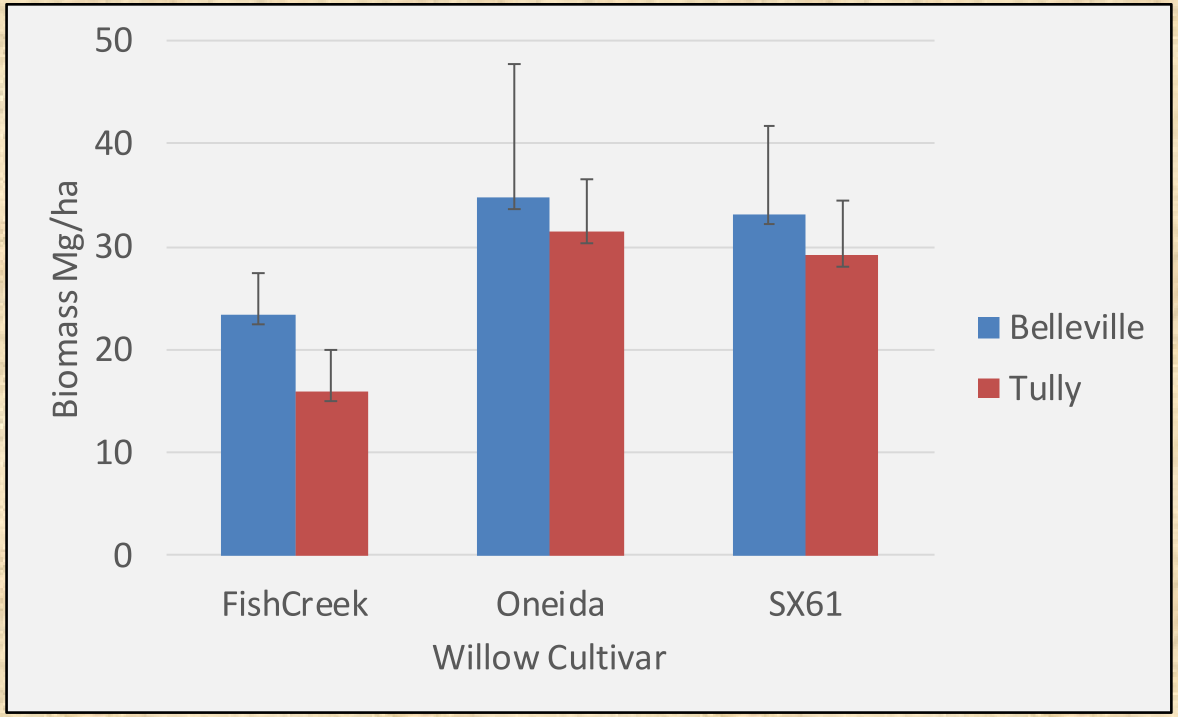
Changes in Belowground Biomass



Model for development of belowground biomass using a chronosequence approach for a single, non commercial cultivar with most data from a single site (Pacaldo et al. 2012)

- Long term data for development of belowground biomass in willow is scarce
- Chronosequence data from non commercial clone is best data
- Need to understand this pattern with new commercial varieties
- What happens to this carbon at end of willow lifecycle
  - Initial assessment shows little change in stored carbon in first couple of years, but management practices, time and location will have a strong impact

Belowground Biomass



Biomass in coarse roots and stool in 10 year old willow for three cultivars (Fish Creek, Oneida, SX61) at two sites in NY (Belleville and Tully)

- Belowground biomass in 10 year old willow varies by cultivar and site
  - Ranges from 15.9 – 34.7 Mg ha^{-1}
- Root:shoot ratio, which is used in LCAs, also varies by cultivar
- These differences will strongly impact overall GHG emissions
- Need to understand impact of both genotype and sites and how this changes over time

What We Need to Understand

- Both soil carbon and belowground biomass are essential to understanding overall life cycle greenhouse gas balances of willow and other woody crops
- Changes in soil carbon under willow and other perennial crops with different land use change scenarios
  - Over long time periods
  - Accounting for spatial variability
- Data on belowground biomass is needed to address uncertainty
  - Changes over long time periods
  - Genotype and spatial variability
- What happens to soil carbon and belowground biomass at the end of the life cycle of the crop

Questions

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