Temperature dependence and acclimation of soil organic matter decomposition

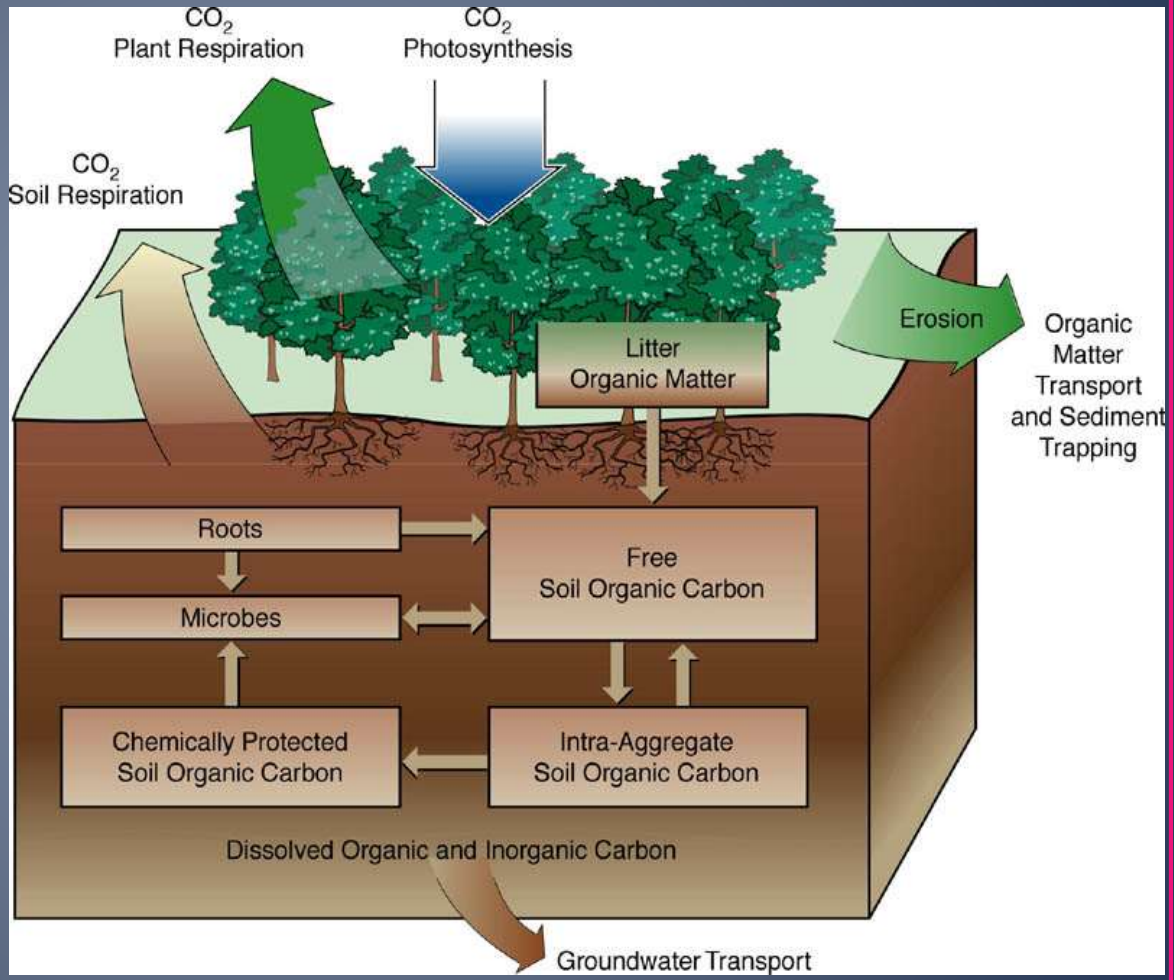
Jennifer Bell, Colin Tucker, and Elise Pendall
Department of Botany
University of Wyoming

Today's Presentation

- Background
- Methods
- Results
- Conclusions

Background

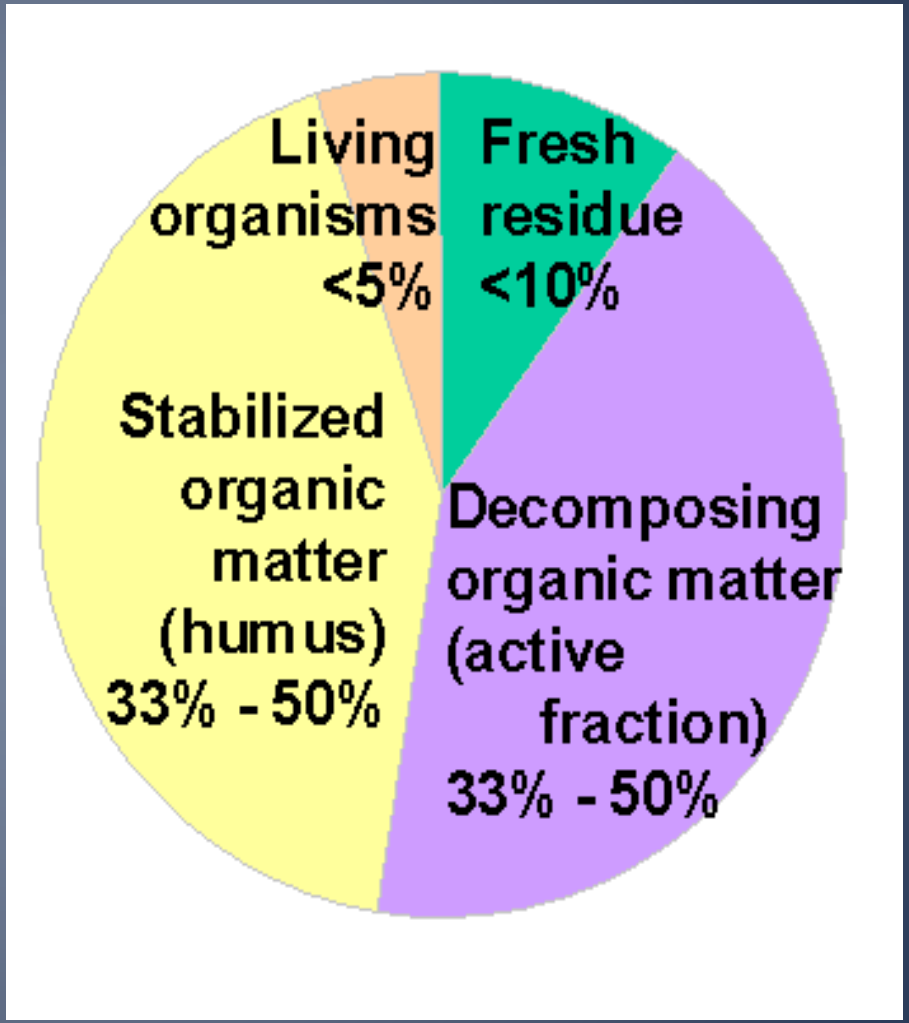
- Soil represents one of the largest stores of carbon
- Major contributor to terrestrial carbon fluxes



http://www.tececo.com/images/graphics/carbon%20cycle/SoilCarbon.jpg

Soil

- Mineral component
- Organic component
  - Labile organic matter
  - Recalcitrant organic matter
  - Living portion



mages/soil_f1.gif

Decomposition

- Decomposition is the breakdown of organic molecules into carbon dioxide (CO_2) and water
- decomposition ≈ microbial respiration

Glucose + Oxygen → Carbon Dioxide + Water + Energy

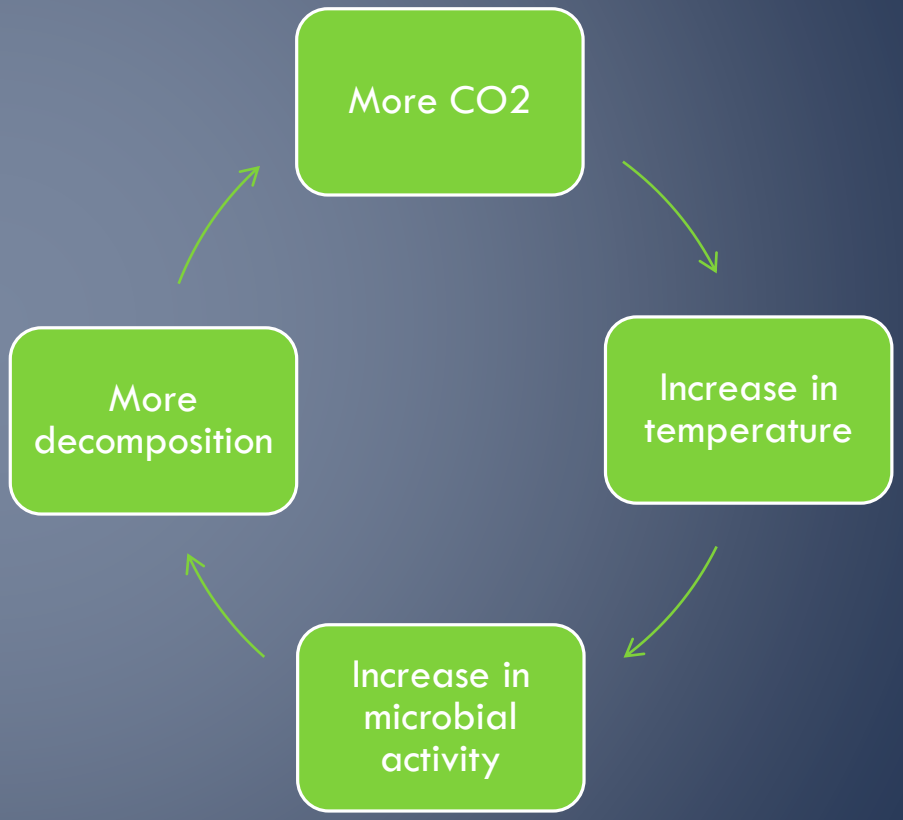
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

Decomposition and global change

- CO_2 is a greenhouse gas
- Greenhouse gases trap heat
- Temperatures can increase

Why temperature is important

- An increase in temperature will lead to increasing microbial activity
- Increasing activity will increase decomposition rates
- More decomposition leads to more CO_2
- More CO_2 leads to higher temperatures
- Self-perpetuating cycle



How will soil microbes respond?

- Soil microbes will respire more with elevated temperatures
- After sufficient time soil microorganisms can acclimate (adjust) to elevated temperatures
  - Reduction in metabolic processes
  - Reduction in respiration (CO_2 production)
- Acclimation could reduce the self-perpetuating cycle

Hypotheses

- Rates of decomposition will increase with increasing temperatures
- Soil microorganisms will acclimate to elevated temperatures

Pretty pictures of Pole Mountain

Photos courtesy of Colin Tucker

Methods

- "Dirt-in-jars"
- 3 temperatures

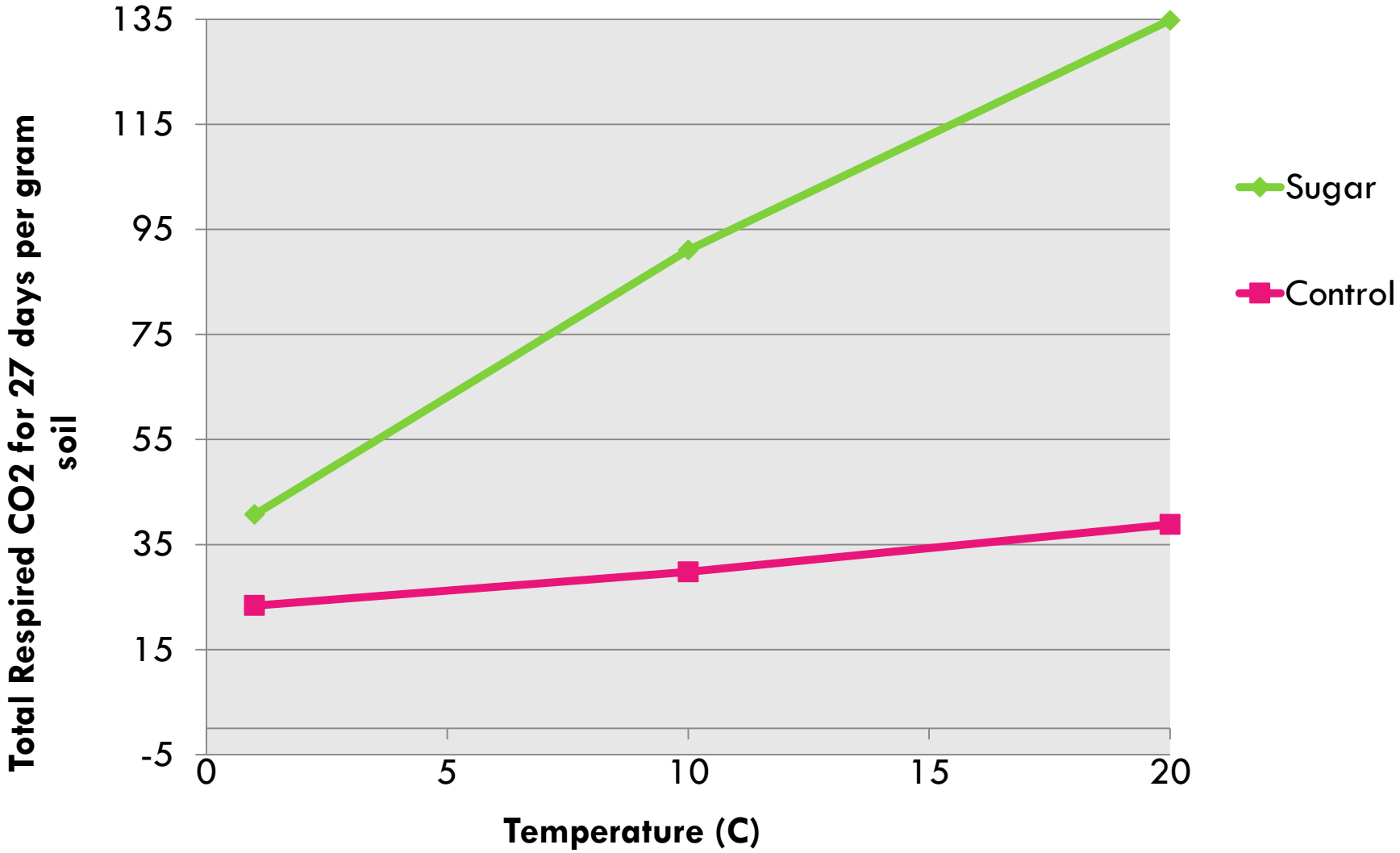
  1, 10, 20 °C
- 2 Substrate treatments
  - Water (control)
  - Water + Glucose
- 8 replicates of each treatment

More Methods

- Respiration was measured at day 1, 2, 4, 10 and 28
- Samples flushed with CO_2 free air
- 15 mL air samples collected after one hour
- Analyzed CO_2 using an infrared gas analyzer

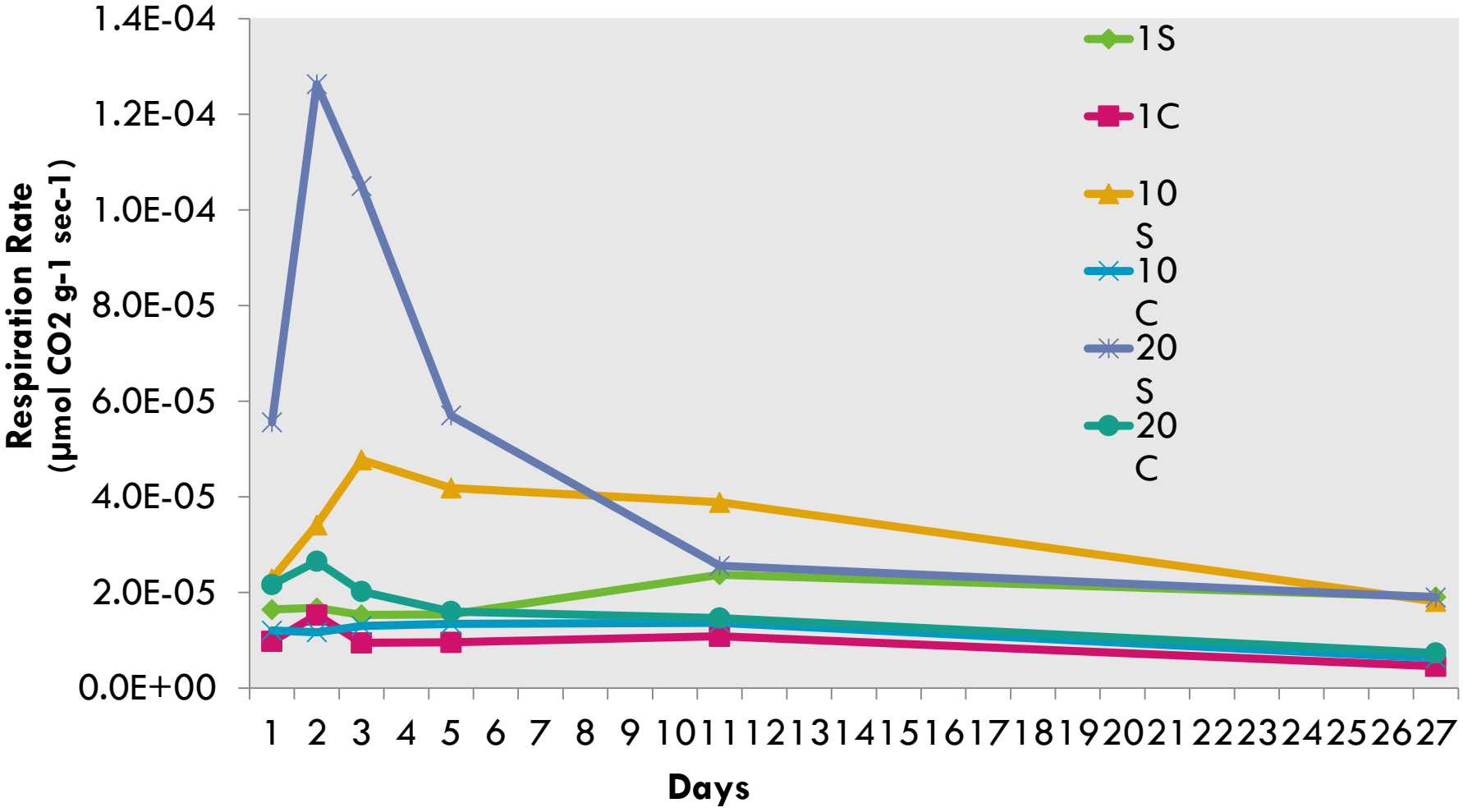
Acclimation Methods

- Day 30
- Either water or sugar added
- Temperatures switched
- 6 hours later respiration measurements were taken



Respiration rates increase with increasing temperature and substrate addition.

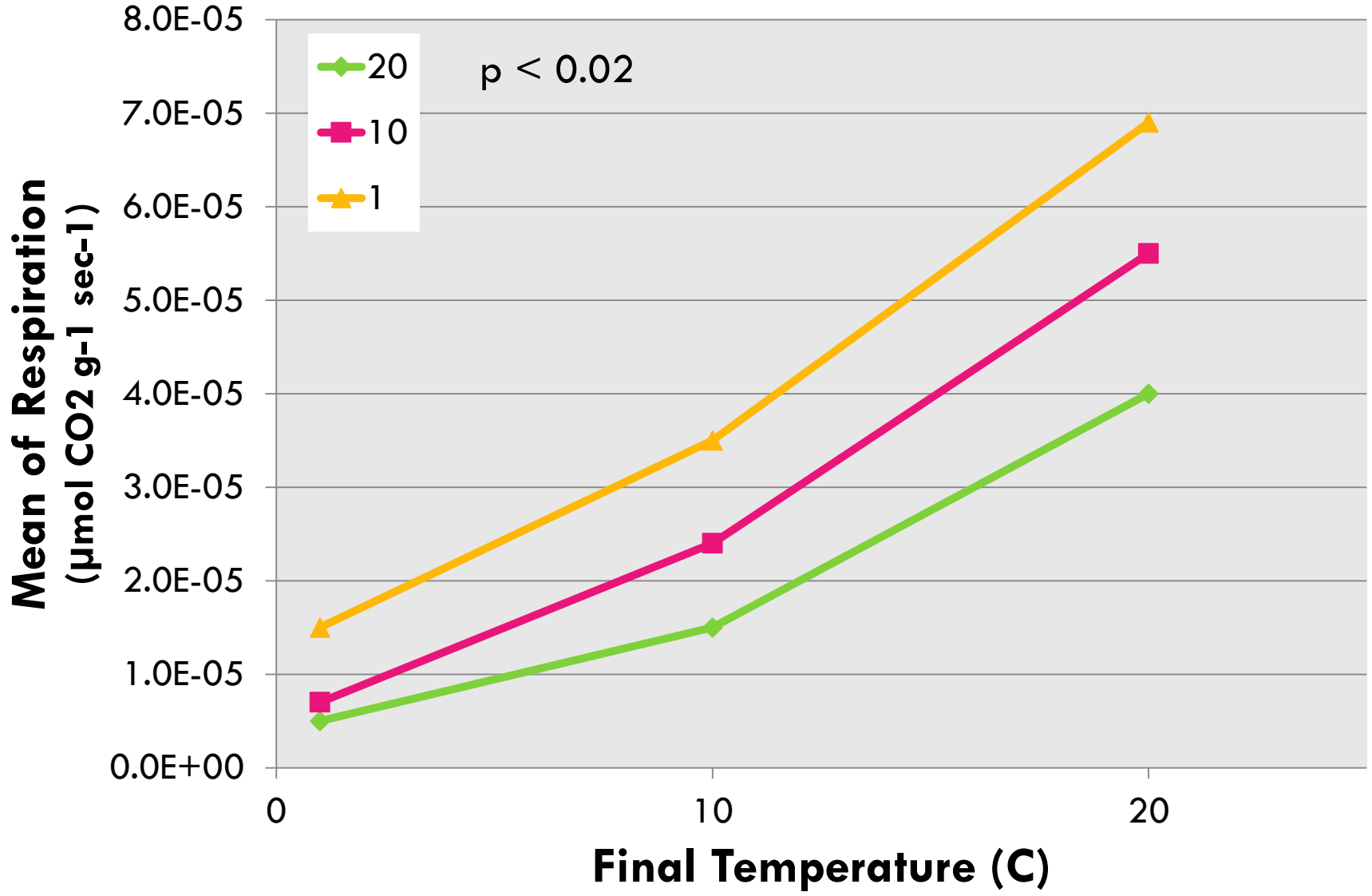
Results



Respiration increases with increasing temperature

Sugar addition had a greater effect

Acclimation



Conclusions

- Decomposition rates do increase with increasing temperatures
- Substrate addition can mask the effects of temperature
- Soil microorganisms can acclimate to elevated temperatures

Acknowledgements

- Colin Tucker
- Elise Pendall
- Sarah Waldron
- The entire Pendall lab
- Botany Department

References

- Balser, T. C. and D. L. Wixon. 2009. Investigating biological control over soil carbon temperature sensitivity. Global Change Biology **15**:2935-2949.
- Davidson, E. A., I. A. Janssens, and Y. Q. Luo. 2006. On the variability of respiration in terrestrial ecosystems: moving beyond Q(10). Global Change Biology **12**:154-164.
- Eliasson, P. E., R. E. McMurtrie, D. A. Pepper, M. Stromgren, S. Linder, and G. I. Agren. 2005. The response of heterotrophic CO2 flux to soil warming. Global Change Biology **11**:167-181.
- Kirschbaum, M. U. F. 2006. The temperature dependence of organic-matter decomposition - still a topic of debate. Soil Biology & Biochemistry **38**:2510-2518.
- Kirschbaum, M. U. F. 2004. Soil respiration under prolonged soil warming: are rate reductions caused by acclimation or substrate loss? Global Change Biology **10**:1870-1877.
- Melillo, J. M., P. A. Steudler, J. D. Aber, K. Newkirk, H. Lux, F. P. Bowles, C. Catricala, A. Magill,
- T. Ahrens, and S. Morrisseau. 2002. Soil warming and carbon-cycle feedbacks to the climate system. Science **298**:2173-2176.
- Luo, Y. Q., S. Q. Wan, D. F. Hui, and L. L. Wallace. 2001. Acclimatization of soil respiration to warming in a tall grass prairie. Nature **413**:622-625.
- Nelson, David L., Cox, Michael M. Lehninger Principles of Biochemistry. 2008. W.H. Freeman and Company. New York. 183- 228.
- Raich, J. W. and W. H. Schlesinger. 1992. The global carbon-dioxide flux in soil respiration and its relationship to vegetation and climate. Tellus Series B-Chemical and Physical Meteorology **44**:81-99.
- von Lützow, M. and I. Kögel-Knabner. 2009. Temperature sensitivity of soil organic matter decomposition-what do we know? Biology and Fertility of Soils **46**:1-15.