1. Introduction
Ecosystem respiration is an increasingly important topic in climate change research. Of the different components of ecosystem-scale respiration, soil respiration (the CO₂ efflux from the soil to the atmosphere) is perhaps the least understood. Because a significant portion of the world’s terrestrial carbon store is found within soils, it is important to study how CO₂ efflux might change with a changing climate. Subalpine mixed-conifer ecosystems are sensitive to warming climate and are dependent on the accumulation of snow, which is expected to decrease in coming years. Thus, this study looks at soil respiration within these ecosystems and explores how the changing snow accumulation and duration of snow cover might affect CO₂ and evaporation effluxes from the soil.

2. Hypotheses

2.1 Soil respiration
- Long snow season areas will have higher CO₂ peak later after snow melt than short snow season sites
- Respiration levels in long snow season sites will remain higher than short snow season sites throughout the summer

2.2 Evaporation
- Evaporation fluxes will be higher during the summer monsoon than during snow melt season
- Evaporation will be higher in the long snow season sites than the short snow season sites throughout most of the growing season

3. Research Site

3.1 Site Description
- Mixed-conifer ecosystem
- Elevation: 2573 m
- Santa Catalina Mountains, southern Arizona
- Water limited system, bimodal precipitation (winter snow, summer monsoon)

3.2 Site Instrumentation
- Eddy covariance tower
- Three understory ‘phenocams’ (to study understory growth and observe snow accumulation and melt)

4. Approach

4.1 Soil Collars
- Time series of camera images used to determine collar placements
- 3 collars installed at each camera site

4.2 Measurements
- Flux measured every 2-4 weeks, between about 9am-12pm
- No measurements conducted if collars are covered in snow
- Lacob 840 gas analyzer measures fluxes for about 2 mins
- Additional measurements: soil and air temp within chamber, soil temp (top 10 cm), soil moisture (top 6 cm), and depth from top of collar to top of soil

4.3 Calculations
- The equation below is used to calculate the flux of soil respiration and evaporation out of the soil. The slope is found from the graph of the flux over time.

\[ \text{SR} = \frac{P}{RT} \ln \left( \frac{V_{\text{soil}}}{A_{\text{soil}}} \right) \]

5. Soil Temperature and Moisture

- Soil moisture differs noticeably between sites throughout most of the year except for part of the summer and fall
- Long snow sites are typically wetter than short snow sites
- Soil temperature is similar between long and short snow season sites, though long snow sites become cooler in late summer
- Moisture and temperature peak seasonally, as expected based on climatic conditions

6. Soil Respiration

6.1 Time Series
- Short snow season sites typically have higher respiration fluxes than long snow season sites
- Soil respiration peaks drastically during the summer monsoon – seems to suggest moisture affects respiration

6.2 Temperature
- Soil respiration vs. soil temperature shows a promising correlation
- Response of soil respiration to temperature fluxes might be hiding effects of other environmental factors

6.3 Soil Moisture
- Soil respiration vs. soil moisture shows a poor correlation
- Either soil moisture plays almost no role in affecting soil respiration, or it is hidden behind the response to temperature

7. Evaporation

7.1 Time Series
- Evaporation vs. soil temperature shows a probable correlation
- This correlation could be overshadowing responses to other environmental factors, such as temperature

7.2 Soil Moisture
- Evaporation vs. soil temperature shows a poor correlation
- Data will be normalized with respect to moisture to see if moisture response is hiding the effects of temperature

7.3 Temperature
- Evaporation vs. soil temperature shows a probable correlation
- This correlation could be overshadowing responses to other environmental factors, such as temperature

8. Future Work
- Conduct measurements in early summer to fill gaps in the time series
- Explore additional collar locations to increase the distribution and quantity of measurements
- Normalize data with respect to the dominant environmental factors, in attempt to isolate responses of other factors
- Conduct summer measurements at a corresponding field site in the Valles Caldera National Preserve and compare results across multiple sites
- Explore potential effects of other complicating factors, such as proximity to trees and roots, shading and radiation, and topographic variables
- Scale-up findings to ecosystem scale using eddy covariance tower measurements

9. Acknowledgements
- Funds from the NSF National Cenosis Observatories Program
- Papuga Research Lab, Dave Breitwieser, Paul Breitwieser, Zilia Sanchez Mejia, Joe Miller

10. References

1. School of Natural Resources and the Environment, University of Arizona, Tucson, AZ
2. Department of Biology, University of Dayton, Dayton, OH
3. Biosphere 2, Earthscience, University of Arizona, Tucson, AZ

11. Tables
- Table 1: Monthly CO₂ measurements from Site 1
- Table 2: Monthly CO₂ measurements from Site 2

12. Figures
- Figure 1: Monthly CO₂ measurements from Site 3
- Figure 2: Monthly CO₂ measurements from Site 4

13. Appendix
- Appendix A: Monthly CO₂ measurements from Site 5
- Appendix B: Monthly CO₂ measurements from Site 6

14. Conclusion
- Mixed-conifer ecosystems are sensitive to warming climate and are dependent on the accumulation of snow, which is expected to decrease in coming years. Thus, this study looks at soil respiration within these ecosystems and explores how the changing snow accumulation and duration of snow cover might affect CO₂ and evaporation effluxes from the soil.

15. Discussion
- Long snow season areas will have higher CO₂ peak later after snow melt than short snow season sites
- Respiration levels in long snow season sites will remain higher than short snow season sites throughout the summer

16. Application
- The Papuga Research Lab in collaboration with Dave Breitwieser, Paul Breitwieser, Zilia Sanchez Mejia, and Joe Miller is conducting research on soil respiration in mixed-conifer ecosystems to better understand the impact of climate change on these ecosystems.

17. Implications
- This research has implications for understanding the role of soil respiration in carbon cycle and the potential for carbon sequestration in mixed-conifer ecosystems.

18. Funding
- This research is supported by the NSF National Cenosis Observatories Program.