Impact of Climate Change on Soil Erosion in the Inland Northwest

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Introduction

- Agriculture depends on a balanced and predictable soil environment, but in the future, climate change could dramatically alter that balance causing an increase in soil loss and damaging crops.
- Changes in temperature and precipitation may have a significant impact on soil erosion, water retention, and crop production (Zhi 2010).
- Projected changes in soil loss rates due to climate change under different cropping practices may help the region better adapt to climate change and avoid climate impacts.

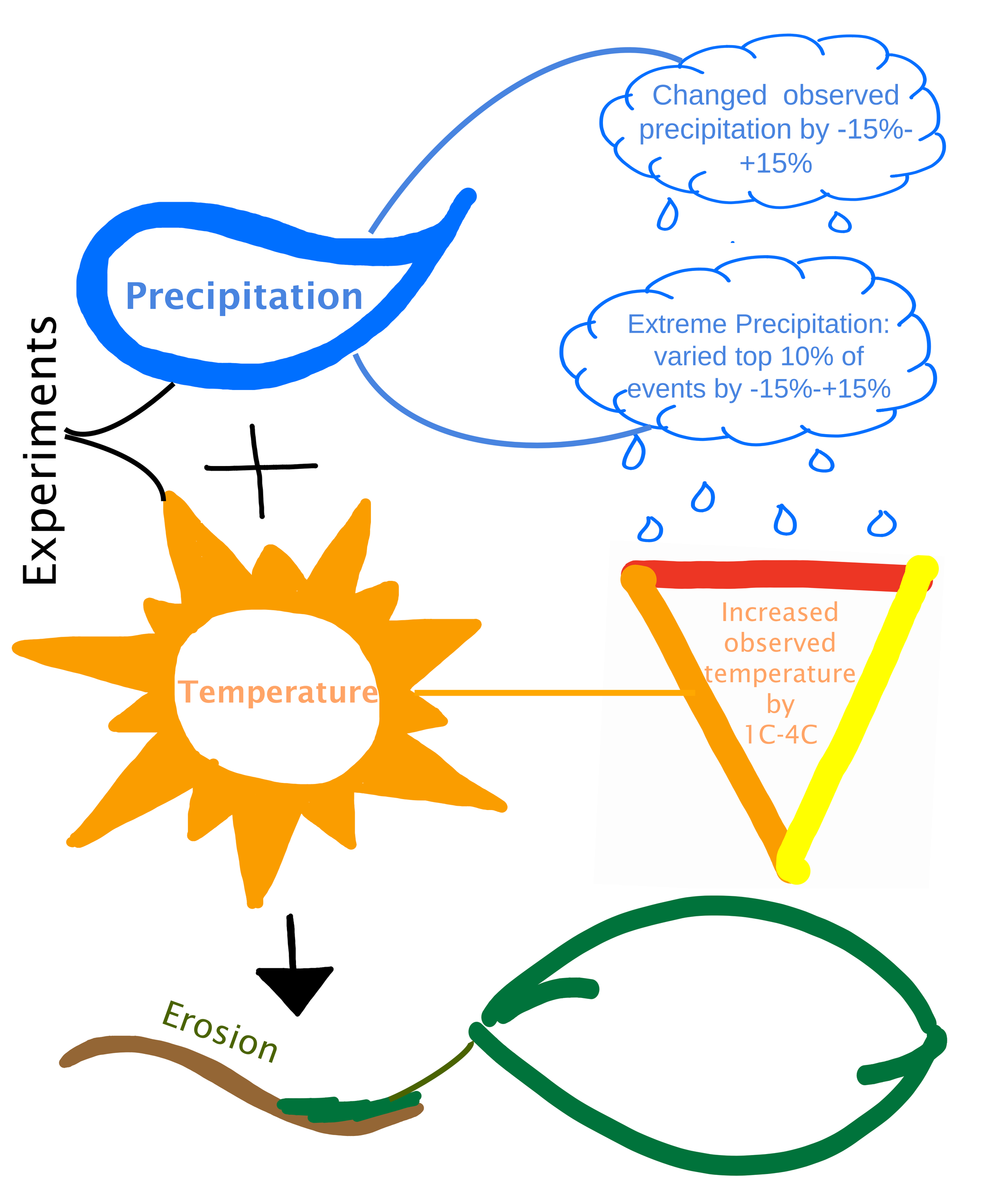
Data

- Daily precipitation and maximum/minimum temperature for Moscow, Idaho were acquired from 1979-2013 (Abatzoglou 2013).
- Land cover data for spatial analysis obtained from the National Land Cover Database (Fry 2011).
- A plausible range of projected changes in mean temperature, precipitation and precipitation extremes were used from CMIP5 models to form the basis of the sensitivity study.

Erosion Modeling

- The Water Erosion Prediction Project (WEPP) is a process based, erosion prediction model that uses hill slopes, soil types, and climate files to predict soil loss (Flanagan 1995).
- Sub daily parameters were generated from Cligen
- WEPP is useful for this research because climatic variables can be adjusted to accommodate a sensitivity analysis providing a range of water driven soil loss scenarios.
- Five hill slopes were used: flat, moderately flat, moderate, moderately steep, and steep.

Sensitivity Analysis



Results

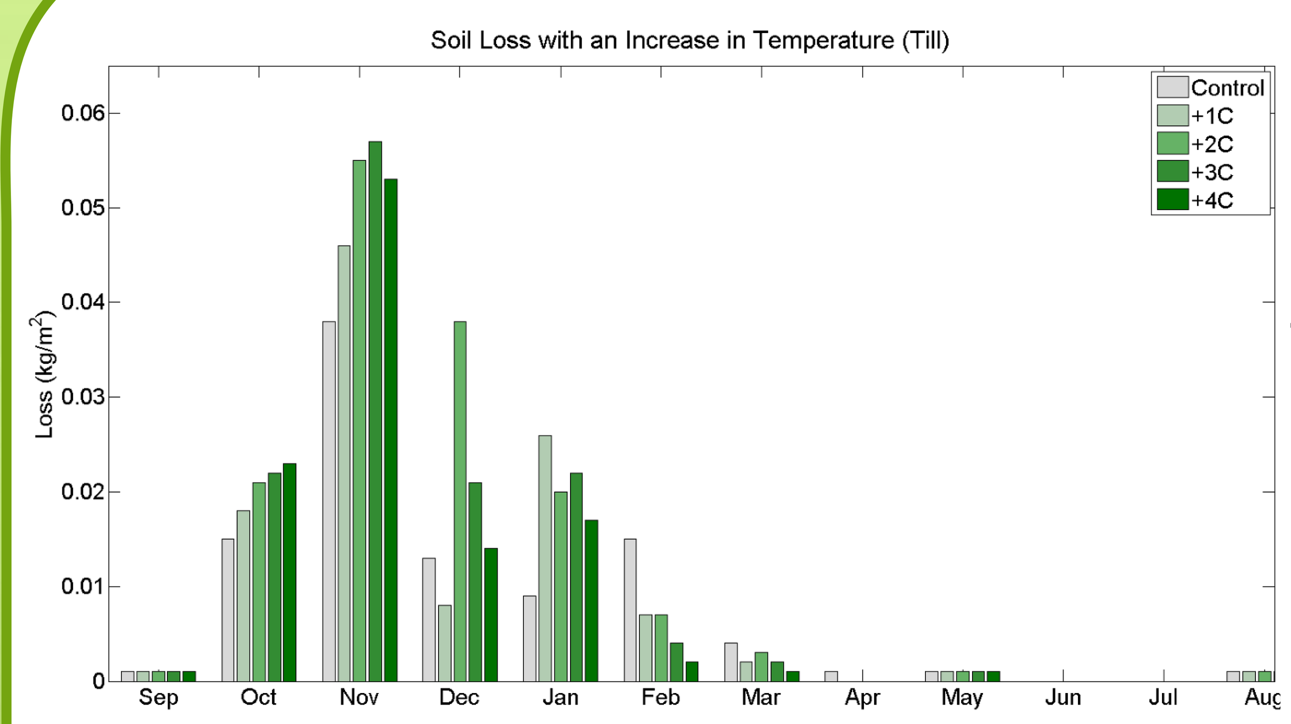


Figure 1: Average soil loss amounts per month over a thirty year period as a result of temperature change and conventional tillage on a moderately sloping hill.

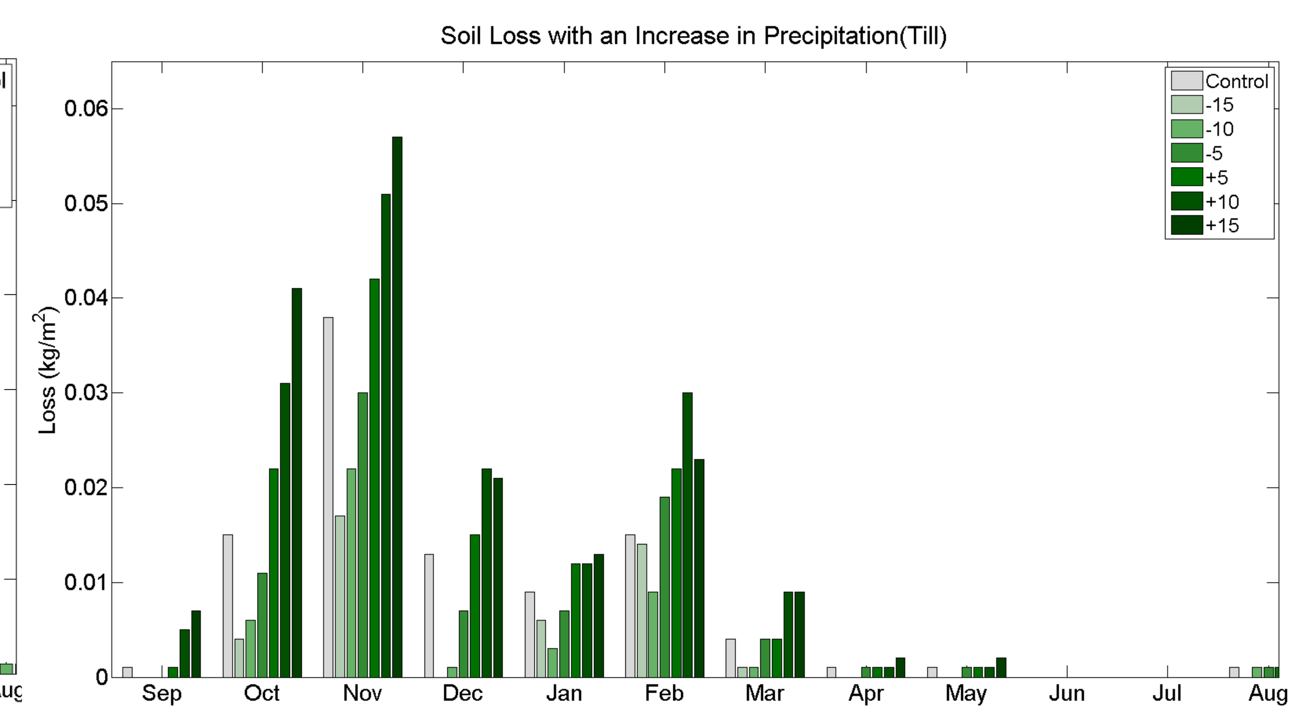


Figure 2: Average soil loss amounts per month over a thirty year period as a result of precipitation change under conventional tillage practices on a moderately sloping hill.

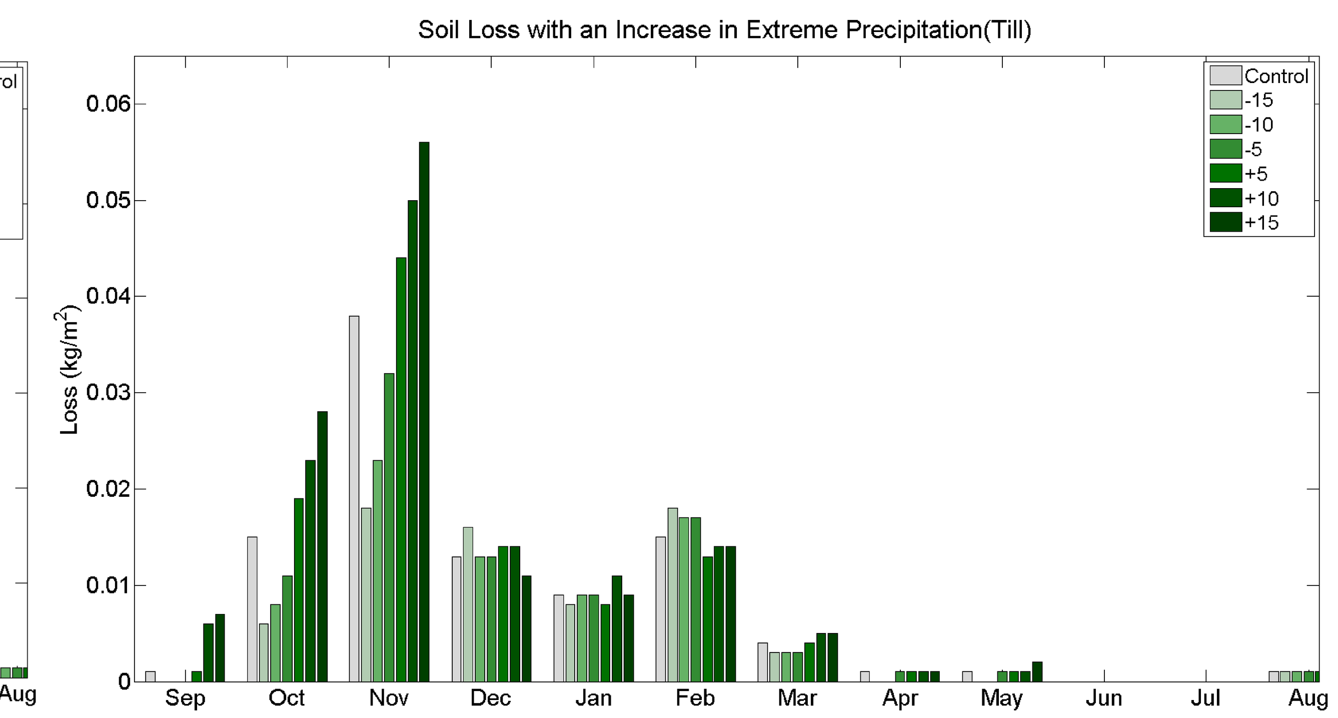


Figure 3: Average soil loss amounts per month over a thirty year period as a result of extreme precipitation change under conventional tillage practices on a moderately sloping hill.

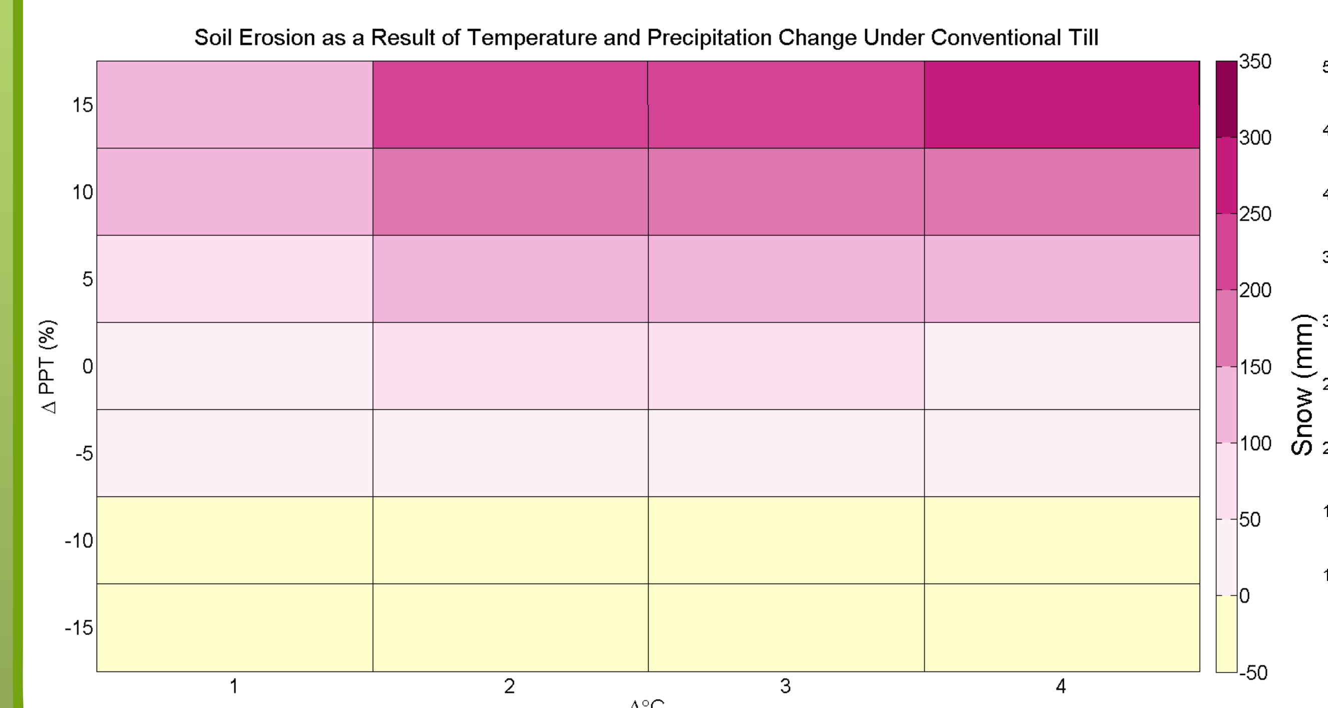


Figure 4: Changes in soil loss, expressed as a percent relative to a control run, for joint changes in temperature (x-axis) and precipitation (y-axis). Changes are shown for conventional till practices on a moderately sloping hill.

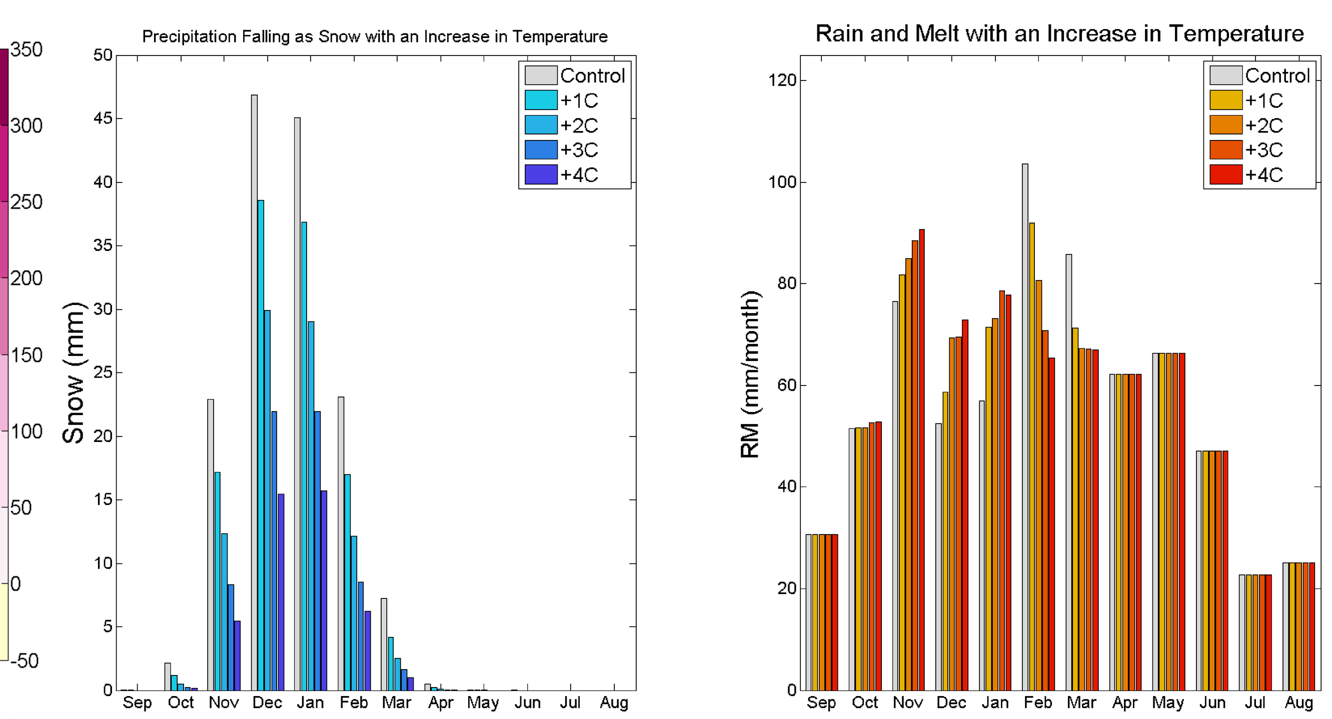


Figure 5: Phase change from snow to rain (left) and the amount of rainfall plus snowmelt (right) with a range of increases in temperature.

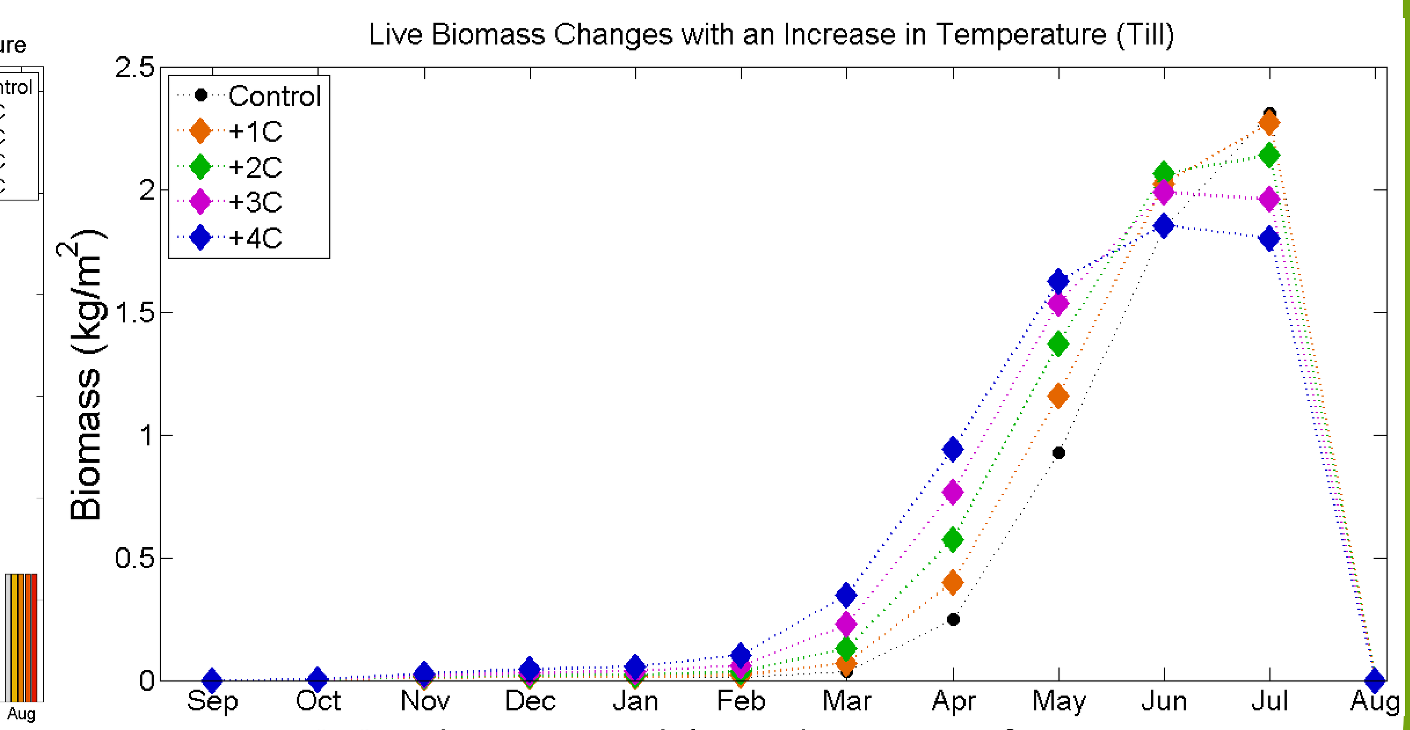


Figure 6: Crop biomass variability under a range of increases in temperature.

Discussion

Sensitivity to changes in precipitation

- Erosion increased linearly from October to January when considering precipitation decreases and increases
- Nonlinear response to changes in precipitation in February
- No-till appears much less sensitive to increases in precipitation extremes than conventional till.

Sensitivity to changes in temperature

- Annual average changes in erosion under conventional tillage could increase from 0.17 ton/acre to 0.5 ton/acre, resulting in a 192% increase in soil loss.
- During winter months, phase changes from snow to rain and the melting that occurs have a significant correlation to the soil loss.
- Rain and snow melt also have a clear impact on the soil loss that occurs and the specific events that cause this will be analyzed in this research.
- Central estimates of +2C warming and +5% increase in precipitation for the mid-21st century yield a 130% increase in soil loss for the Moscow-Pullman region under both tilling practices; however, only 0.022 kg/m² soil loss is seen with no till practices and as much as 0.171 kg/m² of soil loss is seen with conventional till practices.
- In the warming experiments, live biomass increases by 140-260% in February through April. This increase in crop biomass minimizes warming-driven impacts on soil loss by creating insulation for the soil and decreasing erodibility.
- Changes in soil loss occur on a much greater scale under conventional tillage practices than under no-tillage practices. The disparity between tillage decisions is a result of the fact that the no tillage results in limited perturbations to the soil, allowing it to stabilize and reducing its susceptibility to erosion even under a warming scenario. In addition to temperature, precipitation and extreme precipitation can impact areas such as Moscow through large runoff events and increased amounts of rain falling on snow.

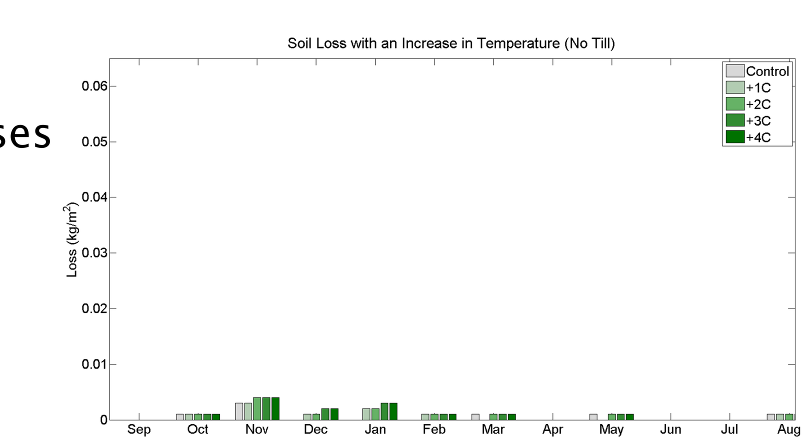


Figure 7: Actual soil loss due to temperature un no till practices and a moderate hill slope (compare to figure 1).

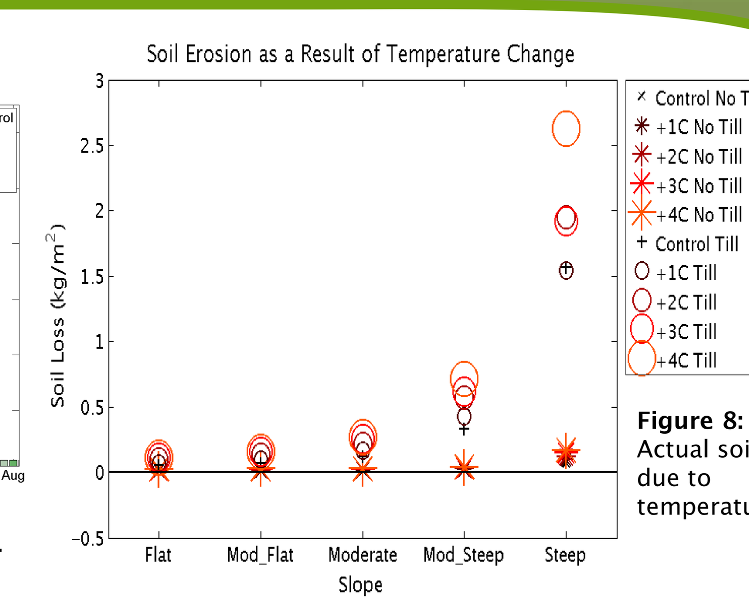


Figure 8: Actual soil loss due to temperature.

References

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4. Li, Zhi, et al. "Assessing the site-specific impacts of climate change on hydrology, soil erosion and crop yields in the Loess Plateau of China." Climatic change 105.1-2 (2011): 223-242.