The impact of climate change on soil erosion

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Projected changes in climate for the inland Pacific Northwest (PNW) as a result of increased greenhouse gas concentrations are warmer temperatures, increased winter precipitation, a larger proportion of precipitation falling as rain rather than snow, and an increase in the intensity of extreme precipitation events. These changes will alter the land-atmosphere relationship that the agricultural industry relies on to remain stable, predictable, and profitable. While some of the projected changes in climate may result in beneficial impacts for certain sectors, other changes may be detrimental. One of the goals of REACCH is to allow farmers to continue to be successful in a changing climate.

IMPACT

The sensitivity of soil erosion to climate change will affect the types of management farmers should consider using in the future. Understanding how a changing climate will affect soil loss can provide a framework of options for farmers and residents of the inland PNW that could help them more easily adapt to a changing climate.

While individual farmers may be unable to change the pace of global climate change through mitigation, they may be able to adapt to climate change and devise management practices that are more resilient to climate impacts. Soil erosion is among the climate-related impacts that concern dryland farmers in the REACCH study area, since conservation of topsoil is critical to sustained productivity in such systems. Moreover, knowledge of potential risks of soil erosion in a changing climate may help inform farmers' agricultural management decisions.

To gain a better understanding of the complex relationship between soil erosion rates and climate change, we examined the sensitivity of soil erosion to warming. While there is a broad range of projected changes in climate, including precipitation, we constrained our focus to a representative warming scenario for the mid-21st century of approximately 4°F. Because erosion rates vary depending on landscape and crop management factors, we considered varying hill slopes ranging from flat to steep and two types of cropping practices: conventional tillage and no-tillage. All of these factors were analyzed using the Water Erosion Prediction Project (WEPP) model for a site representative of the wetter eastern Palouse near Moscow, ID. The WEPP model allows for all of the different climatic variables and other environmental variables to predict soil loss, changes in biomass, winter erosion scenarios, and evapotranspiration.

Within the REACCH region, both increases and decreases in precipitation have a direct and relatively predictable impact on soil loss. However, the effects of warming temperatures on soil loss are more complex. Figure 1 shows changes in soil loss as a result of temperature change on a moderately flat slope compared to a control run that used historical surface meteorology from 1979 to 2009. Annual average changes in erosion under conventional tillage could increase from 0.17 tons per acre to 0.5 tons per acre, resulting in a 192% increase in soil loss.

Historically, soil loss rates are predictably highest in fall and winter months due to the onset of the rainy season following harvest, when crop cover is lowest and unable to buffer soil losses due to runoff events. Overall, fall and winter appear to be the seasons when erosion is most dominant. The warming experiment resulted in an increase in soil loss of about 30% during the late fall under conventional tillage practices, due to decreases in the snow water equivalent in addition to an increase in rain and melt (Figure 2). Even larger increases in erosion rates were found in December and January in the warming experiments, due to a dramatic decrease in the snowpack on the ground and increases in both rain and snowmelt in these months. Snow water equivalent represents the depth of water that would exist if you were to melt the snowpack on the ground. A decrease in snow water equivalent indicates less snowpack and therefore less pro-

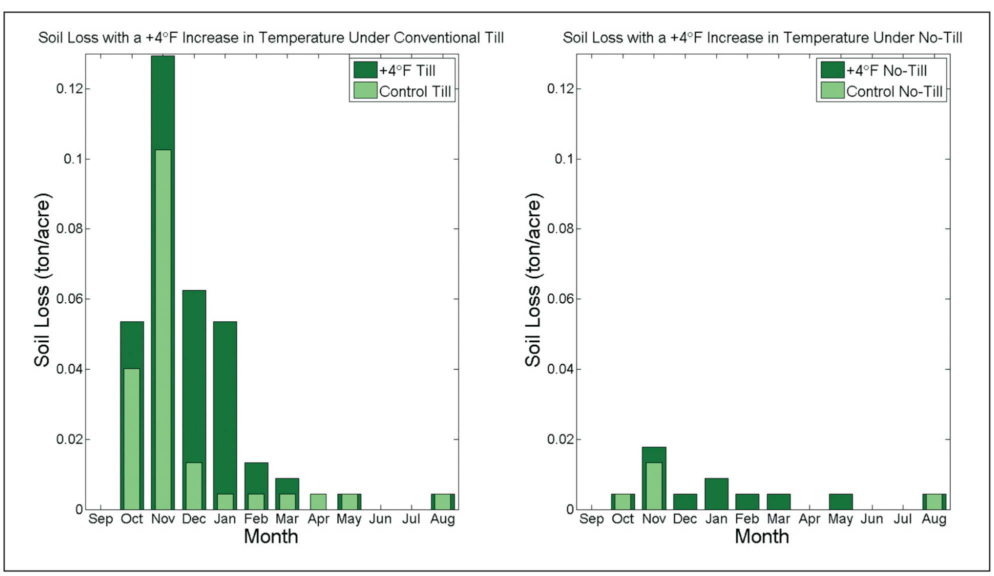

Figure 1. *Monthly average changes in soil loss on a moderately flat slope over a 30-year simulation.*

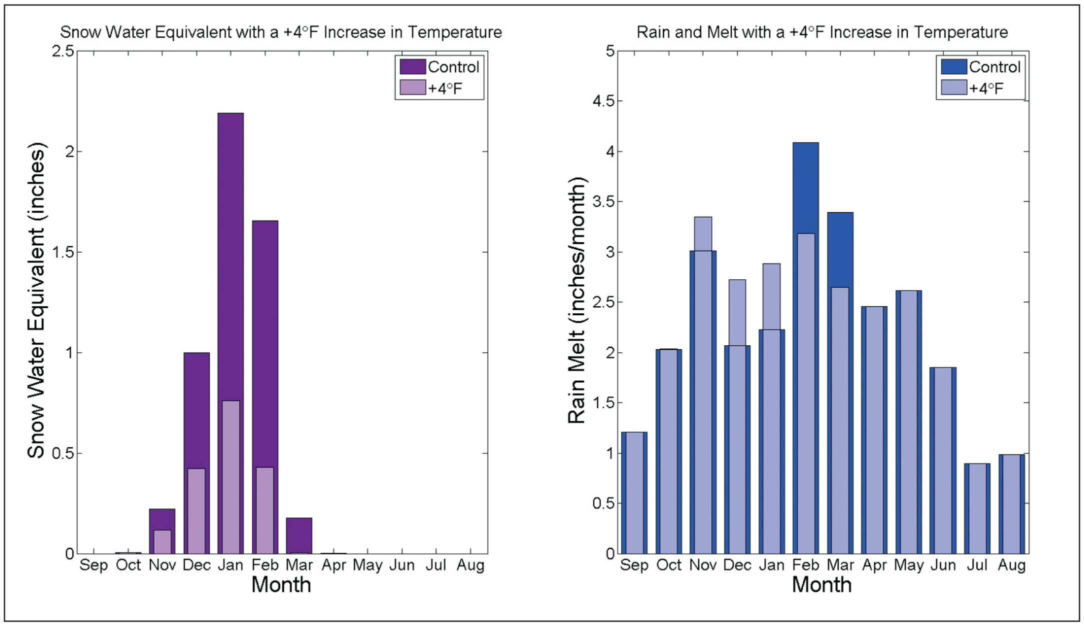

Figure 2. *Monthly change in frozen soil depth under both conventional tillage and no-tillage practices with an increase in temperature.*

tection of the soil. Likewise, with warming, more winter precipitation will fall as rain rather than snow and will facilitate more midwinter erosion events.

Although warming results in an increase in rain and a decrease in snow water equivalent into late winter, soil losses are tempered. We hypothesize that this is due to the early onset of biomass growth caused by warming, which buffers the soil from erosion-induced loss. Live crop biomass historically develops in the late winter and spring months with warming temperatures (Figure 3). In the warming experiments, live biomass increases by 140% to 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 no-tillage practices result 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 affect areas such as Moscow, ID through large runoff events and increased amounts of rain falling on snow. Understanding the various ways in which climate can affect soils and the landscape of the inland PNW can supplement local growers' knowledge and experience, providing a more comprehensive understanding of what changes the future may hold. Some areas within the region may be affected more by precipitation than by temperature. This type of analysis is relevant to many areas of the REACCH region, and we plan to provide similar analyses in other locations. Through this research we hope to help build a framework that will facilitate the prevention of devastating soil losses that may occur as a result of climate change in the region.

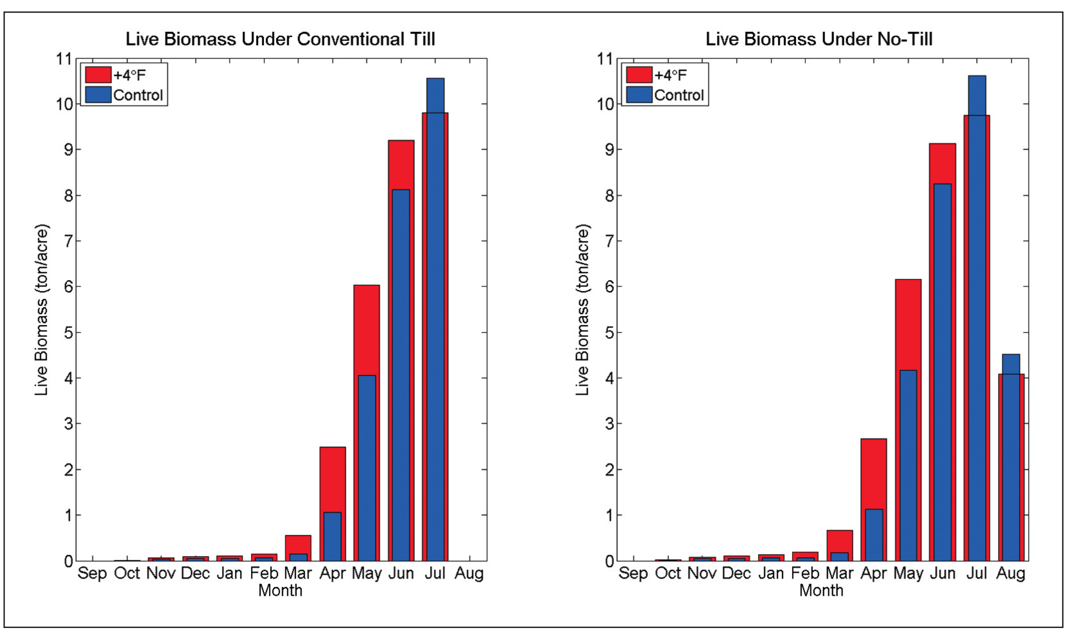

Figure 3. *Monthly amount of live biomass with no climate change (left) and with an increase in temperature (right).*