USDA United States Department of Agriculture

Applying Soil Health Management Systems to Reduce Climate and Weather Risks in the Northwest

AGRICULTURAL AND NATURAL RESOURCE PROFESSIONALS IN THE NORTHWEST will be impacted by climate change in a multitude of ways, which will present both challenges and opportunities. Climate change is expected to increase the vulnerability of our agricultural systems, challenging agricultural producers to adopt resilience strategies to reduce climate and weather related risks. Through this factsheet, we will explore specific climate drivers of change in the Northwest, relevant impacts to soil and cropping systems, and an exploration of soil management systems that can be applied to reduce risks.

Climate Change: Drivers and Impacts

TEMPERATURE

The largest increase in observed U.S. temperatures have occurred in the western U.S. with an average increase to nearly 2°F since 1900 (May et al., 2018). The region is expected to continue this warming trend, particularly at night and during the summer months, along with more frost-free days. Climate trends are dependent on a number of factors, based on management decisions as well as decisions that are made collectively to reduce greenhouse gas emissions. If we consider a lower emission scenario, considered to be a conservative estimate of greenhouse gas emissions, it is predicted that the 30 year mean annual temperature increase will be 5°F by late 21st century (Rupp et al. 2017).

PROJECTED IMPACTS OF TEMPERATURE INCREASES TO NW AGRICULTURE INCLUDE:

1. CROP YIELDS

Increased temperatures may alter germination, harvest and storage timing, impacting crop yield (may be positive or negative, depending on crop).

2. INCREASED PESTS

Higher temperatures for longer periods are associated with increased pest, disease, and weed pressures that may harm crop yields and crop quality.

3. LONGER GROWING SEASON

A longer growing season due to hotter temperatures and more frost free days may be beneficial for certain crops and will likely change the suite of crops (species and varieties) that are grown in our region.

PRECIPITATION EXTREMES

In the Northwest, average precipitation is not expected to change much; however, the timing, intensity, and form of precipitation is likely to change. Overall, in the Western U.S., snowpack, which is basically our water storage bank account, has already declined since 2005 by 15-30% depending on the area (Mote et al. 2018). This trend is expected to continue into the future, with more rain and less snow falling in winter. Generally, more extreme weather events are forecasted with heavy precipitation events in the winter and spring and more frequent periods of drought due to warmer and drier summer conditions.

PROJECTED IMPACTS OF PRECIPITATION EXTREMES TO NW AGRICULTURE

1. DECREASED SNOWPACK

Decreased snowpack and earlier peak flows may reduce availability of water for irrigation later in the growing season.

2. CROP AND LIVESTOCK STRESS

Increased drought and higher temperatures during the summer months will stress plants and animals and may increase reliance on costly inputs.

3. INCREASED FALLOW PRODUCTION

Increased spring precipitation may alter accessibility to field during critical planting times leading to more fallow production in some parts of the region, increasing concerns over erosion.

4. INCREASED FIRE RISK

Higher temperatures coupled with low precipitation is likely to increase the severity and frequency of wildfire, which has consequences for agricultural producers in fire prone areas and will also impact the health of farmers and farmworkers as they are exposed to smoke and poor air quality.

ADVICE FOR TALKING TO FARMERS ABOUT THEIR SOIL RESOURCES AND CLIMATE CHANGE:

1. **Highlight recent extreme weather events:** Strategize about ways to reduce risks associated with similar future events.
2. **Do your homework:** Tailor your messages to your audience and what they care about.
3. **Focus on Action:** Emphasize specific actions that farmers can take to enhance their soil.
4. **Dual Benefits:** Emphasize soil stewardship for long-term resilience yet expand on the short-term benefits.
5. **Build Partnerships:** Develop opportunities for engagement and two-way conversations.
6. **Choose your tools:** Utilize decision support tools that help farmers protect their soil and water resources given the likelihood of more frequent extreme and variable weather events.

Increased Vulnerability of Soil Resources

SOIL ORGANIC MATTER AND SOIL CARBON

Projected climate change impacts, specifically increased annual temperatures without a proportionate rise in annual precipitation, is expected to reduce average soil organic carbon and nitrogen (N) across the inland Northwest (Morrow et al. 2017). Loss of soil organic carbon, and thus soil organic matter (SOM), negatively impacts multiple soil properties important to soil health and function including: reduced aggregate stability, water holding capacity, porosity, root aeration and overall root health, and decreased water infiltration rates and cation-exchange capacity. Soils store 2-3x more carbon than what is held in the atmosphere and vegetation combined, and therefore provide a critical service of stabilizing atmospheric CO_2 (Jackson et al. 2017). Soil management practices that aim to sequester additional carbon and build SOM across cropland, grassland, and agroforestry production systems can help mitigate against extreme and variable weather events (Chambers, Lal and Paustian 2016).

Climate change and subsequent challenges with temperature and precipitation, however, pose a risk for maintaining and building SOM but these impacts will be variable depending on location and cropping system (Allen et al. 2011). Sequestering carbon in our soils is influenced by management choices as well as inherent soil properties (e.g., soil texture, depth to bedrock or a natural restrictive layer and local weather patterns) that cannot be altered by management decisions.

EROSION, SEDIMENTATION AND FIRE

Large rain events, including greater interannual variability in precipitation patterns, may lead to more erosion, particularly on cropland that lacks vegetative cover during winter and spring months. In some parts of the NW, such as rain-limited wheat producing areas, total agricultural productivity may decline due to more land transitioning from annual cropping systems to those that include more annual fallow with less wheat or other cereal crops planted each year. Increasing the amount of land in fallow makes land more susceptible to erosion (Kaur et al. 2017). Impacts, however, will vary based on complex interactions between crop and root productivity, along with soil type, management decisions, and other soil processes (Allen et al. 2011). Increased erosion events create a negative feedback loop that increases soil degradation, as SOM is highest at the surface and SOM loss destabilizes aggregates, reduces the capacity to hold water and nutrients, and reduces microbial biomass and activity levels important for soil functions. Furthermore, soil erosion also has consequences on water quality due to sedimentation, which has detrimental impacts on fish and wildlife.

An increase in fire frequency and extremes will also affect soil resources. In the NW, the areas burned annually due to wildfire, are projected to increase due to climate change (Sankey et al. 2017). This increase in fire, particularly extreme fires, will lead to greater expanses of more severely burned areas which will be much more vulnerable to soil erosion, landslides, and flooding events.

Applying a Range of Soil Health Management Systems to Reduce Risks

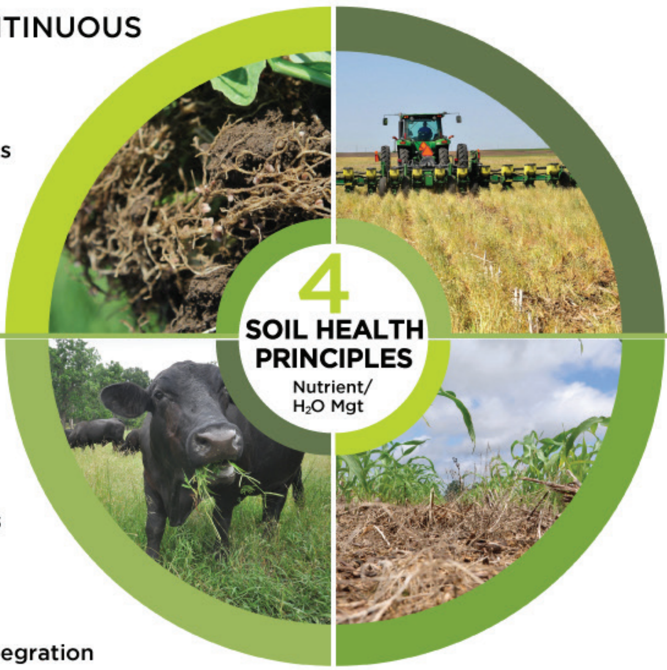
To build greater resilience in the face of more extreme and variable weather, there are a suite of soil health management practices that land managers can adopt to reduce their risks. Many of these have NRCS soil health principles (minimize disturbance and maximize soil cover, biodiversity and presence of roots) at their core. These four principles target improving overall soil health but they also help in creating systems that may be more resilient in the face of climate change and the projected increase in more extreme and variable weather. In addition to sound nutrient and water management plans, the four soil health principles are associated with a variety of practices that not only improve overall soil health but also help increase system resiliency. Adoption and implementation of soil health management systems that address all four principles have shown great promise to improve system resiliency.

MAXIMIZE CONTINUOUS LIVING ROOTS

- Crop Rotation
- Relay Crops
- Forage and Biomass Planting
- Perennial Crops
- Cover Crops

MINIMIZE DISTURBANCE

- No-till
- Reduced Tillage
- Controlled Traffic
- Avoid Tillage When Wet
- IPM



MAXIMIZE BIODIVERSITY

- Crop Rotation
- Rotational Grazing
- IPM
- Pollinator Plantings
- Organic Fertilizers
- Legumes in Mix
- Agroforestry
- Cover Crops
- Crop/ Livestock Integration

MAXIMIZE SOIL COVER

- Mulching
- Reduced Tillage
- Forage and Biomass Planting
- Residue Retention
- Cover Crops
- Green Manures

INCREASE BIODIVERSITY AND PRESENCE OF LIVING ROOTS

Adopting practices, such as diversified rotations, cover crops, agroforestry, amendment applications (e.g., compost and manures), and crop/livestock integration can increase biodiversity and the presence of living roots which benefit the soil by:

- Feeding the soil by increasing the amount of organic inputs into the soil, builds SOM and increases the amount of carbon stored in soil.
- Cover crops chosen to suppress weeds may result in fewer trips in the field reducing energy and fuel costs.
- Cover crops chosen to capture and recycle nutrients may lead to enhanced internal nutrient cycling, reducing the number of inputs needed.
- Increasing microbial and soil faunal diversity by creating communities better equipped to resist disease and environmental stressors, which can reduce pest pressure.
- Soil microbes, both living and dead, help support nutrient cycling through decomposition, and solubilization of nutrients from soil minerals.
- Improving the formation of stable soil aggregates that are critical to resist erosive forces of wind and water, aid in infiltration and water storage capacity.

MINIMIZE DISTURBANCE AND MAXIMIZE SOIL COVER

Adopting practices, such as reduced tillage, cover crops, and agroforestry techniques that minimize disturbance and maximize soil cover benefit the soil by:

- Protecting SOM and soil aggregates important for water infiltration, aeration, and microbial habitat.
- Insulating the soil to protect against diurnal temperature changes which helps reduce plant and microbial stress.
- Reducing evaporative losses by keeping more water in the soil; water helps absorb heat from solar radiation, helping soils stay cool in the summer.
- Living cover absorbs solar radiation and sequesters carbon dioxide.
- Dead and decaying residue reduces the albedo effect and reduces risk from erosive forces from wind and water.

Managing for soil health can address multiple issues facing a landowner, including the challenges posed by climate change, however, a comprehensive plan that considers short- and long-term goals needs to be developed to better gauge the challenges and opportunities for a particular cropping system and a specific site. Finally, plans and progress should be reassessed and modified as needed to address any unexpected outcomes or to realign goals.

CLIMATE TOOLS AND RESOURCES TO ASSIST DECISION MAKING AND PLANNING

AgBizClimate
https://www.agbizlogic.com

An online tool that allows users to integrate local climate change predictions into their financial planning.

AgClimate.net
https://www.agclimate.net/

A web-based hub for data, analysis and communication between regional scientists and agricultural and natural resource professionals regarding climate change and agricultural and natural resources topics.

Climate Mapper
https://climatetoolbox.org/tool/climate-mapper

This online mapping tool provides a series of maps for relevant climate and hydrology information from past conditions to projected future conditions.

Comet Farm
http://cometfarm.nrel.colostate.edu

A whole farm and ranch carbon and greenhouse gas accounting system. The tool works producers through farm and ranch management practices including alternative future management scenarios.

Pacific Northwest Biochar Atlas
www.pnwbiochar.org

This online tool has a suite of educational resources, decision support tools (including a cost/benefit analysis tool), regional supply chain information, and local case studies to assist users in determining whether biochar may be a worthwhile soil amendment

REFERENCES

Allen, D. E., Singh, B. P., & Dalal, R. C. (2011). Soil health indicators under climate change: a review of current knowledge. In Soil health and climate change (pp. 25-45). Springer, Berlin, Heidelberg.

Chambers, A., Lal, R., & Paustian, K. (2016). Soil carbon sequestration potential of US croplands and grasslands: Implementing the 4 per Thousand Initiative. Journal of Soil and Water Conservation, 71(3), 68A-74A.

Jackson, R. B., Lajtha, K., Crow, S. E., Hugelius, G., Kramer, M. G., & Piñeiro, G. (2017). The ecology of soil carbon: pools, vulnerabilities, and biotic and abiotic controls. Annual Review of Ecology, Evolution, and Systematics, 48, 419-445.

Kaur, H., Huggins, D. R., Rupp, R. A., Abatzoglou, J. T., Stöckle, C. O., & Reganold, J. P. (2017). Agro-ecological class stability decreases in response to climate change projections for the Pacific Northwest, USA. Frontiers in Ecology and Evolution, 5, 74.

May, C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York. (2018). Northwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.CH24.

Morrow, J. G., Huggins, D. R., & Reganold, J. P. (2017). Climate change predicted to negatively influence surface soil organic matter of dryland cropping systems in the Inland Pacific Northwest, USA. Frontiers in Ecology and Evolution, 5, 10.

Mote, P. W., Li, S., Lettenmaier, D. P., Xiao, M., & Engel, R. (2018). Dramatic declines in snowpack in the western US. Npj Climate and Atmospheric Science, 1(1), 2.

Rupp, D. E., Abatzoglou, J. T., & Mote, P. W. (2017). Projections of 21st century climate of the Columbia River Basin. Climate Dynamics, 49(5-6), 1783-1799.

Sankey, J. B., Kreitler, J., Hawbaker, T. J., McVay, J. L., Miller, M. E., Mueller, E. R., ... & Sankey, T. T. (2017). Climate, wildfire, and erosion ensemble foretells more sediment in western USA watersheds. Geophysical Research Letters, 44(17), 8884-8892.

This factsheet was prepared by Gabrielle Roesch-McNally with the USDA Climate Hubs, Jennifer Moore-Kucera with the NRCS Soil Health Division and Cory Owens with NRCS Oregon.

USDA United States Department of Agriculture
Natural Resources Conservation Service

USDA Northwest Climate Hub
U.S. DEPARTMENT OF AGRICULTURE