SageSTEP
Sagebrush Steppe Treatment Evaluation Project
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Reducing Carbon Emissions from Sagebrush-Steppe

Sagebrush-steppe ecosystems are one of the most extensive in North America, but they are also one of the most rapidly disappearing. Intensive land use, invasive species, climate change and the increasing occurrence of wildfires cause significant ecosystem degradation and vegetation changes in the Interior West. Exotic annual grass (cheatgrass) invasion and Pinyon-juniper encroachment is changing the character of the sagebrush-steppe (Figure 1). Sagebrush ecosystems, including Pinyon-juniper woodlands in the Great Basin, have become prone to frequent and high severity fire due to increasing cheatgrass cover and tree density. Each year, wildfires burn more than 3,470 square miles (900,000 ha) of treeless sagebrush-steppe and an additional 1,350 square miles (350,000 ha) of pinyon-juniper woodlands (Balch et al. 2013, Figure 2). Degraded sagebrush ecosystems and high-density woodlands that burn under wildfire conditions are unlikely to recover. They will likely become dominated by cheatgrass.

Sagebrush ecosystems evolved with fire, and fire in these systems is not considered a net source of CO_2 to the atmosphere as long as a healthy sagebrush ecosystem returns to the site over time. However, fueled by encroaching woody biomass and invading cheatgrass, fires have become increasingly severe and frequent. Wildfire and subsequent land cover conversion to cheatgrass release several million metric tons of CO_2 into the atmosphere every year.

Scientists at SageSTEP are working with land managers to restore these sagebrush ecosystems to a healthy state, which will minimize the spread of invasive species, reduce the impacts of wildfire and mitigate CO_2 emissions. SageSTEP efforts are focused on identifying restoration practices that are effective at improving the health of native perennial bunchgrasses, minimize cheatgrass invasion and manage Pinyon-juniper encroachment.

Figure 1: This figure shows a healthy Sagebrush Steppe Ecosystem (top) and a Sagebrush ecosystem degraded by the invasion of Cheatgrass (bottom).

If we succeed in improving these lonely and rugged places, even in a modest way, our efforts will help to mitigate climate change.

Consider This:

• On average, one hectare of healthy sagebrush-steppe contains approximately 5 metric tons of carbon in aboveground biomass and over 35 metric

A 10% restoration success would offset more than double the equivalent of the entire DOI and USDA annual motor vehicle fleet emissions.

tons of organic carbon stored belowground (Figure 3; Bradley et al. 2006; Rau et al. 2011).

• Based on historical averages, approximately 1,040 square miles (270,000 ha) of sagebrush ecosystems are converted to cheatgrass dominance each year.

• One hectare of cheatgrass dominated rangelands contains < 1 metric ton of carbon in aboveground biomass and just over 30 metric tons of belowground organic carbon (Figure 3; Bradley et al. 2006; Rau et al. 2011).

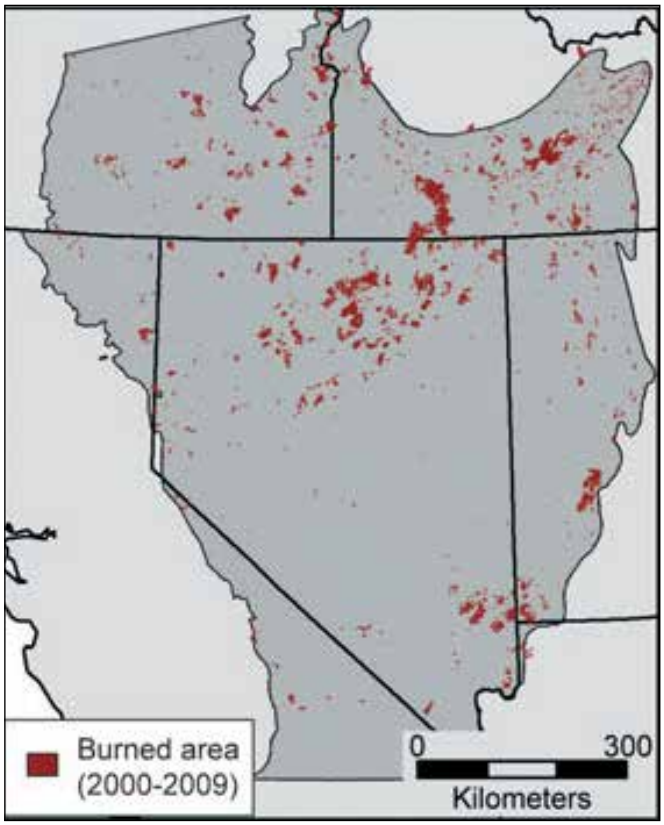

Figure 2. Area Burned by wildfire in the Great Basin from 2000-2009 (Balch et al. 2013).

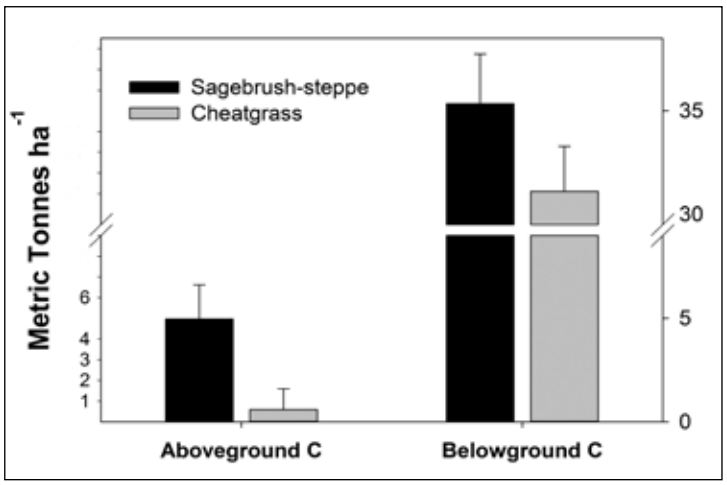

Figure 3. Above and belowground carbon stocks in healthy sagebrush-steppe ecosystems and cheatgrass dominated systems (Bradley et al. 2006; Rau et al. 2011).

• Fires in sagebrush-steppe and the subsequent land cover conversion to cheatgrass release 3-6 metric tons of carbon per hectare from aboveground biomass and cause another 5-7 metric tons of carbon emissions per hectare from soil, as roots and soil organic carbon decompose.

• Pinyon-juniper woodlands in the Great Basin contain 21-60 metric tons of carbon per hectare in aboveground biomass and 51-53 metric tons per hectare of belowground organic carbon depending on tree density (Figure 4; Rau et al. 2012).

• High density woodlands that burn under wildfire conditions are unlikely to recover and likely will become dominated by cheatgrass (Figure 5). Direct combustion of aboveground biomass and near surface soil organic carbon releases 9-39 metric tons of carbon per hectare. Additional carbon is lost during the years that follow due to decomposition of residual aboveground biomass, roots and soil organic carbon (Figure 4; Rau et al. 2012).

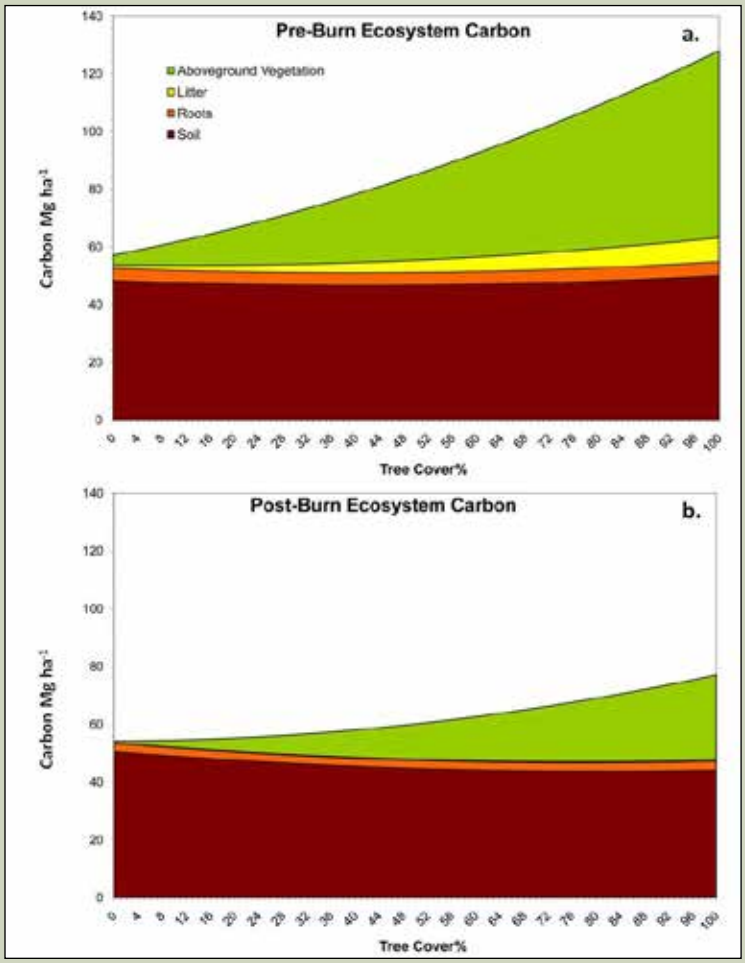

Figure 4. Above and belowground ecosystem carbon stocks in pinyon-juniper woodlands prior to fire (panel a) and after fire (panel b). Post burn graphics represent the residual carbon found on the site immediately after burning at any given cover percentage (Rau et al. 2012).

• This means 8-20 million metric tons of CO_2 are released to the atmosphere each year from fires and the conversion of sagebrush-steppe and Pinyon-juniper woodlands to cheatgrass, based on the historic rate of conversion from sagebrush ecosystems to cheatgrass dominance.

Modest Success Has Major Benefits

Managing sagebrush-steppe and Pinyon-juniper woodlands to reduce woody fuels and restore healthy native perennial herbaceous vegetation is the most effective way to mitigate the spread of cheatgrass and slow large scale land cover conversion. Healthy ecosystems are less likely to experience severe wildfire and more likely to recover to a desirable state following fire. Reducing the number of acres that burn and convert to cheatgrass has significant potential to reduce CO_2 emissions. In addition to reducing current emissions, restoration of degraded sagebrush ecosystems can sequester additional carbon.

• If the DOI and USDA can manage sagebrush-steppe so that the area converted to cheatgrass was reduced by just 10% each year, we would offset 0.53 – 0.97 million metric tons of CO_2 emissions annually.

• If managers could reduce high severity fire by only 10% in high-density stands of Pinyon-juniper woodlands, then another 0.27 – 1.0 million metric tons of CO_2 emission could be offset annually.

• Together, modest restoration success would offset 0.8 – 2.0 million metric tons of CO_2 emissions annually. At a minimum, this represents more than double the equivalent of the entire DOI and USDA annual motor vehicle fleet emissions, and at best more than half of the entire annual U.S. government motor vehicle fleet emissions (2011 Federal Fleet Report).

Further Work Needed

With continued support, scientists at SageSTEP will be able to refine these projections and model carbon stocks in sagebrush ecosystems. We will be able to use remote imagery to quantify land cover changes due to wildfire. We'll obtain soil samples from sites that have been converted to cheatgrass dominance by wildfire (sagebrush steppe and pinyon-juniper woodlands) and re-sample the SageSTEP network 8-10 years following treatment to determine how much carbon has been sequestered due to proactive management.

Figure 5. This landscape was once mixed sagebrush and pinyon-juniper woodland. Following high severity wildfire the dominant species is now cheatgrass. This ecosystem has crossed a threshold and is now a carbon source rather than a sink.

References

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