Wildland Soil Carbon Management

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Introduction

Climate change concerns have called traditional wildland management practices into question, especially with respect to their impact on soil carbon sequestration. 302 million hectares of forested lands and 247 million hectares of grasslands and pasture lands occur within the United States. The USDA Forest Service administers 78.1 million hectares of forest and grasslands and is committed to slowing global warming through forest and grassland management .

The challenge to federal land managers is what practices are appropriate to foster and enhance carbon sequestration. In forested ecosystems, wildfires have been problematic and contribute enormous amounts of carbon into the atmosphere. In grassland ecosystems, historic domestic live stock grazing has reduce the capacity of some grasslands to sequester carbon.

This presentation provides some of parameters that are considered when prescribing land management and mitigation measures to protect and enhance soil carbon sequestration in forest ecosystems on lands administered by the Forest Service.

Forest Ecosystems

A review of the published literature offers numerous insights as to important considerations to incorporate into forest management practices. Here we discuss species, age, and climate aspects that are essential in developing forest management prescriptions.

Summarize published data from a host of studies on carbon sequestration from around the world provides a picture of how carbon is stored on an array of ecosystems (Pregitzer and Euskirchen 2004). One of the conclusions one comes to when looking over this compilation is that forest ecosystems sequester carbon in a variety of ways depending on their climate and species. Base on this compilation, temperate forest ecosystems appear to have the greatest capacity to sequester carbon.

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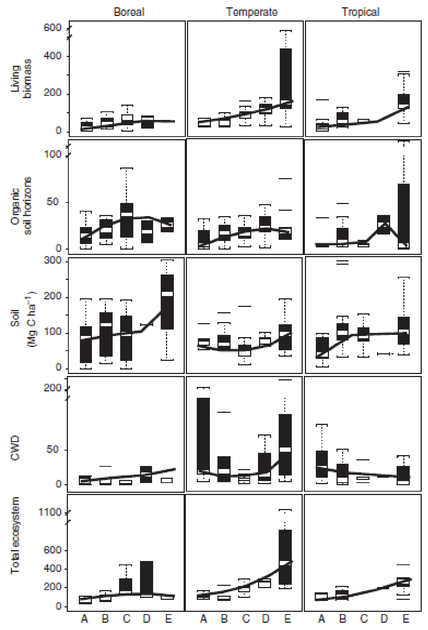
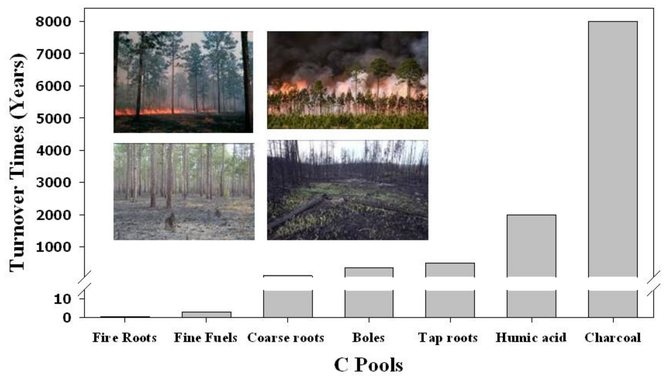


Carbon Pools

Critical to carbon sequestration management prescriptions is understanding the type of organic material being managed. As the figure below illustrates, the life of different carbon substrates have significantly different timeframes in the soil matrix. As one can see, charcoal is the most stable carbon substrate in the array of materials displayed.



Nutrient Cycling

Nutrient cycling in soil can not be overstated. One of the most prominent nutrients is nitrogen. Its role in carbon sequestration is still being investigated, but what is known is that nitrogen is critical for protecting soil productivity.

Forest Fire Management

One of the most profound disturbances of forest ecosystems is fire. Most forests of the western United States are fire adapted and evolved with fire as a key component of their sustainability. However, in recent years forest fire behavior has changed in size, intensity and severity. Fire consumes surface organic matter in various degrees depending on its duration and intensity. As the following table illustrates (Baird et al. 1999) fire affects different forest ecosystems and their chemical composition is different ways also.

Stand Type	C Pre-burn Total (Mg/ha)	C Loss from Fire %	N Pre-burn Total (Mg/ha)	N Loss from Fire %
Pinus ponderosa				
Surface OM	10	90	183	95
Mineral Soil 60 cm depth	77	30	630	23
Total	87	37	813	39
Pinus contorta				
Surface OM	20	90	220	95
Mineral Soil 60 cm depth	64	10	300	13
Total	84	29	520	48

Forest Management Prescriptions

Sustainable forest management is the mission of the Forest Service. One of the major challenges to achieving this mission is understanding the capacity of the soil/site and its limitations and potential to respond to vegetation management prescriptions.

The National Forest Management Act 1976 directs federal land managers to identify lands that are to be managed for forest products and other uses. Those lands identified for timber production, have a host of silvicultural prescriptions that may be applied to them to maintain and/or enhance their capacity to produce timber products. It is anticipated, that with the increased interest in carbon sequestration, vegetation management treatment will be asked how they maintain or improve carbon storage.

The challenges of increasing the capacity of the soil for carbon sequestration is illustrated by Figure 2 (McFarlane et al 2009). The upper portions of the soil profile, as expected, contain the most soil organic carbon. But as the data show from the Garden of Eden Experiment, even with intense vegetation management which included herbicide and fertilization, increases in soil organic matter is a slow process and appears to be more successful on lower productive soil types.

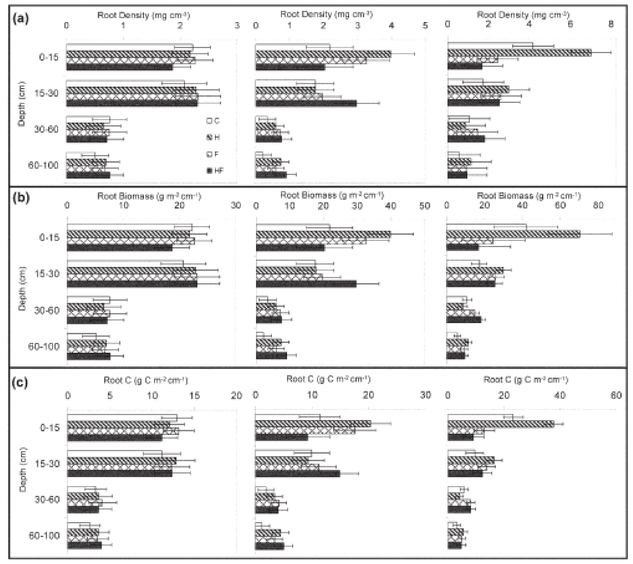


Fig. 2. Fine-root mass (a) density, (b) biomass, and (c) C storage by depth for each treatment at the Elkhorn Ridge (left), Whitmore (middle), and Feather Falls (right) Garden of Eden Study sites. Bars indicate standard errors. Note differences in scale for root density across sites. Data reflect all fine roots, regardless of species. Treatments: C = control, H = herbicide only, F = fertilizer only, HF = fertilizer and herbicide.

Other Considerations

Surficial organic matter has other roles beyond carbon sequestration that are important to note that relate to the climate change discussion. Wildland soils, are limited in the amount of natural debris that are deposited on them. Those annual increments of organic material are used for erosion control, moisture conservation and atmospheric deposition buffering. Nutrient cycling , as previously mention, is how most soils sustain their functionality.

Summary

This literature review sheds some insight on the complexity of carbon sequestration especially related to soil organic matter in forest ecosystems. Forest treatments need to incorporate an understanding of the soil environment to maintain or enhance the soil's capacity to sequester carbon. A review of the literature shows vital data gaps in understanding carbon dynamics in the soil environment. There are clues in the literature: 1.) Different forested ecosystems store carbon in a variety of ways; 2.) Soil texture and soil classification influence soil carbon dynamics; 3.) Past land management plays a significant role on the soil's capacity to sequester carbon. Better understanding of Haans Jenny's factors of soil formation along with baseline soil data and how those factors can be influenced and/or manipulated to foster wildland carbon sequestration is our challenge.

References

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