

A framework for analyzing the effect of management on forest carbon fluxes

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Abstract

Intensification of land use is often considered a primary factor leading to accelerated mineralization of soil carbon. This is particularly evident in agricultural lands, but is also suggested under less intensive management practices, including commercial forestry. If true, such an effect would offset efforts to manage ecosystems for carbon sequestration and climate change mitigation. Yet, recent studies of carbon cycling in managed forests have not found unequivocal evidence of greater respiratory activity compared to unmanaged ones, which is a major process determining carbon balance of ecosystems. In the current study, we evaluated both direct and indirect effects of management on respiratory carbon emissions. The preliminary results indicate minimal systematic effect on respiration rates, whereas the increased frequency of harvest disturbances resulting in more frequent post-disturbance spikes in heterotrophic respiration leads to greater net loss of soil C over time. In contrast, the higher productivity of managed forests results in greater mean net carbon uptake, which partially offsets the respiration losses. The cumulative long-term effect of forest management on ecosystem carbon balance depends on the net balance between productivity and respiration processes, and likely will be more responsive to the fate of harvested biomass than the direct and indirect effects on respiratory dynamics.



Drivers of site carbon balance Drivers of TBCA

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|--|---|
| <ol style="list-style-type: none"> 1. Productivity (either NPP or GPP) 2. Allocation 3. Export off-site 4. Decomposition | <ol style="list-style-type: none"> 1. Disturbance/Age 2. Fertilization/C:N ratio 3. Leaf habit 4. Carbohydrate availability |
|--|---|

Table 1. P-values of the significance of management and disturbance effects on carbon fluxes in forests. Analysis based on global NPP database (Luyssaert et al. 2007).

Flux	P _{mgmt}	P _{disturbance}
GPP	n/s	n/s
NPP _{total}	n/s	0.008
NPP _{AG}	n/s	0.09
NPP _{stem}	n/s	n/s
NEP	0.002	0.09
R _{Eco}	n/s	0.04
R _A	n/s	n/s
R _H	n/s	n/s
BGA	n/s	n/s
R _H :R _S	n/s	0.002
R _H :Detritus	n/s	0.0001

Figure 4. Ratio of heterotrophic respiration to total detritus production in forests. No statistically significant differences were detected between managed and natural forests. Analysis based on Global Soil Respiration Database (Bond-Lamberty & Thomson 2010).

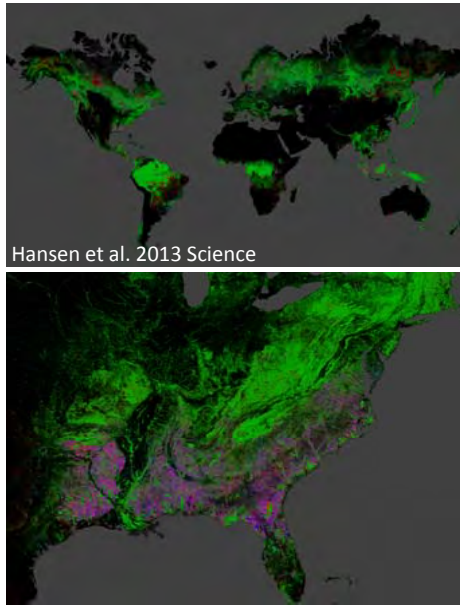
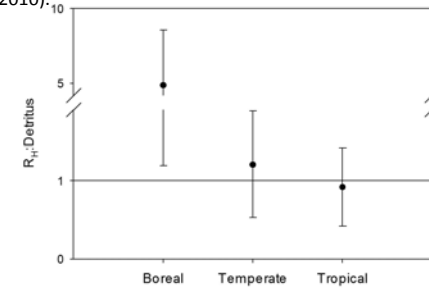


Figure 1. Forest cover change from 2000 to 2012 (Hansen et al. 2013). Green – forest, black – non-forest, red – forest loss, blue – forest gain, purple – both gain and loss. 30% of forests in SE-US underwent change in the 12-year study period. Image source: <http://earthenginepartners.appspot.com/science-2013-global-forest>.

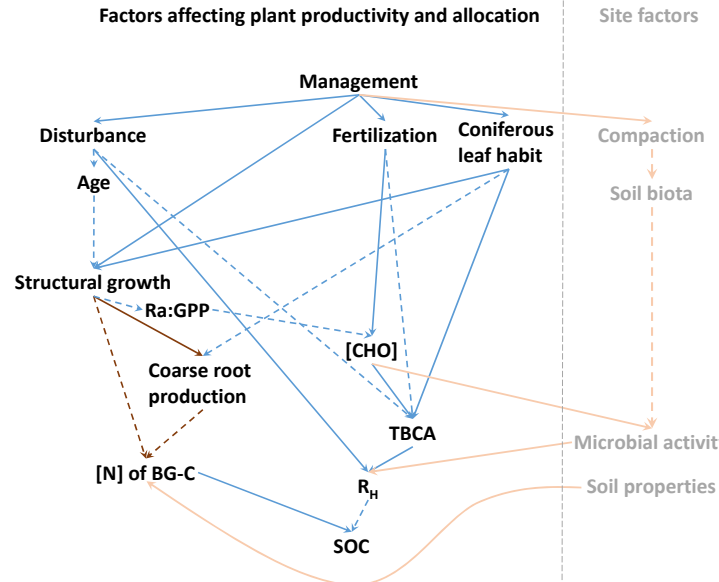


Figure 2. Conceptual diagram of the effect of management activities on soil carbon. Solid arrows indicate positive effect (increase in the value of the causal factor leads to an increase in the effect variable), dashed arrows indicate negative effect. Brown arrows mark processes affecting chemical recalcitrance of SOM (*sensu* Sollins et al. 1996), blue arrows mark other plant-related processes, peach arrows mark site factors unrelated to plant carbon allocation.

Conclusions

1. On average, managed forests differ little from unmanaged ones in terms of carbon fluxes and belowground allocation. Only NEP tends to be consistently higher in managed forests.
2. The ratio of heterotrophic respiration to TBCA tended to be lower in managed than unmanaged stands. It is consistent with reported higher root Ra.
3. Regardless of management status, the majority of sites have negative soil carbon balance.

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Goals

1. Identify functional changes in forest carbon cycling attributable to active management.
2. Assess implications for regional carbon balance and on-site carbon sequestration.

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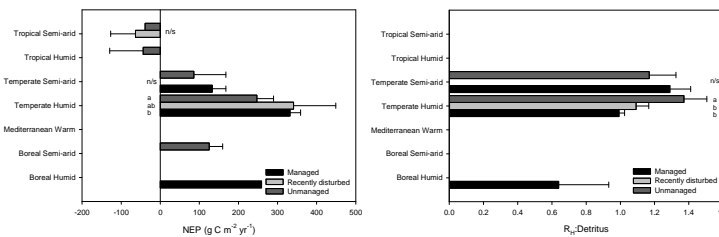


Figure 3. Net ecosystem productivity and the ratio of heterotrophic respiration to detritus production (including coarse roots) in the world's forests. Analysis based on global NPP database (Luyssaert et al. 2007).