Ground layer carbon and nitrogen cycling and legume nitrogen inputs following fire in mixed pine forests

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ABSTRACT

Many mixed pine forests in the southeastern United States undergo prescribed burning to promote open pine savannas. In these systems, soil texture can influence fire's effect on vegetation and nutrient cycling. Our objectives were to examine fire and soil texture effects on carbon (C) and nitrogen (N) pools in ground layer vegetation. We measured biomass and tissue nutrient concentrations and estimated legume N inputs via N2 fixation in frequently burned sandy and clayey sites that were in the first and second seasons following a prescribed fire in 2002 (B02) or had been unburned since 2000 (B00). Mean belowground biomass was significantly greater on sandy than on clayey sites. Total aboveground mean biomass did not differ significantly between B00 and B02 sites, but grasses had greater aboveground biomass in clayey than in sandy sites. Carbon and N pools (measured in grams per square meter) in grasses were greater in clayey than in sandy sites, yet grasses had greater tissue concentrations of C (as a percentage) in sandy sites. Legumes showed significant interaction effects between soil texture and fire frequency for tissue C and N pools, above- and belowground biomass, and acetylene reduction activities. Results suggest that soil texture can influence fire effects on ground layer vegetation in southeastern mixed pine forests.

NO FULL TEXT LINK AVAILABLE

Fertilization Effects on Carbon Pools in Loblolly Pine Plantations on Two Upland Sites

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A study was conducted in loblolly pine (Pinus taeda L.) plantations on sandy and clayey upland sites, with and without the addition of 250 kg ha\(^{-1}\) of diammonium phosphate (DAP) applied at planting, to estimate the effects of fertilization on ecosystem C storage.
Soil C pools were inventoried before planting and in the 11th year of stand development. Tree inventory data were used to convert stand volume to accumulated biomass. During the 11 yr of stand development, total ecosystem C increased by 24.2 Mg ha\(^{-1}\) on average across sites, averaging 2.2 Mg C ha\(^{-1}\) yr\(^{-1}\). Fertilization increased accretion by 25.3 Mg ha\(^{-1}\), or 2.3 Mg C ha\(^{-1}\) yr\(^{-1}\), with the majority of increase (65%) occurring in biomass. The clayey site averaged 64% more total ecosystem C than the sandy site. With the exception of a 12 Mg ha\(^{-1}\) loss in mineral soil C for the 10- to 20-cm depth in nonfertilized (control) plots on the sandy site, soil C in the surface 20 cm did not change during the 11 yr of stand development, suggesting that the mineral soil C is a minor sink in these aggrading pine plantations. The loss in mineral soil C observed in control plots on the sandy site may be explained by the macroporosity of this coarse-textured sandy soil creating an environment conducive to oxidation and in turn optimal for respiration and C losses following site preparation, and a disadvantaged opportunity for C accumulation owing to higher soil temperatures. Fertilization may have improved the opportunity for C accumulation on the plots having been fertilized on the sandy site in early years by creating a cooler soil as a result of more rapid canopy closure and forest floor accumulation.

**FULL TEXT LINK:**
http://soil.scijournals.org/cgi/reprint/70/1/279

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Assessing Change in Soil-Site Productivity of Intensively Managed Loblolly Pine Plantations

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Intensively managed forests are among the most important sources of wood fiber and timber in the southern United States. There is a great deal of concern that wet-weather harvesting disturbances might diminish long-term soil-site productivity. Determining the true effect of harvesting disturbance and silvicultural treatments on long-term productivity of pine plantations is difficult because growth and yield are affected by changes in climate, silviculture, and genetics. Change in productivity rank among treatments was used as a new approach to evaluate harvest disturbance effects on changes in soil-site quality because it is less influenced by the confounding factors that affect tree growth. Three 20-ha loblolly pine (Pinus taeda L.) plantations were subjected to combinations of wet- and dry-weather harvesting and mechanical site preparations. Wet-weather harvesting had no discernable effect at the operational scale (3.3 ha) compared to dry harvesting on changes in soil-site quality when standard site preparation methods were used; however, results based on change in rank for site index indicated that the combination of wet harvesting and flat planting diminished productivity. Polypedon-scale
investigations indicated that silviculture, inherent site factors, and disturbance affected drainage and changes in soil-site productivity. This study showed that the industrial practice of bedding maintained site productivity of wet-weather harvested stands on wet pine flats. These results are potentially important to nonindustrial private landowners whose plantations are not commonly bedded before replanting.

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http://soil.scijournals.org/cgi/reprint/70/1/130

**Applied Geochemistry**
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**Characterization and quantification of biomarkers from biomass burning at a recent wildfire site in Northern Alberta, Canada**

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Abstract

The composition of organic matter (OM) in pine vegetation and soil samples from a pine forest which was charred by a wildfire was analyzed using solid-state nuclear magnetic resonance ($^{13}$C NMR) and gas chromatography–mass spectrometry (GC–MS) of solvent extracts to study the effects of thermal alteration on soil organic matter (SOM). The NMR data revealed the presence of unaltered biomolecules (cellulose, proteins) and low contents of aromatic C (15%) in the charred pine wood and cones while the charred soil samples exhibited higher contents of aromatic C (39–56%). The solvent extraction of charred and uncharred plant and soil samples yielded diterpenoids, triterpenoids, steroids, a series of aliphatic lipids, phenols and carbohydrates indicating the predominant input of higher plant OM and minor contributions from microorganisms and/or fauna. The lower yield of solvent extractable aliphatic lipids in the charred samples versus the uncharred samples suggests that these compounds are thermally degraded during a wildfire. Molecular markers for the burning of cellulose (levoglucosan, mannosan, galactosan) were detected in all charred samples. The comparison of charred and uncharred samples allowed the identification of unaltered pine derived biomolecules and their thermal alteration products in the charred samples. Terpenoid and steroid biomolecules were in part altered during incomplete combustion to aromatic, unsaturated and polar derivatives (“pyromolecules”) that still retained the characteristic skeleton of their precursors. Since some of the polar degradation products found in the charred soils can be generated either
from thermal or microbial degradation, the aromatic and unsaturated hydrocarbon products are preferred as molecular markers for SOM burning. Ratios of biological precursors to aromatic (diterpenoids) or unsaturated products (steroids) indicate that the cyclic lipids in the pine wood and the soil surface horizon were highly altered. In conclusion, the solvent extractable lipids and carbohydrates in charred SOM are valuable, source-specific molecular markers for the burning of plant biomass and for tracing the biogeochemistry of charred residues in soils.

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Soil compaction and forest floor removal affect early growth and physiology of lodgepole pine and Douglas-fir in British Columbia

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Abstract
We investigated the effects of soil compaction and forest floor removal on growth and physiology of lodgepole pine (Pinus contorta ex Loud. var. latifolia Engelm.) and Douglas-fir (Pseudotsuga menziesii var. glauca [Baissn.] Franco) seedlings on a calcareous long-term soil productivity (LTSP) study site near Invermere, British Columbia. Treatments consisted of factorial combinations of soil compaction (noncompacted versus compacted) and forest floor removal (forest floor intact versus forest floor removed) as well as a remedial (rehabilitation) treatment of deep ripping following soil compaction. The experiment was not replicated at the treatment plot level, therefore no statistically based mean comparisons were made. After two growing seasons, we found that the two tree species responded differently to those treatments. Lodgepole pine height and diameter growth and unit needle-weight (dry mass per unit needle) averaged 25, 51, and 30% greater, respectively, in the rehabilitation than in the other treatments, whereas Douglas-fir responded to the rehabilitation treatment by increasing stem diameter growth by 27%, but not height growth (a change of 9%). Forest floor removal decreased height growth in lodgepole pine by 11%, but increased diameter growth in Douglas-fir by 15%. The decreases in growth for lodgepole
pine in the forest floor removal treatments were accompanied by lower foliar N concentrations. Foliar N concentrations were positively correlated with rates of net photosynthesis (r = 0.69, P = 0.004) and height growth (r = 0.76, P = 0.004) in lodgepole pine, but not in Douglas-fir. Low N supply (as observed for lodgepole pine) and depletion of soil moisture as a result of forest floor removal likely played a role in shaping the growth and physiological responses of the trees in this study.

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Foliar δ¹³C and δ¹⁵N response of lodgepole pine and Douglas-fir seedlings to soil compaction and forest floor removal

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Abstract
The effects of soil compaction, forest floor (FF) removal, and rehabilitation treatments on foliar δ¹³C and δ¹⁵N of lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) were studied on a calcareous soil. Regardless of soil compaction, FF removal (which reduces soil water potential) resulted in less negative foliar δ¹³C values of lodgepole pine (from -25.9 to -23.4‰), whereas soil compaction effects on foliar δ¹³C were observed only within the FF intact treatment. This result and the more negative foliar δ¹³C with increasing seedling growth most likely reflected limitation on CO₂ diffusion due to water stress caused by those treatments. However, foliar δ¹³C of Douglas-fir (range -25.0 to -24.5‰) were not affected by the treatments, indicating less susceptibility to water stress. Soil compaction reduced NH₄⁺-N concentrations in the FF (from 48.5 to 28.0) and NO₃⁻-N concentrations in the FF (from 13.8 to 6.4) and mineral soil (from 4.3 to 2.1 mg kg⁻¹), and FF removal tended to decrease NH₄⁺-N concentrations in the mineral soil. Foliar δ¹⁵N of both species were not affected by soil compaction but were increased by the FF removal and rehabilitation treatments, indicating that the latter two treatments dramatically altered soil N dynamics.

Geoderma
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Prescribed burning effects on soil physical properties and soil water repellency in a steep chaparral watershed, southern California, USA
Abstract

Chaparral watersheds associated with Mediterranean-type climate are distributed over five regions of the world. Because brushland soils are often shallow with low water holding capacities, and are on slopes prone to erosion, disturbances such as fire can adversely affect their physical properties. Fire can also increase the spatial coverage of soil water repellency, reducing infiltration, and, in turn, increasing overland flow and subsequent erosion. We studied the impacts of fire on soil properties by collecting data before and after a prescribed burn conducted during Spring 2001 on the San Dimas Experimental Forest, southern California. The fire removed the litter layer and destroyed the weak surface soil structure; leaving a thin band of ash and char on top of, and mixed in with, an unstable, granular soil of loose consistency. Median litter thickness and clay content were significantly decreased after fire while soil bulk density increased. At 7 d post-fire, soil surface repellency in the watershed was significantly higher than prior to the burn. At 76 d post-fire, surface soil water repellency was returning to near pre-fire values. At the 2 and 4 cm depths, 7 d post-fire soil repellency was also significantly higher than pre-fire, however, conditions at 76 d post-fire were similar to pre-fire values. Variability in soil water repellency between replicates within a given 15 × 15 cm site was as large as the variability seen between sites over the 1.28 ha watershed. The increase in post-fire persistence of water repellency was largest beneath Ceanothus (Ceanothus crassifolius) as compared to a small increase beneath chamise (Adenostoma fasciculatum). However, pre-fire persistence was higher under chamise than for ceanothus. Post-fire changes to soil properties may increase the watershed hydrologic response, however the mosaic distribution of water repellency may lead to a less severe increase in hydrologic response than might be expected for a spatially more homogenous increase in repellency.

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