On Long-unburned Sites, Oak-hickory Dominance Can Lead to Greater Delayed Canopy Dieback After Wildfire Due to Greater Duff Consumption and Fine Root Damage

In Appalachian forests, overstory tree mortality after fire is usually associated with high intensity fires (flame lengths >4') that cause significant bark char and bole damage. However, recent studies have shown that in long-unburned longleaf pine sites, the smoldering of accumulated pine duff can lead to significant mortality of large trees stressed by the loss of fine roots that are located in the duff layer. A newly published paper in the journal *Ecosystems, "*Benefit or Liability? The Ectomycorrhizal Association May Undermine Tree Adaptations to Fire After Long-term Fire Exclusion", examines duff and fine root consumption and delayed tree stress in long-unburned oak-hickory forests after a slow-moving wildfire in the southern Appalachians in 2016. The authors focus on how fire effects varied by overstory composition, from sites dominated by ectomycorrhizal (ECM)-associated oaks and hickories- sites with slower decomposition and more duff, to sites dominated by arbuscular mycorrhizal (AM)-associated maples and poplars, with faster decomposition and less duff.

Study Location and Methods:

- Rock Mountain wildfire site in the Chattahoochee and Nantahala National Forests, GA, NC, which burned >22,000 acres in November and December 2016. The fire was mostly slow-moving and low-severity (little immediate post-burn tree mortality) but often burned deep into the duff layer. The forests were oak-hickory with maple and poplar more abundant on mesic sites.
- In 2017 the research team set up plots in adjacent burned and unburned areas, on four site types: ridge, midslope N-facing, mid-slope S-facing, and low-elevation.
- Trees >4" DBH were evaluated each year 2017-2019. Relative dominance (basal area) by ECM (oaks, hickories, others) and AM (maples, poplars, others) trees was determined.
- Depth and mass of the forest floor (litter, duff) was evaluated 1-year post-burn Journal article continued Study location and methods cont.
- Depth and mass of the forest floor (litter, duff) was evaluated 1-year post-burn
- In the laboratory, abundance of fine roots in the duff and upper mineral soil was determined from field samples. • Decomposition rates of ECM (oaks, hickories) litter and AM (maples, poplars) litter were also measured in the field

Key Findings:

- Unburned plots showed that duff loadings increase with oak-hickory dominance. With greater abundance of the ECM oaks and hickories, litter decomposition rates slow and duff accumulates without periodic fire.
- Duff consumption was significant- loadings were 75% lower on burned plots vs. unburned plots – and, because oak-hickory sites had greater amounts of duff, more was consumed on those sites.
- Fine roots were abundant in the duff layer, so on sites dominated by oak-hickory, which had greater duff accumulation, more fine roots were consumed. Of all the fine roots located in upper soil (8") and duff, the authors estimate that 40% were consumed on the strongly oak-hickory dominated sites.
- The greater duff and fine root consumption on oak-hickory dominated sites was related to greater canopy dieback by year 3, as only about 30% of trees had a full crown, though topkill or mortality was relatively low (16% of trees), at least up to year 3.

Take Home Points:

- Although oaks and hickories are fire-adapted, the duff accumulation that occurs with long-term fire exclusion makes oak-hickory dominated sites susceptible to post-fire tree stress and mortality as duff and fine roots are consumed when wildfires occur in drought conditions.
- Prescribed fires conducted in non-drought conditions will have much less duff consumption and fine root damage.
- Repeated fires can limit duff accumulation and thus the probability of fine root damage and tree mortality if a wildfire were to burn under drought conditions.