Vegetation responses to a stand-replacing fire in an old-growth southern boreal forest

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Boreal conifer forest area has declined in the northern Great Lakes region due to a combination of climate change and altered fire regime, among other influences. One consequence of this is the decline in white pine prevalence in these forests, as well as overall species abundance. A study by Apfelbaum et al. (2017) followed vegetation change in an old-growth, fire-origin boreal forest. The natural fire return interval is approximately 100 years, but this study site had not experienced a detectable fire for 400 years. The forest was previously measured in 1977 and 1997, and approximately half of the area was burned severely in September 2006. The objectives of this study were to characterize the effects of the 2006 fire on forest composition and recovery, specifically in the context of pine regeneration.

To measure forest recovery post-fire, the authors established a series of permanent vegetation transects in 1977 and 1997, and re-measured these sites in 2008, 2010, and 2014. Measurements included tree and shrub number and diameter, and non-woody plant species cover. Each species was assigned descriptors based on plant form, seed dispersal, and response to fire. Statistical analyses were used to determine fire-related shifts in vegetation community composition.

Unburned areas exhibited little change in forest structure during the study period. Over the long term (37 years of observation), changes in forest composition in the unburned areas were characterized primarily by an increase in the relative abundance of balsam fir and paper birch, and a decrease in white pine and white cedar.

MANAGEMENT IMPLICATIONS

1. Severe fire resulted in distinct differences in the vegetation communities between unburned and burned old-growth southern boreal forest.
2. Unburned old-growth forests were dominated by white cedar, balsam fir, spruce, and birch, and vegetation composition remained stable over a 37-year study period
3. Burned areas experienced nearly complete overstory mortality, and shifted tree species composition to birch-aspen dominance, with cedar present and balsam fir present and increasing over time.
4. Tree survival from the 2006 fire occurred primarily in wet areas, indicating the importance of microsites in post-fire landscape-scale diversity.
5. Post-fire vegetation surveys found no seedling establishment by white pine, spruce, or balsam fir over eight years of monitoring the burned area.
6. Grasses and sedges exhibited the greatest response to the fire, with increased cover and richness within the first four years of recovery.

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Little change occurred in herbaceous species composition. Species richness decreased during the study period, but the decrease was not statistically significant. Essentially no white pine regeneration occurred during the study period in the unburned areas.

In contrast, major changes to forest structure and composition occurred in burned areas after the severe stand-replacing fire in 2006. At the beginning of the second growing season after the 2006 fire, there was a 55% difference in tree canopy coverage between burned and unburned areas, with only modest canopy recovery evident in 2010 and 2014. Shrub layer species cover decreased by 63% two years post-fire, but recovered rapidly by 2014. Herbaceous vegetation cover increased slightly two years post-fire, and species richness also increased slightly over time. Notably, graminoid (grasses, sedges, etc.) species diversity greatly increased post-fire, but then decreased dramatically after 4-6 years. Multivariate statistical analysis showed clear differences in the composition of forest vegetation between burned and unburned areas.

The long-term measurements in the unburned area indicate that the old-growth forest composition remained relatively stable during the study period, although occasional spruce budworm outbreaks influenced balsam fir abundance and contributed to variability in the herbaceous layer cover and diversity. Most of the white pines were around 400 years old, and although only one died in the unburned area during the time period of this study, the total cover by white pine was very low in the unburned areas (average cover of 4%).

The authors state that 400 years without fire increased the vulnerability of the forest to fire, leading to high fire intensity during the 2006 event. The 2006 fire caused high tree mortality and left very few, scattered white pine surviving in wet areas. White pine that survived the fire in upland areas in the 2008 measurements had all died by 2010. There was also no regeneration for white pine, balsam fir, or spruce seedlings eight years after the fire, suggesting that severe fire may prevent pine regeneration.

Declines in white pine cover relative to historic presence likely occurred because of their advanced age (<400 years) in the forest, and mortality from fire, insects and wind can cause additional mortality over time. The authors predict that in the absence of fire, these forests will remain dominated by white cedar, balsam fir, spruce, and birch, whereas the forest composition in burned areas will be dominated by paper birch and aspen with a patchy white cedar understory, and slowly increasing balsam fir presence over time. Overall, the trends of decreased abundance of fire-adapted species noted in this study mirror similar trends across the United States.

Reference

Apfelbaum, S. I., Haney, A., Wang, F., Burris, J., & Carlson, J. (2017). Old-Growth Southern Boreal Forest Stability and Response to a Stand-Replacing Wildfire. Natural Areas Journal, 37(4), 474-488.