Multidecadal Response in Soil Carbon and Nitrogen to the Great Fires of 1947 Using Paired Watersheds in Acadia National Park, Maine

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Introduction: The Great Fires of 1947

Maine's Great Fires of 1947 burned approximately one-third of Acadia National Park (ANP) on Mt. Desert Island (1, 2). This had a lasting impact on ANP's landscape, altering ecosystem form and function for decades. The area burned in ANP was typically transformed to pioneer hardwood forests which, along with the impact of the fires themselves, altered characteristics that influenced ecosystem biogeochemistry, including pollutant retention and scavenging efficiency (1, 2, 3). The research described here represents the initial phase of a study that is returning to a paired watershed research area in ANP for a second analysis of soils. The current study includes the burned and unburned forested watersheds studied 15 years ago, now nearly 70 years after the fires, to determine the status of soil recovery regarding carbon (C), nitrogen (N), and mercury (Hg).

Methods

The original research compared a burned (Cadillac) and unburned (Hadlock) forested watershed in ANP using a paired watershed design (fig. 1). The burned watershed was dominated by pioneer hardwoods (20% regenerating mixed northern hardwoods and 60% shrub/rock balds) while the reference watershed was in softwoods (70% spruce-fir mature conifer forest) (1, 2). Soils range from Borofolists to Haplorthods. This study returned to these watersheds in 2015 to understand changes over time.

The PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) program was created in 1996 by the Environmental Protection Agency (EPA) and National Park Service (NPS). The specific goal of PRIMENet research conducted within ANP was to address research questions regarding acid rain, N saturation, mercury (Hg), and methylmercury (MeHg), and to determine how watershed characteristics influence the reservoirs and fluxes of N and Hg. Six 15 x15 m soil plots were identified to represent overall watershed characteristics such as vegetative communities and position on the landscape. Five sampling points were established within each plot: one in each corner as well as the center (fig. 2). An 11.4 cm diameter template was used to sample the O, B5 (upper 5 cm of the B horizon), and B horizons.

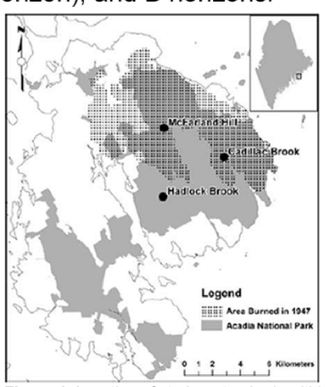

Figure 1. Location of study watersheds within Acadia National Park on Mount Desert Island, Maine, USA. The National Atmospheric Deposition Program site is shown for reference (McFarland Hill). The patterned area was burned in wildfire in 1947. Park boundary and fire extent were provided by ANP, Resource Management. Map projection is NAD83, Zone 19 North.

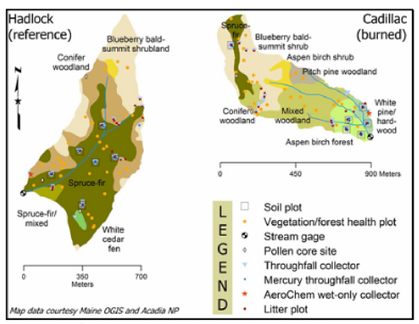

Figure 2. Study watersheds at ANP: Hadlock (unburned) and Cadillac (burned) with PRIMENET plot design for locations of various research elements. Soil plots used in this study are noted as boxes.

Results

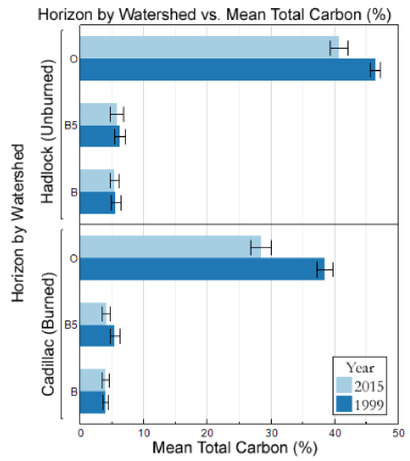

Figure 3. Mean total C percentages for individual soil horizons by watershed in 1999 and 2015. The O horizon means have decreased significantly over time and remain different between Hadlock and Cadillac.

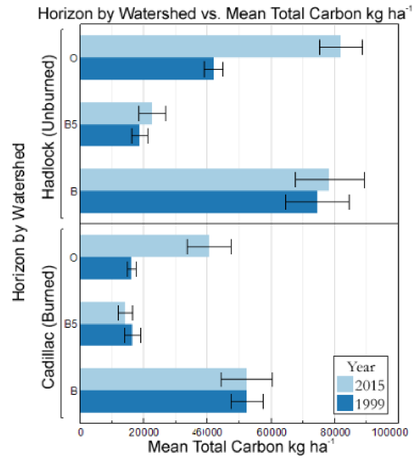

Figure 4. Mean total C kg ha^{-1} for individual soil horizons by watershed in 1999 and 2015. The O horizon means have increased significantly over time and remain different between Hadlock and Cadillac. O horizon means are no longer significantly different from B horizon means.

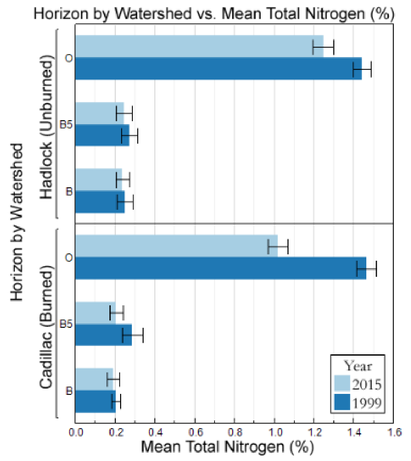

Figure 5. Mean total N percentages for individual soil horizons by watershed in 1999 and 2015. The O horizon means have decreased significantly over time and remain different between Hadlock and Cadillac.

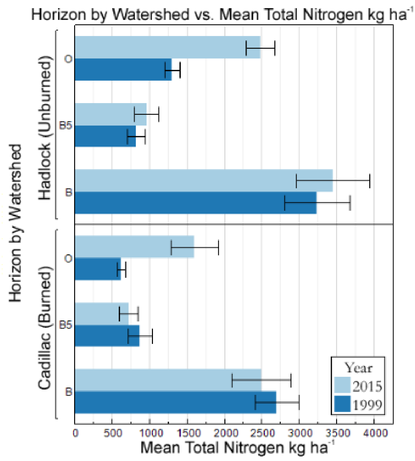

Figure 6. Mean total N kg ha^{-1} for individual soil horizons by watershed in 1999 and 2015. The O horizon means have increased significantly over time and remain different between Hadlock and Cadillac.

Discussion

These data show that the Great Fires of 1947 continue to have a profound influence on ecosystem characteristics, including soil C and N, reflecting the cumulative influence of the fire and altered vegetative communities. Average O horizon depth in Hadlock and Cadillac has increased by 3.64 cm and 3.30 cm, respectively, since 1999 (data not shown). This increase in O horizon thickness across both watersheds at least partly explains 2015 results yielding lower total C and N concentrations and higher C and N contents than in 1999. Accumulating O horizon C and N was anticipated in Cadillac as soils rebuild organic matter stocks following the burn. Similar accumulations in Hadlock were unexpected, and determining causes is a high priority for the research ahead.

Figure 7. Hadlock watershed soil profile horizon sequence.

Conclusions

Carbon (C)

- Total C % and C content remains lower in Cadillac than Hadlock (fig. 3, 4), reflecting losses of soil organic matter as a result of the 1947 fire, and higher rates of organic matter turnover since then due to differences in forest composition and litter quality.
- O horizon total C % has decreased since 1999 for both Cadillac and Hadlock (fig. 3). This is at least partly due to changes in organic matter qualitative factors as well as possible mineral mixing.
- B horizon content has not changed between 1999 and 2015 for either Hadlock or Cadillac (fig 4).
- While total C % has declined in the O Horizon, total C kg ha^{-1} has increased in both watersheds (fig. 4). This is potentially a reflect of recovery from the fire (Cadillac), as well as stand development and other environmental drivers (Cadillac and Hadlock).

Nitrogen (N)

- Total N % and content parallel the patterns seen for C (fig. 5, 6).

Future Direction

Here we present results from the initial analysis after 50 years from the intense wildfire in ANP, as well as the first data from a new study to examine recovery patterns almost 70 years after the Great Fires of 1947. Soil Hg analyses are currently underway and thus not reported here. Additional studies of soils over the next year will further develop these data and allow for a better understanding of response and recovery to fire. Planned research includes soil Hg (total and methyl) analyses, consideration of watershed hydropedological characteristics in supplemental sampling, and future drivers of soil change including changing temperatures and precipitation evident at ANP.

References

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