EFFECTS OF FOREST MANAGEMENT PRACTICE (PRESCRIBED BURNING) ON MERCURY TRANSPORT: A CASE STUDY IN A PAIRED EXPERIMENTAL WATERSHED IN THE LOWER COASTAL PLAIN OF SOUTH CAROLINA

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EXTENDED ABSTRACT

Land use changes and forest management practices (e.g., prescribed burning, mechanical thinning, etc.) are known to alter ecosystem structure and water quality. However, little is known about their short- and long-term impacts on the biogeochemical cycling of mercury (Hg), a global pollutant that can be bioaccumulated and biomagnified in natural food webs, posing a threat to the health of top predators and humans through fish consumption. Forest ecosystems are significant "sinks" for atmospheric Hg, due to the stomatal uptake by leaves. However, silvicultural practices such as prescribed burning and mechanical thinning interferes with Hg storage in forests and potentially increase its export to downstream environment, where it can be a hotspot for transformation into methylmercury (MeHg) production by different anaerobic microbes. Therefore, a better understanding is needed for the impacts of the forest management on Hg bioaccumulation and its export in forested watersheds.

We conducted this study in a paired experimental watershed (WS77 and WS80) with similar size (~150-160 ha) at Santee Experimental Forest on the Atlantic Coastal Plain of South Carolina managed by the Forest Service, U.S. Department of Agriculture, Southern Research Station (as shown in fig. 1).WS77 has been managed for various silvicultural treatments and recently burned in March 2018. WS80 serves as an unburned control. The burn severities were mostly considered as light to moderate burn, with 33 percent light burned area, 66 percent moderate burned area, and ~1 percent not burned area. We collected surface water samples biweekly before and after burning from the outlet of both gauged watersheds from September 2017 to August 2020. We determined the general water quality and total Hg and MeHg concentrations in both watersheds before and after burning in March 2018 and compared total Hg and MeHg export from the watersheds 1- and 2-years post burn. The annual loadings and yields of total suspended solid (TSS), dissolved organic carbon (DOC), total Hg and MeHg in the first year after the burning in

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the paired watershed were calculated and compared. We also examined MeHg in stream biota in both watersheds, including biofilm, macroinvertebrates, and fish from several collection campaigns.

Results showed TSS concentrations in streamwater were higher at the burned site than the control site in the first year post burning ($p<0.05$, t-test), but no difference in the second year post burning. Total Hg and MeHg concentrations in the streamwater did not show statistical differences in either the first year or second year post burning. On an annual basis, as shown in table 1, TSS yield in the WS77 (burned) were 1.6 times higher than TSS yield in the WS80 (control) (6.66 tons Y^{-1} km^{-2} at WS77 compared to 4.17 tons Y^{-1} km^{-2} at WS80). Not surprisingly, the prescribed burning reduced DOC yield considerably (6.28 tons Y^{-1} km^{-2} at WS77 compared to 9.55 tons Y^{-1} km^{-2} at WS80). There was no obvious difference in the total Hg yield between the two watersheds, but much higher MeHg yield (1.71 times higher) in WS77 (burned) than WS80 (control).

We observed much higher MeHg levels in eastern mosquitofish (*Gambusia holbrooki*) (~4 folds) and dollar sunfish (*Lepomis marginatus*) (~2 folds) in WS77 than those in WS80, with similar trends in macroinvertebrates (crayfish [order *Decapoda*], dragonfly larvae [order *Odonata*], water scorpions [family *Nepidae*]), but we found no difference in MeHg levels in streamwater and biofilm samples between the paired watersheds. The higher MeHg contents in fish and macroinvertebrates may be attributed to the different food web structure and organismal growth rate. Further studies are needed to better understand the underlying mechanisms.

In summary, we found there was no significantly ($\alpha=0.05$) elevated total Hg export to the downstream watershed but higher MeHg annual yield in the burned watershed than the control in the short-term. However, we should be aware that repeated prescribed burning may exaggerate this trend and lead to more Hg bioaccumulation in aquatic food webs. Meanwhile, long-term prescribed burning may reduce water use by vegetation, potentially leading to a higher water table in the forested watershed. This would promote a more reducing environment favoring the anaerobic microbes and Hg methylating groups (i.e., promoting more Hg methylation). This study provides new insights into how a forest management practice such as prescribed burning affects the amount and bioavailability of Hg in the downstream aquatic environment and has implication on Hg bioaccumulation in the managed forested watersheds.

Table 1—Comparison of annual loading and annual yield of TSS, DOC, total Hg and MeHg in the watersheds in the first year post-burning

	Annual loading				Annual yield			
	TSS (tons Y^{-1})	DOC (tons Y^{-1})	THg (g Y^{-1})	MeHg (g Y^{-1})	TSS (tons Y^{-1} km^{-2})	DOC (tons Y^{-1} km^{-2})	THg (g Y^{-1} km^{-2})	MeHg (g Y^{-1} km^{-2})
WS77 (Prescribed burned)	10.32	9.73	4.71	0.094	6.66	6.28	3.04	0.060
WS80 (Control)	6.67	15.28	5.41	0.056	4.17	9.55	3.38	0.035

TSS = total suspended solid; DOC = dissolved organic carbon.

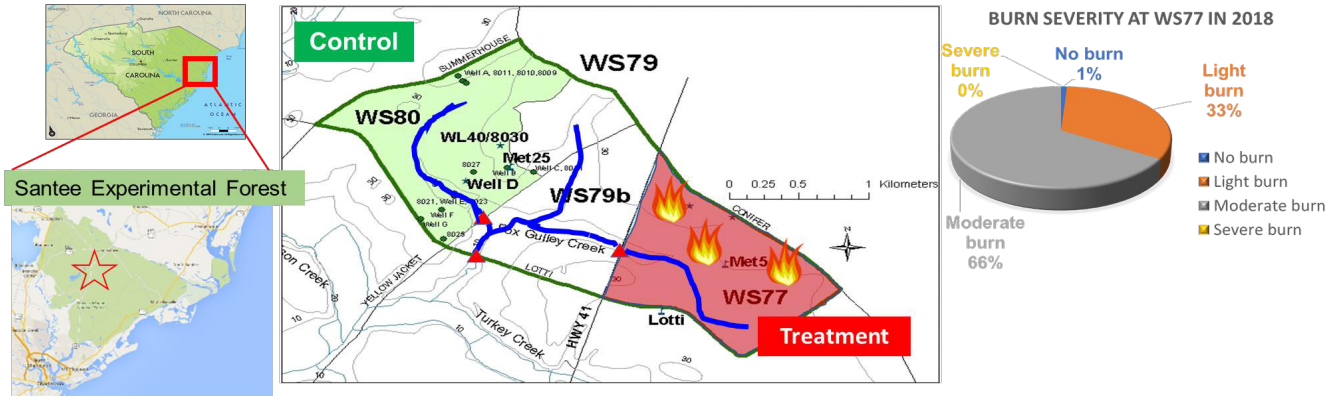

Figure 1—Site map of Santee Experimental Forest, South Carolina. Prescribed burning was conducted at WS77 (red), the managed first order watershed. WS80 (green) is paired unmanaged first order watershed. WS79 is the second order watershed. The burn severity at WS77 in March 2018 was shown on the right.