Relic charcoal hearth geomorphology and hydrology across the northcentral Appalachians, USA

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Previous Research: Relic Charcoal Hearths (RCHs) have been found across parts of Europe, and the Mid-Atlantic, USA. Landscape clearing for RCH construction, and resulting changes in surface geomorphology, could effect forests and soils via hearth-specific soil physical, chemical and hydrologic changes psot construction. We present preliminary research from two RCH sites in Pennsylvania and document differences in hearth characteristics tied to landscape position, RCH morphology, and surface hydrology.

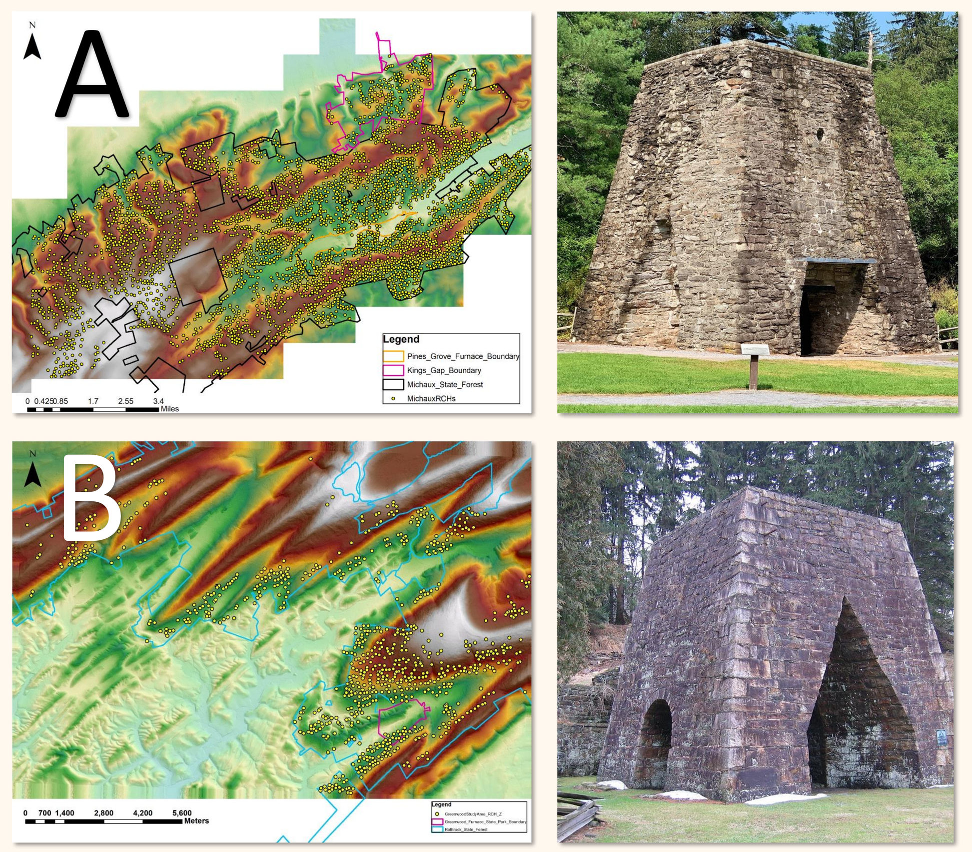

Figure 1. A. RCHs in Pine Grove Furnace State Park and Michaux State Forest (restored furnace in the state park) **B.** RCHs in Greenwood Furnace State Park and Rothrock State Forest (restored furnace in the state park). Photos courtesy of Pennsylvania State Parks.

Hypothesis and Approach: We hypothesize that there is a correlation between RCH shape and their landscape position and that RCHs alter surface hydrology by diverting flow around the hearth.

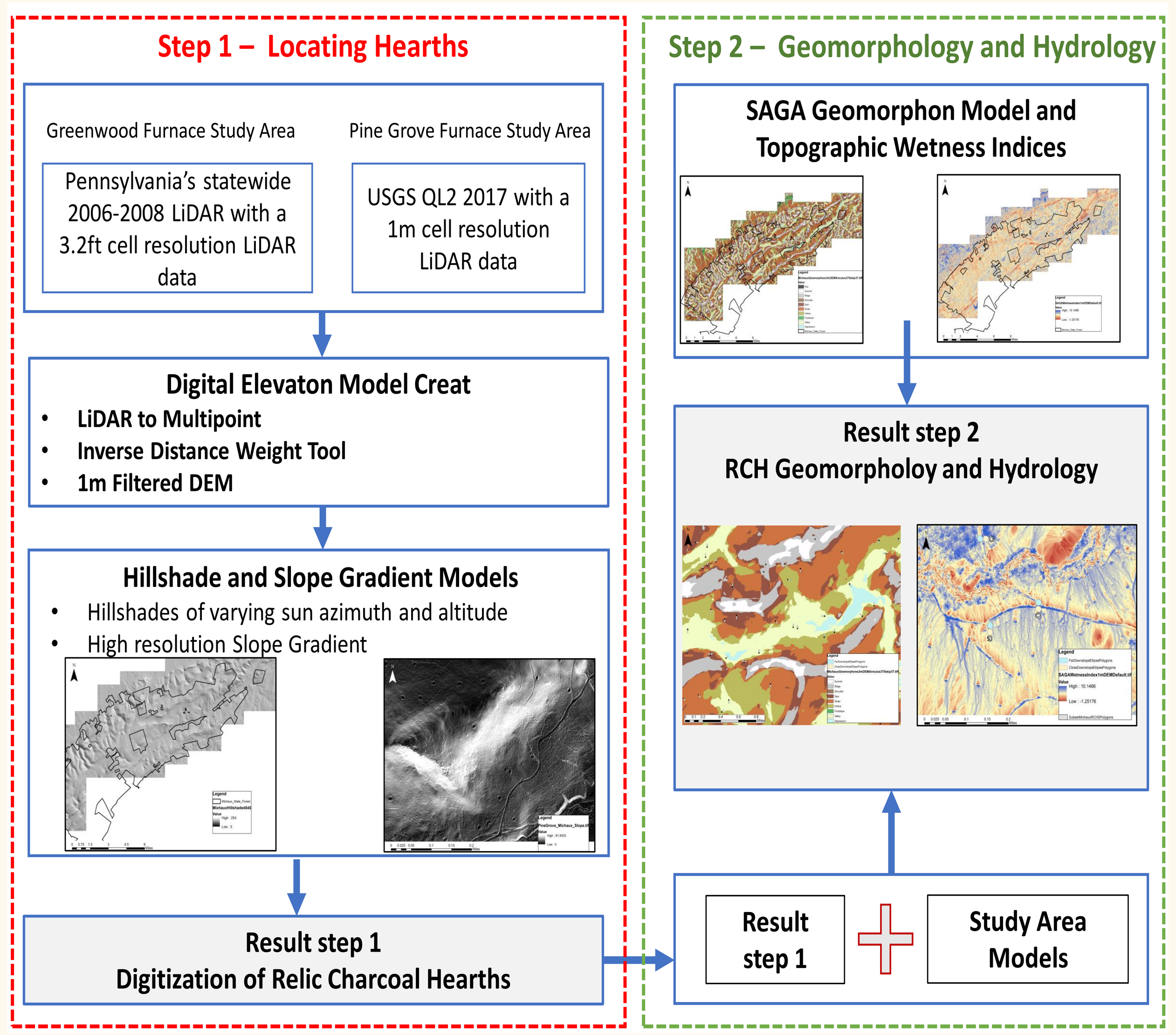

Figure 2. Modeling approach for determining RCH location, morphology shape, geomorphology and hydrology.

Using processed LiDAR data, hillshade and slope gradient maps were derived to digitize >6,100 hearths. A 10% subset of RCHs were fully digitized (inner area and rim) and modelled surface hydrologic data was generated per topographic wetness indices for RCHs and downslope areas.

Study Area Geomorphic Context: Greenwood Furnace State Park is named for the iron furnace, Greenwood Furnace (GF) (Figure 3A), that was in operation from 1834 to the early 1900s. Pine Grove Furnace State Park is named after the Pine Grove Iron Works (PGF), which was built about 1770 (iron production ended in 1895). Both study areas are in the Ridge and Valley physiographic province and have a variety of landscape positions (Figure 3B and C).

Study Area 1, Greenwood Furnace: Area geology consists of Ordovician and Silurian aged rocks dominated by shale, sandstone, siltstone and limestone (Geological Survey of Pennsylvania et al., 1999). Soils are primarily Inceptisols and Ultisols.

Study Area 2, Pine Groves Furnace: Area geology consists of Precambrian and Cambrian rocks dominated by limestones, shales, sandstones, dolomites, and quartzite with intermixed ingenious rocks from the Precambrian (Geological Survey of Pennsylvania et al., 1999). Soils are primarily Inceptisols, Alfisols, and Ultisols.

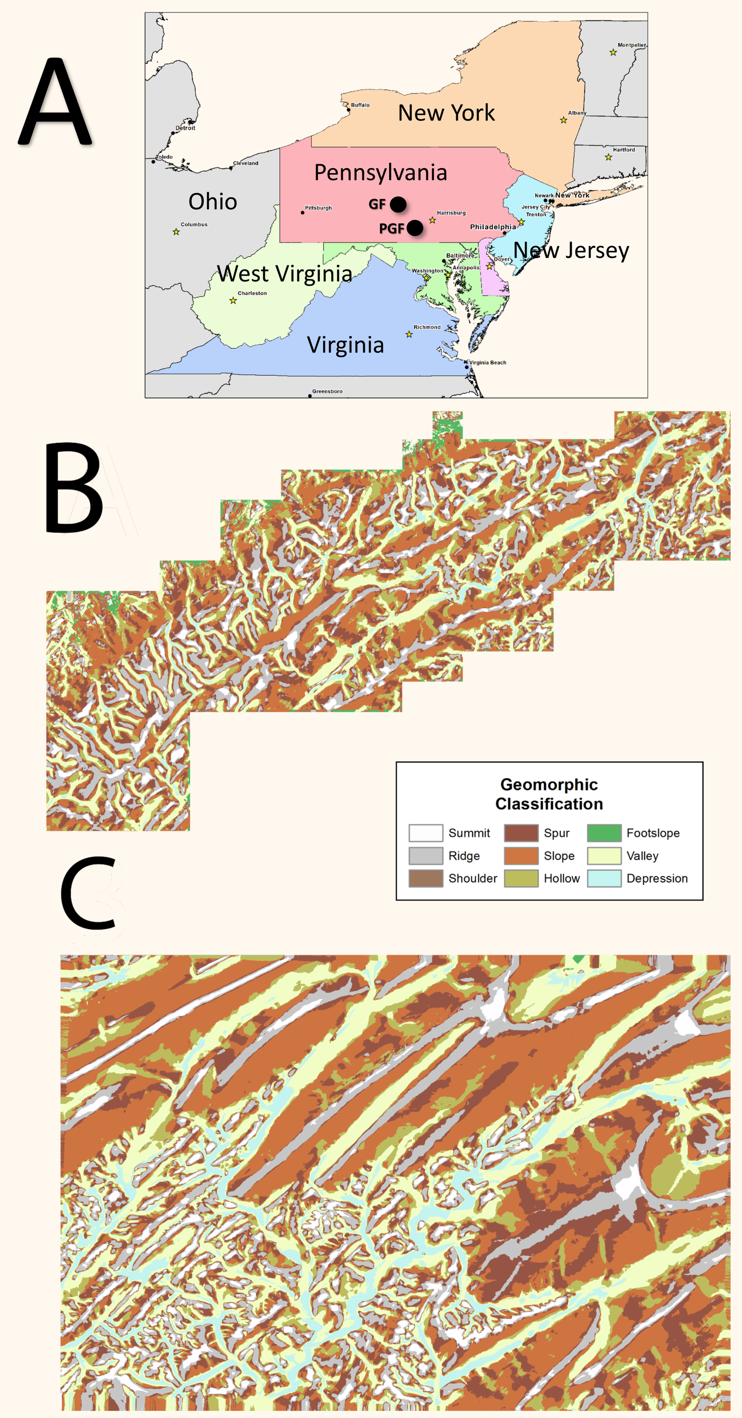

Figure 3. Study Area Geomorphic Context A. USA Mid-Atlantic and study area location. **B.** Geomorphology of Pine Grove Furnace State Park and the surrounding Michaux State Forest. **C.** Geomorphology of Greenwood Furnace State Park and surrounding Rothrock State Forest.

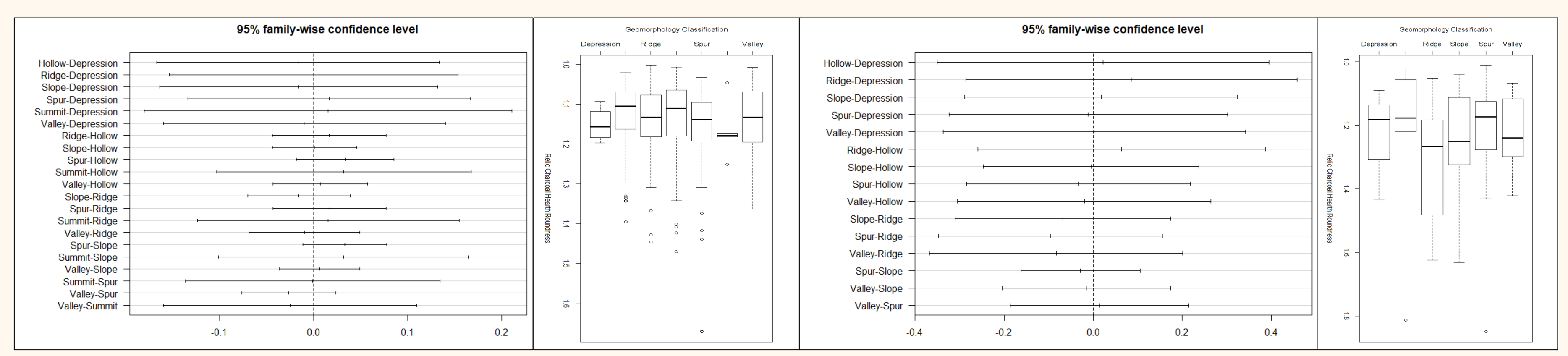

Figure 4, Step 1 Results: ANOVA Tukey pairwise comparisons and boxplots. The left side charts are for the Pine Grove Furnace Study Area while the right side are for the Greenwood Furnace Study Area.

Geomorphology, Preliminary Results and Discussion: ANOVA Tukey pairwise comparison results show that there is no significant difference between shapes and the geomorphic position of RCHs.

Results suggest that colliers created similar shaped platforms for charcoal production regardless of the landscape position and slope, and that over time, RCH shape has not been significantly effected by erosional forces on geomorphic positions.

We generated topographic and SAGA wetness index maps for both study areas. Flow direction maps were used to determine downslope flow direction from existing RCHs. To compare flow difference in an out side RCHs we created similar ellipses downslope from existing RCHs based on existing RCHs. We extracted wetness indices to estimate the effect of RCHs on hydrology.

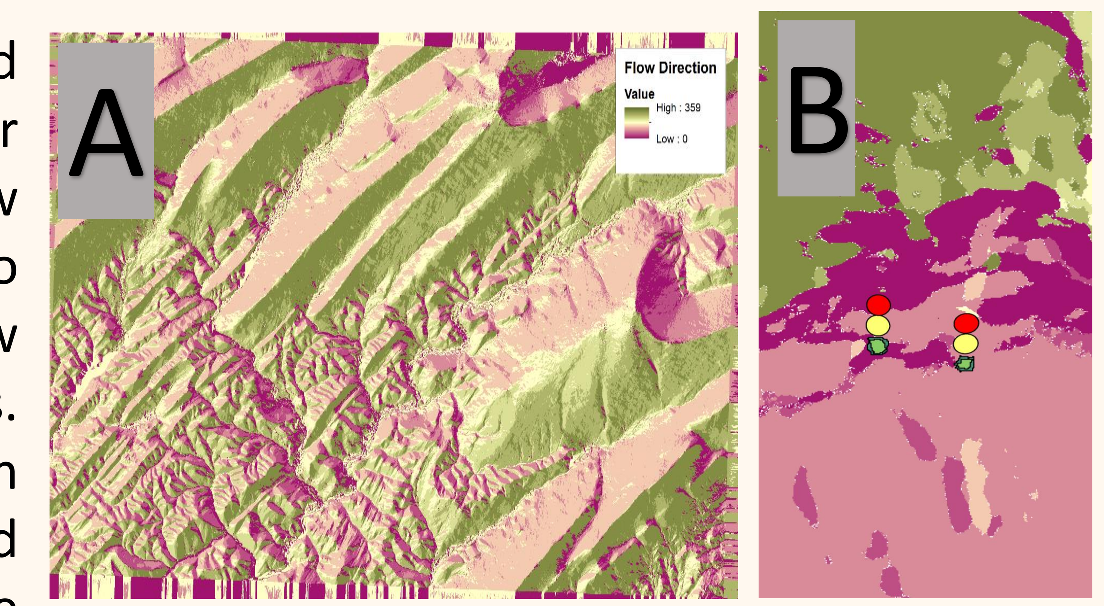

Figure 5: A. Greenwood Furnace Study Area Infinite Flow Direction used to determine downslope ellipse creation. B. Example ellipsoid placement downslope from Existing RCH. Color differences note RCH and modeled hearths.

Hydrology, Preliminary Results and Discussion: Preliminary results indicate that the inner hearth has a higher TWI and SWI value indicating wet conditions. RCH outer rim positions have much lower TWI and SWI values indicating dry conditions.

Preliminary results show that RCHs cause lower TWI and SWI values downslope, which gradually taper with distance.

The cause of this drier downslope hydrology seems to be that flow is being diverted around RCH features. Model results in channels and in low slope areas are less reliable given downslope positions do not exist or have compound slope complexity.

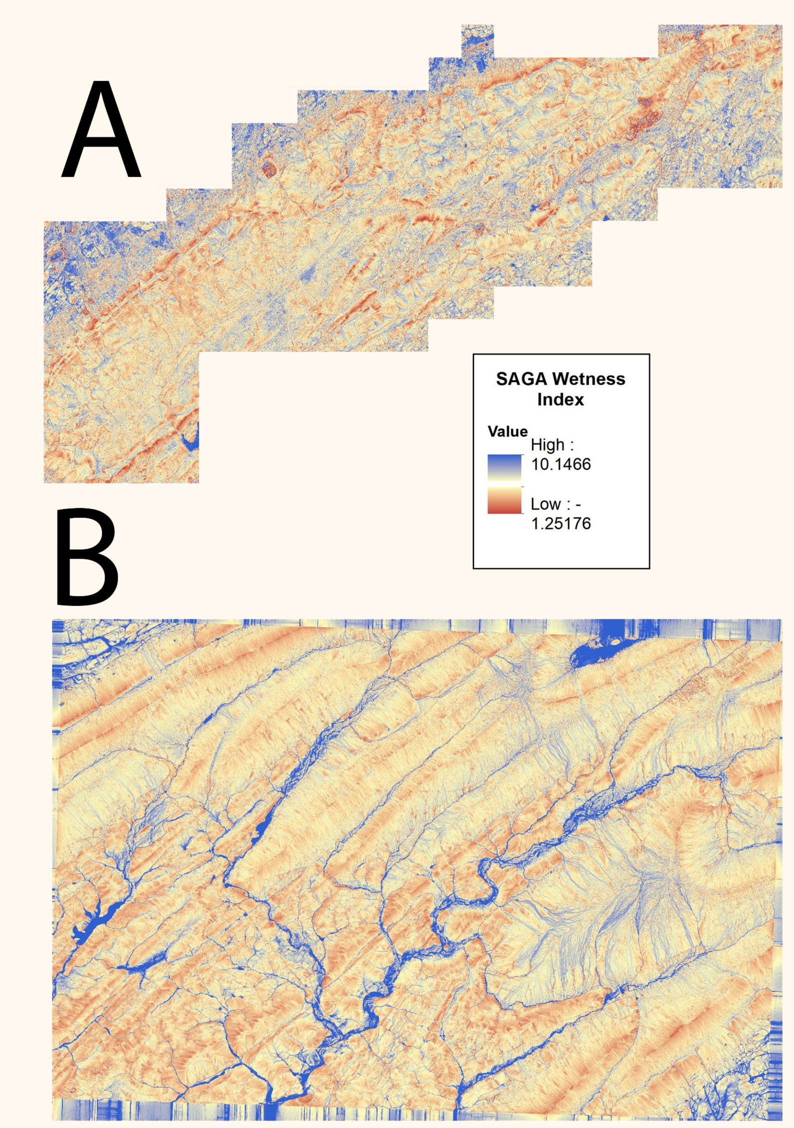

Figure 6: A. SAGA Wetness Index of Pine Grove Furnace State Park and the surrounding Michaux State Forest **B.** SAGA Wetness Index of Greenwood Furnace State Park and the surrounding Rothrock Forest

Conclusions:

1. RCHs are causing significant effects on landscape hydrology.
2. Inner RCH versus outer rim hydrology is different (inner is far wetter)
3. Given the small area and high number of RCHs, the ultimate hydrologic effect could be significant, especially for present vegetation or biogeochemical relationships.