The presence of silty mantles in Northcentral Appalachian, USA soils and their relevance to pedology

Patrick Drohan[1], Thomas Raab[2], and Florian Hirsch[2]

1. The Pennsylvania State University, Ecosys. Sci Mgmt, United States of America (pjd7@psu.edu); [2]. Geopedology and Landscape Development, Brandenburg University of Technology Cottbus-Senftenberg, Cottbus, Brandenburg, Germany

Previous Research: Across the northcentral Appalachians, USA, high silt content soils are found as silty mantles or deep, high silt content pedons. The origin of such soils can be attributed to additions of wind-blown dust deposits (WBD) or local parent materials (i.e. shales or siltstone lithology). Previous research on silt soils originating specifically from WBD attributed to late marine isotope stage (MIS) 2 loess has often been isolated to drainageways receiving outwash from deglaciation.

Figure 1. A. Loess derived silty mantle sitting on MIS2 Susquehanna River terrace. **B.** Deep, residual silt soil (Linden series) derived from siltstone and shale (tape scale in picture, feet). **C.** Deep, local alluvium from post European upload erosion silt soil. Note buried A horizon.

Hypothesis and Approach: We hypothesize that thin (< 25-50 cm) silty mantles and some deep silt soils, occurring farther from outwash systems, are also indicative of post MIS 2 WBD. To test this hypothesis, we took two primary steps:

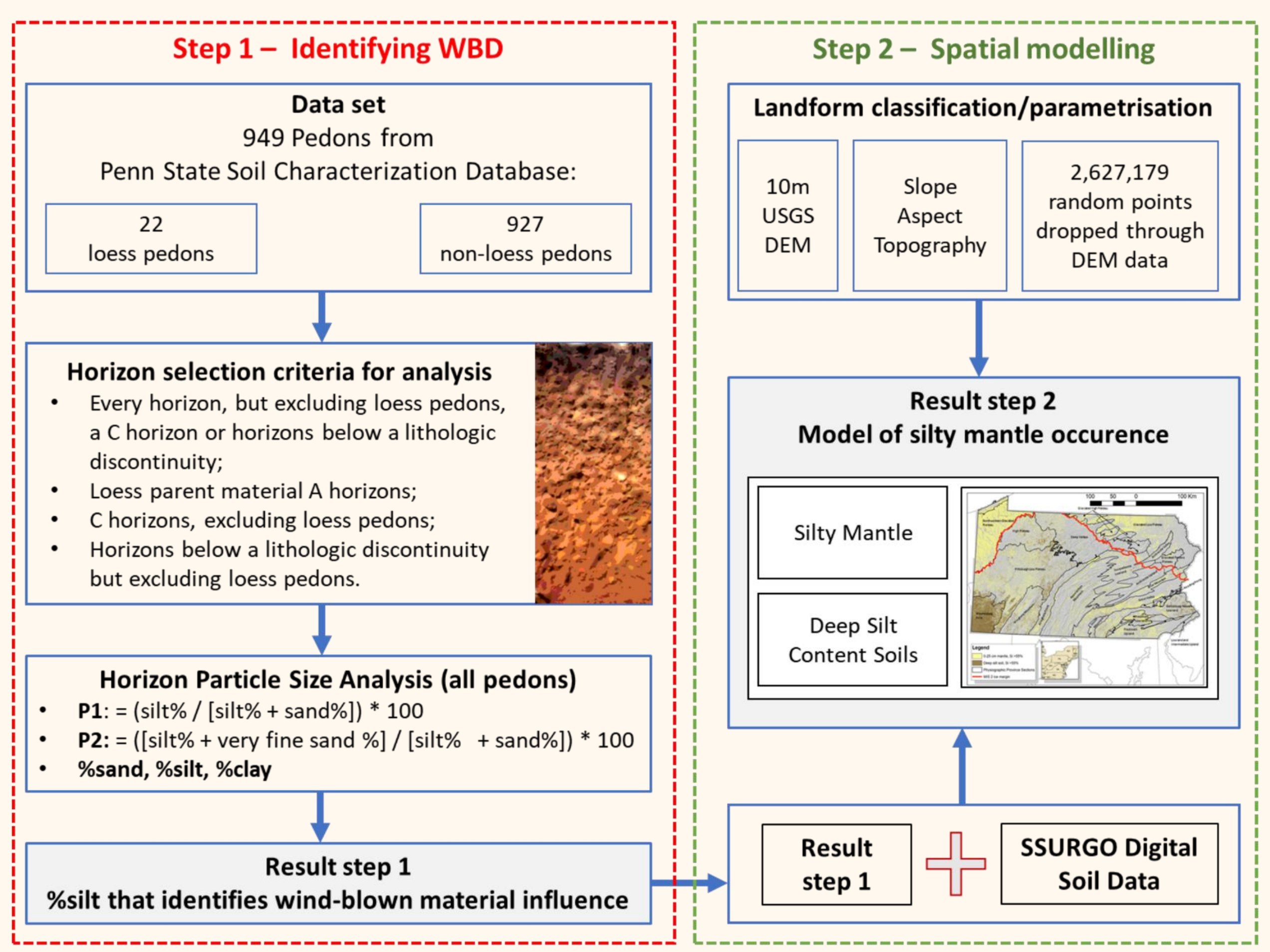

Figure 2. Analysis approach for the PSUSCD WBD signature development and its application with the SSURGO database to model the WBD extent.

The USA Soil Survey Geographic (SSURGO) database (Soil Survey Staff, 2019) was used for all analyses. 22 loess pedons from the study area extent were used to derive % WBD signatures at depth for 949 non-loess pedons (Figure 2).

Study Area Geomorphic Context: The study area (Figures 3A-C) spans 4 physiographic provinces in Pennsylvania, USA. Landscapes have undergone glaciation and periglacial mass wasting and slope evolution (Ballantyne and Harris, 1994). Several area lithologies can result in high sand content soils (Figure 3B) and include sandstones, quartzite, conglomerates, sands. Secondary lithologies include shale, siltstone, limestone or dolostone, gneiss, schist, phyllite (Pennsylvania Bureau of Topographic and Geologic Survey, 2001).

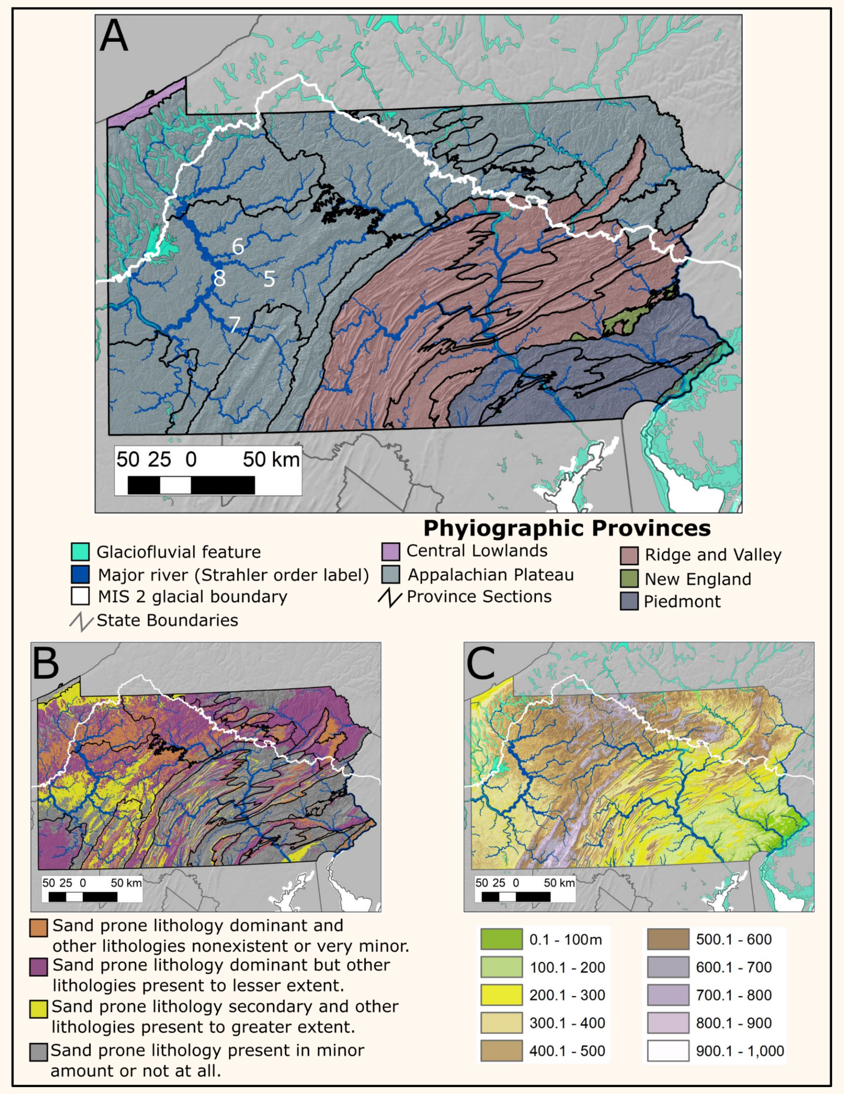

Figure 3. Study Area Geomorphic Context A. Study area Physiographic Provinces and sections within, MIS 2 glacial boundary, glaciofluvial features, Strahler major streams 5-8, and USA states. B. Lithologic influence on sand content dominance in soils. C. Elevation across the study area.

Step 1: A Kruskal Wallace test (Dunn's test) was used to test for significant differences in Step 1 signatures. SSURGO was used to apply results from Step 1 to identify (a) *silty mantles* (0 – 25 cm silt content > 55%) over a 100 - 150 cm depth with <55% silt; and (b) *deep silt soils* (0 - 150 cm depth silt content > 55%).

Step 1, Results and Discussion: Kruskal Wallace tests of the %Total Silt and particle size parameters (P1 & P2) indicate statistically significant differences between several horizon groups and identify a WBD influence with depth (e.g. Figure 4).

Similarities in the %Total Silt and parameters (P1 & P2) for the first three horizon groups, in comparison to the loess A horizon group, suggests the mean depth of WBD influence extends to ~50 cm.

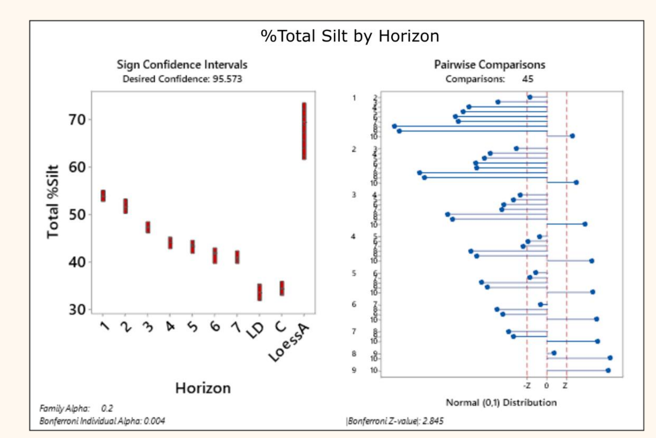

Figure 4, Step 1 Results: Example P1 Kruskal Wallace pairwise comparisons. In right side charts, 8 refers to the LD (lithologic discontinuity), 9 the C horizon, and 10 the Loess A horizons.

Step 2: Using Step 1 results, we applied results from our PSUSCD database analysis to identify (a) silty mantles (0 – 25 cm silt content > 55%) over a 100 - 150 cm depth with <55% silt; and (b) deep silt soils (0 - 150 cm depth silt content > 55%)(Figure 5).

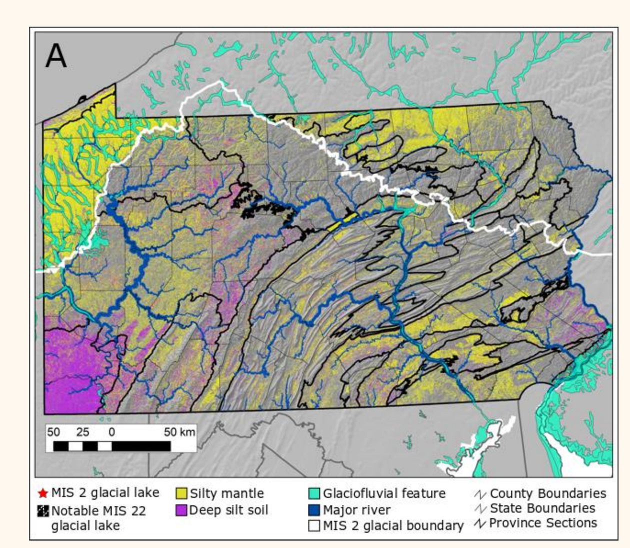

Figure 5, Step 2 Results: The modeled extent of a silty mantle and deep silt profile.

Step 2: Using Step 1 results, we generated from SSURGO a mapped extent for >55% Total silt content at 0 – 25 cm (but not over a silt producing lithology (Figure 3)) and examined trends with topography (Figure 6) and aspect (Figure 7).

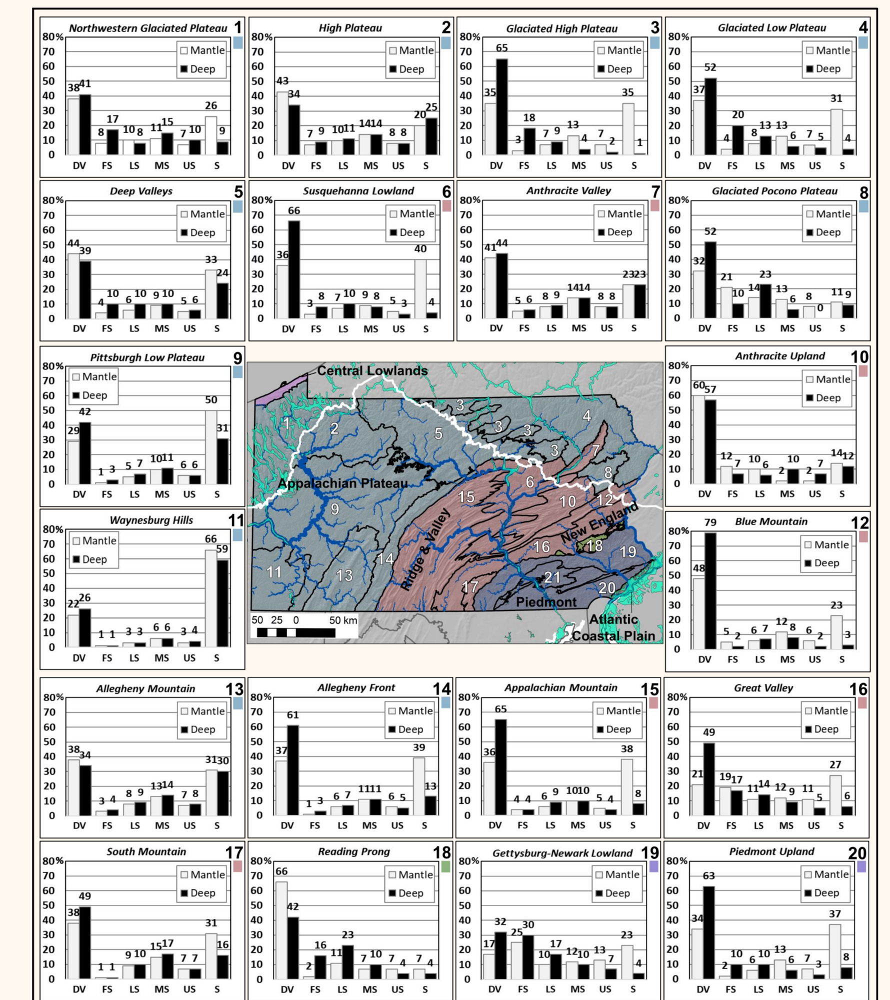

Figure 6. Silty mantle and deep silt profile distribution by topographic position across Physiographic Province Sections. DV = Depression or Valleys; FS = Footslope; LS = Lower Slope; MS = Mid-Slope; US = Upper Slope; S = Summit. Number in upper right of each figure pertains to the numbered section on the map. Colored rectangles in each figure pertain to the color of the Physiographic Province on the map. Numbers above bars are percents.

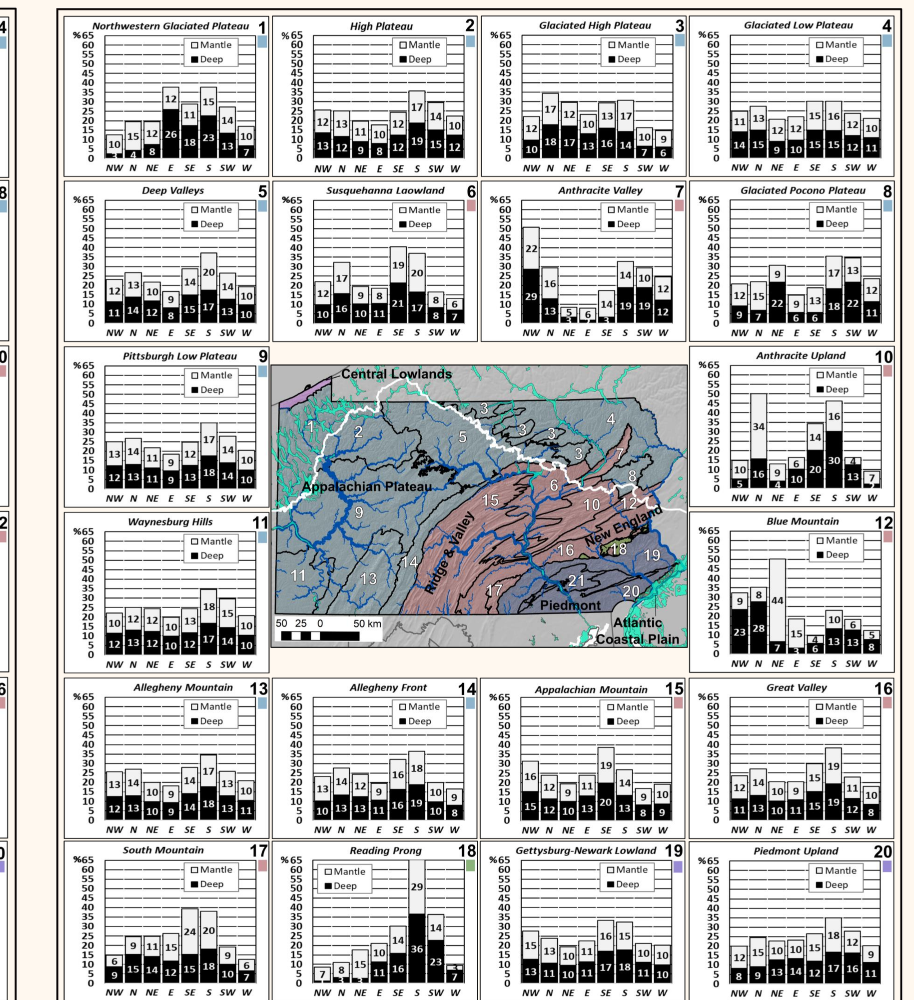

Figure 7. Silty mantle and deep silt profile distribution by geomorphic aspect across Physiographic Province Sections. NW = northwest; N = north; NE = northeast; E = east; SE = southeast; S = south; SW = southwest; W = west. Number in upper right of each figure pertains to the numbered section on the map. Colored rectangles in each figure pertain to the color of the Physiographic Province on the map. Numbers in bars are percents.

Step 2: Per Step 1 results, we used SSURGO to the extent of >55% Total silt content at two depths (0 – 25 cm and 25 to 50 cm) and did not restrict the extent by subsurface particle size or lithology (Figure 8). We also mapped glaciofluvial materials (outwash, glacial lakes, etc.) that could be a WBD source.

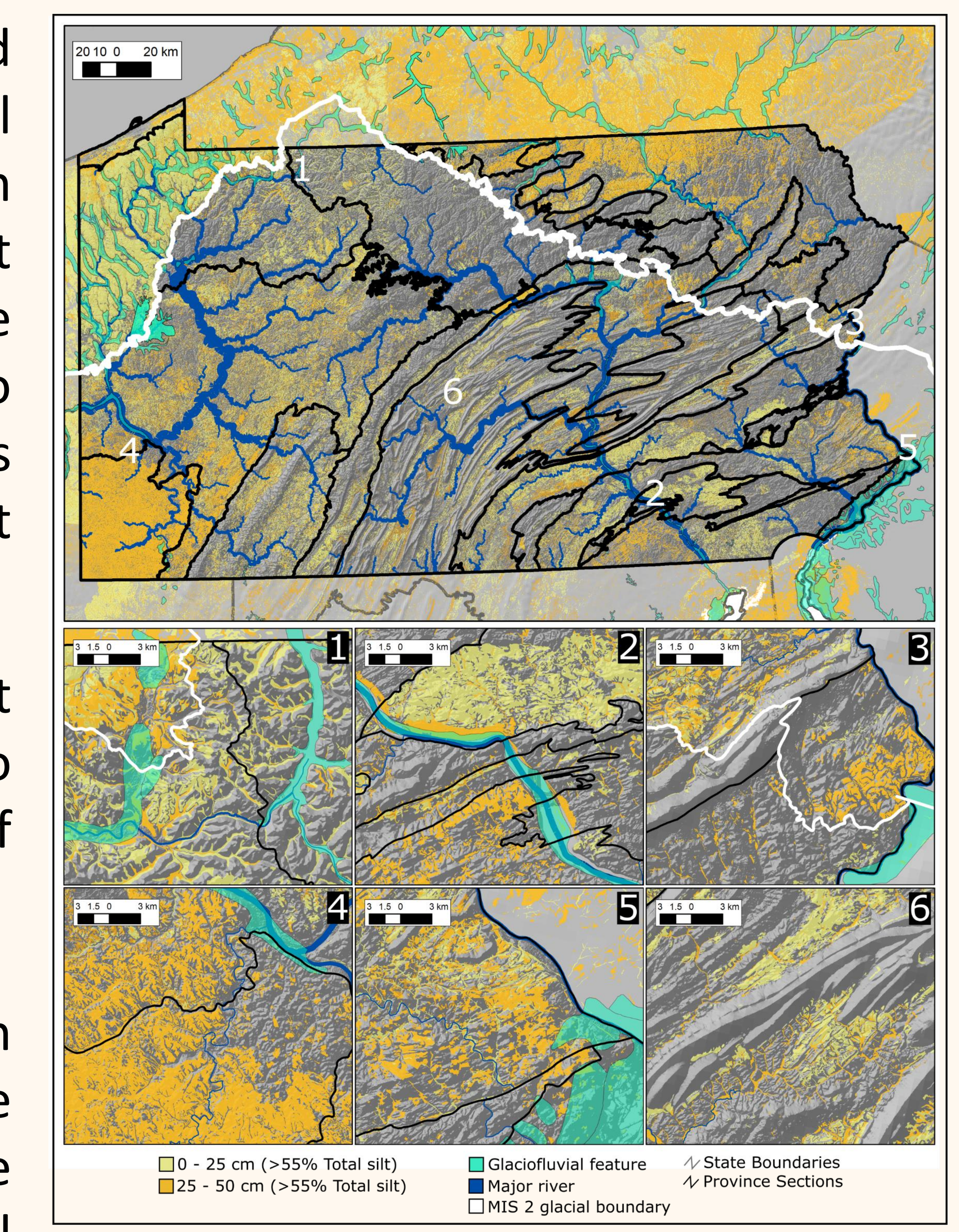

Figure 8, Step 2 Results: Silty mantle (0 – 25 cm and 25 to 50 cm) distribution across study area irrespective of lithology type. Numbers on upper map pertain to smaller maps below.

Conclusions: Aspect dependent deposition of silty mantles is tied to glaciofluvial material sources of WBD deposits.

Proximity to topography, which can act as a trap for WBD, appears to be a key variable explaining silty mantle and deep, high-silt content soil occurrence. Silty mantle deposits correspond strongly to regional studies of loess.