Geospatial Analysis Using SSURGO and LiDAR to Map, and Develop Chronosequences for Morphostratigraphic Units in Southeastern Maryland, U.S.A.

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Abstract

Recent studies have identified extensive eolian deposits in southeastern Maryland where previously such deposits were considered of limited extent. Geospatial analysis using 2-m LiDAR and SSURGO map-unit data allows identification of these deposits and demonstrates the close association between soil series and complexes and these late-Pleistocene morphostratigraphic units. The most striking examples include the association of the Galestown loamy sand with river-bordering dunes on the east bank of the Potomac (fig. 1) and Patuxent rivers; and the Annapolis loamy sand and fine sandy loam and the Donlonton fine sandy loam with bay- and river- bordering dunes in the Annapolis (Mayo) (fig. 2) and southern Baltimore (fig. 3) areas. Ongoing field mapping and sampling for age analysis, combined with geospatial/geomorphic analysis, will allow for development of soil chronosequences and a regional pedo/geochronostratigraphy.

Introduction

Southeastern Maryland is in the upper Coastal Plain physiographic province of the United States with elevations between 0–122 m (0–400 ft), MATs from 11–14 °C (52–57 °F), and MAPs from 1016–1270 mm (40–50 in). Although previous geologic and pedologic studies had identified small areas of eolian deposits in this region (Hack, 1957), landscapes with extensive dunal forms had not been recognized.

Recently, using 2-meter LiDAR, Markewich et al. (2009) identified extensive inactive eolian parabolic dunes along the Potomac and Patuxent Rivers and both erosional and constructional eolian landforms in the upland interstream divide between the two rivers. The origin of these features was attributed to regional NW-WNW winds during the late Pleistocene. Using optically stimulated luminescence (OSL) and radiocarbon analyses they found that the eolian deposits formed from 33–16 ka during the last major glaciation. Pollen data supported the interpretation for dune formation during a cold climate.

As LiDAR elevation data (Calvert County GIS, 2003; Maryland Department of Natural Resources, 2004, LiDAR 2004 Maryland) and SSURGO soil maps have become available (U.S. Department of Agriculture, 2009), the association with these eolian deposits and specific soil series and(or) complexes have become apparent. This poster presents the spatial data showing these associations, particle-size data for pedons (figs. 1–3) within the region (Anne Arundel, Calvert, Charles, St. Marys counties) and a slope map for these same counties (fig. 4) showing the correspondence of low slopes with the areas of eolian deposits and associated soils as shown in figures 1–3.

Data Considerations

One considerable advantage to using LiDAR-based metrics in landform analysis is the opportunity to consistently sample all SSURGO polygons in a geographic area and thus provide a ground-based measure of variability in soil geomorphic properties. In addition to providing the spatial resolution required to identify previously undetermined landforms, LiDAR data can provide a statistical context for the evaluation of SSURGO map-unit attributes that are currently constrained by the use of expert knowledge to "fill-in-the-gaps" around limited field measurements. An example of this application is the LiDAR-derived slope map (fig. 4) that presents the taxonomic slope rather than the positional slope for the selected counties. This view of slope is consistent with SSURGO map-unit attribution, as the slope values displayed are aggregated to the collective set of polygons for each individual map unit. If the aggregation was done to individual polygons, the derived statistics could provide a benchmark for the associated SSURGO attribute data.

Results and Discussion

1. In southeastern Maryland, west of Chesapeake Bay and south of Baltimore, in areas where development has only minimally to moderately modified the original landscape, 2-meter LiDAR elevation data can be used to identify parabolic dunes adjacent to drowned river valleys that are now freshwater estuaries (Markewich et al., 2009).

2. In this area, there is a direct correspondence of some loamy-sand and sandy-loam soils to these constructional eolian landforms, and where close to Chesapeake Bay, the soils commonly are glauconitic.

3. Probably the most striking association is the correspondence of the Galestown and Hammonton loamy sands, and the Galestown-Hammonton complex, with dunes adjacent on the east to the Potomac River in Charles County south of Washington, D.C. (fig. 1) and to the Patuxent River in Anne Arundel County (LiDAR and soils not shown but area outlined by dashed line on the slope map, fig. 4).

4. Eolian deposits are not included as parent material in the Official Series Description (OSD) for either the Galestown (siliceous, mesic Psammentic Hapludults developed in sandy marine deposits) or the Hammonton (coarse-loamy, siliceous, semiactive, mesic Aquic Hapludults developed in loamy fluviomarine sediments).

5. Neither do the OSDs recognize eolian deposits as parent material for the Annapolis (fine-loamy, glauconitic, mesic Typic Hapludults), Donlonton (fine-loamy, glauconitic, mesic Aquic Hapludults), or Downer (coarse-loamy, siliceous, semiactive, mesic Typic Hapludults) soils, which in Anne Arundel County have developed in morphologically distinct (dunal) eolian sand (fig. 2, near Mayo, MD, south of Annapolis).

6. In contrast, although the authors could not find mention in the geologic literature of eolian deposits in northern Anne Arundel County, the Patapsco (loamy, siliceous, subactive, mesic Grossarenic Paleudults), Evesboro (mesic, coated, lamellic, Quartzipsamments), and Fort Mott (loam, siliceous, semiactive, mesic Arenic Hapludults) soils are described in their OSDs as having developed in "sandy marine and eolian deposits" or "sandy eolian over fluviomarine or marine deposits (fig. 3).

7. The disparity between the LiDAR imagery and the available soil and geologic maps suggest that a collaborative effort between soil scientists and geologists is needed to update the surficial geologic mapping and soil/parent-material associations of this region.

8. Continued soil and geologic mapping along with detailed spatial analysis and dating of the region's eolian deposits would increase our understanding of weathering and soil-forming processes during periods of dramatic climate change and allow for development of regional soil chronosequence data.

Such an effort would be timely since this is a densely populated, rapidly expanding urban to suburban area that already is being affected by rapid coastline changes resulting from accelerated erosion and sea-level rise.

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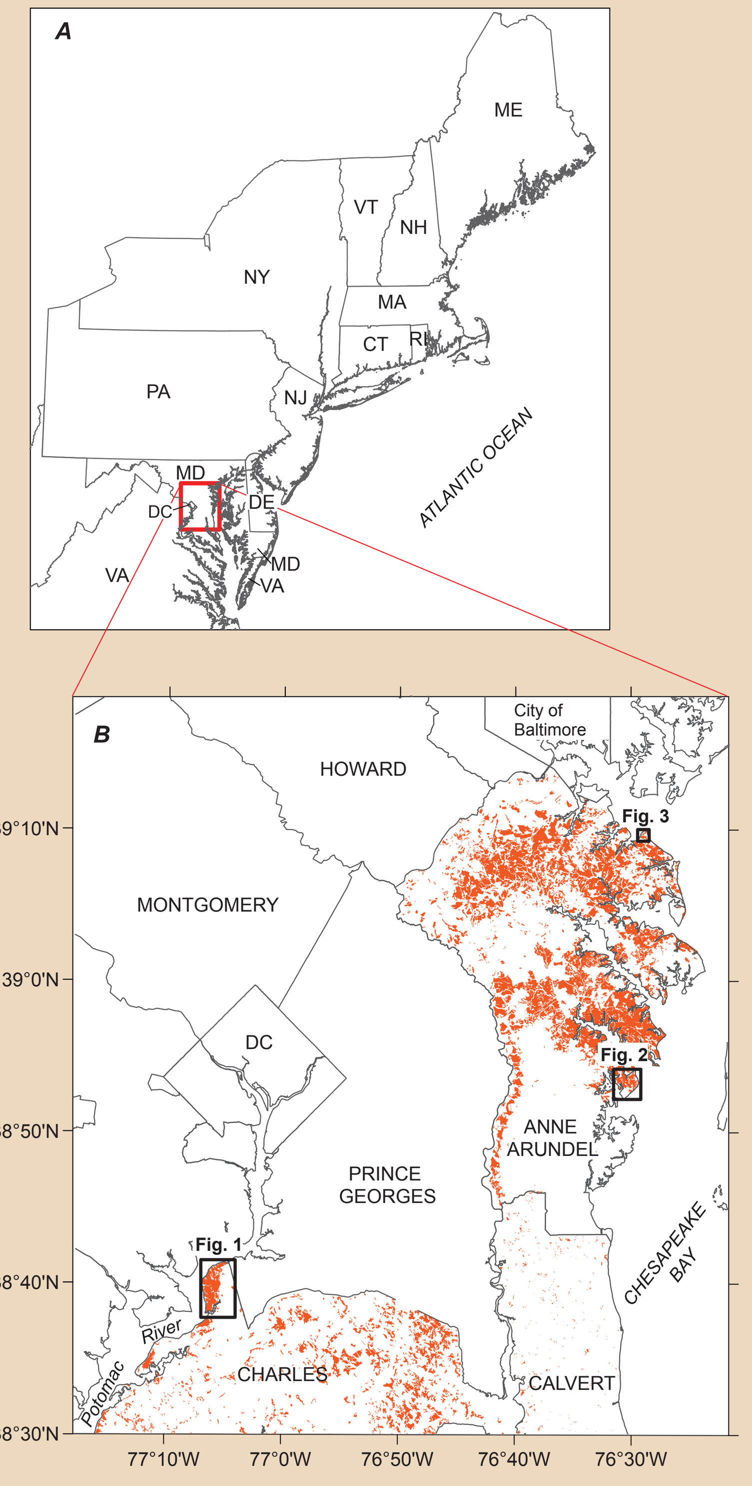
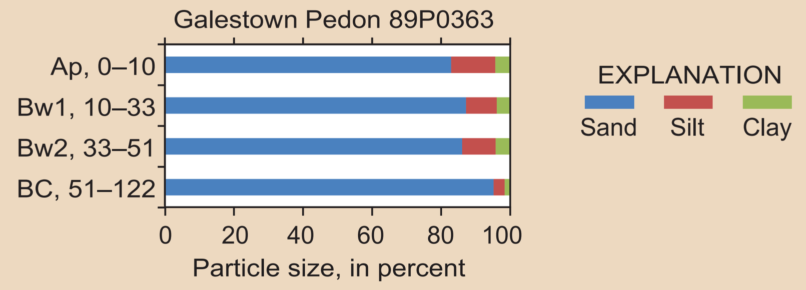


Index Map. Location of: *(A)* study area in the northeastern United States and *(B)* study sites for eolian soils/deposits (shown in orange) in Charles, Anne Arundel, and Calvert Counties, Maryland. Enlargements of these areas are shown in figures 1–3.

GALESTOWN SERIES
Pedon ID: 88MD033007 **Lab Pedon #:** 89P0363
Soil Name as Described/Sampled: Galestown
Location: 39°01'38.00"N, 76°49'22.00"W, Ann Arundel County, MD
Taxonomy: Siliceous, mesic Psammentic Hapludults
Type Location: 38°37'02.00"N, 75°49'42.00"W, Dorchester County, MD
Parent Material (from OSD): Sandy marine sediments and glacial outwash on glacial terminal moraine



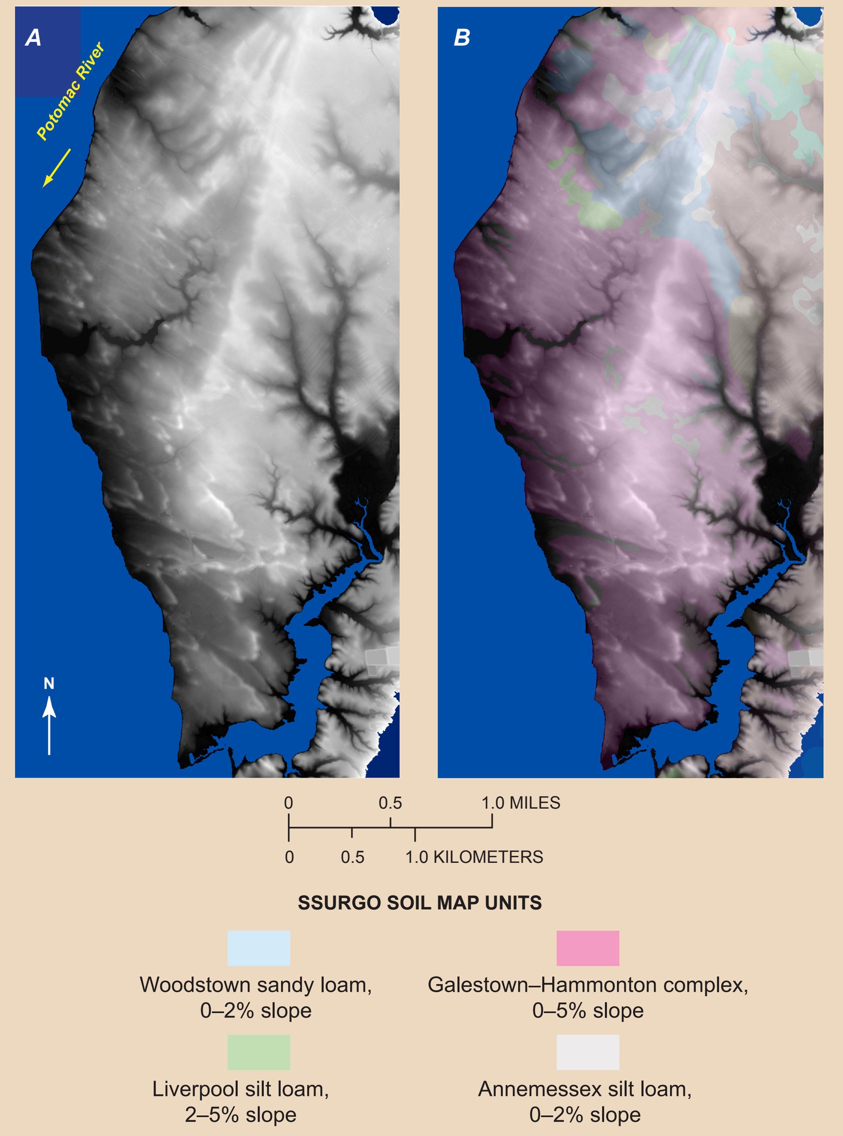
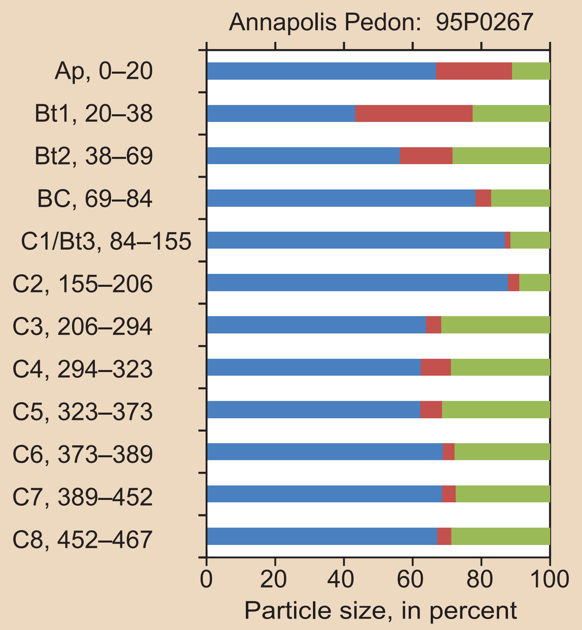
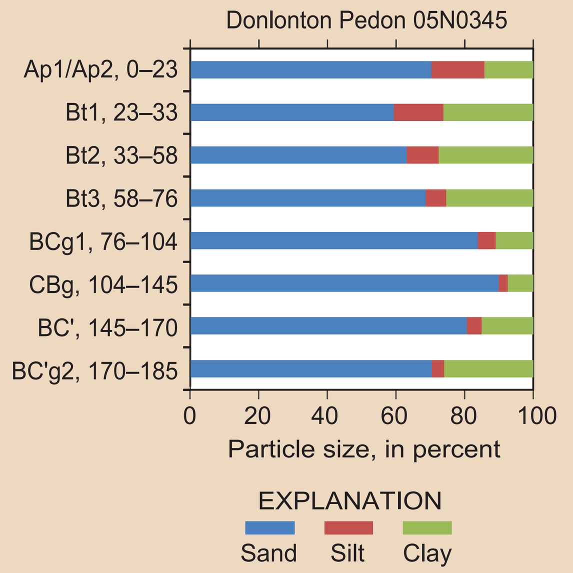


Figure 1. Piscataway Park area, Charles County, Maryland: *(A)* 2-meter LiDAR of late Pleistocene eolian dunes and fluvio-estuarine deposits; *(B)* associated SSURGO map units.

ANNAPOLIS SERIES
Pedon ID: 94MD003017 **Lab Pedon #:** 95P0267
Soil Name as Described/Sampled: Monmouth
Location: 38°58'40.00"N, 76°37'42.00"W
Taxonomy: Fine-loamy, glauconitic, mesic Typic Hapludult
Type Location: 38˚58'42.56" N, 76˚38'11.86" W,
Parent Material (from OSD): Loamy glauconitic fluviomarine deposits



DONLONTON SERIES
Pedon ID: S04MD-033-044 **Lab Pedon #:** 05N0345
Soil Name as Described/Sampled: Donlonton
Location: 38°51'41.30" N, 76°49'20.10" W
Taxonomy: Fine-loamy, glauconitic, mesic Aquic Hapludult
Type Location: Tobacco Exp. Sta., UMD, Prince Georges County, MD
Parent Material (from OSD): Loamy glauconitic fluviomarine deposits



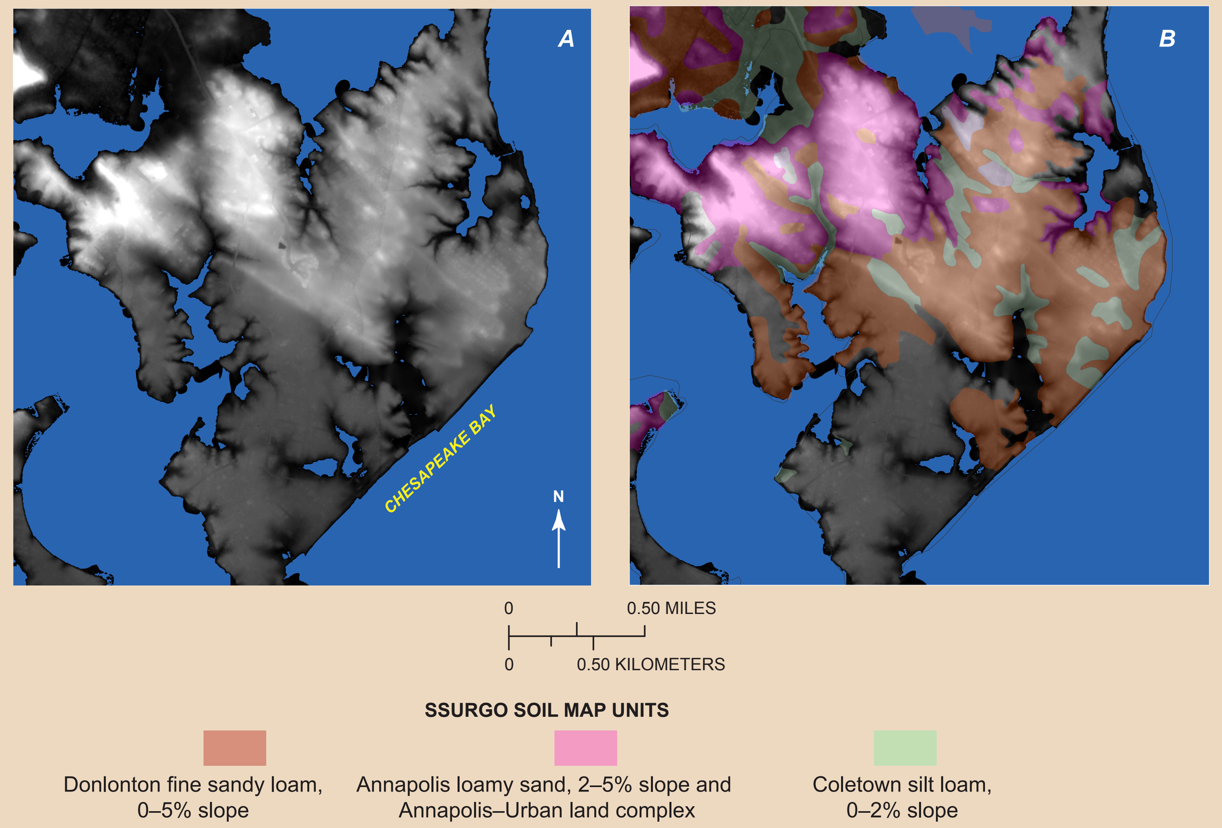
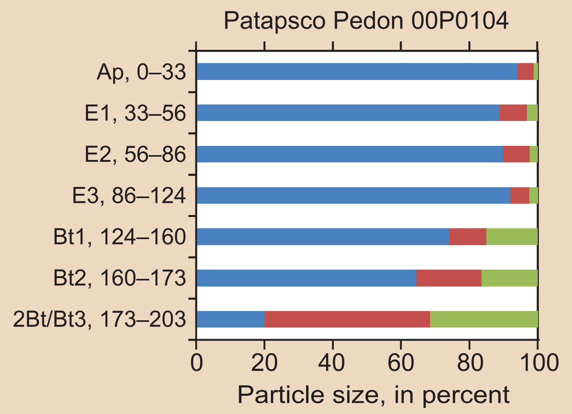
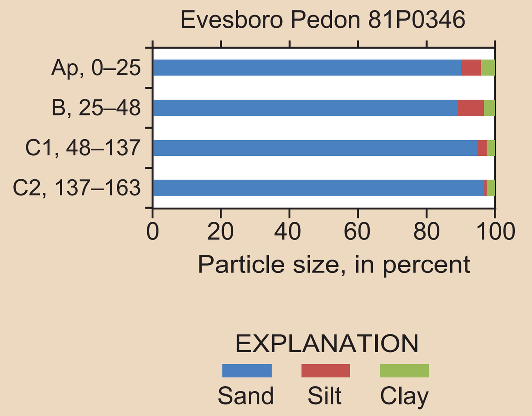


Figure 2. Mayo area (south of Annapolis), Anne Arundel County, Maryland: *(A)* 2-meter LiDAR of late Pleistocene eolian dunes; *(B)* associated SSURGO map units.

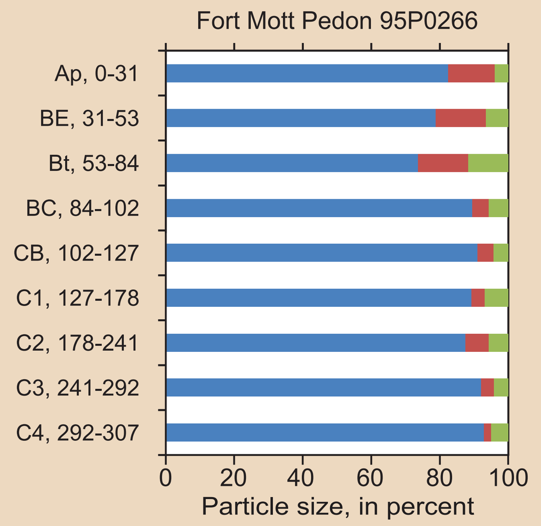
PATAPSCO SERIES
Pedon ID: S99MD-003-008 **Lab Pedon #:**00P0104
Soil Name as Described/Sampled: Patapsco
Location: 39°08'27.00" N, 76°40'55.00" W
Taxonomy: Loamy, siliceous, subactive, mesic Grossarenic Paleudult
Type Location: 39°10'40.41" N, 76°34'15.92" W, Anne Arundel County, MD
Parent Material (from OSD): Sandy eolian deposits over fluviomarine deposits



EVESBORO SERIES
Pedon ID: 74MD033001 **Lab Pedon #:**81P0346
Soil Name as Described/Sampled: Evesboro
Location: on Soil Conservation Rd, 2nd gate past end of NASA; about 38°59'53" N, 76°50'07" W
Taxonomy: Mesic, coated Typic Quartzipsamment **(sampled as)**; Mesic, coated Lamellic Quartzipsamments **(from OSD)**
Type Location: 39°24'37.40" N, 75°04'30.70" W, Cumberland County, NJ
Parent Material (from OSD): Sandy eolian and marine deposits



FORT MOTT SERIES
Pedon ID: 94MD003016 **Lab Pedon #:**95P0266
Soil Name as Described/Sampled: Evesboro
Location: 38°51'41" N, 76°41'44" W
Taxonomy: Loamy, Siliceous, semiactive mesic Arenic Hapludults **(from OSD)**
Type Location: 39°37'34" N, 75°31'56" W, Salem County, NJ
Parent Material (from OSD): Sandy eolian deposits and/or fluviomarine deposits



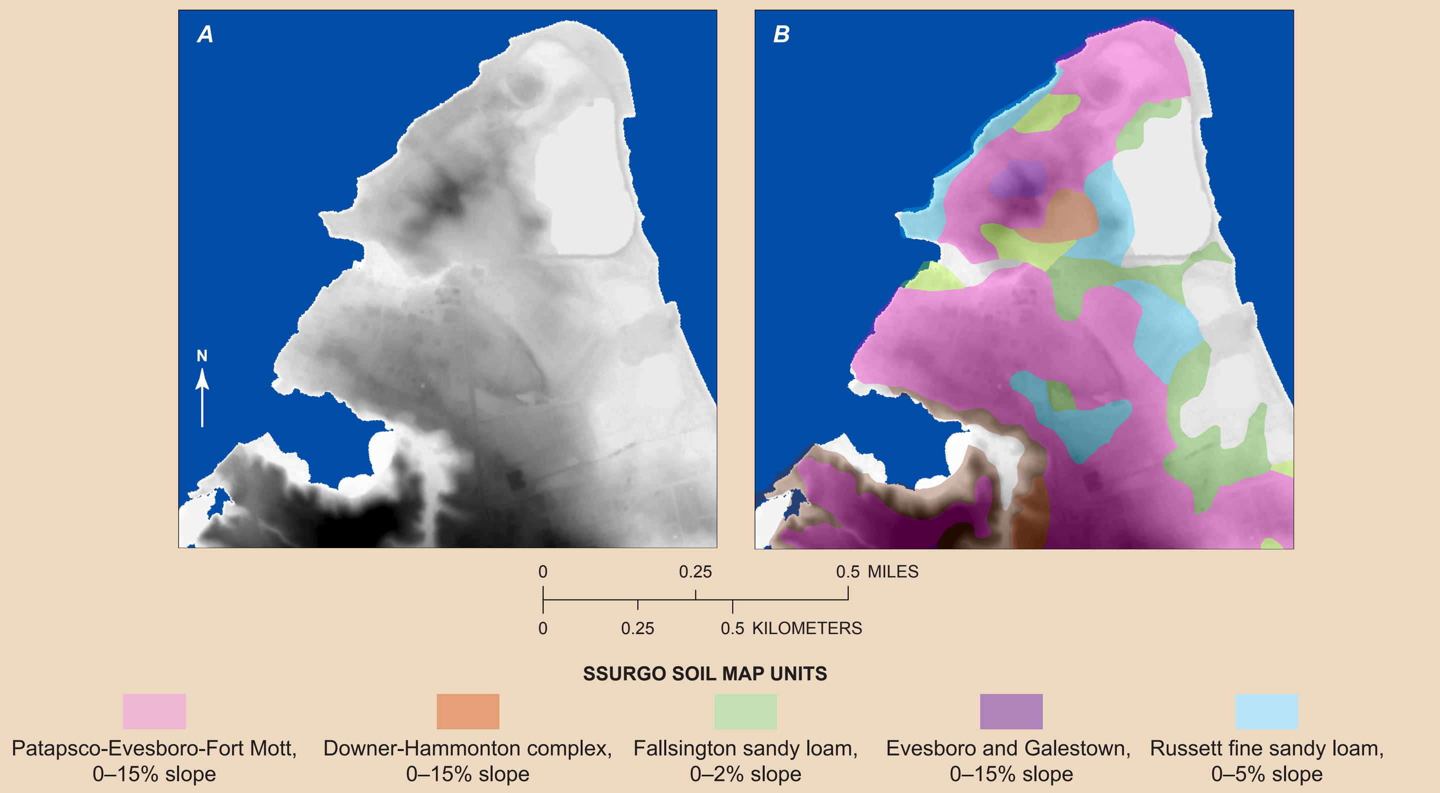


Figure 3. Fort Smallwood Regional Park, northern Anne Arundel County, Maryland: *(A)* 2-meter LiDAR of late Pleistocene eolian dunes; *(B)* associated SSURGO map units.

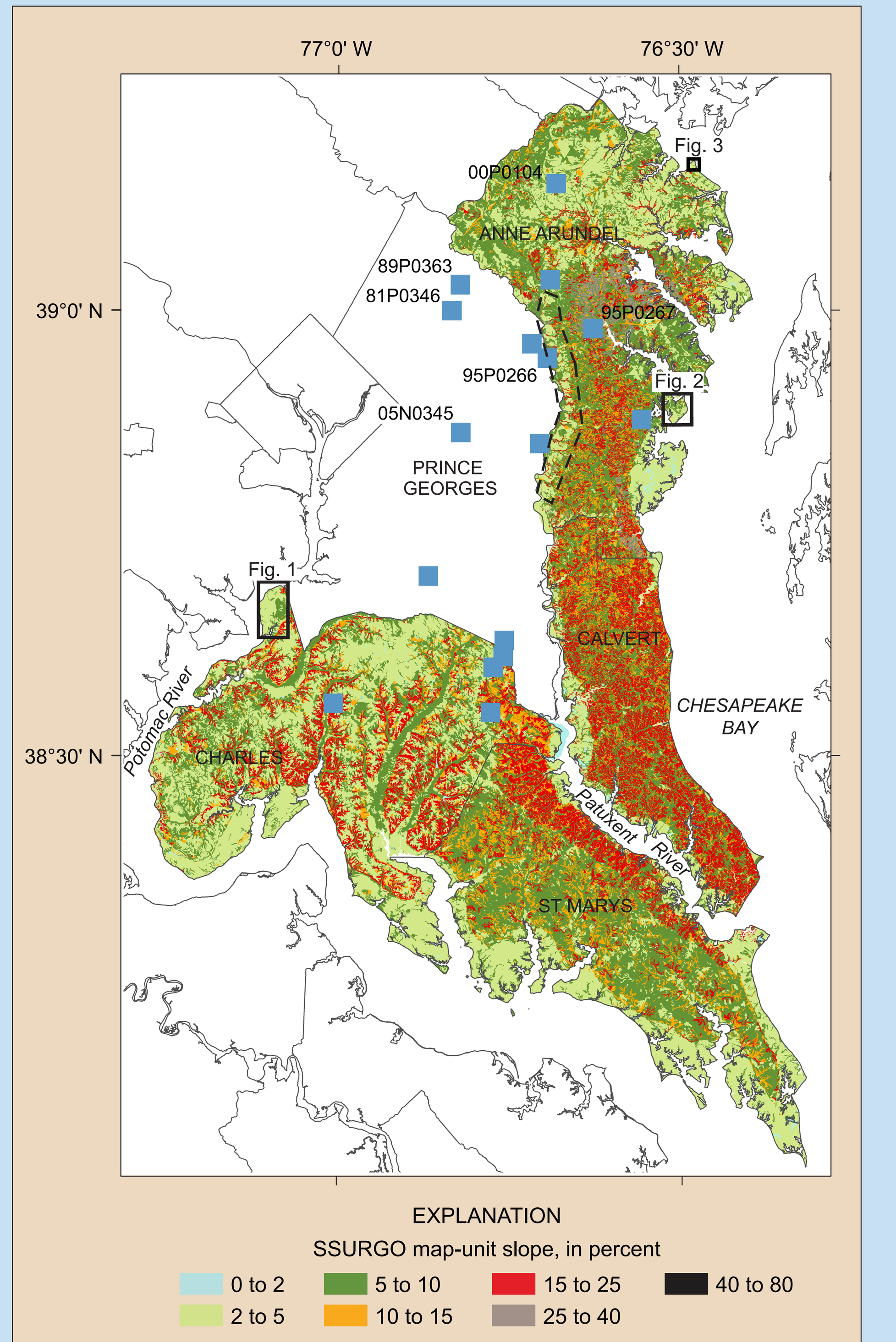


Figure 4. Slope map for Anne Arundel, Calvert, and Charles Counties, MD. Slope values are the mean values of 2-m LiDAR-derived slope for all SSURGO polygons in each SSURGO map unit. Locations of pedons with NSSC soil characterization data are shown by blue squares; data for those pedons labeled with the NSSL lab pedon ID are included in figures 1–3.