A LEGACY OF INTENSIVE AGRICULTURE:
THE TIMING AND CAUSE OF GULLY FORMATION IN THE NORTH CAROLINA PIEDMONT

Spell, Rosalind L*, Johnson, Bradley G.
Environmental Studies, Davidson College, * rospell@davidson.edu,

Background

- Gullies are geomorphological features shaped by running water. They are common in the Piedmont region of North Carolina, and can be ecologically and economically disruptive[1,2].

- Gullies develop in 3 main stages: channel erosion, headward cutting and enlargement, and stabilization[1,3].

- Land that has been disturbed by construction or agriculture is vulnerable to gullying and is often abandoned once gullied[1,2,4].

- Alluvial fans and gully fill act as sedimentary records of erosion events.

- Alluvial sediments sometimes contain charcoal which can be carbon dated to give a limiting age on the gully[5].

- We hypothesize that gully formation in the Davidson area is the result of agricultural practices in the nineteenth and twentieth centuries.

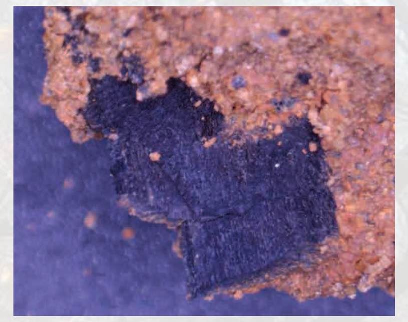
Methods

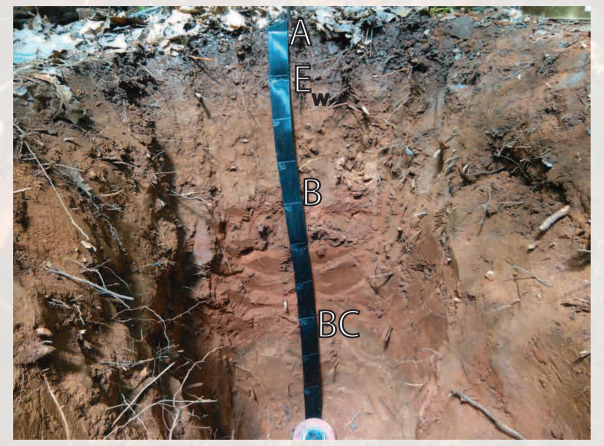
- Identified gully locations using geospatial data[6].

- Ground truthed and photographed gullies and associated alluvial fans.

- Selected subsample of 15 gullies with best alluvial deposition.

- Dug soil pits on depositional surfaces, described soils using Birkeland (1999), and collected samples of horizons and any charcoal for lab analysis. A control pit was dug on the relict upland surface.





- Charcoal samples were sent to DirectAMS[7] for analysis and calibrated using Calib 7.1.

- Pits with radiocarbon dates were analyzed for particle size and carbon content.

- ^{210}Pb and ^{137}Cs sediment dating of alluvial deposits (in progress)[8].

Results

- 63 of 68 gullies in the Davidson area appear to be stabilized, with vegetation on the alluvial fans and gully walls.

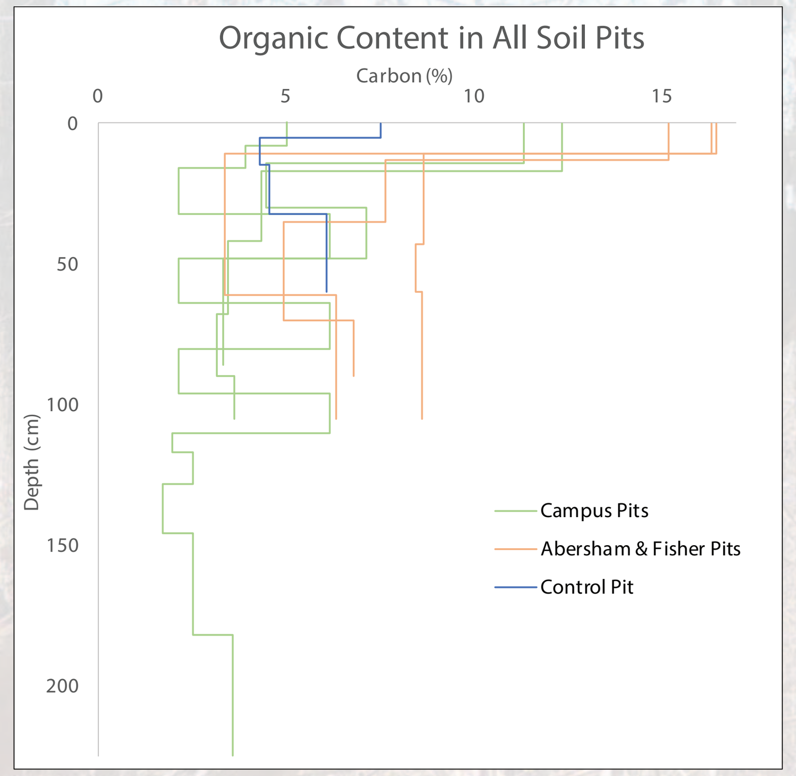
- All gullies were under forest cover.

- Most gullies are bulbous or dendritic in shape, with rounded heads and sloping sides.

- Many gullies showed evidence of direct human interaction:
  - 10 gullies contained trash within the sediments or on the soil surface
  - 15 gullies were affected by power line or natural gas easements
  - Several were crossed by foot or mountain biking trails.

- Some gully heads which intruded into power line easements were planted with kudzu as an erosion control measure.

Organic Carbon



- The control pit topsoil is less organic-rich than the topsoil in alluvial fan and gully fill pits (avg. 48% less organic-rich).

- Alluvial pits do not show a trend for organics in the subsoil.

Discussion

- Date ranges from radiocarbon analysis overlap and match dates of Euro-American settlements in Mecklenburg County, and are older than our original hypothesis.
  - Centre Presbyterian Church — 1765
  - Philadelphia Presbyterian Church — circa 1770

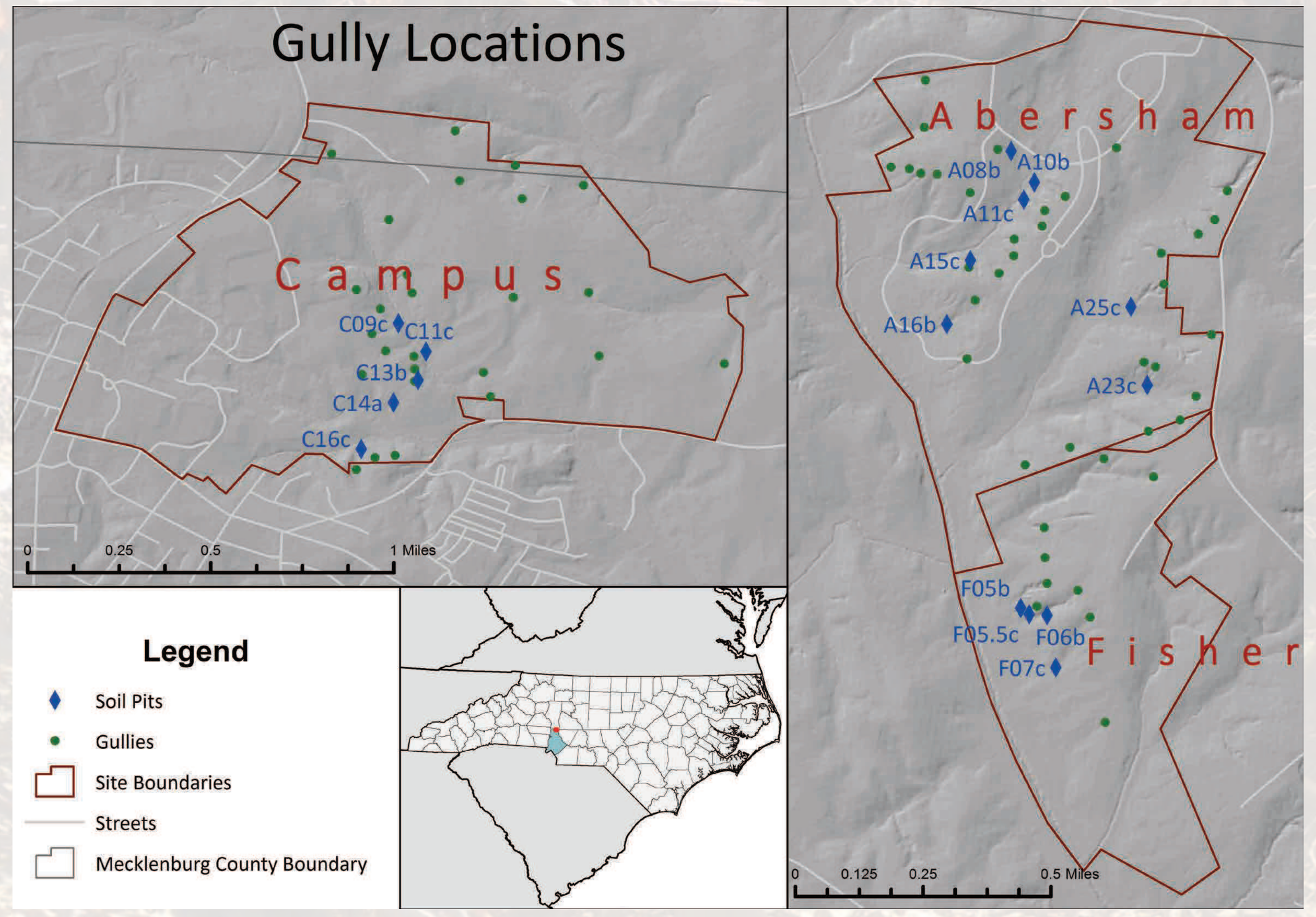
- Most gullies had alluvial fill, meaning that they were originally eroded to a lower level and sediment has partially refilled the gully as the system stabilized.

- Horizonation in gully soils suggest that erosion and deposition happened long enough ago to allow time for soil development, meaning that the gullies have not been disturbed or re-eroded in >100 years.

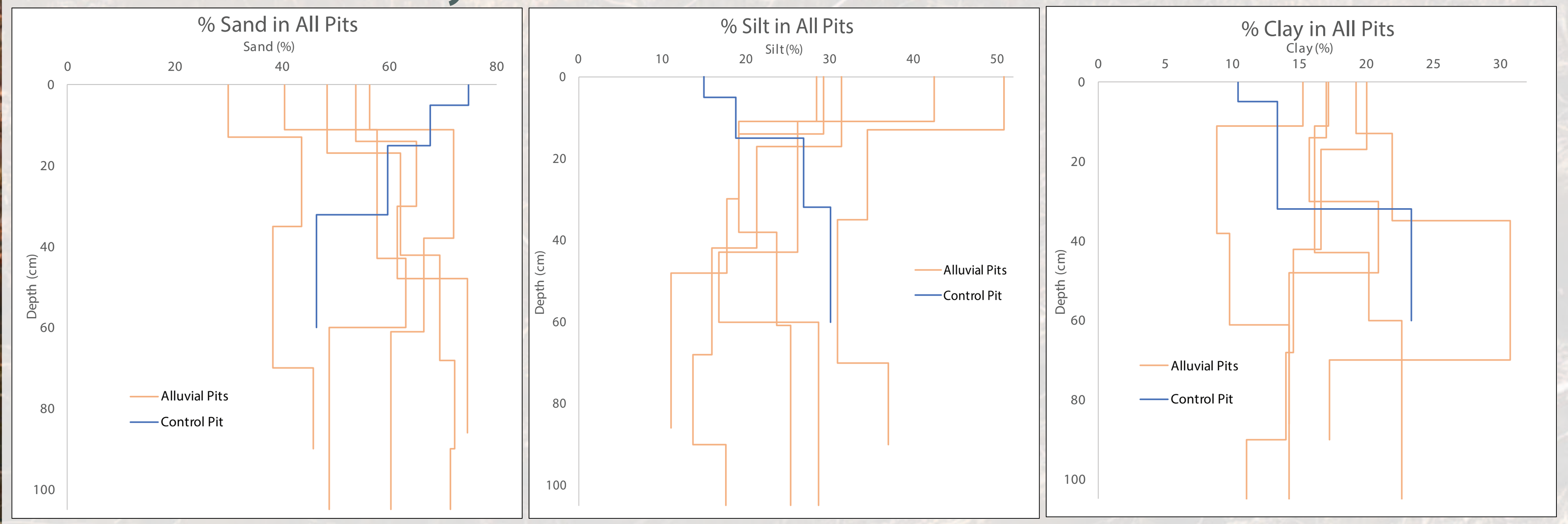
- Some gullies near houses had clear evidence of human presence (trash) up to 40 centimeters deep in the soil profile.

Study Site

3 study sites were chosen for their gullied landscape and accessibility: Abersham Park and Fisher Farm on Shearer Rd, and the Davidson College Ecological Preserve (DCEP). The sites contain more than 70 gullies at varying stages of erosion and stabilization.



Particle Size Analysis



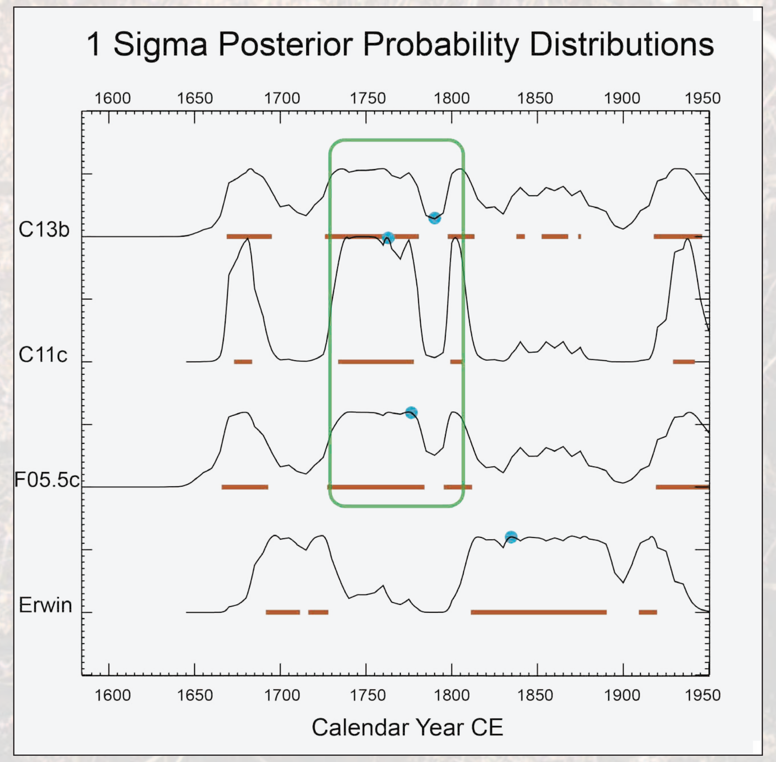
- The upland soils, including our control pit, typically decrease in sand % with depth, but our alluvial pits trend more sandy with depth.

- For the control, silt % increases with depth. The alluvial pits have siltier topsoils, but silt % tends to decrease with depth.

- The control soil's clay % increases with depth. The alluvial pits show no clear trend.

Radiocarbon

Gully ID (depth)	Calendar AD Date Range	Relative Area Under the Probability Distribution	Mean Calibrated Calendar Age (AD years)
Erwin Lodge 4-23.4 (65 cm)	1692-1712	0.167	1835
	1716-1728	0.101	
	1811-1890	0.649	
	1909-1920	0.083	
RS-F05.5c (40 cm)	1666-1693	0.201	1777
	1727-1784	0.455	
	1795-1812	0.117	
	1919-1950	0.225	
RS-C11c (125 cm)	1673-1684	0.140	1763
	1734-1778	0.600	
	1799-1806	0.094	
	1929-1942	0.166	
RS-C13b (45 cm)	1669-1695	0.181	1790
	1726-1781	0.394	
	1798-1813	0.110	
	1838-1843	0.026	
	1852-1868	0.081	
	1874-1875	0.010	
	1918-1946	0.198	



1 sigma (~68.3%) probability distribution of calendar age for charcoal samples. Intervals from the table (brown lines), mean calibrated date (blue circles), and area of greatest overlap (green box) are shown.

- Largest areas of probable charcoal development are mostly in the 1700s, with approximately 75% of age probability distributions in 1666-1813. This is a limiting date—charcoal could not formed (40+ cm deep) after deposition. Mean calibrated dates are tightly clustered in the late 1700s.

- Although Erwin Lodge 4-23.4 does not overlap, its largest continuous time interval is after European settlement and within the period of greatest migration to the Davidson area.

- Early-mid 1900s is also a possible deposition period. ^{210}Pb and ^{137}Cs sediment dating will shed more light on the likelihood of gully formation in this period.

Conclusions

- Gullies in the Davidson College area exhibit some variation in sedimentation and soil development but are consistently less well developed than control soil profiles.

- The radiocarbon ages from Davidson area gullies locates the timing of formation in the 18th century, the same period as European settlement in Mecklenburg County.

- ^{137}Cs and ^{210}Pb sediment dating is currently being performed to determine if the early 1900s radiocarbon peak is an artifact of calibration.

Acknowledgments and References

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