Piedmont Savanna Interim Report

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Executive Summary

The North Carolina Natural Heritage Program (NHP) is a nonregulatory state agency in the Department of Natural and Cultural Resources. Our biologists, data managers, and stewardship specialists assist landowners and managers in assessing and managing properties for the preservation of North Carolina's natural heritage. At the request of the South Atlantic Landscape Conservation Cooperative, NHP conducted a customized review of rare plant species and natural communities associated with the Piedmont Savanna ecosystem. The review was conducted from January 2020 to August 2020.

Purpose of the Report

1. Identify plant and natural communities associated with Piedmont Savannas
2. Provide up-to-date ArcGIS data
3. Provide analysis of results

Introduction

In recent years, more attention has been paid to the so-called Piedmont prairie or Piedmont savanna ecosystem. Often classified as early successional plant communities, these often-sunny ecosystems support a variety of floral and faunal life that are not found within closed-canopy forest systems. These ecosystems were highly managed by Indigenous citizens of the Piedmont through the use of fire (Vivette Jeffries-Logan, Jefferson Currie, personal communication). These ecosystems have been under threat since the mid-1700s with the arrival of Western Europeans and enslaved Africans and their conversion to plantation agriculture (Davis et al. 2002). Displacing the Indigenous citizens and abandoning the previous management regime resulted in decline in these communities all across their former range. Prairie/savanna systems were converted to row crop agriculture, pasture/fodder land or allowed to grow into closed canopy forests. Today, the few remnants of these once-extensive plant communities exist along roadsides, power line rights-of-way, and other places where extreme edaphic conditions or anthropogenic activities prevent canopy closure (Adams 2012).

As a general rule, these remnant communities tend to occur on soils that are rocky, have high shrink-swell potential or have low plant-available water during the growing season (Davis et al 2002, Tompkins et al. 2010). They also have been associated with Alfisols, and less frequently Mollisols. These soil orders typically have higher concentrations of base cations such as calcium and magnesium resulting in relatively less acidic soils than soils found more commonly in the Piedmont region (Benson 2011, Juras 1997). Due to their mineralogy, Alfisols often have higher shrink-swell potential than other soil orders found in the Piedmont region. This is theorized to prevent tree canopy closure, even in the absence of fire. Shrink-swell soils are often associated with hardpans or impermeable layers, below the soil surface that act as a barrier to plant roots. While Alfisols and Mollisols are often associated with significant shrink-swell potential, not all Alfisols exhibit this characteristic. Conversely, other soils orders (Ultisols, Inceptisols, etc) can exhibit significant shrink-swell potential. Adams (2012) also observed that prairie remnants are observed most often on south-facing slopes which to the possible association of these plants and natural communities with landscape position.

Plants have varying light requirements for photosynthesis and reproduction (Rehani et al. 2010). Heliophytic vegetation is characteristic of prairie/savanna systems and requires open canopies for reproduction to occur. Without fire, anthropogenic activities, or extreme edaphic conditions, nearly all upland natural communities in North Carolina become closed canopy forests where little sunlight reaches the ground during the growing season (McCord et. al 2013, Tompkins 2013).

Interest in restoring and managing these ecosystems has grown in recent years with State, Federal, municipal and private land managers instituting prescribed burns and replanting native sun-loving vegetation. As interest grows in the restoration and re-creation of these systems, it becomes important to have accurate data of the particulars of these systems as they exist currently.

In this survey, we looked at the Element Occurrence data for rare vascular plant species and natural communities associated with the Piedmont prairie/savanna systems with the intent of identifying patterns of distribution across the Piedmont region. While other studies have examined the few

Piedmont prairie remnants (Tompkins et al. 2010, Davis et al. 2002, Benson 2011, Adams 2012), our data allows us to look, not just at those sites, but at the individual species level for rare plants and at the natural community level. This allows us to survey a greater breadth of sites than previous studies.

In order to examine habitat distribution of rare sun-loving plants and natural communities, we examined soil properties, relation to anthropogenic activities, and landscape position.

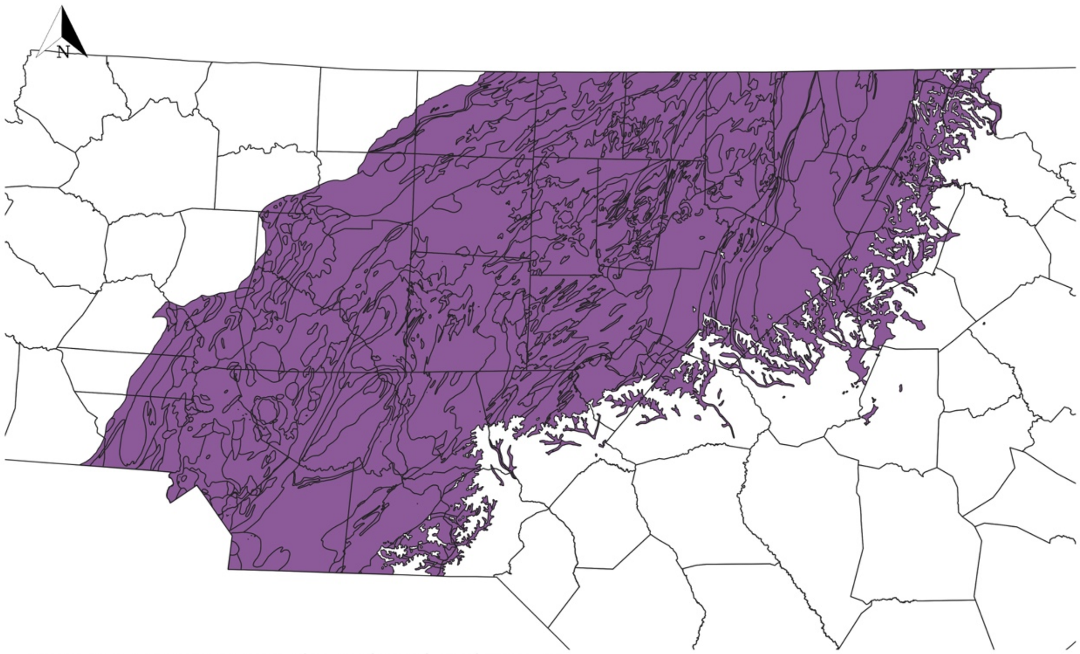
Methods

Analysis

GIS analysis methods were used in this study with the intention of using other statistical methods in future studies.

Geographic extent

The selection of the survey area was based on the geological boundaries of the Piedmont as defined by the NC Geological Survey and includes the Carolina Slate Belt, Eastern Slate Belt, Triassic Basin, Raleigh Belt, Charlotte and Milton Belts. Because the survey area is based on geology and not political boundaries, parts of certain counties were excluded. Counties include Alamance, Anson, Cabarrus, Caswell, Catawba, Chatham, Cleveland, Davidson, Davie, Durham, Forsyth, Franklin, Gaston, Granville, Guilford, Halifax, Harnett, Iredell, Johnston, Lee, Lincoln, Mecklenburg, Montgomery, Moore, Nash, Northampton, Orange, Person, Randolph, Richmond, Rockingham, Rowan, Stanly, Stokes, Union, Vance, Wake Warren, Wilson, and Yadkin counties.



Extent map of survey area, the geological Piedmont, as defined by NC Geological Survey.

Anthropogenic factors

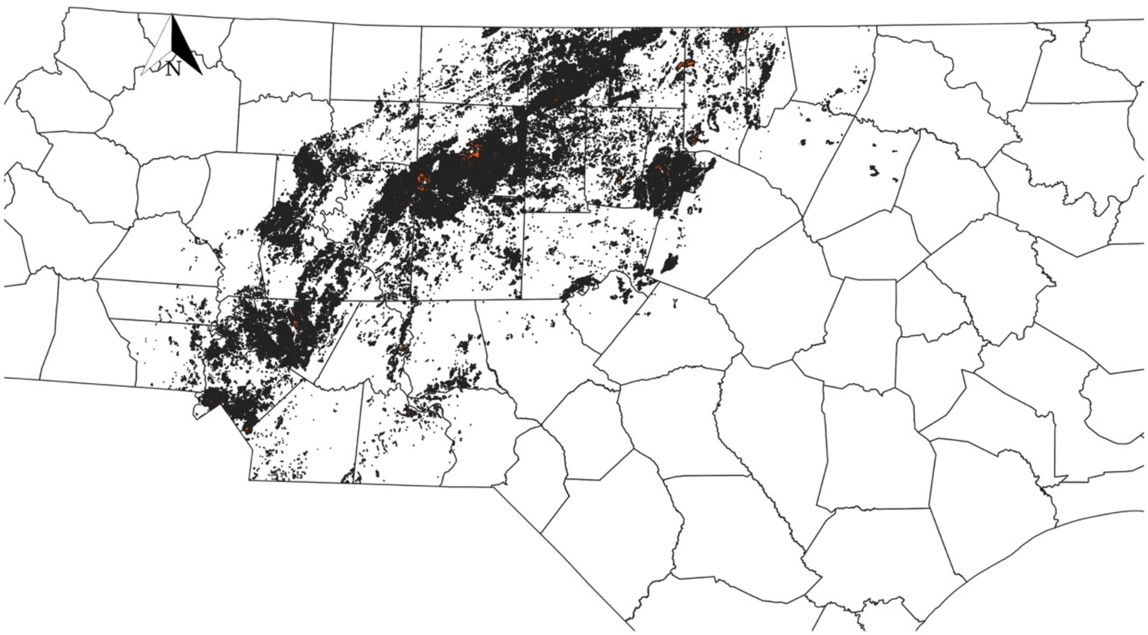
Element Occurrence (EO) data for the NC Piedmont was obtained from NCNHP's Biotics database. Each record was reviewed to look for evidence of plants or natural communities existing in anthropogenic habitats such as roadsides, railroad easements, power line right-of-ways, and other such habitats. Both recent aerial imagery and EO entries were used to determine presence of anthropogenic influences.

Soils

Soils data was obtained via the county soil surveys as aggregated by Web Soil Survey (USDA). Since digital soils data was not available for the categories of interest of this survey, Official Soil Series Descriptions (OSDs) had to be consulted for every soil series found within the survey area.

Alfisols

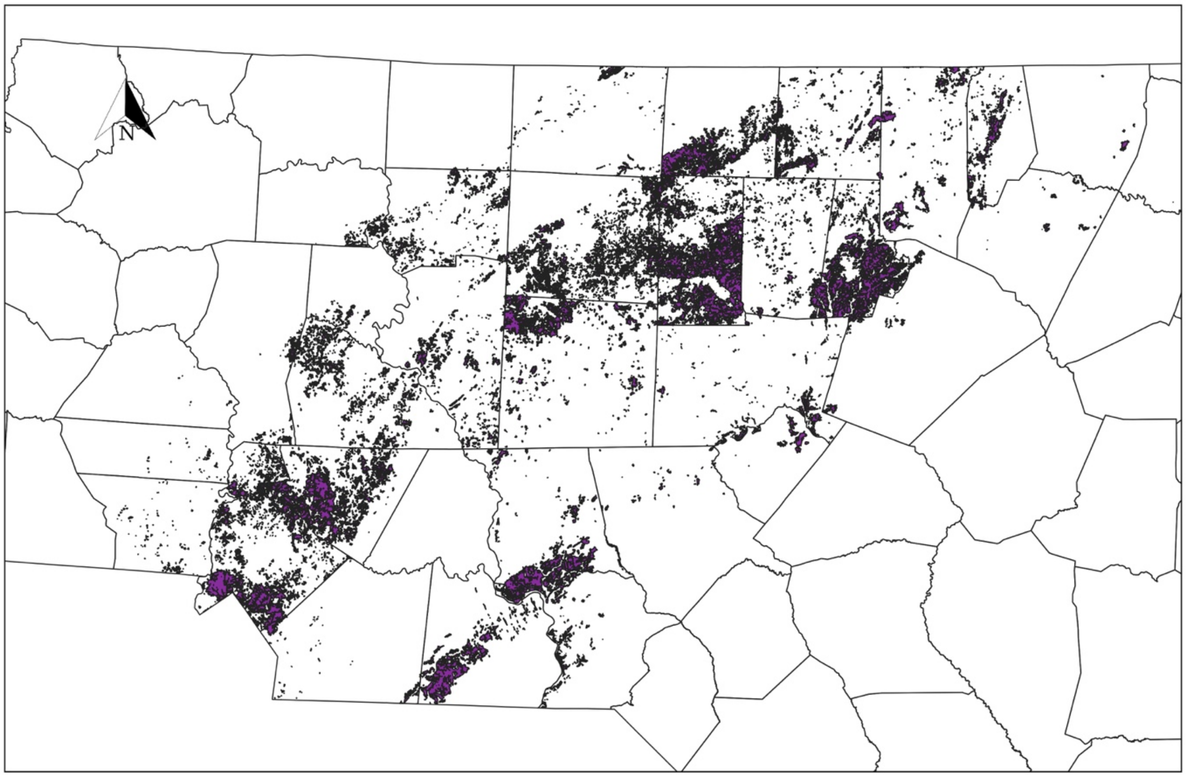
Due to the association of prairie remnants with Alfisols and Mollisols, soils within the survey area were categorized where Alfisols/Mollisols = 1 and all other soil orders (Ultisols, Inceptisols, etc) = 0. Mollisols occur with very little frequency in the survey area but are strongly associated with prairie/savanna vegetation, have shrink-swell mineralogy, and are therefore included here. Due to the overlap of Alfisols/Mollisols and shrink-swell soils, we then separated this factor into non-shrink swell Alfisols/Mollisols (NSS) and shrink-swells (SS) of any soil order.



Extent Map of Alfisols in NC Piedmont

Shrink-Swell Potential

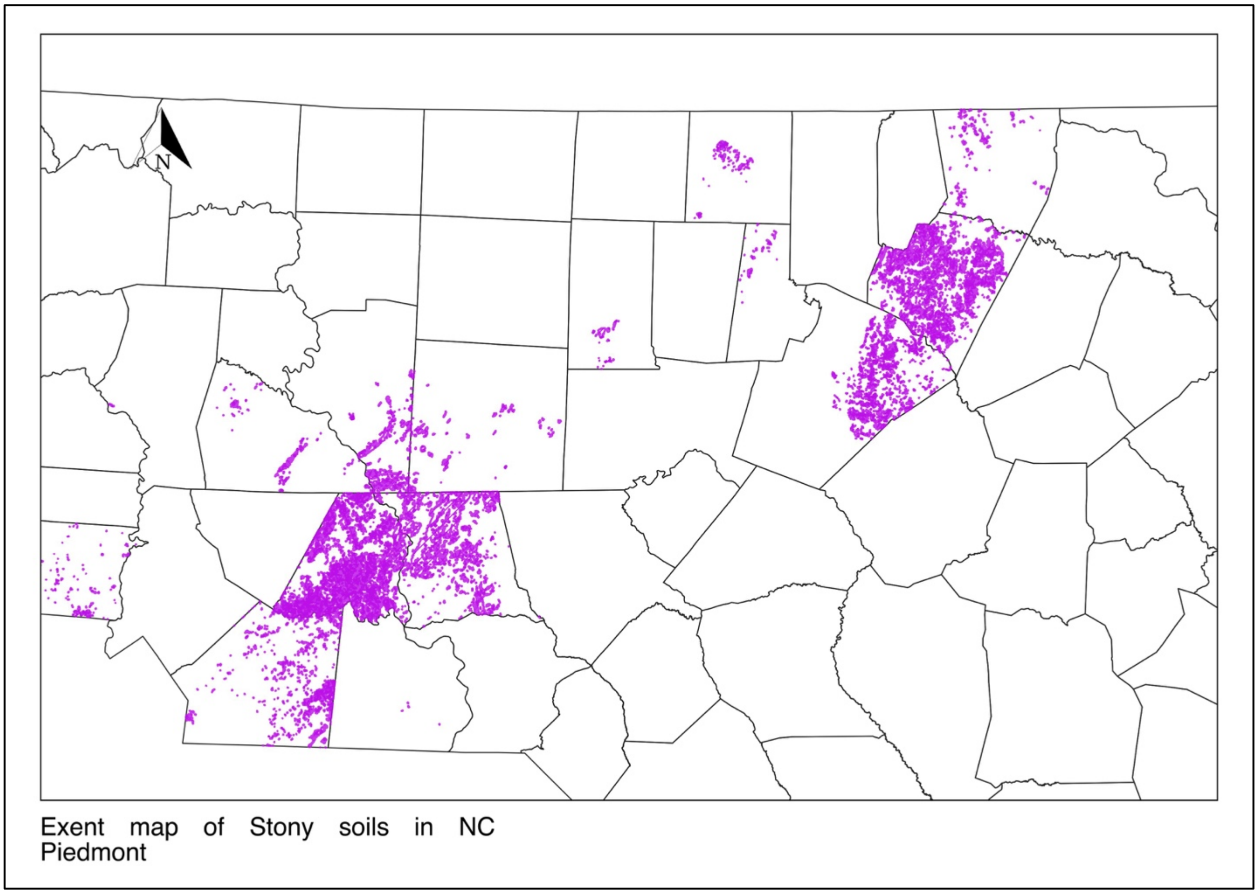
All soil series, regardless of soil order, within the survey area were assessed for shrink-swell potential using OSDs at a depth of 10 inches below the soil surface. Soils with very high shrink-swell potential were assigned a ranking of 3. Soils with high and moderate shrink-swell potential were assigned 2 and 1 respectively. Soils with low shrink-swell potential were assigned 0.



Exent map of shrink-swell soils in NC Piedmont

Stony Soils

All soil series within the survey area were assessed for stoniness at the soil surface as defined by each county soil survey. Soils with extremely bouldery and very bouldery surfaces were assigned a ranking of 4 and 3 respectively. Very stony Lithic Udipsamments and soils with extremely stony surfaces were assigned a ranking of 2. Soils with rocky, stony, very stony, very channery or very cobbly surfaces were assigned a ranking of 1. Lithic Udipsamments were also assigned a ranking of 1. Deep soils with or without rocky surfaces or were assigned 0.



Landscape Position

The position of the vascular plant species or natural community was assessed using ESRI Topo and Google Satellite maps. Vascular plants or natural communities located on bluffs, steep slopes, or monadnocks were assigned a ranking of 1 while all other landscape positions were assigned a ranking of 0.

Vascular Plants and Natural Communities (Element Occurrences)

Vascular plants were selected from NHP's database of rare, threatened and endangered plants. Plants were then selected by staff botanists based on the plants' association with prairie/savanna ecosystems or high rates of insolation required for completion of their life cycle. Selected species were then ranked based on their light requirements in which heliophytes, facultative sciophytes, and facultative heliophytes were assigned a ranking of 1, 2, or 3 respectively. See Appendix 1. The plants surveyed in this study are subsequently referred to as Piedmont Savanna Vascular Plants (PSVP).

Natural communities were selected from NHP's database by staff botanists based on their association with prairie/savanna plants and/or edaphic conditions that impede canopy closure without anthropogenic inputs. See Appendix 2.

Additional Data

Element occurrences data were assessed for date last observed. Records not visited for more than 20 years were assigned a ranking of 1 while all other records were assigned a ranking of 0. Element occurrences that were associated with flatrocks were assigned a ranking of 1 while all other records were assigned a ranking of 0. Vascular plants that were observed within natural communities were assigned a ranking of 1, while all other records were assigned a ranking of 0. If natural communities seem to have extirpated or altered significantly, records were noted with an X.

Results

PSVP

A total of 80 species were selected for a total of 1162 records within the geographic survey area. Species were then assessed for light requirement (see Appendix 1). Heliophytes accounted for 68% (801/1162) of the records while facultative sciophytes accounted for 24% (283/1162) of the total records. Facultative heliophytes accounted 11% (78/1162) of the total number of PSVP. See Table 1.

Light Requirement	Number of Species	Percent of Species	Number of EO Records	Percent of EO Records
Heliophyte	40	50%	801	68%
Facultative Sciophyte	31	38%	283	24%
Facultative Heliophyte	9	11%	78	11%
Total	80	n/a	1162	n/a

Table 1. Number and percent of species by light requirement.

Anthropogenic Factors

The study area is comprised of approximately 9.1 million acres. Within the geographic area, 83% (976/1162) of the PSVP were associated with anthropogenic activity either alone or in combination with other factors. Anthropogenic activities are associated with nearly all viable populations of these rare plants. AA is subsequently used in this paper to describe anthropogenic activity's interaction with other factors that affect the presence of these plants.

Anthropogenic activity alone is associated with 30% (352/1162) of the PSVP. AA with non-shrink-swell Alfisols (AA x NSS) were associated with 10% (124/1162), while AA with all shrink-swell soils (AA x SS), regardless of soil order, were associated with 31% (367/1162) of the PSVP. AA with stony soils (AA x S) were associated with 6.5% (76/1162) of PSVP. AA with landscape position (AA x LP) were associated with .2% (3/1162) of the PSVP. (See Table 2)

Interactions
AA with stony non-shrink-swell Alfisols (AA x S x NSS) were associated with 3.7% (44/1162) and stony shrink-swell soils (AA x S x SS) were associated with .6% (8/1162) of PSVP. Shrink-swell soils on slopes (AA x LP x SS) and stony soils on slopes (AA x LP x′S) each were associated with .08% (1/1162) of PSVP. (See Table 2)

	AA Anthropogenic Activity	NSS Non-Shrink-Swell Soils	SS Shrink-Swell Soils	S Stony Soils	LP Landscape Position	Total AA	Total Records
AA	352 (30%)	124 (10%) x S = 44 (3.7 %)	367 (31%) x S= 8 (.6%)	76 (6.5%)	3 (.2%) x SS= 1 (.08%) x S = 1 (.08%)	976 (83%)	1162

Table 2. Anthropogenic activity alone and in combination with other factors in association with vascular plants.

Soils

Alfisols and Shrink-Swell soils

Alfisols and Mollisols, regardless of mineralogy, account for 1.1 million acres (13%) while shrink-swell soils, of any soil order, account for 626,574 acres (6%) of the geographic survey area. Within the survey area, 50% (587/1162) of the PSVP were associated with Alfisols/Mollisols, regardless of mineralogy, either alone or in combination with other factors.

Non-shrink-swell Alfisols (NSS), alone or in combination with other factors, were associated with 17% (200/1162) of PSVP. NSS with anthropogenic activity (NSS x AA) were associated with 10% (124/1162) while NSS alone (NSS x NSS) is associated with .7% (9/1162) of PSVP. NSS with stony soils (NSS x S) is associated with 1.4% (17/1162) while NSS x LP was associated with .4% (5/1162) of total PSVP. (See Table 3).

Interactions

Non-shrink-swell stony Alfisols with anthropogenic plants (NSS x AA x S) and NSS on slopes with anthropogenic activity (NSS x AA x LP) were associated with 3.7% (44/1162) and .08% (1/1162) of PSVP respectively. (See Table 3).

Shrink-Swell soils

Shrink-swell soils (SS), alone or in combination with other factors, were associated with 35% (411/1162) of PSVP. SS with anthropogenic activity (SS x AA) were associated with 31% (367/1162) of the PSVP. Shrink-swell soils alone (SS x SS) were associated with 2.1% (25/1162) while shrink-swell soils with landscape (SS x LP) were associated with .7% (9/1162) of PSVP. (See Table 3).

Interactions
Stony shrink-swell soils associated with anthropogenic activity (SS x S x AA) are associated with .6% (8/1162) while shrink-swells on slopes with anthropogenic activity (SS x LP x AA) were associated with .08% (1/1162) of PSVP. (See Table 3).

	Anthropogenic (AA)	NSS	SS	Stony	LP	Total	Total Records
NSS	124 (10%) x S=44 (3.7%) x LP = 1 (.08 %)	9 (.7%)	0	17 (1.4%)	5 (.4%)	200 (17%)	1162
SS	367 (31%) x S =8 (.6%) x LP = 1 (.08%)	0	25 (2.1%)	1 (.08%)	9 (.7%)	411 (35%)	1162

Table 3. Non-shrink-swell Alfisols and shrink-swell soils alone and in combination with other factors in association with vascular plants.

Stony Soils

Stony soils account for 260,498 (2%) acres of the geographic survey area. Stony soils (S), alone or in combination with other factors, were associated with 16% (193/1162) of PSVP. Stony soils with AA (S x AA) were associated with 6.5% (76/1162) while stony non-shrink-swell Alfisols (S x NSS) were associated with 1.4% (17/1162) of PSVP. Stony shrink-swell soils (S x SS) were associated with .08% (1/1162) while stony soils alone (S x S) were associated with 3.3% (39/1162) of PSVP. Stony soils on slopes (S x LP) were associated with .6% (8/1162) of PSVP.

Interactions

Stony shrink-swell soils associated with anthropogenic activity (S x SS x AA) and stony non-shrink-swell Alfisols with anthropogenic activity (S x NSS x AA) are associated with 3.7% (44/1162) and .6% (8/1162) of PSVP respectively.

	Anthropogenic (AP)	NSS	SS	S	LP	Total	Total Records
S	76 (6.5%) x NSS = 44 (3.7%) x SS = 8 (.6%)	17 (1.4%)	1 (.08%)	39 (3.3%)	8 (.6%)	193 (16%)	1162

Table 4. Stony soils alone and in combination with factors in association with vascular plants.

Landscape Position

Landscape position (LP), alone or in combination with other factors, was associated with 6.1% (80/1162) of PSVP. LP with anthropogenic activity (SS x AA) was associated with .25% (3/1162) of the PSVP. LP with non-shrink-swell soils alone (LP x NSS) was associated with .4% (5/1162) while LP with shrink-swell soils with landscape (LP x SS) were associated with .7% (9/1162) of PSVP. LP alone was associated with 4.5% (53/293) of PSVP (See Table 5).

	Anthropogenic (AP)	NSS	SS	S	LP	Total	Total Records
LP	3 (.25%) x NSS = 1 (.08%) x SS = 1 (.08%)	5 (.4%)	9 (.7%)	8 (.6%)	53 (4.5%)	80 (6.1%)	1162

Table 5. Landscape Position alone and in combination with other factors in association with vascular plants.

Additional Data

20% (237/1126) of vascular plants were located within natural communities .1% (2/1162) of vascular plants were observed near flatrocks. 14% (166/293) had not been observed in more than 20 years while 1.6% (16/1162) of AP are presumed extirpated based on aerial imagery.

	Found in Natural Communities	Flatrocks	<20 years	Presumed extirpated	Total AP
Vascular Plants	237 (20%)	2 (.1%)	166 (14%)	16 (1.3%)	1162

Table 6. Additional data in association with vascular plants.

Natural Communities

A total of 23 natural community types were selected for a total of 293 records within the geographic survey area.

Anthropogenic Factors

Within the geographic area, 12% (37/293) of the natural community records were associated with anthropogenic activity either alone or in combination with other factors. Anthropogenic factors will be referred to as AA (Anthropogenic activity). Anthropogenic activity alone is associated with 1.7% (5/293) of the natural community records. AA with non-shrink-swell Alfisols (AA x NSS) were associated with 1.3% (4/293) while AA with shrink-swell soils (AA x SS), regardless of soil order, were associated with 3.4% (10/293) of the natural community records. AA with stony soils (AA x S) were associated with 2% (6/293) of natural community records. AA with landscape position (AA x LP) were associated with 1.3% (4/293) of the natural community records.

Interactions
AA with stony non-shrink-swell Alfisols (AA x S x NSS) were associated with 3% (1/293) and stony shrink-swell soils (AA x S x LP) were associated with 2% (6/293) of natural community records. AA with non-shrink-swell soils on slopes (AA x LP x NSS) were associated with .3% (1/293) of natural community records.

	Anthropogenic (AA)	NSS Non Shrink-swell Soils	SS Shrink-swell Soils	S Stony Soils	LP Landscape Position	Total	Total Records
AP	5 (1.7%)	4 (1.3%) x S = 1 (3%)	10 (3.4%)	6 (2%) x LP = 6 (2%)	4 (1.3%) x NSS =1 (.3%)	37 (12%)	293

Non-shrink-swell Alfisols

Non-shrink-swell Alfisols (NSS), alone or in combination with other factors, were associated with 11% (34/293) of natural community records. NSS with anthropogenic activity (NSS x AA) were associated with 1.3% (4/293) while NSS alone (NSS x NSS) is associated with .2% (6/293) of natural community records. NSS with stony soils (NSS x S) is associated with .3% (1/293) while NSS x LP was associated with 2.7 % (8/293) of total natural community records. (See Table 3).

Interactions

Non-shrink-swell stony Alfisols with anthropogenic activity (NSS x AA x S) and NSS on slopes with anthropogenic activity (NSS x AA x LP) were associated with 1.3% (4/293) and .3% (1/293) of natural community records respectively. (See Table 3).

Shrink-Swell soils

Shrink-swell soils (SS), alone or in combination with other factors, were associated with 15% (44/293) of natural community records. SS with anthropogenic activity (SS x AA) were associated with 3.4% (10/293) of the natural community records. Shrink-swell soils alone (SS x SS) were associated with 7% (23/293) while shrink-swell soils with landscape (SS x LP) were associated with 2.3% (7/293) of natural community records. (See Table 3).

Interactions
Stony shrink-swell soils on slopes (SS x S x LP) were associated with .6% (2/293)) of natural community records. (See Table 3).

	Anthropogenic (AA)	NSS	SS	S	LP	Total	Total Records
NSS	4 (1.3%) x S = 4 (1.3%)	6 (2%)	0	1 (.3%)	8 (2.7%) x AA =1 (.3%)	34 (11%)	293
SS	10 (3.4%)	0	23 (7%)	2 (.6%) x LP = 2 (.6 %)	7 (2.3%)	44 (15%)	4293

Stony soils
Stony soils (S), alone of in combination with factors, were associated with 33% (199/293) of natural community records. Stony soils with AA (S x AA) were associated with 2% (6/293) while stony non-shrink-swell Alfisols (S x NSS) were associated with .3% (1/293) of natural community records. Stony shrink-swell soils were associated with .6% (2/293) while stony soils alone were associated with 8% (24/293) of PSVP. Stony soils on slopes were associated with 16 % (47/293) of natural community records.

Interactions

Stony non-shrink-swell Alfisols on slopes soils with anthropogenic activity (S x NSS x AA x LP) were associated with 1% (3/293) of natural community records. Stony soils on slopes with anthropogenic activity (S x LP x AA) and stony non-shrink-swell Alfisols on slopes (S x LP x NSS) were associated with 4.4% (13/293) of natural community records.

	Anthropogenic (AA)	NSS	SS	S	LP	Total	Total Records
S	6 (2)% x LP x NSS =3 (1%)	1 (.3%)	2 (.6%)	24 (8%)	47 (16%) x AA = 3 (1%) x NSS = 13 (4.4%)	99 (33%)	293

Landscape Position

Landscape position (LP), alone or in combination with other factors, was associated with 54% (161/1162) of PSVP. LP with anthropogenic activity (LP x AA) was associated with 1.3% (4/293) of the natural community records. LP with non-shrink-swell soils alone (LP x NSS) was associated with 2.7% (8/293) while LP with shrink-swell soils (LP x SS) were associated with 2.3% (7/293) of natural community records. LP alone was associated with 25% (76/293) of natural community records (see Table 5).

Interactions

Stony non-shrink-swell Alfisols on slopes with anthropogenic activity (S x NSS x AA x LP) were associated with 1% (3/293) of natural community records. Non-shrink-swell Alfisols on slopes with AA (LP x NSS x AA) were associated with .3% (1/293). Stony non-shrink-swell Alfisols on slopes and shrink-swell soils on slopes were associated with 3.4% (10/293) and .6% (2/293) of natural community records respectively.

	Anthropogenic (AA)	NSS	SS	S	LP	Total	Total Records
LP	4 (1.3%) x S x NSS =3 (1%)	8 (2.7%) x AA = 1 (.3%)	7 (2.3%) x S =2 (.6%)	47 (16%) x AP =3 (1%) x NSS = 10 (3.4%) x SS = 2 (.6%)	76 (25%)	161 (54%)	293

Additional Data

19% (57/293) natural community records were associated with flatrocks. 14% (42/293) of natural community records had not been observed in more than 20 years while 4% (14/293) of natural community records are presumed extirpated based on aerial imagery.

	Flatrocks	<20 years	Presumed extirpated	Total Records
Natural Communities	57 (19%)	42 (14%)	14 (4%)	293

Discussion

Vascular plants

The results of this study offer evidence of the importance of anthropogenic activity to rare vascular plants associated with Piedmont prairie/savanna habitats. Anthropogenic activity, without any other factors, was associated 30% of all PSVP. Anthropogenic activity with shrink-swell soils was associated with 31% of plant records. Edaphic conditions, often strongly associated with Piedmont prairie/savanna remnants, were not observed to be strongly associated with the vascular plants included in this survey. Although 50% of the records were associated with Alfisols, 45% of those records were also associated with anthropogenic activity. It should be noted that this study did not investigate individual species and their soil order associations. All soil factors combined (shrink-swell, non-shrink-swell Alfisols, stony) without anthropogenic activity accounts for just 6.1% of the plant records. This study asserts that rare vascular plants associated with Piedmont/prairie remnants may be found on various soil conditions and only occasionally in the absence of human activity.

In North Carolina, shrink-swell soils represent some of the most challenging soils to western European-based agricultural practices and to other human activity such as road building and septic systems. It may be that previously studied prairie/savanna remnants represent the most extreme edaphic conditions that were unsuitable for plowing and thus retain a suite of species no longer found on sites that have been plowed or otherwise disturbed. Our study asserts that while edaphic conditions play a role in the distribution of prairie/savanna associated plants, it is the prevention of canopy closure through anthropogenic activity that is most closely associated with the distribution of these plants at the present time.

The importance of canopy openings by anthropogenic activity is long held by indigenous groups as part of their past and current land management strategies, especially among the Lumbee Tribe. We also have the example of Suther Prairie in Cabarrus County which, according to family lore, was excluded from cultivation by the family patriarch who was reminded of the meadows along the Rhine in Germany. Suther Prairie represents one of the only known examples of a wet-mesic prairie in North Carolina, one of few viable populations of red Canada lily (*Lilium canadense* spp. *editorum*) and a suite of species represented nowhere else in the state. This 5-acre tract is located on floodplain soils (Chewacla) and is surrounded by shrink-swell Alfisols and thus we might imagine that rare plants would be observed in surrounding areas. Due to the land management of surrounding parcels, which has involved plowing and/or allowing canopy closure, these areas do not currently support the same suite of species found at Suther Prairie. Therefore, we might conclude that it is anthropogenic activity that is most similar to Indigenous North Carolinians' management that helps these plants to persist in place.

Natural Communities

The prairie/savanna natural communities in this survey were most strongly associated with landscape position. Natural communities found on slopes and on stony soils were associated with 25% and 8% of all natural community records respectively. The distribution pattern of prairie/savanna natural communities appears to be more complex than that of prairie/savanna rare vascular plants. Their association with slopes and stony soils is supported by the unsuitability of those areas for Western-European based agriculture as these areas represent the driest and rockiest areas of the Piedmont. Interestingly enough, only 20% of all vascular plants investigated in this study occurred within natural communities. This is likely explained by the fact that our study targeted heliophytes, facultative sciophytes, and facultative heliophytes while most natural communities, as defined by NHP, are largely closed canopy systems.

Approximately 2.4% of the records were unexplained by the model. Part of this is due to soil and geologic mapping. Soil mapping is only presumed accurate to the 1-acre scale and therefore does not capture microsites or small incursions of differing soil types.

Conclusion

This study sheds valuable information about the distribution of terrestrial, sun-loving, rare vascular plants in the North Carolina Piedmont. The findings of this study can provide useful information for the management of prairie/savanna ecosystems and for the selection of potential sites for the re-introduction of individual species. Further investigation is needed to determine soil order associations for this group of plants, as this study did not investigate that particular factor.

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APPENDICES

APPENDIX 1.

LATIN NAME	LIGHT
Acmispon helleri	1
Agastache nepetoides	3
Anemone berlandieri	3
Anemone caroliniana	1
Baptisia aberrans	1
Baptisia alba	2
Berberis canadensis	3
Boechera missouriensis	2
Buchnera americana	1
Callitriche terrestris	3
Camassia scilloides	2
Carex bushii	1
Carex meadii	2
Cirsium carolinianum	1
Clinopodium georgianum	1
Crocanthemum propinquum	2
Danthonia epilis	1
Delphinium exaltatum	3
Desmodium fernaldii	1
Dichanthelium annulum	2
Dichanthelium bicknellii	1
Dichanthelium neuranthum	1
Echinacea laevigata	1
Echinacea pallida	1
Echinacea purpurea	1
Eleocharis wolfii	2
Eupatorium saltuense	2
Eurybia spectabilis	2
Fleischmannia incarnata	2
Gaylussacia brachycera	2
Gillenia stipulata	3
Hackelia virginiana	2
Helianthus laevigatus	1
Helianthus schweinitzii	1
Liatris aspera	1
Liatris squarrulosa	1

Lilium canadense ssp. editorum	2
Lilium canadense var. canadense	2
Lithospermum canescens	2
Lysimachia tonsa	2
Marshallia legrandii	2
Matelea decipiens	2
Mnesithea cylindrica	1
Oenothera perennis	1
Packera paupercula var. paupercula	1
Panicum flexile	1
Panicum philadelphicum ssp. lithophilum	1
Parthenium auriculatum	2
Phemeranthus piedmontanus	2
Polygala senega	2
Primula meadia	3
Pseudognaphalium helleri	1
Pseudognaphalium micradenium	1
Pycnanthemum torreyi	2
Pycnanthemum virginianum	1
Rhus michauxii	1
Ruellia humilis	1
Ruellia purshiana	1
Scirpus pendulus	2
Scrophularia lanceolata	1
Scutellaria leonardii	1
Scutellaria nervosa	3
Silphium perfoliatum	2
Silphium terebinthinaceum	1
Solidago plumosa	2
Solidago ptarmicoides	1
Solidago radula	2
Solidago rigida var. glabrata	2
Solidago ulmifolia	2
Stachys cordata	2
Stachys matthewsii	2
Symphyotrichum concinnum	1
Symphyotrichum depauperatum	1
Symphyotrichum georgianum	1
Thermopsis mollis	3
Tradescantia virginiana	2

Trichostema brachiatum	1
Trichostema setaceum	1
Tridens chapmanii	1

APPENDIX 2.

Natural Community Type

Diabase Glade

Dry Piedmont Longleaf Pine Forest

Granitic Flatrock (Annual Herb Subtype)

Granitic Flatrock (Perennial Herb Subtype)

Granitic Flatrock Border Woodland

Low Elevation Acidic Glade (Grass Subtype)

Low Elevation Rocky Summit (Acidic Subtype)

Low Mountain Pine Forest (Montane Pine Subtype)

Mixed Moisture Hardpan Forest

Mixed Moisture Hardpan Forest

Piedmont Acidic Glade

Piedmont Basic Glade (Falls Dam Slope Subtype)

Piedmont Basic Glade (Typic Subtype)

Piedmont Cliff (Basic Subtype)

Piedmont Cliff (Acidic Subtype)

Piedmont Monadnock Forest (Pine Subtype)

Piedmont Monadnock Forest (Typic Subtype)

Ultramafic Outcrop Barren (Piedmont Subtype)

Xeric Hardpan Forest (Acidic Hardpan Subtype)

Xeric Hardpan Forest (Basic Hardpan Subtype)

Xeric Hardpan Forest (Basic Rocky Subtype)

Xeric Hardpan Forest (Northern Prairie Barren Subtype)

Xeric Piedmont Slope Woodland