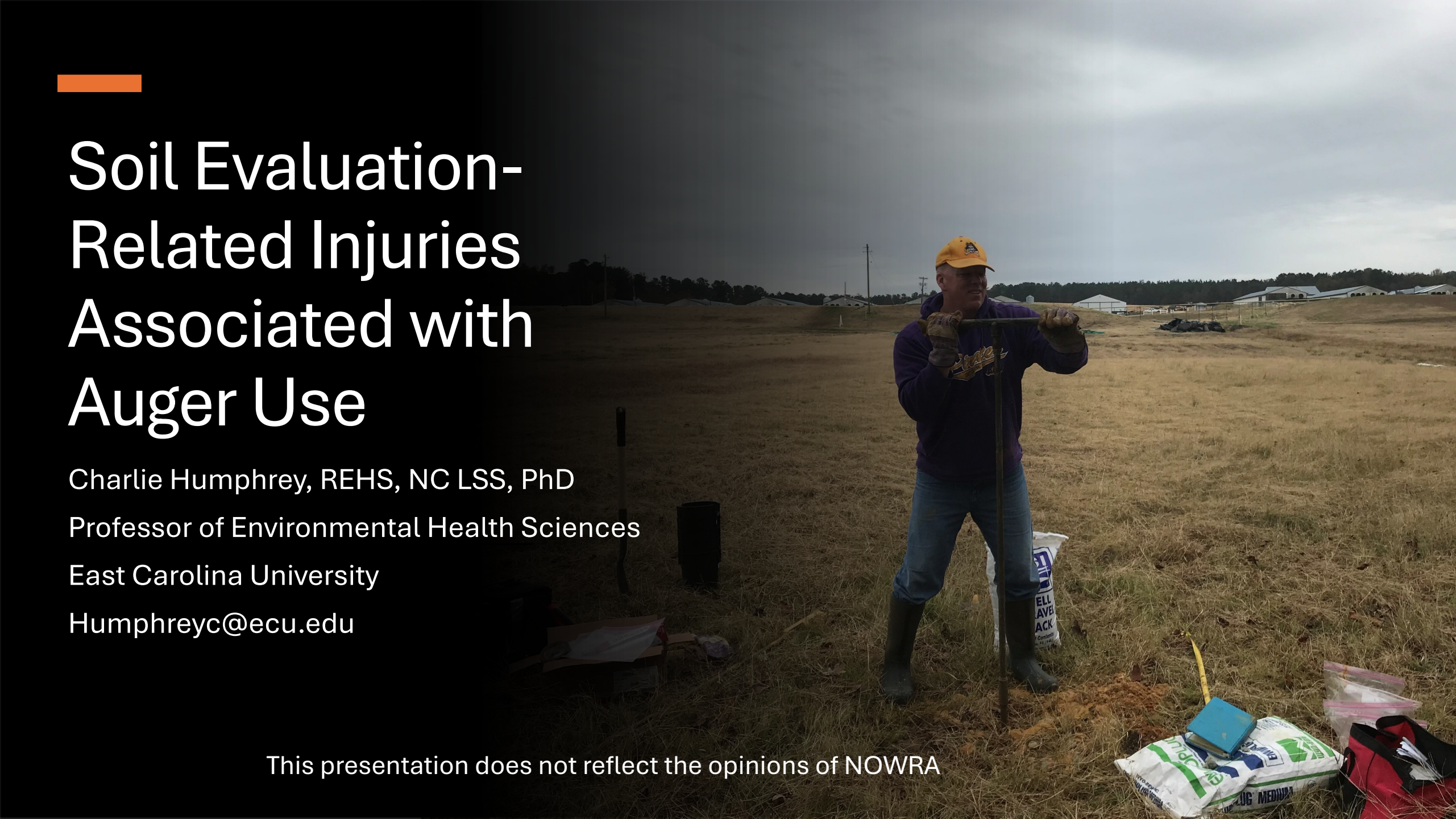
Soil Evaluation-Related Injuries Associated with Auger Use

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Outline

- Background
- Research goal and objectives
- Potential factors
- Methods
- Results and discussion
- Conclusions
- Questions

Soil Auger



Handle: The top part of the tool is used to apply force and rotate the auger

Shaft: A rod that connects the handle and the bucket

Bucket: Located at the bottom of the tool and is a helical blade that twists into the soil.

Environmental health professional use manual-powered soil auger to collect soil samples, characterize subsurface properties.

Auger Characteristics



Variety of bucket styles, shapes, and diameters.





Shaft lengths vary, some models allow extensions



Environmental Health Professionals & Soil Augers

- EH professionals including environmental health specialists, geologists, and soil scientists mostly use manually powered soil augers for soil property characterization and sample collection



Musculoskeletal Disorders and Auger Use

- Musculoskeletal disorder (MSDs) are injuries to the joints, muscles, tendons, or supportive limbs such as the neck and back.
- MSDs can be triggered by exertion and repeated motions.





Repetitive Motions and MSDs



- **Musculoskeletal Strain:** routine use of hand-held tools for janitorial tasks (e.g., vacuuming, mopping) or construction (e.g., sawing, grinding), can lead to muscle fatigue and strain in hands, forearms, and shoulders (Damlund et al., 1986; Song et al., 2021).
- **Repetitive Strain Injuries (RSIs):** RSIs can affect different muscle groups and joints, which can be caused by poor technique or overuse of a group(Hoozemans et al., 2002).
- Repetitive movements such as gripping, twisting, and pushing/pulling increase the risk of injuries like Carpal Tunnel Syndrome (CTS) and Tendonitis (Mayo Clinic, 2024) especially if there is improper tool handling (Song et al., 2021).

MSD Research

- **Importance of Protocols and Safety:** Following guidelines using PPE, and taking breaks are essential for minimizing negative health effects (Bakker et. al., 2021).
- **Tool Design and Ergonomics:** The ergonomic improvements of hand tools such as the bent-handled files and customized tool grips, can reduce the risk of injury by minimizing wrist deviations, grip force, and vibrations (Khan et. al., 2023). The designs of the tool may enhance comfort and reduce musculoskeletal strains in tasks involving both manual and powered tools.
- There is a lack of research on the use of soil augers and MSDs. The tool is frequently used by environmental health professionals in North Carolina and other states.

Factors that May Influence Force and Strain During Auger Usage

- **Soil Type:** Friable and loose soils (Group I and II) may require less torque to create auger borings compared to frim and very firm clay-rich soils (Group III and IV)
- **Roots and Rocks:** May increase resistance, require more torque to create boreholes thus increasing physical strain on the body. May “catch” when trying to pull auger out of borehole.
- **Number of Borings:** EH professionals that create more borings per week on average may be more likely to experience MSD.
- **Auger Bucket Diameter and Borehole Depth:** Wider buckets may require more force to rotate relative to narrower buckets. EH that typically create deeper boreholes may be more at risk of MSD.

Research Goal and Objectives

Goal: Gain a better understanding of the health risks associated with the use of manually powered soil augers by EH professionals.

Objectives

1) Summarize information on EH professionals that use soil augers and the type and presence of MSDs
2) Identify factors most frequently associated with MSD occurrence
3) Determine where in the state auger use and likelihood of MSD occurrence may be greatest

Methods



- A 30-question survey was developed
  - Demographic information was solicited (age and years of experience in onsite wastewater/soil work)
  - Soil auger usage data included the mean number of weekly boreholes, mean depth of borings, auger characteristics, auguring conditions, and soil types (e.g., soil groups I-IV)
  - MSD occurrence and medical attention
  - Workplace policies for excavator pitt usage and training on auger use

Methods- Regional Variability in Auger Use

- NC DHHS onsite activity reports
  - Number of site visits (correlated with auger use)
  - Number of septic permits (correlated with auger use)
  - https://www.dph.ncdhhs.gov/programs/environmental-health/site-water-protection-branch/county-activity-reports
- Better perspective on where most of the work and risks of developing MSDs are in the state.

Methods- Soil Texture/Group Analyses

Goldsboro Series

Ap—0 to 10 inches; dark grayish brown (10YR 4/2) sandy loam; weak medium granular structure; very friable; many fine roots; strongly acid; clear smooth boundary.

BE—10 to 13 inches; yellowish brown (10YR 5/4) sandy loam; common fine faint brown mottles; weak medium subangular blocky structure; friable; many fine roots; strongly acid; clear smooth boundary.

Bt1—13 to 28 inches; yellowish brown (10YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; common fine roots; common distinct clay films on faces of peds; very strongly acid; gradual wavy boundary.

Bt2—28 to 40 inches; yellowish brown (10YR 5/8) sandy clay loam; many medium distinct light yellowish brown (10YR 6/4) mottles and few medium distinct light brownish gray (10YR 6/2) mottles; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; common distinct clay films on faces of peds;



United States Department of Agriculture

Soil Conservation Service

In cooperation with North Carolina Department of Natural Resources and Community Development, North Carolina Agricultural Research Service, North Carolina Agricultural Extension Service, and Bladen County Board of Commissioners

Soil Survey of Bladen County, North Carolina



SL: 13/36 = 0.36

SCL: 23/36 = 0.64

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
AaA	Altavista fine sandy loam, 0 to 3 percent slopes	3,804	0.7
At	Augusta sandy loam	1,265	0.2
AuA	Autryville loamy sand, 0 to 3 percent slopes	10,109	1.8
AyB	Aycock very fine sandy loam, 1 to 4 percent slopes	2,034	0.4
BnB	Blanton sand, 2 to 7 percent slopes	2,895	0.5
BuA	Butters fine sand, 0 to 2 percent slopes	8,013	1.4
By	Byars loam	1,176	0.2
Ca	Cape Fear loam	4,397	0.8
Ce	Centenary sand	25,009	4.4
Ch	Chewacla and Chastain soils, frequently flooded	6,351	1.1
Cn	Congaree silt loam, frequently flooded	7,967	1.4
Co	Coxville loam	6,188	1.1
Cr	Croatan muck, rarely flooded	10,697	1.9
CT	Croatan muck, frequently flooded	8,047	1.4
DgA	Dogue sandy loam, 0 to 3 percent slopes	1,599	0.3
DO	Dorovan muck, frequently flooded	8,905	1.6
Dr	Dunbar fine sandy loam	2,485	0.4
DuA	Duplin sandy loam, 0 to 3 percent slopes	2,303	0.4
DyF	Dystrochrepts, steep	8,748	1.5
ExA	Exum very fine sandy loam, 0 to 3 percent slopes	10,053	1.8
Fo	Foreston loamy sand	11,410	2.0
GbA	Goldsboro sandy loam, 0 to 3 percent slopes	28,750	5.1
GdA	Goldsboro-Urban land complex, 0 to 3 percent slopes	695	0.1
Gh	Grantham very fine sandy loam	6,368	1.1
Gm	Grifton-Meggett complex, occasionally flooded	7,045	1.2
GrB	Gritney fine sandy loam, 2 to 7 percent slopes	5,777	1.0
GrD	Gritney fine sandy loam, 7 to 15 percent slopes	758	0.1
Jh	Johns fine sandy loam	2,711	0.5
JO	Johnston mucky loam, frequently flooded	17,468	3.1
KaA	Kalmia loamy fine sand, 0 to 3 percent slopes	498	0.1
KeA	Kenansville sand, 0 to 3 percent slopes	7,819	1.4
KuB	Kureb sand, 1 to 8 percent slopes	1,181	0.2
LaB	Lakeland sand, 1 to 7 percent slopes	22,354	3.9
LeA	Leon sand, 0 to 3 percent slopes	36,605	6.4
Ln	Lynchburg fine sandy loam	16,355	2.9
Ly	Lynn Haven and Torhunta soils	47,871	8.4
Na	Nahunta very fine sandy loam	7,238	1.3
NoA	Norfolk loamy fine sand, 0 to 2 percent slopes	23,290	4.1
NoB	Norfolk loamy fine sand, 2 to 6 percent slopes	8,948	1.6
NuB	Norfolk-Urban land complex, 0 to 6 percent slopes	561	0.1
Oc	Ocilla loamy fine sand	5,126	0.9
Pa	Pamlico muck, rarely flooded	34,034	6.0
PC	Pamlico muck, frequently flooded	896	0.2
Pe	Pantego loam	8,765	1.5
Pp	Paxville sandy loam	2,218	0.4
Pt	Portsmouth mucky sandy loam	3,651	0.6
Ra	Rains fine sandy loam	29,611	5.2
Rn	Rains-Urban land complex	425	0.1
Ro	Roanoke loam	10,451	1.8
St	Stallings loamy sand	4,433	0.8
To	Toisnot loam	1,826	0.3
Tr	Torhunta mucky sandy loam	19,574	3.4
Ud	Udorthents, loamy	1,188	0.2
WaB	Wagram fine sand, 0 to 6 percent slopes	12,231	2.2
WbB	Wagram-Urban land complex, 0 to 6 percent slopes	754	0.1
We	Wahee loam	4,446	0.8
WgB	Wakulla sand, 1 to 6 percent slopes	12,714	2.2
Wh	Wasda muck	4,995	0.9
WmB	Wickham fine sandy loam, 1 to 6 percent slopes	3,760	0.7
WN	Wilbanks loam, frequently flooded	1,620	0.3
Wo	Woodington loamy sand	14,044	2.5
	Water	5,696	1.0
	Total	568,205	100.0

County Specific Soil Group Percentages

29,445 acres of Goldsboro Series in Bladen County

0.36 x 29,445 = 10,600 acres of SL (GII)

0.64 x 29,445 = 18,845 acres of SCL (GIII)

Comparison of Auger Work (Site Visits, Permits) and Soil Groups Percentages by Region



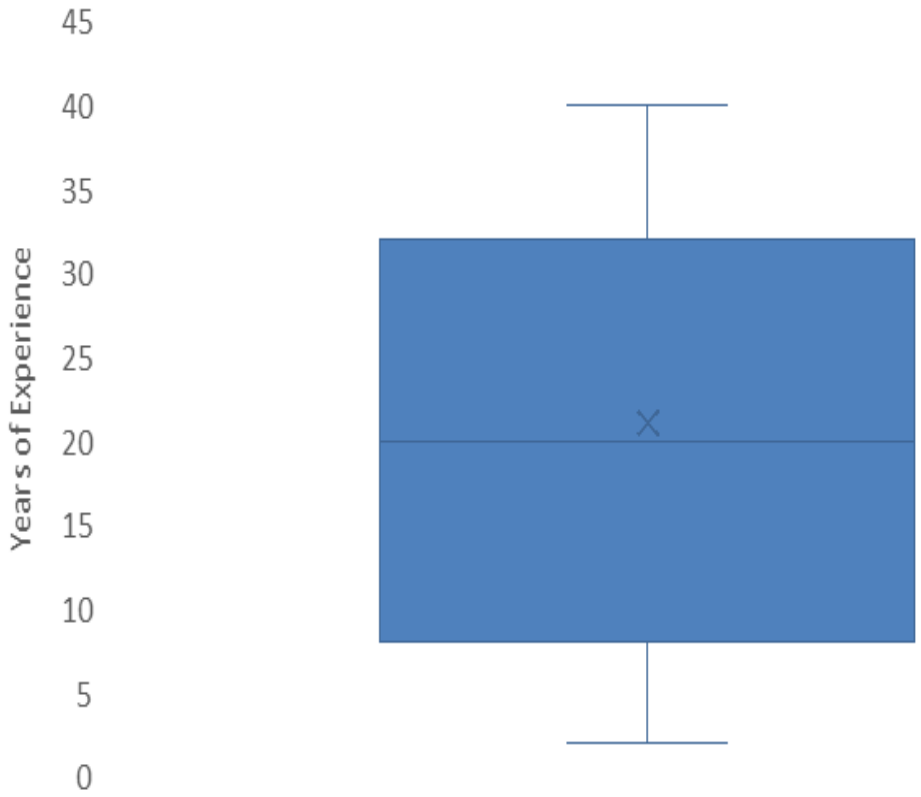
Statistical Analyses

- Summary statistics- percentage of respondents with a MSD, most common MSD, mean number of boreholes/week, etc
- Correlations (Spearman's rank or Pearson) between potential MSD influencing factors (age, years of experience, mean number auger borings/week, percentage of borings in Group III/IV soils, etc)
- T-tests or Mann Whitney tests for determining if number of MSDs for various comparison groups were significantly ($p < 0.05$) different
  - Age (over vs under 45 years)
  - Years of experience (less than 15 years in comparison to more than 15 years)
  - % of borings in group III/IV, through roots

Results

Characteristics of Survey Respondents

- 27 EHS, 32 soil scientists, 1 engineer
- Age: 25 to 75 (mean 46.5, median 48.5)
- Mean and median experience about 20 years

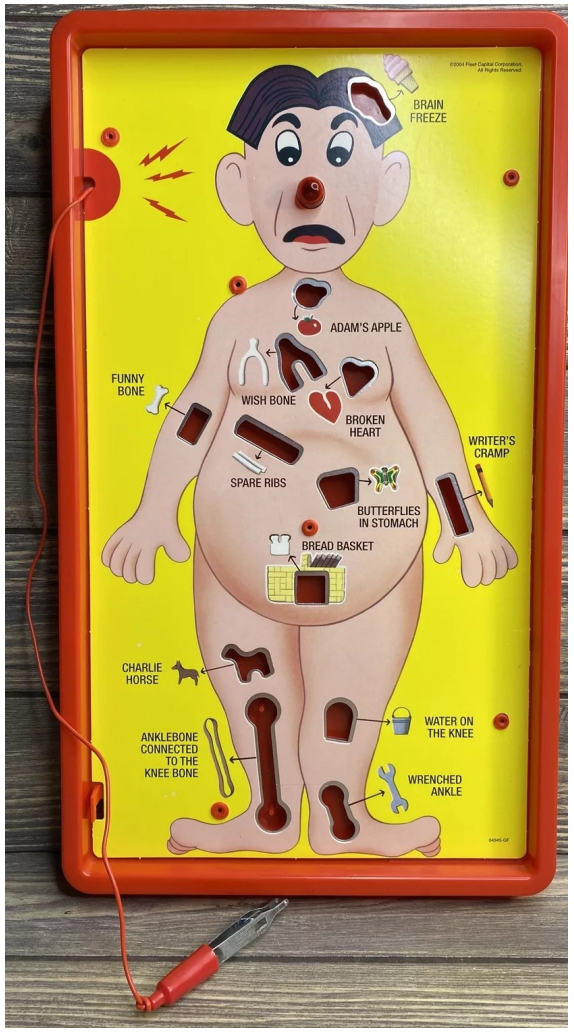


Workload Characteristics

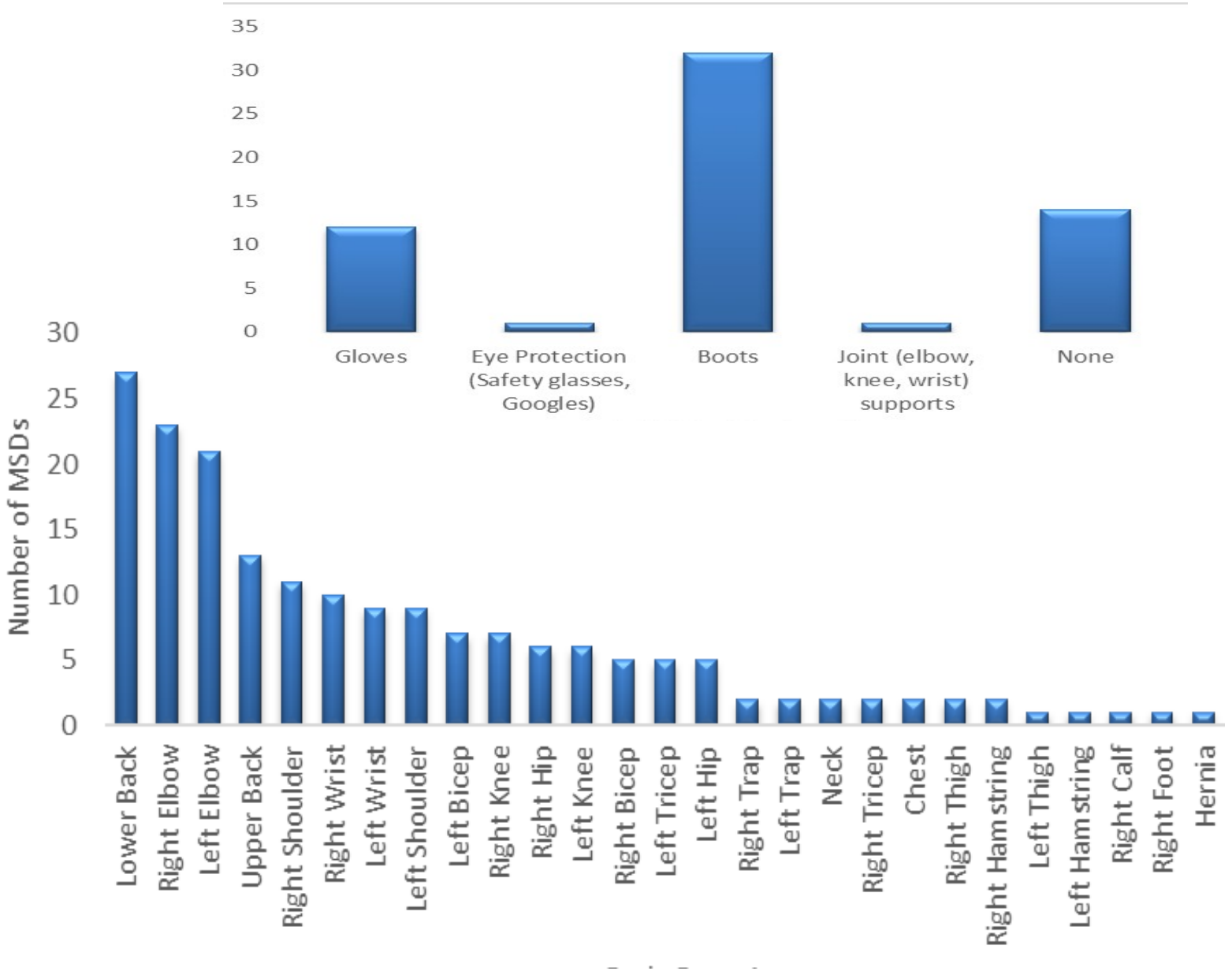
- Mean number of boreholes per week 56, with a median of 30 (range: 1 to 300)
- Mean diameter of auger bucket used was 3 inches and mean length of auger was 55 inches
- Mean depth of borings was 3.78 feet, median was 4 feet
- 40% frequently auger through extensive roots
- 29% frequently auger through rocks

MSDs and Treatment

- 95% of survey respondents reported experiencing at least 1 MSD
  - Most (74%) indicated that their MSD was related to manual auger use
  - 31% required visit to medical professional
    - Physical rehab (32%)
    - Rest (24%)
    - Surgery (15%)
    - Prescriptions (9%)





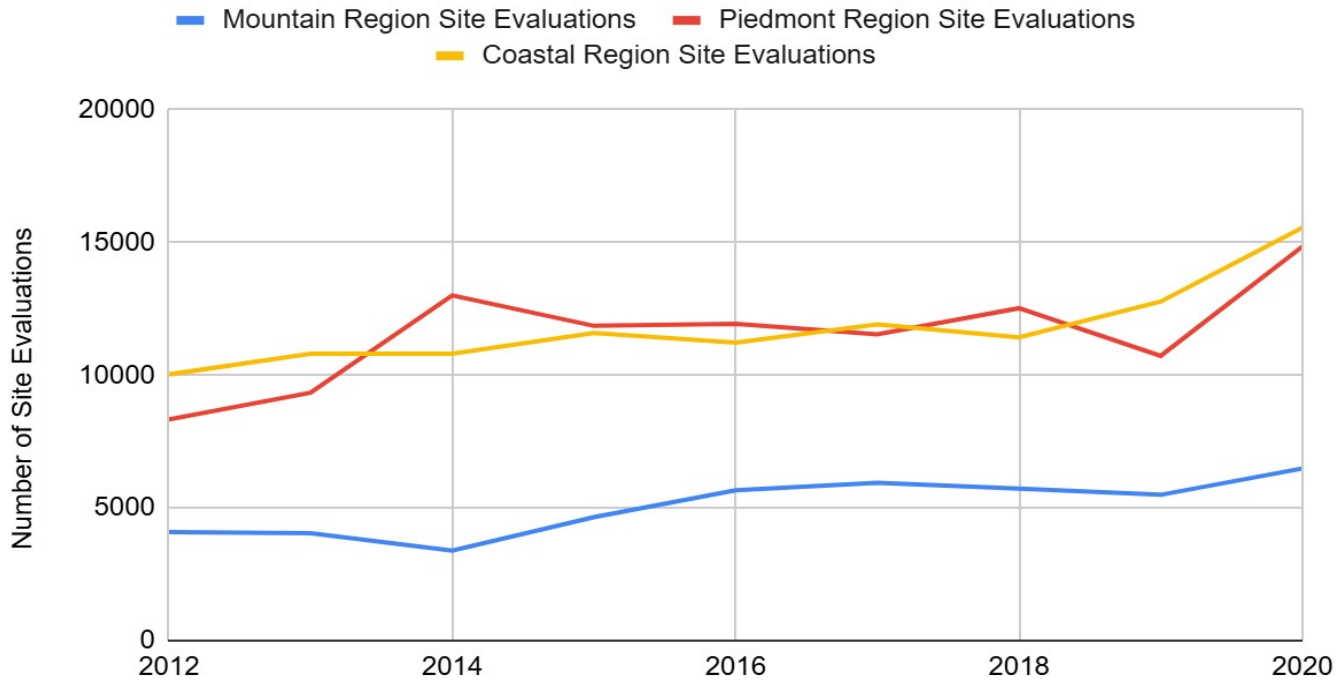


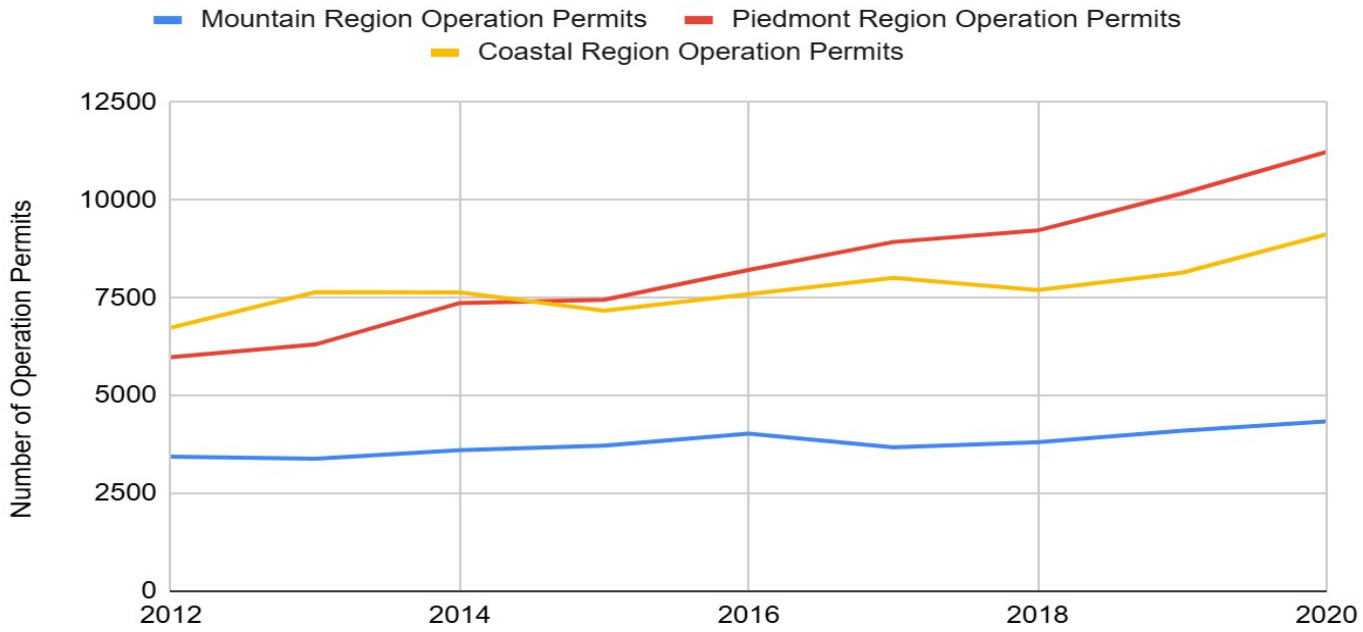
MSDs and PPEs

- MSDs affecting lower back, elbows, upper back, shoulders and wrists most common
- Boots and gloves most commonly used PPE

Hard Times

- Summer the most difficult time of year to work (70%)
- Dry soil was the most difficult moisture condition to auger through (75%)
- Piedmont was most difficult region to work in for professionals working multiple regions (65%)
- EH professionals that auger through roots more than 30% time had significantly ($p < 0.05$) higher number of MSDs ($n = 2.6$) than those who auger through roots less than 30% of the time ($n = 1$)
- EH professionals that auger through rock more than 30% of the time had significantly ($p = 0.05$) higher number of MSDs ($n = 3$) relative to those who auger through rocks less than 30% of the time ($n = 1$)





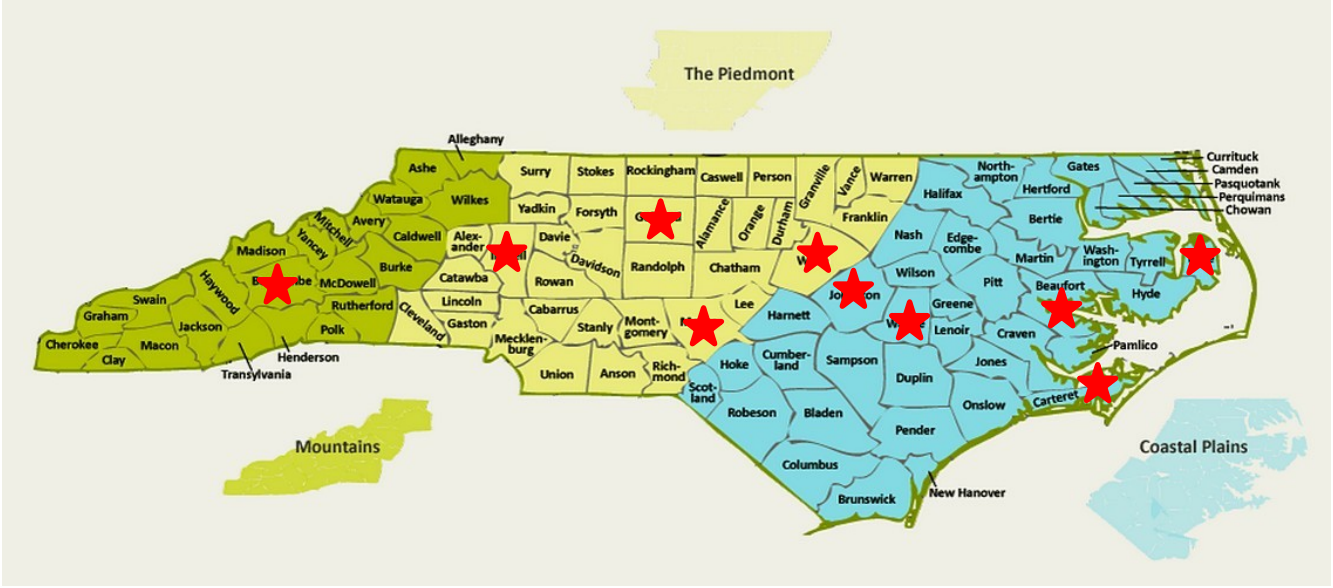
Regional Work Trends

Significant correlations between # sites visits and # permits
Mountain ($r = 0.782$, $p = 0.01$)
Piedmont ($r = 0.711$, $p = 0.03$)
Coast Pl. ($r = 0.915$, $p = < 0.01$)

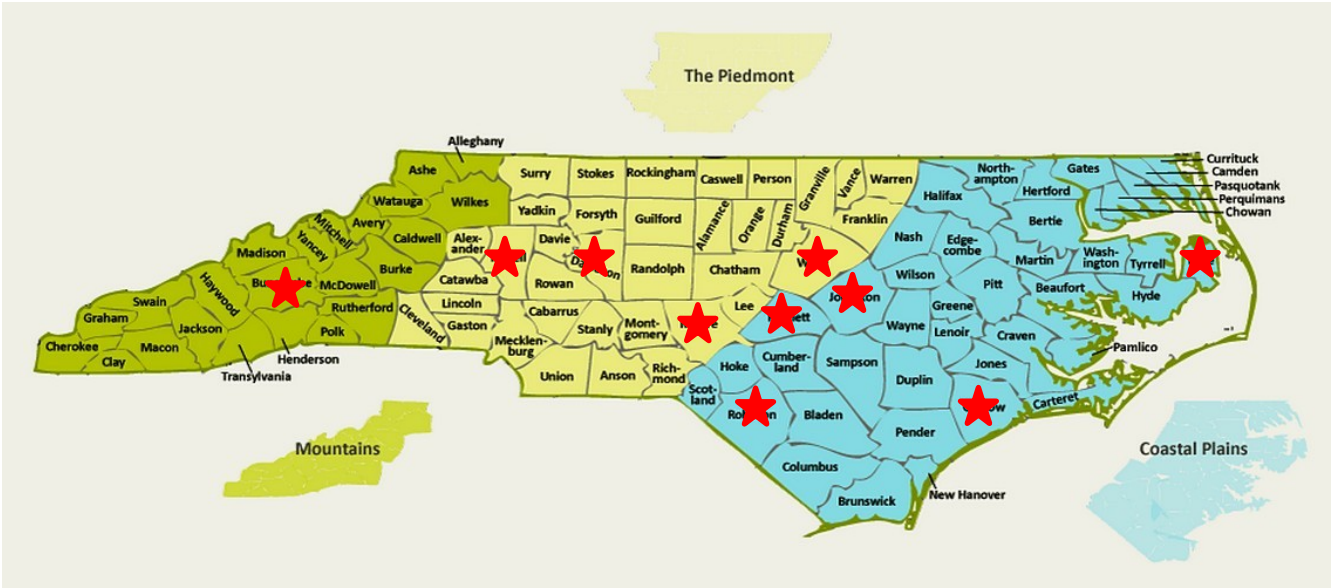
Avg annual visits & permits/county
Mountain: 232 and 149
Piedmont: 329 and 209
Coast Pl: 296 and 171

Counties with Most Site Visits and Permits

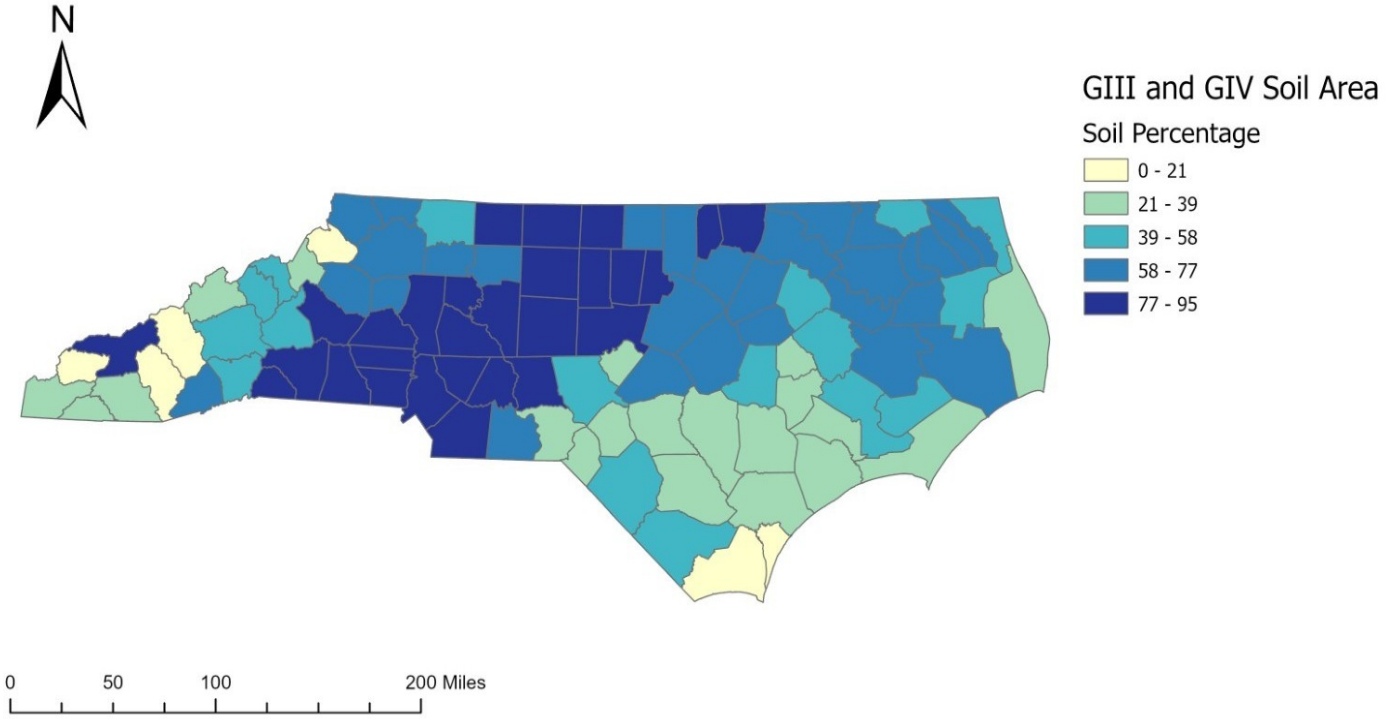
10 Counties Most Site Visits	Total Site Visits
Beaufort	5,817
Moore	6,281
Carteret	6,421
Iredell	6,501
Wayne	7,080
Guilford	8,230
Buncombe	8,473
Johnston	12,989
Wake	16,586
Dare	18,312



10 Counties Most Operation Permits	Operation Permits
Harnett	4,063
Davidson	4,415
Robeson	4,433
Moore	4,855
Iredell	4,911
Buncombe	5,194
Onslow	5,258
Dare	6,334
Johnston	9,055
Wake	12,275

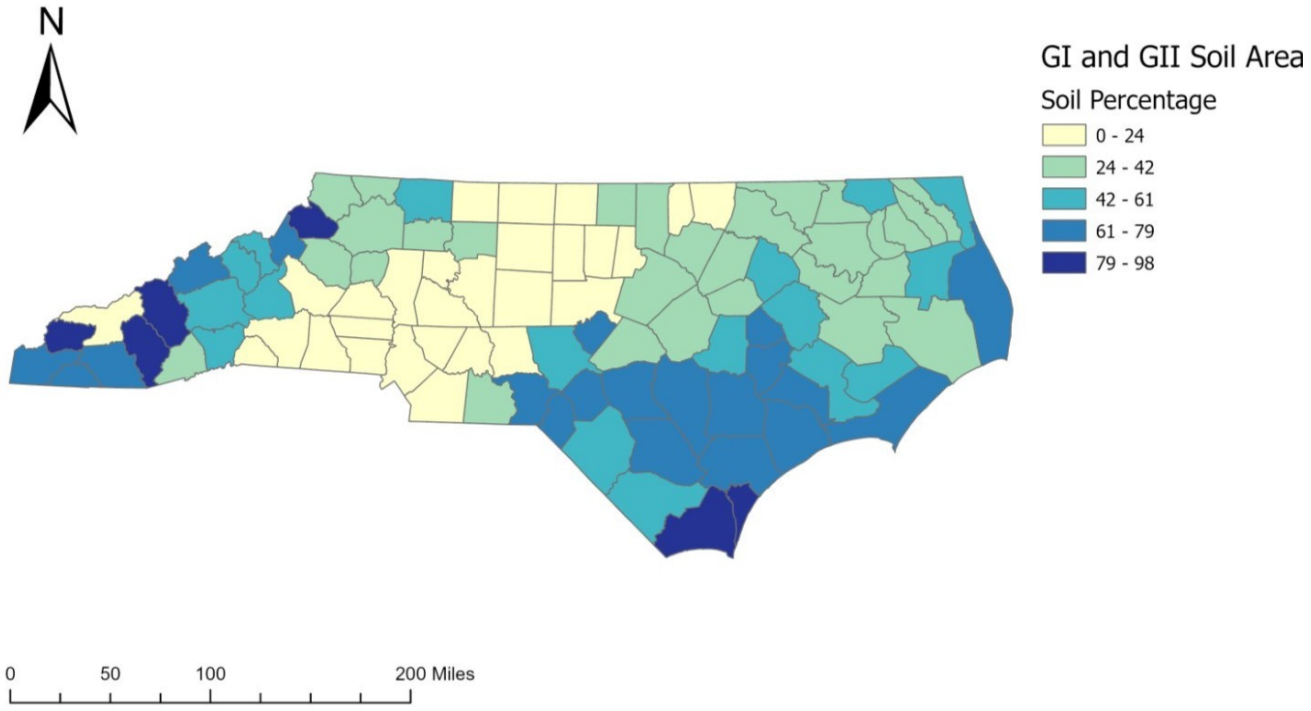


Soil Survey Results (Fine Loams and Clays)



Counties	Soil Percentage (G3 + G4)
Montgomery	95%
Randolph	95%
Cleveland	93%
Stanly	92%
Union	92%
Rowan	91%
Davie	90%
Lincoln	88%
Chatham	87%
Warren	87%

Soil Survey Results (Sands and Coarse Loams)



Counties	Soil Percentage (G1 + G2)
Watauga	98%
Haywood	95%
Graham	91%
New Hanover	87%
Jackson	81%
Brunswick	80%
Cherokee	78%
Onslow	77%
Madison	75%
Clay	74%

Help on the Way?

- No backhoe/excavator soil pit policy for 80% of respondents
- 57% of respondents with soil pit policy indicated some health benefits
- 53% of respondents indicated little to no training when first using auger regarding technique





Alternatives?

- Post hole diggers?
  - Slower
  - Also require repetitive motions
- Gas/electric powered augers?
  - Weight
  - Vibration
  - Noise
  - Mixing of soil
- Mounted probes?
  - More site disturbance
  - Accessibility to difficult sites/terrain (e.g., heavily forested, ditches,)







Respondent Comments

- “Smaller diameter buckets are easier to use in clayey soils”
- “Bucket size makes a difference”
- “After moving to a supervisor position and auguring less, the MSD symptoms are greatly reduced”
- “Thanks for doing this research, we have had multiple staff with back and neck surgeries”
- “I do strength training outside of work and feel that has benefited me in knowing how to use the auger well”

Respondent Comments

- “I feel the requirement for pits on a site significantly reduces the likelihood of MSDs in the long-term”
- “I wish I had proper training with regards to strengthening the smaller muscles that support the shoulder area”
- “Don’t strain too hard to get a hole dug, it’s a pain, but move over and dig again if you need it to save from having pain issues”
- “Get somebody else to do it”

Conclusions

1) Most (95%) of survey respondents reported at least one MSD
2) MSDs were common amongst EH professionals of all age groups and experience (Doesn’t take long to develop MSDs)
3) Back, elbow, shoulder, and wrist MSDs most reported
4) Dry, clayey soils with rocks and roots most difficult to auger in, especially during the summer
    1) Piedmont region has these characteristics (many site visits and permits)
5) Use of PPE, rest and rehab, consulting with medical professional, auger technique and ergonomics, strength training, may be important in reducing likelihood of MSDs

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Questions?