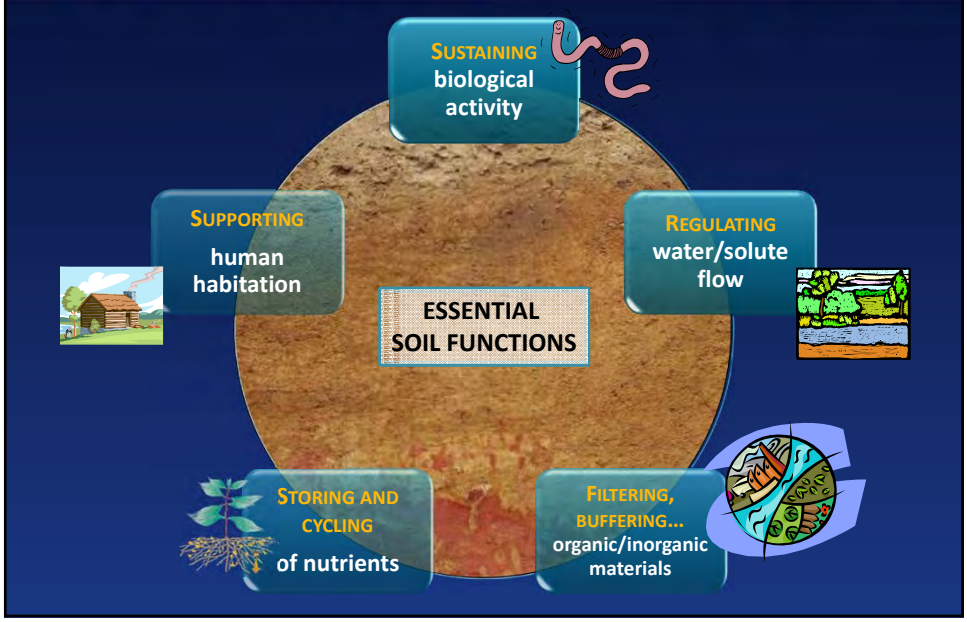
United States Department of Agriculture
Natural Resources Conservation Service

Forest Biomass Harvesting: Soil Resistance, Resilience, and Sustainability

Pamela Thomas, Ph.D.
USDA-NRCS
Columbia, SC

United States Department of Agriculture
Natural Resources Conservation Service



United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

RESISTANCE

- Capacity of a soil to resist change caused by a disturbance

RESILIENCE

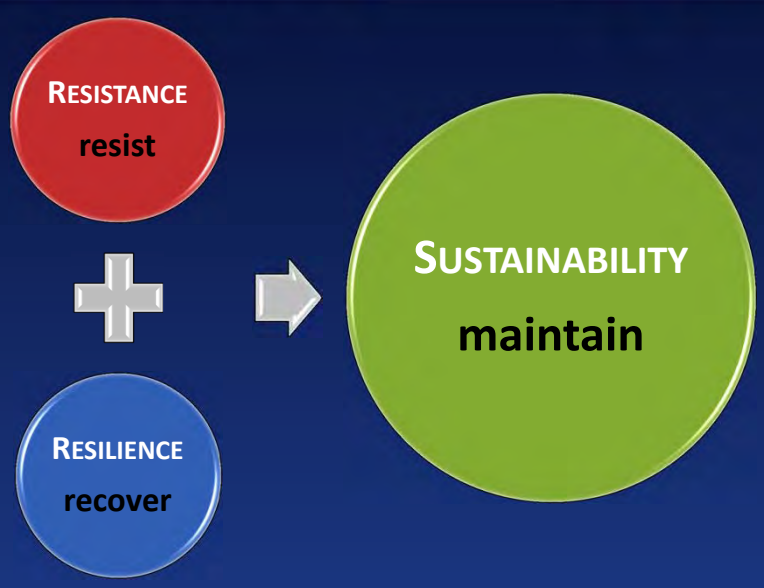
- Capacity of a soil to recover its functional and structural integrity after a disturbance

SUSTAINABILITY

- Ability of a soil to maintain function over time

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS



United States Department of Agriculture
Natural Resources Conservation Service
USDA
NRCS
Boreal conifer trees are prone to fire, but well-adapted; ecosystem rapidly regenerates.
This forest is not resistant to fire but it is highly resilient.

United States Department of Agriculture
Natural Resources Conservation Service
USDA
NRCS
Longleaf pine trees are resistant and resilient to fire.

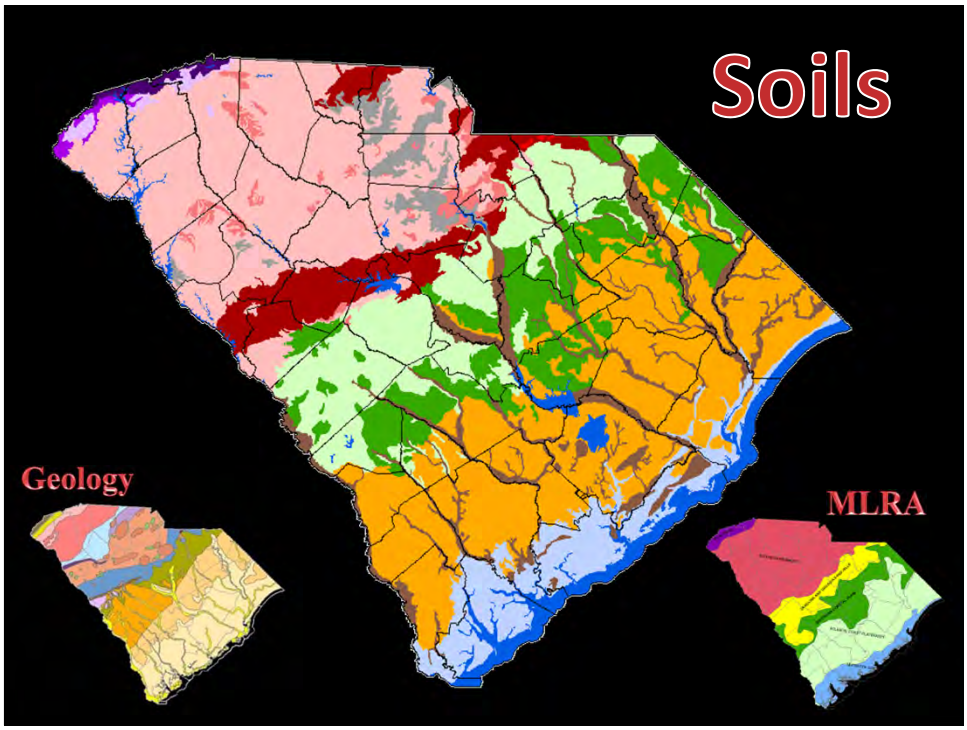
United States Department of Agriculture
Natural Resources Conservation Service

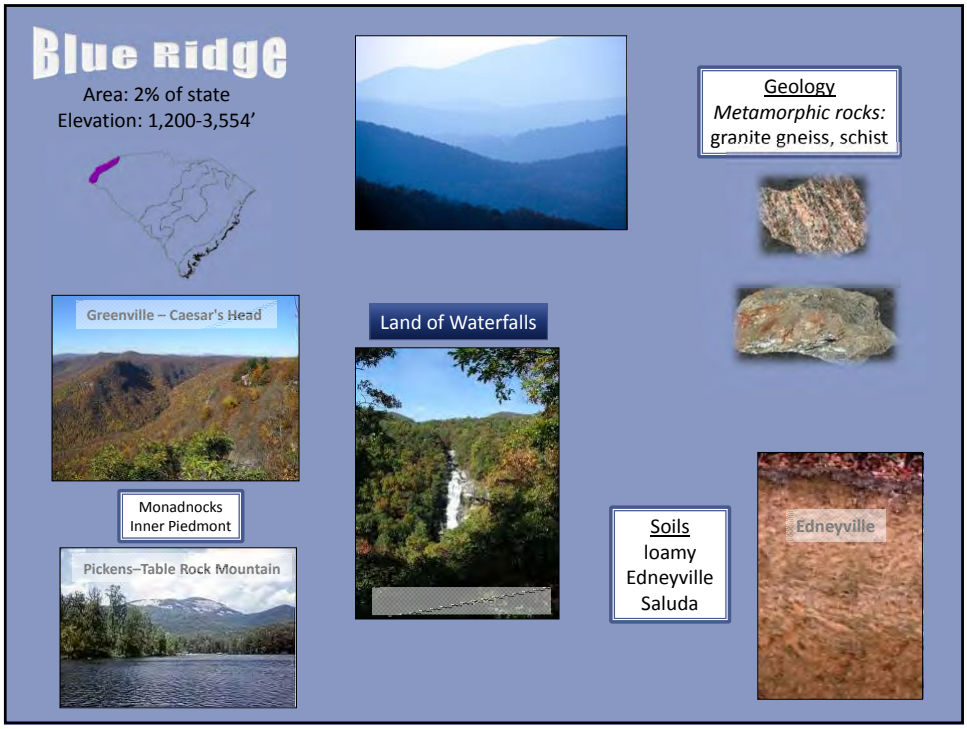
USDA NRCS

Factors Affecting Resistance and Resilience

Soils

- Vegetation
- Climate
- Land use
- Scale
- Disturbances



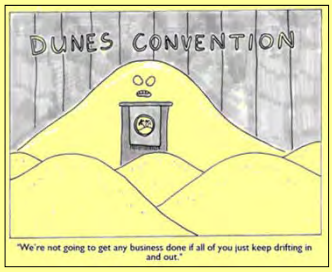

Blue Ridge
Area: 2% of state
Elevation: 1,200-3,554'
Geology
Metamorphic rocks:
granite gneiss, schist
Greenville – Caesar's Head
Land of Waterfalls
Monadnocks
Inner Piedmont
Pickens–Table Rock Mountain
Soils
loamy
Edneyville
Saluda
Edneyville

Piedmont
Area: 32% of state
Elevation: 400-1,200'
Typical Piedmont landscape
Geology
Igneous and metamorphic rocks:
granite, gneiss, diabase
Sedimentary rocks:
siltstone (Triassic Basin, Chesterfield)
Spartanburg County; 1933
Site of 1st SES erosion control
project in the southeastern U.S.
Berry Gully - Before
Berry Gully - After
Soils
deep, red, clayey
Cecil, Appling
high shrink-swell
Iredell, Brewback
Cecil
Ir. dell

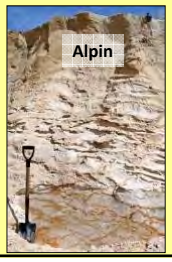
Sandhills

Area: 15% of state
Elevation: 200-600'

Geology
Eolian sands
Ancient river deposits
Weathered clays



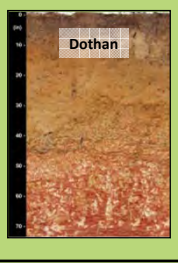
Soils
sandy to fine-loamy
Alpin, Ailey



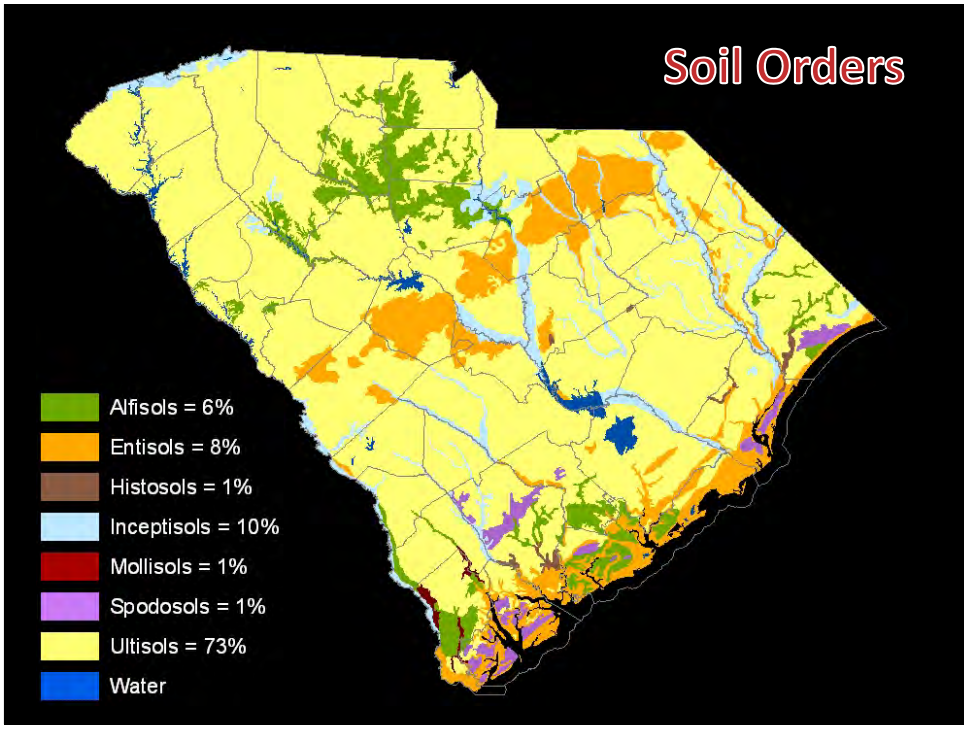
Coastal Plain

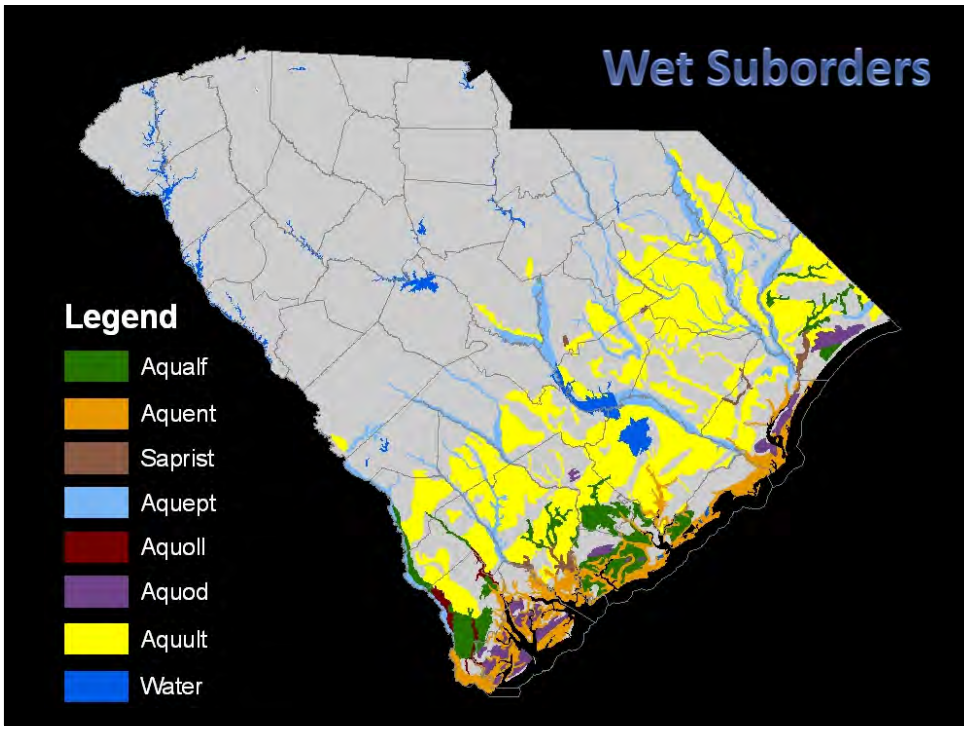
Area: 50% of state
Elevation: 0-640'

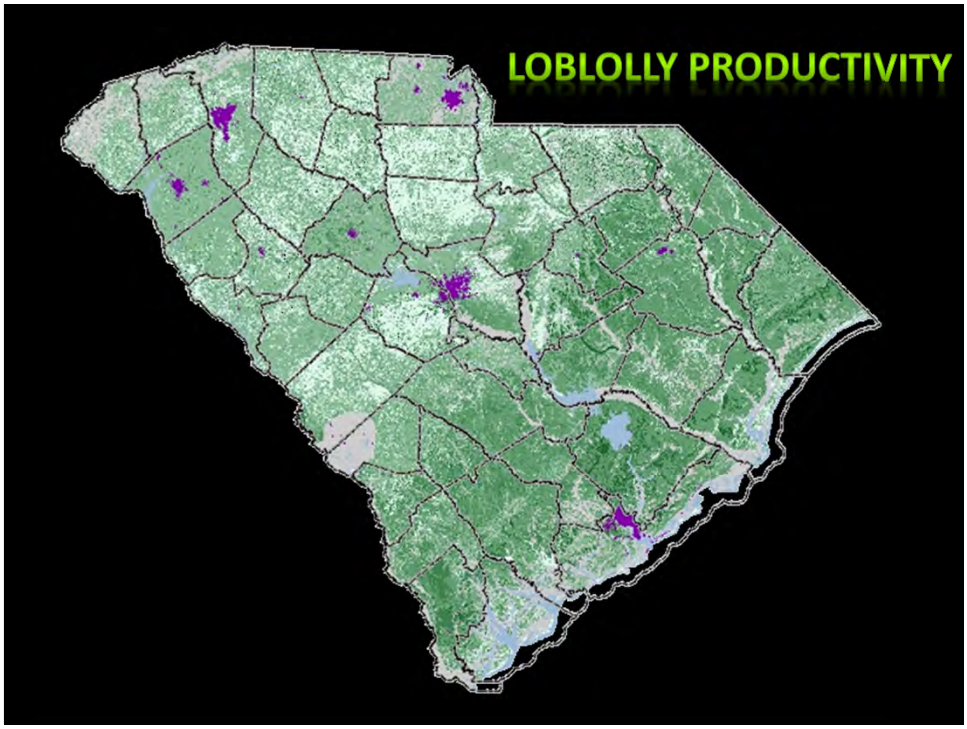
Geology
Marine deposits
River deposits



Soils
sandy to clayey
well drained to very poorly drained
Dothan (well drained)
Rains (poorly drained)


Soil Orders
Alfisols = 6%
Entisols = 8%
Histosols = 1%
Inceptisols = 10%
Mollisols = 1%
Spodosols = 1%
Ultisols = 73%
Water


Wet Suborders
Legend
Aqualf
Aquent
Saprist
Aquept
Aquoll
Aquod
Aquult
Water



United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Potential Harvesting Impacts on Soils

Exposure of soil surface

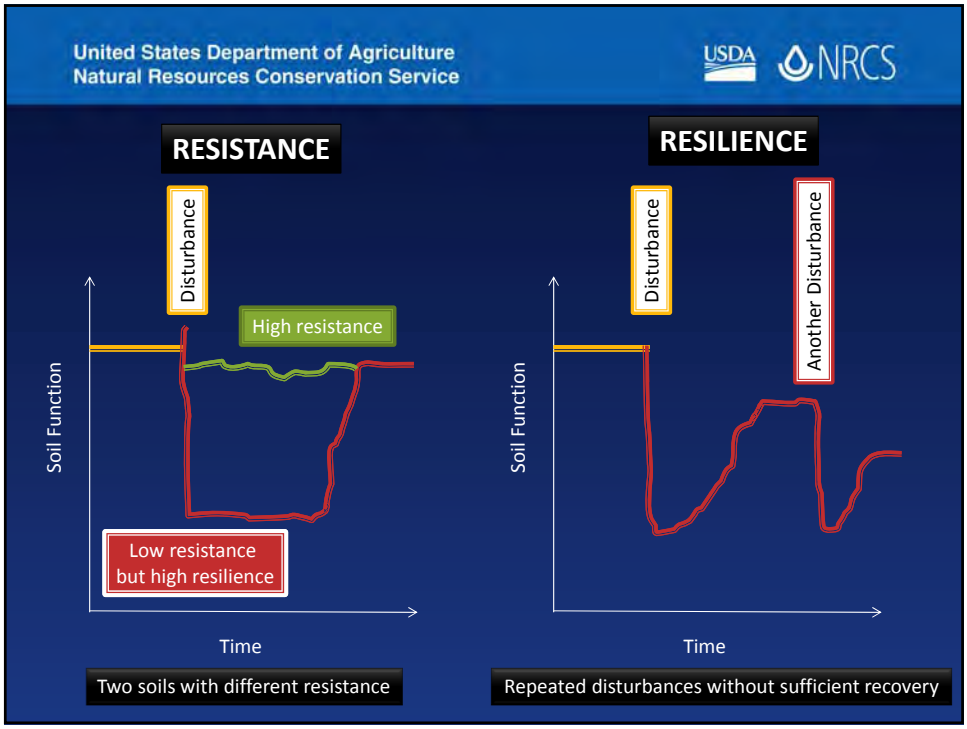
- Drying of surface layer, Temperature extremes, Erosion

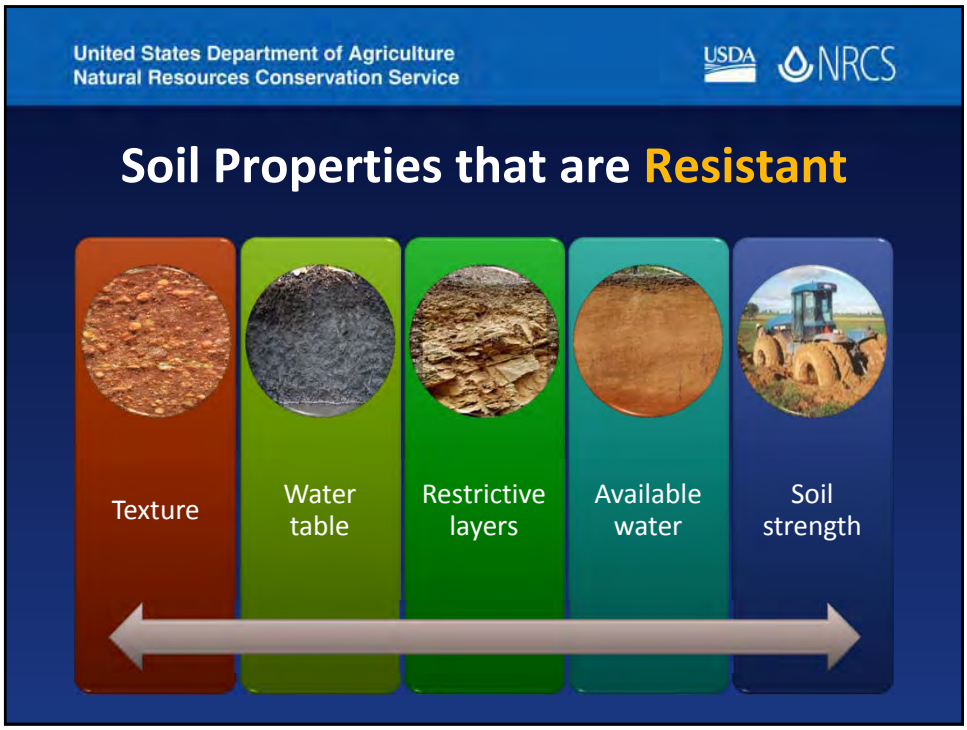
Compaction

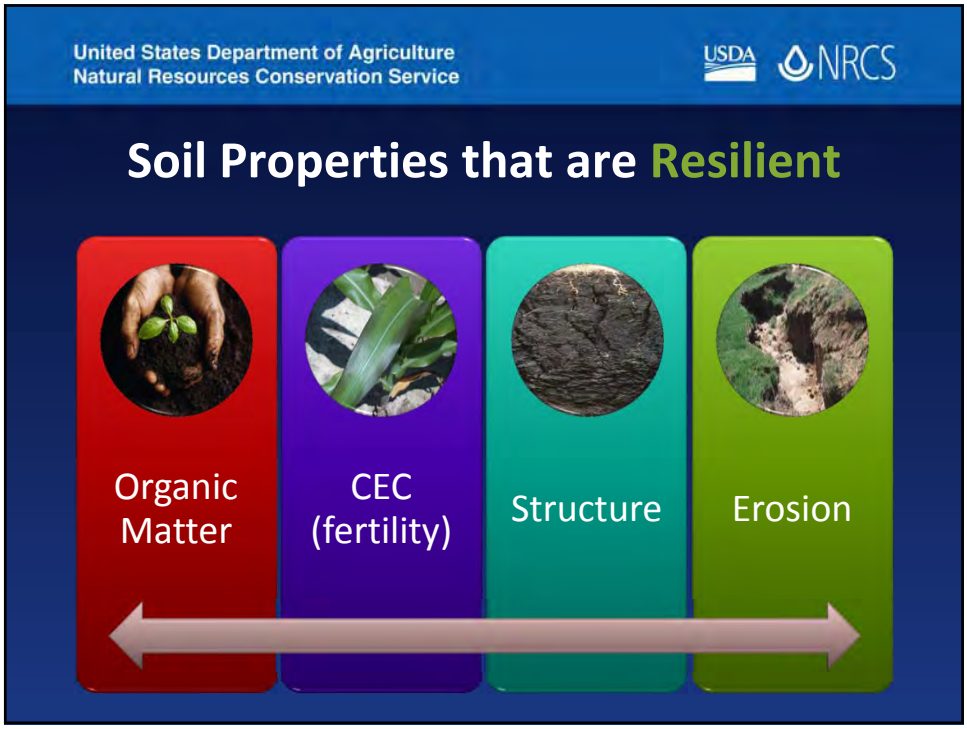
- Decreased porosity/oxygen/infiltration
- Waterlogged ruts

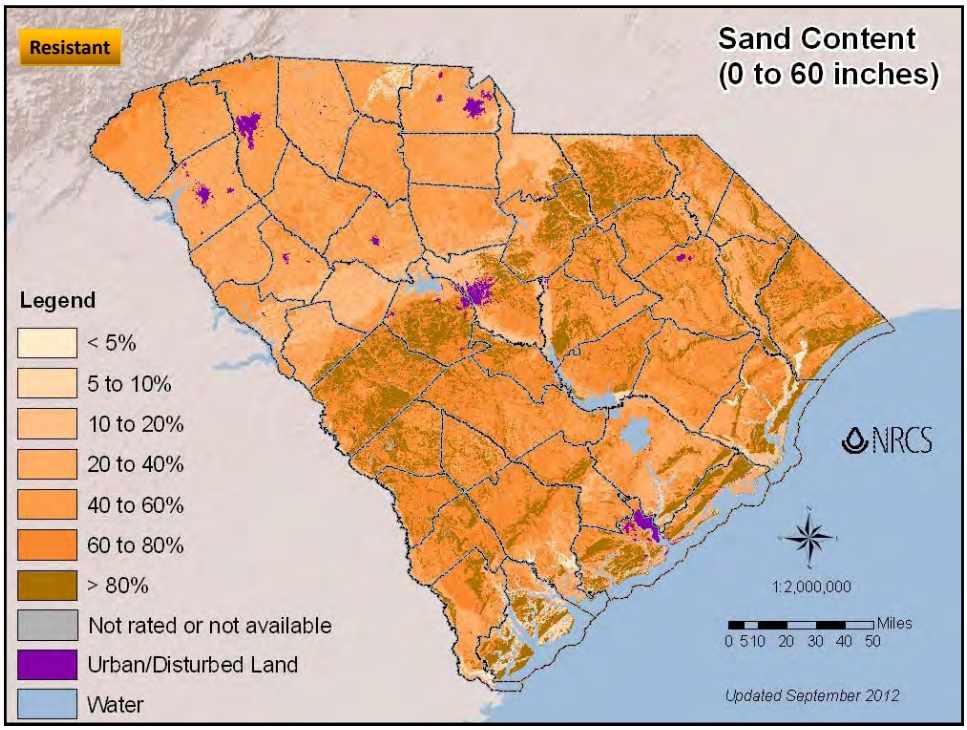
Nutrient removal

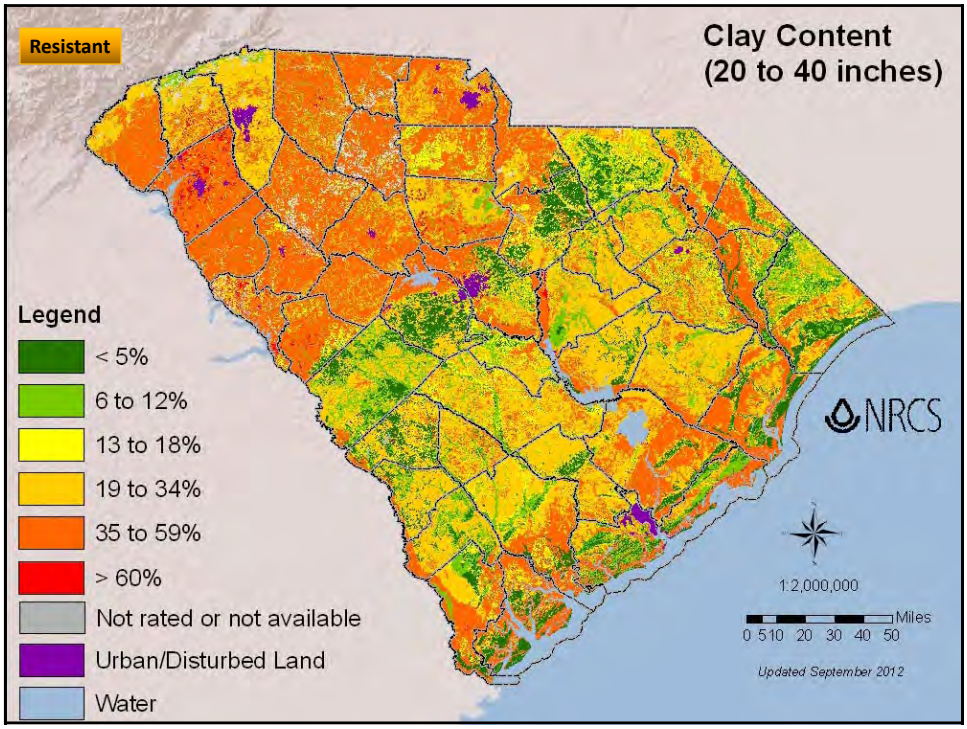
Accumulation of toxic substances

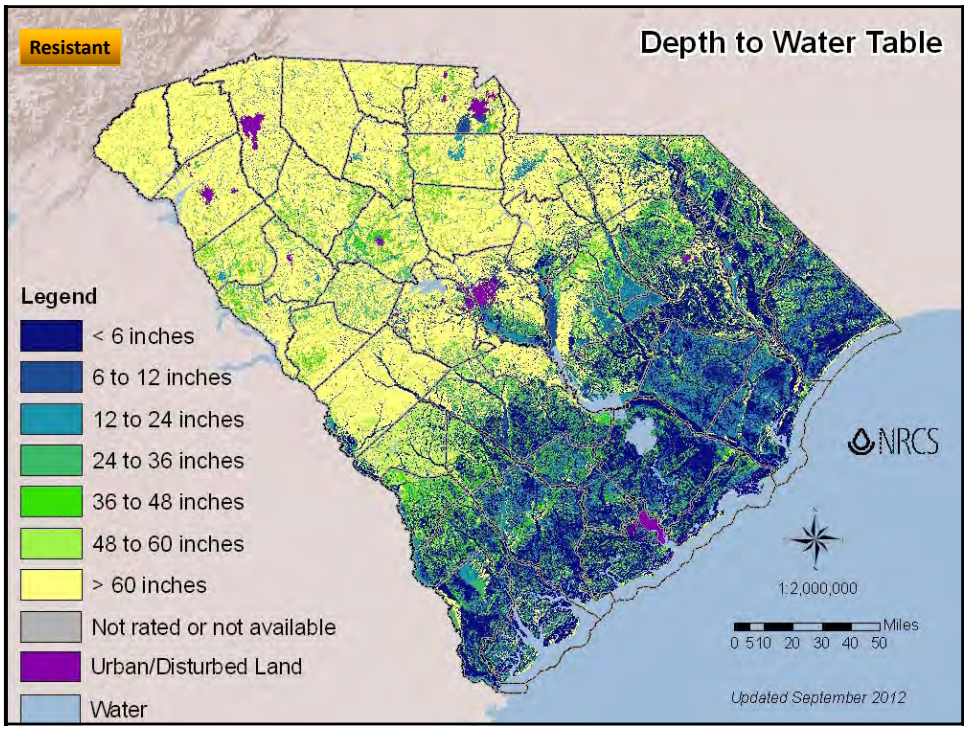

United States Department of Agriculture
Natural Resources Conservation Service
USDA
NRCS
RESISTANCE
Disturbance
High resistance
Soil Function
Low resistance
but high resilience
Time
Two soils with different resistance
RESILIENCE
Disturbance
Another Disturbance
Soil Function
Time
Repeated disturbances without sufficient recovery

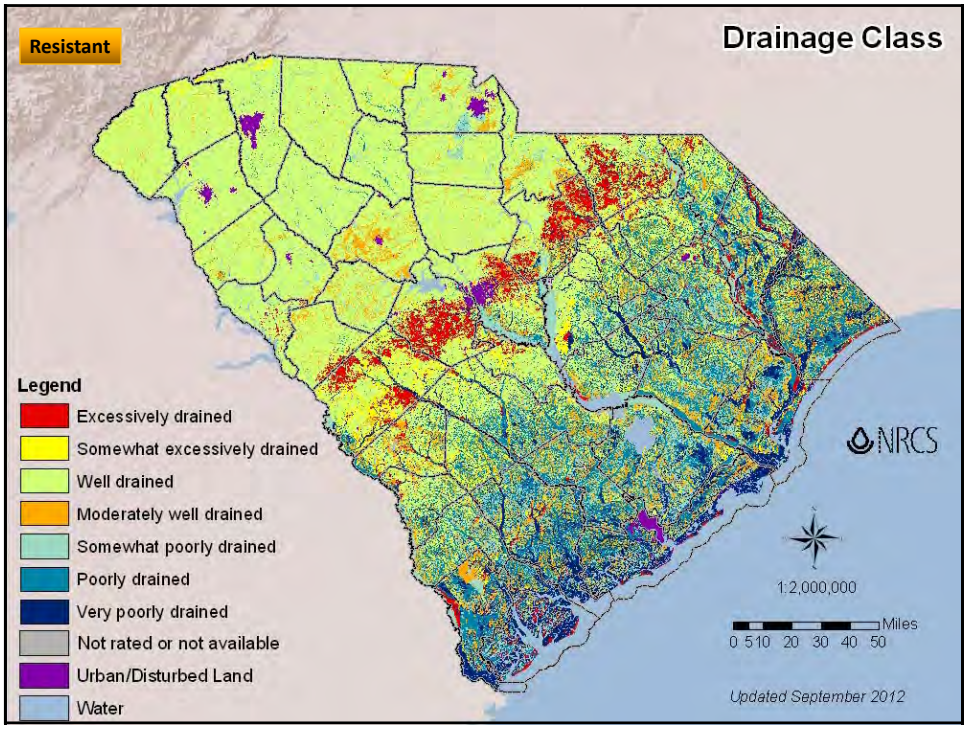

United States Department of Agriculture
Natural Resources Conservation Service
USDA
NRCS
Soil Properties that are Resistant
Texture
Water table
Restrictive layers
Available water
Soil strength

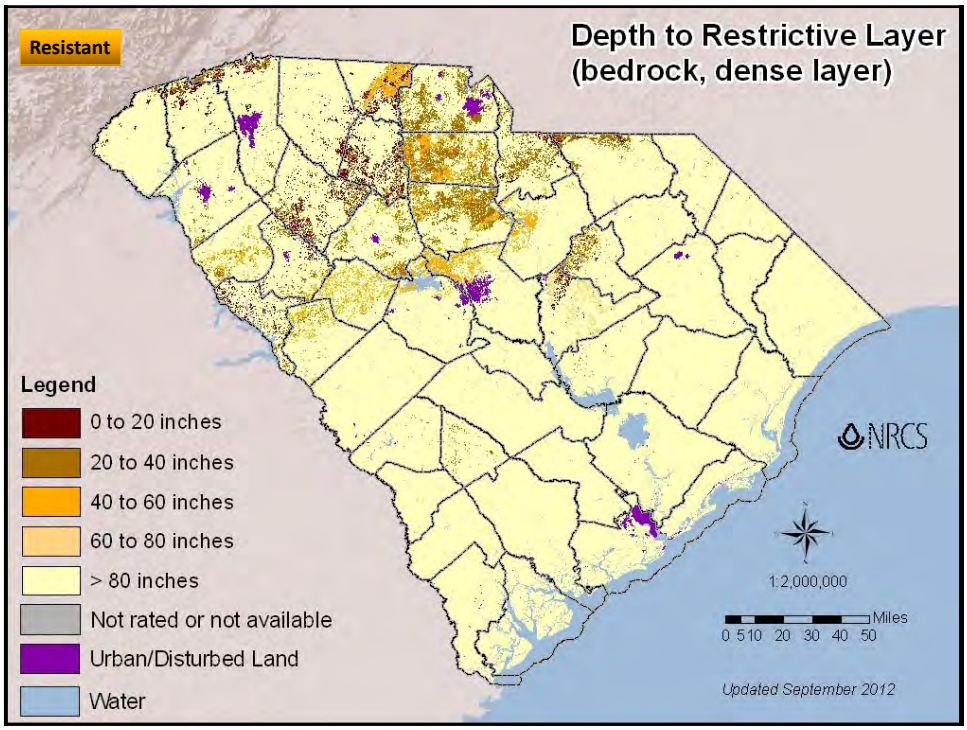

United States Department of Agriculture
Natural Resources Conservation Service
USDA
NRCS
Soil Properties that are Resilient
Organic Matter
CEC (fertility)
Structure
Erosion

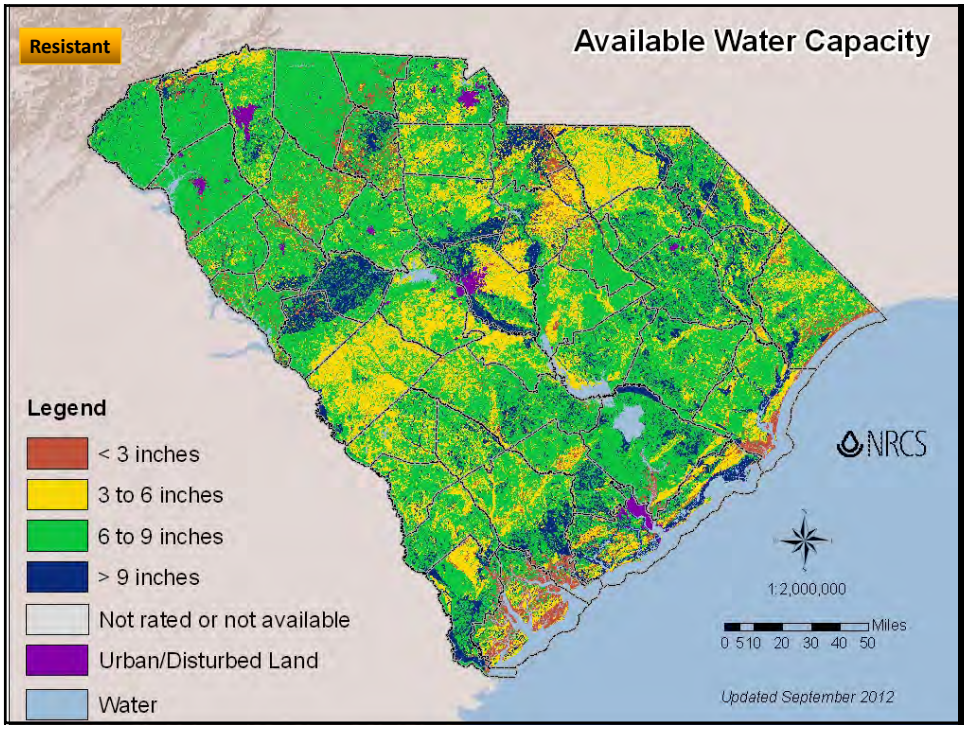

Resistant
Sand Content
(0 to 60 inches)
Legend
< 5%
5 to 10%
10 to 20%
20 to 40%
40 to 60%
60 to 80%
> 80%
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

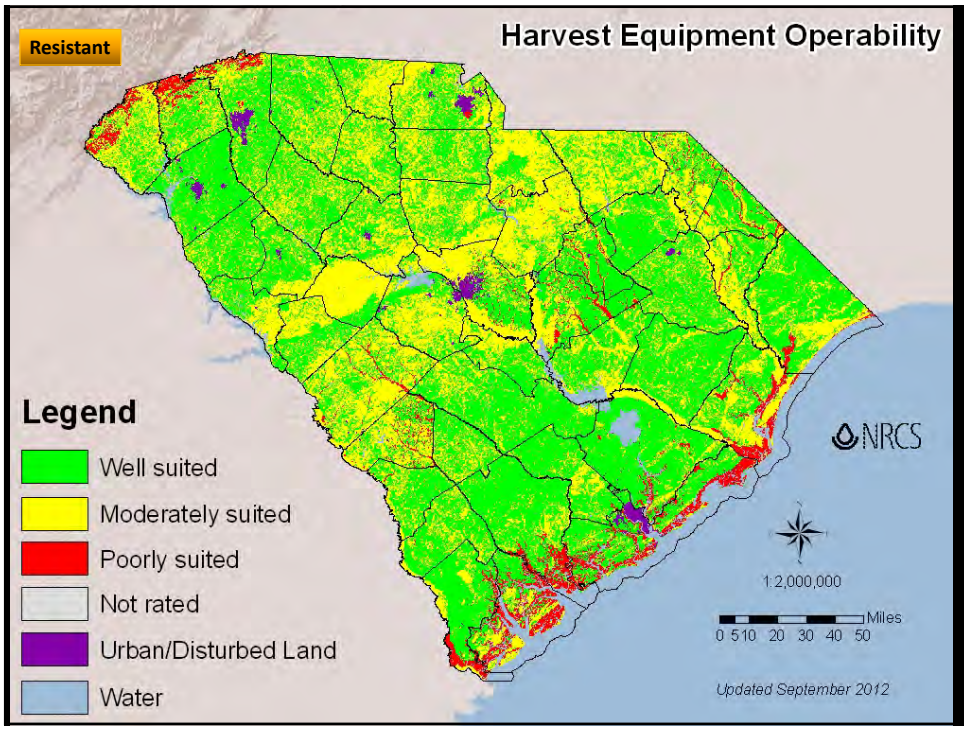

Resistant
Clay Content
(20 to 40 inches)
Legend
< 5%
6 to 12%
13 to 18%
19 to 34%
35 to 59%
> 60%
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

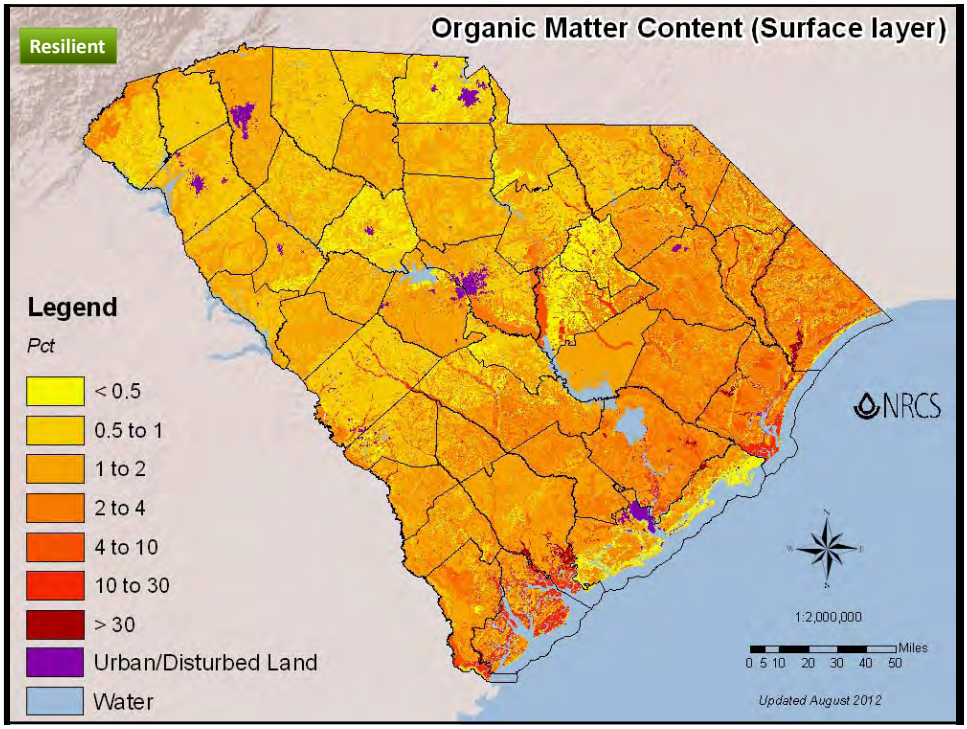

Resistant
Depth to Water Table
Legend
< 6 inches
6 to 12 inches
12 to 24 inches
24 to 36 inches
36 to 48 inches
48 to 60 inches
> 60 inches
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

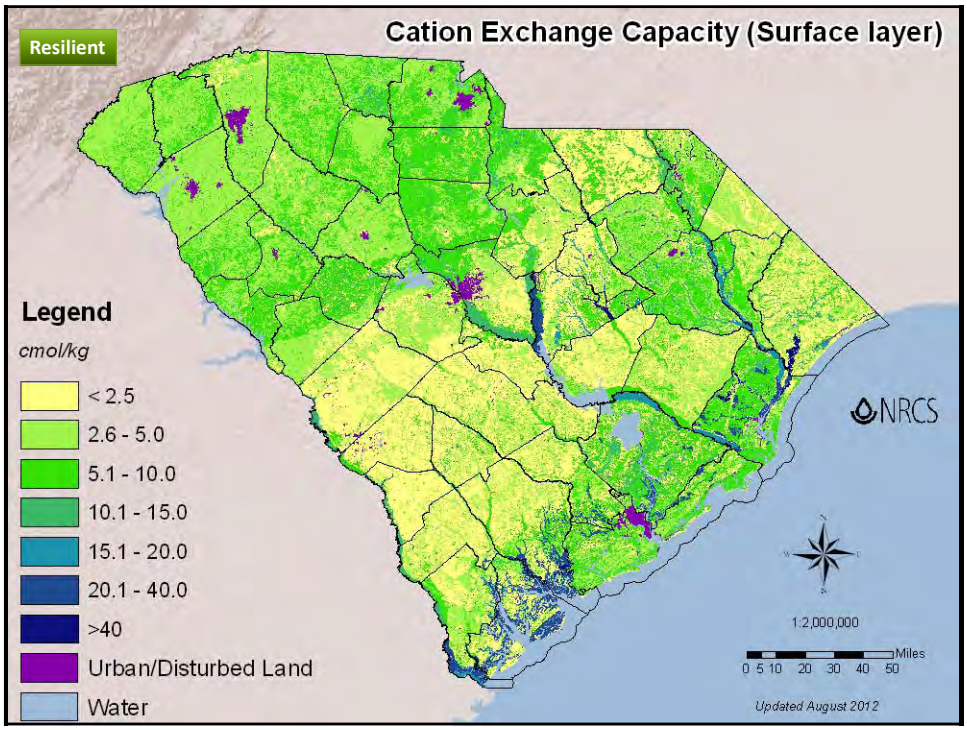

Resistant
Drainage Class
Legend
Excessively drained
Somewhat excessively drained
Well drained
Moderately well drained
Somewhat poorly drained
Poorly drained
Very poorly drained
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

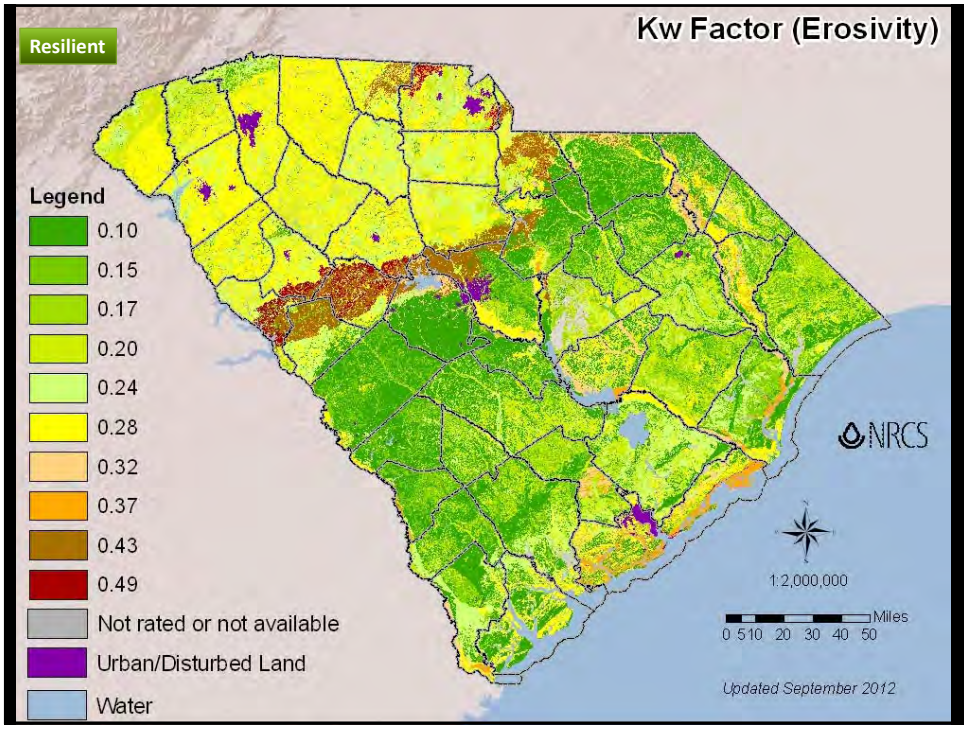

Resistant
Depth to Restrictive Layer
(bedrock, dense layer)
Legend
0 to 20 inches
20 to 40 inches
40 to 60 inches
60 to 80 inches
> 80 inches
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

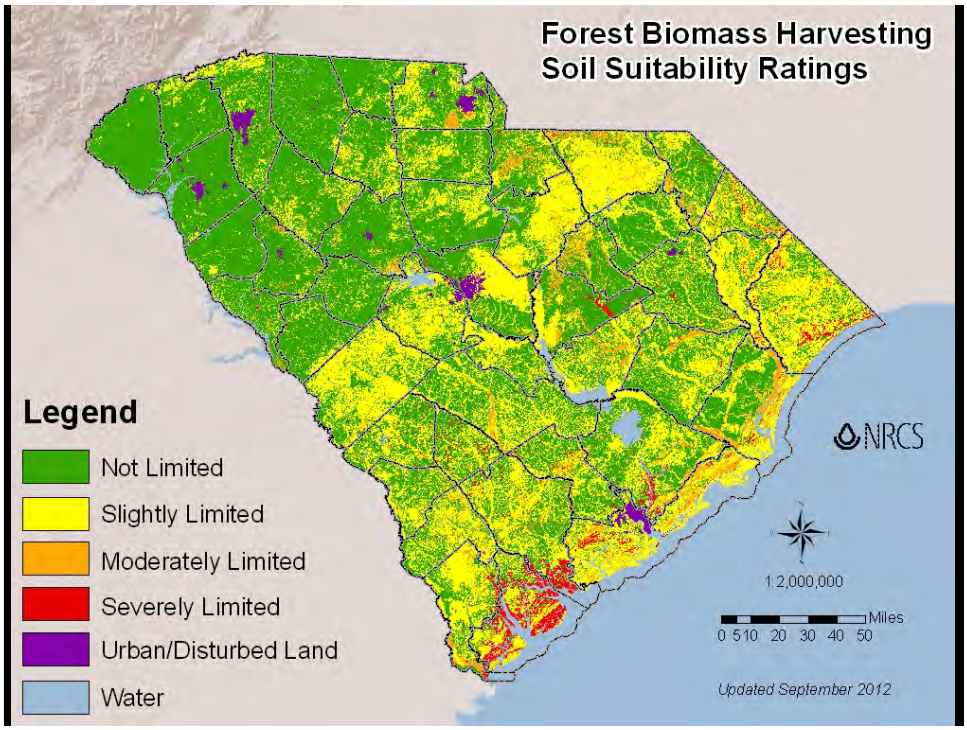

Resistant
Available Water Capacity
Legend
< 3 inches
3 to 6 inches
6 to 9 inches
> 9 inches
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

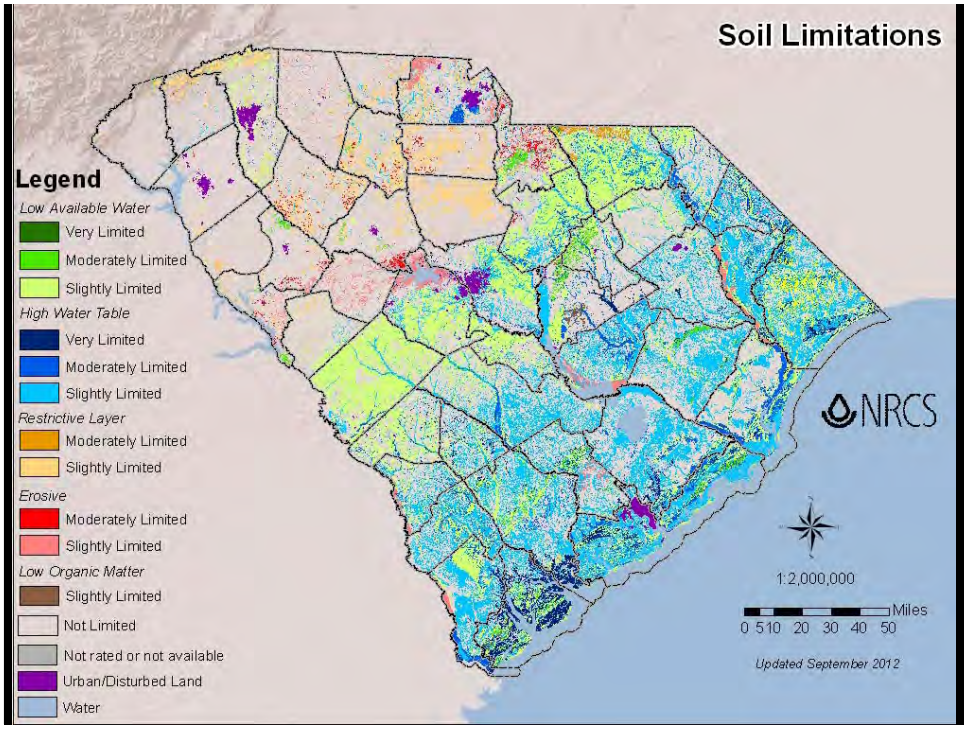

Resistant
Harvest Equipment Operability
Legend
Well suited
Moderately suited
Poorly suited
Not rated
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

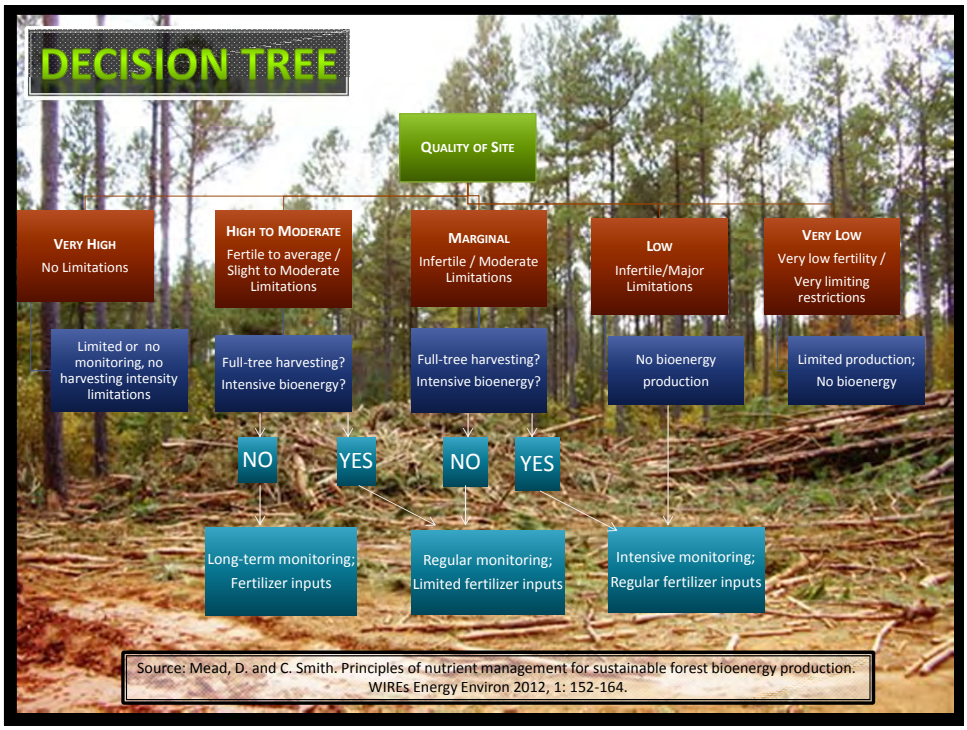

Resilient
Organic Matter Content (Surface layer)
Legend
Pct
< 0.5
0.5 to 1
1 to 2
2 to 4
4 to 10
10 to 30
> 30
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated August 2012


Resilient
Cation Exchange Capacity (Surface layer)
Legend
cmol/kg
< 2.5
2.6 - 5.0
5.1 - 10.0
10.1 - 15.0
15.1 - 20.0
20.1 - 40.0
>40
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated August 2012


Resilient
Kw Factor (Erosivity)
Legend
0.10
0.15
0.17
0.20
0.24
0.28
0.32
0.37
0.43
0.49
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012


Forest Biomass Harvesting
Soil Suitability Ratings
Legend
Not Limited
Slightly Limited
Moderately Limited
Severely Limited
Urban/Disturbed Land
Water
NRCS
1:2,000,000
Miles
0 5 10 20 30 40 50
Updated September 2012

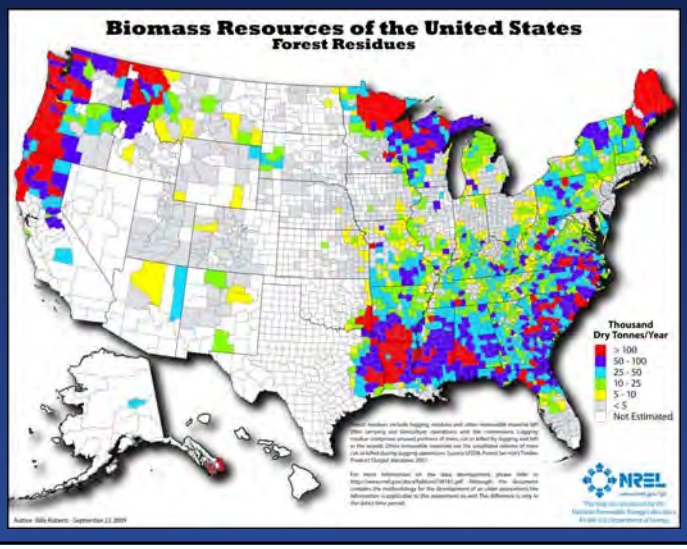

Soil Limitations
Legend
Low Available Water
Very Limited
Moderately Limited
Slightly Limited
High Water Table
Very Limited
Moderately Limited
Slightly Limited
Restrictive Layer
Moderately Limited
Slightly Limited
Erosive
Moderately Limited
Slightly Limited
Low Organic Matter
Slightly Limited
Not Limited
Not rated or not available
Urban/Disturbed Land
Water
NRCS
1:2,000,000
0 5 10 20 30 40 50
Miles
Updated September 2012


DECISION TREE
Quality of Site
Very High
No Limitations
High to Moderate
Fertile to average / Slight to Moderate Limitations
Marginal
Infertile / Moderate Limitations
Low
Infertile/Major Limitations
Very Low
Very low fertility / Very limiting restrictions
Limited or no monitoring, no harvesting intensity limitations
Full-tree harvesting? Intensive bioenergy?
Full-tree harvesting? Intensive bioenergy?
No bioenergy production
Limited production; No bioenergy
NO
YES
NO
YES
Long-term monitoring; Fertilizer inputs
Regular monitoring; Limited fertilizer inputs
Intensive monitoring; Regular fertilizer inputs
Source: Mead, D. and C. Smith. Principles of nutrient management for sustainable forest bioenergy production. WIREs Energy Environ 2012, 1: 152-164.

United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Questions, Comments, Rebuttals…



United States Department of Agriculture
Natural Resources Conservation Service

USDA NRCS

Additional Information

Pamela J. Thomas, Ph.D.
State Soil Scientist

NRCS

United States Department of Agriculture
Natural Resources Conservation Service

1835 Assembly Street, Room 950
Columbia, SC 29201

Voice: (803) 253-3896 • FAX: (803) 253-3670
Email: pam.thomas@sc.usda.gov

http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm