Factors Determining Thresholds of Reliable Change Detection in Water Quality Resulting from Stream Restoration: A question of signal to noise.

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History and Drivers for Water Quality Measurement in Restoration/Mitigation in NC

- Water quality improvement is often stated as a goal in restoration, but infrequently measured **Palmer et al., (2007)**
- The functional efficacy of restoration for pollutant attenuation absent watershed controls has been questioned, particularly in urban settings**. Walsh et al., 2005; Bernhardt and Palmer, 2007; Selvakumar et al., 2010.**
- The last decade has shown a range of results, but understanding efficacy considering scale, setting, and specific practices still requires attention. (**Craig et al., 2008; Palmer et al. (2014**); **Newcomer Johnsen et al., (2016); Lammers and Bledsoe (2017)**
- 2008 Federal Mitigation rule requiring "ecological performance standards" **USACE 33CFR 325, 332; USEPA 40CFR 230**
- NCIRT encourages/incentivizes water quality assessment **USACE Federal Public Notice October 24, 2016**

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DMS Resources and Opportunity to Evaluate WQ in Mitigation

1. Large provider of Mitigation in NC.

2. Opportunity for long term observation and monitoring.

3. Tied to a robust watershed planning approach.

DMS Objectives for Water Quality Monitoring of Mitigation

1. Provide case examples of water quality response to restoration for settings and mitigation practices in NC.

2. Gain understanding of the relative efficacy of different practices.

3. Gain understanding of the time frames of improvement and their sustainability.

4. Utilize data collected to potentially refine current models in use in mitigation plans for pollutant reduction estimates.

5. **Gain an understanding of the reach and watershed attributes that inform detection of change in water quality to help refine stated mitigation plan goals (i.e. examine a gradient of "signal to noise")**

6. Gain understanding of sampling regime necessary

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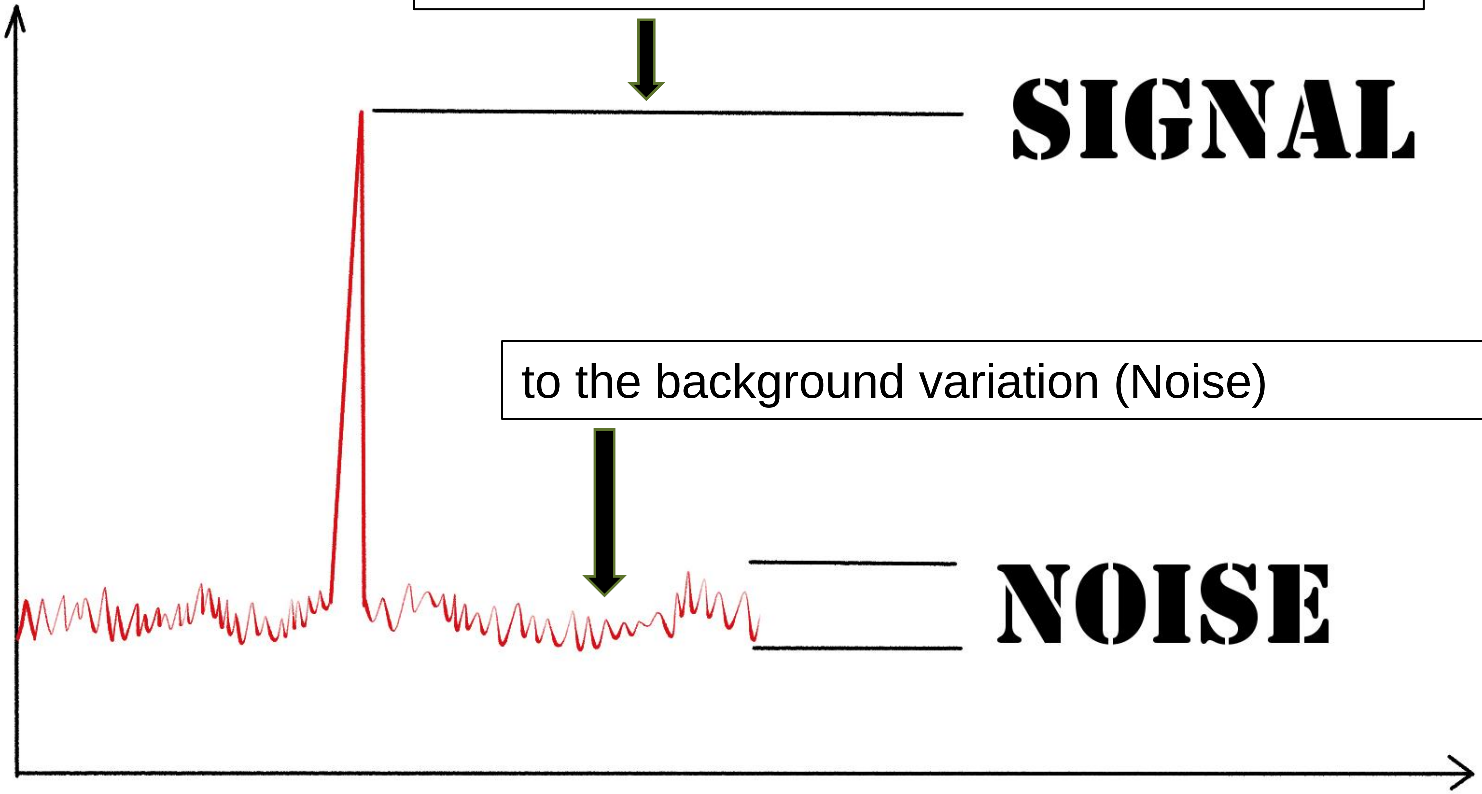
General Concept of Signal to Noise

The separation or relative magnitude of what you want to measure (Signal).



Larger the difference in magnitude (i.e. larger the signal to noise ratio), the greater resolving power for detecting differences/changes)

Categories of Reach and Watershed Attributes that Characterize Signal to Noise

1. Spatial Distribution / Proportions of Stressor Areas Treated

2. Stressor Intensity

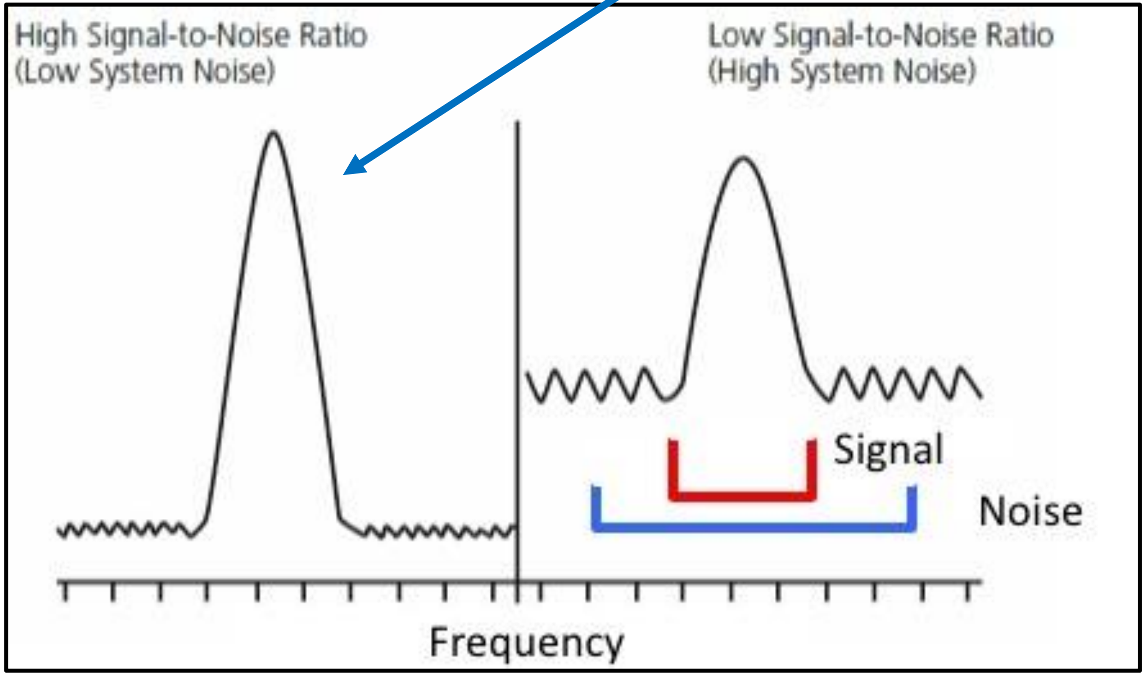
3. Stressor Types

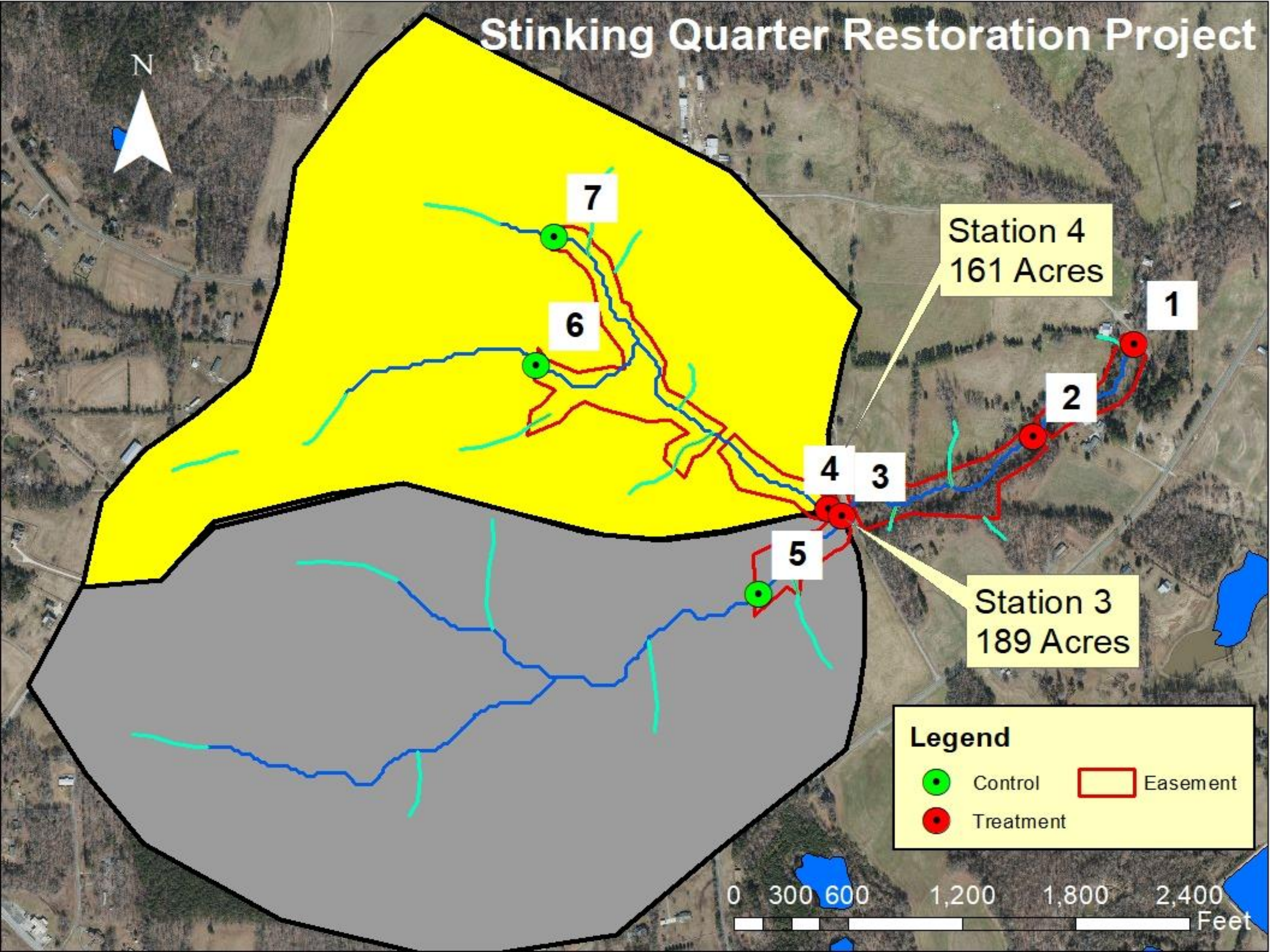
Concept of Signal to Noise in Restoration Context

1. Distributions of Stressor Areas

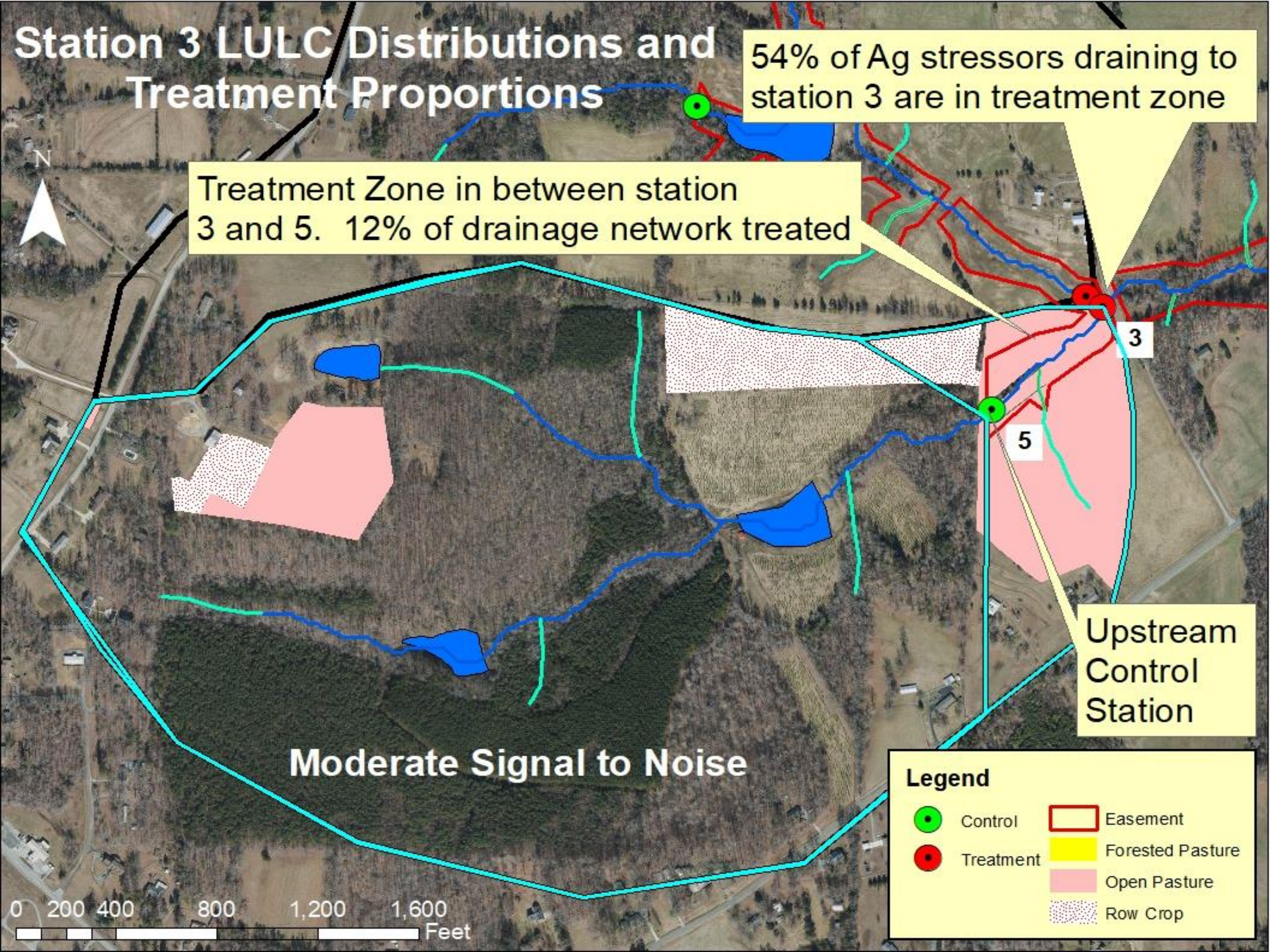
2. Stressor Intensity

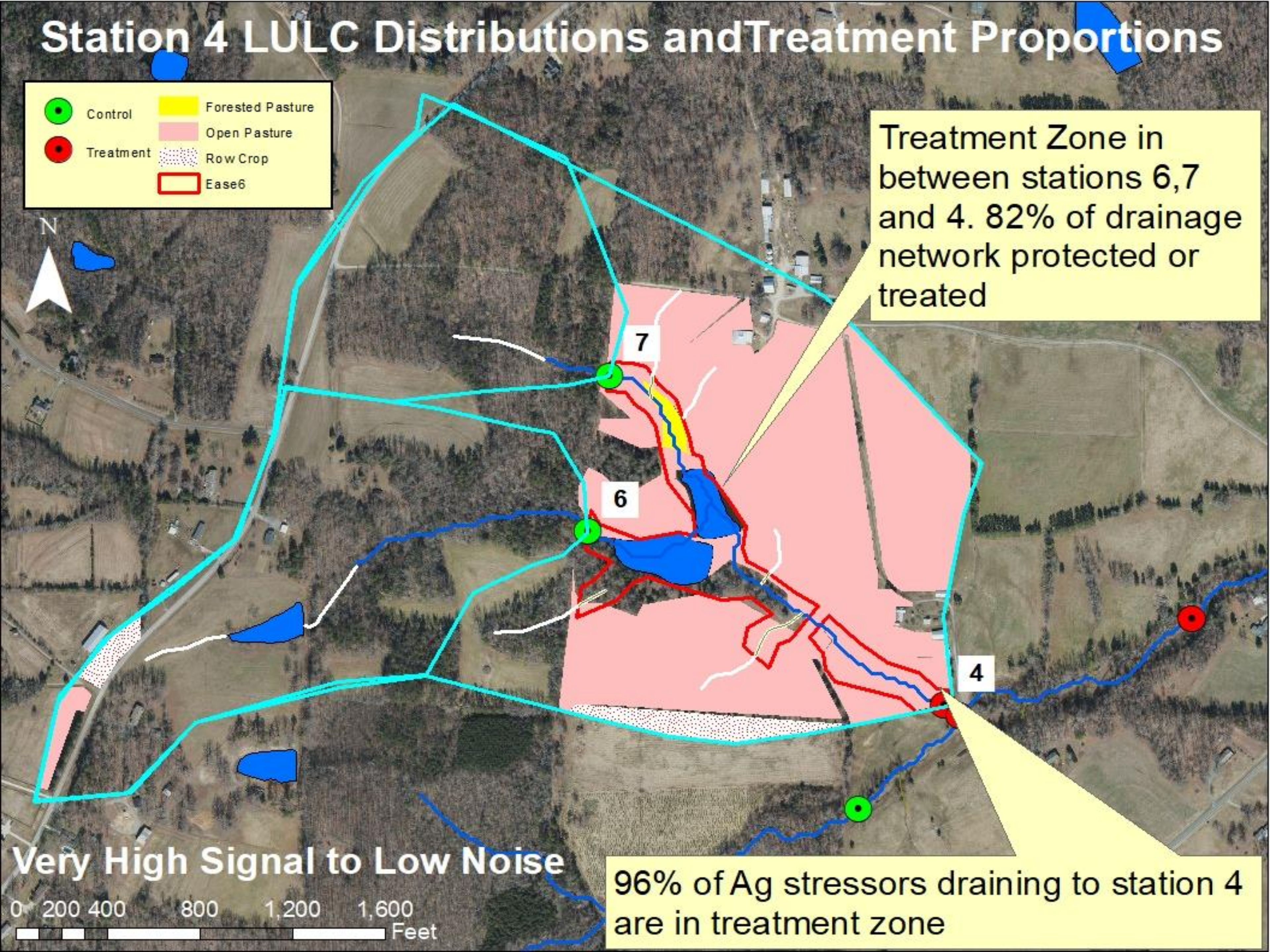
The combination of these can be viewed as the overall stressor load at the downstream 'treatment' station for a reach. The greater the proportion of items 1 and 2 that exists within the treatment area (i.e. protected and treated via restoration) the greater the likelihood of reliable detection in change or improvement. High signal to low noise. **Better resolving power**

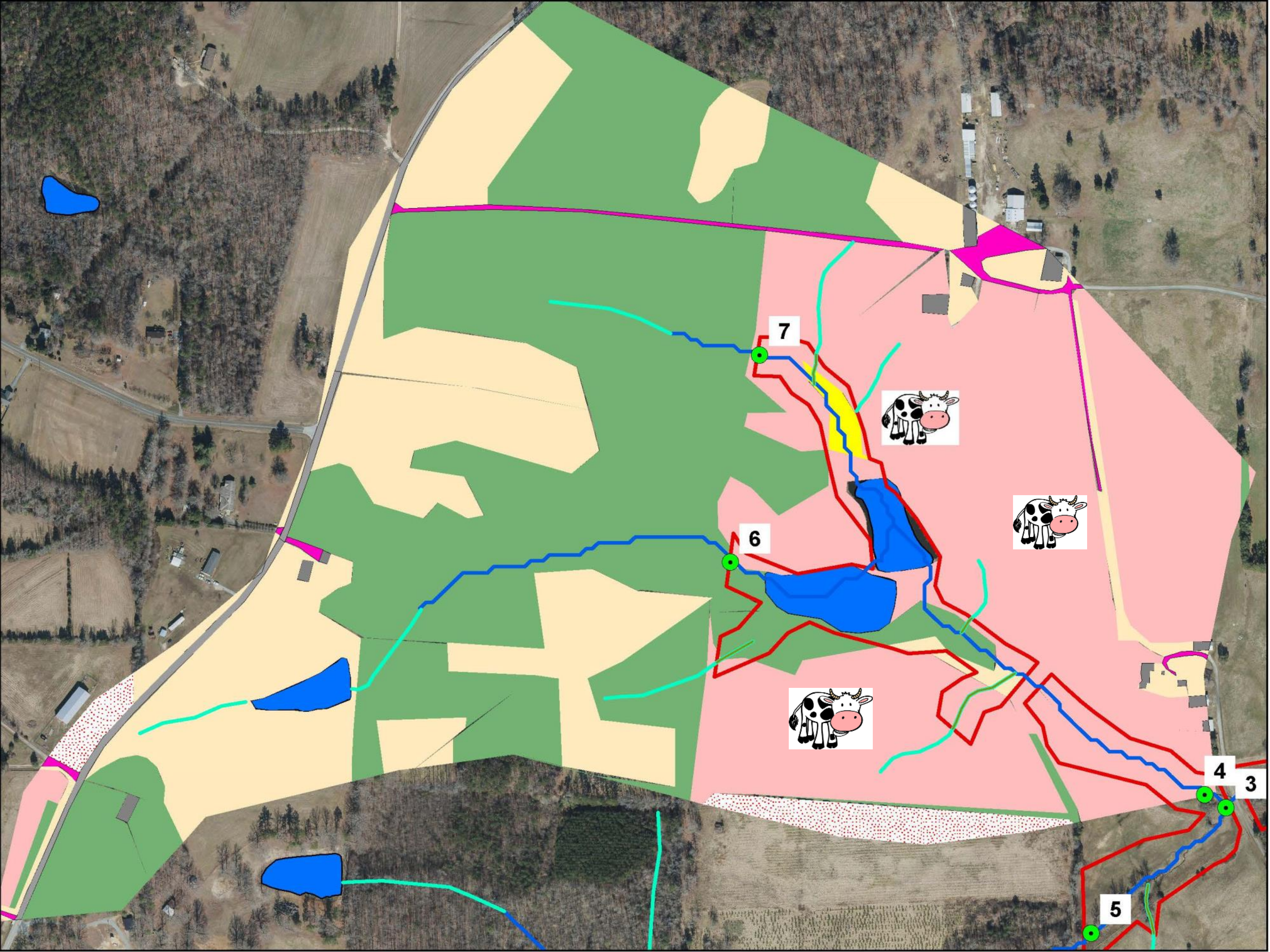




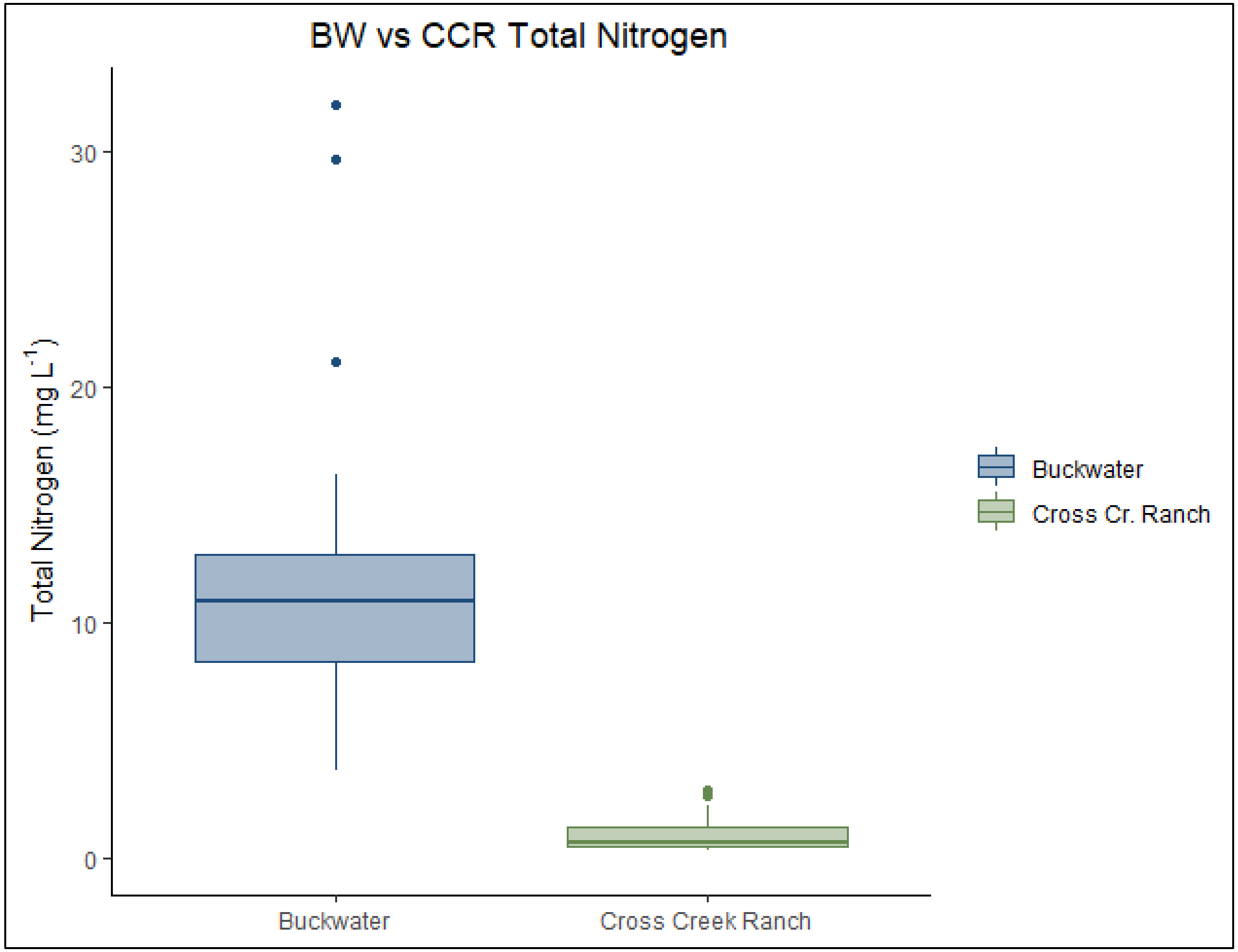
Stinking Quarter Restoration Project
N
7
6
Station 4
161 Acres
1
2
4
3
5
Station 3
189 Acres
Legend
Control
Treatment
Easement
0
300
600
1,200
1,800
2,400
Feet


Station 3 LULC Distributions and
Treatment Proportions
54% of Ag stressors draining to
station 3 are in treatment zone
N
Treatment Zone in between station
3 and 5. 12% of drainage network treated
3
5
Upstream
Control
Station
Moderate Signal to Noise
Legend
Control
Treatment
Easement
Forested Pasture
Open Pasture
Row Crop
0 200 400 800 1,200 1,600
Feet


Station 4 LULC Distributions andTreatment Proportions
Control
Treatment
Forested Pasture
Open Pasture
Row Crop
Ease6
N
7
6
4
Treatment Zone in between stations 6,7 and 4. 82% of drainage network protected or treated
96% of Ag stressors draining to station 4 are in treatment zone
Very High Signal to Low Noise
0 200 400 800 1,200 1,600
Feet


7
6
4
3
5

Differences in Pre-Restoration water quality distributions as stressor intensity varies



Supporting LULC data DMS is Collecting

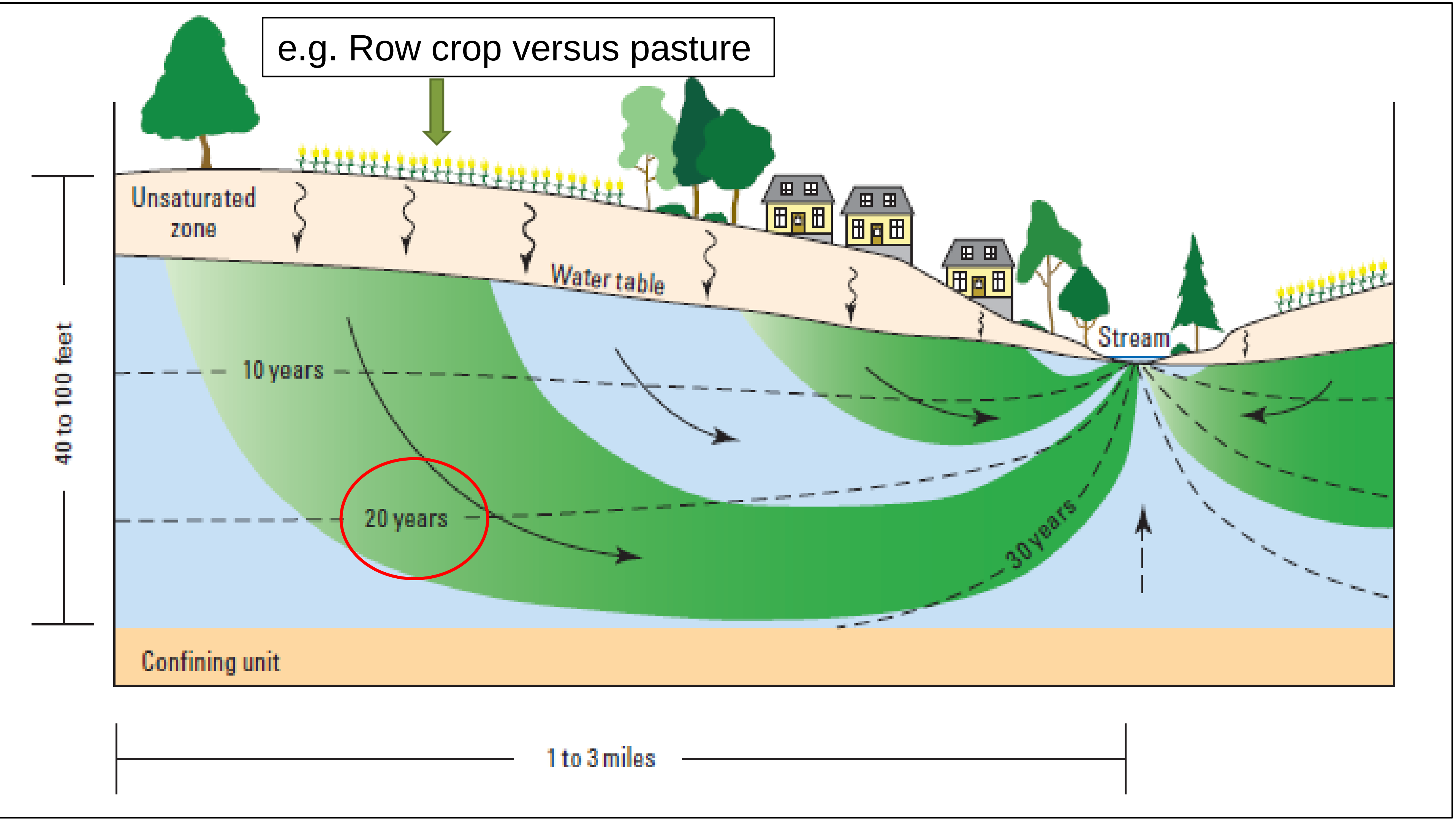
- LULC history to help document stressor intensity and distribution

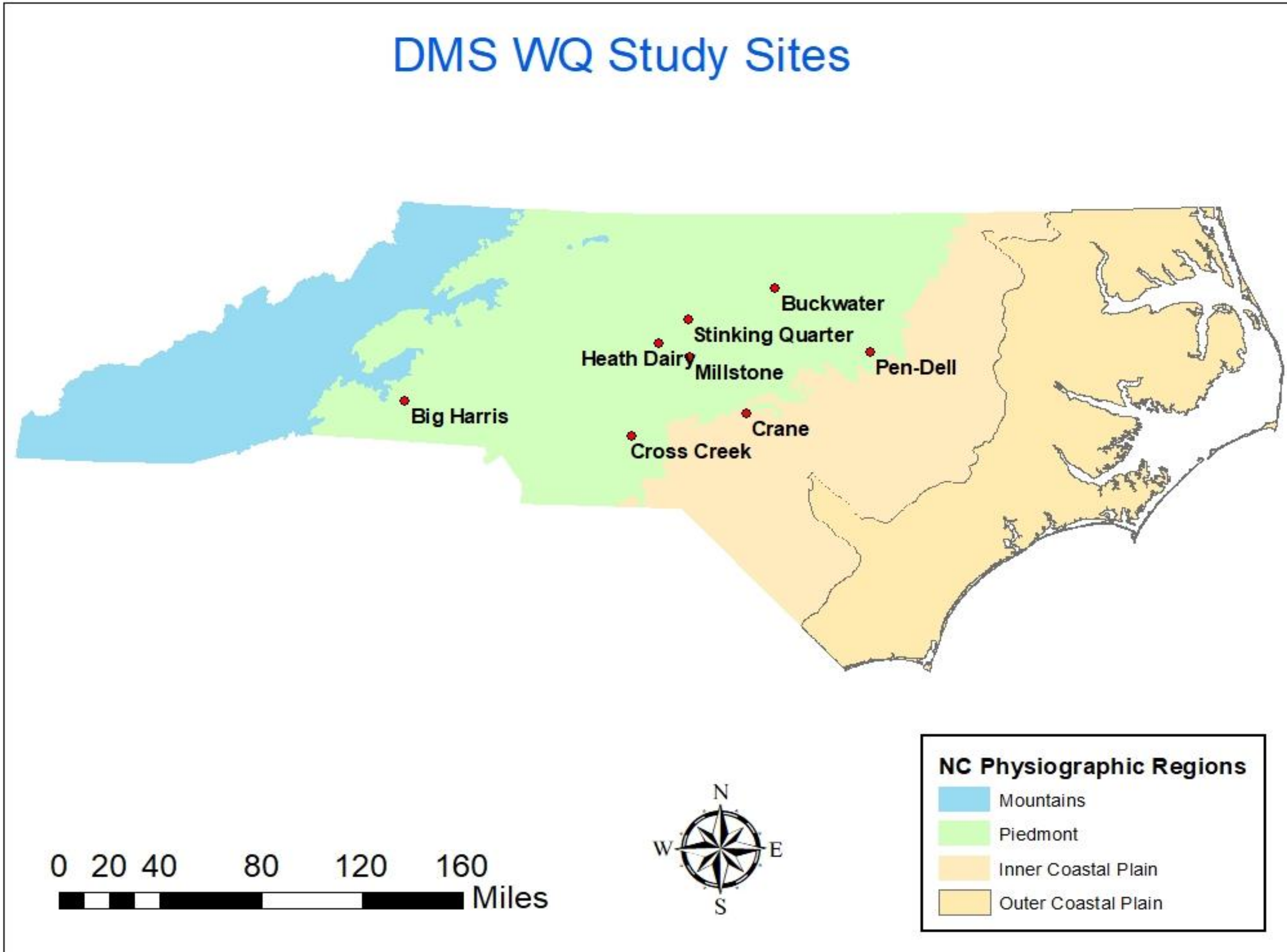
- Historical orthoimagery

- Landowner discussions

    e.g. Livestock densities
    e.g. Rotation schedules
    e.g. Application rates

Type of Stressor – Effects on change detection expectations in mitigation timeframes




DMS WQ Study Sites
Buckwater
Stinking Quarter
Heath Dairy
Millstone
Pen-Dell
Big Harris
Crane
Cross Creek
NC Physiographic Regions
Mountains
Piedmont
Inner Coastal Plain
Outer Coastal Plain
N
W
E
S
0 20 40 80 120 160
Miles

DMS WQ Study Sites

Project	# of Reaches	Param	Years Pre	Years Post
Heath Dairy*	2	F,N,S,M	3	1.7
Millstone*	2	F,N,S,M	1.3	1/0.5
Pen Dell	1	F	1	2
Buckwater	1	F,N,S	0.8	2
Big Harris**	13	F,N,S,FS,M	5	3
Cross Crk. Ranch	1	F,N,S	1	0
Crane Creek	1	F,N,S	1.3	0
Stinking Quarter	4	F,N,S,M	0.1	0
	Indicates a year or more of post restoration data			

* Dan Line P.E. NCSU **Dr. Jerry Miller WCU
F – Fecal; N – Nutrients; S – Total Suspended Solids;
M–Macrobenthos FS – Fish

In Conclusion

- DMS will continue to add reaches of varying scale and complexity to provide an adequate gradient of signal to noise in order to:

  - Identify factors of scale, stressor distributions, and treatment proportions that could inform change detection expectations.

  - Assist mitigation practitioners in grouping reaches and sub-watersheds within a project into coarse bins of 'likelihood' in terms of reliable change detection.

  - Add spatial granularity to the development of goals and performance standards within Mitigation Plans.

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  WCU (Dr. Jerry Miller)

  Big Harris Project

- Mitigation Provider Partners

  Land and Water Solutions (Pen Dell)
  Restoration Systems (Crane Creek, Stinking Quarter)
  Wildlands Engineering (Buckwater, Cross Creek, Big Harris)

Citations

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Questions?