Linking Science and Policy: Use of Critical Deposition Loads to Inform Environmental Protection Strategies

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Roadmap for Today's Talk

Critical load:

- What is it?
- How is it calculated?
- How is it used?

Some examples:

- Virginia and West Virginia – Steady State Model Approach
- Shenandoah National Park – Dynamic Model Approach

What are we doing in New York?

What is a critical load?

What are the sensitive receptors that we want to protect?

How is a critical load calculated?

How can the critical load concept be used?

Major Decision Points

- Aquatic vs terrestrial
- Acidification vs nutrient enrichment
- Steady state vs dynamic
- Critical load vs target load
- Chemistry vs biology
- Site-specific vs regional
- What other factors must be considered in calculating a critical or target load?

Biological Indicators	Receptors	Chemical Criteria	Critical Limit	Units
Fish; other aquatic biota	Surface water chemistry	ANC NO_3^- concentration	0, 20, 50 5, 20	µeq/L µeq/L
Forest health	Soil B horizon chemistry	Base saturation	10, 15	%
	Soil solution (B-horizon) chemistry	Ca:Al molar ratio	1, 10	Unitless
N uptake	Tree foliar chemistry (species TBD)	Foliar N concentration Chemical ratio (TBD)	TBD TBD	TBD TBD

Example Models for Calculating Critical Loads:

1) Steady State Water Chemistry Model

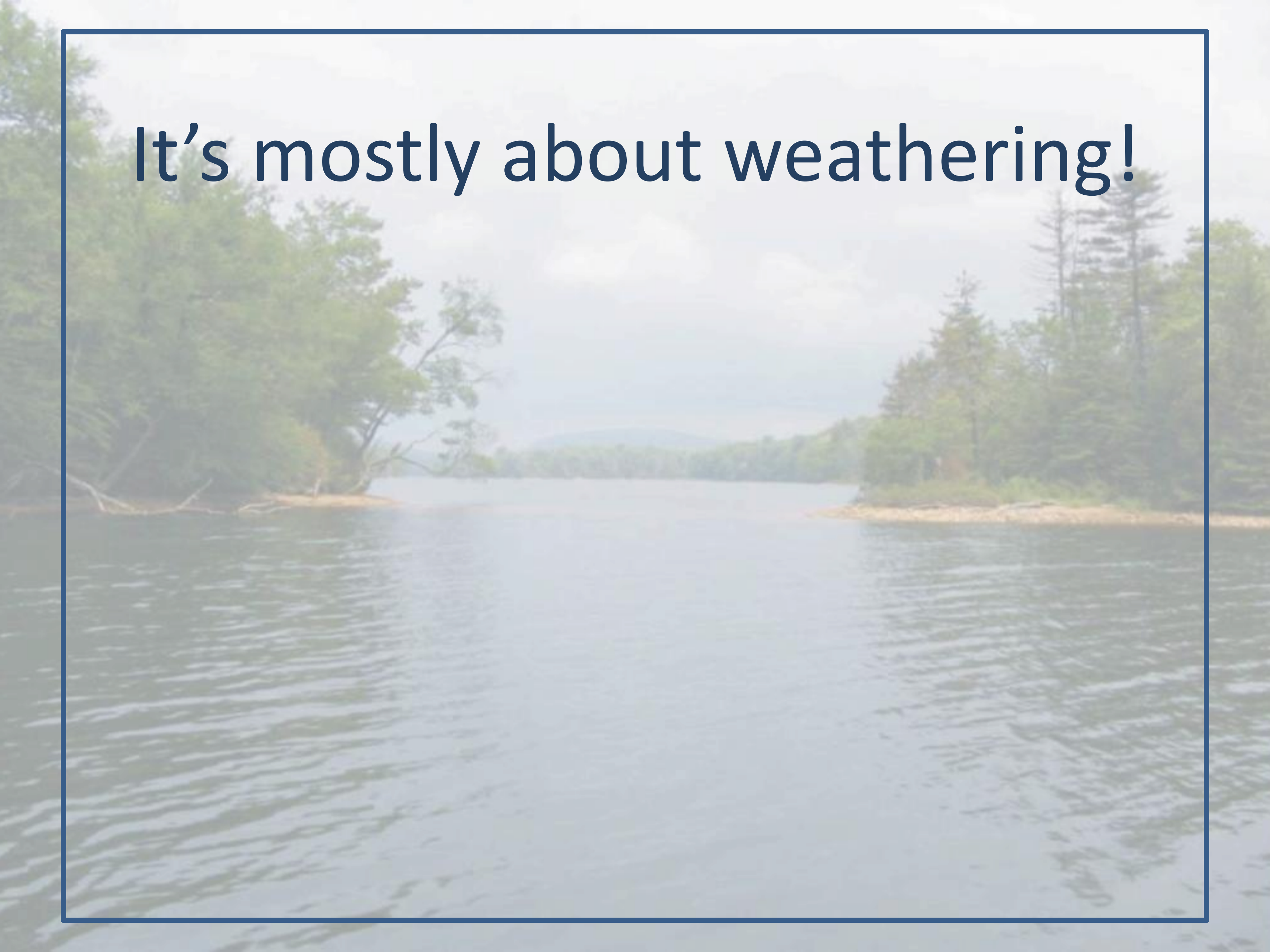
   $CL(A) = BC_{dep} + BC_{w} - Bc_{up} - ANC_{limit}$

2) Dynamic Model

   MAGIC

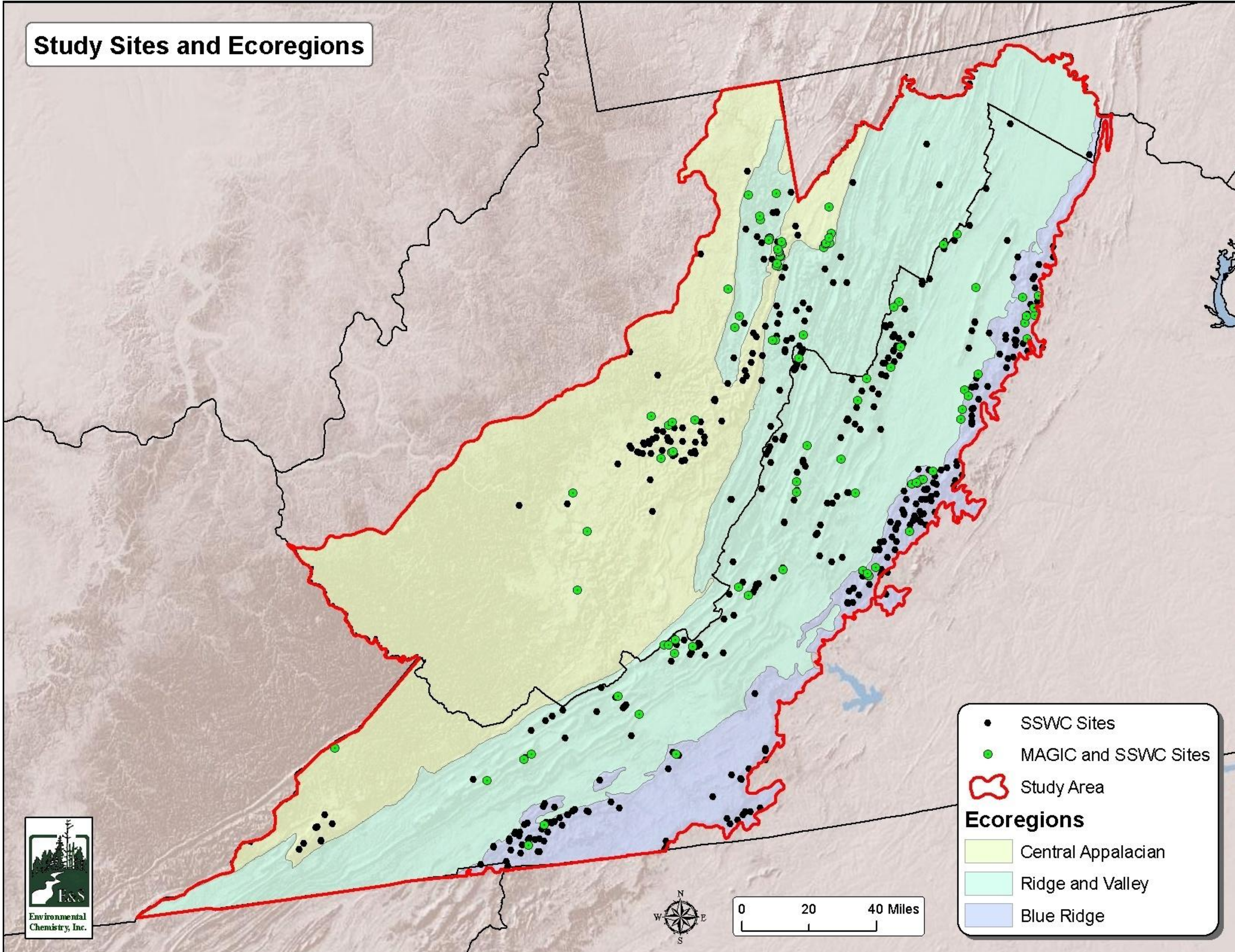
   PnET-BGC

It’s mostly about weathering!



A Steady State Example:

Regional Application of SSWC to Streams in VA and WV



Study Sites and Ecoregions
SSWC Sites
MAGIC and SSWC Sites
Study Area
Ecoregions
Central Appalacian
Ridge and Valley
Blue Ridge
0
20
40 Miles
N
S
W
E
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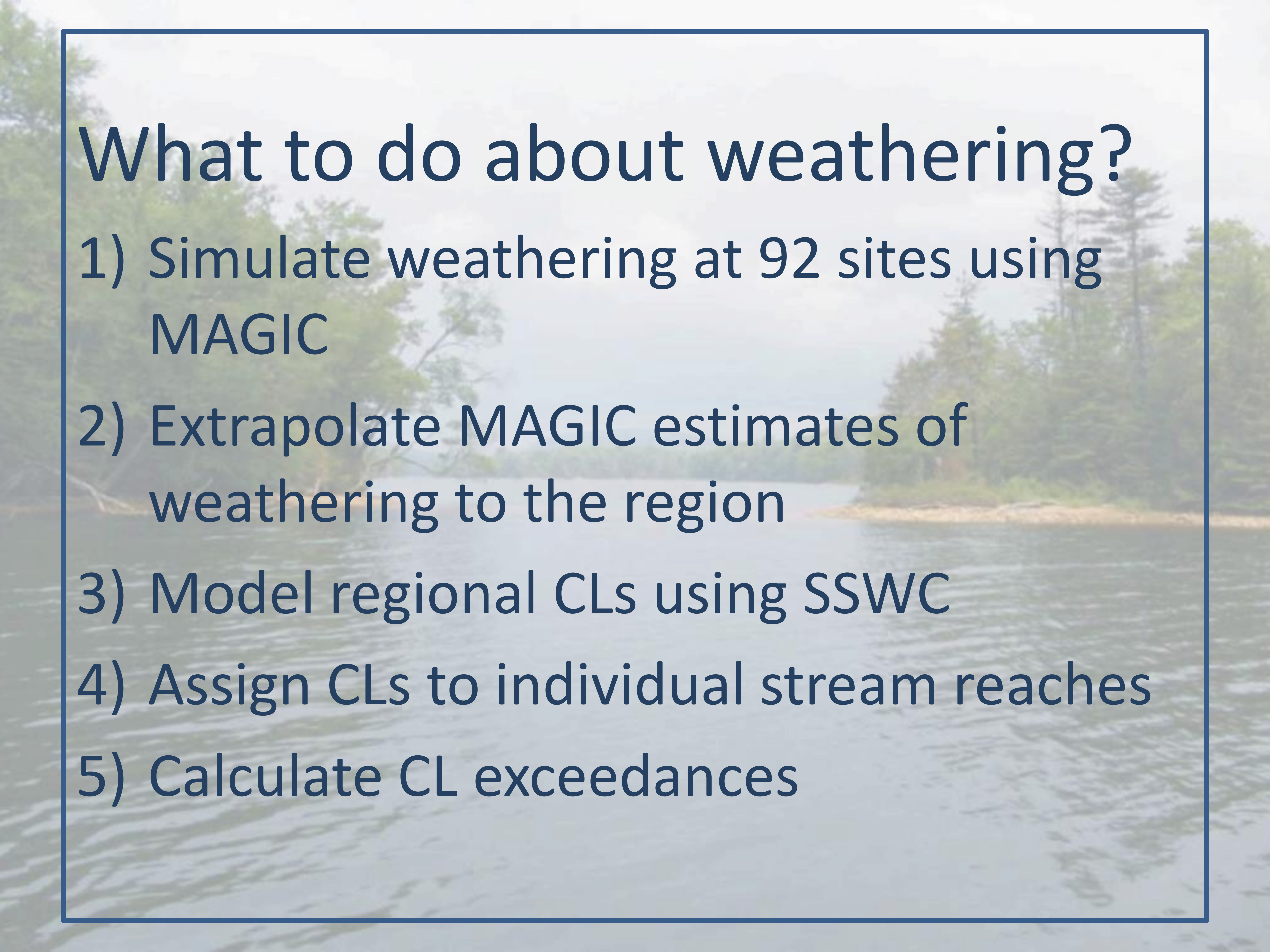

What to do about weathering?
1) Simulate weathering at 92 sites using MAGIC
2) Extrapolate MAGIC estimates of weathering to the region
3) Model regional CLs using SSWC
4) Assign CLs to individual stream reaches
5) Calculate CL exceedances

BC_w Predictor Variables

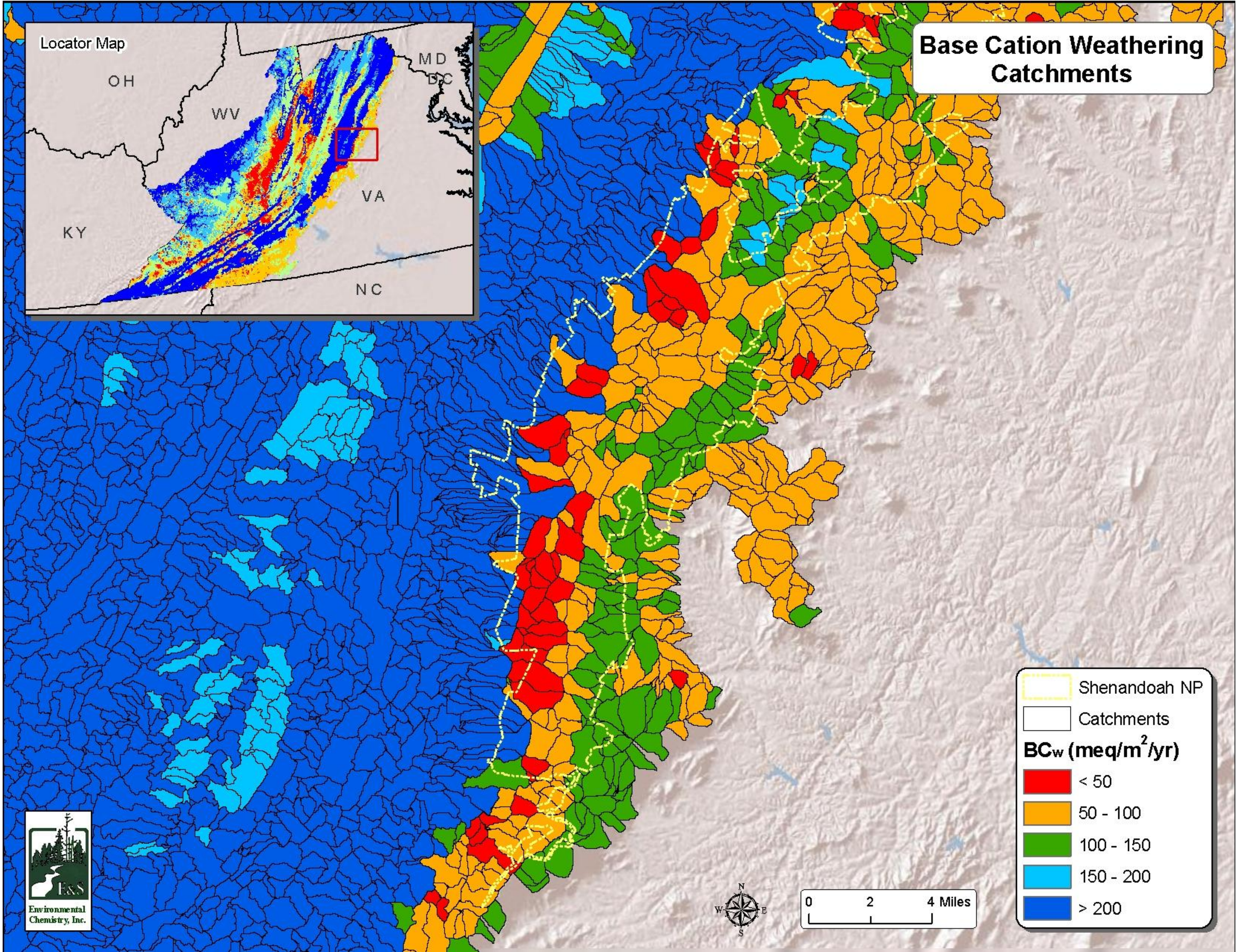
- Landscape Characteristics
  - Watershed Area
  - Elevation
  - Slope
  - Geologic classes
  - Soil variables (% clay, pH, depth)

- Water Chemistry (500+ sites)
  - Sum of base cations
  - Sum of base cations – chloride
  - ANC
  - Sulfate
  - Nitrate

Predicting BC_w from Available Spatial Data

Ecoregion	n	Predictor Variables	r^2
With Water Chemistry:			
Central Appalachian	24	SBC NO_3 WS Area	0.93
Ridge & Valley	42	SBC Elevation (-) Slope (-)	0.85
Blue Ridge	26	ANC NO_3	0.90

Ecoregion	n	Predictor Variables	r^2
Without Water Chemistry:			
Central Appalachian	24	Soil pH (-) WS Area Elevation (-)	0.66
Ridge & Valley	42	% Siliciclastic (-) % Carbonate Elevation (-)	0.64
Blue Ridge	26	% Siliciclastic (-) Soil % Clay Soil Depth (-)	0.86



Base Cation Weathering
Catchments
Locator Map
OH
WV
MD
DC
VA
KY
NC
Shenandoah NP
Catchments
BCw (meq/m2/yr)
< 50
50 - 100
100 - 150
150 - 200
> 200
0
2
4 Miles
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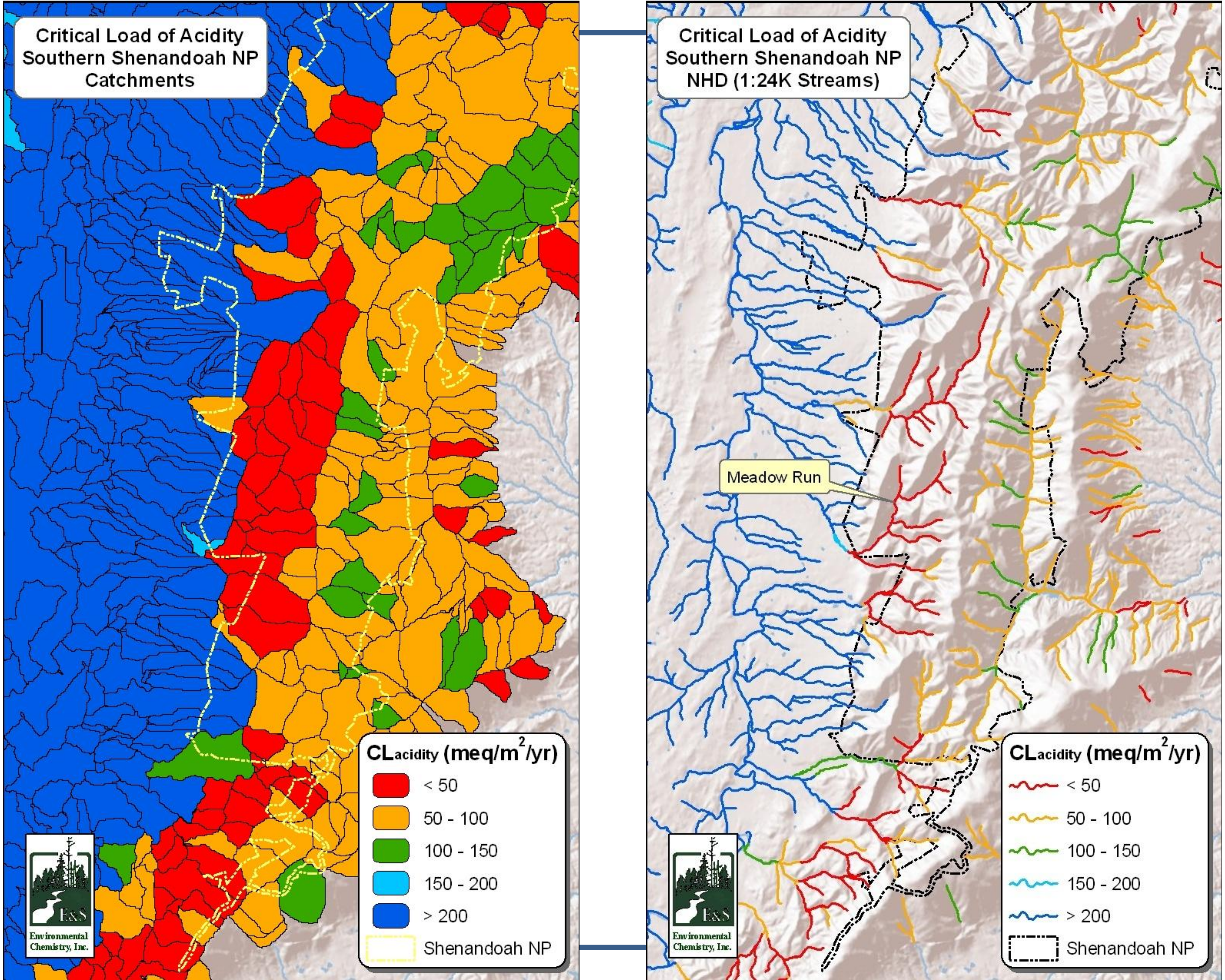
Steady State Water Chemistry Model (SSWC)

$$CL(A) = BC_{dep} + BC_{w} - Bc_{up} - ANC_{limit}$$


Critical Load of Acidity
Southern Shenandoah NP
Catchments
CLacidity (meq/m2/yr)
< 50
50 - 100
100 - 150
150 - 200
> 200
Shenandoah NP
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Critical Load of Acidity
Southern Shenandoah NP
NHD (1:24K Streams)
Meadow Run
CLacidity (meq/m2/yr)
< 50
50 - 100
100 - 150
150 - 200
> 200
Shenandoah NP
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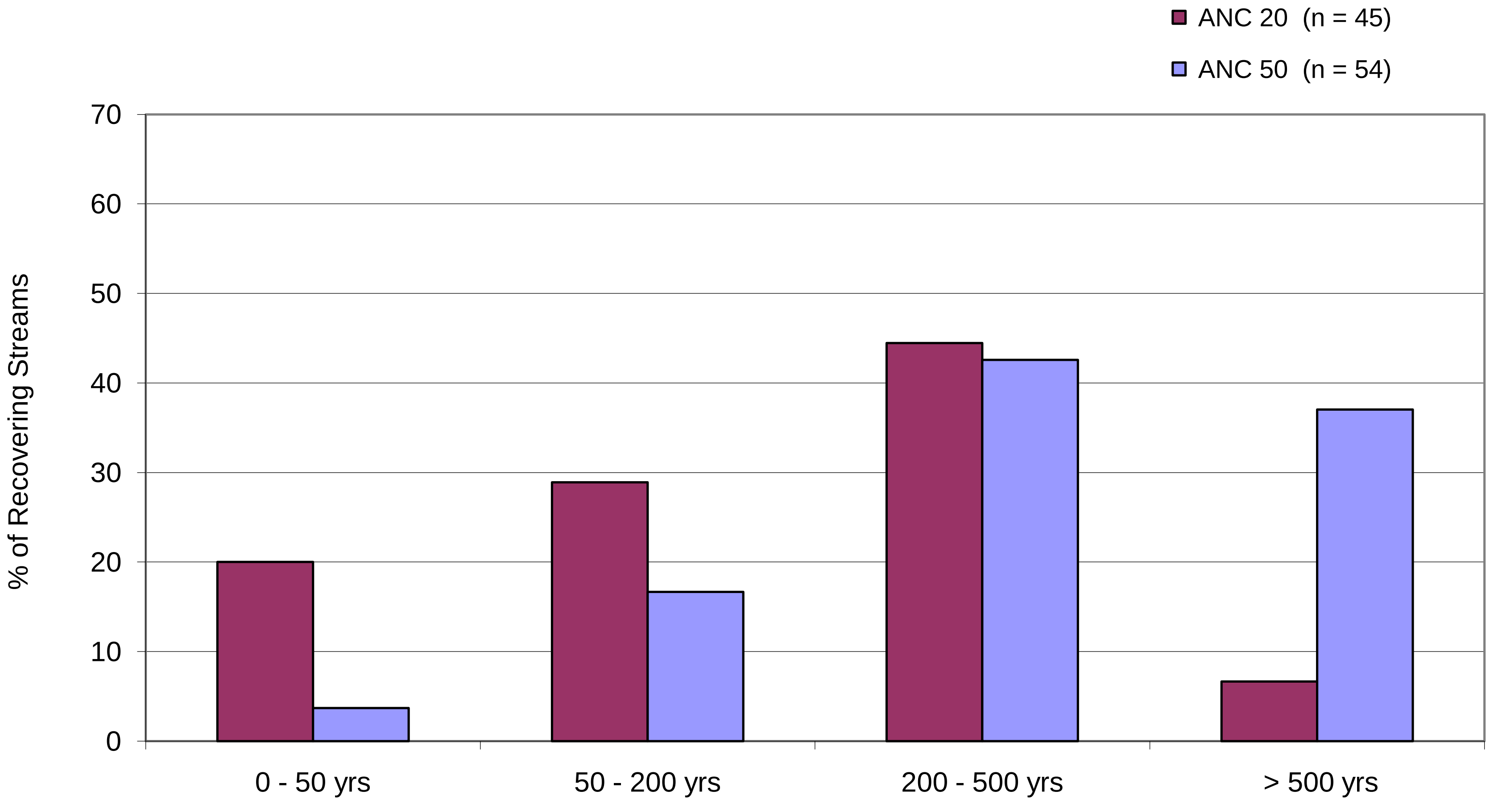
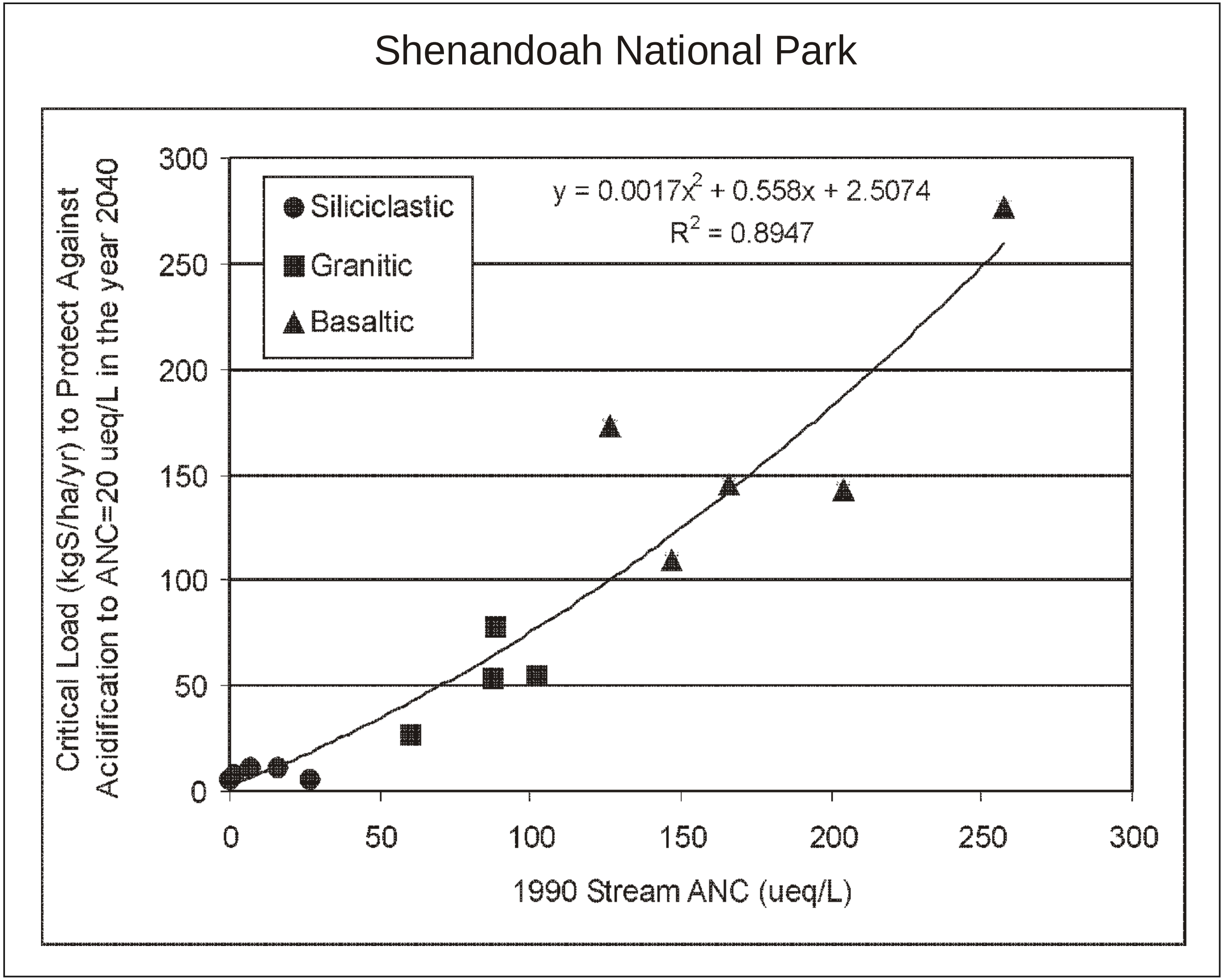
Time to Steady State ANC (μeq/L) Starting 2020 Using SSWC Critical Loads




Shenandoah National Park
Critical Load (kgS/ha/yr) to Protect Against Acidification to ANC=20 ueq/L in the year 2040
1990 Stream ANC (ueq/L)
Siliciclastic
Granitic
Basaltic
y = 0.0017x^2 + 0.558x + 2.5074
R^2 = 0.8947
0
50
100
150
200
250
300

Things to move from the back of your mind to the front of your mind when addressing critical and target loads

1. Time frame matters.
2. There are multiple possible chemical indicators; each relates somehow to biology.
3. Do you want to base policy on one lake or one stream? You need to know about the broader population of lakes and/or streams.

4. Most lakes or streams in a given region are generally NOT acid-sensitive (critical load is very high). Focus on the relatively small number of waters that are sensitive.
5. Some acidified lakes and streams are not projected to recover to critical criteria values even if deposition is reduced to zero because they were not that high to begin with.
6. It's important to separate the science (objective) from the policy (judgment). The science is reflected in the modeling. There are MANY policy judgments to be made, and they should be clearly documented.