

Assessing Impacts Due to Small Impoundments In North Carolina

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DWR 401 Staff Concerns Over Impoundments

NCDENR

- Regulatory Concerns
 - WQ Standards
 - No mit. req'd for impounded reach (DWR)
 - Mit. credit awarded for dam removal
- > Ecological Concerns
 - Lakes not natural in Piedmont and Mtns
 - Loss of nat. aquatic features (riffle-pool small stream habitat)
 - Fragmentation/aquatic life passage



Background/Existing Literature

- NCDENR
- ➤ Published literature* reports that impounding streams has negative effects on:
 - Habitat
 - Flood hydrology
 - Nutrient cycling
 - Sediment transport
 - Aquatic life movement

Fitz, R.B. 1968; Baxter 1977; Ward and Stanford 1979; Bain et al. 1988; Neves and Angermeier 1990; Martinez et al. 1994 Ligon et al. 1995; Clay 1995; Benstead et al 1999; Pringle et al 2000; Santucci et al 2005; Saila et al 2005; Maxted et al. 2005; *Arnwine et al. 2006*; among others.



North Carolina Data???

- NCDENR
- ➤ DWR Lake and Reservoir Assmnts. (89):
 - 67% eutrophic or hypereutrophic (19%)
 - 24% 303(d) listed
 - Most large, but some as small as 12 acres
 - Many water supply reservoirs
- > 303(d)/305(b) Integrated Report (2008)
 - >40,000 impounded FW acres considered "Impaired" (Piedmont and Mtns)



General Study Sites Summary

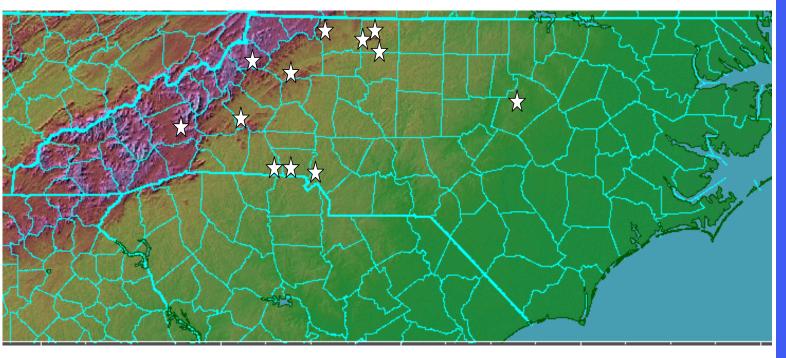
- ➤ Six each in Piedmont and Blue Ridge Ecoregions (Level III)
- \triangleright Near headwater (1st 3rd order)
- ➤ Size range from 12 135 acres
- ➤ Age from 1927 2000 (some refurbished recently)
- Nine top release, one bottom release, two combined
- ➤ WQC: C = 6, B = 5, WS = 3; Tr = 2; ORW = 2; HQW = 3





Study Site Locations







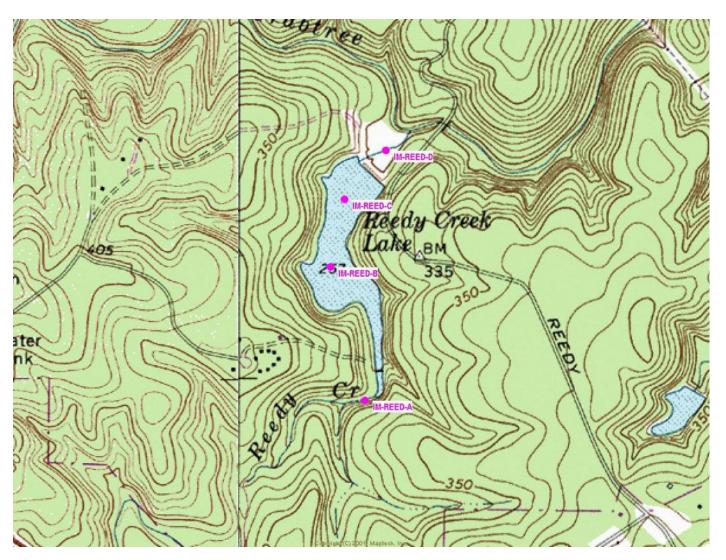
Scope of Work

- ➤ Literature review/available data
- Physical/chemical monitoring
- > Primary productivity
 - ➤ NC Trophic State Index
 - ➤ Chlorophyll-a
 - ➤ Periphyton biomass
- ➤ Benthic macroinvertebrate community tolerance
- > Habitat assessments





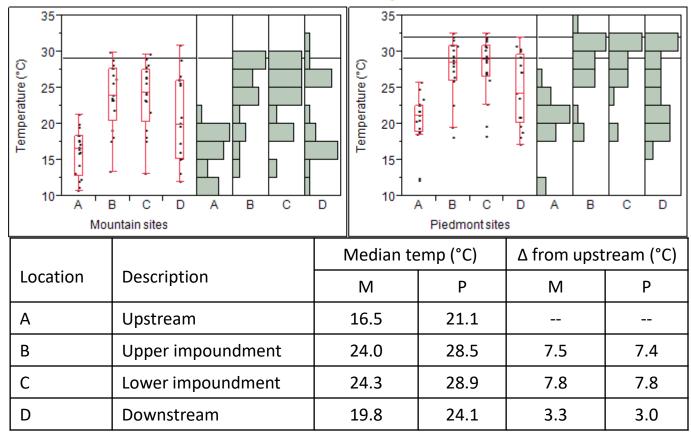
Sample Locations







Surface Temperature



- Impoundment and downstream are significantly different from upstream
- Temperature changes between upstream/impoundment and upstream/downstream >WQ standard





Daily Mean Water Temperatures by Ecoregion

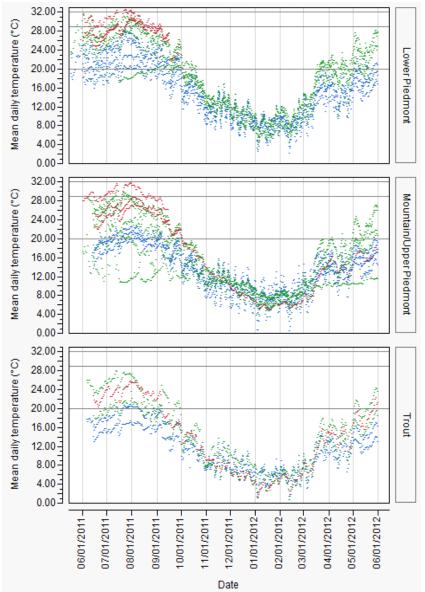
Blue = Upstream

Red = Impoundment

Green = Downstream

Water Quality Stds (Temperature)

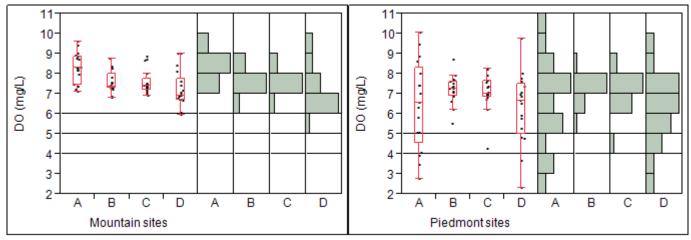
Lower Piedmont = 32 C Upper Piedmont/Mtn = 29 C Trout = 20 C







Surface Dissolved Oxygen (DO)



	Description	Median DO (mg/L)			
Location		М	Р		
А	Upstream	8.3	6.5		
В	Upper impoundment	7.4	7.3		
С	Lower impoundment	7.4	7.0		
D	Downstream	6.9	6.7		

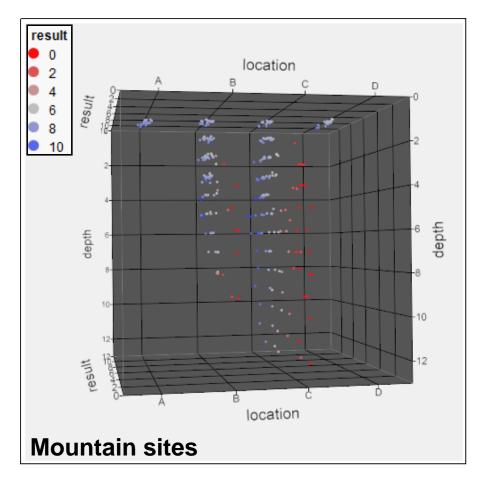
- Mountains: Impoundment and downstream significantly different from upstream. Downstream significantly different from impoundment
- ➤ Piedmont: No significant differences. Several instances of readings <WQ standard (4.0 mg/L)

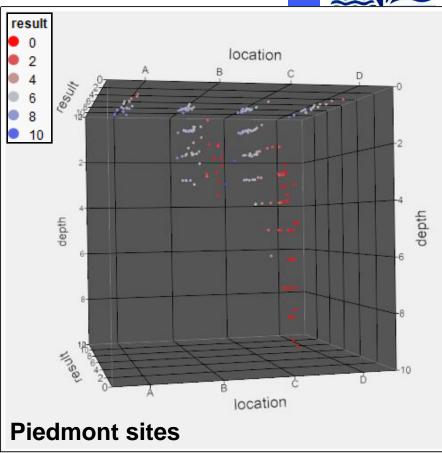




DO by depth







Note low DO values at relatively shallow depths



Water Quality Parameters Summary of Matched Pairs Analysis

	BLUE RIDGE			PIEDMONT								
	B-A	C-A	C-B	D-A	D-B	D-C	B-A	C-A	C-B	D-A	D-B	D-C
DO % saturation				4	+	4					4	4
DO concentration	4	Ψ		4			1	1			4	4
рН						\downarrow						
SC					1	1	1	1			1	1
Temperature	1	1		1	→	→	1	1	1	1	↓	V
NOx	V	4		V	1	1	V	1		V	1	
TKN							1	1		1		
TN	V	V	1	1	1					Λ.		
TP	V										1	
TN:TP				\downarrow			1	1				
Chlorophyll	1	1	1	1	→	↓	1	1	1	1		



Green Arrow = Change in favorable direction Red Arrow = Change in unfavorable direction

Black Arrow = Neutral change (neither favorable nor unfavorable)

No Arrow = No significant change

Favorable = 16

Unfavorable = 39

Neutral = 8



Primary Productivity

- ➤ Investigate nutrient enrichment in impoundment and downstream
- ➤ Primary productivity too high → bad for things higher up the food chain ("fishable"/aquatic life support)
- Nutrient samples alone not conclusive (for streams)
- ➤ Alt. measures: chlorophyll-a, NCTSI, periphyton biomass





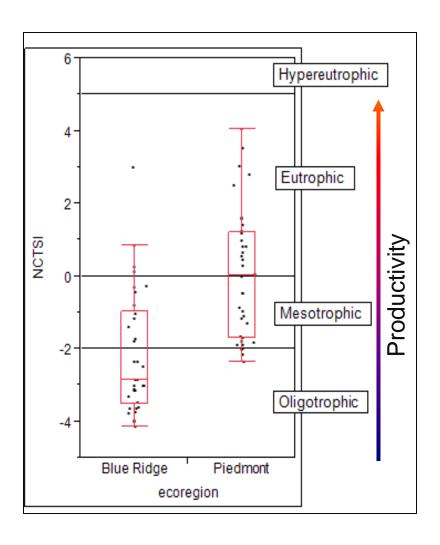
NC Trophic State Index (NCTSI)

- ➤ Calculation of lake biological productivity
- Takes into consideration Secchi depth, Total N, Total P and Chlorophyll-a.
- Classifies lakes as Oligotrophic, Mesotrophic, Eutrophic or Hypereutrophic





NCTSI- All Sites

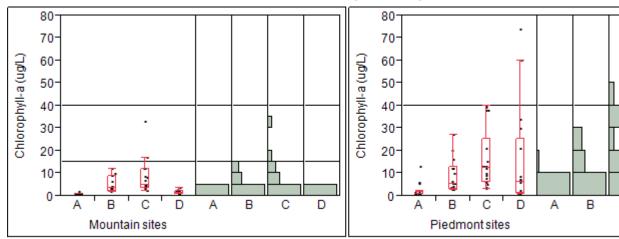


- Most Mountain (Blue Ridge) lakes are Oligotrophic or Mesotrophic
- Piedmont impoundments significantly more enriched- half are rated Eutrophic





Chlorophyll-a



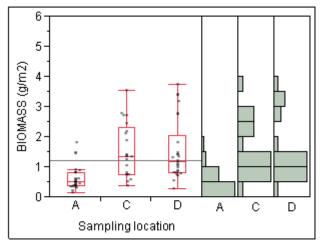
	Description	Median Chl-a (ug/L)			
Location		M	Р		
А	Upstream	1.0	1.0		
В	Upper impoundment	3.6	5.3		
С	Lower impoundment	4.8	12.5		
D	Downstream	1.4	6.0		

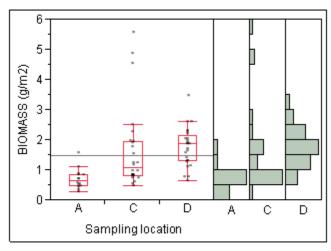
- Mountains: Impoundment significantly different from both upstream and downstream. WQ standard exceeded twice for designated Tr waters (Trout Lake)
- Piedmont: Upstream significantly different from all other locations. Upper and lower impoundment significantly different from each other. Downstream values very high overall— unusual to see detectable in headwater streams.





Periphyton Productivity





Mountains

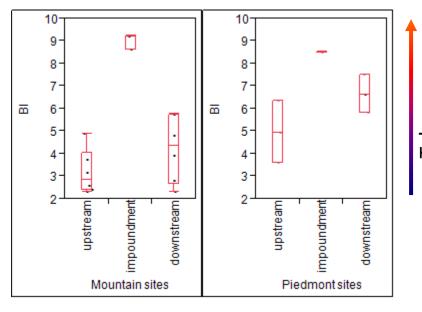
Piedmont

- ➤ Both ecoregions show significant increases in periphyton biomass in impoundments and downstream reaches as compared to reference (upstream).
- Downstream increase unexpected





Benthic macroinvertebrate biotic index (BI)



Note: Three Piedmont sites excluded from

analysis;

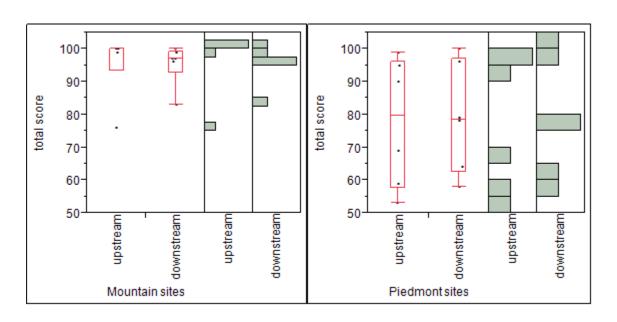
sample

missing either upstream or downstream

- Impoundment communities highly tolerant (high BI), significantly different from stream communities
- Mountain impoundments show greater change in BI (upstream BIs lower)
- Downstream median BIs higher



Instream habitat



- No significant differences between upstream and downstream overall
- Site-by-site: 6 had lower habitat scores downstream,
 4 had higher scores downstream,
 2 no change





Summary

- ➤ Main issues noted:
 - Temperature changes
 - Negative temp. changes between upstream/impoundment and upstream/downstream
 - Exceedances of WQ std (short-term and longterm
 - Surface DO:
 - Downstream significantly different from upstream (Mtns)
 - Downstream significantly different from impoundment (Mtns)
 - Sev. instances of readings <WQ std (Piedmont)





Summary

- ➤ Main issues noted:
 - DO decreases rapidly with depth
 - Increases in primary productivity within impoundment and <u>also below dams</u>
 - Changes in macrobenthos community
 - Decrease in intolerant taxa (increased BI)
 - Impoundment communities much less diverse, more tolerant (some samples had no benthos)
 - <u>Not</u> habitat-related





Summary



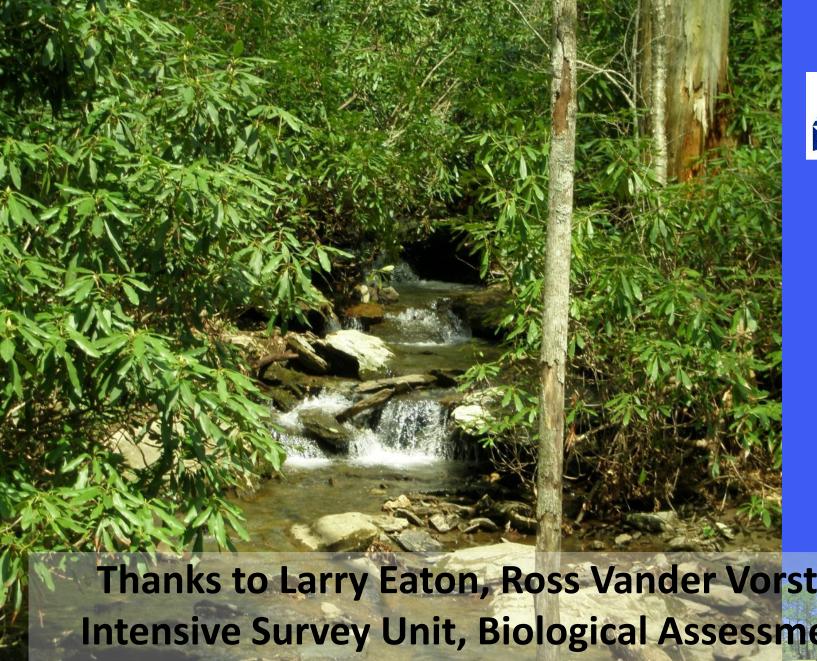
> Trends:

- Piedmont streams appear more sensitive, possibly due to already stressed conditions
- Changes in trophic structure of macrobenthos community

> Followup:

 Phase II (new EPA grant): Assess extent of downstream effects/conditions







Thanks to Larry Eaton, Ross Vander Vorste, Intensive Survey Unit, Biological Assessment Unit, Mark Vander Borgh, and Chemistry Lab