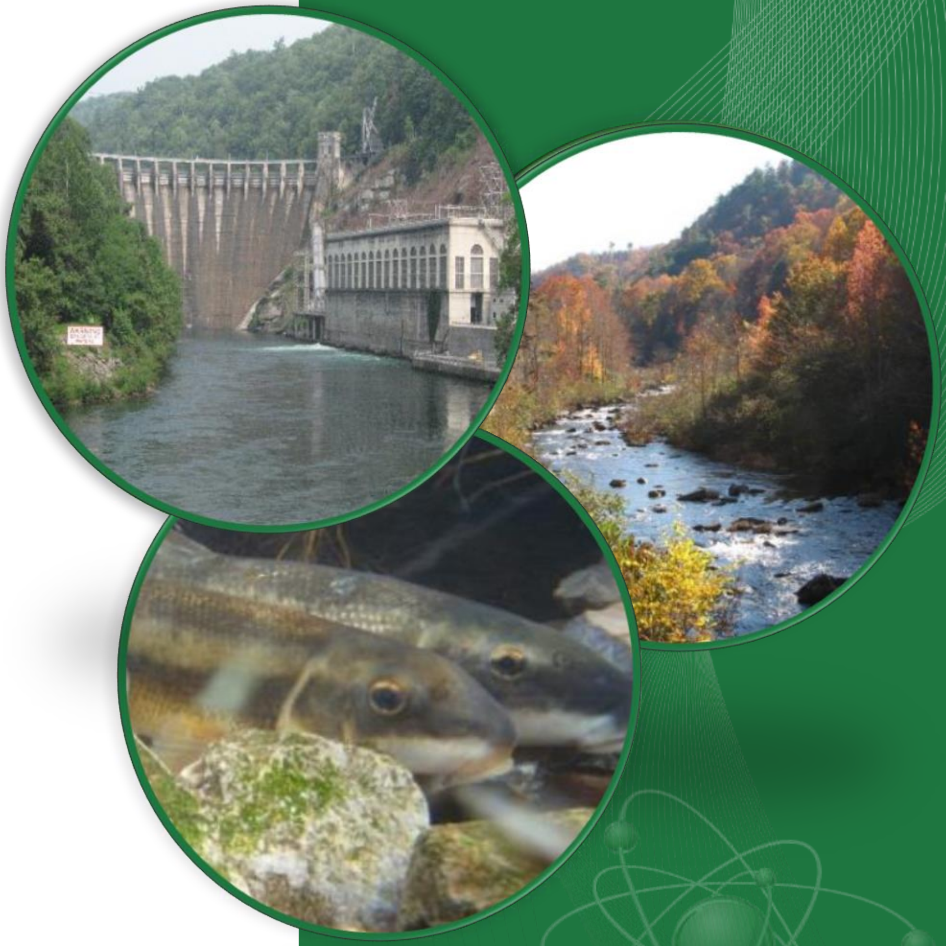
Cheoah River Case Study: Outcomes of FERC relicensing



Ryan McManamay

FLOW 2018

April 24, 2018

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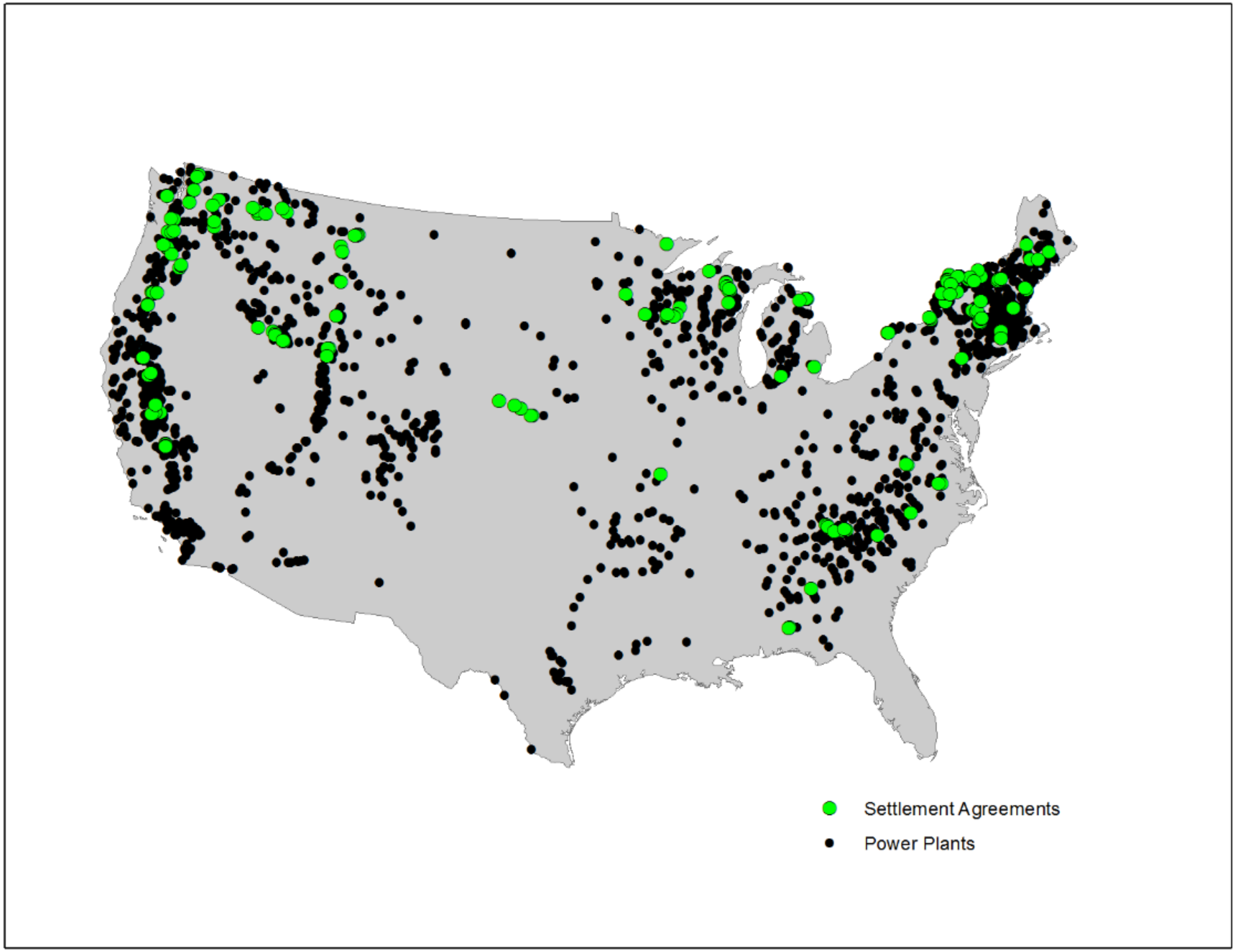
Settlement agreements are rare… but lead to holistic assessment & mitigation



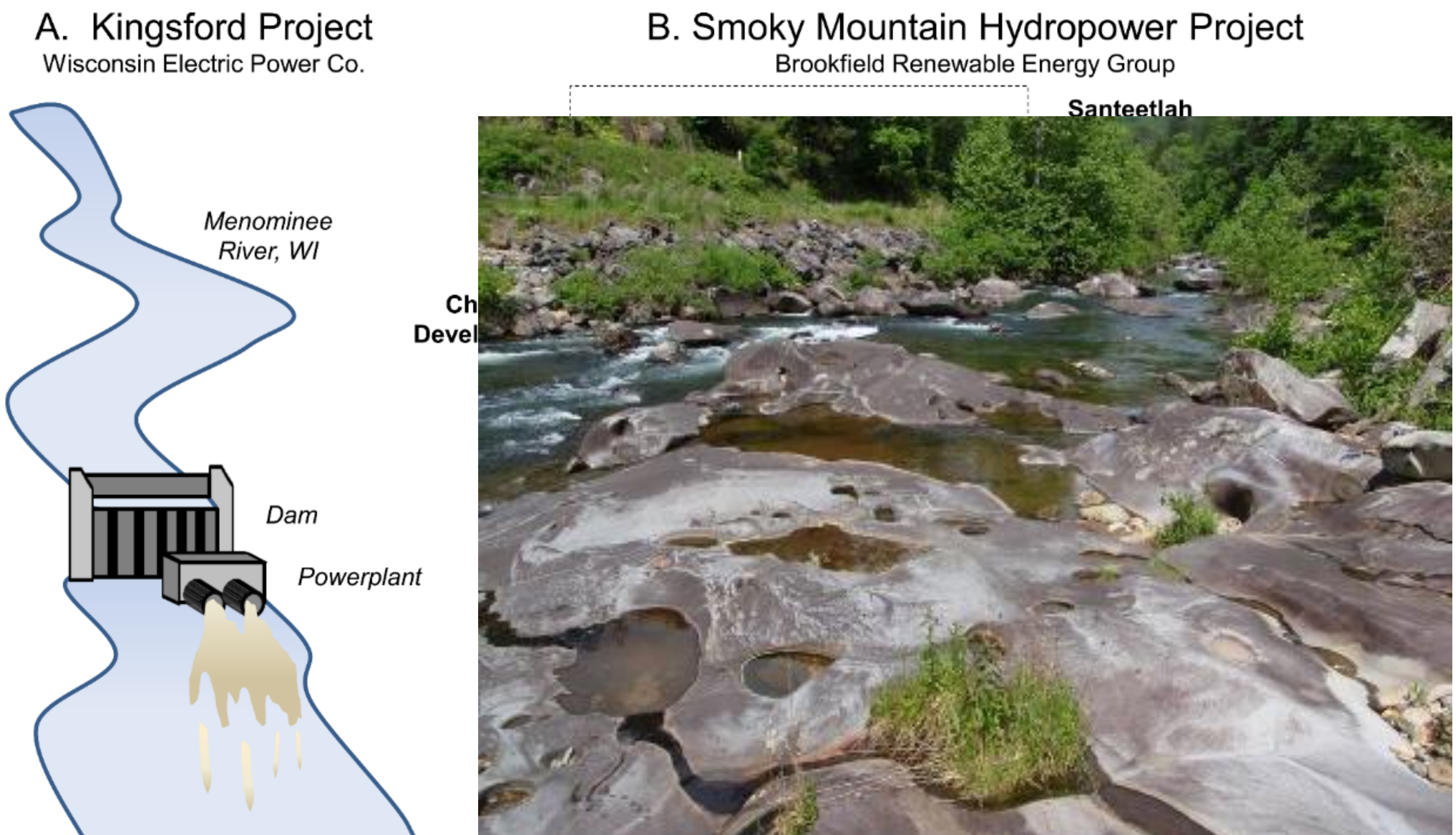
Outline

- Flow Restoration
  - Hydrologic Components
  - Geomorphology
  - Temperature regime
  - Riparian Conditions
  - Fish Community
  - River chub (*Nocomis micropogon*) nesting activity
- Gravel addition
  - Substrate conditions
  - Fish spawning activity
  - Macroinvertebrate response
- Sensitive species-focused conservation efforts
- Regional Perspective
- Take-away messages

Papers

- McManamay et al. 2010. N Am J Fish Manag
- McManamay et al. 2013. Env Management
- McManamay et al. 2013. SE Naturalist
- Peoples et al. 2014. J Fisheries Ecology
- McManamay et al. 2015. C J Fish Aquatic Sciences

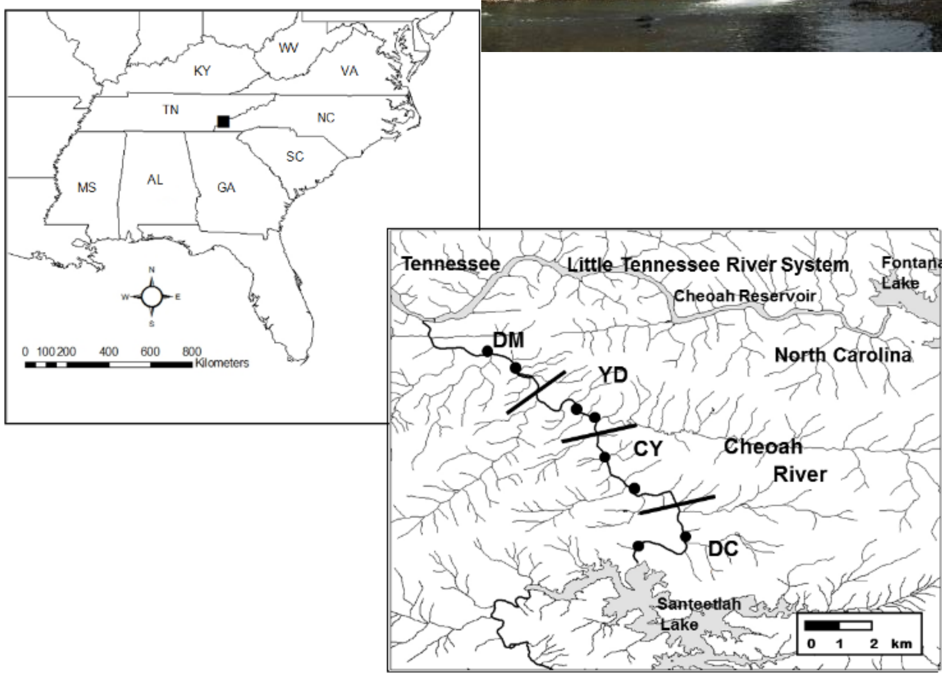
Complex system and infrastructure

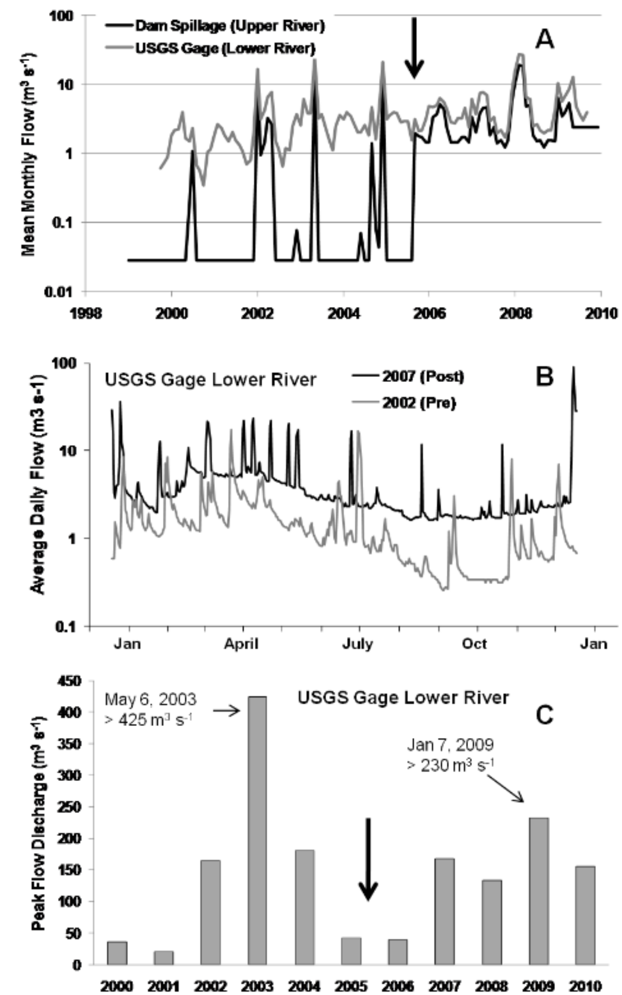


McManamay et al. 2016. River Research & App

Flow restoration

- Outcome of 2005 FERC relicensing agreement
- Includes flow enhancement plan & monitoring

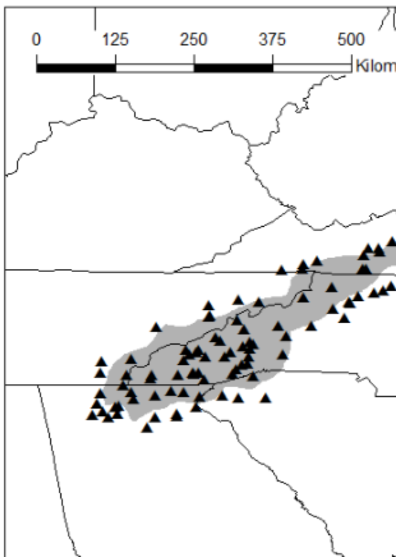


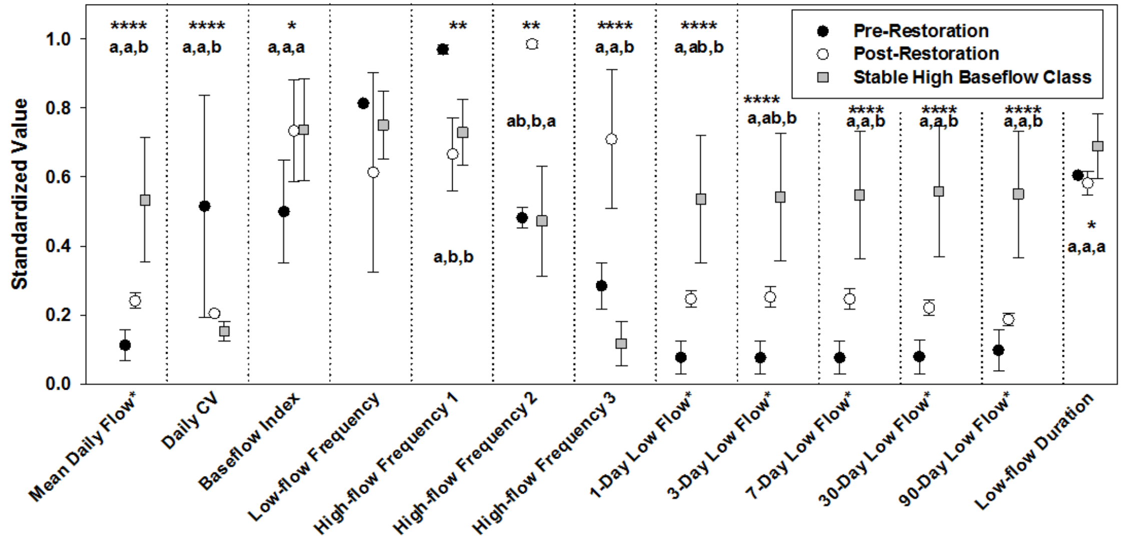


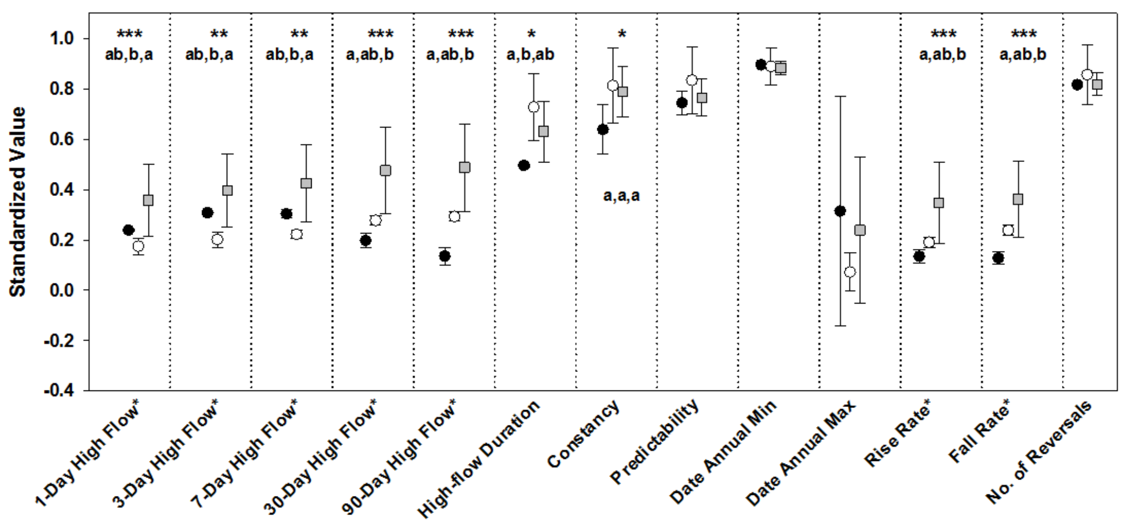

Baseflow 100 cfs


Peak flow > 1000 cfs

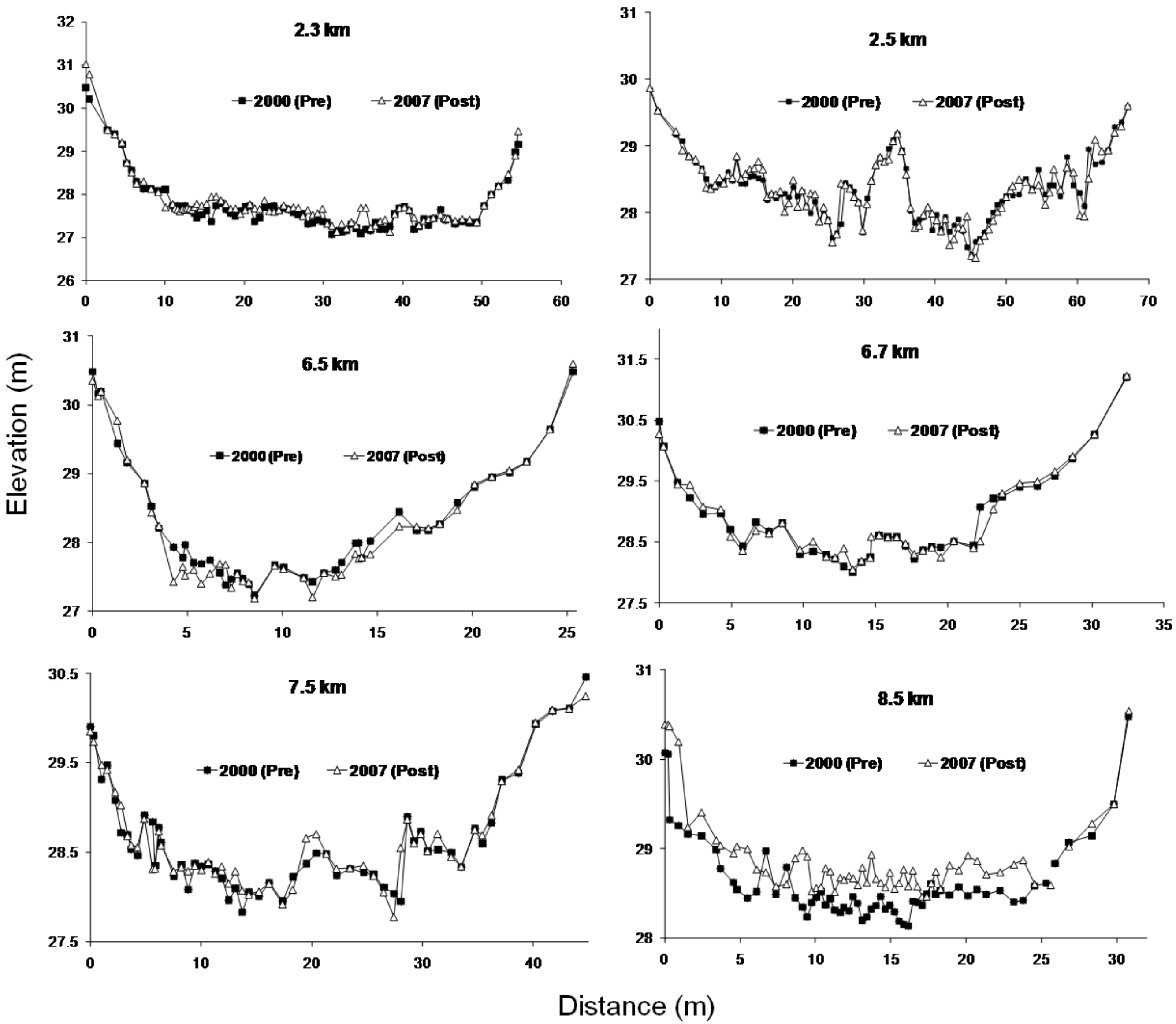
Flow Restoration – Hydrologic Components







Geomorphologic Responses to Flow Restoration



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Geomorphic Responses to Flow Restoration

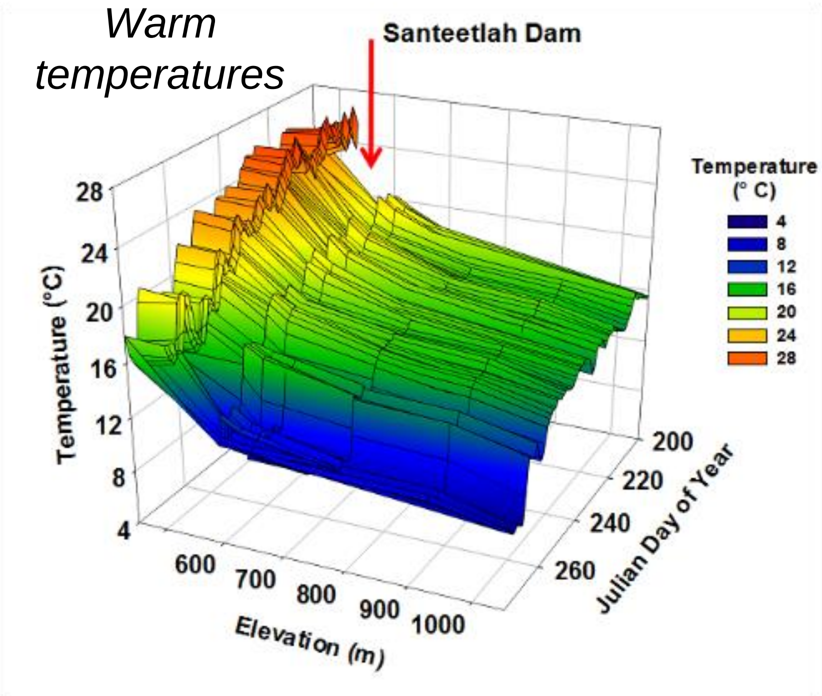
- Include Substrate responses

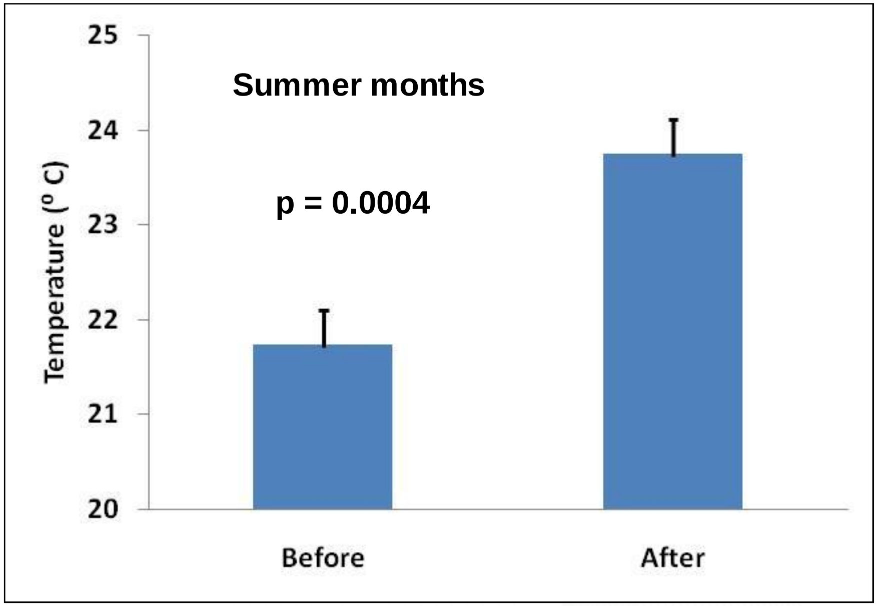
Table 6 Percent changes in the median particle size (D_{50}) of pebble counts conducted at eight sites during 2002 and 2008 along the length of the Cheoah River

Transect	Distance from Dam (km)	D_{50} (mm) 2002	D_{50} (mm) 2008	% change	*P* value
DC3	0.6	762	160	−79	<0.001
DC7	2.3	1676.4	1000	−40.35	0.991
CY3	5.5	457.2	270	−40.94	0.004
CY8	6.7	304.8	160	−47.51	0.064
YD2	8.5	279.4	195	−30.21	0.186
YD7	9.5	914.4	350	−61.72	0.005
DM2	11	228.6	250	9.36	0.852
DM5	12.5	203.2	257.5	26.72	0.028

P values represent results from Kruskal–Wallis tests

Temperature responses to flow restoration





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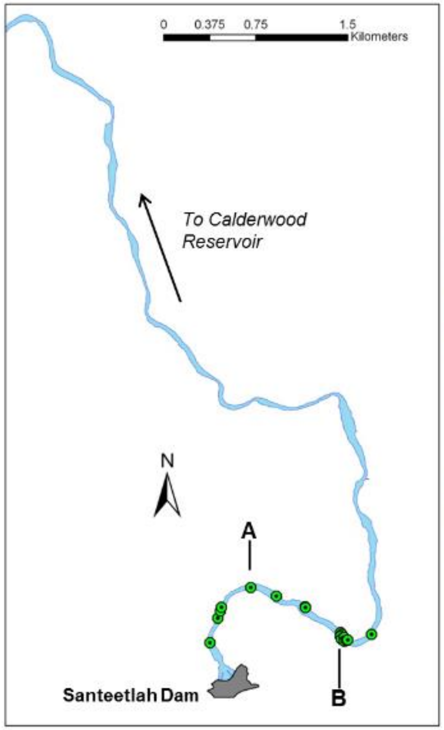
Riparian responses to flow restoration



- Major physical changes in the river
- Removal of encroached riparian vegetation

McManamay et al. (2013) Environmental Management

Fish Community Responses to Flow Restoration

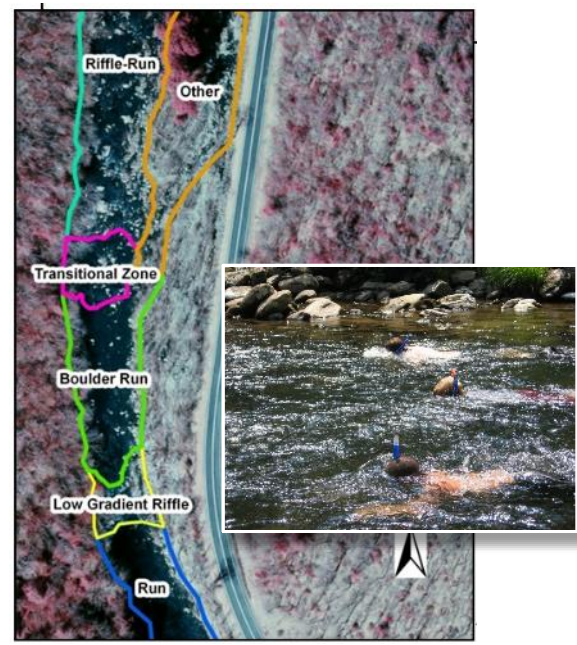
- No “new” species colonized the river
- Occupancies of several species declined after flood and after flow restoration



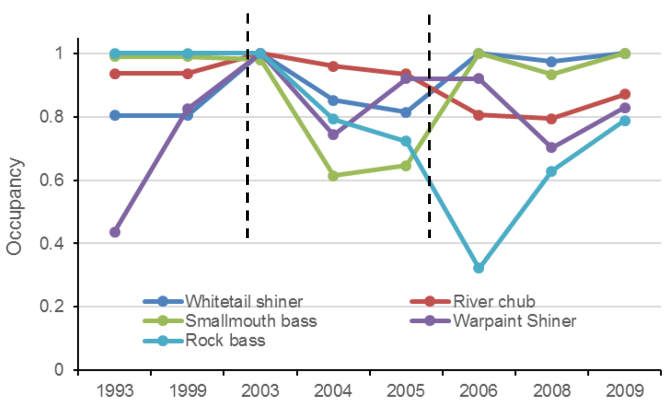


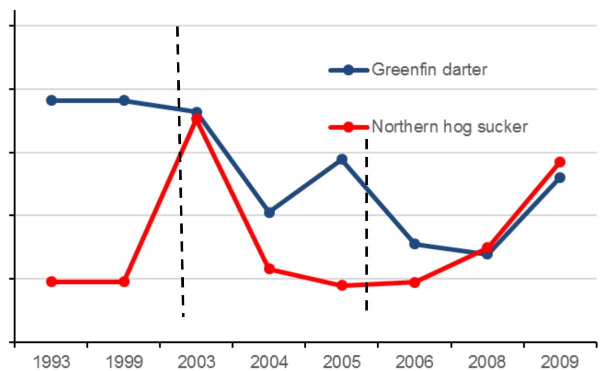


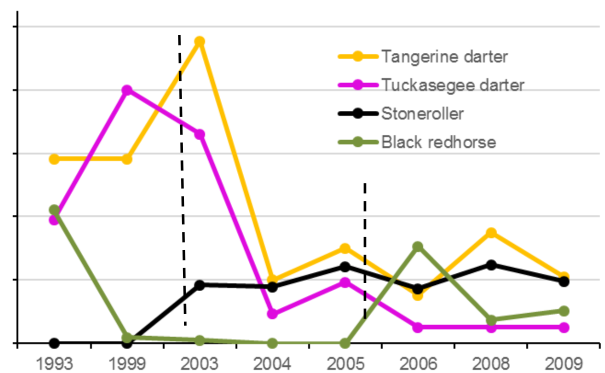


McManamay et al. (2013) Env Manag
McManamay et al. (2014) Fish Manag & Ecol



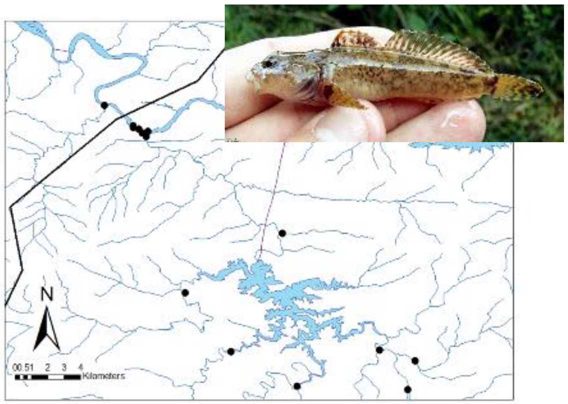




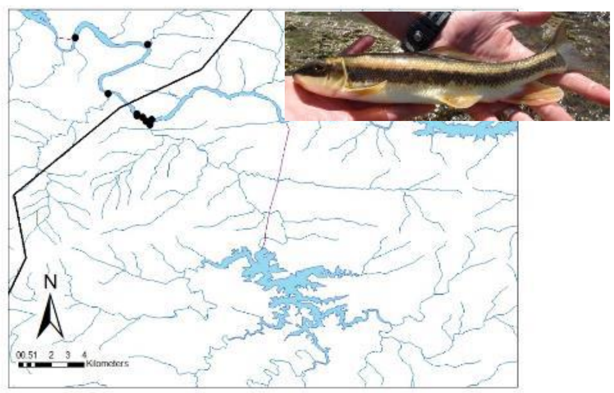
Fish Community Responses to Flow Restoration

- All potential immigrants didn’t immigrate
- Reintroduction of two endemic species
  - Spotfin chub
  - Wounded darter

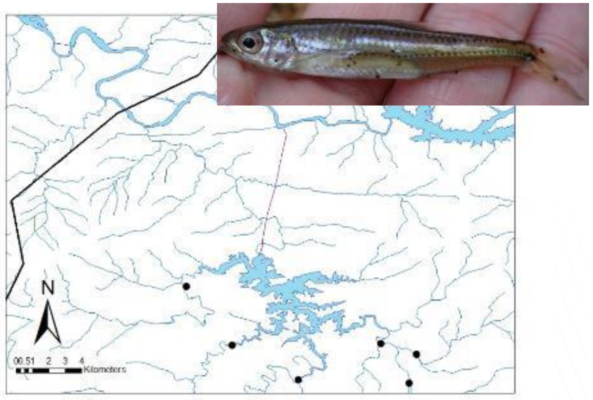
Mottled Sculpin



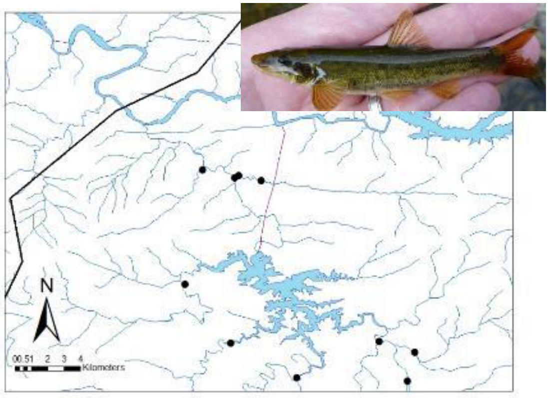
White sucker



Tennessee Shiner



Longnose dace



River chub nesting habitat and responses to high-flow pulses

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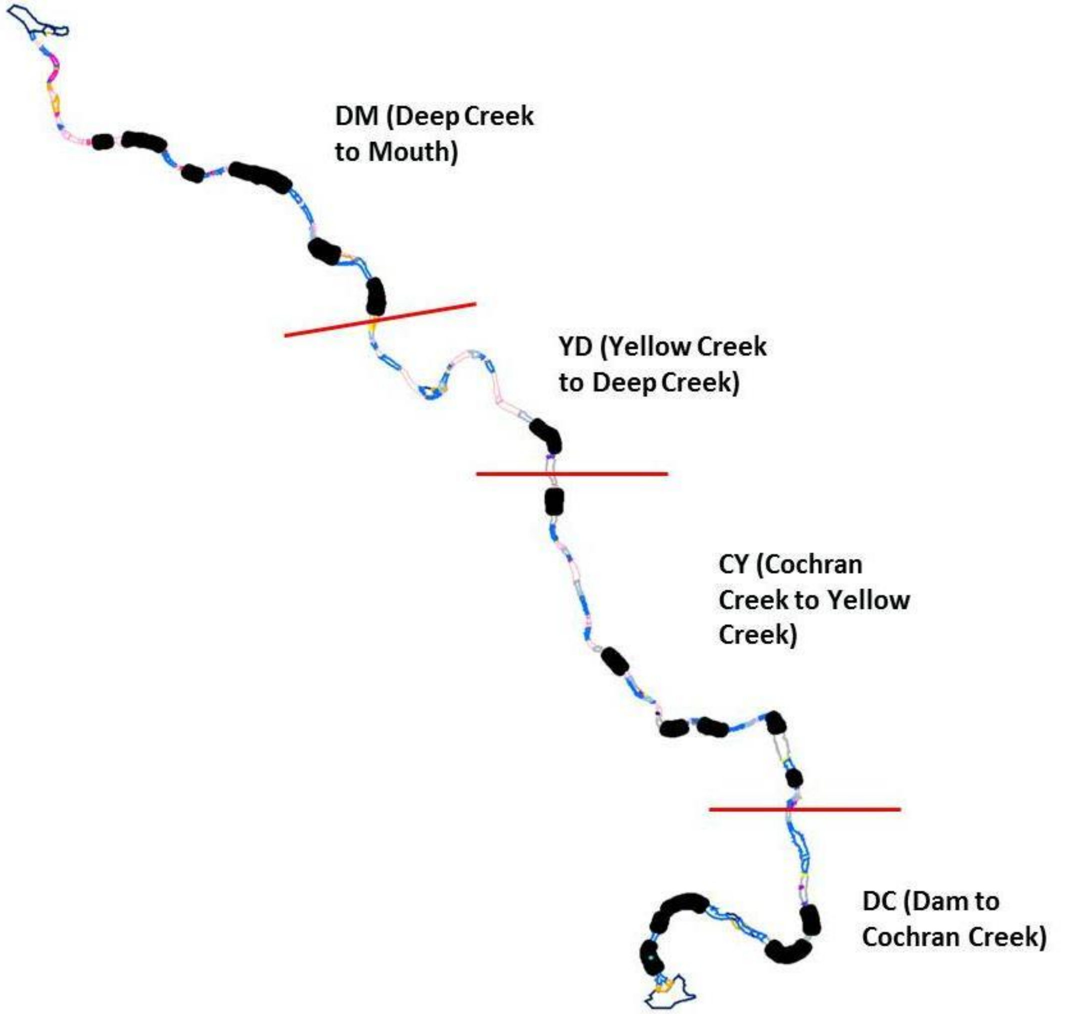

River chub nesting habitat and responses to flow restoration

Table 1. Depth (cm), current velocity (cm s-1), intermediate substrate diameters (cm), and water percolation rates (cm s^{-1}) (± standard error) of river chub nests and paired transects in the Cheoah River, NC.

	Depth	Current velocity	Substrate diameter	Percolation rate (cm s^{-1})
Nest	42.1±1.6	0.22±0.01	2.9±0.04	0.09±0.006
Paired transect	51.9±1.8	0.42±0.03	16.1±0.67	0.06±0.007

Table 2. Parameter estimates (± standard error, SE), p-values, cumulative model weights (Σwi), and relative importance of mesohabitat scale variables in generalized linear mixed models predicting river chub nest presence and abundance, respectively. Ranks range from 1 (most important) to 3 (least important).

	y= nest presence				*y= nest abundance*			
Variable	Parameter estimate ± SE	p-value	Σw_i	Rank	Parameter estimate ± SE	p-value	Σw_i	Rank
S_{AVG}	-7.1±2.3	0.0034	1.0	1	-4.2±0.6	<0.0001	1.0	1
D_{AVG}	-9.5±4.9	0.0593	0.94	2	-2.7±1.4	0.0642	0.72	3
% outcrop	4.8±7.5	0.5221	0.49	3	3.9±2.1	0.0683	0.73	2

Table 3. Average dimensions (± standard error, SE) of 27 river chub nests before and after a two-day dam release event.

Time	Length (cm)	Width (cm)	Height (cm)
Pre-discharge	74.0±2.9	65.2±4.1	21.1±1.2
Post-discharge	79.3±4.6	77.0±5.2	17.0±1.3

Gravel Addition – Passive Technique

- Total 200 yd^3 dumped at 4 sites, recurrent on a biannual basis
- Site 1: High gradient, 100 yd^3
- Site 2: Moderate-High gradient, 20 yd^3
- Site 3: Very-low gradient, 40 yd^3
- Site 4: Low gradient, 40 yd^3

- Recommended & ordered amount = 500 yd^3 per site on annual basis

Gravel addition at Site 1

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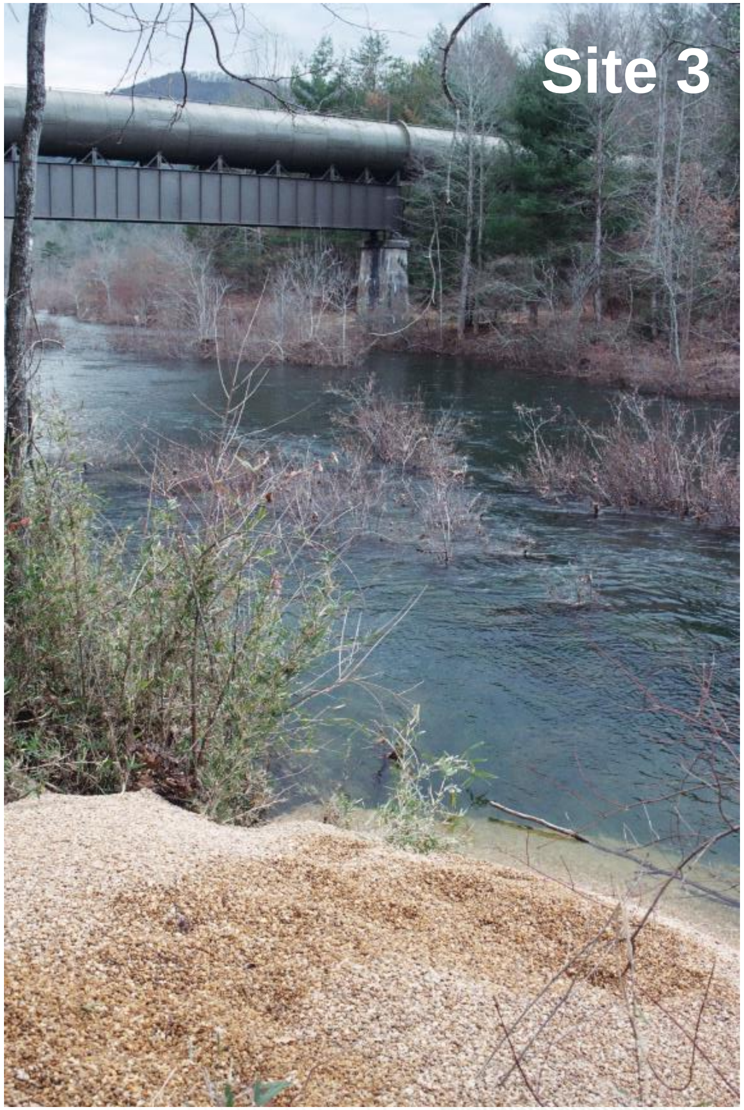
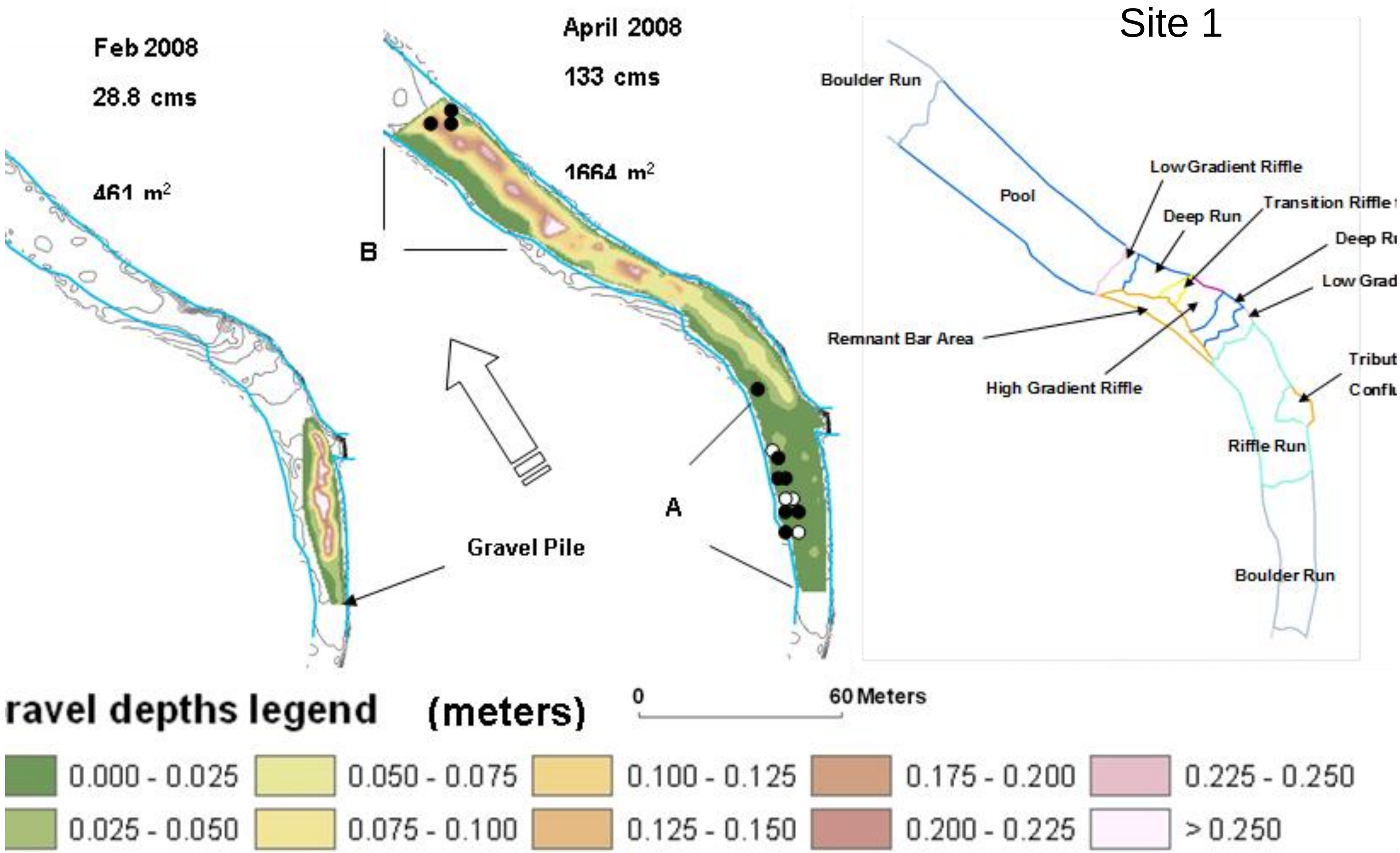
Gravel addition at Sites 2 and 3



Gravel addition at Site 4

Gravel migration and entrainment



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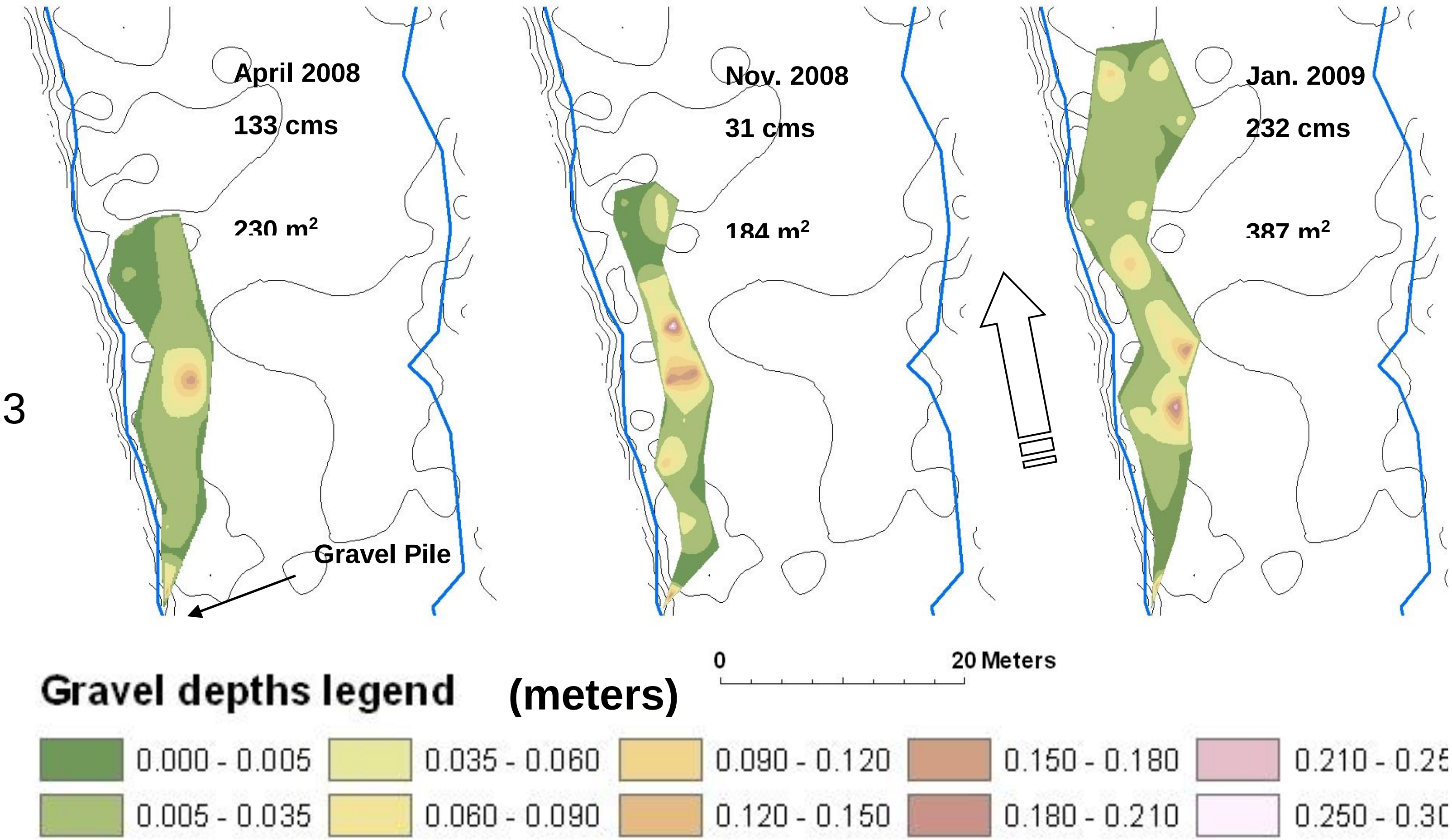
Gravel migration and entrainment

Site 3



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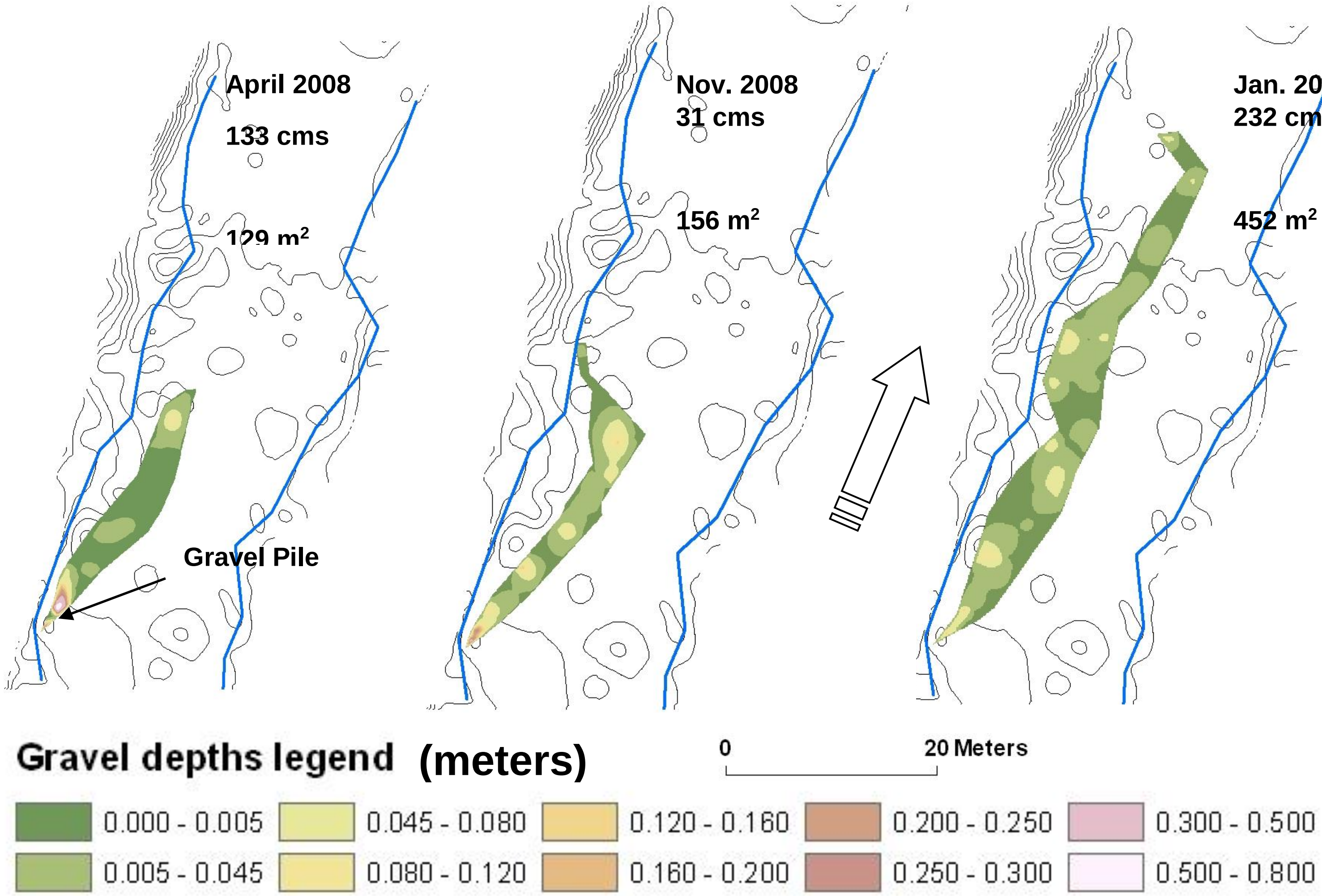
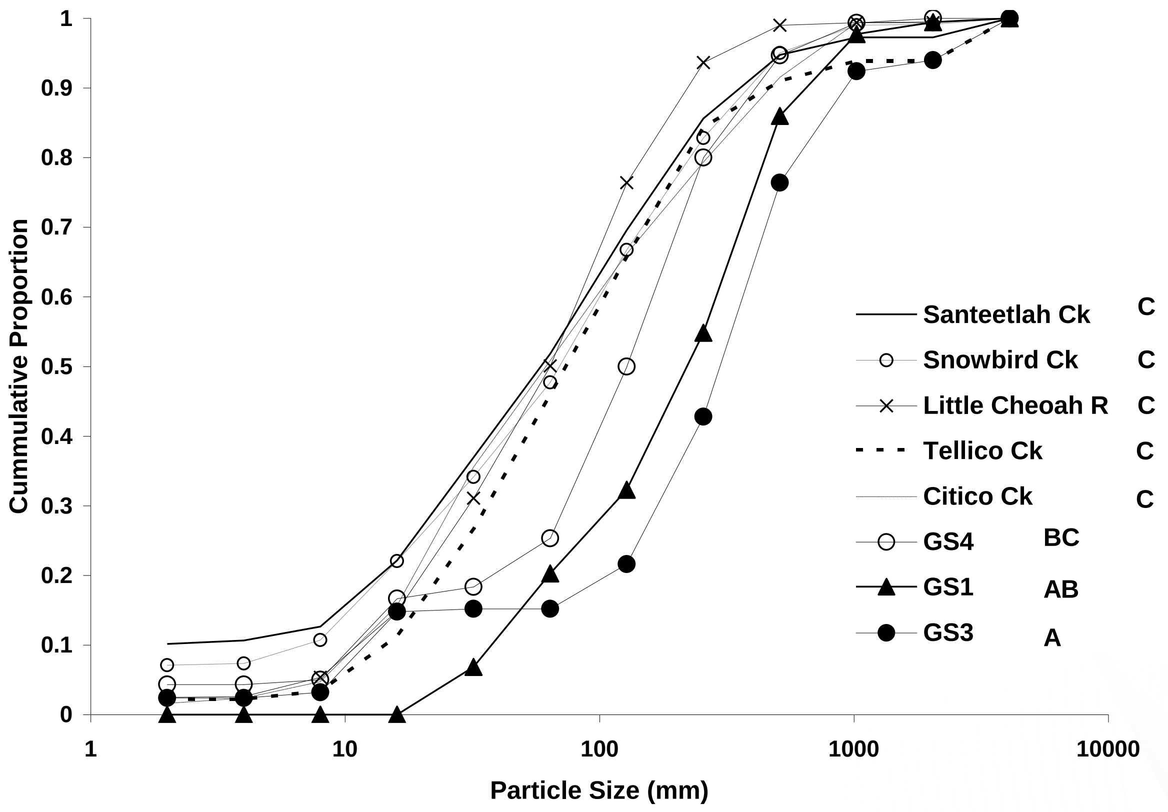
Gravel migration and entrainment

Site 4

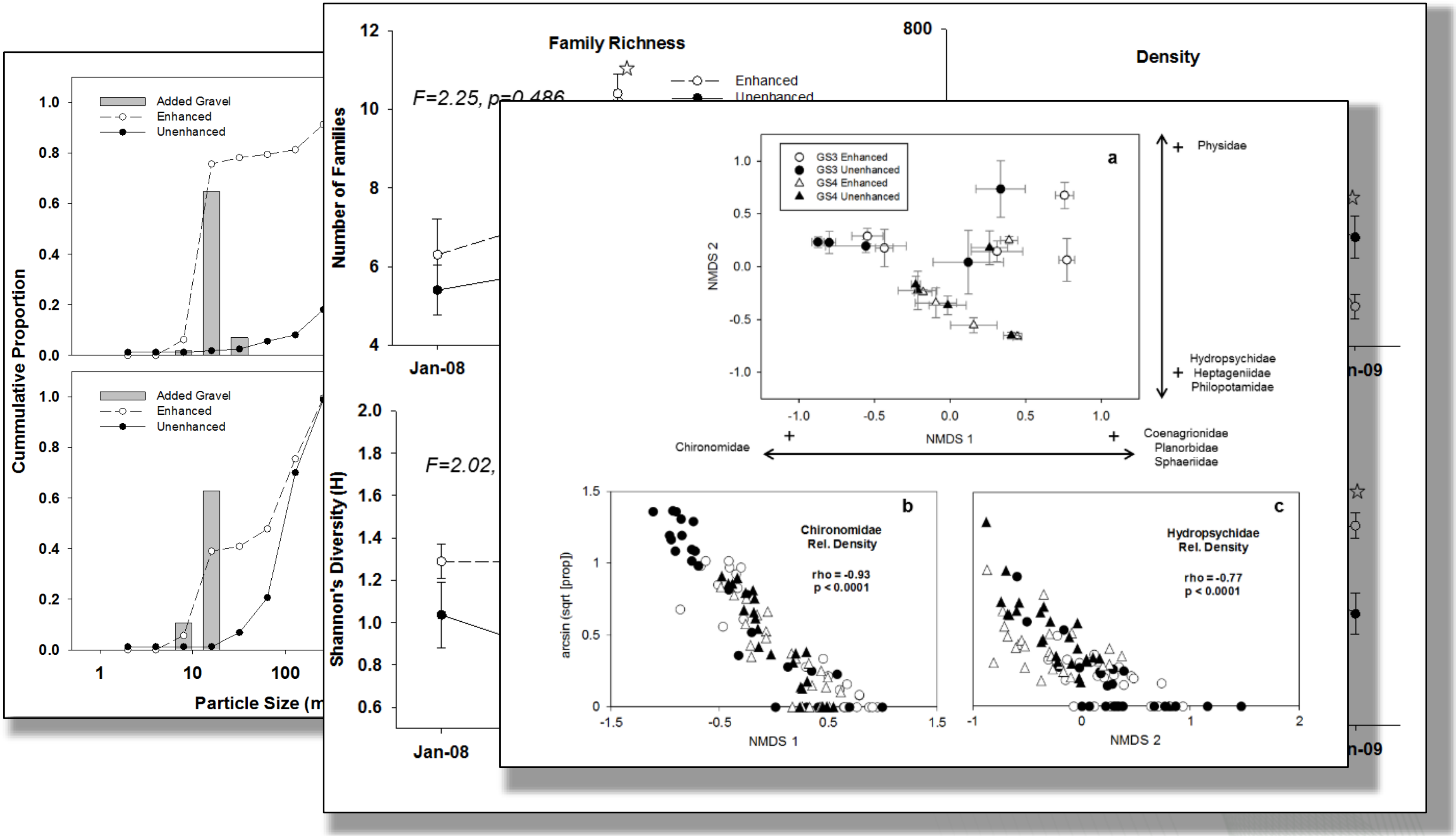


Substrate Conditions Following Gravel Addition

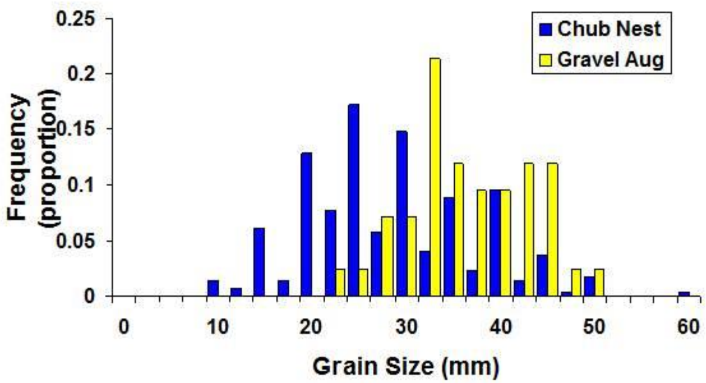


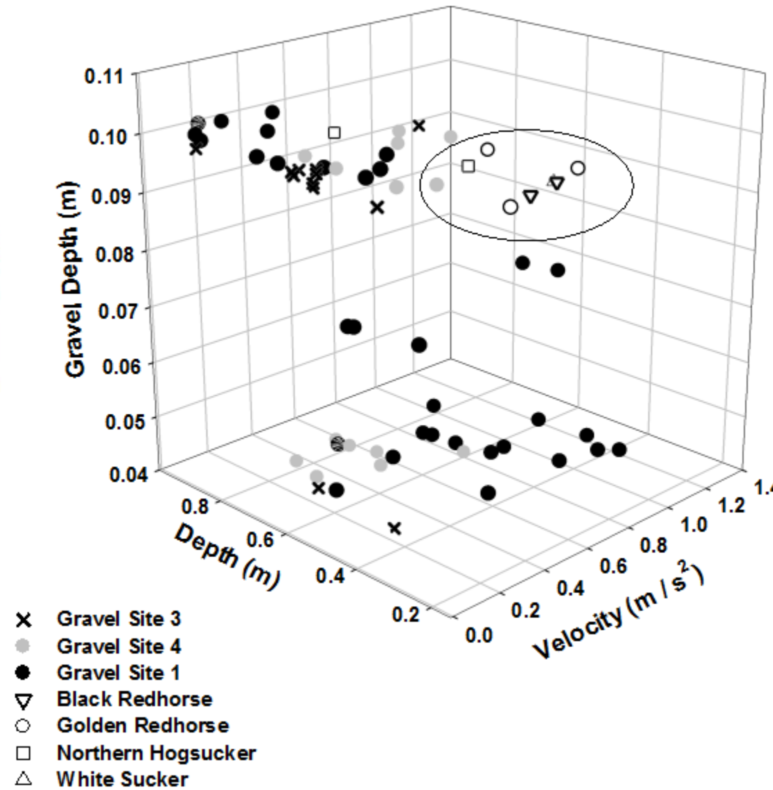
- Gravel augmentation to mitigate bedload loss
- In sufficient volumes to provide adequate habitat for most fish species.

Macroinvertebrate responses to gravel addition



Fish spawning responses to gravel addition





Three-dimensional graph of habitat measurements (water depth, velocity, and gravel depth) taken at three gravel addition sites and compared to measurements found in literature for four catostomid species. Gravel depths greater than 0.1 m were automatically assigned 0.1 m. All catostomids were assumed to need 0.1 m of gravel depth as sufficient spawning habitat. Oval circle highlights the multi-dimensional space designated as suitable catostomid spawning habitat.

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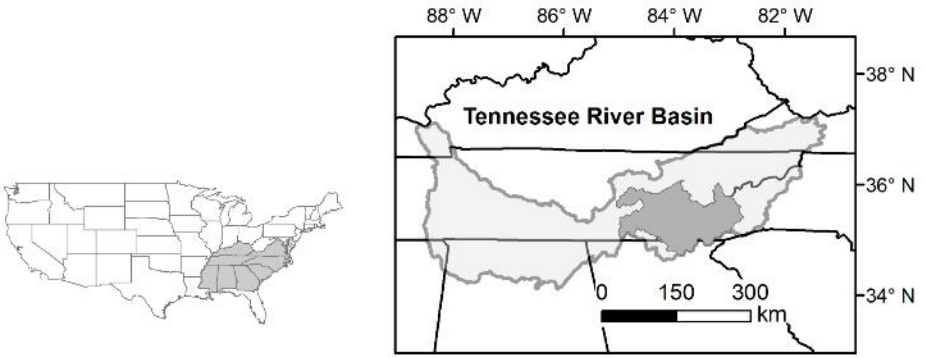
Species of concern conservation efforts

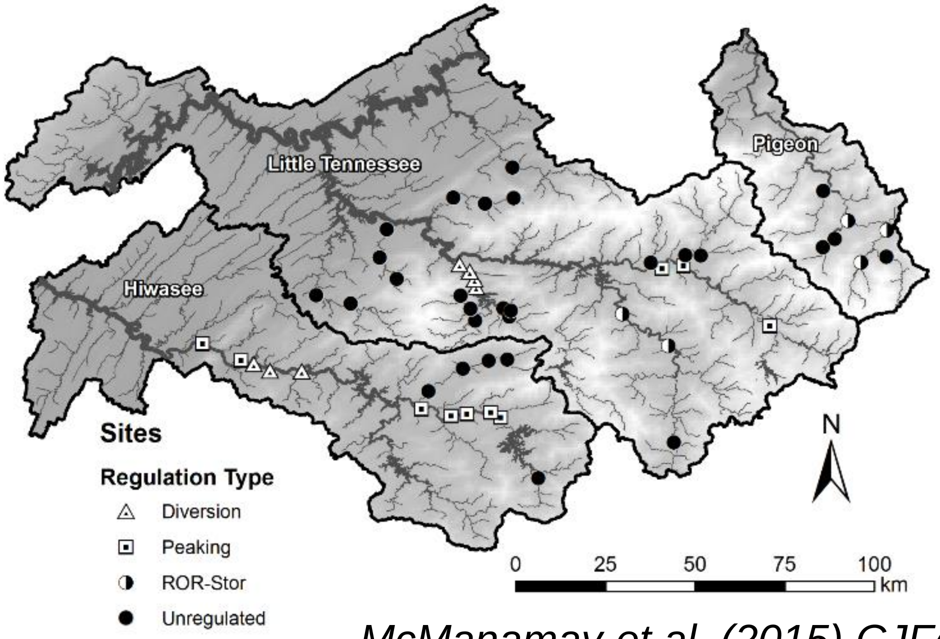
- Reintroduction of two endemic species
  - Spotfin chub 
  - Wounded darter 
- Virginia spirea monitoring and invasive plant removal
- Appalachian elktoe monitoring

Regional Perspective

- What are the major factors driving fish communities in regulated rivers in the Tennessee River Basin?

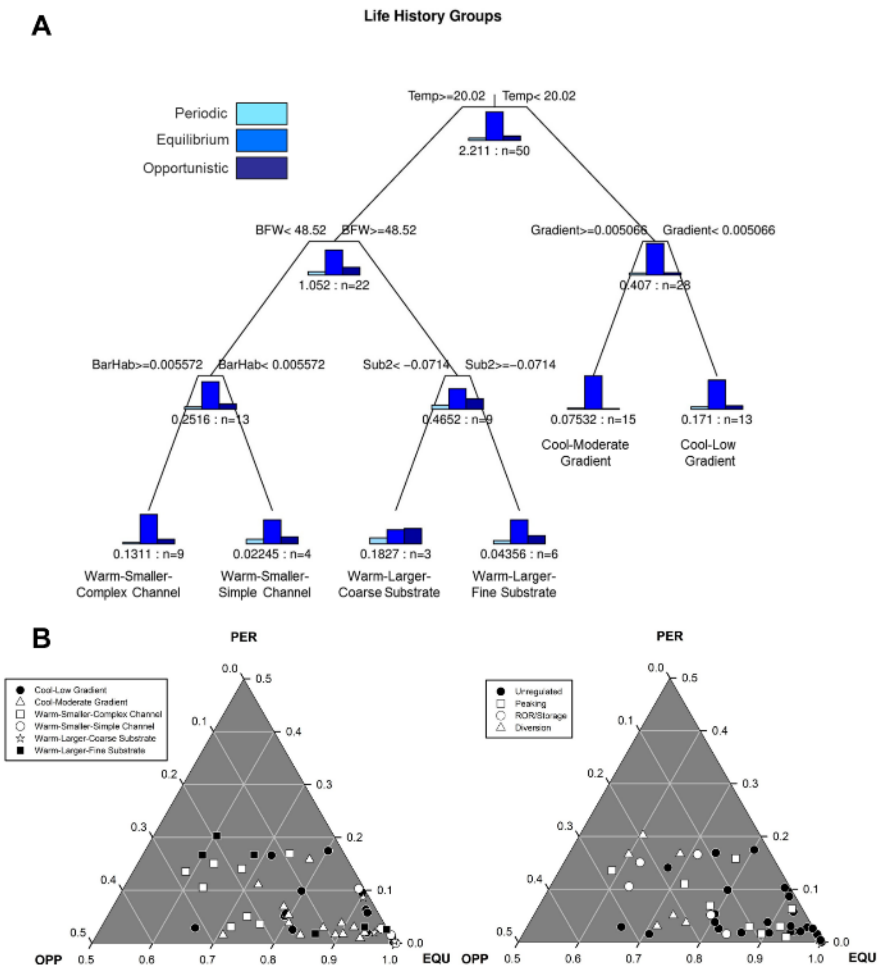
- Hierarchical design
  - Large-scale factors
    - Dam operations
    - Fragmentation
    - Watershed
    - Elevation
    - Gradient
  - Instream habitat
    - Flow
    - Temperature
    - Substrate
    - Channel Morphology

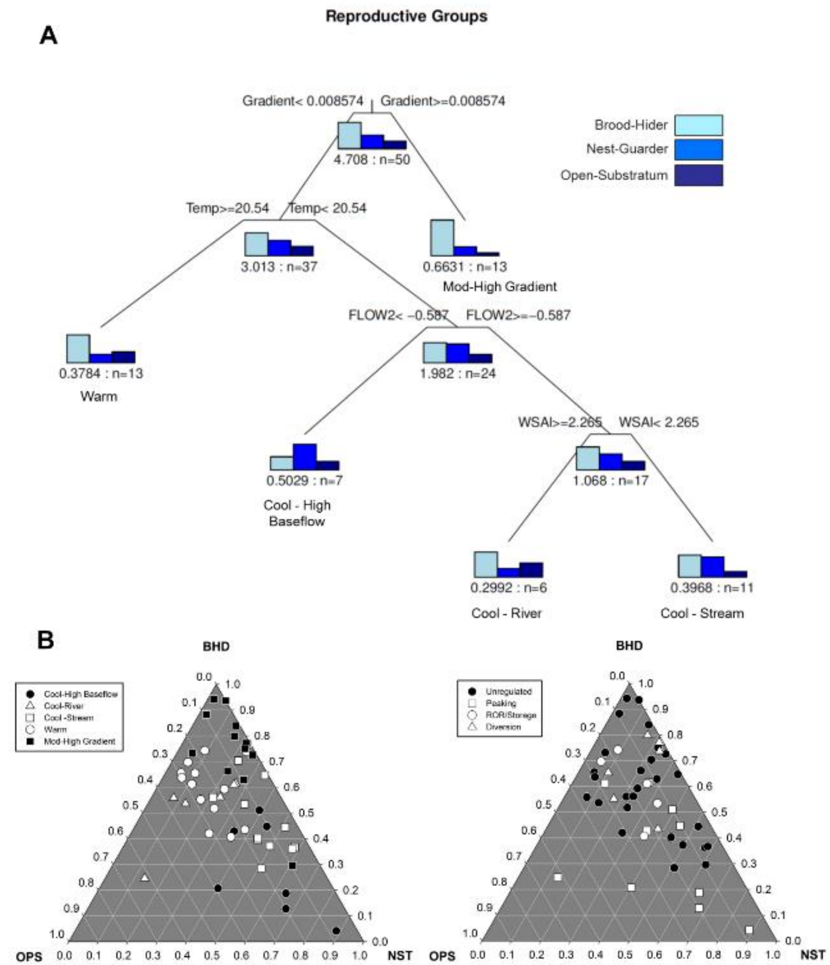




McManamay et al. (2015) CJFAS

Is Flow King of the Regulated River Jungle?





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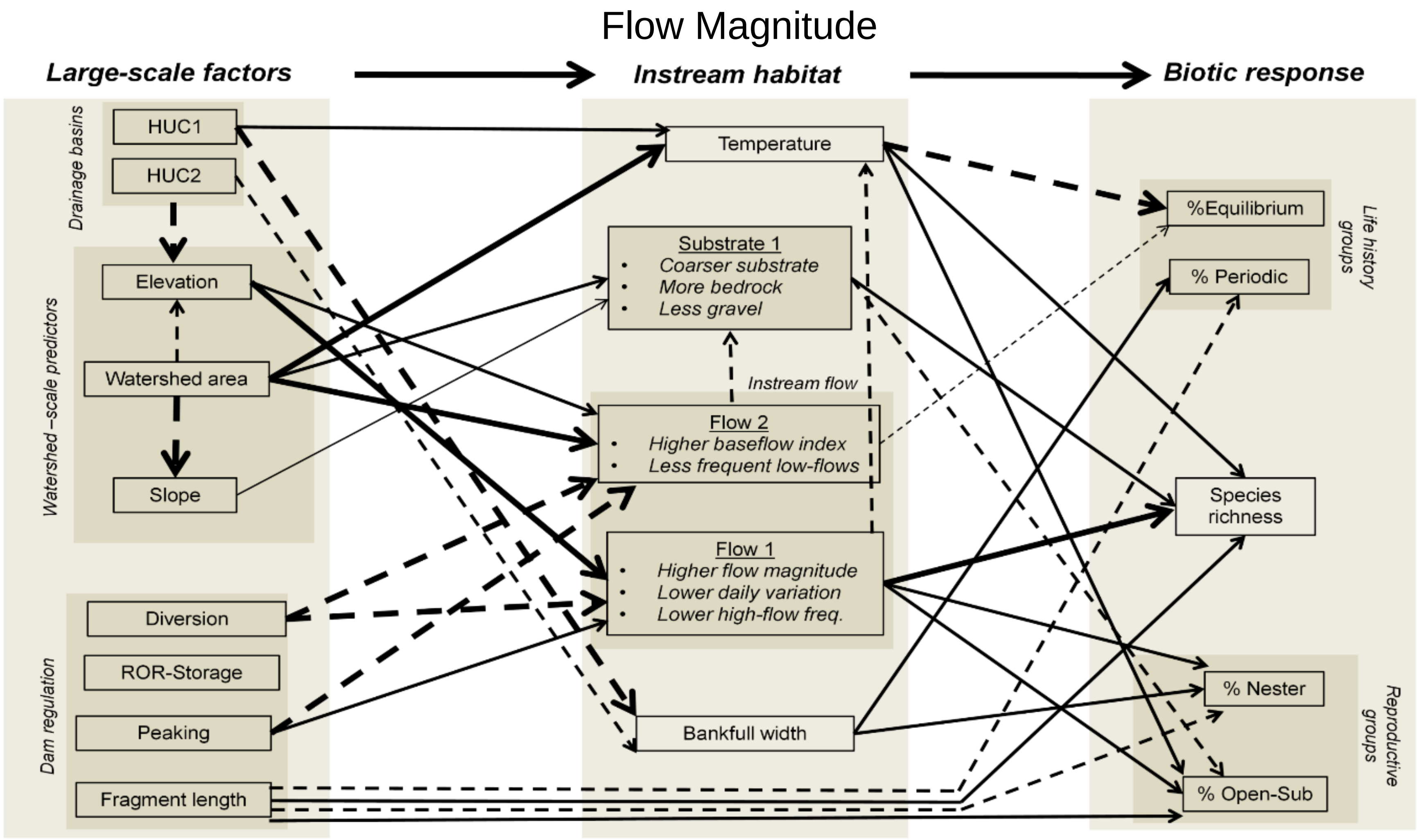

McManamay et al. (2015) CJFAS

Takeaway Messages

- Physical and riparian responses to flow restoration clearly observed
- Lack of response by fish community due to other constraints

- Gravel addition was not executed according to the specifications in the enhancement plan and led to a poor-treatment effect and very little habitat enhancement
- Did not provide “improved” habitat conditions for macroinvertebrates and fish

- Constraints on the system – finding the limiting factor. Increased temp? Fragmentation? Substrate habitats?

- Post-restoration studies were short-term, need a long-term perspective

- Lack of current monitoring

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