Ecological Flows Science Advisory Board (EFSAB)
Meeting Summary – June 19, 2012
Archdale Building, Raleigh NC

X APPROVED for distribution

Attendance

Members
Donnie Brewer, Environmental Mgt Commission
Mark Cantrell, US Fish & Wildlife Service
Bob Christian, East Carolina University
Tom Cuffney, U.S. Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jim Mead, NC Division of Water Resources
Sam Pearsall, Environmental Defense Fund
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Fritz Rhode, US National Marine Fisheries Service (online)
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Division of Forest Resources

Alternates
Vernon Cox, NC Department of Agriculture
Sarah McRae, US Fish & Wildlife Service
Steve Reed, NC Division of Water Resources
Van Stancil, NC Wildlife Resources Commission
Fred Tarver, NC Division of Water Resources

NC Division of Water Resources
Don Rayno
Sarah Young

Guests (onsite)
Alex Cohn, TNC
Leigh Habegger, APNEP
Jennifer Phelan, RTI
Ian McMillian, DWQ
Breda Munoz, RTI
Erin Thompson, APNEP
Jason Williamfeld, NC Forest Service

Guests (online)
Craig Brombley
Bill Crowell
Lisa Gordon
Kyle Hall
Haywood Pthisic, LNBA

NCSU Cooperative Extension Facilitation Team
Mary Lou Addor, Natural Resources Leadership Institute (NRLI)
Patrick Beggs (WECO) Watershed Education for Communities and Officials
Christy Perrin (WECO) Watershed Education for Communities and Officials
Nancy Sharpless, Natural Resources Leadership Institute (NRLI)

In memory of our friend, Steve Reed
This summary comes out following the passing of our friend and colleague, Steve Reed, NC DWR. The facilitation team expresses our sincere condolences to his friends and colleagues. We will miss him and his leadership in the EFSAB process, and will do our best to support DWR and the EFSAB in meeting their goals as we move forward.

The purpose of the Ecological Flows Science Advisory Board:
The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information about the E-Flows SAB are available at: www.ncwater.org/sab The presentations from the June meeting are available at http://www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20120619/

The EF SAB will meet August 28 at the Stan Adams Education Center at 9:00am.

Address and map are on the last page.

I. Executive Summary

Comparison of 3 Current Studies (Jim Mead)

Jim provided a hand-out that clarified and compared three external studies that were originally scheduled for presentations on the agenda. (Item 3 was postponed for the August meeting.)

1. Bio-Fidelity Test Hydrologic Stream Classification
2. RTI Internal Research & Development Project
3. The Nature Conservancy's Four-Basin Environmental Flow Project

Update: Biological Fidelity Analysis of Stream Classes (Jennifer Phelan)

RTI is undertaking a study with the Environmental Defense Fund. An update was given. The project objective is to adopt a stream classification system that represents the distribution of aquatic biota in North Carolina, by evaluating the 7 EFS stream classes, comparing fidelities of aquatic biota to different stream classification systems (EFS and McManamay et al., 2011), and determining if the current EFS stream classes need to be modified to more accurately describe the distribution of biota. RTI intends on including 578 NHD+ catchments (217 mountain, 231 Piedmont, 130 coastal plain) in the biofidelity analyses. These catchments were selected based on "minimally altered" water quality and flow condition status and presence of at least one biological monitoring station (NC Benthic Macroinvertebrate, NC Fish Community and/or Natural Heritage Inventory programs). Aquatic bioata data from the 1981-2010(30 year) period of record will be used in the fidelity analyses. Stream classes will be determined using 40 years (1967-2006) WaterFALL hydrologic data and current instream flow alterations (withdrawals, discharges and dams). Jennifer shared the results of a preliminary Random Forest statistical analyses testing the fidelity of individual species to the 7 EFS stream classes. These preliminary analyses were conducted on 106 of the 185 NHD+ catchments used to develop the EFS stream classes. The fidelities of benthic macroinvertebrates (presence- absence) were assessed in the analyses. Although some species showed some degree of fidelity to some of the stream classes, the results were inconclusive due to the small and uneven number of records for each stream class, the potential confounding influences of water quality and instream flow alteration (analyses were not restricted to minimally altered NHD+ catchments), and the uneven and generally low number of records for each species.

Macroinvertebrate Assemblage Correspondence to Hydrologic Classes & Discussion (Tom Cuffney)

Tom discussed how he addressed some of the analysis issues: a) 1 class with only 1 site; b)rare taxa, c) data collected from multiples seasons, there is not one index period, d) data is ordinal, e)ambiguous taxa, f) what is lowest taxa level you want to represent in data.

After addressing those issues within the data, he conducted 2 analyses, using the same macroinvertebrate dataset (106 NHD+ catchments) as RTI:

ANOSIM (Analysis of Similarity) hypothesis: there is no difference between the assemblages of classes. Results: For the qualitative data set without Class E, it is not significant, no difference. For the qualitative (presence/absence data), it is significant, but with low values.

He identified another question to consider: is there a hydrologic classification that optimizes the correlation to the distribution of assemblages?
Based on this question he conducted additional analyses: Indicator value index and Phi Analysis for Fidelity. Results: for both species and genus, quantitative and qualitative analyses did show statistically significant association.

Fidelity analysis conclusions:

- We can extract taxa that are indicators of hydrologic clusters
- The key question is whether the clusters are optimal as indicators, if not then fidelity analyses are not informative
- Identifying optimal clusters is really important.

The data used for these analyses included all benthic macro invertebrate sites, including impaired sites, which introduces a lot of variability. These analyses could be repeated using the data associated with the 578 minimally altered NHD+ catchments identified and provided by RTI.

Discussion about Fidelity testing

Some main discussion points included:

- the desire to overlay a category such as ecoregion to the hydrologic classification to help develop subsets of classes.
- It's a challenge to fit the biological systems with the hydrologic systems
- The work to link biology to stream classes is at the forefront, won't be perfect but will improve over time

RTI internal project: Flow Alteration-Biological Response Relationships to assist with the determination of ecological flows & small group discussion

Jennifer Phelan provided an overview of RTI's approach of using

- Unaltered/Historic and current flows determined with WaterFALL model and a modification/subset of the TNC Indicators of Hydrologic Alteration (IHA) flow metrics
- Large state-wide NC fish community dataset
- Potential inclusion of other influential factors in the analyses (e.g., habitat, interspecific interactions, preceding year climatic events, water quality).

to determine species-specific flow alteration-biological response relationships that are useful to water managers. She presented the criteria used for selecting fish species to include, the criteria for selecting flow metrics, and other influential factors (and sources) that could be included in a multiple regression analysis. She provided handouts with the resources used for selecting fish species, a table of some of the fish species, and the flow metrics that will be used in the analyses.

General suggestions from EFSAB included:

- Abandon the parameter of "presence on 303(d) list", since not all listings are created for the same reasons. Using some of the variables leading to 303(d) listing makes more sense.
- Consider grouping the species into guilds, and adopt guild metrics (species diversity, total count, and.or diversity index (e.g., Shannon-Weaver) as the biological response variable.
- Consider including 7Q10 as a flow metric

- The EFSAB would like to see the guild species list
- Consider temperature as a water quality variable

The EFSAB broke into small groups to answer specific questions. See main section for responses.

Revisiting the DWR Trial Balloon Discussion

The EFSAB responded again to DWR's proposals to:

Stop using >120% of habitat available under a flow regime in habitat modeling

There appeared to be general support from the group to keep the > 120% scenario in winter analyses. The majority of EFSAB are okay with dropping the >120% analysis in the other seasons, with a few members wanting to keep it in spring as well as winter, and with a strong preference from a member to keep the >120% analysis in all seasons.

Reduce the number of flow scenarios analyzed, based on the table presented in April.

The EFSAB agreed to the table of proposed flow scenarios for DWR to analyze, with the exception that 7Q10 should be analyzed later as it's a commonly used flow standard employed by other states. The EFSAB does not need to see it included in the results presented to them.

Table of Contents / June 19, 2012 Agenda (click to go to section)

I. Executive Summary 2
II. Introduction 5
III. April 24, 2012 Meeting Summary 5
IV. Comparison of 3 current studies 5
V. Update - Biological Fidelity Analysis of Stream Classes 7
VI. Macroinvertebrate Assemblage Correspondence to Hydrologic Classes 13
VII. Discussion 18
VIII. RTI internal project: Flow Alteration-Biological Response Relationships to assist with the determination of ecological flows 20
IX. Small Group Discussion 26
X. Revisiting the DWR Trial Balloon Discussion 28
XI. Upcoming Agenda Discussion 30
XII. Directions to August Meeting 31

II. Introduction

May Lou Addor welcomed everyone to the 13th meeting of the NC Ecological Flows Science Advisory Board. Attendees, in person and online, introduced themselves and their affiliation. The EFSAB was reminded about the ground rules, the process for raising questions, and reminded to project their voice loudly to for the room microphone to be able to pick it up. Attendees were reminded that the session was being recorded.

III. April 24, 2012 Meeting Summary

The April 24, 2012 meeting summary needs a few editorial changes, such as the meeting location was incorrect. The meeting summary for April 24, 2012 was approved upon correction of those changes.

All approved Meeting Summaries of the EFSAB are located at: **www.ncwater**.org/sab

IV. Comparison of 3 current studies

Jim Mead summarized the 3 concurrent studies taking place that will aid the EFSAB.

We previously discussed two potential pathways to determine ecological flows:

1. habitat modeling, and
2. incorporating biological data into flow mechanisms.

At the April EFSAB meeting, we focused on habitat modeling approach again. This month we are talking mainly about the biological approach. Studies are underway by RTI and The Nature Conservancy that we will all benefit from. The Nature Conservancy project will be presented at our August meeting. The following table summarizes the differences & similarities between the 3 projects:

	Bio-Fidelity Test Hydrologic Stream Classification	RTI Internal Research & Development Project	The Nature Conservancy's Four-Basin Environmental Flow Project
WaterFALL Hydrologic Modeling	• 30 to 40-year climate data • 2006 land cover • Minimize upstream flow alteration and water quality effects by site selection	• 30 to 40-year climate data 1. 2006 land cover, plus any flow alterations 2. Potential natural vegetation (PNV) or 1970 land cover, and no flow alterations	• 30 to 40-year climate data 1. 2006 land cover, plus any flow alterations 2. 1970 land cover and no flow alterations
Flow Analysis	• Stream Classification using EFS and McManamay systems	• Compare #1 to #2 for degree of flow alteration • Focus more on mid- and low flow metrics for water management	• Compare #1 to #2 for degree of flow alteration • Evaluate full range of flow metrics
Biological Data	• Benthos, fish & Natural Heritage Program data • Individual species (RTI) and community-based analysis approaches (USGS-Tom Cuffney)	• Fish: up to 20 species from a "hydrology" guild • Guilds based on Persinger et al., 2010 • Fish metric based on count	• Fish – similar guilds to RTI • Plus EPT, crayfish and mussels • Fish metric based on count
Sites	• Separate mountain, piedmont & coastal • Filter eliminates sites with upstream flow alteration if total drainage area at the monitoring site is less than twice the total drainage area of the upstream alteration. • Within region, stratified by yes/no upstream flow alteration • For each region randomly select ~200 sites rated excellent to good-fair	• ~600 sites associated with fish sampling data (NC Fish Community and USGS NAQWA)	• Cape Fear, Tar, Roanoke and Little Tennessee basins • Focus on sites with multiple samples over time • Greater detail on fewer sites
Results	• How well do the stream classes describe the spatial distribution of aquatic biota (i.e., a higher probability of a species or community being present in one stream class over another) • Does the classification system need revision?	• Ecological response curves: x-axis =% flow alteration y-axis = fish metric based on species level count • Uses space (multitude of sites with varying amounts of flow alteration) as surrogate for change in flow in (same site)over time	• Ecological response curves: x-axis = % flow alteration y-axis = fish metric based on species level count • Uses flow changes over time from multiple samples • Also will include descriptive analysis of basin conditions
Timeline	• Complete by 9/30/12	• Complete by 9/30/12	• Complete by June 2013

V. Update - Biological Fidelity Analysis of Stream Classes

Jennifer Phelan of RTI International presented an update of their work on Biological Fidelity Analysis of Stream Classes. The Environmental Defense Fund is funding this project. The slideshow is available on the project website: http://www.ncwater.org

Outline of Presentation

- Background
- Current Status:
    - Site selection
    - Aquatic biota
    - Stream classification
    - Preliminary statistical analysis results
        - Individual species
        - Community assemblage

Project Objectives:

- To adopt a stream classification system that represents the distribution of aquatic biota in North Carolina.
    - Evaluate the 7 stream classes of the Environmental Flow Specialist (EFS) hydrological stream classification system.

        A. Coastal Streams
        B. Small Stable Streams
        F. Medium Stable Streams
        C. Large Stable Streams
        E. Large Piedmont Rivers
        D. Small Flashy Streams
        G. Small Seasonal

    - Compare fidelities of aquatic biota to different stream classification systems
    - If necessary, modify the EFS stream classes to more accurately describe the distribution of biota

Study Methods:

- Aquatic Biota and Datasets:
    - Fish (NCDENR DWQ Fish Community, USGS NAQWA, WRC Trout, WRC Diversity (Gameland Surveys))
    - Benthos (Aquatic species in Natural Heritage Program database)
    - Aquatic species (NCDENR Natural Heritage Program database)

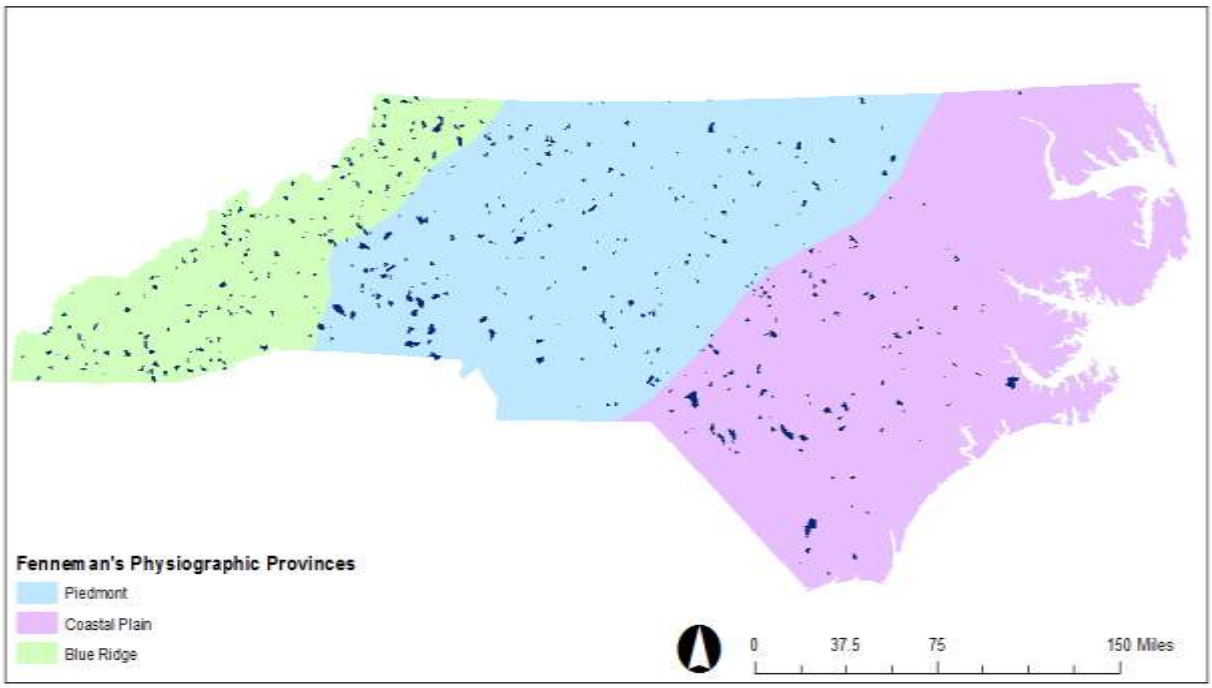
- Sites:
    - 185 NHD+ catchments with USGS gages (used to develop EFS stream classes)
    - Add additional sites for a final number of ~600 NHD+ catchments with stream classes based on WaterFALL hydrologic data
- Aquatic biota data within each NHD+ catchment will be paired with the assigned stream class
- Stream Classifications Systems (all three use flow metrics):
    - EFS
    - McManamay et al. (2011)
    - Konrad (in review)
- Statistical Analyses:
    - Random Forest (individual species)
    - Similarity Analyses (communities)

Current Status:

1. Site Selection
2. Aquatic Biota
3. Stream Classifications
4. Preliminary Statistical Analyses

1. Site Selection

- 185 NHD+ catchments with EFS stream classes. These sites paired with NC Benthic Macroinvertebrate monitoring station data were used in th preliminary analyses that will be presented today (a total of 106 of the 185 NHD+ catchments had monitoring stations)Criteria for choosing the additional sites (for a total of ~ 600 sites) include:
    - equal representation of 3 physiographic regions
    - "minimally impaired" condition:
        - Water quality: Excellent, Good or Good-Fair Benthos site condition
        - Water quantity (instream flow alteration): total drainage area of monitoring station is at least twice the size of the total drainage area of the closest upstream flow alteration
    - Within each physiographic region, proportional representation of streams with and without upstream flow alterations (Example- if 20% of sites had upstream flow alterations, then 20% of sites selected in a physiographic region also did)
    - Random selection of qualifying sites
- Final number of sites (selection criteria applied to 185 NHD+ catchments + new sites):
    - 578:
        - 217 mountains
        - 231 piedmont
        - 130 coastal plain



Question: looking at the map, is there a reason why the Albemarle Pamlico Sound plain is devoid of sites.
Response: I imagine it is the availability of sites paired with the selection criteria.
Comment: There are very few sites out there that fit all the criteria.

3. Aquatic Biota
   - ll monitoring sites within 578 NHD+ catchments:
     - Fish, benthos, NHP aquatic species
     - 30 years of data (1981-2010) assuming stream classes based on ~ 2010 condition (the following table is not reflective of the date restriction- these will likely be reduced.)

Aquatic Biota	**Number of Monitoring Sites**
Benthos	636
Fish	238
Natural Heritage Inventory	656

3. Stream Classification

- Stream classes based on WaterFALL hydrologic data:
  - Generate for all 578 NHD+ catchments:

        - 2006 NLCD
        - 40 years of climate date (1967-2006)- 40 years is a length of time that minimizes probability of stream class changes
        - Instream flow alterations (dams, withdrawals and discharges – 1995-2012)
    - Plan to generate these stream classes within the next couple of months
    - Calibrate and QAQC stream classes with a comparison against classes determined by USGS gage data
- Stream classification systems:
    - EFS (7 classes), McManamay et al. (2011) (8 classes)

4. Preliminary Statistical Analyses

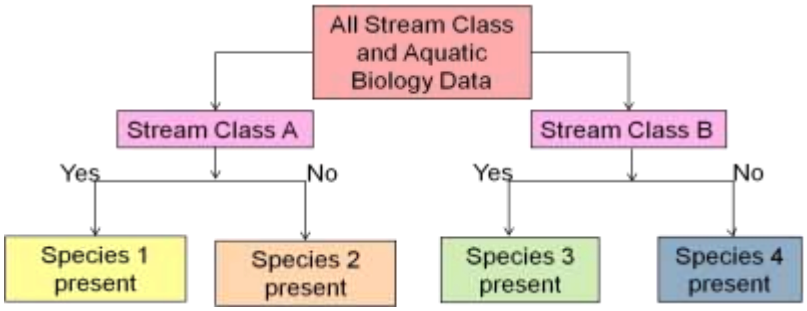
- Analyses:
    - Random Forest (individual species)
        - Presence/absence
- Similarity Analysis (communities)
        - Presence/absence
        - Abundance
- Dataset:
    - Benthos (106 out of 185 NHD+ catchments with EFS stream classes)
    - Taxonomic ambiguity resolved (by Tom Cuffney)
    - Remove Parent – Keep Child (resolved to Genus level) dataset used in both sets of analyses
- Number of NHD catchments for each stream class

Stream Class	**Number of NHD+ Catchments**
A	14
B	41
C	6
D	30
E	1
F	8
G	6

Random Forest Approach

Random Forest is a decision-tree modeling and classification approach (Cutler et al., 2007)

A decision tree is a predictive model that uses a set of binary rules (yes/no) to split the data based on the predictor variable



Example Table 1: Random Forest Analysis – An example of Biological fidelity to stream class

Aquatic species	Stream Class						
	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

= high probability
= medium probability
= low probability
= absent

Example Table 2: Random Forest Analysis – An example of NO Biological fidelity to stream class

Aquatic species	Stream Class						
	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

= high probability
= medium probability
= low probability
= absent

In the Example Table 1, for species 2 and 10 there is high fidelity to stream classes, in contrast to Example Table 2, which shows that the class system is not working well.

Table 3: Preliminary Statistical Analyses

	Stream Class						
Taxa	A	B	C	D	E	F	G
Ceratopsyche	0.032	0.034	0.005	0.076	0.000	0.012	0.032
Serratella	0.031	0.008	-0.003	0.071	0.000	0.000	-0.010
Heptagenia	0.013	-0.003	0.034	0.025	0.000	0.001	0.010
Pycnopsyche	-0.012	0.011	-0.006	0.019	0.000	0.004	0.027
Phylocentropus	0.038	0.001	0.001	0.002	0.000	0.000	0.005
Cardiocladius	0.000	-0.004	-0.004	0.001	0.000	0.016	0.001
Pteronarcys	0.007	0.000	0.013	0.019	0.000	0.004	0.004
Neophylax	0.014	0.008	0.011	0.013	0.000	-0.006	-0.015
Paragnetina	0.004	0.005	0.008	0.013	0.000	0.000	0.007
Brachycentrus	-0.006	0.000	-0.001	0.013	0.000	-0.005	0.004
Promoresia	0.007	0.000	-0.003	0.012	0.000	0.004	0.008
Epeorus	0.008	0.005	0.008	0.011	0.000	-0.005	0.009
Microtendipes	-0.010	0.006	0.010	0.011	0.000	-0.008	0.010

Importance:
High
Medium
Low

- Table 3 shows a subset of the initial results (13 of the 408 species included in the analysis, shown because they illustrate some level of fidelity)
- Red shows a higher level probability of likelihood of occurrence
- Probability ranges from -1 to 1. The closer to 1, there is higher correlation to the species being there. If the value is negative, there is no correlation.
- Only ~10% of taxa (41 out of 408) showed a higher fidelity to one stream class over another
- Some of the results may be an artifact of the low numbers of NHD+ catchments for each stream class (1-41)
- If the number is small, it is positive correlation, but without much strength
- Values can be translated into probability values, though the values are low. Importance value is a measure of occurrence of species in stream class and ability to predict stream class by occurrence.
- Stream Class E has only 1 record (site), whereas stream class D has 30.
- Minimum number of NHD+ catchments for more robust analyses is ~ 40.
- 36% of taxa had $\leq$ 3 records
- Fidelities could be further confounded by including all benthos sites in the analysis
- The lowest level in this analysis is genus.

VI. Macroinvertebrate Assemblage Correspondence to Hydrologic Classes

This section summarizes Tom Cuffney's (US Geological Service), presentation on his work. Rather than looking at each genus or taxa, we're looking at correspondence of assemblages in to the hydrologic classes. We've talked about some of the analysis issues: a) 1 class with only 1 site; b)rare taxa, c) data collected from multiples seasons, there is not one index period, d) data is ordinal, e)ambiguous taxa, f) what is lowest taxa level you want to represent in data. When you talk about things that are genus or species level, that is the lowest level that is represented in the data. The data actually had data recorded for higher levels, so it's not all genus or all species.

a) Regarding uneven distribution, you have several groups with multiple sites, but class E only has one. We eliminated Class E because you can't handle a class with one site when doing these analyses. There is such a difference among classes, I did simulations where I randomly pulled out 10 sites from ABD, and ended up data sets with all classes with all data classes. So data used in analyses include all sites, all sites except E, and 10 random sites from A,B, and D.
b) Rare Taxa- along the y access is number of taxa in a group, X access is number of sites they appear in. First one, 22% of taxa in data set appeared in only one site. 13% appeared in 2 data sets. 55% of the taxa appear at 5 or fewer sites. There are a lot of rare taxa in here. What we did here was to create additional data sets- a data set that had all the taxa in it, a data set that had taxa that occurred in more than 5 sites, more than 15, and then I lost patience at 20.
c) Multiple seasons- most data is from July, Aug(~56% of it). I would up not doing anything with this because I didn't want to throw out the other 44% of the data. Bear in mind that these data are from all months of the year, if you know about benthic you know some won't be there all times, or they may be there but may be too small to identify.
d) Ordinal Data - data produced by the state is ordinal data, its listed as absent, rare, common or abundant. In quantitative analysis they are typically assigned 0,1,3, 10 when they are calculating a benthic index, so that's what we did.
e) Ambiguous parent- lets look at site 1, we've got data at order, genus, and 2 species within that genus. We have some redundant information, if you have Baetas pluto (species), you know you have Baetis (genus), Baetidae (Family) and Ephemeroptera (order). We want to eliminate as much redundancy as we can. That's what I mean when talking about resolving ambiguous taxa. For this site 1, Ephemeropter and Baetidae are ambiguous parents.

   Resolving ambiguous taxa and recoding data (tiny table). What we do is to remove ambiguous parents $\geq$ order level. We dropped it out.

   For baetis where we had with 3 individuals, we divided them among 3 children in proportion to their abundance. So in this example we added 1/11 to *B. flavistriga* to equal 1.3, and added 10/11 to *B. pluto* to equal 12.7. Once we had all that done, then we recoded it back to original ordinal data (1,3,10).

   We also did qualitative presence/absence recoding, so everything is just ones or zeros.

   So now we have 2 more data sets- we have a lot of data sets.

f) Lowest Taxonomic level- genus and species level is lowest. When we look at the number of ambiguous taxa, specifying your particular lowest taxa has an effect on that. If we specify the species level we have 116 taxa that were ambiguous parents, that's 19% of the total, 5,819 is

almost 18%. If we go to genus then it drops to 27 and only 6.6% that are ambiguous, and the abundance drop to 2.6%. We're really reducing amount of ambiguity in data sets.

So we added to the analyses one more analysis with species level, and one with genus level as lowest.

Data preparation steps included:

1. Set lowest taxa level: Genus, Species
2. Took that data set and remove rare taxa: 0, 5, 10, 15, 20 sites
3. Remove ambiguous parents ≥ Order
4. Resolve ambiguous taxa:
   Distribute abundance of ambiguous parents among children, proportionately
   Resolve ambiguities separately for each sample- so it reduces the number of ambiguous parents but does not remove them from the data set.
5. Ordinal and Qualitative (P/A) data sets
6. 10 site simulations for clusters A, B, and D

Analysis:

<u>ANOSIM(Analysis of Similarity)</u>: which tests correspondence between hydrologic classes and invertebrate classes

<u>Indicator Value Analysis</u>: after running ANOSIM I got interested in another analysis that identifying indicator values that differentiate among hydrologic classes. Other methods for identifying indicator values.

<u>ANOSIM</u>

Comes from a commercial package called Primer 6. In this case, hydrologic classes represent treatments within the ANOVA. Analysis is based on resemblance (similarity or dissimilarity) of assemblages between sites. It looks at ranks of those similarities between samples in the underlying triangular similarity matrix. Looks at resemblances between sites, and looks at ranks of those similarities in the underlying similarity matrix.

(Slide 12)Data Matrix (Site by species, with abundances in the table) is the upper one on the slide. Can run similarity based on assemblages. For qualitative, used Kendal Rank Correlations on that, since data was ordinal. For qualitative analysis (presence/absences) used a Sorenson Index. That results in a site by site resemblance matrix so you get a sense of how similar those sites are in terms of assemblages. That's the data this ANOSIM works with. (Slide 13) It looks at the average within and between classes of the assemblage matrix- that's the colored areas represented within classes , (A vs A) then , like ANOVAs do, compares those with areas outside of that.

The Test statistic is R (slide 14) is actually the average rank similarity between classes, the diff between that and the average rank similarity within classes divided by a constant based on the end number of samples.

Hypothoses Ho: There is no differences between the assemblages of classes. R=0. This is comparing permutations- is it different from a random permutation of the data? See slide 14 for equations and variables.

IT does Global and Pair-wise tests:

Global test of significance: a significant result means there are differences somewhere that should be examine further.
Pair-wise test of significance

- Extract pairs of classes
- Re-ranked
- Repeat test

ANOSIM results (slide 16): **For quantitative data set**, here is one with all sites and classes, without Class E, **ns means it's all not-significant**. On basis of quantitative analysis there is no match, none randomly better. If you do it **qualitatively, you do get significant results** (Slide 17)**.** These are R values that vary from 0 to 1, most are pretty low (~ .20 for example). While better than totally random, I wouldn't classify them as very good.

All that effort put into doing those random 10 things with the other stuff, in final analysis was wasted time.

Look at Pair-wise test for genus level, the yellow values are p values that are significant, 5% or or less. What's interesting is that there are 7 that are insignificant. 5 of the 7 are all associated with class D. There is something problematic with class D.

Interpretation: Quantitative analysis shows no correspondence. It's not statistically significant, it's random.

Qualitative: there is a statistically significant correspondence is relatively low.

Unanswered question: **is there a hydrologic classification that optimizes the correlation to the distribution of assemblages?** This can't be answered with what we are doing today. The qualitative analysis shows it is better than random, but is it better than an alternative? We don't know.

So I took it further and did **different kind of fidelity analysis** to identify the taxa most strongly associated with a-priori groups/hydrologic clusters. I used 2 different methods commonly used in ecology.

Indicator value index (Dufrene and Legendre 1997): looks at indicator value for species I- max of indicator value of species I for the different clusters. Each indicator value for a species within a cluster is based on average abundance and on occurrence within clusters. Average abundance refers to *specificity*, occurrence of species in different clusters is referred to as *fidelity*. For a quantitative analysis it takes into account specificity and fidelity.

Phi Analysis for Fidelity (Tichy and Chytry 2006)- only works with occurrence data. Long denominator (slide 24) they say helps this analysis work better when you have differences in sample size among clusters, which is what we have here.

Fidelity analysis data sets (slide 25)- just used a couple data sets (the one where we distributed ambiguous parents among the children, remove ambiguous parents ≥ Order, no rare taxa removed). Did use species, genus, and looked at both quantitative and qualitative.

Global results were both for species and genus- quantitative and qualitative analyses did show statistically significant association.

(Slide 27) Hydrologic Class A: These are the ones where the indicator values scores were statistically significant under random permutation. Want you to notice the size of this. It's nice to look through here and see where we've got a species here, you find the same genus of that species winds up being important in a lot of cases.

Hydro class B: Lots of candidates here.

Class C: Also a lot of candidates.

Class D: Only 1 taxa made that cut. There are definitely some problems with class D.

Class E was eliminated since it included only 1 site.

Class F: There were also a lot of candidates.

Class G: May also have some problems, relatively few candidates in there.

Fidelity Analysis Conclusions:

- We *can* extract taxa that are indicators of hydrologic clusters,
- the key question is *not* whether we can do that its whether the clusters are optimal as indicators. If not, then fidelity analyses are not informative.
- Identifying optimal clusters is really important. In the fidelity analyses I did here, you can identify the optimal clusters for individual taxa by looking at different cluster methods…decide which is the best cluster for a particular species, then it gets interesting because then you say, how many taxa show a good peak at x number of clusters, and start getting the idea of how many clusters do you need to have to start pulling it apart. I guarantee it will be tedious- 610 species in this data set. We can weed that down by getting rid of rare taxa, then you have several hundred taxa…as you keep repeating same test over and over your error rate goes up but there are ways of doing that.

Q: The tables near the end in the fidelity analysis, some of those taxa show up significant in multiple classes, right? Or are they all unique to a class?

Response (R): They are all unique. It looks for the maximum value of the cluster.

Q: Is that for the genus level as well?

R: Yes, it is true for both genus and species, each one is a separate analysis but combined in one table.

Q: Benthos- this is all sites included regardless of impairment?

R (RTI): The Data set included all benthos data that could be matched up with the 185 USGS sites. A total of 106 NHD+ catchments (and associated Benthos data) were included in the analyses. . There were no water quality of flow condition filters applied to this preliminary data set.

R (Cuffney): Then we may not be seeing correspondence because there are crappy sites in there.

C: Seems like presence/absence data it might be a better indicator.

R: Quantitative data you have probability that you will encounter the organism, and there's also a probably that there is a certain abundance level, and that joint probability will be a lot noisier. In the work we've done for urban stuff, the qualitative stuff usually gives a clearer interpretation.

R(RTI): Of the 106 sites, approximately 60 of them meet criteria of the qualitative.

Q: from webinar: Would we gain any information (better resolution) by stratifying hydro classes A-G by eco-region (mtn, piedmont, coast)? Example- Class B in mtns, Class B in piedmont, Class B at coast?

R: Possibly, it's a reasonable approach.

C: We had 185 gauged sites to develop EFS classes, at 106 we had a corresponding biological monitoring site. That is the set Tom and RTI used. But if you apply the filters (any upstream flow

alteration need to be 2 times the drainage area, needs to be no lower biological classification than good-fair/good-excellent) do you know how many sites would be left?

R: ~ 60 sites.

Jim: So 40 of those points that your preliminary and Tom's analyses, some had either water quality or water quantity alterations or both, which we are trying to remove as we go forward. The Class D, the one with only 1 taxa associated, is the small flashy streams, Carolina Slate belt, has real mix of some highly altered watersheds and some not. It could be Ellerbe creek for example.

C: Either most prone to impairment, or it would drive benthos to not be a good indicator of health.

R (Cuffney): To really evaluate either of these things, we need to work with sites with no impairment. I have no confidence in this now. If there are really bad sites in here, that introduces a lot of variability.

R (RTI): The idea for preliminary analysis was to use what data we had. Now that we have 578 sites that have gone through all the selection criteria…that would be the master data base, we can do the same analysis on it and do a better analysis.

C: So good news is, it sounds like we have the techniques to do it, to remove the bad sites.

C: RTI can give you the data and you'll have to go through all the computations again.

Q: This was fidelity of taxa to a-priori hydrologic classifications. You're good at flipping it around and looking at the community classes. Would they give us a different hydrologic break-down, to do a cluster analysis of communities? If you looked at communities and see how they interpret the hydrology?

R(Cuffney): yes, I'm a biologist and that's how I'd go at it, someone who is a hydrologist would do it the other way, the best would be to meet in middle, which we're working at.

C: You can come up with a valid biological classification, but if you get a stream without any biological data, how do you classify it without collecting more data?

C: Back to the canary in coal mine…if you could come up with some class for those streams…then they could then be used as predictors of classification if you know the hydrology.

R: Once we have the 578 sites we can look at a number of alternative hydrologic classes and see how those match up, can even do fidelity analysis, go through alternatives and see where you get the max benefit, or indicator of Phi score in this case. Then look at it and say, this one works for this set of species, etc., settle down to the classification that works best and subset of organisms that works best.

Q: Regarding the WaterFALL model will this data be geospatially tagged? (facilitator didn't hear answer)

R(RTI): We will have a lot more data ready that can go through analysis (600 benthos site, 200 fish sites, NHP sites).

C: We're not just trying EFS class, but also McManamay class, to see if that had any greater community association or species presence absence data.

Jen: if theEFS and McManamay classification systems are different, then it makes sense to test the fidelities of biota to each set of stream classes. This repeated analysis is not be a problem since the hydrology data will have already been generated for the sites.

Jim: I would not be surprised if there were similarity in classes.

Jen: EDF has already done analysis between EFS and McManamay systems to see if similar?

Sam: EFS and McManamay looked at each other's systems and reported to us they were extremely similar.

VII. Discussion of biofidelity analyses

Comment (C): It suggests to me - this is a very preliminary glimpse and it could really change when you add a lot more data and filter out the streams that don't fit our criteria.

Response (R) (RTI): But, what if you added an overlay classification of mountain, Piedmont, and coastal, or a different sorting category, like gradient or size. Usually there is a correlation between location downstream and size of drainage area of a subwatershed. These different things may be able to be used as overlays on top of the hydrologic classification. Plus, these things can be done without site specific data.

R: I agree we have looked at such small samples that is hard to draw conclusions from them. I'm optimistic that when we look at a lot more sites we may see some better correlations.

C: The working hypothesis for the RTI work is that we will not find a high degree of fidelity until we subset our classes using some strategy that takes into account topoedaphic factors, such as the shape of the land and the soils. So that remains as a future step, that is not yet funded.

C: It is important for us to remember that what we are trying to figure out is how to create a set of classification for rivers and streams in NC based on hydrology. The issue is about altering hydrology and determining how much alteration constitutes a breach of ecological integrity. We need to come up with classes based on hydrology and then report how those classes effect ecological integrity.

C: All the IFIM work and the fidelity work bears on that question. We are building up a pretty good pile of ideas about what we should say about those classes in terms of how to define ecological integrity or thresholds of ecological integrity or hydrologic regimes that insure ecologic integrity, and we need to do that for every class. Currently we are still trying to figure out the classes and this fidelity testing is to see if we have good classes and if not to see if we can come up with good classes.

C: Based on our mandate, the classes need to be based on hydrology because that is what people are altering.

C: Unfortunately these classes don't deal with alterations of water quality, such as a pollutant.

Question (Q): Is there some fidelity related to an ecoregion overlay of current EFS classes?

R: We've talked about various kinds of topoedaphic or other strategies to overlay classes to subset them, and ecoregion definitions were one of them.

C: It seems like the fidelity we are searching for is actually going to be tied more closely to whatever type of ecoregion we would overlay.

C: The hydrology alone is not trying to describe the distribution or the distinction of between biology in different physiographic regions.

C: Mary Davis's work is about stream classification, not hydrologic or biologic classification.

C: RTI approach is unique by trying to test the biofidelity classes, trying to actually link the biology to the stream classes.

R: All the other classifications systems out there are theoretical in nature, so testing this stuff puts us in the forefront

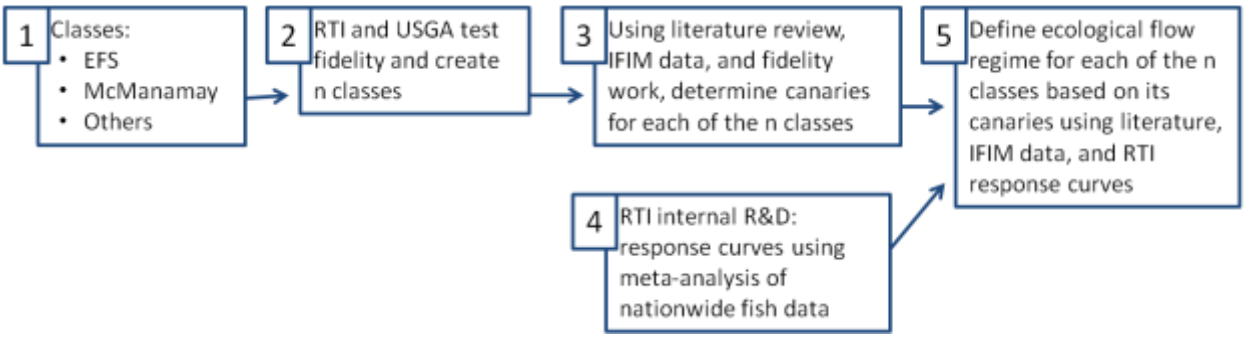
C: This seems to be a philosophical discussion here. There are 2 hierarchical systems, one for biology and one for hydrology, and at the top level we can say all streams have life and at bottom we say only 1 stream has an individual of any particular type. We are trying to force-feed these two hierarchies into one another. We are trying to get a specific species or guild to fit into a hydrology hierarchy at a certain level. I think there is a balance of what biological hierarchical level corresponds to a hydrological hierarchical level. This is a challenge.

C: In terms of terrestrial systems, we do this all the time and it is relatively easier because the variables are easier to measure and we have better data about the species that occupy unique climatic topoedaphic spots. We are struggling with how to do this with aquatic systems all across the country. We will come up with something that is really good, but probably flawed and that will get better over time.

Online comment: I think it is impossible to separate water quality conditions from ecological integrity. Flow must play a role as well.

Q: At one point in the analysis do you start adding that level of detail in to determine if it makes a difference ?

R: The process we developed is to test the fidelity at 600+ sites and assuming that we will not see a great deal of revealed fidelity, subset the classes using multiple different strategies to see if one of those results demonstrates higher fidelity.



Process flow chart:

Box 2 is the multi step process we are talking about, including all of the RTI work and Tom's work.

Box 3 and 4 begin the convergence of all the work

Box 5 is when we take all this and make decisions.

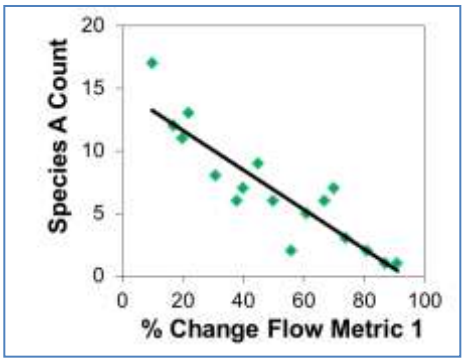
VIII. RTI internal project: Flow Alteration-Biological Response Relationships to assist with the determination of ecological flows

Jennifer Phelan, Research Triangle Institute (RTI), provided an overview of their internal research and development project. A summary follows: We thought our internal project would be of interest to NC because we are developing flow alteration-biological response relationships in NC using NC data. We don't have results yet. We've spent time trying to fine-tune methods with input from many of you. I'm going to try to keep this presentation as simple as possible.

Project Objectives:
To use a combined approach of:

- Unaltered/historic and current flows determined with WaterFALL model
- large, state-wide aquatic biota datasets (monitoring programs)

to determine species-specific flow alteration – biological response relationships that are useful to water managers (some flow metrics are challenging for water resource managers to use).



One of the outputs we'd like to produce is like this curve (slide 3 and shown here), expressing species responses to changes of flow. We are planning on doing a specific species analyses and representing species response by changes in abundance.

To explain our statistical approach, we wanted to use a space for time approach as opposed to a time for time approach. You can go to one location and change the flow and see biological response. In our case we're trying to take a large set of data to try to represent those changes across the landscape. (slide 4) Instead of evaluating changes in flow and species response in a single location, we intend on estimating % change in flow at each location where monitoring data (and species responses) are available and use a scatterplot of these points to produce the curves. There are issues of other factors that influence responses, but we will try to address that as well.

Poff & Zimmerman did meta- analysis of data and studies concluded with this statement. I highlighted words relevant to our analyses.

"Transferable quantitative relationships between flow alteration and ecological response" cannot be easily developed, and "**large databases**, if analyzed with an eye toward degree of **flow alteration**, carefully selected **response metrics**, stream typology, and **multiple environmental drivers**, hold the potential to reveal important relationships" – Poff and Zimmerman (2010)

This type of approach has been attempted with variety of other studies (slide 6)

- Middle Potomac Environmental Flows (Mary Davis presented on this, a quantile regression approach)
- Virginia DEQ Environmental Flows (in process)
- Carlisle et al. (2011) –a USGS effort across U.S. using NAQWA USGS gauges to show biological responses to alterations. He showed with these large data sets that changes in flow is a significant predictor.

Describing methods by focusing on each of the components of biological response/flow alteration relationship curve:

1. What species will be used in the analyses to represent the biological response
2. Flow metrics that will be used to represent flow alteration
3. The statistical analyses that will be used to determine the significance and nature of the relationship (ie. the response equation)

1. *Methods: Species- Fish*

- Top of the food chain integrators
- Relatively fast recovery time to climatic events that may cause local extirpation
- Valued by wide segments of society so may be easier to translate and communicate to public

Datasets:

- NC DWQ Fish Community
- USGS National Water Quality Assessment Program (NAQWA)
  Both datasets use comparable methods, comparable stream lengths, number of passes, record species abundance and/or count values.

Species criteria:

- Look at individual species relationships AND
- Assign species to guilds indicative of flow conditions (4 different guilds identified by Persinger in North Fork of Shenendoah River, VA(2010).
  - Fast-generalist
  - Riffle
  - Pool-run
  - Pool-cover
- Up to 20 species (to do a very good job on a fewer number of species rather than a so-so job on larger number of species)
- Riffle guild- will apply our method of analysis to a single guild as a pilot Criteria used in selecting species to include in the analyses:
  - Well distributed (state or regionwide)
  - Large number of records to make analysis easier and robust (> 50)
  - Life history stages and requirements well known
  - Single guild through-out life

This is a collaborative efforts- thanks to Chris Goudreau and Bryn Tracy. We've identified all the species for NC and which guilds they're associated with. Why a combined species/guild approach? We want to identify canaries- those species most responsive to flow alterations-then by linking them with guilds there might be an ability to extrapolate flow metrics to entire guild. There could be value in linking individual species to guild. Also, DWR's PHABSIM (habitat simulations) are built upon guilds, we talked about possibility of assigning those different guilds to the 4 guilds identified here to compare results of these methods in later stages of the block diagram discussed just before lunch.

Although still in the planning phase, we may conduct an exploratory statistical analyses on all species that fall under riffle guild and do show significant responses to flow alterations and try to use that as a criteria to narrow down species for fuller suite of analyses.

2. *Methods- Flow metrics*

Criteria for flow metrics:

- Biologically relevant - can be related to biological response/supported by flow-biology hypotheses
    - Review of flow-biology hypotheses for fish:
    - Increases and decreases in low, high and median/stable/base flows important to fish
    - Important events all months of the year
- Amenable to management - water managers can both understand and use them to determine ecological flows
    - Metrics represented the five components of flow, but removed 2
    - Magnitude, timing, duration (I removed frequency and, rate of change since they would be difficult for managers to use for water allocation/withdrawal policy)
    - Also decided to focus on low flows since these are the challenges DWR is facing in determining ecological flows
- Can be expressed as % change- some metrics are difficult to express as percentage changes (e.g., flow fall and rise rate or time of occurrence)
- Can be effectively modeled within WaterFALL –some parameters are more challenging to model (e.g., rise and fall rates or rate of change measures)

Flow metrics

- Reviewed TNC Indicators of Hydrologic Alteration (IHA) = 67 metrics, in light of criteria
- Additional metrics were added

Monthly Measures	Annual Measures
Extreme low flow (10th percentile)	**3-, 7-, 30-, and 90-day minimum**
Low flow (25th percentile)	**3-, 7-, 30-, and 90-day maximum**
Median/Base flow (50th percentile)	**Extreme low flow (10th percentile)**
High flow (75th percentile)	**Extreme low flow count**
	Extreme low flow duration (longest duration during year)

A final list of flow metrics were provided as a handout. In the table, **bold= IHA metrics**, the others are added.

We combined both monthly measures, annual measures. For monthly measures, percentiles of distributions for those months over a long period of record . For annual metrics, rolling averages of 3, 7,30, and 90 day minimums and maximums over the entire year. We'll also account for extreme low flow events. For low flows, together with low flow counts (number times below value), and of the longest duration of low flow events during the year. Reason was for this came from meeting with Jim, rather than an average, it was better to take the longest duration of the low flow because these events are likely to have more impact on biology than the median or average extreme low flows.

Flow metric calculations:

- WaterFALL hydrographs for unaltered/historic and current condition:
  - Unaltered/Historic = Potential Natural Vegetation (PNV) or 1970s land-cover
  - Current condition = 2006 NLCD + sources of instream flow alteration (dams, withdrawals, discharges)
- 30+ years of climate data (to reduce influences due to climatic variation and express % change as from human alterations)
  - Expressed as % change
- Focus analyses on reductions in flow (you can have positive changes in relationships, we want to focus on the decreasing flows)

Q: Unaltered condition is related back to 1970s?
R: Either potential natural vegetation if there had not been land use changes, or 1970s data layer. Reason is that in discussions with TNC and others, there is an argument to use 1970s for base layer.
C: I wouldn't call that unaltered.
R: Yes, you're right, the 1970's layer is an earlier time (historic), while the other layer is unaltered.

Unaltered (historic) vs current layer expressed as % change.
-We'll focus on the decreases in flows relationships.

3. *Method: statistical analysis approach*

The distinction between multivariate and univariate analysis (slide 22):

Multivariate = (equation shown on left of slide)multi-dimensional relationship often represented as an equation. These X represent the influential factors (e.g., water quality, climate, habitat, those kind of factors as predictors of biological response- arrows show those factors), and the flow metrics would be one or several of these factors.

Univariate = (graph shown on right)relationship between single influence (e.g., flow metric) and biological response

Benefits of using multiple predictors (multiple regression): gain a better understanding of the degree to which species is influenced by altered flows versus other factors; and reduces the amount of error (i.e., accounts for a larger proportion of the variance in the relationship).

We can tease out variation to say 10% is due to fragmentation, 20% is due to water quality, and it can show what are the main drivers for certain species. It can help managers determine which species is most sensitive to altered flows.

Negatives of multiple regression analyses- Application of relationship is restricted to locations where have data for the other factors (or need to assume default or average values for factors); Complicates the flow alteration – biological response relationship since you have to use defaults or average factors if you don't have the data, but allows us to have an understanding of other factors.

Co-variates including in the statistical analyses	
Component	**Attribute/Dataset**
Water Quality	DO, pH, conductance (DWQ Habitat and USGS NAQWA datasets)
	303d listing (possibly)
Channel Morphology	Sinuosity/Linear Length
	Slope
	Physiographic Region
Habitat	NC Habitat Score (DWQ Habitat dataset)
	Fragmentation- 2 ways (stream length between obstructions) – same stream length and summed stream length of network
Climatic Events	Preceding year total precipitation (to account for drought or high water years)
	Average of preceding 3 years of total precipitation
Date	Sampling Month
Interspecific Interactions	Influence of exotic and injurious introduced/ exotic fish species

More on some of these components: Channel morphology- we think changes in flow will have different effects based on morphology. Habitat- a variety of habitats exist in a stream length (amount of cover, channelization, alterations). DWQ dataset has done good job of characterizing these variables. We think fragmentation will be a significant factor- what habitat will species have access to based on barriers to upstream, downstream movement (like dams). Fragmentation can be done 2 ways- stream length between upstream and downstream barriers, for a single stream length, versus a network analysis which takes into account all connected streams which are bounded by barriers.

Univariate analysis- linear or quartile regressions (or comparable non-parametric analyses). We will determine which approach based on distribution of data.
Benefit is only based on response to % change of flow metric, so application in water management is more straight forward.
Negative is a potentially large amount of error which will reduce the strength of the relationships.

We hope the combination of analyses will provide:

- water managers with an understanding of the relative importance of flow alterations and other influential variables for each species (some species are more influenced by flow metrics than others).
- Flow-biology relationships with which to model/predict the impacts of flow alteration on biological responses (will help to develop ecological flows).

The project is still in the planning phases. Any questions?

Q: Multivariate- you've shown multiple regressions, and simple regressions. Multivariate regressions would have multiple x and multiple y.
R: It is a single y, with multiple variables.
C: The term multivariate analysis is incorrect. You're conducting multiple simple regressions, both are univariate procedures. **I suggest clarifying that in because statisticians would notice.**

Q: Is the parameter of 303 (d) list a presence-absence? Was it current list? Will you include the parameter that caused it to be on the 303(d) list?
R: we're still examining it , it will be categorical.
C: I suggest you abandon that because the 303(d) list combines policy decisions with water quality decisions, doesn't necessarily give you a ranking about water quality. You can use some of the variables considered for the 303(d) list without the complexities of the policy decisions.
R: Good feedback. The problem would be the variables that are measured at water quality monitoring stations, how far you can extrapolate those monitoring values?
C: That needs to be teased out, as an example, all streams are on 303(d) list because of the mercury advisory, clearly you don't want to include all those.

Q: Isn't 303(d) those water bodies that are waiting for TMDLs?
C: No, it's more complex. It is a list of impaired waters, but there are also policy decisions in that not just those biologically challenged, but others get on the list too.

Online Q: **Will you share guild species lists with group**?
R: Good point. We think it will be useful for the committee so when its ready we'll share it with group.
C: Brynn and I (Chris Goudreau) are sharing first draft, Fritz Rhodes (EFSAB member representing National Marine Fisheries) is an excellent fish taxonomist we can run it by him.
R: Great, more minds and more consensus reached it will be better.
(Fritz says he is glad to help)

Online Q: how were water quality variables chosen, were temp, DO, PH, conductance considered?
R: Temperature is one of the variables in dataset, and we did consider it. We could include it in the analysis as exploratory, yes.

Q: Regarding the handout of flow metrics- for the list of annual metrics- 3, 7, 30, and 90 day minimums are listed twice? Should that read "maximum"?
R: Yes that is a typo, my apologies.

IX. Small Group Discussion

The SAB broke into 4 groups for discussion. Planning team members composed 5 questions to help move the discussion forward. The groups kept notes and reported out afterward. Since we only had enough people for 4 groups, we set #3 aside and asked all the groups to discuss it if they had time.

The questions were:

1. Flow metrics proposed for RTI IR&D – How do you think the proposed metrics could be adopted to establish ecological flows and include in river basin models and planning? Are some more suitable as triggers for red flags than others? Are there any not currently included in the list outlined in the presentation that you think should be added?
2. Single species biological response proposed for RTI IR&D – What are your thoughts on the proposed approach of evaluating individual species within a guild (probably the riffle guild described by Persinger et al, 2010) to determine "canary" species for ecological flow determinations? Will this identify the most flow sensitive organisms? Will this be explainable and defensible for non-scientists?
3. Statistical analysis proposed for RTI IR&D – could both the univariate and multivariate analysis results be used to determine ecological flows. If so, how?
4. Process diagram for stream classification through ecological flows – Do you agree with proposed path for determining ecological flows, as outlined by the block diagram? Are there any important steps missing?
5. Large piedmont rivers are not assessed by the state biological monitoring programs and the coastal plain has a fewer number of monitoring stations. In addition, the link between flow and habitat and species response to flow is less well understood for the coastal plain and possibly less direct. Therefore, it may be difficult to determine ecological flows for these 2 stream types using biological response or habitat alteration models. What do you propose would be an appropriate pathway(s) to determine ecological flows for these rivers/region?

Report of the small group discussion follows.

1. Flow metrics proposed for RTI Internal Research & Development project. How do you think the proposed metrics could be adopted to establish ecological flows and include in river basin models and planning? Are some more suitable as triggers for red flags than others? Are there any not currently included in the list outlined in the presentation that you think should be added?

Small group discussion results:

Add the 7Q10, the 1-day low, and the 1-day high. These are metrics that are easily understandable and widely used, allowing more people to understand and compare the work.

2. Single species biological response proposed for RTI IR&D – What are your thoughts on the proposed approach of evaluating individual species within a guild (probably the riffle guild described by Persinger et al, 2010) to determine "canary" species for ecological

flow determinations? Will this identify the most flow sensitive organisms? Will this be explainable and defensible for non-scientists?

Small group discussion results:

- Why not use the count of all species within a guild rather than selecting a particular group
- Assign each species to one of four Persinger guilds.
- Determine count by total number of individuals for each species within each guild
- Allow richness (number of species) at each site, as well as abundance (count).
- We will have regional differences whether by guild or species.

Q: I'm concerned there will a guild or two missing from the analysis. Certainly mussel habitats are being left out.

R: In this analysis RTI is currently focusing only on the fish, as a first step, but there will be other studies, such at the TNC study which will be broader than just fish.

R: With respect to what guilds to include for fish, we compared the different guilds that are used by Persinger and other researchers and some species don't fit into any of the four Persinger guilds. This category is currently called other. it is a place holder for now. The TNC work may pick up some of these.

We are comparing these species against the literature about species habitat in southern states.

3. Statistical analysis proposed for RTI IR&D – could both the univariate and multivariate analysis results be used to determine ecological flows. If so, how?

From management perspective, the univariate approach lends itself to the model.

Multiple regression might be useful as foundation information for understanding what is going on out there in addition to flow. What else helps explain the differences in species or guild count? But it doesn't seem to plug into the final use of the model.

Also a propensity score analysis would allow the percentage contribution of each variable.

4. Process diagram for stream classification through ecological flows – Do you agree with proposed path for determining ecological flows, as outlined by the block diagram? Are there any important steps missing?

Small group discussion results:

- Incorporate feedback loops
- Add filters such as physiographic province/edaphic features into a feedback loop
- Define canaries as indicator species or drivers; will canaries be readily identifiable?
- Overall it is a good plan or process, and discussion throughout today has identified important issues.

Online question: has DWQ clarified that tolerant species = canaries?

Response: As it relates to flow, no, this has not been determined. Current tolerant and intolerant species lists were developed for water quality standards, not flow. (think, pollution tolerance.)

5. Large piedmont rivers are not assessed by the state biological monitoring programs and the coastal plain has a fewer number of monitoring stations. In addition, the link between flow and habitat and species response to flow is less well understood for the

coastal plain and possibly less direct. Therefore, it may be difficult to determine ecological flows for these 2 stream types using biological response or habitat alteration models. What do you propose would be an appropriate pathway(s) to determine ecological flows for these rivers/region?

Small group discussion results:

We broke that into 2 topics.

1. How many streams don't already have FERC licensing or something tied to them that already contributes flow information.
2. Is there the same response relationship between small wadable streams and their biology and the larger streams, because we don't have as much data. Is there another stream class that does have enough data, that through this biological evaluation and looking at eco-regions, etc, maybe one of these other stream classifications may apply to large Piedmont streams.

How many stream are we talking about here and will we find something comparable that we can substitute.

C: Most Piedmont rivers have some kind of altered flow.

Coastal Plain:

We talked about the break between upper coastal plain and the lower area that has tidal influence, where OASIS stops working. We may need to put a line on the map to define what will work with our methodology and what will need a new method. Development is occurring in the lower coastal plain and technology improves, they may be withdrawing brackish water.

We discussed what may need to be addressed. Is it just hydrograph, or do we include dissolved oxygen and salinity.

Depending on what happens upstream, the tidal wedge line may creep upstream so that needs to be considered.

Is WATERFALL a better use for the lower coastal plain? We are not sure.

There are also groundwater issues in the coastal plain that need to be incorporated.

X. Revisiting the DWR Trial Balloon Discussion

In April, NCDWR presented a "Trial Balloon", which refers to a proposal to test reactions. The entire proposal is detailed in the April Meeting summary. In brief summary, it was to discontinue analyzing the flow scenarios of >120%, Annual and Monthly 7Q10, September Median in Spring and Winter, and the Percentage of Mean Annual Flows of 10%, 20% and 30% in Spring and Winter. The remainder flow scenarios were to be kept. Also, DWR suggested establishing criteria that err on the side of slightly higher ecological flows so there would be lead time to meet increasing water demands

Small groups met to discuss various habitat modeling scenarios, and the trial balloon proposal in April (summarized in April Summary). Mary Lou Addor handed out copies of the summary, and reviewed the results of these discussions. She explained a few minor items in the summary that she would correct. Pages 9-10 include a summary of responses to the trial balloon. Question 3

(regarding the suggestion to err conservatively) was discussed for feedback, and did not need a specific response from the group for moving forward. Questions 2 and 4 regarding the Trial Balloon need to be revisited to ensure everyone's interests are considered. These are:
Question 2 (in brief): We propose to focus on habitat results <80% of habitat available under an unaltered flow regime, and not continue analyzing the >120% threshold
Question 4 (in brief): The 15 flow scenarios listed in the table should be used in analyses moving forward (dropping the scenarios listed in the first paragraph above).

Mary Lou asked the group to take a few minutes to look at questions 2, 4, look at trial balloon, and think if is there anything that needs to be added or shared with Jim and Fred as they move forward with their analyses. Particularly if you were not present in April, this is an opportunity to share with the group. John Crutchfield is not here, she'll call him next week to get his feedback. We want to make sure everybody is on same page moving forward.

Regarding Question 2: Are there any changes to this? It sounds like there wasn't agreement for various reasons.

C: I still feel strongly that >120 can be informative. If you have wide increases in certain types of habitat it's because other types of habitat are being reduced. I think there is info to be gained.

C: Some wanted to drop, some didn't.
C: I think Jim picked up on point in winter when flows are high there is more reason to keep it, because when reducing flows you are impacting in positive ways shallow guilds. In winter it may come into play more so than other seasons.

C: When I looked at arranging raw data into different chart formats, it seemed clear that in the >120 groups there was really significant increases in some types of habitat, which reflects decrease in other types of habitat. If we didn't continue to run the 120 scenario for all seasons, I think we'll lose info.

Facilitator's note: There appears to be general support to keep the > 120% scenario in winter analyses. The majority of EFSAB are okay with dropping the >120% analysis in the other seasons, with a few members wanting to keep it in spring as well as winter, and with a strong preference from a member to keep the >120% analysis in all seasons.

Question 4: The table below indicates which of the 15 flow scenarios analyzed so far, by season, should continue to be evaluated. In April we heard: Group 1- keep all spring scenarios; Group 2- keep all summer scenarios; Group 3- Agree with proposal for Fall scenarios (but analyze 7Q10 further into the analysis so people know it was analyzed); Group 4- agree with proposal for winter scenarios. Seemed like there was more agreement here, regarding what scenarios to keep in based on season. Are there any more comments?

Q: if you look on chart, if you keep 2 of the seasons but drop 2, it may be confusing to look at the overall picture. Was there discussion about whether we should you keep it all for that reason?
Jim: I recall folks said they were agreeable not including 7Q10 in the charts but advising it would be useful to run it to have in back pocket for final report because it is commonly used. I agree, it is not hard to run it, we have a template, but not burden everyone by putting it in our graphs for our meetings.

Q: Relative to the meeting discussion and today's discussion about which efforts to add in, this is regarding PHABSIM analyses. Today we talked about keeping in other metrics in the biological analyses, would it be useful to have for comparison sake, the 7Q10 and low end (10% mean annual flow)?

Jim: I think in terms of using flow metrics for RTI study, it picks up more of that -duration points rather than % of average flow, it's a frequency based number as opposed to % of an annual amount. I think it may have more lending itself to a biological response curve- the duration or frequency based approach. Don't see a need to make them all line up. I agree with the 7Q10 suggestion.

Facilitator's note: The EFSAB agreed to the table of proposed flow scenarios for DWR to analyze, with the exception that 7Q10 should be analyzed as it's a commonly used flow standard employed by other states. The EFSAB does not need to see it included in the results presented to them.

XI. Upcoming Agenda Discussion

The remaining 2012 meeting dates and meeting locations are listed below and posted online at www.ncwater.org/SAB.

August 28, 2012 - Stan Adams Training Center, Jordan Lake Educational State Forest
Sept 25, 2012 - Stan Adams Training Center, Jordan Lake Educational State Forest
October 23, 2012 - Stan Adams Training Center, Jordan Lake Educational State Forest
November 27, 2012 - Archdale Building

Over the next few meetings, the SAB will:

- Hear an update on the RTI biofidelity work,
- Have a presentation from The Nature Conservancy on their current 4 basin environmental flow project
- Hear from Division of Water Resources on a plan for 2012-2013.
- Hear a presentation from Thomas Payne. DWR will request him to review EFSAB plan of action and habitat modeling results so far. Thomas will be visiting Duke's Nicolas School in October.

Issues to be addressed:

- The use of Persinger's 4 guilds and what species may be missing.
- How does using the Piedmont based guild set affect the EFSAB work in the mountains and coast?
- What other guidelines for the coast are needed? What ecological concerns are present for the EFSAB coastal work?

XII. Directions to August Meeting

On August April 28, 2012 we will meet at the:

Stanford M. Adams Training Facility at Jordan Lake Educational State Forest

2832 Big Woods Road, Chapel Hill, NC 27517

Map link: http://go.ncsu.edu/stanadams

From Rt 64 and Big Woods Road, it will be the first Forest Service sign on the right. Pass the office building and continue on through the gate to the education center.