Middle Potomac Watershed Assessment
Flow Alteration - Ecology Relationships 2

Fifth of a seven-part webinar series

September 8, 2011

The webinar will start momentarily.

Audio feed is by telephone

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Middle Potomac Watershed Assessment
Flow Ecology Relationships Part 2

Speakers

Andrew Roach, U.S. Army Corps of Engineers, Baltimore District

Carlton Haywood, Interstate Commission on the Potomac River Basin

Project website: http://potomacriver.org/sustainableflows

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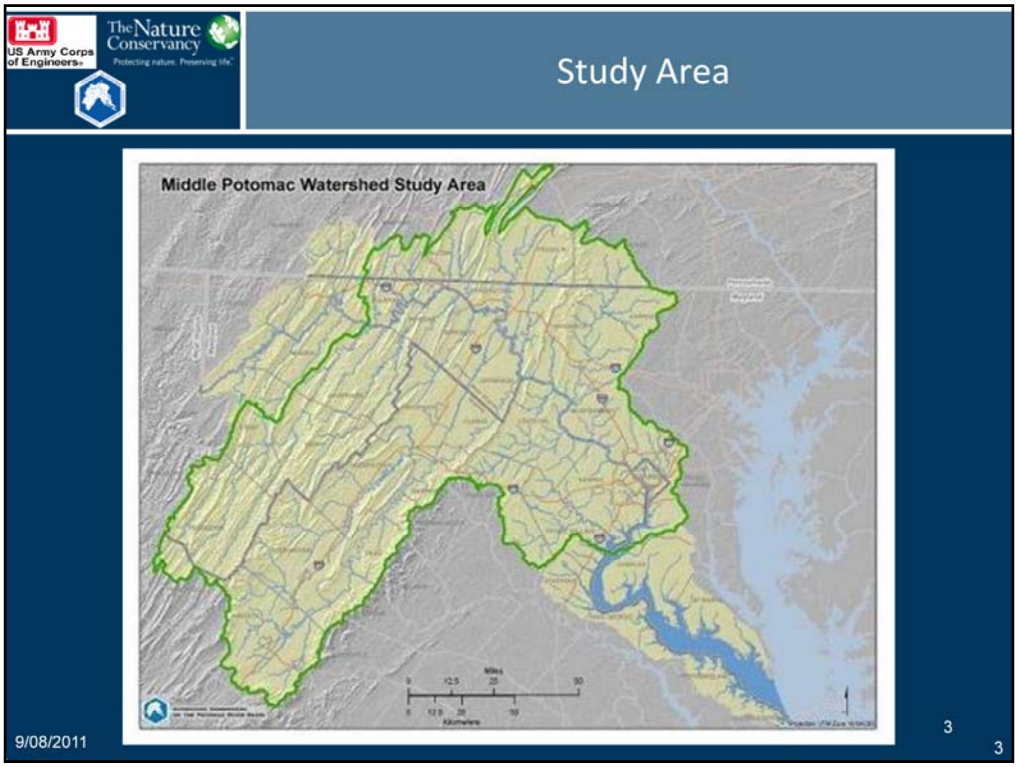
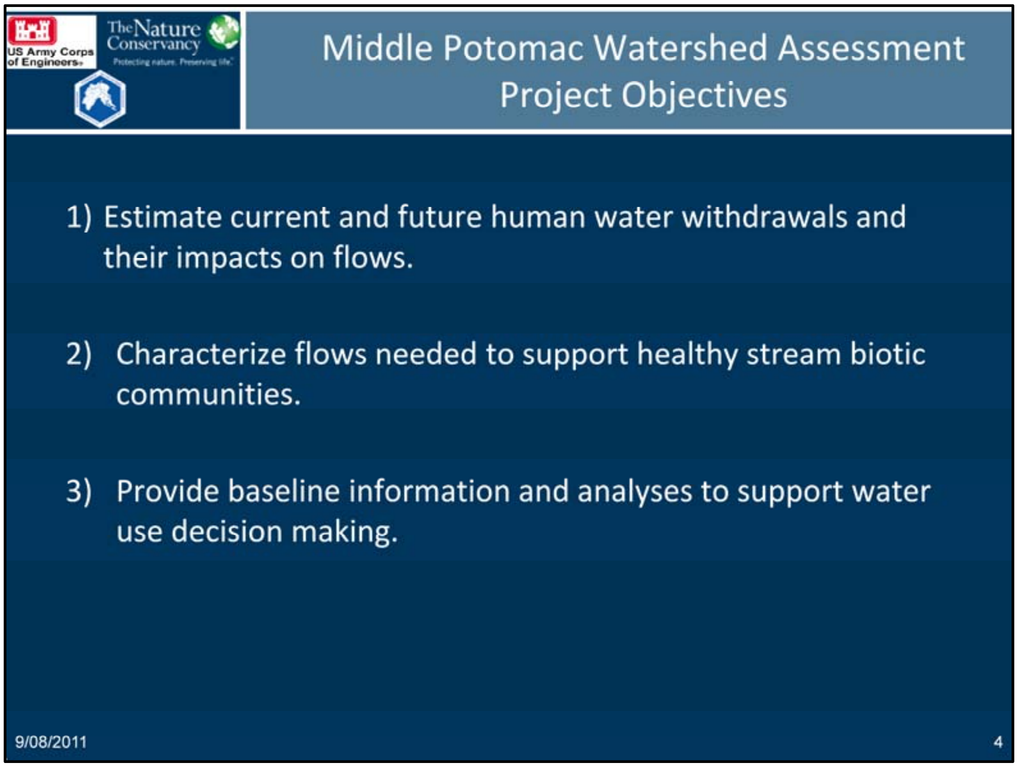


Study area comprises approximately 11,500 sq. miles of the 14,670 sq. miles of the entire Potomac watershed.

Parts of four states, MD, PA, VA, WV and all of the District of Columbia.

Note that the official study area does not include the North Branch. Recognizing, however, that flow from the North Branch watershed is an essential driver for flows in the Potomac mainstem, this study includes the North Branch for some analytical purposes.



Project Purpose

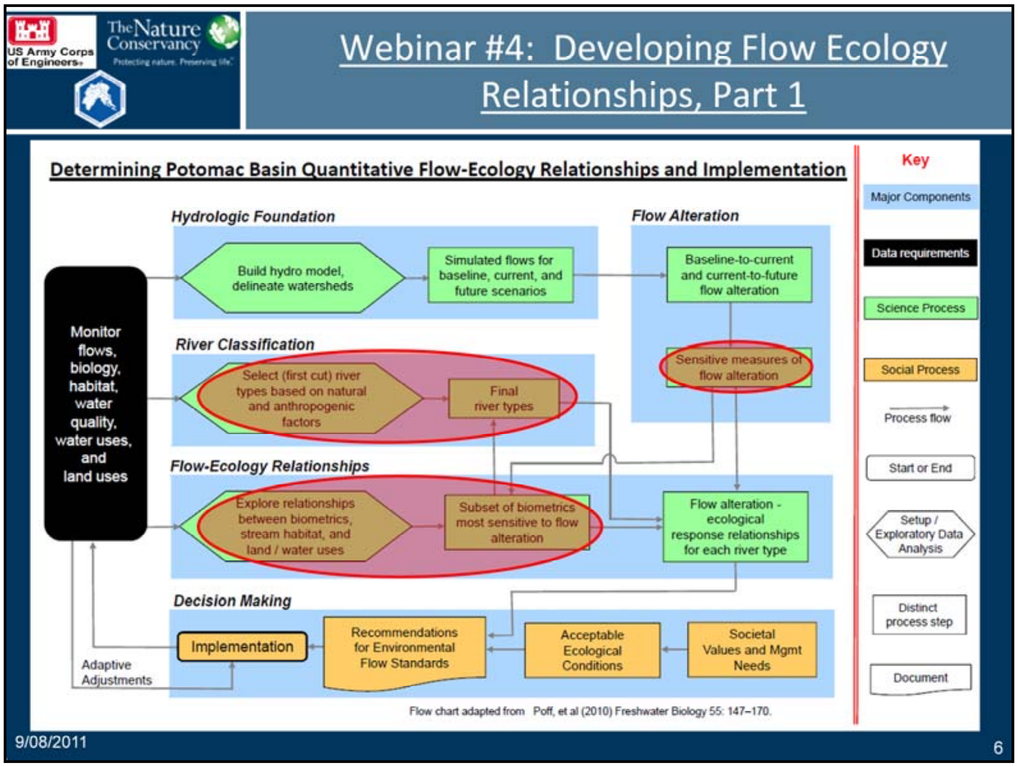
To develop information and tools that enable the Potomac watershed jurisdictions to protect **environmental flows**,

which are

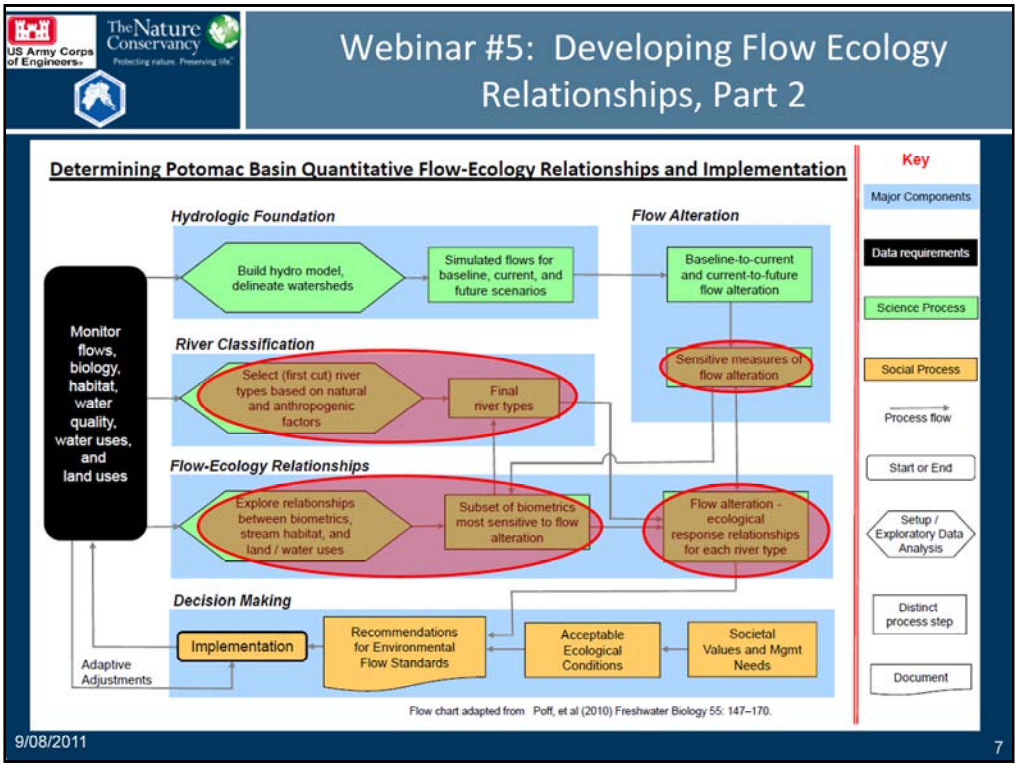
the stream flow characteristics that sustain healthy river ecosystems and the goods and services that people derive from them.

Note: There have been some changes in the schedule and subject matter of webinars and the workshop

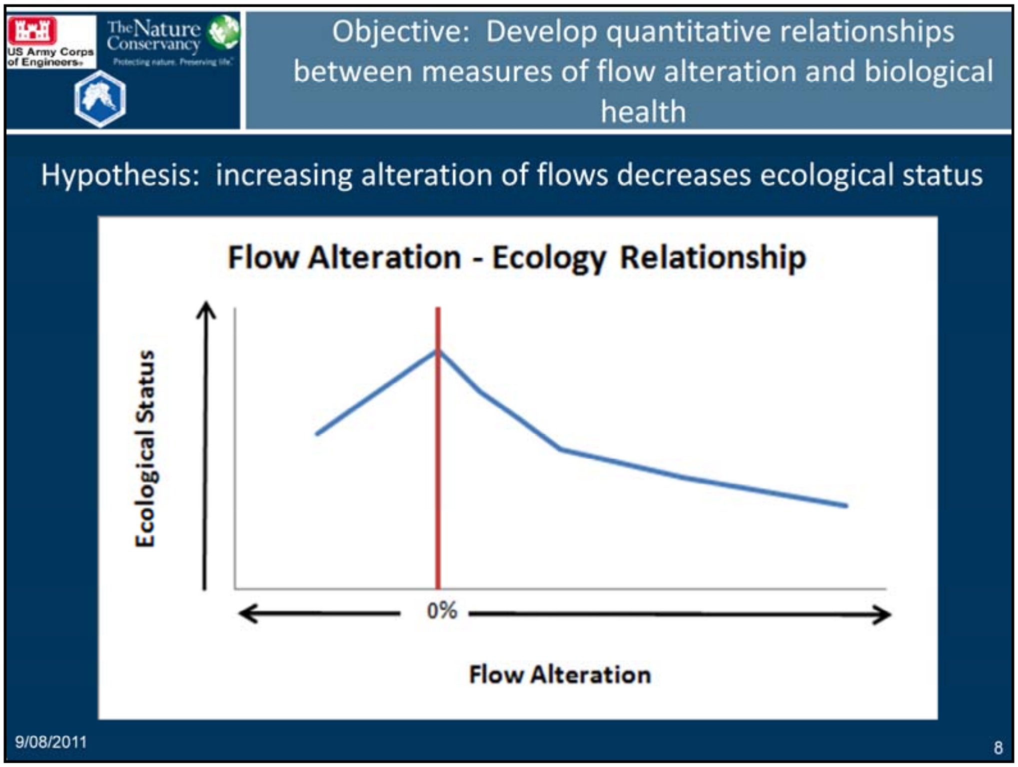
This will be explained at the end of this webinar.



In the last webinar we described the variables and data sets we are assembling to create flow alteration – ecological response relationships and the methodology we planned to use to test relationships, as indicated by the red ovals on this process flow chart.



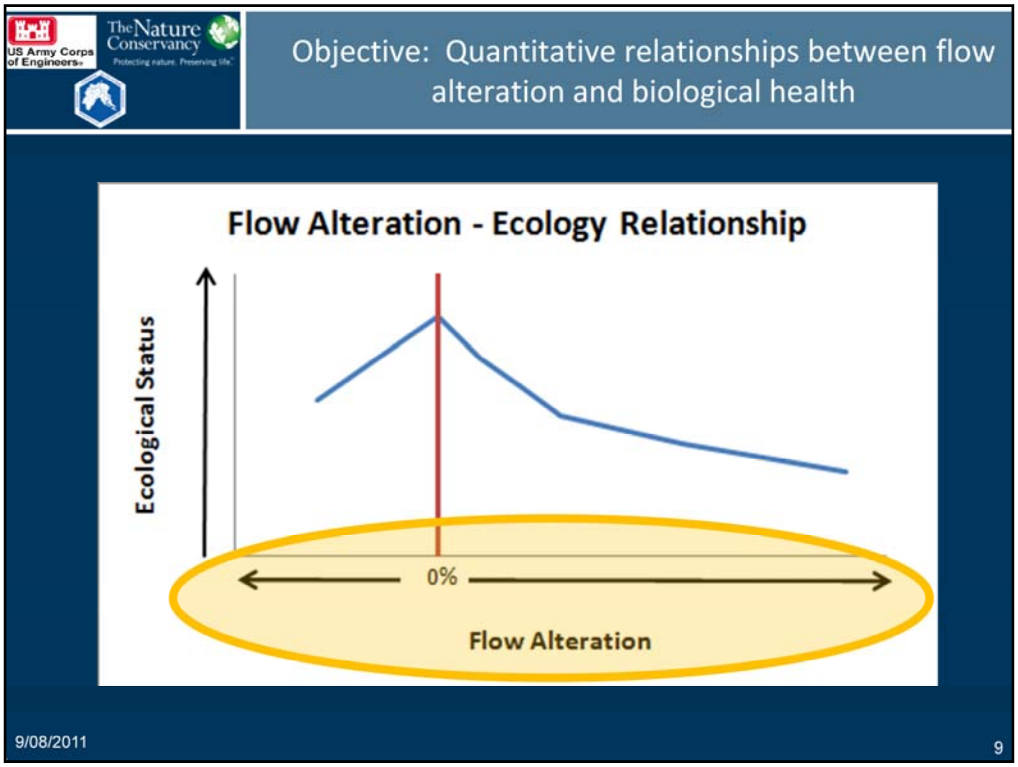
In this webinar I'll show how flow alteration – ecology plots are constructed, provide some examples, and discuss next steps for our analysis.



Before plunging into today's topic, I want to acknowledge the contributions of the team here at ICPRB Claire Buchanan, Heidi Moltz, Jim Palmer, and Adam Griggs as well as the productive relationship we've had with Rob Burkholzer at VA DEQ. Thank you for all your contributions.

This is a conceptual plot only, which we've shown in previous webinars.

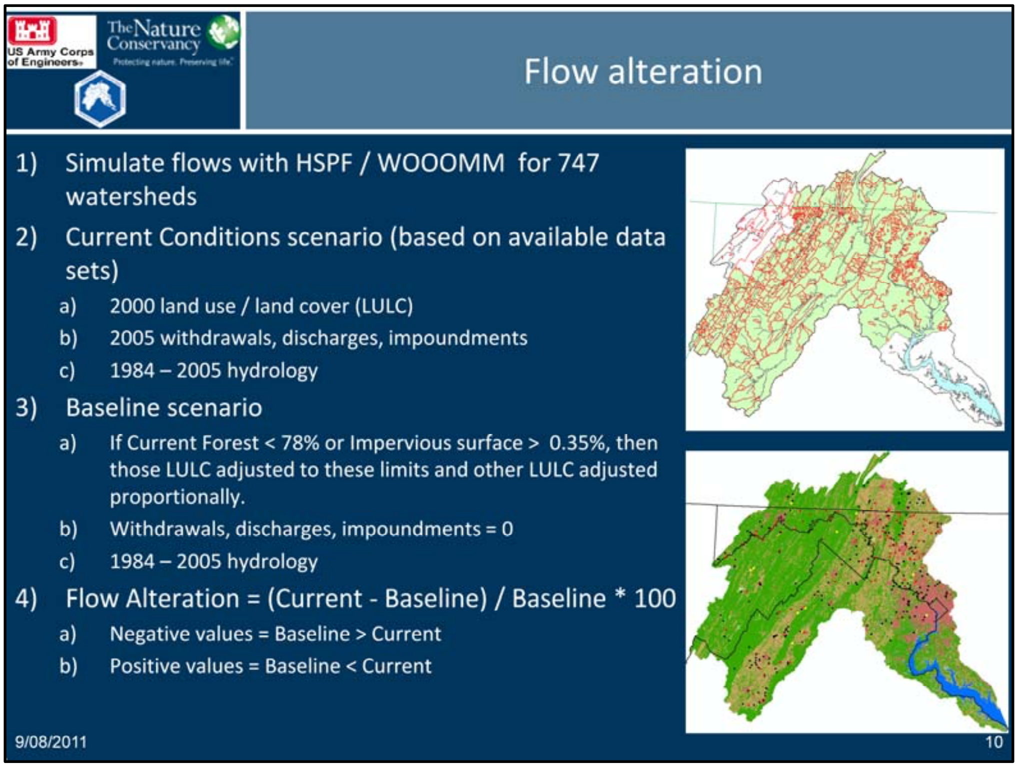
We've discussed methods in previous webinars, but I'm going to revisit that methodology today in the context of how the various components contribute to this plot and, along the way, I'll explain some of the testing of assumptions we've done that should provide some understanding and confidence in the results.



Let's begin with flow alteration …

There is abundant evidence in the literature that human activity alters stream flow.

We'll use our model to simulate daily flows for many watersheds and to show what impacts on those flows result from anthropogenic factors.



Discussed previously in the June webinar.

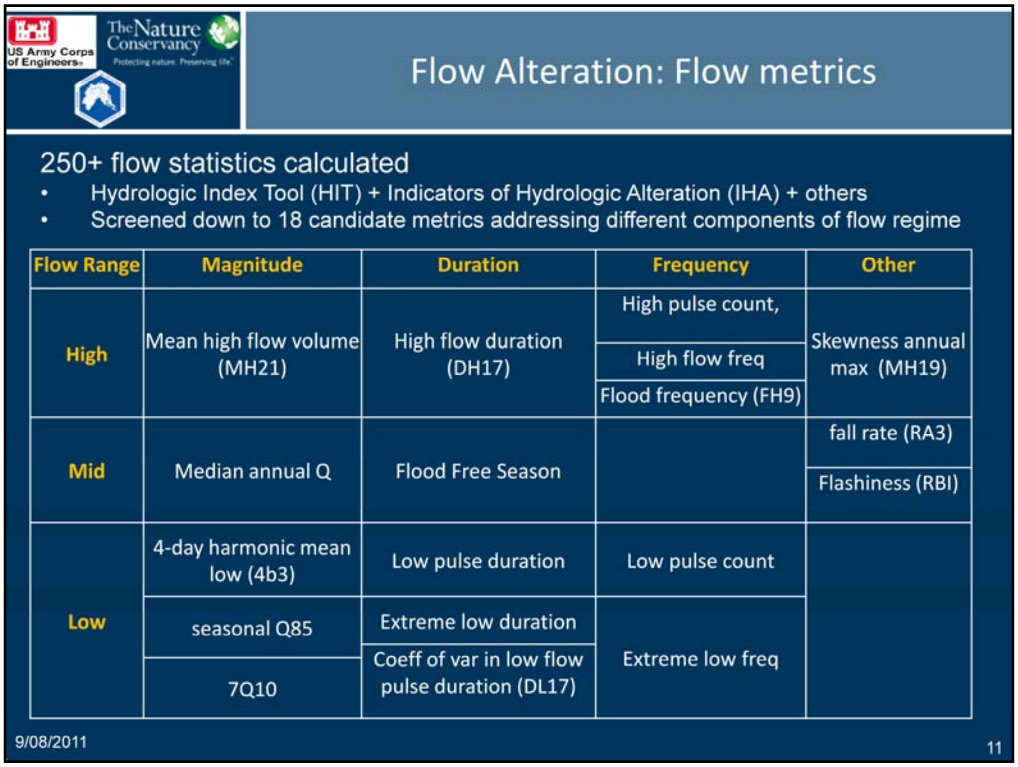
These key points provided here for your reference when you download these slides.

Download the June webinar slides for more information about the model, scenarios, and flow alteration

Summarize briefly as

• We have built a model and simulated Current and Baseline scenario flows for 747 watersheds

• We've calculated flow statistics and the difference between Current and Baseline for those statistics



More than 250 flow statistics have been calculated.

A screening process, described in the June webinar, was used to identify 18 flow metrics that we'll generate flow alteration ecology plots. (although we can go back to the pool of 250 for another view)

Provided here as reference when pdf copy of this presentation is downloaded.

Download the June webinar slides for more information about calculation of flow statistics and the screening process.

What evidence that we are reasonably simulating flows?

	Land Uses				Water Uses		
Selected Flow Metrics	Forest	Ag	Urban	Impervious	Withdrawals	Discharges	Impnd
Mean high flow volume							
High flow duration		*	†				
High pulse count	*	*	*			†	
High flow freq.		*	*		†		
Flood freq.	*	*	*	*			
Skewness of ann.max.	*	*	*			†	
Normalized median		*				†	
Flood free season	†	*	*	†	†		
Fall rate/area	†				†		†
Flashiness	*	*	*	*	†		
4B3/area	†		†	*			
Q85 seas/area	*	*	*	*			
Low pulse duration						†	
Extreme low dur.	*	*	*	*			
CV, low flow dur.	†	†	†	*	†		
Low pulse count	*	*	†	†			
Extreme low freq.	†	*					
7Q10/area						†	

* = identical RPART thresholds in simulated vs observed flows
† = RPART thresholds +/- 10% in simulated vs observed flows
= No primary splits on these watershed factors

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Some comparisons between modeled and simulated flows were provided in the June webinar. Here is another comparison and I'll show a few additional examples later in this webinar.

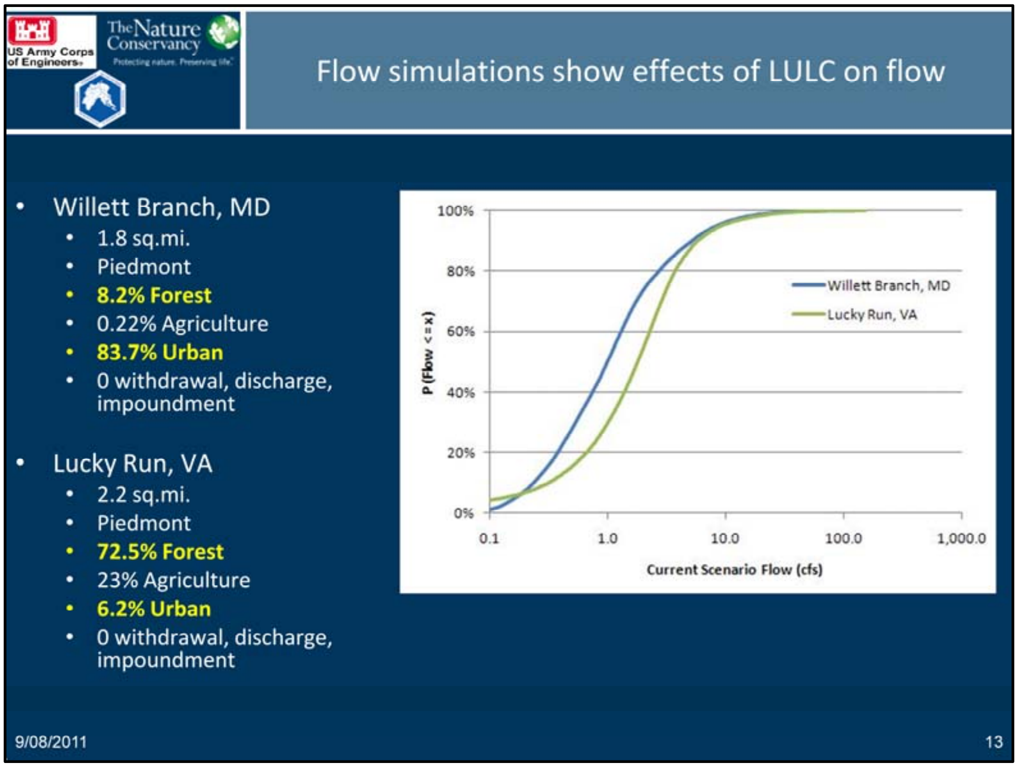
This table shows results from a regressive partitioning (RPART) analysis to test whether the modeled current scenario is able to replicate the effects of anthropogenic watershed factors (columns) on selected flow metrics (rows). Does RPART discern the same influential factors and critical thresholds in metrics derived from modeled and observed flows. Number of watersheds =31, but only ~20 with withdrawals and discharges, and only 5 with impoundments.

"*" means that RPART found identical thresholds in the simulated and observed data sets. "+" means that RPART found a similar threshold (+/- 10%). Green filled cells indicate RPART did not identify this factor as significant. One can see by the many * and + isymbols n the land use portion of the table, the model does a good job at replicating the influences of land use. The influences of withdrawals and discharges are harder to tease out because of small N size. Impoundments did not show up as being very important in the simulated or observed flow metrics, probably due to very small N size.

This analysis, and others that we've done, support the proposition

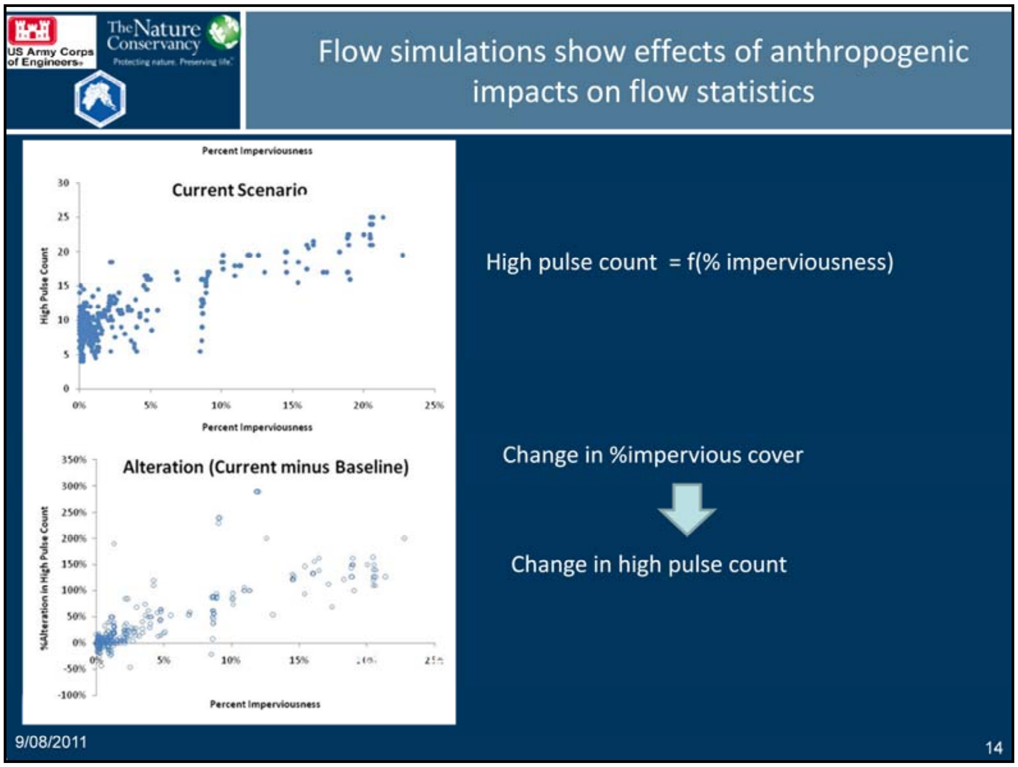
that the HSPF watershed model adequately simulates current condition daily mean flow;

and that, by removing impacts from LULC change, withdrawals, discharges, and impoundments, the model can simulate daily mean flow for the same watersheds in a "nearly" un-altered, or baseline, flow state.



Here is one simple example from model simulations showing the effects of different LULC on flows.

Plot shows distribution of daily flows for two watersheds that are similar in size, located in the same physiographic province (Piedmont), and neither have modeled withdrawals, discharges, or impoundments. The forested watershed, Lucky Run (green line) has higher high and median flows and lower low flows.



Another example: This one showing that we can link anthropogenic factors, in this case % Impervious land cover, to our flow statistics, and change in anthropogenic factors to change in flow statistics values.

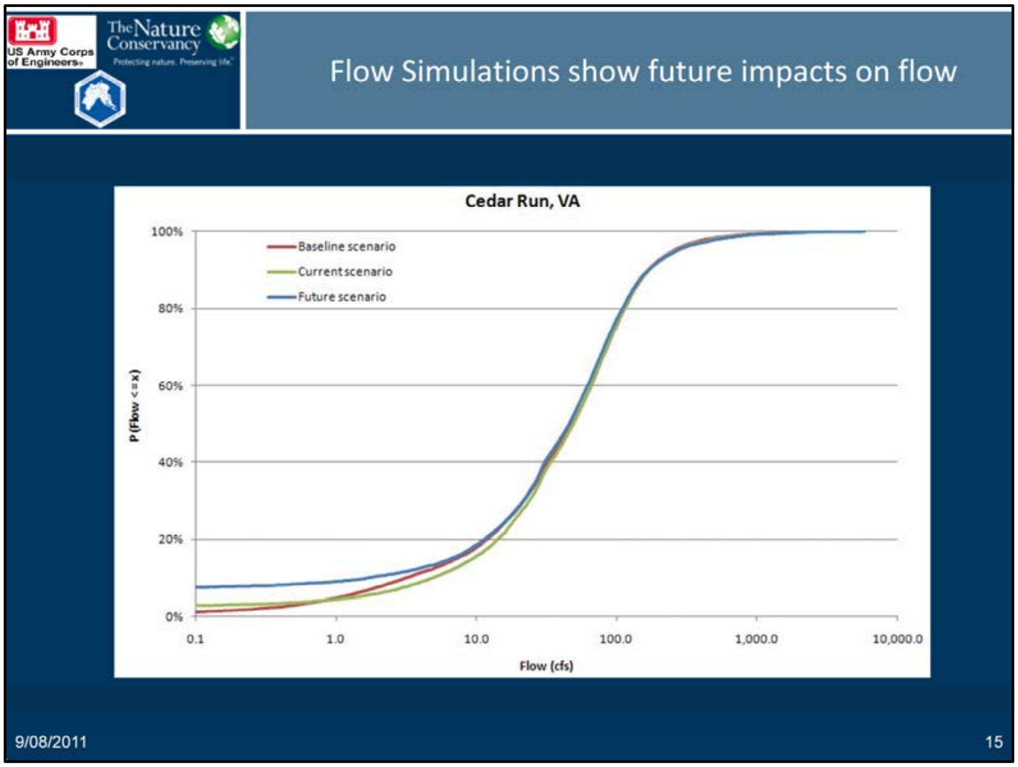
Take this opportunity to remind everyone that our analysis is assessing impacts from only four specific anthropogenic impacts:

1) Land use/cover (%forest, %agric., %impervious surface (urban))

2) Withdrawals

3) Discharges

4) Impoundments



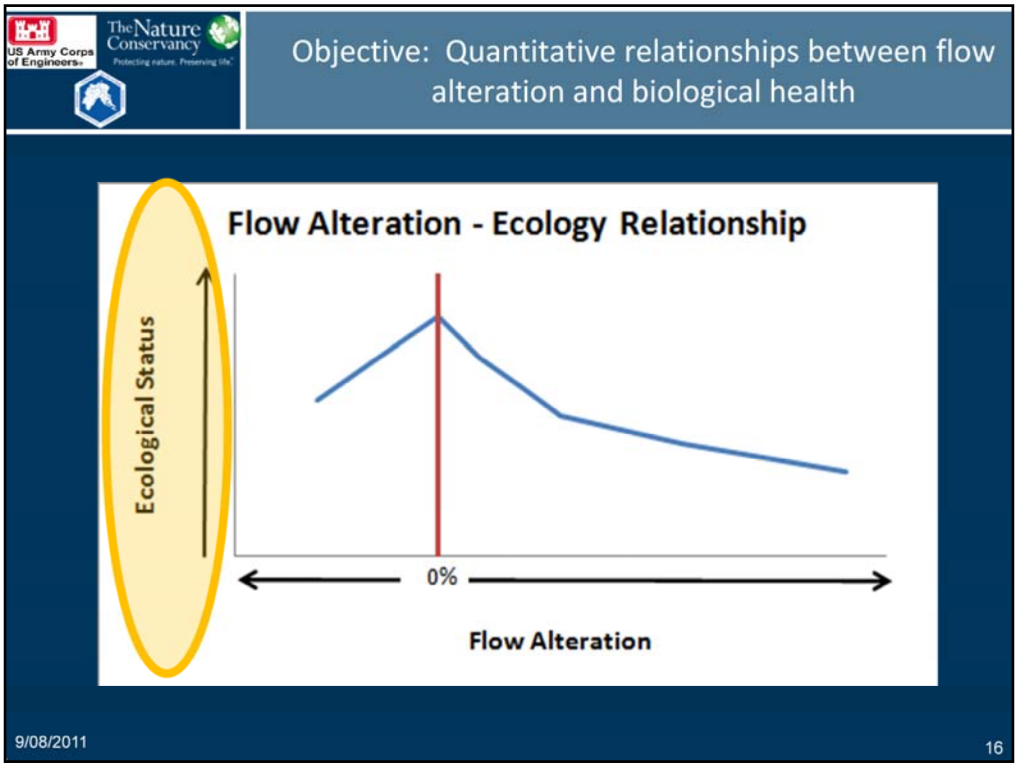
Still to be done in this project is to generate future scenarios and to estimate the effects on flow of future development.

Development of these future scenarios was the subject of our May webinar.

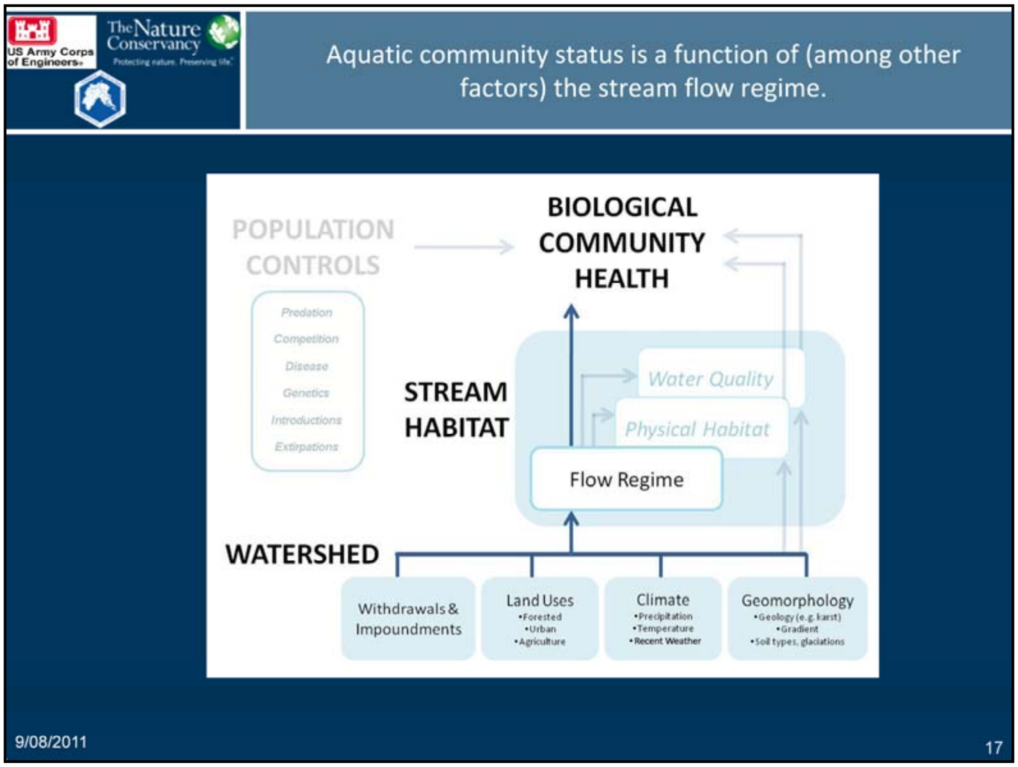
But even before we get the results of those future scenario model runs we can show that the model will find some future scenario effects on flow.

Here is a cumulative distribution of flows for one watershed under three scenarios: baseline, current, and future.

The Cedar Run watershed, ~92 square miles in the Piedmont, is expected to experience continued urbanization through 2030 – more than doubling the area of urban land use between 2002 and 2030. The watershed contains two withdrawals – one for public water supply and one for mining – whose uses were projected through 2030.



Now let’s examine the Ecological Status component of our plots



•We know that biological health is the result of many factors, of which flow is just one.

•For this project, we want to tease out what are the flow impacts, and more specifically the flow impacts that result from anthropogenic causes.

•Because community health is the net of so many factors, assigning cause and effect can be very difficult (impossible?), with high data requirements, even for a single site or small watershed.

•At the large watershed scale that we are interested in (the Potomac basin), we are data limited and we are working with a landscape that is already highly altered (i.e. no “before and after” case studies)

•Our approach to test the proposition that aquatic community status is a function of the stream flow regime, then, is somewhat indirect.

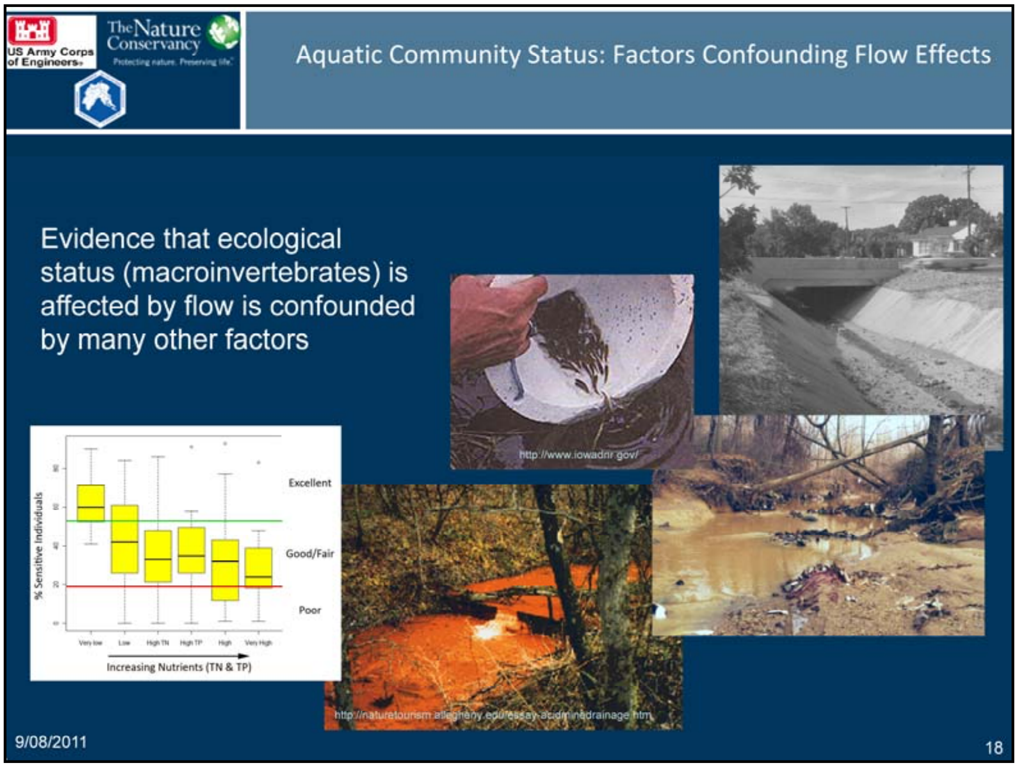
-Use a model to simulate flow time series for current conditions at many sites more than what is available from observed flows

- Identify what we think are key factors affecting the flow regime and use model to generate flow time series for same watersheds but with anthropogenic factors removed or reduced to no-impact level.

- Calculate the flow statistics for both current conditions and baseline simulations, and then calculate the relative change in flow statistics.

-We infer that watersheds with large difference between current and baseline scenario flow statistics are watersheds largely impacted by flow alteration.

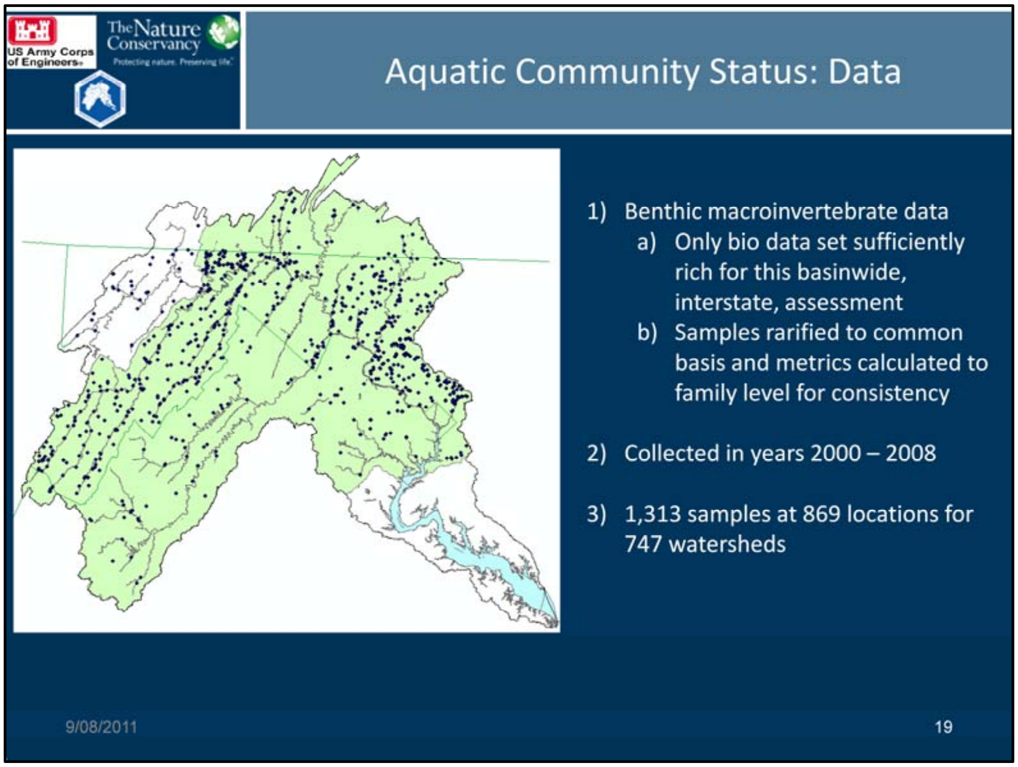
-We then use the relationship of (current conditions) biometrics to %change in flow statistics, and relationships for flow alteration factors, to make statements about how anthropogenic impacts change the flow regime, which in turn impacts biological community health.



It is very important to not forget that aquatic communities are responding to many factors in addition to flow.

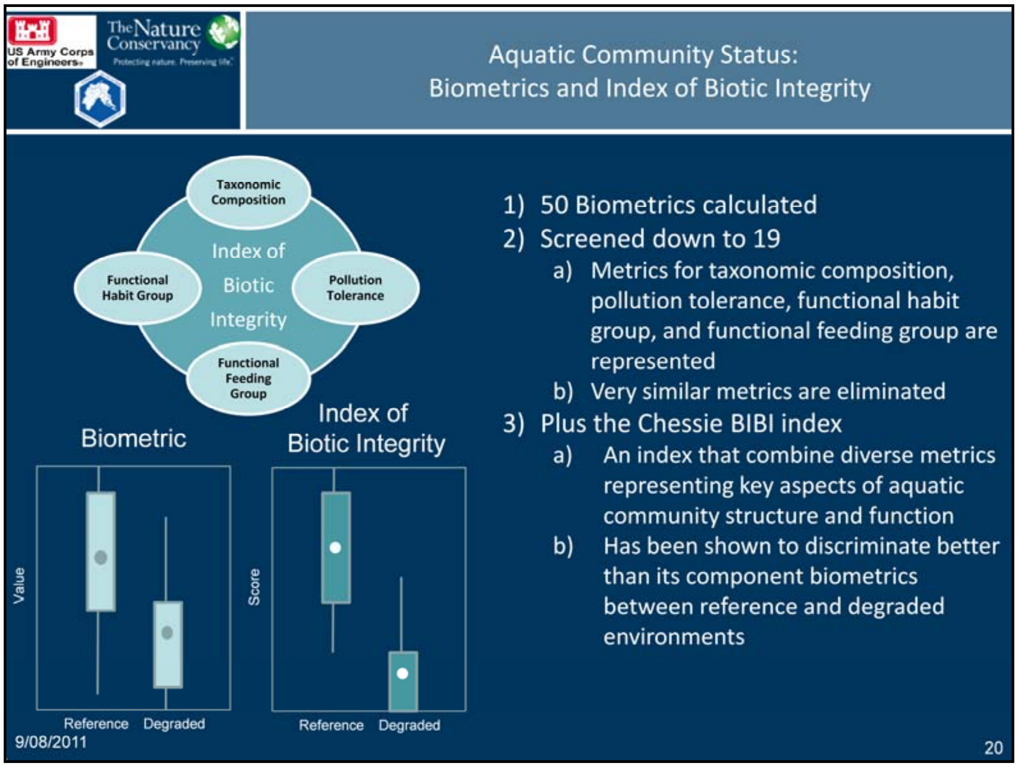
The pictures are illustrative of the many non-flow impacts on aquatic health.

The histogram shows that a common biometric, %sensitive individuals, is affected by nutrient pollution



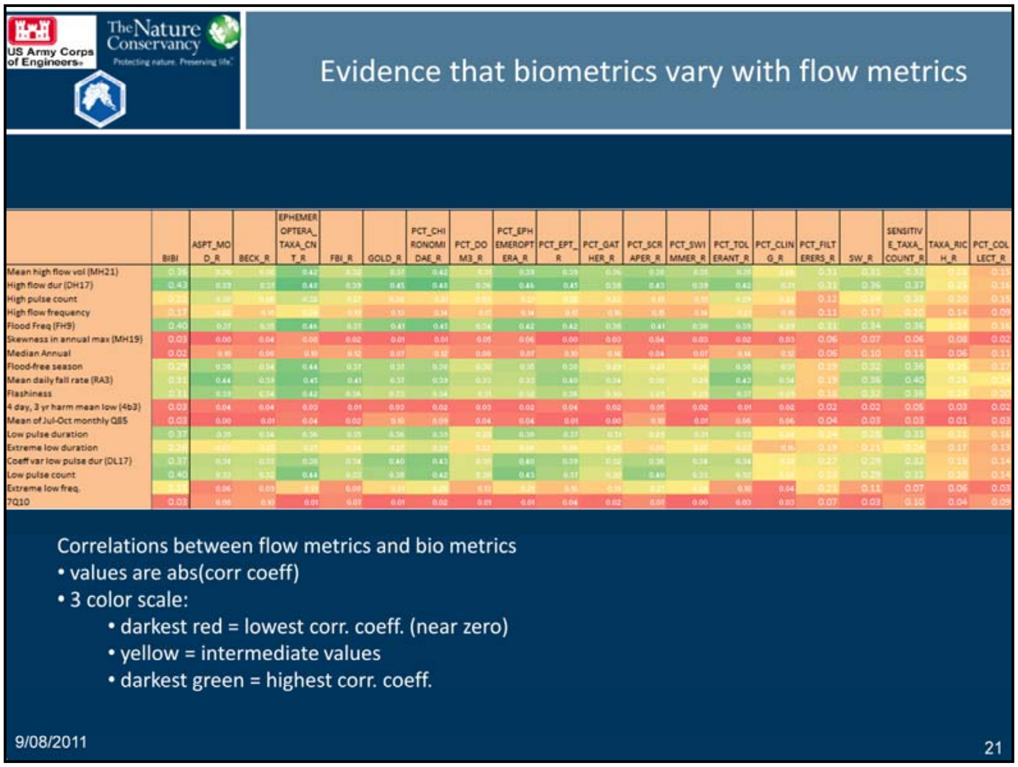
Our biological data sources were described in our July webinar

This slide is a reminder of the size and distribution of our biological data set, and repeats some key points for your reference when you download these slides.



In addition to biometrics, a composite index, which takes into account multiple metrics, can represent overall community health.

Reference: Buchanan et al (2011), Development of a Basin-wide Benthic Index of Biotic Integrity for Non-tidal Streams and Wadeable Rivers in the Chesapeake Bay Watershed, ICPRB, ICPRB Report 11-1. Available on the Publications tab at www.potomacriver.org.



	BIBI	ASPT_MOD_R	BECK_R	EPHEMEROPTERA_TAXA_CNT_R	FBI_R	GOLD_R	PCT_CHIRONOMIDAE_R	PCT_DOM3_R	PCT_EPHEMEROPTERA_R	PCT_EPT_R	PCT_GATHER_R	PCT_SCRAPER_R	PCT_SWIMMER_R	PCT_TOLERANT_R	PCT_CLING_R	PCT_FILTERERS_R	SW_R	SENSITIVE_TAXA_COUNT_R	TAXA_RICH_R	PCT_COLLECT_R
Mean high flow vol (MH21)	0.36	[illegible]	[illegible]	0.42	[illegible]	[illegible]	0.42	[illegible]	0.33	0.39	0.36	[illegible]	[illegible]	[illegible]	[illegible]	0.31	0.31	0.32	0.22	0.15
High flow dur (DH17)	0.43	[illegible]	[illegible]	0.40	0.39	0.45	0.40	0.26	0.46	0.45	0.38	0.43	0.39	0.42	[illegible]	0.31	0.36	0.37	0.25	0.16
High pulse count	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.12	[illegible]	[illegible]	0.20	0.15
High flow frequency	0.17	[illegible]	[illegible]	[illegible]	[illegible]	0.10	0.14	[illegible]	0.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.11	0.17	0.20	0.14	0.09
Flood Freq (FH9)	0.40	[illegible]	[illegible]	0.46	[illegible]	0.41	0.41	0.24	0.42	0.42	0.38	0.41	0.39	0.39	[illegible]	0.31	0.34	0.36	[illegible]	0.16
Skewness in annual max (MH19)	0.03	0.00	0.04	[illegible]	0.02	0.01	0.01	0.05	0.06	0.00	0.03	0.04	0.03	0.02	0.03	0.06	0.07	0.06	0.08	0.02
Median Annual	0.02	[illegible]	0.06	[illegible]	[illegible]	0.07	[illegible]	0.06	0.07	[illegible]	[illegible]	0.04	0.07	[illegible]	[illegible]	0.06	0.10	0.11	0.06	0.11
Flood-free season	[illegible]	0.38	0.34	0.44	0.37	[illegible]	[illegible]	[illegible]	0.35	0.38	[illegible]	[illegible]	[illegible]	0.38	[illegible]	[illegible]	0.32	0.36	0.25	[illegible]
Mean daily fall rate (RA3)	[illegible]	0.44	0.39	0.45	0.41	0.37	[illegible]	[illegible]	0.33	0.40	0.34	[illegible]	[illegible]	0.43	0.34	[illegible]	0.36	0.40	[illegible]	[illegible]
Flashiness	[illegible]	[illegible]	0.34	0.42	[illegible]	[illegible]	0.34	[illegible]	[illegible]	0.38	[illegible]	[illegible]	[illegible]	0.37	[illegible]	[illegible]	0.32	0.38	[illegible]	[illegible]
4 day, 3 yr harm mean low (4b3)	0.03	0.04	0.04	0.03	0.01	0.03	0.02	0.03	0.02	0.04	0.02	0.05	0.02	0.01	0.02	0.02	0.02	0.05	0.03	0.02
Mean of Jul-Oct monthly Q85	0.03	0.00	0.01	0.04	0.02	[illegible]	[illegible]	0.04	0.04	0.01	0.00	[illegible]	0.01	0.06	0.06	0.04	0.03	0.03	0.01	0.03
Low pulse duration	0.37	[illegible]	[illegible]	[illegible]	[illegible]	0.36	[illegible]	[illegible]	0.38	[illegible]	0.31	[illegible]	0.31	[illegible]	[illegible]	[illegible]	[illegible]	0.33	[illegible]	0.16
Extreme low duration	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.17	0.13
Coeff var low pulse dur (DL17)	0.37	[illegible]	[illegible]	[illegible]	[illegible]	0.40	0.43	[illegible]	0.40	0.39	[illegible]	0.36	0.34	0.34	[illegible]	[illegible]	[illegible]	0.32	0.19	0.14
Low pulse count	0.40	[illegible]	[illegible]	0.44	[illegible]	0.38	0.42	[illegible]	0.43	0.37	[illegible]	0.40	[illegible]	[illegible]	[illegible]	[illegible]	0.29	[illegible]	[illegible]	0.14
Extreme low freq.	[illegible]	0.06	0.03	[illegible]	0.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	[illegible]	0.11	0.07	0.06	0.03
7Q10	0.03	[illegible]	[illegible]	0.01	[illegible]	0.01	0.02	0.01	0.01	0.04	0.02	[illegible]	0.00	0.03	0.03	0.07	0.03	0.10	0.04	0.09

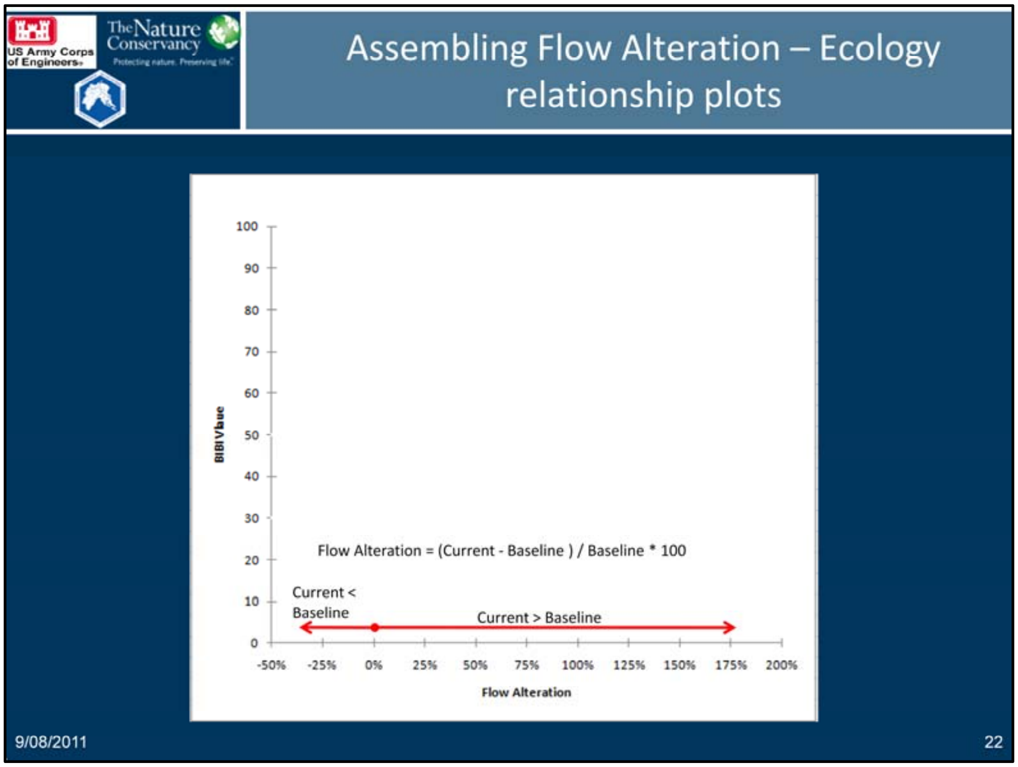
We tested for correlations between a large suite of biometrics and the candidate flow metrics.

This chart provides a visual indication of the degree of correlation between flow metrics and biometrics.

Where there are higher correlation coefficients this result provides some support for the proposition that there are links between flow and macroinvertebrate status.

These correlation results also help winnow down the list of biometrics that would get further analysis coupled with our understanding (from literature) of macroinvetebrate responses to flow (and everything else).

Note: as explained earlier, the biometrics we use are based on family-level taxonomic counts as opposed to genus-level counts. The question of whether or not flow alteration relationships to family-level metrics differ substantially from those to genus-level metrics was not tested in this project. Five of our 19 biological metrics will have the same value regardless of whether they are calculated from genus-level or family-level counts (FBI, GOLD, %Chironomidae, %Ephemeroptera, and %EPT). Flow alteration relationships for these metrics will not be affected by taxonomic identification level. Four of our biometrics have very different values if they are calculated from genus-level counts (Ephemeroptera taxa count, Shannon-Wiener Index (SW), sensitive taxa count, and taxa richness). Flow alteration relationships involving the raw values of these four biometrics will be affected by taxonomic identification level. However, if the biometrics are scored the differences could prove to be minimal. Scoring the biometrics converts each of them to standardized scale. The raw values of ten of our biometrics will differ slightly if they are calculated from genus-level counts (ASPT_Modified, Beck's Index, %dominants3, %Gatherers, %Scrapers, %Swimmers, %Tolerants, %Clingers, %Filterers, and %Collectors). Again, we suspect the flow alteration relationships will not differ substantially once the raw values of these biometrics are scored.



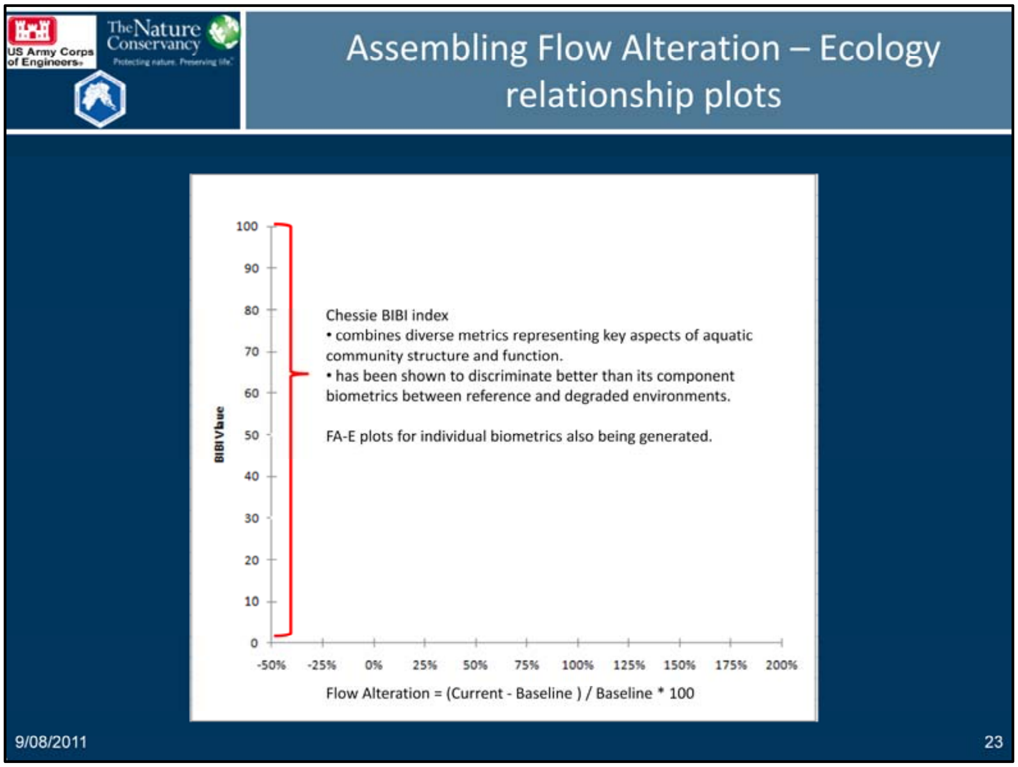
Now let's start assembling our flow alteration information and our biological information into Flow Alteration – Ecology relationships.

On the X-axis is Flow Alteration, calculated as (Current – Baseline) / Baseline * 100

Think of it as "what is the change from baseline condition?"

-If Current > Baseline, then flow alteration is positive, and

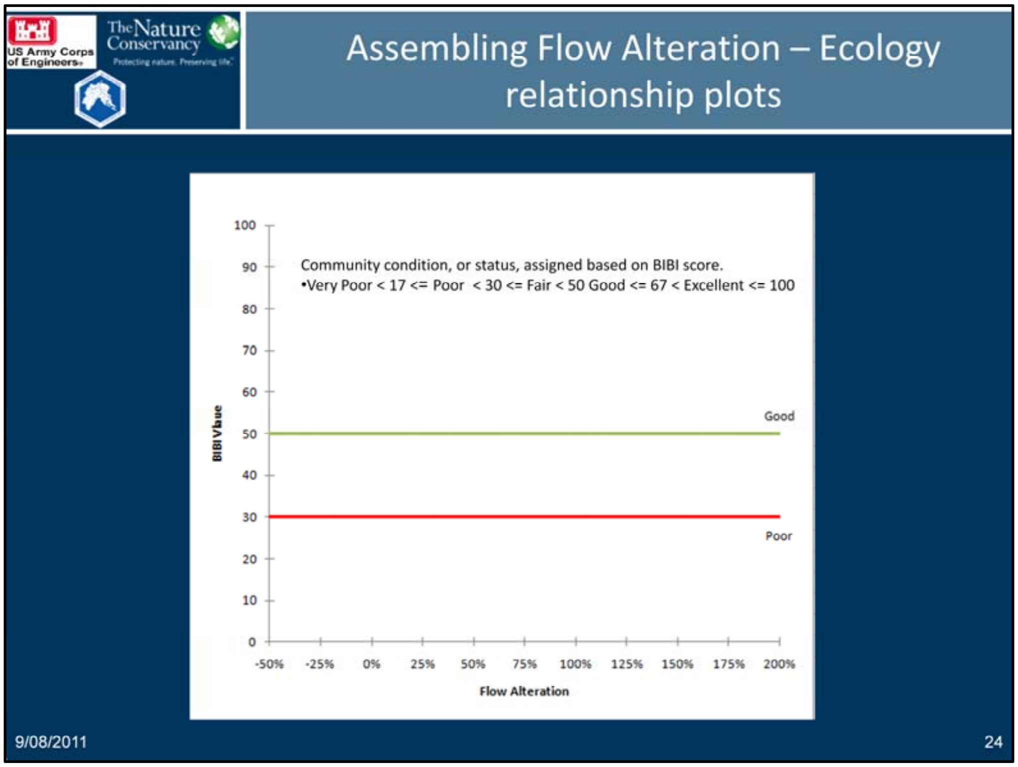
- If Current < Baseline, then flow alteration is negative



On the Y-axis is BIBI score, which varies from 0 (worst) to 100 (best).

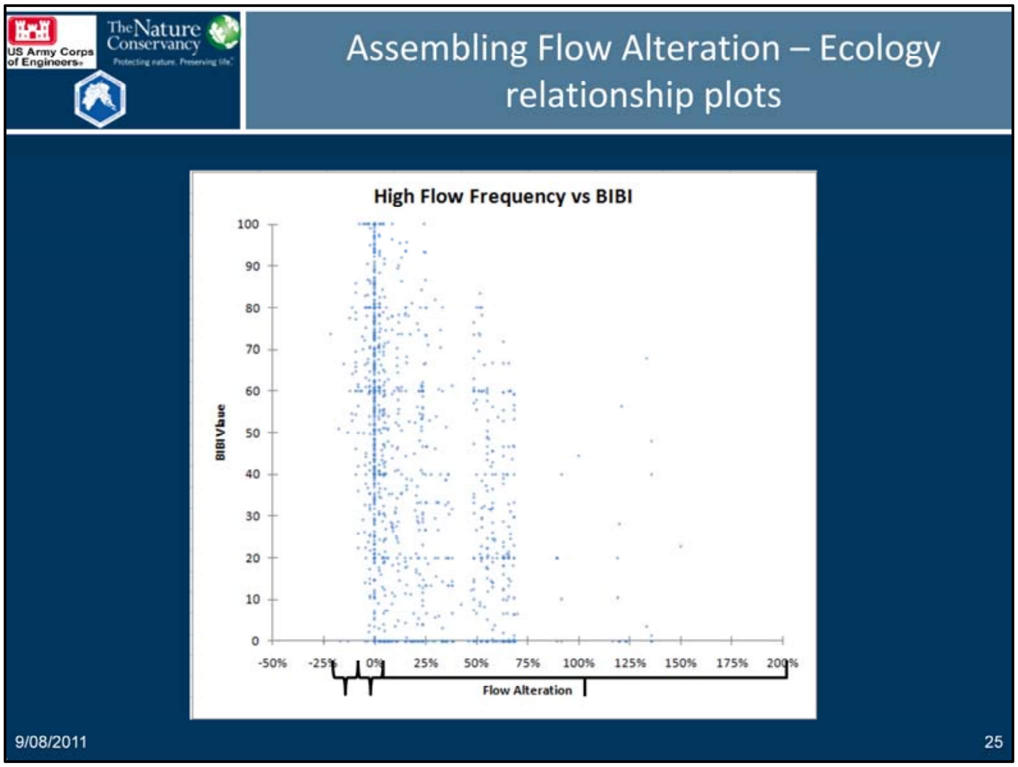
We like the BIBI because it combines multiple metrics representing key aspects of aquatic community structure and function.

We will be generating and evaluating FA-E plots for individual biometrics



Community conditions, or status, have been assigned to ranges of BIBI scores from Very Poor to Excellent. I'm going to use just the Good and Poor boundary lines as qualitative reference marks.

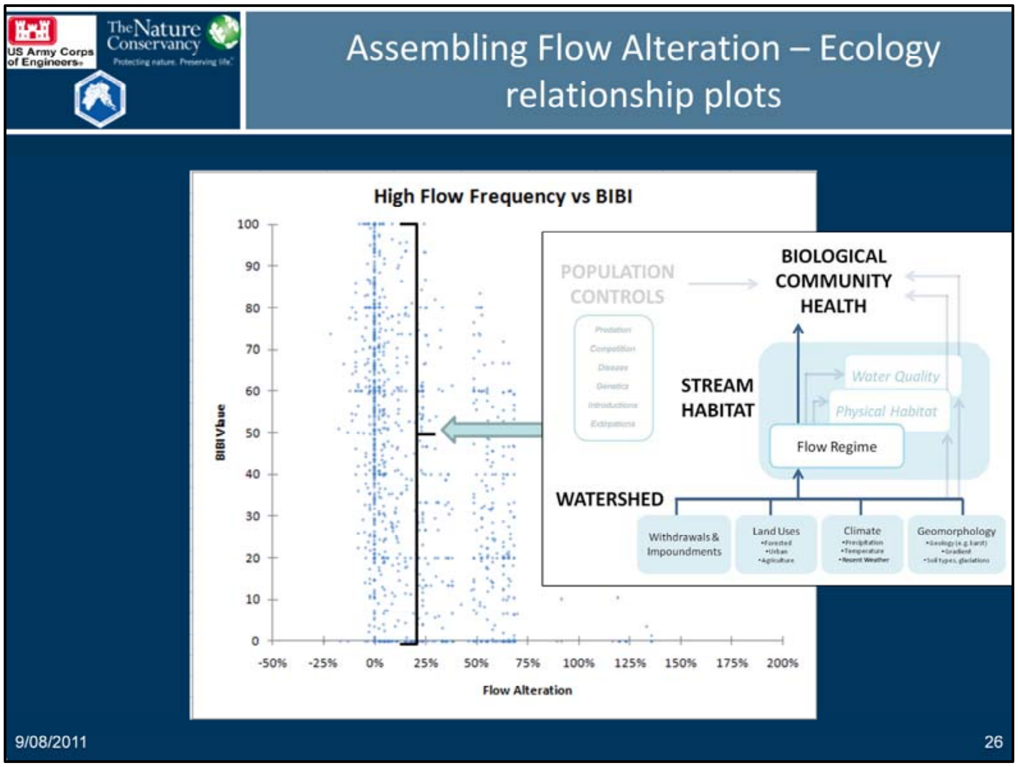
A note: the Chessie BIBI is not being used for state regulatory purposes.



Now we add some data. In this case the flow metric is High Flow Frequency, calculated by the IHA software, and Ecological status is represented by BIBI score.

Note the concentration of points at 0% alteration. We have approximately 200 watersheds for which there is no difference between the current scenario and the baseline scenario.

Note also that most points indicate a positive flow alteration, i.e. Baseline High Flow Frequency is lower than for Current Conditions. Most flow metrics show both positive and negative flow alteration but most are predominantly in one direction (either way).



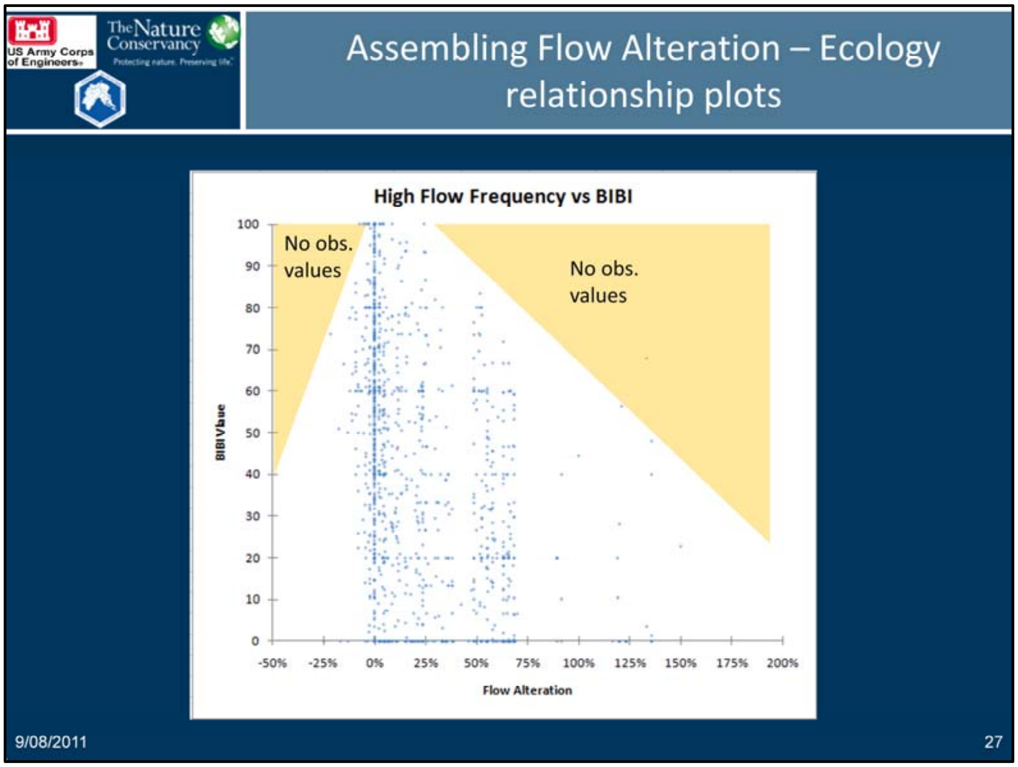
Note the distribution of BIBI values from 0 (worst possible) to 100 (best possible).

This graphically illustrates the influence of all of the many factors, other than flow alteration, that determine aquatic community health.

So how do we determine the influence of flow alteration on aquatic community status?

1. Recall that we are relating observed, current conditions, biology with a simulated difference between current and baseline flow.
2. We do not have "before and after" biology data with which to directly measure change in biology as a function of change in flow.
3. And, for each data point, we cannot separate, without a great deal of site specific analysis, the contribution of each of the many factors affecting community status.

We do observe, however, (next slide)



The maximum observed BIBI value decreases as flow alteration increases.

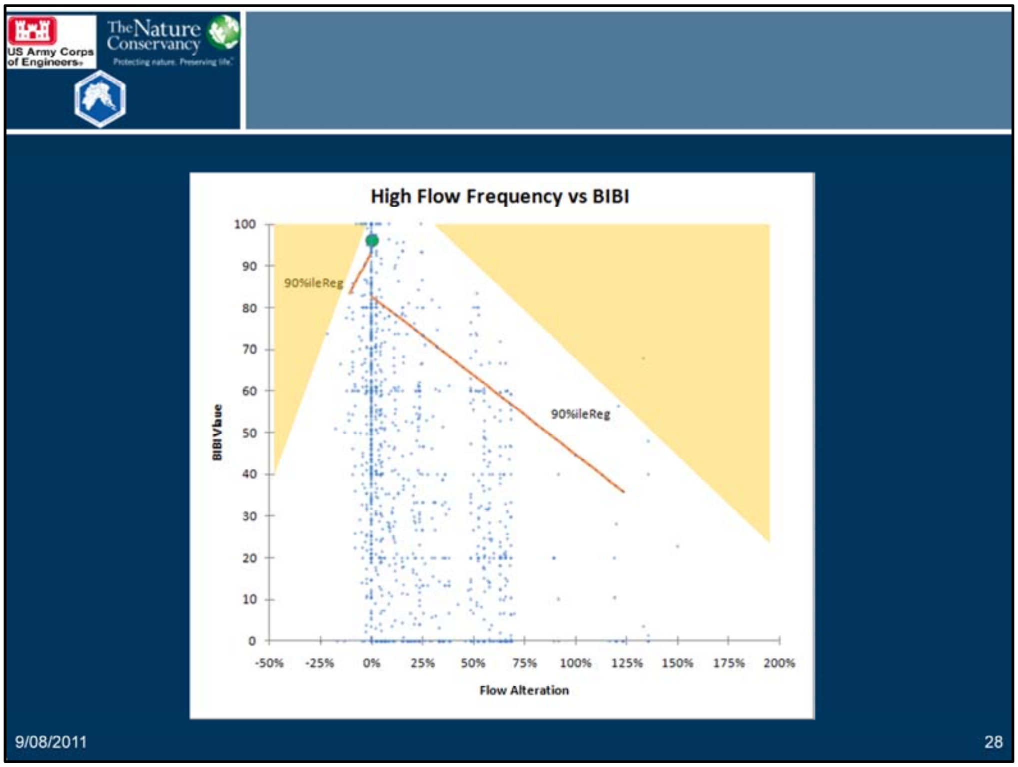
Recall that the only difference between the baseline and current conditions flow simulations is that anthropogenic factors, LULC, withdrawals, discharges, and impoundments, have been adjusted to a “no effects” level (LULC) or eliminated.

As already noted, we don’t have “before” biology but the locations with high levels of flow alteration are more highly altered, with respect to flow, from their baseline condition.

It appears, then, that the effect of anthropogenic flow alteration is to limit the maximum possible biology status.

Flow alteration effects are likely across the range of biological condition values but those influences are not so clearly observed as at the margin.

One more point. The biology samples represent status at a single point in time but we are using them to represent status over some longer period of time (years). Thus, there is some uncertainty in the true biological status around the value calculated from a single point. We account for that uncertainty by focusing on the 90th percentile in the vertical distribution of points rather than the maximum values.



Here, you see 90th percentile regression lines drawn through the data.

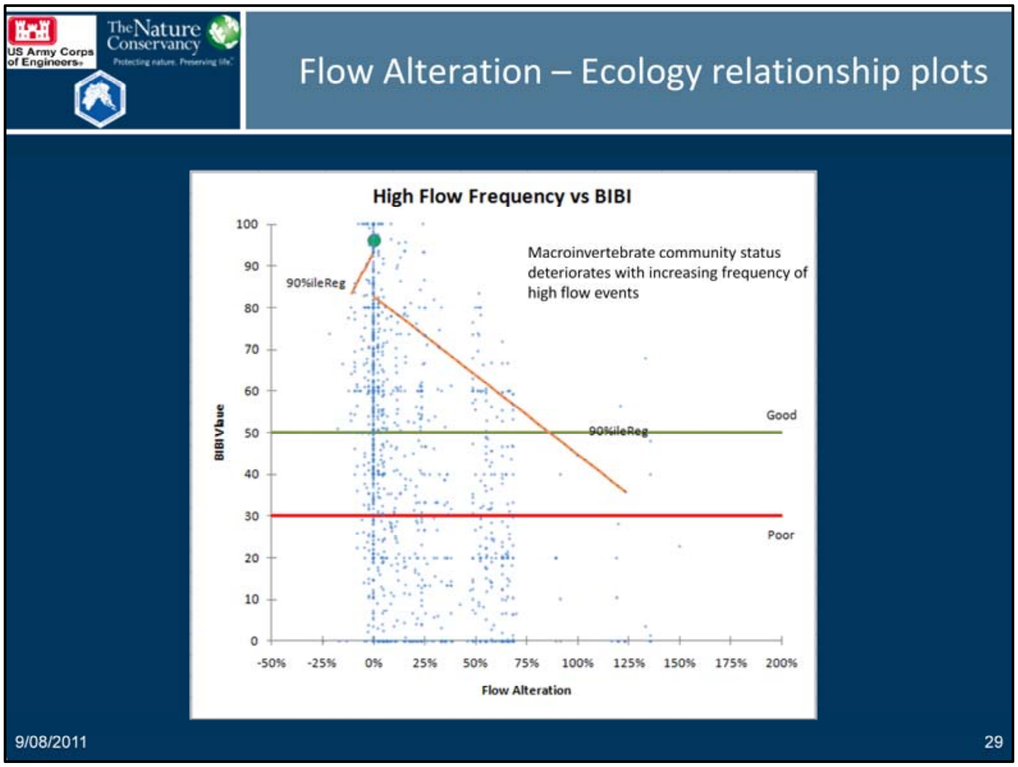
Separate regressions are drawn for points with negative and positive flow alteration and note that they are not mirror images.

The green dot is the 90th percentile of the 0 flow alteration points. One might think of the green dot (96) as representing the “gold standard” for community status.

Note also that the two regression lines do not meet at 0% flow alteration. Not surprising, since the regressions are calculated from non overlapping data sets. But the location of the 0% flow alteration end point for the regression lines is not very important (both endpoints are well up into the Excellent range for BIBI status). More important is the slope of the line, which shows the impact of human flow alteration on macroinvertebrate community status.

Not shown on this plot are confidence intervals or measures of statistical significance for the line slopes. These are yet to be calculated.

Reference: quantile regressions calculated with the Blossom program available at http://www.fort.usgs.gov/Products/Software/blossom/



Adding Good and Poor BIBI status boundaries completes the FA-E relationship plots.

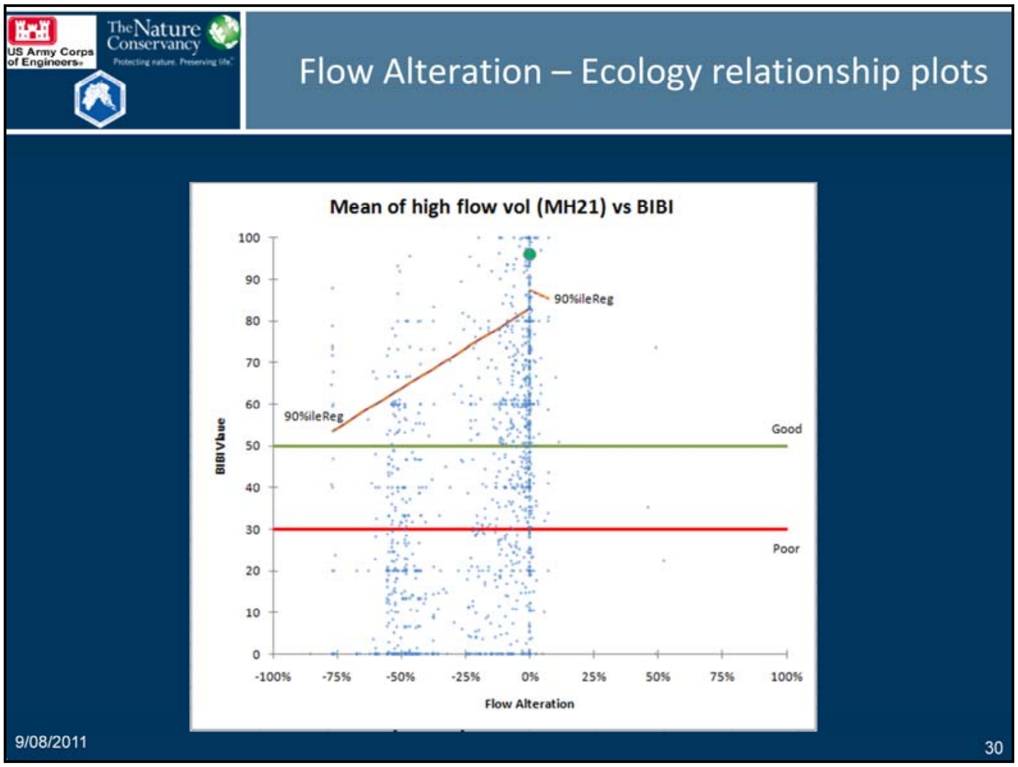
Let's review what this plot shows:

First, these plots DO NOT say that flow alteration up to the point that the regression line crosses the Good line is acceptable.

The regression lines are our empirical estimate of the best possible biological score (with 10% allowance for uncertainty) for a given level of flow alteration. The biological score that a location actually achieves, for a given amount of flow alteration, will be somewhere between this line and 0 (zero), depending on the impact of all other factors. Where the regression line crosses the Good line is a level of flow alteration beyond which the best possible BIBI score, if all other factors are ideal, is no better than a Fair status, which is a sad state of affairs given that all other factors are rarely ideal.

One possible way to interpret these plots for management purposes is to use the slope of the regression line to relate a max allowable change in BIBI score (a policy decision), anywhere on the Y axis, to a max allowable %change in flow statistic, which we might then relate to an amount of change in LULC, withdrawals, discharges, or impoundments.

Now let's look at some selected additional examples.

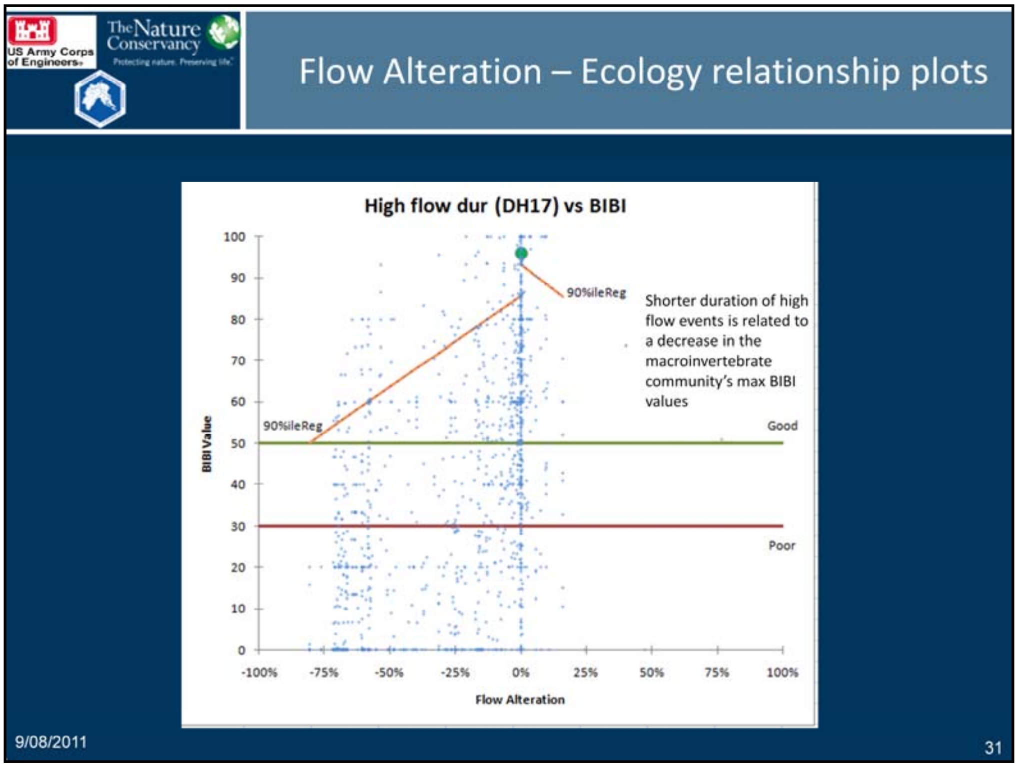


Here is Mean of high flow volume, where the effect of flow alteration is almost always negative (Baseline > Current)

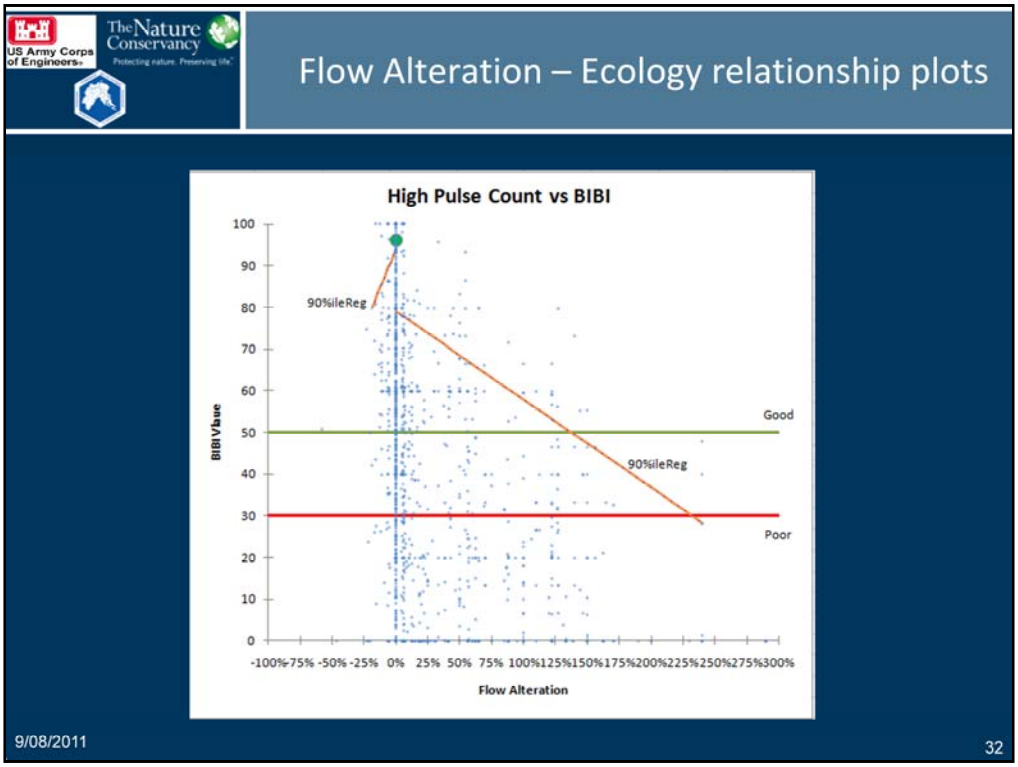
And, on closer examination, one finds that Mean high flow vol (MH21) quantile regression is a mirror image of the high flow frequency quantile regression.

0% Intercepts are virtually identical

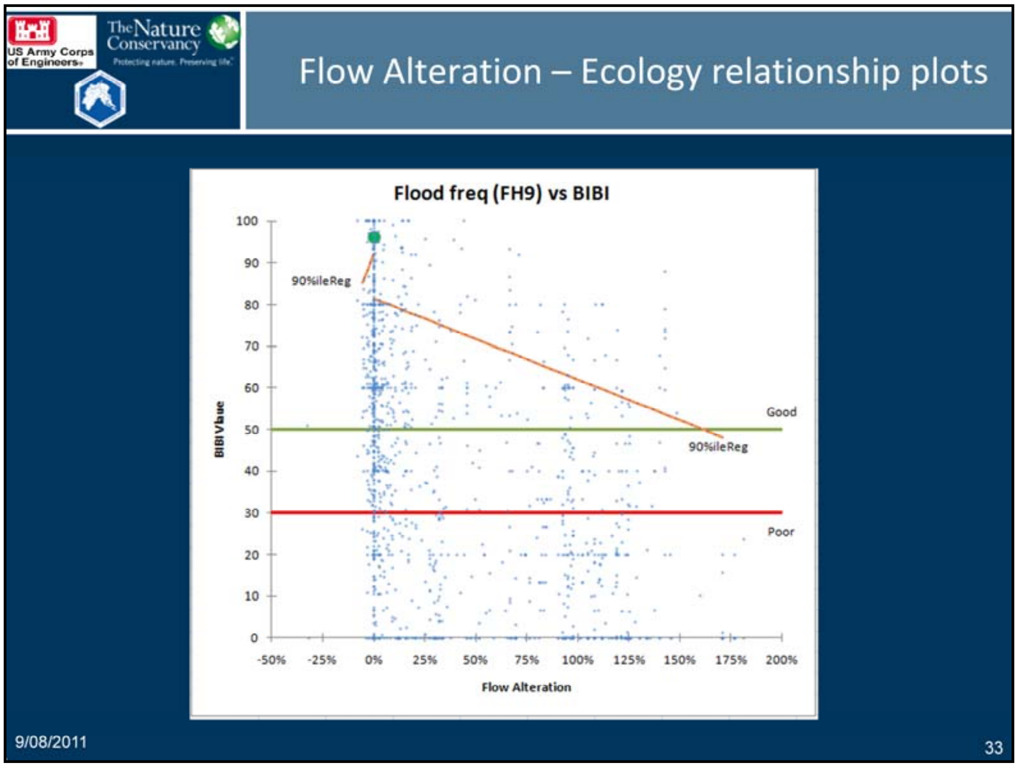
Slope of Mean high flow vol = -1 * slope of high flow frequency



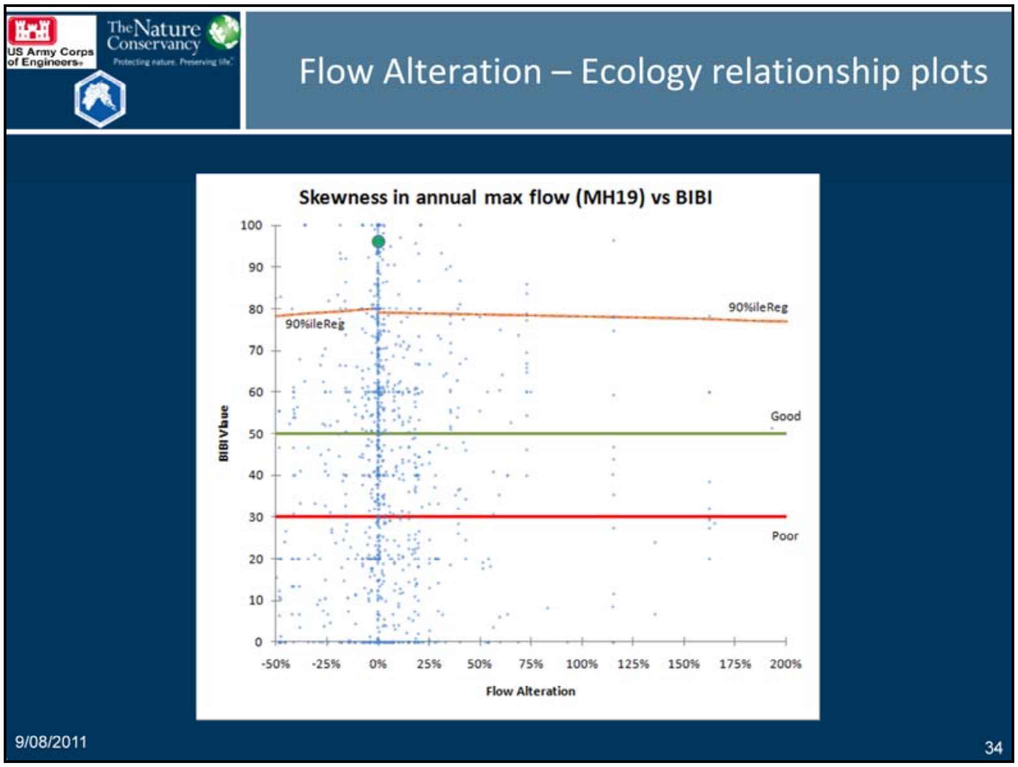
High flow duration – intercept and slope are very close to the previous slide, mean high flow volume



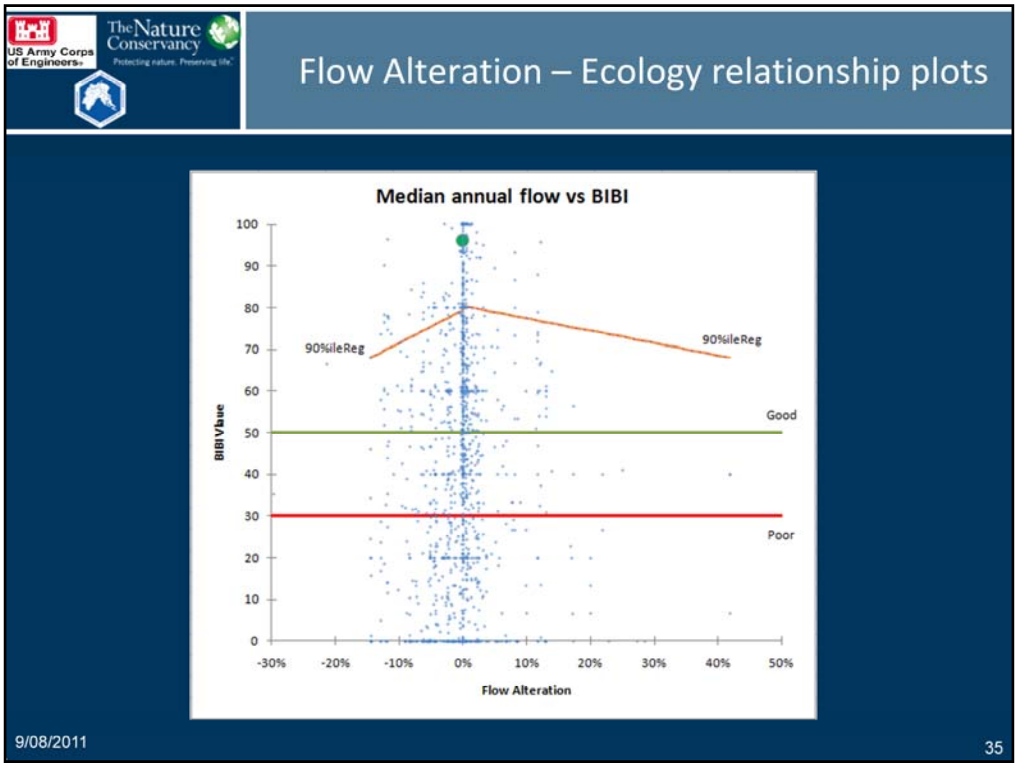
High Pulse Count, mostly positive (Current > Baseline)



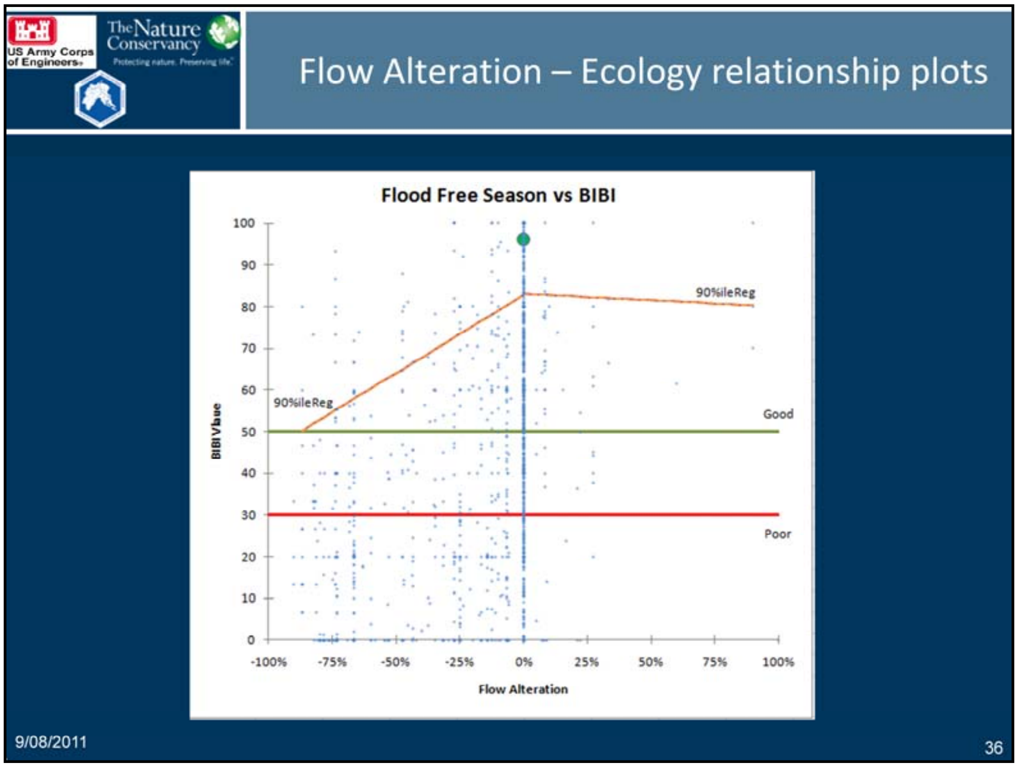
Flood frequency



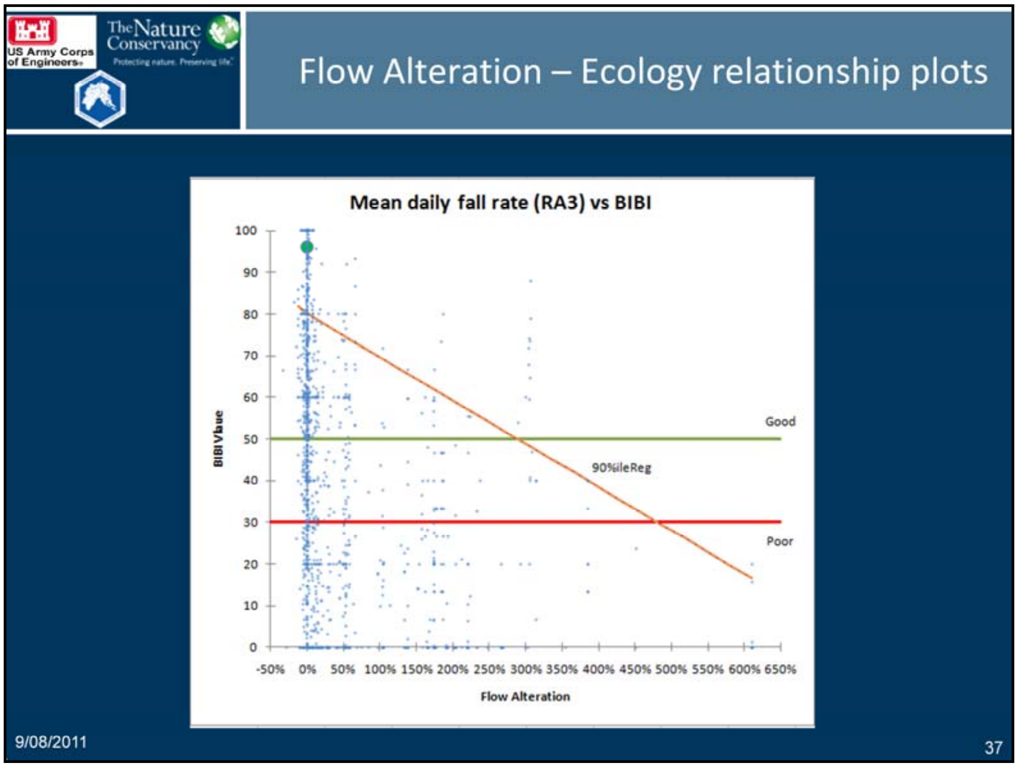
Here's one that doesn't show a relationship with BIBI value. If you refer back to the correlation table, you'll see that Skewness in annual max flow has very low correlations with BIBI and all of the biometrics.



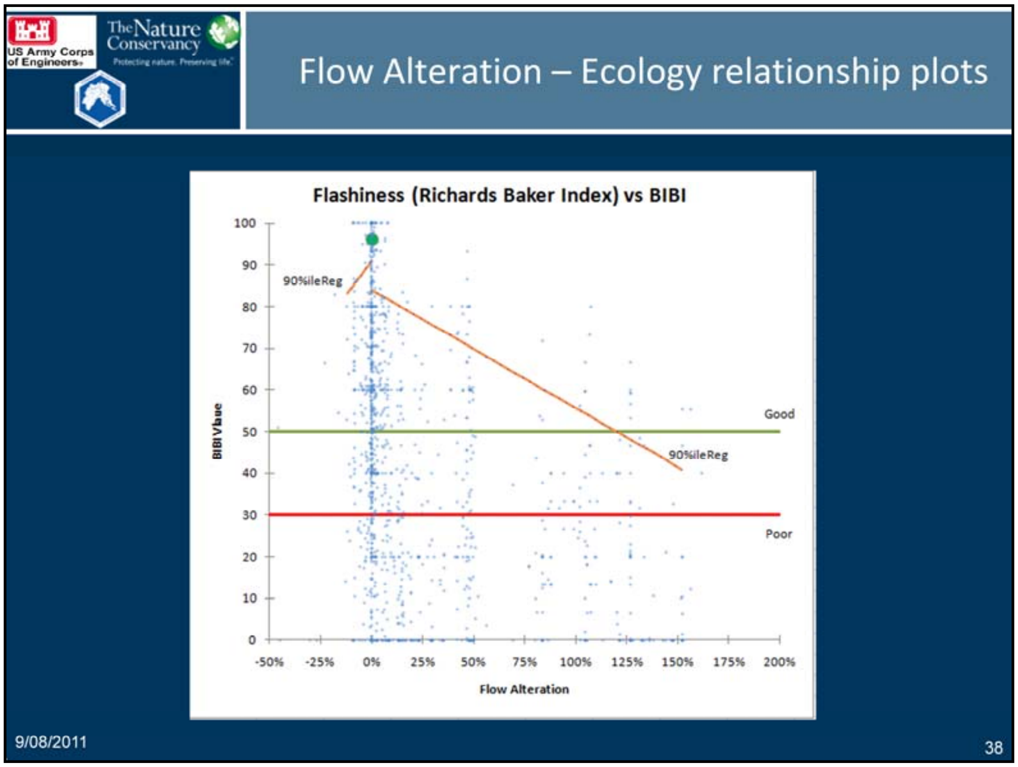
Median annual flow. Here the regressions have a moderate slope, but note the data are about evenly split between Current < Baseline and Current > Baseline



Flood Free Season



Mean daily fall rate. This is a statistic that we are finding is strongly correlated with biometric values. It will be interesting to see how it relates to our flow alteration factors.


Flow Alteration – Ecology relationship plots
Flashiness (Richards Baker Index) vs BIBI
BIBI Value
Flow Alteration
90%ileReg
90%ileReg
Good
Poor
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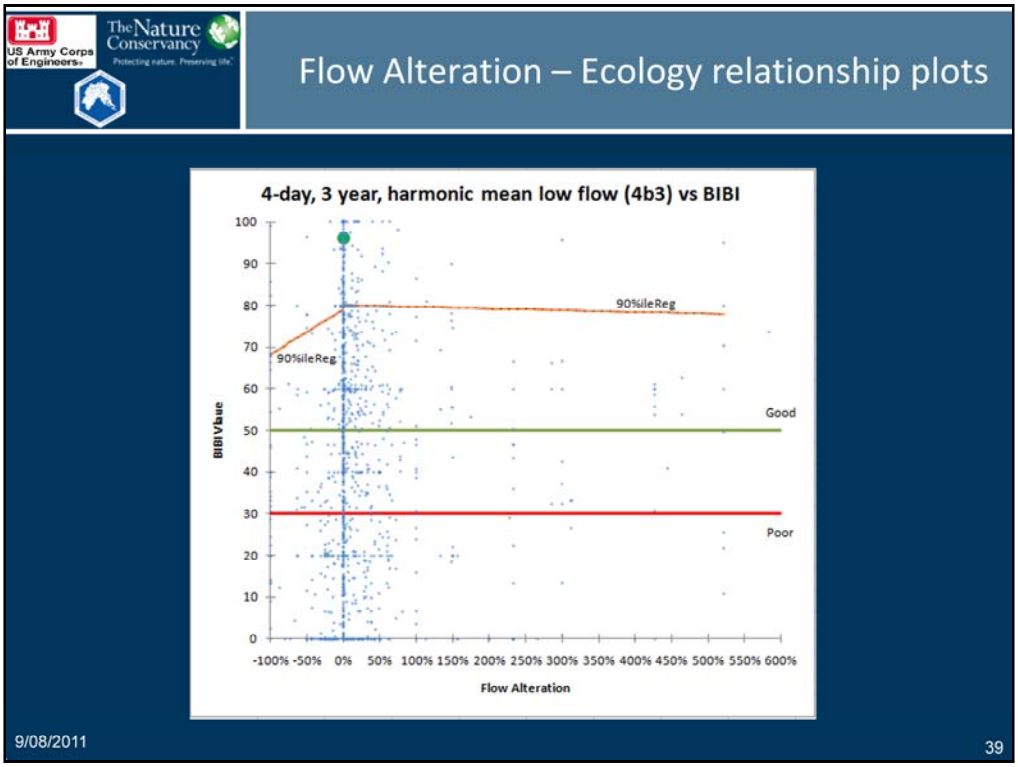
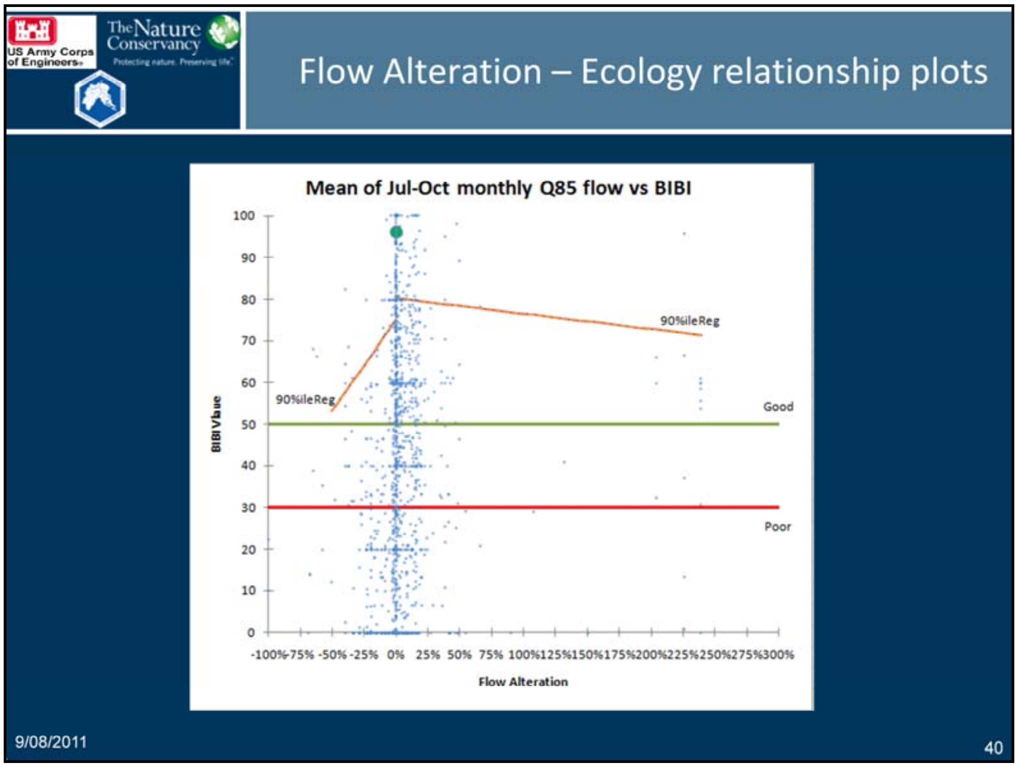
Flashiness

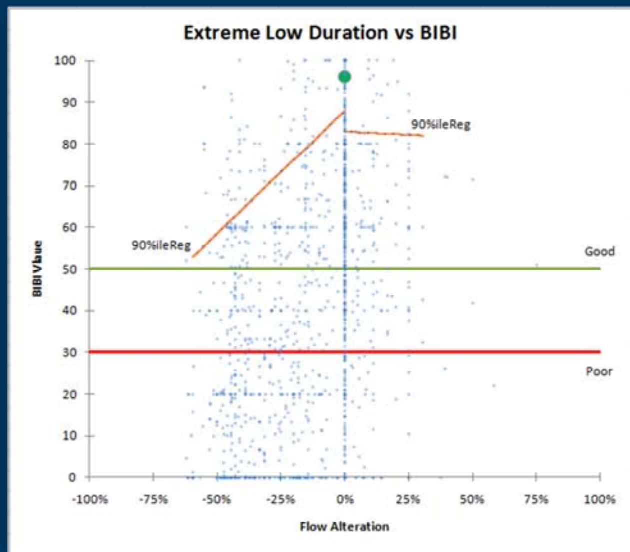


4b3 – not much of interest here



Our version of Maryland's seasonal Q85

Flow Alteration – Ecology relationship plots



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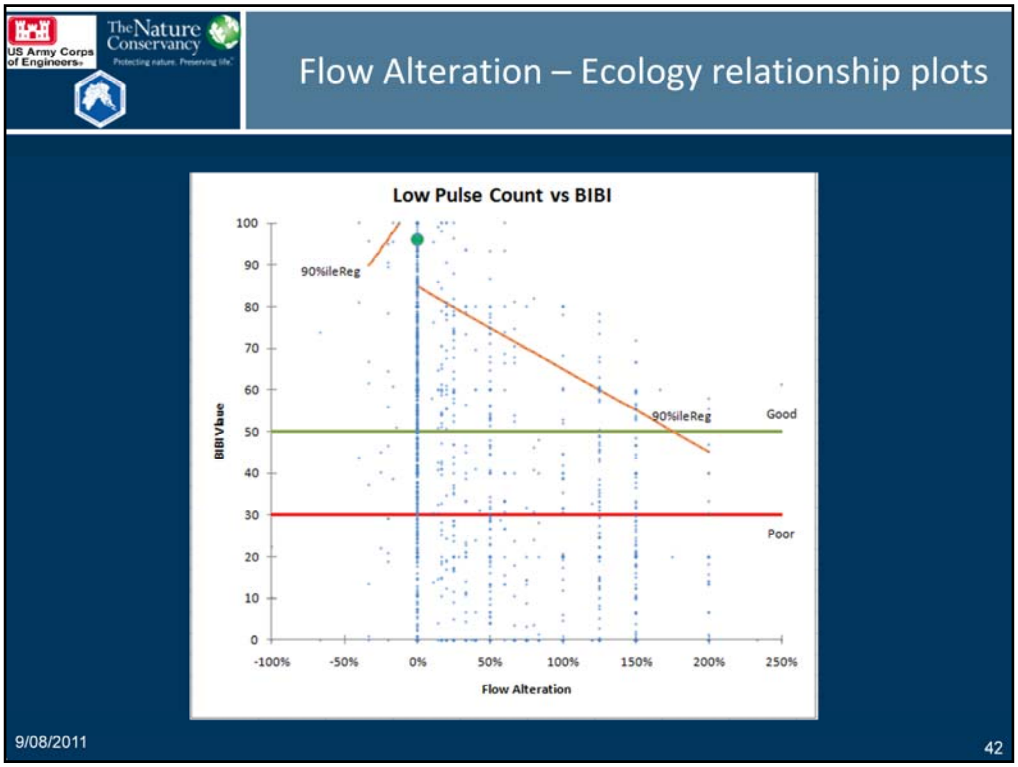
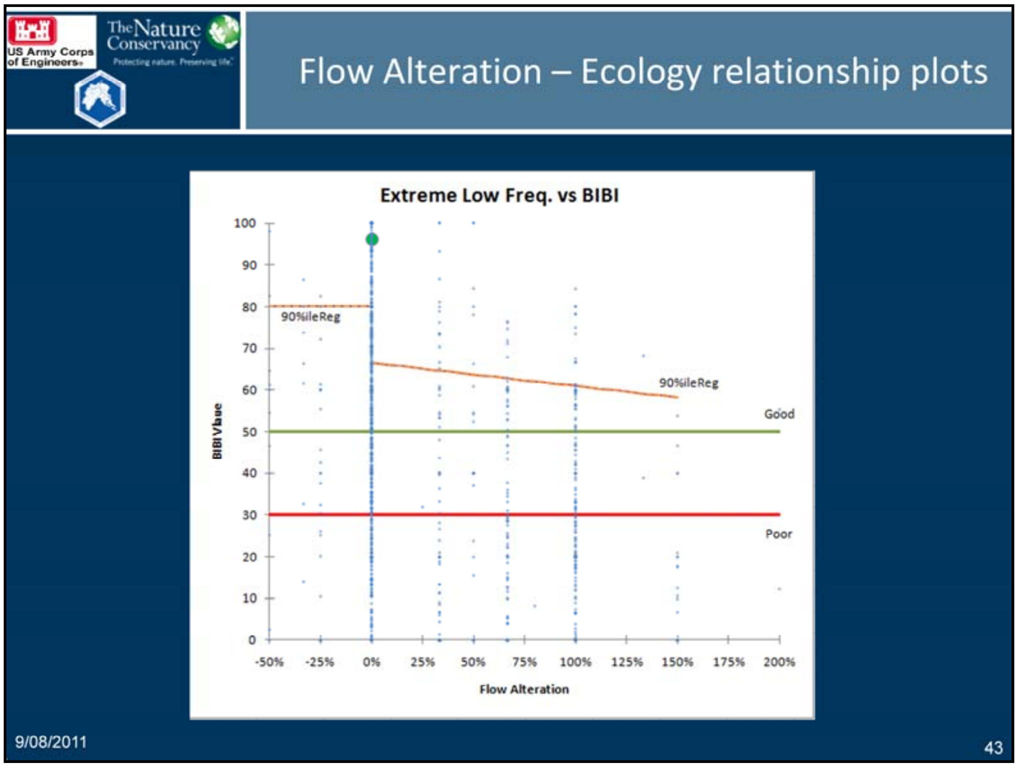
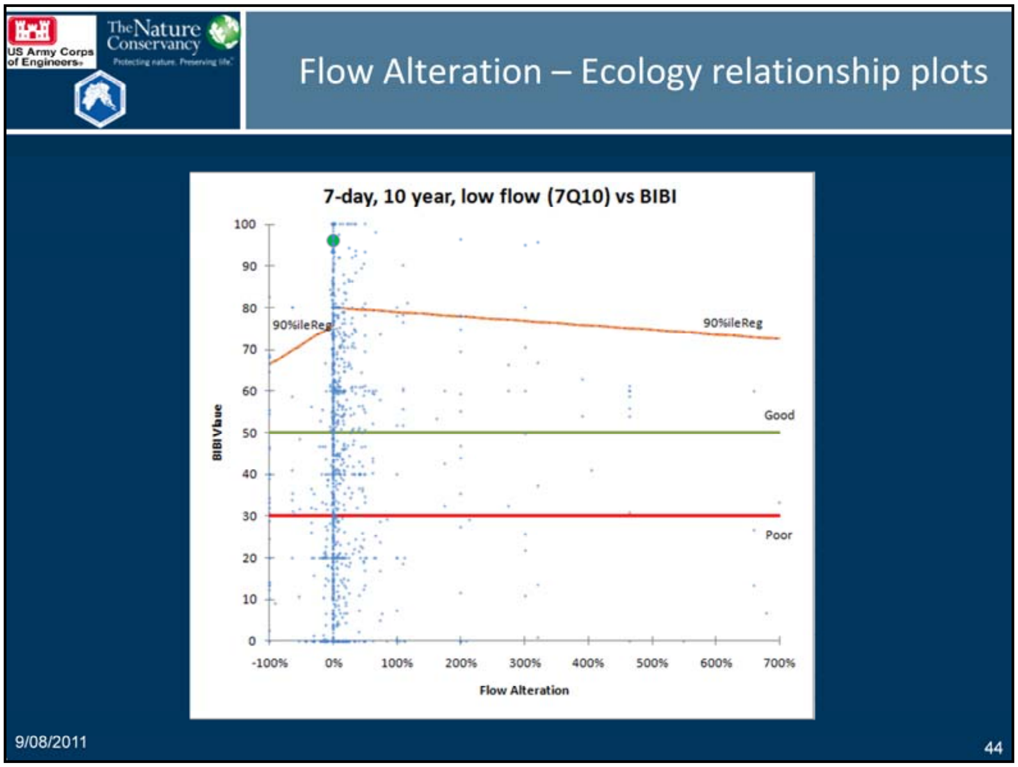


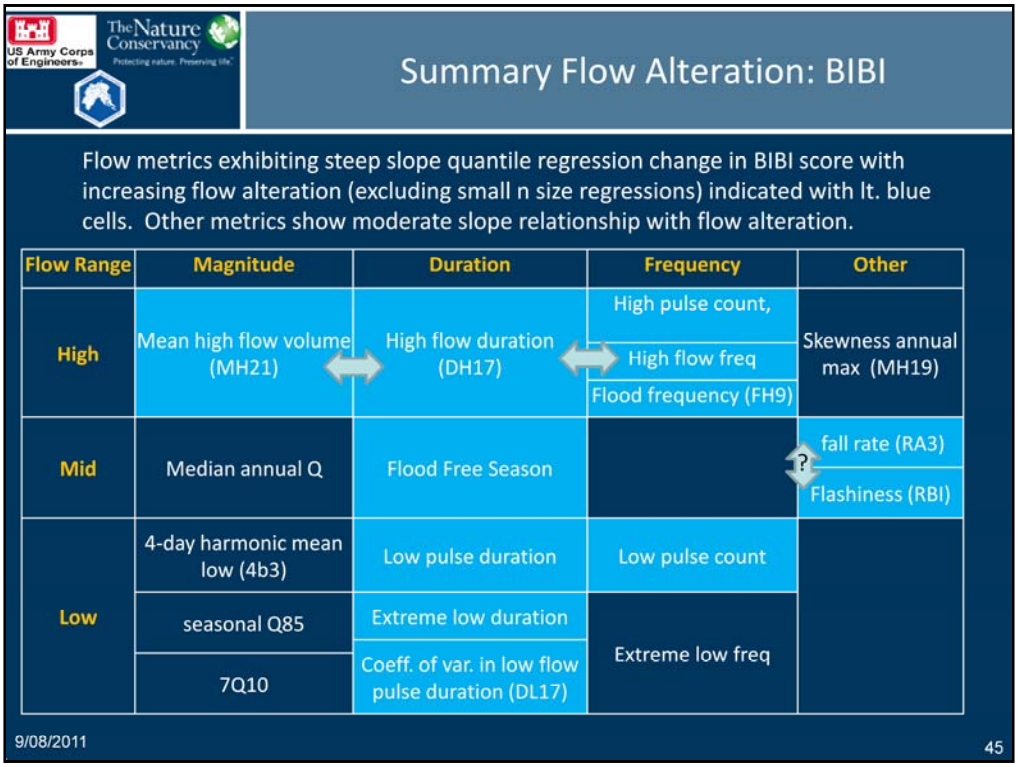
Low Pulse Count. The data line up in neat columns because Pulse Counts are integer values of small magnitude and flow alteration is the ratio of two small integers 1:2, 3:4, 4:5, 3:2, etc.



Extreme Low Freq. – not much here



7Q10 – not a strong relationship – something of a surprise.



Summary Flow Alteration: BIBI

Flow metrics exhibiting steep slope quantile regression change in BIBI score with increasing flow alteration (excluding small n size regressions) indicated with lt. blue cells. Other metrics show moderate slope relationship with flow alteration.

Flow Range	Magnitude	Duration	Frequency	Other
High	Mean high flow volume (MH21)	High flow duration (DH17)	High pulse count, High flow freq Flood frequency (FH9)	Skewness annual max (MH19)
Mid	Median annual Q	Flood Free Season		fall rate (RA3) ? Flashiness (RBI)
Low	4-day harmonic mean low (4b3)	Low pulse duration	Low pulse count	
	seasonal Q85	Extreme low duration	Extreme low freq	
	7Q10	Coeff. of var. in low flow pulse duration (DL17)		

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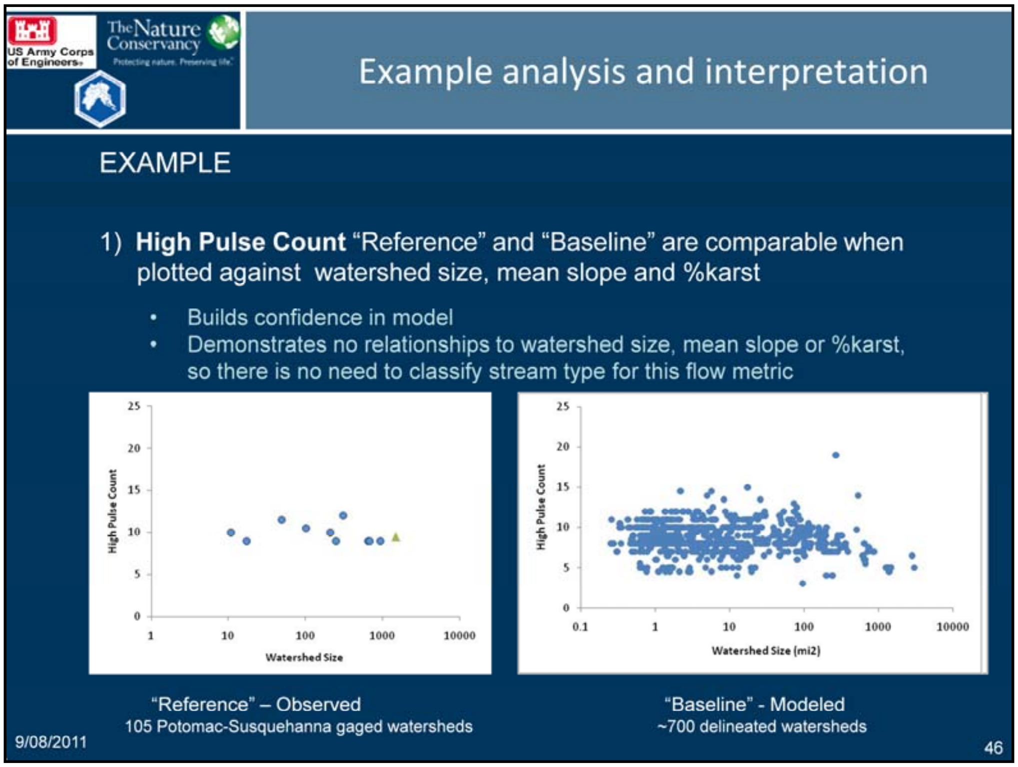
I'll try to some up

-Repeated over and over: BIBI score decreases as flow alteration increases

- Lots of similar patterns, but not identical

- A few flow metrics are not very illuminating

-In this chart, I've attempted a qualitative evaluation of the strength of Flow Alteration – Ecological Status relationship based on steepness of slope (discarding low sample size cases). Light blue fill cells indicate metrics with strong slope. Double sided arrows link metrics that are fairly clearly showing the same relationship. With some statistical testing and perhaps some numerical transformations perhaps other metrics can be shown to be duplicative.

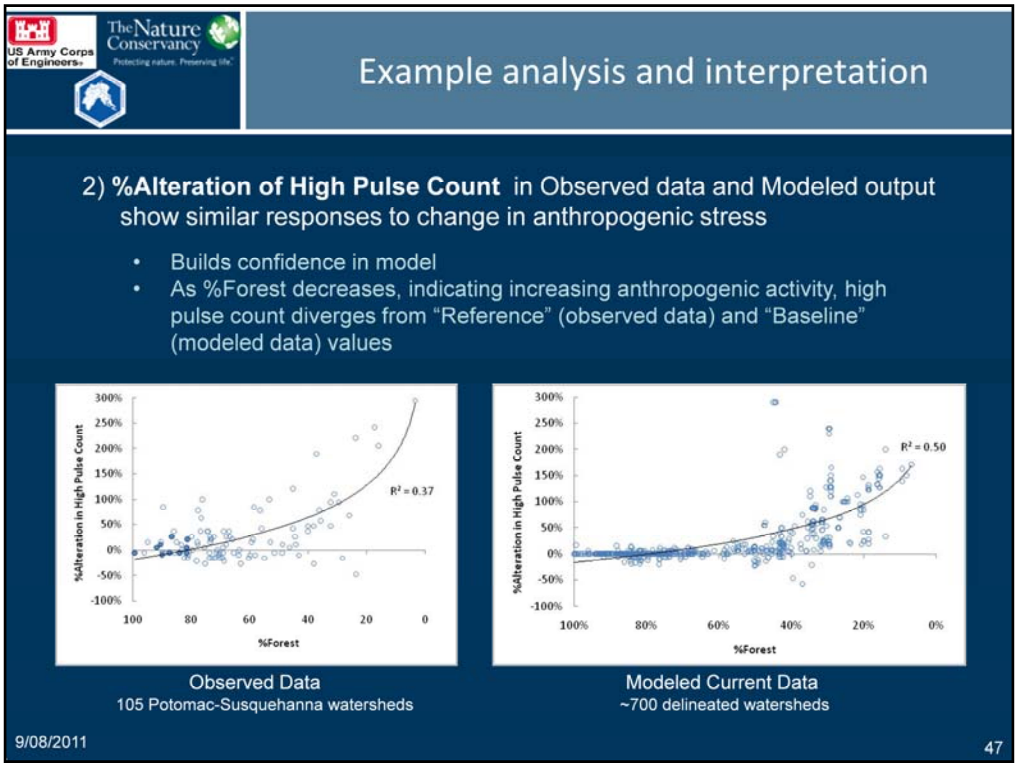


A first step is to compare the behavior of each flow metric in "Reference" watersheds (a subset of the observed data) and "Baseline" watersheds (modeled data). These two data sets are, by definition, minimally disturbed by anthropogenic factors: (loss of) forest, impervious surface, impoundments, and withdrawals. Only nine gaged watersheds in our data set of 105 gaged streams and rivers in the Potomac and Susquehanna basins met the stringent qualifications for Reference. One large watershed (green triangle) came close to meeting the qualifications and was included. For the modeled flows, you will recall that a Baseline scenario is created for each of the watersheds. So, this data set is much larger than the Reference subset. The criteria for Baseline are the same as those for Reference.

To compare Reference and Baseline flows, each set is plotted again watershed size and against mean slope. The comparisons accomplish two things.

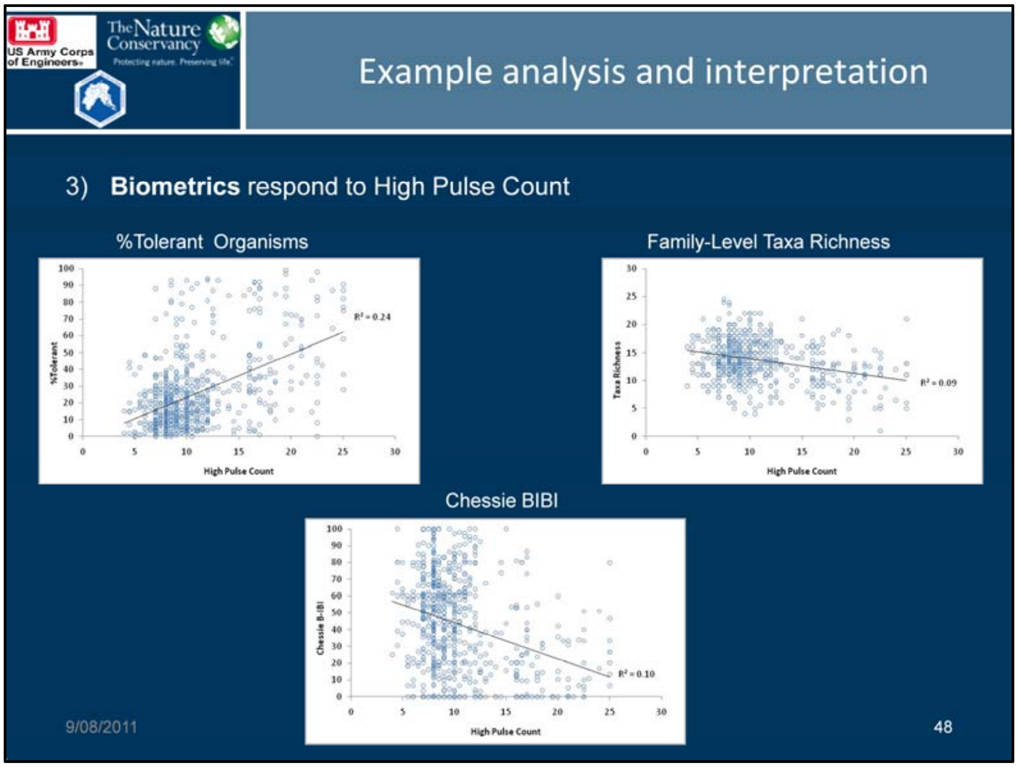
• First, they confirm whether or not the watershed model is accurately portraying flow in the absence of anthropogenic disturbance. The comparisons build confidence in model output if the results are comparable and points out problems to be fixed in the model if they are not comparable. In this project, the Reference and Baseline comparisons pointed out a subset of delineated watersheds that did not "behave" properly for multiple flow metrics. Examination of these data by Heidi Moltz of ICPRB and Rob Burgholzer of Virginia DEQ are indicating the model might have difficulty portraying flow over impervious surfaces in karst regions. We have no Reference watersheds in karst regions and therefore cannot confirm if the karst geology is actually causing the differences or if the model is at fault. It appears that the model may be having problems with these few watersheds because other karsted watersheds behave like non-karsted watersheds. For the time being, we have removed the problematic watershed from consideration. Overall, however, flow metrics in the Reference and Baseline data sets have proved to be very comparable.

• Second, the Baseline results indicate which flow metrics need to be classified by stream type in order to reduce natural variability. In this project we were primarily concerned with watershed size (which is a surrogate for stream order), channel mean slope (which is analogous to gradient), and the %karst. In the case of High Pulse Count, meaningful (r^2>0.10) and/or significant (p<0.01) relationships were not found for the three factors. Thus, stream type does not need to be classified for this flow metric.



Comparisons are also made between all the Observed data and the Current scenario model data. This is to see if they respond similarly to various anthropogenic stressors. At this point we are using %alteration in each flow metric, or the change in the flow metric from its Reference and Baseline values. For the Observed data, this involves subtracted the median of the Reference values from each of the Observed values and expressing the result as a percent of the Reference median. For the modeled data, each watershed's Baseline scenario value is subtracted from its Current scenario value and expressed as a percent of the Baseline.

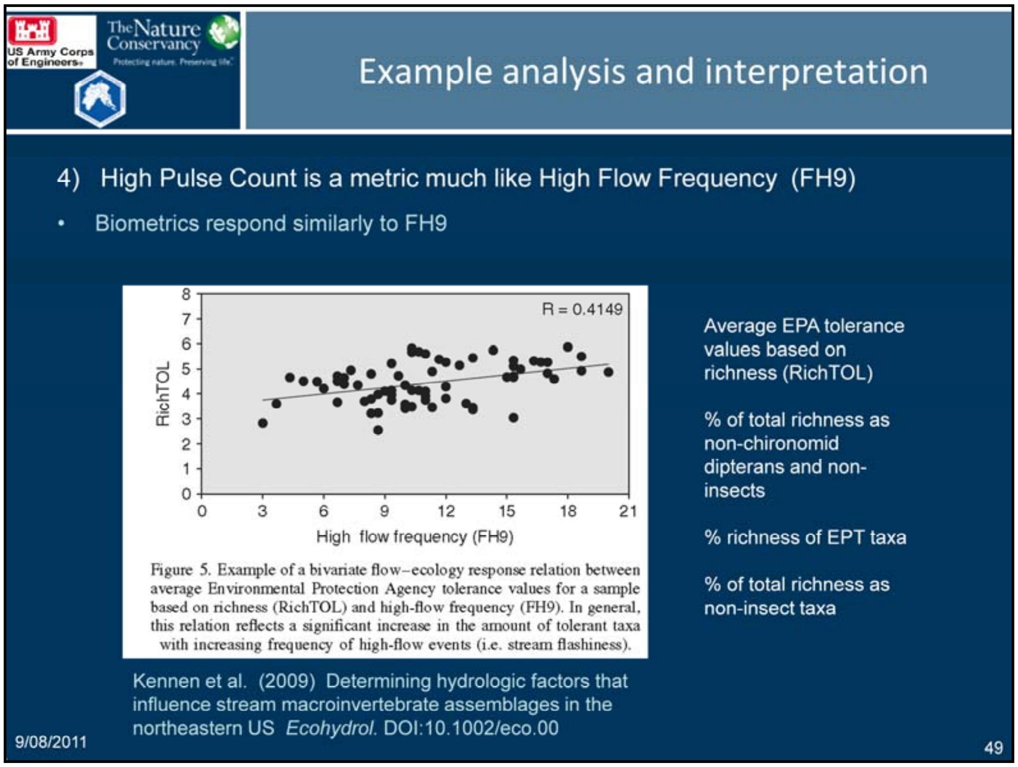
In the example above, we use %Forest as a surrogate for overall anthropogenic activity. Using High Pulse Count again, we see that as %Forest decreases – meaning overall anthropogenic activity increases – High Pulse Count deviates (increases) from both the Reference median and each watershed's Baseline value. The two regressions are strong. They are not expected to be identical because they are based on different data pools. This comparison, and others for %Agriculture, %Impervious, etc., are good enough to reassure us the model is accurately portraying the effects of individual anthropogenic factors on this flow metric.



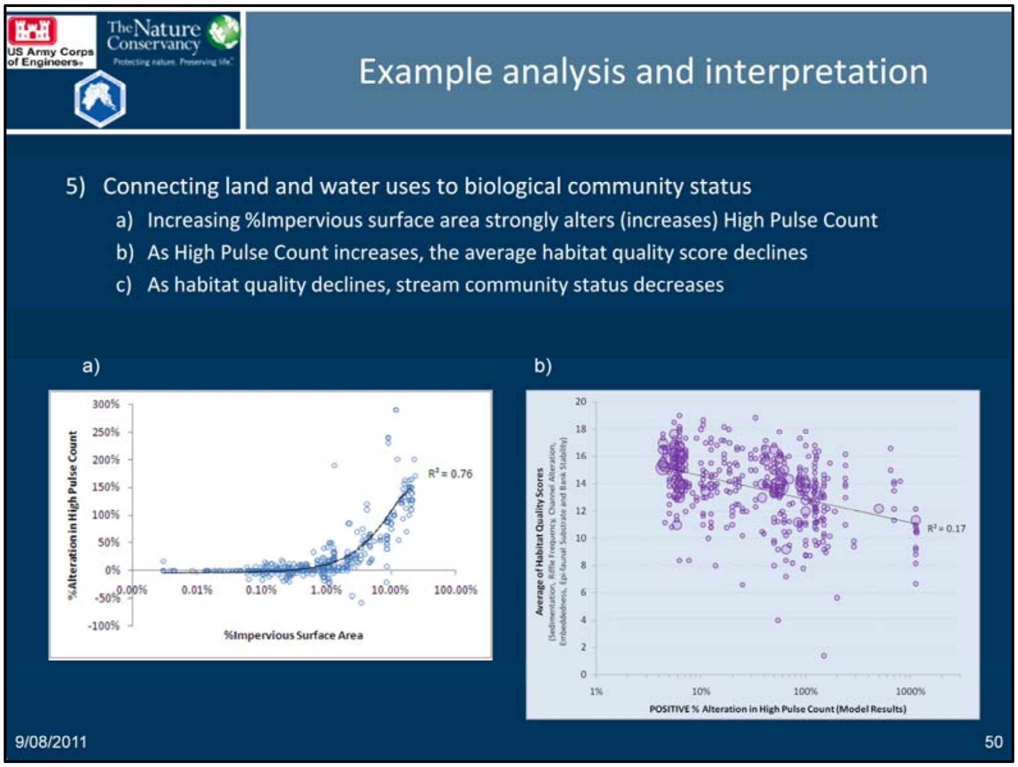
The next step is to discover if and how biological metrics respond to each flow metric. This slide shows some of the biological responses to High Pulse Count….

Previously you saw a table showing correlation results for regressions between our selected flow metrics and biological metrics. If you recall, it indicated there were 5 or 6 flow metrics that did not appear to affect any of our 15 biological metrics and the Chessie B-IBI. Conversely, there were a number of biological metrics that responded strongly to all of the remaining flow metrics. After this initial screening for correlations between biological metrics and flow metrics, we need to decide if these relationships are spurious or have some basis.

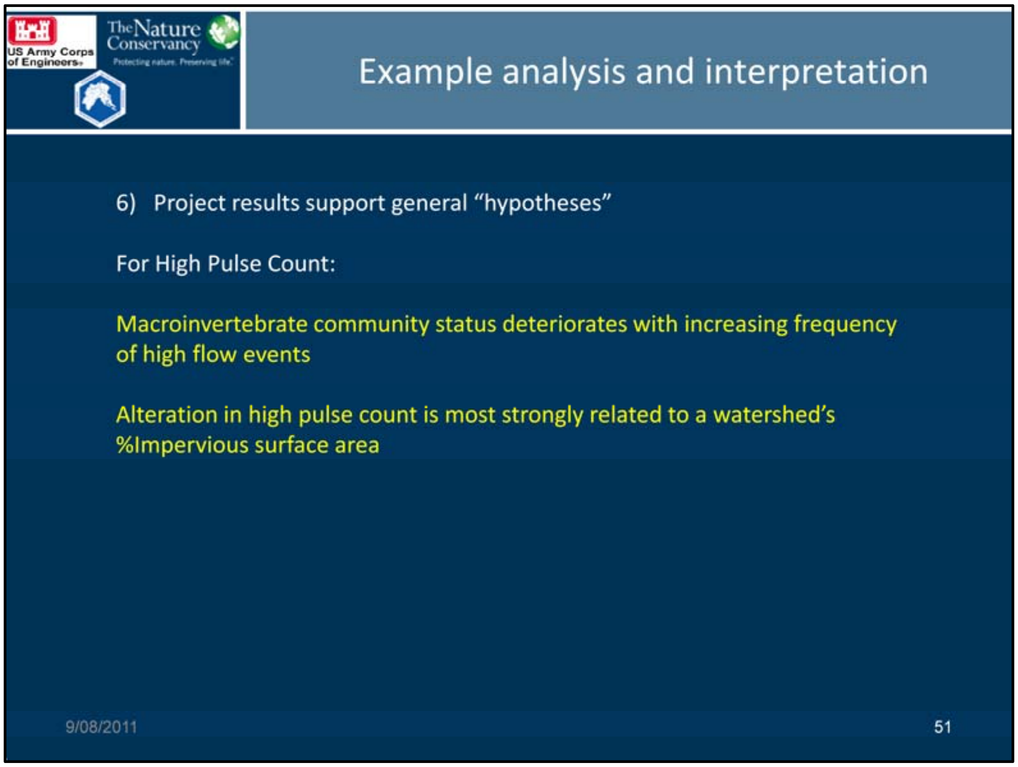
In most cases, the connection is fairly obvious. We know, for example, that high pulse count corresponds to an increase in anthropogenic activity. One of our propositions, or underlying assumptions, is that increasing anthropogenic activity impacts stream communities. In the graphs above, increasing High Pulse Count corresponds to an increase in the percent of organisms tolerant of disturbance and stress, to a slight decrease in the number of taxonomic families present, and to a decrease in an index representing stream community status. This agrees with our general knowledge of streams. Our interpretation of the results is that anthropogenic disturbance expressed as an increase in the number of high flow events affects different segments of the stream community to varying degrees and decreases overall stream community status.



We can find support for our interpretation in the literature for metrics similar to High Pulse Count. High Flow Frequency (FH9) is one such flow metric. Kennan et al. (2009) found that RichTOL and four other pollution-tolerant and pollution-sensitive metrics respond significantly to FH9. They concluded that the amount of tolerant organisms increases with increasing frequency of high-flow events. Aquatic macroinvertebrates were identified to the lowest possible taxonomic level (usually genus) in the Kennan et al. study.

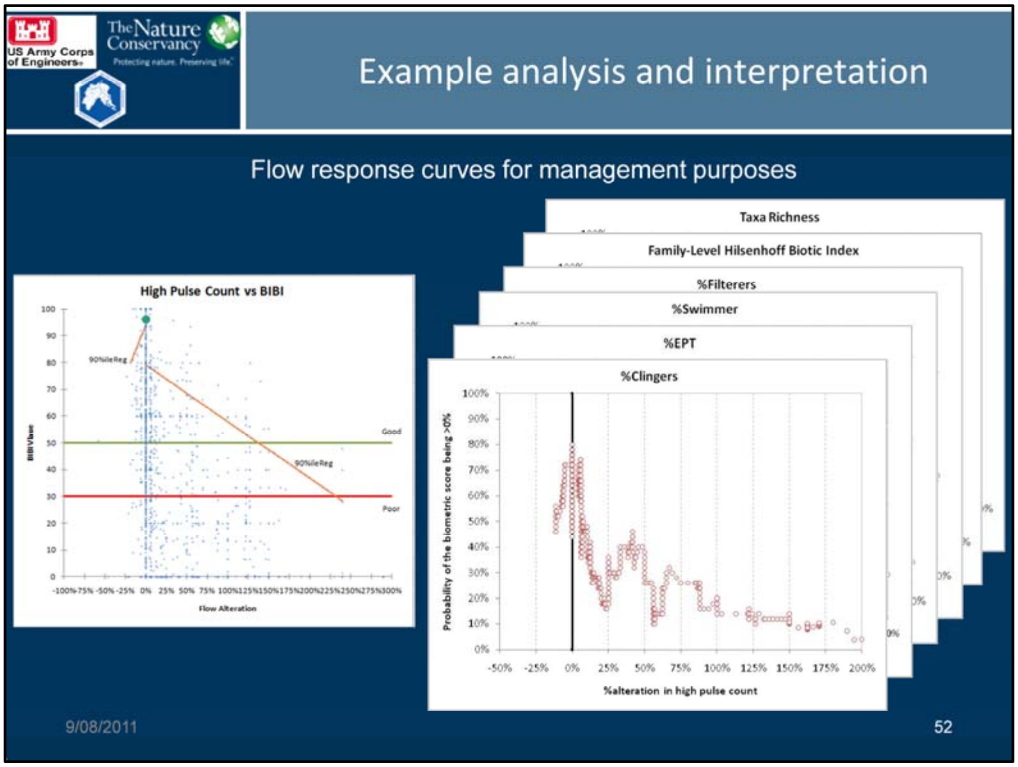


In our previous examination of flow metric responses to individual anthropogenic stressors, where we used scatter plots like the one above as well as recursive partitioning analysis, we began to identify those anthropogenic factors that could be primarily responsible for flow metric alteration. Staying with the High Pulse Count example, we found that alteration in High Pulse Count shows a very strong relationship to %Impervious surface area (a) and does not regress significantly or meaningfully with agriculture, impoundments, or withdrawals – at least in the Middle Potomac data set. As %alteration of High Pulse Count increases above ~5%, habitat quality scores tend to decline (b). As most indexes of biotic integrity show, degrading habitat quality strongly impacts stream macroinvertebrate communities and decreases IBI scores.



From these relationships, we can hypothesize that:

- Macroinvertebrate community composition deteriorates with increasing frequency (count) of high flow events
- Alteration in high pulse count is most strongly related to a watershed's %Impervious surface area



Based on this foundation, a series of flow response curves can be developed for management purposes. The Chessie B-IBI is used in the example in this slide. It represents overall stream community status and incorporates onto a common scale the positive and negative responses of the different taxonomic and functional groups to stream degradation.

Note: The %Clingers graphic presents a different way of showing flow alteration – ecology relationships, which we are currently developing. In this case, the Y-axis is the conditional probability that a location's %Clingers score is like a Reference condition score. Although there is some "up & down", the general trend is, as % alteration in high pulse count increases then the likelihood that a location will have a Reference condition %Clingers decreases.

We think that introducing conditional probability has some conceptual advantages, but we are still developing this approach.

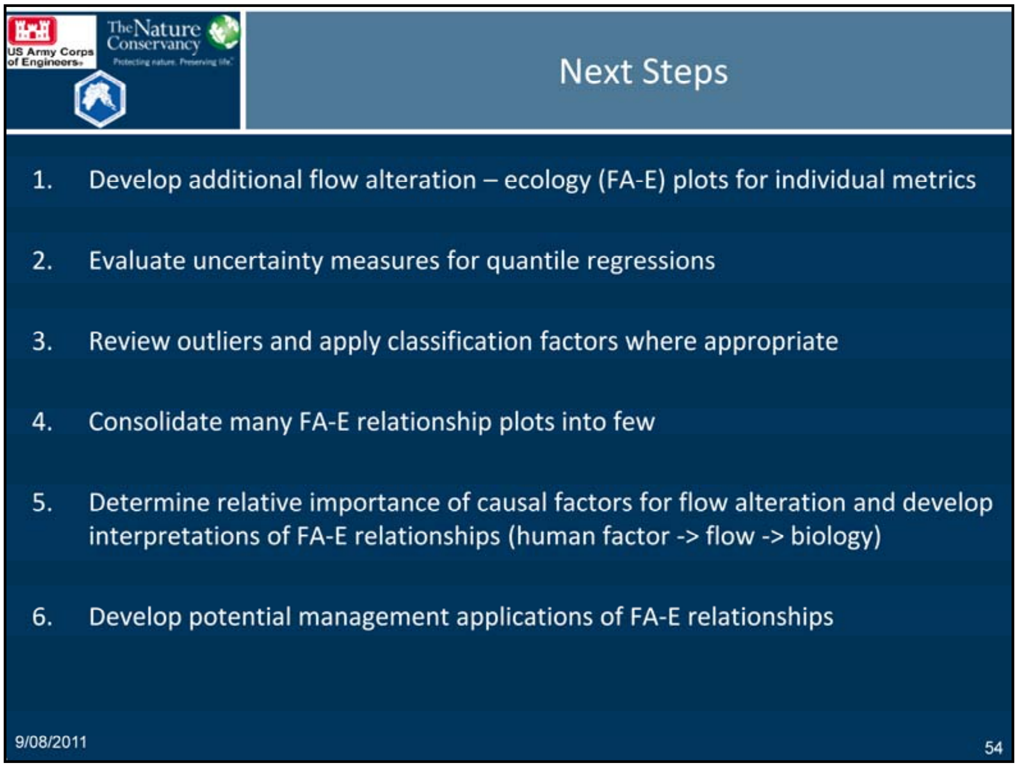
Accomplished so far

1. By examination of observed data have identified watershed characteristics that affect flow and have identified levels for those characteristics for which flow is not affected.

2. Built a model that can simulate daily flow for any watershed we define.

3. Used the model to simulate daily flow baseline and current conditions

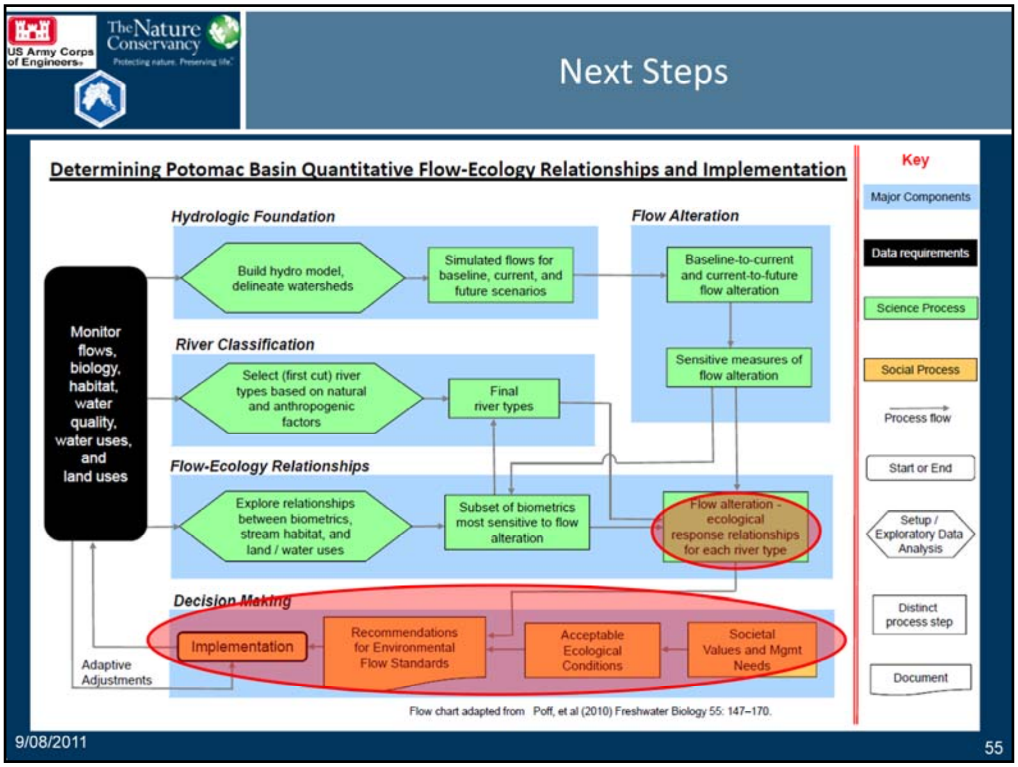
4. Shown that benthic community status decreases as flow alteration increases for many flow metrics.



A note on classification: Not talked about today (an editorial decision due to the amount of time available today), but want to say that we have been testing for classification factors for some time and, so far, there doesn't seem to be much need.

"Classification" refers to identifying watershed characteristics such as bioregion, drainage area, mean slope, bedrock geology, etc., for which either the flow metrics or biometrics behave significantly differently and it is necessary to account for that difference with separate FA-E plots.

(The BIBI and biometrics scores already take bioregion into account when raw biometric values are converted to scores on a uniform scale)



In this Process Chart, in the next several months, we will be finishing off the FA-E relationships and transitioning into consideration of potential management applications.

Technical Advisory Group

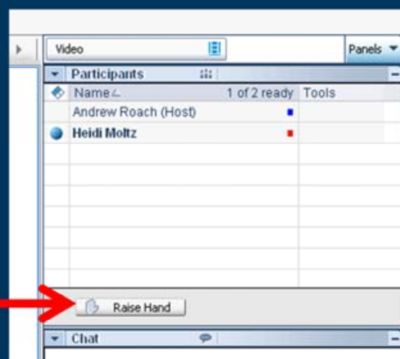
- We have a group of volunteers, but still accepting additional volunteers willing to participate, particularly those with macroinvertebrate, stream hydrology, or ELOHA backgrounds
- Time commitment: two 1-day meetings (late Sep., late Oct.), one 2-day workshop, possible conference calls, review technical memoranda
- Expect to send later today to TAG volunteers a memo describing scope and expectations
- Contact Carlton Haywood if interested

Changes:

1) Topic for Oct 27 might change
2) Nov workshop 2 days only, intended for Technical Advisory Group and some others. Focus will be on science of FA-E relationships. Invitation only.
3) New, 7th, webinar planned to share the workshop findings and recommendations with all stakeholders.
4) We recognize that all the watershed jurisdictions have either ongoing or planned/desired flow analyses related to water resources management. Briefings for state agencies planned for Dec.-Jan. to discuss how these results can be applied to their water planning processes.

Questions? Comments?

- Raise your hand by clicking on the button on the webinar menu.
- Please remain muted until the conference organizer calls on you.
- Once called upon, un-mute your phone by selecting *7.
- Afterward, please mute your phone again by selecting *6.



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Post Webinar Follow-up

Contact for this webinar

- Carlton Haywood, chaywood@icprb.org, (301) 274-8105

More info about project and copy of this webinar's slides

- http://potomacriver.org/sustainableflows/

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