The Effect of Drought on Macroinvertebrates and Fishes in Connecticut Streams

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Presentation Outline

1) **Project Background**

2) **Drought Definition**

3) **Drought Effects on Biological Communities: Fish & Macroinvertebrate**

4) **Future Directions**

Project Details

6 Years (2004-2009)

12 Sites (Some sites discontinued, others started later)

Stream ecology projects

- Temporal and spatial variation in invertebrate communities
- Pre & post dam removal community changes
- Trophic and environmental interactions
- Riffle and pool community comparison

LOTS OF DATA!

Methods

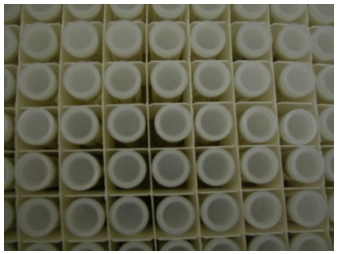
Backpack Electrofishing
- Identification to Species

USGS Gauging Stations

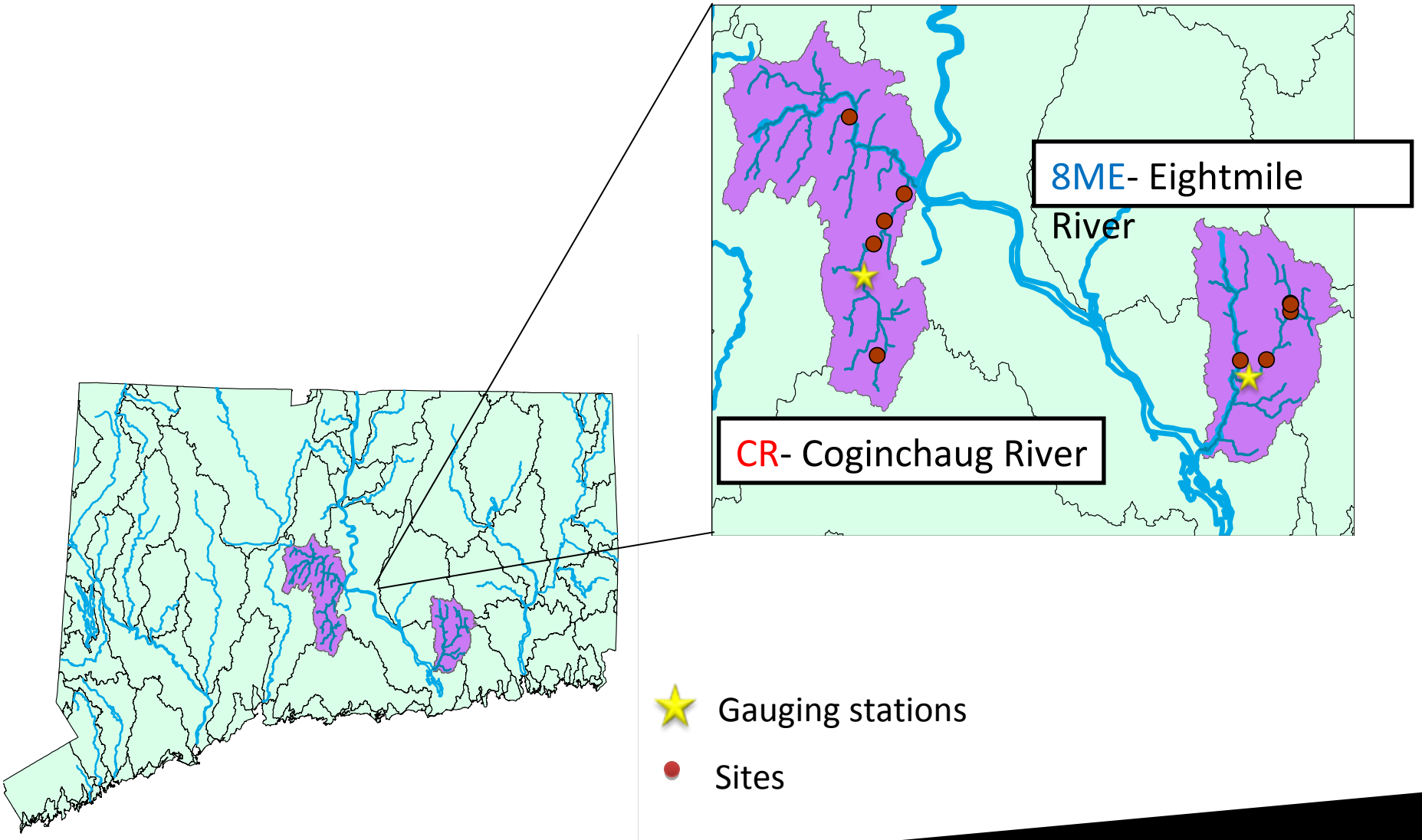
Water Chemistry taken with YSI

Surber Sampling for Macroinvertebrates
- 3 Replicates per riffle (25% Subsamples)

- Identification to Family Level



Connecticut Locations



What we already know about these aquatic biological communities

- Temporal Variability
  - Year, Season
- Variability between sites
  - Landscape & Habitat Characteristics
- Variability between watersheds
  - Water Chemistry
  - Groundwater?
  - Local precipitation?

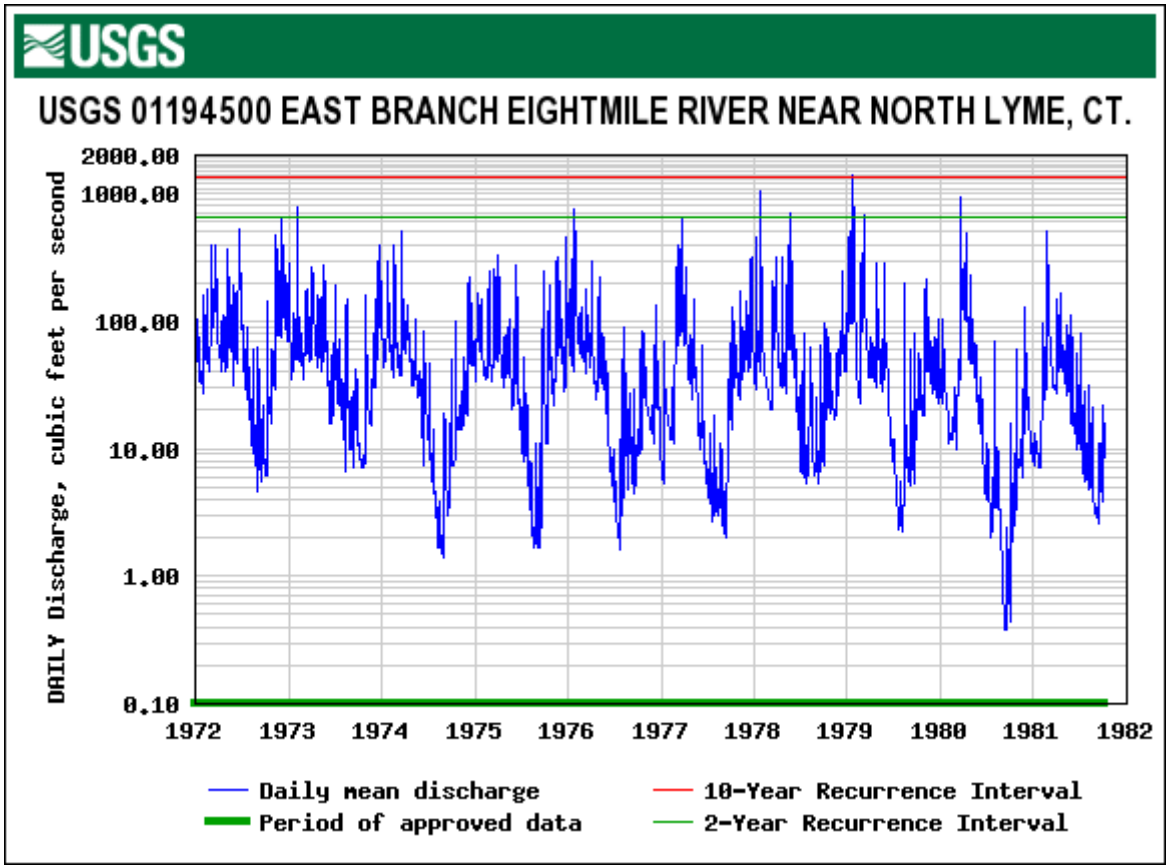
But we need to look at these patterns and the variation in more detail…

What we do NOT know:

1. What is the effect of drought on the macroinvertebrate community?
   - Immediate or lagged?
   - Abundance and/or richness?

2. What is the effect of drought on the fish community?
   - Immediate or lagged?
   - Abundance and/or richness?

Connecticut Hydrologic Regime



- Seasonal decreases are normal
- July – Sept = Lowest Flow
- But when drought occurs, how low does it need to go to affect the biological communities?

How do we define drought?

Many forms of Drought

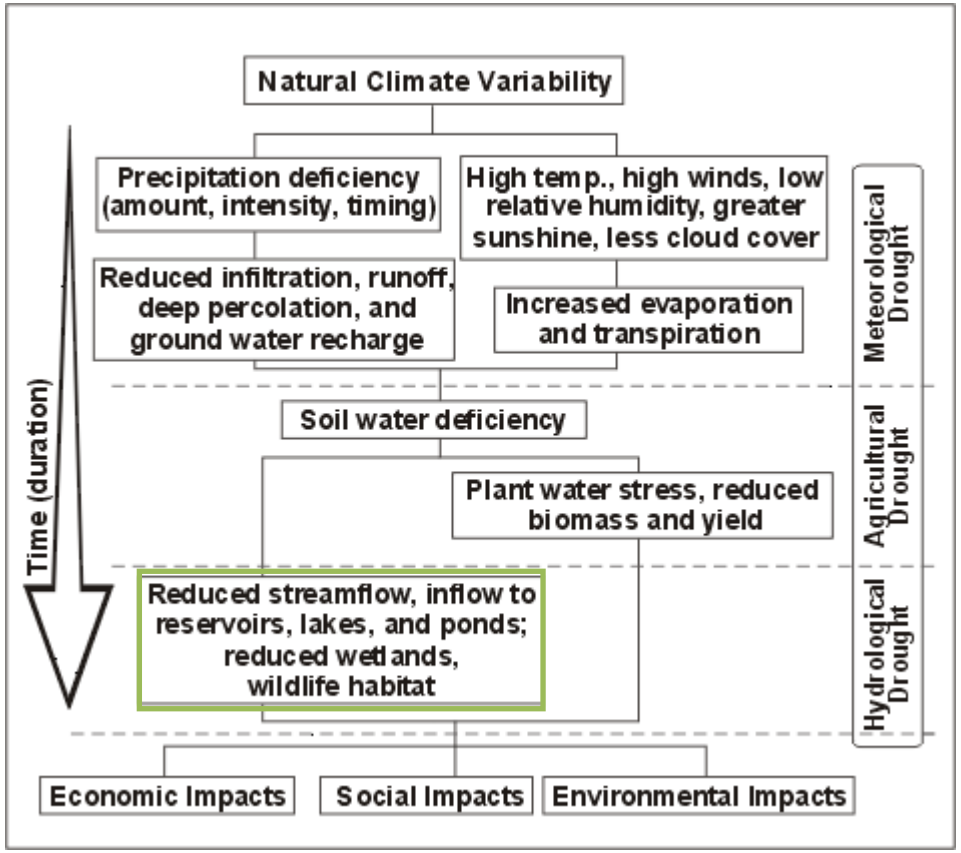
- Meteorological
- Agricultural
- Hydrological

Precipitation shortfalls

➡ Surface or subsurface water supply deficits

Frequency and severity often defined on a watershed or river basin scale

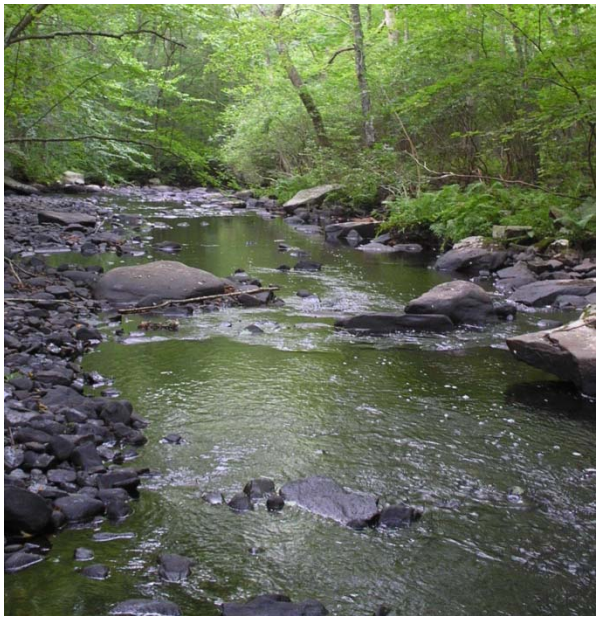
(Wilhite 2000)



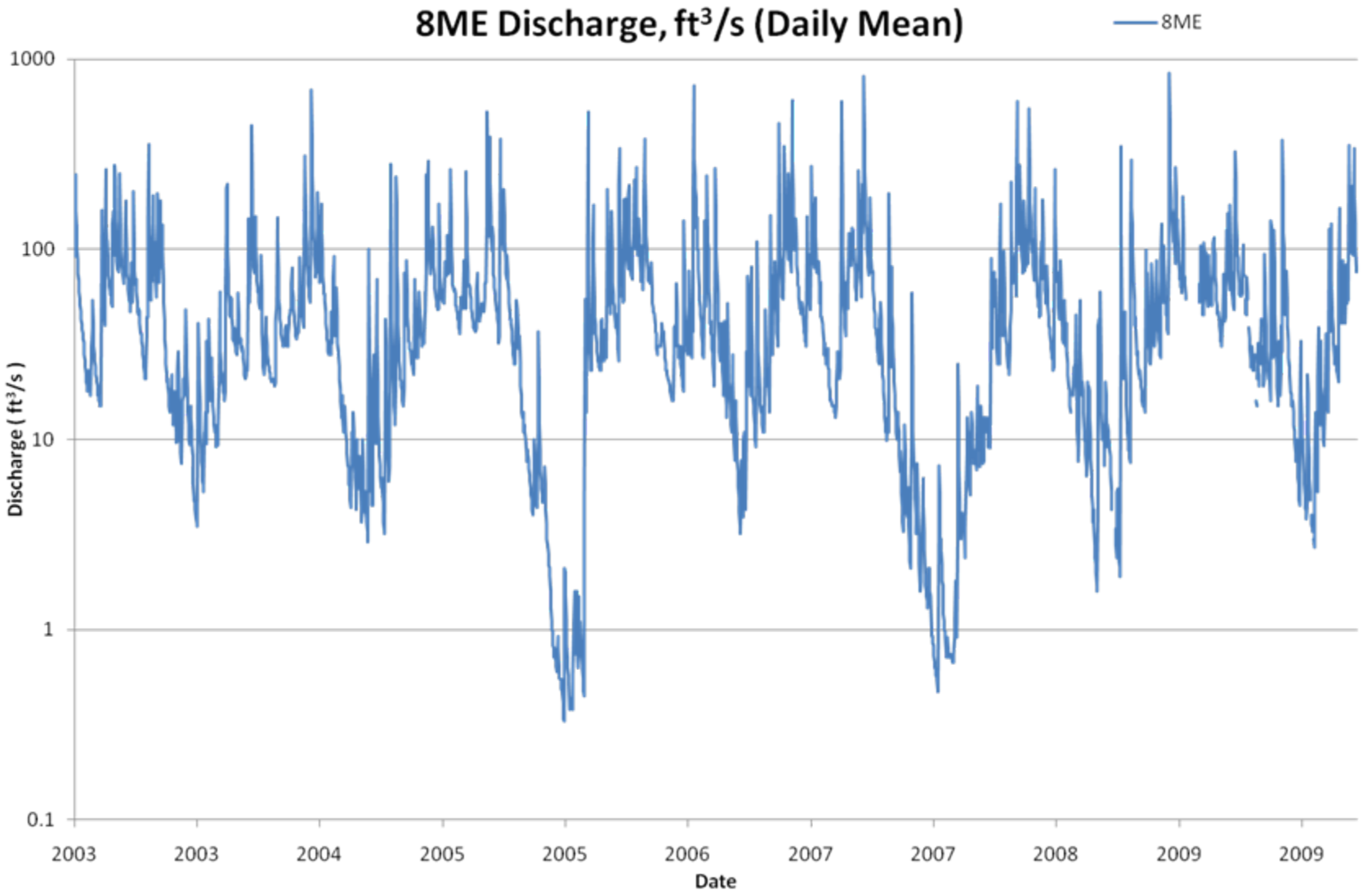
Source: http://drought.unl.edu/whatis/concept.htm

2007

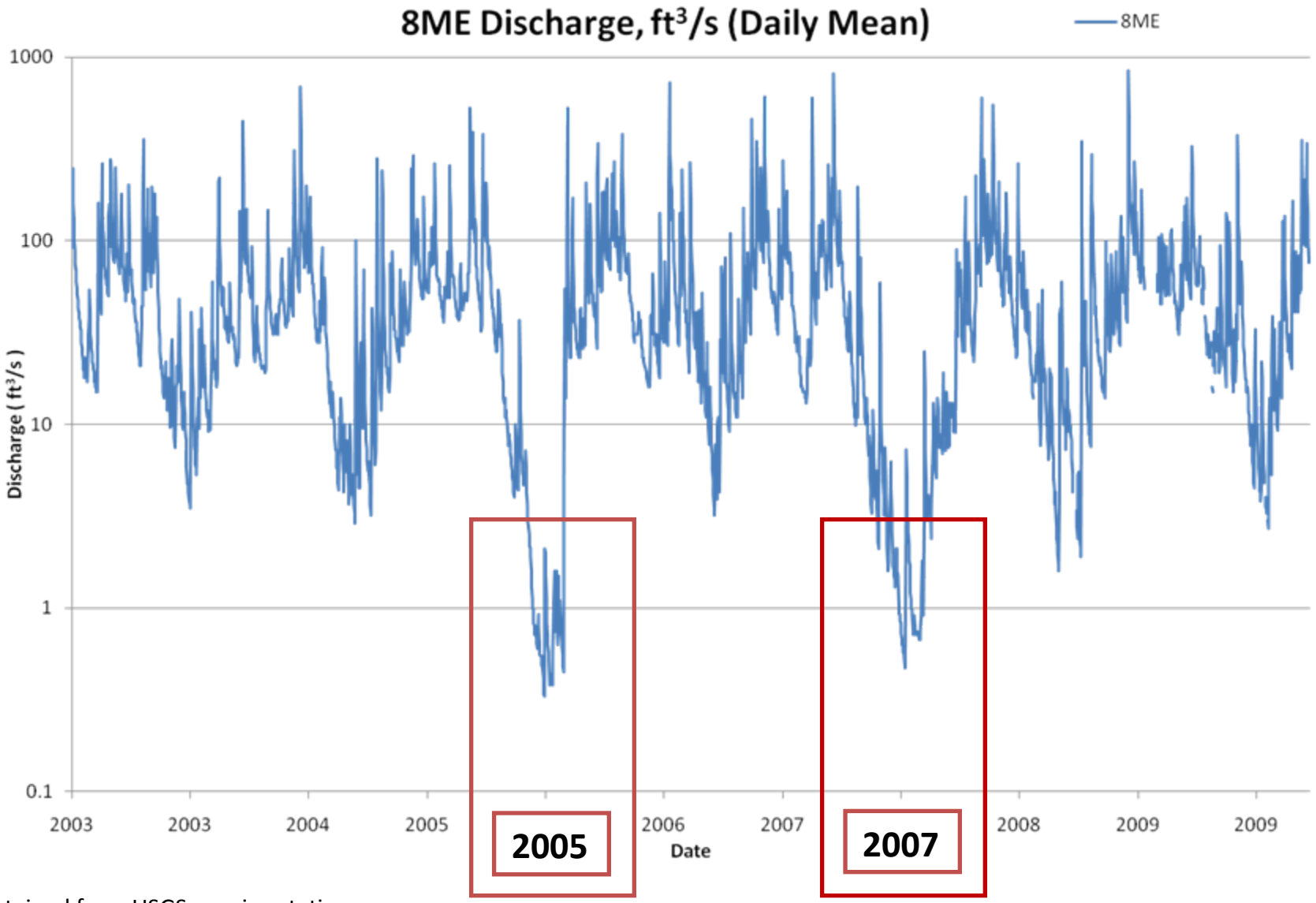
East Branch Eightmile River
Salem, Connecticut



2008

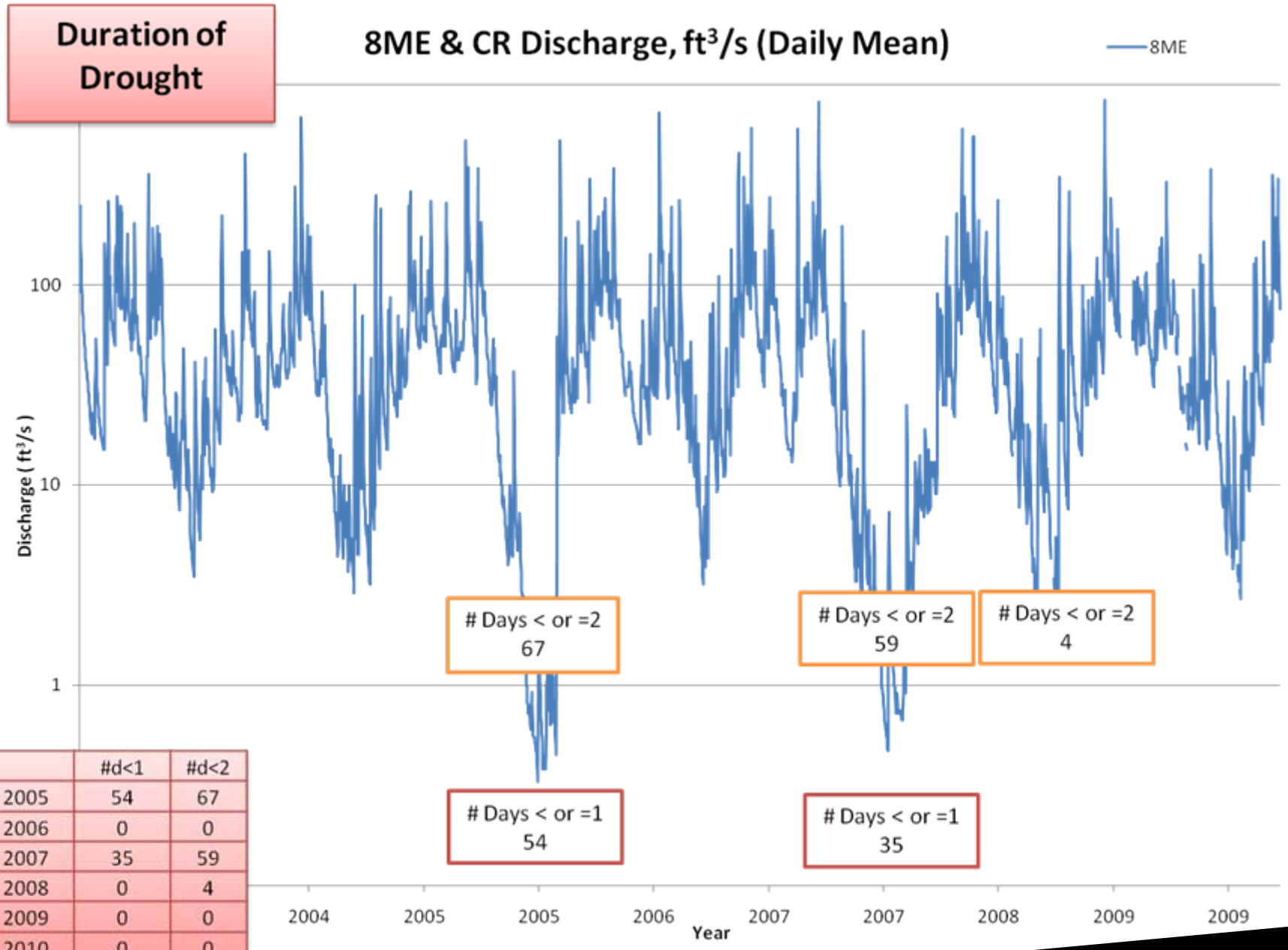


Data obtained from USGS gauging station:
USGS 01194500 EAST BRANCH EIGHTMILE RIVER NEAR NORTH LYME, CT



Data obtained from USGS gauging station:
USGS 01194500 EAST BRANCH EIGHTMILE RIVER NEAR NORTH LYME, CT

Duration of Drought



	#d<1	#d<2
2005	54	67
2006	0	0
2007	35	59
2008	0	4
2009	0	0
2010	0	0

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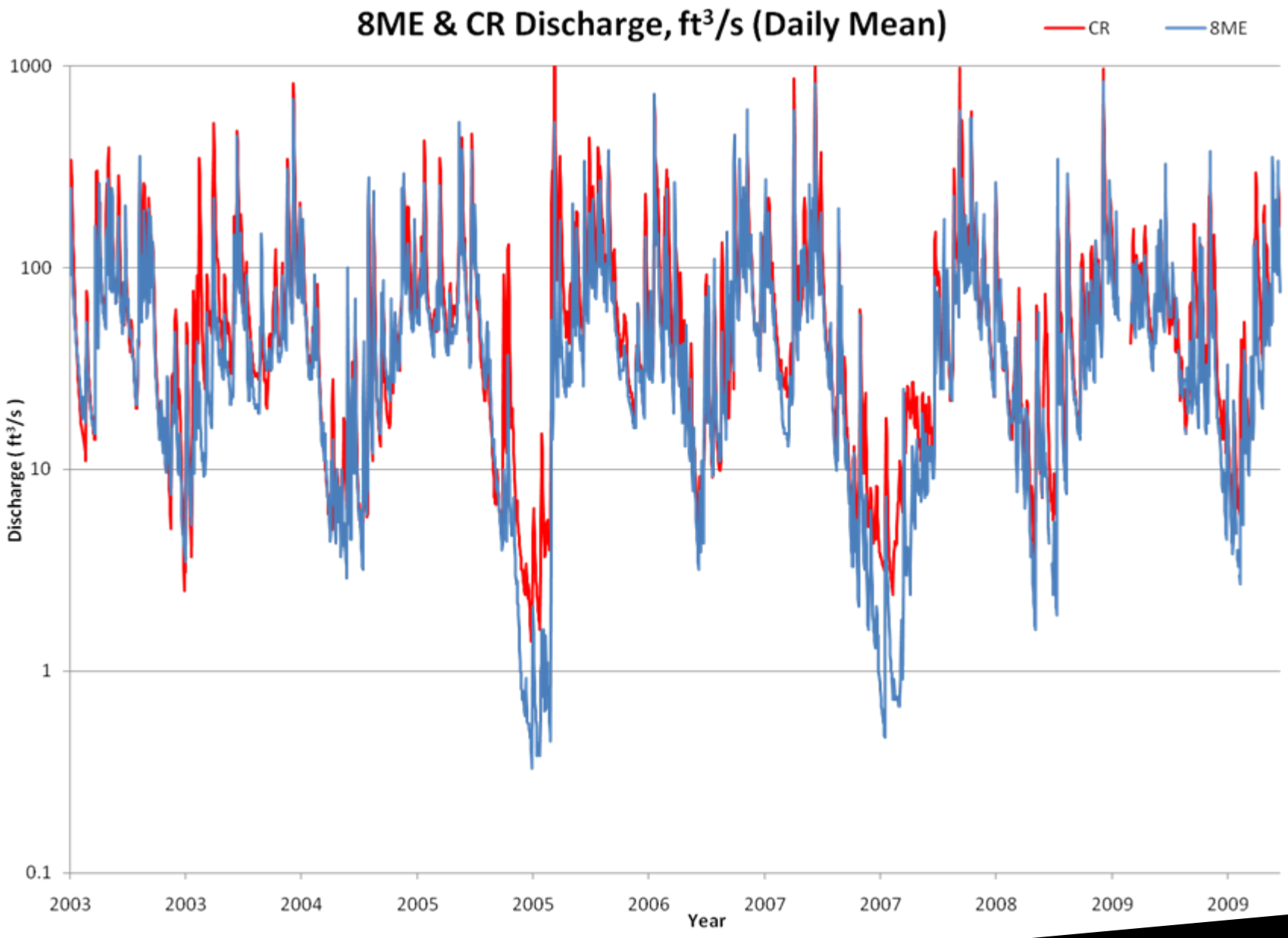
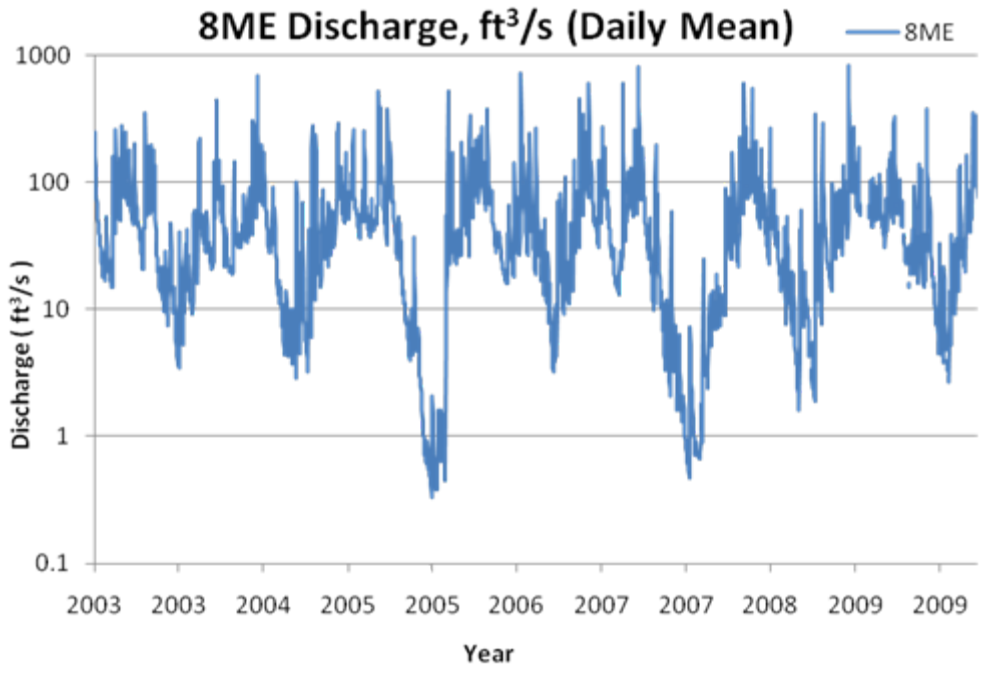
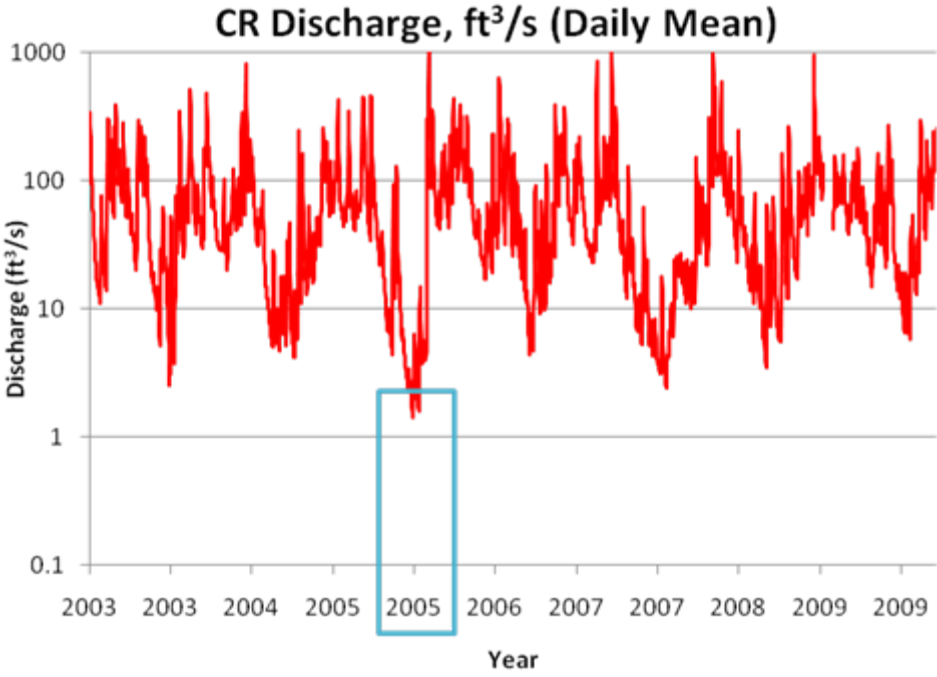


Differences in Discharge: Only noticeable at the extremes

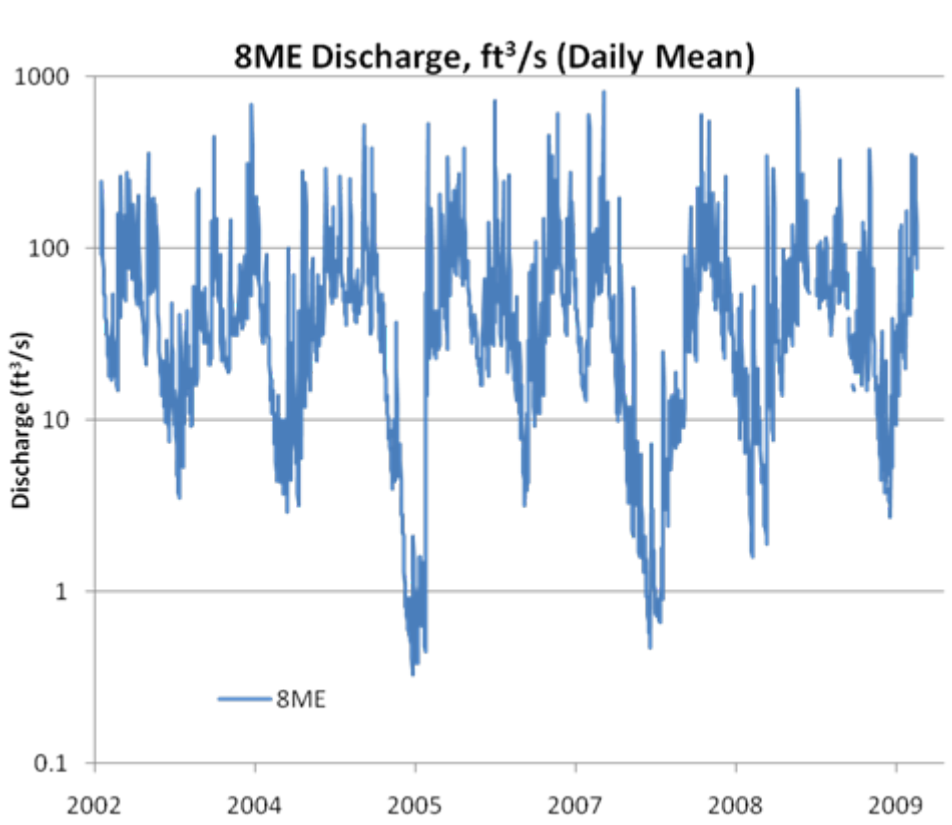


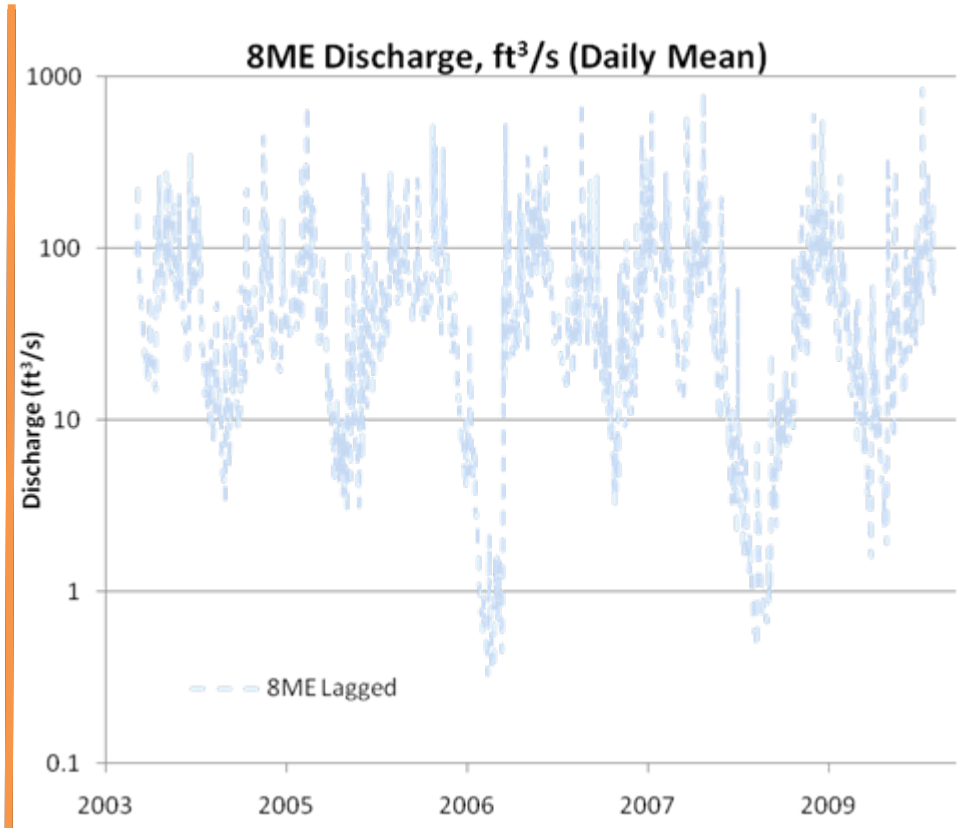


?

- Groundwater influence at CR saving it from more extreme drought conditions
- Local precipitation may vary slightly
- Rural vs. Urban landscape (lower vs. higher runoff into streams, respectively)

Discharge Lagged





Normal

ADD 1 - Year

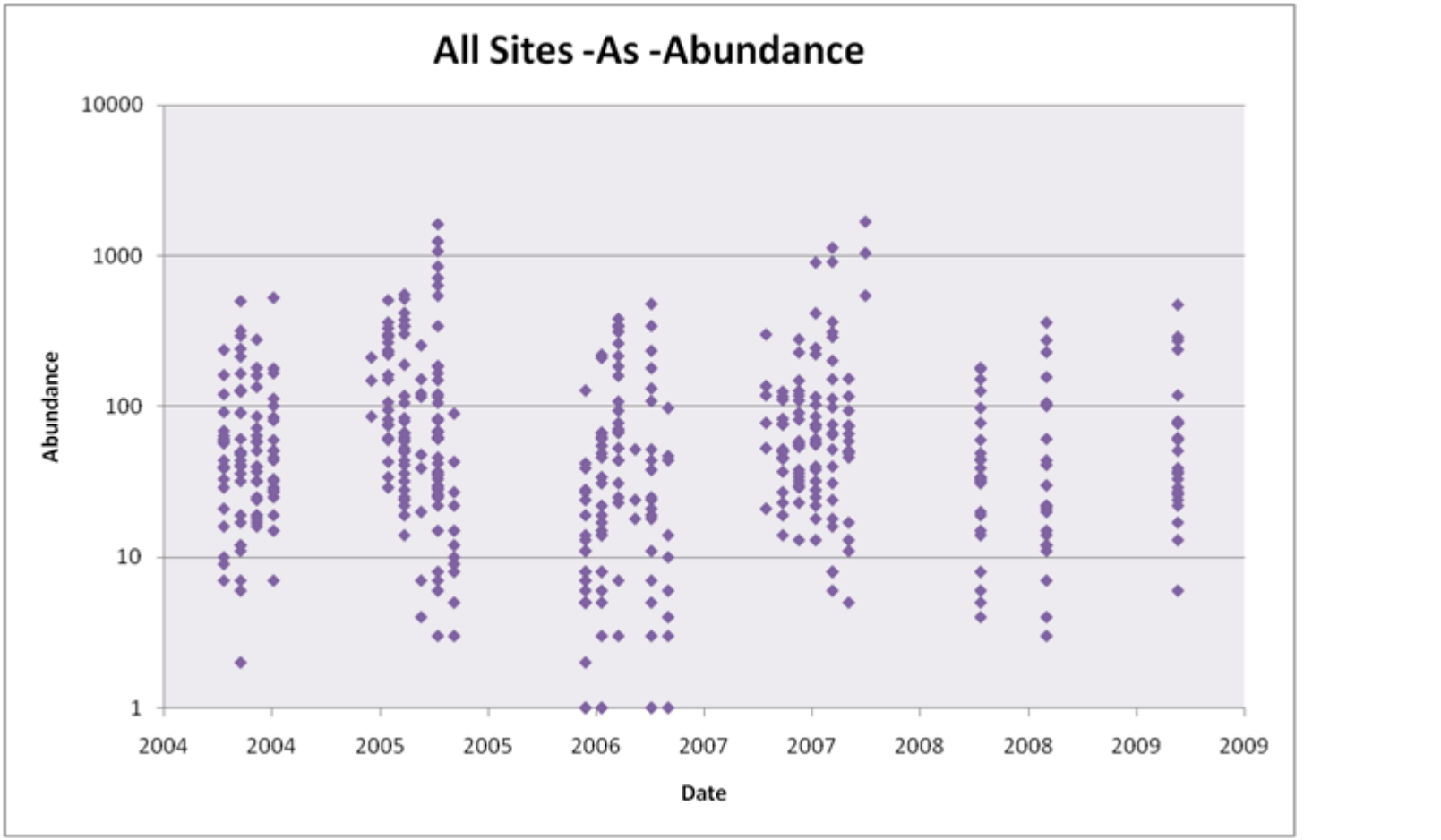
Lagged

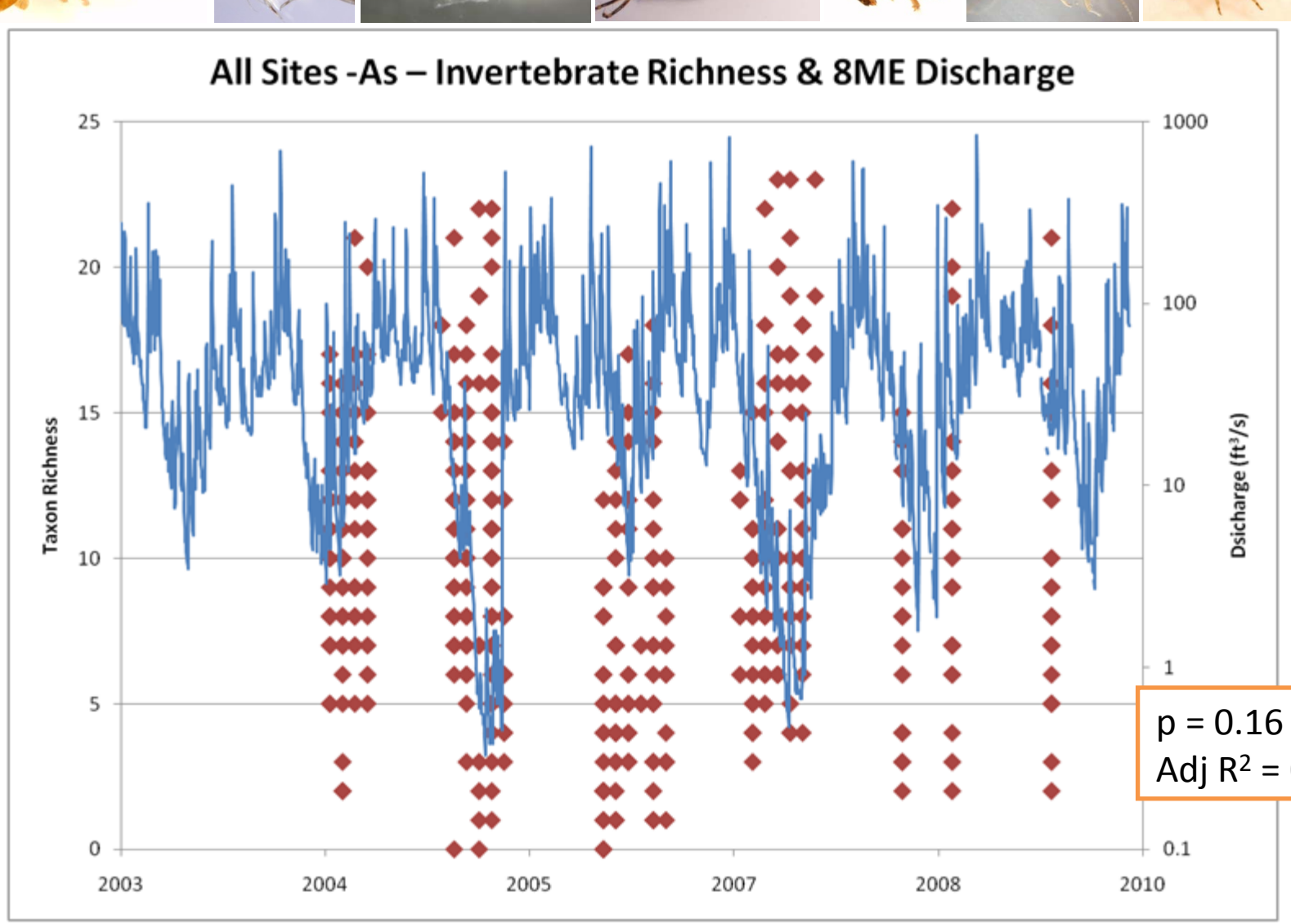
Questions

1. Are macroinvertebrates affected by drought?
   - Immediately or Asynchronously?
   - Their abundance and/or richness?

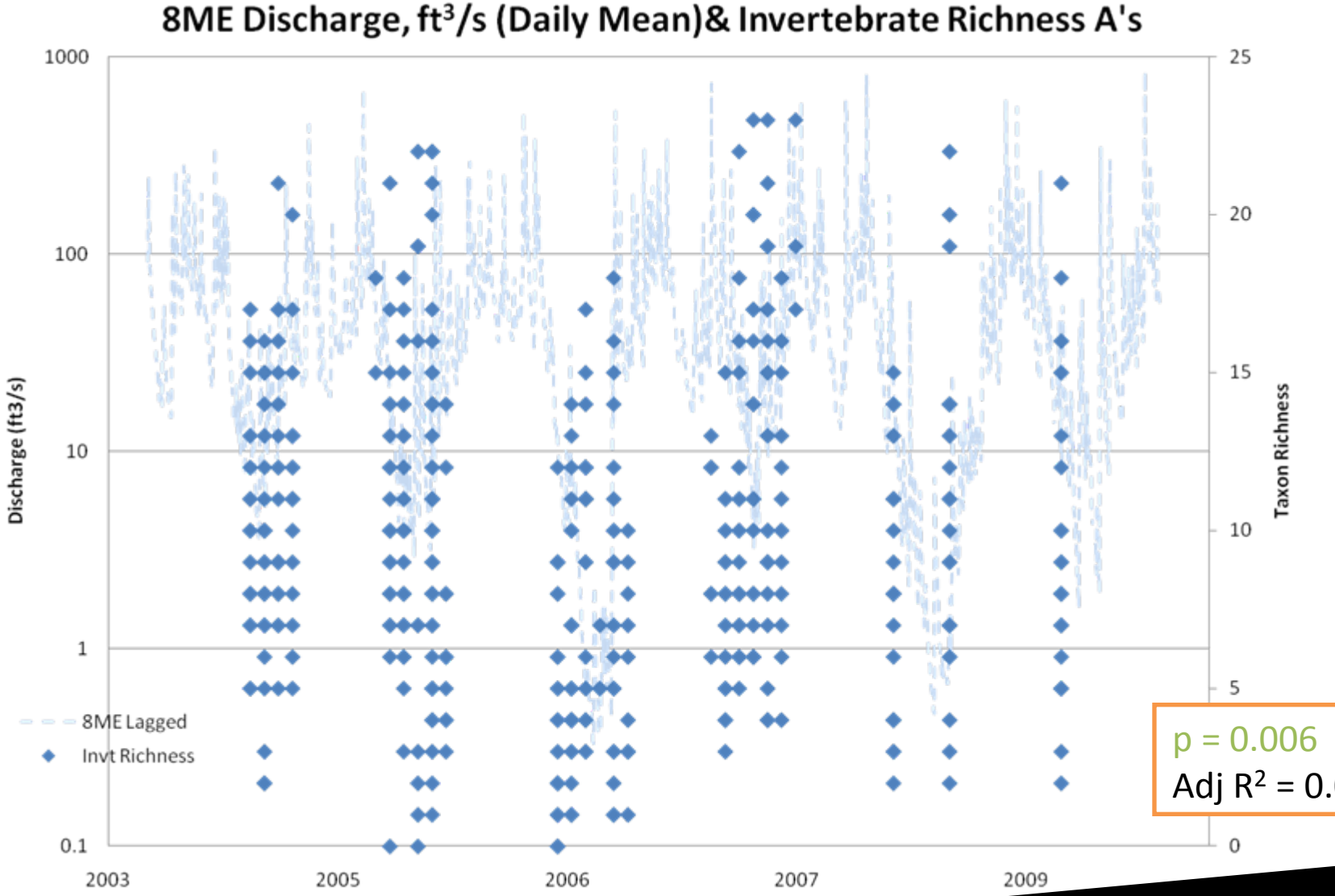
2. Are fishes affected by drought?
   - Immediately or Asynchronously?
   - Their abundance and/or richness?


All Sites -As -Richness
Taxon Richness
25
20
15
10
5
0
2004
2004
2005
2005
2006
2007
2007
2008
2008
2009
2009
Date





p = 0.16
Adj R^2 = 0.002



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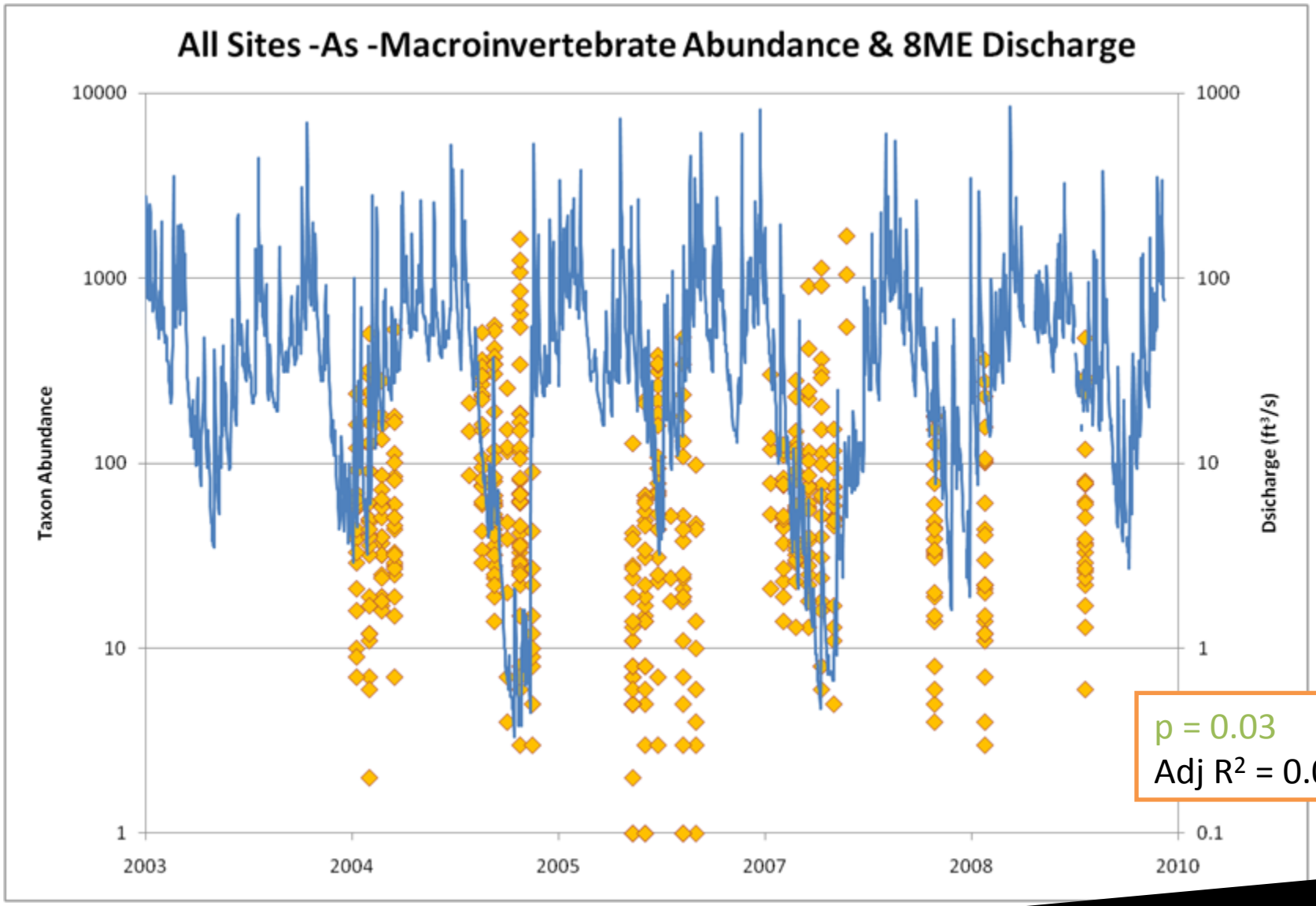
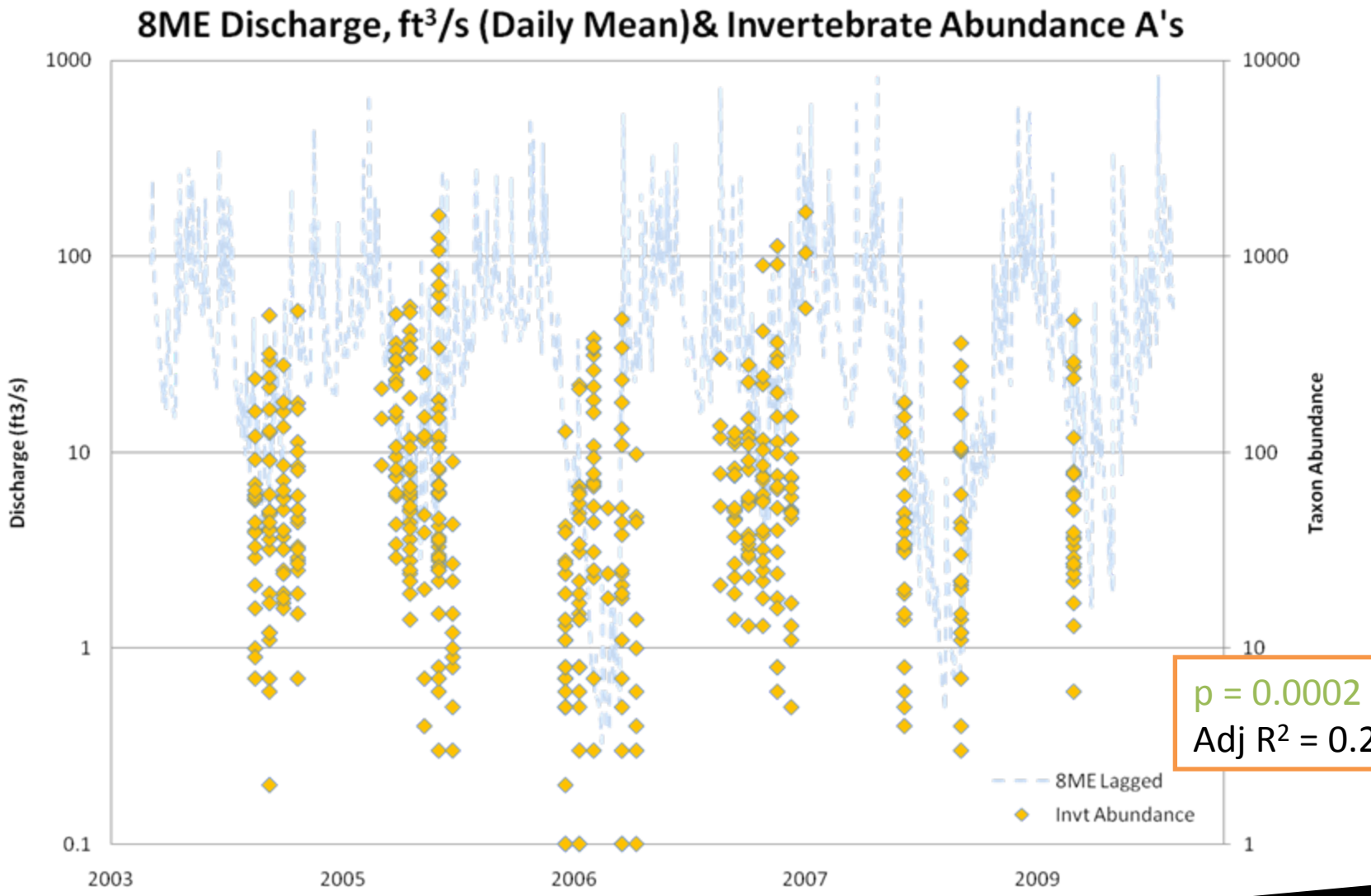

All Sites -As -Macroinvertebrate Abundance & 8ME Discharge
Taxon Abundance
Dsicharge (ft³/s)
10000
1000
100
10
1
1000
100
10
1
0.1
2003
2004
2005
2007
2008
2010
p = 0.03
Adj R² = 0.008



Summary: Drought Effects on Macroinvertebrates

Statistical Results of Linear Regressions

Invertebrate Richness X Discharge LAGGED

Simple Regression

Univariate Tests of Significance for Sum of rich (LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

Effect	SS	Degr. of	MS	F	p
Intercept	3308.14	1	3308.137	142.4089	0.000000
Log Dish Lag Avg	178.17	1	178.167	7.6697	**0.005828**
Error	11429.09	492	23.230		

Invertebrates Richness X Discharge NO LAG

Simple Regresssion

Univariate Tests of Significance for Sum of rich (NO LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	9638.18	1	9638.184	410.2187	0.000000
Log dish Avg	47.60	1	47.598	2.0259	0.155274
Error	11559.66	492	23.495		

Inverts Richness x Lagged
p=0.006

Log Likelihood Ratio Test

G = 2.64 > 1.90

Proves regressions of lagged is a significantly better fit

Lagged Effect on Richness!

Summary: Drought Effects on Macroinvertebrates

Statistical Results of Linear Regressions

Invertebrates Abundance X Discharge LAGGED

Simple Regression

Univariate Tests of Significance for Log Abun (LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	97.5576	1	97.55764	301.2011	0.000000
Log Dish Lag Avg	4.5836	1	4.58355	14.1513	**0.000189**
Error	158.0609	488	0.32390		

Invertebrates Abundance X Discharge NO LAG

Simple Regresssion

Univariate Tests of Significance for Log Abun (NO LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	278.9087	1	278.9087	845.2964	0.000000
Log dish Avg	1.6270	1	1.6270	4.9311	**0.026835**
Error	161.0174	488	0.3300		

Inverts Abundance x Lagged
p=0.0002

Inverts Abundance x NO Lag
p=0.03

Log Likelihood Ratio Test

G = 2.07 > 1.90

Proves regressions of lagged is a significantly better fit

Lagged Effect on Abundance!

Some immediate effect on abundance

Questions

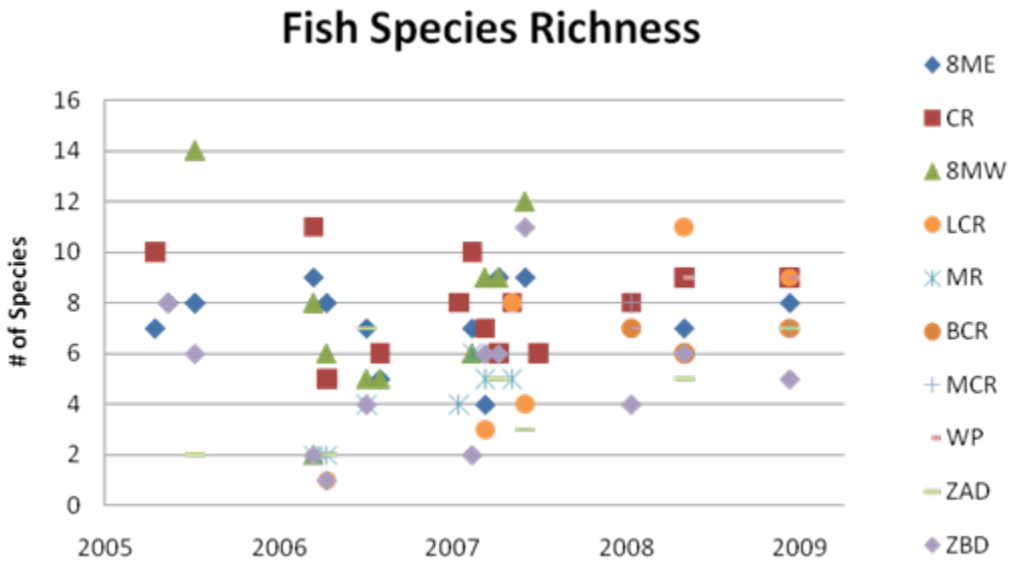
1. Are invertebrates affected by drough

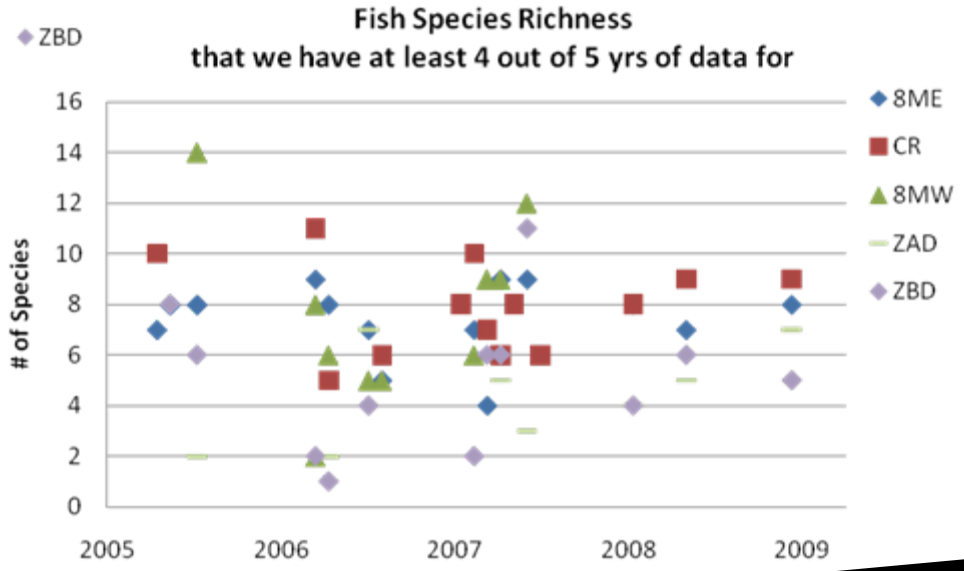
- Immediately or Asynchronously?
- Their abundance and/or richness?

2. Are fish affected by drought?

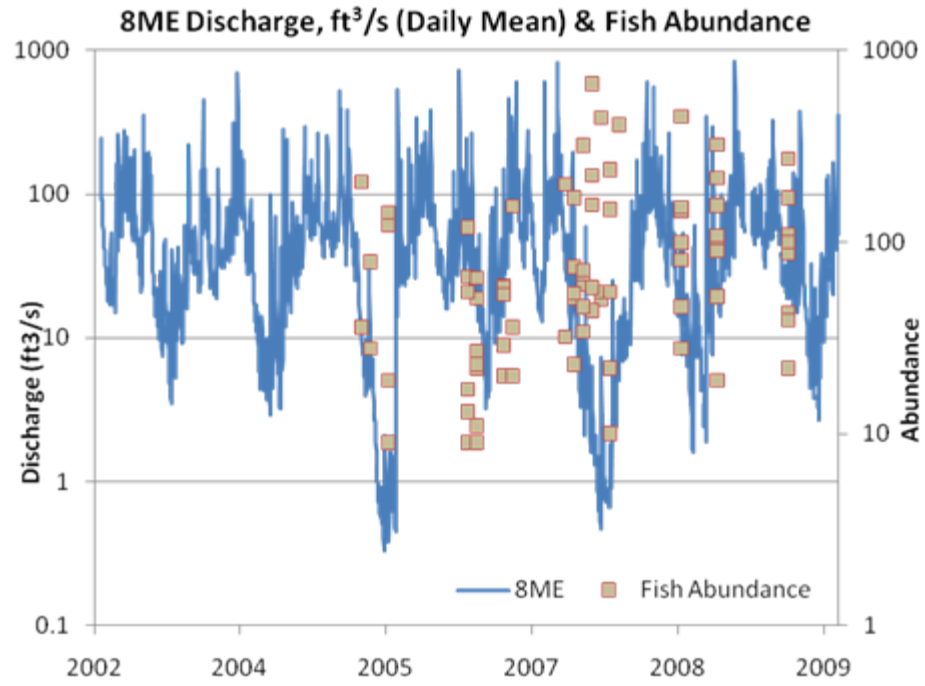
- Immediately or Asynchronously?
- Their abundance and/or richness?

Fish Richness Variation

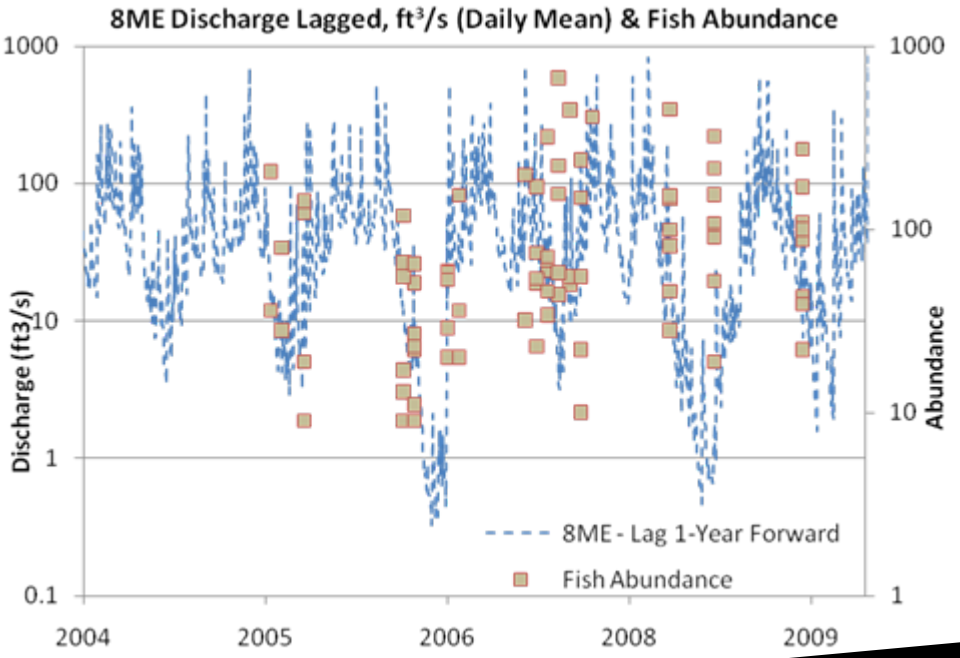




Drought Effect on Fish Abundance is Lagged

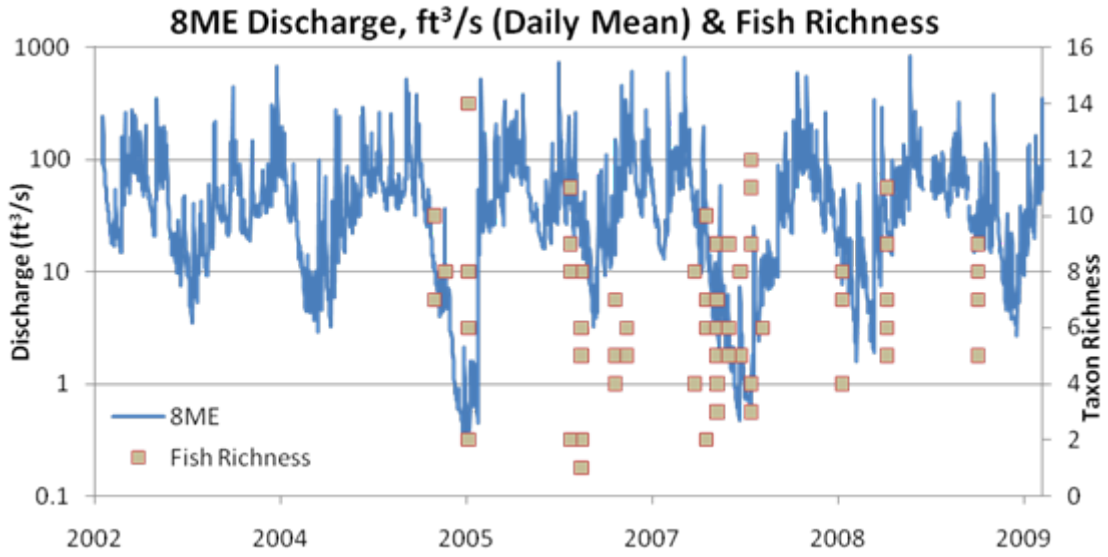


NO Lag
p= 0.48
Adj R^2 = -0.002

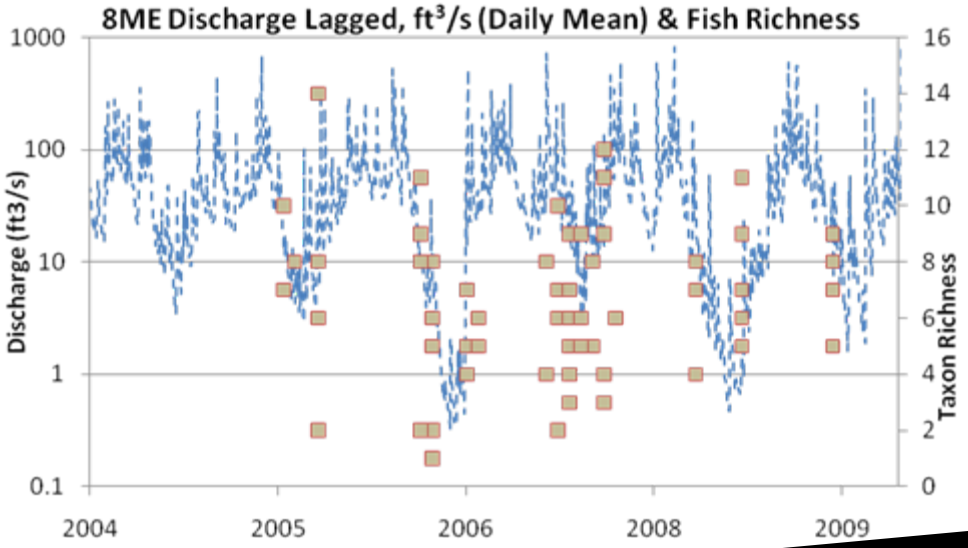


Lagged
p= 0.04
Adj R^2 = 0.012

Drought Effect on Fish Richness is Immediate



NO Lag
p= 0.03
Adj R^2 = 0.014



Lagged
p= 0.24
Adj R^2 = 0.001

Summary: Drought Effects on Fishes

Statistical Results of Linear Regressions

Fish Richness X Discharge LAGGED

Simple Regression

Univariate Tests of Significance for Sum of Frich (LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	1118.324	1	1118.324	160.7977	0.000000
Log Dish Lag Avg	9.383	1	9.383	1.3491	0.246515
Error	1794.352	258	6.955		

Fish Richness X Discharge NO LAG

Simple Regression

Univariate Tests of Significance for Sum of Frich (NO LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	2852.182	1	2852.182	415.2330	0.000000
Log dish Avg	31.566	1	31.566	4.5954	**0.032992**
Error	1772.169	258	6.869		

Fish Richness x NO Lag
p=0.033

Log Likelihood Ratio Test

G = 2.64 > 1.90

Proves regressions of NO Lag is a significantly better fit

Monthly Avg of Discharge x Each Fish Richness

Immediate Effect on Richness!

Summary: Drought Effects on Fishes

Statistical Results of Linear Regressions

Fish Abundance X Discharge LAGGED

Simple Regression

Univariate Tests of Significance for Log Fabun (LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	84.08688	1	84.08688	481.4708	0.000000
Log Dish Lag Avg	0.71945	1	0.71945	4.1195	**0.043419**
Error	45.05863	258	0.17465		

Fish Abundance X Discharge NO LAG

Simple Regression

Univariate Tests of Significance for Log Fabun (NO LAG dishxinvtxfish 2-22-10)

Sigma-restricted parameterization

Effective hypothesis decomposition

	SS	Degr. of	MS	F	p
Intercept	183.4825	1	183.4825	1036.087	0.000000
Log dish Avg	0.0884	1	0.0884	0.499	0.480489
Error	45.6897	258	0.1771		

Fish Abundance x Lagged
p=0.043

Log Likelihood Ratio Test

G = 4.19 > 1.90

Proves regressions of lagged is a significantly better fit

Lagged Effect on Abundance!

Summary of Results

No Rain = Meterological Drought → Hydrological Drought → Biotic Response

Time →

Immediate & Lagged

Biotic Response

Immediate

- Fish Richness
- Macroinvertebrate

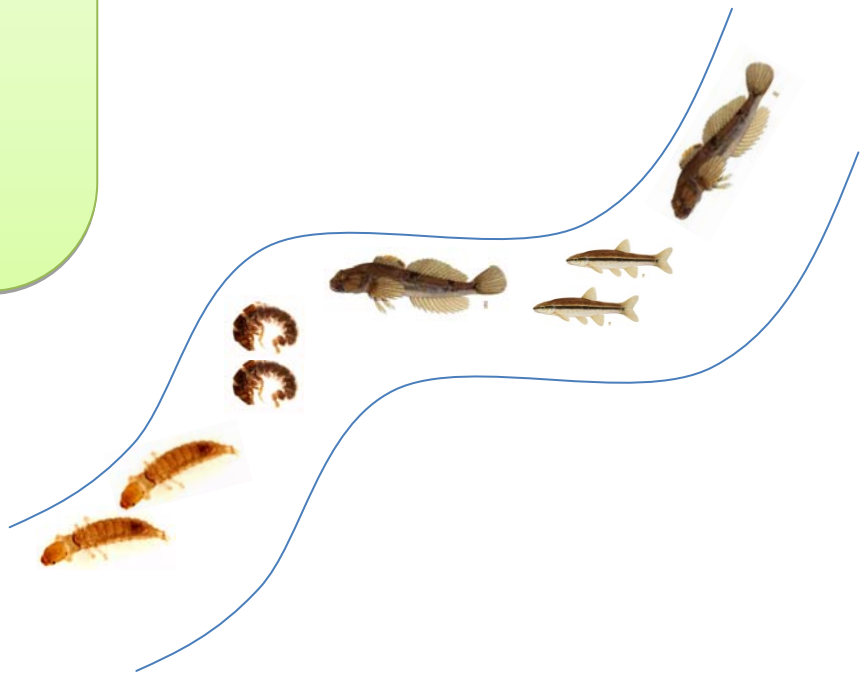
Abundance

Lagged

- Fish Abundance
- Macroinvertebrate Richness

Macroinvertebrate Abundance

Drought

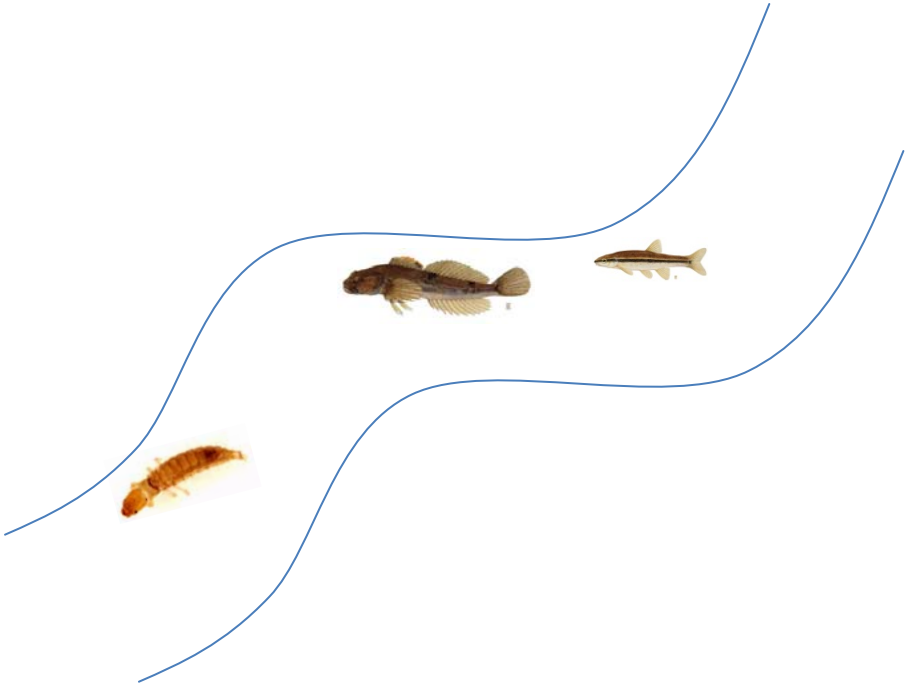


No Rain = Meterological Drought → Hydrological Drought → Biotic Response

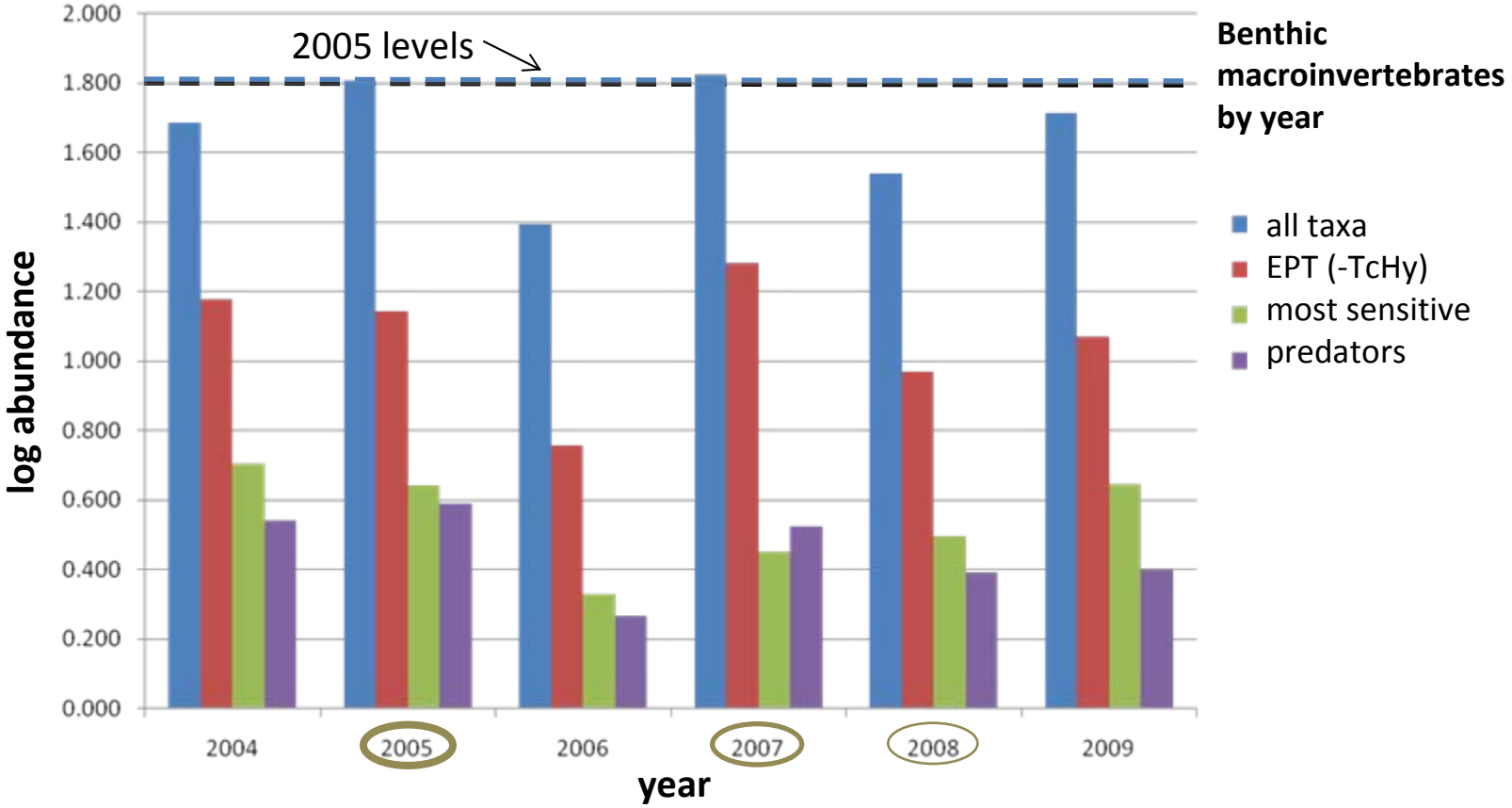
Time →

Immediate & Lagged

Empty Streams?



Components of the benthic macroinvertebrate community respond differently to drought



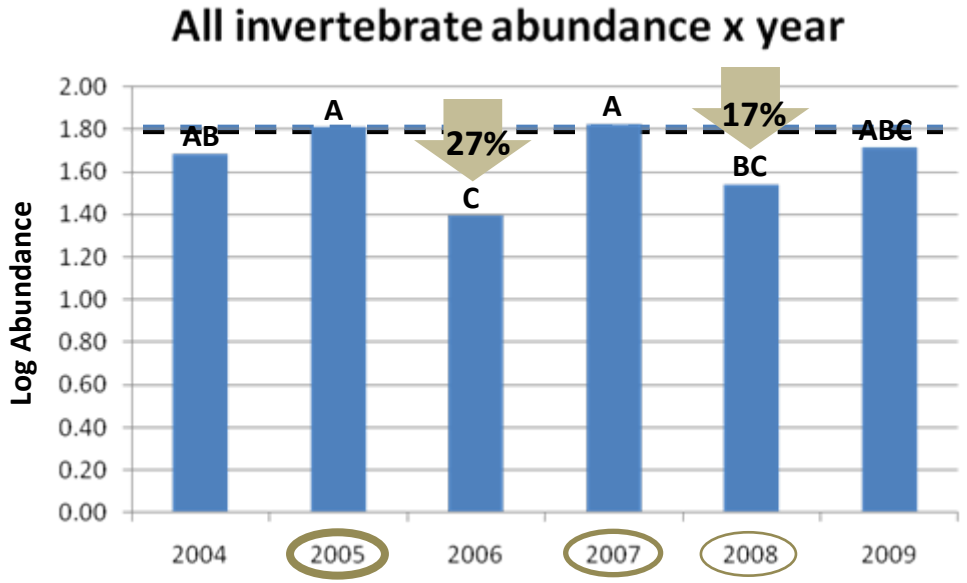
All taxa = 83 families; EPT (-TcHy) = 32 families; MS = all Plecoptera + Trichoptera families Glossosomadidae, Rhyacophilidae, Brachycentridae, Isonychiidae; P = certain Plecoptera, Diptera, and Coleoptera, Acariformes, Megaloptera, Odonata, and Trichoptera Rhyacophilidae.

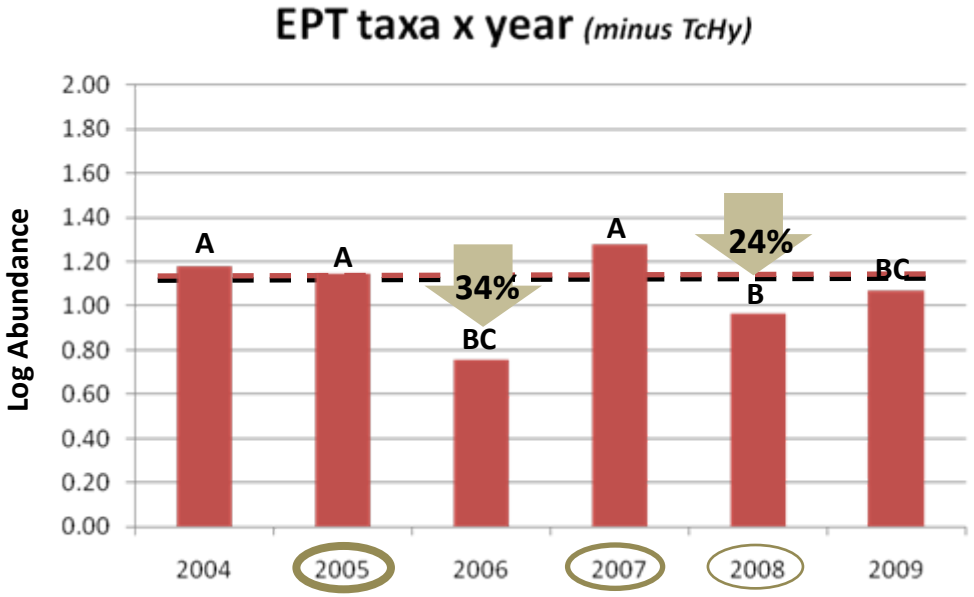
Abundance of all invertebrates declines more after 2005 vs. 2007 (F=1.57, df=100,100; p<.05)

All invertebrate abundance recovers to near 2005 levels in 2007 and in 2009

Response of EPT taxa is similar, though there is no significant difference between declines from 2005 vs. 2007.

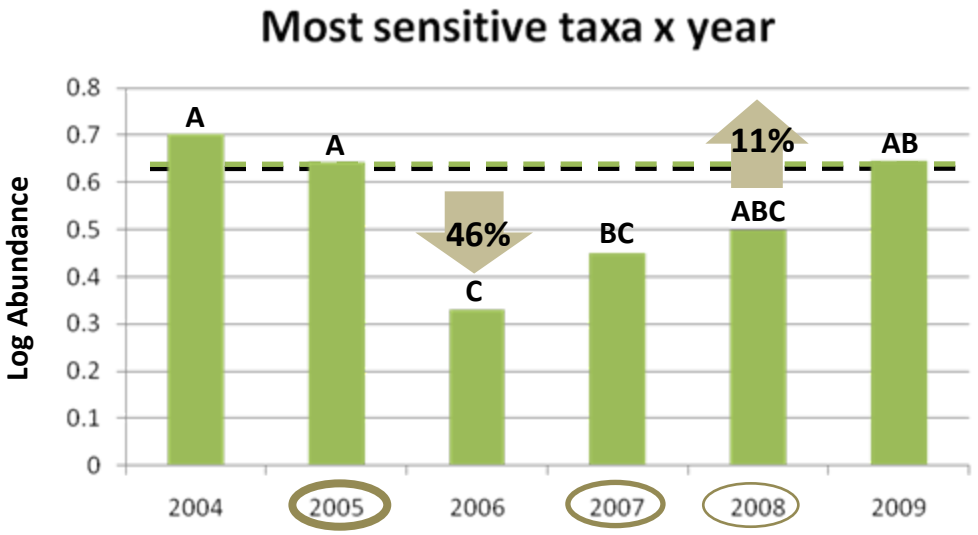
Significant difference between years (ANOVA, p=.0000). Tukey post-hoc test for pairwise comparisons.



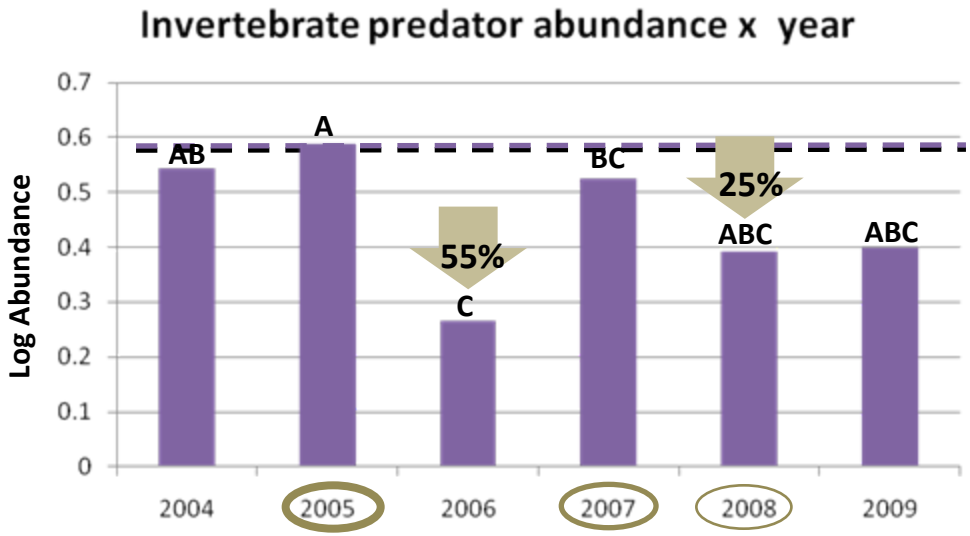


Most sensitive taxa decline more after 2005 than all/EPT- taxa ($p<.05$) and do not decline at all after 2007.

MS abundance does not return to pre-drought levels until 2009

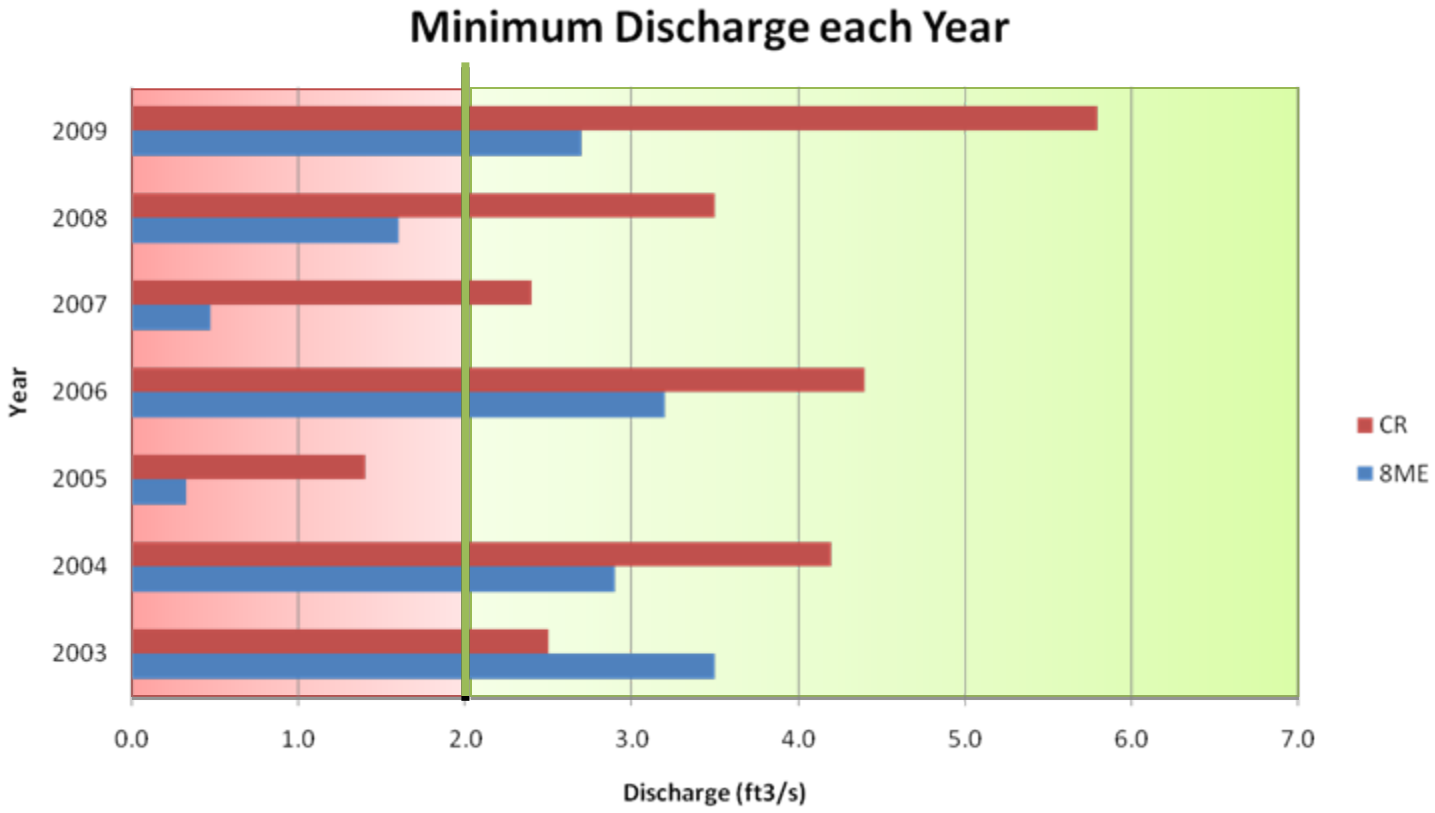


Predator taxa decline more than all/EPT- taxa ($F=1.82$; $df=100,100$; $p<.025$). Predator taxa do not seem to have recovered to 2005 abundance levels.



For both communities, declines in 2005 were greater than those in 2007 ($p<.005$).

When is the Flow too Low?



Looking Forward

- Minimum water flow rules would be helpful to mitigate the negative effects of drought on the biological communities…

  Thanks to the data, we know:

  'Why', 'When' & 'What Happens'

  However…

  Future studies are needed to determine the 'How'
  (and explain the extra variation)

- Climate Change!
  - Will droughts occur more frequently?
  - How will the biological communities adapt?

Acknowledgements

The Chernoff Lab members past and present

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Gabby Jehle
Chris Fragoso
Lucy Sprung
Heather
Kerry Bannon

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Fish and other photos by **Michelle Tipton & Kate Miller**
–Chernoff Lab

Funding
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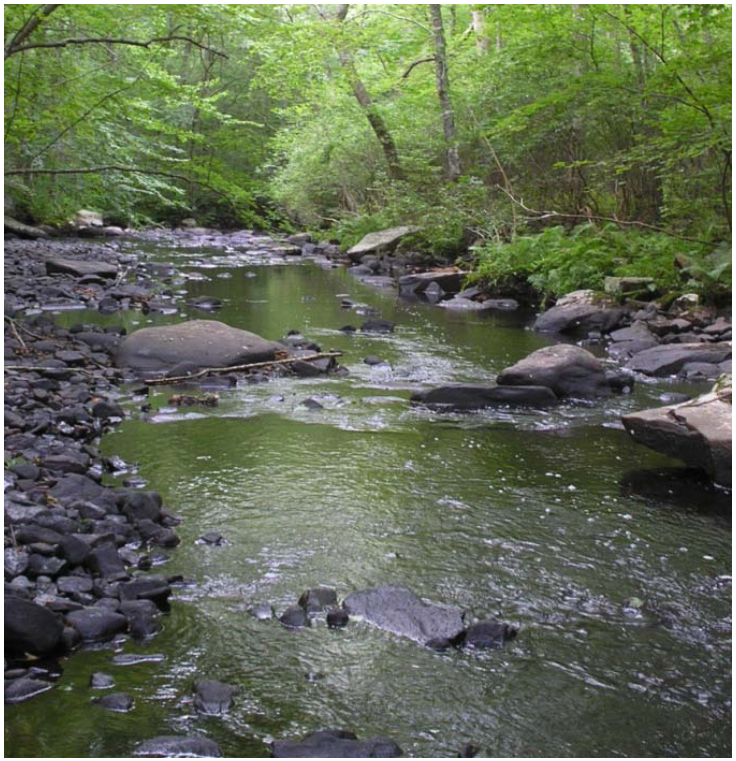
Shuman Foundation
Wesleyan University

Questions

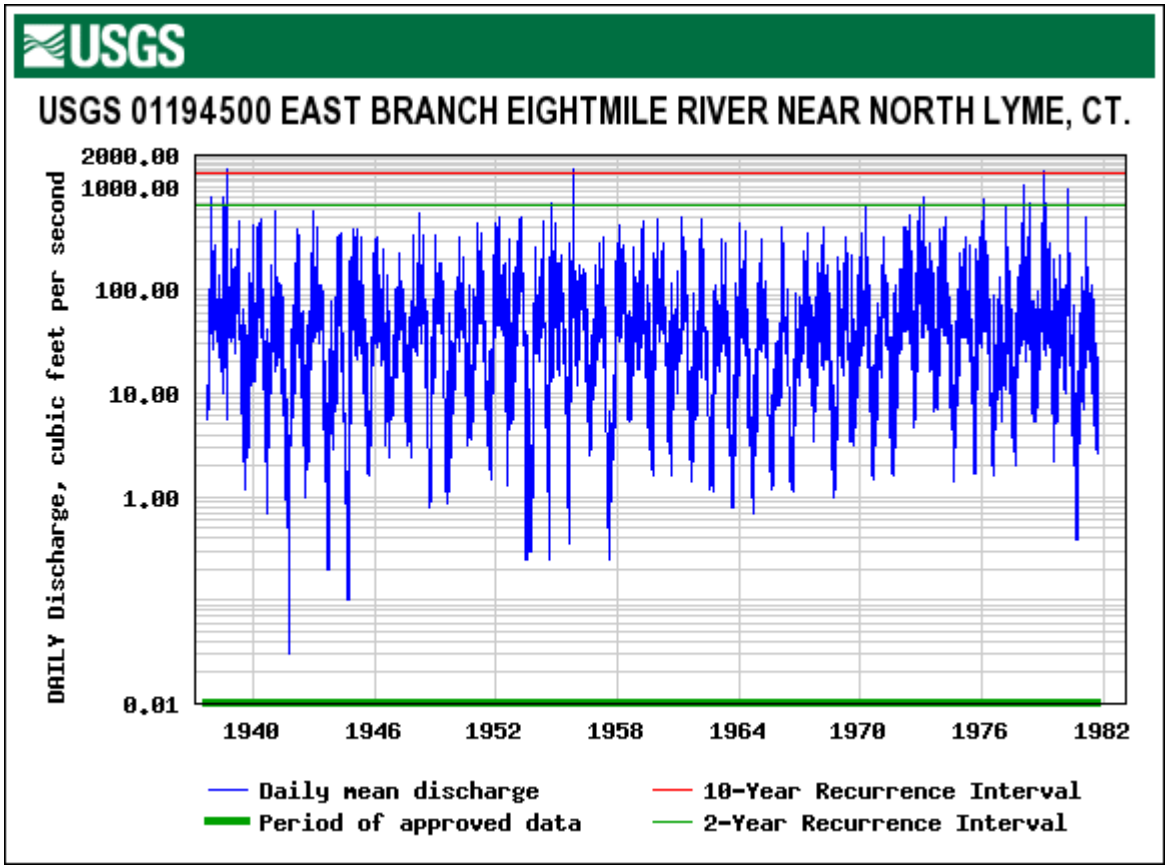


Suggestions

Comments

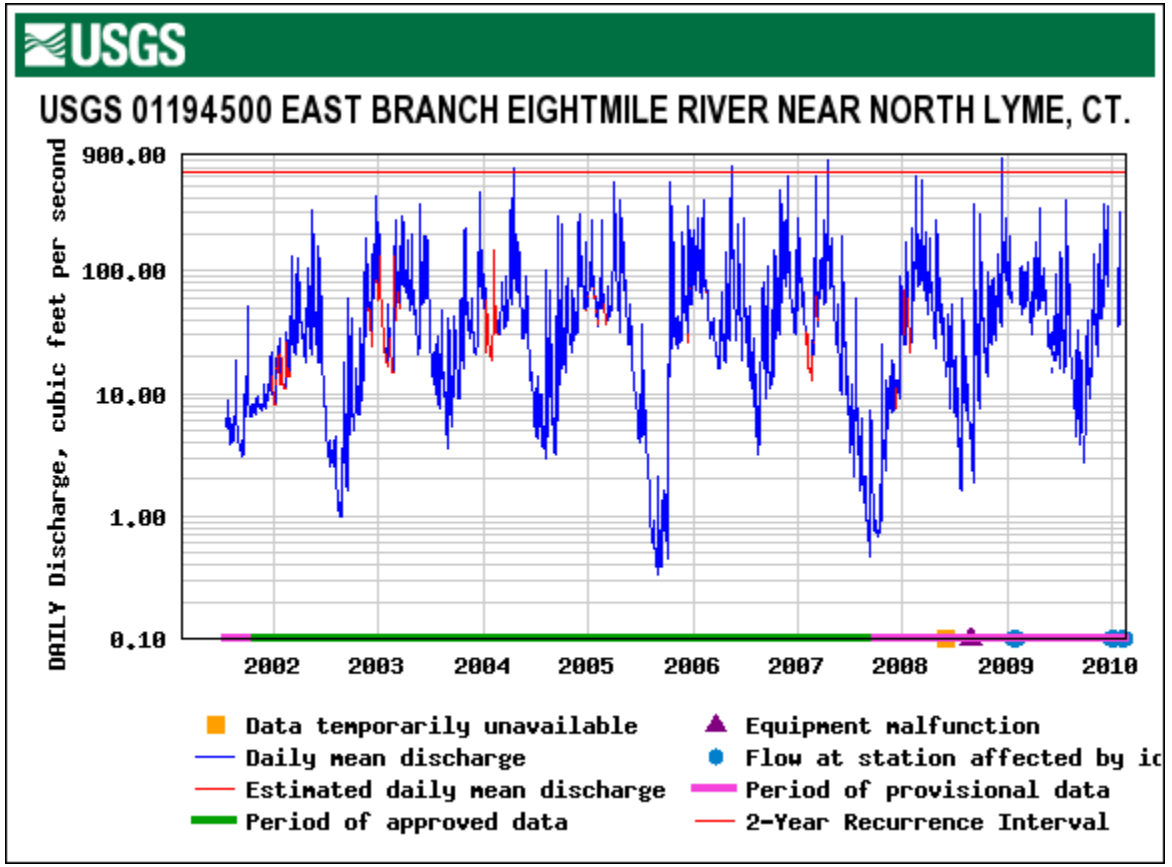
Template

- Hi

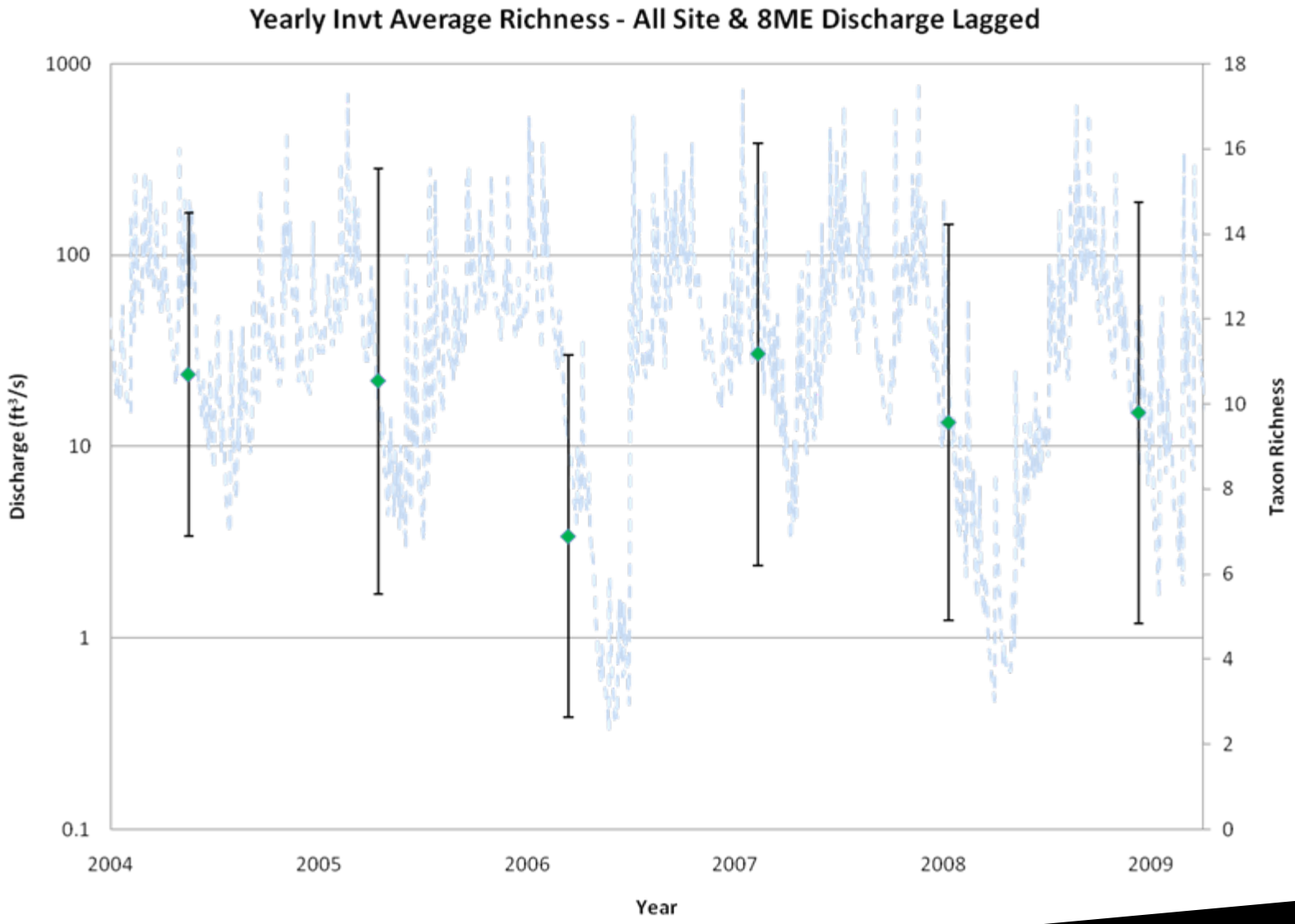

USGS
USGS 01194500 EAST BRANCH EIGHTMILE RIVER NEAR NORTH LYME, CT.
DAILY Discharge, cubic feet per second
2000.00
1000.00
100.00
10.00
1.00
0.01
1940
1946
1952
1958
1964
1970
1976
1982
Daily mean discharge
Period of approved data
10-Year Recurrence Interval
2-Year Recurrence Interval

Template

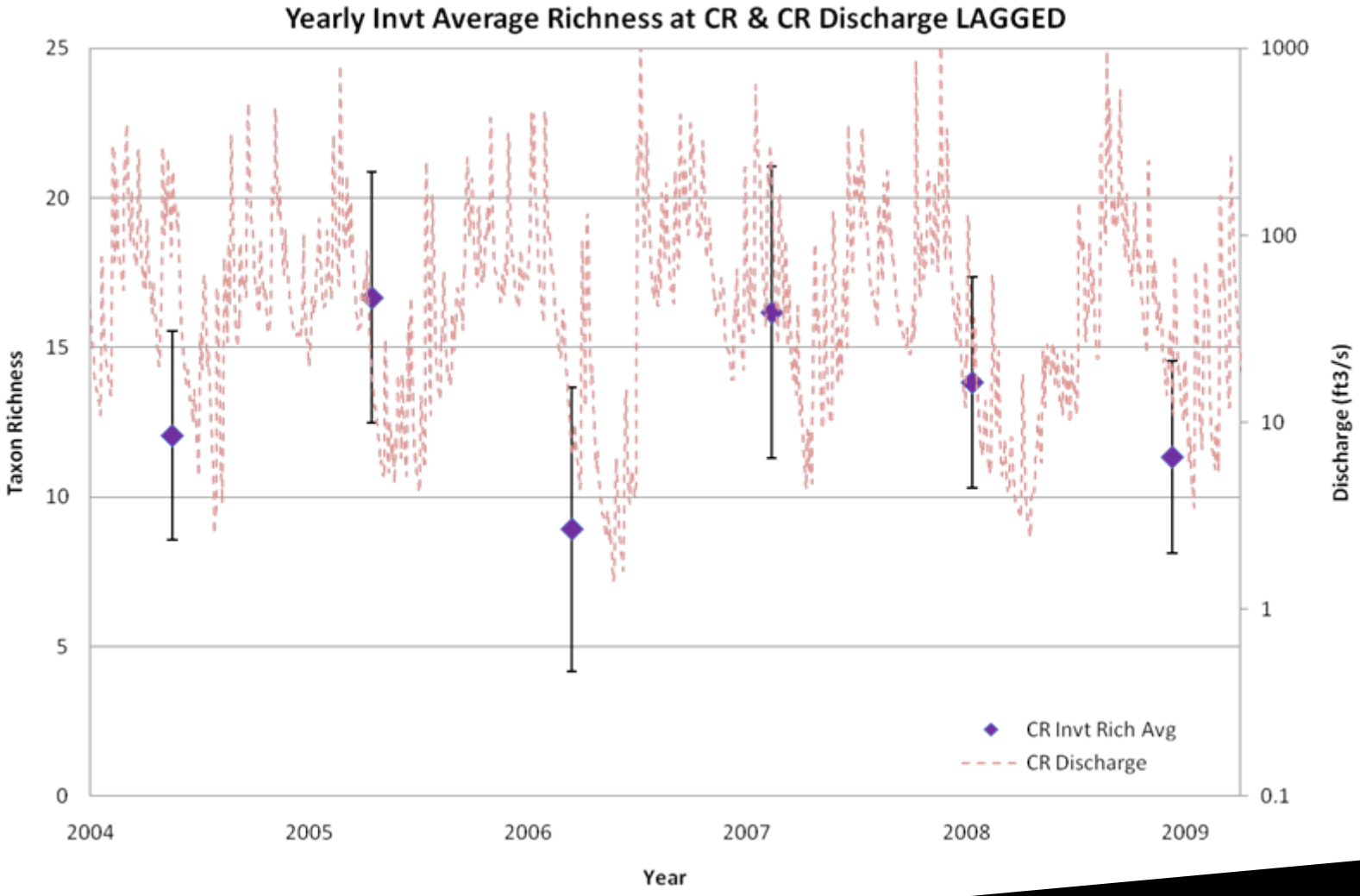
- Hi


USGS
USGS 01194500 EAST BRANCH EIGHTMILE RIVER NEAR NORTH LYME, CT.
DAILY Discharge, cubic feet per second
900.00
100.00
10.00
1.00
0.10
2002
2003
2004
2005
2006
2007
2008
2009
2010
Data temporarily unavailable
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Equipment malfunction
Flow at station affected by ic
Period of provisional data
2-Year Recurrence Interval

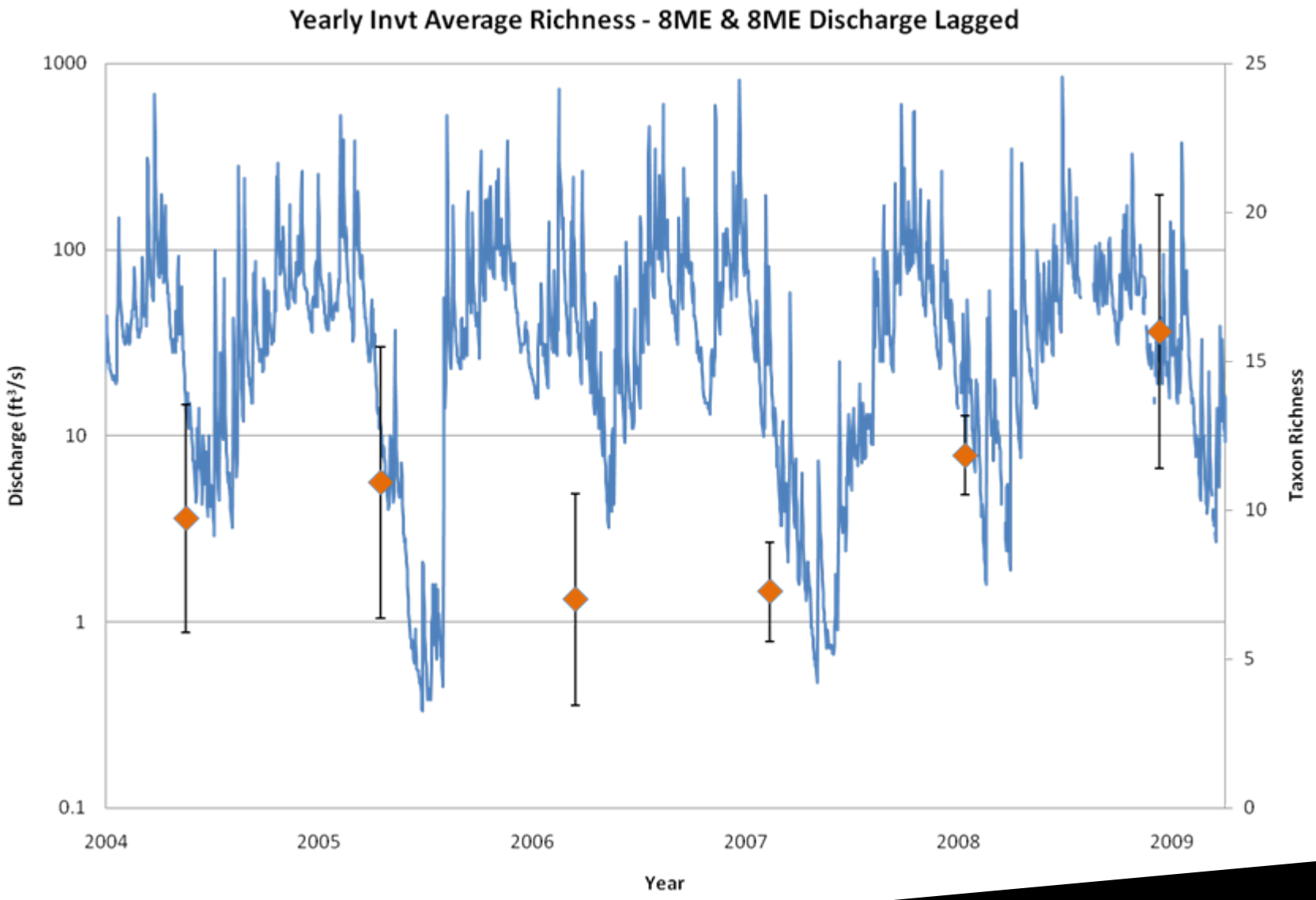
Macroinvertebrates



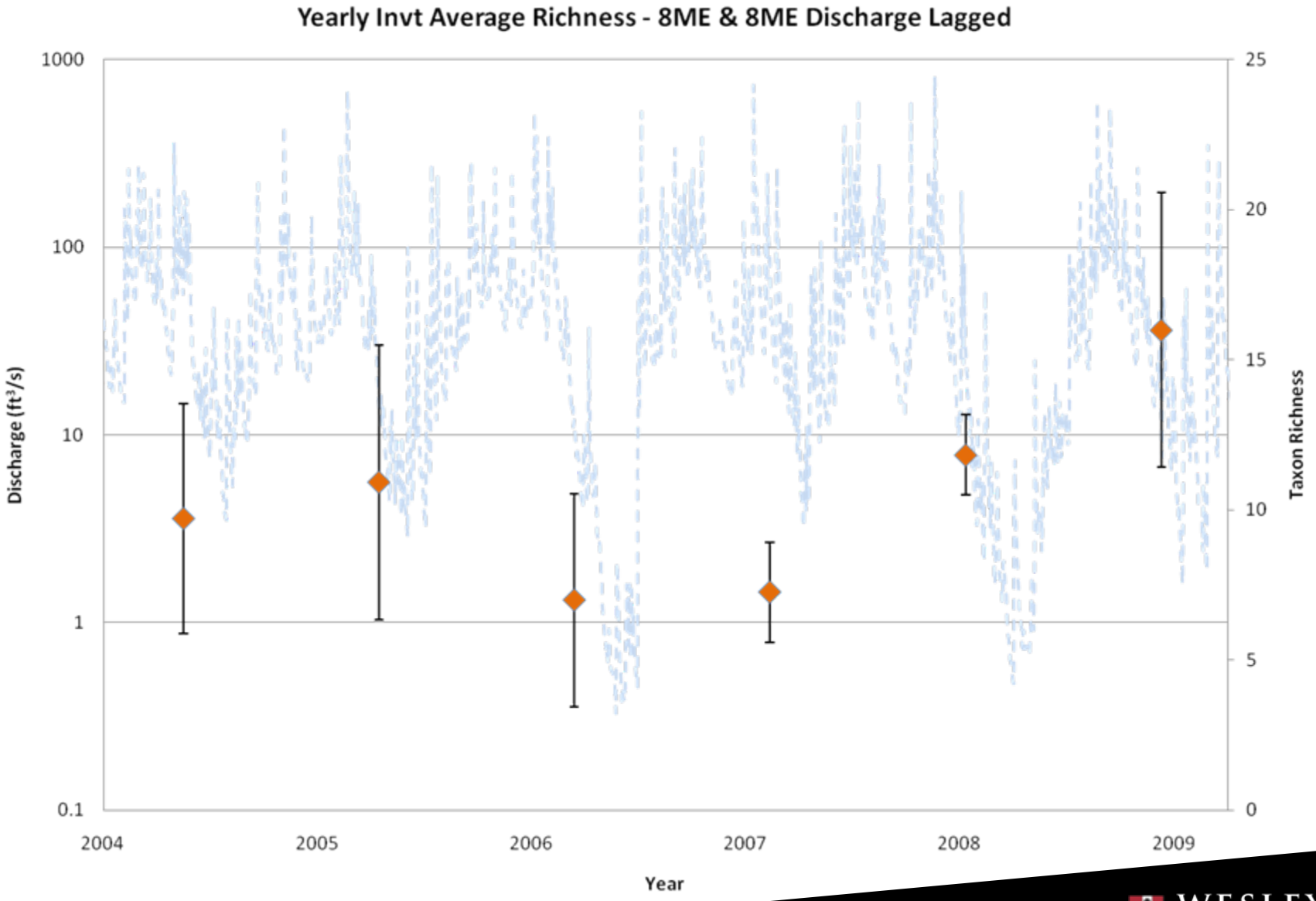
Macroinvertebrates



Macroinvertebrates



Macroinvertebrates



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