Monitoring And Data Management To Inform Conservation In The Delaware River Watershed Initiative

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NCER 2016

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Delaware River Watershed Initiative “Ensuring Sufficient Clean Water Through Healthy Watersheds and Human Communities”

WILLIAM PENN FOUNDATION

NATIONAL FISH AND WILDLIFE FOUNDATION
NFWF

INSTITUTE FOR CONSERVATION LEADERSHIP

OPEN SPACE INSTITUTE

Targeted Funding: Restoration and Preservation

Working Through “Grasstops” Organizations

- Not top down, 50+ organizations
- Many Partners

Continual Evaluation of Program Value and Transferability (lessons learned)

- Use data to inform next steps

Coordinated Actions Throughout The Basin

Targeting land use-water quality relationships

Restoration projects

- Agricultural runoff
- Stormwater
- Aquifer overexploitation & contamination

Land preservation

- Protect against development threats
- Connect adjacent parcels to maximize connectivity
- Parcels with connections to surface and groundwater quality

Monitoring before and after

Let’s work together!!

Targeting: Subwatershed Cluster & Partner Selection Process

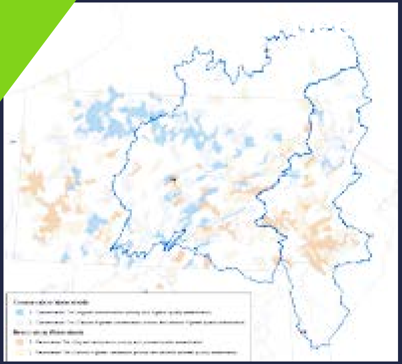
Science screen

– Led by Academy of Natural Sciences

Science-based focus areas

- Physical
- Biological
- Development trends
- Protected lands
- Ground water

Ranking of watersheds by conservation /



Feasibility Screen

– Led by Open Space Institute in consultation with ANS and key experts

- Capacity
- Impact/investment
- Measurability

5 to 12 clusters of watersheds with greatest potential

Develop scale-appropriate indicators linked to specific strategies

2012-2013

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What Are Our [Scientific] Objectives?

Connect to theories: nutrient reduction → stream ecosystem integrity
Inform on effectiveness of single or suite of agricultural BMPs and land preservation

Globalflyfisher.com

Troutnut.com

What Are Our [Scientific] Objectives?

Build up baseline data on current ecosystem conditions

To gauge response, lag time, and changes over time

INDICATORS OF ECOSYSTEM RECOVERY AT DIFFERENT STAGES

Mancini et al., 2005

Meals et al., 2010

Sweeney & Newbold, 2014
Xie et al., 2015, Palmer 2014,
Withers et al., 2014

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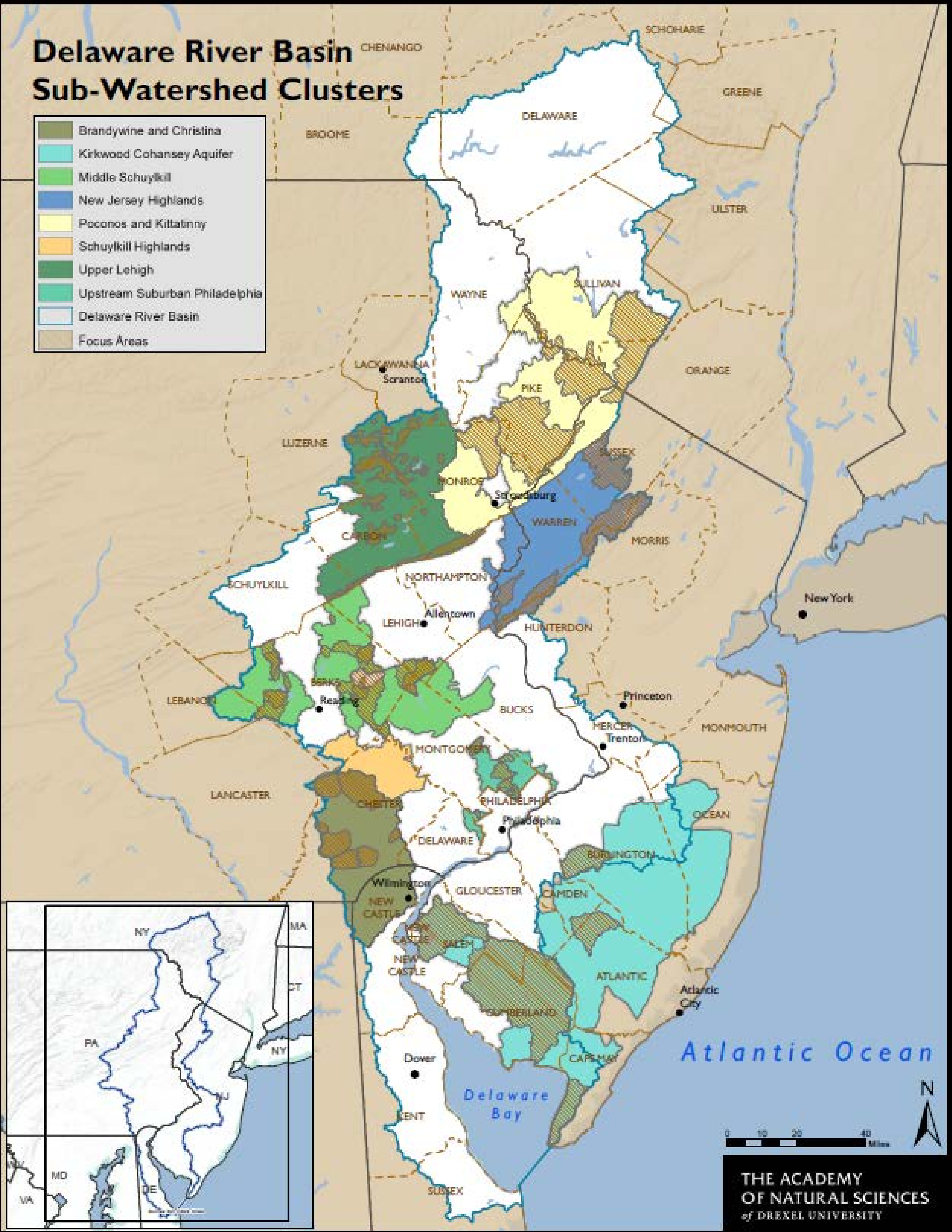
Underlying Questions

How are in-stream ecosystems responding to on-the-ground actions?

Which indicators best respond to current stressors and conditions, as well as changes in water (and ecosystem) quality over time?

How can monitoring results inform the DRWI and similar work in the future?



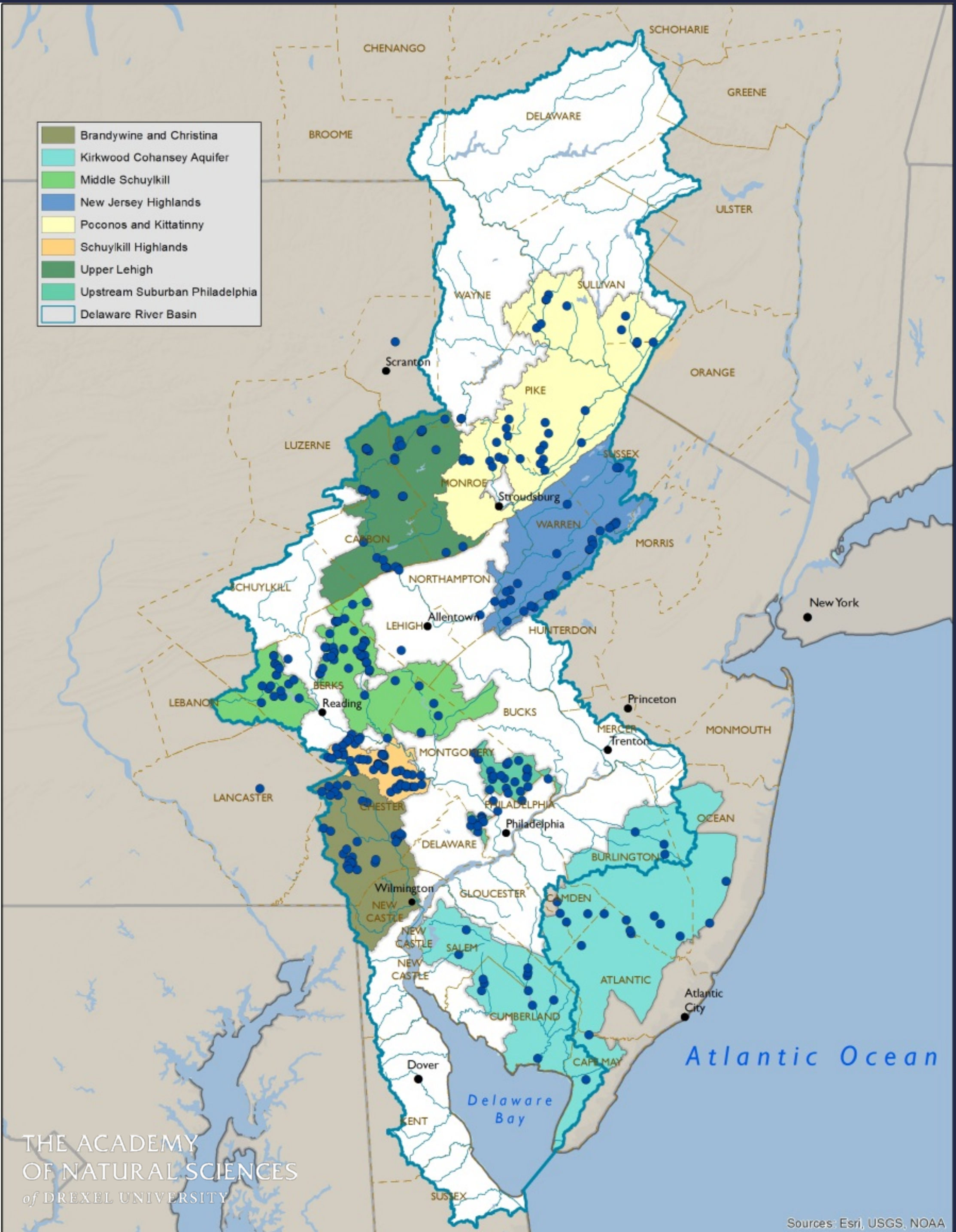
Phase I Focus Areas

Phase I: 2014-2016

Little scientific input on strategic project locations or types

Following work in progress by partners

Emphasis on collaboration



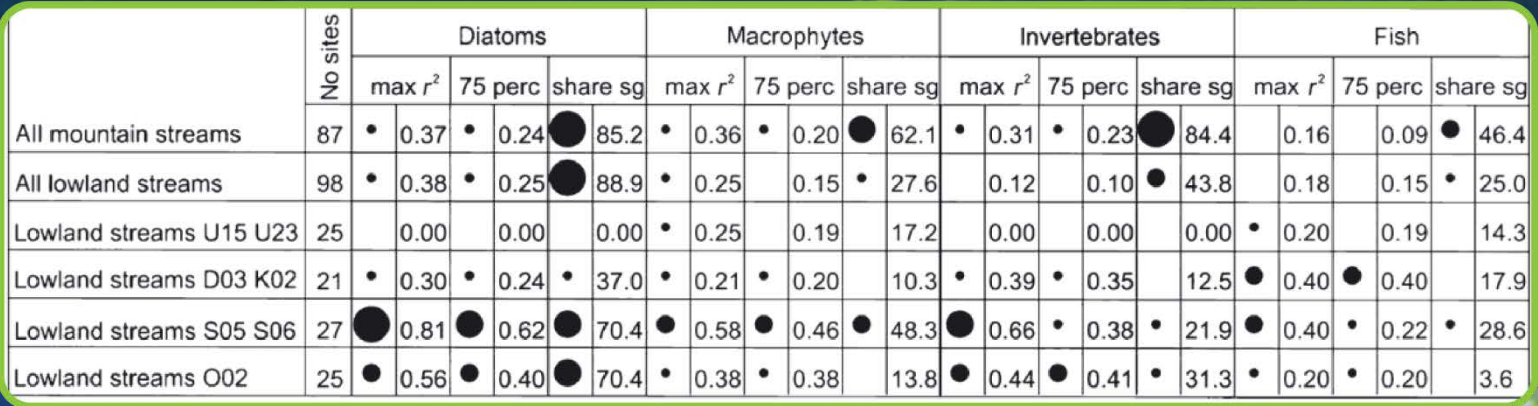
Sources: Esri, USGS, NOAA

Investment in monitoring: Over 200 sampling sites and counting! $4 million+ to date

2013-2015

ANS & partners

Indicators



	No sites	Diatoms			Macrophytes			Invertebrates			Fish		
		max r^2	75 perc	share sg	max r^2	75 perc	share sg	max r^2	75 perc	share sg	max r^2	75 perc	share sg
All mountain streams	87	• 0.37	• 0.24	● 85.2	• 0.36	• 0.20	● 62.1	• 0.31	• 0.23	● 84.4	0.16	0.09	● 46.4
All lowland streams	98	• 0.38	• 0.25	● 88.9	• 0.25	0.15	• 27.6	0.12	0.10	● 43.8	0.18	0.15	• 25.0
Lowland streams U15 U23	25	0.00	0.00	0.00	• 0.25	0.19	17.2	0.00	0.00	0.00	• 0.20	0.19	14.3
Lowland streams D03 K02	21	• 0.30	• 0.24	• 37.0	• 0.21	• 0.20	10.3	• 0.39	• 0.35	12.5	● 0.40	● 0.40	17.9
Lowland streams S05 S06	27	● 0.81	● 0.62	● 70.4	● 0.58	● 0.46	● 48.3	● 0.66	• 0.38	• 21.9	● 0.40	• 0.22	• 28.6
Lowland streams O02	25	● 0.56	● 0.40	● 70.4	• 0.38	• 0.38	13.8	● 0.44	● 0.41	• 31.3	• 0.20	• 0.20	3.6

Hering et al. (2004)
Flinders, Horwitz, Belton (2008)

Use of multiple indicators can increase clarity regarding stressor impacts, but can also yield confusing correlation patterns

Three Tiered Sampling Approach

Tier	Chemistry	Chemistry Lab	Macroinvertebrate Sampling, ID level	Fish Sampling	Habitat Assessment	Algae
I	ANS or other designated lab, YSI sonde	Low detection levels	Surber sampler Genus/ species	Quantitative, multiple pass depletion sampling	EPA WSA, Habitat Index, Riparian Index	Multi-habitat (SWAMP Protocol)
2	Hach kit or other kits, non-designated lab	Higher detection levels	Kick net Family / [illegible]	Single-pass, [illegible] presence/ [illegible]	Habitat Index	None
3	Hach kit or other chemistry kit	No laboratory analysis	Kick nets Family, order	None	Habitat Index, None	None

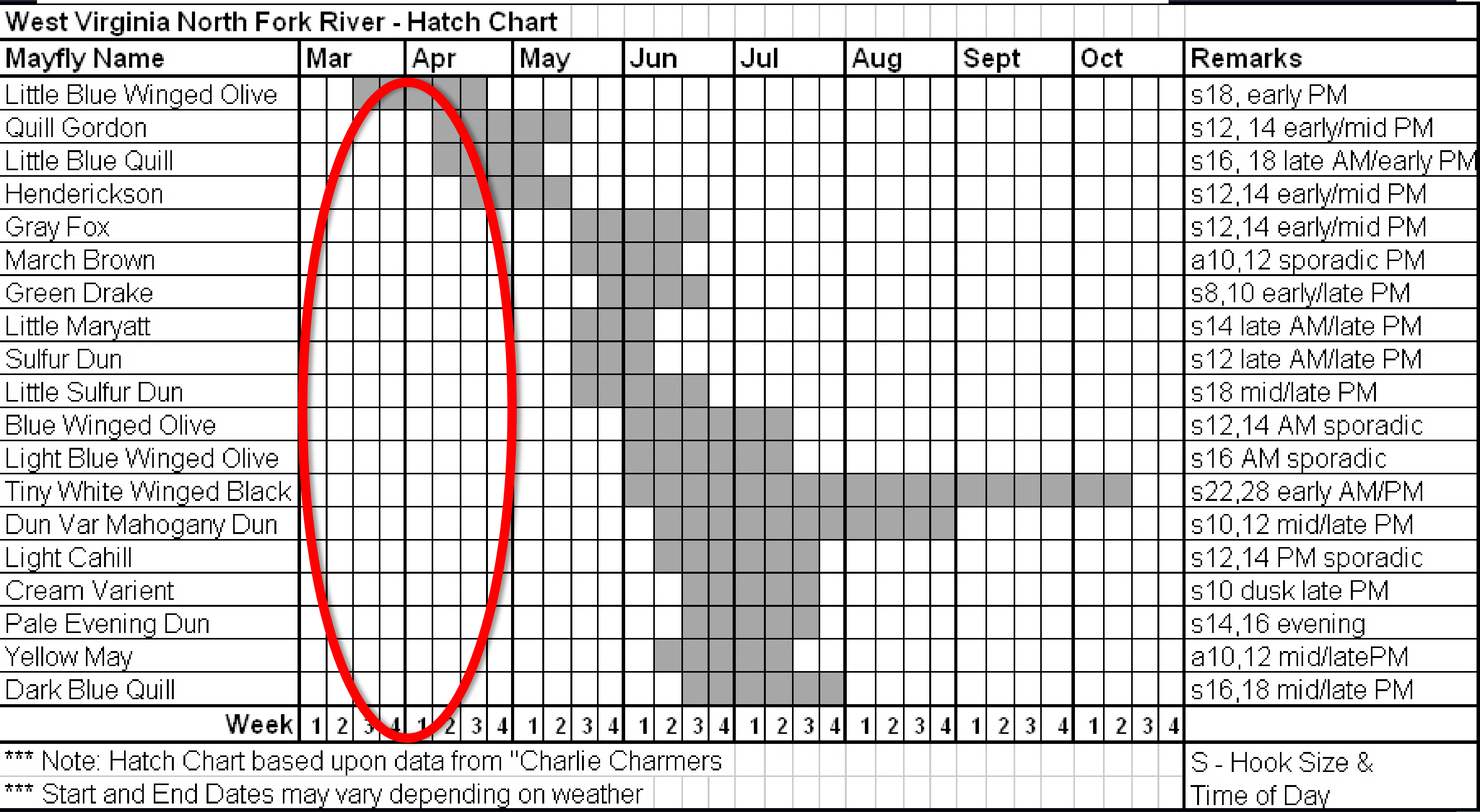
Outreach and Data Quality

TRAINED VOLUNTEERS, QA/QC

Numerous, Enthusiastic

ANY VOLUNTEERS, NO QA/QC

Macroinvertebrates: Spring



West Virginia North Fork River - Hatch Chart

Mayfly Name	Mar				Apr				May				Jun				Jul				Aug				Sept				Oct				Remarks
Little Blue Winged Olive			■	■	■	■	■																										s18, early PM
Quill Gordon						■	■	■	■	■																							s12, 14 early/mid PM
Little Blue Quill						■	■	■	■																								s16, 18 late AM/early PM
Henderickson							■	■	■	■																							s12,14 early/mid PM
Gray Fox											■	■	■	■	■																		s12,14 early/mid PM
March Brown											■	■	■	■																			a10,12 sporadic PM
Green Drake												■	■	■	■																		s8,10 early/late PM
Little Maryatt											■	■	■																				s14 late AM/late PM
Sulfur Dun											■	■	■																				s12 late AM/late PM
Little Sulfur Dun											■	■	■	■	■																		s18 mid/late PM
Blue Winged Olive													■	■	■	■	■	■															s12,14 AM sporadic
Light Blue Winged Olive													■	■	■	■	■	■															s16 AM sporadic
Tiny White Winged Black													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			s22,28 early AM/PM
Dun Var Mahogany Dun														■	■	■	■	■	■	■	■	■	■	■									s10,12 mid/late PM
Light Cahill														■	■	■	■	■	■														s12,14 PM sporadic
Cream Varient															■	■	■	■	■														s10 dusk late PM
Pale Evening Dun															■	■	■	■	■														s14,16 evening
Yellow May														■	■	■	■	■															a10,12 mid/latePM
Dark Blue Quill															■	■	■	■	■	■													s16,18 mid/late PM
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	

*** Note: Hatch Chart based upon data from "Charlie Charmers

*** Start and End Dates may vary depending on weather

S - Hook Size & Time of Day

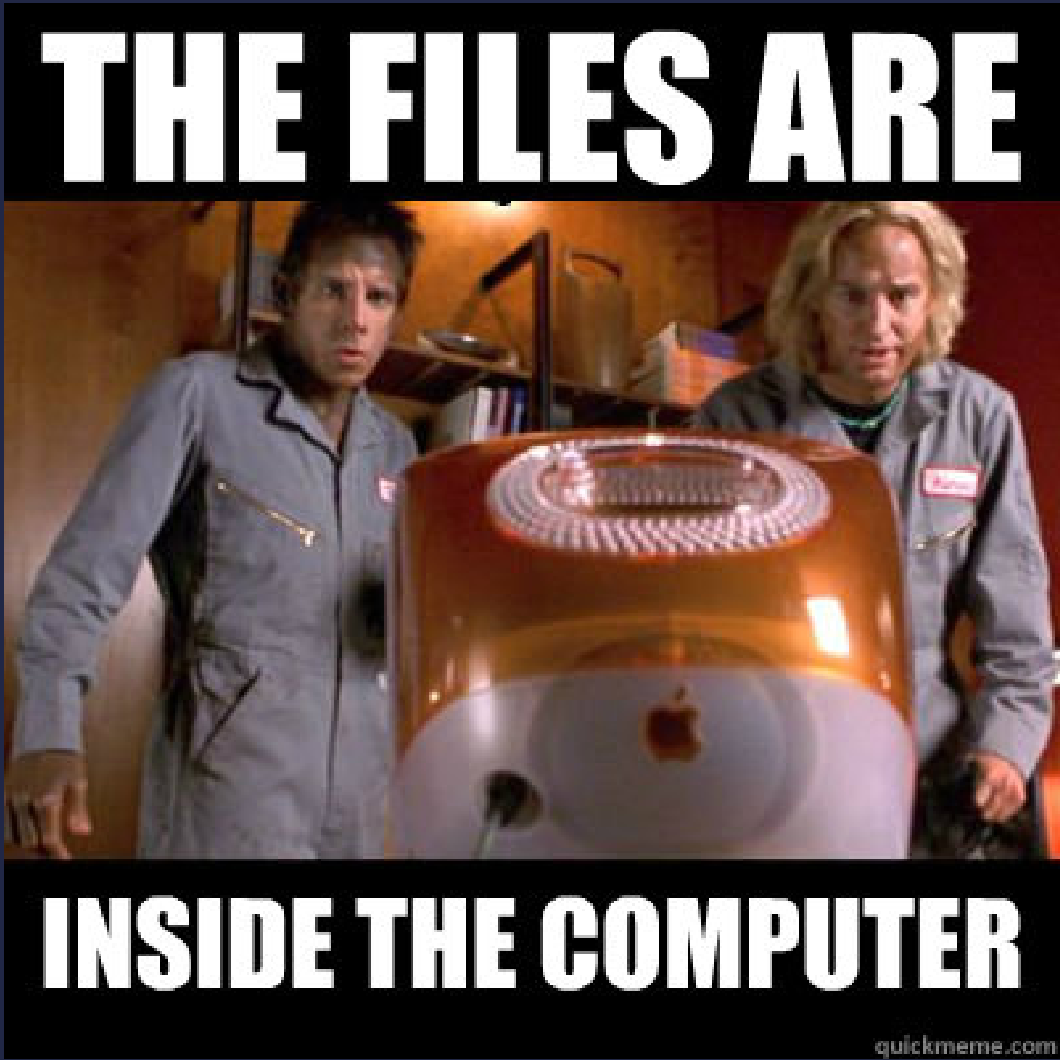
Fish & algae: Summer

Getting Monitoring Data Back to Partners: Integrated Spatial Database

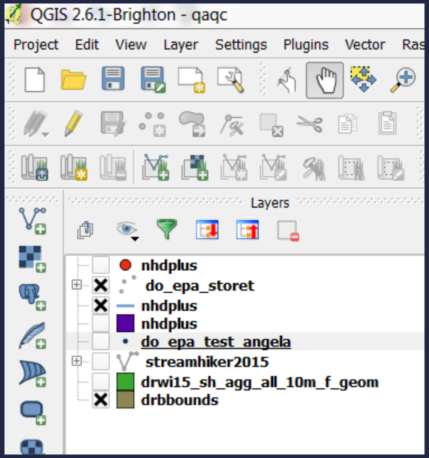
Bring data from DRWI and other sources into one platform

Provide assessment output that stakeholders can understand and use

Encourage sharing to reduce duplication of effort



Open Source Software, Uses for All Skill Levels



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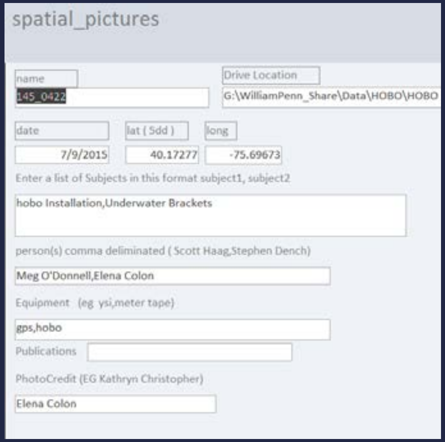
- do_epa_test_angela
- streamhiker2015
- drwi15_sh_agg_all_10m_f_geom
- ☒ drbbounds



spatial_pictures

name: 145_0422

Drive Location: G:\WilliamPenn_Share\Data\HOBO\HOBO

date: 7/9/2015

lat (Sdd): 40.17277

long: -75.69673

Enter a list of Subjects in this format subject1, subject2: hobo Installation,Underwater Brackets

person(s) comma deliminated (Scott Haag,Stephen Dench): Meg O'Donnell,Elena Colon

Equipment (eg ysi,meter tape): gps,hobo

Publications:

PhotoCredit (EG Kathryn Christopher): Elena Colon

django

The web framework for perfectionists with deadlines.

Phase II: More Science

- Project Planning for the Potential Impact of BMPs: Stream Reach Assessment Tool
- Tools and datasets developed by collaborators
- Watershed ecologists weigh in on proposed projects for funding decisions

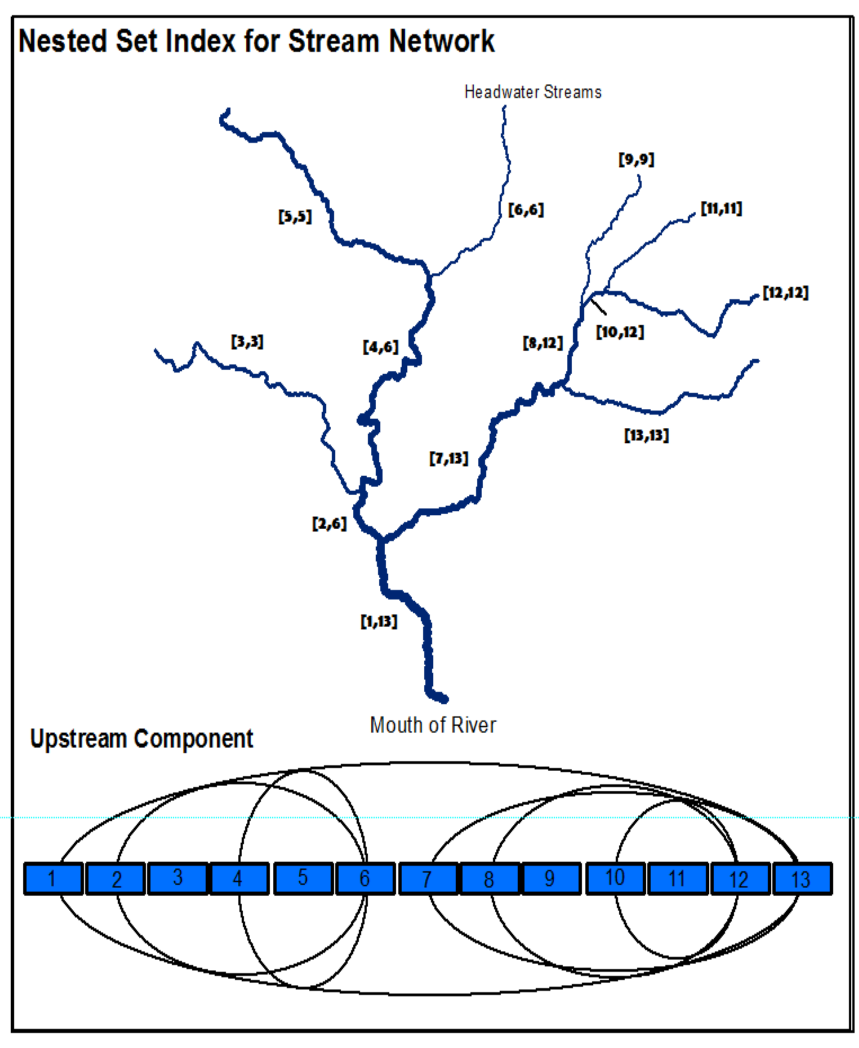
TARGETING

Related Tools and Outputs of the DRWI

- **Faster river routing code to analyze data throughout network -ANS**
- **“Phase II” Stream Reach Assessment Tool-ANS & Barry Evans (Penn State)**
- **SLEUTH Land Use Change Model-Shippensburg U & USGS**
- **High resolution LiDAR imagery of 7 land use/land cover categories -UVM**
- **Connections/ impediments to water quality-related policies – DVRPC**
- **Alternative Funding Strategies – Univ. MD ERC**
- **SWAT Model for the whole Delaware River Watershed - CNA**

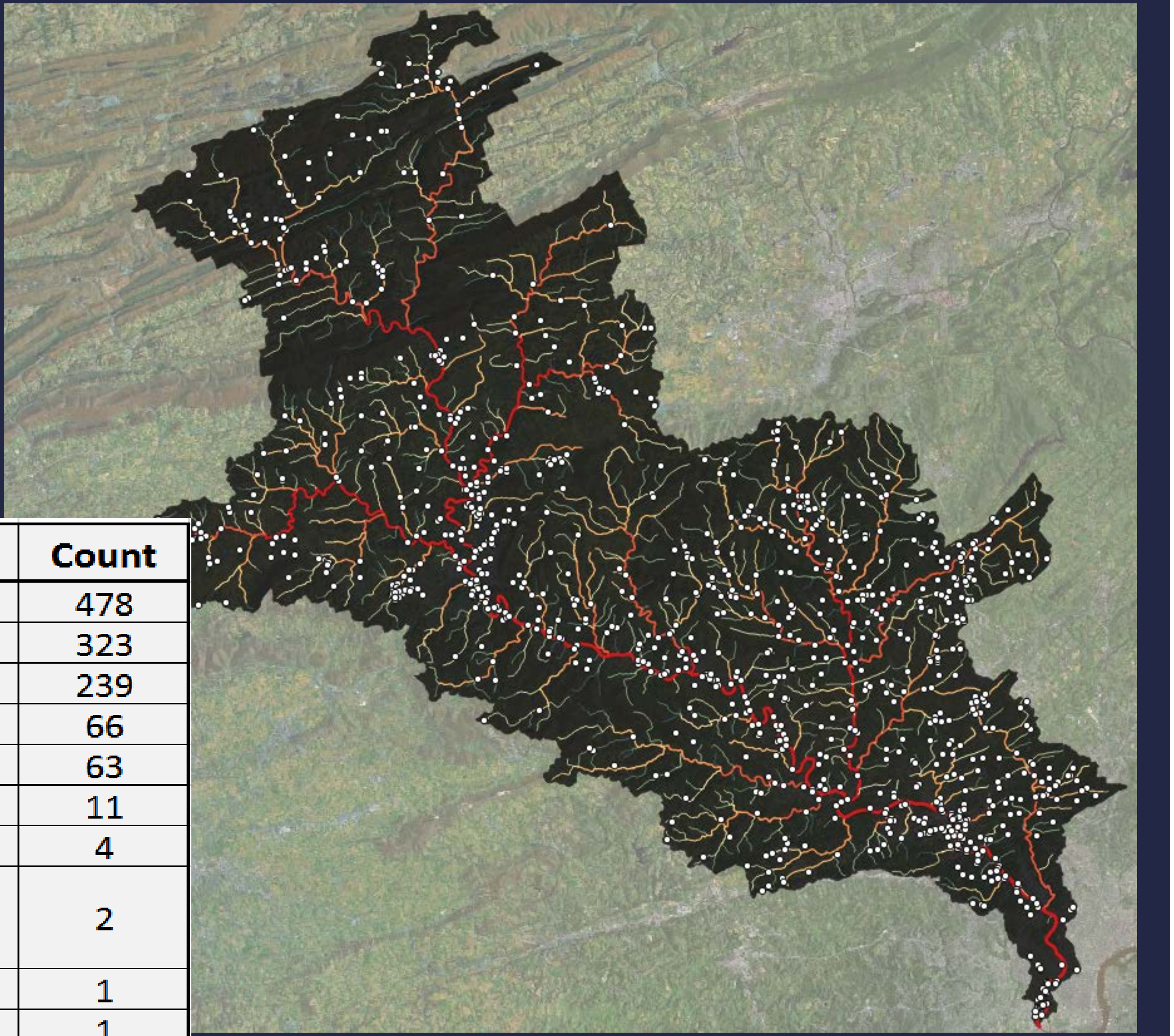
Applications of a Nested Set Index For River Routing

1) **Aggregating upstream pollutant loads**
2) **Aggregating upstream demographic datasets**
3) **Ecological connectivity (Wiener index)**
4) **Simulation models (Monte Carlo) and machine learning techniques.**



Stream Reach Assessment Tool

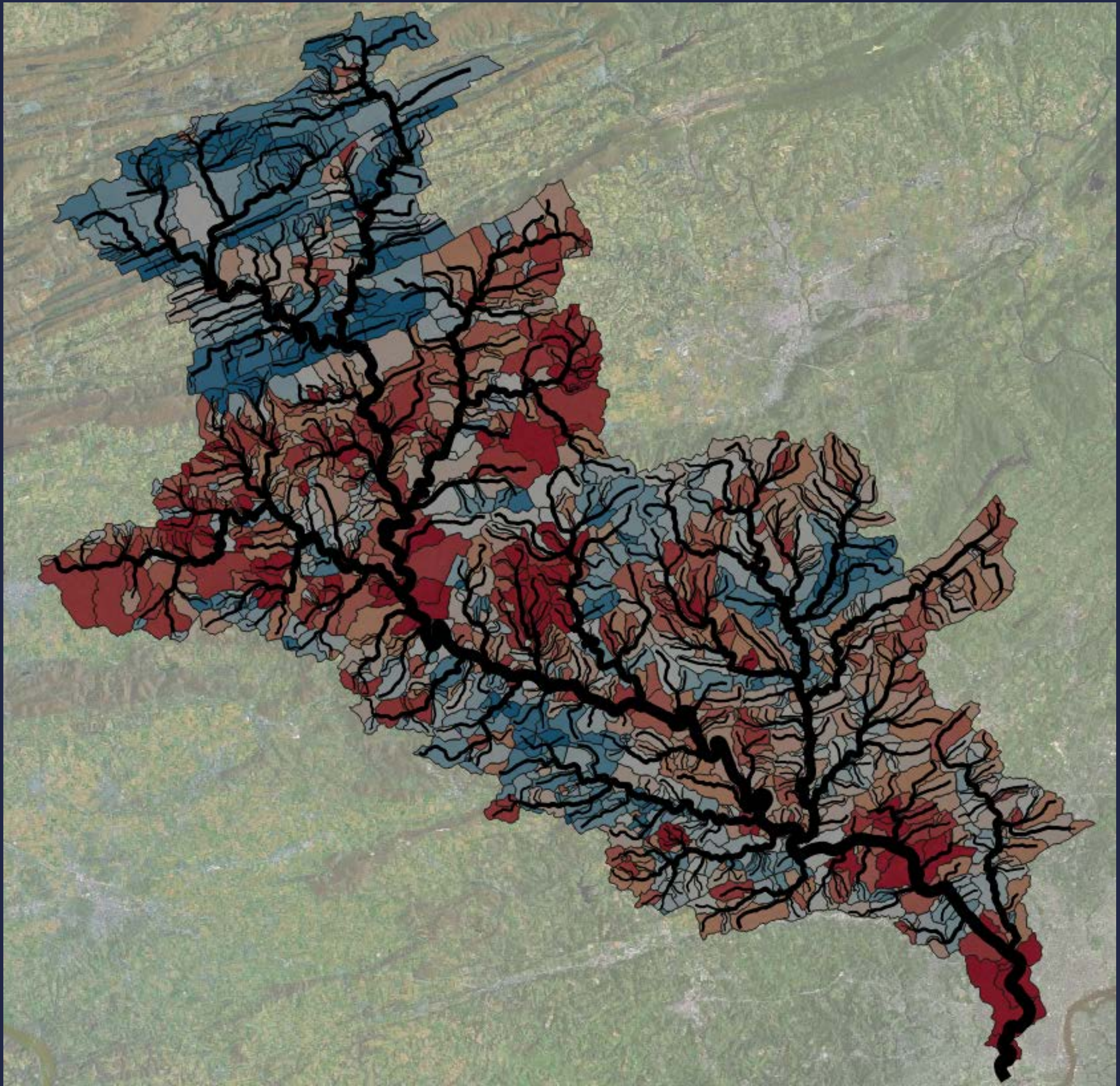
National Pollutant Discharge Elimination System (NPDES) n = 1,188



Facility-Code	Facility	Count
POF	Privately Owned	478
CTH	Corporation	323
CTG	Municipality	239
MWD	Municipal or Water	66
UNK	Unknown	63
STF	State Government	11
MXO	Mixed Ownership	4
FDF	Federal Facility (U.S. Government)	2
SDT	School District	1
IND	Individual	1

Stream Reach Assessment Tool: Nutrient Loading Using Mapsheds Model

Draft distribution of Total Nitrogen from MapSheds model



Results & Interpretation

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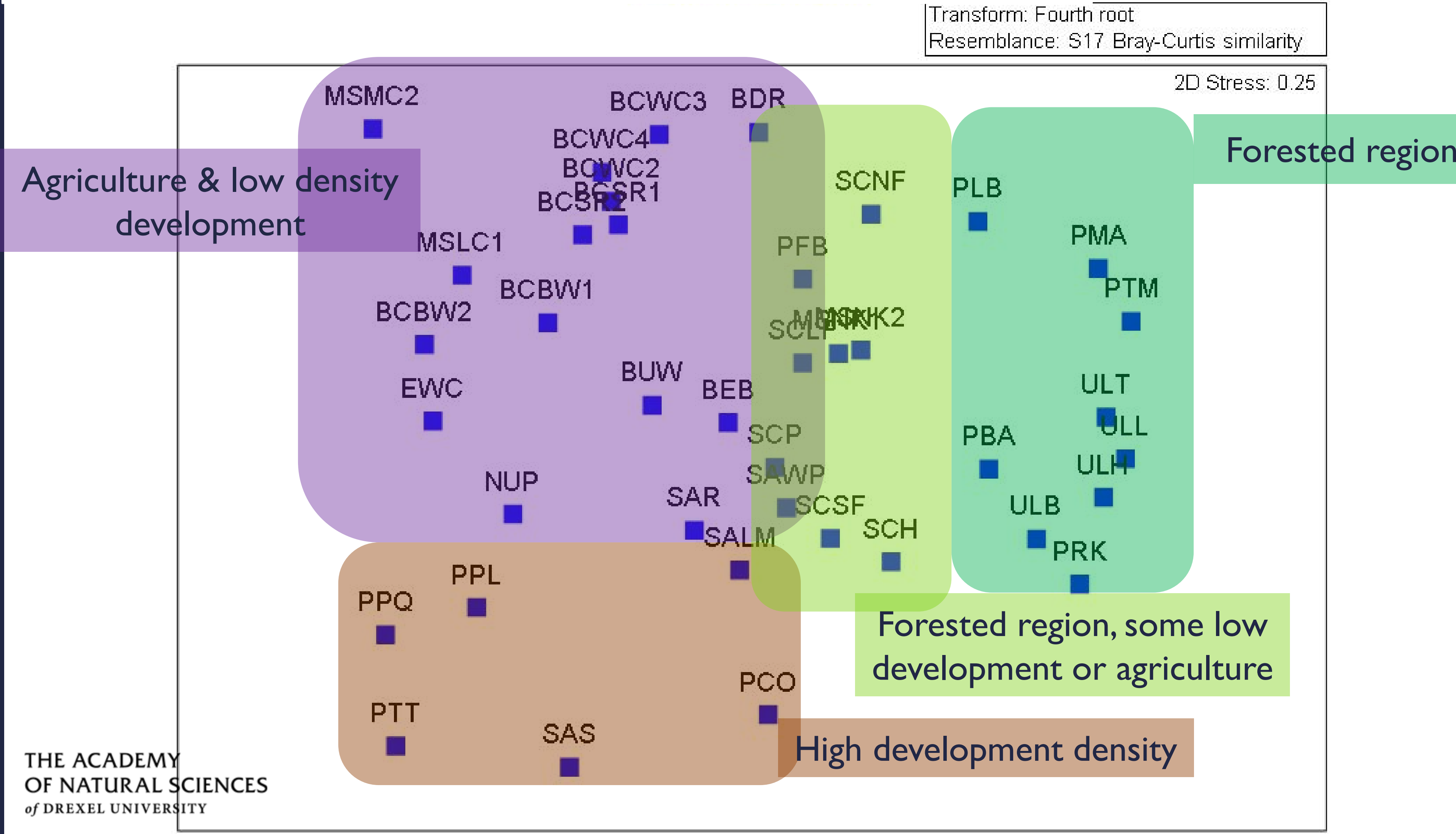
Indicator Group Ordinations

100 taxa: Fish, macroinvertebrates, diatoms

Combined MDS with land use, habitat, chemistry ordination scores



Agriculture & low density development

Forested region

Forested region, some low development or agriculture

High development density

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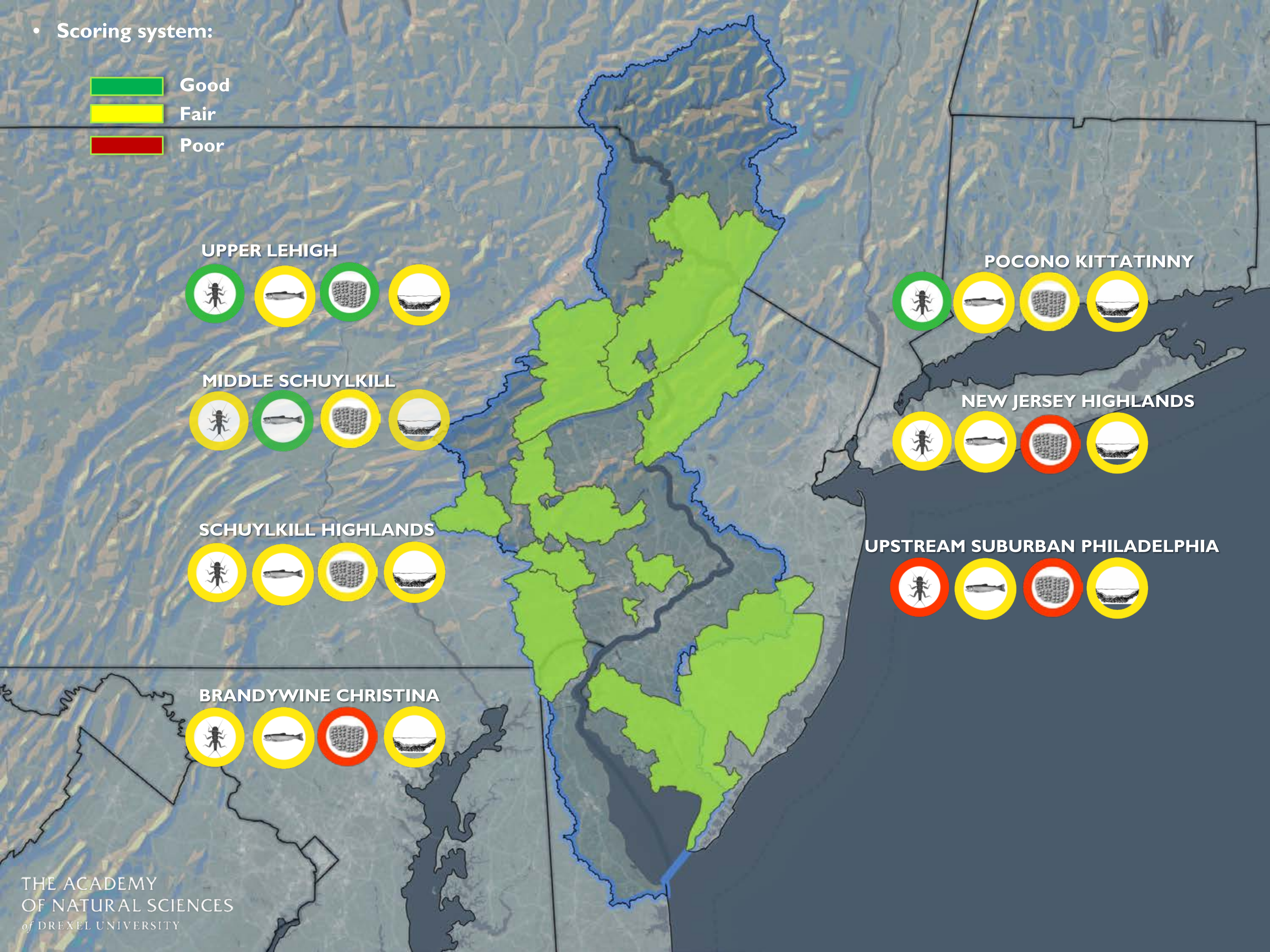
- Scoring system:

🟩 Good
🟨 Fair
🟥 Poor



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MIDDLE SCHUYLKILL
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SCHUYLKILL HIGHLANDS
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BRANDYWINE CHRISTINA
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POCONO KITTATINNY
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NEW JERSEY HIGHLANDS
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UPSTREAM SUBURBAN PHILADELPHIA
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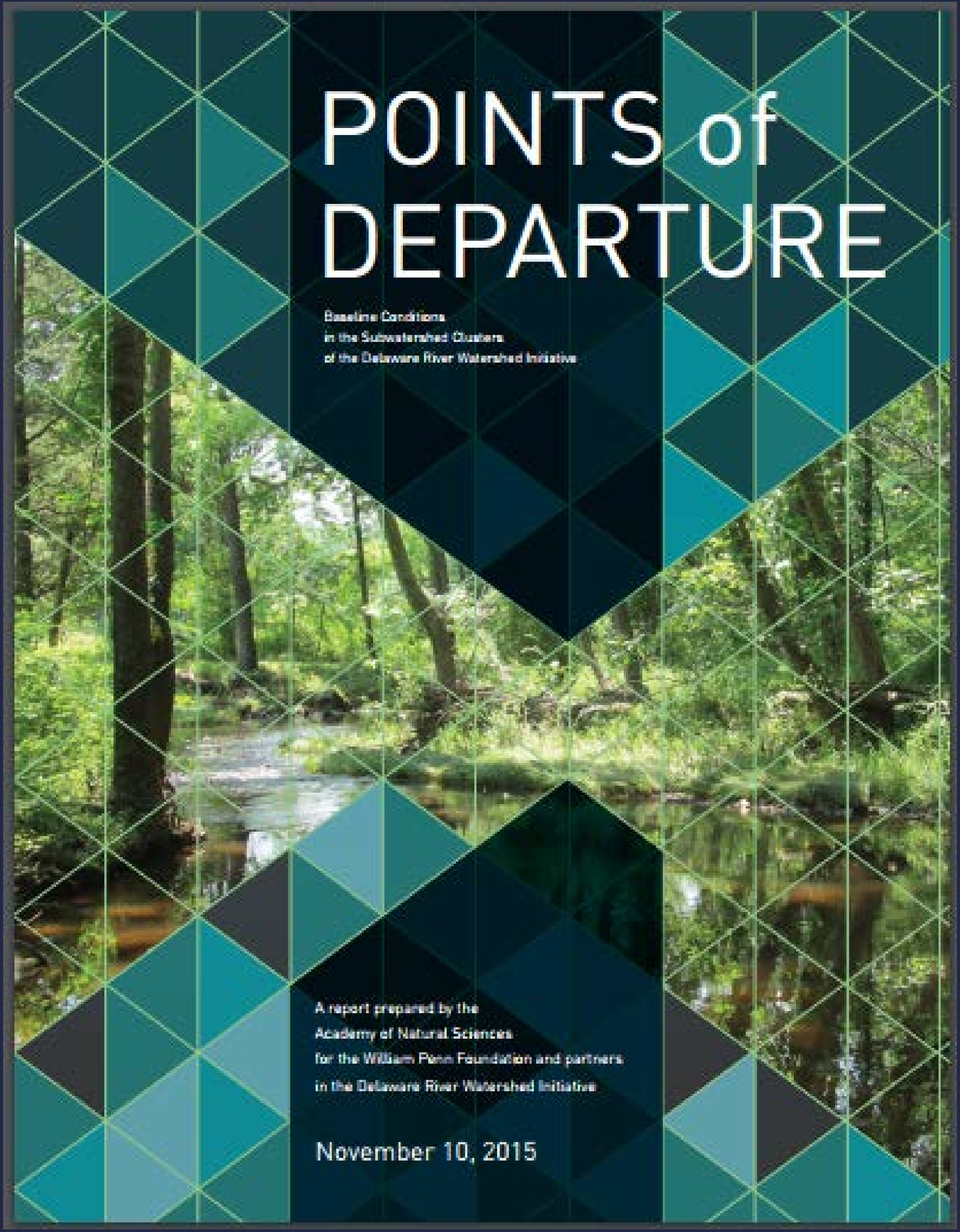

POINTS of DEPARTURE

Baseline Conditions
in the Subwatershed Clusters
of the Delaware River Watershed Initiative

A report prepared by the
Academy of Natural Sciences
for the William Penn Foundation and partners
in the Delaware River Watershed Initiative

November 10, 2015

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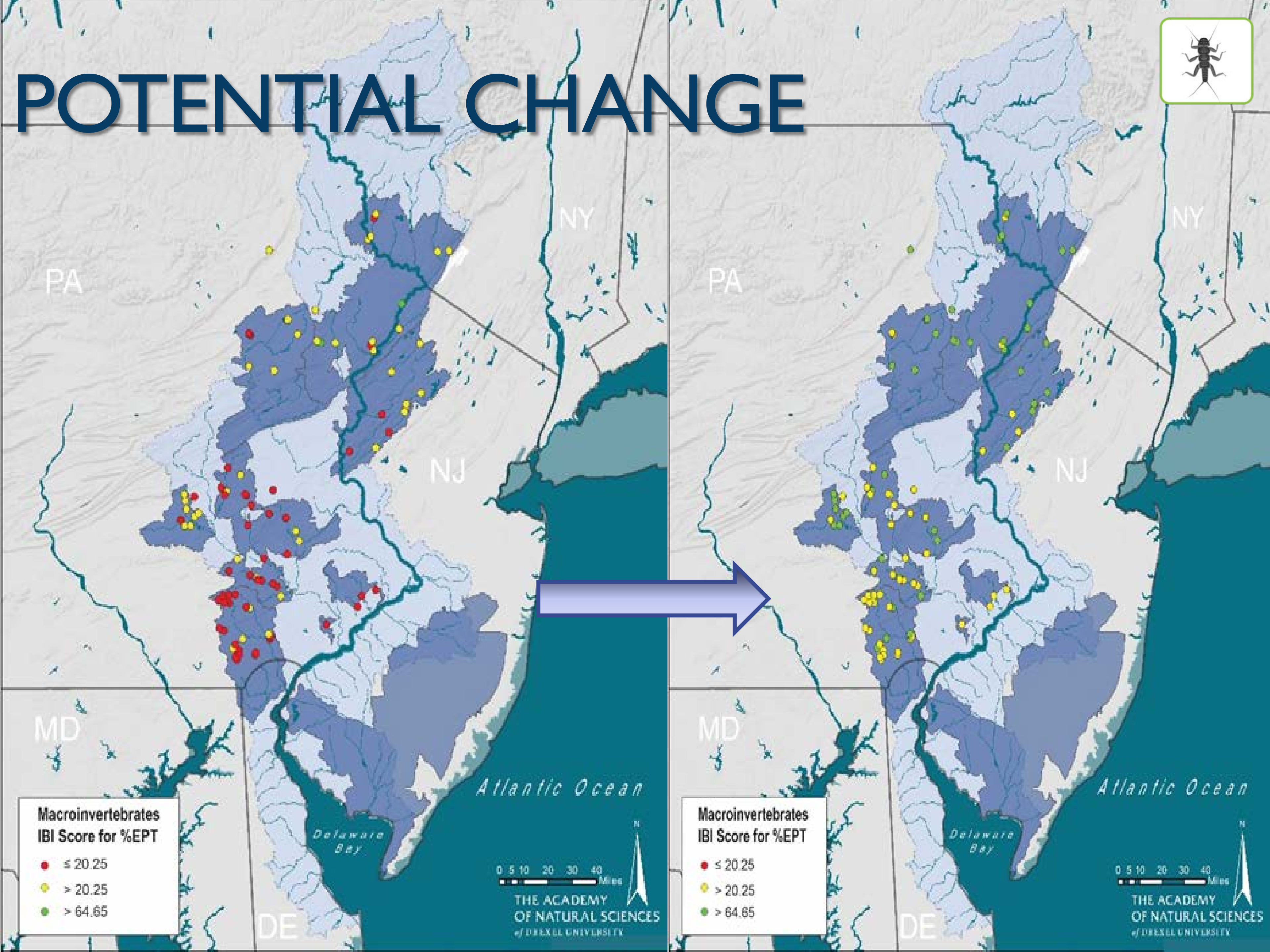
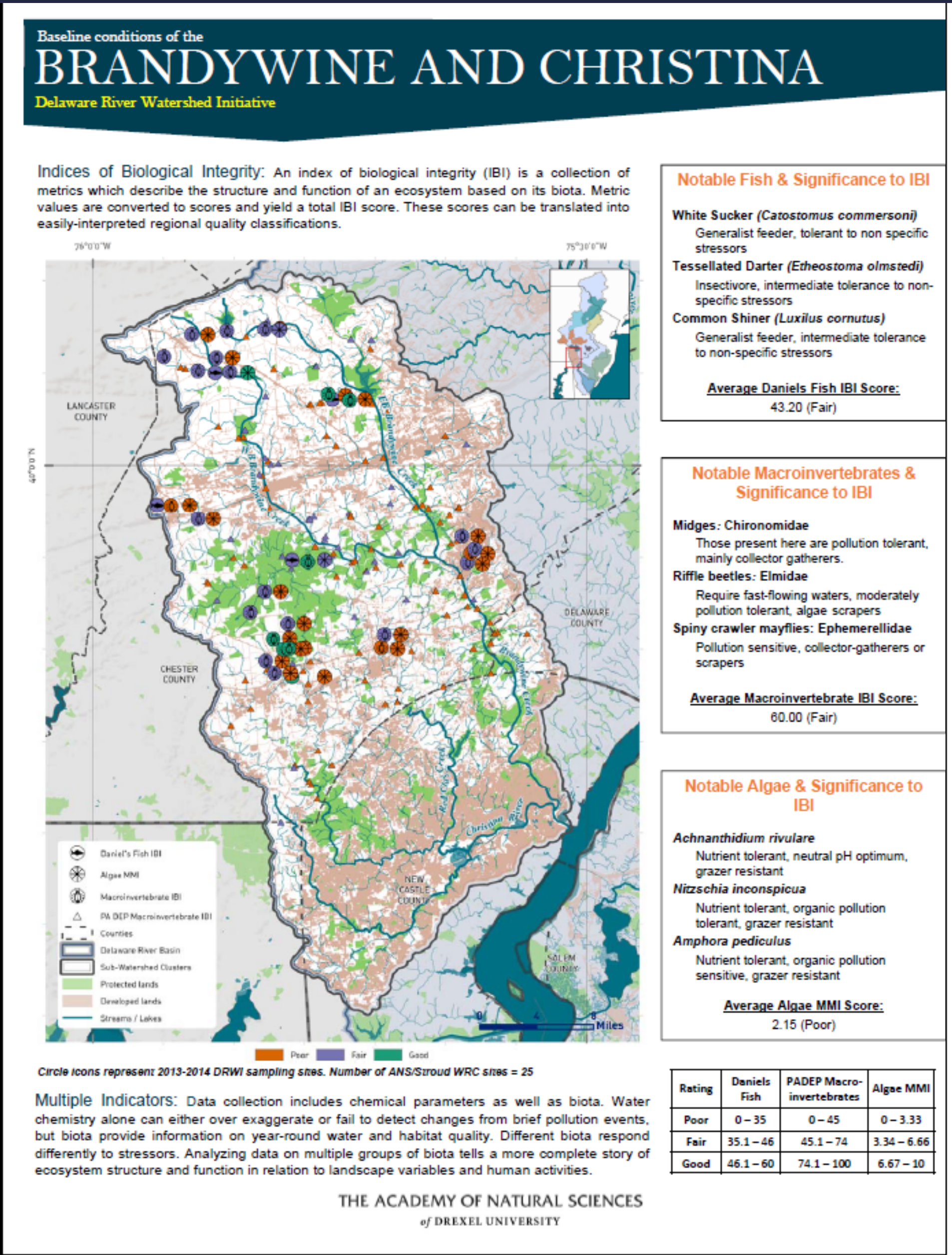
POTENTIAL CHANGE



<table>
<tr><th></th><th>Cluster</th><th colspan="2">Algae</th><th colspan="3">Macroinvertebrates</th><th></th><th colspan="2">Fish</th></tr>
<tr><th></th><th></th><th>Now</th><th>Future</th><th>Now</th><th colspan="2">Future</th><th colspan="2">Now</th><th>Future</th></tr>
<tr><td rowspan="5">Restoration</td><td>New Jersey Highlands</td><td>All sites dominated by high nutrient and pollution-tolerant taxa</td><td>Reduce dominance by tolerant taxa, increase from "poor" to "fair"</td><td rowspan="3">Tolerant, low mayfly, low diversity, low “flow-sensitive”</td><td colspan="2" rowspan="3">Higher in nearly all metrics</td><td colspan="2">No eels, lamprey, warm water fishes</td><td>Greater diversity, more cool water fishes</td></tr>
<tr><td>Brandywine-Christina</td><td>All but 1 site "poor," high percentage of indicators of high nutrient and ion concentrations</td><td>"Fair" IBI scores, with fewer nutrient-tolerant taxa</td><td colspan="2" rowspan="2">Warm water assemblages, site-dependent, some cool water fishes (reproducing and stocked trout)</td><td rowspan="2">Greater diversity, decreased biomass, more cool water fishes, more reproducing trout, increases inpollution-intolerant insectivores</td></tr>
<tr><td>Middle Schuylkill</td><td>High nutrient and ion-tolerant taxa</td><td>Higher index values (fair-good) with lower nutrient-tolerant taxa</td></tr>
<tr><td>Upstream Philadelphia</td><td>All but 1 site "poor," high percentage of indicators of high nutrient and ion concentrations</td><td>"Fair" IBI scores, with fewer nutrient-tolerant taxa</td><td>All metrics low</td><td colspan="2">Higher in nearly all metrics</td><td colspan="2">Low diversity</td><td>More diversity, stable functioning and biomass</td></tr>
<tr><td>Kirkwood-Cohansey</td><td>Not analyzed; to be included in 2015</td><td>Not analyzed; to be included in 2015</td><td>Some sites low diversity</td><td colspan="2">Maintain high diversity in good sites, increase diversity in others</td><td colspan="2">Not analyzed; to be included in 2015</td><td>Not analyzed; to be included in 2015</td></tr>
<tr><td rowspan="3">Protection</td><td>Schuylkill Highlands</td><td>Range of percentages of tolerant taxa, some sites low quality</td><td>Low quality sites: higher index range, Good sites: maintain quality</td><td>Tolerant, few “flow-sensitive” taxa, low diversity</td><td colspan="2">Fewer pollution-tolerant taxa, higher diversity</td><td colspan="2">Trout in few sites, warm water fishes</td><td>More trout & other cool water fishes</td></tr>
<tr><td>Upper Lehigh</td><td>All sites have high scores for nutrients and ions</td><td>Maintain high scores</td><td rowspan="2">Low % EPT, mayfly, relatively high pollution tolerant</td><td rowspan="2">Improve in EPT, lower pollution tolerant, maintain overall</td><td rowspan="2">Lehigh & Poconos (for fish)</td><td>Large streams</td><td>No eels, lamprey, some warm water fishes (ponds)</td><td>Maintenance of communities, more reproducing trout</td></tr>
<tr><td>Poconos-Kittatinny</td><td>Range of percentages of tolerant taxa, some sites low quality</td><td>Low quality sites: higher index range, Good sites: maintain quality</td><td>Small streams</td><td>Sculpin, natural and stocked trout</td><td>Maintenance of communities, more native Brook Trout, more pollution-intolerant fish</td></tr>
</table>

Cluster Report Cards, 2015



Baseline conditions of the

BRANDYWINE AND CHRISTINA

Delaware River Watershed Initiative

Indices of Biological Integrity: An index of biological integrity (IBI) is a collection of metrics which describe the structure and function of an ecosystem based on its biota. Metric values are converted to scores and yield a total IBI score. These scores can be translated into easily-interpreted regional quality classifications.

Circle icons represent 2013-2014 DRWI sampling sites. Number of ANS/Stroud WRC sites = 25

Multiple Indicators: Data collection includes chemical parameters as well as biota. Water chemistry alone can either over exaggerate or fail to detect changes from brief pollution events, but biota provide information on year-round water and habitat quality. Different biota respond differently to stressors. Analyzing data on multiple groups of biota tells a more complete story of ecosystem structure and function in relation to landscape variables and human activities.

Notable Fish & Significance to IBI

White Sucker *(Catostomus commersoni)*
Generalist feeder, tolerant to non specific stressors

Tessellated Darter *(Etheostoma olmstedi)*
Insectivore, intermediate tolerance to non-specific stressors

Common Shiner *(Luxilus cornutus)*
Generalist feeder, intermediate tolerance to non-specific stressors

Average Daniels Fish IBI Score:
43.20 (Fair)

Notable Macroinvertebrates & Significance to IBI

Midges: Chironomidae
Those present here are pollution tolerant, mainly collector gatherers.

Riffle beetles: Elmidae
Require fast-flowing waters, moderately pollution tolerant, algae scrapers

Spiny crawler mayflies: Ephemerellidae
Pollution sensitive, collector-gatherers or scrapers

Average Macroinvertebrate IBI Score:
60.00 (Fair)

Notable Algae & Significance to IBI

Achnanthidium rivulare
Nutrient tolerant, neutral pH optimum, grazer resistant

Nitzschia inconspicua
Nutrient tolerant, organic pollution tolerant, grazer resistant

Amphora pediculus
Nutrient tolerant, organic pollution sensitive, grazer resistant

Average Algae MMI Score:
2.15 (Poor)

Rating	Daniels Fish	PADEP Macro-invertebrates	Algae MMI
Poor	0 – 35	0 – 45	0 – 3.33
Fair	35.1 – 46	45.1 – 74	3.34 – 6.66
Good	46.1 – 60	74.1 – 100	6.67 – 10

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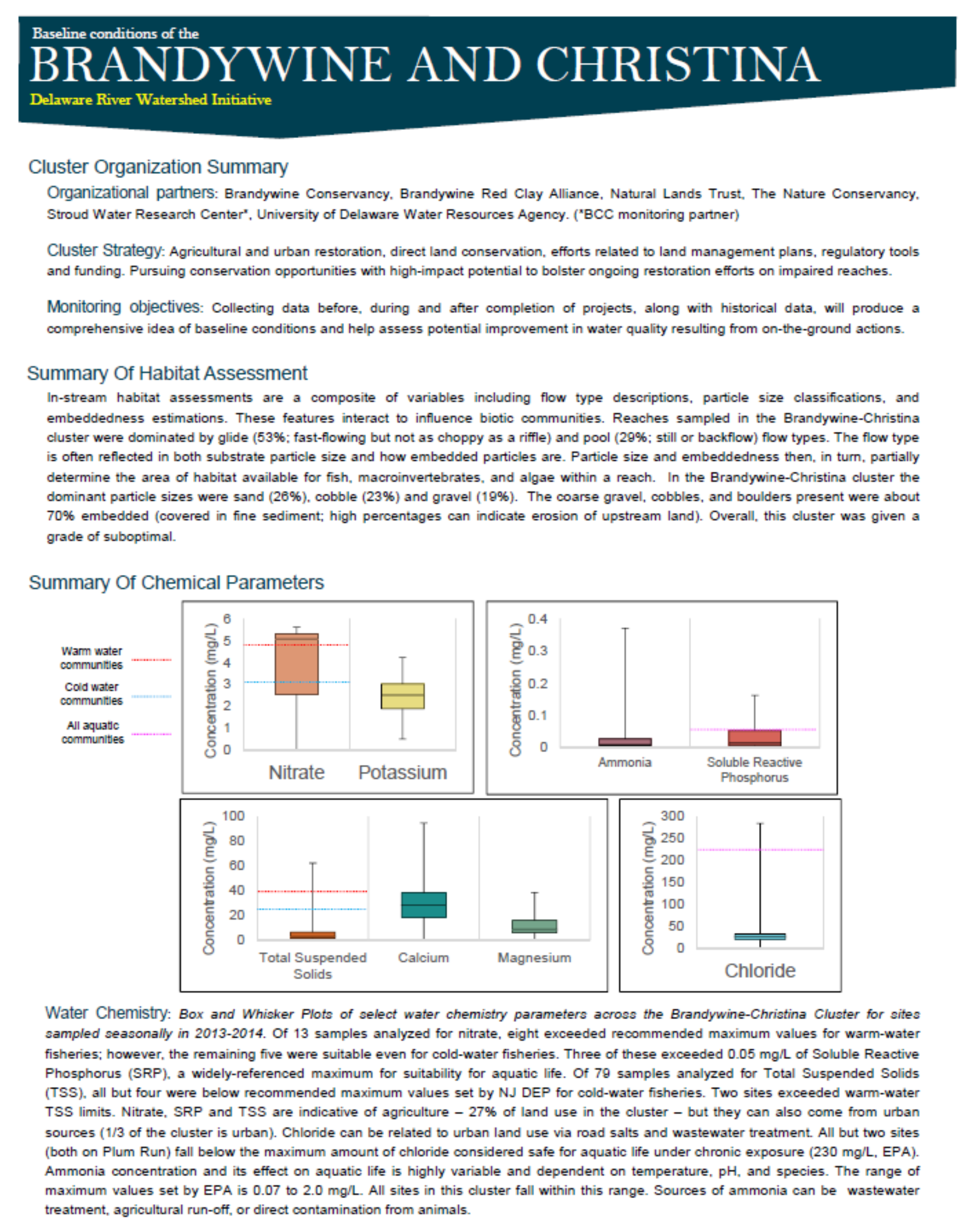


Baseline conditions of the

BRANDYWINE AND CHRISTINA

Delaware River Watershed Initiative

Cluster Organization Summary

Organizational partners: Brandywine Conservancy, Brandywine Red Clay Alliance, Natural Lands Trust, The Nature Conservancy, Stroud Water Research Center*, University of Delaware Water Resources Agency. (*BCC monitoring partner)

Cluster Strategy: Agricultural and urban restoration, direct land conservation, efforts related to land management plans, regulatory tools and funding. Pursuing conservation opportunities with high-impact potential to bolster ongoing restoration efforts on impaired reaches.

Monitoring objectives: Collecting data before, during and after completion of projects, along with historical data, will produce a comprehensive idea of baseline conditions and help assess potential improvement in water quality resulting from on-the-ground actions.

Summary Of Habitat Assessment

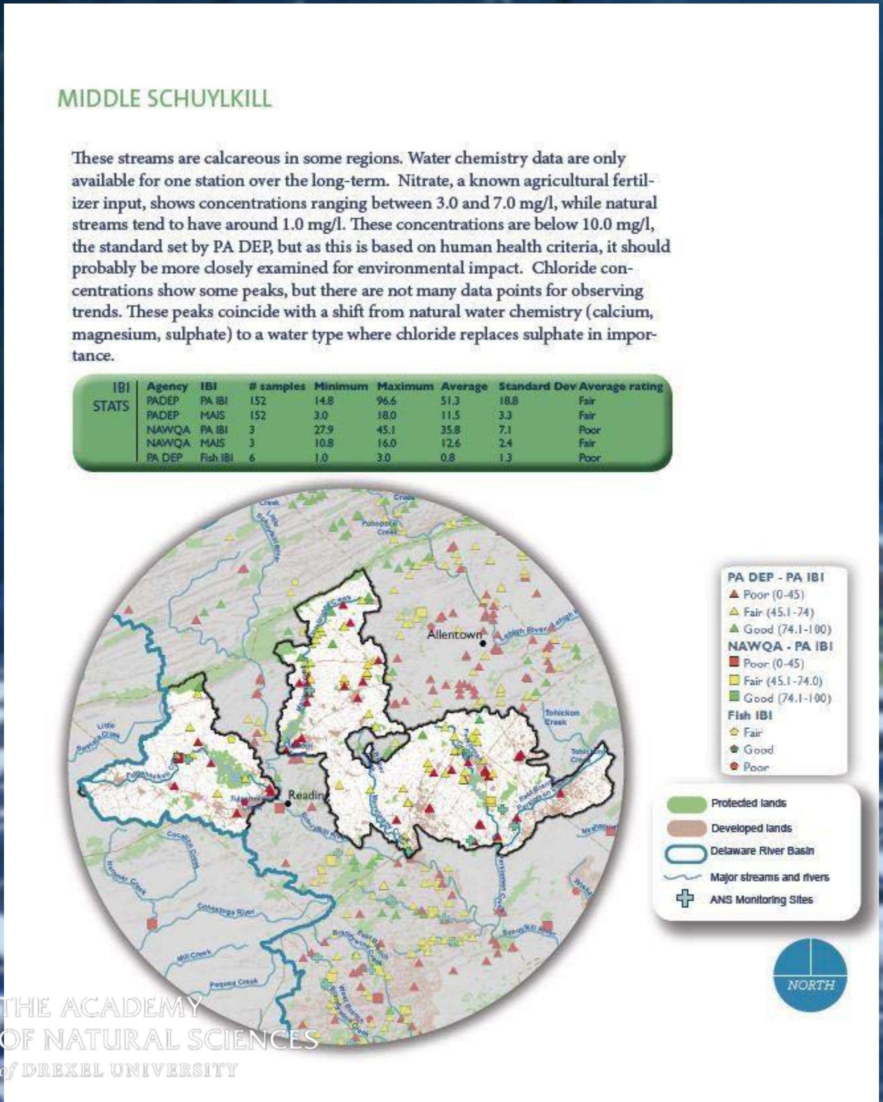
In-stream habitat assessments are a composite of variables including flow type descriptions, particle size classifications, and embeddedness estimations. These features interact to influence biotic communities. Reaches sampled in the Brandywine-Christina cluster were dominated by glide (53%; fast-flowing but not as choppy as a riffle) and pool (29%; still or backflow) flow types. The flow type is often reflected in both substrate particle size and how embedded particles are. Particle size and embeddedness then, in turn, partially determine the area of habitat available for fish, macroinvertebrates, and algae within a reach. In the Brandywine-Christina cluster the dominant particle sizes were sand (26%), cobble (23%) and gravel (19%). The coarse gravel, cobbles, and boulders present were about 70% embedded (covered in fine sediment; high percentages can indicate erosion of upstream land). Overall, this cluster was given a grade of suboptimal.

Summary Of Chemical Parameters

Water Chemistry: *Box and Whisker Plots of select water chemistry parameters across the Brandywine-Christina Cluster for sites sampled seasonally in 2013-2014.* Of 13 samples analyzed for nitrate, eight exceeded recommended maximum values for warm-water fisheries; however, the remaining five were suitable even for cold-water fisheries. Three of these exceeded 0.05 mg/L of Soluble Reactive Phosphorus (SRP), a widely-referenced maximum for suitability for aquatic life. Of 79 samples analyzed for Total Suspended Solids (TSS), all but four were below recommended maximum values set by NJ DEP for cold-water fisheries. Two sites exceeded warm-water TSS limits. Nitrate, SRP and TSS are indicative of agriculture – 27% of land use in the cluster – but they can also come from urban sources (1/3 of the cluster is urban). Chloride can be related to urban land use via road salts and wastewater treatment. All but two sites (both on Plum Run) fall below the maximum amount of chloride considered safe for aquatic life under chronic exposure (230 mg/L, EPA). Ammonia concentration and its effect on aquatic life is highly variable and dependent on temperature, pH, and species. The range of maximum values set by EPA is 0.07 to 2.0 mg/L. All sites in this cluster fall within this range. Sources of ammonia can be wastewater treatment, agricultural run-off, or direct contamination from animals.

“Cluster” Characterization

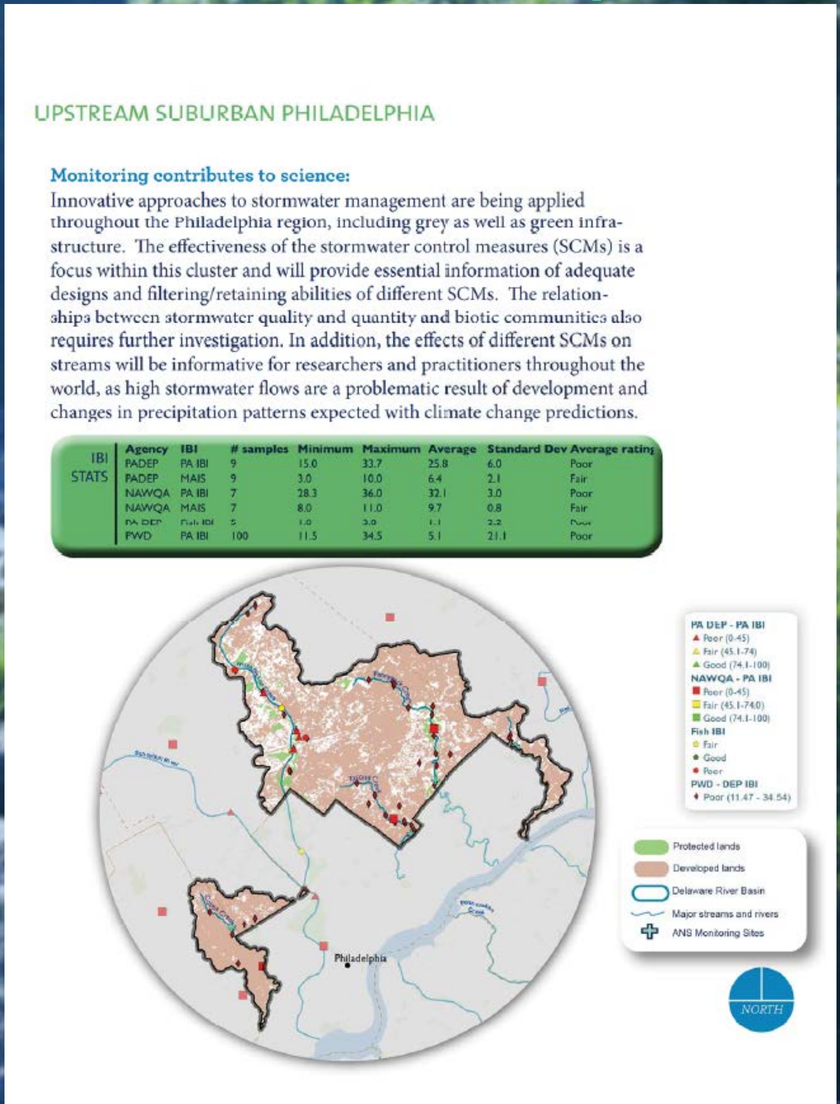
An Assessment of Existing IBIs by Agencies



MIDDLE SCHUYLKILL

These streams are calcareous in some regions. Water chemistry data are only available for one station over the long-term. Nitrate, a known agricultural fertilizer input, shows concentrations ranging between 3.0 and 7.0 mg/l, while natural streams tend to have around 1.0 mg/l. These concentrations are below 10.0 mg/l, the standard set by PA DEP, but as this is based on human health criteria, it should probably be more closely examined for environmental impact. Chloride concentrations show some peaks, but there are not many data points for observing trends. These peaks coincide with a shift from natural water chemistry (calcium, magnesium, sulphate) to a water type where chloride replaces sulphate in importance.

IBI STATS	Agency	IBI	# samples	Minimum	Maximum	Average	Standard Dev	Average rating
	PADEP	PA IBI	152	14.8	96.6	51.3	18.8	Fair
	PADEP	MAIS	152	3.0	18.0	11.5	3.3	Fair
	NAWQA	PA IBI	3	27.9	45.1	35.8	7.1	Poor
	NAWQA	MAIS	3	10.8	16.0	12.6	2.4	Fair
	PA DEP	Fish IBI	6	1.0	3.0	0.8	1.3	Poor



UPSTREAM SUBURBAN PHILADELPHIA

Monitoring contributes to science:

Innovative approaches to stormwater management are being applied throughout the Philadelphia region, including grey as well as green infrastructure. The effectiveness of the stormwater control measures (SCMs) is a focus within this cluster and will provide essential information of adequate designs and filtering/retaining abilities of different SCMs. The relationships between stormwater quality and quantity and biotic communities also requires further investigation. In addition, the effects of different SCMs on streams will be informative for researchers and practitioners throughout the world, as high stormwater flows are a problematic result of development and changes in precipitation patterns expected with climate change predictions.

IBI STATS	Agency	IBI	# samples	Minimum	Maximum	Average	Standard Dev	Average rating
	PADEP	PA IBI	9	15.0	33.7	25.8	6.0	Poor
	PADEP	MAIS	9	3.0	10.0	6.4	2.1	Fair
	NAWQA	PA IBI	7	28.3	36.0	32.1	3.0	Poor
	NAWQA	MAIS	7	8.0	11.0	9.7	0.8	Fair
	PA DEP	Fish IBI	5	1.0	3.0	1.1	2.2	Poor
	PWD	PA IBI	100	11.5	34.5	5.1	21.1	Poor

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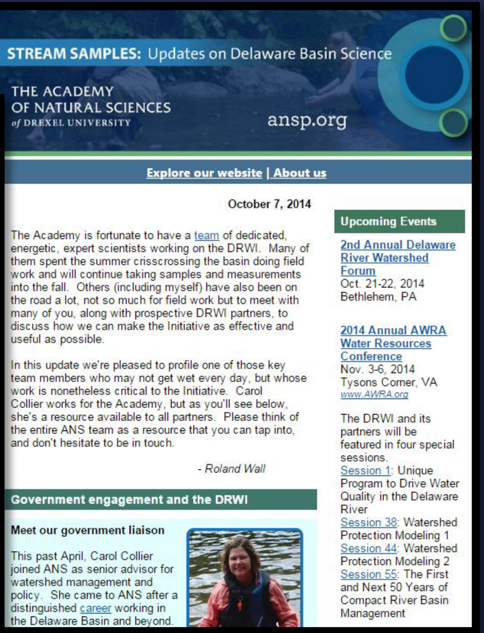

STREAM SAMPLES: Updates on Delaware Basin Science

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October 7, 2014

The Academy is fortunate to have a team of dedicated, energetic, expert scientists working on the DRWI. Many of them spent the summer crisscrossing the basin doing field work and will continue taking samples and measurements into the fall. Others (including myself) have also been on the road a lot, not so much for field work but to meet with many of you, along with prospective DRWI partners, to discuss how we can make the Initiative as effective and useful as possible.

In this update we're pleased to profile one of those key team members who may not get wet every day, but whose work is nonetheless critical to the Initiative. Carol Collier works for the Academy, but as you'll see below, she's a resource available to all partners. Please think of the entire ANS team as a resource that you can tap into, and don't hesitate to be in touch.

- Roland Wall

Government engagement and the DRWI

Meet our government liaison

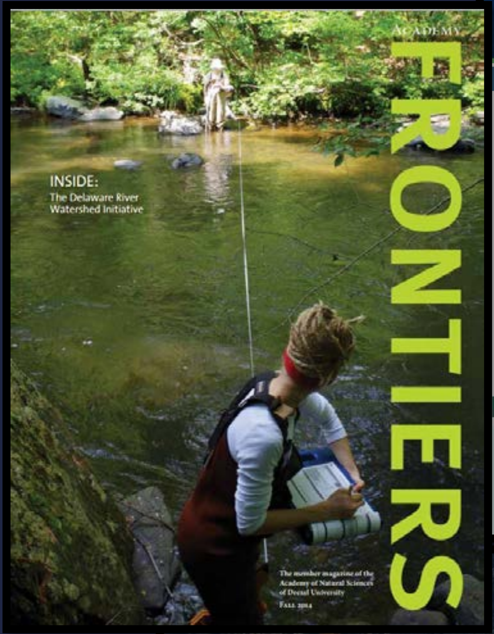
This past April, Carol Collier joined ANS as senior advisor for watershed management and policy. She came to ANS after a distinguished career working in the Delaware Basin and beyond.

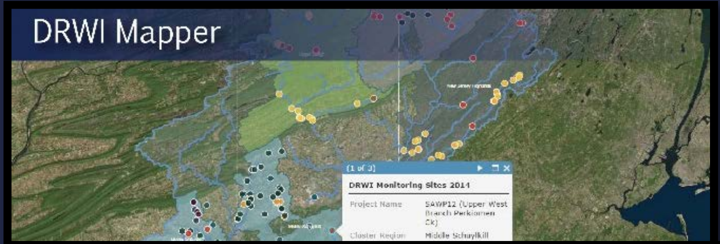
Upcoming Events

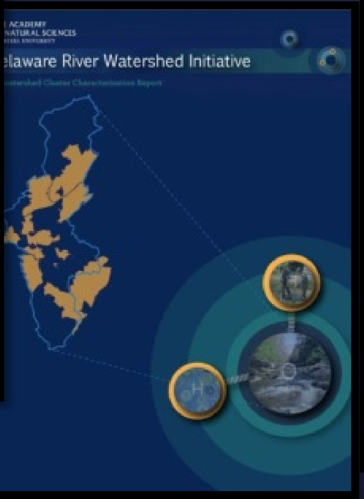
2nd Annual Delaware River Watershed Forum
Oct. 21-22, 2014
Bethlehem, PA

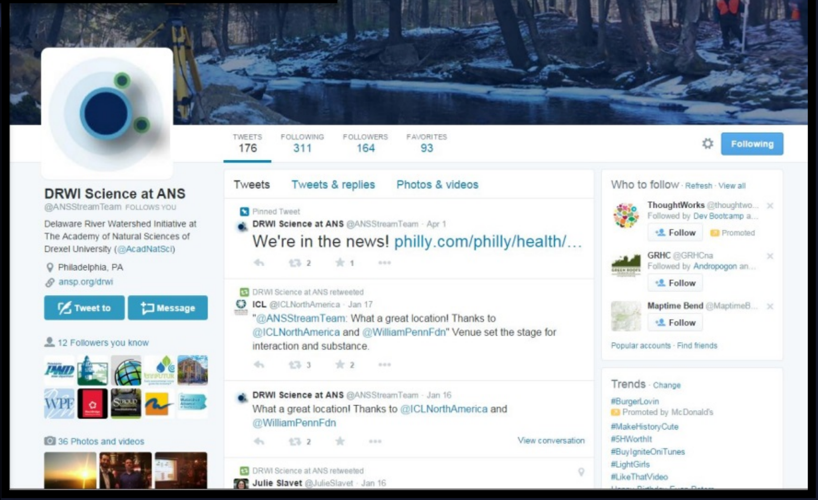
2014 Annual AWRA Water Resources Conference
Nov. 3-6, 2014
Tysons Corner, VA
www.AWRA.org

The DRWI and its partners will be featured in four special sessions.
Session 1: Unique Program to Drive Water Quality in the Delaware River
Session 38: Watershed Protection Modeling 1
Session 44: Watershed Protection Modeling 2
Session 55: The First and Next 50 Years of Compact River Basin Management









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"@ANSStreamTeam: What a great location! Thanks to @ICLNorthAmerica and @WilliamPennFdn" Venue set the stage for interaction and substance.
3 · 2

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Challenges

- Format of output
- Uncertainty and nature's timelines
- Legacy sources of contaminants
- Spatial distribution of willing landowners
- Data unavailable from NRCS

Acknowledgements

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Lin Perez
Allison Stoklo
Roland Wall
ANS Field Cr

Thank you!

Questions?

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