NUTRIENT TRADING OBSTACLES & OPPORTUNITIES

To Improve Water Quality in the Long Island Sound

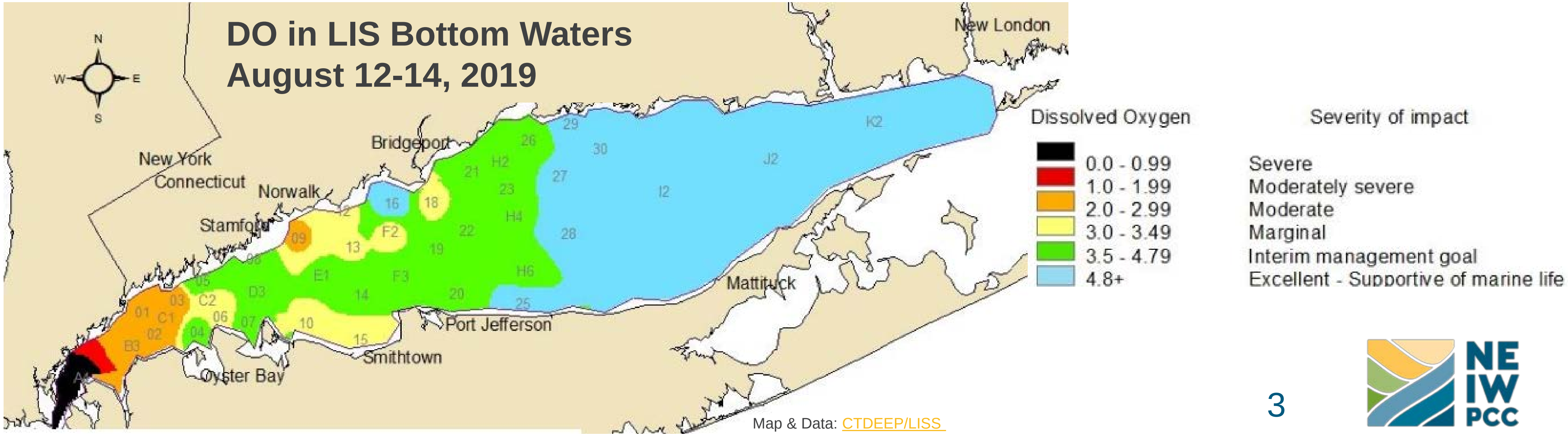
June 23, 2021

TODAY'S AGENDA

3:00 – 3:10	Introduction & project overview *Emma Gildesgame, NEIWPCC*
3:10 – 3:45	**Presentation:** Economic Obstacles and Opportunities *Rachel Bouvier, rbouvier Consulting*
3:45 – 4:20	**Presentation:** Trading in the Ecosystem Context *Paul Stacey, Footprints in the Water, LLC*
4:20 – 4:30	Q&A, initial feedback
4:30-5:00	Optional: Q&A, discussion, and feedback.

LIS Needs More WQ Improvements

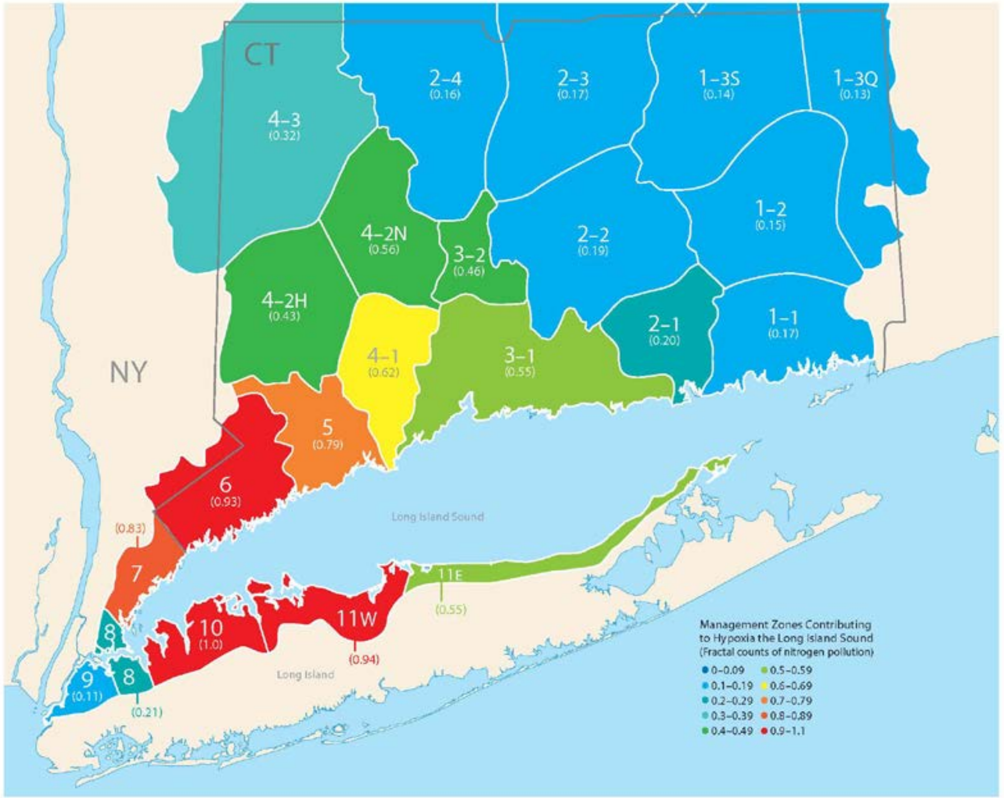
- Meeting some TMDL N reduction targets
- Significant WQ improvements
- Hypoxia, other WQ challenges persist
- Reductions needed from nonpoint sources



Map & Data: CTDEEP/LISS

Trading as a Tool for Cleaner Water?

- CT Nitrogen Credit Exchange – successful for WWTFs!
- Point – Nonpoint Trading?
- Interstate Trading?
- Trading beyond single-pollutant approach?



Trade equalized N loading to the LIS
Map: LISS

Learning from Others: What is Successful Trading?

- Watershed-Specific
- Simple, Flexible, Accountable, & Transparent
- Reduce costs (transaction, administrative, monitoring)
  - Build on existing programs, partnerships
- Stack credits, recognize co-benefits
- Point – Nonpoint Trading
  - PS – Ag NPS most common
  - NPS trades require tracking, accounting

NE IW PCC

LEARNING FROM OTHERS: BALANCING GOALS

- **Baselines** set the starting point for trading
- **Trade ratios** account for differences between buyers + sellers
- Address and mitigate **risks**
- Determine **market** size and participants

Balancing Goals: Maximize Trading Program

- **Baseline** less stringent
- **Trade ratios** closer to 1:1
- Address and mitigate liability, economic **risk**
- Maximize **market** size and participants

Balancing Goals: Maximize Ecosystem Improvements

- **Baseline** more stringent
- **Trade ratios** reflect variation in discharge types, locations, etc.
- Address and mitigate **risk** of pollution hotspots, lack of WQ improvement
- Local **markets** – small watershed or subwatershed

Balancing Goals: Find a Happy(ish) Medium?

- Ecosystem conditions & goals
- Supply & demand factors
- Frameworks to reduce risk
- Existing programs & support
- **Goals need to be clear**

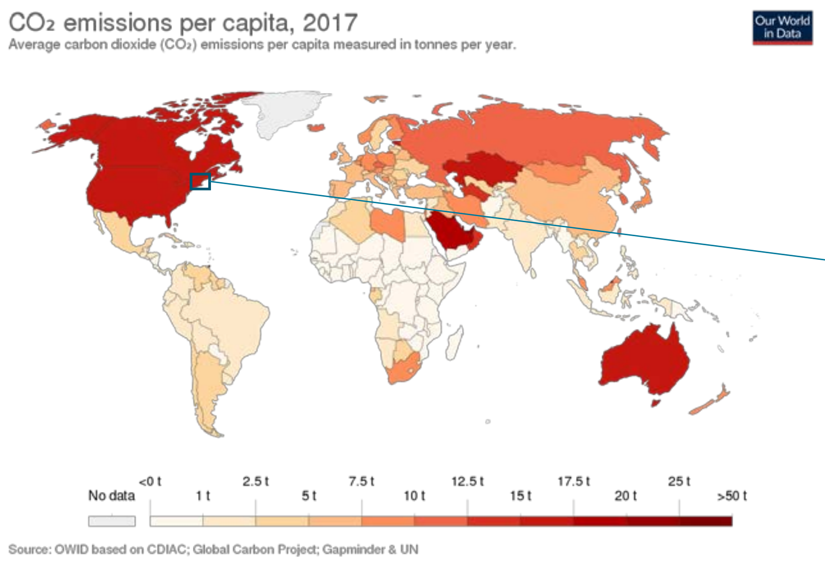
NE IW PCC

Recommendations Report - Fall 2021

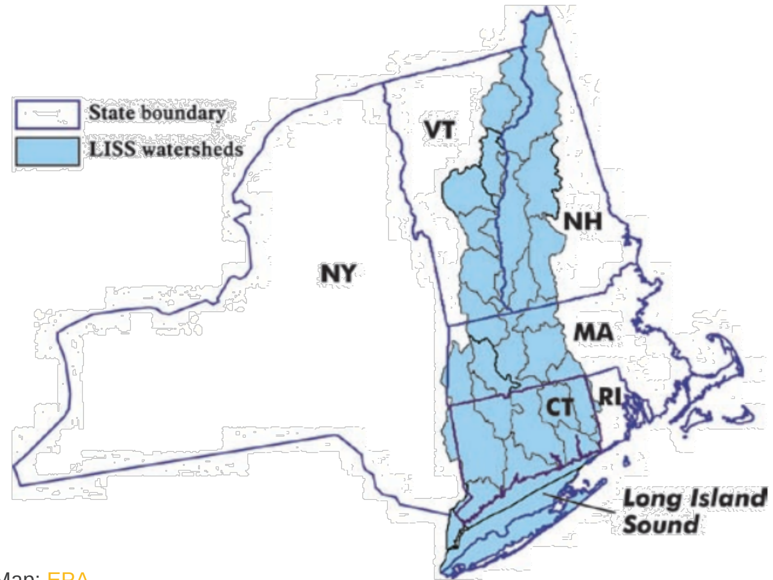
- What goals can trading support in the LIS Watershed?
- Lessons from existing trading programs
- Recommendations for successful trading:
  - Economic factors
  - Ecosystem considerations
- Identification of potential drivers needed for trading
- What further studies, information are needed?

WQ Trading ≠ Carbon / Climate Trading

- **Pollution Scale:** Watershed vs. planetary
- **Markets:** Local vs. global
- **Drivers:** Regulatory, social pressure



By Our World in Data - CO_2 emissions per capita.
Our World in Data., CC BY 4.0



Map: EPA

THE PROJECT TEAM

Jane Stahl, NEIWPCC Commissioner

Emma Gildesgame, NEIWPCC

Paul Stacey, Footprints in the Water

Claire James. rbouvier Consulting

Richard Friesner, NEIWPCC

Rachel Bouvier, rbouvier Consulting

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Averi Varney rbouvier Consulting

Raphaella Mascia, NEIWPCC

Bessie Wright, EPA

Economic Obstacles and Opportunities

Rachel Bouvier, rbouvier Consulting

A Thought Experiment: Nutrient trading in the LIS watershed

Presented to: LIS Nutrient Trading Options and Obstacles Evaluation

June 23, 2021

Overall Project Purpose Statement and Tasks

- Purpose: To explore the economic opportunities and obstacles in developing a nutrient trading program for the Long Island Sound Watershed.
- Tasks:
  - Task 1: Literature Review
  - Task 2: Interviews
  - Task 3: Inventory
  - Task 4: Conclusions and Recommendations

This presentation describes the results of a "thought experiment" that we are using to explore and demonstrate our findings.

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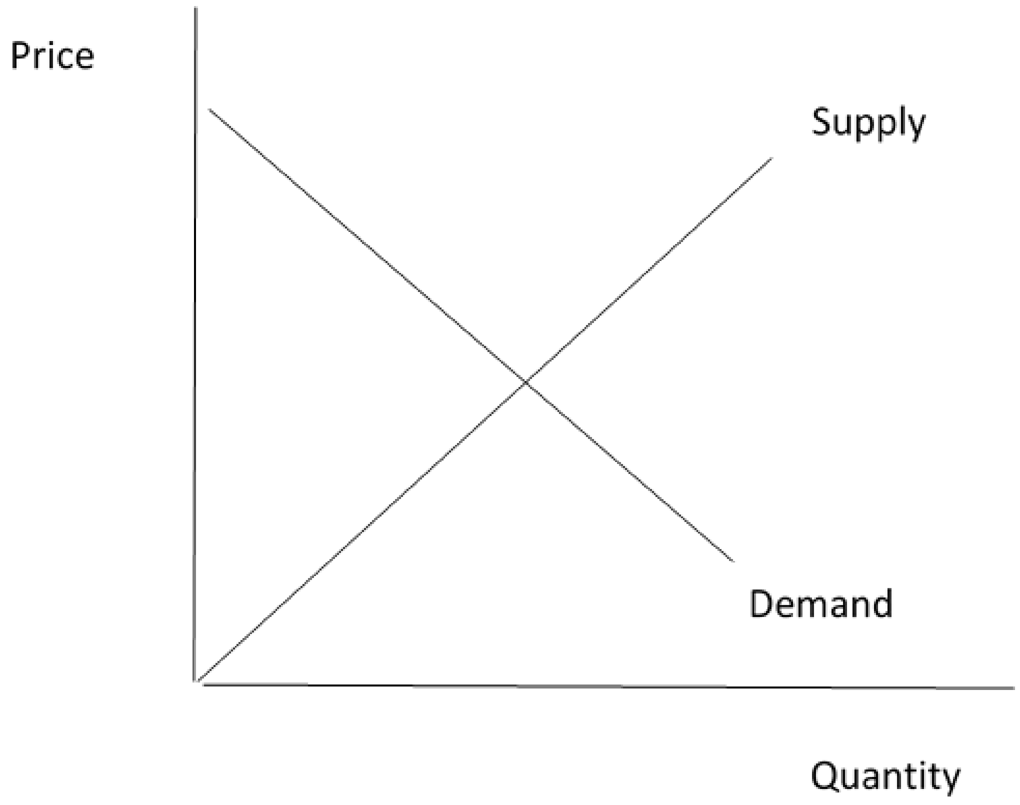
An Idealized Credit Market



A thought experiment

- How many pounds of nitrogen and phosphorus are currently being discharged into Long Island Sound? And what is the breakdown by source?
- How do the current discharges of nitrogen and phosphorus compare to the limits that are in place?
- What are the possible physical strategies (BMPs) that could be followed in order to reduce nitrogen and phosphorus from entering Long Island Sound?
- What are the costs of these strategies, and how do the costs of these strategies compare to the cost of treatment facility upgrades?
- What are the possible "wedges" between supply and demand?
- What trends are likely to affect these economic factors in the future?

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Thought Experiment Methodology and Limitations

- We used a report written by the University of Maryland's Center for Environmental Science (Price et al., 2019).
- They collected data (types, efficacy, and cost) on 353 BMPs from the Chesapeake Bay Partnership's Chesapeake Assessment Scenario Tool (CAST).
- Data on cost include construction, engineering, land acquisition and opportunity cost, installation, operations and maintenance, annualized over the lifespan of each BMP.
- Data on efficacy come from CAST, and are presented in edge-of-tide terms.
- **CAVEAT:** Dollar figures are average annualized costs. Actual BMP costs can vary widely. Actual BMP efficacy can vary widely. Edge-of-tide depends on geographic area. **Results are suggestive, not conclusive.**

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Question 1: How many pounds of nitrogen and phosphorus are currently being discharged into Long Island Sound? And what is the breakdown by source?

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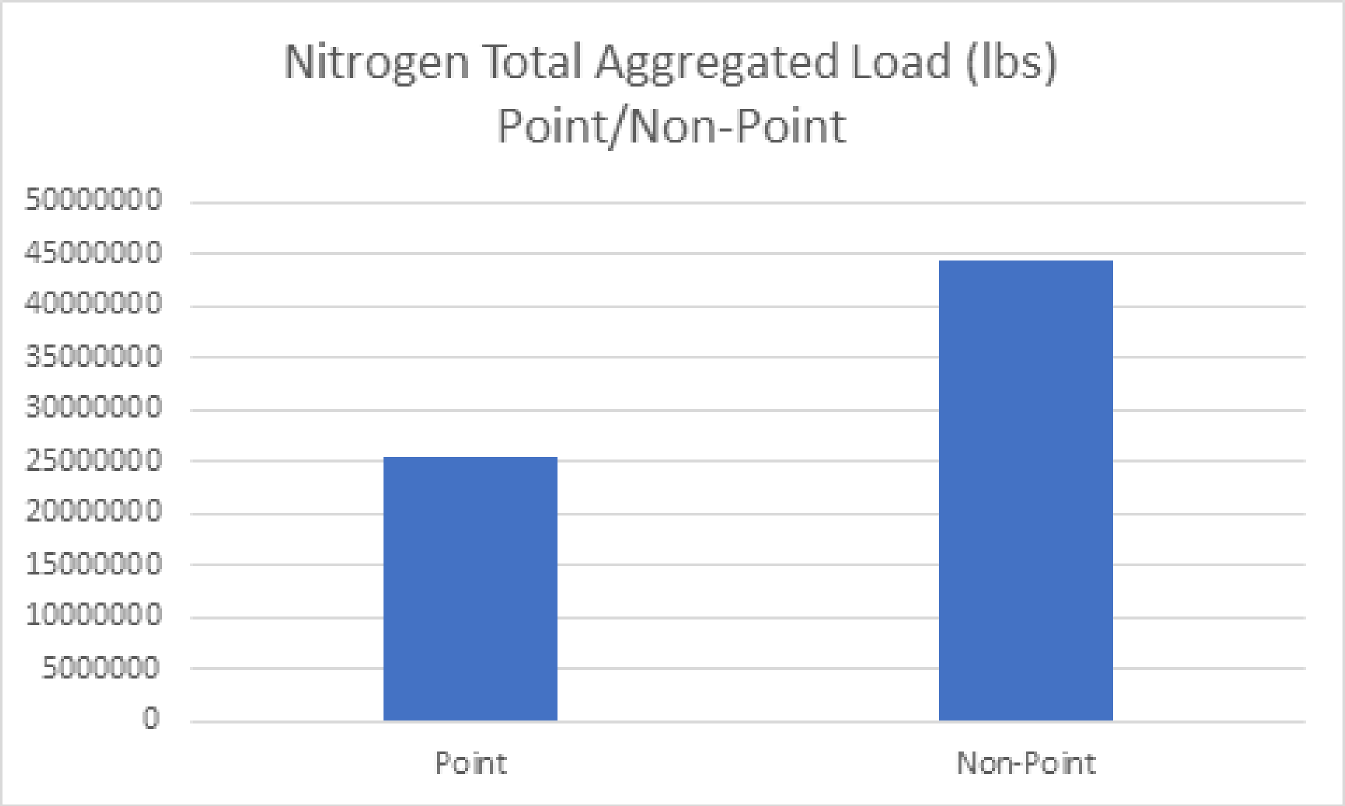

Point and non-point nitrogen load for the Long Island Sound watershed (United States Geological Survey, 2020)

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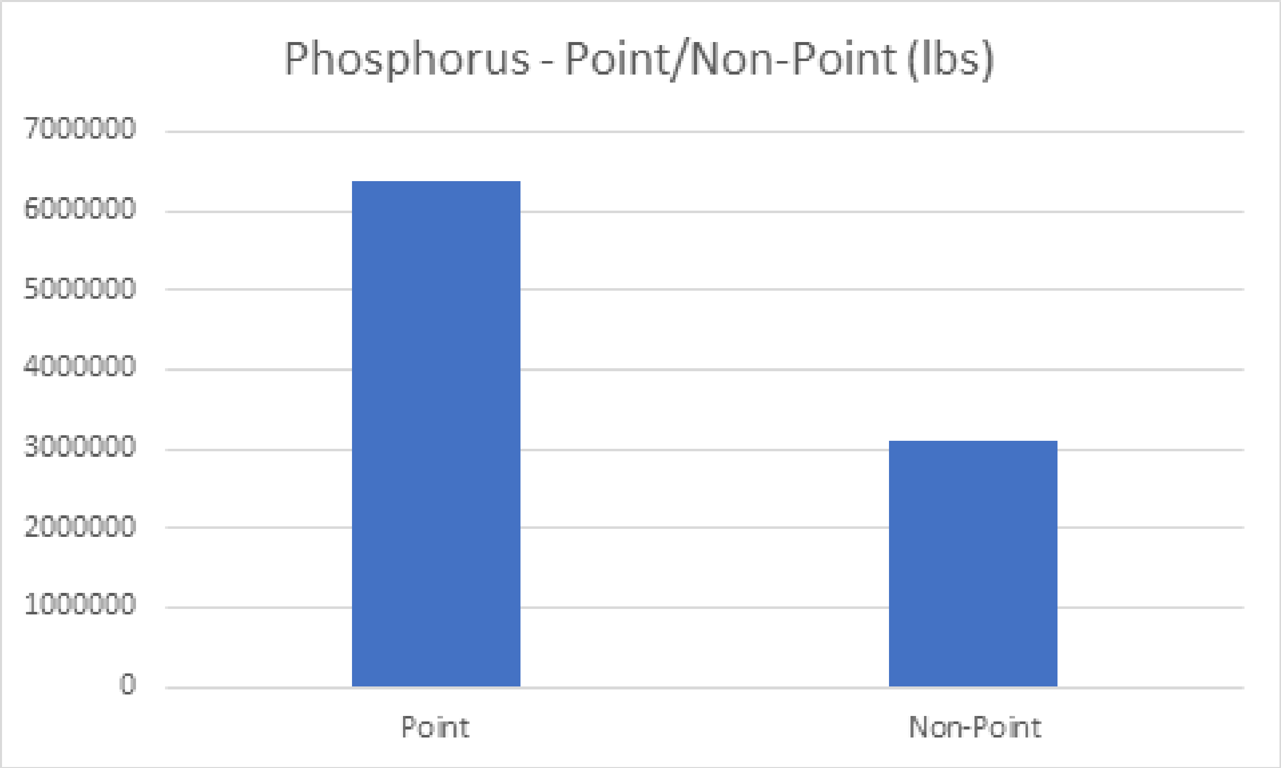
Question 1: How many pounds of nitrogen and phosphorus are currently being discharged into Long Island Sound? And what is the breakdown by source?



Point and non-point phosphorus load for the Long Island Sound watershed (United States Geological Survey, 2020)

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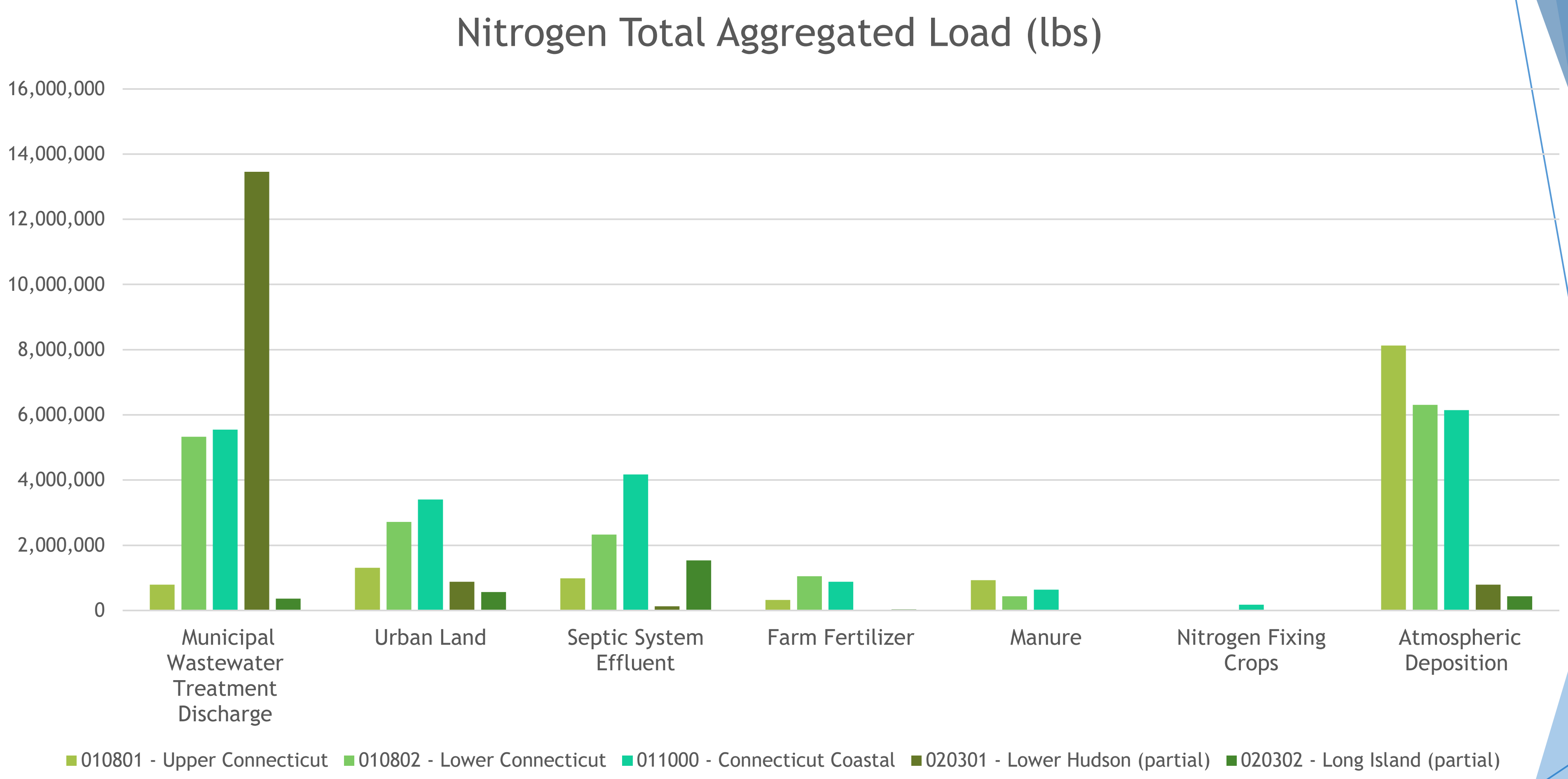

Source: United States Geological Survey, 2020.

Question 2: How do the current discharges of nitrogen and phosphorus compare to the limits that are in place?

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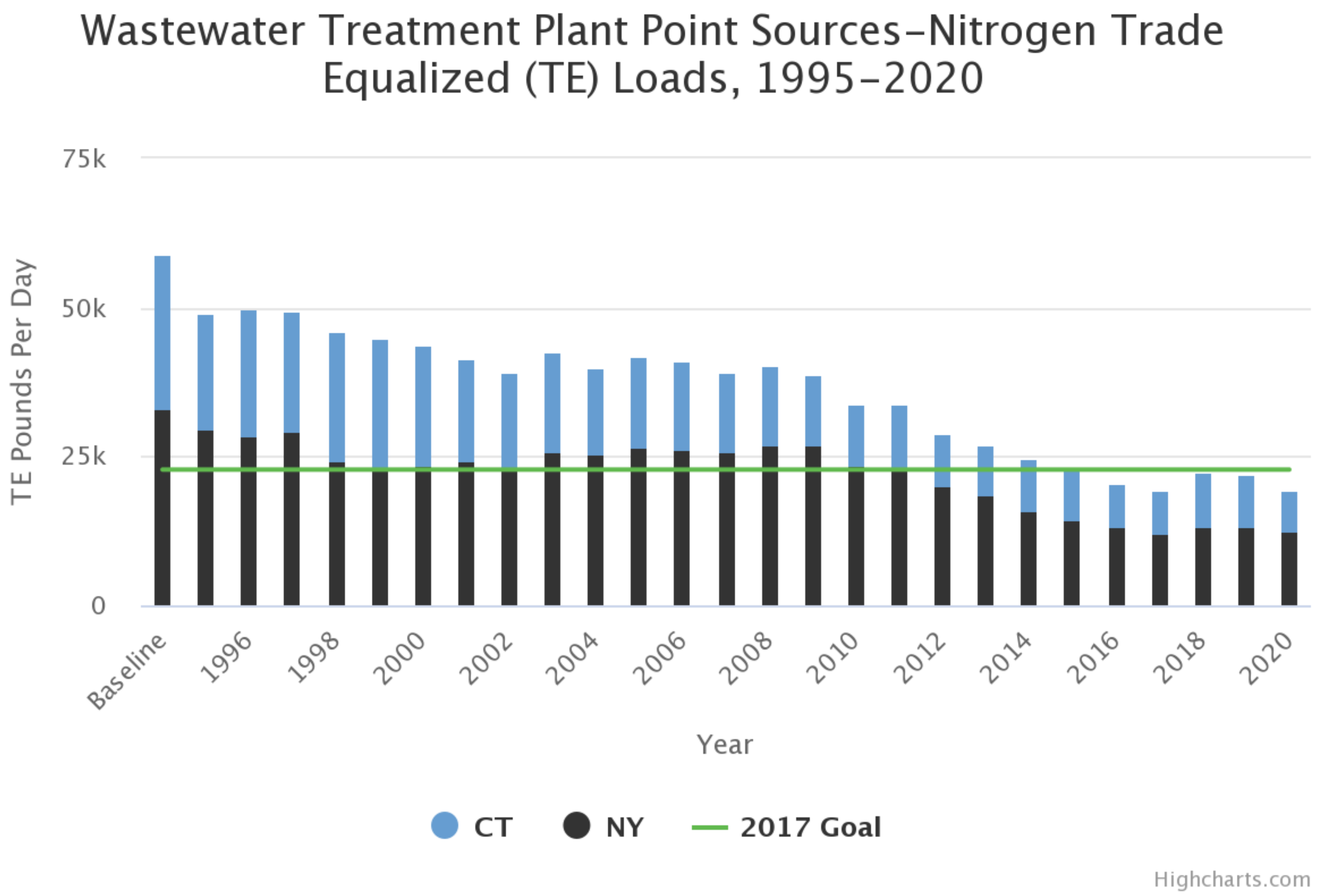

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(Source: Long Island Sound Study, 2020)

Point sources discharging into impaired waterways: percent over NPDES limits

Year	Nitrogen Load Over Limit	% Total Load	Phosphorus Load Over Limit	% Total Load
2012	14,549	0.07%	801	0.08%
2013	3,786	0.02%	1,094	0.02%
2014	4,679	0.03%	577	0.02%
2015	2,887	0.02%	1,555	0.07%
2016	2,127	0.01%	349	0.01%
2017	12,718	0.01%	908	0.02%
2018	7,784	0.05%	385	0.01%
2019	10,955	0.07%	40,418	1.02%
2020	3,755	0.00%	10,680	0.24%

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Source: ECHO

Question 2 (continued): How do the current discharges of nitrogen and phosphorus compare to the limits that are in place?

- Addressing nitrogen and phosphorus reductions from nonpoint sources will be more challenging.
- 75 percent of nitrogen loads in the Long Island Sound Study area comes from non-point sources, while reverse is true for phosphorus.
- Very few cases of WWTPs in the watershed exceeding their allocated load.
- Atmospheric deposition is an issue.

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Question 3: What are the possible physical strategies (BMPs) that could be followed in order to reduce nitrogen and phosphorus from entering Long Island Sound?

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Question 3 (continued): What are the possible physical strategies that could be followed in order to reduce nitrogen and phosphorus from entering Long Island Sound?

- Rain gardens
- Bioretention
- Bio-swale
- Filters
- Tree Planting
- Infiltration Basins or Trenches
- Catch Basin Cleaning
- Stream Restoration
- Wet Ponds and Wetlands
- And others…

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Question 4: What are the costs per pound of these strategies, and how do the costs of these strategies compare to the cost per pound of treatment facility upgrades?

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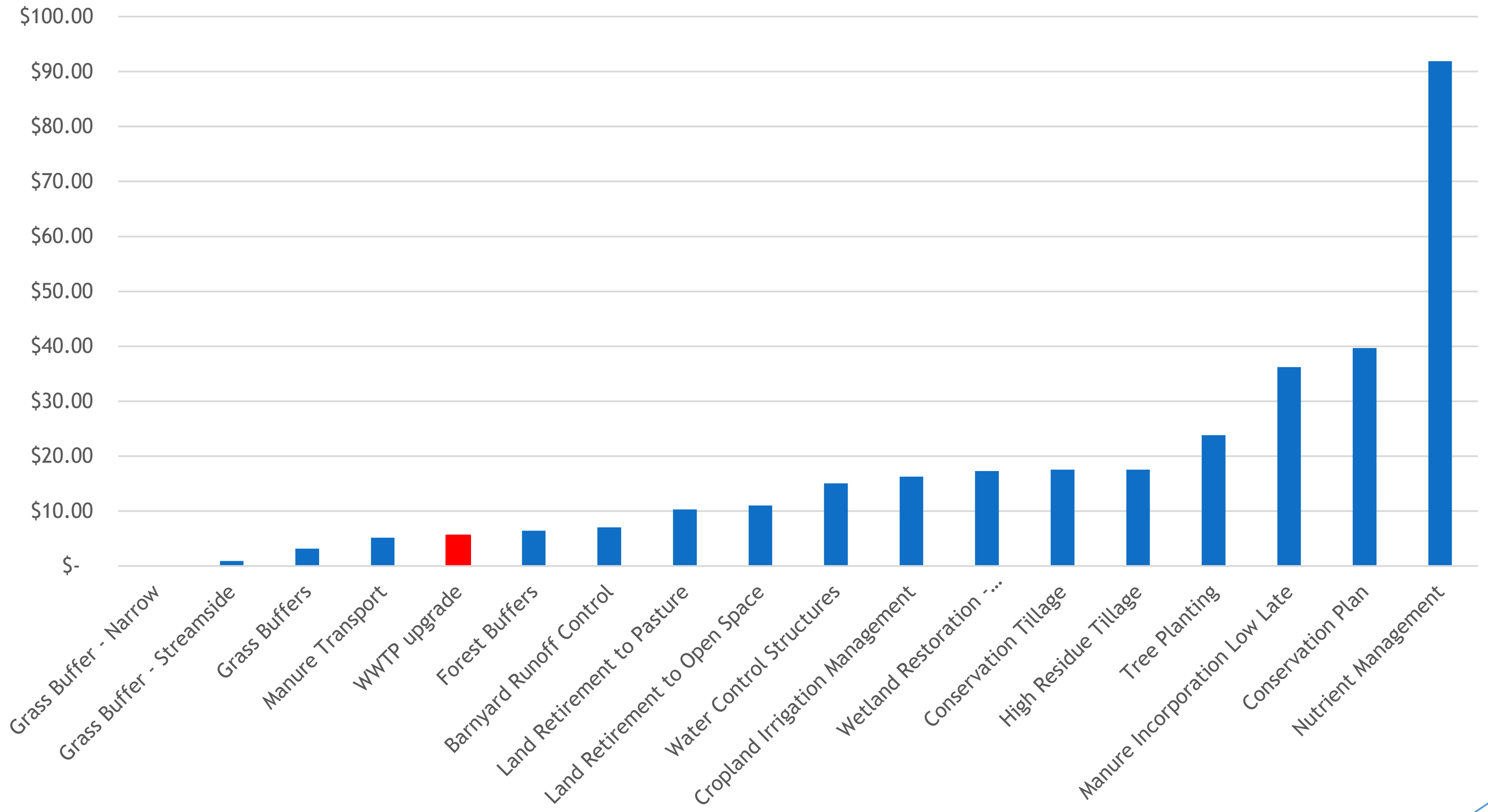
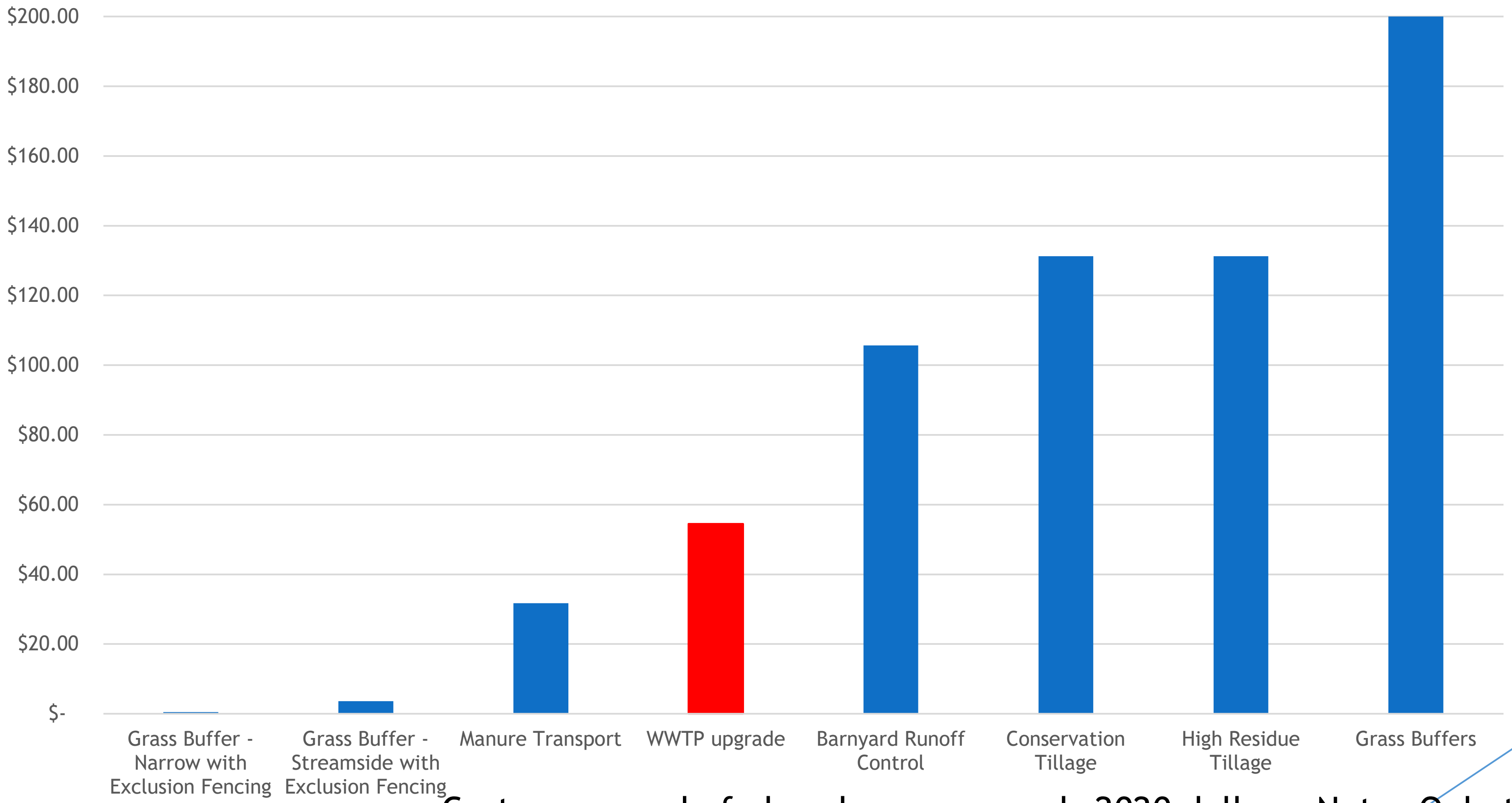
*Question 4, part 1: What are the costs per pound of BMPs for **nitrogen**, and how do the costs of these strategies compare to the cost per pound of treatment facility upgrades?*



Cost per pound of nitrogen removal. 2020 dollars. Note: Only those less than $100 per pound are included in the table. *(Source: Price et al, 2019)*

*Question 4, part 1: What are the costs per pound of BMPs for **phosphorus**, and how do the costs of these strategies compare to the cost per pound of treatment facility upgrades?*



Cost per pound of phosphorus removal. 2020 dollars. Note: Only those less than $200 per pound are included in the table. *(Source: Price et al, 2019)*

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Question 5: What are the likely "wedges" between supply and demand?

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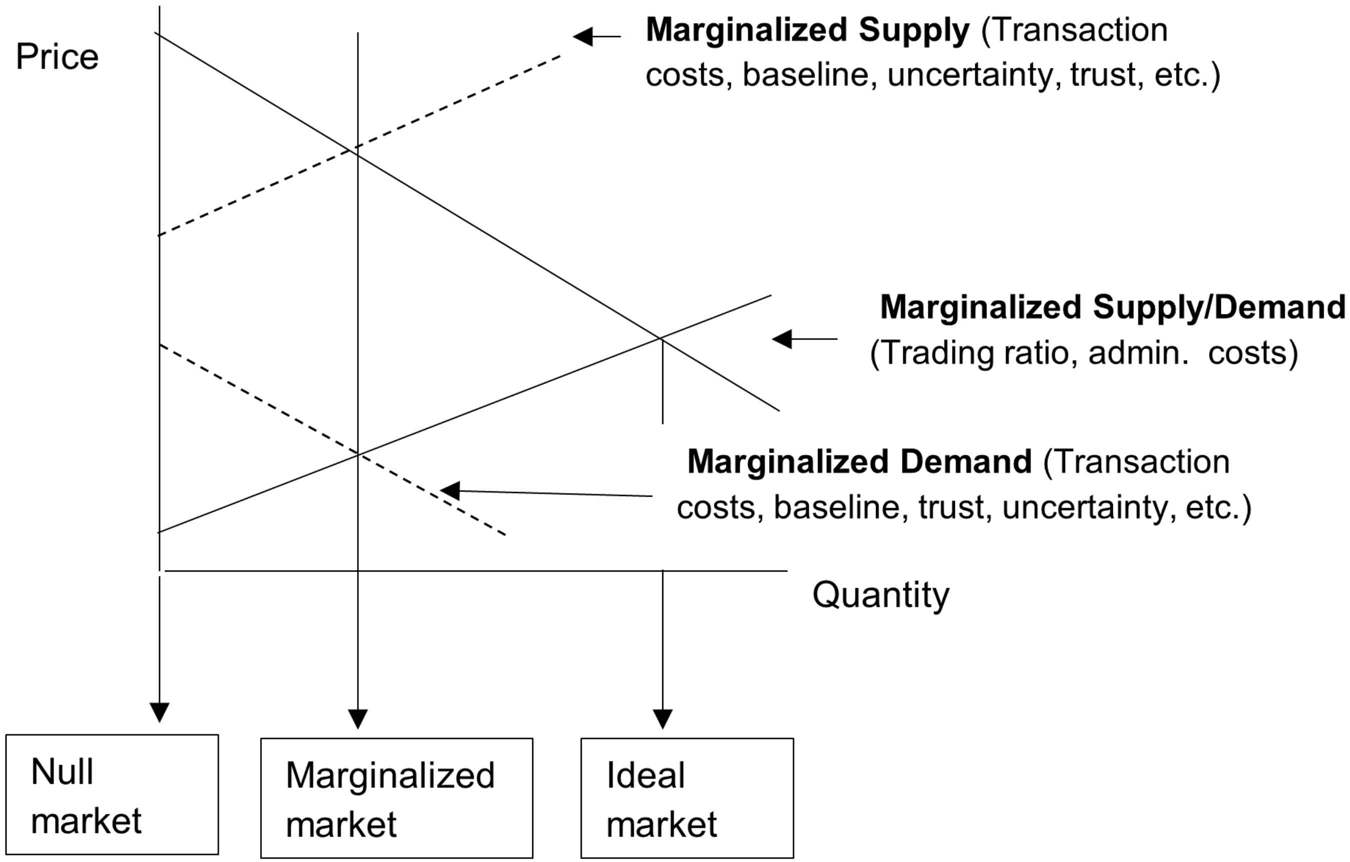
Question 5: What are the likely "wedges" between supply and demand?



(Source: Adapted from Hoag et al., 2017)

“Wedges” Between Supply and Demand

- Farmers’ willingness to participate
- Trust and perceived fairness
- Administrative costs (regulatory design, credit creation, market transaction, monitoring and enforcement)
- Trading ratio
- Uncertainty

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Question 6: What trends are likely to affect these economic factors in the future?

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Factors Influencing Potential Demand

- Regulatory pressure
- Population growth
- Growth in impervious surface area
- Transactions costs
- Cost of alternatives to trading
- Geographic area

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Factors Influencing Potential Supply

- Share of land cover in agriculture
- Shellfish and seaweed aquaculture
- Opportunity cost of installing BMPs
- Baseline
- Geographic restrictions

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Conclusions/Implications

- Under current conditions, potential for trading is marginal at best.
- Point sources generally meeting their allocated loads.
- In other trading schemes, demand seems to be the "limiting reagent" in any trades. Scenario seems to be similar here.
- Supply is a wildcard – we don't know how much potential supply is out there without a comprehensive survey of farms / MS4s to determine how much they are discharging, what kind of BMPs are in place (if any), and what reductions are possible.
- We also don't know how willing the "sellers" are going to be.
- Interstate trading has never arisen in the Chesapeake Bay. Not likely to be politically viable, even if it were ecologically sound (also not likely).
- Personally (and this is an opinion, rather than something I can demonstrate), stormwater may be the best bet for trading, rather than ag. But there's a **difference between economically viable and ecologically viable**.

THANK YOU!

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References

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- Hoag, D. L. K., Arabi, M., Osmond, D., Ribaudo, M., Motallebi, M., & Tasdighi, A. (2017). Policy Utopias for Nutrient Credit Trading Programs with Nonpoint Sources. *JAWRA Journal of the American Water Resources Association*, *53*(3), 514–520. https://doi.org/10.1111/1752-1688.12532
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- Price, E., Holladay, T., & Waigner, L. (2019). *Cost Analysis of Stormwater and Agricultural Practices for Reducing Nitrogen and Phosphorus Runoff in Maryland*. University of Maryland Center for Environmental Science.
- United State Environmental Protection Agency. (2021). Various Discharge Monitoring Reports. Enforcement Compliance History Online Water Pollution Search Tool | ECHO | US EPA. EPA. https://echo.epa.gov/trends/loading-tool/water-pollution-search.
- United States Geological Survey. (2020). 2012 SPARROW Models for the Northeast: Total Phosphorus, Total Nitrogen, Suspended Sediment, and Streamflow. Retrieved from USGS.gov: https://sparrow.wim.usgs.gov/sparrow-northeast-2012/

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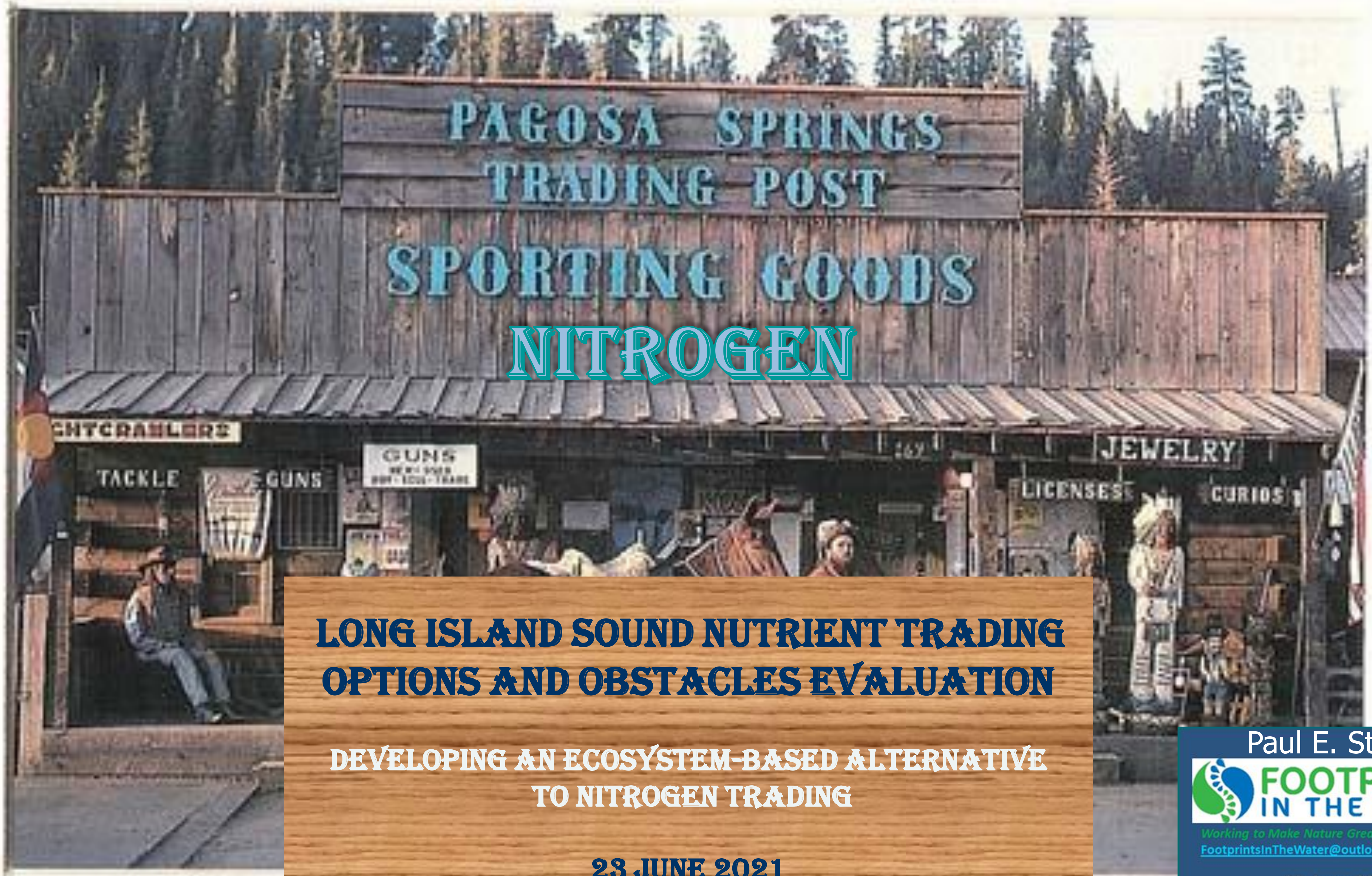
Trading in the Ecosystem Context

Paul Stacey, Footprints in the Water, LLC



LONG ISLAND SOUND NUTRIENT TRADING OPTIONS AND OBSTACLES EVALUATION

DEVELOPING AN ECOSYSTEM-BASED ALTERNATIVE TO NITROGEN TRADING

23 JUNE 2021

Paul E. Stacey
FOOTPRINTS IN THE WATER
Working to Make Nature Great Again
FootprintsInTheWater@outlook.com

23 June 2021

A Work in Progress:

Long Island Sound Study
A Partnership to Restore and Protect the Sound

LISS Enhancement Project

Development of a Watershed and Nonpoint Source Decision Support Framework and Tool at a Local Scale using a Conservation Approach

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
Center for Land Use Education & Research
CLEAR

Chet Arnold **Cary Chadwick**
Emily Wilson **David Dickson**
Qian (Rachel) Lei-Parent

CONNECTICUT ENERGY ENVIRONMENT

Chris Bellucci
Mary Becker

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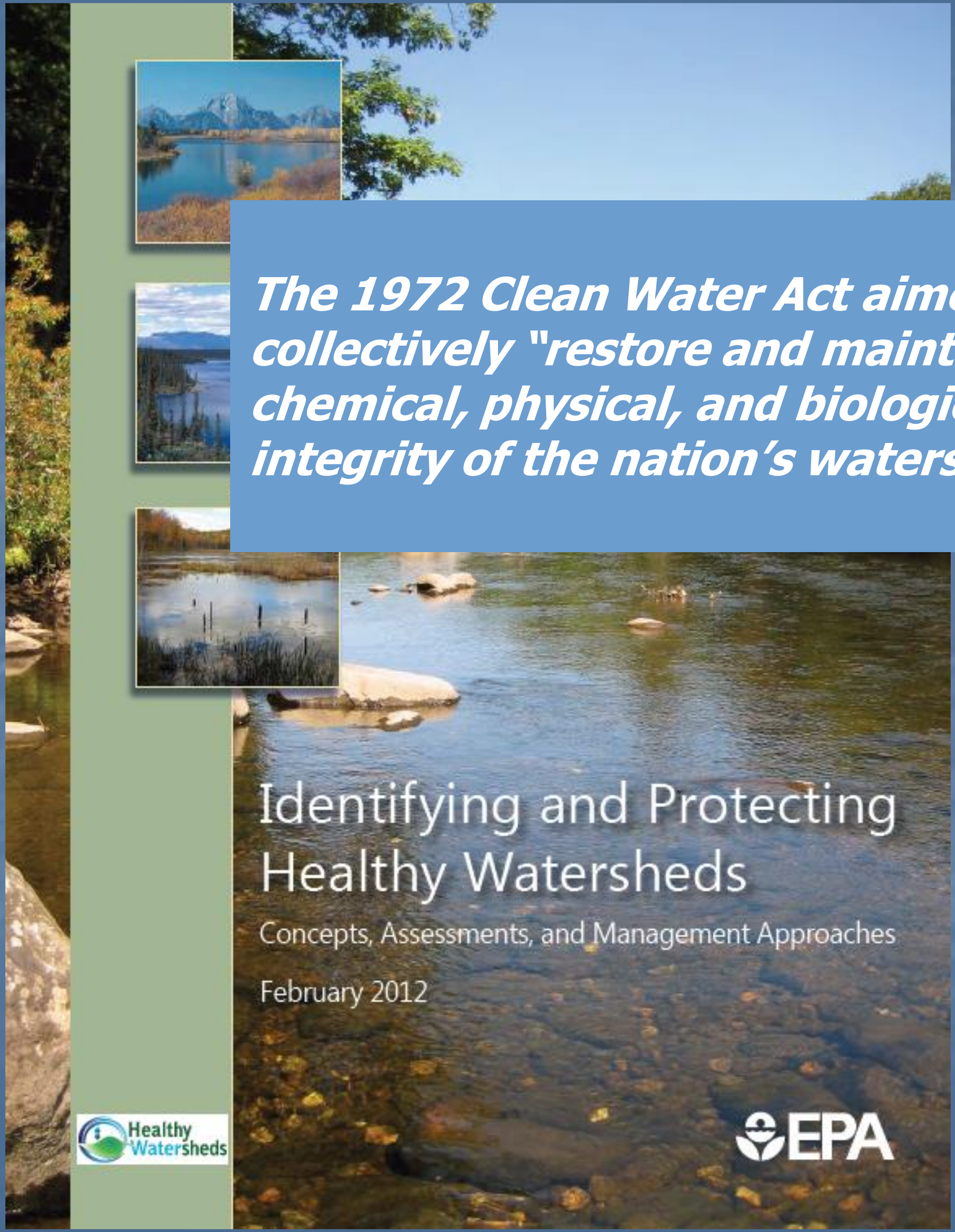
Management Challenges:

Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html

NASA Earth Observatory

Ecosystem Management Goal:

The 1972 Clean Water Act aimed to collectively "restore and maintain the chemical, physical, and biological integrity of the nation's waters."



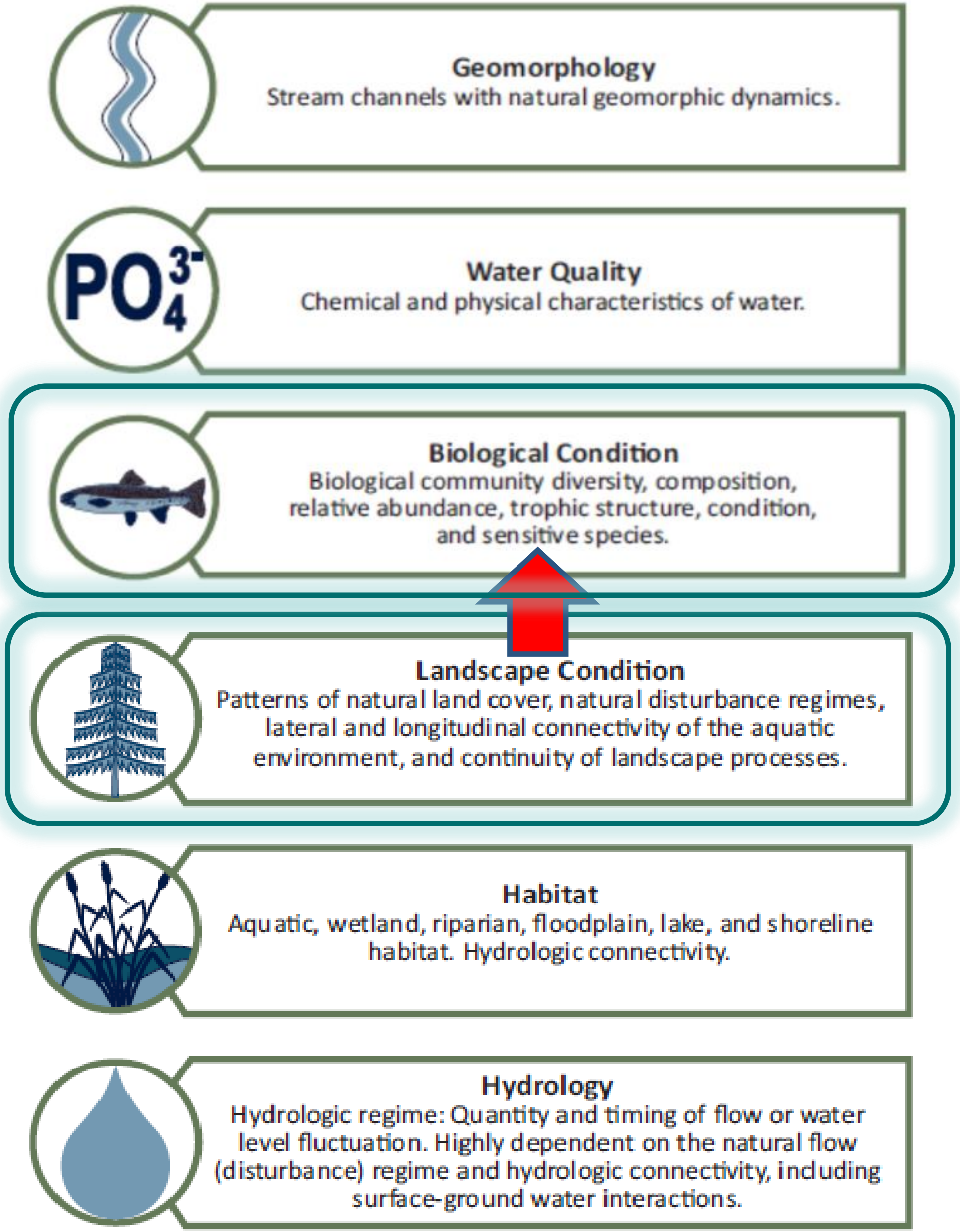
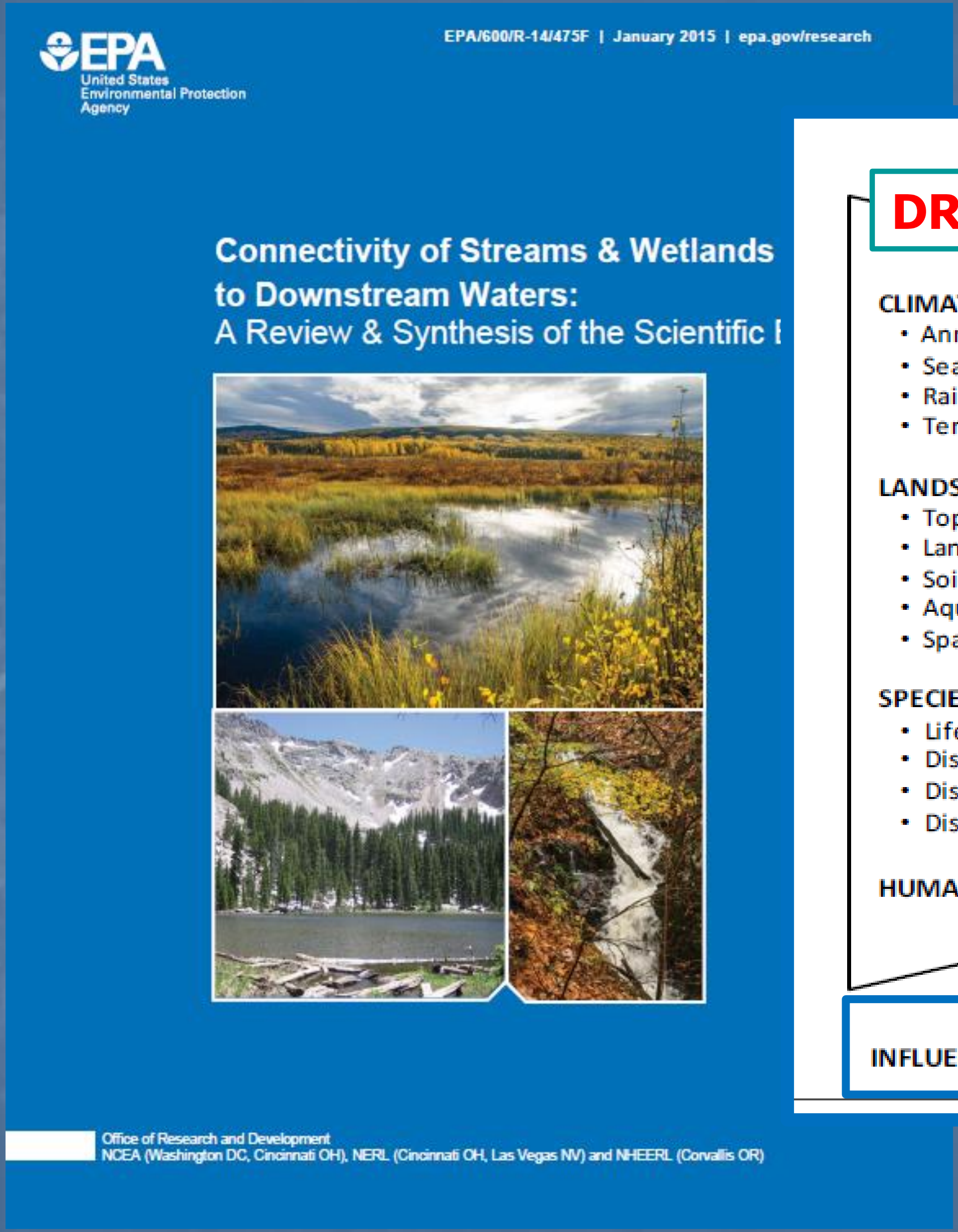
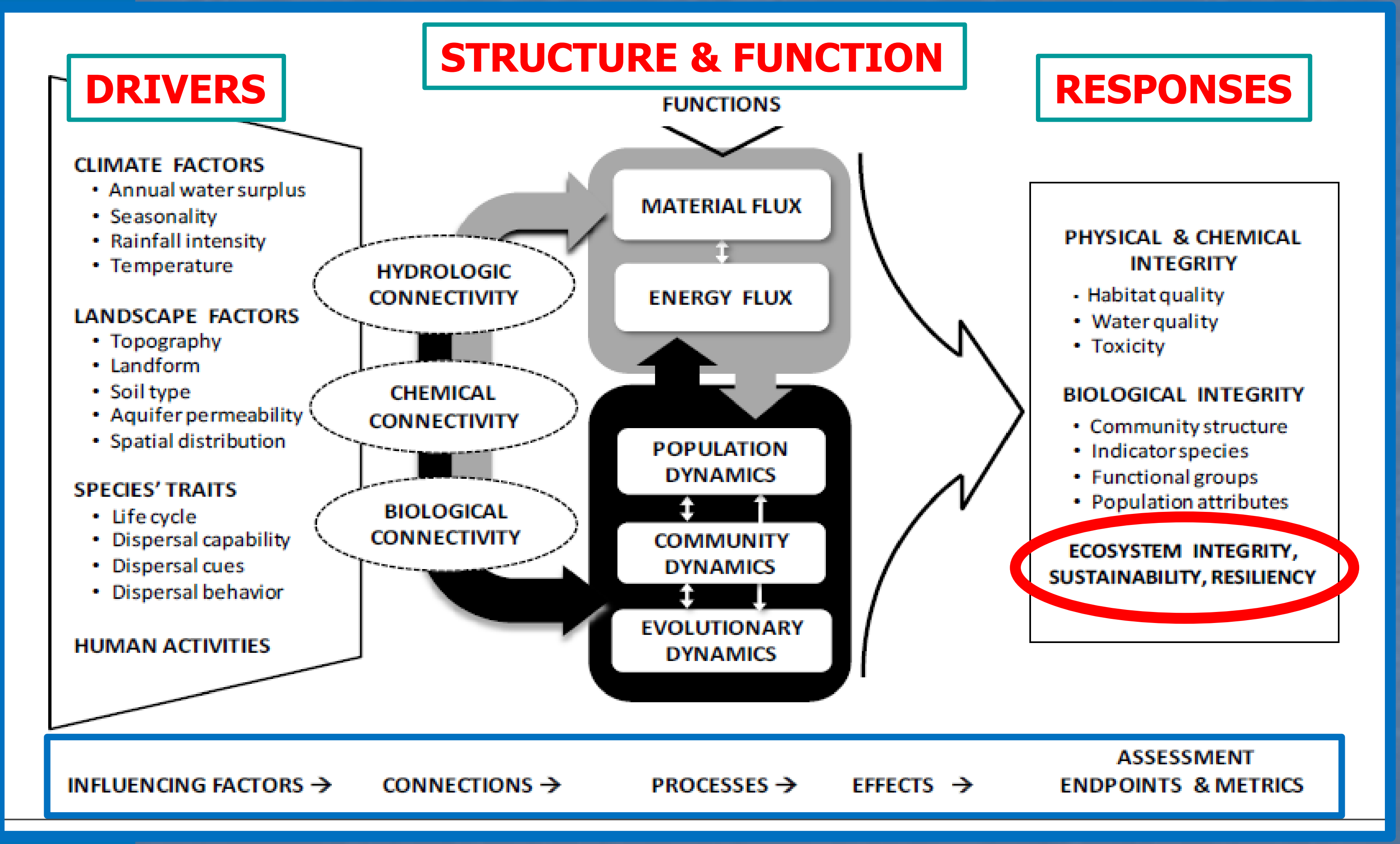


Figure 2-4 Healthy watersheds assessment components

Making the Connection:





How's it Going?

United States Government Accountability Office

GAO

Report to Congressional Requesters

December 2013

CLEAN WATER ACT

Changes Needed If Key EPA Program Is to Help Fulfill the Nation's Water Quality Goals

- **Pollutants had been reduced in many waters, but *few impaired water bodies have fully attained water quality standards.***

GAO-14-80

United States Government Accountability Office

GAO

Report to the Honorable Sheldon Whitehouse, U.S. Senate

October 2017

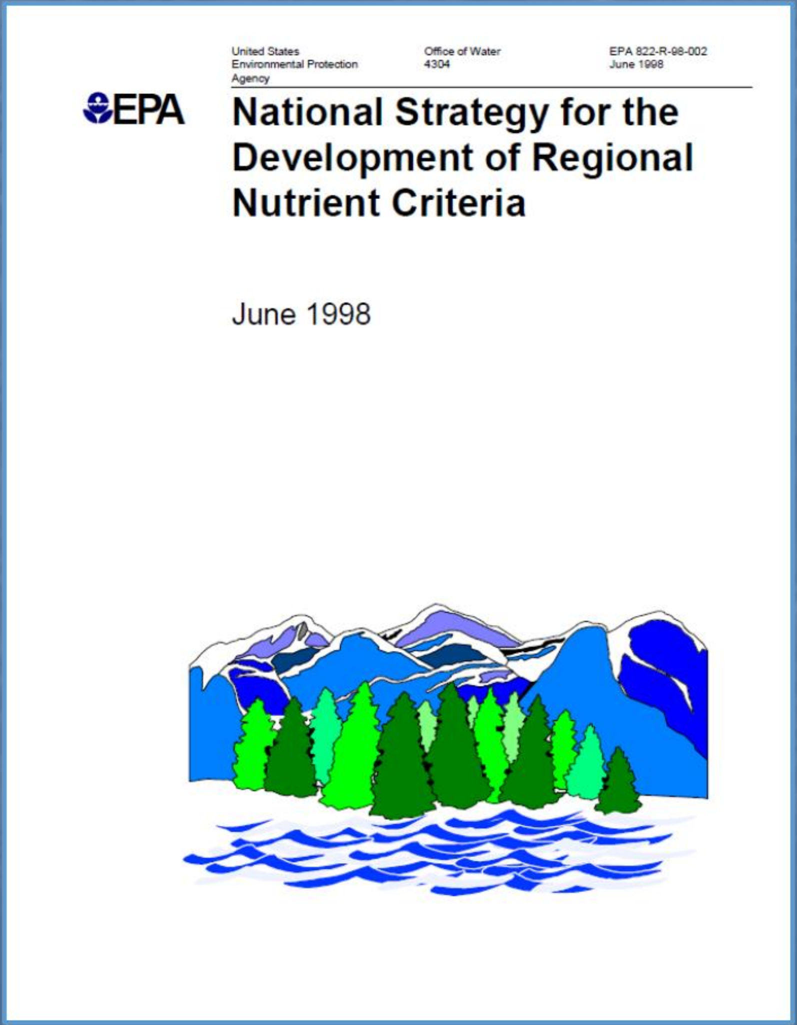
WATER POLLUTION

Some States Have Trading Programs to Help Address Nutrient Pollution, but Use Has Been Limited

- ***The importance of nutrient discharge limits***
- ***The challenges and uncertainties of nonpoint source nutrient reductions***

GAO-18-84

What Ever Happened to Nutrient Criteria?



United States Environmental Protection Agency | Office of Water 4304 | EPA 822-R-98-002 June 1998

EPA

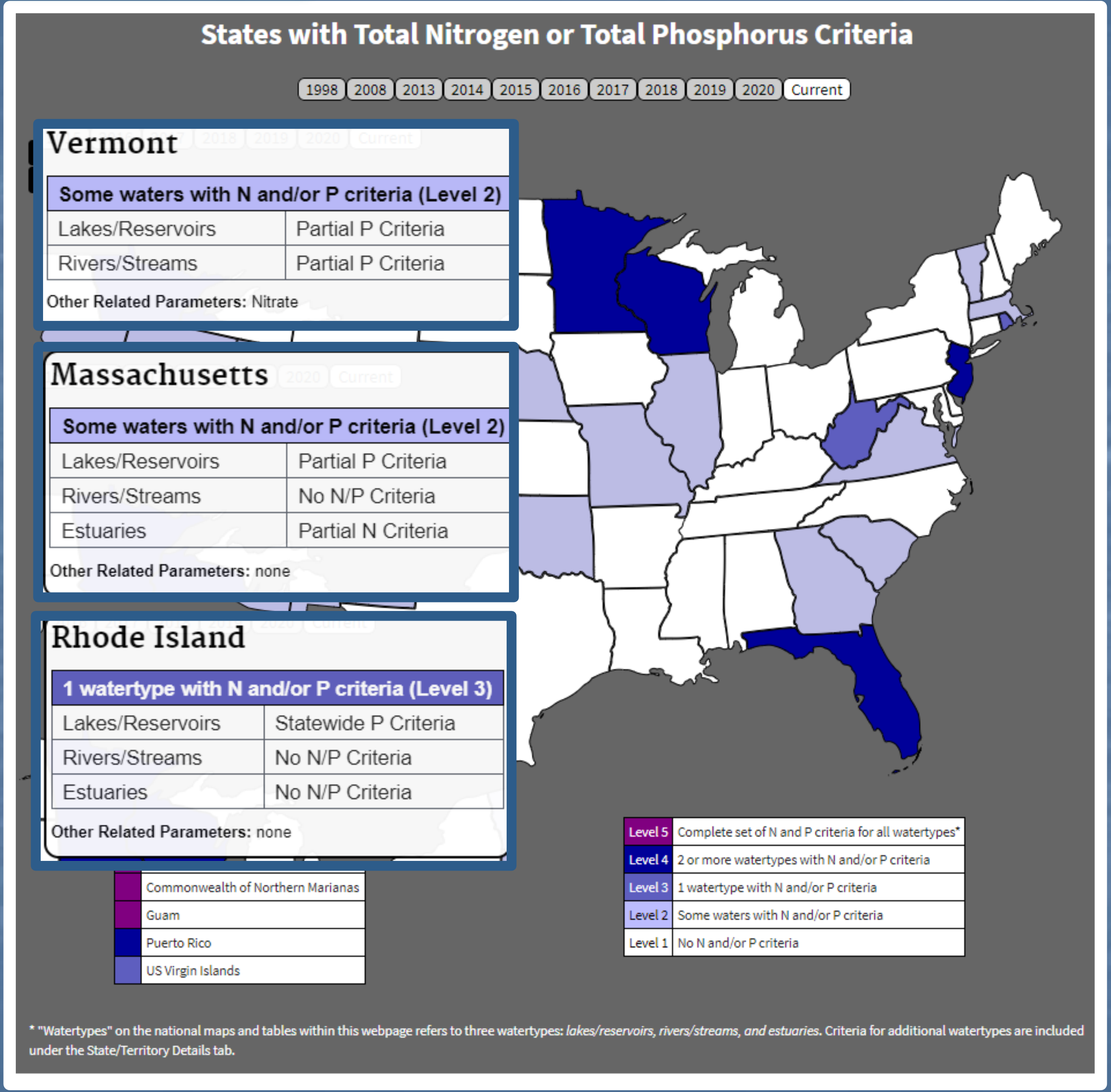
National Strategy for the Development of Regional Nutrient Criteria

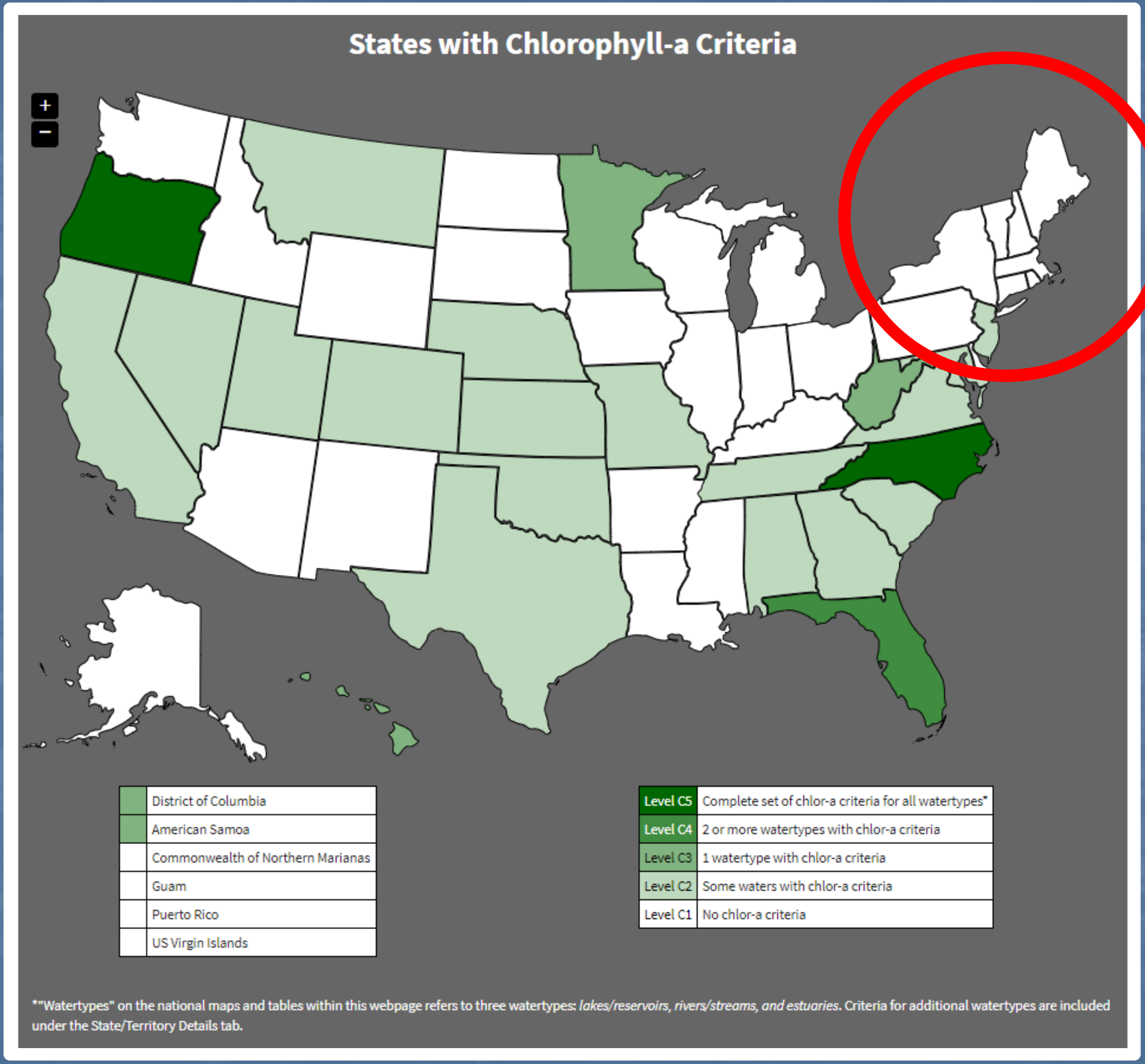
June 1998

The goal was for the States/Tribes to establish these criteria as part of their water quality standards *__within three years of completion of the guidance__* i.e., by the end of the calendar year *__2003__*

Nitrogen:

Nutrient Criteria Adoption Status

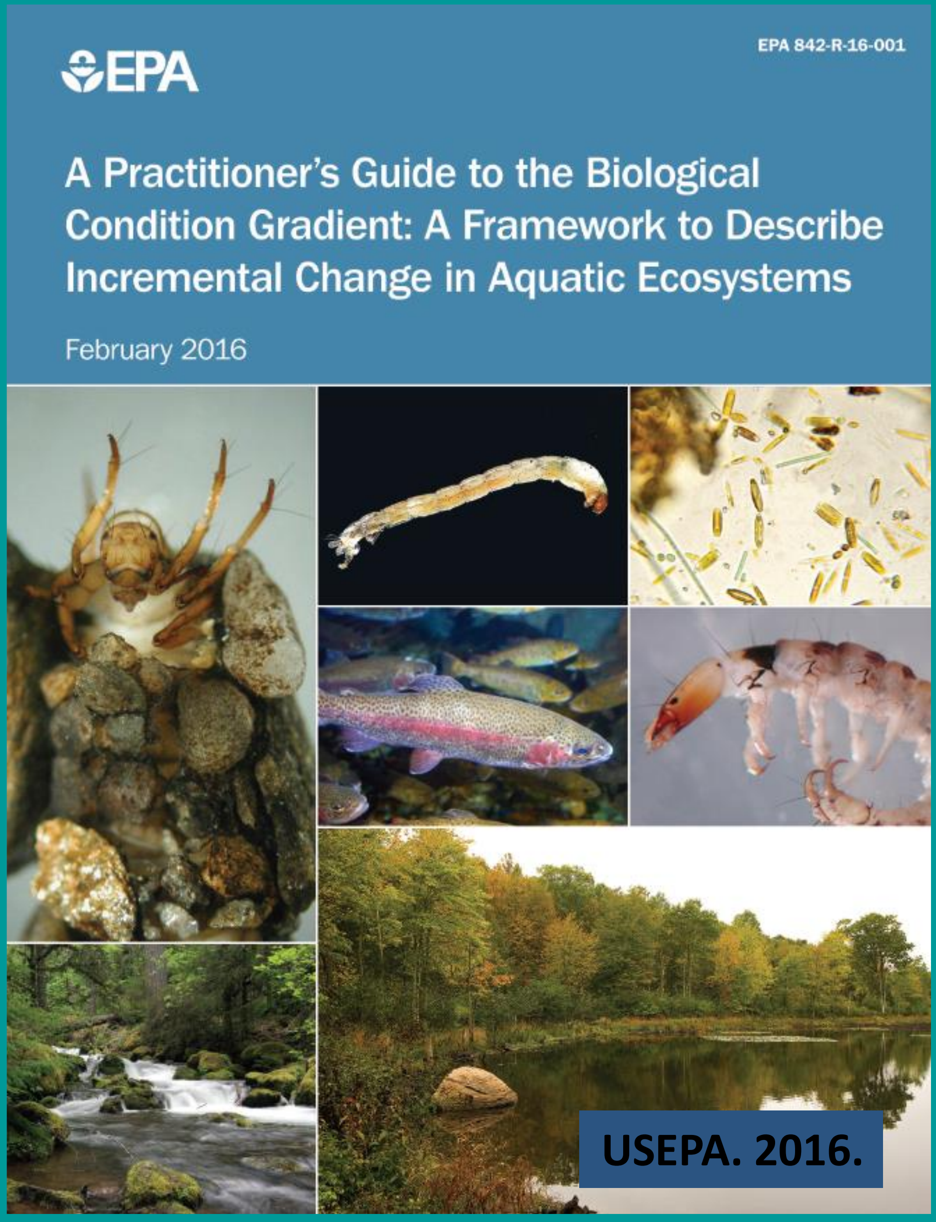




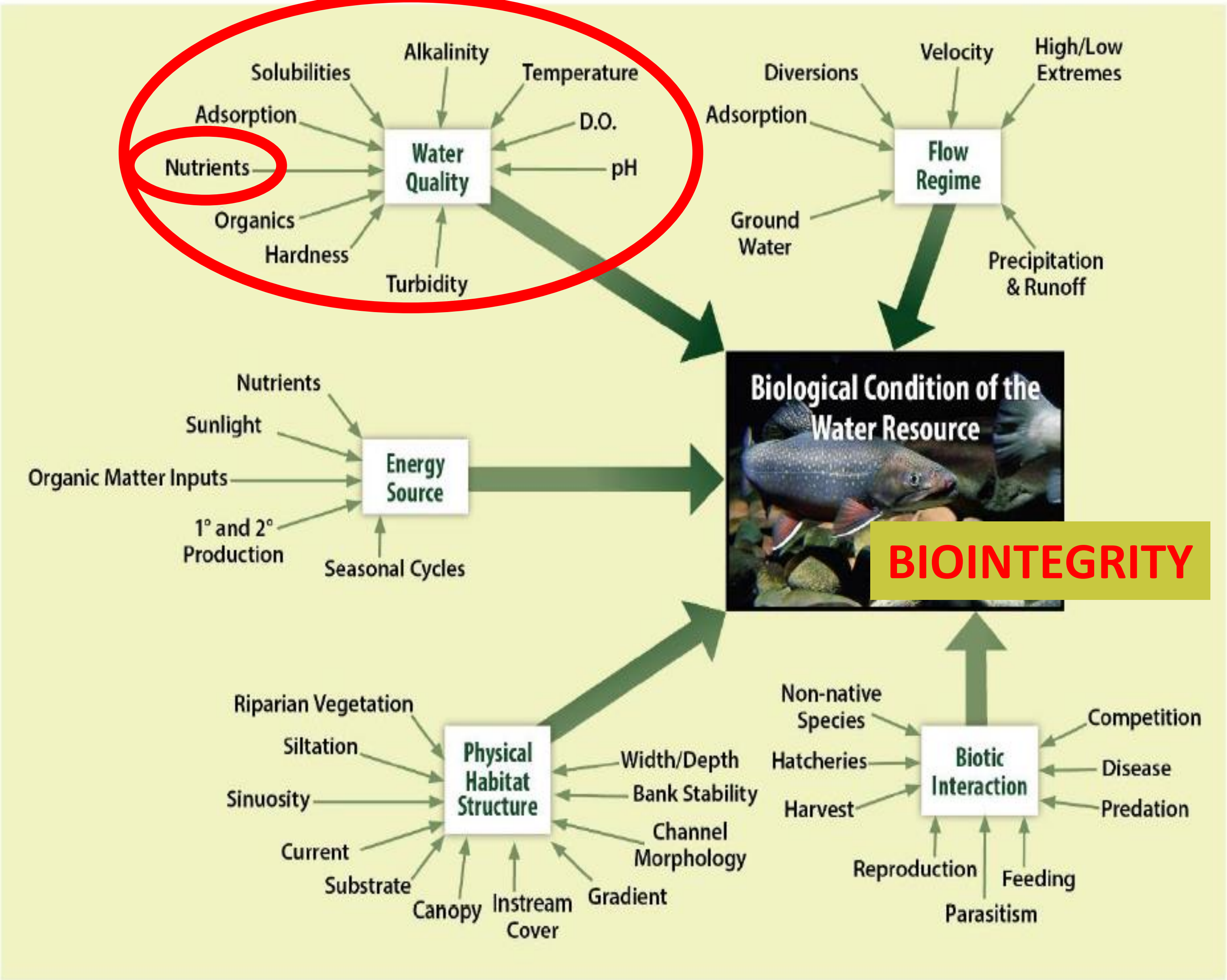
Trading Fundamentals

- Common water quality problem
- Technically feasible to meet pollutant reduction target
- Compelling member benefits, especially economic
- Ability to quantify and track pollutant loads
- Credit costs based upon agreed protocols
- Diverse market, viable supply and demand
- Reduce overall cost
- Transaction costs low relative to price

Causal Analysis:



Five Major Factors that Determine Biological Condition



Ecosystem Context:

Benefits of an Ecosystem Approach

- ***A single pressure index*** for assessment, planning and decision support
- ***Integrates and harmonizes*** multiple external drivers and pressures
- Relates to a robust ***response indicator*** of aquatic ecosystem ***health, and vulnerability***
- Incorporates a range of ecosystem ***functional outcomes*** reflective of ***structural health*** or condition to guide management
- ***Widely applicable*** throughout the trading domain
- Provides a ***simple and salient*** platform and currency for trading

Causal Analysis:

The Biological Condition Gradient (BCG)

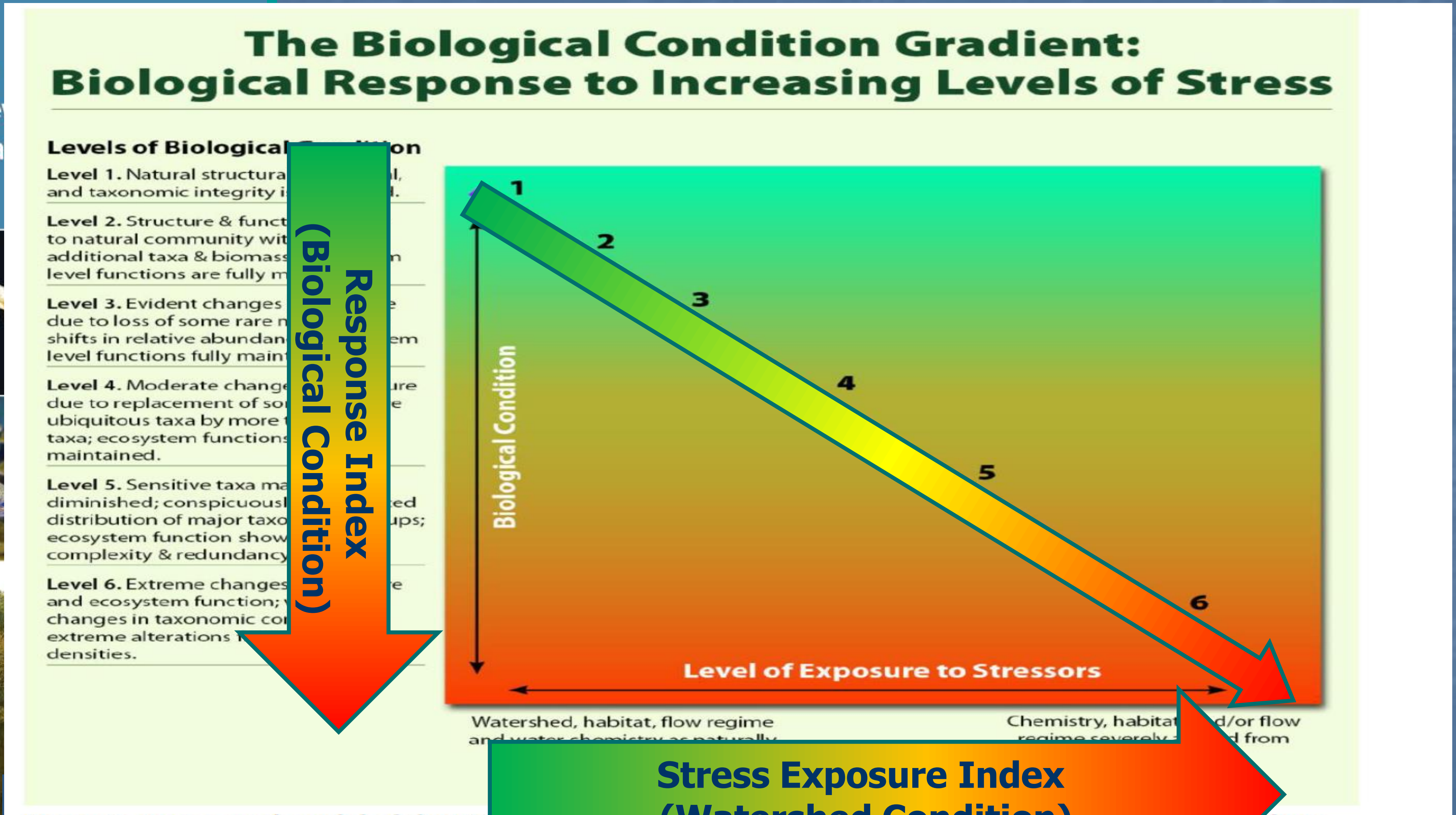
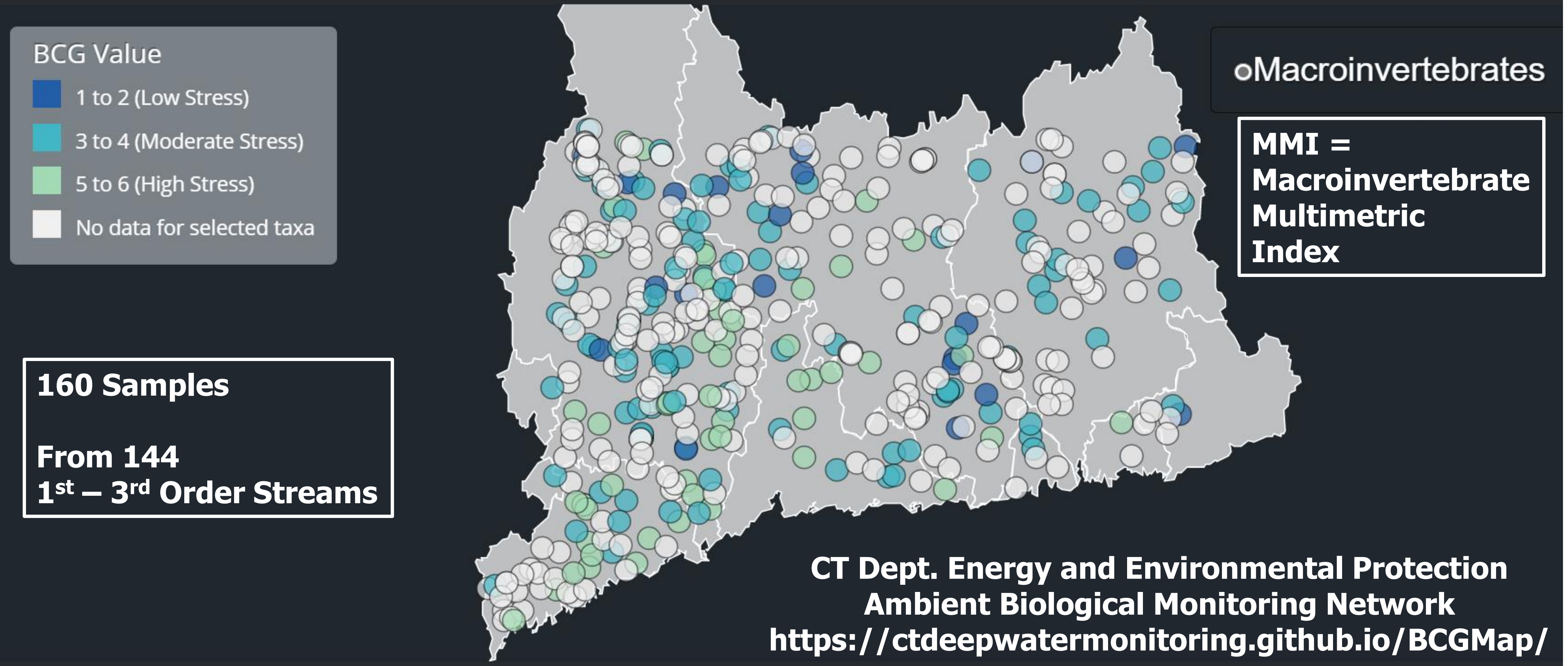


Figure 2. Conceptual model of the BC... their cumulative effects on the biota is likely nonlinear, the relationship is presented as such to il... ate the concept.

Macroinvertebrate Response Indicator:

Biological Condition Gradient (BCG) Data 2020 Assessments



MMI = Macroinvertebrate Multimetric Index

160 Samples

From 144
1st – 3rd Order Streams

CT Dept. Energy and Environmental Protection
Ambient Biological Monitoring Network
https://ctdeepwatermonitoring.github.io/BCGMap/

Land Cover Pressure Indicator:

Table 1. Aggregation of land cover classifications into three categories for data sets used in the analysis.

Aggregated Class	30-meter NLCD - 2011 WikiWatershed.org	30-meter CCAP - 2016 CLEAR	10-meter CCAP - 2016 CLEAR	1-meter CCAP - 2016 CLEAR
Natural	Deciduous Forest Evergreen Forest Mixed Forest Shrub/Scrub Woody Wetlands Emergent Herbaceous Wetlands Open Water	Grassland Deciduous Evergreen Mixed Forest Scrub/Shrub Bare Land Palustrine Forested Wetland Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Estuarine Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Unconsolidated Shore Bare Land Open Water	Upland Forest Scrub/Shrub Bare Land Palustrine Forested Wetland Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Estuarine Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Unconsolidated Shore Bare Land Open Water	Grassland Deciduous Evergreen Mixed Forest Scrub/Shrub Bare Land Palustrine Forested Wetland Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Estuarine Scrub/Shrub Wetland Emergent Wetland Aquatic Bed Unconsolidated Shore Bare Land Open Water
Agriculture-Like*	Barren Land (Rock/Sand/Clay) Grassland/Herbaceous Pasture/Hay Cultivated Crops	Developed Open Space Cultivated Land Pasture/Hay	Upland Herbaceous	Developed Open Space Cultivated Land Pasture/Hay
Developed*	Developed Open Space Low Intensity Medium Intensity High Intensity	High Intensity Medium Intensity Low Intensity	Impervious Cover	Impervious Cover

*Originally comprised the "Non-Natural" category.

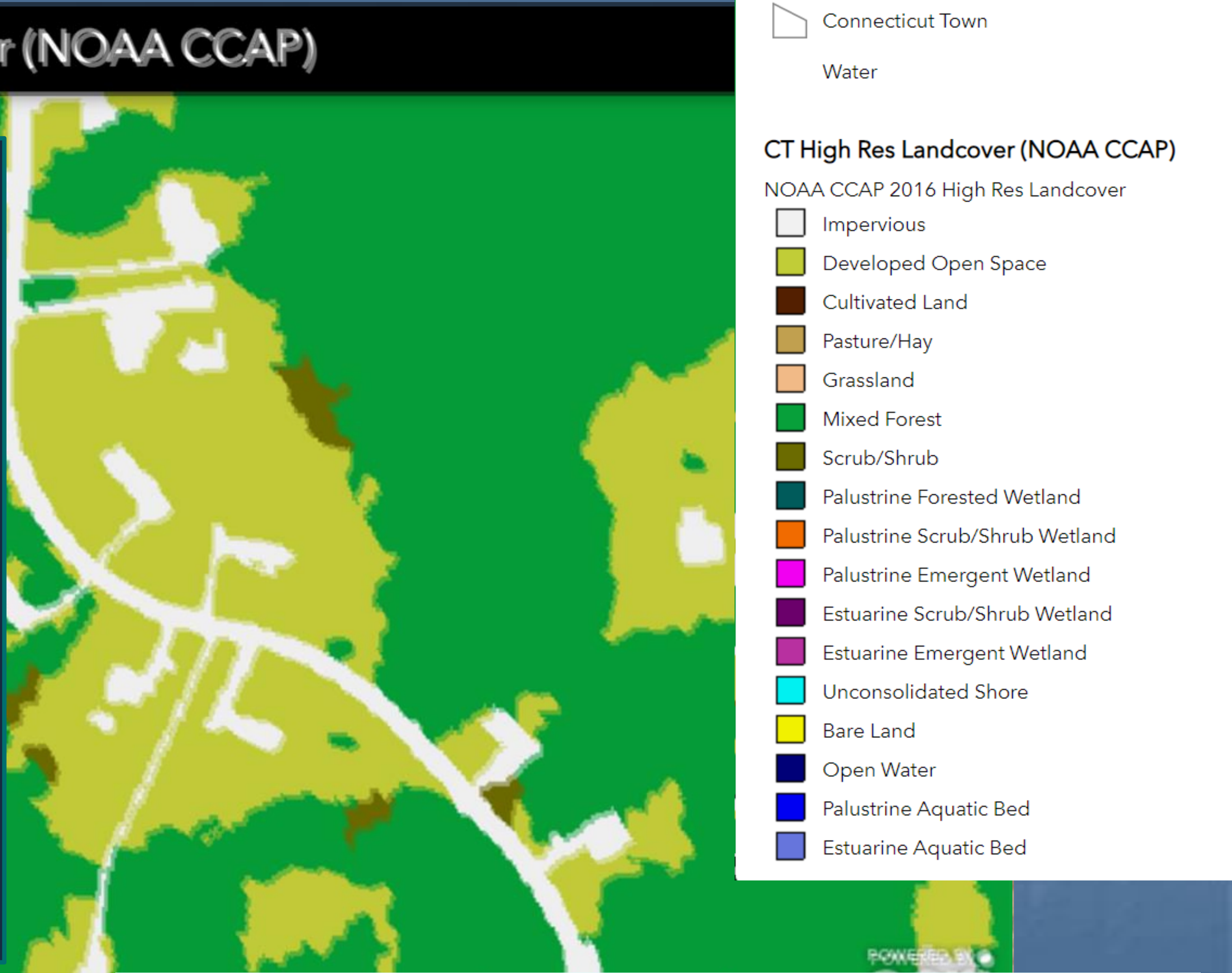
1-Meter Resolution!

- **Combined Condition Index (CCI)**

- **Watershed Condition (WCI)**
- **Buffer Condition (BCI)**

CCI =

WCI x (1+(BCI-WCI))



http://clear.uconn.edu/projects/landscape/highres/index.htm

The CCI Puts on Some Weight:

Land Class	Weight
Natural	1
Ag-Like	2
Developed/ Impervious	7

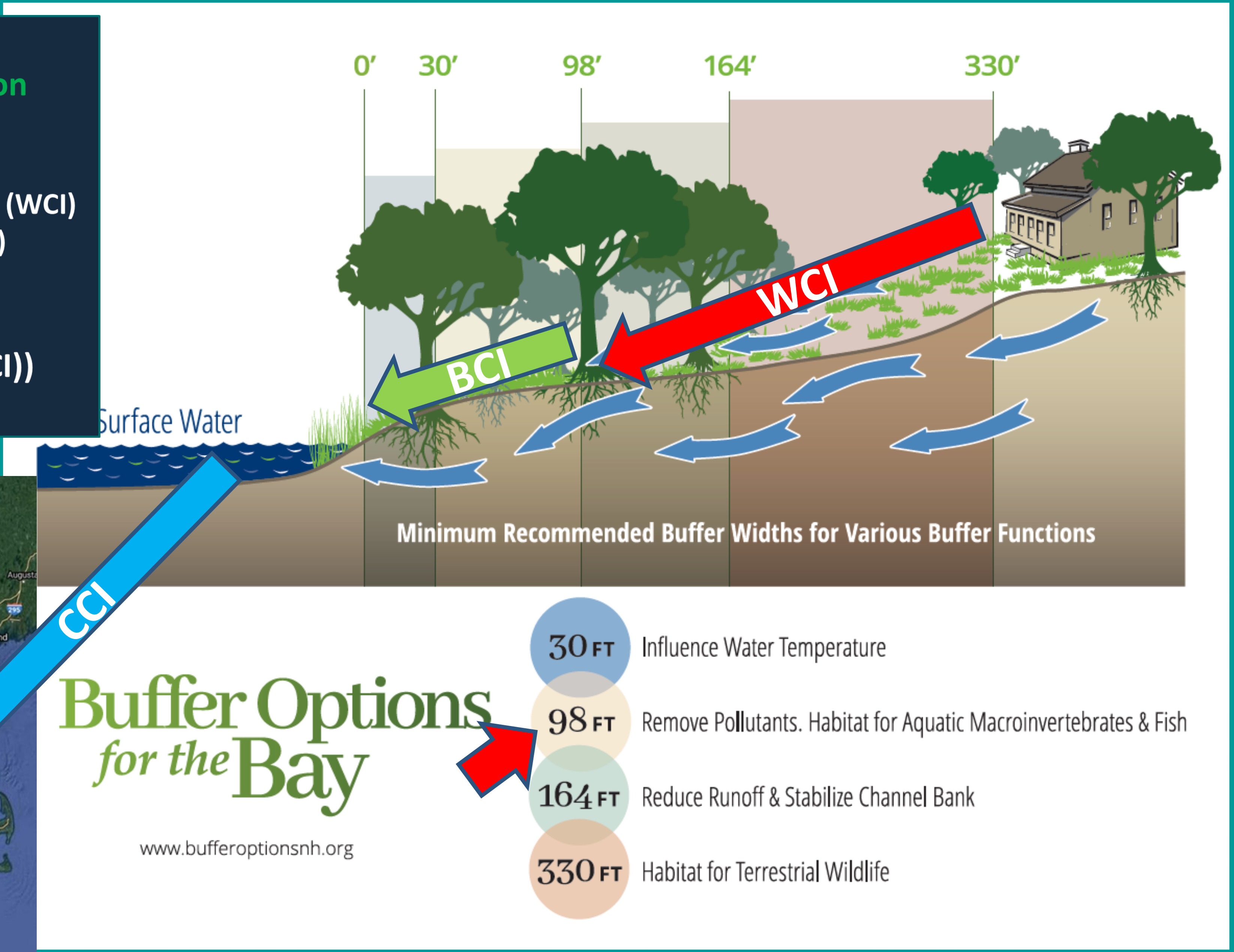
Indicator	Equation
Watershed Condition Index (WCI)	WCI = Natural acres/(Natural acres + (Ag-Like acres * 2) + (Developed acres * 7))
Buffer Condition Index (BCI)	BCI = Natural acres/(Natural acres + (Ag-Like acres * 2) + (Developed acres * 7))
Weighted Combined Condition Index (CCI)	Weighted CCI = WCI * (1 + (BCI – WCI))

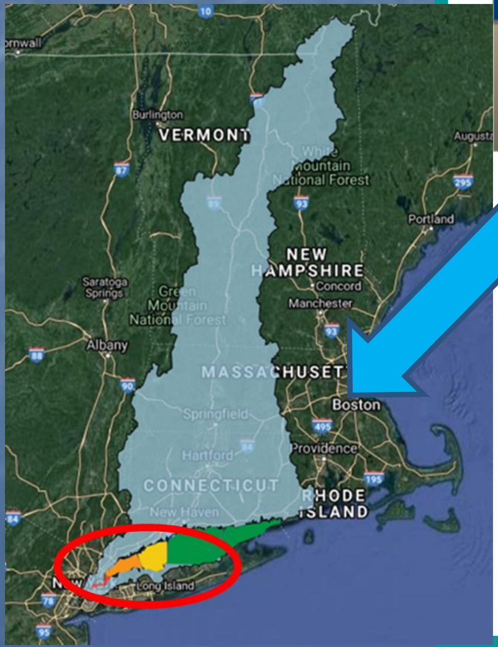
Buffer Structure & Function:

- **Combined Condition Index (CCI)**

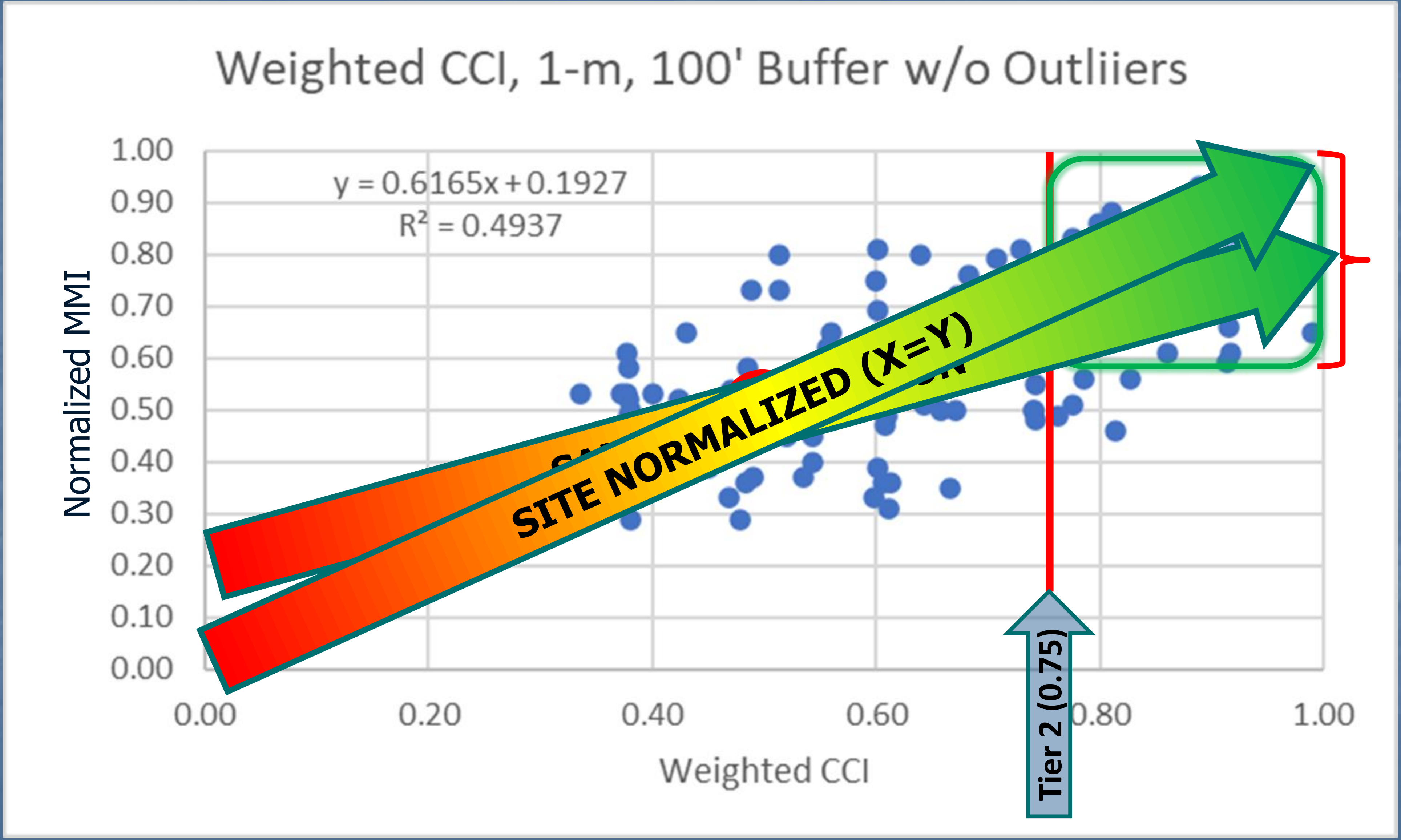
- Watershed Condition (WCI)
- Buffer Condition (BCI)

CCI =
WCI x (1+(BCI-WCI))



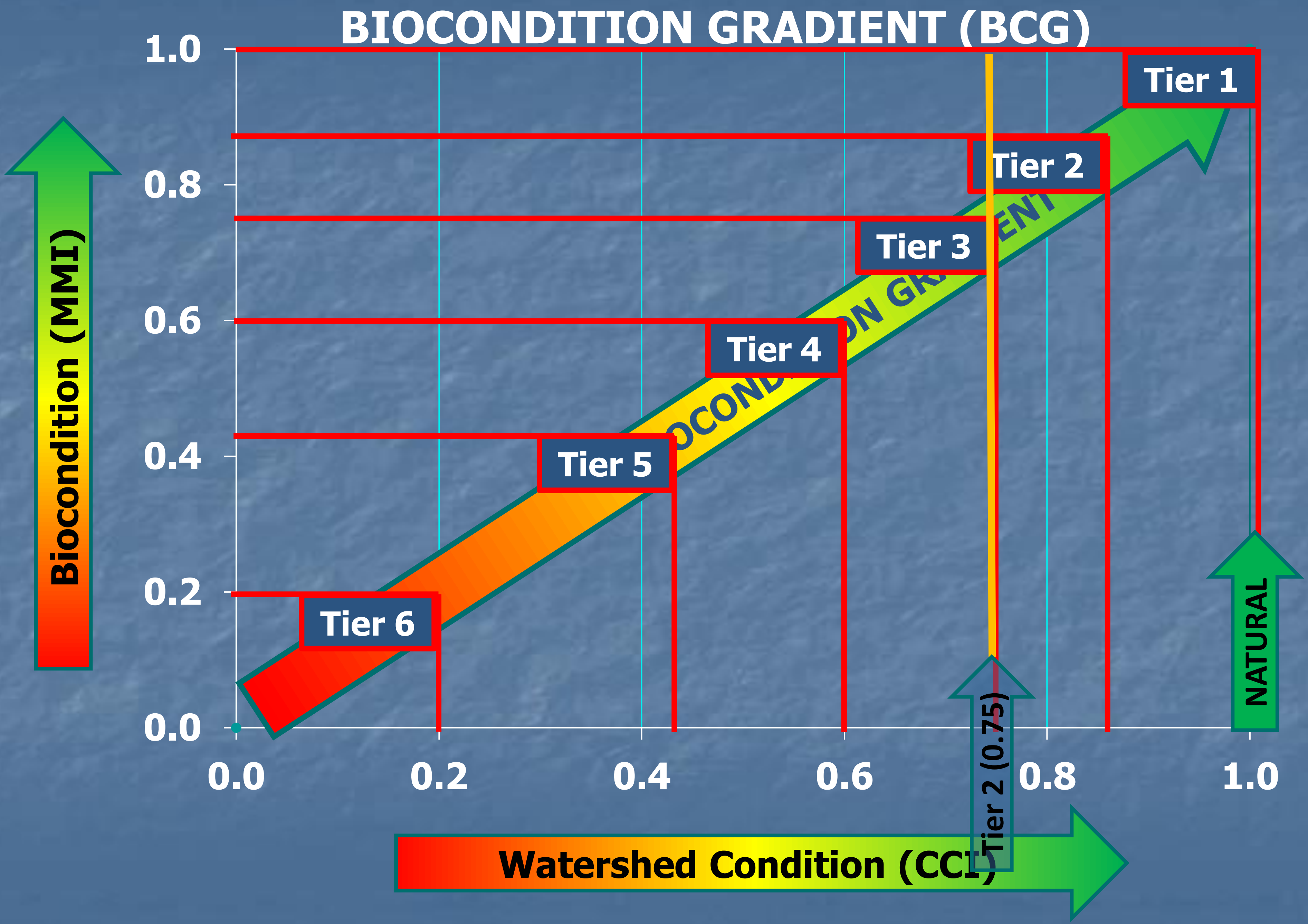


The Combined Condition Index:



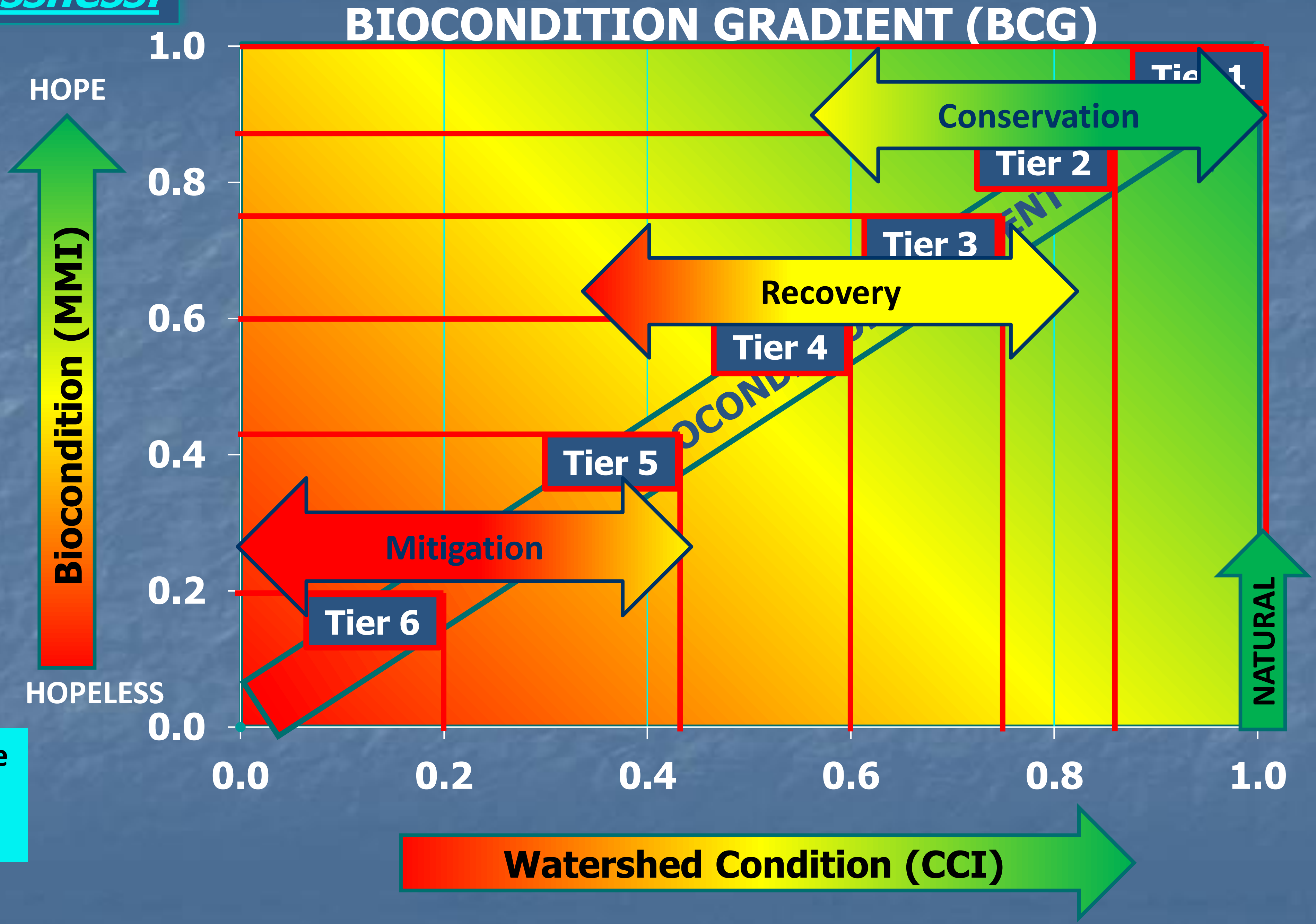
Benchmarking:

Tier	Benchmark
1	0.88
2	0.75
3	0.60
4	0.43
5	0.20
6	0.00



Hope and Hopelessness:

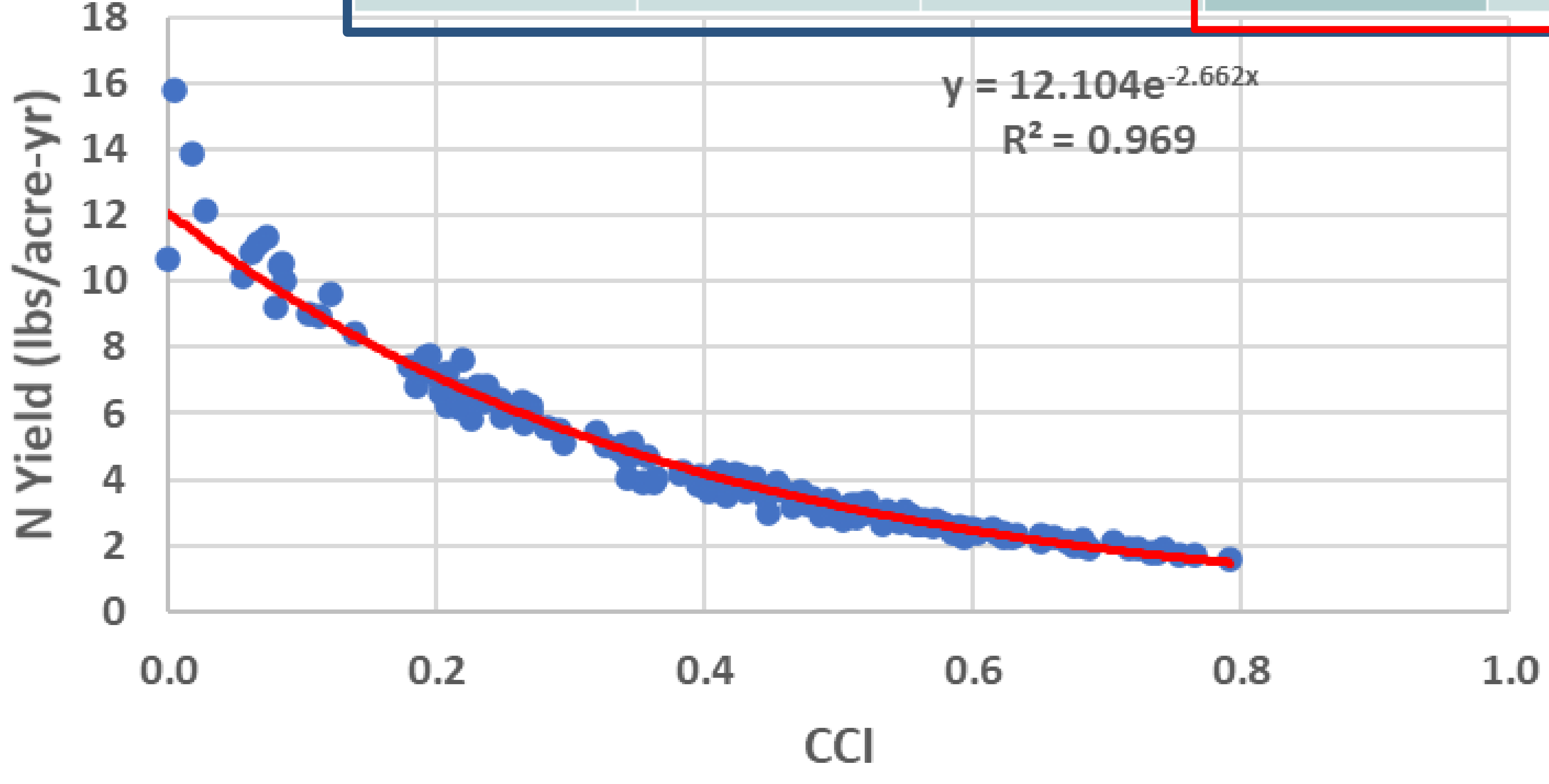
Tier	Benchmark
1	0.88
2	0.75
3	0.60
4	0.43
5	0.20
6	0.00



*After Bellucci, Beauchene and Becker (2008) *Streams of Hope* concept.

Nitrogen and the CCI:

Land Cover	LIS TMDL	Literature	CCI Input	CCI Export
Urban	12	14	20	12
Ag-Like	6.8	4.0	12	3.6
Forest	3.8	0.62	6.0	0.84

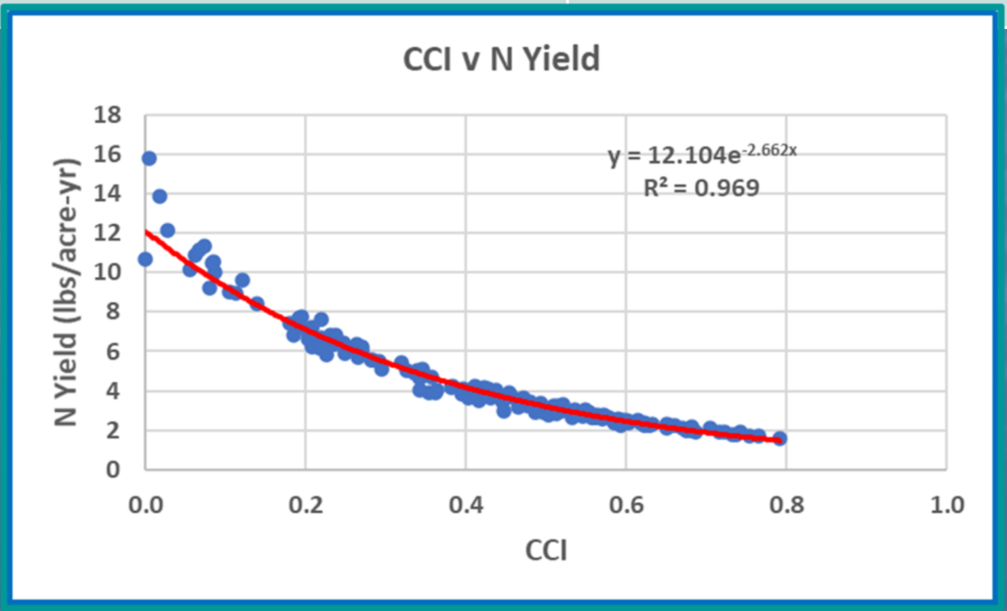


Trading Ground Rules

- Consistent with EPA Trading Policies and Guidance
- Consistent with State and Federal Regulations
- Performed on a Watershed Scale that Assures Connectivity
- Meets Water Quality Standards in each Trading Sub-Unit
- Consistent with Antidegradation Policies
- Meets Most Sensitive Designated Use, i.e., Aquatic Life Use
- Integrates and Balances Ecosystem Goods & Service Benefits
- Fair and Equitable Accounting and Accountability

Currencies:

Currency	Units	Credit Calculation
Biocondition or Biointegrity	Acres	CCI * area in acres
Total Nitrogen	Pounds/yr	$(12.104e^{-2.66(CCI)})$*acres
Enrichment Factor (EF) (Proportional Dose) UNDER DEVELOPMENT	TN Normalized Yield	TN Yield/0.84

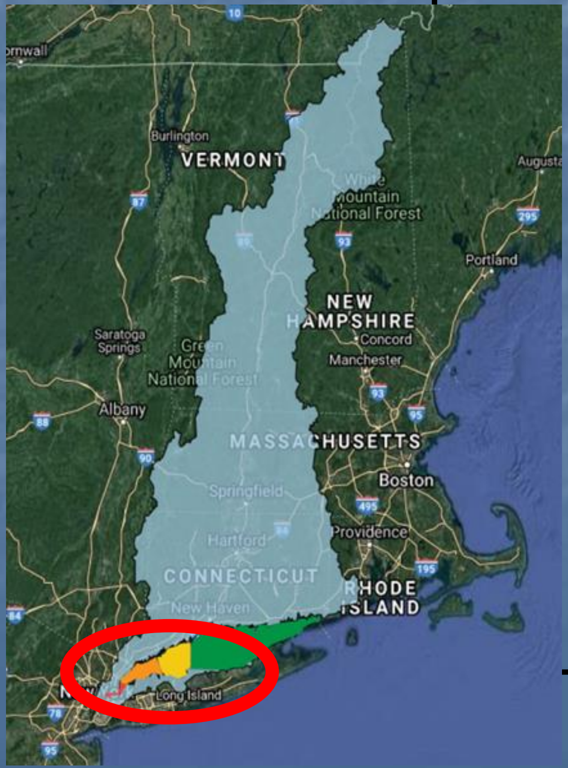


EF = Enrichment Factor (Becker, 2014)

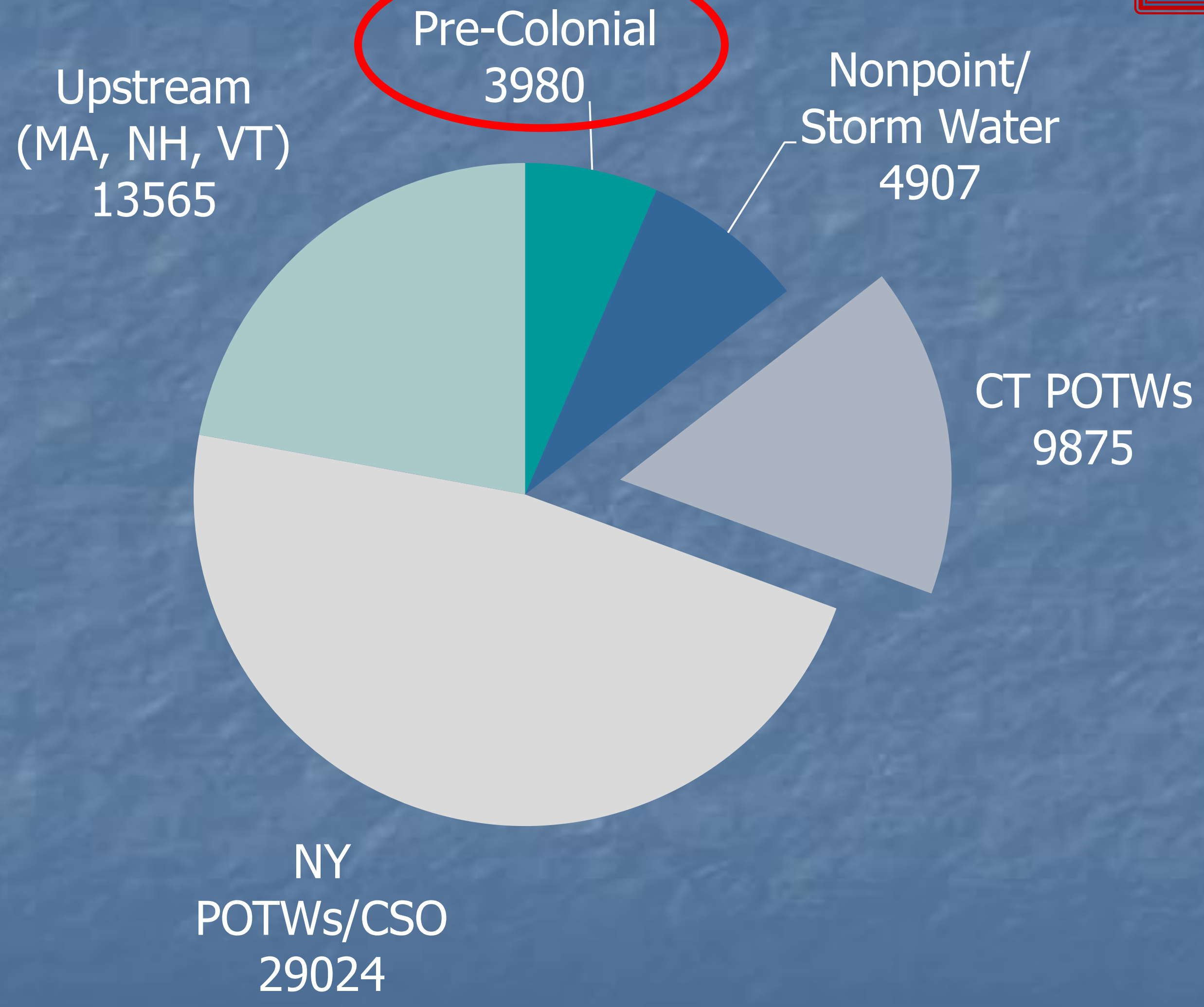
Proportional Dosing:

Baseline Load = 61,351 tons N/Year

Baseline
Enrichment Factor = Total Load/ Pre-Colonial Load =
~ 15



Nitrogen Loads (Tons N/Year) by Source
Delivered to Long Island Sound



Enrichment Factor = Load/Natural Load

58.5% Reduction = 24,570 tons N/Year

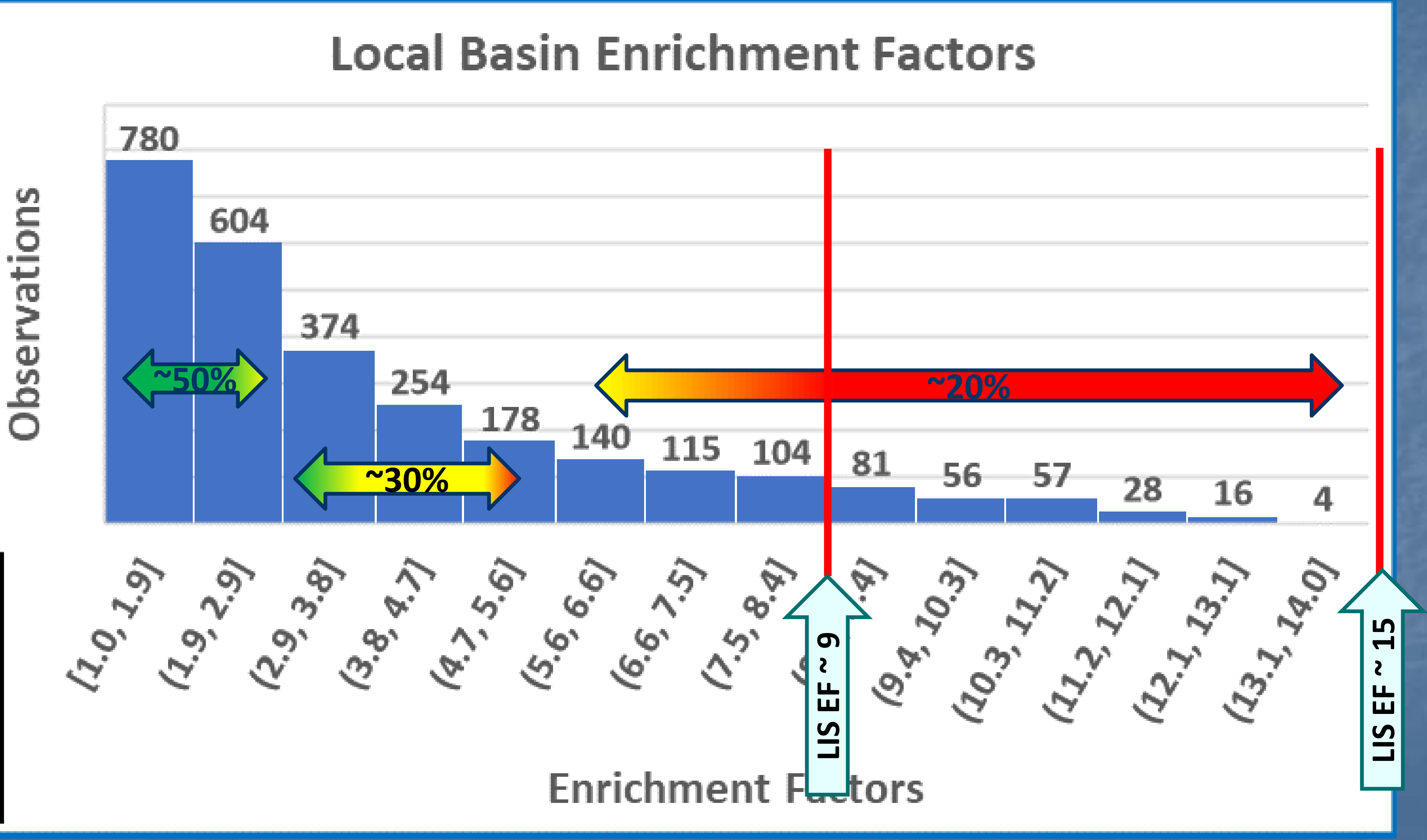
TMDL Load = 36,781 tons N/Year

TMDL
Enrichment Factor= TMDL Load/ Pre-Colonial Load =
~ 9

EF = Enrichment Factor (Becker, 2014)

Translation to Nitrogen:

Tier	CCI	EF
1	0.88	<1.4
2	0.75	2.0
3	0.60	2.9
4	0.43	4.6
5	0.20	8.5
6	0.00	>8.5



Enrichment Factors	
Mean	3.85
S.E.	0.05
Median	2.88
Count	2791

Watershed Scale:

November 2020

Water Quality Trading on a Watershed Scale

Executive Summary

The Environmental Protection Agency's (EPA's) 2019 memorandum *Updating the Environmental Protection Agency's Water Quality Trading Policy to Promote Market-Based Mechanisms for Improving Water Quality* identifies six broad market-based principles that, if implemented, will help modernize and promote the development of environmental markets. The first of those principles is that "states, tribes, and stakeholders should consider implementing water quality trading and other market-based programs

"Establishing an appropriately defined trading area is necessary to provide a viable trading market and to ***ensure that targeted water quality concerns are addressed throughout the trading area***.

"EPA recommends that the scale of a market-based water quality improvement program, including water quality trading, be ***informed by the hydrology and ecology of the watershed in conjunction with the effects and the extent of the pollutants of concern***."

i

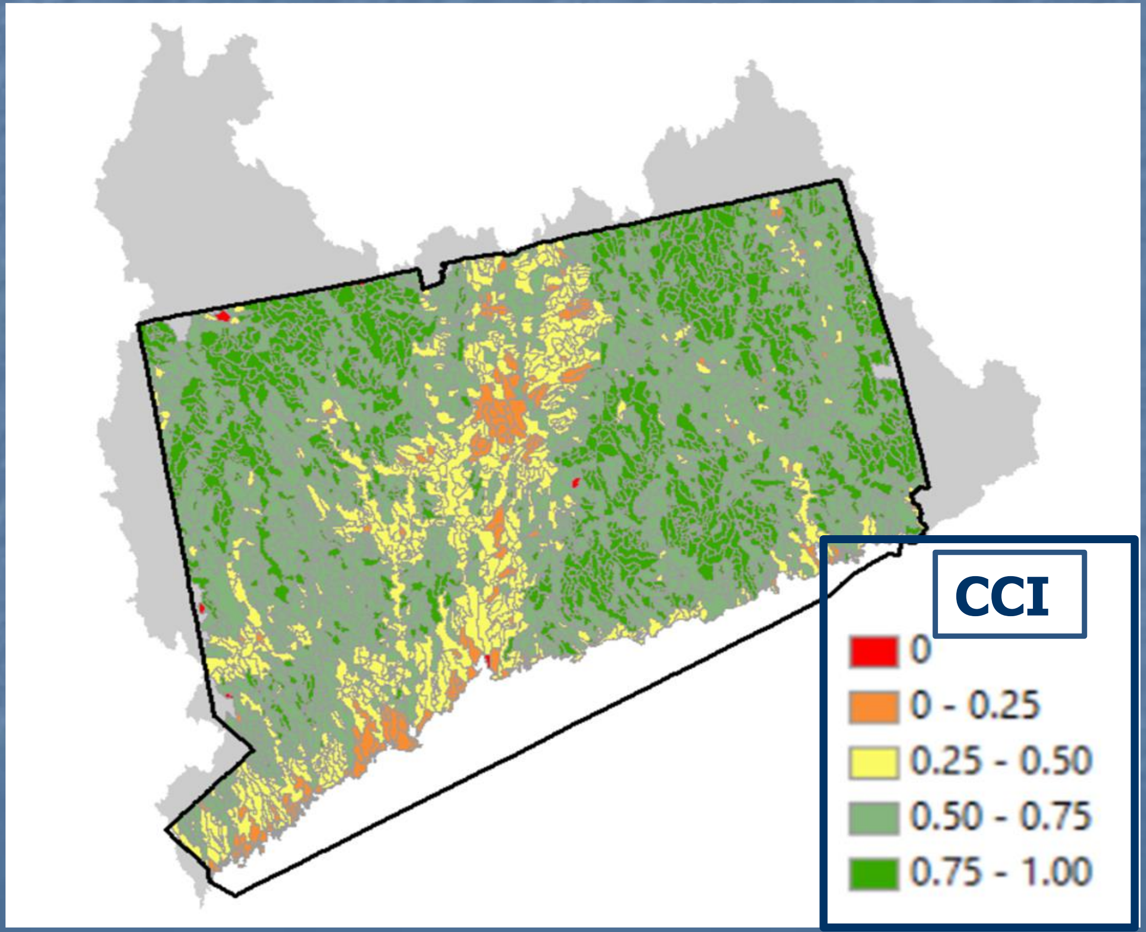
Water Quality Goals, Connectivity and Pollutant Processing

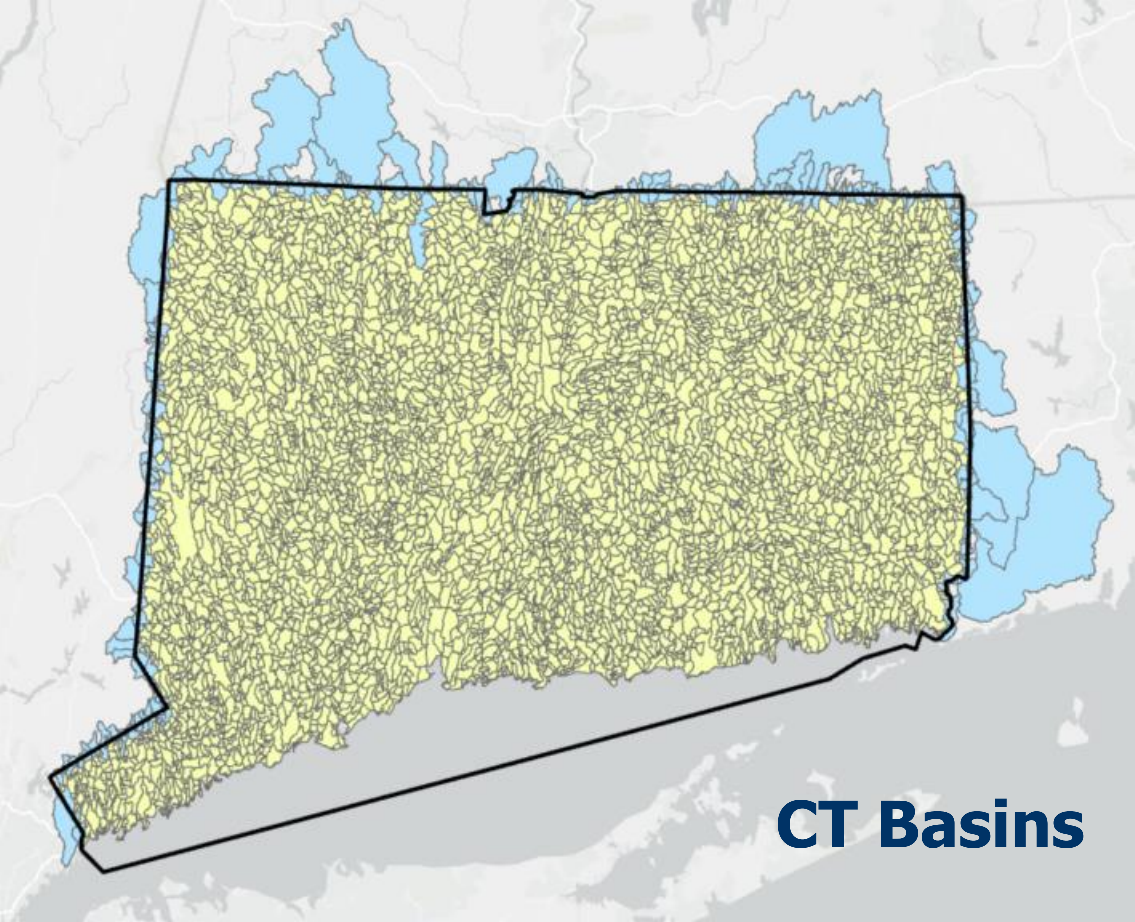
- ✓ Identify water quality goals, including pollutants of concern and their sources, and waters targeted for improvement.
- ✓ Determine how upstream and downstream waters are connected using the best available maps and tools for the watershed of interest.
- ✓ Determine the upstream and downstream extent of impact for the pollutant of concern.
- ✓ Identify watershed features that may inform the trading area.

Appropriate Scale:

Study Area

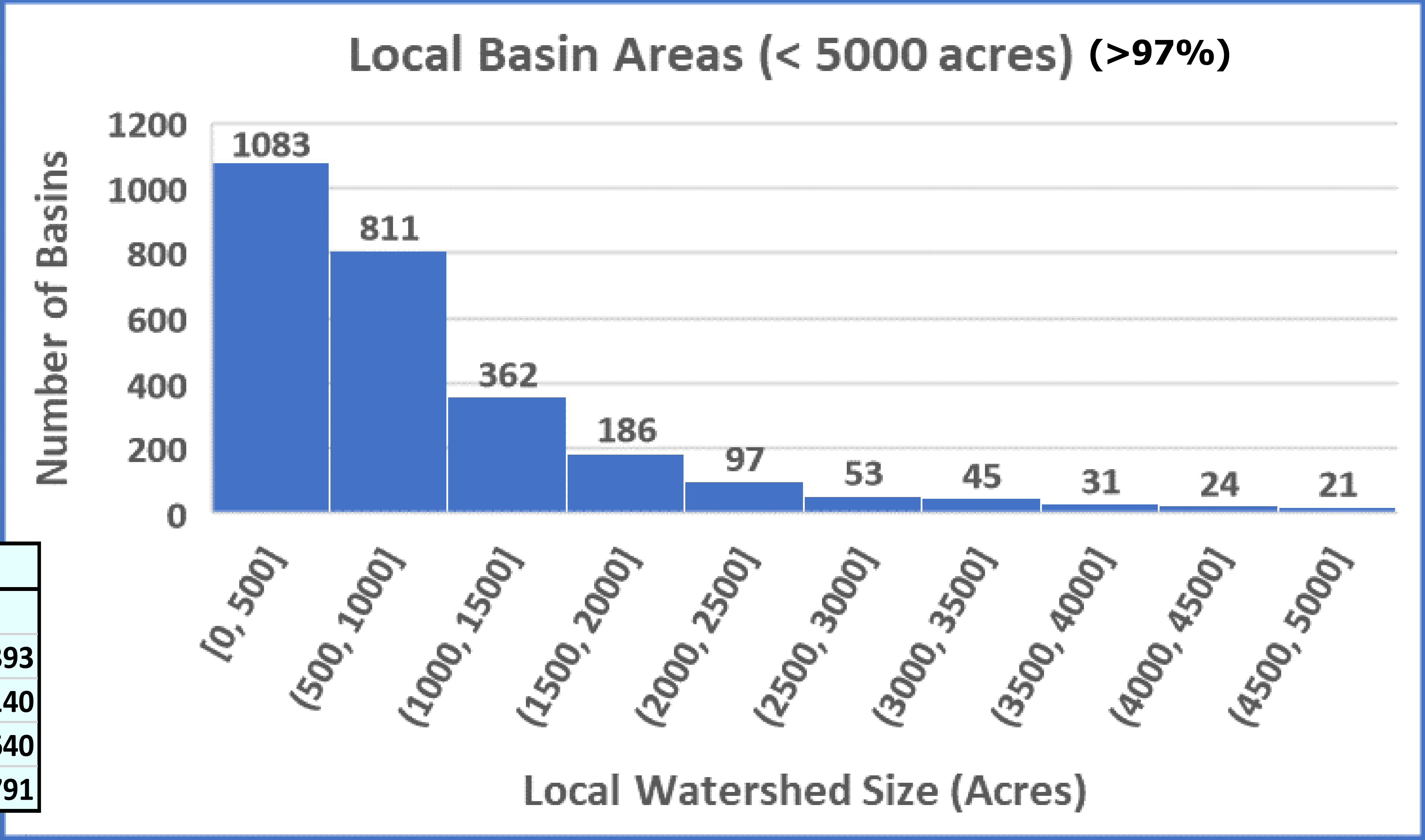
(yellow)	Full coverage within CT
(light blue)	Partial coverage within CT, flagged and no quantitative analysis
(pink)	Basins included that are not part of LIS watershed





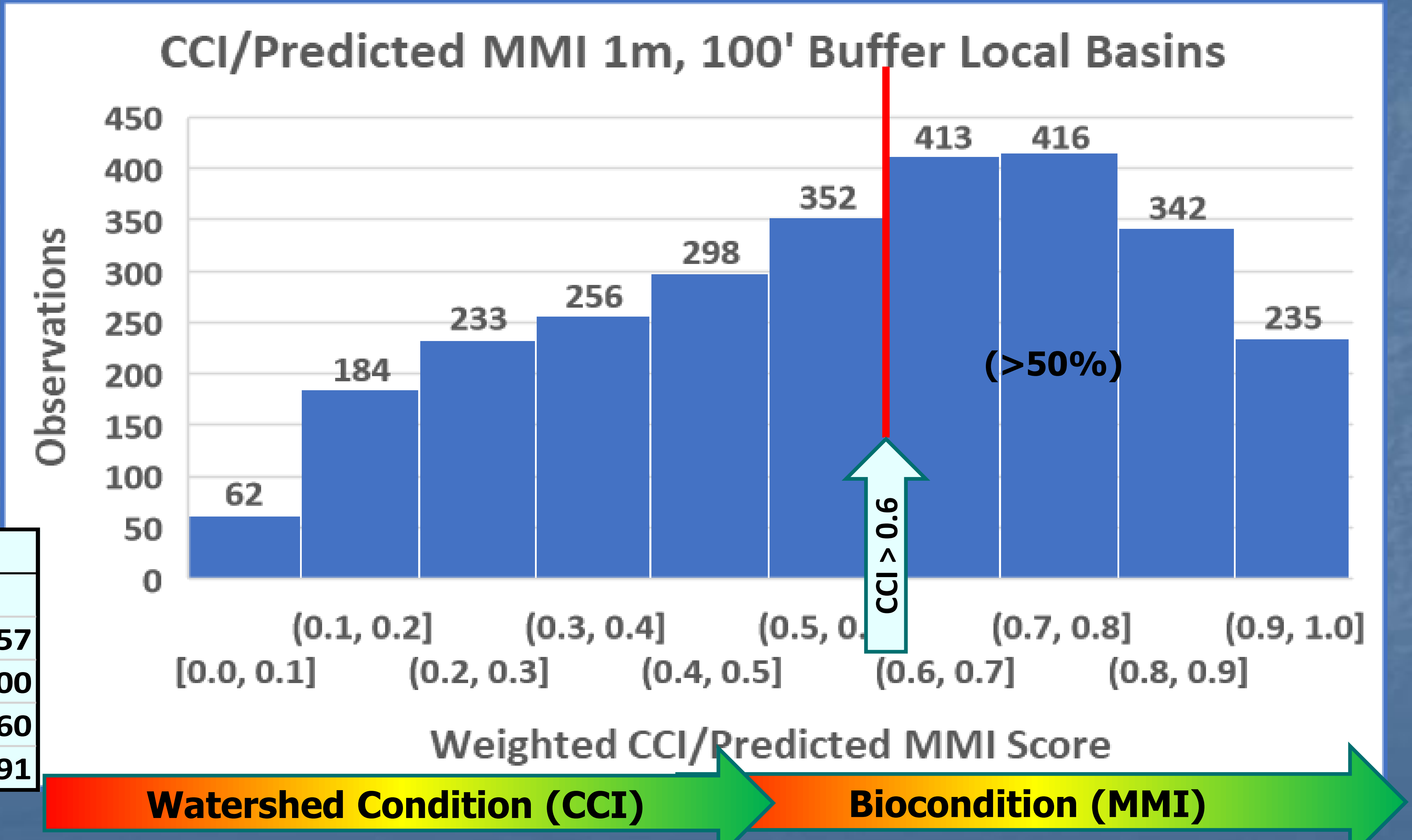
CREDIT: Q. Lei-Parent

Application to Local Basins:



Area (acres)	
Mean	1393
S. E.	140
Median	640
Count	2791

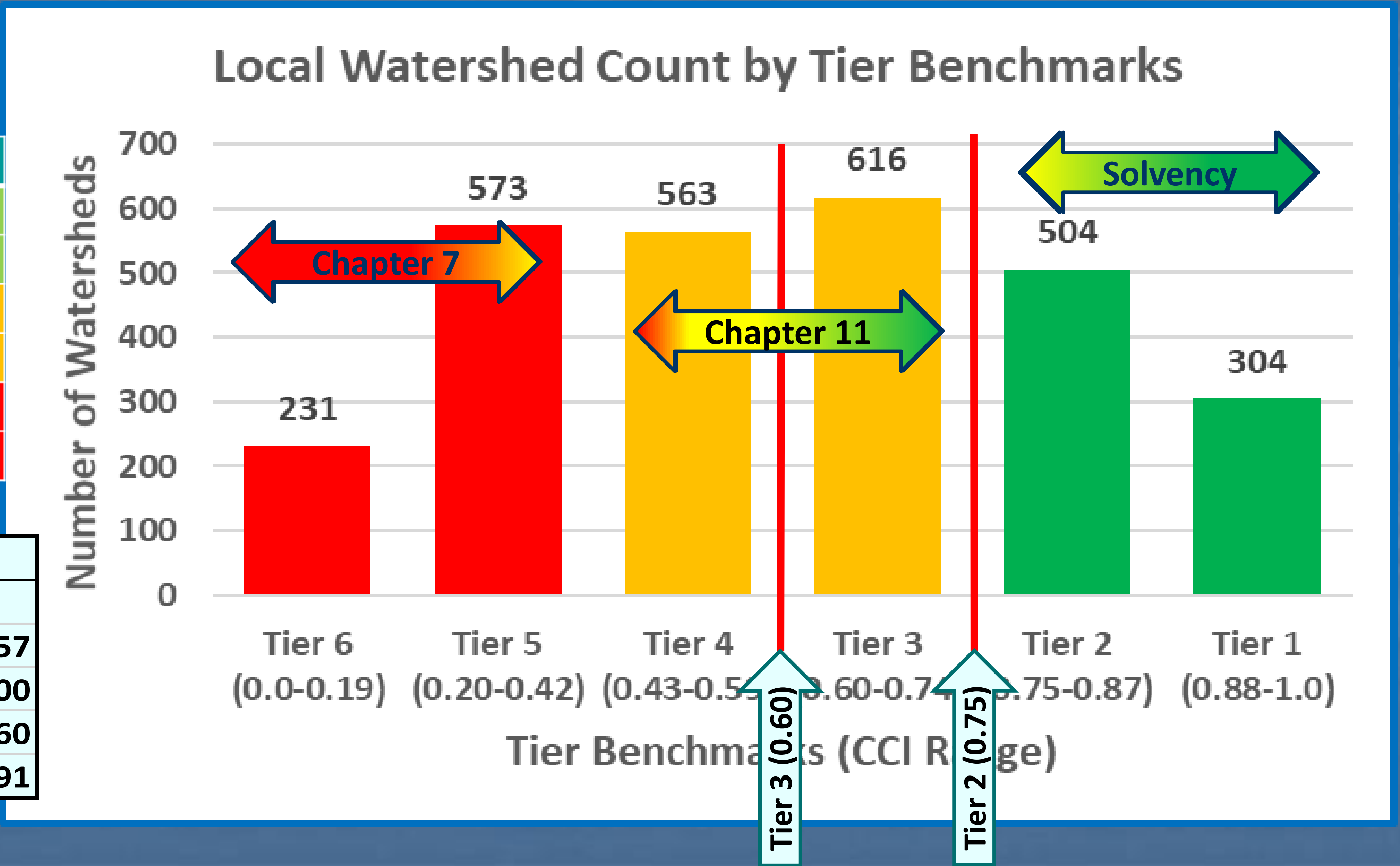
Stream Ecosystem Health:



Weighted CCI	
Mean	0.57
S.E.	0.00
Median	0.60
Count	2791

Shed No Tiers:

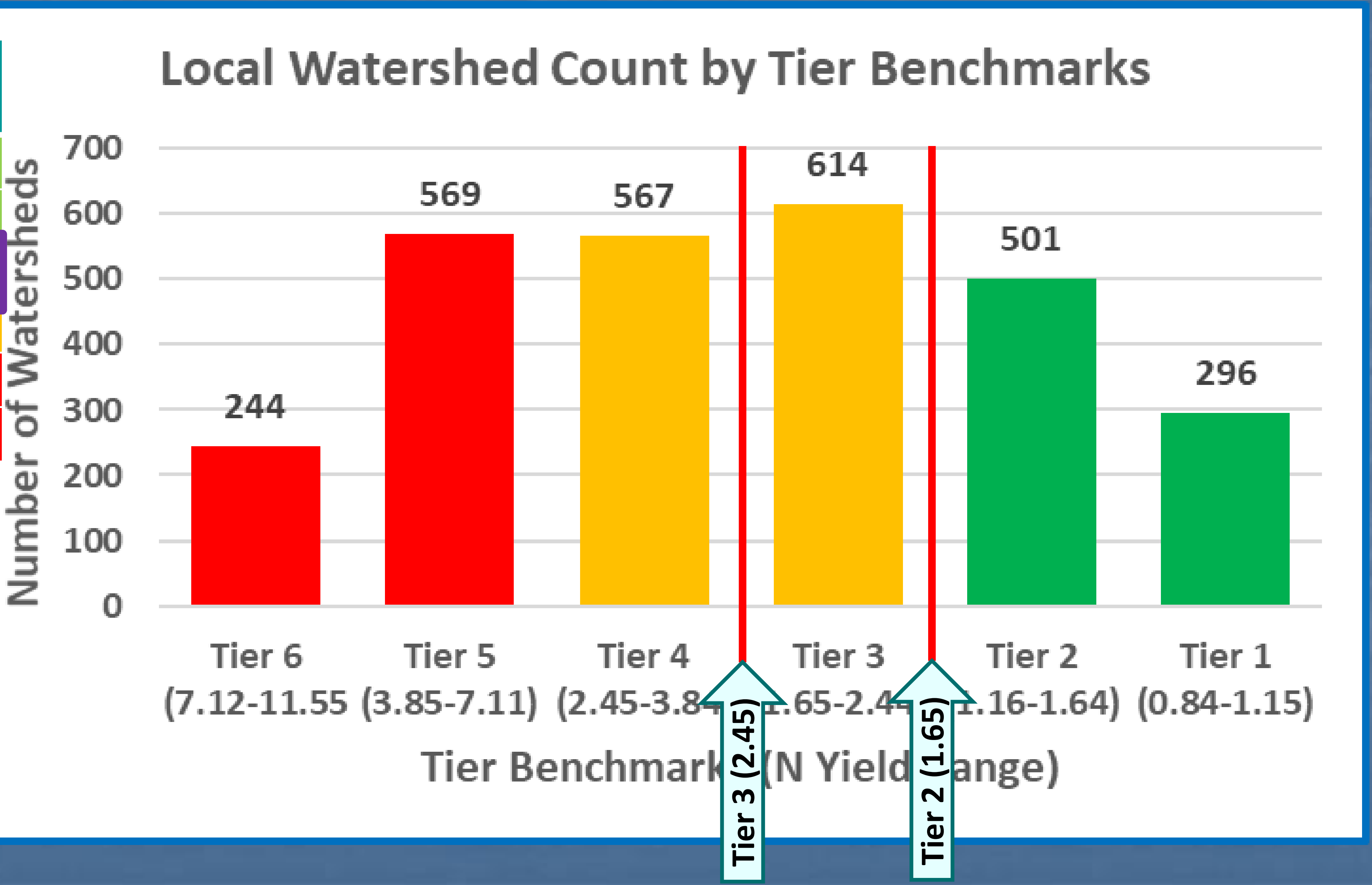
Tier	Benchmark
1	0.88
2	0.75
3	0.60
4	0.43
5	0.20
6	0.00



Weighted CCI	
Mean	0.57
S.E.	0.00
Median	0.60
Count	2791

Nitrogen Yield Benchmarks:

Tier	CCI	N Yield
1	0.88	<1.16
2	0.75	1.65
3	0.60	2.45
4	0.43	3.85
5	0.20	7.12
6	0.00	>7.12



N Yield (lbs/acre-yr)	
Mean	3.26
S.E.	0.04
Median	2.44
Count	2791

Salmon River Example:

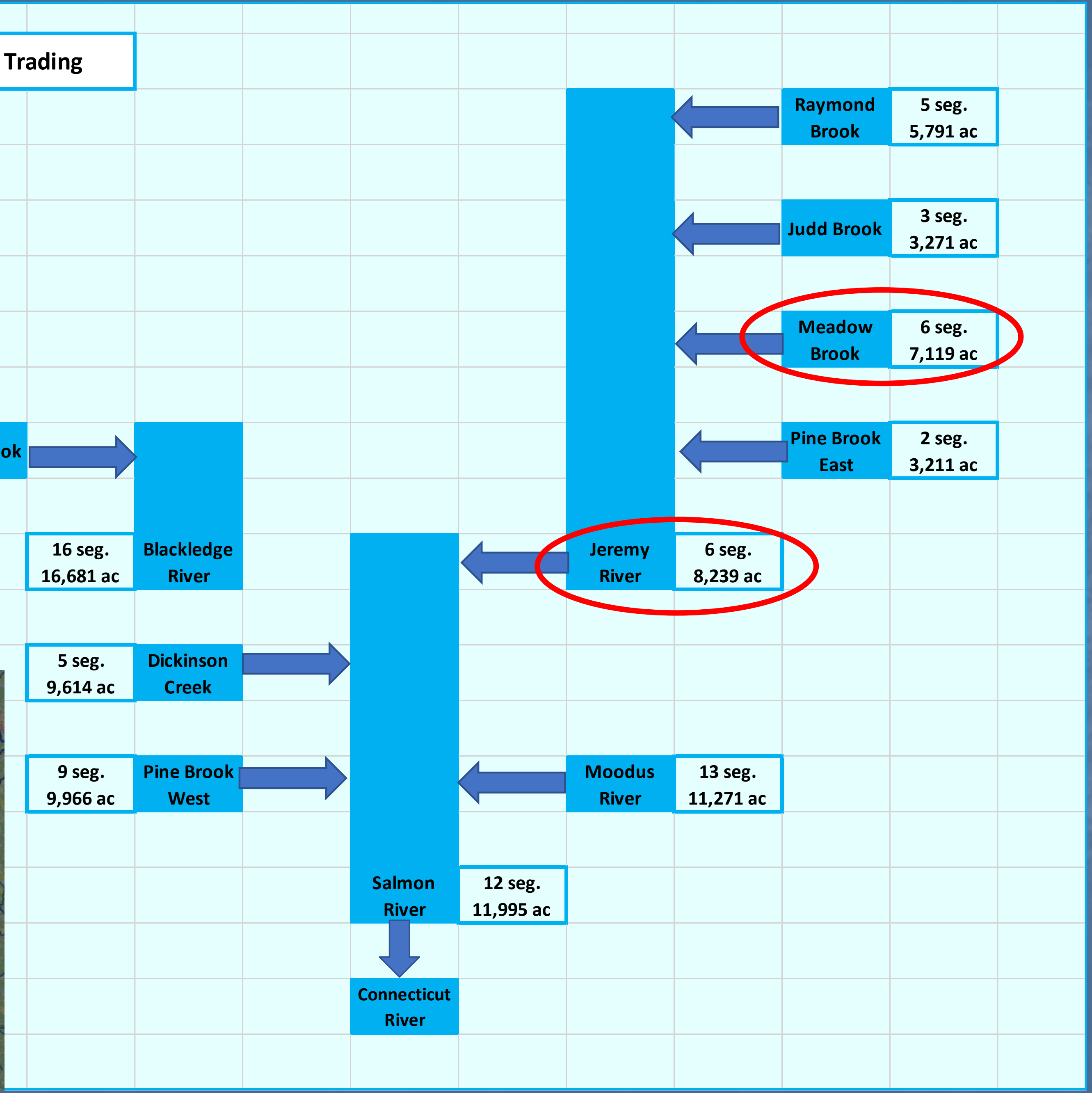
Salmon River Watershed

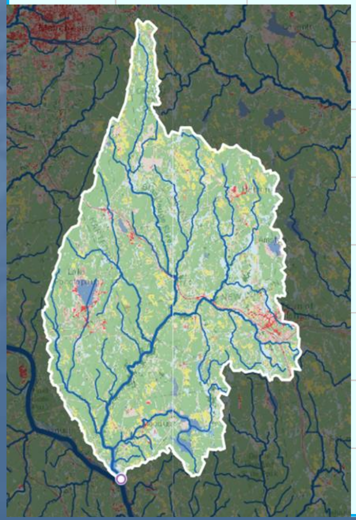
- 95,353 acres (150 sq. mi)
- 11 sub-basin trading units
- 82 segments (local basins)

Tier	CCI	N Yield
1	0.88	<1.16
2	0.75	1.65
3	0.60	2.45
4	0.43	3.85
5	0.20	7.12
6	0.00	>7.12

Tier 3 Benchmark = 0.60

Sub-Basin	Area (acres)	Segments	WCI	BCI	CCI
Raymond	5,791	5	0.55	0.68	0.62
Judd	3,271	3	0.58	0.80	0.70
Meadow	7,119	6	0.43	0.70	0.54
Pine East	3,211	2	0.63	0.93	0.82
Jeremy	8,239	6	0.59	0.83	0.73
Fawn	8,195	5	0.58	0.88	0.76
Blackledge	16,681	16	0.55	0.79	0.68
Dickinson	9,614	5	0.63	0.80	0.74
Pine West	9,966	9	0.57	0.70	0.64
Moodus	11,271	13	0.58	0.72	0.66
Salmon	11,995	12	0.73	0.85	0.81
Total	95,353	82	0.58	0.78	0.70





Jeremy River Trading Ledger:

Jeremy River Watershed – Current Status

BIOCONDITION CREDITS

BASIN_UID	Name	Watershed Area (acres)	WCI Developed (acres)	WCI Ag-like (acres)	WCI Natural (acres)	Weighted WCI (N=1; AL=2; IC=7)	BCI Developed (acres)	BCI Ag-like (acres)	BCI Natural (acres)	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)
4705-00	Jeremy River	5420	263	607	4075	0.57	10	10	455	0.84	0.72
4705-01	Jeremy River	826	40	92	640	0.58	1	1	52	0.86	0.74
4705-02	Jeremy River	533	8	8	475	0.87	0	0	42	0.94	0.93
4705-03	Jeremy River	545	21	59	411	0.61	1	3	51	0.79	0.72
4705-04	Jeremy River	333	10	23	258	0.69	1	1	40	0.79	0.76
4705-05	Jeremy River	581	40	59	420	0.51	2	4	56	0.72	0.62
4705-SUM	Jeremy River Tot	8239	382	848	6280	0.59	15	20	695	0.83	0.73

Tier 3 Benchmark = 0

Conservation

BASIN_UID	Name	Watershed Area (acres)	Weighted CCI (N=1; AL=2; IC=7)	CCI Target = 0.6	CCI Surplus(+)/ Deficit(-)	Credit(+)/ Deficit(-) (acres)	Cumulative Credit Balance
4705-00	Jeremy River	5420	0.72	0.60	0.12	662	662
4705-01	Jeremy River	826	0.74	0.60	0.14	116	778
4705-02	Jeremy River	533	0.93	0.60	0.33	175	953
4705-03	Jeremy River	545	0.72	0.60	0.12	65	1018
4705-04	Jeremy River	333	0.76	0.60	0.16	54	1072
4705-05	Jeremy River	581	0.62	0.60	0.02	10	1082
4705-SUM	Jeremy River Tot	8239	0.73	0.60	0.13	1060	1082

- Combined Condition Index (CCI)

- Watershed Condition (WCI)
- Buffer Condition (BCI)

$$CCI = WCI \times (1+(BCI-WCI))$$

Jeremy River Trading Ledger:

Jeremy River Watershed – Managed Status

BIOCONDITION CREDITS

BASIN_UID	Name	Watershed Area (acres)	WCI Developed (acres)	WCI Ag-like (acres)	WCI Natural (acres)	Change Must = 0	Weighted WCI (N=1; AL=2; IC=7)	BCI Developed (acres)	BCI Ag-like (acres)	BCI Natural (acres)	Change Must = 0	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)
4705-00	Jeremy River	5420	0	0	0	0	0.57	-10	0	10	0	0.96	0.79
4705-01	Jeremy River	826	0	0	0	0	0.58	-1	0	1	0	0.97	0.81
4705-02	Jeremy River	533	0	0	0	0	0.87	0	0	0	0	0.99	0.98
4705-03	Jeremy River	545	0	0	0	0	0.61	-1	0	1	0	0.90	0.78
4705-04	Jeremy River	333	0	0	0	0	0.69	-1	0	1	0	0.93	0.86
4705-05	Jeremy River	581	0	0	0	0	0.51	-2	0	2	0	0.87	0.70
4705-SUM	Jeremy River Tot	8239	0	0	0	0	0.59	-15	0	15	0	0.95	0.80

Current State

Conservation

Managed State

BASIN_UID	Name	Watershed Area (acres)	Weighted CCI (N=1; AL=2; IC=7)	CCI Target = 0.6	CCI Surplus(+)/ Deficit(-)	Credit(+)/ Deficit(-) (acres)	Cumulative Credit Balance	CCI Surplus(+)/ Deficit(-)	Credit(+)/ Deficit(-) (acres)	Cumulative Credit Balance
4705-00	Jeremy River	5420	0.72	0.60	0.12	662	662	0.19	1045	1045
4705-01	Jeremy River	826	0.74	0.60	0.14	116	778	0.21	172	1217
4705-02	Jeremy River	533	0.93	0.60	0.33	175	953	0.38	200	1418
4705-03	Jeremy River	545	0.72	0.60	0.12	65	1018	0.18	101	1518
4705-04	Jeremy River	333	0.76	0.60	0.16	54	1072	0.26	87	1605
4705-05	Jeremy River	581	0.62	0.60	0.02	10	1082	0.10	56	1661
4705-SUM	Jeremy River Tot	8239	0.73	0.60	0.13	1060	1082	0.20	1656	1661

Meadow Brook Trading Ledger:

Meadow Brook Watershed – Managed Status

BIOCONDITION CREDITS

BASIN_UID	Name	Watershed Area (acres)	WCI Developed (acres)	WCI Ag-like (acres)	WCI Natural (acres)	Change Must = 0	Weighted WCI (N=1; AL=2; IC=7)	BCI Developed (acres)	BCI Ag-like (acres)	BCI Natural (acres)	Change Must = 0	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)
4703-00	Meadow Brook	1961	0	0	0	0	0.44	-5	0	5	0	0.91	0.65
4703-01	Meadow Brook	1193	0	0	0	0	0.38	-7	0	7	0	0.88	0.57
4703-02	Meadow Brook	1569	0	0	0	0	0.50	-3	0	3	0	0.92	0.71
4703-03	Meadow Brook	316	0	0	0	0	0.19	-4	0	4	0	0.81	0.31
4703-04	Meadow Brook	417	0	0	0	0	0.20	-3	0	3	0	0.66	0.30
4703-05	Meadow Brook	1663	0	0	0	0	0.56	-1	0	1	0	0.95	0.78
4703-SUM	Meadow Brook	7118	0	0	0	0	0.43	-23	0	23	0	0.90	0.63

Current State

Managed State

BASIN_UID	Name	Watershed Area (acres)	WCI Developed (acres)	WCI Ag-like (acres)	WCI Natural (acres)	Weighted WCI (N=1; AL=2; IC=7)	BCI Developed (acres)	BCI Ag-like (acres)	BCI Natural (acres)	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)
4703-00	Meadow Brook	1961	177	260	1383	0.44	5	7	129	0.72	0.56
4703-01	Meadow Brook	1193	118	194	761	0.38	7	8	105	0.62	0.48
4703-02	Meadow Brook	1569	106	189	1115	0.50	3	7	149	0.80	0.65
4703-03	Meadow Brook	316	77	58	157	0.19	4	2	17	0.37	0.23
4703-04	Meadow Brook	417	90	97	213	0.20	3	3	10	0.27	0.22
4703-05	Meadow Brook	1663	83	198	1264	0.56	1	3	115	0.88	0.74
4703-SUM	Meadow Brook	7118	652	996	4892	0.43	23	30	525	0.70	0.54

Meadow Brook Nitrogen Trading Ledger:

NITROGEN CREDITS

Meadow Brook Watershed – Managed Status

Current State

BASIN_UID	Name	Watershed Area (acres)	Weighted WCI (N=1; AL=2; IC=7)	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)	N Yield (lbs/acre-yr)	N Yield Target = 2.45	N Yield Surplus(+)/ Deficit(-) (lbs/ac-yr)	N Load Credit(+)/ Deficit(-) (lbs/yr)	Cumulative N Load Credit Balance
4703-00	Meadow Brook	1961	0.44	0.72	0.56	2.71	2.45	-0.26	-517	-517
4703-01	Meadow Brook	1193	0.38	0.62	0.48	3.40	2.45	-0.95	-1132	-1649
4703-02	Meadow Brook	1569	0.50	0.80	0.65	2.15	2.45	0.30	466	-1183
4703-03	Meadow Brook	316	0.19	0.37	0.23	6.62	2.45	-4.17	-1318	-2501
4703-04	Meadow Brook	417	0.20	0.27	0.22	6.76	2.45	-4.31	-1798	-4299
4703-05	Meadow Brook	1663	0.56	0.88	0.74	1.67	2.45	0.78	1296	-3003
4703-SUM	Meadow Brook	7118	0.43	0.70	0.54	2.84	2.45	-0.39	-2786	-3003

Managed State

BASIN_UID	Name	Watershed Area (acres)	Weighted WCI (N=1; AL=2; IC=7)	Weighted BCI (N=1; AL=2; IC=7)	Weighted CCI (N=1; AL=2; IC=7)	N Yield (lbs/acre-yr)	N Yield Target = 2.45	N Yield Surplus(+)/ Deficit(-) (lbs/ac-yr)	N Load Credit(+)/ Deficit(-) (lbs/yr)	Cumulative N Load Credit Balance
4703-00	Meadow Brook	1961	0.44	0.91	0.65	2.17	2.45	0.28	548	548
4703-01	Meadow Brook	1193	0.38	0.88	0.57	2.63	2.45	-0.18	-210	338
4703-02	Meadow Brook	1569	0.50	0.92	0.71	1.84	2.45	0.61	957	1295
4703-03	Meadow Brook	316	0.19	0.81	0.31	5.27	2.45	-2.82	-890	405
4703-04	Meadow Brook	417	0.20	0.66	0.30	5.48	2.45	-3.03	-1262	-857
4703-05	Meadow Brook	1663	0.56	0.95	0.78	1.51	2.45	0.94	1568	711
4703-SUM	Meadow Brook	7118	0.43	0.90	0.63	2.27	2.45	0.18	1313	711

Salmon River Watershed Summary:

Tier 3 Benchmark = 0.60			Current State			Managed State	
Sub-Basin	Area (acres)	Segments	WCI	BCI	CCI	Biocondition Credits	Nitrogen Credits
Raymond	5,791	5	0.55	0.68	0.62	368	1,097
Judd	3,271	3	0.58	0.80	0.70	406	1,748
Meadow	7,119	6	0.43	0.70	0.54	314	711
Pine East	3,211	2	0.63	0.93	0.82	715	3,514
Jeremy	8,239	6	0.59	0.83	0.73	1,661	5,789
Fawn	8,195	5	0.58	0.88	0.76	1,338	6,809
Blackledge	16,681	16	0.55	0.79	0.68	1,625	6,602
Dickinson	9,614	5	0.63	0.80	0.74	1,324	7,000
Pine West	9,966	9	0.57	0.70	0.64	764	2,005
Moodus	11,271	13	0.58	0.72	0.66	756	3,485
Salmon	11,995	12	0.73	0.85	0.81	2,533	12,494
Total	95,353	82	0.58	0.78	0.70	11,804	51,253

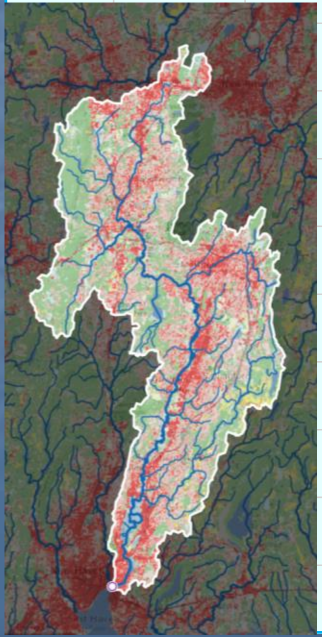
Quinnipiac River Example:

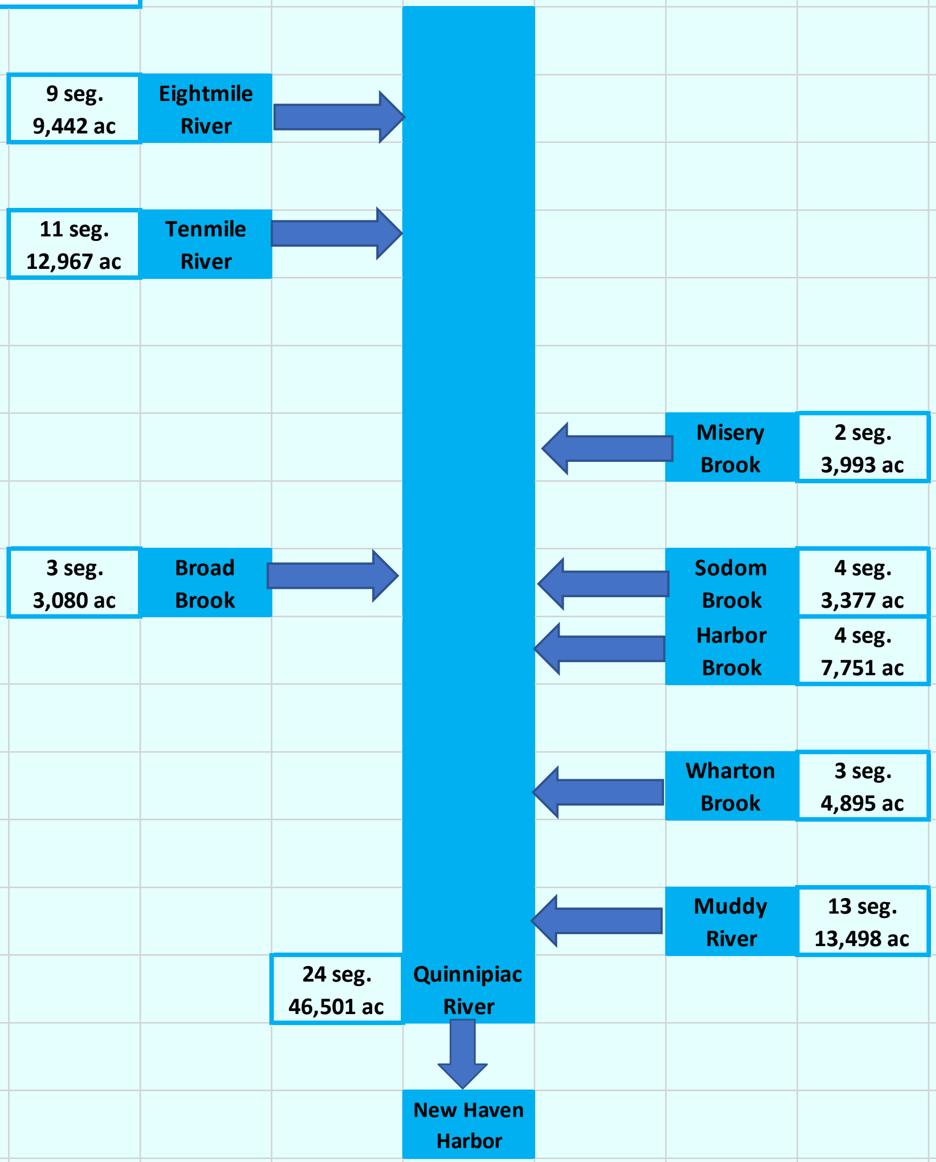
Quinnipiac River Watershed

- 105,955 acres (165 sq. mi)
- 9 sub-basin trading units
- 73 segments (local basins)

Tier	CCI	N Yield
1	0.88	<1.16
2	0.75	1.65
3	0.60	2.45
4	0.43	3.85
5	0.20	7.12
6	0.00	>7.12

Tier 3 Benchmark = 0.60			Tier 4 Benchmark = 0.43		
Sub-Basin	Area (acres)	Segments	WCI	BCI	CCI
Eightmile	9,442	9	0.35	0.60	0.44
Tenmile	12,967	11	0.35	0.59	0.43
Misery	3,993	2	0.25	0.56	0.32
Broad	3,080	3	0.52	0.87	0.70
Sodom	3,377	4	0.24	0.26	0.25
Harbor	7,752	4	0.16	0.31	0.19
Wharton	4,895	3	0.16	0.10	0.15
Muddy	13,948	13	0.30	0.58	0.39
Quinnipiac	46,501	24	0.18	0.40	0.22
Total	105,955	73	0.23	0.47	0.28





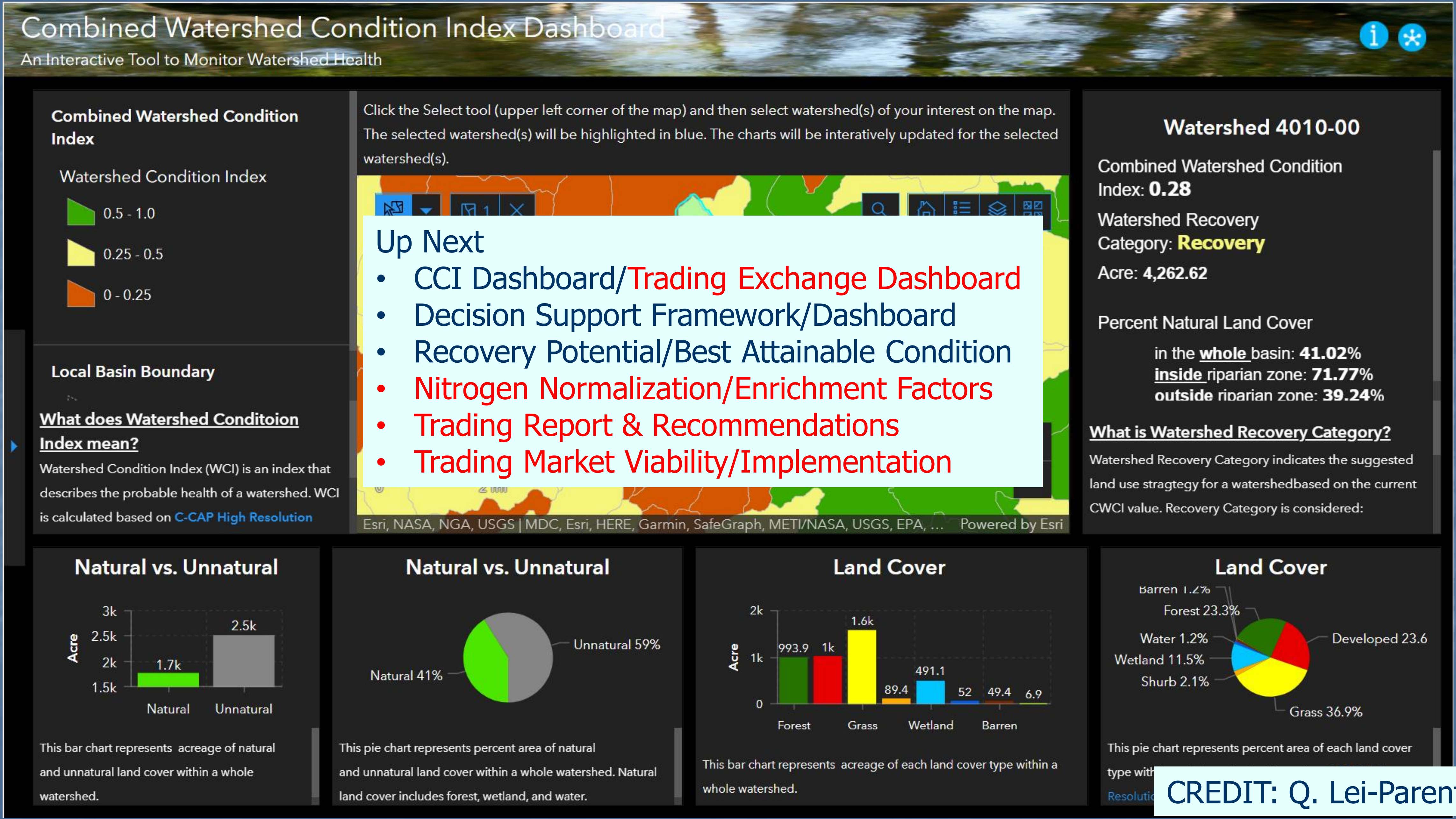
Quinnipiac River Watershed Summary:

Mitigation

Tier 3 Benchmark = 0.60			Tier 4 Benchmark = 0.43				
Sub-Basin	Area (acres)	Segments	WCI	BCI	CCI	Biocondition Credits	Nitrogen Credits
Eightmile	9,442	9	0.35	0.60	0.44	-1,248	-13,922
Tenmile	12,967	11	0.35	0.59	0.43	-1,777	-17,720
Misery	3,993	2	0.25	0.56	0.32	-1,099	-10,776
Broad	3,080	3	0.52	0.87	0.70	312	1,763
Sodom	3,377	4	0.24	0.26	0.25	-1,210	-13,286
Harbor	7,752	4	0.16	0.31	0.19	-2,928	-36,380
Wharton	4,895	3	0.16	0.10	0.15	-1,891	-21,618
Muddy	13,948	13	0.30	0.58	0.39	-2,708	-26,519
Quinnipiac	46,501	24	0.18	0.40	0.22	-17,198	-196,639
Total	105,955	73	0.23	0.47	0.28	-29,747	-335,097

NOT INCLUDING POINT SOURCES!

Put You in the Driver's Seat:



Up Next
- CCI Dashboard/Trading Exchange Dashboard
- Decision Support Framework/Dashboard
- Recovery Potential/Best Attainable Condition
- Nitrogen Normalization/Enrichment Factors
- Trading Report & Recommendations
- Trading Market Viability/Implementation

CREDIT: Q. Lei-Parent

In Conclusion:

Making Nature Great Again

(*Occam's Razor* – the rationality of simple explanations)

A Viable Method!

- Applications:
  - Assessment
  - Diagnostics/Feasibility
  - Biointegrity Endpoints
  - Nutrient Targets
  - Management Planning/TMDLs
  - Watershed Management
  - Buffer Management
  - Biocondition and Nutrient Trading

In an Ecosystem Context!

Whole Ecosystem Outcomes!

- Natural Recovery is:
  - Functional
  - Adaptive
  - Transitional
  - Resilient
  - Low Cost
  - Aimed at Well-being Outcomes

A Stable Platform for a Changing World!

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QUESTIONS, COMMENTS, FEEDBACK?

Online form: **http://bit.ly/LIS-Trading-Feedback** *(case sensitive!)*

Send feedback directly to **egildesgame@neiwpcc.org**

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