Ecosystem-based Integrated Water Resource Management (IWRM) in Today's Social Ecological System (SES) Context

A "One-Water" Example for Connecticut

NEWEA 2024
Annual Conference
& Exhibit

January 21–24
Boston Marriott Copley Place
Boston, Massachusetts

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

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

NASA Earth Observatory

Changing Management Perspectives for Changing Times:

Pre Clean Water Act
Nature for Itself – Conservation

1972 – Clean Water Act
Nature Despite People – Regulation

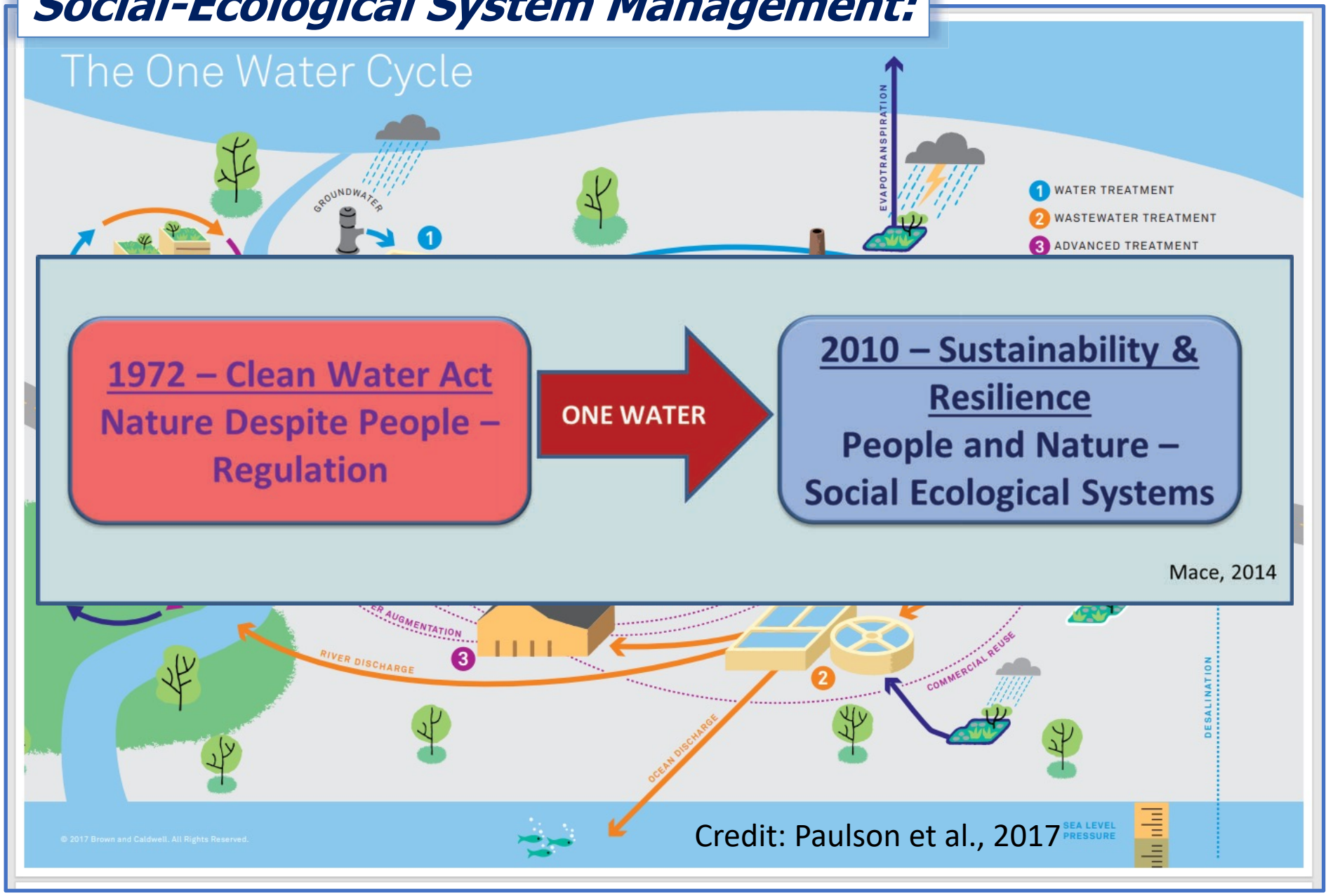
ONE WATER

2000s – Ecosystem Structure & Function
Nature for People – Ecosystem Services

2010 – Sustainability & Resilience
People and Nature – Social Ecological Systems

Mace, 2014

Social-Ecological System Management:



Credit: Paulson et al., 2017

One Water Defined

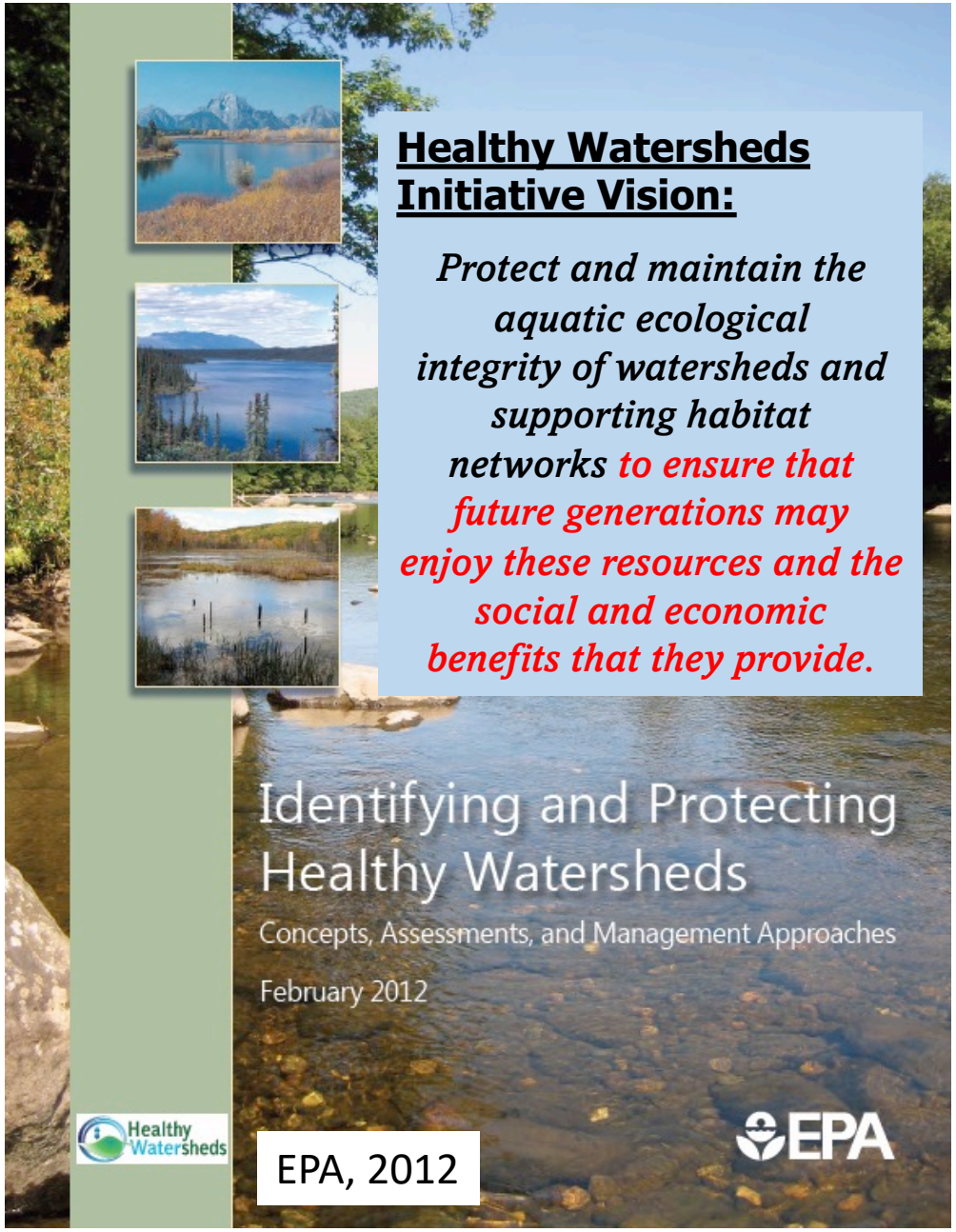
One Water is an integrated planning and implementation approach to managing finite water resources for long-term resilience and reliability, meeting both community ***and ecosystem needs***

Credit: Paulson et al., 2017

The difference between animals and humans is that animals change themselves for the environment, but humans change the environment for themselves

– Ayn Rand

One Water Ecosystem-Based Mgmt:



EPA, 2012

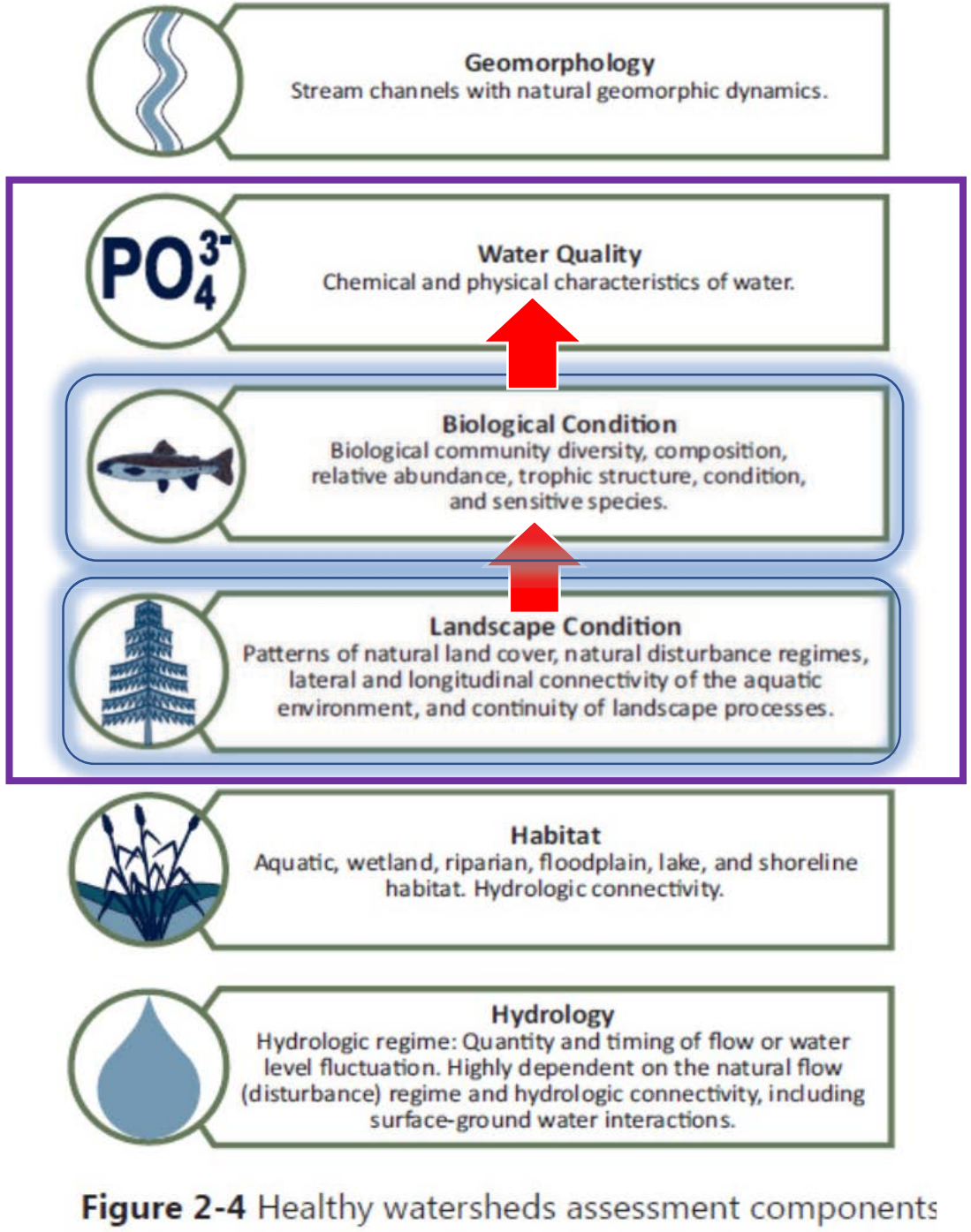


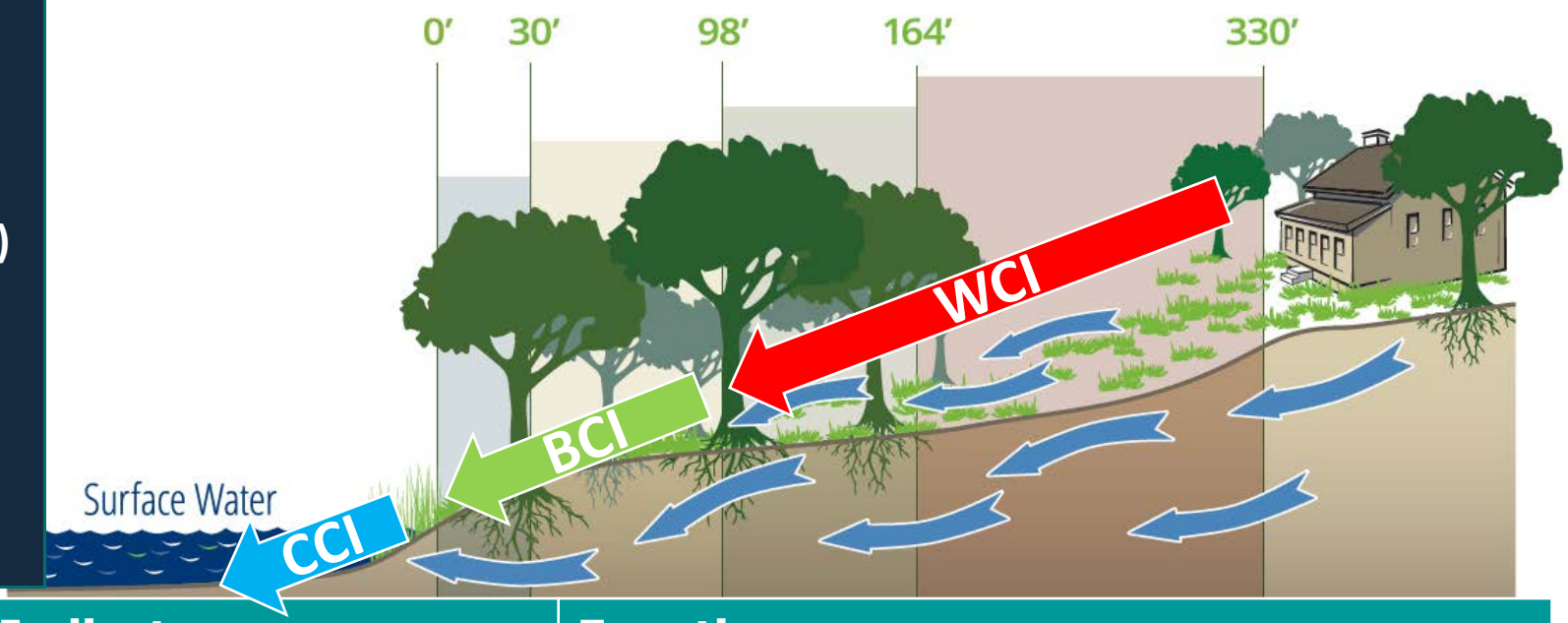
Figure 2-4 Healthy watersheds assessment components

Combined Condition Index (CCI):

- **Combined Condition Index (CCI)**

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

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



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

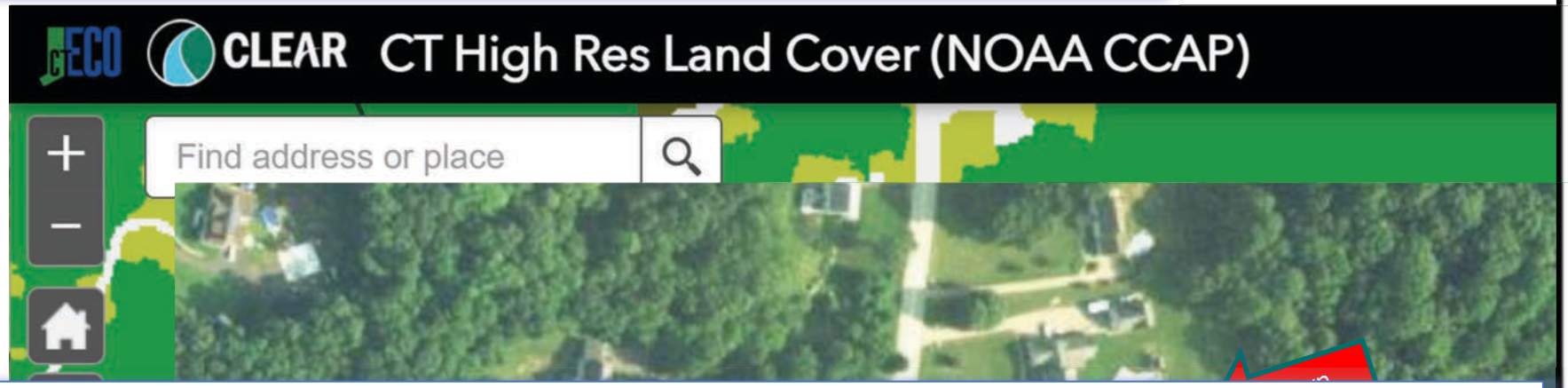
CCI is Based on:
- Structural and
- Functional

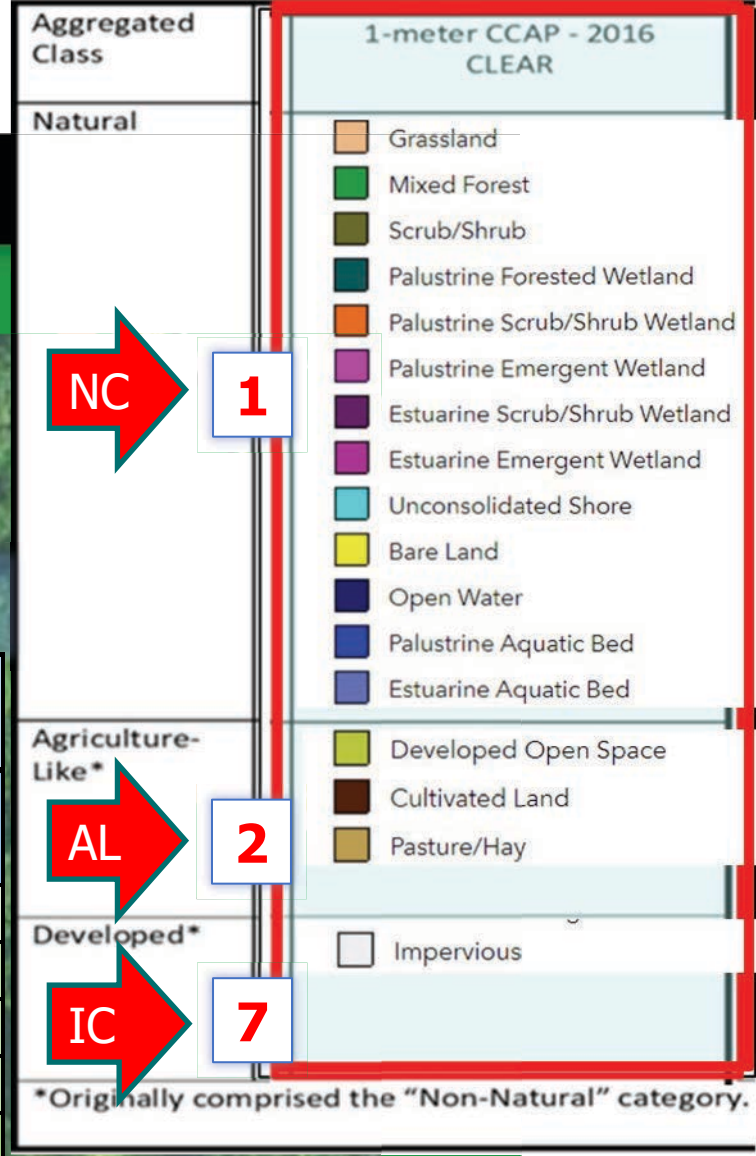
Health of the Watershed

Degree of "Naturalness"

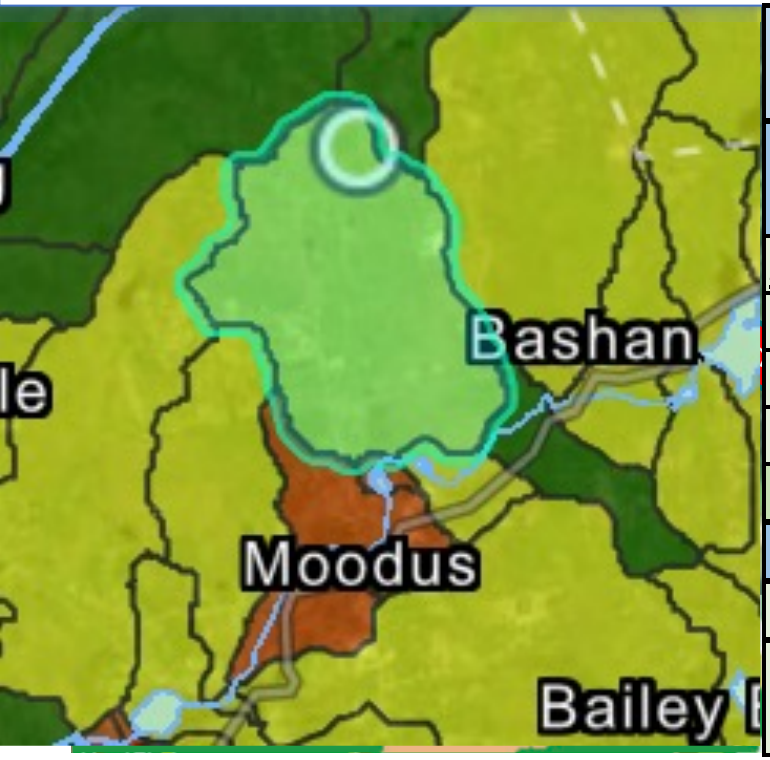
Graphic Credit: Buffer Options for the Bay NH

1-Meter Resolution Precise & Accurate!





CLEAR Local Watershed Assessment Tool (LWAT)



Moodus River - Local Watershed 4710-08			
Outcomes	**100-ft Buffer**	**Upland of Buffer**	**Total**
Area (acres)			
Impervious	0.63	33.7	34.3
Ag-Like	8.1	109	117
Natural	24.9	390	415
Total	33.7	533	566
Condition Indices	**BCI**	**WCI**	**CCI**
Index Value	0.55	0.46	0.50
Nitrogen	Nitrogen Yield (EF) =		4.0
	Nitrogen Load (tons/yr)		1.14

CLEAR, CT ECO

Ecosystem Context:

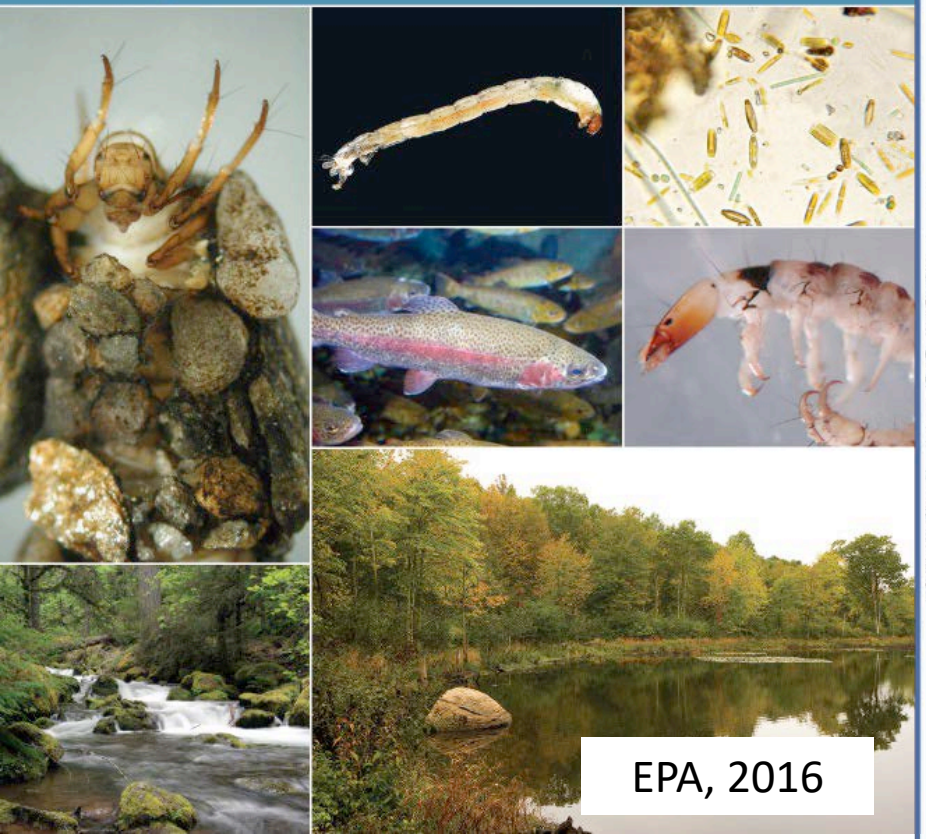
The Biological Condition Gradient (BCG)

EPA 842-R-16-001

EPA

A Practitioner's Guide to the Biological Condition Gradient: A Framework to Describe Incremental Change in Aquatic Ecosystems

February 2016



EPA, 2016

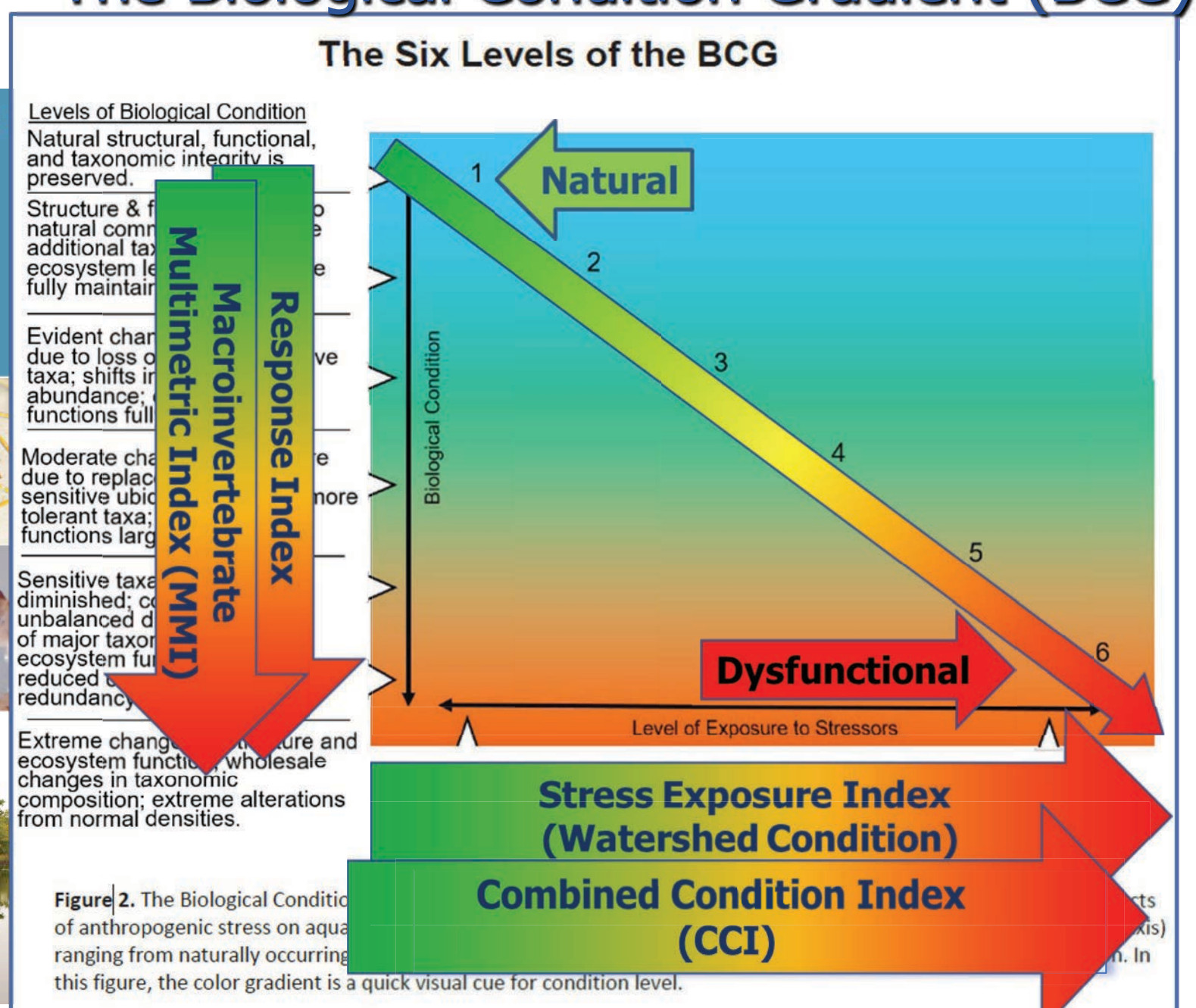
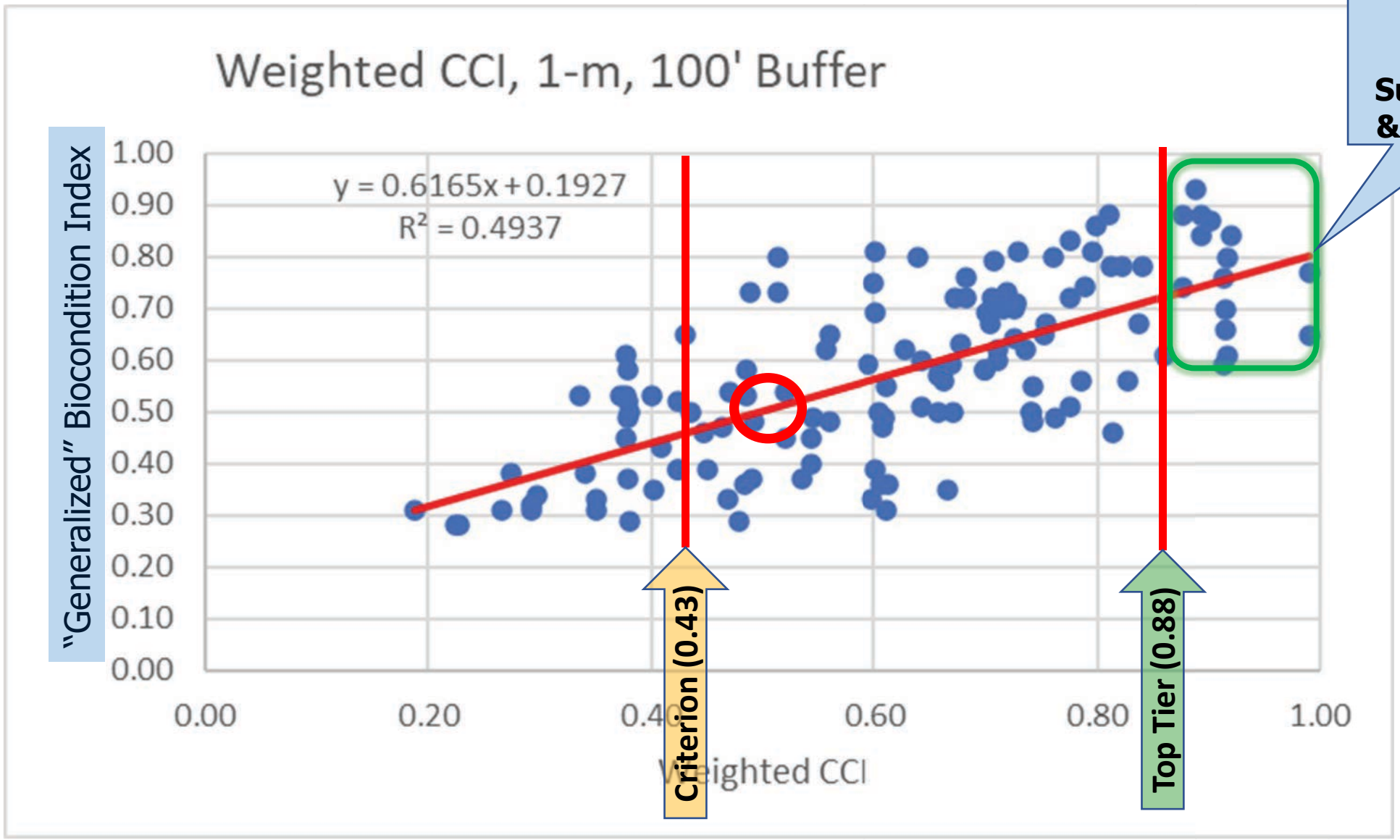


Figure 2. The Biological Conditio
of anthropogenic stress on aqua
ranging from naturally occurring
this figure, the color gradient is a quick visual cue for condition level.

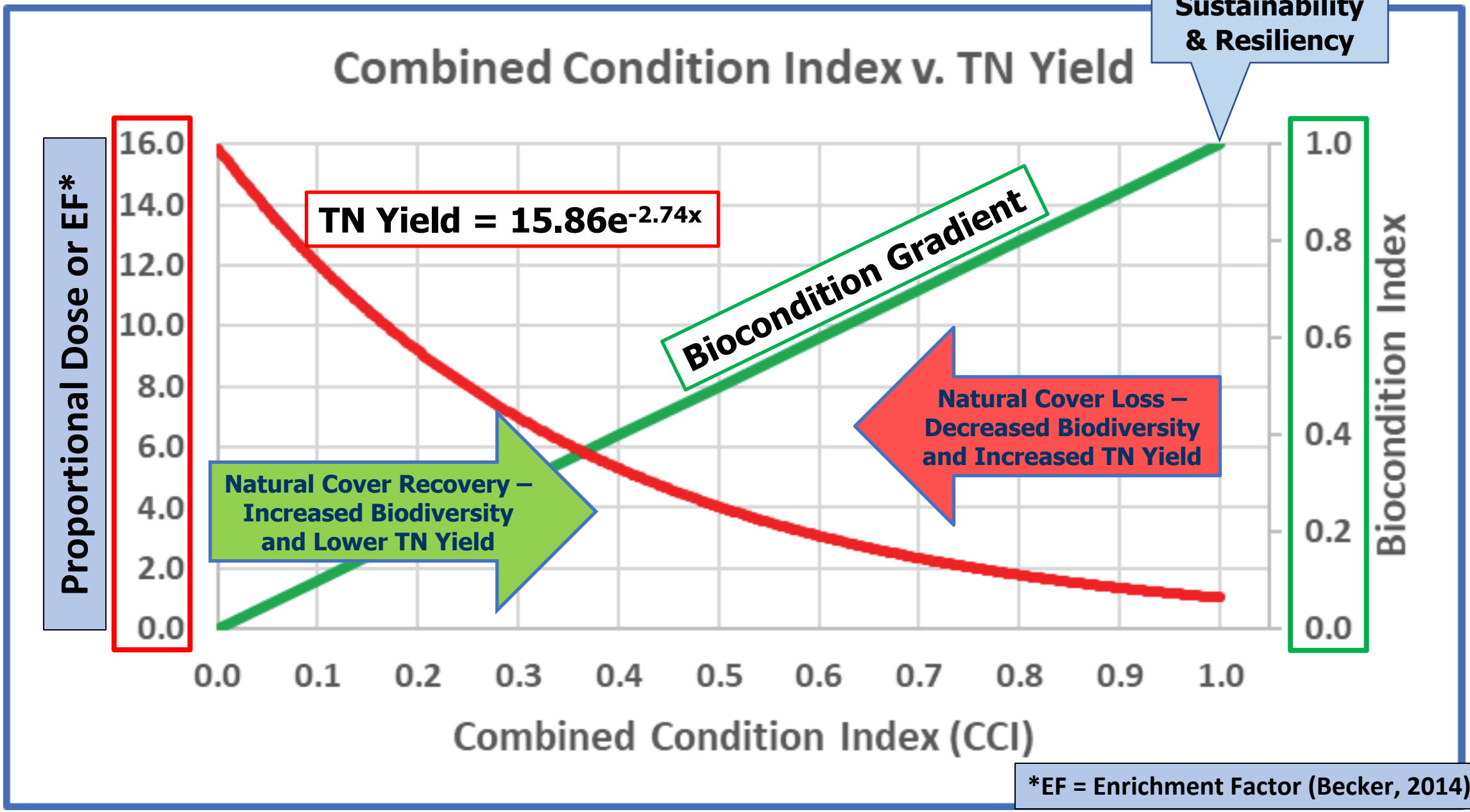
The CCI and Biointegrity:



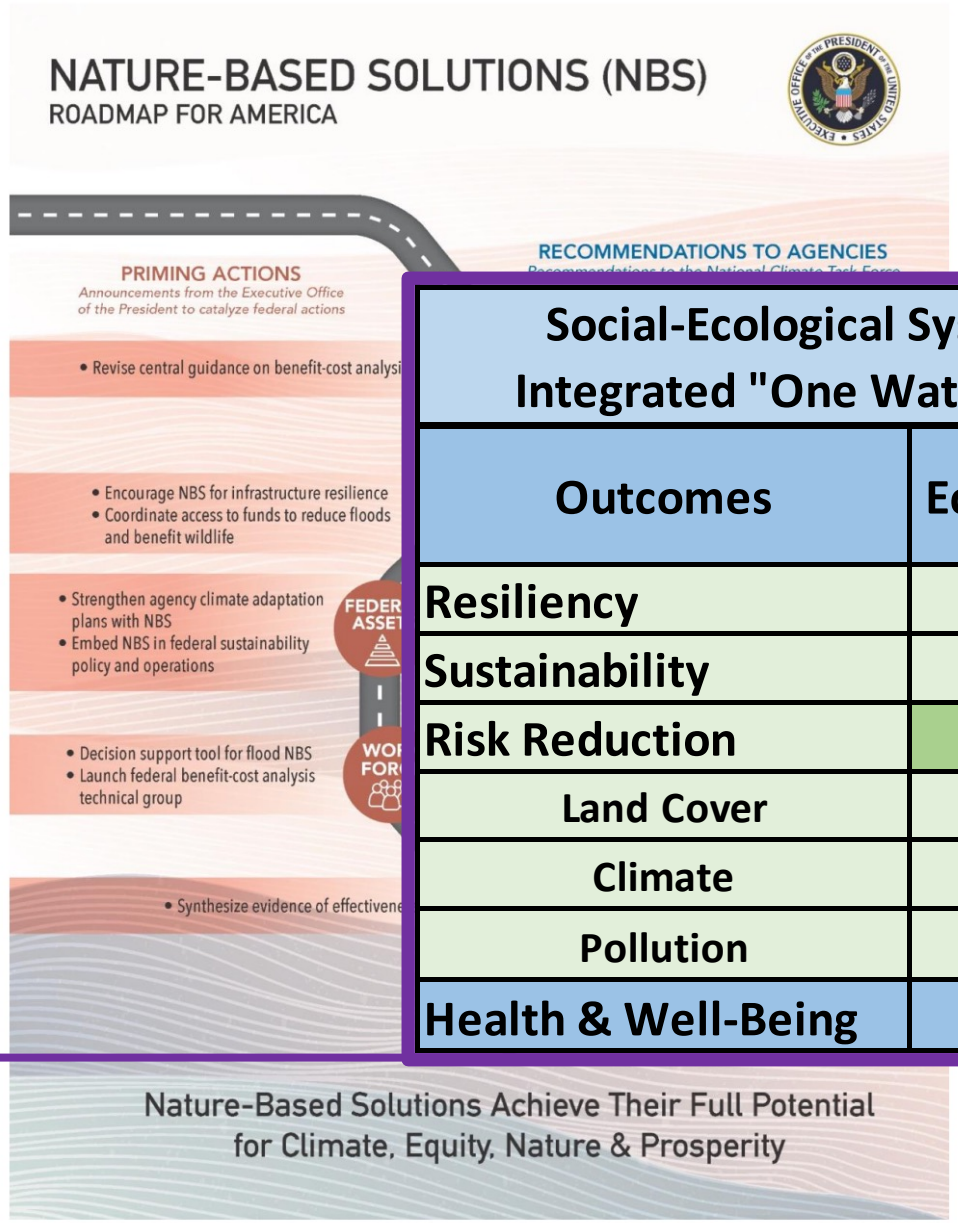
Data Source: CT DEEP Ambient Biological Monitoring Program

*Concept – Lietaer et al. 2010
Interpretation – Belchamber, 2010

Management Model Summary – Simple, Salient, Effective:



Natural/Nature-Based Solutions:



White House Council on Environmental Quality, 2022

Social-Ecological System Benefits of Integrated "One Water" Management		
Outcomes	**Ecosystem**	**Society**
Resiliency	✓	✓
Sustainability	✓	✓
Risk Reduction		
Land Cover	✓	✓
Climate	✓	✓
Pollution	✓	✓
Health & Well-Being	✓	✓

What are natural and Nature-based (NNB) solutions?

Actions to protect, sustainably manage, recover or restore natural or modified ecosystems to address societal challenges, simultaneously providing benefits for people and the environment

Box 1. Benefits of Nature-Based Solutions.

This list is not exhaustive.

- Climate mitigation (reduced greenhouse gas emissions and enhanced carbon storage)
- Reduction of major climate risks, such as:
  - Coastal floods and shoreline erosion
  - Inland floods
  - Stormwater and sewer overflow
  - Extreme heat
  - Wildfire
  - Drought
- Job opportunities
- Improved water and air quality
- Fish, timber, and other natural products
- Recreational opportunities and access
- More resilient infrastructure
- Improved physical and mental health
- Cultural benefits
- Wildlife and biodiversity support
- Community development and economic revitalization

Benchmarking CCI & TN to Aquatic Life Tiers:

Enrichment Factor = Yield/Natural Yield

TN Yield = $15.86e^{-2.74x}$

Tier	Combined Condition Index	EF
1	0.88 - 1.00	1.5 - 1.0
2	0.75 - 0.88	2.0 - 1.5
3	0.60 - 0.75	3.0 - 2.0
4	0.43 - 0.60	5.0 - 3.0
5	0.20 -0.43	9.0 - 5.0
6	0.00 - 0.20	16 - 9.0

Designated Use

ALUS =
Aquatic Life Use Support
TALU =
Tiered Aquatic Life Use*

*Gerritsen and Jessup (2007)

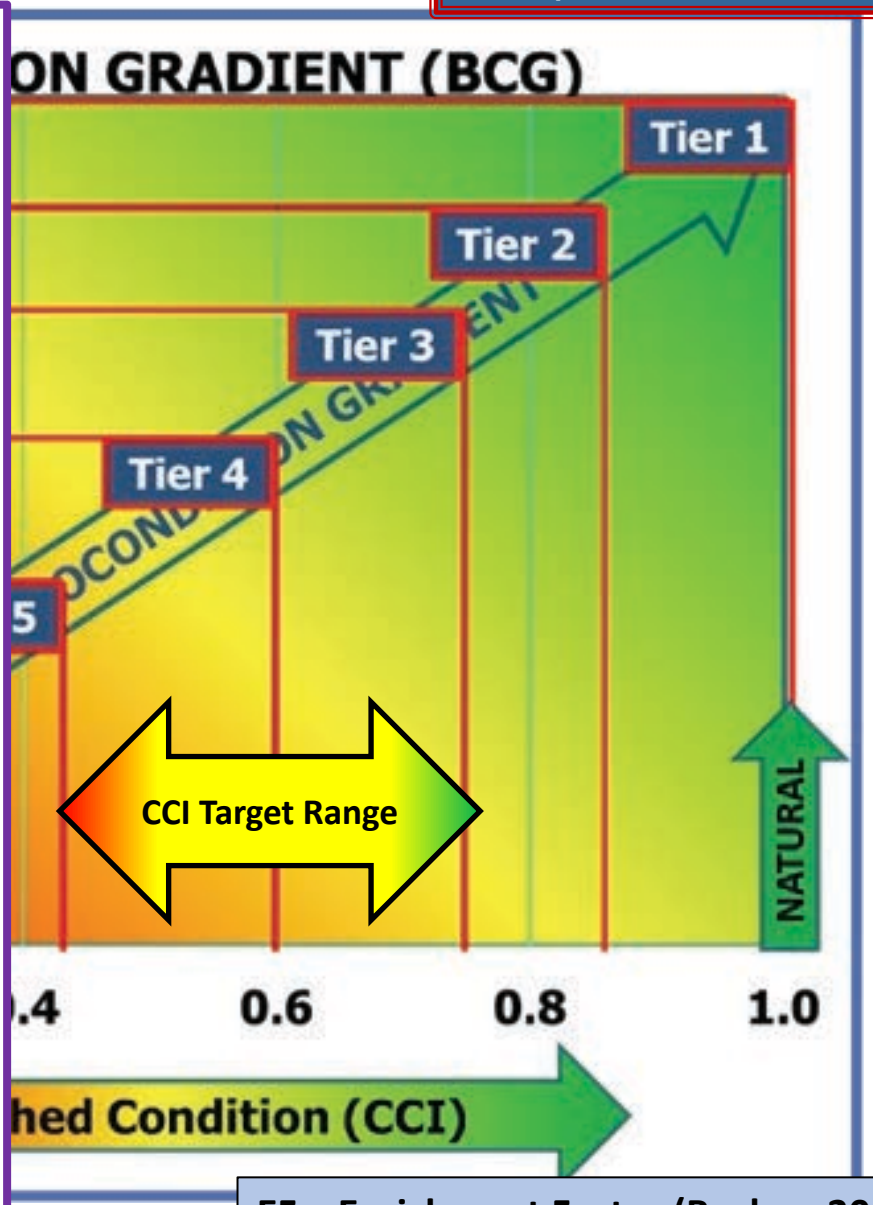
Ecosystem-Based Management (EBM) Watershed Strategies

Conservation

Recovery

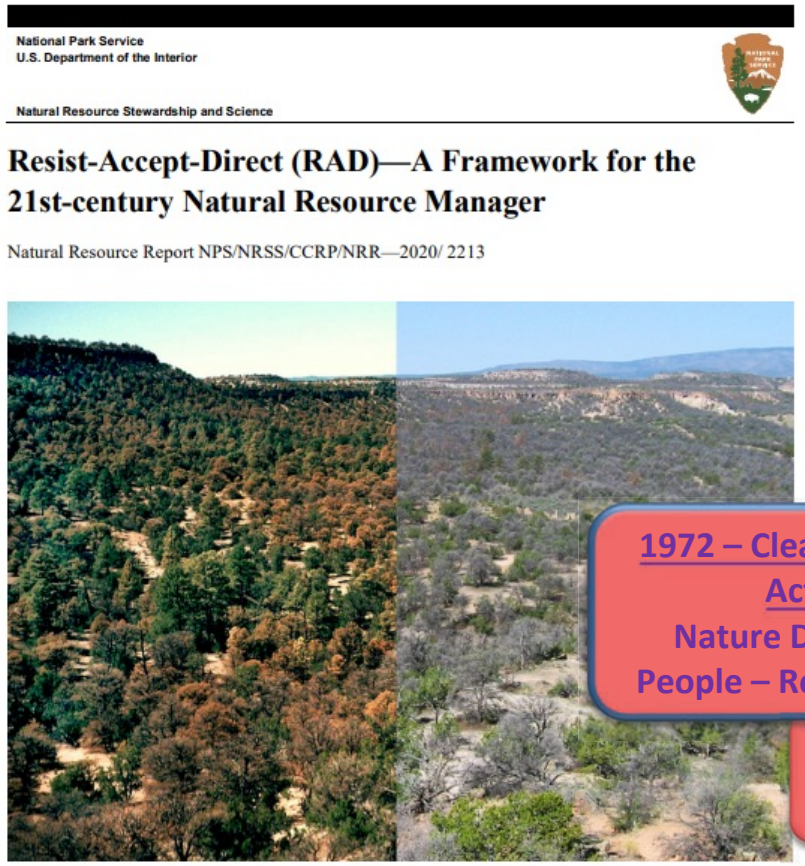
Mitigation

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



EF = Enrichment Factor (Becker, 2014)

BCG Strategic Management:


National Park Service
U.S. Department of the Interior

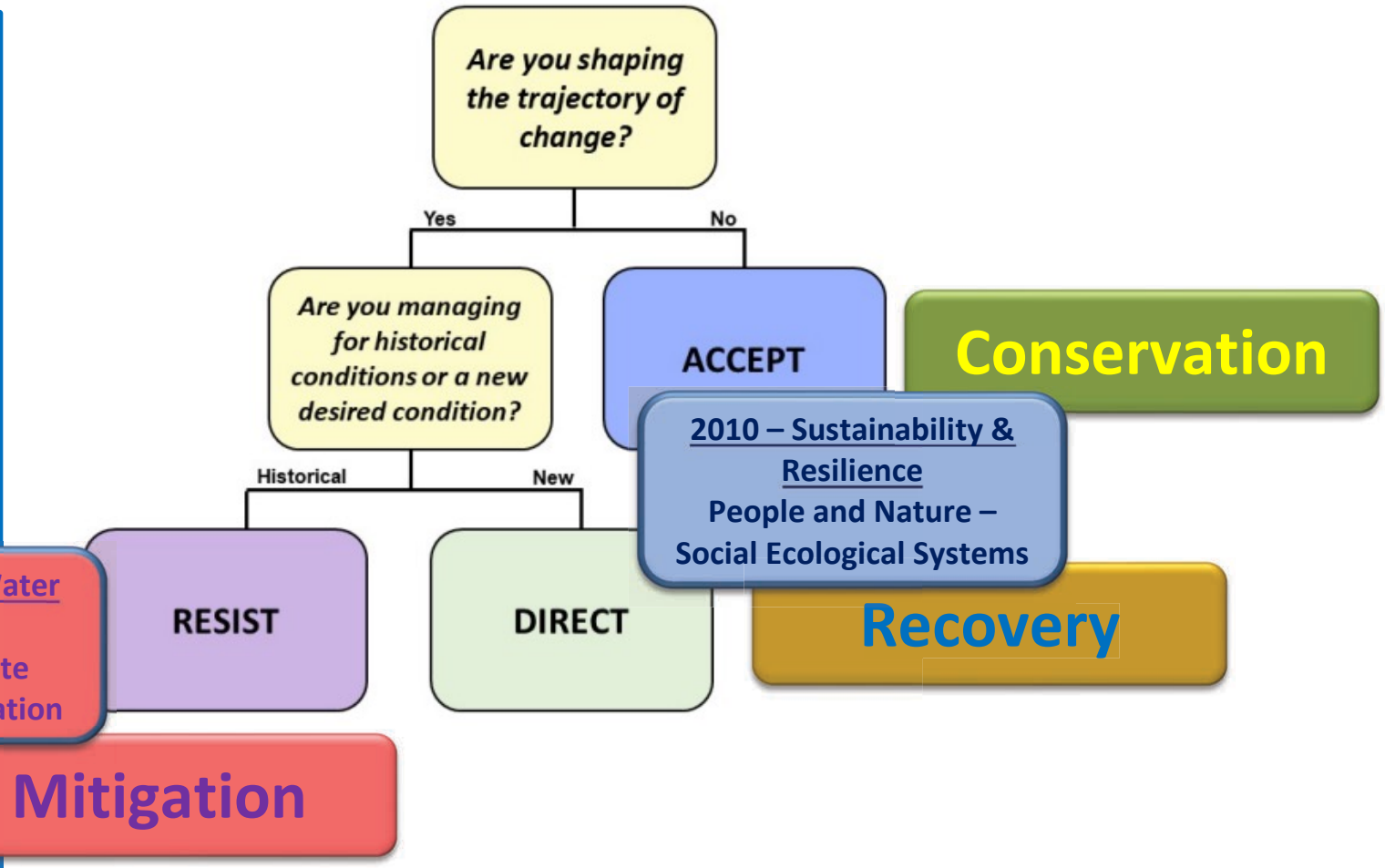
Natural Resource Stewardship and Science

Resist-Accept-Direct (RAD)—A Framework for the 21st-century Natural Resource Manager

Natural Resource Report NPS/NRSS/CCRP/NRR—2020/ 2213

…a tool for responding to ecosystems facing the potential for rapid, irreversible ecological change.

Resist-Accept-Direct (RAD) Framework



"…making informed, purposeful choices about how to respond to the trajectory of change… [using]a straightforward approach to support resource managers in collaborating at larger scales across jurisdictions, which today is more urgent than ever.."

Schuurman et al., 2020

Biointegrity Distribution:

CLEAR Local Watershed Assessment Tool* (LWAT)

* Local Watershed Assessment Tool (arcgis.com) https://clear.uconn.edu/

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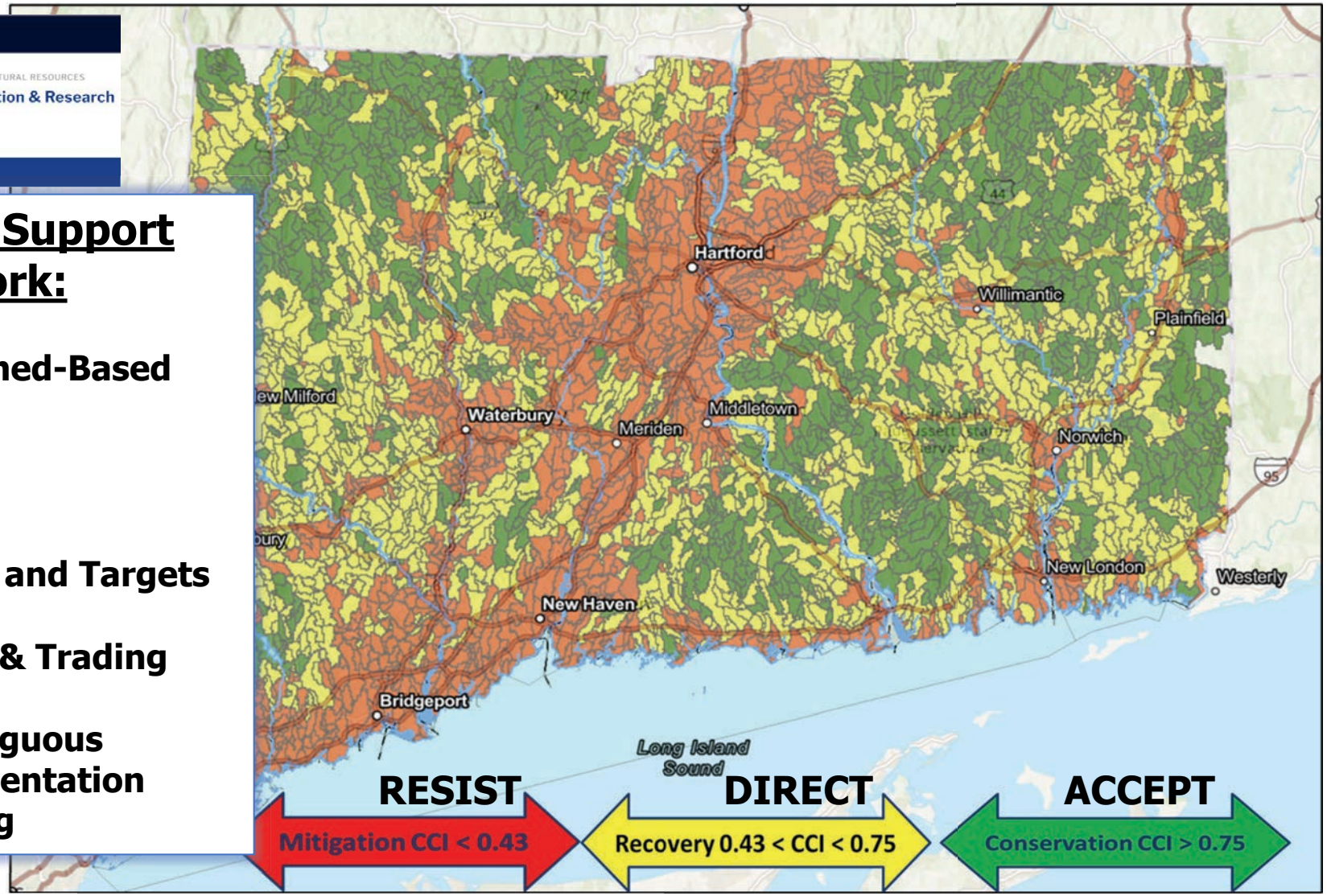
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
Center for Land Use Education & Research
CLEAR



Decision Support Framework:

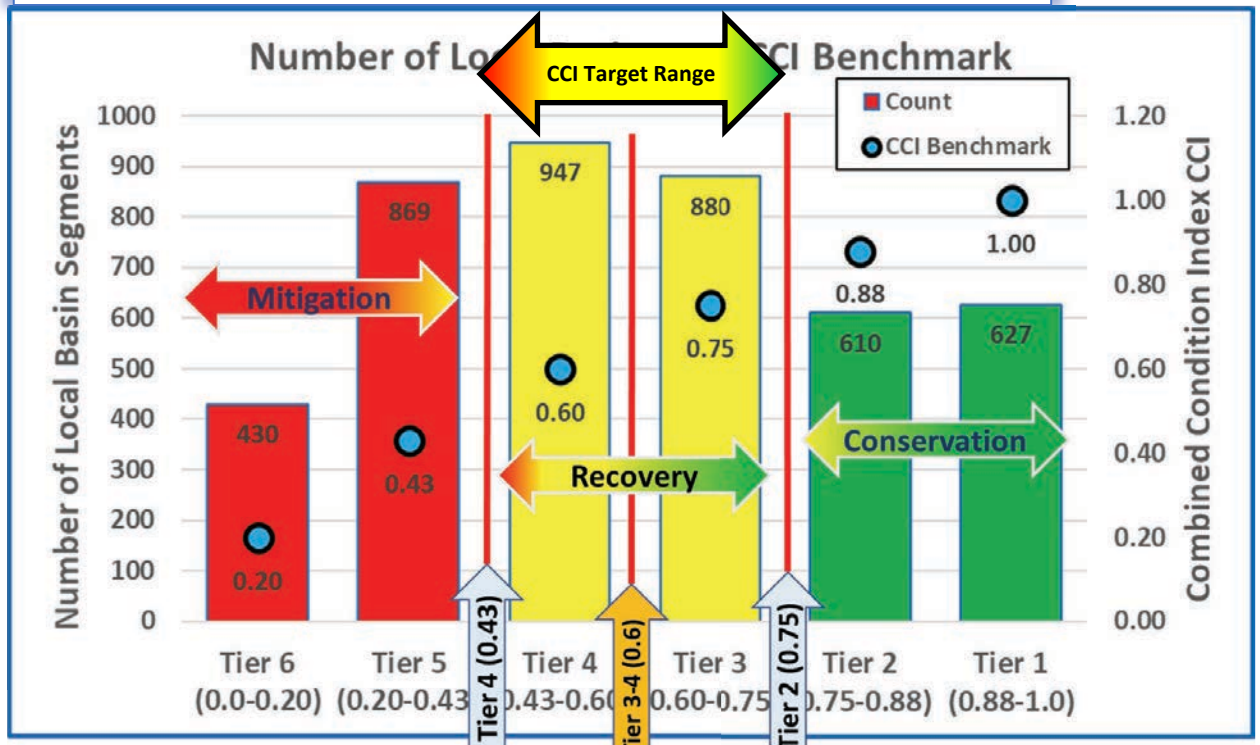
- Watershed-Based Plans
- TMDLs
- Criteria and Targets
- Offsets & Trading
- Unambiguous Implementation Tracking

LWAT Attributes:

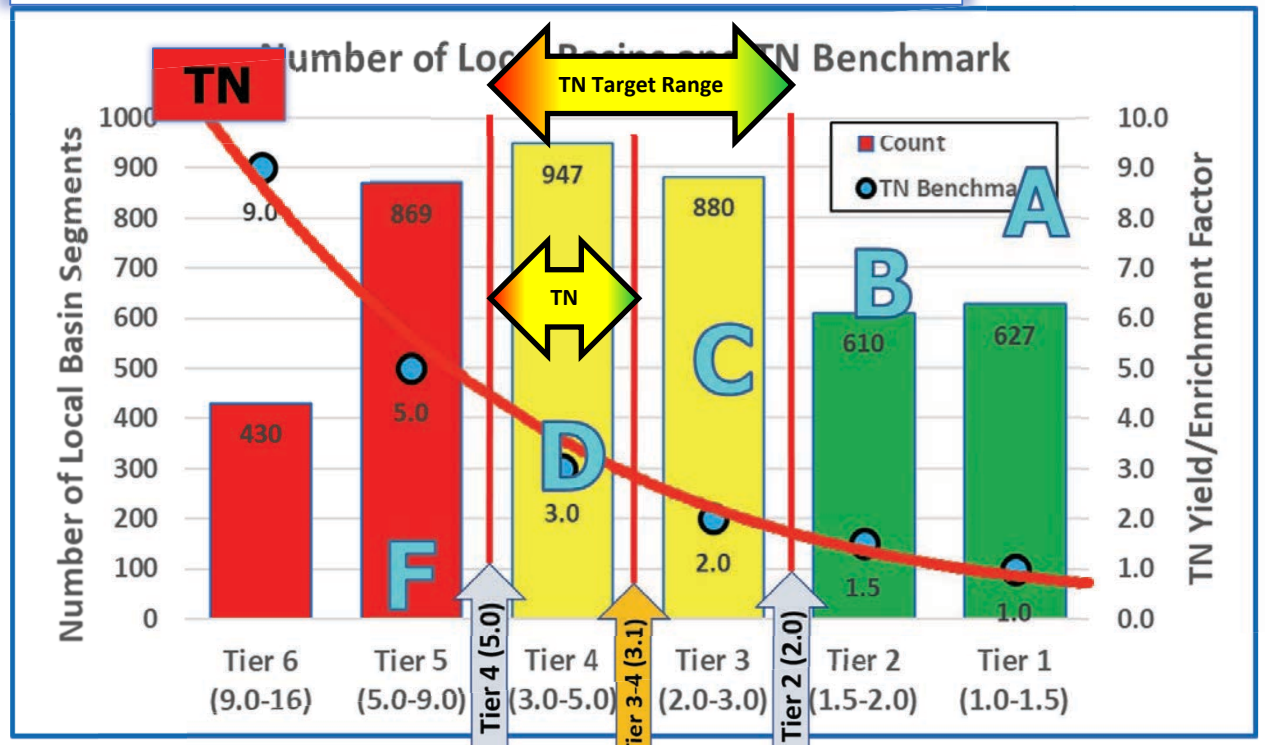
- 1-meter resolution
- 4363 local basins
- Median <500 acres
- TALU Application
- Biointegrity and TN loading assessments
- Strategic Management

Tier	Combined Condition Index	EF
1	0.88 - 1.00	1.5 - 1.0
2	0.75 - 0.88	2.0 - 1.5
3	0.60 - 0.75	3.0 - 2.0
4	0.43 - 0.60	5.0 - 3.0
5	0.20 -0.43	9.0 - 5.0
6	0.00 - 0.20	16 - 9.0

Biointegrity Distribution – CCI:



Total Nitrogen Distribution:



CCI	
Mean	0.57
Median	0.59
Minimum	0.00
Maximum	1.00
Count	4363

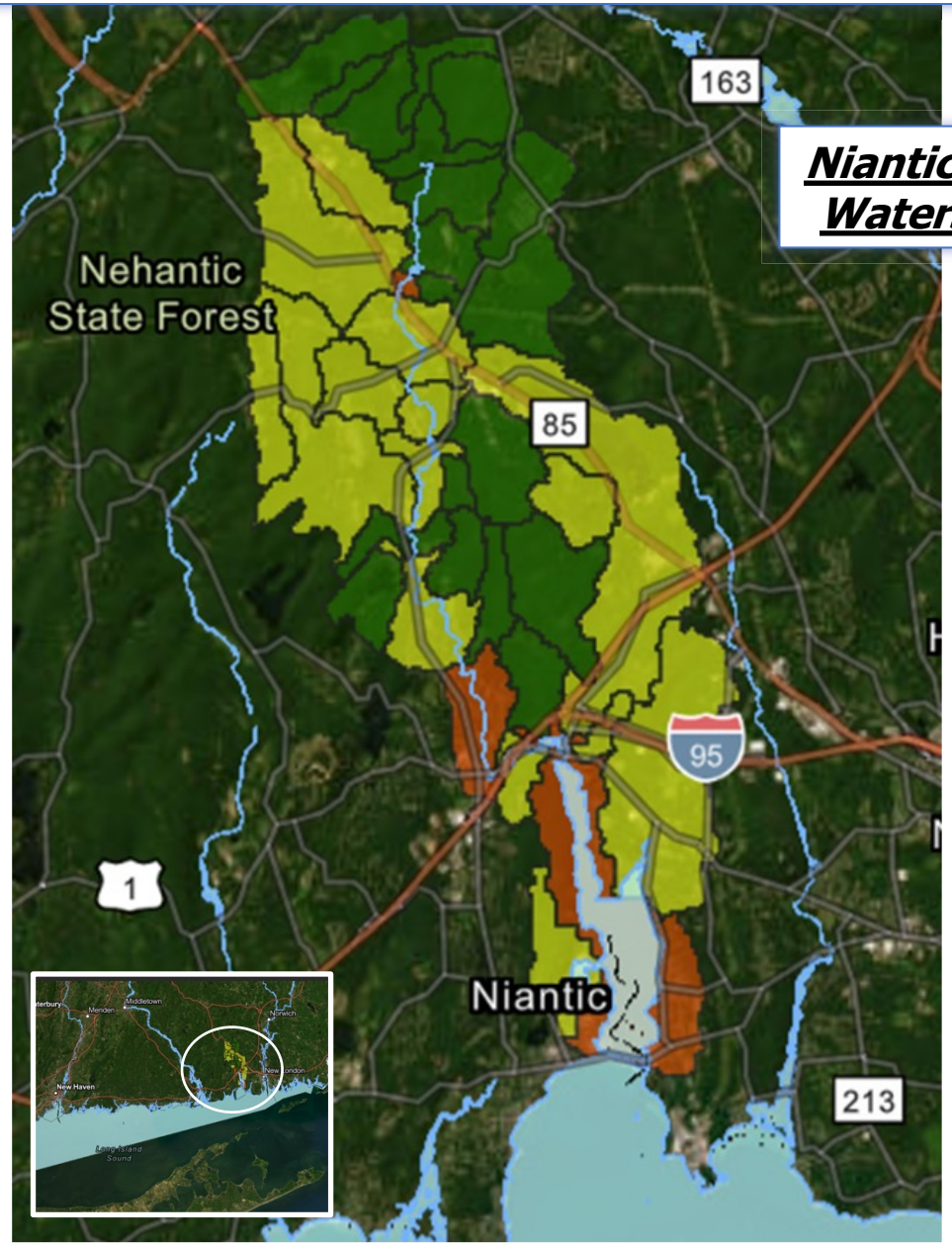
Tier	Combined Condition Index	EF
1	0.88 - 1.00	1.5 - 1.0
2	0.75 - 0.88	2.0 - 1.5
3	0.60 - 0.75	3.0 - 2.0
4	0.43 - 0.60	5.0 - 3.0
5	0.20 -0.43	9.0 - 5.0
6	0.00 - 0.20	16 - 9.0

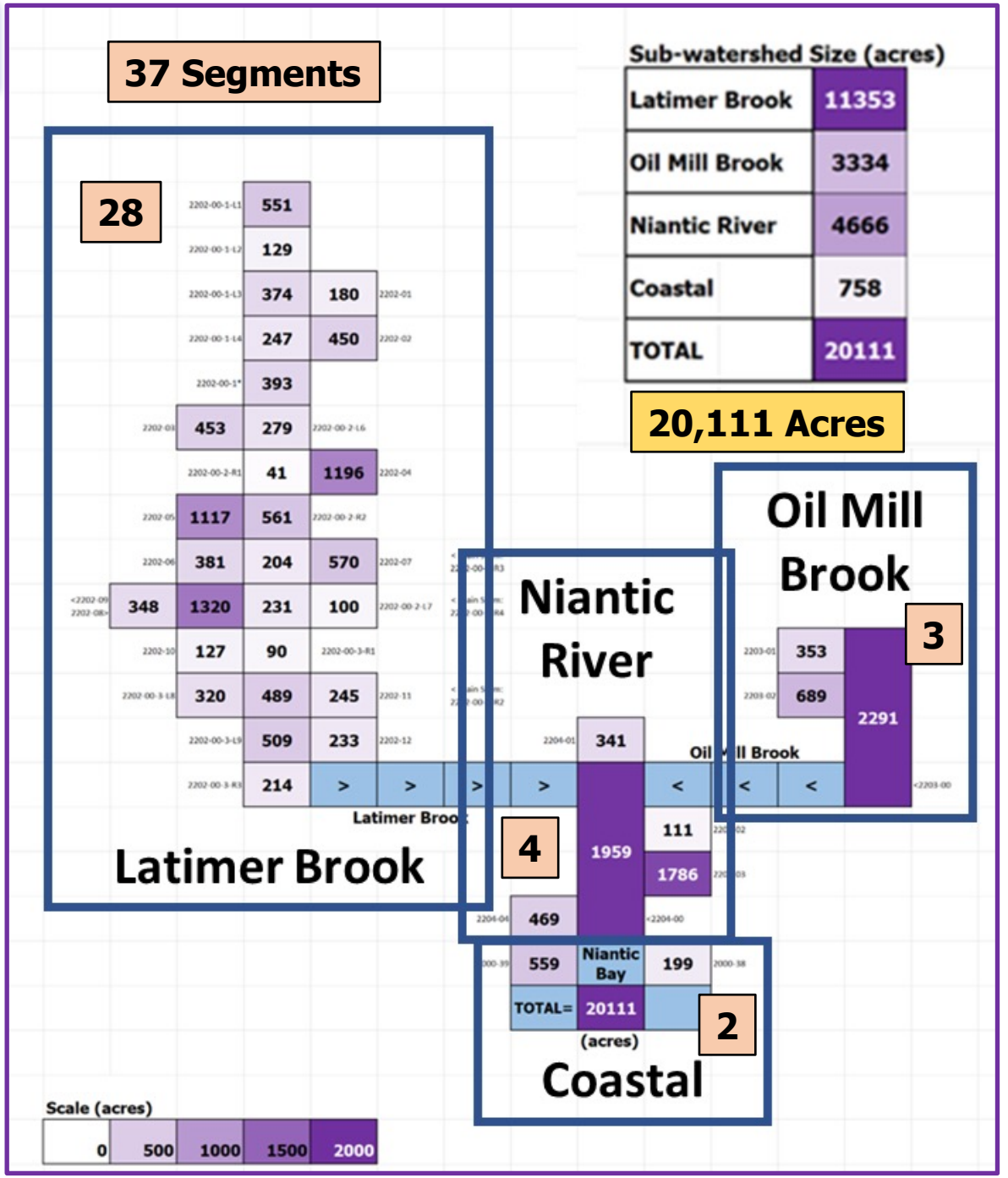
Local Watershed Distribution by Tier and Management Strategy

Tier	Number	Strategy	Number	Percent
1	627	Conservation	1237	28
2	610			
3	880	Recovery	1827	42
4	947			
5	869	Mitigation	1299	30
6	430			
Total	4363		4363	100

TN Yield or EF	
Mean	4.20
Median	3.11
Minimum	1.02
Maximum	15.7
Count	4363

LWAT Decision Support Framework:





LWAT Decision Support Framework:

EF = 3.0
TIER 4
TARGET

Current Condition

BAC = Best Attainable Condition

TN

Total Nitrogen	Natural		Current		Target		BAC	
Sub-watershed	Tons/yr	EF	Tons/yr	EF	Tons/yr	EF	Tons/yr	EF
Latimer Brook	5.7	1.0	13.4	2.4	17.0	3.0	8.5	1.5
Oil Mill Brook	1.7	1.0	3.6	2.2	5.0	3.0	2.2	1.3
Niantic River	2.3	1.0	9.8	4.2	7.0	3.0	4.6	2.0
Coastal	0.4	1.0	3.8	10.2	1.1	3.0	2.5	6.7
NPS/SW Total	10.1	1.0	30.7	3.1	30.2	3.0	17.8	1.8
Sewage	0.0		0.0		0.0		0.0	
TOTAL	10.1	1.0	30.7	3.1	30.2	3.0	17.8	1.8

Sub-watershed Condition (CCI)	Current	Current Grade	BAC	BAC Grade
Latimer Brook	0.708	C	0.892	A
Oil Mill Brook	0.734	C+	0.913	A
Niantic River	0.465	D	0.766	B
Coastal	0.163	F	0.316	F+
TOTAL	0.598	D+	0.837	B

Tier	Combined Condition Index	EF
1	0.88 - 1.00	1.5 - 1.0
2	0.75 - 0.88	2.0 - 1.5
3	0.60 - 0.75	3.0 - 2.0
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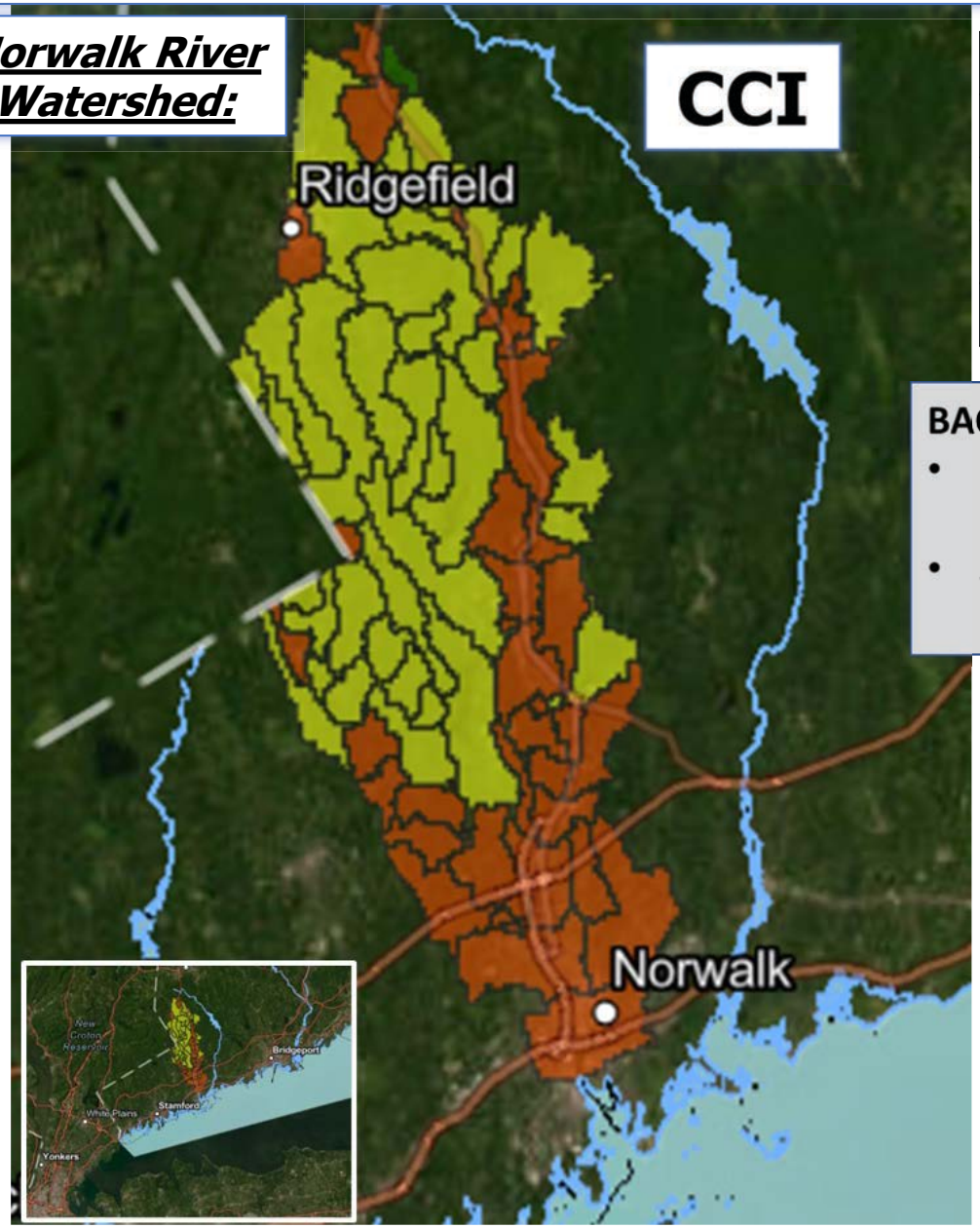
5	0.20 -0.43	9.0 - 5.0
6	0.00 - 0.20	16 - 9.0

LWAT Decision Support Framework:

Norwalk River Watershed:



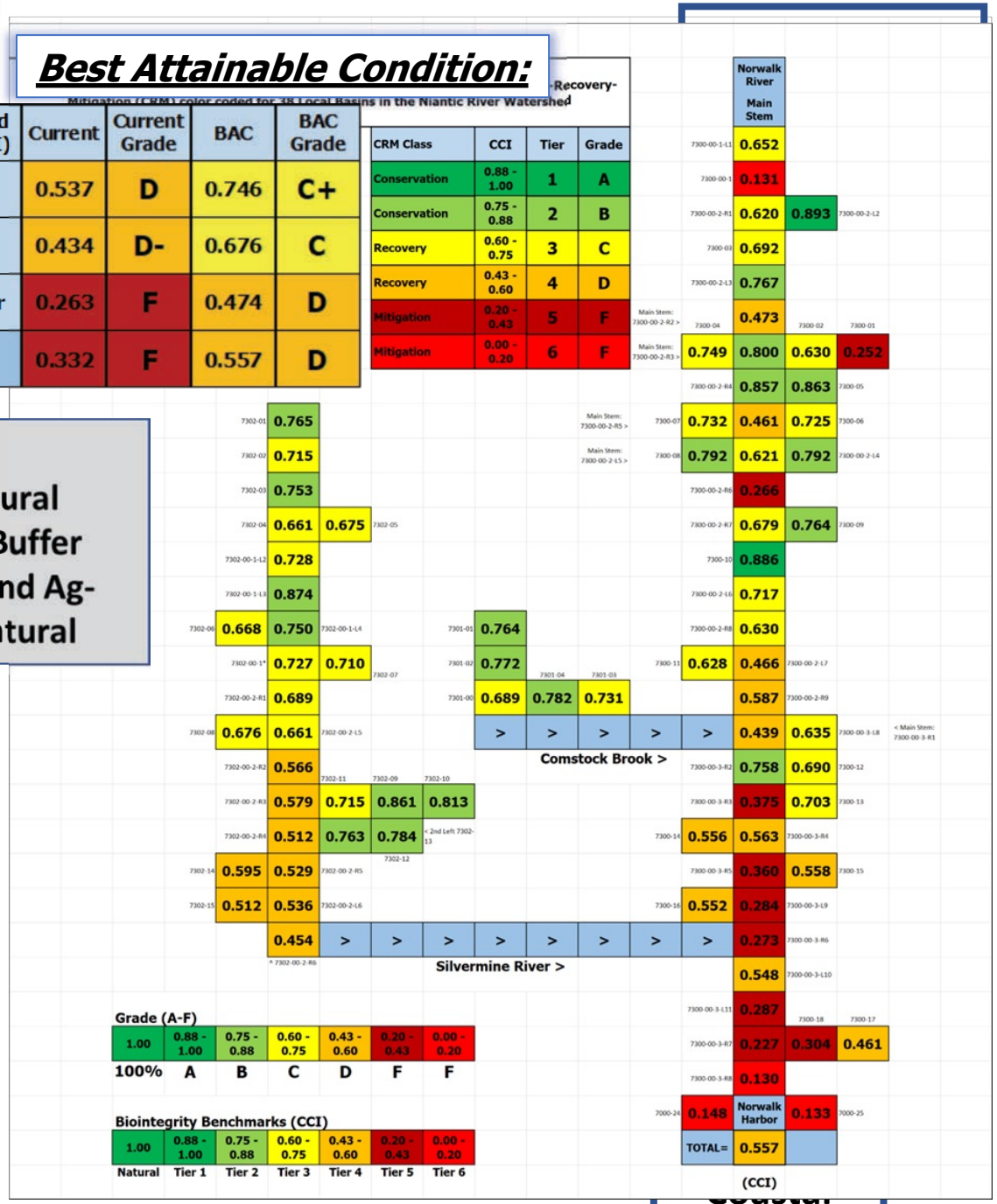
Best Attainable Condition:

Sub-watershed Condition (CCI)	Current	Current Grade	BAC	BAC Grade
Comstock Br	0.537	D	0.746	C+
Silvermine R	0.434	D-	0.676	C
Norwalk River	0.263	F	0.474	D
TOTAL	0.332	F	0.557	D

BAC =
- 100% Natural Riparian Buffer
- 50% Upland Ag-Like to Natural

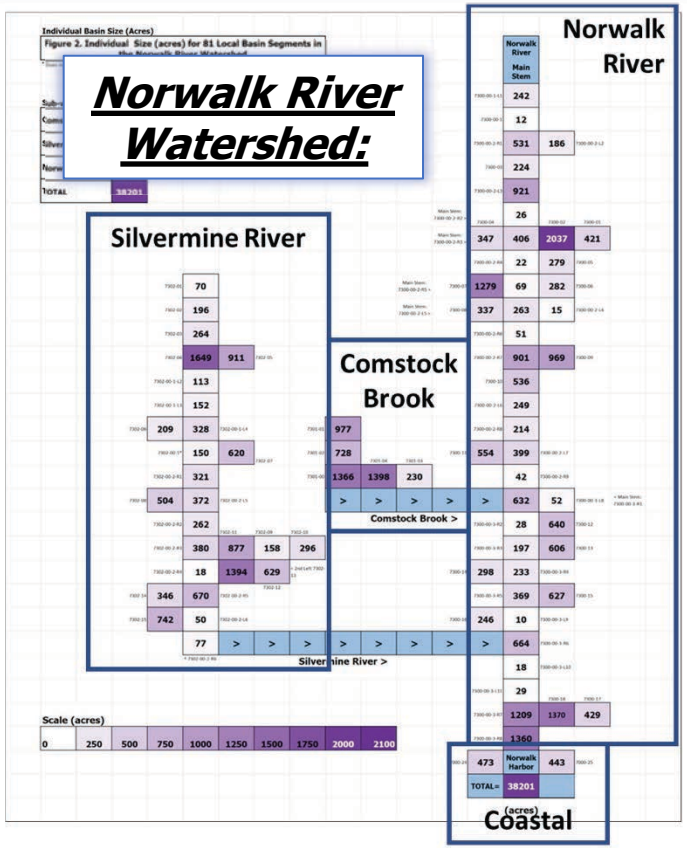
Mitigation (CRM) color coded for 48 Local Basins in the Niantic River Watershed

CRM Class	CCI	Tier	Grade
Conservation	0.88 - 1.00	1	A
Conservation	0.75 - 0.88	2	B
Recovery	0.60 - 0.75	3	C
Recovery	0.43 - 0.60	4	D
Mitigation	0.20 - 0.43	5	F
Mitigation	0.00 - 0.20	6	F



LWAT Decision Support Framework:

Norwalk River Watershed:



Sub-watershed Condition (CCI)	Current	Current Grade	BAC	BAC Grade
Comstock Br	0.537	D	0.746	C+
Silvermine R	0.434	D-	0.676	C
Norwalk River	0.263	F	0.474	D
TOTAL	0.332	F	0.557	D

TN

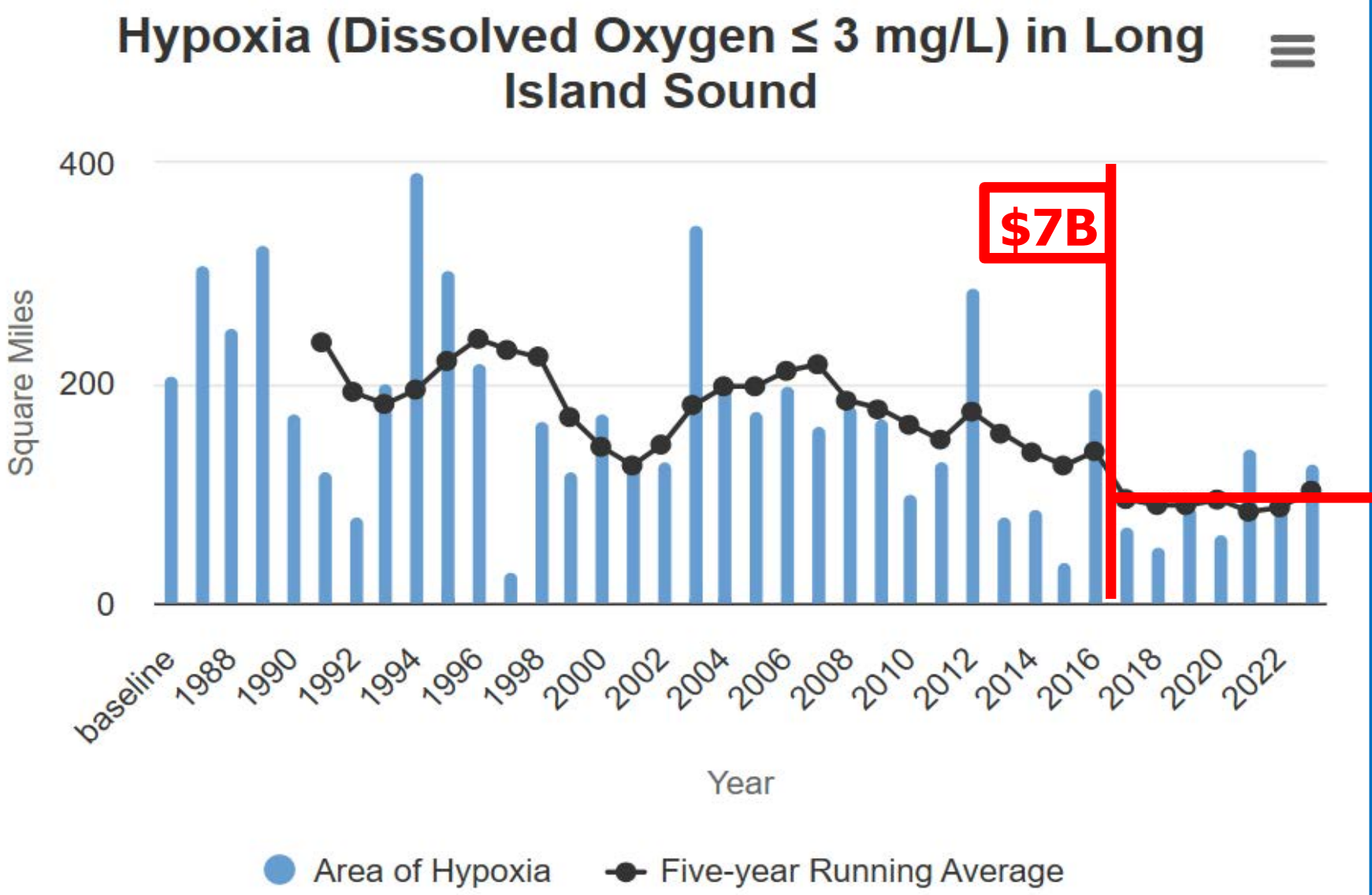
Tier	Combined Condition Index	EF
1	0.88 - 1.00	1.5 - 1.0
2	0.75 - 0.88	2.0 - 1.5
3	0.60 - 0.75	3.0 - 2.0
4	0.43 - 0.60	5.0 - 3.0
5	0.20 -0.43	9.0 - 5.0
6	0.00 - 0.20	16 - 9.0

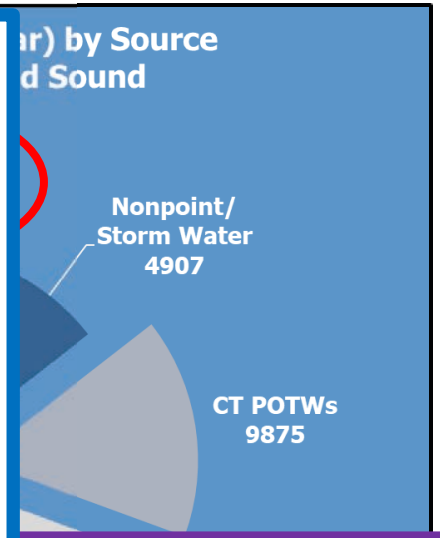
EF = 5.0 TIER 4 TARGET

Total Nitrogen	Natural		Current		Target		BAC	
Sub-watershed	Tons/yr	EF	Tons/yr	EF	Tons/yr	EF	Tons/yr	EF
Comstock Br	2.3	1.0	8.6	3.7	11.8	5.0	4.8	2.1
Silvermine R	5.9	1.0	28.3	4.8	29.4	5.0	14.9	2.5
Norwalk River	10.9	1.0	78.1	7.2	54.4	5.0	48.6	4.5
NPS/SW Total	19.1	1.0	114.9	6.0	95.5	5.0	68.3	3.6

Application to Long Island Sound TN Management:

Source: Long Island Sound Study (LISS)





Source	Load Reduction To Date	Additional Load Reduction
	1000 Tons TN/yr	1000 Tons TN/yr
CT Land	0.4	
CT Sewage	6.3	
CT Total	6.7	3.2
LIS Land	0.5	
LIS Sewage	24.1	
LIS Basin	24.6	11.8

In Summary:

Making Nature Great Again

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

Takeaway Conclusions:

Managing watersheds back to health is the ***best action that can be taken to meet biodiversity and nutrient/pollutant goals*** for:

- ❖ Resilient and Sustainable Social & Ecological Outcomes
  - ❖ Watershed and Stream Aquatic Ecosystems
  - ❖ Benefits that cascade downstream
    - ❖ Local Estuaries
    - ❖ Greater Long Island Sound

With contributing benefits to ***Human Health and Welfare*** including ***Environmental Justice*** in the watershed – ***Where People Live!***

Acknowledgements, Credits, and References:

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

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Center for Land Use Education & Research
CLEAR

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

CT DEEP
Ambient Biological Monitoring Program

Credits:

Paulson, C., L. Stephens and W. Broley. 2017. Blueprint for One Water. Project 4660. Denver, CO: The Water Research Foundation.
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Source: Uconn, CLEAR, CTECO (CT Env. Cond. Online. https://maps.cteco.uconn.edu/https://maps.cteco.uconn.edu/projects/landcover/ct-highres/
Source: UConn CLEAR Local Watershed Assessment Tool (LWAT): https://experience.arcgis.com/template/68b1ebdd244a4f1a800a15af0e600307
White House CEQ. 2022. https://www.whitehouse.gov/wp-content/uploads/2023/12/Nature-Based-Solutions-Resource-Guide-2.0-FINAL.pdf

Thank you!

NEWEA 2024
Annual Conference
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January 21–24

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Boston, Massachusetts

Paul E. Stacey

FOOTPRINTS IN THE WATER

Working to Make Nature Great Again

FootprintsInTheWater@outlook.com