Approximating Loads and Yields Based on Stormwater Nutrient Data and Drainage Basin Ratios

Presentation to the Water Quality Management Agency of Cayuga County

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Value of Nutrient Loading Estimates from Cayuga Lake Tributary Streams

- Having loads and yields for many tributary streams, even if they are approximations, can help prioritize sub-watersheds for nutrient management
- In sub-watersheds with high nutrient yields, monitoring nutrient concentrations at multiple locations from headwaters to mouth has the potential to identify “hot spot” catchment areas for nutrients
- Management efforts can prioritize “hot spot” catchments, saving time and money while also distributing the burden of management more equitably across county and municipal jurisdictions
- Watershed-wide nutrient load and yield approximations should complement the Cayuga Lake TMDL once it is released by DEC

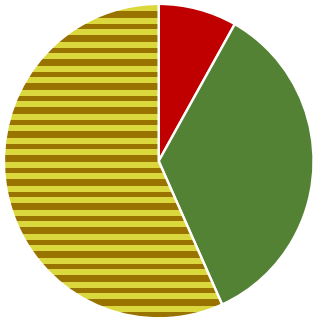
CSI-Volunteer Monitoring Partnerships: Monitored and Unmonitored Drainage Areas

Landcover Legend

National Land Cover Database (NLCD)
2016 land cover classifications

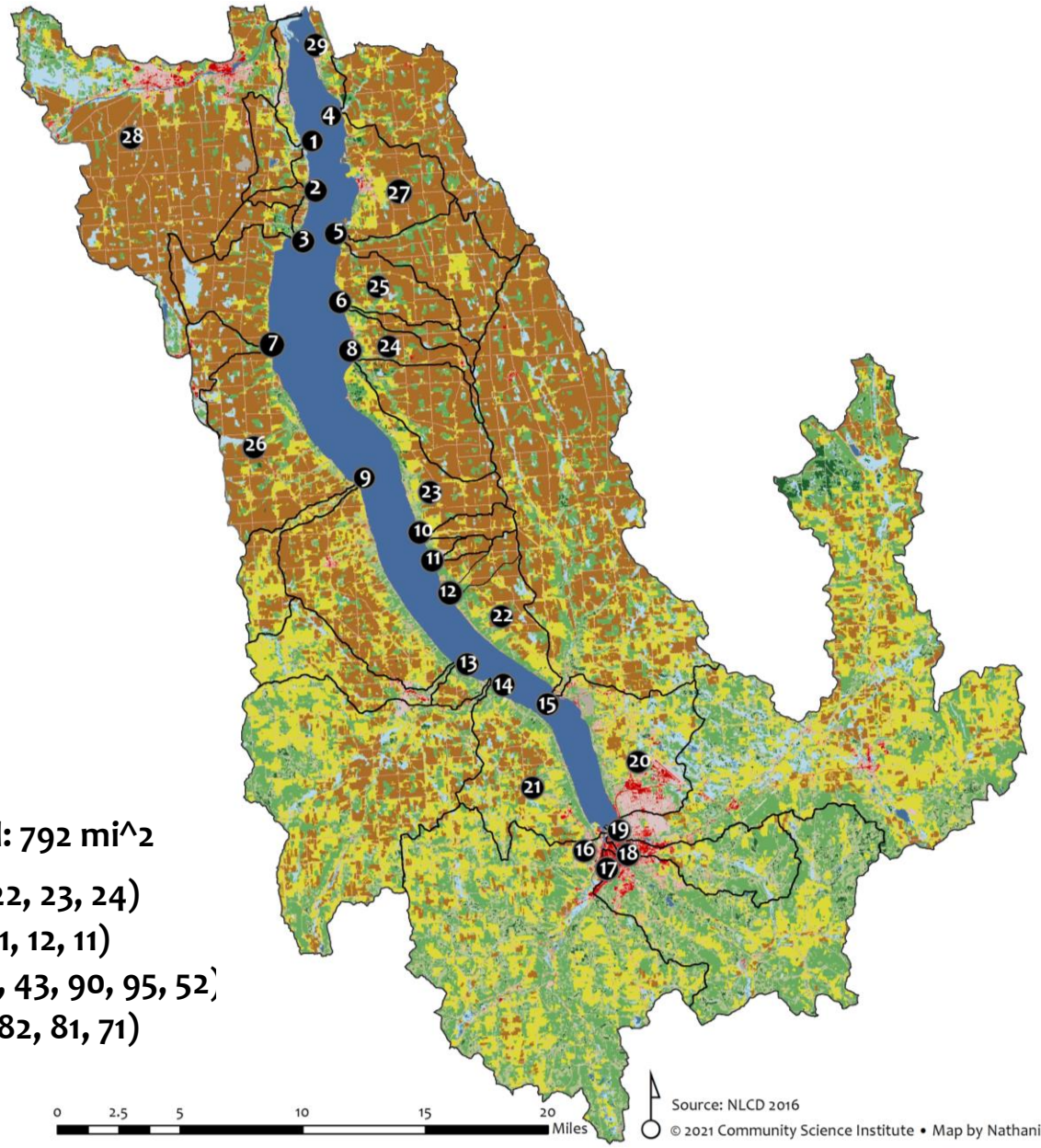
- 11 Open Water
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Iensity
- 24 Developed, High-Intensity
- 31 Barren Land
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 81 Pasture/ Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands
- 12, 51, 52, 71, 72, 74 Other

Cayuga Lake Watershed Area and Land Cover Percentages



Cayuga Lake Watershed: 792 mi^2

- 8% Developed (21, 22, 23, 24)
- <1% Other (72, 74, 51, 12, 11)
- 35% Forested (41, 42, 43, 90, 95, 52)
- 57% Agriculture (31, 82, 81, 71)



Monitored Drainage Areas: 516 sq. mi.

1. Canoga Creek
2. Williamson Creek
3. Burroughs Creek
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5. Great Gully
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Unmonitored Drainage Areas: 267 sq. mi.

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29. Northern Marshes Direct Streams

Approach to Approximating Nutrient Loading from 14 Monitored, Ungauged Cayuga Lake Tributary Streams

- Use modeling software to calculate nutrient loading at two locations with USGS gauging stations on Fall Creek and Six Mile Creek
  - **Load = Flow x Nutrient Concentration**
  - Flows are obtained from USGS gauging stations
  - Nutrient concentrations provided by CSI-volunteer monitoring partnerships
- Use nutrient loads at the USGS gauging stations as “Index Loads” to approximate loading from 14 other monitored but ungauged streams
- Assumptions
  - Drainage basin ratio can be used to approximate flow in ungauged stream
  - Nutrient loading is proportional to nutrient concentrations at high flows

Question: How Accurate is this kind of load approximation? Answer: Reasonably accurate

- Example: Approximate soluble reactive phosphorus (SRP) loading at USGS gauging station on Six Mile Creek by "indexing" it to SRP loading at USGS gauging station on Fall Creek:
  - **"Index Load" is 3.81 tons/yr**, the multiyear (2009-2013) average of SRP loads calculated with modeling software at USGS gauging station on Fall Creek
  - **The drainage basin ratio is 0.31** (Bethel Grove on Six Mile Creek/Forest Home on Fall Creek) = (39 mi^2/126 $mi^{2)}$ = 0.31
  - **The long-term stormwater SRP ratio is 0.91** from CSI database: (Mean SRP at Bethel Grove on Six Mile Creek (2004-2020, N=31))/Mean SRP at Cayuga Street Bridge on Fall Creek (2004-2020, N=38)) = (22.6 ug/L / 24.8 ug/L) = 0.91
  - **Approximated SRP Load for Bethel Grove on Six Mile Creek = (Fall Creek "Index Load") x (drainage basin ratio) x (stormwater SRP ratio) = 3.81 tons/yr x 0.31 x 0.91 = 1.07 tons/yr**
  - **Calculated SRP load at Bethel Grove = 0.85 tons** (multiyear average, 2009-2013, of five annual loads calculated with modeling software)
  - **(Approximated SRP load)/(Calculated SRP load) = 0.85/1.07 x 100 = 79%**

Approximate SRP, TP, NOx and TKN Loading for 14 Monitored, Ungauged Cayuga Lake Tributary Streams

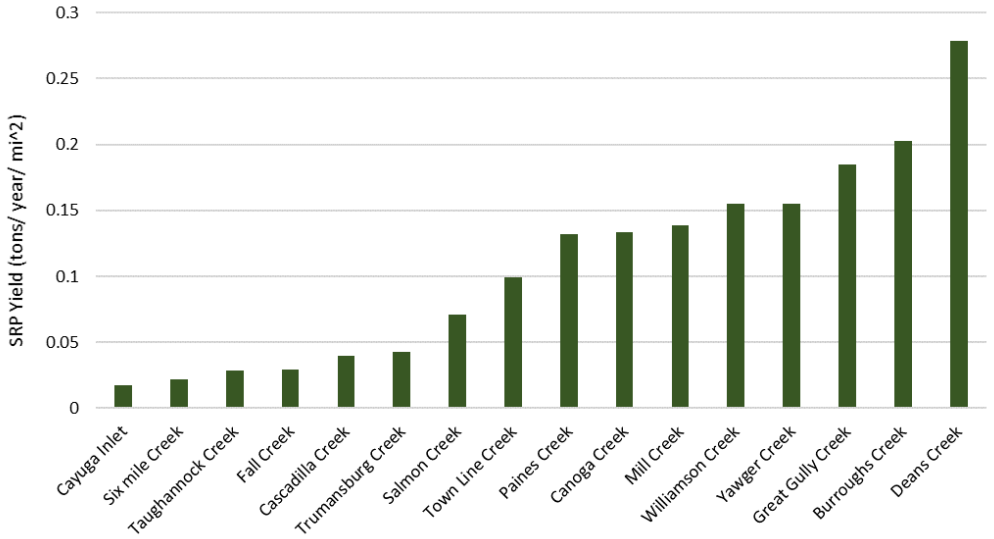
- Perform two approximations for each monitored, ungauged tributary stream
  - Base one approximation on Fall Creek nutrient load as the “Index Load”
  - Base other approximation on Bethel Grove nutrient load as the “Index Load”
  - Take average of two approximated loads
- Use average approximated loads to estimate nutrient yields in units of tons/year/mi^2
- Plot nutrient yields (tons/year/mi^2) vs. % agricultural land use in monitored sub-watersheds

Approximated Nutrient Loads in 14 Monitored, Ungauged Cayuga Lake Tributary Streams

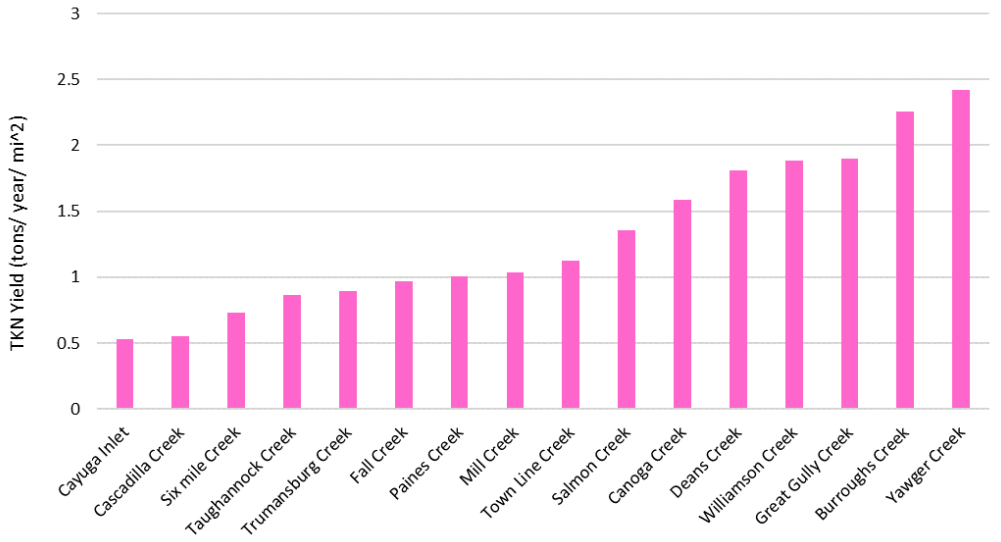
Monitored Drainage Areas within Cayuga Lake Watershed			Two Sets of Nutrient "Index Loads" and Yields in Gauged Streams							
Watershed	Drainage Area (mi^2)	Percent Agriculture	Average SRP Load (tons/ year)	SRP Yield (tons/year/mi^2)	Average TP Load (tons/year)	TP Yield (tons/year/mi^2)	Average NOx Load (tons/ year)	NOx Yield (tons/year/mi^2)	Average TKN Load (tons/ year)	TKN Yield (tons/year/mi^2)
Fall Creek	129	46%	3.81	0.030	19.56	0.15	156	1.21	124.8	0.97
Six mile Creek @ Bethel Grove	39	24%	0.85	0.022	5.69	0.15	21.8	0.56	28.5	0.73
					Average Approximated Loads and Yields (based on two "Index Loads," above)					
Cayuga Inlet	92.37	36%	1.63	0.02	8.13	0.09	39.87	0.43	49.27	0.53
Cascadilla Creek	13.7	24%	0.55	0.04	1.07	0.08	5.40	0.39	7.58	0.55
Taughannock Creek	66.8	57%	1.89	0.03	7.90	0.12	183.39	2.75	57.82	0.87
Trumansburg Creek	13.07	66%	0.56	0.04	0.94	0.07	35.21	2.69	11.71	0.90
Salmon Creek	89.2	71%	6.33	0.07	15.34	0.17	740.83	8.31	121.19	1.36
Town Line Creek	1.7	75%	0.17	0.10	0.24	0.14	19.34	11.38	1.91	1.13
Mill Creek	1.4	86%	0.19	0.14	0.41	0.29	21.27	15.19	1.45	1.04
Paines Creek	15.3	76%	2.02	0.13	2.73	0.18	126.01	8.24	15.40	1.01
Deans Creek	3.2	76%	0.89	0.28	1.00	0.31	43.21	13.50	5.80	1.81
Burroughs Creek	3.7	74%	0.75	0.20	1.35	0.36	23.00	6.22	8.34	2.25
Williamson Creek	1.4	80%	0.22	0.16	0.54	0.39	6.53	4.66	2.63	1.88
Great Gully Creek	15.56	79%	2.88	0.18	4.44	0.29	72.54	4.66	29.60	1.90
Canoga Creek	5.83	75%	0.78	0.13	1.50	0.26	27.70	4.75	9.27	1.59
Yawger Creek	24.91	80%	3.87	0.16	8.34	0.33	120.86	4.85	60.26	2.42

Nutrient Yields for Each Monitored Drainage Area in the Cayuga Lake Watershed

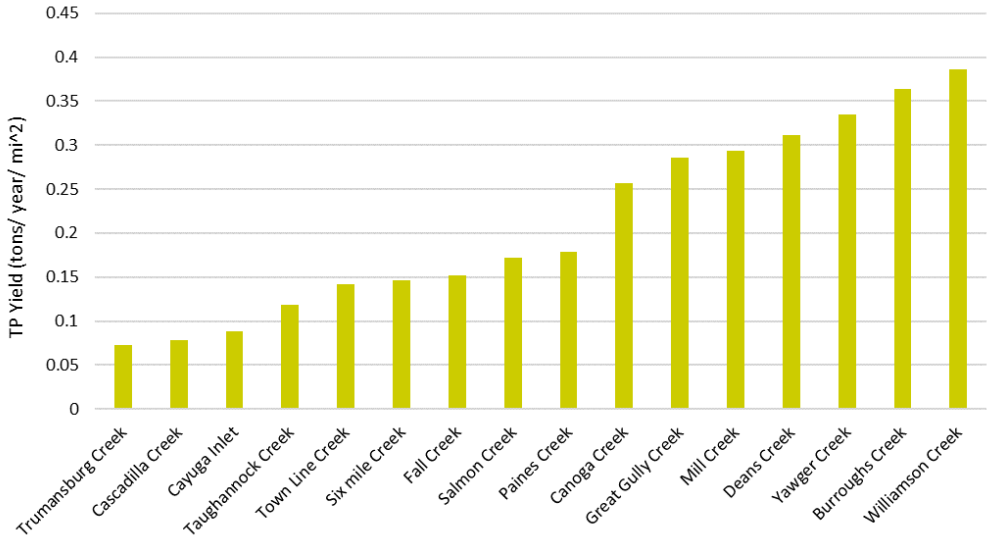
a) SRP Yields



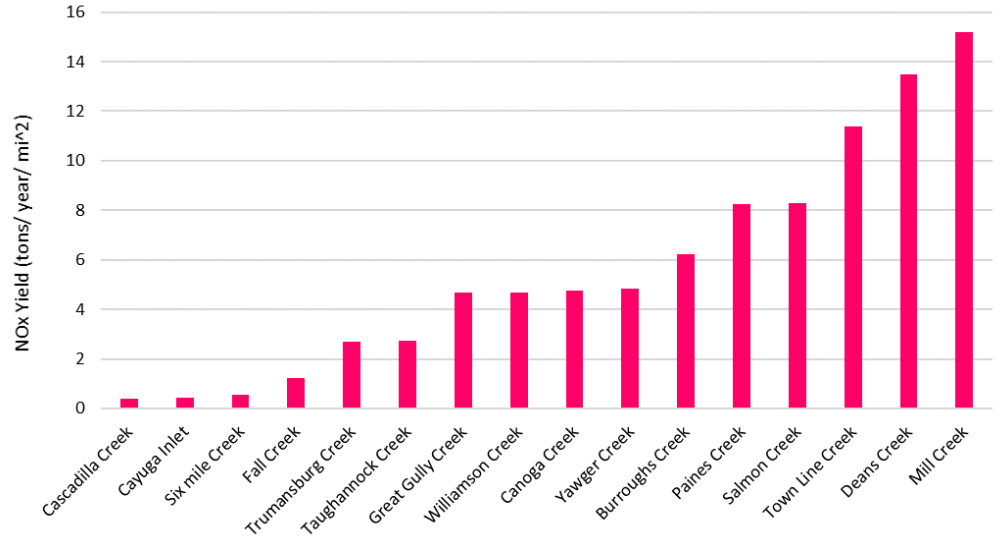
d) TKN Yields



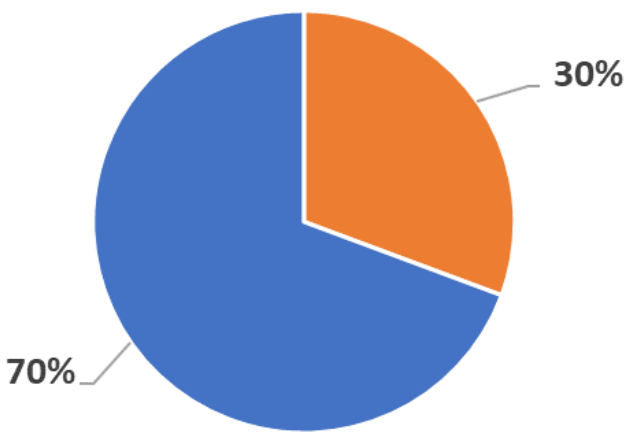
c) TP Yields

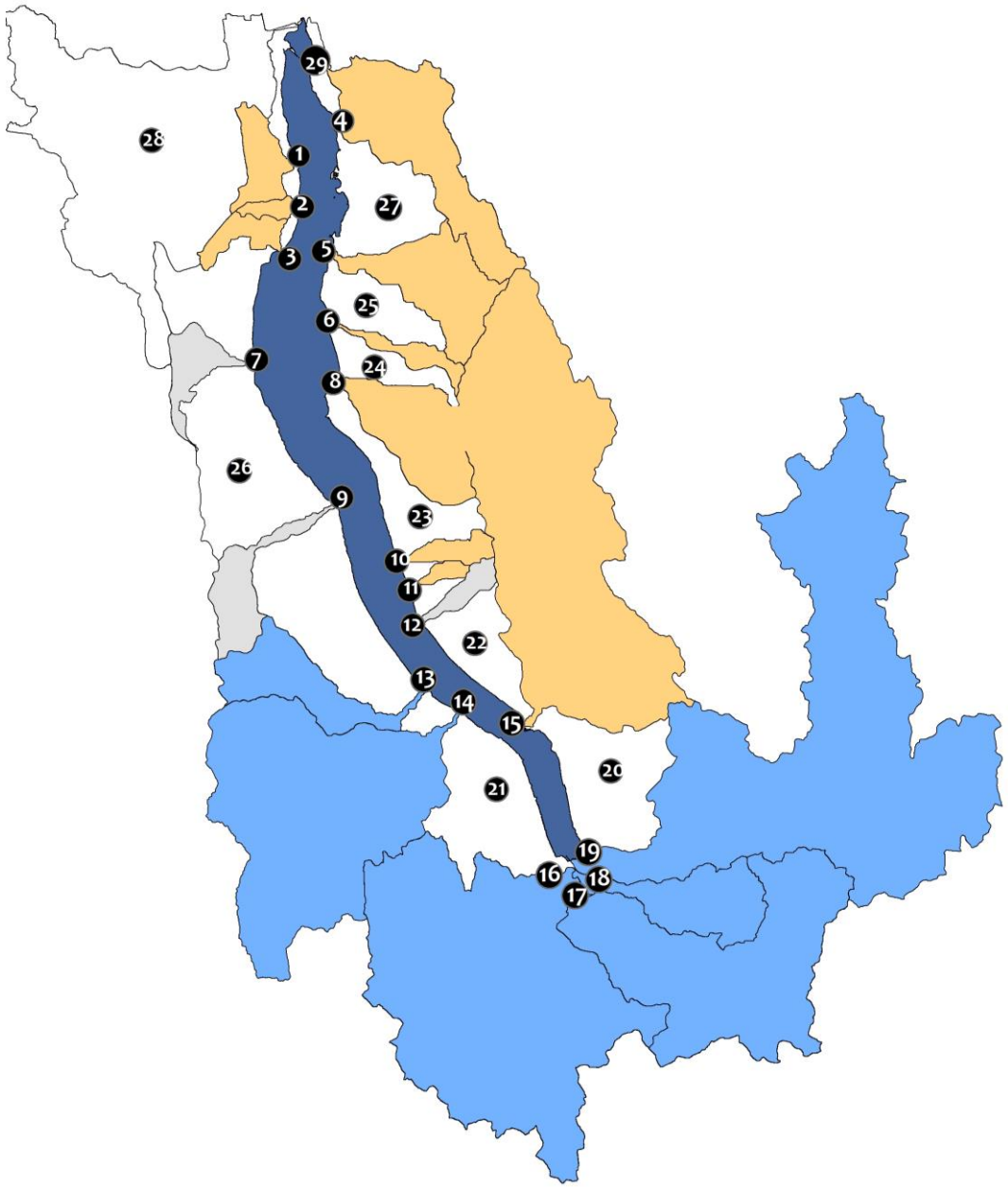


b) NOx Yields



Monitored Drainage Areas in the Cayuga Lake Watershed Grouped by Two Agricultural Land Cover Categories





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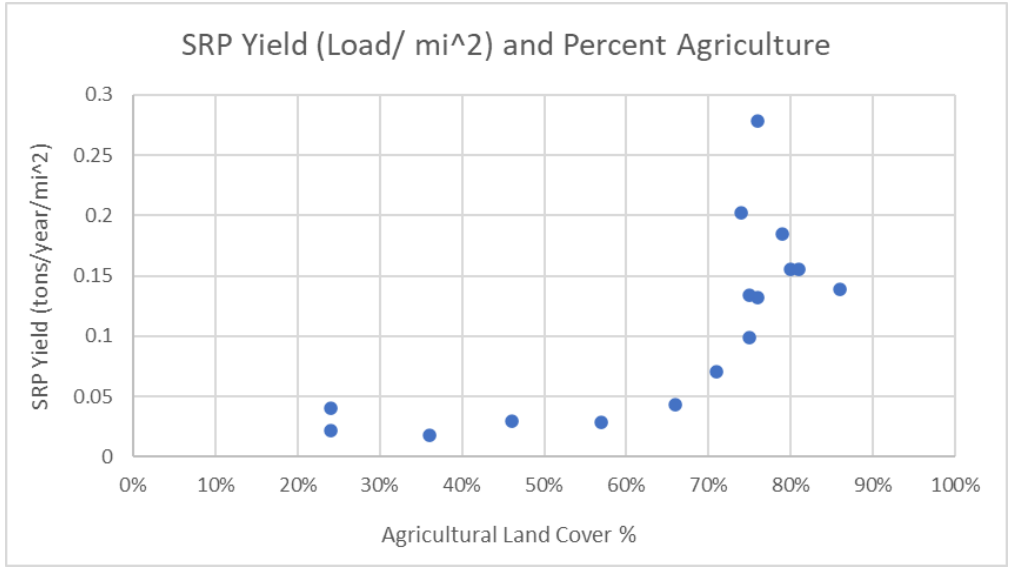
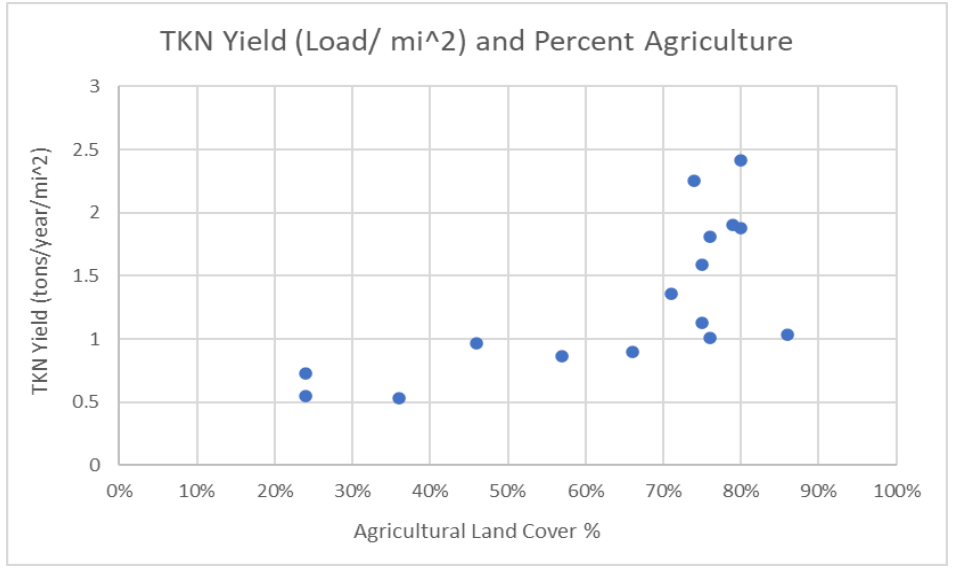
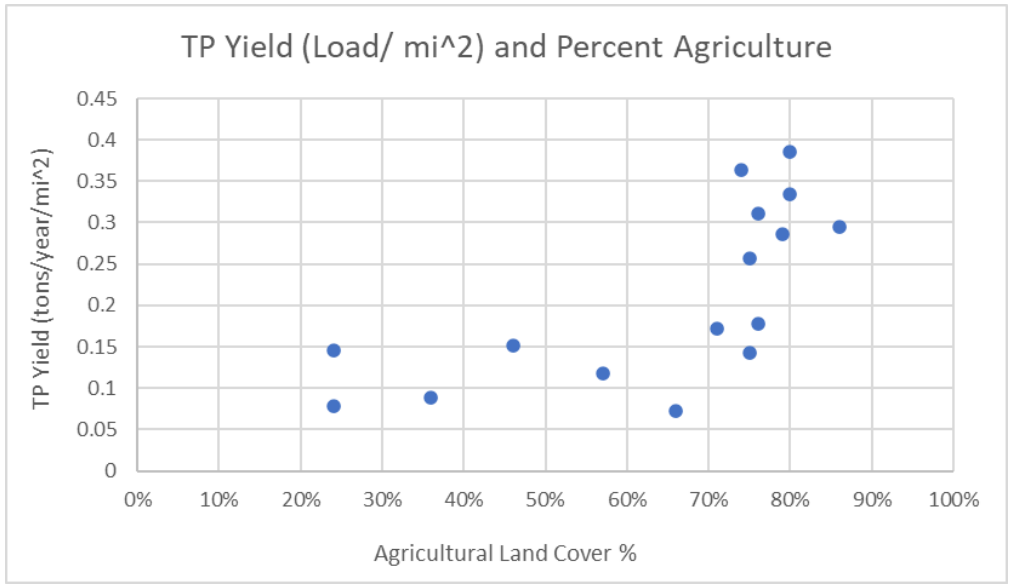
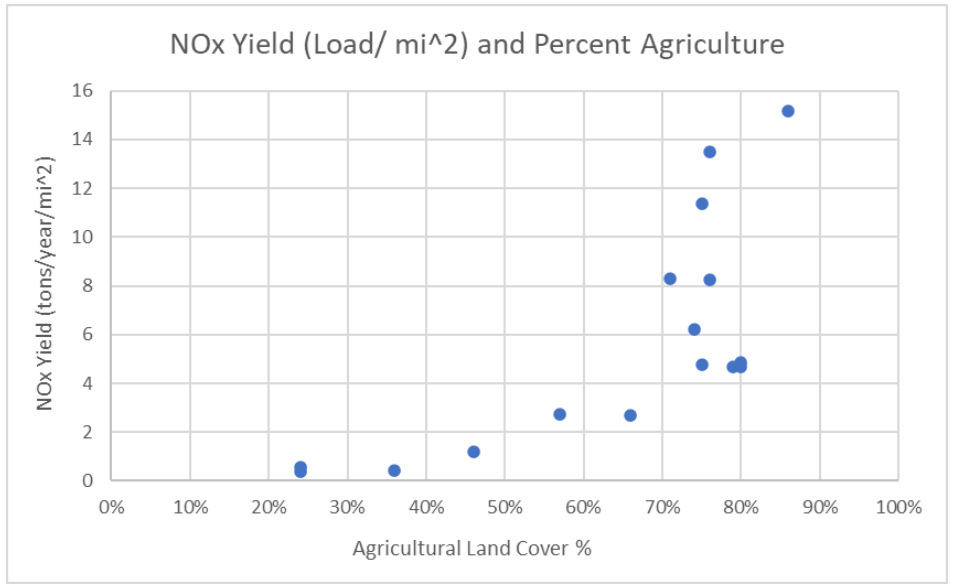
Dependence of Nutrient Yield on % Agricultural Land Cover









Relationship of Nutrient Yield to % Agricultural Land Use is Biphasic

- Little or no increase in nutrient yields from 24% to 67% agriculture
- Steep increase in nutrient yields above 67% agriculture
  - Steep increase takes place between about 70% and 80% agricultural land use
  - This suggests that the type of agricultural land use is a bigger factor in nutrient yield than the amount of land in agriculture
- Calculate average nutrient yields for a) Monitored sub-watersheds with 67% agriculture or less, and b) Monitored sub-watersheds with greater than 67% agriculture
- Use average nutrient yields to estimate nutrient loading from unmonitored drainages: Nutrient Loading = (area of unmonitored drainage) x (average nutrient yield from monitored watersheds)

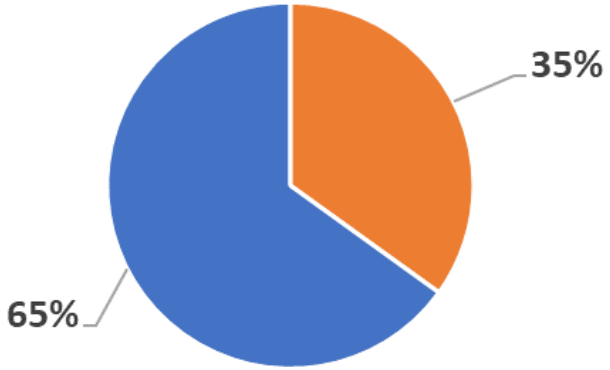
Approximated Nutrient Loads in Unmonitored Drainages in the Cayuga Lake Watershed

Unmonitored Drainages within Cayuga Lake Watershed			Approximated Loads (drainage area x average yield in monitored drainages for either <67% or >67% agriculture category)			
Watershed	**Drainage Area (mi^2)**	**Percent Agriculture**	**SRP Load (tons/year)**	**TP Load (tons/year)**	**NOx Load (tons/ year)**	**TKN Load (tons/year)**
Lansing Direct Streams	19.66	36%	0.59	2.14	26.32	14.90
Northwest Ithaca Direct Streams	23.5	56%	0.71	2.56	31.46	17.81
King Ferry Direct Streams	14.29	64%	0.43	1.56	19.13	10.83
North Lansing Direct Streams (includes Milliken Creek)	15.8	61%	0.47	1.72	21.15	11.97
Aurora Direct Streams	9.21	73%	1.43	2.34	75.30	15.09
Scipio Direct Streams	7.74	76%	1.20	1.97	63.28	12.68
Union Springs Direct Streams	14.44	76%	2.24	3.67	118.06	23.66
Northern Marshes Direct Streams	6.95	44%	0.21	0.76	9.30	5.27
Seneca Outlet and Tributaries	75.21	65%	2.26	8.20	100.69	56.99
Hayt Corners Direct Streams (includes Johnsons Creek and Sheldrake Creek)	80.00	74%	12.41	20.34	654.08	131.09

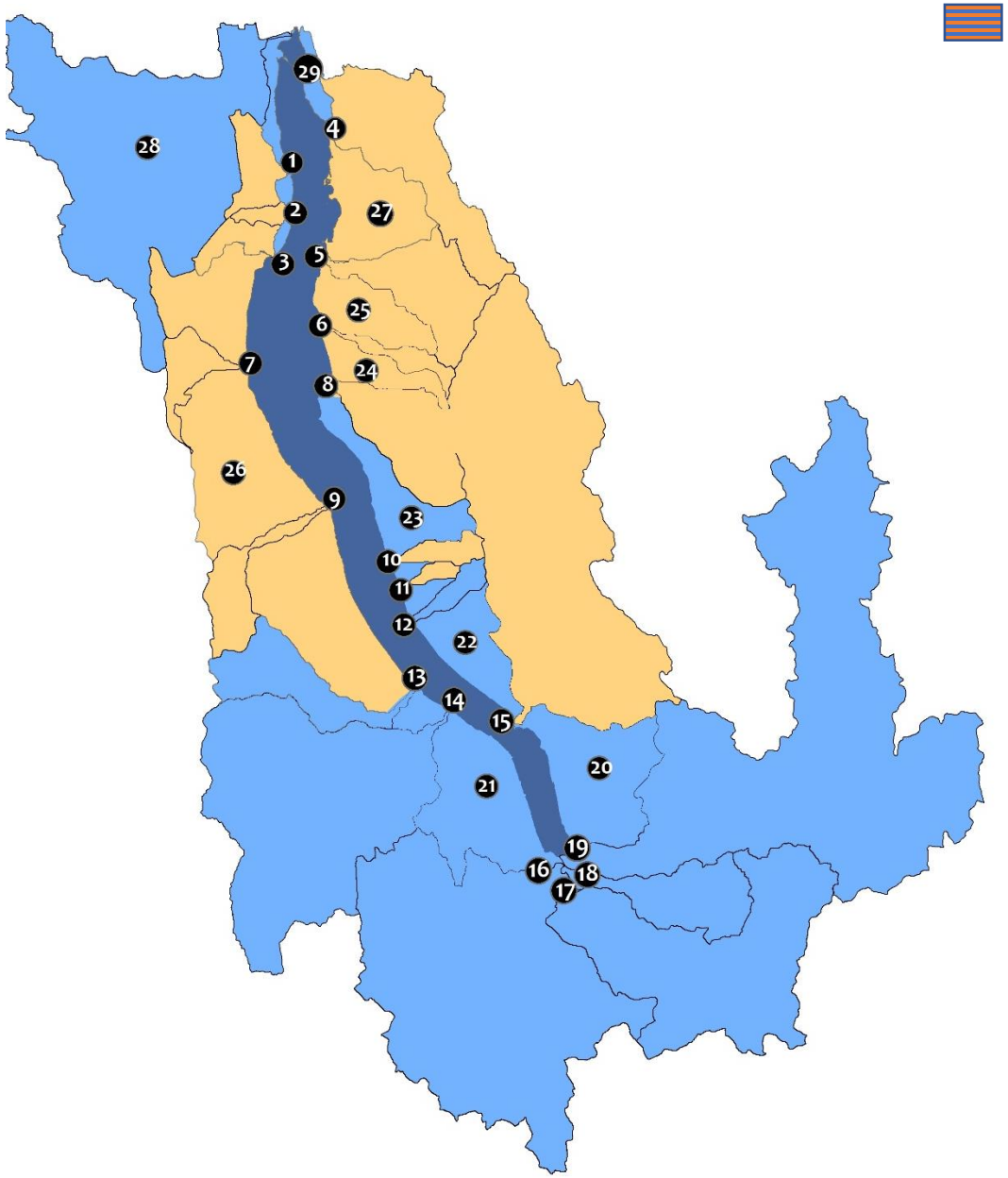
Monitored and Unmonitored Drainage Areas in the Cayuga Lake Watershed Grouped by Two Agricultural Land Cover Categories

Monitored and Unmonitored Drainage Areas in the Cayuga Lake watershed: **782 sq. mi.***

*sum of monitored and unmonitored drainage areas listed in the tables



- Drainage Areas >67% Agriculture
- Drainage Areas <67% Agriculture



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Total Cayuga Lake Watershed Nutrient Loads from Two Agricultural Land Cover Categories

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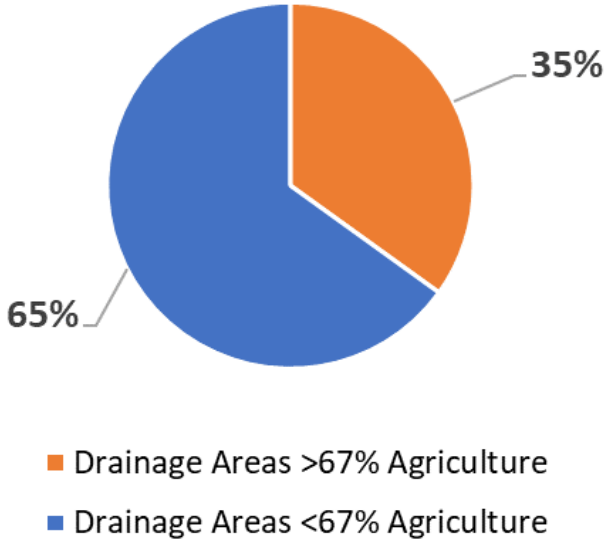
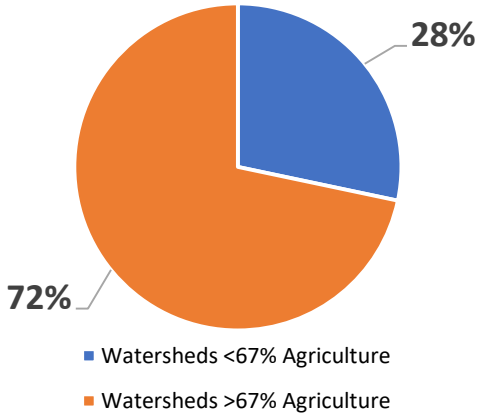
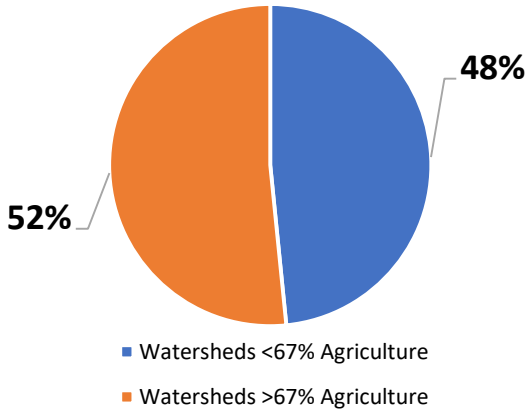


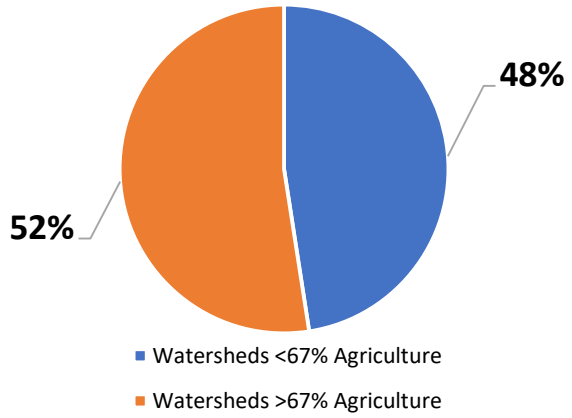
Total Watershed SRP Load:
49 tons/ year



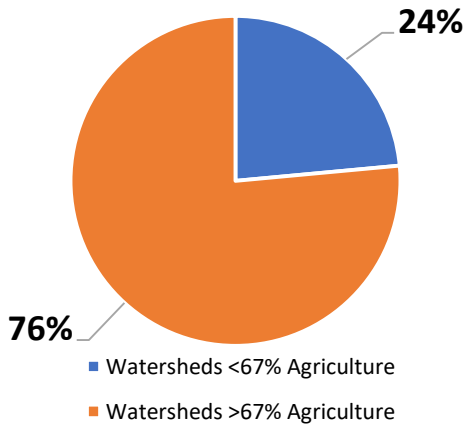
Total Watershed TP Load:
124 tons/ year



Total Watershed TKN Load:
836 tons/ year



Total Watershed NOx Load:
2,761 tons/ year



Conclusions

- Widespread, long-term stream monitoring partnerships between volunteer groups and CSI's certified lab, including stormwater nutrient sampling, makes it possible to obtain back-of-the-envelope estimates of non-point source nutrient loading and nutrient yields
- These estimates suggest that agricultural land use has minimal impact on nutrient loading until it reaches about 70%
- Between ~70% and 80% agricultural land use, nutrient yields increase 2.5x to 5x, depending on the nutrient, suggesting the type of agriculture may have an important role in nutrient loading
- These findings can be used to: a) Prioritize sub-watersheds and catchment areas for nutrient management; and b) Estimate nutrient loading from the Cayuga Lake watershed as a whole