Water Quality of the Connecticut River Watershed

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Introduction:

Land usage in the areas surrounding watersheds influences both the water quantity and quality within the system. This study will investigate the connection between agricultural land usage and water quality, along with its future implications, within the Middle Connecticut Watershed using a continuous simulation model. Fluctuations in discharge and pollutant loads influence biodiversity, viability of sensitive ecosystems, bank erosion, and sediment yield. Understanding these connections informs and promotes proper watershed management and can result in higher water quality for communities supported by the Middle Connecticut Watershed. This study seeks to better understand what current land use projections may predict for the health of the Middle Connecticut in the future. Successfully understanding this relationship allows for more efficient mitigation of externalities imposed onto the watershed both locally and beyond.

Objectives:

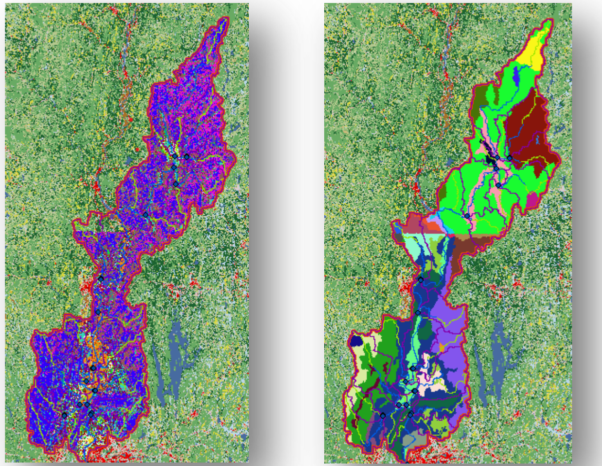
General Study: Identify the impacts communities with high agricultural land usage impose onto a watershed system.

a) Examine the specific impacts said land usage typing has regarding nutrient and sediment loading.

b) Identify management strategies that could mitigate externalities of agricultural practice on the watershed both locally and regionally.

Study Area:

The Middle Connecticut Watershed is the central sub-basin of the Connecticut River Watershed. The Connecticut, being the largest of New England's rivers, provides 70% of freshwater for the Long Island Sound. The Middle Connecticut comprises 661,024 acres of space within Vermont, New Hampshire, and Massachusetts. Both Springfield and Northampton are included within this watershed. The system supports 7 counties in its entirety as well as a strong agricultural community.



Figures 1 : Pictured Left to Right; Middle Connecticut Land Usage and Soil Reclassifications

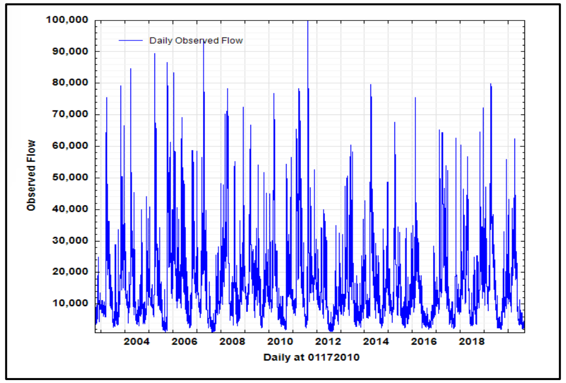
Methodology:

In order to create accurate simulations for the subject watershed, further delineation was required. The Middle Connecticut was then divided into 31 spatially-explicit sub-basins via a digital elevation model (*DEM*) and the National Hydrography Dataset (*NHD*). Each of these sub-basins ultimately drains into the mainstem Connecticut River. Assessments for maximum flow and accuracy of model were conducted using the southernmost USGS Daily Discharge Station (*Station No. 01172010*) in Holyoke, MA. Readings were recorded in (*ft^3/second*) and prior to calibration converted to (*m^3/second*). Daily flow data was collected for the years 2002-2020. National Land Coverage Data (NLCD) and State Soil Data (STATSGO) for Massachusetts, Vermont, and New Hampshire were overlaid prior to soil, land use, and slope reclassification. Threshold values for these reclassifications when defining the hydrologic response units (HRU) were set to 10%, 5%, and 5% respectively. The final composition includes 751 HRU's across the 31 subbasins within the Middle Connecticut.

Results:

Table 1: Distribution of Land Usage Classes

LANDUSE:	Area [ha]	Area[acres]	%Wat.Area
Forest-Deciduous	134867.8143	333265.1125	50.29
Forest-Evergreen	68465.5884	169181.8922	25.53
Forest-Mixed	41042.1352	101417.1681	15.30
Wetlands-Forested	6147.9190	15191.8153	2.29
Water	1439.6705	3557.4979	0.54
Agricultural Land-Row Crops	5657.1219	13979.0310	2.11
Residential-Medium Density	3973.1497	9817.8517	1.48
Residential-High Density	2672.7135	6604.4087	1.00
Residential-Low Density	2781.0328	6872.0711	1.04
Hay	1145.3761	2830.2817	0.43



Graph 1: USGS Discharge Station 01172010

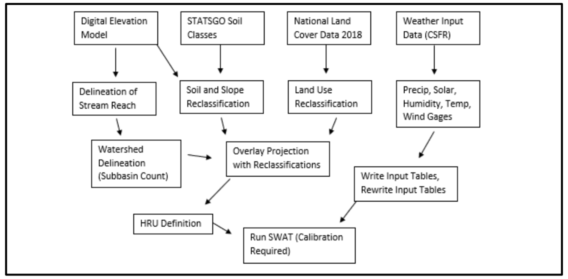


Figure 2: SWAT Model Flow Chart

Table 2: SWAT Output Values, Aquifer and Budget

AVE ANNUAL BASIN VALUES

PRECIP = 1473.8 MM	TOTAL AQ RECHARGE = 645.54 MM
SNOW FALL = 285.66 MM	TOTAL WATER YLD = 1217.43 MM
SNOW MELT = 278.59 MM	PERCOLATION OUT OF SOIL = 644.14 MM
SUBLIMATION = 1.74 MM	ET = 239.1 MM
SURFACE RUNOFF Q = 371.37 MM	PET = 647.8MM
LATERAL SOIL Q = 210.48 MM	TRANSMISSION LOSSES = 0.00 MM
TILE Q = 0.00 MM	SEPTIC INFLOW = 0.00 MM
GROUNDWATER (SHAL AQ) Q = 603.25 MM	TOTAL SEDIMENT LOADING = 15.89 T/HA
GROUNDWATER (DEEP AQ) Q = 32.34 MM	
REVAP (SHAL AQ => SOIL/PLANTS) = 12.83 MM	
DEEP AQ RECHARGE = 32.28 MM	

Table 3: SWAT Output Values, Stresses and Yields

AVE MONTHLY BASIN VALUES

MON	RAIN (MM)	SNOW FALL (MM)	SURF Q (MM)	LAT Q (MM)	WATER YIELD (MM)	ET (MM)	SED YIELD (T/HA)	PET (MM)
1	101.62	71.56	35.87	4.00	82.26	4.98	2.16	9.05
2	106.55	77.68	45.27	2.73	71.77	3.31	3.05	6.16
3	118.24	47.08	92.12	22.61	140.87	12.25	5.36	28.06
4	122.72	7.84	31.01	27.20	111.97	14.36	1.29	56.76
5	134.00	0.00	15.32	24.06	110.09	23.23	1.15	89.38
6	149.39	0.00	17.60	25.20	114.91	34.27	0.56	90.06
7	114.16	0.00	11.73	16.36	95.34	46.58	0.22	118.95
8	132.60	0.00	22.44	19.44	98.30	42.21	0.47	104.36
9	119.46	0.00	18.67	18.00	86.58	27.52	0.30	73.22
10	152.03	3.59	27.14	25.80	107.80	15.54	0.43	38.72
11	93.44	11.49	12.03	17.42	89.70	8.65	0.18	22.00
12	128.63	65.40	41.69	7.71	107.21	6.27	0.68	11.28

AVE ANNUAL BASIN STRESS DAYS
WATER STRESS DAYS = 0.65
TEMPERATURE STRESS DAYS = 78.96
NITROGEN STRESS DAYS = 99.88
PHOSPHORUS STRESS DAYS = 0.14
AERATION STRESS DAYS = 0.00

Discussion:

For greater accuracy and development of the model, calibration is required. Continuation of the research will involve continued optimization of parameter ranges through 5 simulation iterations such as to increase the correlation between historical data and the model itself.

Conclusion:

a) Agricultural communities such as the studies subject consume high levels of fertilizer and growth supplements when tending to crops. High levels of nitrogen are to be expected as the externalities of these fertilizers are later imposed upon the system. The model generated over 99 days of nitrogen stress in the system highlighting the impact land use has over local water systems.

b) In order to mitigate these nitrogen stresses recommendations for surrounding communities would involve riparian buffer zones of deep-rooted local plant life. These zones would reduce the amount of agricultural run-off from entering the system thus reducing the stress imposed.