Leveraging existing data in the Riverine Environmental Flow Decision Support System (REFDSS) to estimate sediment retention services provided by freshwater mussels in the Upper Delaware River Basin

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Project Details

- Sustaining Environmental Capital Initiative (SECI) pilot study
  - Develop/enhance science and research on ecosystem services in support of improving natural resource management

- Delaware River Basin pilot evaluates biofiltration, nutrient flux, storage and retention associated with freshwater mussel populations
  - Benefit estimate models for sediment retention allow us to quantify the economic value of ecosystem services provided by freshwater mussels

- Develop benchmark values for flow scenarios using river discharge fluctuation, mussel tissue dry mass, clearance rates, and sediment/nutrient loading for 11 sites along the Upper Delaware River

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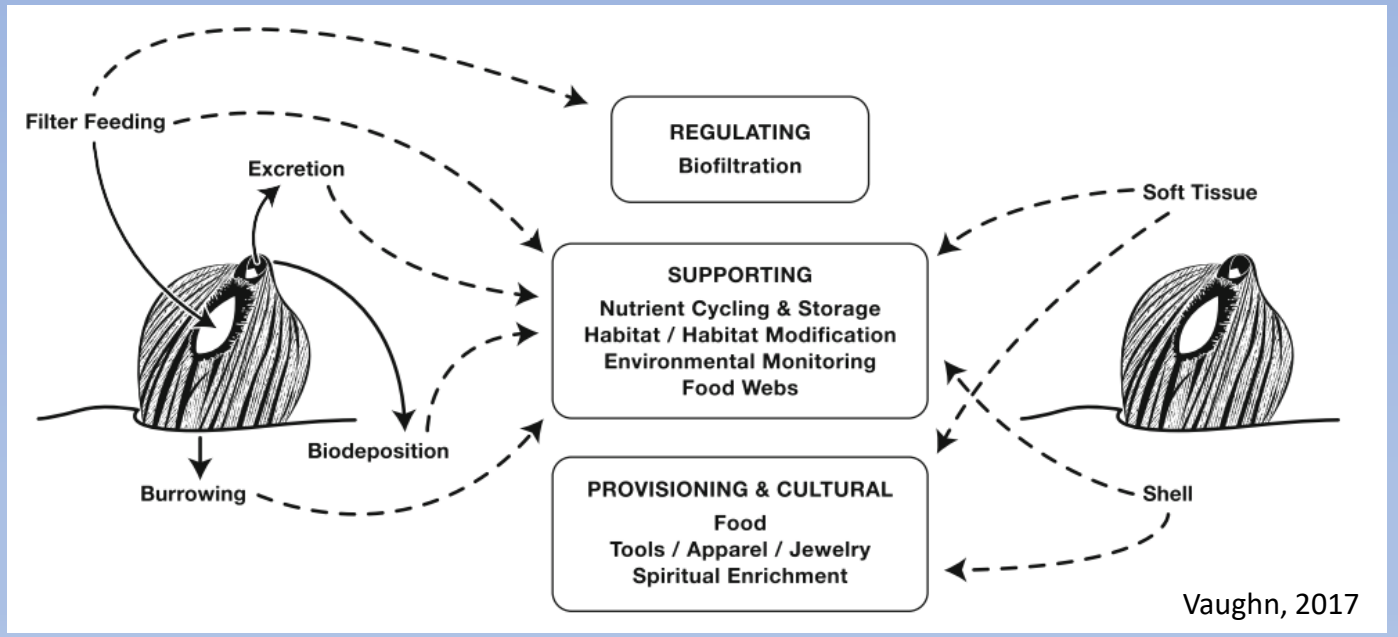
Ecosystem service benefits

- Regulating, Supporting, Provisioning and Cultural services
  - Study focuses mostly on regulating and supporting services

- Biofiltration

- Nutrient Cycling & Storage

- Economic Valuation



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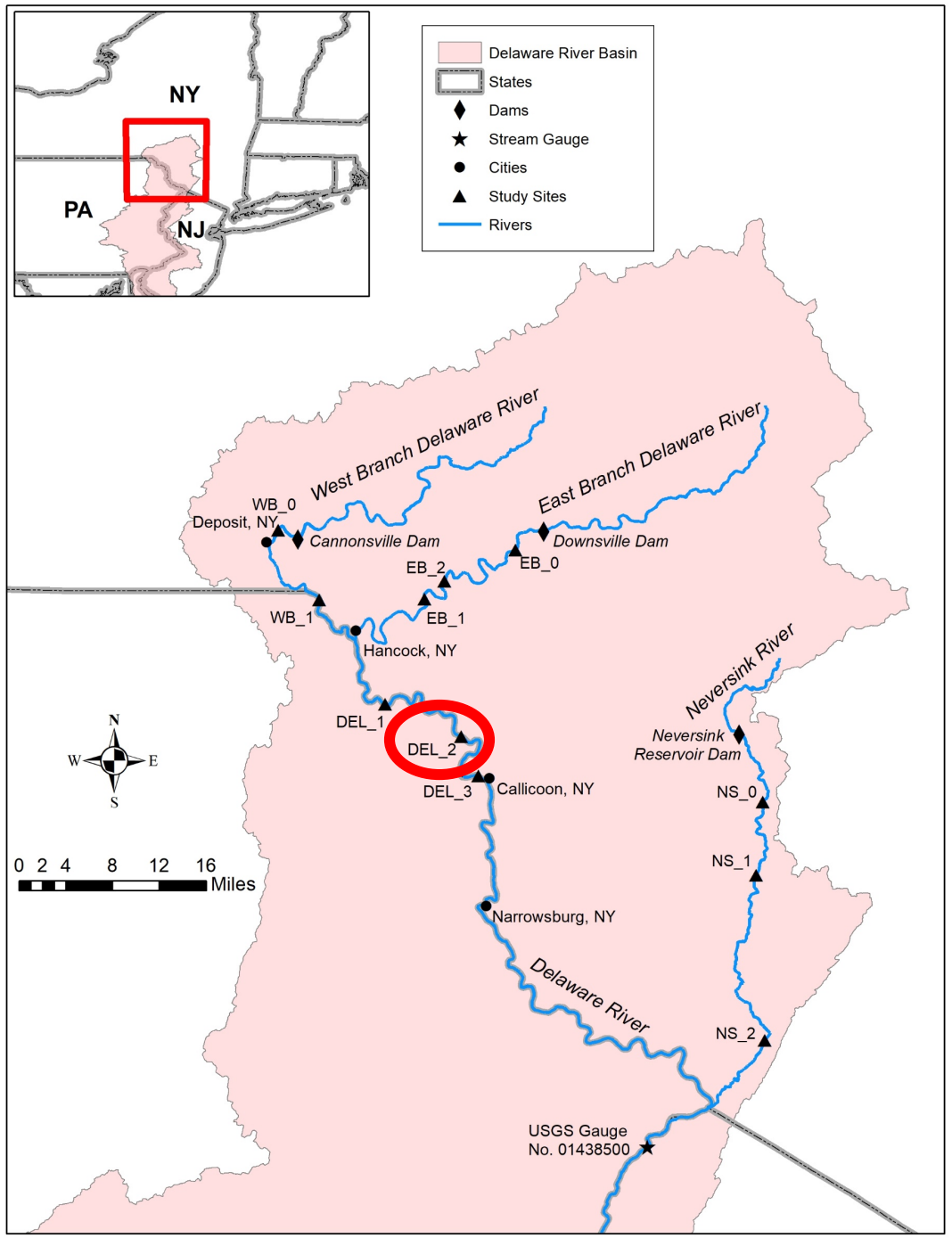
Study Area

- Drains total land area of 33,016km^2
- Provides water for nearly 17 million people
  - Three dams constructed in the mid-1990s to control flow targets
- World class trout fishery managed by reservoir releases
- Data already collected at 11 sites for use in a preliminary EDSS looking at available habitat



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Data Requirements

- Operational Analysis and Simulation System (OASIS)
  - Reservoir operations and flow-routing model
  - Daily flow-release values of depth & velocity for unique discharge values modeled as GeoTIFFs for 11 sites along the Upper Delaware River
- Mussel Density – Field reporting combined with kriging interpolation
- Mussel Dry Tissue Mass – Field reporting used to create averages
- Clearance Rate – Literature review of various Bivalve species
- SPARROW – Modeled sediment and nutrient loads by river segment (NHD)

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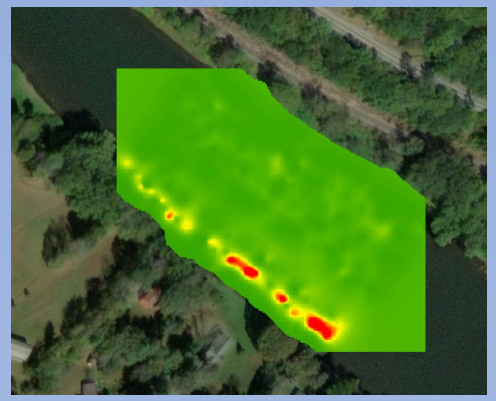
Processing Data – Mussel Clearance and River Discharge

Mussel Density (g/m^2)



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Mussel Dry Tissue Mass (g)

	Elliptio complanata dry tissue mass per individual mussel (g)
max	2.02
min	0.45
range	1.57
average	1.07
median	1.01
stdev	0.30

X

Mussel Clearance Rate (L/hr/g)

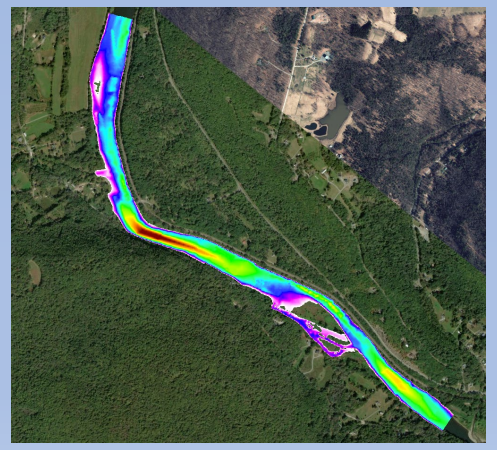
	Clearance Rate (L $hr.^{-1}$ g dry tissue $mass^{-1}$)	
	All unionids	Elliptio complanata
max	29.50	1.50
min	0.04	0.30
range	29.46	1.20
average	4.36	0.92
median	2.34	0.95
stdev	5.65	0.33

=

Total water cleared by mussels (L/hr)

Mussel Clearance total divided by River Discharge total

River Discharge (ft^3/s)



Convert to L/hr

River Discharge (L/hr)

=

Total water passed over each pixel (L/hr)

=

Percentage of total water discharge able to be cleared by mussels present in study area

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Analyzing Data – SPARROW and Benefit Estimates

- 2002 SPARROW model estimates Nitrogen and phosphorous loads from surrounding land cover/use
- Load estimates from SPARROW for manure and non-farm areas
- Soil conservation benefits for 11 practices in the Northeast region *(Hansen and Ribaudo, 2008)*
- Soil composition for concentration estimated at 2.32 lbs of Nitrogen and 1 lb of Phosphorus in a ton of eroded soil *(USDA/NRCS)*

SPARROW load estimates (kg/yr)

COMID	MANC_N	MANC_P	MANU_N	MANU_P	NOFARM_N	NOFARM_P
2617392	41.77	7.83	23.27	5.94	57.16	8.72
2617386	0	0	0	0	1.47	0.19
2616856	1.74	0.33	0.97	0.25	6.35	0.84
2617384	424.63	79.56	236.54	60.36	34.82	5.21
2617404	0	0	0	0	17.85	2.65
2616814	0	0	0	0	18.57	2.45
2616816	0	0	0	0	25.42	3.35
Total	468.14	87.72	260.78	66.55	161.64	23.41

SPARROW by COMID
Sediment Retention Valuation
(kg N/P)

Benefit estimates ($/ton)	
Irrigation ditches/canals	0.01
Road drainage ditches	0.2
Municipal water treatment	0.27
Flood damages	0.77
Marine fisheries	0.93
Freshwater fisheries	0
Marine recreational fishing	1.57
Municipal/Industrial use	1.45
Steam powerplants	0.66
Soil productivity	1.27
Dust cleaning	0
Total water-related	7.12
Total wind-related	1.27

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Results

Nutrient Mussel Clearance Rate Valuation

Flow Targets (ft^3/s)	Value of Mussel Filtration	Societal Savings ($/lb N and P)	Reduced N (lbs)	Reduced P (lbs)	Reduction of N (kg)	Reduction of P (kg)
466	$131.45	0.63	173.5	34.6	78.7	15.7
596	$135.11	0.63	178.4	35.5	80.9	16.1
762	$141.24	0.63	186.3	37.3	84.5	16.9
974	$146.67	0.63	193.6	38.6	87.8	17.5
1243	$152.23	0.63	200.9	40.1	91.1	18.2
1585	$129.56	0.63	170.9	34.2	77.5	15.5
2023	$120.65	0.63	159.2	31.8	72.2	14.4
2577	$122.04	0.63	161.0	32.2	73.0	14.6
3298	$123.24	0.63	162.7	32.4	73.8	14.7
4209	$123.93	0.63	163.6	32.6	74.2	14.8
5374	$123.93	0.63	163.6	32.6	74.2	14.8
6858	$124.94	0.63	164.9	32.9	74.8	14.9
8754	$125.64	0.63	165.8	33.1	75.2	15.0
11177	$123.68	0.63	163.2	32.6	74.0	14.8
14267	$124.69	0.63	164.5	32.9	74.6	14.9

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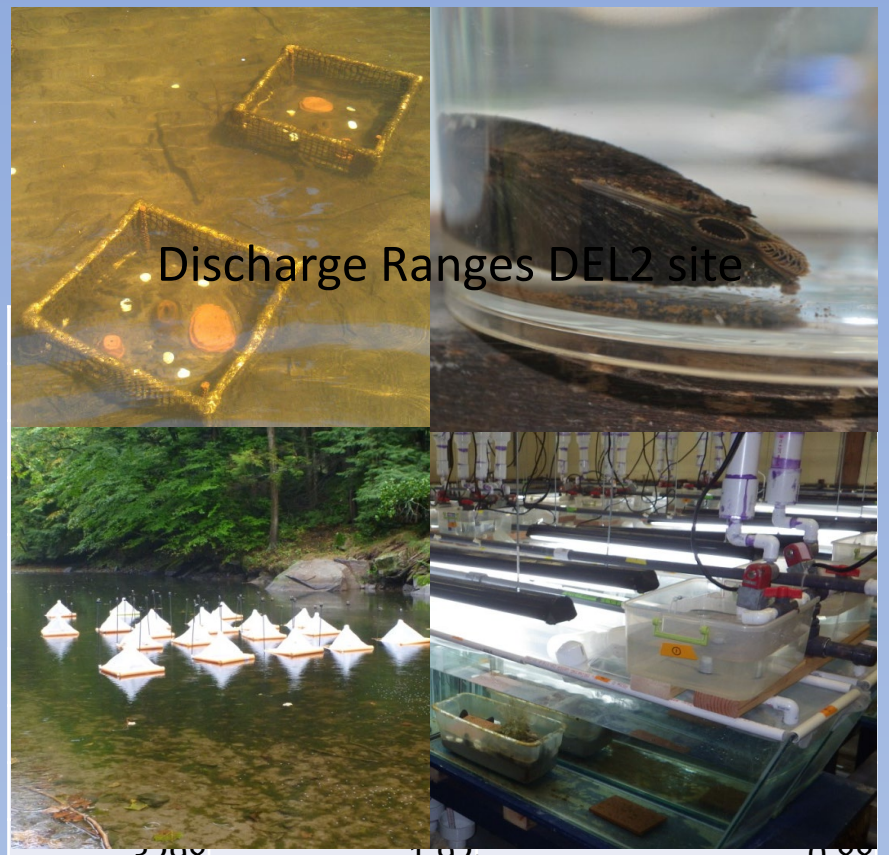
Discussion

- Optimal discharge for mussel filtration difficult to estimate
  - Substrate
  - Lab testing
  - Field monitoring



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Mussel Field Observations

Observations	Sites	Mean velocity (ft^3/s)
all mussels	149	0.93
14 mussels	1	1
11 mussels	1	0.2
7 mussels	1	0.8
6 mussels	1	0.3
5 mussels	8	0.7
4 mussels	5	0.72
3 mussels	12	0.84
2 mussels	45	0.93
1 mussel	75	1.01

3298	1.92	0.88
4209	2.37	1.12
5374	2.92	1.41
6858	3.62	1.78
8754	4.49	2.25
11177	5.7	2.84
14267	7.11	3.61

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Next Steps…

- Expand analysis to include 10 other sites on the East and West Branch of the Delaware and Neversink Rivers
- Confirm filtration efficiencies for mussels under various flow regimes
- Utilize dynamic SPARROW modeling (when available) to estimate current sediment and nutrient loads
- Incorporate datasets as they come available to improve filtration/mussel presence analysis
  - Substrate and Temperature datasets to improve mussel presence interpolation
  - Mussel Size and Weight for improved filtration estimates
- Examine how information gained from this analysis can be transferred to less pristine river such as the adjacent Susquehanna

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Thank you all for attending!

Questions?

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