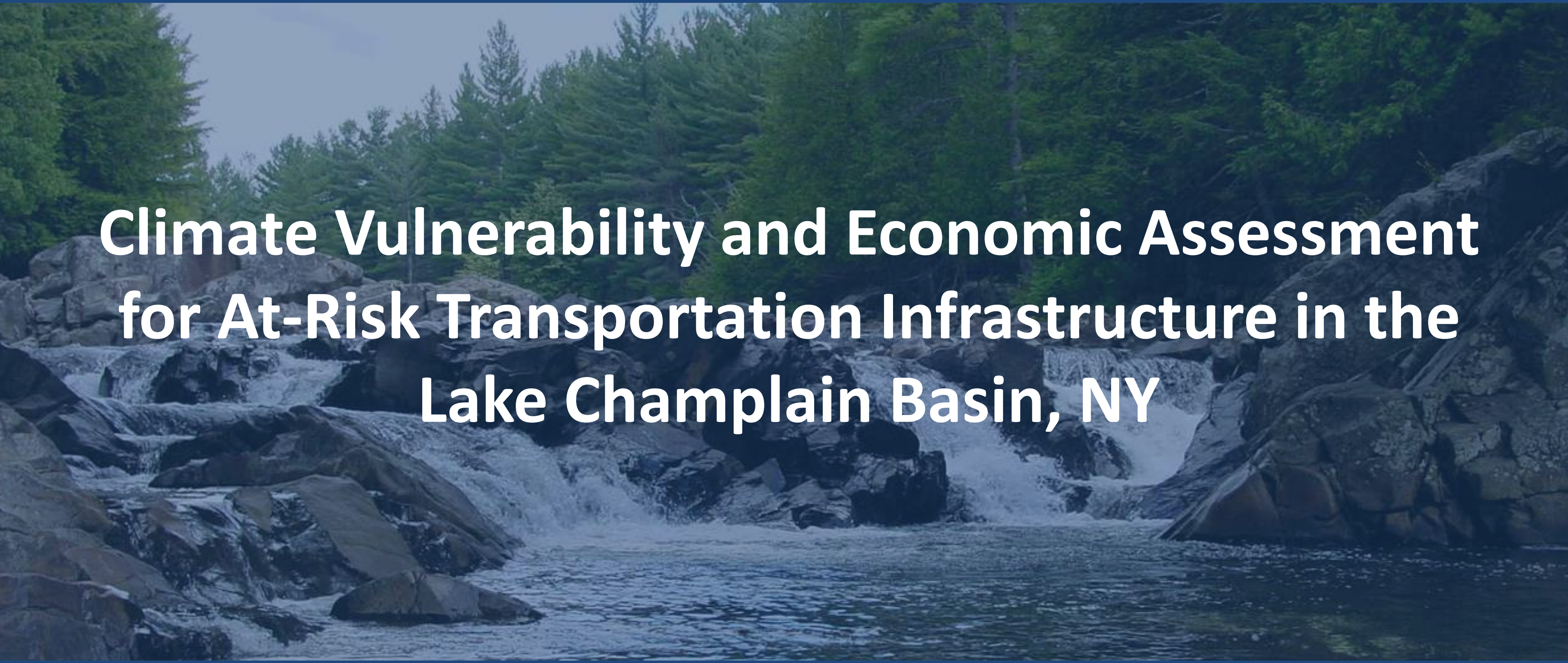

Climate Vulnerability and Economic Assessment for At-Risk Transportation Infrastructure in the Lake Champlain Basin, NY

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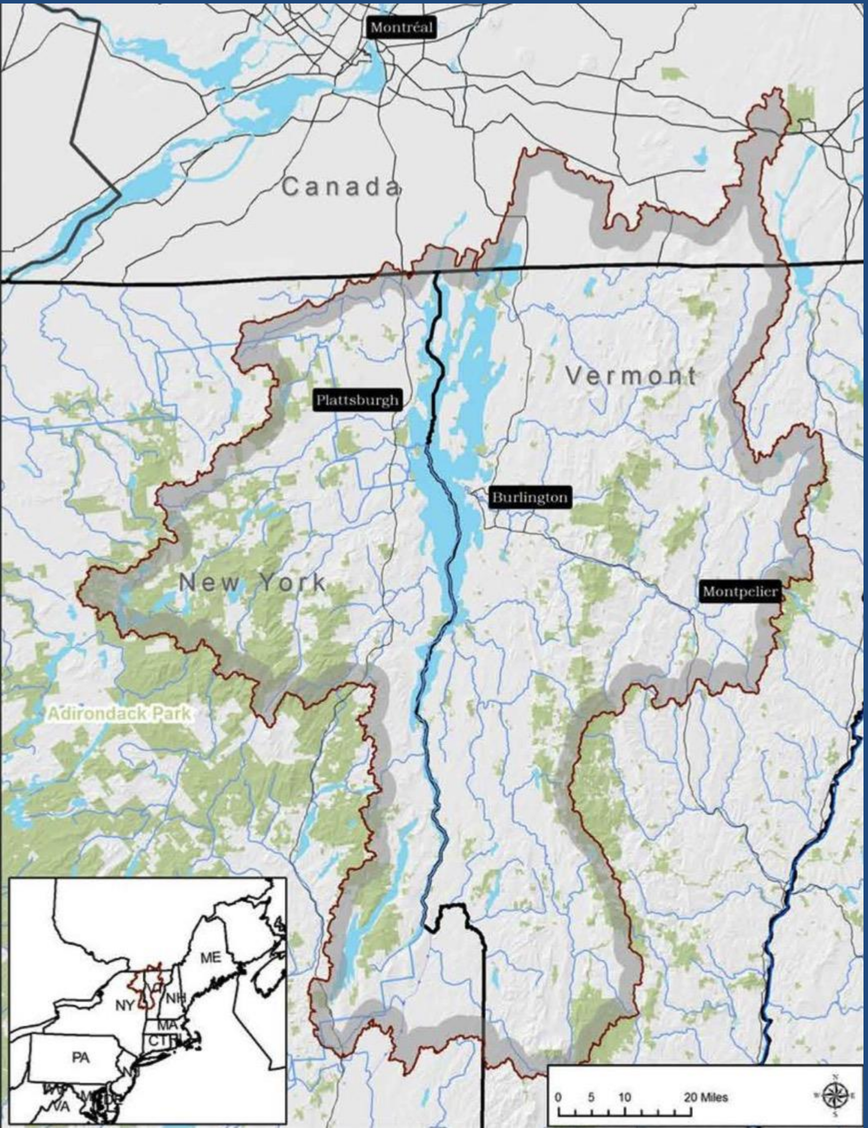
Goal



Integrate climate vulnerability data into NYSDOT planning tools and guidelines and develop an economic approach to focus investments to improve vulnerable infrastructure.

What is the climate problem?

Prediction: temperature increases ranging between 6 and 11°F

- more droughts in the summer
- warmer stream conditions
- more stress on brook trout

Prediction: precipitation increases between 10 and 15% and more frequent and intense storms

- more high water events
- more stress on infrastructure
- human communities more at risk

Culverts and the Triple Bottom Line

RIGHT SIZE CULVERTS can provide multiple benefits

ECOLOGICAL:

- Fish populations with access to cold, upstream waters
- Improved habitat
- Decreased erosion of banks
- Avoided water quality impacts

ECONOMIC:

- Avoided flood damage
- Avoided travel delays
- Avoided loss of business/tourism income from road closures
- ROI improves over time

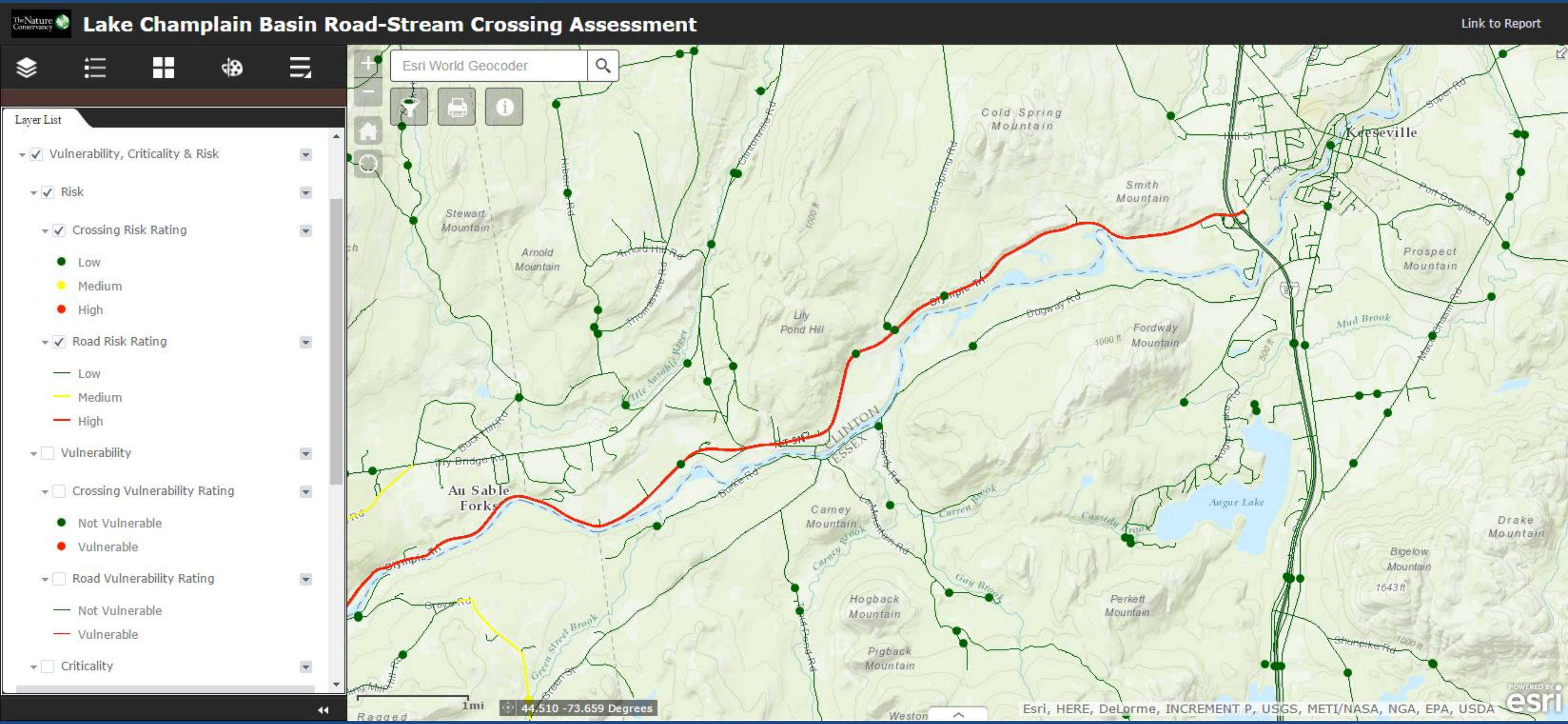
SOCIAL:

- Improved safety and mobility on transportation systems, including access to emergency services
- Avoided health impacts

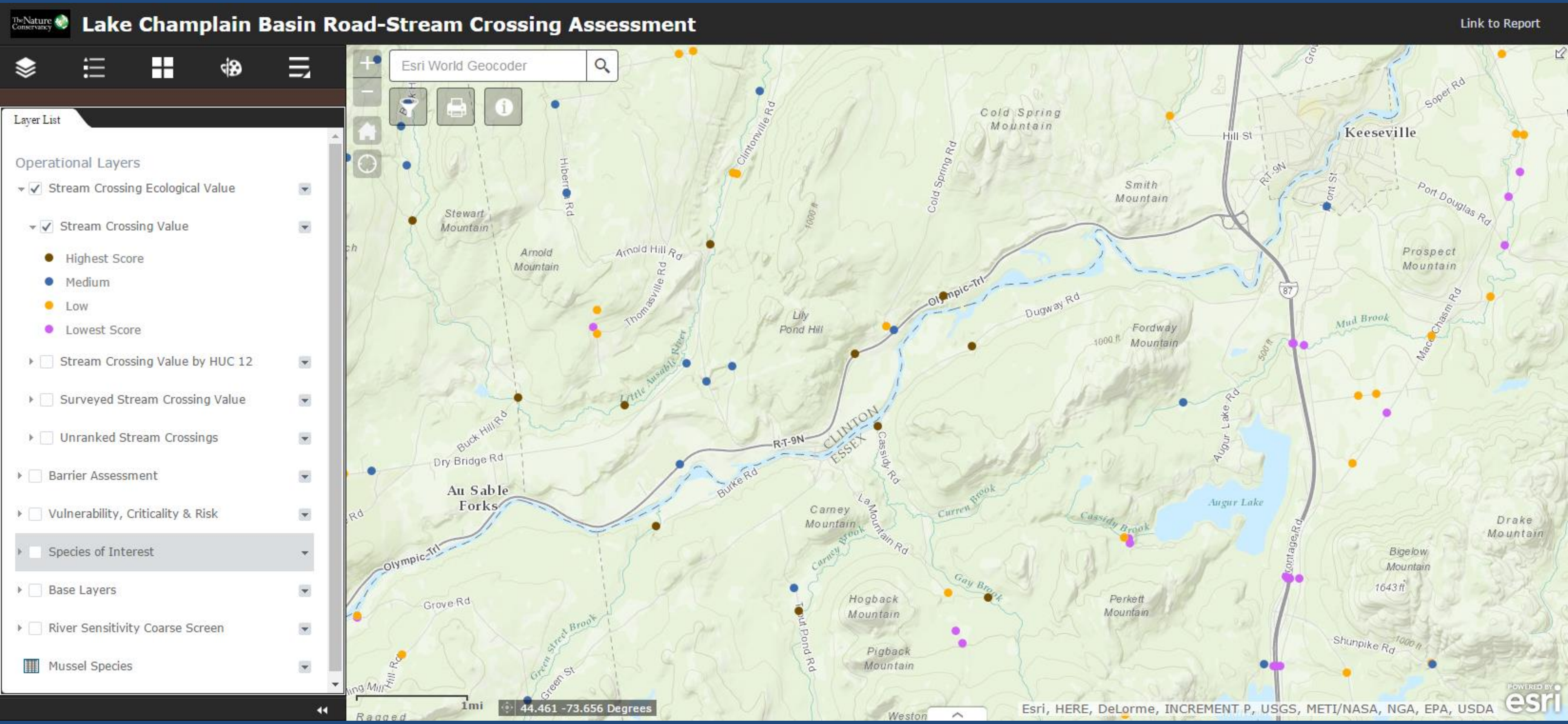
Factors evaluated

- Risk factors (vulnerability, criticality)
- Predicted future flows
- Environmental values
- Social benefits
- Economic benefits
- Cost scenarios

Risk factors (vulnerability, criticality)



Environmental values



Benefits Valuation (data rich)

Total annual benefits =

(social benefits + economic benefits) * environmental benefits

Table 4. Approaches for Benefit Valuation: Social Benefits

Benefit ($/year)	Formula (Required data inputs are indicated in *bold italics*)
Mobility: additional travel cost from road closure	Annual travel cost = *Detour length (miles)* x Standard mileage rate ($0.565/mile[1]) x *Average daily traffic count* x *Duration of road closure (days)* x *Annual probability of road-closing flood*
Mobility: additional travel time from road closure	Annual travel time = *Time to travel detour (hours)* x Travel t ($30.69/vehicle-hour[2]) x *Average daily traffic count* x *Durat closure (days)* x *Annual probability of road-closing flood*
Access to critical services: loss of access to fire station	Annual cost of inaccessible fire station = *Daily cost of inacce station*[3] x *Duration of road closure (days)* x *Annual probabi closing flood*
Access to critical services: loss of access to EMS	Annual cost of inaccessible EMS = *Daily cost of lost access tc Duration of road closure (days)* x *Annual probability of roa flood*
Access to critical services: loss of access to hospital	Annual cost of loss of access to hospital = *Daily cost of lost a hospital*[5] x *Duration of road closure (days)* x *Annual probab closing flood*

Table 5. Approaches for Benefit Valuation: Economic Benefits

Benefit ($/year)	Formula (Required data inputs are indicated in ***bold italics***)
Avoided flood damage	Annual flood damages to be calculated with FEMA BCA tool using Damage Frequency Assessment (DFA) module; data needs: flood damage value for at least three storm events, year of storm events, year structure built, return period for storm events
Avoided freight disruption: detour cost	Annual detour cost = ***Annual probability of road-closing flood*** x ***Duration of road closure (days)*** x ***Daily number of truck trips*** x Direct transport cost per vehicle-mile ($1.39/truck-mile[8]) x ***Length of detour (miles)***
Avoided freight disruption: delay cost	Annual delay cost = ***Annual probability of road-closing flood*** x ***Duration of road closure (days)*** x ***Daily number of truck trips*** x Direct transport cost per vehicle-hour ($59.03/truck-hour[9]) x ***Increase in delivery time (hours)***
Avoided freight disruption: inventory cost	Annual inventory cost = ***Annual probability of road-closing flood*** x ***Duration of road closure (days)*** x ***Daily number of truck trips*** x *Average payload (lbs)*[10] * 1 ton/2000 lbs. x ***Increase in delivery time (hours)*** x Average truck freight value/ton-hour ($0.98/ton-hour[11])

Benefits Valuation (data rich)

Total annual benefits =

(social benefits + economic benefits) * environmental benefits

Data

Data Value	NYS 9N, Ausable
AADT (two-way)	2,251
Detour length (miles)	3.7
Duration of road closure (days)	3
Probability of road closing flood (percent)	15%
Time to travel detour (hours @ 40 mph)	0.093
Daily number of truck trips	119
Increase in delivery time (hours)	0.093

Total annual benefits =

($2,117.57 + $2,875.59 + $276.11 + $293.14) * 1.2

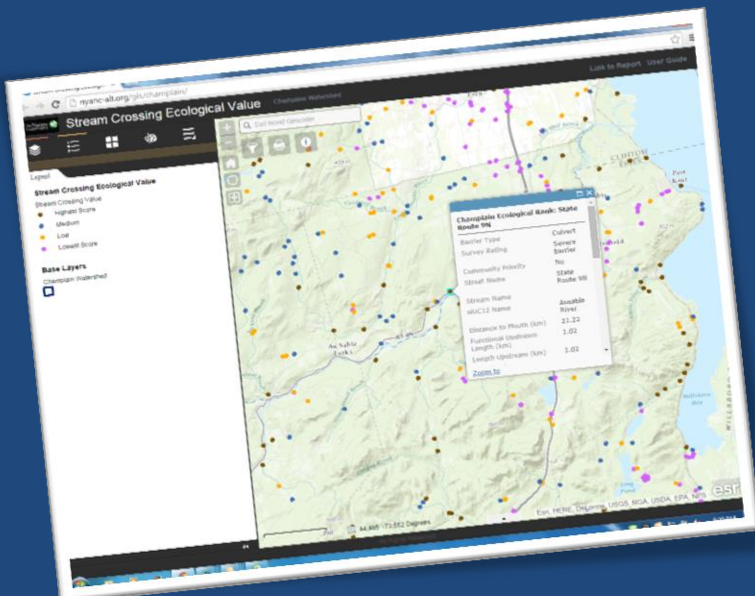
= $6,674.89

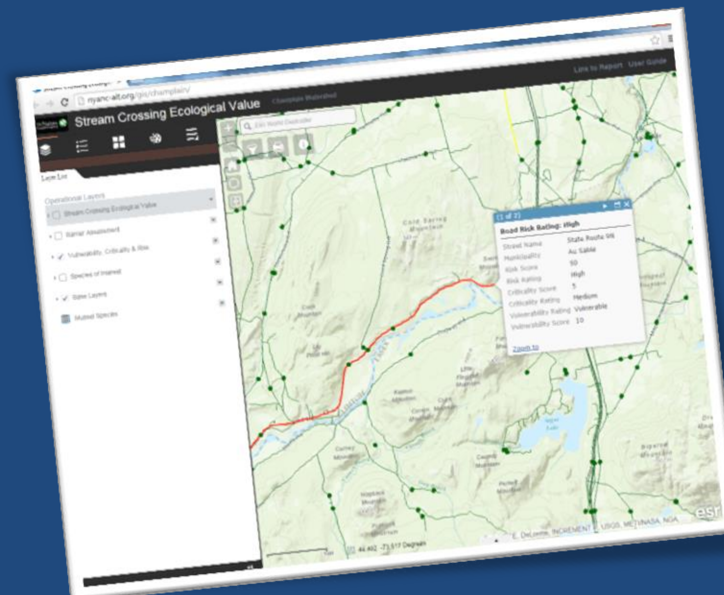
Valuation

Benefit ($/yr)	NYS 9N, Ausable
Social Values	
mobility benefit (additional travel cost)	$2,117.57
mobility benefits (additional travel time)	$2,875.59
Economic Values	
avoided freight disruption (detour cost)	$276.11
avoided freight disruption (delay cost)	$293.14
Environmental Values	
environmental benefits value	1.2

Benefits Valuation (data poor)

Total annual benefits = environmental benefits score * risk score





Risk Value	NYS 9N, Ausable
Vulnerability Score	10
Critical Facility Score	0
Functional Classification Score	5
Criticality Score	5
Risk Score	50
Risk Value*	1.2

*Risk Value – High = 1.2; Medium = 1.1; Low = 1.0

Cost scenarios

Methods - Compared costs for three types of culvert replacements: 1) in-kind, 2) climate-sized, and 3) stream-sized

Results - Future streamflow projections generally consistent with meeting ecological best practices (1.25 bankfull flow)

Lessons Learned

- Flexible ecological framework is scalable and replicable
- Institutional knowledge has pros and cons
- Aquatic organism passage often consistent with future streamflow – needs additional study
- Benefits data lacking
- A robust decision support tool should include risk score (criticality + vulnerability), social benefits, economic benefits, and environmental value
- Strong asset management is key to adapting transportation system

Thanks

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