Ecosystem Service Analysis of River Systems

Quantifying and valuing ecosystem goods and services of the Reedy River watershed, S.C.

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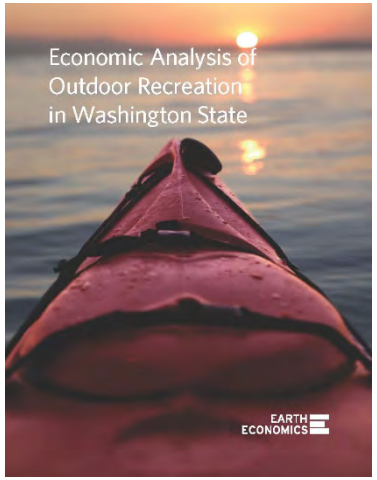
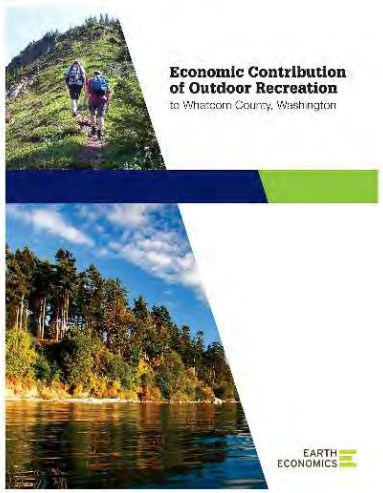
EARTH ECONOMICS





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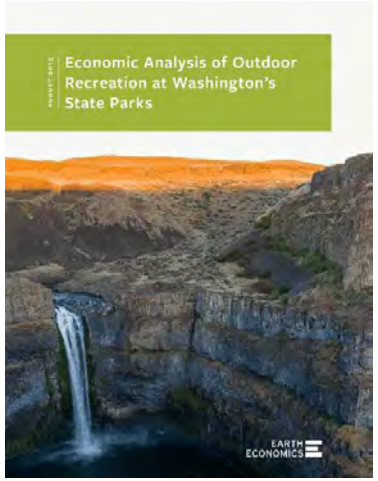
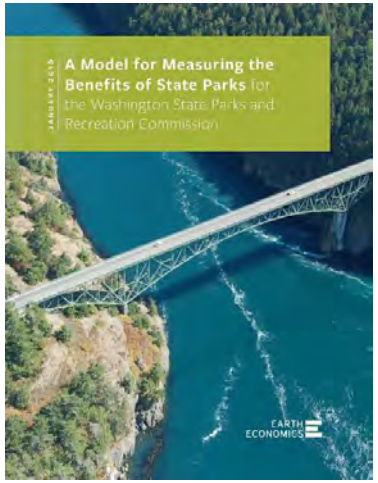
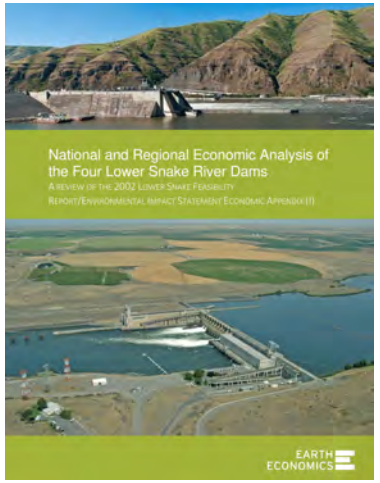
“Taking nature into account.”







Applications

- Science-based economics to land-use decision making
- Determine the value of the ecosystems (e.g. river systems)
- Demonstrate the value of (water) conservation efforts or alternative management regimes
- Assist with cost-sharing frameworks

Framework for valuation

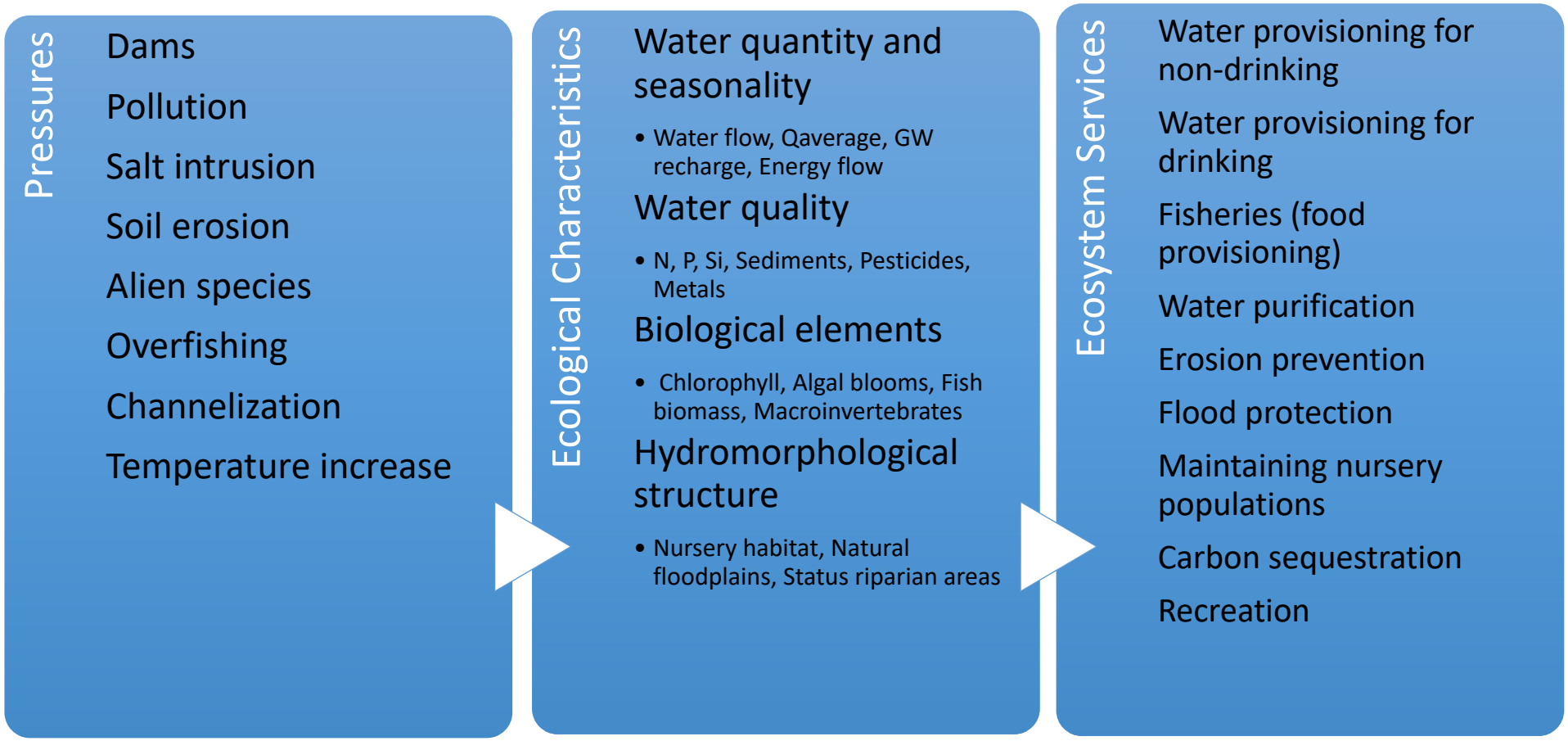
- What are water-related services? Who are the beneficiaries? Where do we draw the boundary of the system?

- Is the service ‘water supply’ useful? Or, is it better to talk about the combination of several intermediate attributes (e.g. storage, capture, quality, quantity) as they support specific services (e.g. hydropower, drinking water, recreation)?

Ecohydrologic process (what the ecosystem does)		**Hydrologic attribute** (direct effect of the ecosystem)	**Hydrologic service** (what the beneficiary receives)
Local climate interactions Water use by plants	→	Quantity (surface and ground water storage and flow)	**Diverted water supply:** Water for municipal, agricultural, commercial, industrial, thermoelectric power generation uses **In situ water supply:** Water for hydropower, recreation, transportation, supply of fish and other freshwater products **Water damage mitigation:** Reduction of flood damage, dryland salinization, saltwater intrusion, sedimentation **Spiritual and aesthetic:** Provision of religious, educational, tourism values **Supporting:** Water and nutrients to support vital estuaries and other habitats, preservation of options
Environmental filtration Soil stabilization Chemical and biological additions/subtractions	→	Quality (pathogens, nutrients, salinity, sediment)	
Soil development Ground surface modification Surface flow path alteration River bank development	→	Location (ground/surface, up/downstream, in/out of channel)	
Control of flow speed Short- and long-term water storage Seasonality of water use	→	Timing (peak flows, base flows, velocity)	

Brauman et al. (2007)

Impact framework



Water quality

- Indices quantify changes in water quality for valuation
  - Examples include EPA's scale or Water Resource Center's index

Factor	Input data here	Range of Data	Units Required	Q-value	Weight	Total
Dissolved oxygen	70	0-140	% saturati	75	0.17	13
Fecal coliform	100	0-100001	#/100 mL	44	0.15	7
pH	7	1.9-12.1		88	0.12	11
Biochemical oxygen demand	3	0-31	mg/L	67	0.1	7
Temperachure change	0	-10 to 30	Celsius	93	0.1	9
Total phosphate	5	0-10	mg/L	13	0.1	1
Nitrates	5	0-100	mg/L	65	0.1	7
Turbidity	10	0-101	NTU	76	0.08	6
Total Solids	50	0-501	mg/L	87	0.08	7
WQI - Arithmetic Mean						***67***
WQI - Geometric Mean						***60***
WQI - Harmonic Mean						***69***

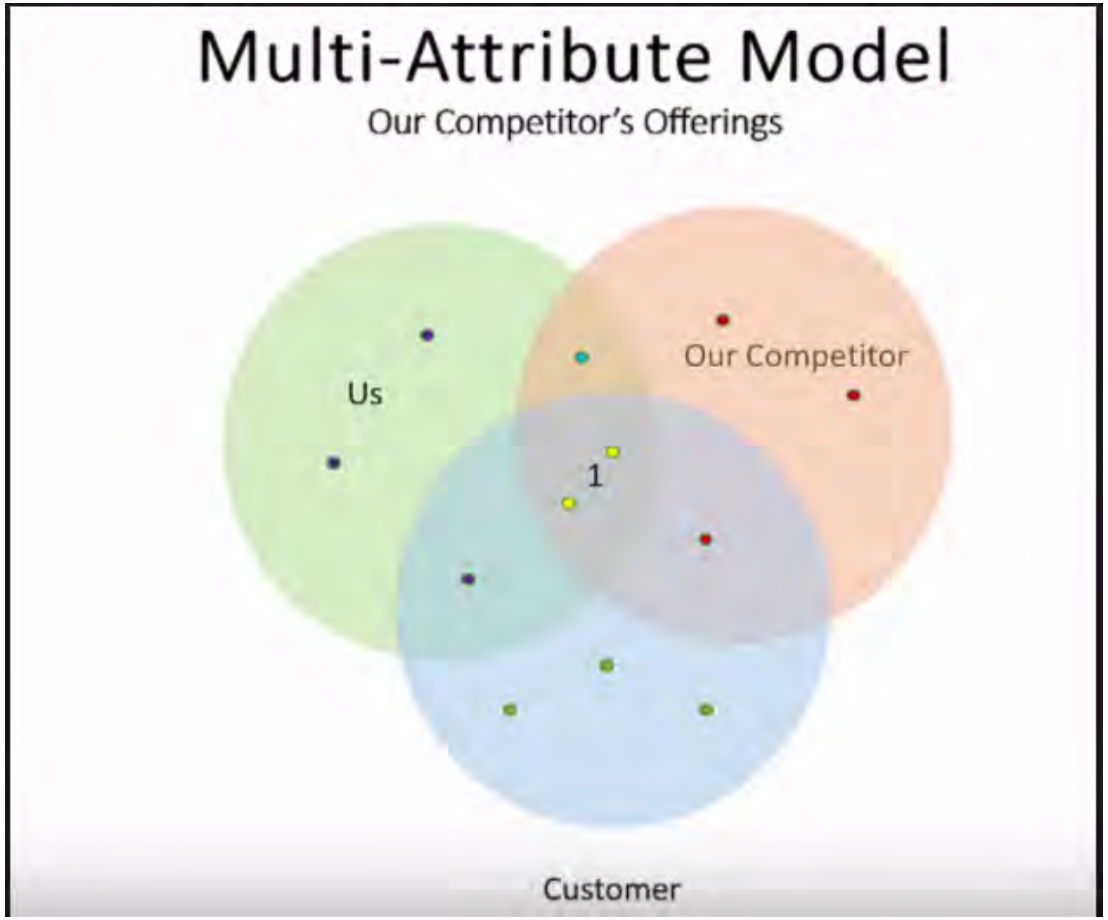
Water quantity

- Areal (e.g. river miles) / Volumetric (e.g. acre feet)/Temporal dimension (e.g. per second)to capture flow/ Demographic (e.g. household)
- Issues with marginal values and increasing value under scarcity
- Issues with excess water
- Storage and reliability represent the complex dynamic between demand and supply

Conveyance and supply

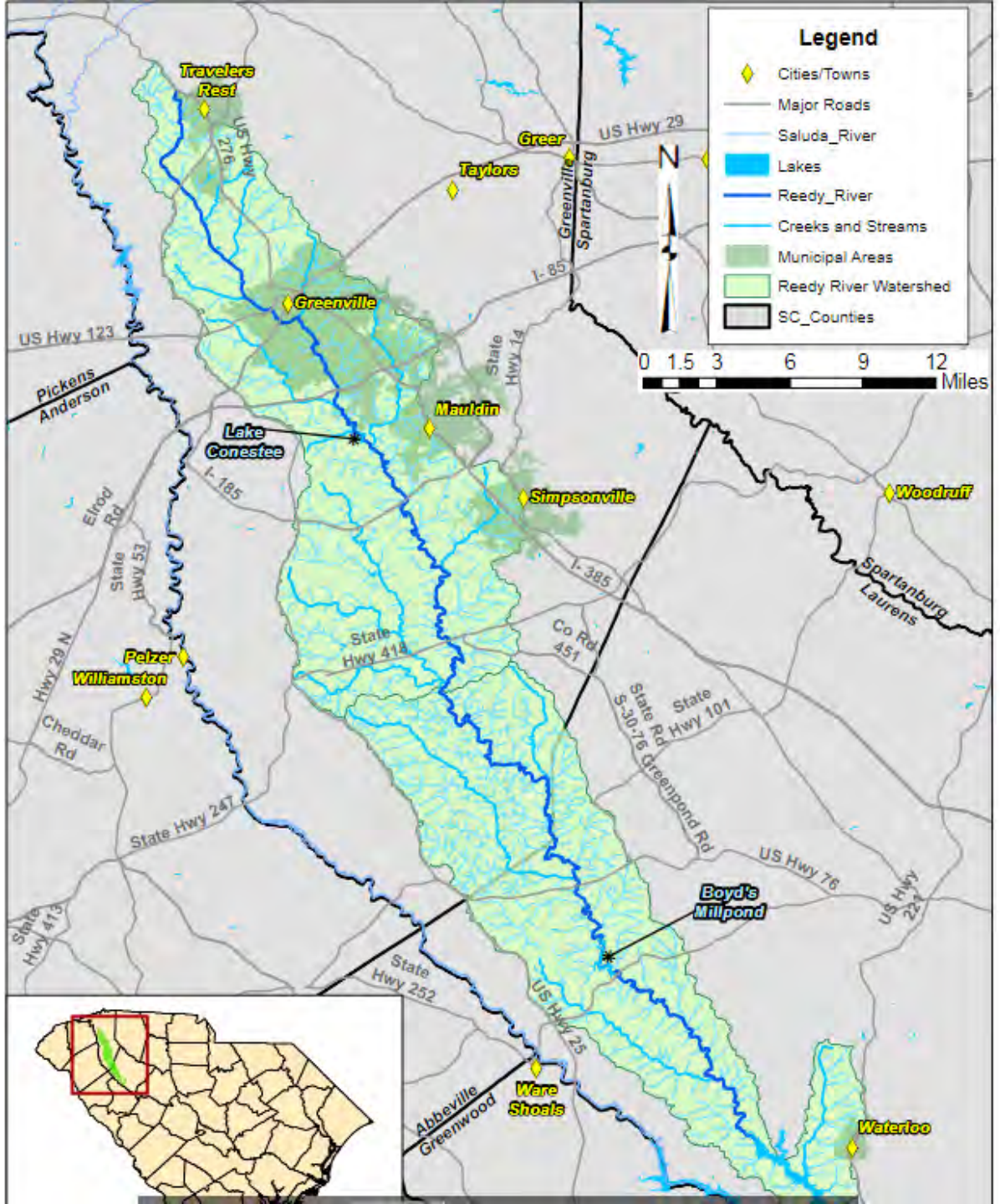
- Physical structure of river systems to distribute water
- Compared to installing pipeline substitute for distribution
- About biophysical structure

Water ecosystem services

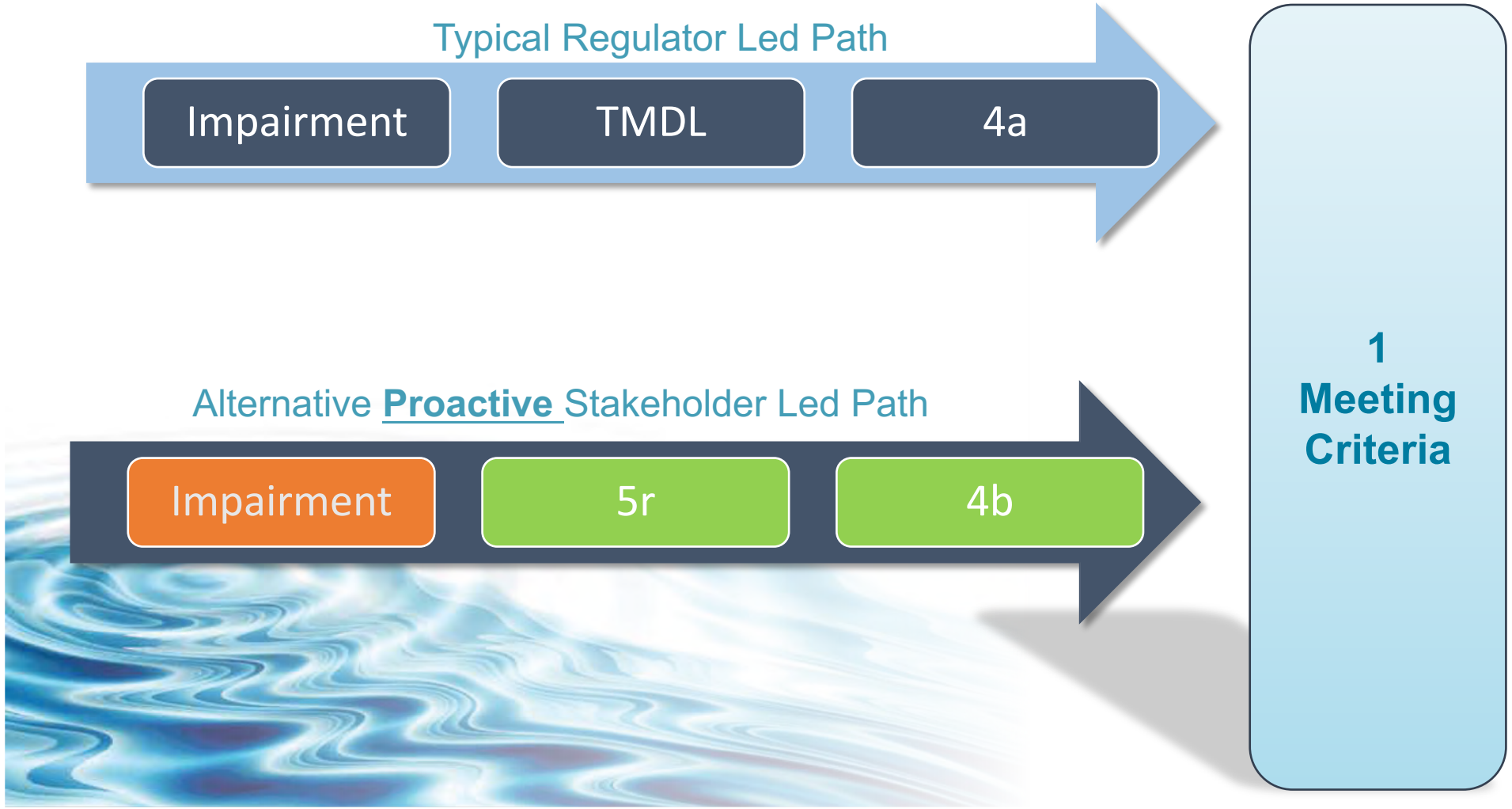


Reedy River, SC

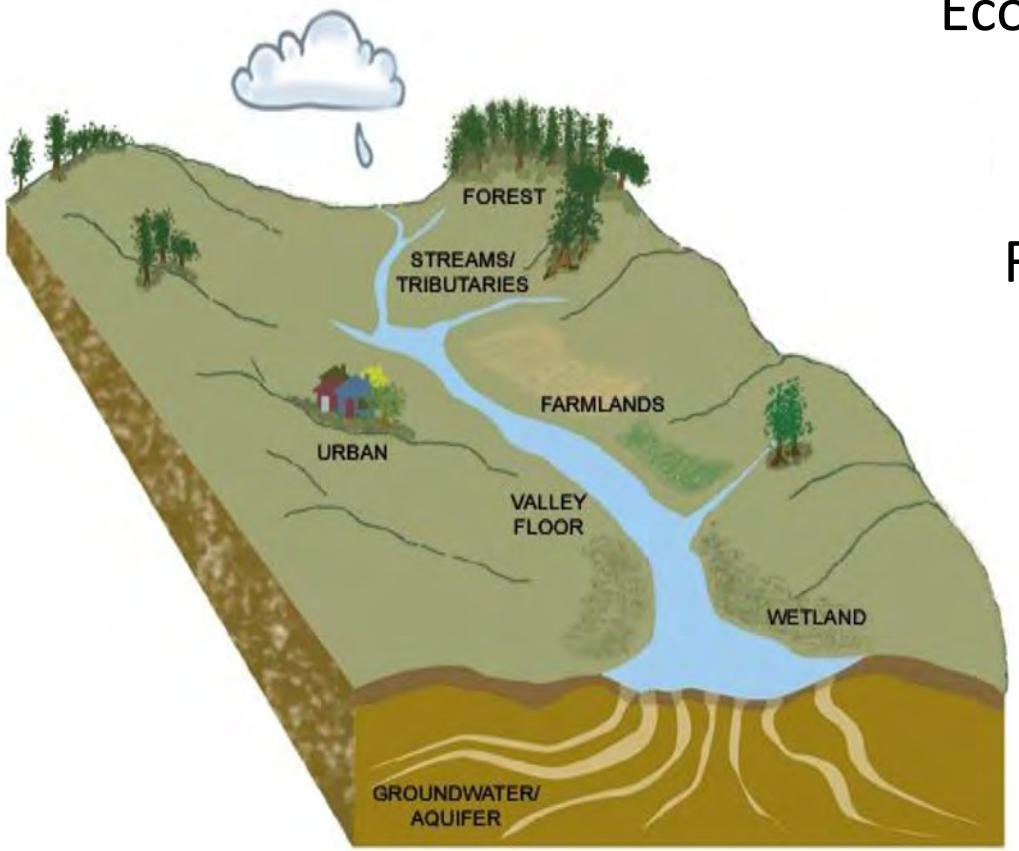
- Located in Greenville County
  - Impaired waters to be addressed with 5R Plan instead of TMDL abatement
- Analyze cost and benefit of each approach
- 5R Plan to include riparian vegetation expansion



Alternative approaches



Ecosystem service assessment



Ecosystem: Watershed

Function: Collection & Filtration

Service: Water Supply


Benefit Transfer
many values available

Per acre values by ecosystem service $2016 Baseline, riparian

	Cultivated		Forests		Grasslands		Water		Wetlands		Shrublands	
Ecosystem Servic	Min of min	Max of ma	Min of mir	Max of ma	Min of mi	Max of ma	Min of mir	Max of ma	Min of mir	Max of ma	Min of Mi	Max of Ma
Aesthetic	$ 30	$ 73	$ 57	$ 8,275	$ 26	$ 37			$ 38	$ 38		
Air Quality			$ 419	$ 419	$ 67	$ 126						
Biological Control	$ 17	$ 80	$ 2	$ 12	$ 28	$ 326						
Climate Stability	$ (27)	$ (4)	$ 31	$ 782	$ 193	$ 640			$ 21	$ 935		
Cultural Value			$ 3,289	$ 9,203					$ 1,004	$ 6,509		
Disaster Risk Reduction			$ 11,841	$ 11,841	$ 3,987	$ 3,987			$ 1	$ 8,471	$46	$63
Energy & Raw Mat	$ 32	$ 32	$ 15	$ 81					$ 12	$ 165	$17	$433
Food	$ 67	$ 200							$ 178	$ 9,255		
Habitat			$ 176	$ 3,838			$ 3	$ 18	$ 1	$ 1,616	$28	$578
Pollination & Seed	$ 133	$ 133	$ 202	$ 202								
Soil Formation	$ 7	$ 8										
Soil Retention	$ (8)	$ (7)			$ 38	$ 3,259						
Water Capture, Conveyance, & Supply			$ 56	$ 1,926			$ 32	$ 99	$ 0	$ 4,235		
Water Quality	$ (391)	$ (391)	$ 1,219	$ 4,324	$ 6,466	$ 21,069	$ 9	$ 9	$ 17	$ 11,067		
Water Storage							$ 34	$ 1,215	$ 457	$ 1,273	$34	$575

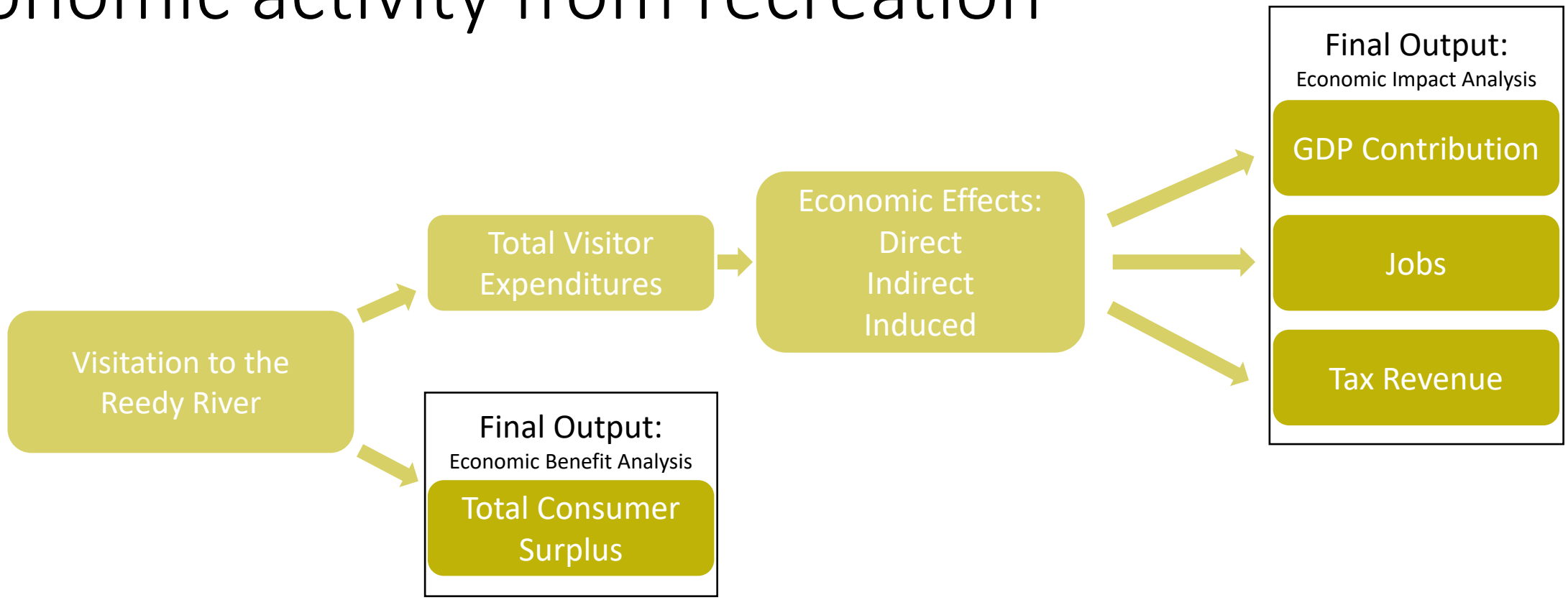
ES values by land cover

	Attribute	Acres	Low(USD/acre/year)	High(USD/acre/year)	Total Low(USD/year)	Total High(USD/year)
Cultivated		6,863	$ 316.05	$ 717.01	$ 2,169,031.86	$ 4,920,808.15
Riparian	X	389	$ (139.25)	$ 124.95	$ (54,166.51)	$ 48,606.95
Forests		62,861	$ 5,241.38	$ 17,781.00	$ 329,478,190.33	$ 1,117,731,484.81
Riparian	X	11,185	$ 17,306.55	$ 40,902.79	$ 193,573,781.13	$ 457,497,689.79
Grasslands		18,651	$ 290.81	$ 813.91	$ 5,423,980.63	$ 15,180,291.86
Riparian	X	1,376	$ 10,805.48	$ 29,443.63	$ 14,868,334.45	$ 40,514,440.19
Non Herbaceous		887			$ -	$ -
Riparian	X	0			$ -	$ -
Water		2,039	$ 64.30	$ 1,340.97	$ 131,105.07	$ 2,734,230.59
Riparian	X	0	$ 78.43	$ 1,340.97	$ -	$ -
Wetlands		193	$ 1,720.41	$ 39,298.04	$ 332,038.77	$ 7,584,521.90
Riparian	X	0	$ 1,728.43	$ 43,563.13	$ -	$ -
Shrubland		7,447			$ -	$ -
Riparian	X	883	$ 124.35	$ 1,649.59	$ 109,800.14	$ 1,456,590.61
Commercial/Residential/Urban		53,655			$ -	
Totals		166,429			$ 546,032,095.86	$ 1,647,668,664.85

Real estate hedonic values, proximity to river

Band (m)	Band midpoint (m)	Premium at band midpoint ($2015) - Adjusted for housing price difference[1]	% of Value attributed to the river
0-500	250	$15,047.43	9.00%
500-1000	750	$13,041.11	7.80%
1000-1500	1,250	$11,034.78	6.60%
1500-2000	1,750	$9,028.46	5.40%
2000-2500	2,250	$7,022.13	4.20%
2500-3000	2,750	$5,015.81	3.00%
3000-3500	3,250	$3,009.49	1.80%
3500-4000	3,750	$1,003.16	0.60%

Economic activity from recreation



Recreation Impacts

Economic impact of the Greenville Health System Swamp Rabbit Trail			
Location	Participant Days	Spending	Employment
GHS SRT	501,236	$6,974,198	65

Cost of Nitrogen and Phosphorous Abatement

Table 1
Costs associated with nutrient removal based on various BMPs.

	Costs per kg (pound) of nitrogen removed	Costs per kg (pound) of phosphorus removed
Stephenson (2008)		$1230–3300($560–1500)
National Research Council (2008)	$130–5500($60–2500)	
Chesapeake Bay Commission (2012)	Median ($300)	Median ($10,000)
Center for Watershed Protection (2013)	($83–2090*)	($235–9890*)
Busch (2013)	($67–972*)	$759–4118*)
Average	**$154–4080($70–1850)**	**$992–11,400($451–5170)**

* Costs do not include permeable pavement or street sweeping.

(Source: Privette et al. 2014)

Cost: $70-1,850/ lb TN removed
Amount: 642,537 lbs TN
Cost for RR: ???

Cost: $451-5,170/ lb TP removed
Amount: 50,680 lbs of TP
Cost for RR: ???

Application and Policy

- Expand and compare BCA ratios for projects with water impacts
- Engage more stakeholders in conservation efforts
- Exceed goals and enhance conservation efforts
- Plan for expected impacts
- Prioritize high ROI conservation efforts
- Include non-monetary values in decision-making

Thank you!