The Economics of Sustainability: Willingness to Pay for the Benefits of LID

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Sustainability and Development

I. Dixon and Fallon, 1983, 27 peer reviewed definitions of sustainability classified into single resource (fishery), ecosystem (wetland), socioeconomic subsets

II. "Economic Growth, Carrying Capacity and the Environment"
Statement by 11 prominent academic economists and ecologists in the policy forum section of Science, 1995

1. The environmental resource base is finite
2. There are limits to the carrying capacity of the planet
3. Economic growth is not a panacea for diminishing environmental quality

III. UN sponsored Bruntland Commission Report, Our Common Future, 1987

"Development which meets the needs of the present without sacrificing the ability of the future to meet its needs is sustainable"

Sustainability and Development

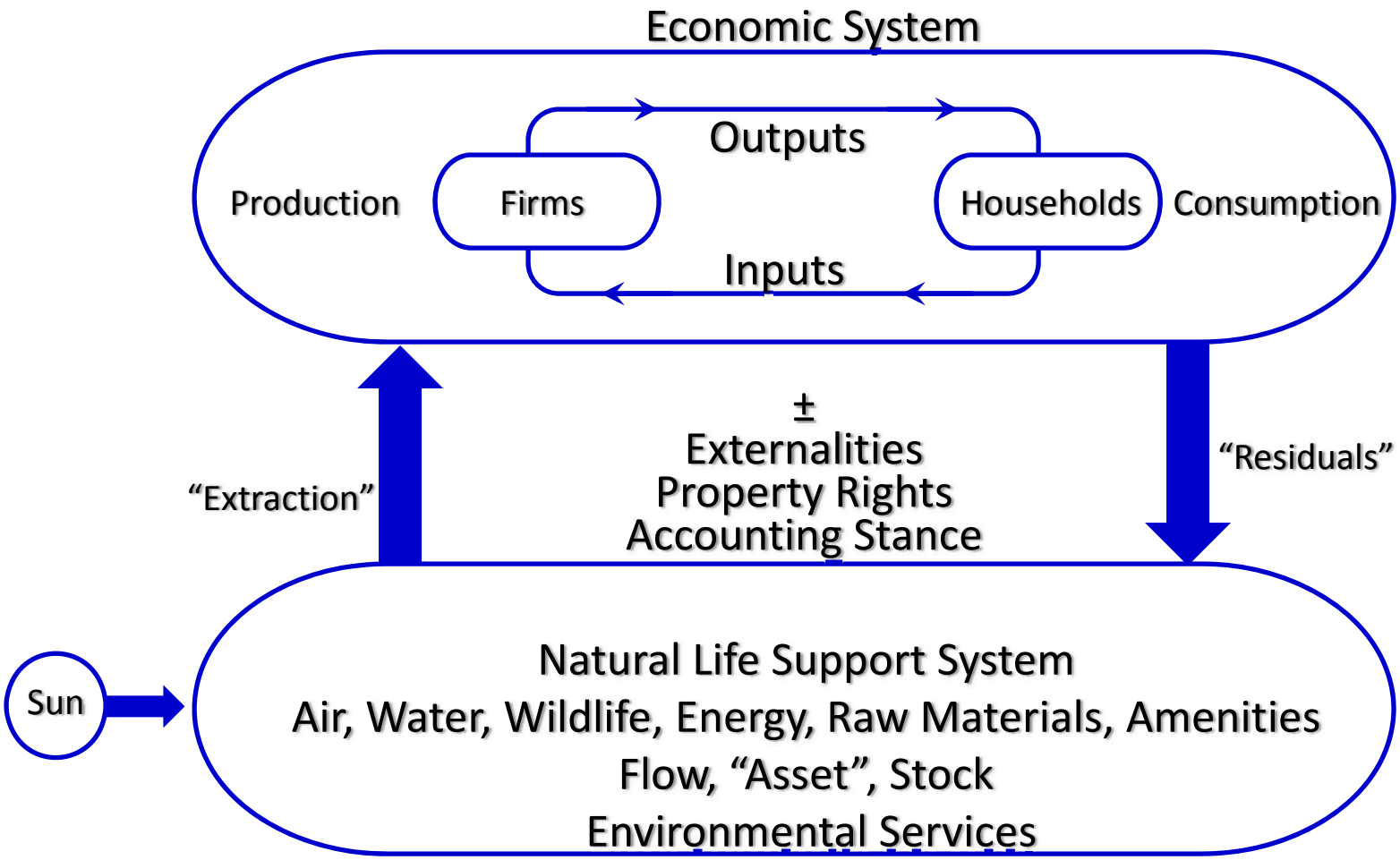
IV. Neoclassical Economic Approaches

- ✓ Property rights e.g., Coase, etc.
- ✓ Pigovian taxes and subsidies
- ✓ Safe Minimum Standards (SMS)
- ✓ **Pricing / internalizing residuals and service flows** → <u>Macro GDP accounts</u>

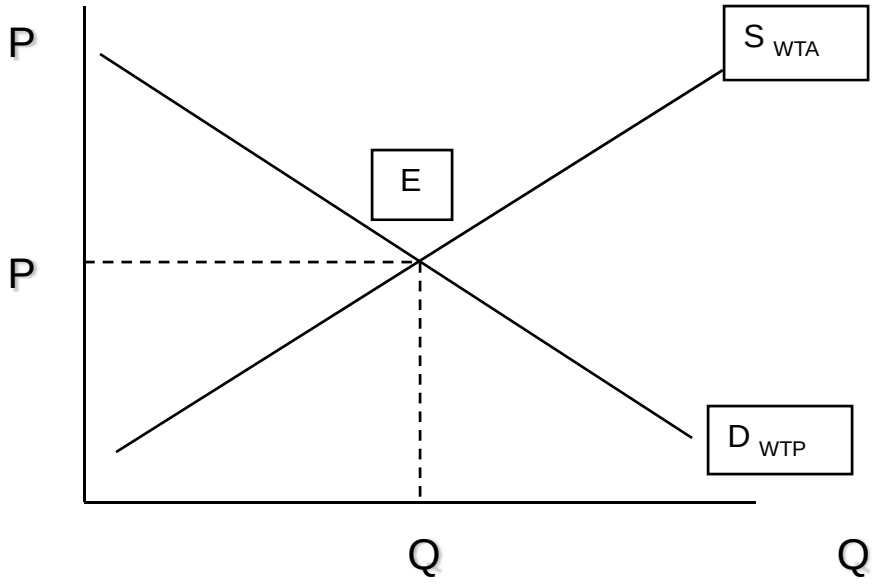
V. Ecology / Thermodynamics Approaches

- ✓ Eco-system and service flows
- ✓ Ecological paradigms
- ✓ Environmental Impact Statements (EIS)
- ✓ Environmental sustainability and footprints
- ✓ Energy flow / value analysis
- ✓ Sustainable scale – steady state

The Economic System and the Environment



Willingness to Pay and Accept



- **In market context, equilibrium (E) point where WTP = WTA leads to market clearing price (P) and quantity (Q)**
- **But, markets don't always capture full WTP or WTS, particularly of environmental goods and services**
  - **e.g., externalities or spillovers**
- **So, extra and non-market valuation methods useful**

Pollution Externality

- **Pollution – simply the transmission, beyond the recognized legal boundary of the producer, of some quantity of matter that gives rise to costs for others. These effects are called externalities – precisely because the impact on others are external to the unit that makes the decisions about the resources allocation.** (Bromley, 1997)

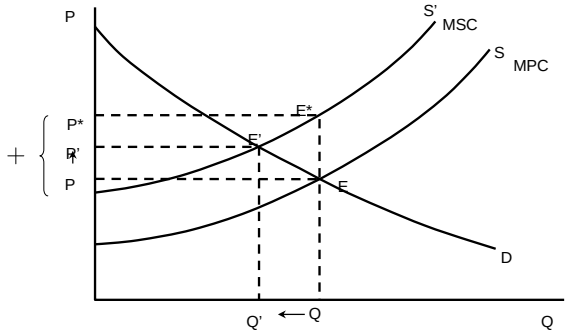
- **Technological Externality-**
  - Necessary condition
    - Physical interdependence of production and/or utility functions.

- **Sufficient condition**
  - Interdependence not fully priced or compensated

(Dasgupta and Pearce, 1978)

Figure 1. Externalities of High Impact Development

Figure 2. Externalities of High Impact Development



S = marginal private (e.g., local producer) cost function
S^1 = marginal social (e.g., global) cost function
D = demand or marginal benefit function
Q = output quantity
P = price/unit of output
P* = inclusion of externalities such as soil erosion, wetland loss, air pollution, congestion from autos, strip mining spoils, water pollution, etc.

= private market equilibrium
$P^1Q^1E^1$ = equilibrium after internalization of externality
+ = Pigouvian tax to internalize costs of HID

Examples of LID Environmental Economic Benefits

1. Proper reclamation of surface coal mines to improve downstream water quality
   - e.g., increased lake based recreation and residential property values

2. Upstream control of soil erosion from agriculture to reduce downstream sedimentation
   - e.g., reduced costs of dredging and water treatment, increased recreation and residential property values

3. Full mitigation of functional wetland losses from development
   - e.g., sequestration and treatment of waste, reduced flood damage and improved habitat

4. Proper treatment of human and industrail wastes to protect rivers and beaches.
   - e.g., increased economic activity from fishing, swimming, and boating

5. Dam and toxics removal from rivers
   - e.g., improved aquatic habitat and recreation

6. River greenways for stormwater management
   - e.g., reduced damage from overflow and flooding and recreation benefits

7. Restrictions on in-stream gravel mining
   - e.g., increased river based recreation and residential property values

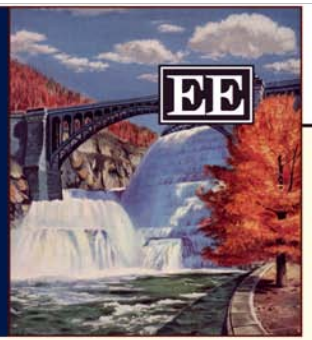
Measurement of Extra and Non-Market Economic Values

- 1. Private and public expenditures for development related disamentities.
- e.g., avoidance, clean up and treatment costs
- 2. Surrogate market or revealed preference measurers of development related amenities gained or lost (use values)

  a. Travel cost (TC)
     - Willingness to incur private costs (including time and other travel related costs) to avoid disamenities or gain amenities related to development

  b. Hedonic pricing (HP)
     - Development related amenities and disamenities capitalized into property values (primarily residential)
- 3. Constructed market or contingent valuation (CV) surveys of stated preferences for development related amenities or disamenities (use and non-use values)
  - Willingness to pay or accept compensation
- 4. Capture and Transfer of benefits and generalization of results.
- 5. Incidence of net economic gains and losses (unweighted and weighted) by income class, ethnicity, etc.

Economic Valuation of River Systems



Edited by **Fred J. Hitzhusen**, Professor of Environmental and Natural Resource Economics, The Ohio State University, US

Environmental economists, ecological engineers and aquatic biologists detail in this volume their research on the benefits and costs of various water quality, infrastructure, scenic and historic river corridor impacts and improvements as a guide to policy on river and related watershed restoration. Treatment costs, hedonic pricing, contingent valuation, benefit transfer and capture estimation, aquatic biology, and hydrodynamic–ecologic simulation models and methods are developed to value river corridor impacts. While the study focuses on rivers in the Great Lakes region, the methods and results have important implications for river systems in other areas of the US as well as Europe and various temperate, developed regions of the world.

Contributors include: A. Abdul-Mohsen, R. Ayalasomayajula, J. Ferrati-Meza, L. Forster, T. Granata, T. Haab, F. Hitzhusen, M. Hnytka, S. Irvin, P. Jeanty, S. Kruse, S. Lowder, C. Murray, B. Sohngen, A. Sommer, D. Warren, U. Zika

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ECONOMIC VALUATION OF RIVER SYSTEMS

Fred J. Hitzhusen, Editor

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THE OHIO STATE UNIVERSITY RIVER CORRIDOR RESEARCH PROJECTS

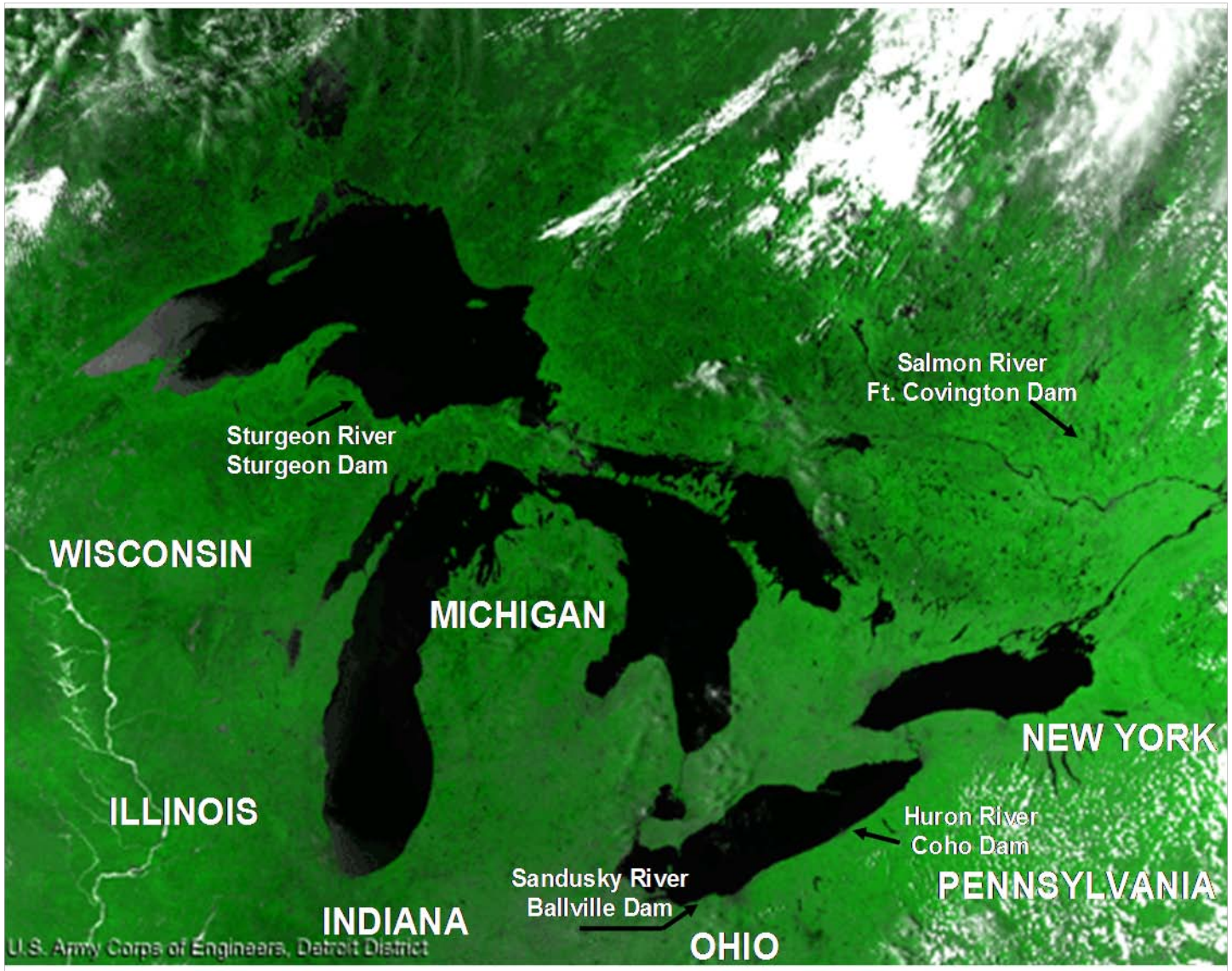
Study / Location	Pollution Source	Environmental Economic Valuation Technique	Study Objectives	Expected Benefits from study
Muskingum River Valuation	**Household/ domestic wastes, point Source from industries and Households**	**Benefit Transfer, Hedonic Pricing, CVM**	**Quantifying net benefits resulting from selected corridor improvements: dam and lock repair, sewer and septic, zoning and greenway extension**	**•Increasing residential property value** **•Increase tax base, and tax revenues to local governments and school districts of the area** **•Increasing recreation and therefore benefiting the local economy**
Dredging / Toxic Removal in Mahoning	River bed sediments, heavy metal deposits from industries	Travel Cost Method, CVM, Hedonic Pricing	Determine benefits from improved water quality from dredging of toxics	•Healthier ecosystem •Lifting human health advisory •Recreational activities •Increasing residential property value •Enhancing local economy
All surface Waters in Ohio	All NPDES and PTI permits to discharge	CVM	Derive demand function for available pollutant assimilative capacity (APAC)	•Fulfill requirements of the Clean Water Act by estimating benefits lost from a lowering of water quality •Protocol of OEPA evaluation of discharge permits
Pesticide Study in Maumee	Non-point source agricultural runoff	Multivariate Regression analysis	Determine benefits from alternate farm management	•Provide farm management practices that reduce treatment costs •Increase water quality

THE OHIO STATE UNIVERSITY RIVER CORRIDOR RESEARCH PROJECTS

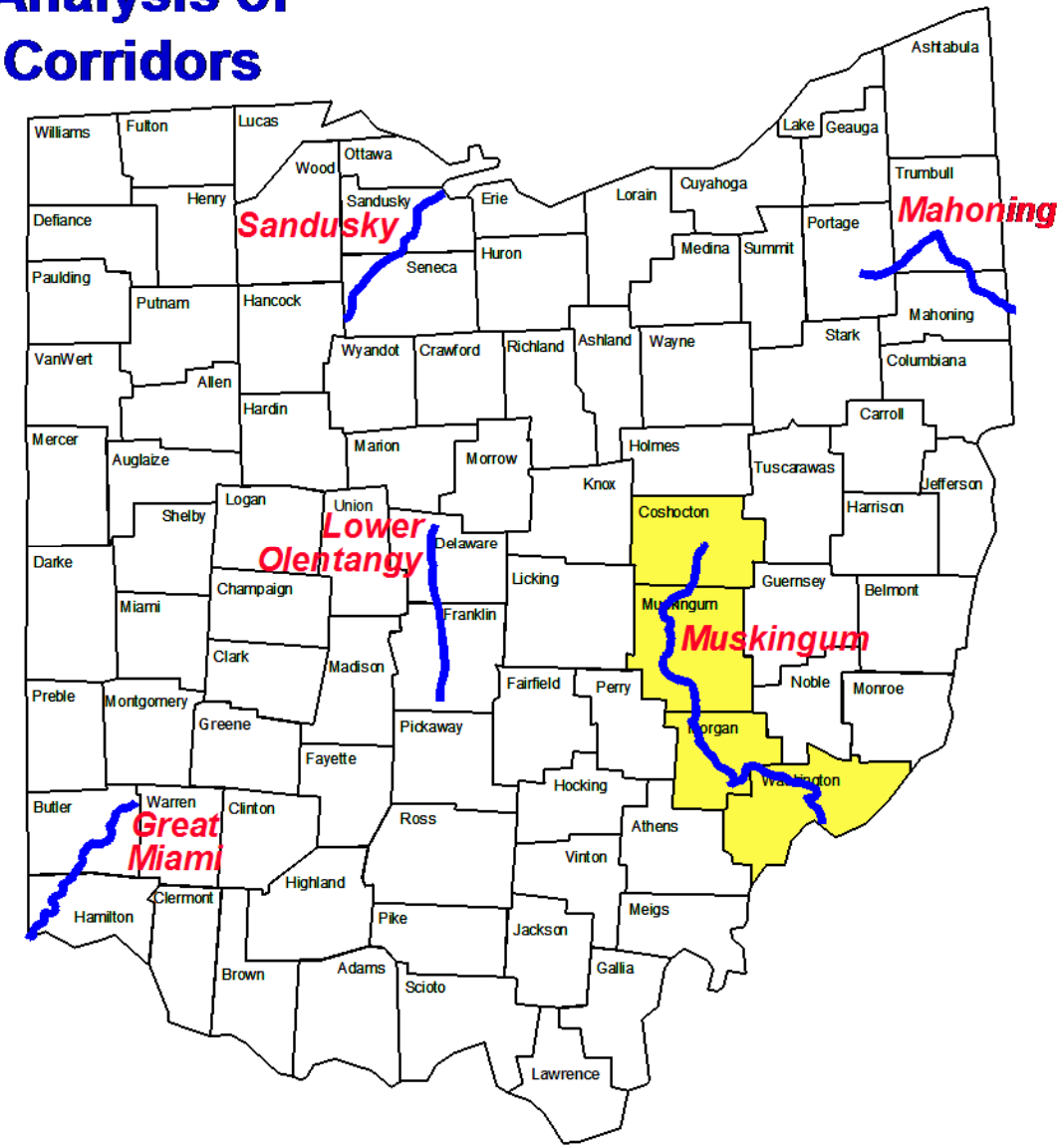
continued

Study / Location	**Pollution Source**	**Environmental Economic Valuation Technique**	**Study Objectives**	**Expected Benefits from Study**
Dam Removal Study in Ohio, New York, and Michigan	Sediments behind the dam structure, impeding migration of sport fish to Great lakes, disruption of natural stream habitat	Ecological-Engineering-Economics Methodologies	Estimate benefits with and without dam removal and/or restoration	•Increased walleye population in the river and lake Erie •Increased tourism •Restoration of natural stream habitat •Free flowing river for non motorized boating and fishing
Channelized Stream Restoration in Ohio	Restrict a free flowing river to artificial channels, increased erosion, loss of habitat	Engineering-Economic Models	Determine benefits from restoring channelized streams	•Restore the flood plain of the river, reduce flooding •Healthier river ecosystem
The Great Miami River Valuation	Gravel mining, point sources from households and industries	Hedonic Pricing, Benefit Transfer	Determine benefits from decreased / regulated gravel mining, septic improvements, increased access to the river for recreationists	•Healthier ecosystem •Increasing residential property values •Increase tax base •Increased recreation

Study Areas in the Great Lakes Region



Economic Analysis of Ohio River Corridors



Economics of Rivers

Economic functions of rivers

a. Water supply, transportation, drainage, waste assimilation, residential/vacation home sites, recreation and tourism, cooling, etc.

b. Historically viewed more as transportation and waste assimilation/disposal.

c. Recreation (e.g. fishing, boating) and other amenities more recent.

d. Appears to be less economic evaluation of rivers than lakes, wetlands and other ecosystems.

e. Citizens, local officials, environmental groups, increasingly concerned with “economics” of river systems.

The Muskingum River

a. Located in SE Ohio

b. Ten historic locks and dams built between 1837 and 1841 for barge transport of goods.

c. Local officials (e.g. Morgan County) concerned with depressed economy but interested in low impact, sustainable development.

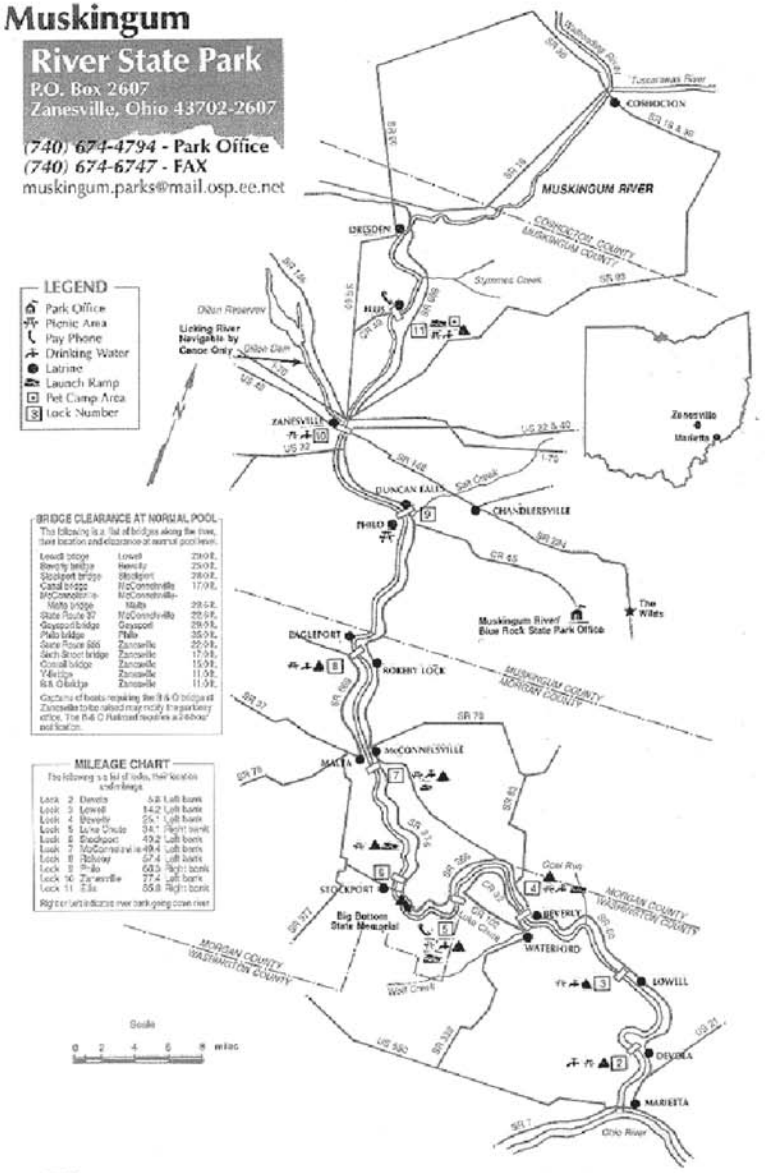
- Contacted Rivers Unlimited.
- R.U. contacted us at OSU.
- Joint applied enterprise to do case study, develop methods and expand to other river corridors.

Muskingum

River State Park

P.O. Box 2607
Zanesville, Ohio 43702-2607

(740) 674-4794 - Park Office
(740) 674-6747 - FAX
muskingum.parks@mail.osp.ee.net



BRIDGE CLEARANCE AT NORMAL POOL

The following is a list of bridges along the river, their location and clearance at normal pool level.

Lowell bridge	Lowell	23.0 ft.
Beverly bridge	Beverly	25.0 ft.
Stockport bridge	Stockport	28.0 ft.
Canal bridge	McConnelsville	17.0 ft.
McConnelsville-Malta bridge	McConnelsville-Malta	28.0 ft.
State Route 37	McConnelsville	22.0 ft.
Graysport bridge	Graysport	29.0 ft.
Philo bridge	Philo	35.0 ft.
State Route 666	Zanesville	22.0 ft.
Sixth Street bridge	Zanesville	17.0 ft.
Conrail bridge	Zanesville	15.0 ft.
Y bridge	Zanesville	11.0 ft.
B & O bridge	Zanesville	11.0 ft.

Captains of boats navigating the B & O bridge at Zanesville to be raised may notify the park ranger office. The B & O Railroad requires a 24-hour notification.

MILEAGE CHART

The following is a list of locks, their location and mileage.

Lock 2	Devola	6.8	Left bank
Lock 3	Lowell	14.2	Left bank
Lock 4	Beverly	25.1	Left bank
Lock 5	Lake Chute	34.1	Right bank
Lock 6	Stockport	43.2	Left bank
Lock 7	McConnelsville	49.4	Left bank
Lock 8	Robbey	57.4	Left bank
Lock 9	Philo	63.5	Right bank
Lock 10	Zanesville	77.4	Left bank
Lock 11	Ella	85.8	Right bank

Right or left indicates river bank going down river.

Methods for Estimating Costs and Benefits of LID

a. Phase I estimated $12.7 million annually in Muskingum River from recreation, tourism, and residential rent equivalents. Also, developed hedonic pricing and fishing visitation models.

b. Lock and dam repairs, extension of an existing bike trail, improved household septic systems and zoning were identified as low impact corridor improvements for benefit cost comparisons in Phase II.

c. Cost estimates of various improvements time consuming but fairly straight forward – full opportunity costs.

d. Benefit estimates involved more complicated non-market estimation and <u>benefit transfer approaches</u> – lower bound estimates.

Methods for Estimating Costs and Benefits of LID - continued

e. All benefits and costs expressed in discounted present values at discount rates of 4-15 percent.

   e.g. 4% = STP e.g. 15% = POC max

f. Both net present values and benefit/cost ratios as decision criteria.

g. Benefit capture is an issue with non-market valuation, particularly with hypothetical CVM bids and tax revenue implications of hedonic pricing models. This research links property tax revenue functions to first stage hedonic results and develops CVM bid functions to shed light on the benefit capture problem.

Table 1. Summary of Aggregate Bennefit Cost Results in 1999 Dollars (Using a 10% Discount Rate)

	Present Value of Benefits	Present Value of Costs	Net Present Value (B-C)	Benefit Cost Ratio
Zoning	$912,000	$144,000	$769,000	6.35
Septic (Cost Sharing)	$6,552,000	$4,641,000	$1,910,000	1.41
Bike Trail	$13,311,000	$2,050,000	$11,261,000	6.49
Lock & Dam	$17,511,000	$11,635,000	$5,876,000	1.51
TOTAL	$38,286,000	$18,470,000	$19,816,000	2.07

Table 2. Estimated Annual Property Tax Revenue Increases from Corridor Improvements

City	Tax Millage ($)	Coefficient Estimate	Number of Houses in the Area	Tax Revenue Increase ($)
		Zoning		
Zanesville	44.22	269	485	5782.21
Marietta	43.18	269	464	5389.55
		Septic System		
Muskingum	44.22	67	1002	2975.38
Washington	43.18	67	726	2100.36

Table 3. Estimated Annual School District Tax Revenues Generated by Zoning and Septic System

City	Tax Millage ($)	Coefficient Estimate	Number of Houses in the Area	Increase in Tax Revenue ($)
		Zoning		
Muskingum	24.61	269	1487	9844.07
Washington	26.23	269	1190	8396.49
		Septic System		
Muskingum	24.61	67	1002	1652.60
Washington	26.23	67	726	1275.70

CONCLUSIONS

a. Most LID corridor improvements economically viable except:
   - Fully subsidized household septic systems.
   - Dam and lock repairs at discount rate of 4 percent.

b. Net present value for the aggregate of four corridor improvements $19.8 million.

c. Rank (B/C) of improvements (at 10% discount rate).

• 1st Bike trail	6.49
• 2nd Zoning	6.35
• 3rd Locks and dams	1.51
• 4th Septic (cost shared)	1.41

d. Property Tax Revenue
   - Zoning resulted in $30,000 increase in property tax revenue to Zanesville and Marietta municipalities.
   - Functional household septic systems resulted in $8300 increase in property tax revenues to Muskingum and Washington counties local governments and $25,000 to 12 school districts.
   - Functional septic system added $15,000 to Morgan County local governments.

Conclusions - continued

e. Bid functions from CVM Ohio survey (probit)

- <u>Locks and dams</u>
  - Income (+)
  - Previously boated on Muskingum (+)
  - Believe locks and dams not important (-)
  - Visited Ohio River Museum (+)
- <u>Bike trails</u>
  - Income (+)
  - Have used bike trail (+)
  - Male respondents (-)
- <u>Septic systems</u>
  - Income (+)
  - Previously fished in Muskingum (+)
  - Previously fished in Muskingum (+)
  - Visited Ohio River Museum (-)

IMPLICATIONS

1. It is possible to estimate benefits and costs of LID.
2. Relative strong economic rationale for most river corridor LID improvements and B/C/ ratio provides order for proceeding.
3. Some limitations of Phase I & II:
   - Difficult to decouple zoning from set of municipal attributes and their impact on residential property.
   - Did not include AEP cooling and Coshocton County residential housing.
   - CVM response rates and question format.
   - Question of benefit capture refinements for local residents.
     - e.g. CVM bid functions
     - e.g. HPM tax revenue functions
4. Implications for Benefit Capture.
   - Publicize additional property tax revenue to local governments and school districts.
   - Contact boaters, fishermen and museum visitors for donations.
   - Promote biking among males, other?
   - Benefit Transfer to other sites? e.g. codification
5. Implications for other river related and natural resource projects?

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