Moving toward Floodplain Restoration at Scale on the Illinois River and Upper Mississippi Basin: Valuing Ecosystem Services, Demonstrating Flood Reduction, and Policy Implications

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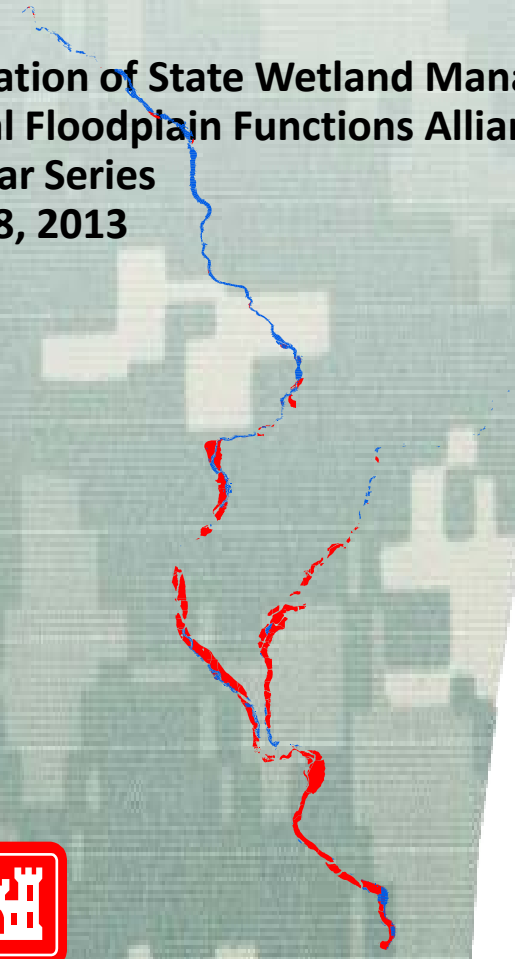
Mississippi Valley Division
Regional Technical Specialist

Association of State Wetland Managers
Natural Floodplain Functions Alliance
Webinar Series
Nov. 18, 2013



US Army Corps
of Engineers

Motivation to Study Ecosystem Goods and Services (EGS)

- Changing hydrology
  (Frequent extreme floods)
- Aging infrastructure
  (Residual Risk)
- Nutrient management (Hypoxia)
- Nature-based infrastructure
- IWRM Strategic Plan (2011)
- Mississippi River Commission Call to Action (2013)

Principles and Requirements for Federal Investments in Water Resources

A. Evaluation Framework

"…common framework…Such methods should apply an ecosystem services approach in order to capture all effects (economic, environmental, social)…"

"…not limited to: water quality, nutrient regulation, mitigation of floods and droughts, water supply, aquatic and riparian habitat, maintenance of biodiversity, carbon storage, food and agricultural products, raw materials, transportation, public safety, power generation, recreation, aesthetics, and education and cultural values…"

FEMA

MITIGATION POLICY – FP-108-024-01

I. TITLE:

Consideration of Environmental Benefits in the Evaluation of Acquisition Projects under the Hazard Mitigation Assistance (HMA) Programs

II. DATE OF ISSUANCE:

JUN 18 2013

III. POLICY STATEMENT:

FEMA will allow the inclusion of environmental benefits in benefit-cost analyses (BCA) to determine cost effectiveness of acquisition projects.

Table I: Annual Estimated Monetary Benefits per Acre per Year

Environmental Benefit	Green Open Space	Riparian
Aesthetic Value	$1,623	$582
Air Quality	$204	$215
Biological Control	--	$164
Climate Regulation	$13	$204
Erosion Control	$65	$11,447
Flood Hazard Reduction	--	$4,007
Food Provisioning	--	$609
Habitat	--	$835
Pollination	$290	--
Recreation/Tourism	$5,365	$15,178
Storm Water Retention	$293	--
Water Filtration	--	$4,252
Total Estimated Benefits	$7,853	$37,493

ES Definition: *Ecosystem goods and services are socially valued aspects or outputs of ecosystems that depend on self-regulating or managed ecosystem structures and processes.*

Natural System: Abundant and Diverse Fauna and River Habitats

Ecosystem "Infrastructure"

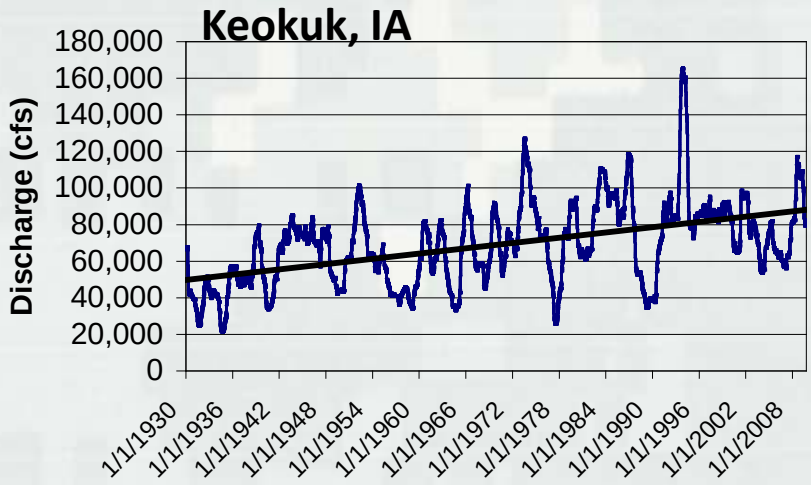
- Largest river North America and third largest in the world
- 2.6 million acres of land and water area
- 297,000 acres of National Wildlife Refuge System
- >300 bird, 57 mammal, 45 amphibian and reptile, 150 fish, and ~50 mussel species
- 40% of North America's migratory waterfowl and shorebirds
- 60% of all bird species in North America
- 25% of all fish species
- Habitat for 286 State-listed and 36 Federal-listed T&E species
- Boating, camping, hunting, trapping and other recreation

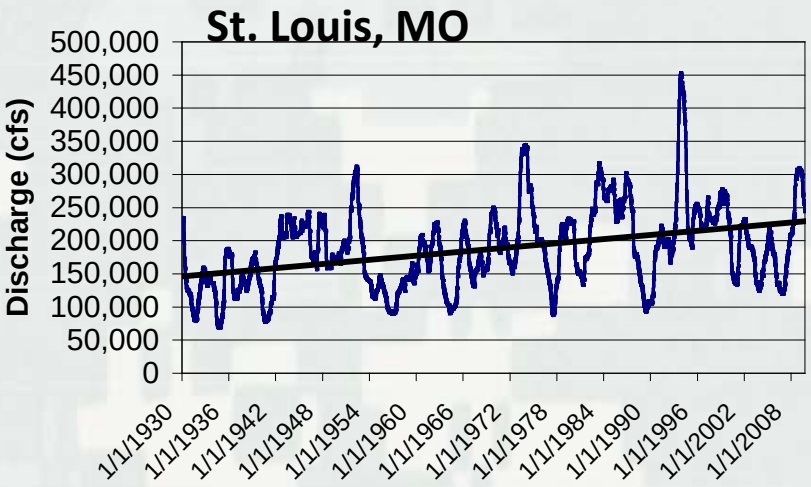
Contemporary System: Altered Boundary Conditions and Drivers

- Watersheds
- Floodplains
- Upland-Floodplain

Discharge is Increasing

(3-Year Moving Average Discharge)





Mississippi River Basin Nutrient Sources

Science for Solutions

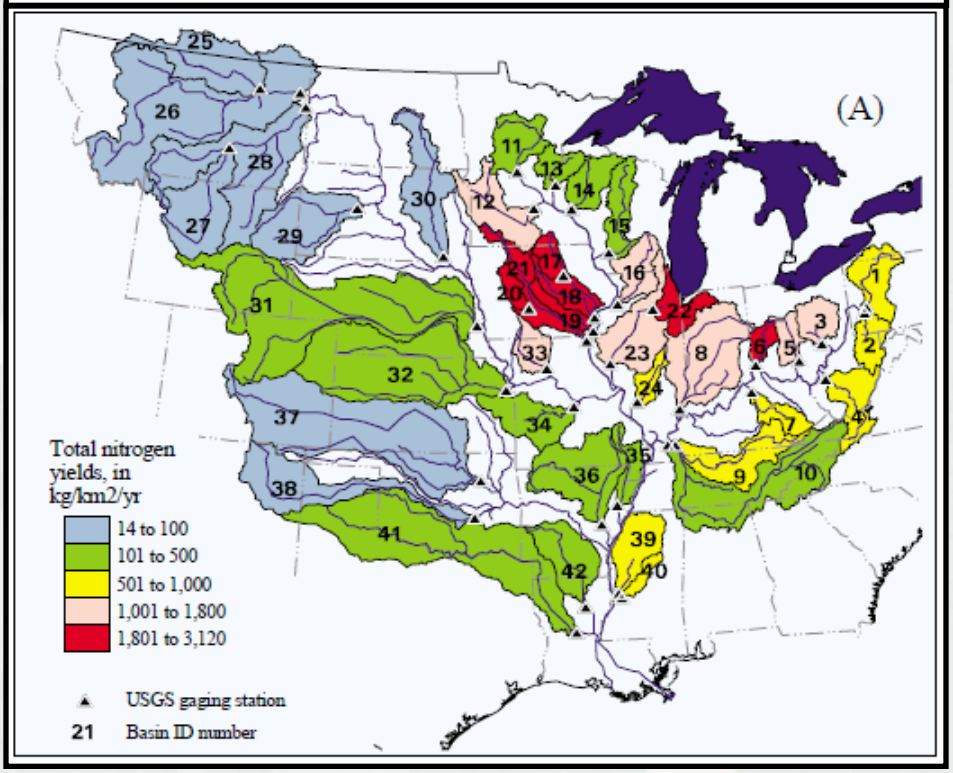
NOAA COASTAL OCEAN PROGRAM
Decision Analysis Series No. 17

Flux and Sources of Nutrients in the Mississippi–Atchafalaya River Basin

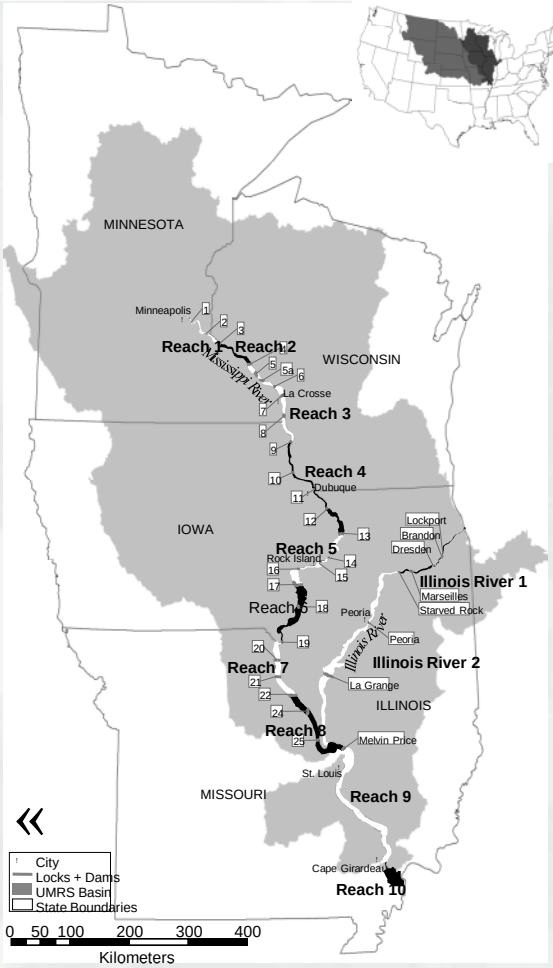
Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico

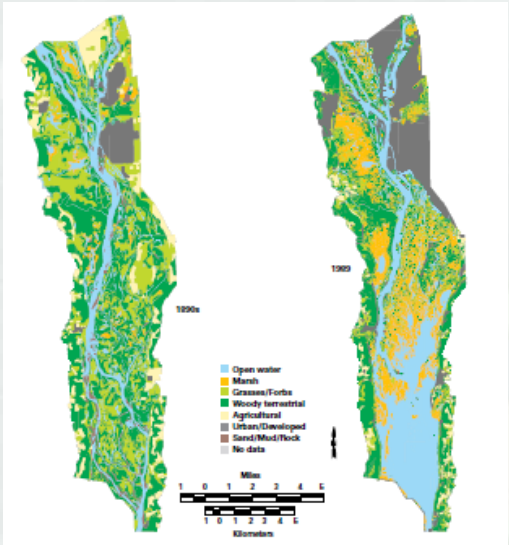
Donald A. Goolsby, William A. Battaglin, Gregory B. Lawrence,
Richard S. Artz, Brent T. Aulenbach, Richard P. Hooper,
Dennis R. Keeney, and Gary J. Stensland

May 1999



River-Floodplain Connectivity





- 1,200 miles of 9-foot deep channels,
- 37 lock and dam sites,
- Thousands of channel training structures,

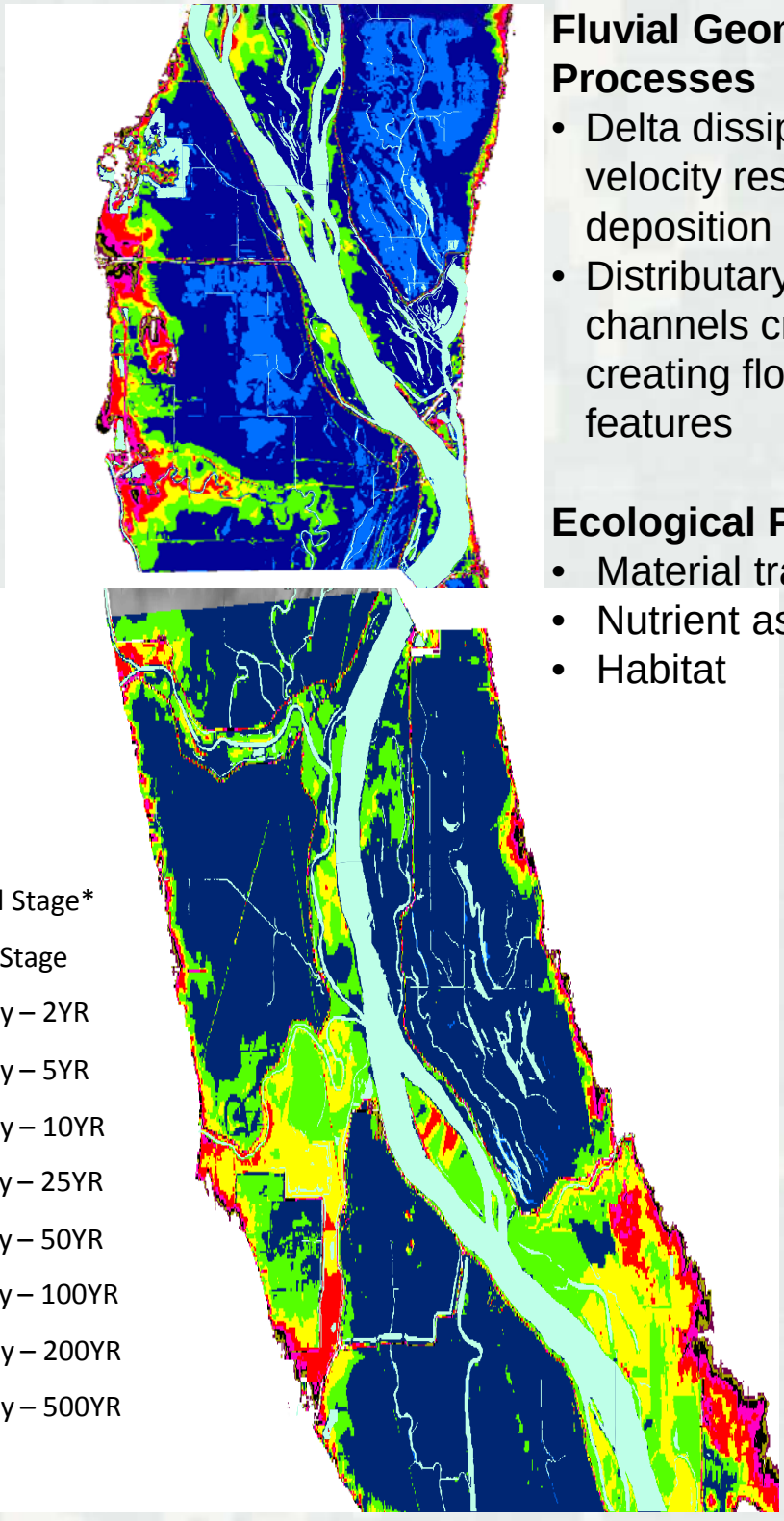
- 180 flood protection systems protecting urban and agricultural areas.
- 2,200 miles of floodwalls and levees.
- Concentrated in South
- Separated by tributaries

Watershed-Floodplain Connectivity

Fabius River Delta

Illinois River

Tributary Delta Functional Process Zone



Legend

- Regulated Pool Stage*
- Modeled Pool Stage
- 50% probability – 2YR
- 20% probability – 5YR
- 10% probability – 10YR
- 4% probability – 25YR
- 2% probability – 50YR
- 1% probability – 100YR
- 0.5% probability – 200YR
- 0.2% probability – 500YR

Fluvial Geomorphic Processes

- Delta dissipates stream velocity resulting in deposition of sediment
- Distributary of branching channels crossing delta creating floodplain features

Ecological Processes

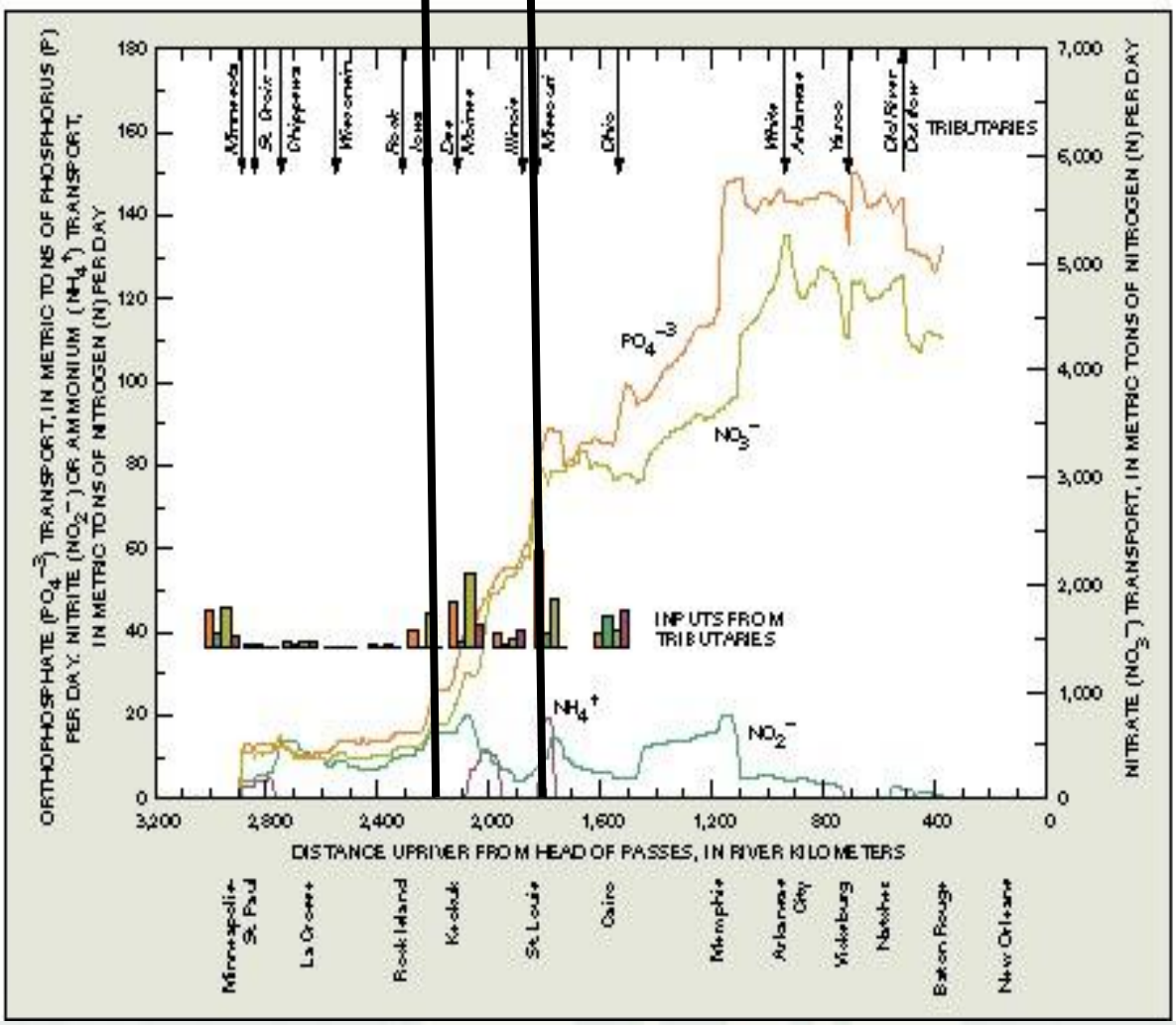
- Material transport
- Nutrient assimilation
- Habitat

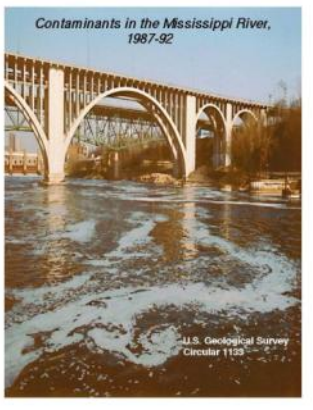
Nutrient Loads

Illinois River

Peoria, IL Grafton, IL

Iowa River Missouri River



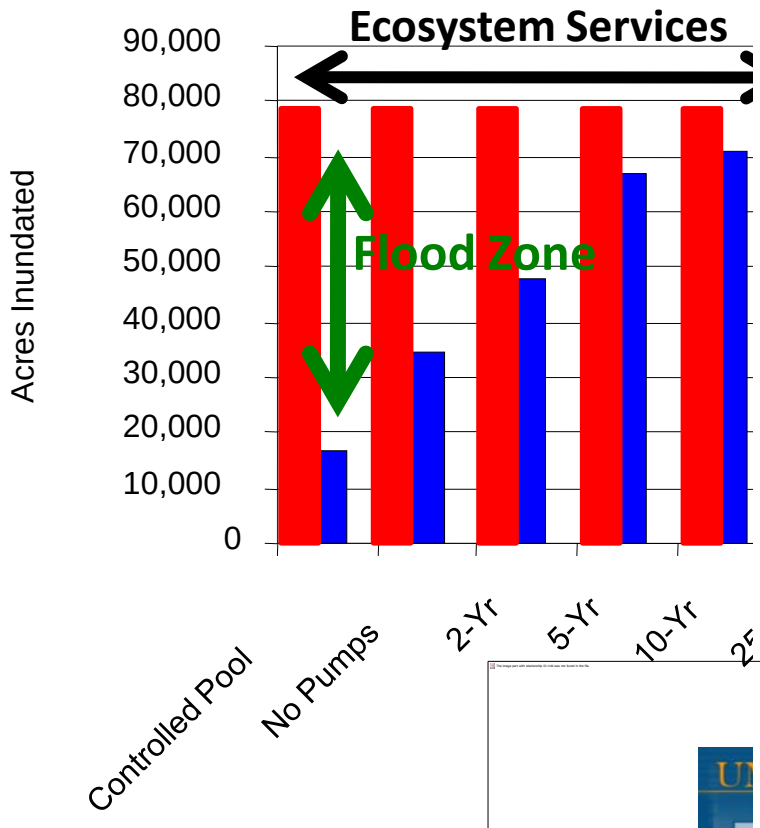


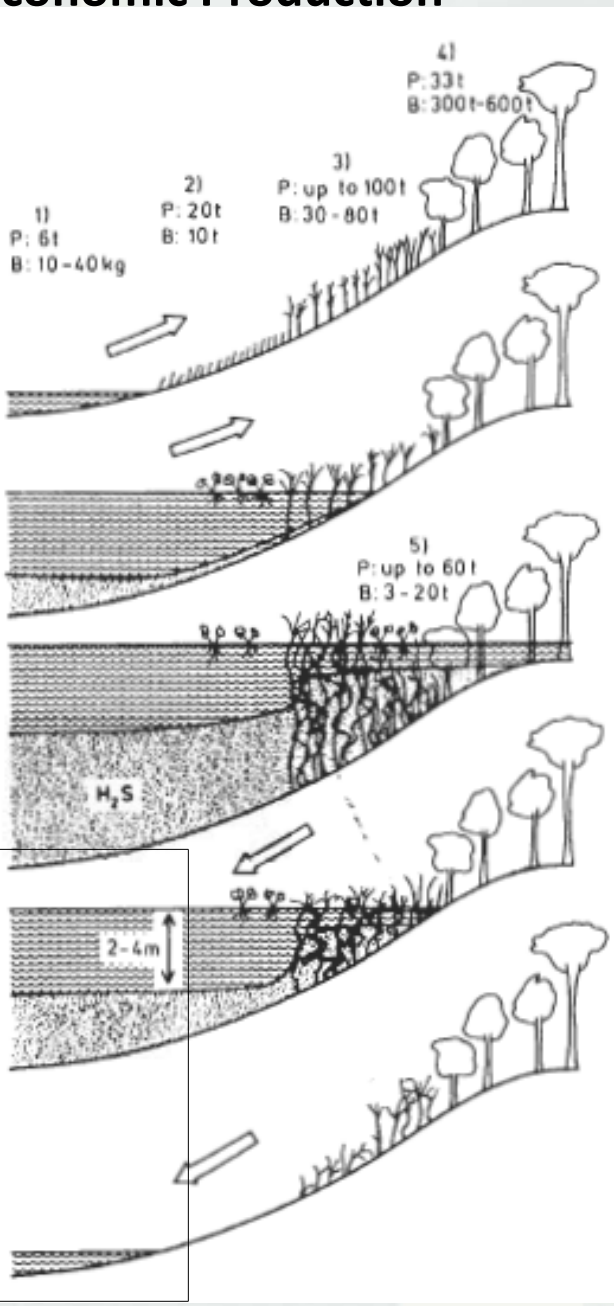
Contaminants in the Mississippi River, 1987-92
U.S. GEOLOGICAL SURVEY CIRCULAR 1133
Reston, Virginia, 1995 Edited by Robert H. Meade

Integrated Water Resource Management

Managing Conflicting Objectives, Risk, and Cost

Ecosystem Production vs Economic Production





Potential Acres Inundated = **Ecosystem Production Function**

Relative Flood Damage Prevented = **Economic Production Function**

In Addition to Conflict and Competition, There is Also Risk

The New York Times

13 June, 2008 Cedar Rapids, IA - In Eastern Iowa, the City That 'Would Never Flood' Goes 12 Feet Under

PAGE A6 • QUAD-CITY TIMES • THURSDAY, AUGUST 12, 2010

Arturo Fernandez/THE DES MOINES REGISTE

Rising water from floods surrounds Hilton Coliseum, top right, Wednesday in Ames, Iowa. Thunderstorms have hit Iowa for three consecutive nights, sending rivers and creeks rolling over their banks.

Flooding kills 1 in Iowa; hundreds evacuated

8/12/2010

Three nights of ra… caus… flood… entra… owa

DES MOINES — …year-old girl died Wednesday when raging floodwaters swept three cars off a road near Des Moines, and hundreds had to evacuate their homes as widespread flooding struck Iowa after three nights of rain.

In Ames, flooding contributed to a water main break that forced the city to shut off water to its roughly 55,000 residents and left Iowa State University's basketball arena under 4 to 5 feet of water.

Rivers and creeks rose after

Doug Phillips, a division chief … the P… Sheriff's … said … usual … 3 feet deep … feet … early Wedn… morn… looked like … river."

… residents … were asked to leave Wednesday afternoon because of flooding by Four Mile Creek, and utility workers turned off natural gas and electric service to homes. A shelter was opened at an elementary school, and police said everyone needed to leave immediately.

"It's such a serious and dangerous situation any time there is water around these homes because of the electricity and gas," Police Sgt. Lori Lavorato said.

In Ames, about 30 miles north of Des Moines, officials shut off

Steve Pope

ABOVE:

Birds Point, New Madrid Floodway

Heartland NEWS

"Historic conditions" prompt Corps to activate levee plan

Posted: Apr 26, 2011 3:34 PM CDT
Updated: Apr 27, 2011 2:46 PM CDT

By Christy Hendricks - bio | email
By Kathy Sweeney - bio | email

MISSISSIPPI COUNTY, MO (KFVS/AP) - A representative from the Army Corps of Engineers office in Memphis tells Heartland News "historic conditions on the river" prompted the Corps to activate the Birds Point-New Madrid Floodway Operations Plan.

Jim Bodrun joined leaders from Mississippi County and U.S. Representative Jo Ann Emerson at a meeting Tuesday afternoon in East Prairie to talk about the plan that could lead to the artificial breach of the levee that runs from New Madrid, MO to Cairo, IL.

"We're facing historic conditions on the river," Bodrun said. "And the plan of operation of the floodway is part of our overall system of flood control works. We have to get ready to operate it just in case it's needed."

The purpose of the floodway is to lower flood stages upstream and adjacent to the floodway during major flood events. The Floodway is some 35 miles in length and varies from 4 to 12 miles in width. It comprises about 205 square miles of alluvial valley land.

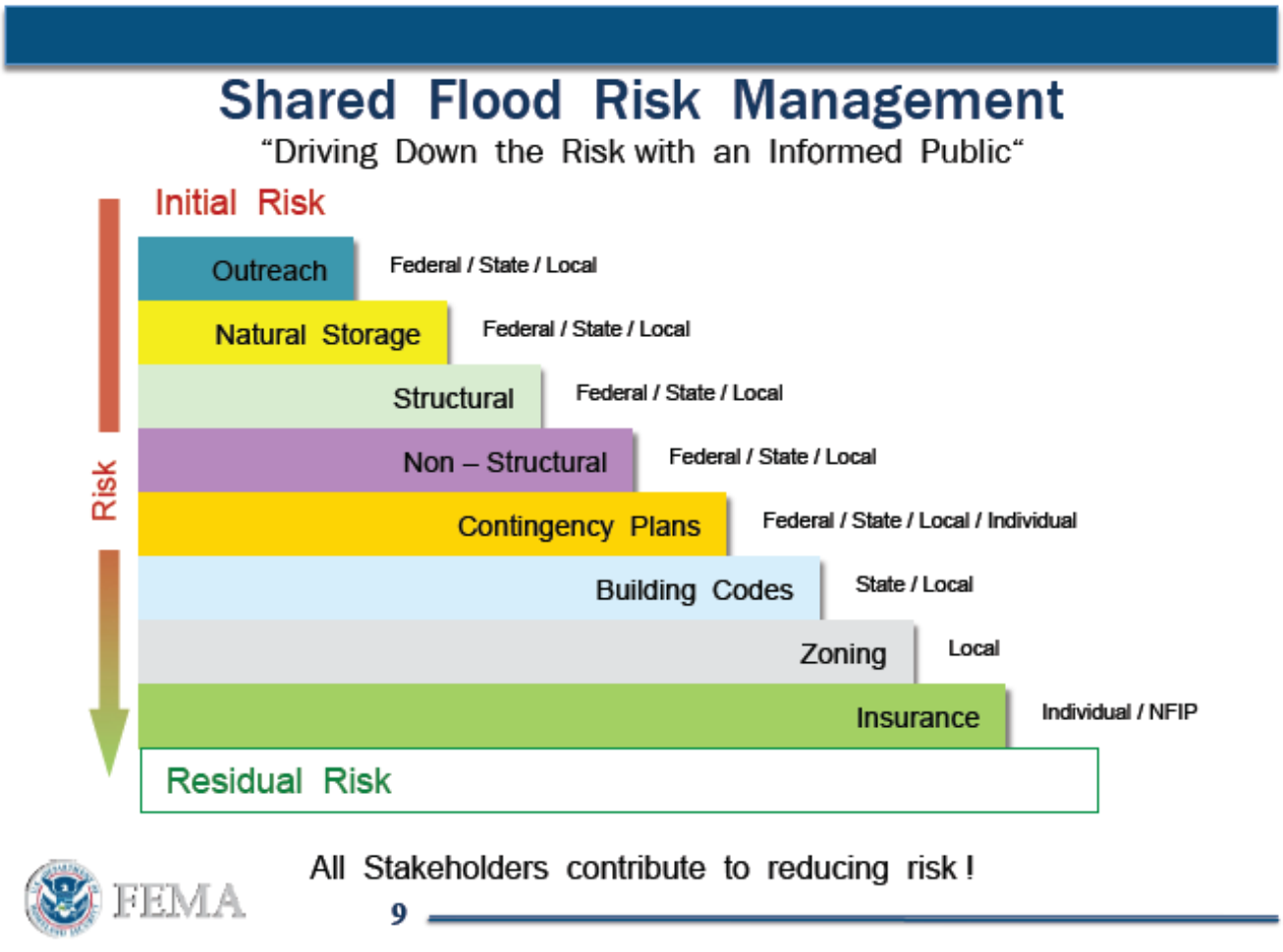
2011 Missouri River Floods

“Unprecedented pretty well sums it up”

Jody Farhat – Chief Mo. R. Water Mgmt. Office (USACE)

- Upper Midwest unusually heavy snow
- 300 – 600 percent greater than normal spring rain
- 35 – 40 percent more mountain snowpack

Residual Risk



UMRS Floodplain Adaptation Challenges

- Increased flood frequency/risk
- Increased pumping costs
- Uncertainty - Flood stationarity (or not)?
- Levee ratings
- FEMA Levee certification
- Nat’l Flood Insurance Program rate changes
- Wetland management challenges

IWRM is about a Systems Approach

Watershed – Floodplain – River - Ocean

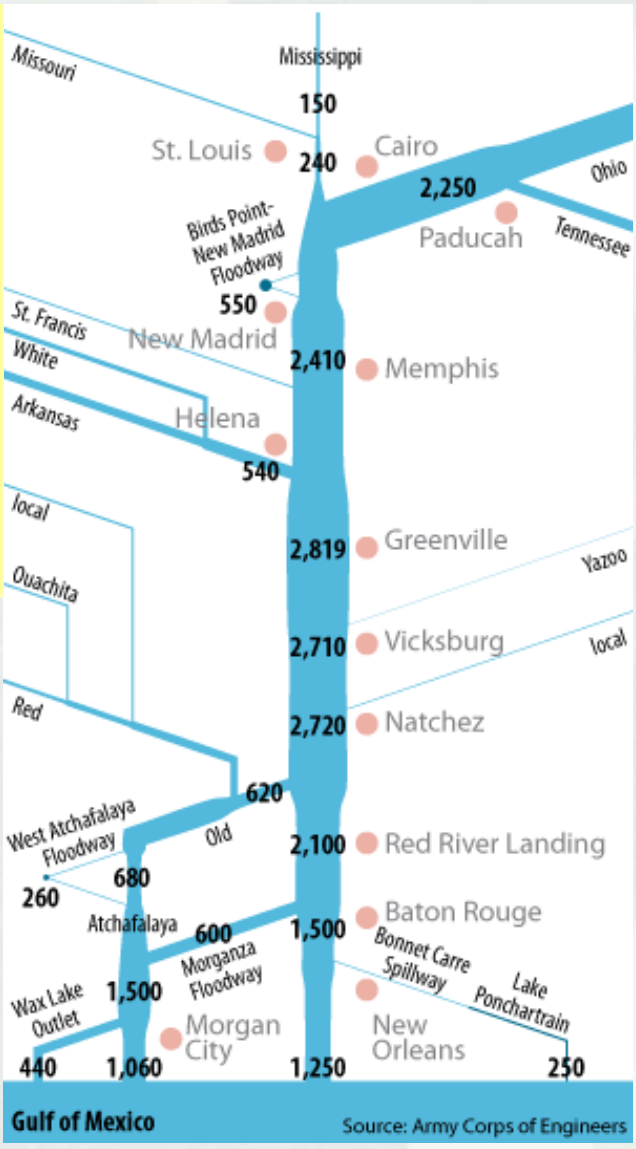
The ecological role of the floodplain has been neglected though.

The “kidney” function of the floodplain ecosystem is compromised by tributary diversions between levee districts

Systemic Flood Protection

Missouri River Multi-Purpose Storage Reservoirs

Mississippi River and Tributaries Project: Designed Floodways



Driving Down Flood Risk on the Upper Mississippi River

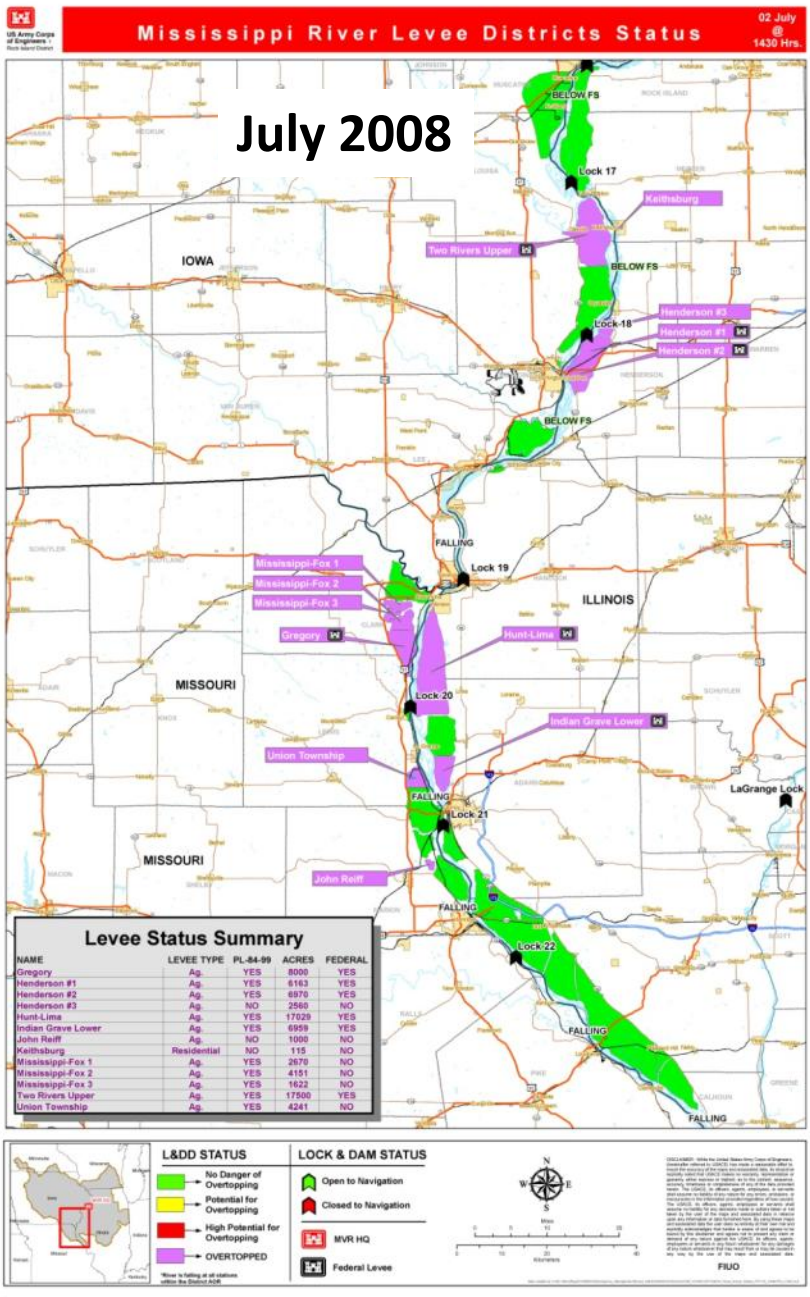
Stepped Inundation

It fits these needs:

- Anticipatory (or proactive) adaptation
- Planned adaptation
- Private adaptation
- Public adaptation

It integrates things like:

- Flood risk
- Alternative land use
- Flood insurance
- Public incentives

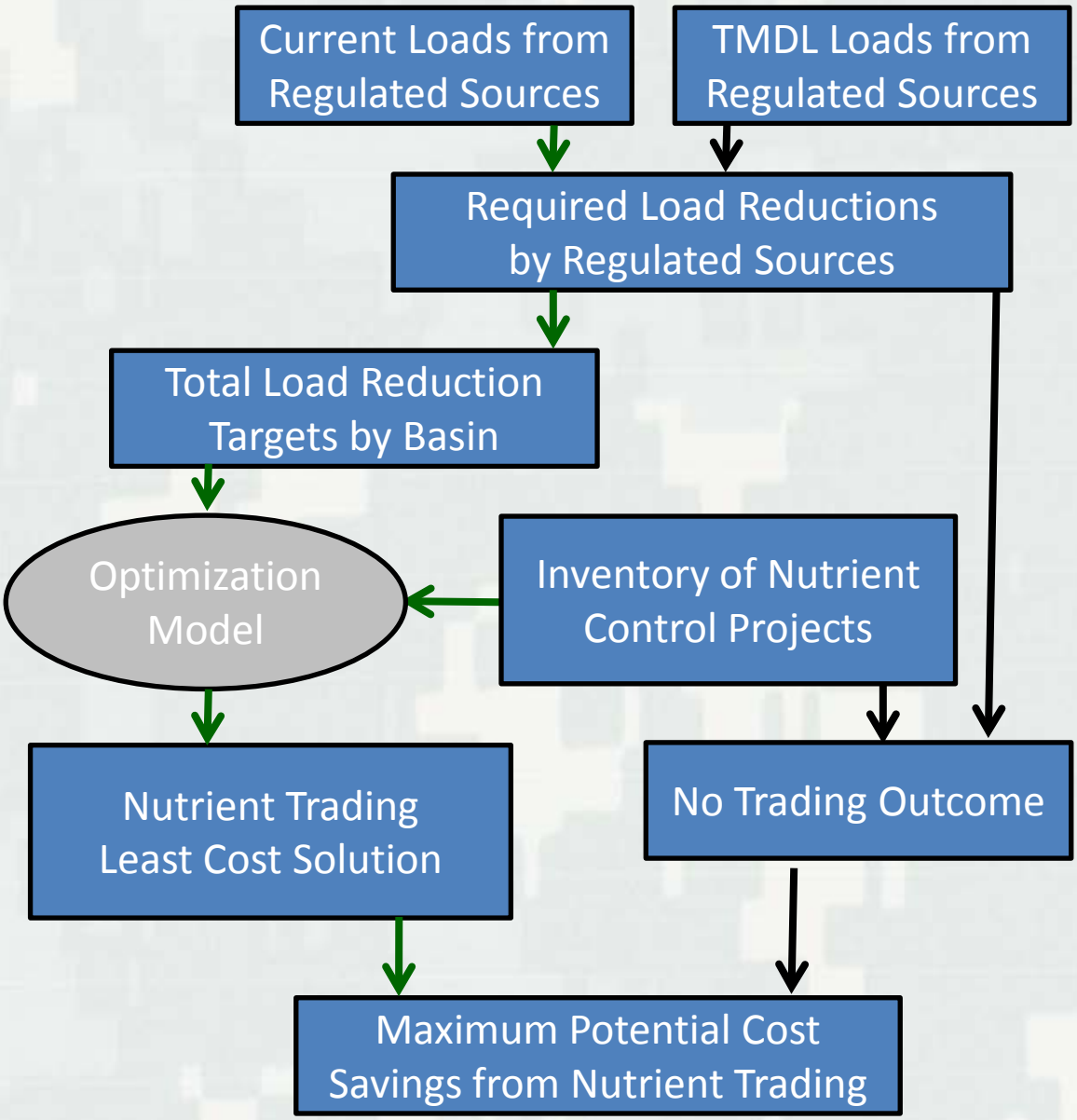


Hardened spillways

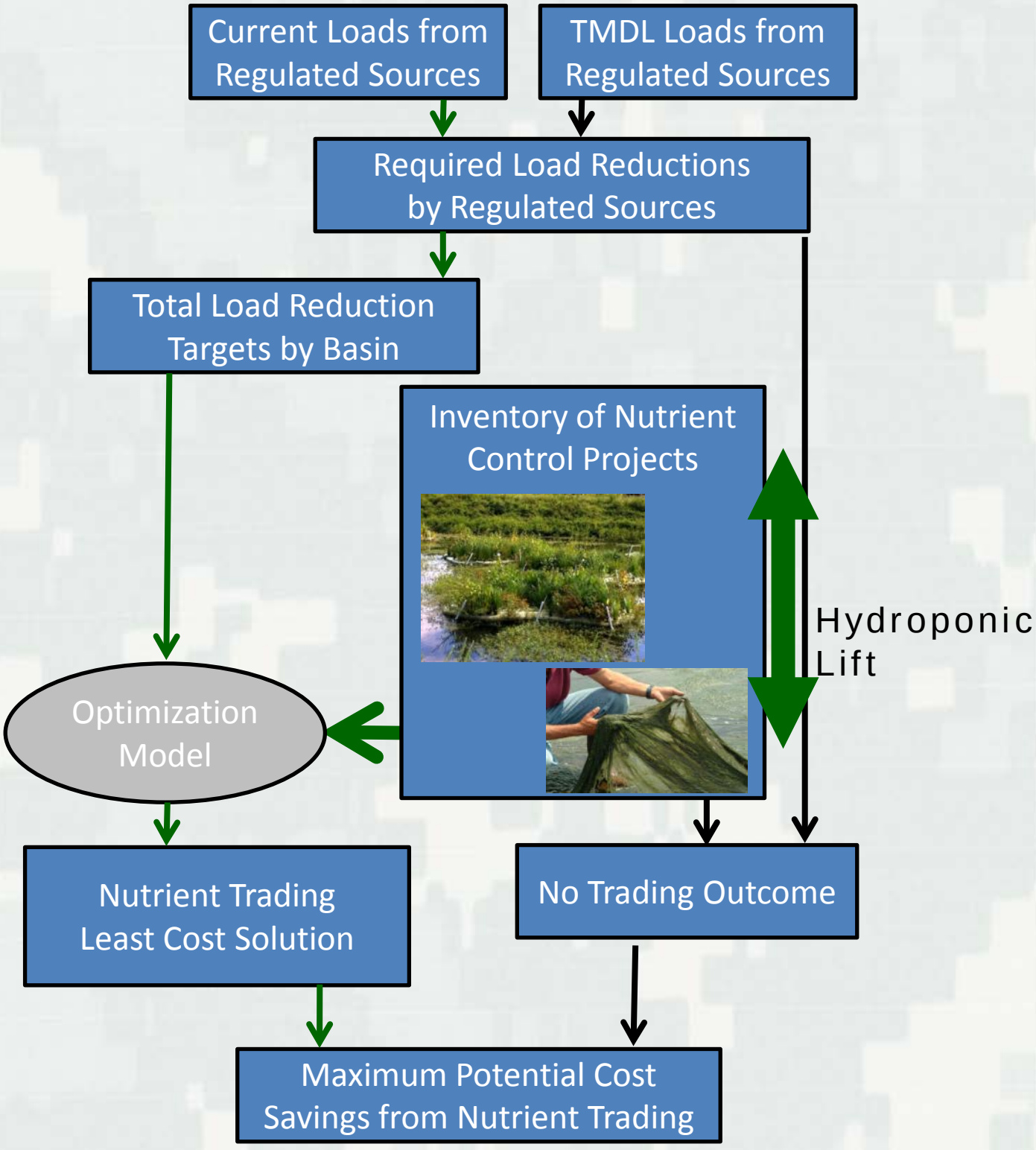
Elevated pumps

Nutrient Credit Trading

In January 13, 2003, Administrator Christine Todd Whitman announced the issuance of the final water quality trading policy by stating that, "**the most effective and economical way to reduce pollution is to provide incentives to encourage action by those who can achieve reductions easily and cost-effectively**". The policy supports the trading of nutrients and sediments within a watershed.



Hydroponic Enhancement to Inventory of Nutrient Control Projects (BMPs)



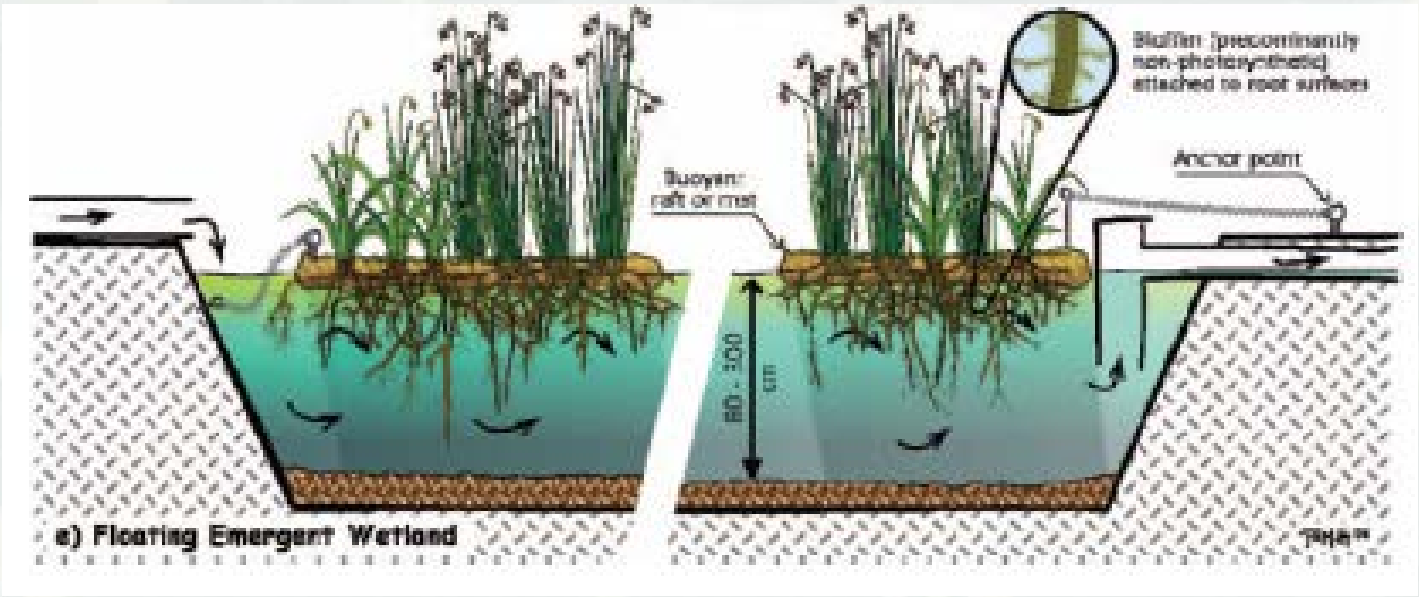
Hydroponic Nutrient Abatement

- **BioHaven® Floating Treatment Wetlands**
  - Bruce Kania - Floating Island International
  - “Concentrated Wetland Effect”

- **Algal Turf Scrubbers ®**
  - Dr. Walter Adey – Smithsonian Inst.
  - “Cleaning surface waters with solar energy while producing a biofuel”

Floating Treatment Wetlands

- "Concentrated Wetland Effect"
- Biofilm and periphyton reactors
- Accumulate and mineralize nutrients



Critical Reviews in Environmental Science and Technology, 42:2261–2310, 2012

ISSN: 1064-3389 print / 1547-6537 online
DOI: 10.1080/10643389.2011.574108

Constructed Wetlands With Floating Emergent Macrophytes: An Innovative Stormwater Treatment Technology

T. R. HEADLEY[1,2] and C. C. TANNER[3]
[1]*Helmholtz Centre for Environmental Research, Leipzig, Germany*
[2]*Wetlands Competence Center, BAUER Environment, Muscat, Sultanate of Oman (Current address)*
[3]*National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand*

Applications

- Waterscaping (beautification)
- Turbidity reduction
- Phosphorus reduction
- Ammonia reduction
- Nitrate reduction
- Fishery enhancement
- Nutrient cycle enhancement (periphyton)
- Algae control
- Odor control
- Bank stabilization & erosion control
- Wildlife, waterfowl & shorebird habitat
- Invasive submerged plant control

Algal Turf Scrubbers®

Algal Turf Scrubbing: Cleaning Surface Waters with Solar Energy while Producing a Biofuel

Author(s): Walter H. Adey, Patrick C. Kangas and Walter Mulbry

Source: BioScience, 61(6):434-441. 2011.

Published By: American Institute of Biological Sciences

The algal turf scrubber™ utilizes native algae that grow attached to a screen in a shallow, flowing water system.

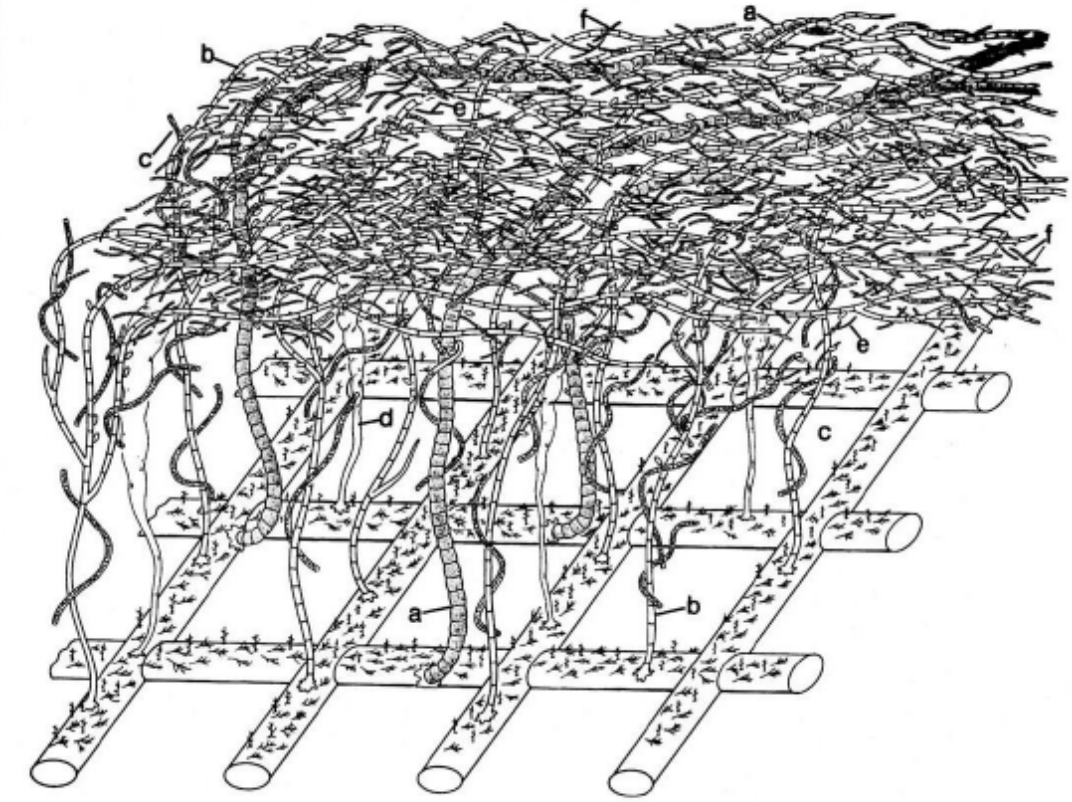


FIGURE 25.7 Schematic drawing of primary algal turf species growing on the ATS screen of the Florida Everglades study: (a) *Compsopogon coeruleus*, (b) *Cladophora crispata*, (c) *Spirogyra rivularis*, (d) *Enteromorpha microcca*, (e) *Eunotia pectinalis*, (f) *Melosira varians*. The very small branched alga attached directly to the screen is *Stigeoclonium tenue*, while the numerous small ovoid shapes in the algal canopy represent several species of small pennate diatoms, particularly *Amphora* and *Cocconeis* spp. Drawing by Alice Tangerini, Department of Botany, National Museum of Natural History. From Adey *et al.* (1993).

This technology contrasts with most algal growth systems that utilize suspended algae instead of attached algae. One advantage of the ATS is that attached algae are easier to harvest than suspended algae.

Biofuel Production

Omega 3s

Compost/Organic Fertilizer

Livestock Feed

Biohabitats HydroQual HAZEN AND SAWYER

Algal Turf Scrubbers Pilot

Description: An Algal Turf Scrubber (ATS) was constructed at the Rockaway WWTP. This technology will use algae to filter WWTP effluent for nutrient removal and as a source for biofuel.

Schedule: Sept. 2010

Estimated $387,000

Algae to Butanol in New York City

Sun

Carbohydrate Extraction

www.oilmillmachinery.com/

Protein Residue

(Fertilizer)

Algae

(renewable resource)

Contaminated Water

(sewage, estuaries)

Clean Water

http://home.wangjianshuo.com/archives/20030513_tahiti.htm

Biobutanol

CO_2

Existing Technology

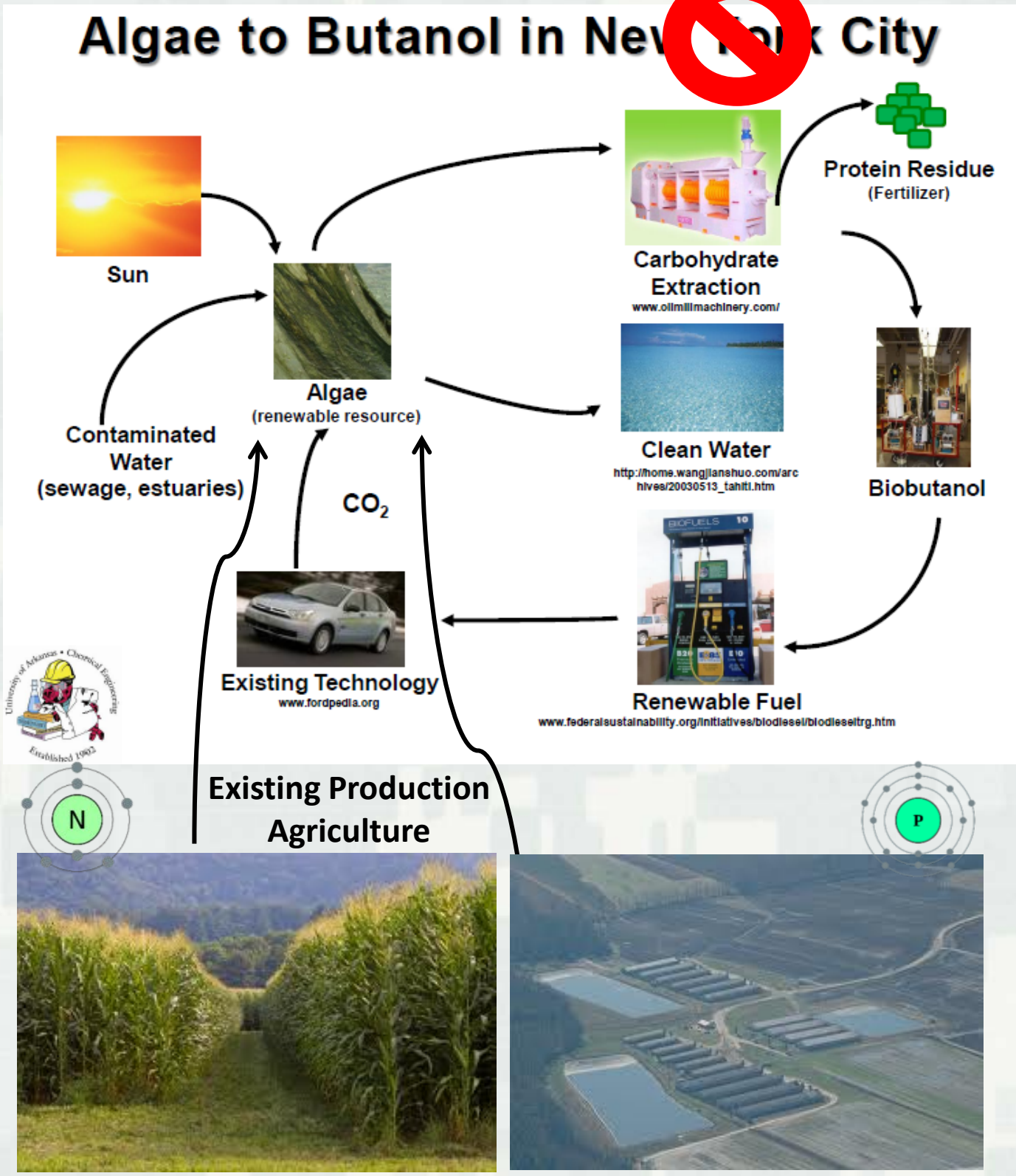
www.fordpedia.org

Renewable Fuel

www.federalsustainability.org/initiatives/biodiesel/biodieseltrg.htm

To date, land availability is the primary limiting factor to consider when evaluating the treatment potential of ATS at WWTPs with large discharges. However, the pilot ATS at the Rockaway WWTP will continue to evaluate the ability of algal turf scrubbers to assist in the removal of nitrogen and other pollutants.

the Corn Belt



UMRS Drainage Districts Overcome Algal Biomass Limitations Identified by the National Research Council

(October 2012)

The committee pointed out several high-level concerns for large-scale development of algal biofuel, including:

- the relatively large quantity of water required for algae cultivation;
- magnitude of nutrients, such as nitrogen, phosphorus, and CO_2, needed for cultivation;
- amount and location of land area necessary to contain the ponds that grow the algae; and
- uncertainties in greenhouse gas emissions over the production life cycle.

Missouri: North Fabius River

Using a Diverse Watershed Approach Reduces Sedimentation

Fabius River Delta

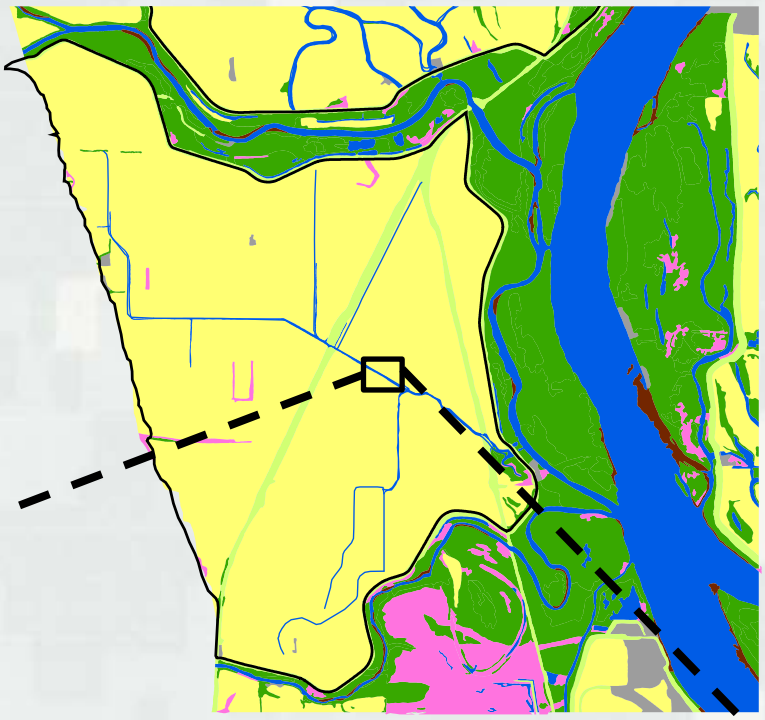
Contemporary Infrastructure

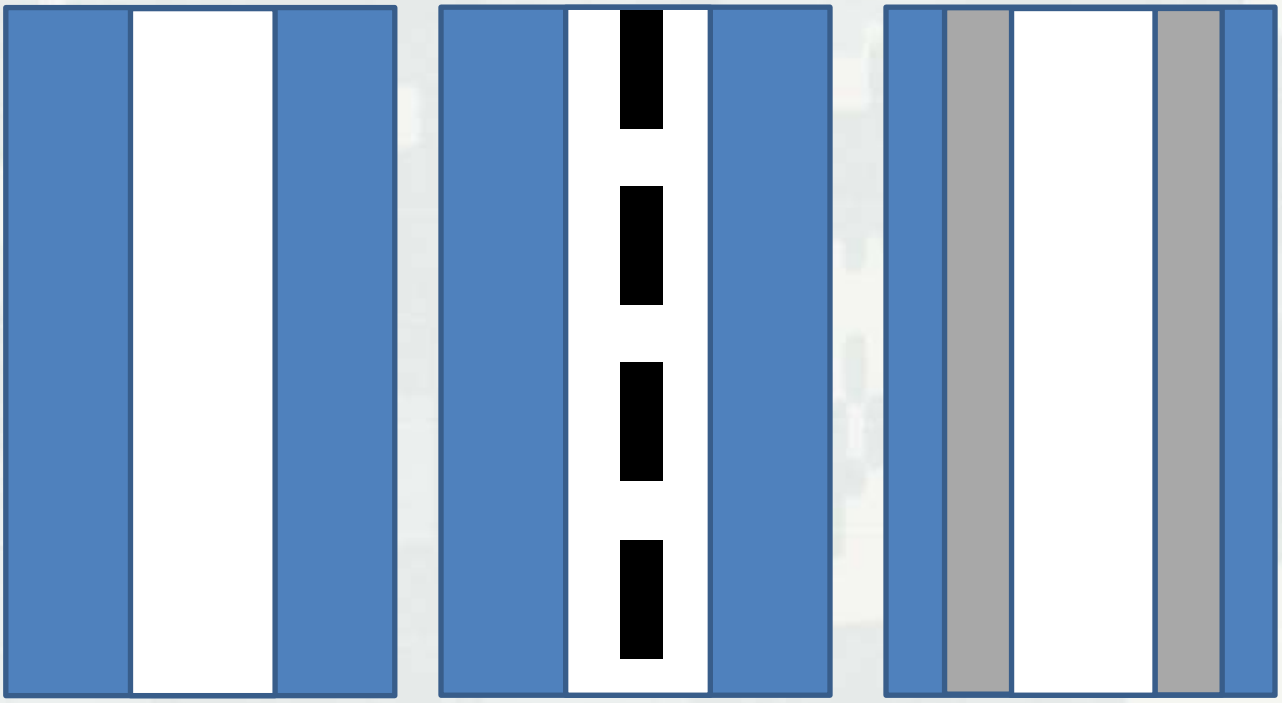
Union Twp DD
4700 ac.
4.7 mi. ditches

Fabius R DD
15,000 ac.
36.7 mi. ditches

Marion Co DD
4125 ac.
8.4 mi. ditches

Fabius River Delta
Alternative Future Conditions





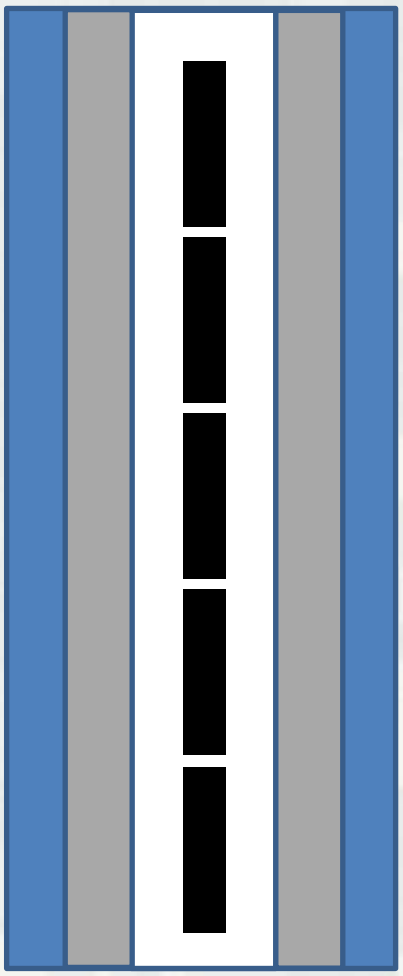
Open Ditches

Floating Islands

Lateral/In-line ATS Raceways

Integrated Systems

Crop-ATS-FTW-Aquaculture



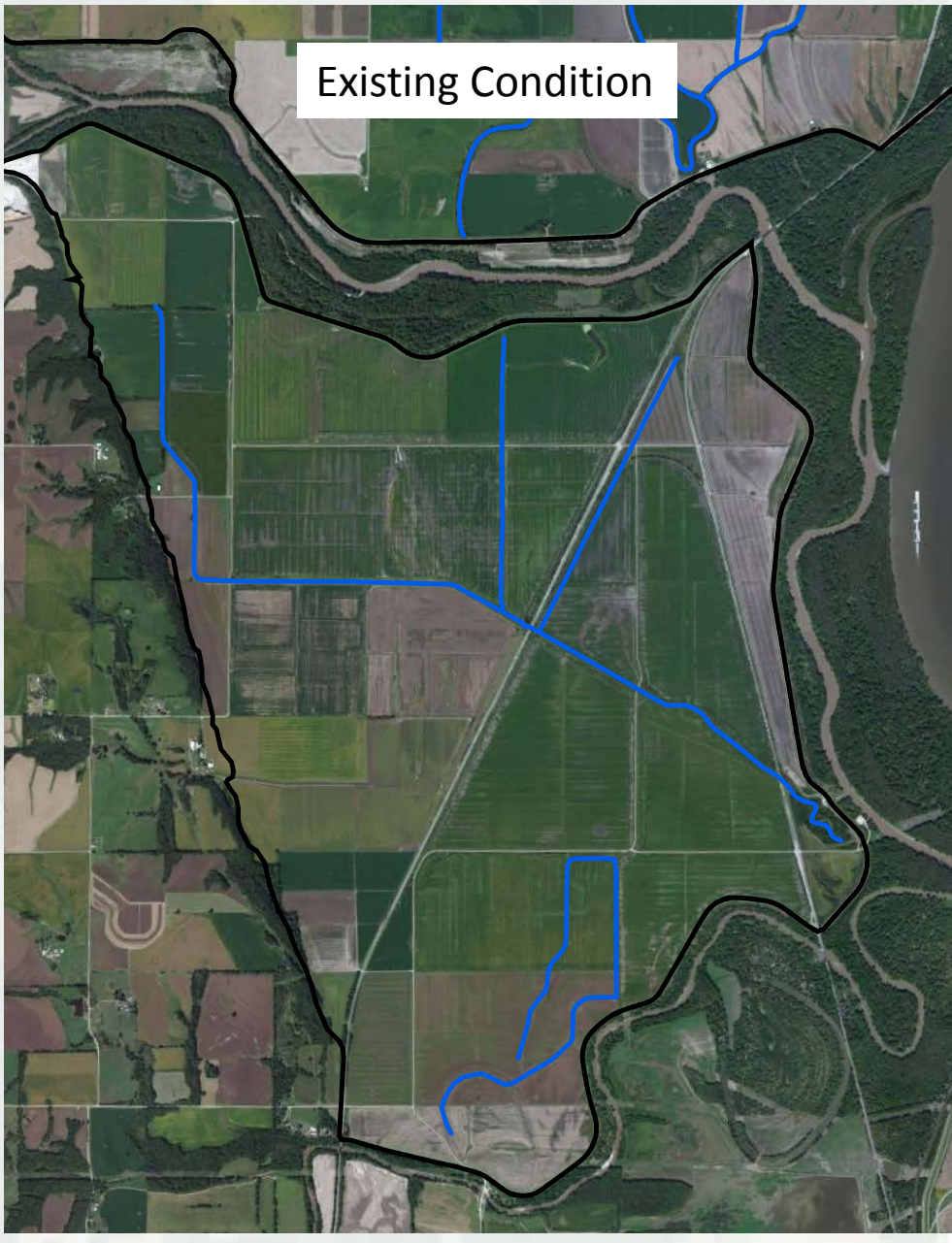
Conceptualizing Benefits & Ecosystem Services

Local TMDL: Interior Drainage

Ecosystem Service Checklist

✓Crops

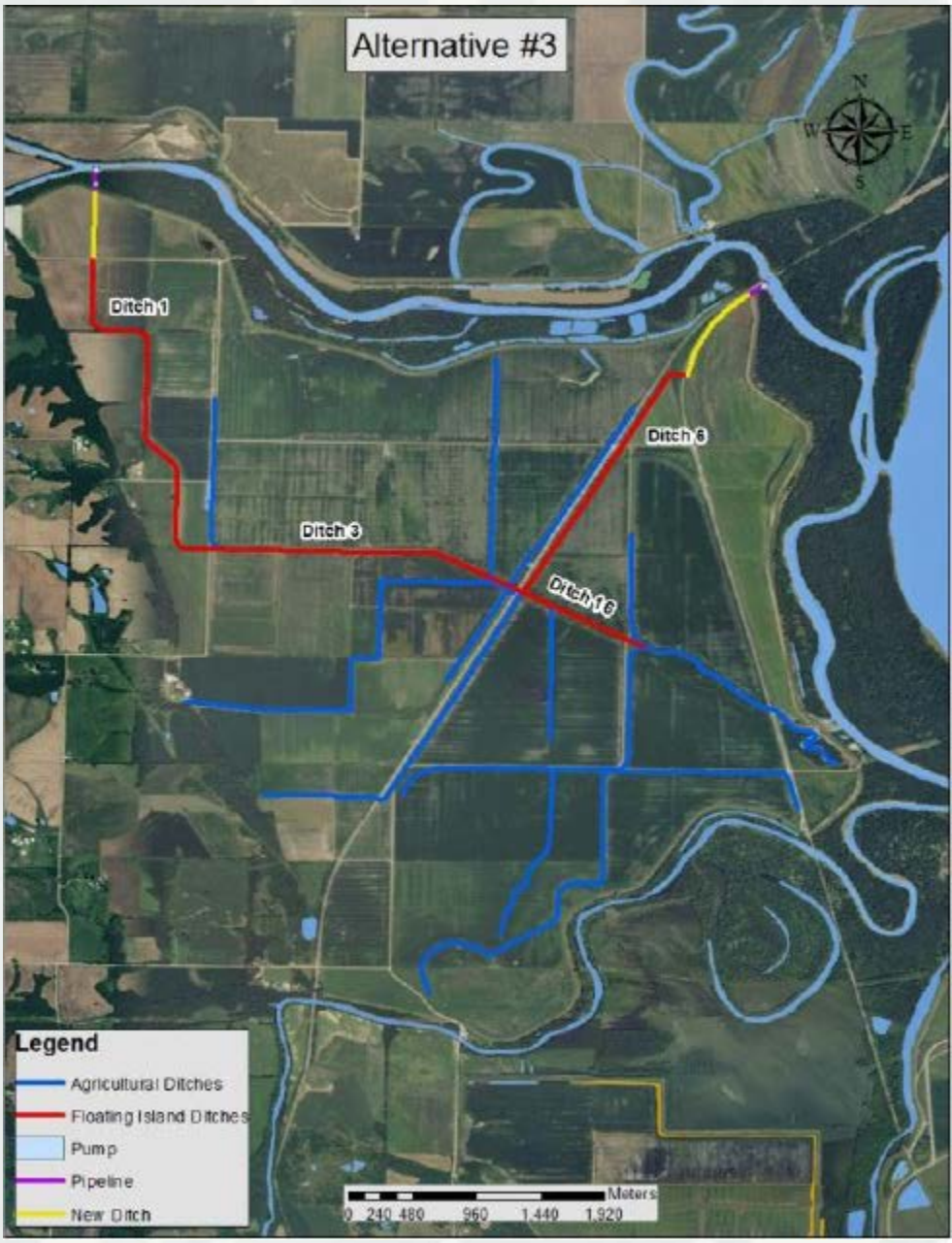
✓Adjacent watershed and internal TMDL



Watershed TMDL: Decant Water From Tributary and Mainstem:

Ecosystem Service Checklist

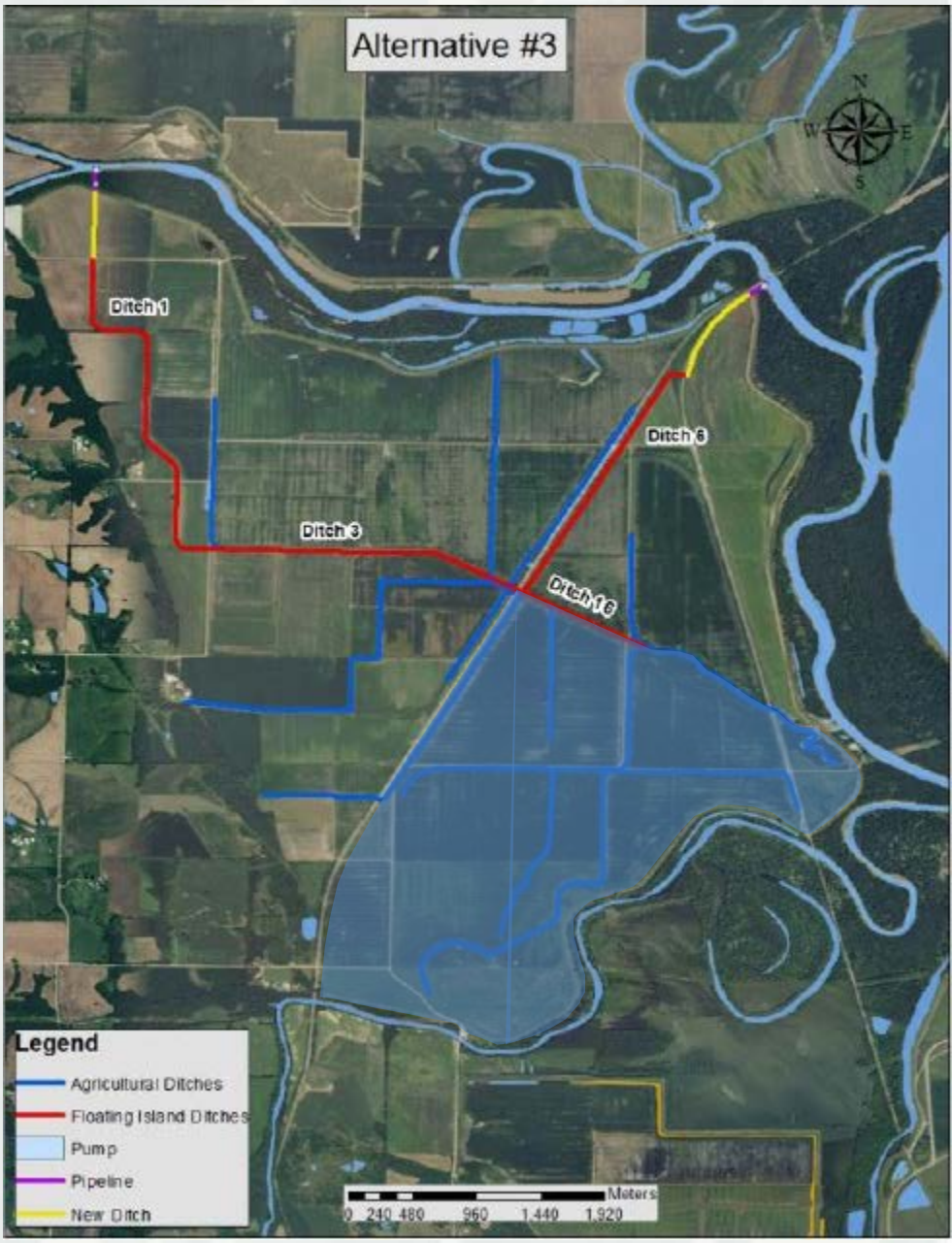
- ✓Crops
- ✓Interior TMDL
- ✓Intercept tributary runoff for high flow TMDL
- ✓Decant tributary or Mississippi River for low flow TMDL



Watershed TMDL & Habitat Concept: Restore Tributary and Decant Mainstem

Ecosystem Service Checklist

- ✓ Crops
- ✓ Interior TMDL
- ✓ Intercept tributary high flow TMDL
- ✓ Decant Mississippi River TMDL
- ✓ Native habitat
- ✓ Fishing and Hunting
- ✓ Feedstock



Managed Wetland or ATS farm

Hydroponic Nutrient Sequestration Accounting

Subwatershed Area

Subwatershed	Miles^2	Acres^2	km^2
North Fabius River	916	586,240	2,372
South Fabius River	620	396,800	1,606
North River	373	238,720	966

Loading Assumption*
Low (3kg/ha/yr)
Med (5kg/ha/yr)
High (10kg/ha/yr)

* Vache, Eilers, and Santelmann. 2002. Water quality modeling of alternative agricultural scenarios in the U.S. Corn Belt. JAWRA 38.

Hydroponic Substrate Requirement:

(High Loading Assumption; acres)

Subwatershed	N load (lb/yr) at 10 kg/ha/yr	Acres FTW	Acres ATS
North Fabius River	5,219,368	196	1,338
South Fabius River	3,532,760	133	906
North River	2,125,354	80	545

Implementation Considerations

Cost:

11.9 million ft^2 (410 acres) of Biohaven® FTWs @ <10ft^2$ = **$119 million**

Relative to:

- Water quality impairments
- Nutrient market revenue
- Conservation incentive programs
- Hunting leases
- Property value
- Other BMPs
- Etc…

As part of a sustainable and resilient plan that includes multiple ecosystem services

Conceptualizing the Value of Great River Floodplains: Illinois, Mississippi, and Missouri River Confluence Region

Jennifer Harrison-Cox,
Nora Wahlund

EARTH ECONOMICS

John Hoal
Derek Hoeferlin

Washington University in St. Louis

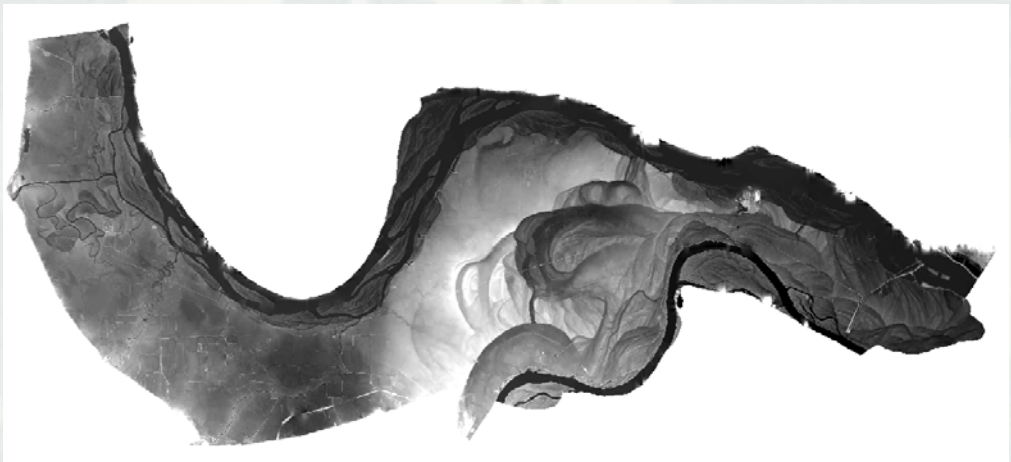
SAM FOX SCHOOL OF DESIGN & VISUAL ARTS

Dale Morris

Kingdom of the Netherlands
Royal Netherlands Embassy
Washington, DC.

Chuck Theiling

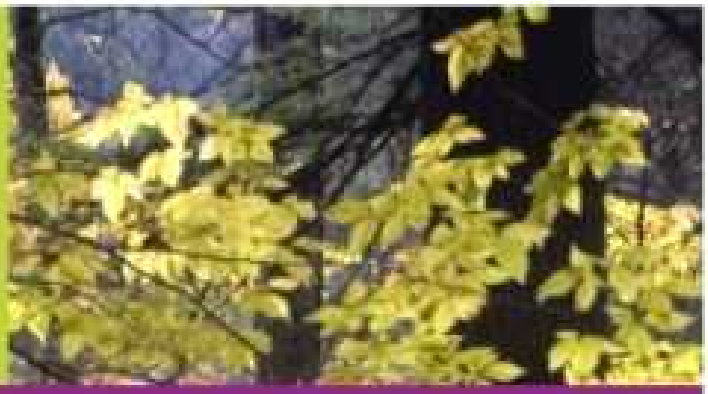
Columbia-American Bottoms



Workshop Objectives

- Learn about natural capital appraisal
- Learn how natural capital values have been used to shift investment
- Evaluate ecosystem service potential for alternative land use scenarios from Misi-Ziibi workshop
- Conduct rapid prototype modeling (Valuation Exercise)
- Identify gaps in valuation database

EARTH ECONOMICS



WHAT IS YOUR PLANET WORTH?

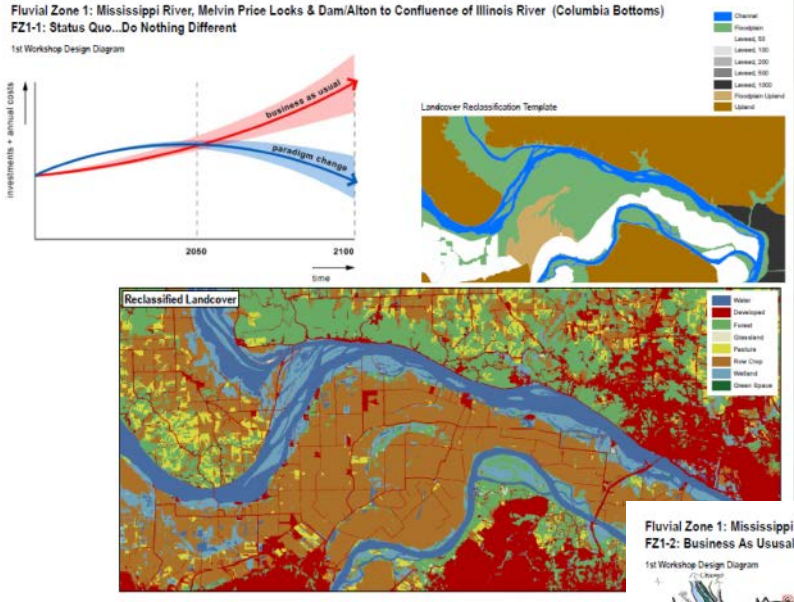
A Handbook for Understanding Natural Capital

By Allyson Schrier, Justine Bronfin, and Jennifer Harrison-Cox

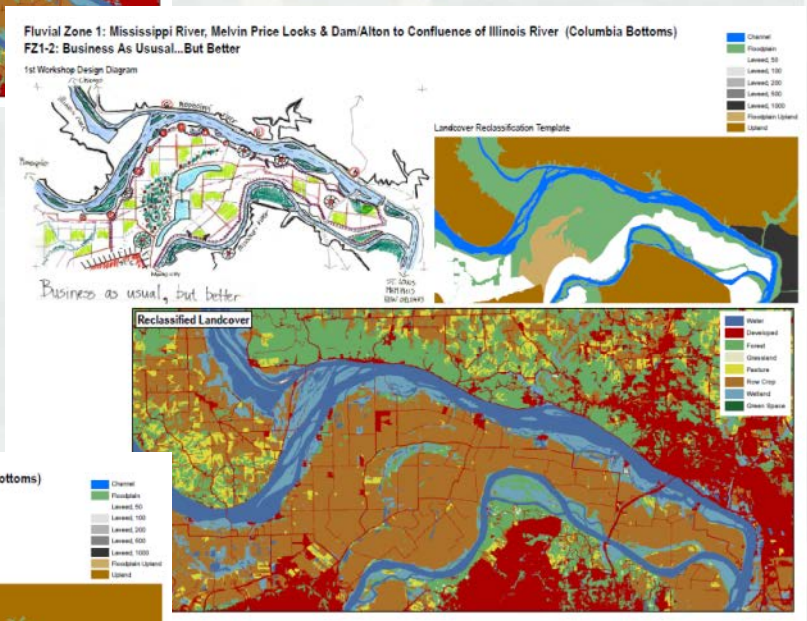
September 2013

Agricultural Zone

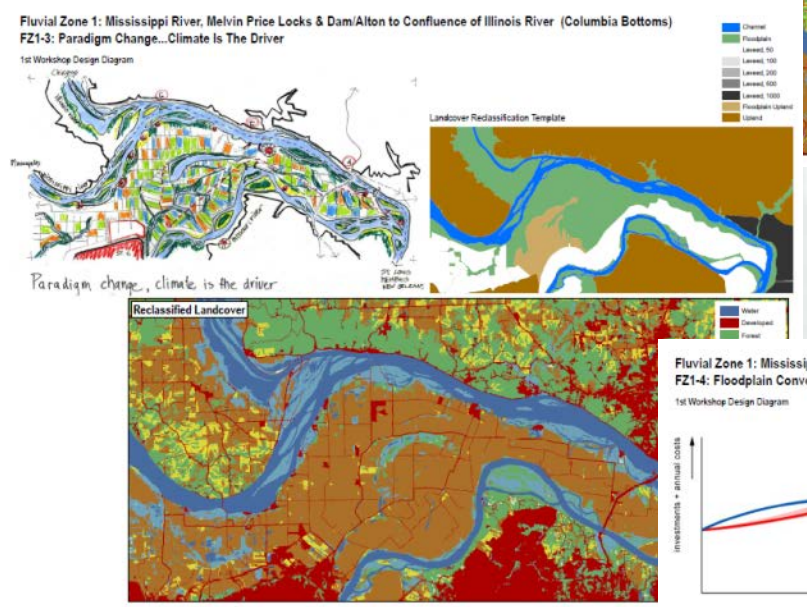
Business as Usual



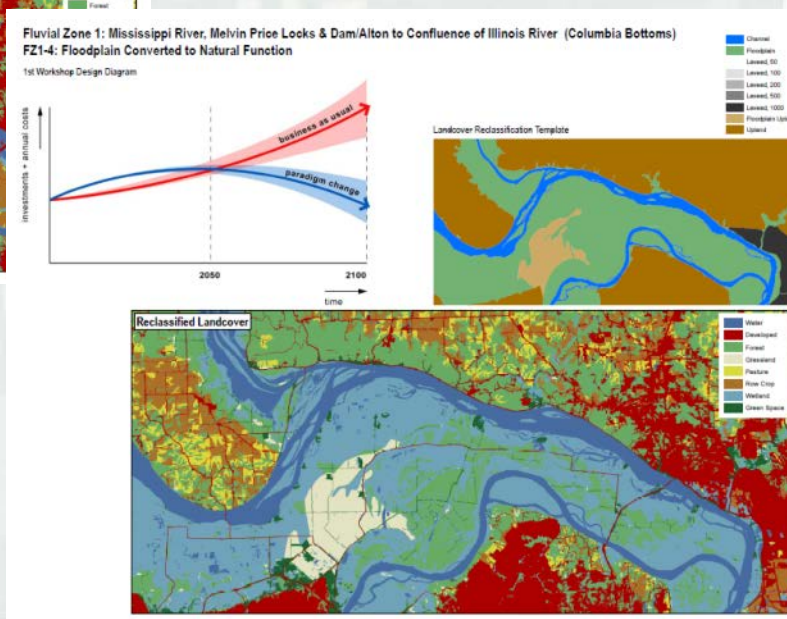
Business as Usual but Better



Business as Usual, Climate Drives the Future

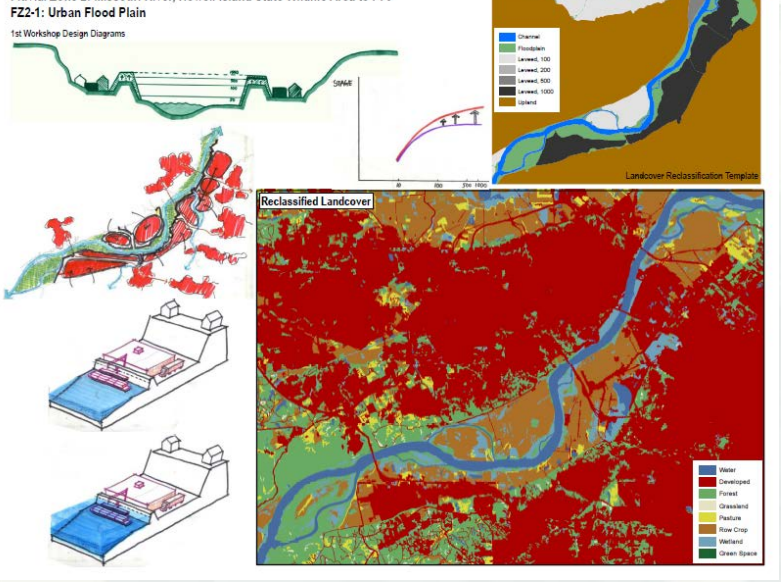


Natural Function

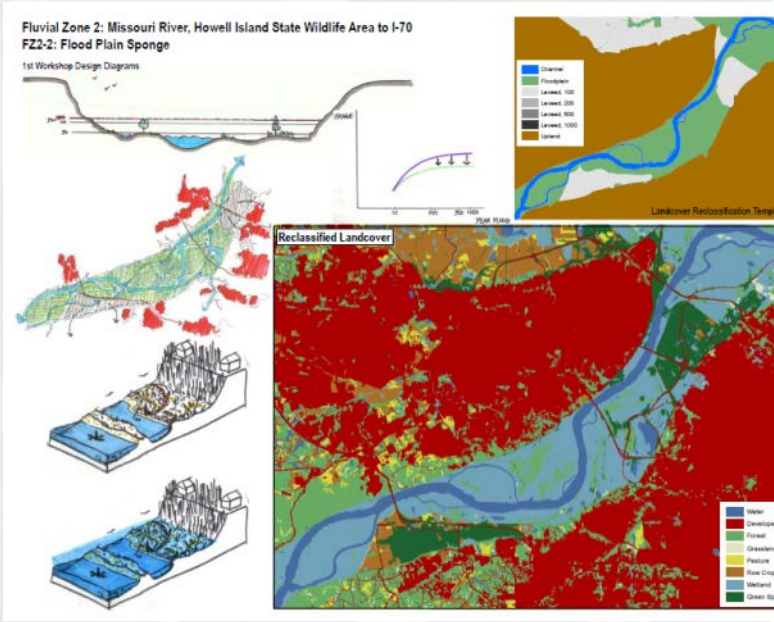


Suburban Zone

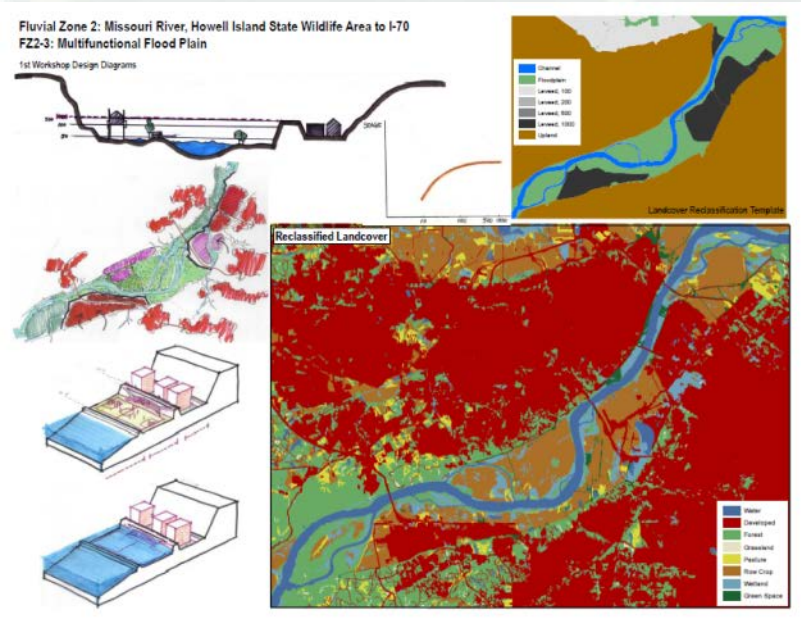
Urban Floodplain



Floodplain Sponge

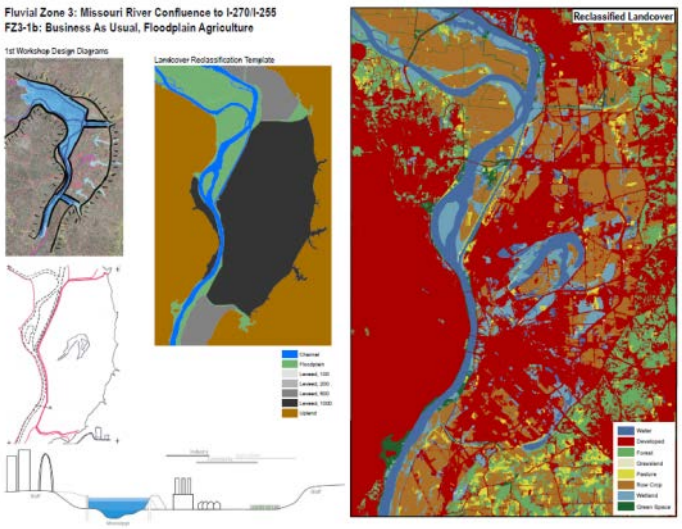


Multifunctional Floodplain

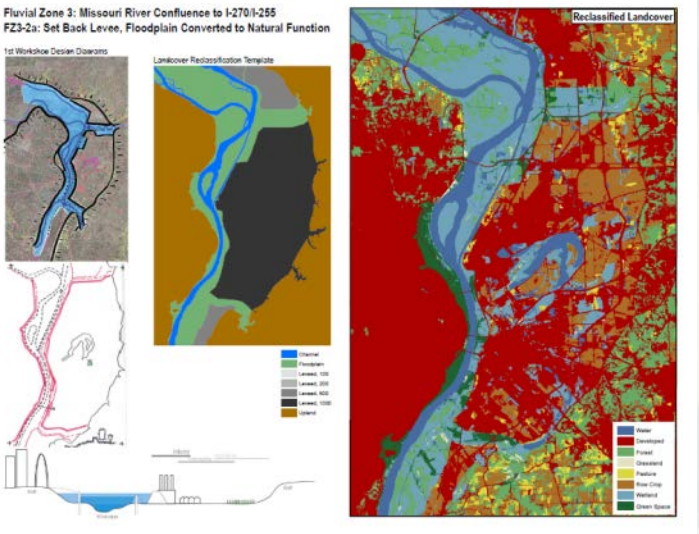


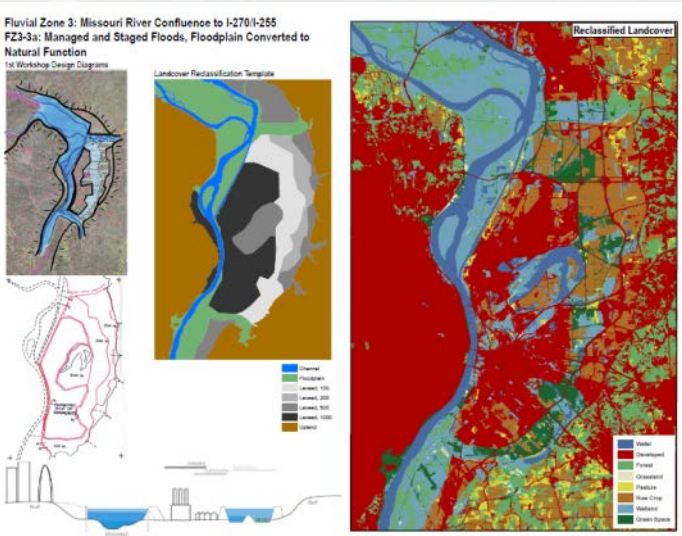
Urban Zone

Business as Usual

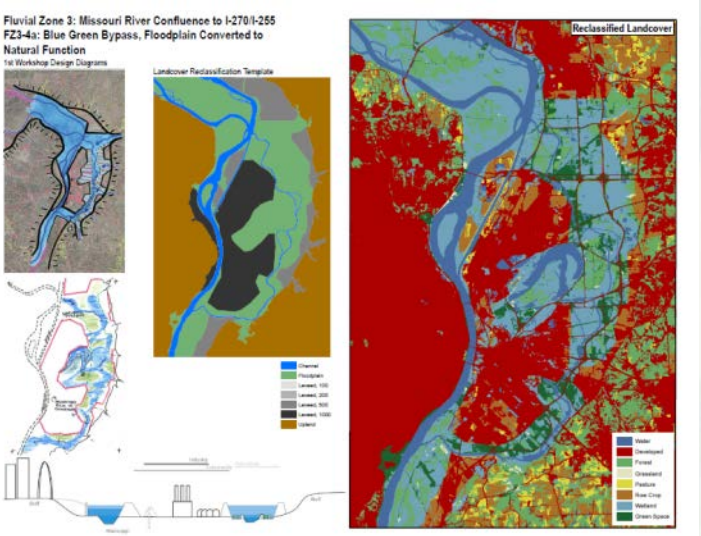


Set Back Levees, Natural Function Upstream



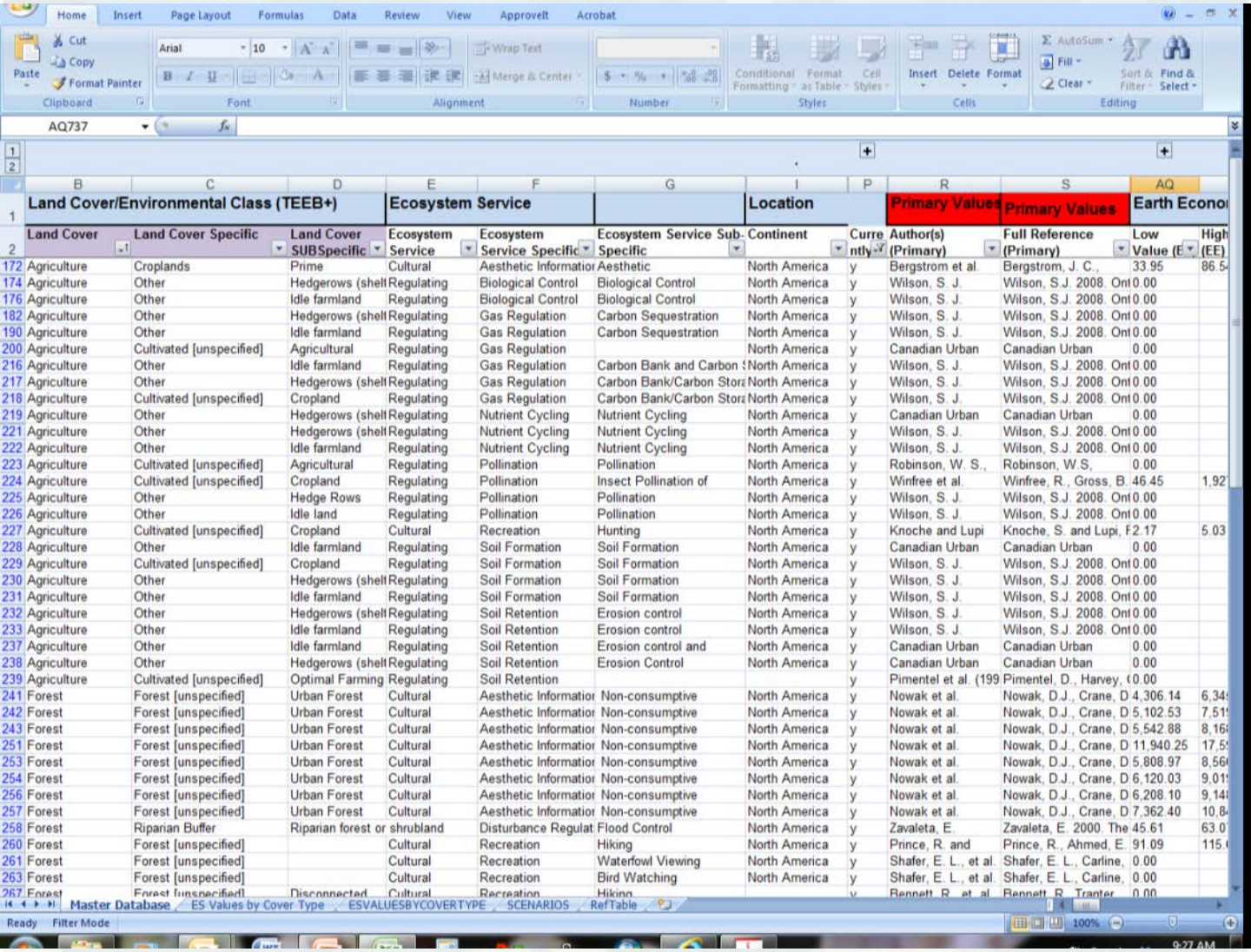


By-Pass Channel, Managed and Staged Floods



Blue-Green By-Pass, Natural Function

Ecosystem Services Valuation Bibliography



	B	C	D	E	F	G	I	P	R	S	AQ
1	Land Cover/Environmental Class (TEEB+)			Ecosystem Service			Location		Primary Values	Primary Values	Earth Econo
2	Land Cover	Land Cover Specific	Land Cover SUBSpecific	Ecosystem Service	Ecosystem Service Specific	Ecosystem Service Sub-Specific	Continent	Currently	Author(s) (Primary)	Full Reference (Primary)	Low Value (E	High (EE)
172	Agriculture	Croplands	Prime	Cultural	Aesthetic Information	Aesthetic	North America	y	Bergstrom et al.	Bergstrom, J. C.,	33.95	86.5
174	Agriculture	Other	Hedgerows (shelt	Regulating	Biological Control	Biological Control	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
176	Agriculture	Other	Idle farmland	Regulating	Biological Control	Biological Control	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
182	Agriculture	Other	Hedgerows (shelt	Regulating	Gas Regulation	Carbon Sequestration	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
190	Agriculture	Other	Idle farmland	Regulating	Gas Regulation	Carbon Sequestration	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
200	Agriculture	Cultivated [unspecified]	Agricultural	Regulating	Gas Regulation		North America	y	Canadian Urban	Canadian Urban	0.00	
216	Agriculture	Other	Idle farmland	Regulating	Gas Regulation	Carbon Bank and Carbon S	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
217	Agriculture	Other	Hedgerows (shelt	Regulating	Gas Regulation	Carbon Bank/Carbon Stora	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
218	Agriculture	Cultivated [unspecified]	Cropland	Regulating	Gas Regulation	Carbon Bank/Carbon Stora	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
219	Agriculture	Other	Hedgerows (shelt	Regulating	Nutrient Cycling	Nutrient Cycling	North America	y	Canadian Urban	Canadian Urban	0.00	
221	Agriculture	Other	Hedgerows (shelt	Regulating	Nutrient Cycling	Nutrient Cycling	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
222	Agriculture	Other	Idle farmland	Regulating	Nutrient Cycling	Nutrient Cycling	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
223	Agriculture	Cultivated [unspecified]	Agricultural	Regulating	Pollination	Pollination	North America	y	Robinson, W. S.,	Robinson, W.S,	0.00	
224	Agriculture	Cultivated [unspecified]	Cropland	Regulating	Pollination	Insect Pollination of	North America	y	Winfree et al.	Winfree, R., Gross, B.	46.45	1,92
225	Agriculture	Other	Hedge Rows	Regulating	Pollination	Pollination	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
226	Agriculture	Other	Idle land	Regulating	Pollination	Pollination	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
227	Agriculture	Cultivated [unspecified]	Cropland	Cultural	Recreation	Hunting	North America	y	Knoche and Lupi	Knoche, S. and Lupi, F	2.17	5.03
228	Agriculture	Other	Idle farmland	Regulating	Soil Formation	Soil Formation	North America	y	Canadian Urban	Canadian Urban	0.00	
229	Agriculture	Cultivated [unspecified]	Cropland	Regulating	Soil Formation	Soil Formation	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
230	Agriculture	Other	Hedgerows (shelt	Regulating	Soil Formation	Soil Formation	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
231	Agriculture	Other	Idle farmland	Regulating	Soil Formation	Soil Formation	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
232	Agriculture	Other	Hedgerows (shelt	Regulating	Soil Retention	Erosion control	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
233	Agriculture	Other	Idle farmland	Regulating	Soil Retention	Erosion control	North America	y	Wilson, S. J.	Wilson, S.J. 2008. Ont	0.00	
237	Agriculture	Other	Idle farmland	Regulating	Soil Retention	Erosion control and	North America	y	Canadian Urban	Canadian Urban	0.00	
238	Agriculture	Other	Hedgerows (shelt	Regulating	Soil Retention	Erosion Control	North America	y	Canadian Urban	Canadian Urban	0.00	
239	Agriculture	Cultivated [unspecified]	Optimal Farming	Regulating	Soil Retention			y	Pimentel et al. (199	Pimentel, D., Harvey, (	0.00	
241	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	4,306.14	6,34
242	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	5,102.53	7,51
243	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	5,542.88	8,16
251	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	11,940.25	17,5
253	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	5,808.97	8,56
254	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	6,120.03	9,01
256	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	6,208.10	9,14
257	Forest	Forest [unspecified]	Urban Forest	Cultural	Aesthetic Information	Non-consumptive	North America	y	Nowak et al.	Nowak, D.J., Crane, D	7,362.40	10.8
258	Forest	Riparian Buffer	Riparian forest or	shrubland	Disturbance Regulat	Flood Control	North America	y	Zavaleta, E.	Zavaleta, E. 2000. The	45.61	63.0
260	Forest	Forest [unspecified]		Cultural	Recreation	Hiking	North America	y	Prince, R. and	Prince, R., Ahmed, E.	91.09	115.
261	Forest	Forest [unspecified]		Cultural	Recreation	Waterfowl Viewing	North America	y	Shafer, E. L., et al.	Shafer, E. L., Carline,	0.00	
263	Forest	Forest [unspecified]		Cultural	Recreation	Bird Watching	North America	y	Shafer, E. L., et al.	Shafer, E. L., Carline,	0.00	
267	Forest	Forest [unspecified]	Disconnected	Cultural	Recreation	Hiking		y	Bennett, R., et al.	Bennett, R., Tranter,	0.00	

Master Database | ES Values by Cover Type | ESVALUESBYCOVERTYPE | SCENARIOS | RefTable

Ready | Filter Mode | 100%

Ecosystem Services Valuation Database

Annual, Per-Acre Ecosystem Service Values by Land Cover Type | **FZ #1 Agricultural Land Use & Pooled River**

Ecosystem Service	Agriculture		Forest		Wetland		Grassland		Green Space		River	
	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/acre/year)	High Value ($/acre/year)
Aesthetic	34	87	4306	17596	45	1420			348	23059	30	832
Biological Contr	17	17										
Climate Regulation							274	274	46	56		
Cultural and Artistic												
Disturbance Regulation			46	63	156	7754			90	127		
Food Production	524	694			350	350						
Gas Regulation	11	126			74	516	11	166	31	170		
Genetic Resources												
Habitat and Biodiversity					167	1723						
Medicinal Resources												
Nursery												
Nutrient Regula	10	24										
Ornamental Resources												
Pollination	13	1928					420	420				
Raw Materials												
Recreation	2	5	91	561	44	12754					433	23871
Science and Education			438	438								
Soil Formation	3	6										
Soil Retention	2	130					7	7				
Spiritual and Historic												
Waste Treatment			282	283	221	11550						
Water Regulation									141	432		
Water Supply					11	22901					642	642
TOTAL	**$ 616**	**$ 3,016**	**$ 5,163**	**$ 18,942**	**$ 1,068**	**$ 58,967**	**$ 712**	**$ 867**	**$ 656**	**$ 23,844**	**$ 1,105**	**$ 25,346**

Ecosystem Services Valuation Scenario Spreadsheets

FZ1_1: Status Quo...Do Nothing Different

Land Cover Class	Area (acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Agriculture		616	2,322	-	-
Forest		5,163	18,942	-	-
Wetlands		1,068	58,967	-	-
Grassland		712	867	-	-
Green Space		656	23,844	-	-
River		1,105	25,346	-	-
Pasture		427	427	-	-
Developed Land		Not Valued	Not Valued	Not Valued	Not Valued
TOTAL	**0**			**$ -**	**$ -**

FZ1_2: Business as Usual...But Better

Land Cover Class	Area (acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Agriculture		616	2,322	-	-
Forest		5,163	18,942	-	-
Wetlands		1,068	58,967	-	-
Grassland		712	867	-	-
Green Space		656	23,844	-	-
River		1,105	25,346	-	-
Pasture		427	427	-	-
Developed Land		Not Valued	Not Valued	Not Valued	Not Valued
TOTAL	**0**			**$ -**	**$ -**

FZ1_3: Paradigm Change...Climate is the Driver

Land Cover Class	Area (acres)	Low Value ($/acre/year)	High Value ($/acre/year)	Low Value ($/year)	High Value ($/year)
Agriculture		616	2,322	-	-
Forest		5,163	18,942	-	-
Wetlands		1,068	58,967	-	-
Grassland		712	867	-	-
Green Space		656	23,844	-	-
River		1,105	25,346	-	-
Pasture		427	427	-	-
Developed Land		Not Valued	Not Valued	Not Valued	Not Valued
TOTAL	**0**			**$ -**	**$ -**

Ecosystem Services Valuation Database Report

Land Cover	Ecosystem Service Sp	Author(s) (Primary)	Full Reference (Primary)	Minimum (do not change	Maximum (do not change
Agriculture	Aesthetic Information	Bergstrom et al.	Bergstrom, J. C., Dillmar	33.94937613	86.54059718
	Biological Control	Wilson, S. J.	Wilson, S.J. 2008. Ontar	17.26503833	17.26503833
	Gas Regulation	Canadian Urban Institute.	Canadian Urban Institute.	99.13998064	99.13998064
		Wilson, S. J.	Wilson, S.J. 2008. Ontar	126.0200997	126.0200997
				10.83451131	10.83451131
				120.0361349	120.0361349
				124.1364616	124.1364616
	Nutrient Cycling	Canadian Urban Institute.	Canadian Urban Institute.	23.50741809	23.50741809
		Wilson, S. J.	Wilson, S.J. 2008. Ontar	9.858898592	9.858898592
	Pollination	Robinson, W. S., et al.	Robinson, W.S, Nowogrc	13.03638186	13.03638186
		Wilson, S. J.	Wilson, S.J. 2008. Ontar	420.2040255	420.2040255
		Winfree et al.	Winfree, R., Gross, B., K	46.44980964	1927.560073
	Recreation	Knoche and Lupi	Knoche, S. and Lupi, F.	2.169772349	5.028766503
	Soil Formation	Canadian Urban Institute.	Canadian Urban Institute.	6.132369937	6.132369937
		Wilson, S. J.	Wilson, S.J. 2008. Ontar	2.54233619	2.54233619
	Soil Retention	Canadian Urban Institute.	Canadian Urban Institute.	6.132369937	6.132369937
		Pimentel et al. (1995)	Pimentel, D., Harvey, C.,	129.8139745	129.8139745
		Wilson, S. J.	Wilson, S.J. 2008. Ontar	2.349354427	2.349354427
Forest	Aesthetic Information	Nowak et al.	Nowak, D.J., Crane, D.E.	5102.526405	7519.512501
				4306.135023	6345.88322
				6208.104937	9148.786353
				11940.24903	17596.15643
				6120.033519	9018.996682
				5542.884015	8168.460592
				7362.404074	10849.85853
				5808.972384	8560.590793
	Disturbance Regulation	Zavaleta, E.	Zavaleta, E. 2000. The E	45.61279321	63.06623693
	Recreation	Bennett, R., et. al.	Bennett, R., Tranter, R.,	191.8760296	191.8760296
		Prince, R. and Ahmed, E.	Prince, R., Ahmed, E. 19	91.09380694	115.6904608
		Shafer, E. L., et al.	Shafer, E. L., Carline, R.	560.5817195	560.5817195
				101.1389807	101.1389807
	Science and Education	Shafer, E. L., et al.	Shafer, E. L., Carline, R.	438.4291445	438.4291445
	Waste Treatment	Zhongwei, L.	Zhongwei, L. 2006. Wate	283.3062189	283.3062189
				282.1303448	282.1303448

UMRS Planning is Compartmentalized by Design:

- Upper Mississippi River-Illinois River System Navigation Feasibility Study – 2004
- Ecosystem component added in 2000
- UMR Comprehensive Plan (Flood Protection) – 2006
- Three major watershed studies, 1,000's (?) of small watershed studies
- Environmental Management Program (since 1986)

We Need to Get Out of the Box!

Cross-Cutting IWRM Strategies

- Risk Informed Decision Making and Communication
- Systems Approach
- State-of-the-Art Technology
- Adaptive Management
- Collaboration and Partnering
- Innovative Financing

UMRS Floodplain Adaptation Benefits

- Managed Flood risk
- Nutrient Abatement (Reduced Gulf hypoxia)
- Increased Food and fiber
- Innovative Revenue Sources
- R&D Opportunities
- Domestic Fuel (corn, cellulose, butanol)
- National Security (Navy & Air Force fuel)
- Climate Change Mitigation