Quantifying Potential Floodplain Restoration Benefits in the Upper Mississippi River Basin, USA

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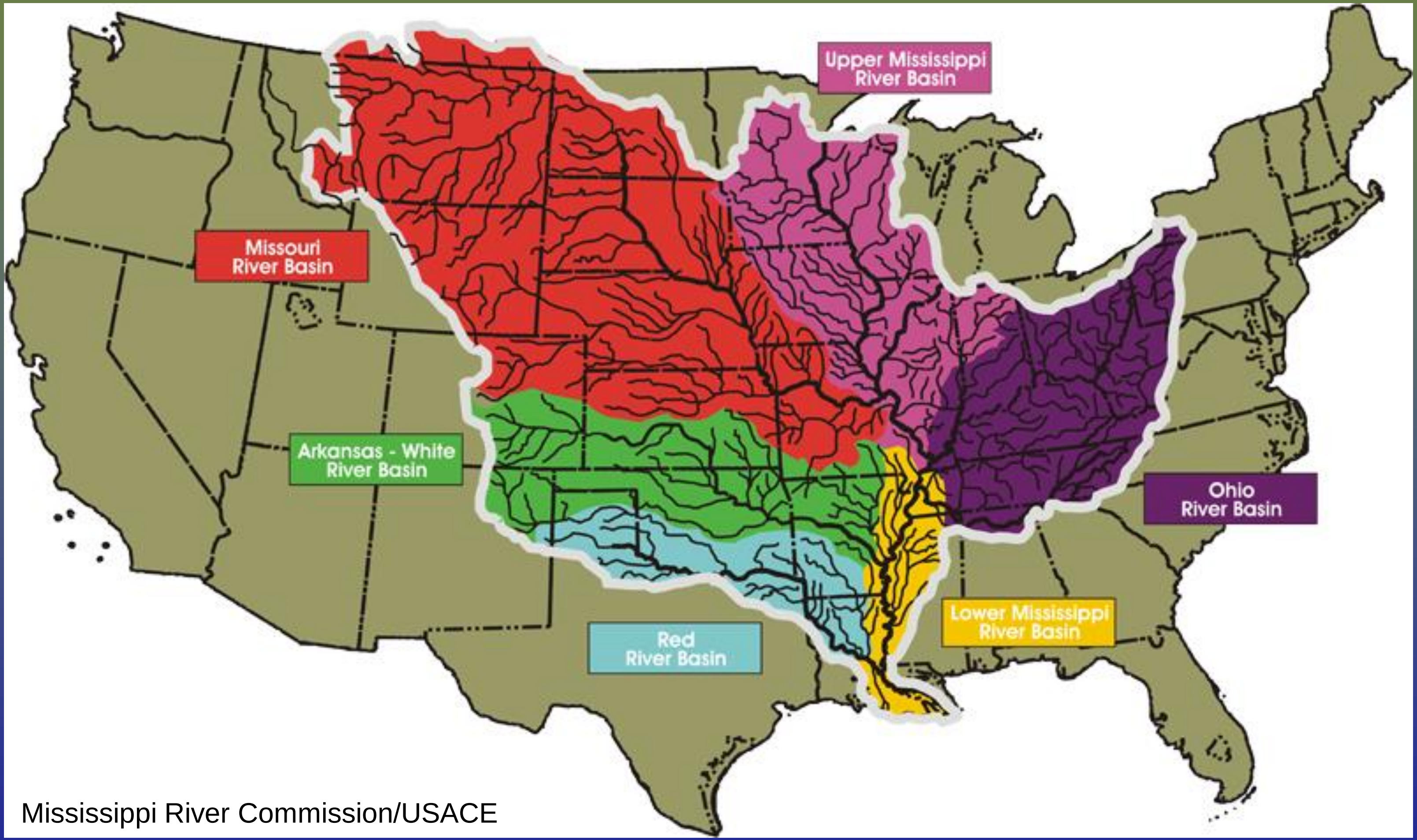

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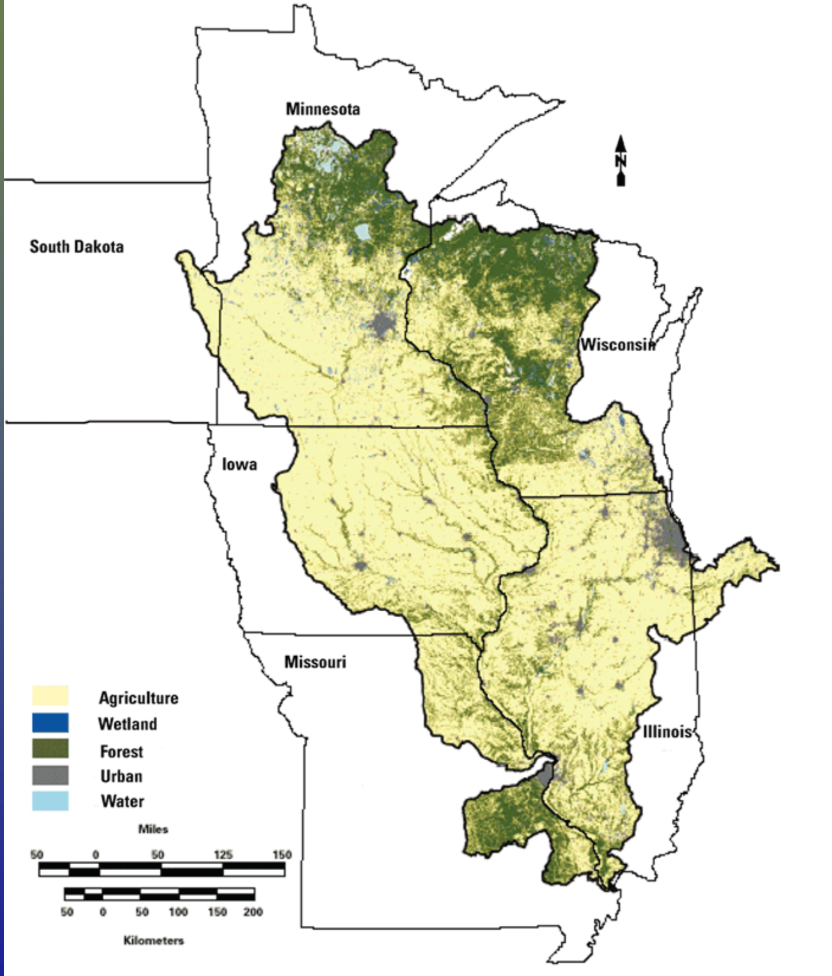
Upper Mississippi Watershed



- Portions of eight states
- 190,000 mi^2
- Floods driven by rainfall and/ or snowmelt
- Generally low gradient, wide flat floodplains

American Rivers UMRB Focus

- Develop strategies to remove barriers to protecting and restoring natural floodplain function
- Policy recommendations for developing incentives and removing barriers
- Technical analysis on floodplain benefits
- Set the groundwork for implementing projects
- Increase outreach on alternatives to structural floodplain control

Levee Removal/Setback – Multiple Benefits

- Sediment Trapping

Levee Removal/Setback – Multiple Benefits

- Nutrient Transformation

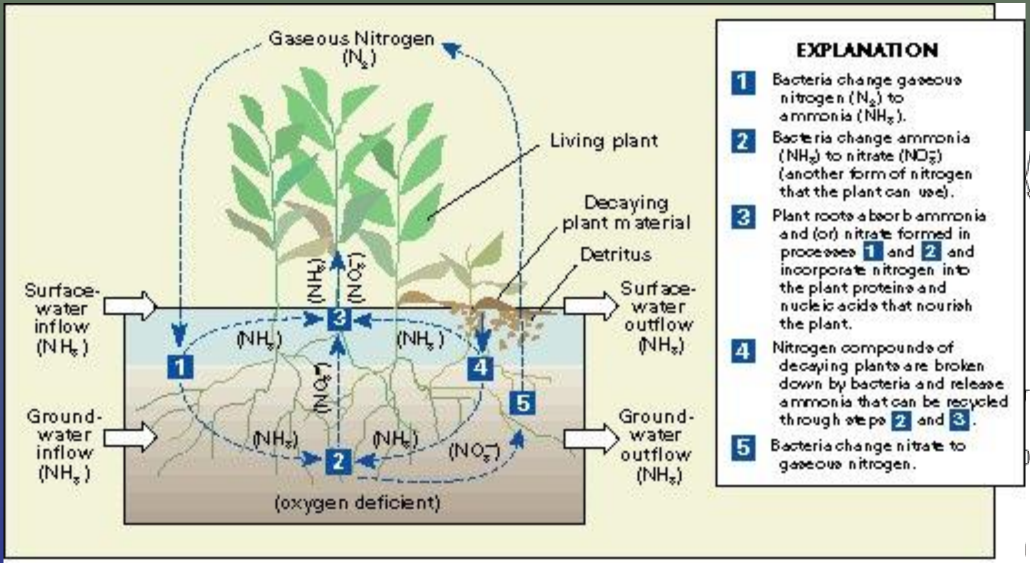
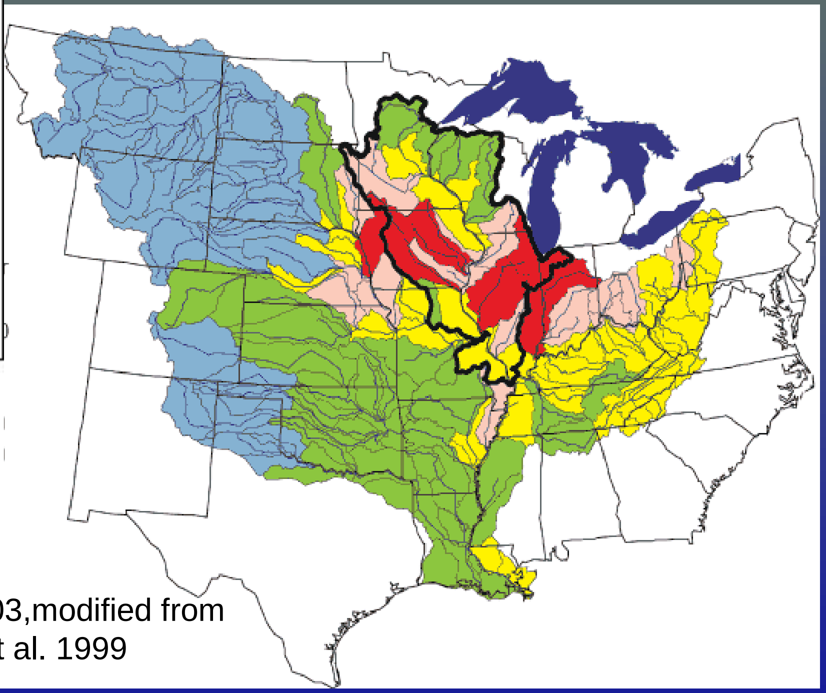


Figure 26. Simplified diagram of the nitrogen cycle in a wetland.

USGS WSP 2425



USGS 2003,modified from Goolsby et al. 1999

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Levee Removal/Setback – Multiple Benefits

- Habitat

Levee Removal/Setback

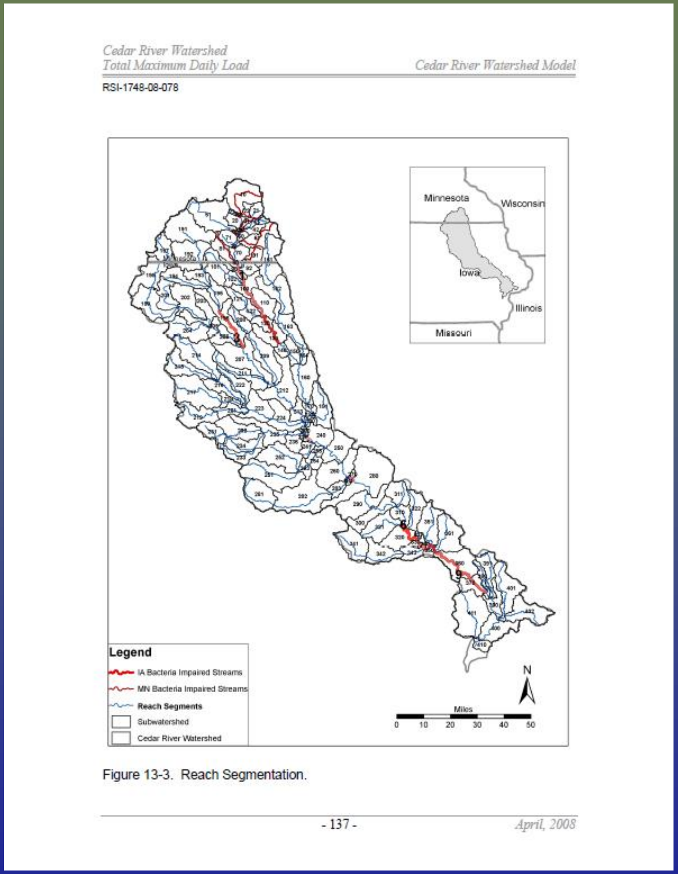
- Focus on flood risk reduction:
  - Provide floodplain volume
    - Floodplain active for more frequent events
    - Number of factors relevant to storage benefits:
      - Volume
      - Location
      - Hydrograph characteristics
      - Elevation/Time when storage is engaged
  - In some cases, improves hydraulics (reduced constriction)

Motivation

- American Rivers was looking for a concept-level method to quantify flood reduction benefits of restoring floodplain volume (removing levees) in Upper Mississippi River Basin
  - Local proponents can determine what are reasonable expectations of level of benefits and/or level of effort necessary to meet expectations

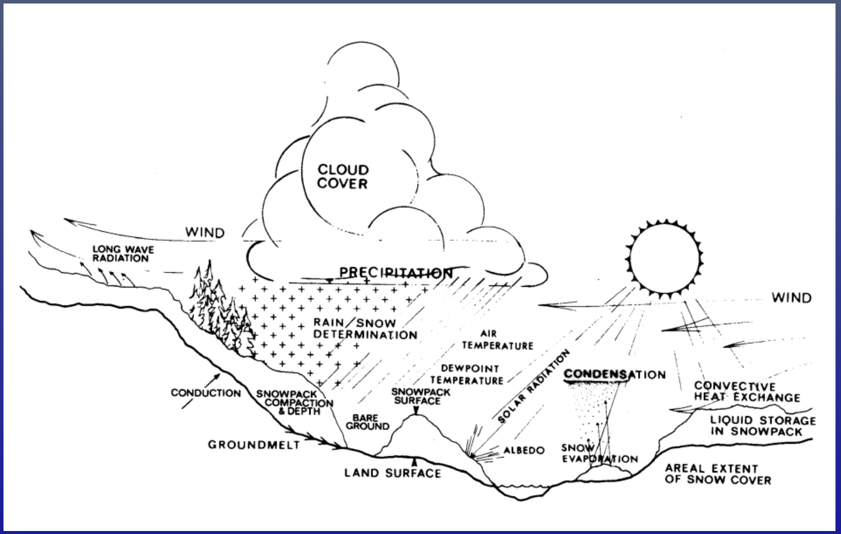
Modeling

- HSPF v. 12 – BASINS
- Existing Data
  - Levee databases
  - USGS topo or LIDAR
  - Hydrography
  - USGS Gage Records



HSPF

- Continuous simulation of hydrologic and water quality processes
- Uses meteorological input records to generate synthetic watershed output (e.g. streamflow) over extended time periods (e.g. years or decades)



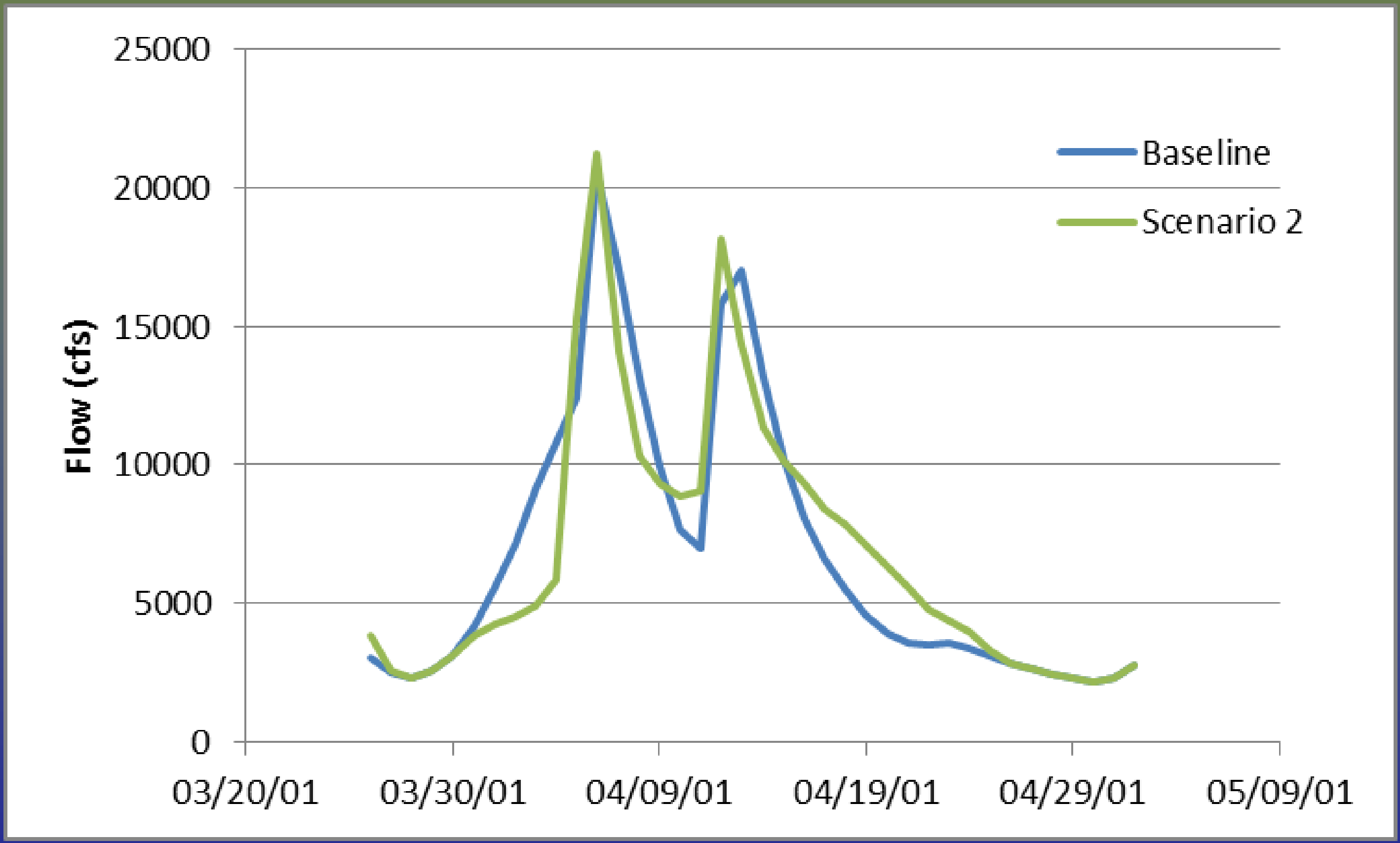
Modeling

- Looked at three different watersheds (MRBI focus)
  - Spoon River, IL
  - Middle Minnesota River, MN
  - Cedar River, IA
- Watersheds identified had existing HSPF models developed and calibrated by others (for TMDLs or other purposes)
- Did not focus on mainstem Mississippi or Illinois Rivers

Methodology

- Run the model, develop "baseline hydrographs" throughout watershed
- Add representation of storage areas to model
- Rerun model, look at hydrograph changes

Mean Daily Flow at Janesville



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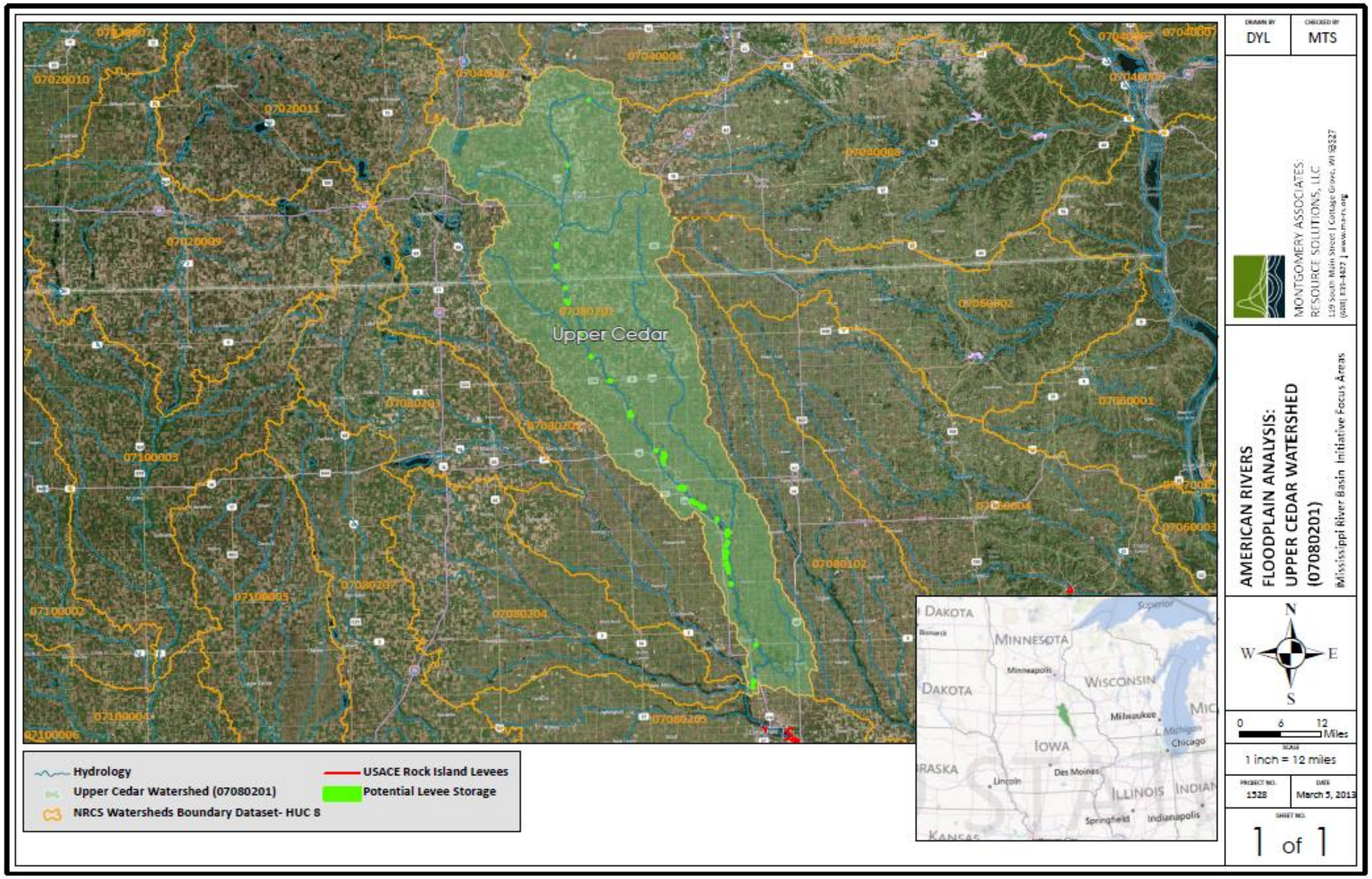
Restoration Scenarios

- Using aerial photography and USGS topos identified 29 "potential" sites
- Delineated areas using Arc GIS
- Assumed levee heights
  - (along Upper Cedar River = 4.5 ft)
- Compiled "potential" volume by reach

Conceptual Scenario



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Results

- For flood study, used annual peak flow analysis
- Relevant factors –
  - Volume storage vs. stream flow
  - Location of storage vs. benefit observed
  - Elevation of restored floodplain

Weighted Storage Volume Ratio

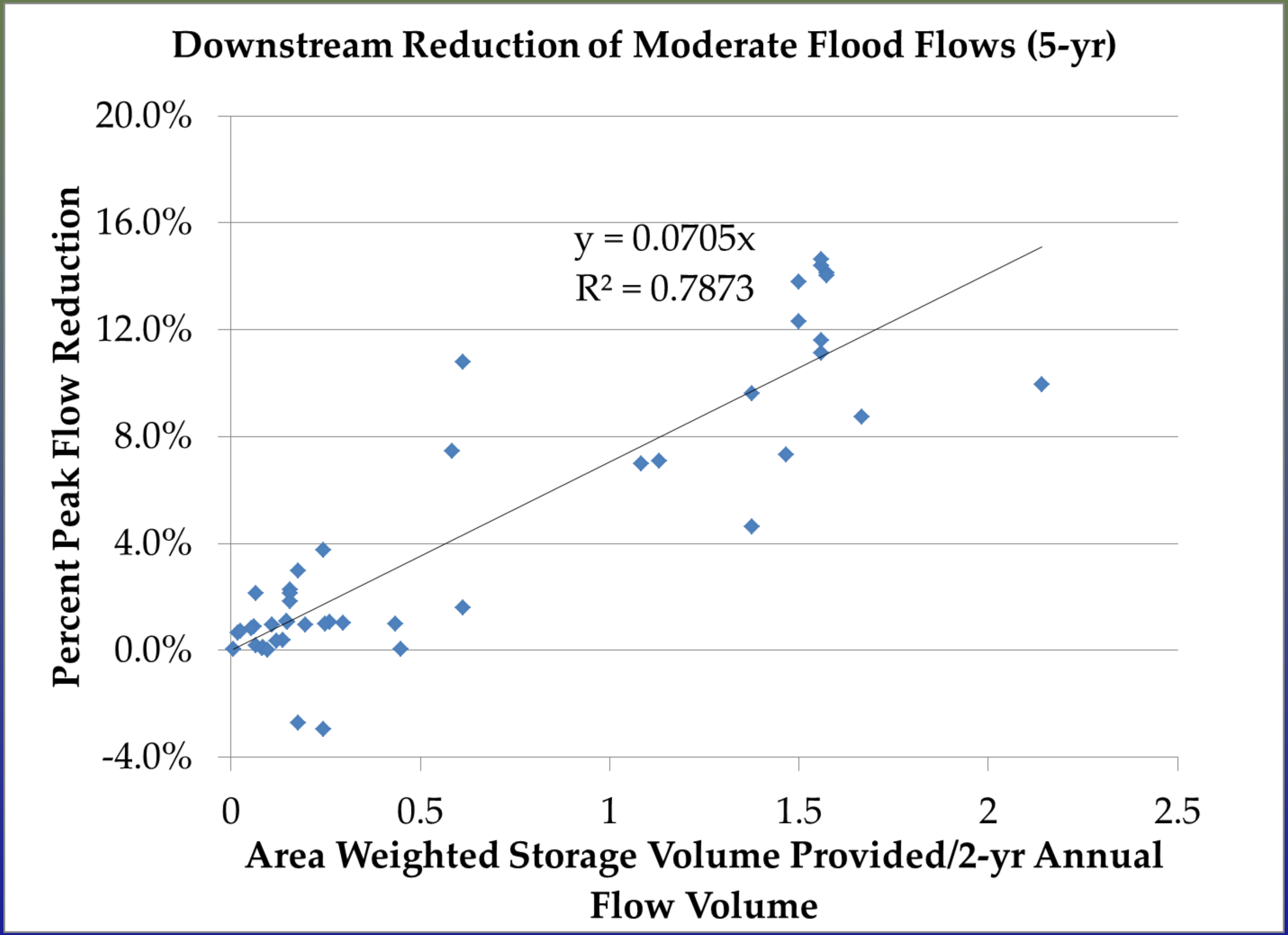
WSR =

Ratio of Drainage Areas (Restored site/Site of benefits)

x

Volume Ratio (Restored floodplain/2-year, 24-hour streamflow volume)

Results – All Three UMRB Watersheds



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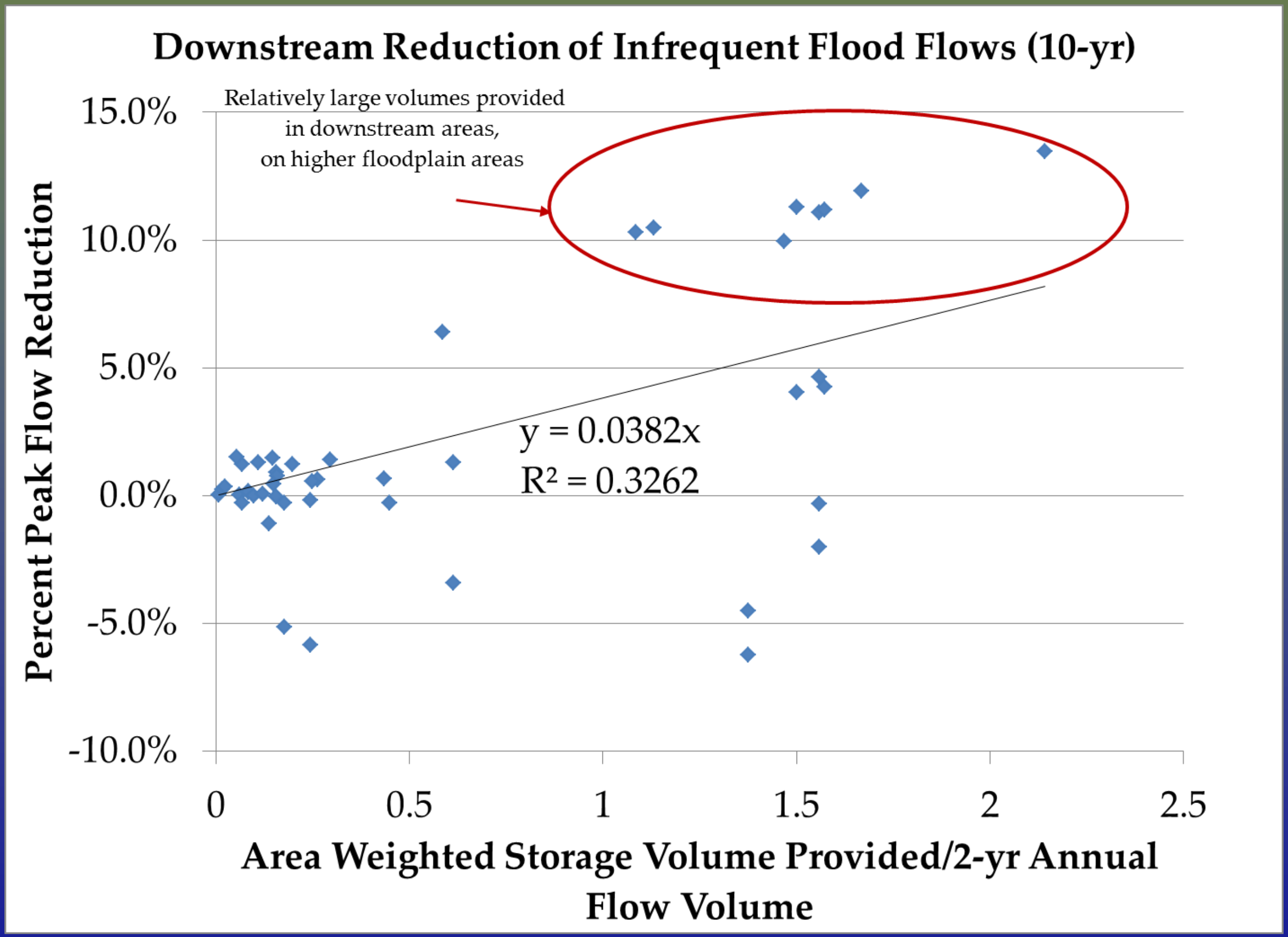
Results – All Three UMRB Watersheds



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Results

- Benefits primarily for small to moderate events (<10 year recurrence), with some exceptions
- Minimum restored subbasin area ~1-2% to see flood reduction benefits
- Seem to be generally applicable in investigated watersheds

Planning-Level Analysis

- Calculate the WSR for the project and benefit location
- Decision tree for benefits based on:
  - Elevation relative to 2-yr floodplain
  - Level of channelization vs. meander belts
- Percent reduction for moderate (2-10 yr) floods =

  7.1 x WSR

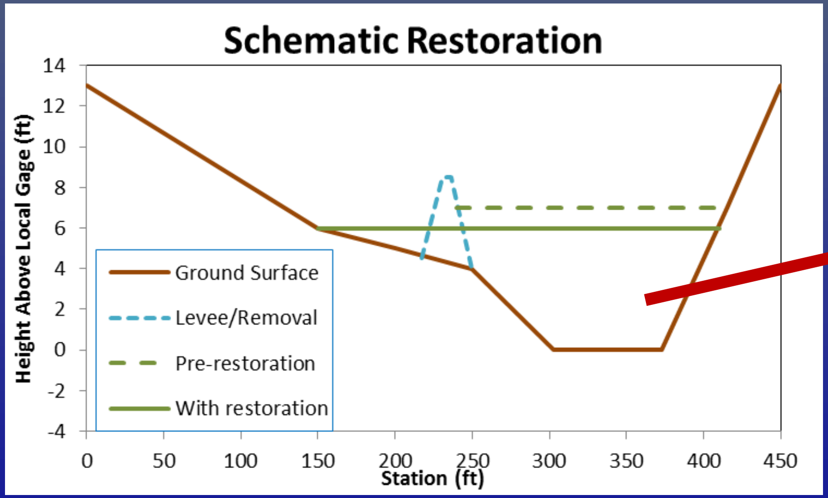
General Method to Analyze Potential Restoration Benefits

- Identify continuous model of watershed
- Formulate restoration goals in terms of
  - Stage/depth
  - Duration
  - Temperature
  - Time of Year
  - Other?
- Develop a range of conceptual restoration scenarios
- Revise and run model reflecting scenarios
- Investigate weighted ratios to explain observed watershed responses to restoration

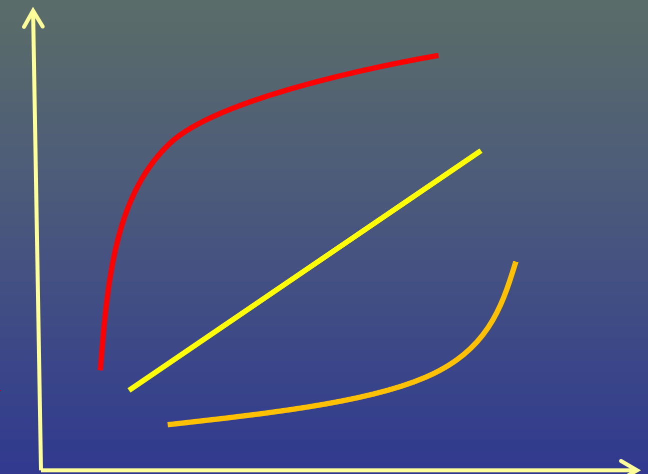
Nutrient Transformation Analysis

Example:

How much area is experiencing extended inundation and how can restoration increase that area?

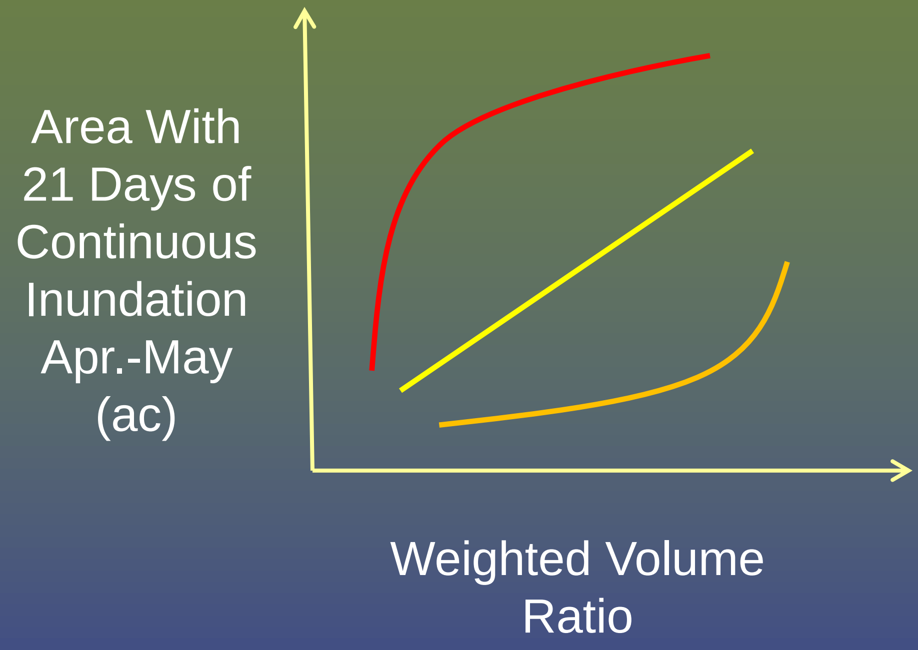


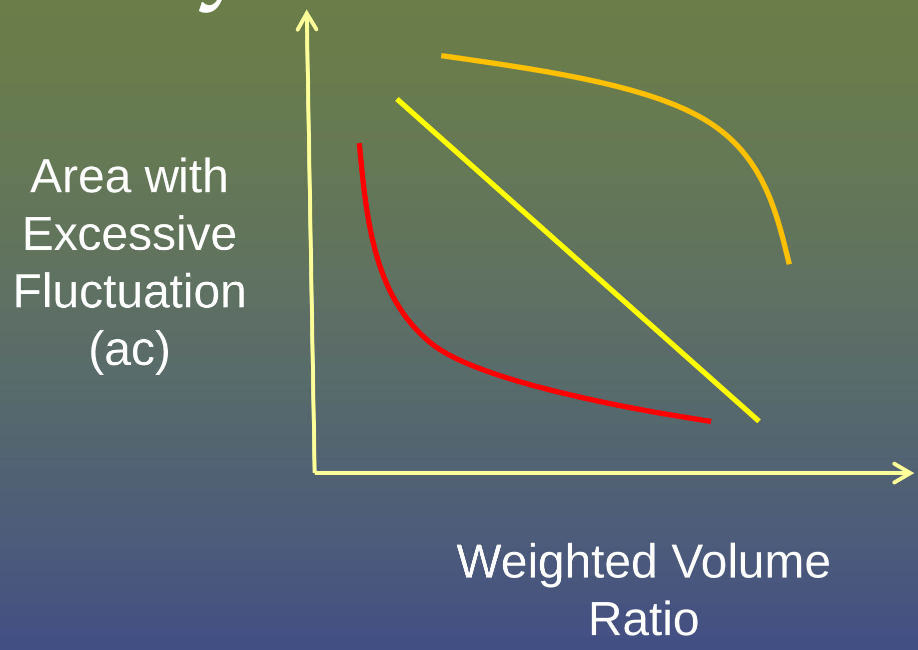
Area Inundated for 3-5 Continuous Days (ac)



Weighted Volume Ratio

Habitat Analysis





- How much area is experiencing desirable inundation characteristics (season, duration, etc.), and how can restoration increase this area?
- Where is hydrologic fluctuation excessive and can that be reduced?

Key Takeaways

- Methods developed to evaluate project benefits without full-scale studies
- Flood reduction benefits for setting back agricultural-type levees accrue for small to moderate events (may not be a match if focused only on very large floods)
- Model can be used to evaluate non-flood risk benefits as well