Contemporary Hg Loading From Eroding Banks

New Estimates – Waynesboro-Port Republic

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Order of Presentation

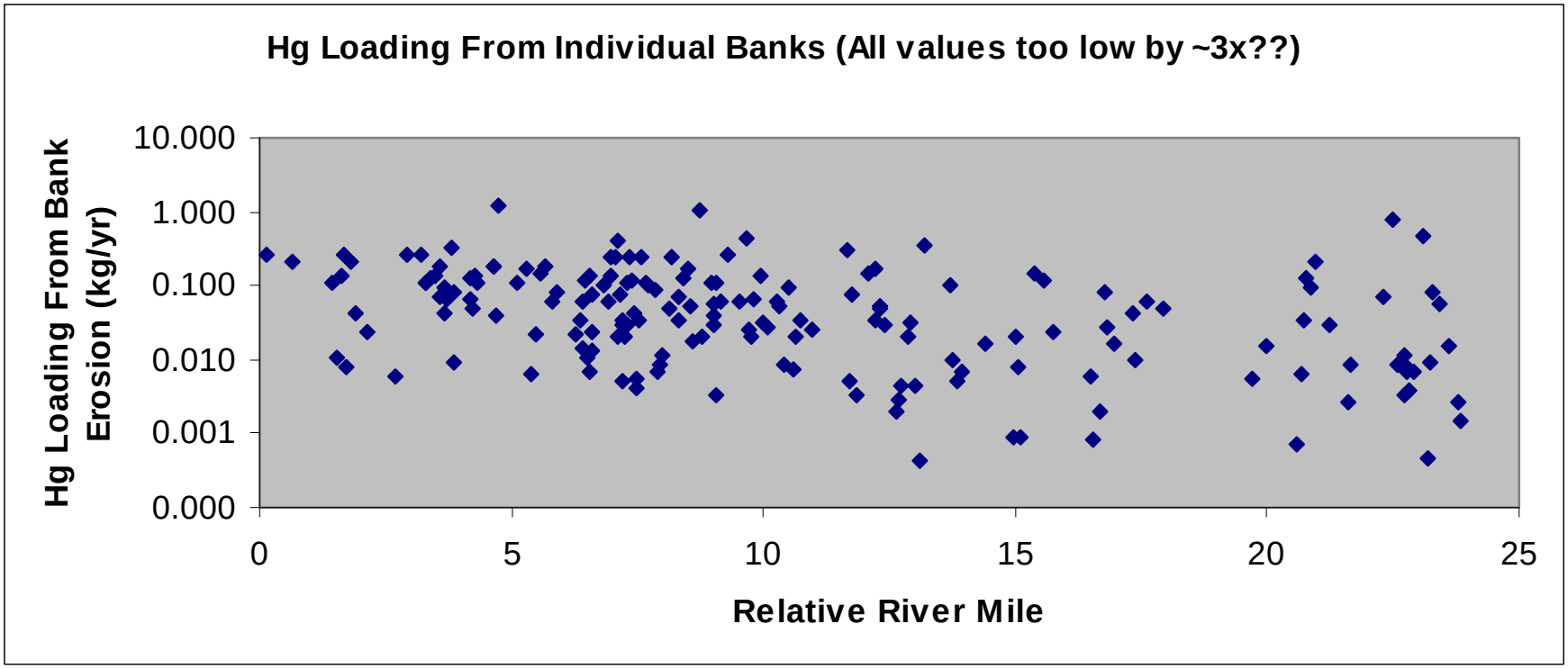
- Results presented first
- Nature of the estimates then described
  - Datasets and methods
  - Caveats, limitations, accuracy

Three Data Sets Presented

1. Annual Hg loading rates from every eroding bank identified from Waynesboro-Port Republic
2. Annual Hg loading rates binned at 1 mile intervals, Waynesboro-Port Republic
3. Cumulative loading – ordered from largest loading to smallest loading
    - vs cumulative length of eroding banks

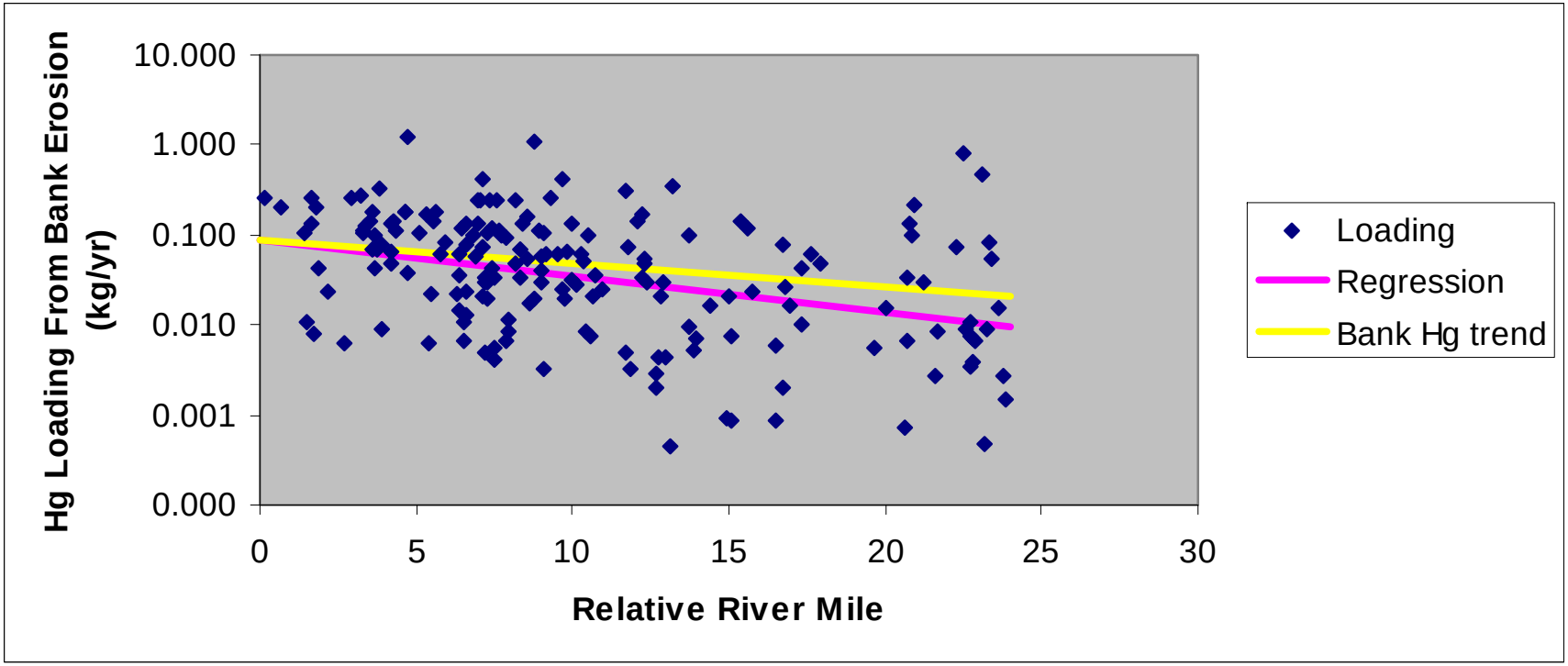
Two Important Caveats

1. Reaches with islands are neglected
2. Factor used to correct longer term average rates to contemporary annual rates is poorly constrained
   - All estimates may be too low by
     - Factor of 3??



Local variance of 2 orders of magnitude is largely a result of local variations in bank erosion rates.

Mercury concentrations vary greatly in eroding banks, but these variations cannot be predicted in areas where there are no measurements.

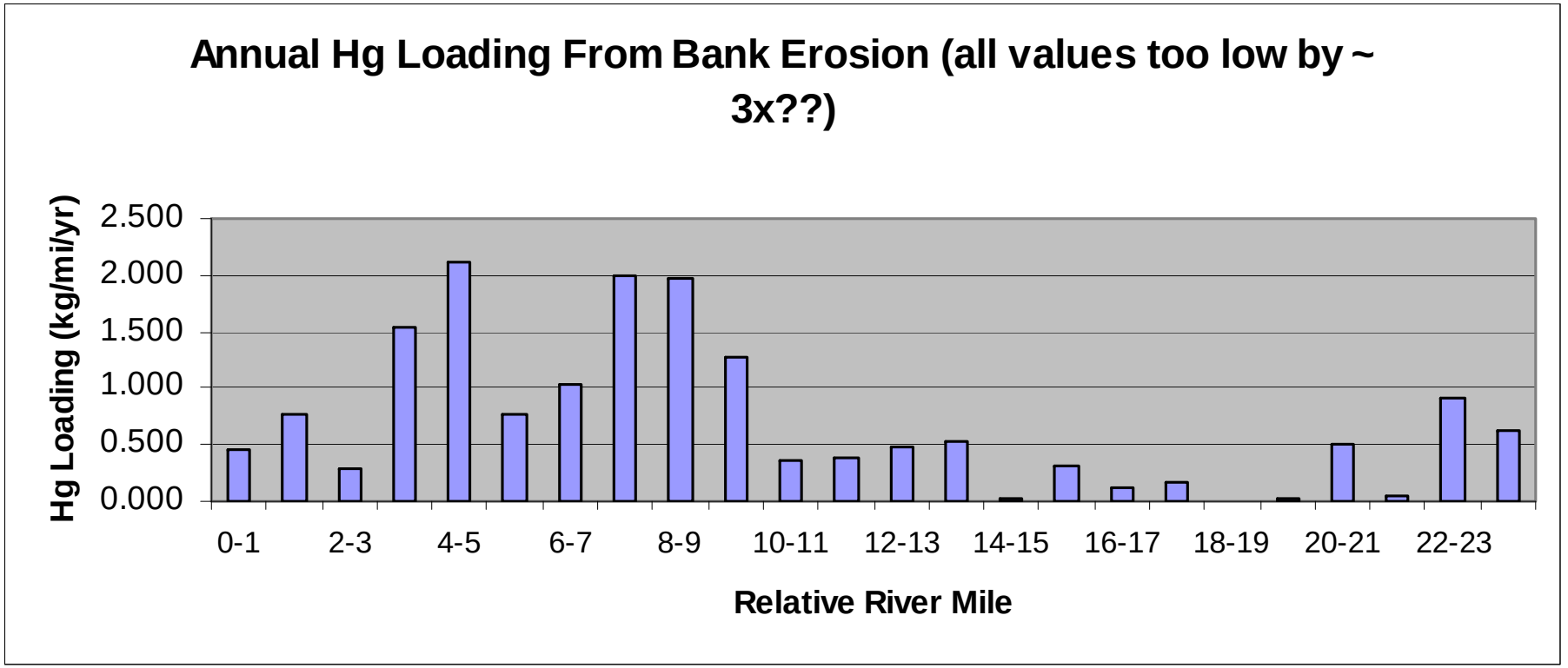


Regression analysis demonstrates that Hg loading from bank erosion decreases significantly with increasing distance downstream.

The rate of decrease is slightly faster than the decrease in concentration of mercury in eroding banks.

Decrease in bank erosion rates and lack of banks composed of alluvium downstream are additional factors.

Loading Totaled Every Mile

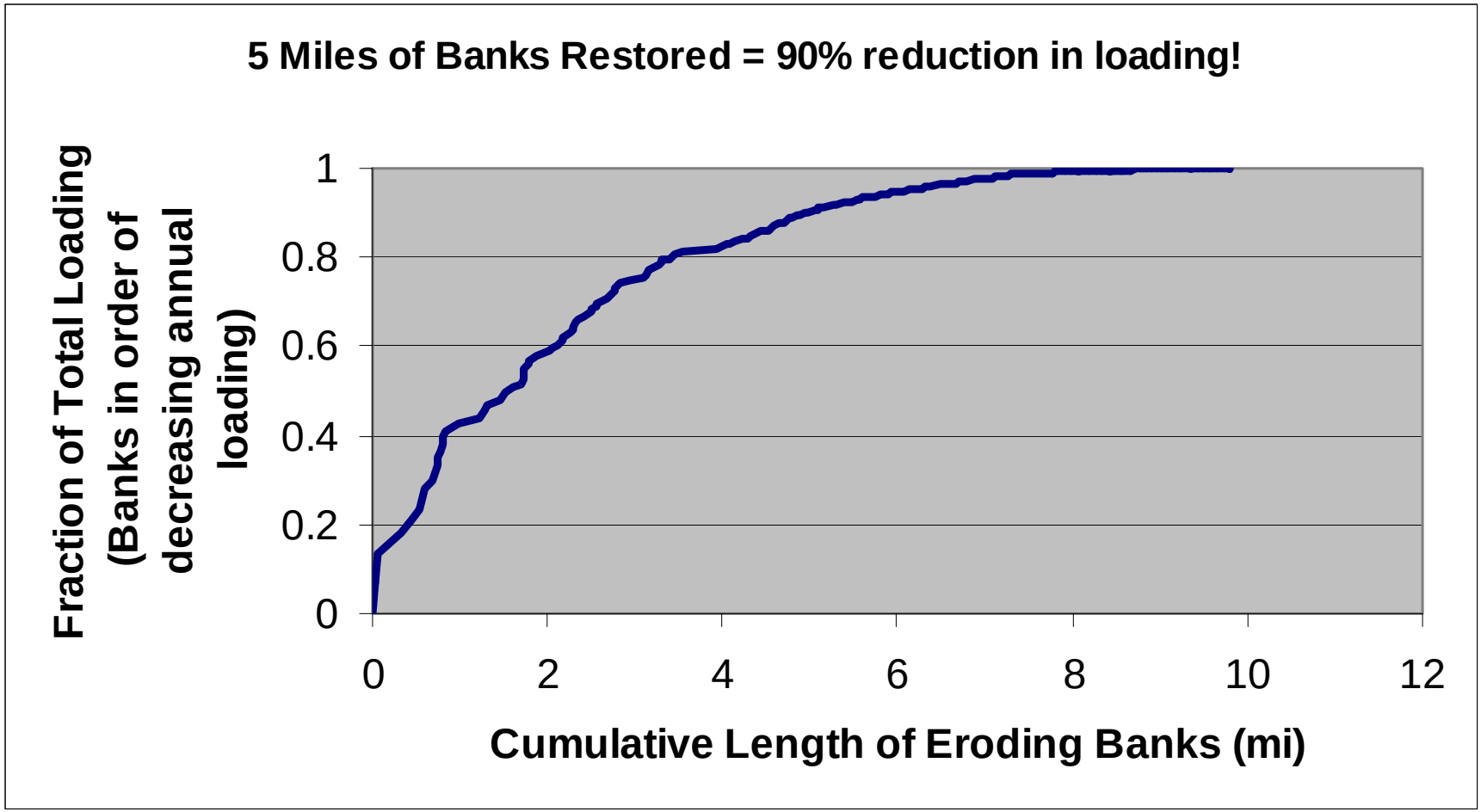


An Application

- What is the total length of bank stabilization required to achieve varied levels of reduced loading?

To Answer This Question

- Order banks by decreasing loading rate
  - Start with the banks producing the highest loading
  - Add banks with progressively decreasing loading rates
- What total length of banks must be stabilized to reduce loading along the river to various levels?


5 Miles of Banks Restored = 90% reduction in loading!
Fraction of Total Loading (Banks in order of decreasing annual loading)
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Cumulative Length of Eroding Banks (mi)

Methods Used to Obtain These Estimates

- Classify riverbanks by geomorphic/geologic setting
- Estimate Hg concentrations in riverbanks
- Estimate time-averaged volumetric bank erosion rates
- Convert volumetric bank erosion rates to sediment mass erosion rates
- Convert mass erosion to mass of mercury loading
- Correct long-term average (mostly decadal) loading rates to contemporary annual loading rates

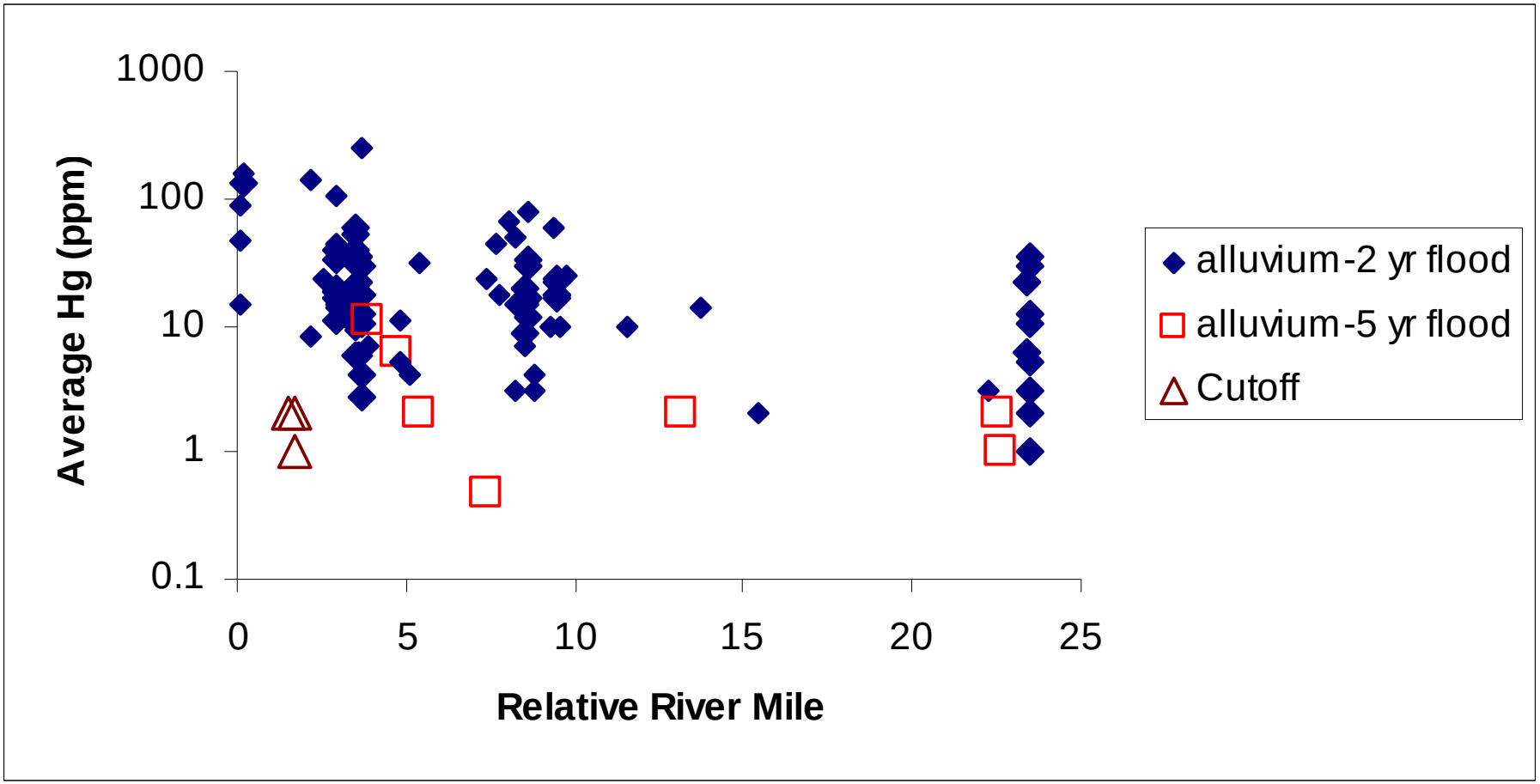
Geomorphic/Geologic Setting of River Banks

Bank Classification	Description
Frequently inundated alluvium	The bank materials are composed of alluvium and are developed on a surface that is inundated by floodwaters approximately every 2 years or less
Frequently inundated alluvium - islands	Same as above but in reaches with well-developed islands
Infrequently inundated alluvium	The bank materials are composed of alluvium and are developed on a surface that is inundated by floodwaters every 2-5 years
Terrace or alluvial fan	Banks are composed of terrace or alluvial fan deposits defined by field observations and published geologic mapping
Bedrock	Bank materials are primarily composed of bedrock
Anthropogenic	Banks are composed of fill or other engineered bank materials

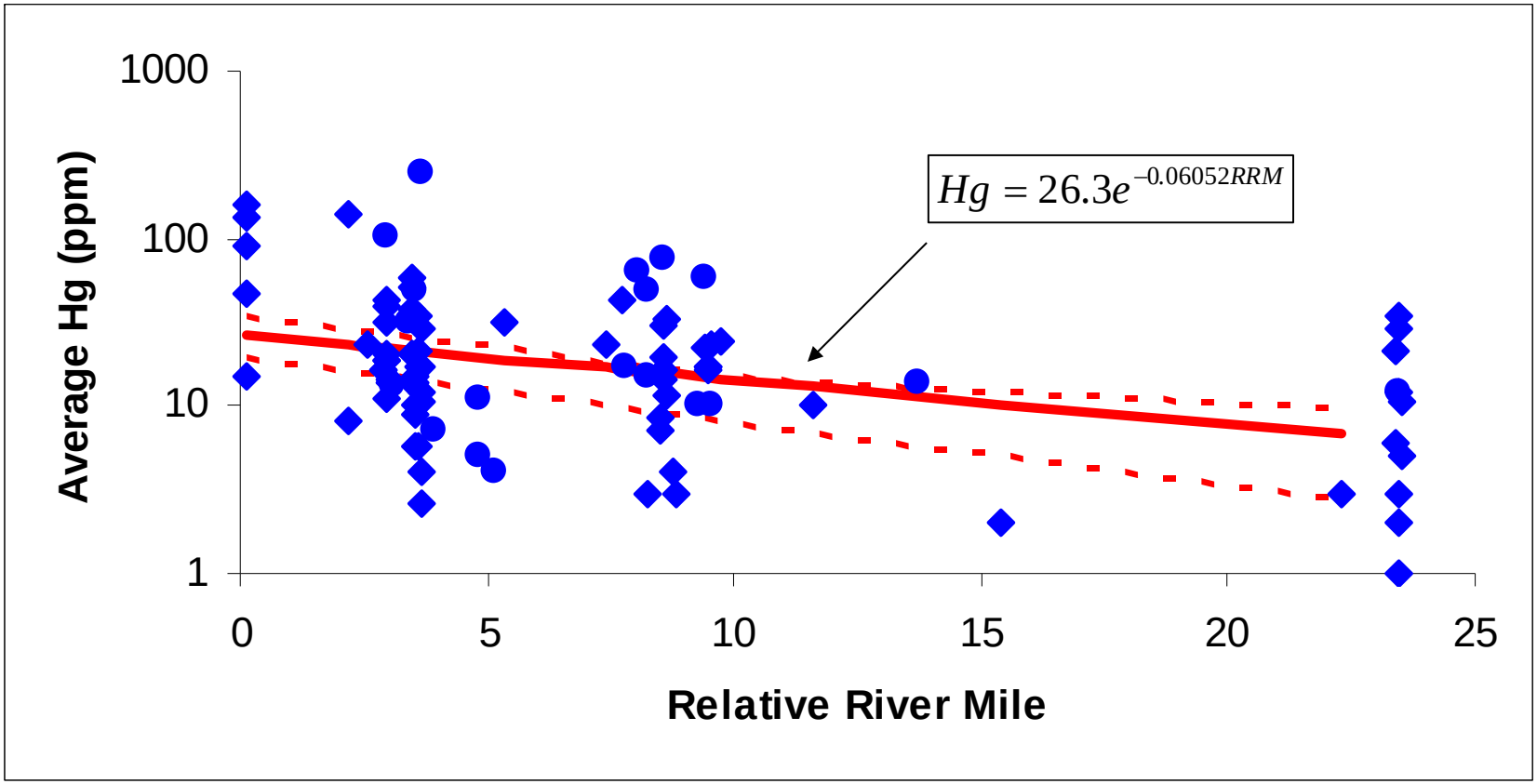
Hg Concentration in Eroding Banks

- Based on available sampling

Hg Concentrations in Eroding Banks



Hg Concentrations – Frequently Inundated Alluvium



Note very substantial UNEXPLAINED VARIANCE – “hotspots” cannot be predicted!

Hg Concentrations in Different Geomorphic/Geologic Settings

Bank Classification	Hg Concentration Estimate
Frequently inundated alluvium	From regression equation
Frequently inundated alluvium - islands	Neglected
Infrequently inundated alluvium and cutoff	2 ppm
Terrace or alluvial fan	0 ppm
Bedrock	0 ppm
Anthropogenic	Variable, but mostly 0 ppm

Erosion Rate Estimates From:

1. Calibrated hydrodynamic model
   - Bank retreat related to “near-bank” velocity
   - Appropriate for alluvial reaches without bedrock
2. 1937-2005 aerial photo analysis
3. Visual mapping of eroded banks
   - If not identified by 1 and 2 above
   - Constant retreat of 1.5 m 1937-2005 assumed
4. Tripod mounted lidar
   - Only available at 6 locations
5. Bank erosion by tree analysis
   - Bank stabilization pilot study
   - Above Dooms Dam

Estimating the Height of Eroding Banks

- Aerial LIDAR Analysis
  - Rhoades et al. 2009
- 2 foot contours derived from aerial LIDAR
- Field surveys
  - Only available at selected sites

Converting Sediment Volume To Mass

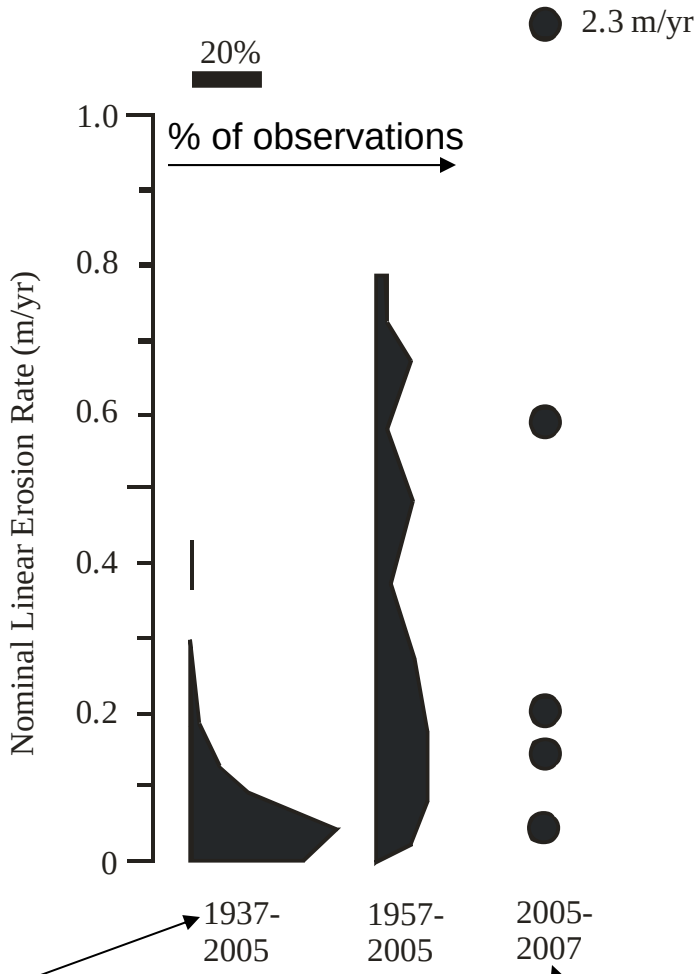
- Bulk density of eroding banks:
  - 1200 kg/m^3 assumed
  - No measurements?

Converting Time-Averaged Erosion Rates to “Contemporary” Rates

- Most estimates are based on aerial photo analysis
  - 1937-2005
- Erosion rates are higher now than early in the 20th century

Observations:

- largest data set shows lowest erosion rates averaged over 1937-2005
- other data from different methods at a few locations
- more recent estimates are MUCH higher than those of 1937-2005, BUT:
- methods, locations, not directly comparable



1937-2005 analysis, entire study area (Rhoades et al., 2009)

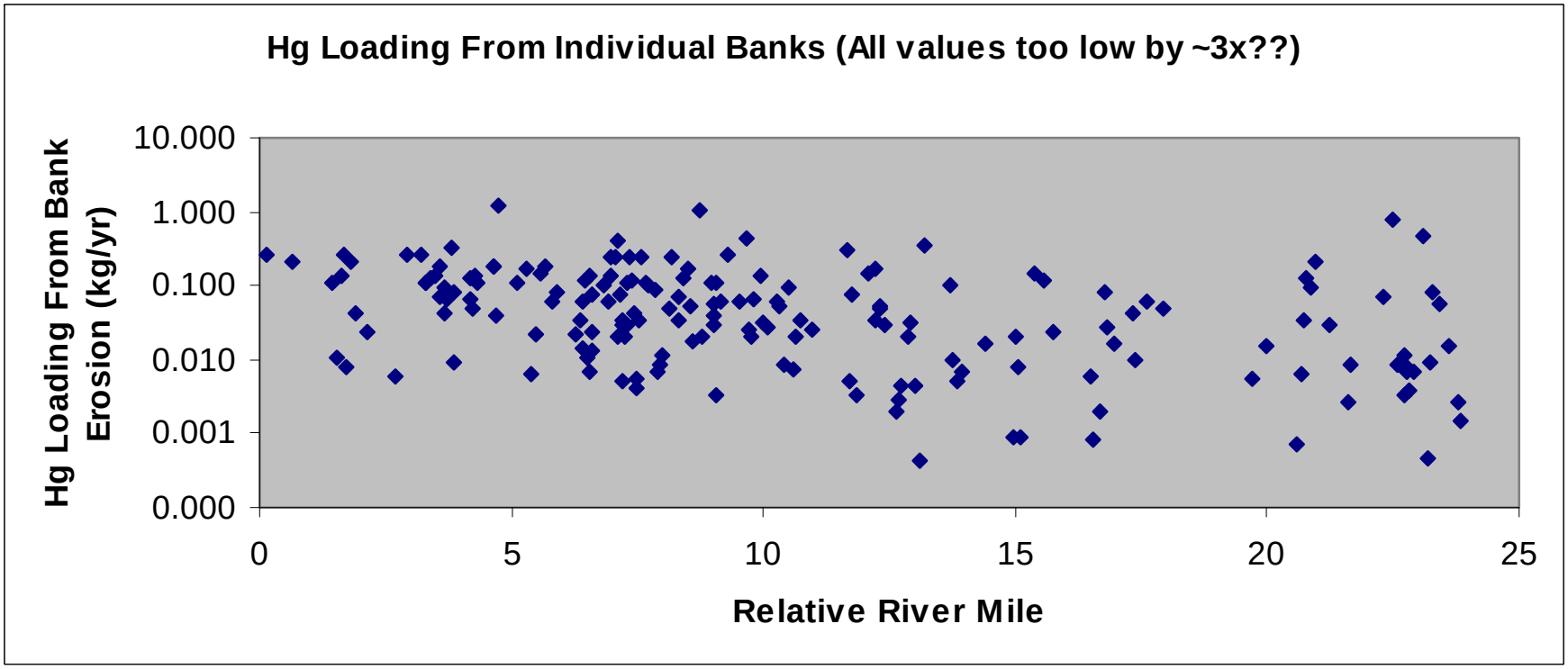
Pizzuto and O'Neal, 2009, 14 rapidly eroding bends

Pizzuto and O'Neal, tripod LIDAR surveys, 6 bends

Approach

- I used the Pizzuto and O'Neal (2009) data for 14 rapidly eroding bends to correct 1937-2005 rates to "contemporary rates"
  - 3 time periods available
    - 1937-1957
    - 1957-1977
    - 1977-2005
- This approach corrects 1937-2005 rates to "more recent decades".
- The correction factor is only 1.2
  - "recent" rates are only 20% higher than 1937-2005 average rates
- Probably not very accurate
  - Need additional data to improve this

Summary – The Results Again



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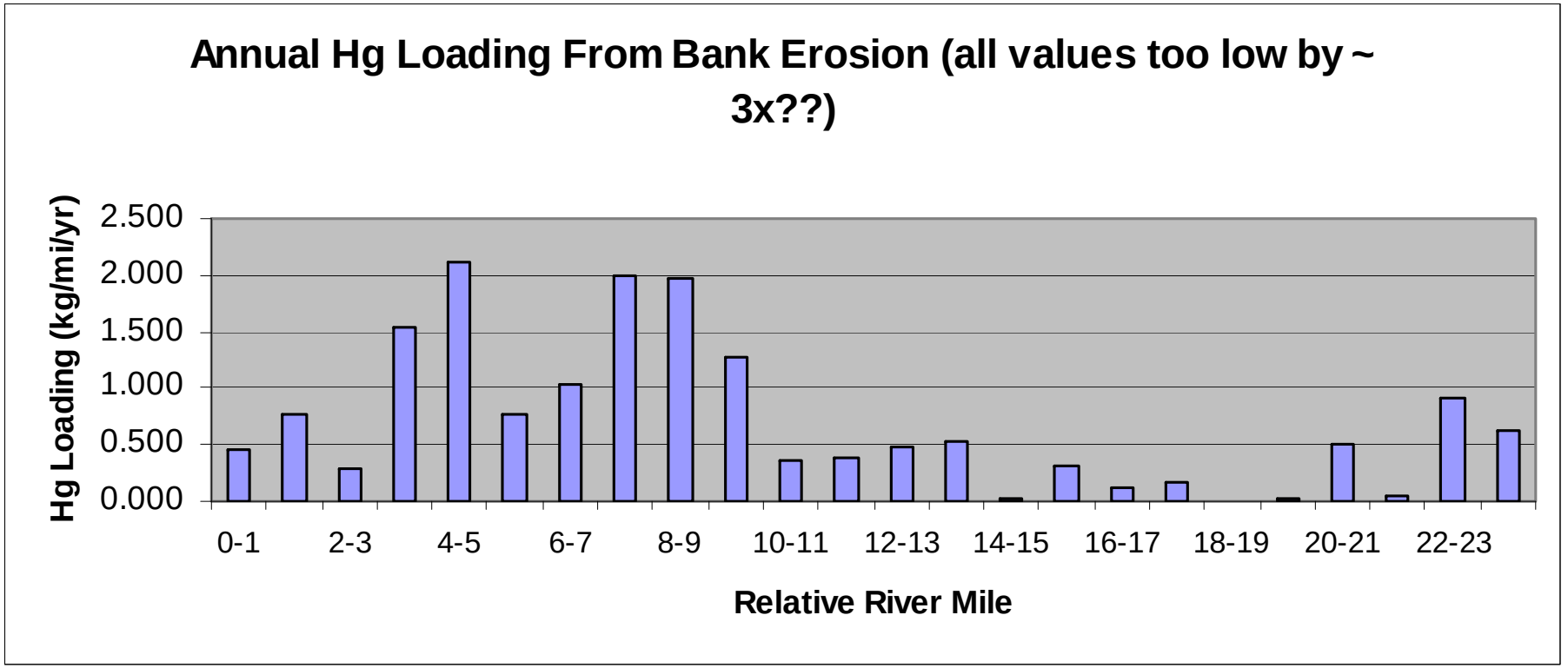

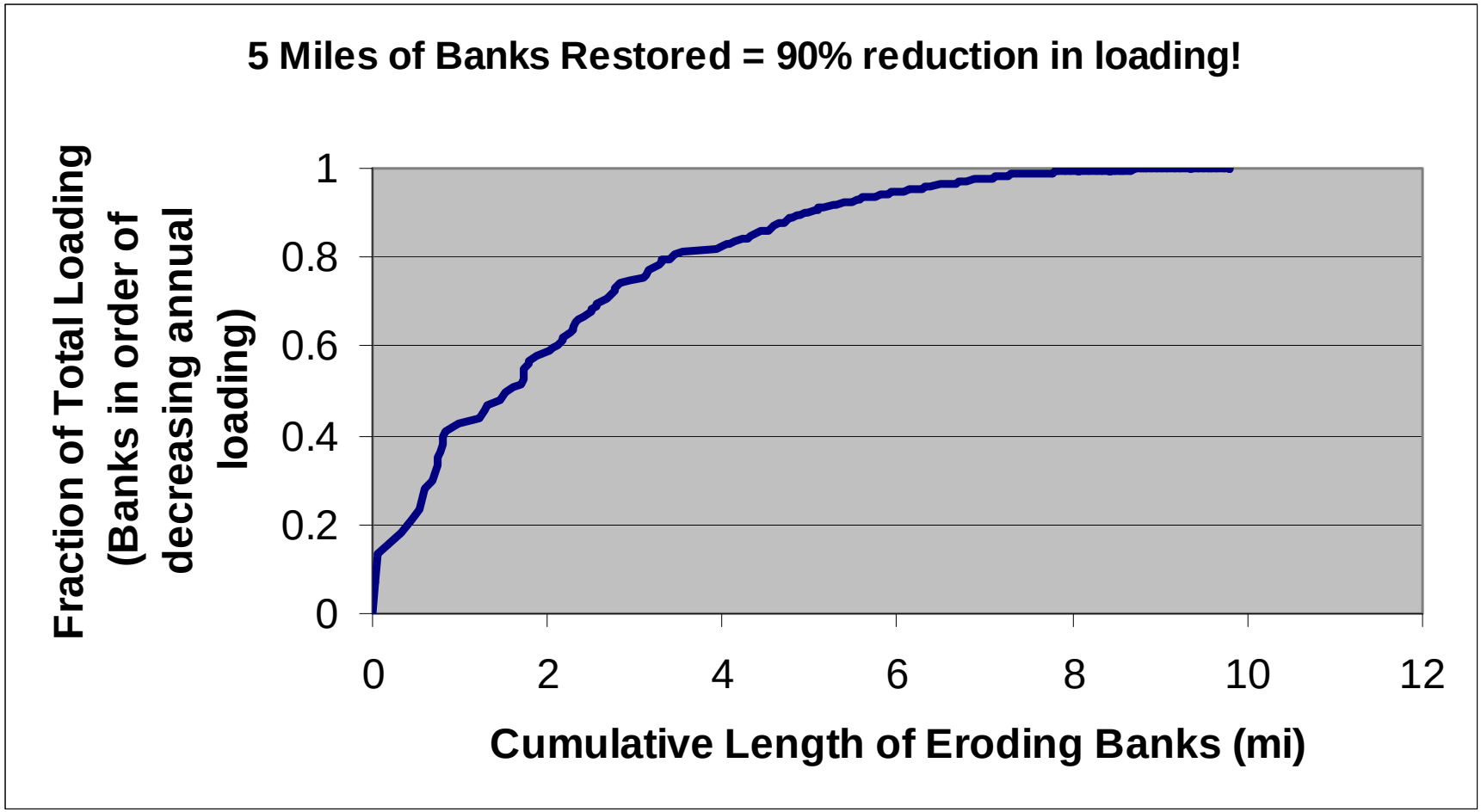
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