Are current soil erosion control efforts effective?

Insights from sediment accumulation rates in Iowa lakes

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Agricultural intensification of Iowa

- 83% land in farms by 1900
- 90% of wetlands drained by 1956
- Largest ag. intensification post-1950

Heathcote & Downing (2012) *Ecosystems*
Common scenery of Iowa
Outline

• Study investigating sediment accumulation rates in Iowa lakes
• Sediment fingerprinting approach to determine sediment sources
• Comment briefly on effective management strategies

Watershed Sediment Losses to Lakes Accelerating Despite Agricultural Soil Conservation Efforts

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Are current soil erosion control efforts effective?

- Sediment and nutrient pollution impair water quality
- $5$ billion spent annually on soil and water conservation

$294$ billion spent on soil and water conservation since 1935

Heathcote et al. (2013) *PLoS ONE*
32 glacial lakes included in this study
Estimating sediment accumulation and nutrient-fueled in-lake production

- $^{210}$Pb-dated cores used to calculate sediment accumulation rates
  - Erosional sediment defined as inorganic fraction + 42% of OM (Heathcote and Downing 2012)
  - In-lake deposition defined as remaining OM + calcite precipitates

- Conservation practices present in all watersheds (Avg: 6% of area)
Sediment core characteristics

AGE

W. Okoboji

E. Okoboji

Minnewashta

Center

Silver (Dickinson Co.)

Lower Gar

Upper Gar

Little Spirit

Lizard
210Pb dating

29 of 33 lakes had core bottom older than 1850
Sediment accumulation rates

- 7-fold increases in both erosion and in-lake production
  - Up to 75% derived from watershed erosion
  - In-lake production from eutrophication has tripled since 1950

- Erosion and eutrophication continues to accelerate
- **1850:** 1 mm sediment per 1.7 yrs
- **2010:** 1 mm sediment per 59 days

Heathcote et al. (2013) *PLoS ONE*
Cumulative loss from watersheds

- Eroded sediment spread over total watershed for each lake
- Current losses range from 0.2 – 1.4 t ha\(^{-1}\) yr\(^{-1}\)
- Averaged across all lakes:
  - \textbf{1850}: 0.1 t ha\(^{-1}\) yr\(^{-1}\)
  - \textbf{2010}: 0.4 t ha\(^{-1}\) yr\(^{-1}\)
  - Cumulative sediment delivery 28 t ha\(^{-1}\) over the last 180 years
  - \textapprox 1400 km\(^2\)
  - 4 x 10\(^6\) t of sediment

\[\times 303,000\]
Study findings

- External inputs from erosion as well as deposition from eutrophication both increased 7-fold
- Largest increases after agricultural intensification, rather than land clearance
- Sediment accumulation rates continue to increase, despite conservation efforts

Heathcote et al. (2013) *PLoS ONE*
Where is sediment coming from?

Upland erosion

Stream bank erosion

Modified from A. Gellis
Sediment fingerprinting approach

- Sediment sources can be characterized using diagnostic physical and chemical properties

- Comparison of these fingerprints with same characteristics of lake sediment allows us to determine source and relative contribution

On fine sediments – silts and clays

Walling et al. (1999)
Sediment fingerprinting approach

1. Identify sources
2. Sample sources (fields, stream banks, gravel roads)
3. Collect sediment core
4. Analyze samples
5. Use mixing models to determine contribution from each source

Modified from A. Gellis
Sediment fingerprint properties

Lake sediment

1. Elemental analyses (ICP-MS, OES)
2. Radionuclides ($^{137}\text{Cs}$, $^{210}\text{Pb}$, $^7\text{Be}$, $^{10}\text{Be}$)
3. Stable isotopes ($^{13}\text{C}$, $^{15}\text{N}$)
4. Color
5. Magnetics
6. Mineralogy

Sediment source

Modified from A. Gellis
Chesapeake Bay case study

Determine sediment sources from five watersheds draining into bay

Devereux et al. (2010)
Seeking volunteers to grant access to fields!

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Are practices to reduce these inputs effective?

- Sediment and nutrient inputs continue to increase, despite efforts
- Voluntary easements (i.e., CRP) alone are not enough to protect soil and water resources in the most intensively agricultural settings
- Requires a targeted management strategy
Easter Lake study

Pie chart for sediment:
- South: 21.0%
- Southwest: 4.5%
- Unconsolidated Watershed: 11.8%
- Rain & Dryfall: 0.0%
- West: 62.8%

Pie chart for phosphorus:
- South: 13.3%
- Southwest: 3.5%
- Rain & Dryfall: 1.5%
- West: 69.5%
- Unconsolidated Watershed: 22.2%
Acknowledgements

Google “Iowa limnology”

Allen Gellis