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Using a Century of Carbon and Nitrogen Records to Quantify Social-ecological Relationships in Watersheds of the Continental U.S.

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Cincinnati, OH
30 April 2014
# Analyses of water from Bull Run River near Bull Run, Oreg.

[Parts per million, except as otherwise designated.]

<table>
<thead>
<tr>
<th>Date (1911-12)</th>
<th>Turbidity (SiO₂)</th>
<th>Silica (Fe)</th>
<th>Iron (Ca.)</th>
<th>Magnesium</th>
<th>Sodium and potassium (Na + K)</th>
<th>Calcium</th>
<th>Carbonate radicle (CO₂)</th>
<th>Bicarbonate radicle (HCO₃⁻)</th>
<th>Subphosphate radicle (SO₄²⁻)</th>
<th>Nitrate radicle (NO₃⁻)</th>
<th>Chlorine</th>
<th>Dissolved solids</th>
<th>Mean discharge (feet)</th>
<th>Mean suspended matter (tons per day)</th>
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* Sodium and potassium, determined on combined alkali residues.
| Total annual denudation. | 520 | 21,000 |

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190 Stations | 152 Rivers and Lakes

Department of Commerce with assistance of U.S. Geological Survey

[Information on page missing]
\[ \mu \text{NO}_3 = 0.60 \text{ mg N} \]

\[ \mu \text{NO}_3 = 1.79 \text{ mg N} \]
• Carrollton water treatment plant, New Orleans
• >100 years old
• Treat water with lime to protect system of pipes
• Measure alkalinity of the Mississippi since 1900
Daily alkalinity measurements of the Mississippi River since 1961 and monthly records dating back to 1902.

The data set used here represents tens of thousands of measurements over 100 years and is therefore the most complete long-term data set for riverine carbon for a major world river ever reported and a data set of primary importance with respect to understanding...
Mississippi Annual Averages

Discharge (km$^3$ yr$^{-1}$)

1900 1920 1940 1960 1980 2000

200 300 400 500 600 700 800 900

2.2e+13 2.0e+13 1.8e+13 1.6e+13 1.4e+13 1.2e+13 1.0e+13 8.0e+12 6.0e+12 4.0e+12
Time Series of Watershed Response Factor

Bicarbonate flux at avg. discharge (Tg C yr⁻¹)

Year

1900 1920 1940 1960 1980 2000
Time Series of Watershed Response Factor

Bicarbonate flux at avg. discharge (Tg C yr⁻¹)

Year

1900 1920 1940 1960 1980 2000
Shift in Watershed Response Factor

$\text{Annual HCO}_3^-$ Export (g C yr$^{-1}$) vs. Annual Discharge (km$^3$ yr$^{-1}$)

$r^2 = 0.84$

$r^2 = 0.92$

Data points for 1910-1920 and 1994-2004 are shown.
Anthropogenic Forcings Increase Discharge

Δ Discharge at Avg. Precip. (m yr⁻¹)

% Cropland
Mississippi River discharge is increasing and the proportion of water from agricultural land cover is also increasing - which is changing the chemistry of the River.

- Nitrate concentrations across the continental US have increased on average by 300% in the last century.
- Bicarbonate fluxes from the Mississippi have increased 50% in the last half century.
- Increases are partly due to climate, fertilizer use, liming, and changes in ag hydrology (tile drainage, mechanical tillage).
- Linear relationship between NN and land in cropland at the beginning and end of the 20th Century.
- Anthropogenic land management practices increased NN concentration, discharge, and bicarbonate flux.
- Federal farm policies do influence land use and water quality.
There is still a lot to learn about how land use and climate change are impacting food production in the United States and how these interactions alter water quality and quantity.

Large spatial data sets like Clarke and long term data sets like Carrollton are rare but tremendously important when studying these issues.