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Nitrogen and Phosphorus Balances of Cranberry Bogs in Southeastern Massachusetts Coastal Watersheds

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Nitrogen and Phosphorus Balances of Cranberry Bogs in Southeastern Massachusetts Coastal Watersheds

Christopher Neill, Lindsay Scott, Casey Kennedy, Rachel Jakuba and Carolyn DeMoranville
Nutrient Exchanges Are Important

- Nutrients from agriculture threaten estuaries in many places
- Cranberries are important in the region and are the main crop in the Buzzards Bay watershed
- Cranberry cultivation is intimately associated with water
- Controversial and little data
- Better understanding could lead to ways to reduce N and P in discharges
Approach

Three study bogs
- Typical wetland bogs
- Single bog beds
- Typical fertilizer management
- Coordination with managers

Instrumentation
- Groundwater wells up- and downgradient
- Gaging of inlets and outlets to calculate water flows and water balance
- Gaging frost and summer irrigation volumes
- Automated sampling of water for chemistry during harvest floods, winter floods, base flows, and summer rains
Approach

Water chemistry
- Forms of nitrogen ($\text{NH}_4^+$, $\text{NO}_3^-$, DON, PON)
- Forms of phosphorus ($\text{PO}_4^{3-}$, Organic P, Total P)

What we get
- Water balance for different management phases
- Nitrogen and phosphorus inputs and outputs for different management phases
- Recommendations for reducing nitrogen and phosphorus outputs
Results—Water Budgets

Example of stage and outlet discharge
## Results—Water Budgets

### Inputs—mm/y

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>1,164 – 1,184</td>
</tr>
<tr>
<td>Harvest flood</td>
<td>391 – 646</td>
</tr>
<tr>
<td>Winter flood</td>
<td>239 – 847</td>
</tr>
<tr>
<td>Irrigation—frost</td>
<td>428 – 606</td>
</tr>
<tr>
<td>Irrigation—summer</td>
<td>102 – 387</td>
</tr>
<tr>
<td>Groundwater (net)</td>
<td>0 – 5,970</td>
</tr>
</tbody>
</table>
## Results—Water Budgets

### Outputs—mm/y

<table>
<thead>
<tr>
<th>Output</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evapotranspiration</td>
<td>696</td>
</tr>
<tr>
<td>Harvest flood</td>
<td>218 – 693</td>
</tr>
<tr>
<td>Winter flood</td>
<td>285 – 1,443</td>
</tr>
<tr>
<td>Non-flood baseflow</td>
<td>1,684 – 6,446</td>
</tr>
<tr>
<td>Rainstorms</td>
<td>57 – 136</td>
</tr>
<tr>
<td>Groundwater (net)</td>
<td>0 – 175</td>
</tr>
</tbody>
</table>

### Main messages:
- Water use similar in harvest floods, irrigation
- Winter floods more variable
- Hydro-geographical setting varies and is very important
- 53 to 69% of all water leaves in non-flood baseflows
Results—Nitrogen Balances

Harvest flood

A

\( \text{NO}_3 \) (mgN/L)

\[ \begin{array}{c}
0.000 \\
0.005 \\
0.010 \\
0.015 \\
0.020 \\
0.025 \\
0.030 \\
0.035 \\
0.040 \\
0.045 \\
0.050 \\
\end{array} \]

Hours

Flood On

Flood Off

D

PON (mgN/L)

\[ \begin{array}{c}
0.0 \\
0.1 \\
0.2 \\
0.3 \\
0.4 \\
0.5 \\
0.6 \\
\end{array} \]

Hours

White Springs

State

Rocky Pond

NO

3 (mgN/L)

NH

4 (mgN/L)

DON (mgN/L)

PON (mgN/L)
Results—Phosphorus Balances

\[ \text{PO}_4^{3-} \quad (\text{mgP/L}) \]

- Flood On
- Flood Off
Results—Annual Fluxes

Two bogs were small net sinks of N (0.1 kg N/ha, 2.0 kg N/ha)

One bog was a large source of N (12.7 kg N/ha)

All bogs were small sources of P (2.2 to 4.5 kg P/ha)
# Nitrogen and Phosphorus Balances

Percent of fluvial outputs in different water sources

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest floods</td>
<td>5 – 15</td>
<td>15 – 31</td>
</tr>
<tr>
<td>Winter floods</td>
<td>3 – 9</td>
<td>1 – 14</td>
</tr>
<tr>
<td>Non-food periods</td>
<td>73 – 77</td>
<td>55 – 81</td>
</tr>
<tr>
<td>Rainstorms</td>
<td>0 – 2</td>
<td>0 – 2</td>
</tr>
</tbody>
</table>
Comparison with Other Studies

Lower N and P export in harvest floods and winter floods compared with DeMoranville and Howes (2005)

Lower annual export compared with export measured from flow-through bog by Howes and Teal (1995)
Applications to Management

Address N and P in continuous water output
- Water high in DIN and comes during growing season
- Potentially discharge to streams with high N uptake in complex channels

Most available forms of N are high late during harvest flood release but when water flux is low, but most available form of P is higher at beginning of flood discharge. This complicates addressing both with one strategy

N and P released in winter floods less important for nutrient management

Summer storms might still be important in years with average or high summer rainfall
Future Directions

Have to understand setting of bogs in watershed to understand groundwater flows and effects on N and P exchanges

Bog location within watersheds will also influence amount of N and P that travels to ponds or estuaries because of in-stream attenuation

Other bog types are growing in importance but N and P exchanges are not measured

Increasingly possible to model N and P delivered to estuaries from different bog types and locations in stream networks

Also possible to compare these modeled N load estimates to estimates from watershed N load models
Acknowledgments

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