Rise of nutrient runoff following a re-intensification of land use and increased water discharge in a small rural catchment in Eastern Europe, 1987–2011

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Outline:

The Porijõgi River as a marked example of land use changes and nutrient loss dynamics in Eastern European agricultural catchments

Measurements

Modelling

Changes in nutrient losses from the Porijõgi River explained by water discharges and the re-intensification of agriculture under the EU Common agricultural Policy
Location of Estonia within the EU
The Porijõgi catchment with sub-catchments
Land use in the Porijõgi catchment 1987
Land use dynamics in the Porijõgi catchment
Instrumental measurements following the APHA standards:

- 1987-2000: 4-12 per year by the Dept. Geography + 9-12 per year by the national monitoring programme
- 2001-2006: 7-12 per year by the national monitoring programme
- 2007-2011: 6-7 per year by the national monitoring programme + 2-11 per year by the Dept. Geography

Sub-catchments:
- 1987-2000: 4-12 per year by the Dept. Geogr.
- 2001-2011: 2-11 per year by the Dept. Geogr.
Catchment-scale N and P loss model

\[ N_{\text{runoff}} = F_1 \times F_2 \times F_{3N} \times F_4 \times 20 \]

\[ P_{\text{runoff}} = F_1 \times F_2 \times F_{3P} \times F_4 \times 0.5 \]

where

- \( F_1 \) - integrated land use factor characterizing the dominant land use pattern in the catchment (varies between 1.0 and 3.5: 1.0 if natural/seminatural grasslands and forests dominate, and the share of arable lands <20%; 3.5 if >75% of the area is used for intertilled crops);
- \( F_2 \) - integrated soil factor (varies from 0.3 to 1.0: 0.3 by loamy hydromorphic soils and 1.0 by sandy automorphic soils);
- \( F_{3N} \) - fertilization factor for nitrogen (0.1, 0.5, 1.3 and 1.7 for 10, 100, 250 and 300 kg N kg ha\(^{-1}\) yr\(^{-1}\), correspondingly);
- \( F_{3P} \) - fertilization factor for phosphorus (0.1, 0.5, 1.3 and 1.7 for 5, 50, 70 and 100 kg P ha\(^{-1}\) yr\(^{-1}\), respectively);
- \( F_4 = Q_{\text{annual}} / Q_{\text{long-term annual}} \).
Annual average water discharge in the Porijõgi River [m³ s⁻¹]
N losses from the Porijõgi River catchment
P losses from the Porijõgi River catchment
N losses from the forested Porijõgi upper course catchment (control).
P losses from the forested Porijõgi upper course sub-catchment (control).
N losses from the Sipe sub-catchment
N losses from the Vända sub-catchment

- Calculated N losses \([\text{kg}\cdot\text{ha}^{-1}\cdot\text{a}^{-1}]\)
- Measured N losses \([\text{kg}\cdot\text{ha}^{-1}\cdot\text{a}^{-1}]\)
Conclusions

• The N and P losses from the agricultural catchments of the Porijõgi in 1997–2011 increased due to the magnification of water discharges and the re-intensification of agriculture under the EU Common Agricultural Policy.

• The recovery of nutrient flows fell remarkably short of expectations, probably owing to the retention within the catchment.
Land use dynamics in the Porijõgi River catchment area and its sub-catchments in 1987-1997

A- Porijõgi whole, B – Upper course, C – Sipe, D – Vända

### Factors in the empirical model:

- **F₁** – land use factor
- **F₂** – soil factor
- **F₃** – fertilization factor
- **F₄** – hydrological factor

<table>
<thead>
<tr>
<th>Factors</th>
<th>Specification, description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F₁</strong></td>
<td>grassland, forest, &lt;20% arable</td>
<td>1.0</td>
</tr>
<tr>
<td>dominant land use</td>
<td>grassland, &lt;40% less intensively cultivated arable lands</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>mixed grasslands and arable land</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>&gt;50% arable lands</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>&gt;50% intensively cultivated arable land</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>&gt;75% intertilled crops</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>F₂</strong></td>
<td>auto-morphic soil</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>hydro-morphic soil</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>sand</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>loamy sand</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>loam</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>F₃N and F₃P</strong></td>
<td>N (kg ha⁻¹ yr⁻¹) P (kg ha⁻¹ yr⁻¹)</td>
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</tr>
<tr>
<td>fertilization</td>
<td>(average for arable land)</td>
<td>0.1</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
<td>0.5</td>
</tr>
<tr>
<td>250</td>
<td>70</td>
<td>1.3</td>
</tr>
<tr>
<td>300</td>
<td>100</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>F₄</strong></td>
<td>Long-term annual discharge</td>
<td>F₄ = Qannual/Qlong-term annual</td>
</tr>
<tr>
<td>water discharge</td>
<td>Qlong-term annual (m³ s⁻¹)</td>
<td>1.7</td>
</tr>
</tbody>
</table>

*Mander et al 2000*

*Landscape Ecology 45(3), 187-199*
P losses from the Sipe sub-catchment
P losses from the intensively managed Vända sub-catchment