Nitrogen and carbon concentrations in Swedish headwater streams in relation to forest status determined by the probabilistic classifier method

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Classification of forest status in 200 small catchments

Analysis of stream water chemistry
Calibration of forest classification from satellite images against data from Swedish National Forest Inventory

~ 20 000 permanent plots
The concept of probabilistic classifier - a cost-efficient method for terrestrial monitoring

Preliminary classification
"mixed forest" tree species & age
8 classes
pixel=25 x 25 m

Calculation of entropy
red= not OK
Green & yellow= OK

Calculation of probability for each pixel
(∑ = 1)

Probability distribution per pixel

New field survey in selected areas

New improved classification
**Forest classification:**

- Forest growth + Biomass (mean)
- Percent coverage of 8 forest classes

<table>
<thead>
<tr>
<th>Forest growth</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands, High basal area</td>
<td>Wetlands, Low basal area</td>
</tr>
<tr>
<td>Clear-cuts</td>
<td></td>
</tr>
<tr>
<td>&gt;70% Pine</td>
<td>&gt;70% Spruce</td>
</tr>
<tr>
<td>&gt;50% Deciduous</td>
<td></td>
</tr>
<tr>
<td>20-50% Deciduous</td>
<td>&gt;70% Other</td>
</tr>
</tbody>
</table>

- Forest productivity
- Fens and bogs
- Clear-cuts
- Dominating tree species
- Mixed forests
- Satellite data from whole catchment
- Satellite data for 20-25 m wide buffer zone along the stream
Water chemistry data

- 100 randomly selected forested headwater catchment per region
- Four seasons (spring, summer, autumn, late autumn)
- Total organic carbon (TOC)
- Total Nitrogen (TN)
- Total inorganic nitrogen (TIN)
Bayesian Model Averaging

Models that perform well enough are accepted and the goodness of fit used as weights.

Example of outputs:
• Probabilities for variables to be included in the models.
• Proportion of positive or negative signs in the models.
• Means for coefficients in the model.
• Best model
TOC

Predicted vs. Observed for best models for each season (Log scale)

<table>
<thead>
<tr>
<th>Season</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>0.56</td>
</tr>
<tr>
<td>Summer</td>
<td>0.26</td>
</tr>
<tr>
<td>Autumn</td>
<td>0.50</td>
</tr>
<tr>
<td>Late autumn</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Bubble size:
Chance of being included in models.

Y axis:
Index of positive or negative sign in models.

X axis:
Four seasons.

Red bubbles:
Included in top model
Spring: $R^2=0.66$
Summer: $R^2=0.47$
Autumn: $R^2=0.61$
Late autumn: $R^2=0.61$
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</tr>
<tr>
<td>Clear-cuts</td>
<td>Pine70</td>
</tr>
<tr>
<td>&gt;70% Pine</td>
<td>Spruce70</td>
</tr>
<tr>
<td>&gt;70% Spruce</td>
<td>Deciduous50</td>
</tr>
<tr>
<td>&gt;50% Deciduous</td>
<td>Deciduous2050</td>
</tr>
<tr>
<td>20-50% Deciduous</td>
<td>Other</td>
</tr>
<tr>
<td>&gt;70% Other</td>
<td></td>
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</table>
Forest growth

Biomass

Wetlands, High basal area
Wetlands, Low basal area

Clear-cuts

>70% Pine
>70% Spruce
>50% Deciduous

20-50% Deciduous
>70% Other
10 percentage points increase in wetland with high basal area will lead to:

29% increase in TOC concentration.
12% increase in TN concentration.

(mean of weighed coefficients)
10 percentage points increase in clearcuts
  → 9% increase in TIN concentration

10 percentage points increase in mixed forest:
  → about 20% decrease in TIN concentration.
Conclusions

• Carbon and nitrogen concentrations could be successfully modeled using forest status classified from satellite images.

• Data for near-stream buffer zone are usually not important in models.

• TOC and TN are positively related to forest growth and wetlands.

• Clearcuts lead to increased and mixed forests to decreased TIN concentrations.

• More model testing necessary.