The comparative cost efficiency of three buffer zone programs to reduce phosphorus losses in a small Swedish catchment

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BACKGROUND

- Increasing eutrophication of the Baltic Sea
- Of the total anthropogenic phosphorus loads from Sweden, 40% originate from farmland
- Riparian buffer zones are the only measure which has been used extensively in Sweden to reduce phosphorus losses from agricultural land
- Supported by payments to landowners from the EU Rural Development Program (RDP)
- Uneven and low participation in the program
Agri-environmental program evaluation

- “Is agri-environment support well designed and managed?” EU Court of Auditors (2011)

- Report recommendations to the EU Commission:
  - agri-environmental expenditures should be more precisely targeted;
  - there should be a higher rate of EU contribution for sub-measures with a higher environmental potential;
  - there should be a clear distinction between simple and more demanding agri-environment sub-measures;
  - and that the Member States should be more proactive in managing agri-environment payments.
Why aren’t programs targeted?

- Uniform payments are easy and accepted by:
  - Swedish Board of Agriculture and Ministry
  - Program administrators (County boards)
  - EU (and WTO)
  - Farm lobby groups (fairness)

- There is also a common belief that efficiency gains from targeting will be equal to or less than the higher costs of administering targeted programs
Transaction costs

- Costs for entering into a contract \((ex \ ante\) and \(ex\ post\))
- Include costs of information, contracting and control
- There has been little attention paid to how to reduce transaction costs to increase efficiency.
- One of the reasons for the lack of attention has been the difficulties associated with calculating these types of costs.
Model support for lowering the transaction costs of targeting

- Current support for buffer zones in Sweden; uniform payments, for buffer zones to reduce P losses (biodiversity), voluntary participation (6-20 meters wide zones along water courses)
- Assignment in 2012 from the Swedish National Water Authorities to SLU WaterHUB to develop a model for high resolution evaluation of buffer zone cost efficiency
- Result: FyrisSKZ
FyrisSKZ: Assignment

- Develop a tool which will be able to estimate and summarize the cost effectiveness of buffer zones along lakes, watercourses and drainage ditches in the 12,864 sub-catchment areas of Sweden.
- Develop a web application to make this information available to users.
FyrisSKZ: Construction features

- Use of GIS to calculate the cultivated area contributing to P losses from agricultural land around lakes and watercourses (impact area)
  - 60 meter wide zone of agricultural land (blocks) along water courses (min 30 meters running length)
- Use of the FyrisCOST model to estimate the effects of buffer zones on the impact area (reduction in P losses).
- Use of opportunity costs for taking agricultural land out of production, and the costs for construction and maintenance of the buffer zone
FyrisSKZ: Model structure

- National data
  - PLC-data
  - GIS-data
- GIS-calculations
- Buffer zone costs

FyrisCOST
GIS impact area; purple areas
FyrisCOST (DSS)

- The effect of abatement measures is calculated from available databases which include high resolution climate data, land use data, hydrological data, crop types, soil types, soil P levels, land elevations (gradient toward the watercourse) and buffer zone widths.

- Models included in FyrisCOST:
  - NLeCCS (ICECREAMDB, SOILNDB)
  - FyrisNP (Fyris)
FyrisCOST:
Reduction effect: Buffer zone width on one soil type, three gradients

![Graph showing reduction effect vs buffer zone width for three gradients (lut 1, lut 2, lut 3).]
Buffer zone costs

- Construction and maintenance costs uniform for all production areas
- Evaluation of opportunity costs for land use in eight production zones
  - based on leasing prices for agricultural land (90th percentile)
  - data from Swedish Board of Agriculture
Cost per hectare for income loss from buffer zones (90%)

<table>
<thead>
<tr>
<th>Country</th>
<th>€ cost/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO8</td>
<td>719</td>
</tr>
<tr>
<td>GSS</td>
<td>462</td>
</tr>
<tr>
<td>GMB</td>
<td>347</td>
</tr>
<tr>
<td>GNS</td>
<td>239</td>
</tr>
<tr>
<td>SS</td>
<td>239</td>
</tr>
<tr>
<td>GS</td>
<td>148</td>
</tr>
<tr>
<td>MSS</td>
<td>114</td>
</tr>
<tr>
<td>NN</td>
<td>95</td>
</tr>
<tr>
<td>ÖN</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>458</td>
</tr>
</tbody>
</table>
Web Application:
http://fyrisskz.slu.se/haro/
Web Application: Selected catchment area

Kostnad för reduktion av 1 kg P vid 2 m kantzon
-2 - Onödlig gräsfördelning
-1 - Ofullständig indata
0 - Ingen jordbruksmark
1 - 1000 kr
1000 - 3000 kr
3000 - 15000 kr
15000 - 50000 kr
50000 - kr

Zooma, markera och panorera i kartan
- Håll muspekaren över kartan och rulla mushjulet för att zooma in (⌘) eller ut (⇧) i vild punkt.
- Håll nere Shift + vänster musknapp och rta en rektangel för att zooma in. Startpunkten måste ligga utsökt av ett uttryck för polygon.
- Håll nere vänster musknapp, pekaren måste vara utanför polygonerna, och drag i kartan för att panoraera.
- Välj en polygon genom att klicka på den med vänster musknapp.
- På delavrinningsområden kan man välja flera delavrinningsområden och häller nere Shift och klickar med vänster musknapp.
- Håll muspekaren över en rubrik i tabellen för mer information.
## FyrisSKZ: Results table - inputs

<table>
<thead>
<tr>
<th>Catchment name</th>
<th>Subcatchment ID</th>
<th>Subcatchment area (km²)</th>
<th>Runoff (mm/yr)</th>
<th>Agricultural area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Svärtaån</td>
<td>652798-157219</td>
<td>42.0</td>
<td>239.67</td>
<td>32.642</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pasture area (%)</th>
<th>Soil type</th>
<th>Phosphorus class (1-3)</th>
<th>Slope class (1-3)</th>
<th>Impact area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.4</td>
<td>Silty Clay</td>
<td>3</td>
<td>3</td>
<td>303</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact area along watercourse (km)</th>
<th>Possible buffer zone length (km)</th>
<th>Land opportunity cost (SEK/ha)</th>
<th>Area of support 2008 (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.23</td>
<td>40.25</td>
<td>2033</td>
<td>13.17</td>
</tr>
</tbody>
</table>

IPW7 Uppsala
# FyrisSKZ: Results table - outputs

<table>
<thead>
<tr>
<th>Reduction 2m (kg P/ha)</th>
<th>Reduction 6m (kg P/ha)</th>
<th>Reduction 10m (kg P/ha)</th>
<th>Reduction 15m (kg P/ha)</th>
<th>Reduction 20m (kg P/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.52</td>
<td>1.42</td>
<td>1.06</td>
<td>0.81</td>
<td>0.66</td>
</tr>
<tr>
<td>Potential reduction 2m (kg P)</td>
<td>Potential reduction 6m (kg P)</td>
<td>Potential reduction 10m (kg P)</td>
<td>Potential reduction 15m (kg P)</td>
<td>Potential reduction 20m (kg P)</td>
</tr>
<tr>
<td>20.28</td>
<td>34.25</td>
<td>42.84</td>
<td>48.92</td>
<td>53.43</td>
</tr>
<tr>
<td>Reduction cost 2m (SEK/kg P)</td>
<td>Reduction cost 6m (SEK/kg P)</td>
<td>Reduction cost 10m (SEK/kg P)</td>
<td>Reduction cost 15m (SEK/kg P)</td>
<td>Reduction cost 20m (SEK/kg P)</td>
</tr>
<tr>
<td>807</td>
<td>1433</td>
<td>1910</td>
<td>2509</td>
<td>3063</td>
</tr>
</tbody>
</table>
Kostnad att reducera 1 kg P vid 2 m bred kantzon

Legend
Kostnad reducera 1 kg P vid 2 m kantzon (kr)
- 0-1000
- 1000-5000
- 5000-15000
- 15000-50000
- 50000-
FyrisSKZ: Application

- Svärta River catchment area
- Three program scenarios

Water sampling stations:
- Lake
- River
- Subcatchments
- Arable land
The Svärta river catchment

- located in central Sweden south of Stockholm
- total land area 345 km²
- 25% is used for agriculture (9000 ha) with 7500 ha of this in crop production
- two dominant soil types in the catchment silty clay loam (80%) and silty loam.
- majority of the soil has a high soil P concentration and is erosion sensitive
- 14 sub-catchment areas
Buffer zone program scenarios

- Scenario 1: Baseline data from RDP 2008, buffer zone areas by sub-catchment, PLC5 average for 10 meter wide buffer zones.
- Scenario 2: Buffer zones on all potential area, 6m wide
- Scenario 3: Efficient allocation of buffer zones (max width for each sub-catchment where the cost/kg P reduction is less than € 172/kg P).
## Scenario results

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer zone area (ha)</td>
<td>162</td>
<td>110</td>
<td>*71.5</td>
</tr>
<tr>
<td>Total reduction (kg P)</td>
<td>97.2</td>
<td>124.5</td>
<td>102</td>
</tr>
<tr>
<td>Average reduction (kg p/ha)</td>
<td>0.6</td>
<td>1.13</td>
<td>1.42</td>
</tr>
<tr>
<td>Cost per ha buffer zone (€/ha)</td>
<td>234</td>
<td>234</td>
<td>234</td>
</tr>
<tr>
<td>Total cost (€)</td>
<td>37 922</td>
<td>25 740</td>
<td>16 731</td>
</tr>
<tr>
<td>Cost/kg P reduction (€/kg P)</td>
<td>390</td>
<td>207</td>
<td>163</td>
</tr>
</tbody>
</table>

* Scenario 3 results: 6 sub-catchments with 6m wide zones
Scenario results

- Targeting improves cost effectiveness
- Is Scenario 3 the most efficient?
  - No, just more cost efficient per kg P reduced than the other two scenarios evaluated. There are many more scenarios!
  - No transaction costs are included. Would these be higher than for uniform costs? Probably.
Who will use the results?

- Allows for targeted evaluation
  - Programs (ex ante and ex post)
  - Individual measures (for example as trading offsets)
- But uniform payments are easy and accepted by:
  - Swedish Board of Agriculture and Ministry
  - Program administrators (County boards)
  - EU (and WTO)
  - Farm lobby groups (fairness)
- Who will change their policy? How? Why?
Thank you!