The European CAP and feasible eco-hydrological impacts for the Dill catchment, Germany

Agricultural practice in marginal regions is decreasing, leading to land abandonment and changes in the economic structure.

- ... but landscapes provide many services!
  (Costanza et al., Nature 387, 253-260)

- Required: An integrated assessment of land use change effects
Dill catchment

Land use scenarios

- Grassland bonus
- Field size allocation
- Outwintering suckler cows
- European Common Agricultural Policy

Size ~ 692 km²

54 % forest
21 % pasture
9 % settlement
9 % fallow
7 % agriculture
CAP Land use scenarios

Baseline
AGRL 6.5 %
PAST 20.5 %

Agenda2000
AGRL 8.0 %
PAST 25.5 %

CAP
AGRL 3.7 %
PAST 30.4 %
Model validation

Discharge [mm d⁻¹]

1983 1985 1987 1989 1991 1993 1995 1997 1999 2001

calibration period
Model validation

![Discharge Graph]

- **Measured**
- **Calculated**

**NS = 0.784**

Discharge [mm d⁻¹]

![Graph](image-url)
Hydrology

Baseline (mixed forest)
- 942 → 60
- 476 → 318
- 318 → 60
- 60 → 85

Agenda 2000
- 942 → 66
- 476 → 315
- 315 → 66
- 66 → 86

CAP
- 942 → 62
- 478 → 316
- 316 → 62
- 62 → 86
Subcatchments

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Agenda2000</th>
<th>CAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>AGRL 7%</td>
<td>AGRL 12%</td>
<td>AGRL 0%</td>
</tr>
<tr>
<td></td>
<td>PAST 25%</td>
<td>PAST 33%</td>
<td>PAST 46%</td>
</tr>
<tr>
<td>32</td>
<td>AGRL 30%</td>
<td>AGRL 39%</td>
<td>AGRL 8%</td>
</tr>
<tr>
<td></td>
<td>PAST 30%</td>
<td>PAST 23%</td>
<td>PAST 56%</td>
</tr>
</tbody>
</table>
Subcatchments

7
AGRL 7 %
PAST 25 %

AGRL 12 %
PAST 33 %

AGRL 0 %
PAST 46 %

32
AGRL 30 %
PAST 30 %

AGRL 39 %
PAST 23 %

AGRL 8 %
PAST 56 %
Biogeochemistry

- Apart from hydrological modelling a focus of SFB299 is on nutrient cycling
- Analysis of simulated N cycle in HRU did not perform satisfactorily

<table>
<thead>
<tr>
<th>Process</th>
<th>Nitrate kg N ha(^{-1}) a(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilisation</td>
<td>151.7</td>
</tr>
<tr>
<td>Denitrification</td>
<td>135.5</td>
</tr>
<tr>
<td>Plant uptake</td>
<td>44.3</td>
</tr>
<tr>
<td>Lateral flow</td>
<td>23.9</td>
</tr>
<tr>
<td>Leaching</td>
<td>4.4</td>
</tr>
<tr>
<td>Surface runoff</td>
<td>5.1</td>
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</tbody>
</table>
Biogeochemistry

Decomposition/mineralization

N fresh → N active → N stable

Residue | Humus

Fertilizer $N_{\text{org}}$

$NH_4^+$ → Nitrification → $NO_3^-$ → Denitrification

Nitrification

Fertilizer $N_{\text{anorg}}$ → Precipitation $NO_3^-$

$NH_3$ volatilization

Plant biomass

$N_2$-Fixation

N-losses
- Harvest
- Gaseous
- Surface runoff
- Percolation
- Lateral flow
- Gaseous
Biogeochemistry

Conceptual approach

Decomposition/mineralization

N fresh  →  N active  →  N stable

Residue  →  Humus

20 %

80 %

Fertilizer N<sub>org</sub>

NH<sub>4</sub><sup>+</sup>  →  Nitrification  →  NO<sub>3</sub><sup>-</sup>

N<sub>2</sub>-Fixation

Plant biomass

Denitrification

N<sub>2</sub>-losses

Harvest

Gaseous

Surface runoff

Percolation

Lateral flow

Gaseous

Fertilizer N<sub>anorg</sub>

Precipitation NO<sub>3</sub><sup>-</sup>

NH<sub>3</sub> volatilization
Biogeochemistry

DNDC model
process oriented
Li et al. 1992, 2000
Zhang et al. 2002

Decomposition/mineralization

Fertilizer N\textsubscript{org}

Very labile Labile Stable
Labile microbes Stable microbes Microbes
Labile humads Stable humads Humads

NH\textsubscript{4}\textsuperscript{+}

Adsorption
Nitrification

NH\textsubscript{3} volatilization
Precipitation NH\textsubscript{3}

N\textsubscript{2}-Fixation

Plant biomass

N-losses
Harvest
Erosion

Gaseous
Surface runoff
Percolation
Lateral flow

Gaseous
Validation of SWAT-DNDC

Daily discharge and monthly nitrate load

- E = 0.46
- R² = 0.53

- E = 0.54
- R² = 0.71
### Farm management

<table>
<thead>
<tr>
<th>Arable land:</th>
<th>kg N ha⁻¹</th>
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<th>kg N ha⁻¹</th>
<th>Arable land:</th>
<th>kg N ha⁻¹</th>
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</thead>
<tbody>
<tr>
<td>Winter rape</td>
<td>145</td>
<td>Maize silage</td>
<td>22</td>
<td>Maize silage</td>
<td>17</td>
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<tr>
<td>Winter barley</td>
<td>50</td>
<td>Maize silage</td>
<td>22</td>
<td>Sugar beet</td>
<td>149</td>
</tr>
<tr>
<td>Oat</td>
<td>50</td>
<td>Winter wheat</td>
<td>132</td>
<td>Winter wheat</td>
<td>103</td>
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<tr>
<td>Pasture:</td>
<td></td>
<td>Pasture:</td>
<td></td>
<td>Winter barley</td>
<td>32</td>
</tr>
<tr>
<td>Extensively used</td>
<td>50</td>
<td>Extensively used</td>
<td>33</td>
<td>Extensively used</td>
<td>29</td>
</tr>
</tbody>
</table>

Baseline

Agenda2000

CAP
N export related to land use

Agenda2000

N export:
13.4 kg N ha\(^{-1}\) a\(^{-1}\)

CAP

N export:
11.6 kg N ha\(^{-1}\) a\(^{-1}\)
Conclusion

- SWAT was already useful for hydrological assessment
- Through the coupling of SWAT and DNDC the credibility of N simulation could be enhanced
- Minor impacts on both water quantity and quality through moderate land use changes
- SWAT provides valuable tool as part of ITE²M to predict changes in water and nutrient fluxes due to land use change