Quantifying trade-offs between bioenergy production, food production, water quality and water quantity aspects in a German case study
Sven Lautenbach, Martin Volk, Michael Strauch, G. Whittaker
Trade-offs

- What are the searching for?

- How much do we gain in goal A if we decrease goal B?
- Functional relationships between different goals?
- Functional relationships between goals and policy instruments?
From model results to management support?
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- Model
  - Climate
  - Land use
  - Management action
  - Optimization
  - Yield
  - Low flow
  - Water quality

- Yield
- Low flow
- Water quality
Trade-offs

- for bioenergy/food production in the Parthe -

optimization

crop rotation schemes

food

bioenergy

eexisting land use distribution

arable land

non arable land

SWAT

objective function

5 perc. min discharge

average NO$_3^-$ conc

yield food

yield bioenergy

Lautenbach, Seppelt, Strauch, Volk, in prep
Genetic algorithm

- Population of Genoms
- Objective function
- Selection
- Genetic Operators (Crossover, Mutation)
The study area: Parthe watershed

- **Area:** 315 km²
- **Topography:** Flat (106 m and 230 m a.s.l.)
- **Precipitation:** 590 to 640 mm/a (1981-2000).
- Typical lowland river.
- **Runoff dynamics:** High flows in spring (snow melt and rainfall); Low flows in summer with occasional storm flow events.
Management scenarios

Actual crop rotations
(Abraham et al. 2004)
- 32% winter wheat
- 20% winter barley
- 20% winter oilseed rape
- 7% maize

Scenario Food
- no energy crops
  (no rapeseed) in crop rotations

Scenario Biodiesel
- extended rapeseed
  (added to crop rotations)
  ➞ 30% of cropped area
  (+ radical scenario: 100%)

Scenario Biogas
- pure energy crop rotation
  for whole-plant-silage
- two-culture-system
  (Scheffer 1998)
  ➞ 30% of cropped area
  (+ radical scenario: 100%)
Management scenarios

Example: scenario Biogas

*Two-culture-system* according to Scheffer (1999) with crop rotation:

- **January**  → Winter Rye
- **February**  → Sunflower
- **March**  → Winter Barley
- **April**  → Winter Barley
- **May**  → Maize
- **June**  → Winter Rye
- **July**  → Winter Rye
- **August**  → Sorghum Sud.
- **September**  → Triticale
- **October**  → Maize
- **November**  → Winter Rye
- **December**  → Winter Rye

- fermentation residue as fertilizer, direct seeding of summer crop

Sven Lautenbach, Martin Volk, Michael Strauch, Gerald Whittaker
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Biodiesel - rapeseed
Biogas - rapeseed

Biogas, biodiesel, food only
Considering policy constraints
Conclusions/Outlook/Vision

- Importance of spatial configuration
- Policy support needs functional trade-offs
  - Optimization techniques are an important tool for that
- To dos:
  - Additional crop rotation schemes
  - Adaptation of management schemes depending on HRU properties
  - Include contribution margin or and protein content?
Thank you for your attention

Questions?