

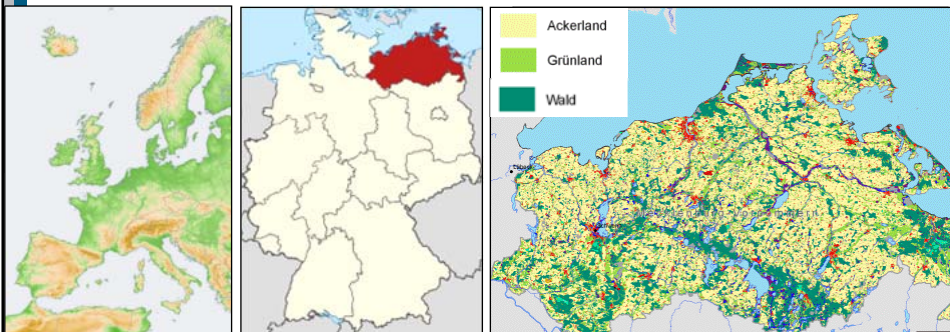
## Nitrogen reduction requirements to reach quality targets for groundwater and coastal waters and the effectiveness of agricultural management adaptations in Mecklenburg-Vorpommern (Germany)

Frank Wendland<sup>1</sup>, Luise Keller<sup>1</sup>, Petra Kuhr<sup>1</sup>, Ralf Kunkel<sup>1</sup>,  
Franka Koch<sup>2</sup> & Björn Tetzlaff<sup>1</sup>

1: Forschungszentrum Jülich, Agrosphere Institute (IBG-3) - 52425 Jülich

2: Federal State Agency for Environment, Nature Protection and Geology  
Mecklenburg- Vorpommern (LUNG) – 18273 Güstrow

## Mecklenburg - Vorpommern



- **One of the 16 Federal German States**
- **Total area: ca. 23.200 km<sup>2</sup>**
- **Population: ca. 1.6 Mio.**
- **Geology: unconsolidated glacial deposits (Weichsel): tills, sand, fens**
- **Land use: agriculture > 60%; forest ca. 22%**

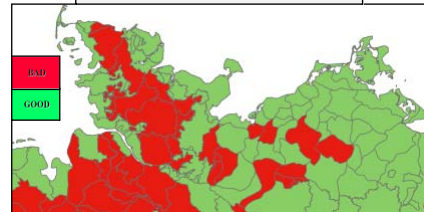
## Status of water resources in Mecklenburg - Vorpommern



Status of surface waters and coastal waters (North Sea and Baltic Sea)



Status of groundwater bodies (nitrate)



Initiation of R&D project on behalf of **Federal State Agency for Environment, Nature Protection and Geology Mecklenburg-Vorpommern (LUNG)** to:

- determine **actual N inputs** into groundwater, surface waters and coastal waters from diffuse and point sources
- assess **N input reduction necessary** to reach quality targets for groundwater and coastal waters
- forecast the **effects of agricultural management adaptations**



Funding period (2011 – 2015)

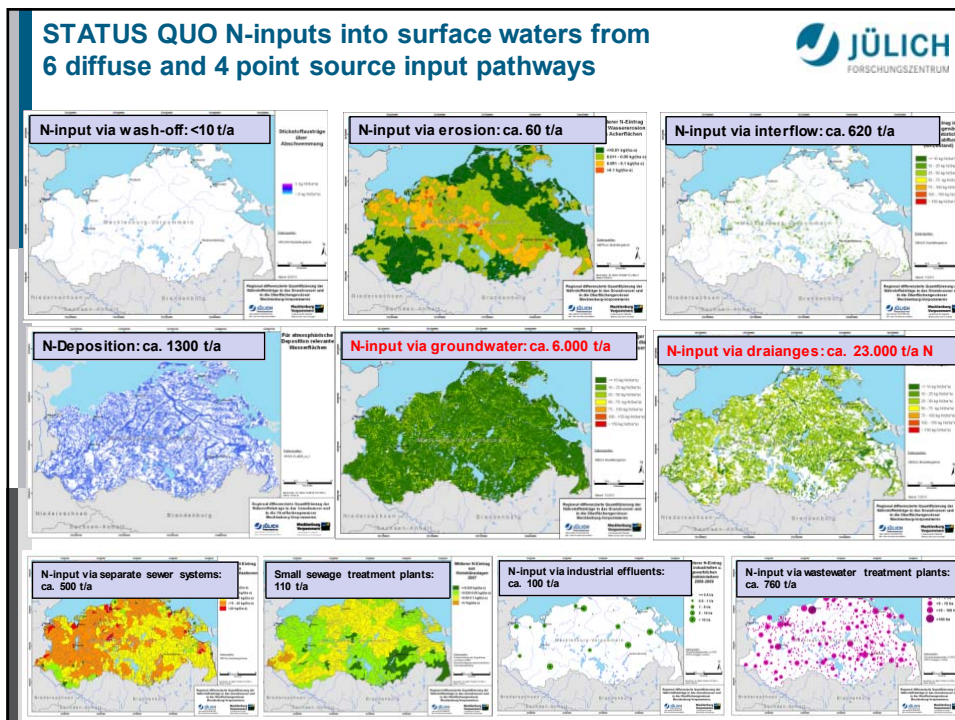
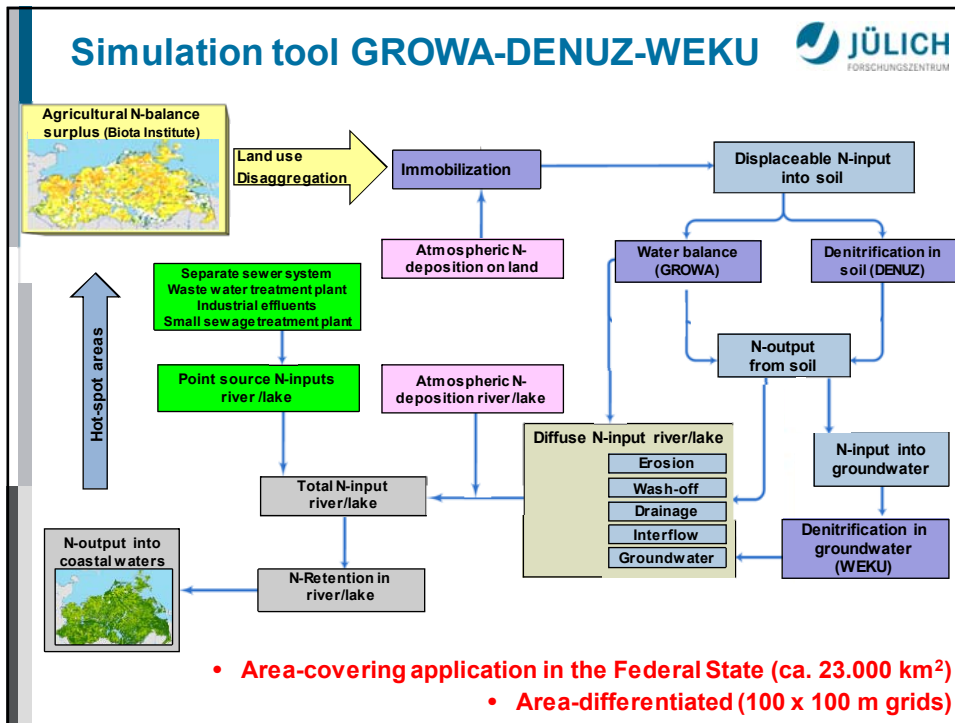
Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

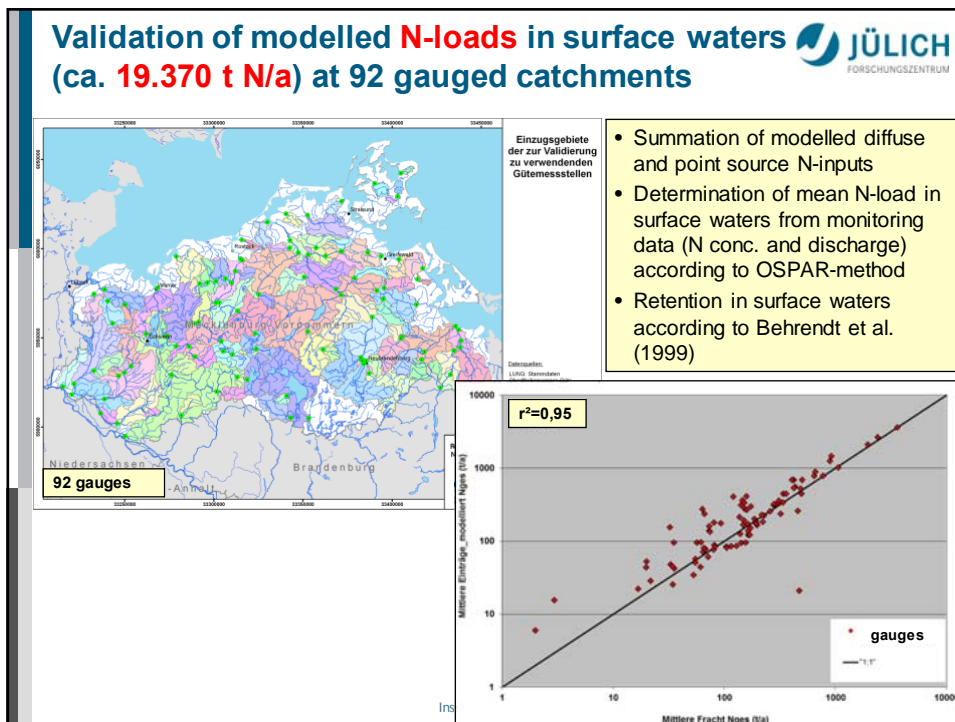
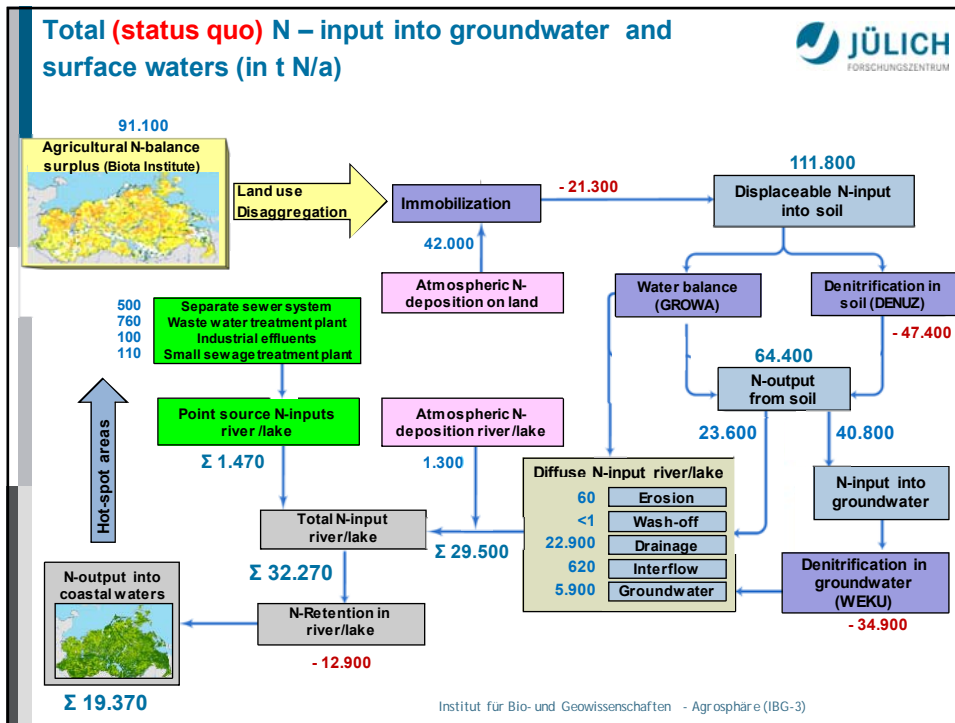
## Structure of talk



1. **Quantification of diffuse and point source N- inputs into groundwater, surface waters and coastal waters based on the simulation tools GROWA-DENUZ-WEKU (status quo analysis)**
2. **Assessment of N reduction requirement:**
  - to reach quality target for groundwater (50 mg/l)
  - to reach quality target for North Sea (2,8 mg N/l) and Baltic Sea (2,6 mg/l)
  - Impact of combined target groundwater/coastal water
3. **Prognosis of effects of agricultural management adaptations**

Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)



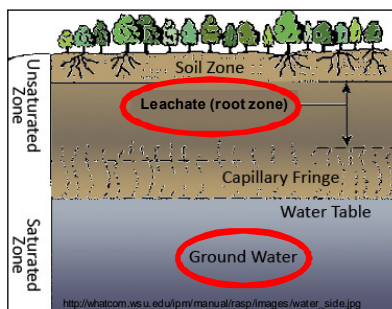


## Structure of talk

1. Quantification of diffuse and point source N- inputs into groundwater, surface waters and the coastal waters based on the simulation tools GROWA-DENUZ-WEKU (status quo analysis)
2. **Assessment of N reduction requirement:**
  - to reach quality target for groundwater (50 mg/l)
  - to reach quality target for North Sea (2,8 mg N/l) and Baltic Sea (2,6 mg/l)
  - Impact of combined target groundwater/sea
3. Prognosis of effects of agricultural management adaptations

## Quality target for groundwater

- Already **nitrate in leachate** shouldn't exceed 50 mg/l



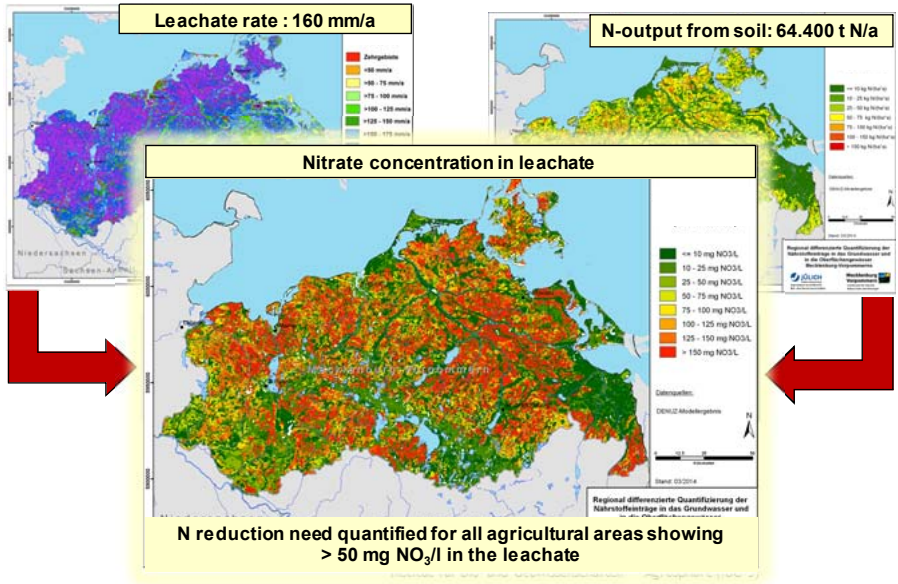
### Positive (side) effects of 50 mg/l nitrate in leachate:

- groundwater quality target will be reached on the long run in any case
- Conservation of substances in groundwater involved in denitrification process (e.g. pyrite)
- Counteract secondary problems for water suppliers due to nitrate pollution of groundwater:
  - *Release of Ni, As, Zn etc. from pyrite in denitrification process*
  - *Precipitation of FeOOH (Goethit) in withdrawal devices*

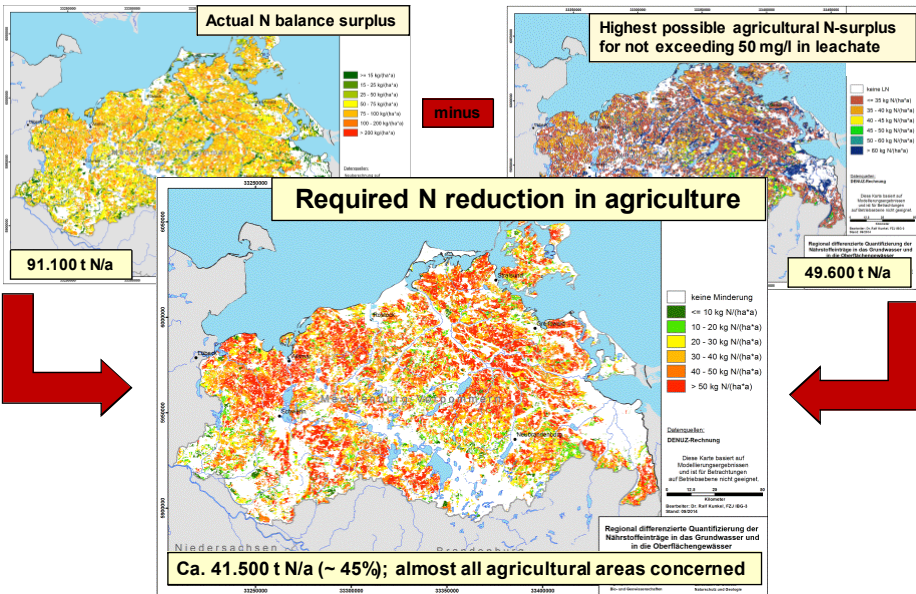
- **EU groundwater directive:** 50 mg/l nitrate in groundwater



## Nitrate concentration in leachate



## Required N reduction in agriculture in order to reach 50 mg/l in leachate (per grid)

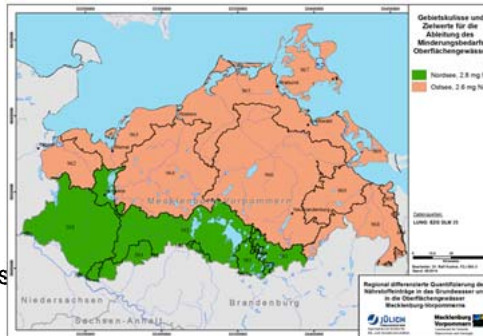


## Quality target for North Sea / Baltic Sea

- Quality target according to BLANO\* (2011, 2014) based on marine ecological reference values to reduce eutrophication of coastal waters:

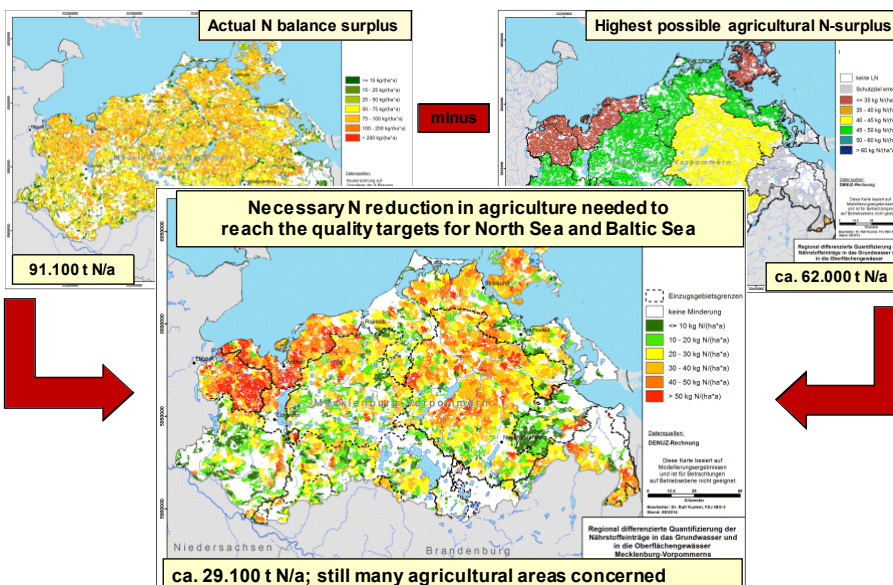
- **North Sea: 2,8 mg N/L**
- **Baltic Sea: 2,6 mg N/L**

- N concentration to be achieved at the outlet of catchments
- Areal settings : catchments displaying „3-character“ LAWA\*\*-classification numbers (18 sub-units)



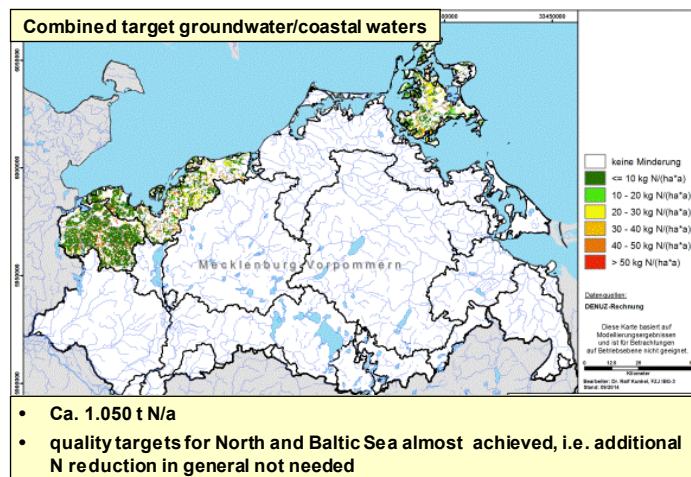
- \*BLANO: Federal/Länder Committee on the North Sea and Baltic Sea
- \*\*LAWA: German Working Group on water issues of the Federal States and the Federal Government represented by the Federal Environment Ministry

## Necessary N reduction in agriculture needed to reach the quality targets for North Sea and Baltic Sea



## Combined target groundwater/coastal waters

Additional N reduction in agriculture necessary to reach quality targets for North Sea and Baltic Sea **after area-covering implementation** of N reduction necessary to reach 50 mg/l in leachate



## Structure of talk

1. Quantification of diffuse and point source N- inputs into groundwater, surface waters and coastal waters based on the simulation tools GROWA-DENUZ-WEKU (status quo analysis)
2. Assessment of N reduction requirement:
  - to reach quality target for groundwater (50 mg/l)
  - to reach quality target for North Sea (2,8 mg N/l) and Baltic Sea (2,6 mg/l)
  - Impact of combined target groundwater/sea
3. Prognosis of effects of agricultural management adaptations



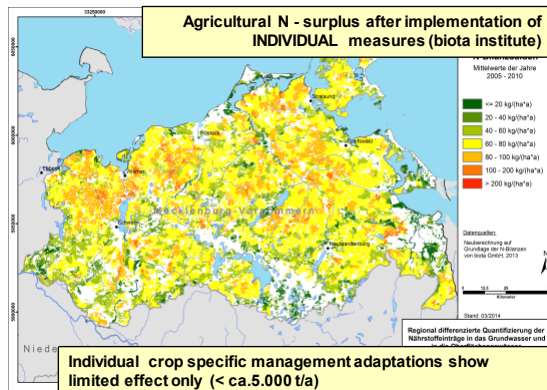
## Prognosis of effects of agricultural management adaptations

### State-wide limitation of N-balance surplus:

- Down to 60 kg N/(ha-a) according to **actual German fertilizer ordinance**
- Further limitation down to 50 kg N/(ha-a) (**revision of German fertilizer ordinance "in discussion"**)

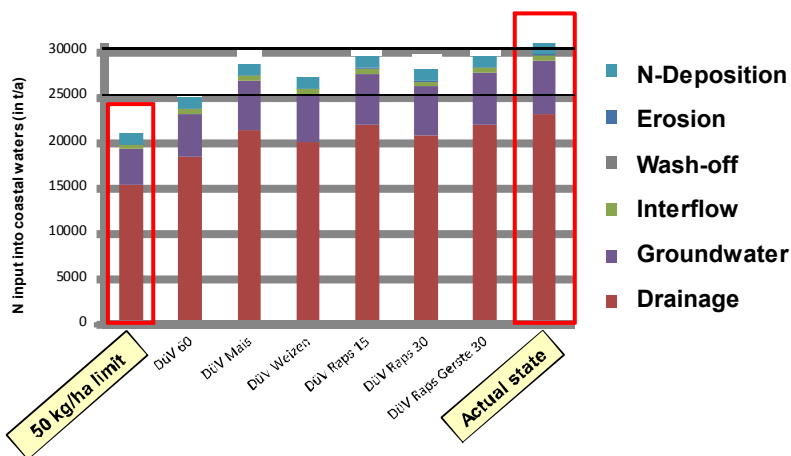
### N surplus reduction by **INDIVIDUAL** agricultural adaptation measures:

- **By 40 kg N/(ha-a)** on all areas where **corn** is grown
- **By 12 kg N/(ha-a)** on all areas where **wheat** is grown and by 27 kg N/(ha-a) in case wheat follows canola (rape)
- **By 15 kg N/(ha-a)** on all areas where **canola (rape)** is grown
- **By 30 kg N/(ha-a)** on all areas where canola (rape) is grown depending on the N-assimilation in autumn and taking the 1. fertilization dose in spring into account
- **By 30 kg N/(ha-a)** exclusively on all areas where canola (rape) is grown corresponding to the **winter barley-cultivation**



Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

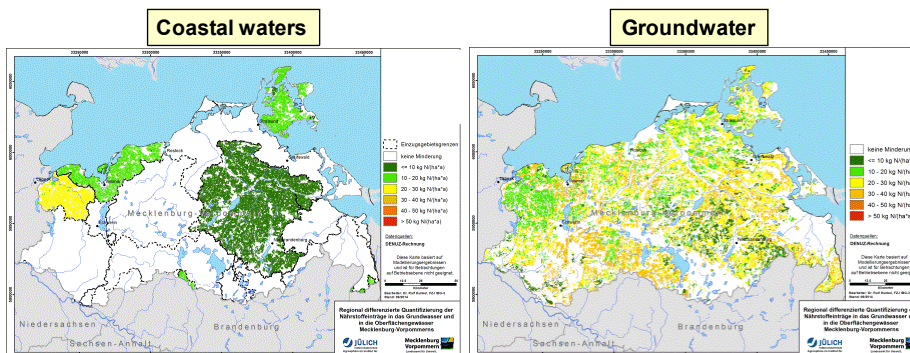
## Effect of agricultural management adaptations on diffuse N input into coastal waters (in t/a)



- **Individual crop specific management adaptations: low impact (< ca.5.000 t/a)**
- **State-wide 50 kg/ha limitation: high impact (ca. 10.000 t/a)**

Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

## Impact of N surpluses limitation down to 50 kg N/(ha·a) with regard to reaching quality targets for...



- Quality targets achievable in many catchments
- remaining additional N reduction: ca. 6.400 t N/a

- groundwater quality target not achievable in many catchments
- remaining additional N reduction: ca. 20.700 t N/a (still half way to go)

Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

## Summary: Key findings from status quo analyses

- Total N export into coastal waters: **ca. 19.000 t/a**
- Total N input into surface waters from 6 diffuse and 4 point sources: **ca. 32.000 t/a**
- 70% of total N input into surface waters originate **via drainages** (ca. 22.900 t/a)
- Contribution from point sources N inputs <5%.
- N input **into groundwater**: ca. 40.800 t/a (ca. 2/3 of N-output from soil)
- However, relative low N input into surface waters **via groundwater**: ca. 5.900 t/a (ca. 18%) as at present ca. 80% of N input into groundwater is still denitrified
- Good agreement between modelled and observed N loads in surface waters

Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

### Summary:

### Key findings concerning N reduction requirement and agricultural adaptation strategies



#### Actual agricultural N surpluses have to be reduced:

- by ca. 41.500 t N/a to reach groundwater quality target
- by ca. 30.000 t N/a to reach quality targets for coastal waters
- quality targets for coastal waters can almost be achieved **after area-covering implementation** of N surplus reduction to reach groundwater target (combined target)

➤ *Strategies to reach the quality targets for coastal waters should include the implementation of area-covering measures to reach 50 mg/l in leachate*

#### Effects of analyzed agricultural adaptation strategies:

- Reduction potential of individual (commonly applied) agricultural adaptation measures will not be high enough to achieve the quality targets for groundwater and coastal waters.
- Even a throughout limitation of N-balance surplus to maximal 50 kg N/(ha·a) alone will not be enough to achieve the groundwater quality target
- *The combined application of agricultural adaptation measures in addition to a throughout limitation of N-balance surplus to maximal 50 kg N/(ha·a) may show positive effects; corresponding scenario analyses may help to find "regional optimal" combinations*

Institut für Bio- und Geowissenschaften - Agrosphäre (IBG-3)

