Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Volkswirtschaftsdepartement EVD
Forschungsanstalt Agroscope Reckenholz-Tänikon ART

Impact and causes of decreasing nitrate contents in the groundwater of the canton of Berne

Ernst Spiess and Volker Prasuhn

Agroscope Reckenholz-Tänikon ART, Zürich

Ecological measures in Swiss agriculture

1993 Introduction of direct payments for:

Integrated Production (until 1998)

Organic Agriculture

Extensive production of cereals and oilseed rape

Ecological compensation areas

etc.

Ökologischer Leistungsnachweis (since 1999)

Cross Compliance

- equilibrated whole-farm N and P balance (Swiss Balance)
- adequate share in ecological compensation areas
- adequate crop rotation (maximal share for main crops)
- appropriate soil protection in the winter period (cover crops)
- etc.

Other influencing factors

- New policy measures (due to WTO, bilateral treaties between Switzerland and the EU etc.)
- Change in nutritional habits (e.g. lower meat consummation, more organic food)
- Technical progress (e.g. direct drilling, heavier machines)

➢ Other price-cost relationships for agricultural products
Change in land use and in animal numbers

- Reduction of NOx emissions (lower N deposition)
- etc.

Evaluation of ecological measures

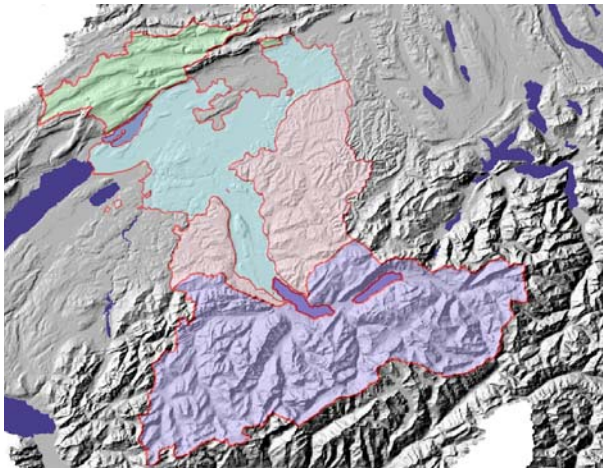
Target of the Federal Office for Agriculture:

Nitrate contents of selected, fully representative groundwaters are to be reduced by 5 mg NO_3/L on average between 1990/92 and 2005.

Case study „Canton of Berne“

Model calculations of the decrease in the amount of nitrate leached between 1990 and 1999

Characterisation of the canton of Berne



	Altitude	Forest	Arable land	Grassland	Other
Alps	550 - 4200	27%	0%	33%	39%
Prealps	500 - 1500	36%	24%	33%	7%
Central Plains	400 - 900	25%	41%	12%	21%
Jura	450 - 1600	53%	11%	30%	6%

Model calculations with MODIFFUS

- Empirical statistical **mo**del for the estimation of **diffus**e inputs of nitrogen and phosphorus into ground and surface waters
- Use of the modules "Water flows" and "Nitrate leaching"
- Estimation of the amount of nitrate leached under grid cells (1 ha) by coupling of land use data with loss coefficients by means of a GIS

Model calculations with MODIFFUS 2

- Standard loss coefficients for nitrate leaching, taken from our own lysimeter trials, literature and expert knowledge (multi-annual mean values)
- Standard values are corrected with factors for:
  - amount of percolating water
  - altitude (duration of the growing season)
  - soil type
  - N fertilization
  - intensity of grassland management
  - denitrification potential
  - tile drainage

Data used for MODIFFUS

Spatial data:

- land use statistics 1989/95 (grid size of 1 hectare)
- digital elevation model (DEM) (altitude, slope, exposition)
- soil map (Bodeneignungskarte) 1 : 200'000
- climate map (Klimaeignungskarte) 1 : 200'000
- map of long-term precipitations (grids of 4 km^2)
- map of Swiss municipalities

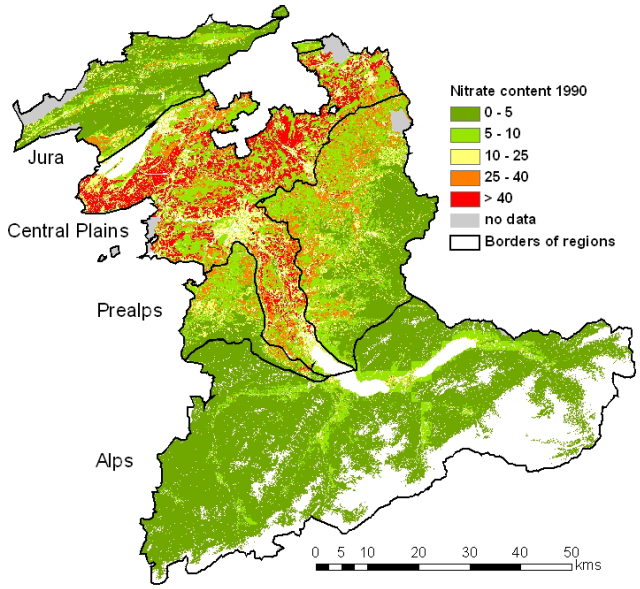
Statistical data from annual agricultural census:

- land use per farm (grassland, arable crops)
- animal numbers per farm (manure N)

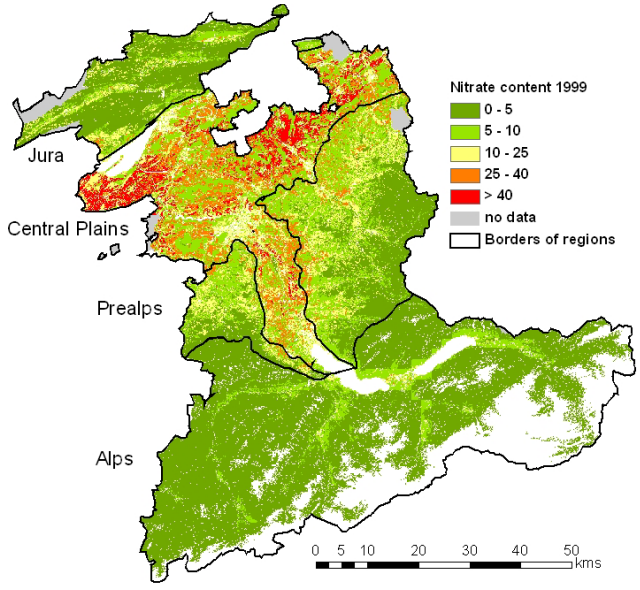
Precipitations, amount of percolating water and amount of nitrate leached in 1999

Region	Precipitation	Percolating water		Nitrate quantity	Nitrate content
	mm	mm	Mio. m^3	t N	mg NO_3/L
Alps	1823	820	2238	1259	2.5
Prealps	1376	749	900	1691	8.3
Central Plains	1127	457	584	2832	21.5
Jura	1504	924	487	590	5.4
Total	1545	734	4209	6372	6.7

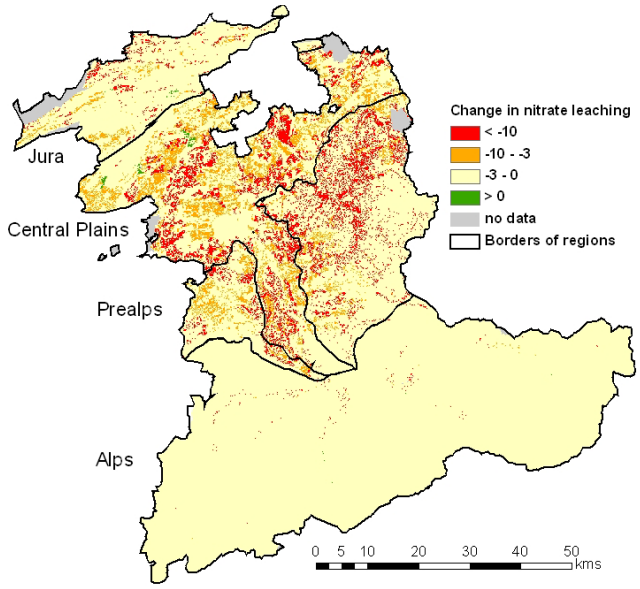
Nitrate contents below the soil profile 1990
(in mg NO_3/L)



Nitrate contents below the soil profile 1999
(in mg NO_3/L)



Change in nitrate leaching 1990-99
(in kg N/ha)



Reduction of nitrate leaching 1990-99 by various measures
(in % of nitrate leaching under total land area in 1990)

Influencing factor	Reduction
Change in the shares of arable crops	4%
Lower N fertilizer use in arable farming	4%
More intensive cover cropping	3%
Decreasing atmospheric N deposition	1%
Grassland with no or low N fertilization	< 1%
Total	12%

Reduction due to ecological measures: > 6%

Causes for reduction in nitrate leaching

- Change in the shares of crops in arable farming:
  less potatoes (-27%, 1990-99), cereals (-16%),
  more temporary grassland (+18%), sugar beets (+32%)
- Lower N fertilizer use in arable farming:
  lower mineral N fertilizer use (-24% in CH, 1990-2000)
  lower use of animal manure (- 9% in the canton of Bern;
  higher decrease in the Central Plains and the Prealps)
- More intensive cover cropping:
  no change in the area of cover crops, but less spring-sown crops and thus a less winter fallow;
  "Bodenschutzindex"

Plausibility tests for MODIFFUS

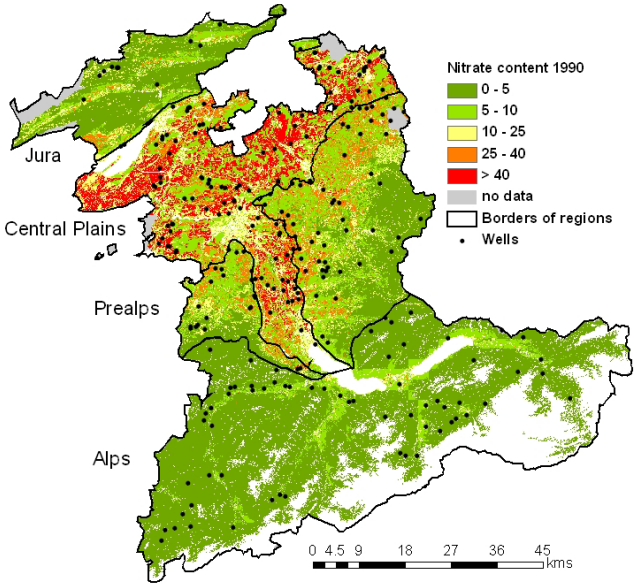
Comparison of model results with :

- water discharge at the outlet of 37 sub-catchments
- N load at the outlet of 37 sub-catchments
  (calculation of all diffuse N loss pathways
  and of N inputs by point sources is necessary)
- nitrate contents of groundwater in wells of
  drinking water supplies

Comparison of modelled nitrate contents with those of wells

Region	MODIFFUS mg NO_3^-/L			Wells of drinking water supplies mg NO_3^-/L			*number*
	1990	1999	change	1990-92	1999-01	change	*of wells*
Alps	2.6	2.5	-3%	2.5	2.6	1%	*64*
Prealps	9.8	8.3	-16%	19.6	16.9	-14%	*76*
Central Plains	24.7	21.5	-14%	25.8	24.1	-7%	*109*
Jura	5.9	5.4	-10%	7.5	7.4	-1%	*14*

Sites of analyzed wells



Conclusions

- Nitrate contents decreased between 1990 and 1999.
- Three influencing factors could be identified as contributing much to the decrease in nitrate contents.
- MODIFFUS is suitable for calculations in great areas where we often have a lack of base data.
- A comparison of modelled nitrate contents with measured values gave satisfying results.