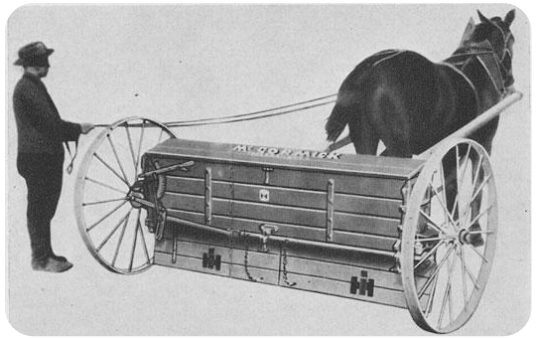
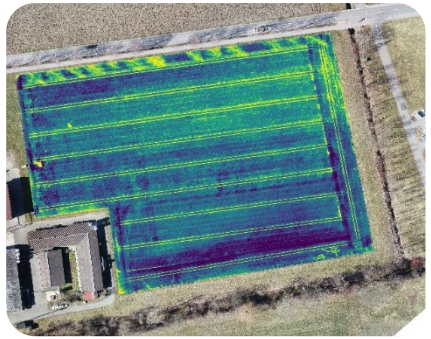
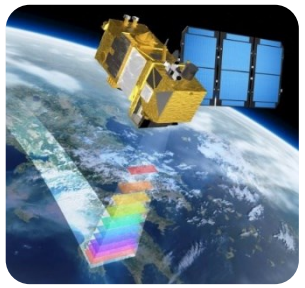
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie,
de la formation et de la recherche DEFR

Agroscope

The Swiss fertilizer recommendation - historic development, current status, integration in legislation and ways forward to sustainable nutrient management



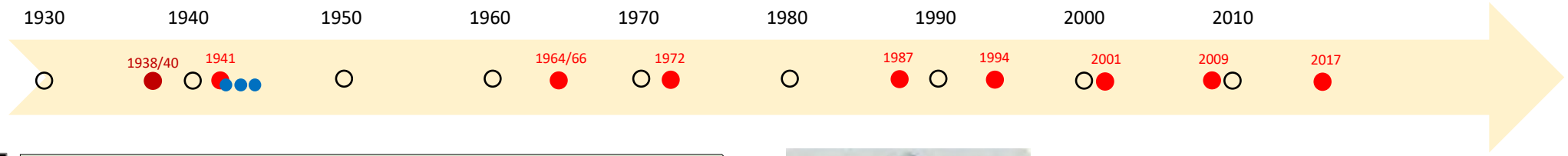
Liebisch F. et al.

Agroscope, Gewässerschutz und Stoffflüsse, 8046 Zürich, Schweiz

Outline

- Historic development and current fertilizer recommendation
- Examples for ways forward for fertilizer recommendation
- The NGO Nitrate project ahead of legislation?!

History of fertilizer guidelines in Switzerland



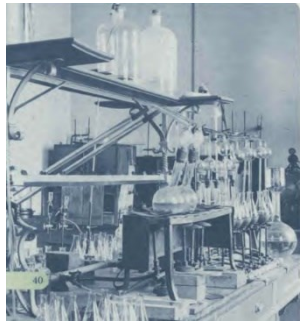
Neue Impulse..

Since 1930 till 1980: analytical Developments, chemical extraction
Fertilizer value of organic sources, and rough estimation of demand

Nmin, um 1980

Abbildung 9: Bodenprobenahme mit dem automatischen Stechgerät von bodenproben.ch. Bild: Joe San

Beispiele



Labor für Agrarkulturchemie, ZH Oerlikon.

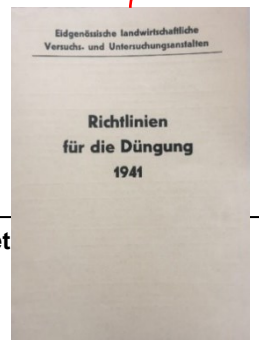
Fields specific estimation, soil Nmin method mentioned (Wehrmann & Scharpf, 1977) (since 1987 in PRIF)

Corrected fertilizer Norm and Nmin, Sensors mentioned

N

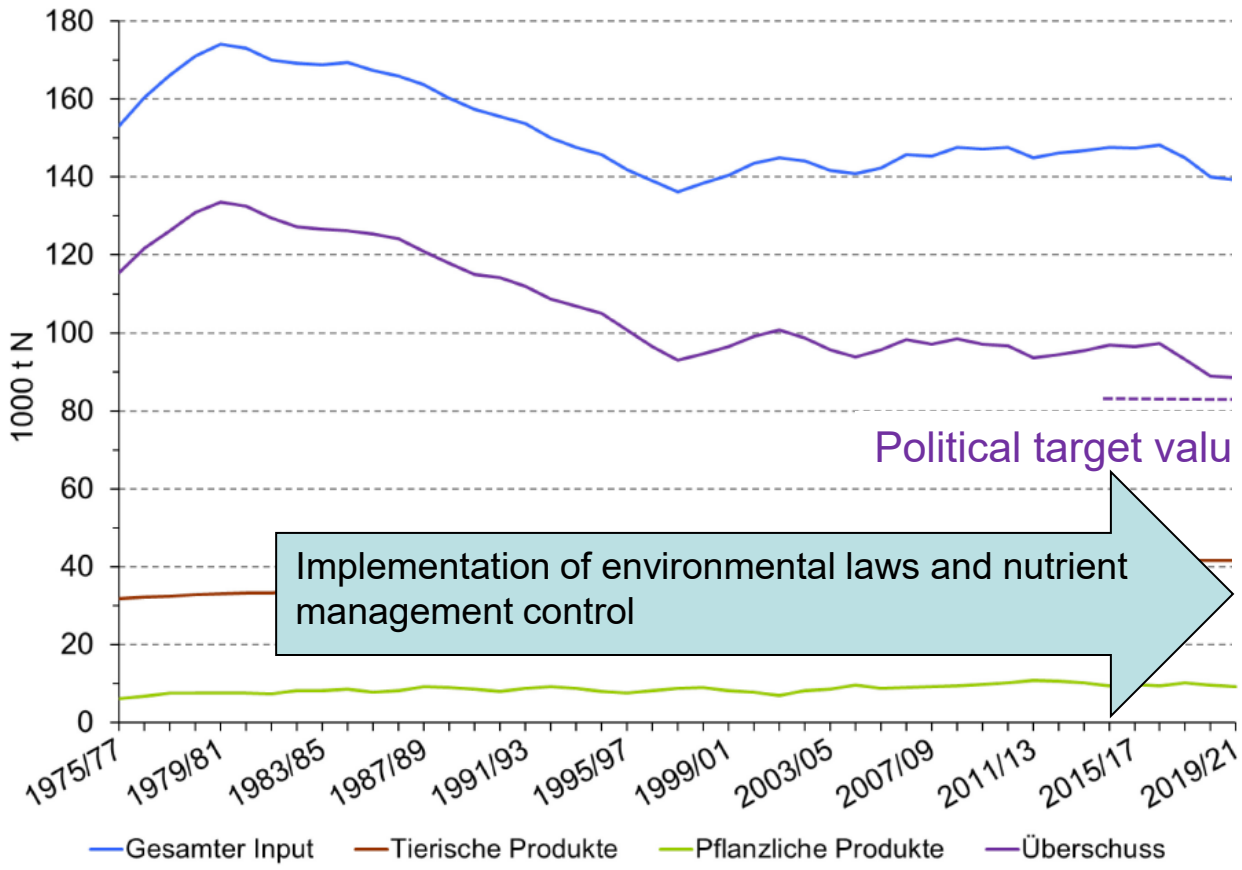
1987

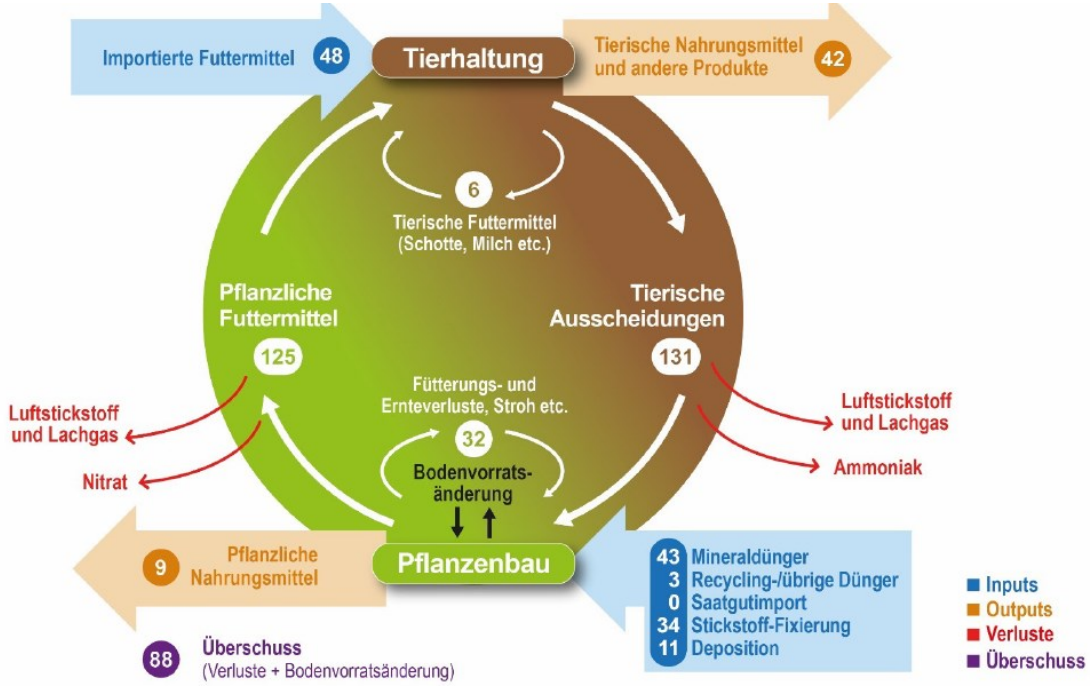
First detailed guideline for Nmin



Liebisch et

The Swiss agricultural Nitrogen balance (farm gate) indicates inefficient nutrient managment



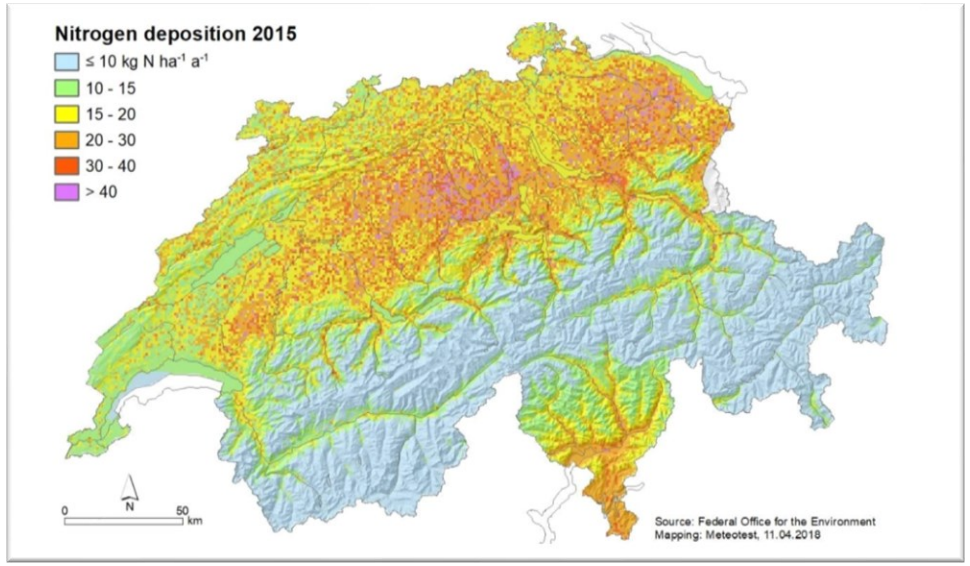


The Swiss N cycle Ø 2019-2021 (in thousend t), Spiess und Liebisch 2023

~ 37 % N recovery / use

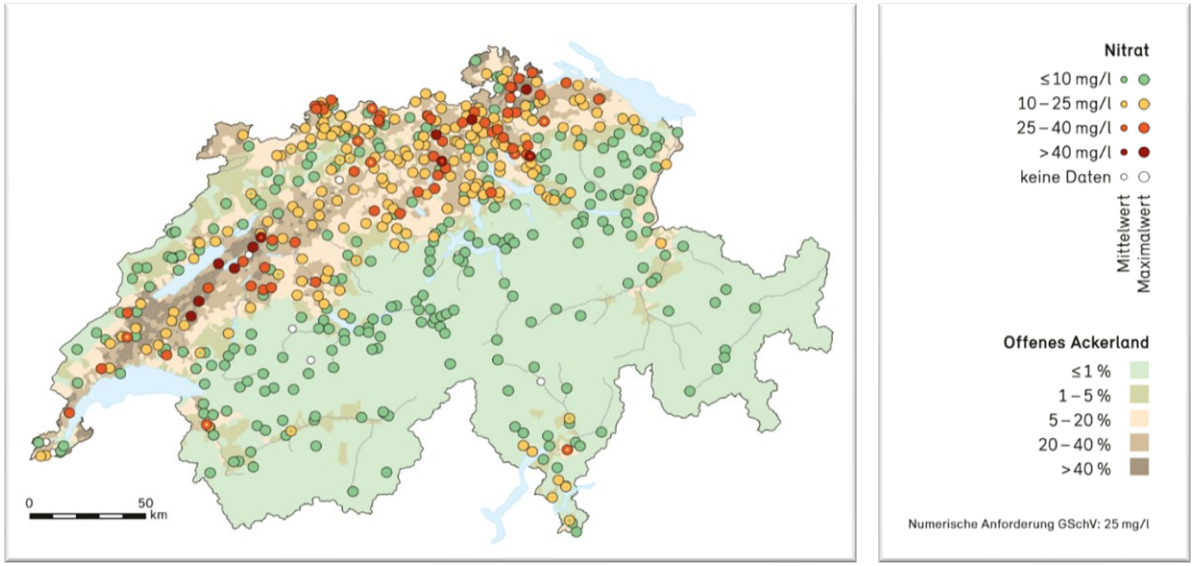
In Switzerland N use in agriculture is linked to environmental problems

Nitrogen deposition, modelled



High N deposition is strongly related to high animal density and thus Ammonia emissions, (Rihm, B., Künzle, T. , 2019: Mapping Nitrogen Deposition 2015 for Switzerland)

Nitrate in drinking water resserves



15-20% of measured reserves are above the quality threshold, mostly under intensive agricultural use (FOEN, 2019)

The principles of fertilization (PRIF): the base for fertilization norms and corrections

Fertilization Norm (kg N/ha Table 9)

↓

Correction according to the soil, climate and management

↓

Correction according to the nutritional status of the plant and the soil in situ, precision methods

Base

Used in legal context

Good practice

Available,
use not binding

Best practice?

Partly available, emerging, to be developed and integrated

W. Richner et al. GRUD, Agrarforschung 06 2017, https://www.agrarforschungschweiz.ch/archiv
T. Guillaume, F. Liebisch

PRIF Methods for N correction:

N_{min} & Adjusted Norm

Ref. value - N_{min} - Correction factors = Recommendation

- Time-intensive and expensive
- Direct measurement in the soil

Norm + Correction factors = Recommendation

$$= \text{Norm} + f_{yield} + f_{SOM} + f_{mech} + f_{PC} + f_{OF} + f_{precip} + f_{ST}$$

Düngungsnorm (kg N/ha, Tabelle 9) Korrektur in Abhängigkeit des Ertrages (Tabelle 11 [1])	+/–	**Korrekturen nach Boden-, Klima- und Anbaubedingungen** 1. N-Mineralisierungspotenzial des Bodens und Tongehalt: Tabelle 12 2. Vorfrucht: Tabelle 13 3. Nachwirkung von organischen Düngern: Tabelle 14 4. Winter- und Frühlingsniederschläge: Tabelle 15 5. Hacken nach dem Auflaufen der Kultur: Tabelle 16 6. Auswirkungen der Bedingungen im Frühling auf die Mineralisierung von OS: Tabelle 17	=	**zu düngende N-Menge** (kg N/ha) X

- Based on model-predictions and more information about the field is required i.e. previous crop,
- Free of costs, digitally available (soon)

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International Comparison of fertilizer recommendation

TABLE 4 Components (inputs and outputs) included in the nitrogen budget by each country, ranked in decreasing order of number used.

	Outputs (direct or through coefficient)					Inputs (or not needed to be brought)										
	S_{end}	C_{end}	L	A	AUC	S_{start}	C_{start}	Hu	Past	CR	IC	Ir	M_1	M_{n-1}	Atm D	AdY
	Soil end	Uptake	Leach.	Atmos. Losses	Apparent Use Coef.	Soil start	Crop start	Humus min.	Pasture min.	Crop residues	Interm. crops	Irrigat.	Manure	Manure Year-1	Atmos. deposition	Adjust. of the yield
France																
Italy																
Switzerland		Norm	Verluste													
Belgium (Wal.)																
Germany																
United Kingdom																
Spain																
The Netherlands																
Ireland																
Luxembourg																

Note: C_{Start} = Nitrogen alre
and variety criteria for cere
harvest; Hu = Nitrogen ne
type of residues; IC = Effec
M_1 = Nitrogen from the or
brought the year before; L
prevailing during its spreading.

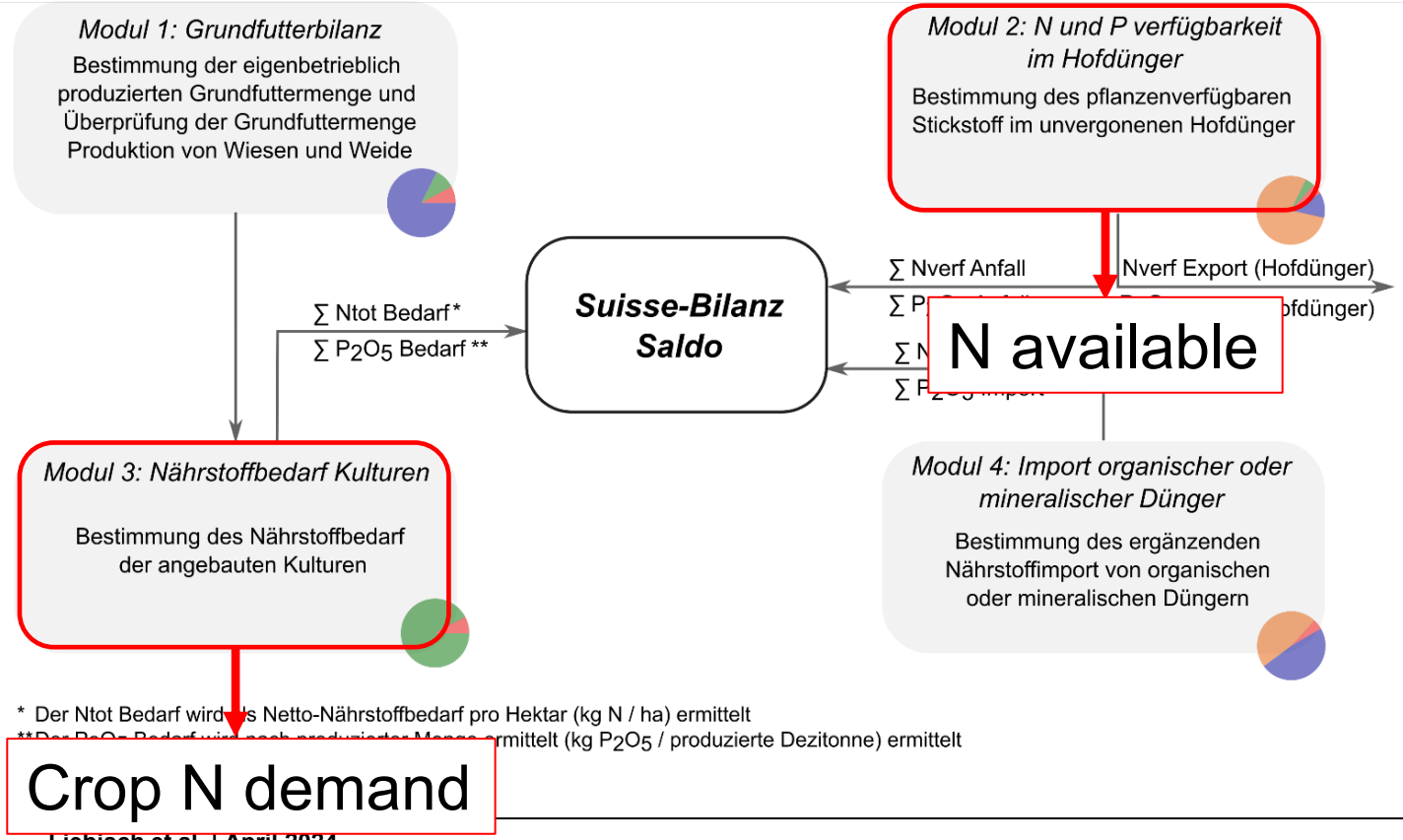
~ SuisseBilanz

Fertilizer planning or good fertilization is mandatory (not binding)
The legal enforcement tool for nutrient management ist the Suisse Bilanz

- Integrates no additional sources of N then fertilizer (no environment, soil or management factors)
- Allows environmental losses
- Average on farm level

Lionel Jordan-Meille et al. 2023 Comparison of nitrogen fertilisation recommendations of West European Countries. https://doi.org/10.1111/ejss.13436

Swiss farmers need to prove an even balance between N input from animal production and fertilizers and crop N demand at farm level → the **Suisse-Balance**



- changes in livestock, manure and field management improved agricultural production
- society and policy ask for more sustainable nutrient management.
- Broader knowledge base
- No deep revision since 90ies

Liebisch et al. | April 2024

Color in pie chart explains data sources for the modules

Ways forward for fertilizer recommendation

- Integrating a model into the suisse balance to use current knowledge on the feed and manure cascade and N use
- Making better use of soil extraction information, soil and climate factors
- Digital transformation, software and web support
- Remote sensing and precision farming

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Evaluating a model implementation for an improved nitrogen management regulation in Switzerland

Liebisch, F., Mayer, J. & Epper, C.A.

Agroscope, Gewässerschutz und Stoffflüsse, Zürich

RAMIRAN 2023
Cambridge UK

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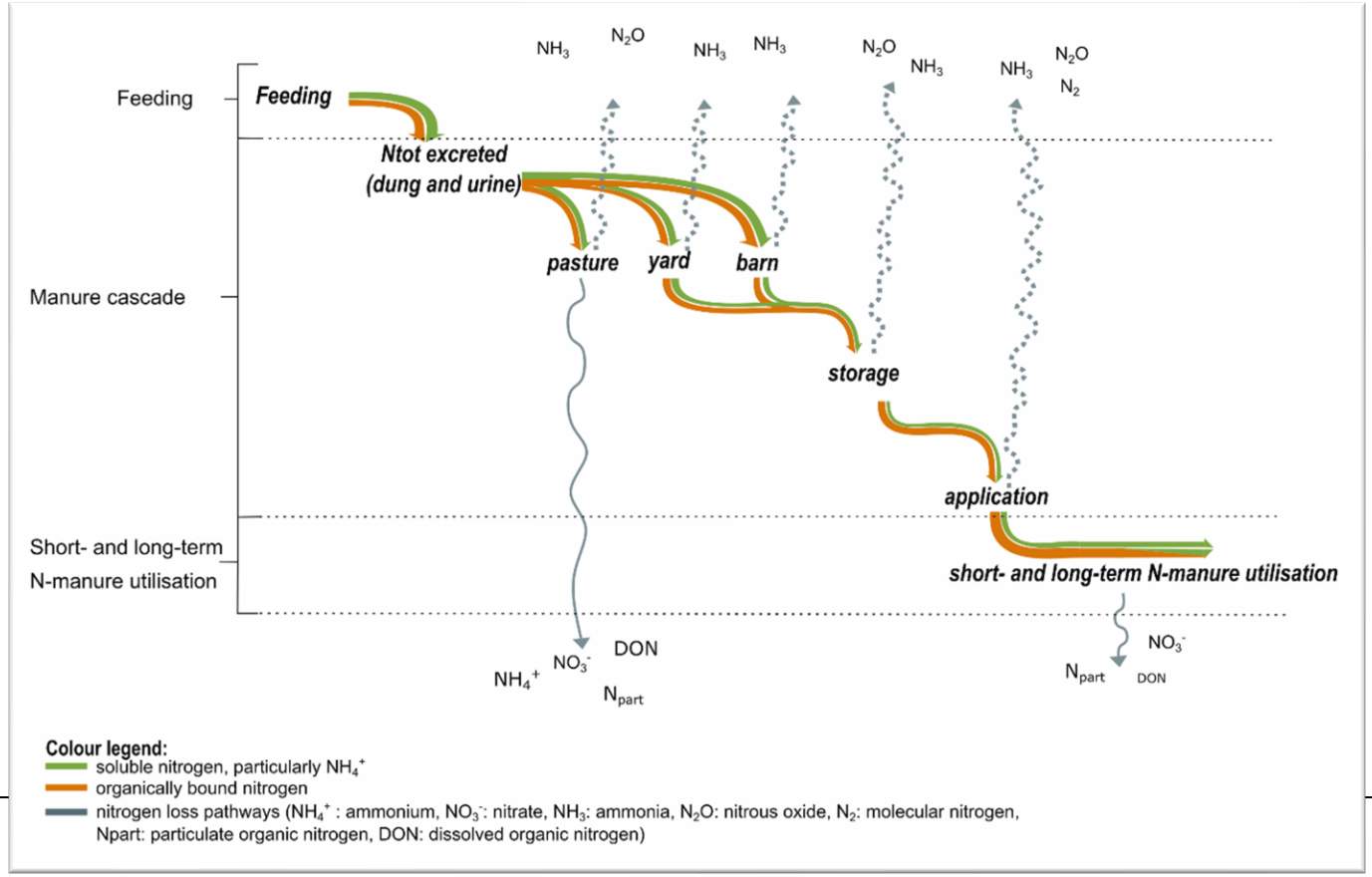
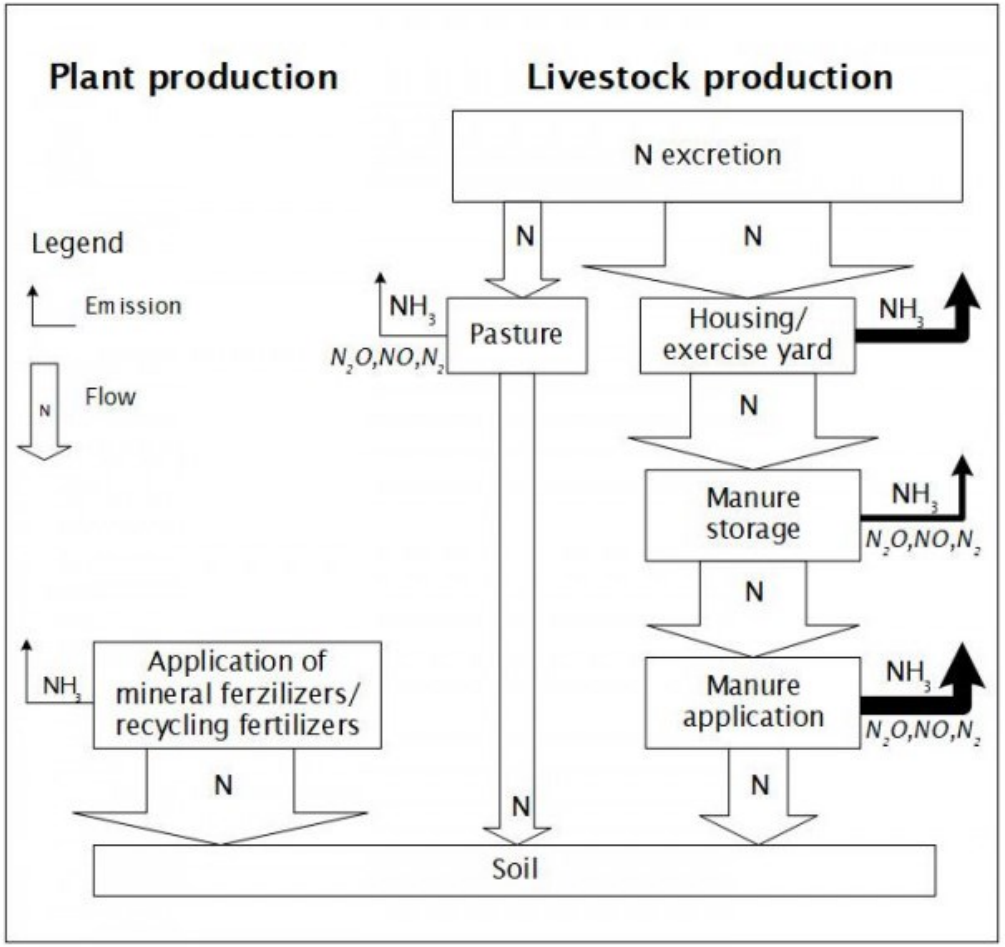
Base and aim of the study

- Integrate actual knowledge into the balance
- Allow evaluation of loss reduction measures along manure cascade
- Compare current and modelled N available from animal manure



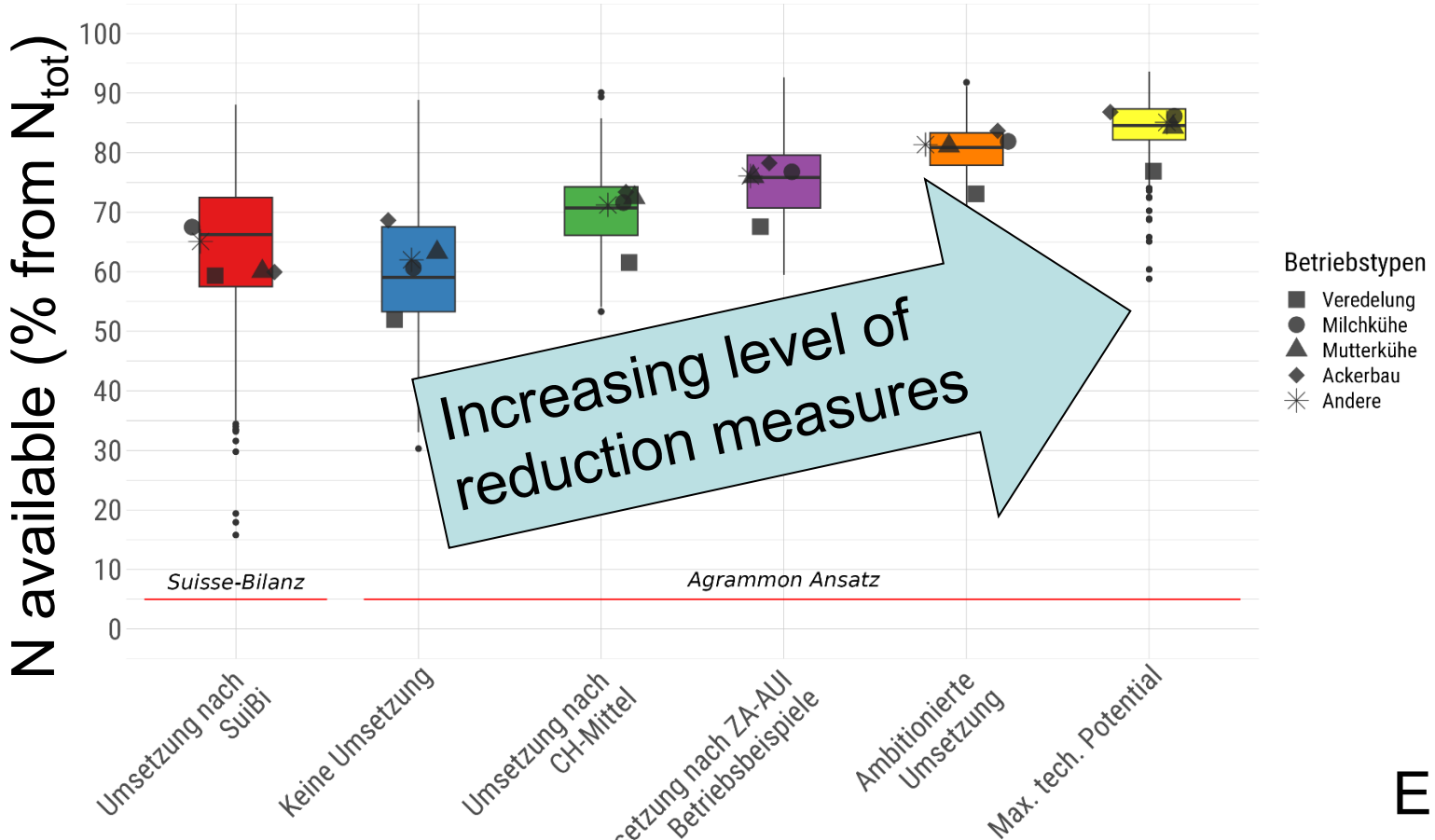
Methodology: Modelling the manure cascade and loss reduction measures



- Flux model

Agrammon, 2022. https://agrammon.ch/

Current Balance underestimates available N Model is farm specific and allows targeted implementation of meassures



Epper et al.

P-K Fertilizer recommendation in Switzerland

1. Soil K Test for available K

HNO3

Mehlich3

BaCl2

AA-EDTA, AA, AL

Bray

CO_2-H_2O, H_2O

Madaras and Koubova 2015
Zebec et al. 2017

2. Yield calibration

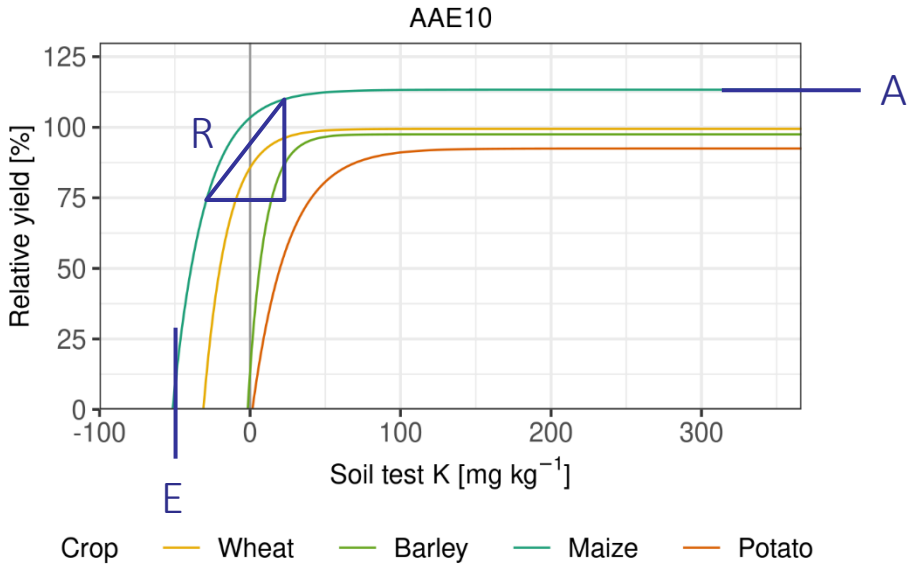
yield ~ soil K + soil clay content

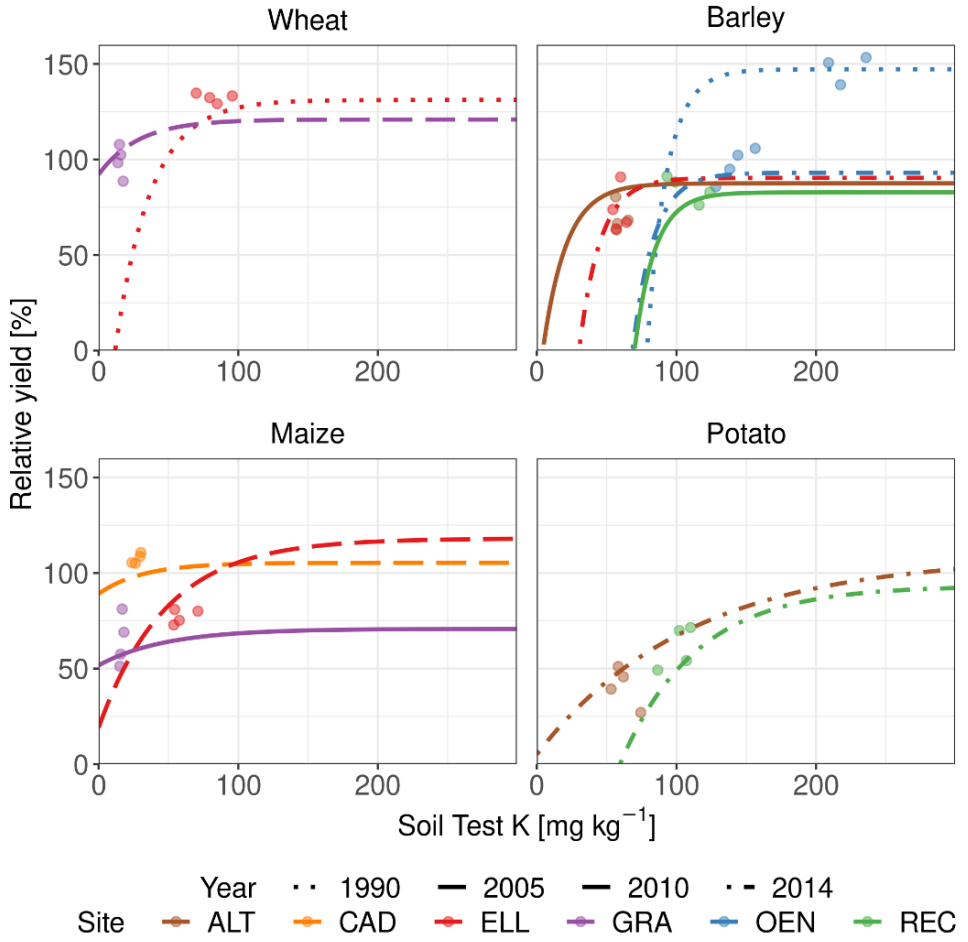
Acker- und Futterbau					
AAE10-K	Tongehalt der Feinerde (%)				
mg K/kg	< 10	10–19,9	20–29,9	30–39,9	≥ 40
0–19,9	1,5	1,5	1,4	1,4	1,2
20–39,9	1,5	1,4	1,4	1,4	1,2
40–59,9	1,4	1,4	1,3	1,2	1,0
60–79,9	1,4	1,2	1,2	1,2	1,0
80–99,9	1,2	1,2	1,2	1,0	1,0
100–119,9	1,2	1,2	1,0	1,0	1,0
120–139,9	1,2	1,0	1,0	1,0	0,8
140–159,9	1,0	1,0	1,0	1,0	0,8
160–179,9	1,0	1,0	1,0	0,8	0,8
180–199,9	1,0	1,0	0,8	0,8	0,6
200–219,9	1,0	0,8	0,8	0,8	0,6
220–239,9	0,8	0,8	0,8	0,6	0,6
240–259,9	0,8	0,8	0,6	0,6	0,4
260–279,9	0,8	0,6	0,6	0,6	0,4
280–299,9	0,6	0,6	0,6	0,4	0,0
300–319,9	0,6	0,6	0,4	0,4	0,0
320–339,9	0,6	0,4	0,4	0,0	0,0
340–359,9	0,4	0,4	0,0	0,0	0,0
360–379,9	0,4	0,0	0,0	0,0	0,0
380–399,9	0,0	0,0	0,0	0,0	0,0
400–419,9	0,0	0,0	0,0	0,0	0,0
≥ 420	0,0	0,0	0,0	0,0	0,0

3. Boden K Versorgungsklassen

PRIF, 2017

Yield effect of soil K





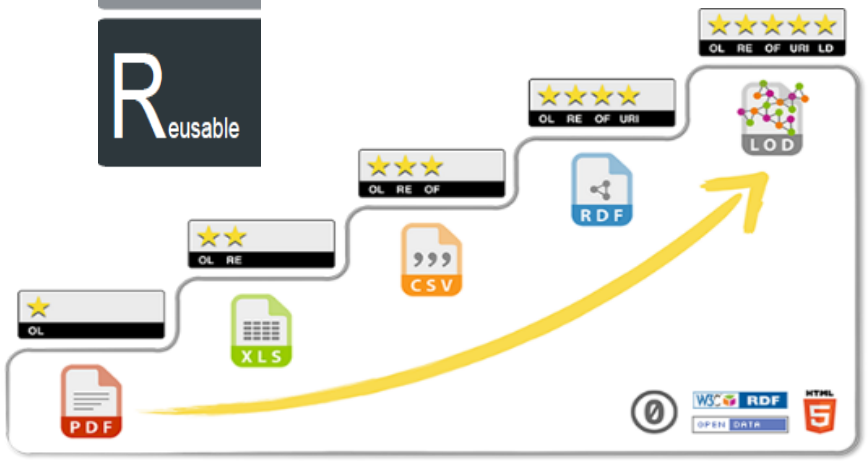
Covariables: crop + fertilization + Ca + Mg + clay content + pH + temperature + precipitation

Random effects on asymptote: year / location

$$\text{relativer Ertrag} = A * (1 - e^{-R * (STP + E)})$$

Project WebGRUD

Pilotproject to get the book / fertilizer recommendation into the digital age (Open Government Data)



Daten oder Datenmodell

maschinenlesbar, vollständig,

aktuell, durch Metadaten beschrieben und soweit möglich, Rohdaten.

offene Nutzungsbedingungen, nicht proprietär.

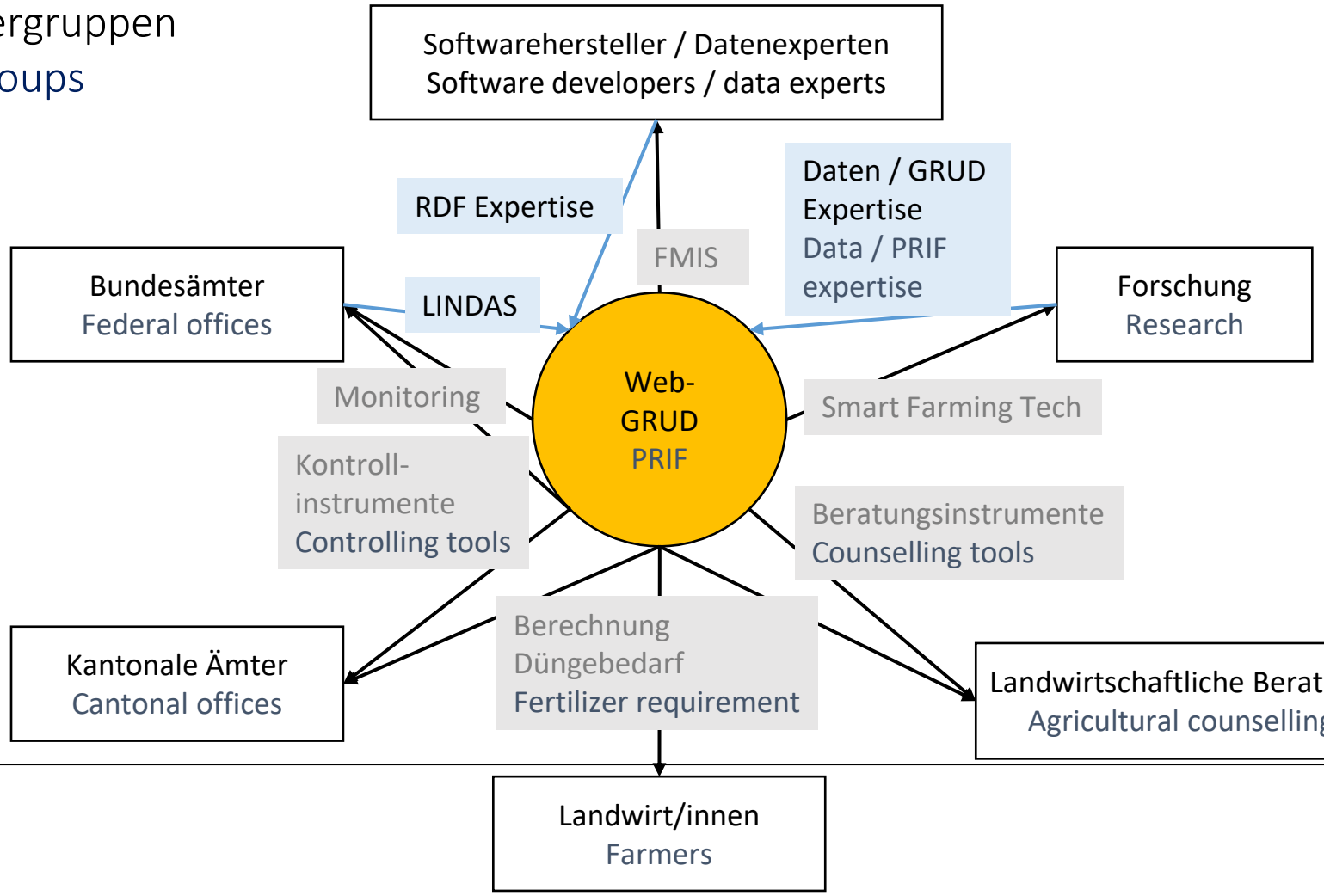
uneingeschränkt und diskriminierungsfrei,

einfach auffindbar, permanent verfügbar.

Machine readable formats

Lösung und erwartetes Ergebnis
Solution and expected outcome

WebGRUD Nutzergruppen
WebPRIF user groups



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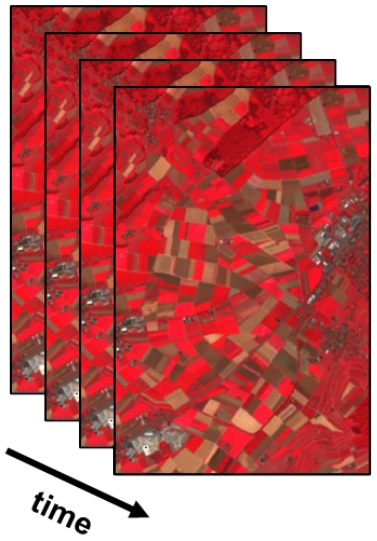
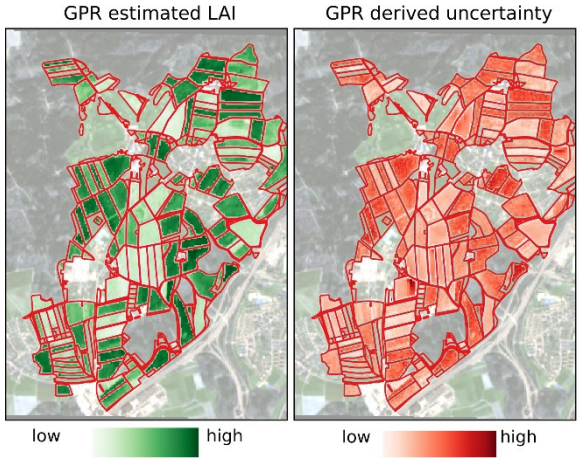
Remote sensing systems: Vegetation status and productivity

Satellite data



Inference

Training



validation

Training and validation sites

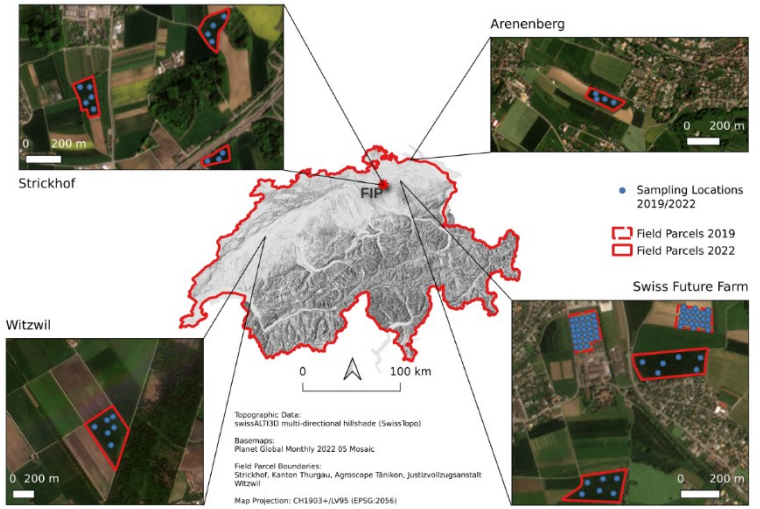
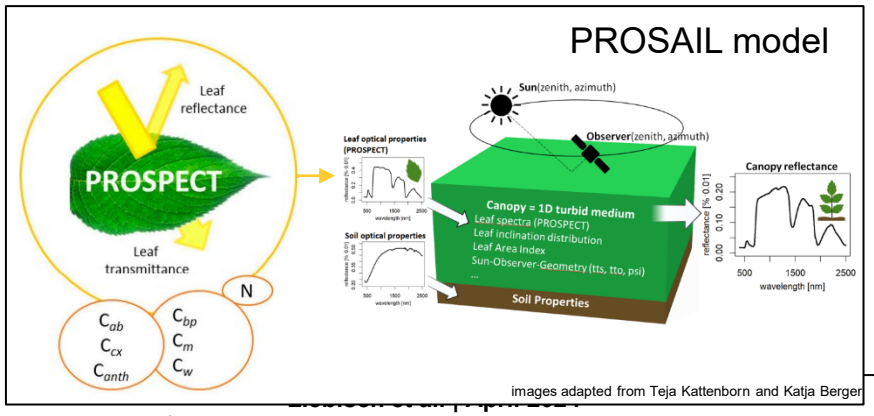


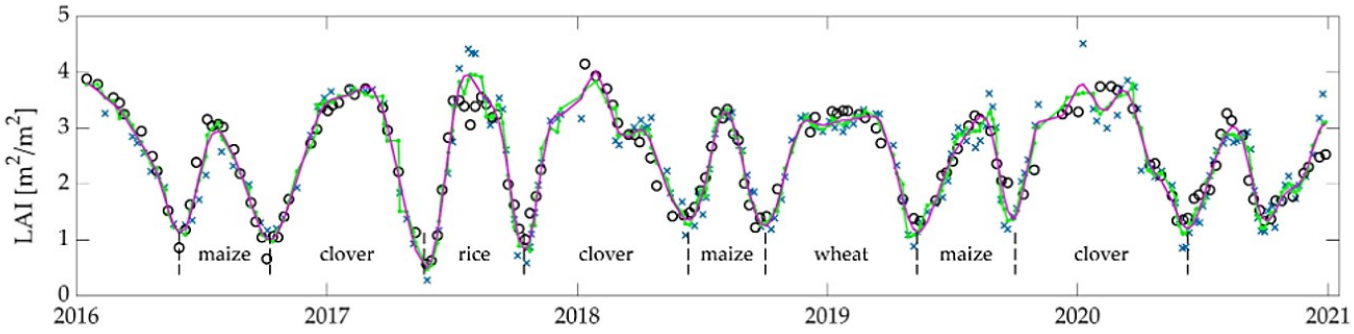
Figure 1: Overview map showing the locations where in-situ samples were taken in 2019 (dashed field parcel boundaries) and 2022 (solid lines). FIP denotes the location of the field-phenotyping platform of ETH Zürich.

Physically based radiative transfer model



images adapted from Teja Kattenborn and Katja Berger

Time series



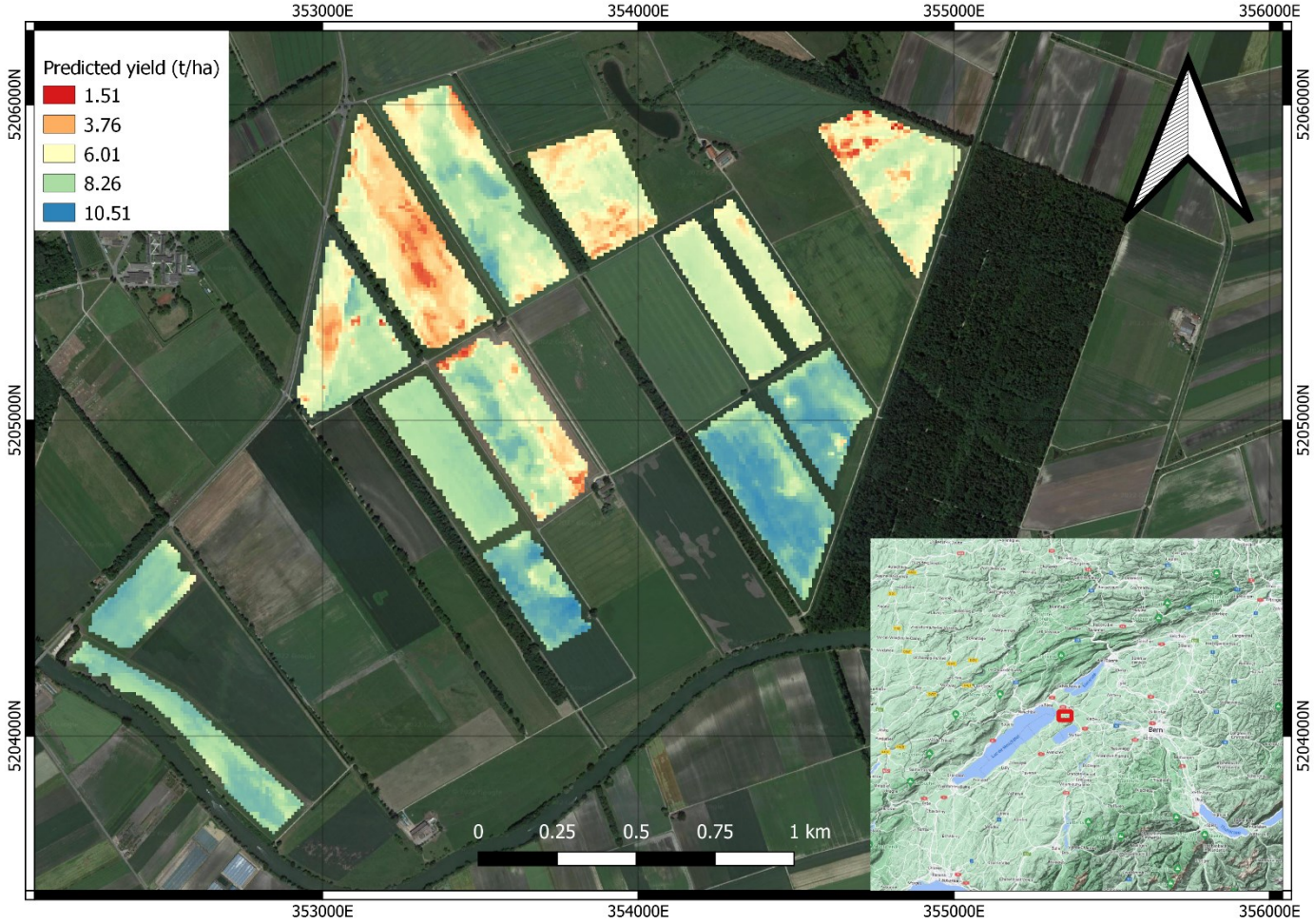
Agroscope

EOA
Earth Observation of Agroecosystems team

Thanks a lot to our partners!
(ETH CS, HAFL, Strickhof, SwissFutureFarm, Arenenberg)

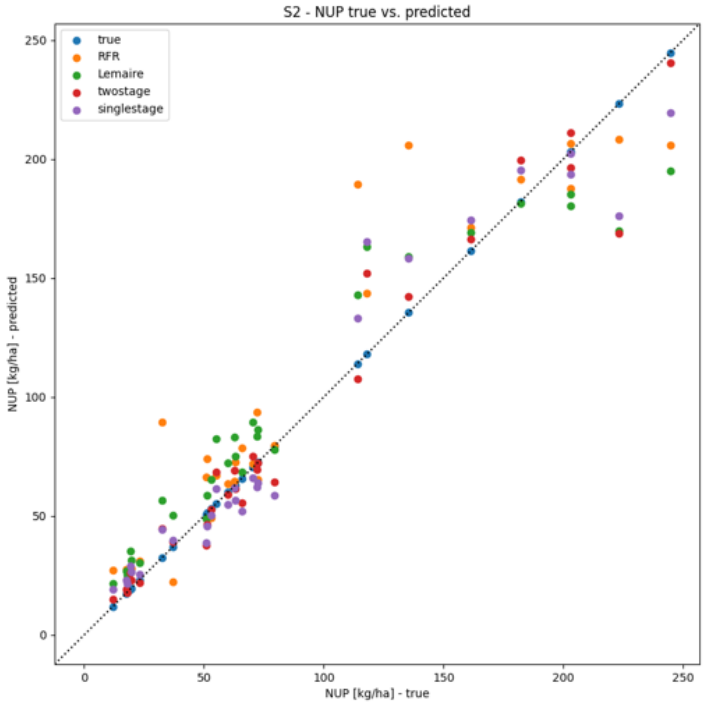
20

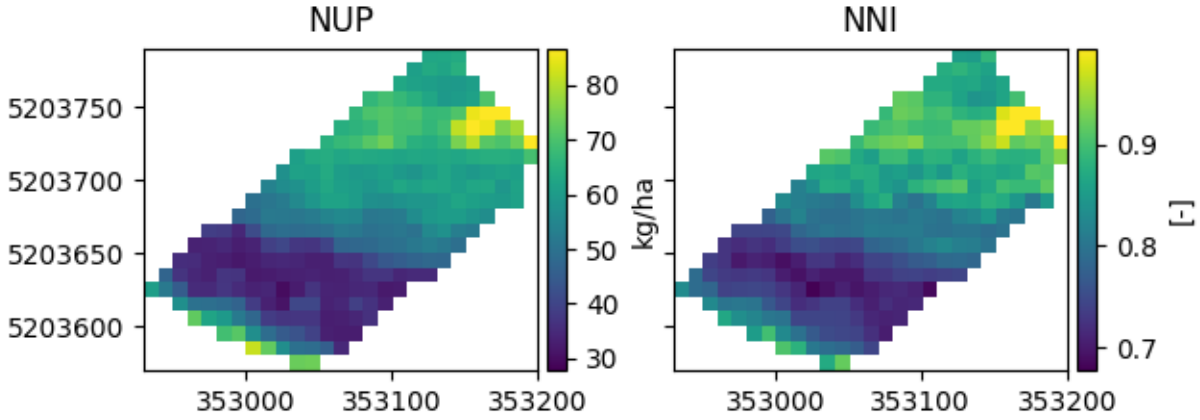
Yield mapping: combination of combine harvester data, satellite imagery and climate data (soil map planned)



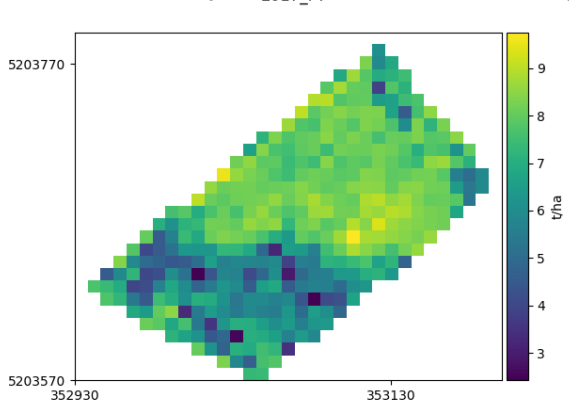
Perich et al. 2023, field crops research

Outlook: Remote sensing based in season N status detection





Yieldmap (combine harvester)



Perich et al. in preparation

Outlook: Satellite-based N status estimation explains up to 57% of the crop yield variation at field level.

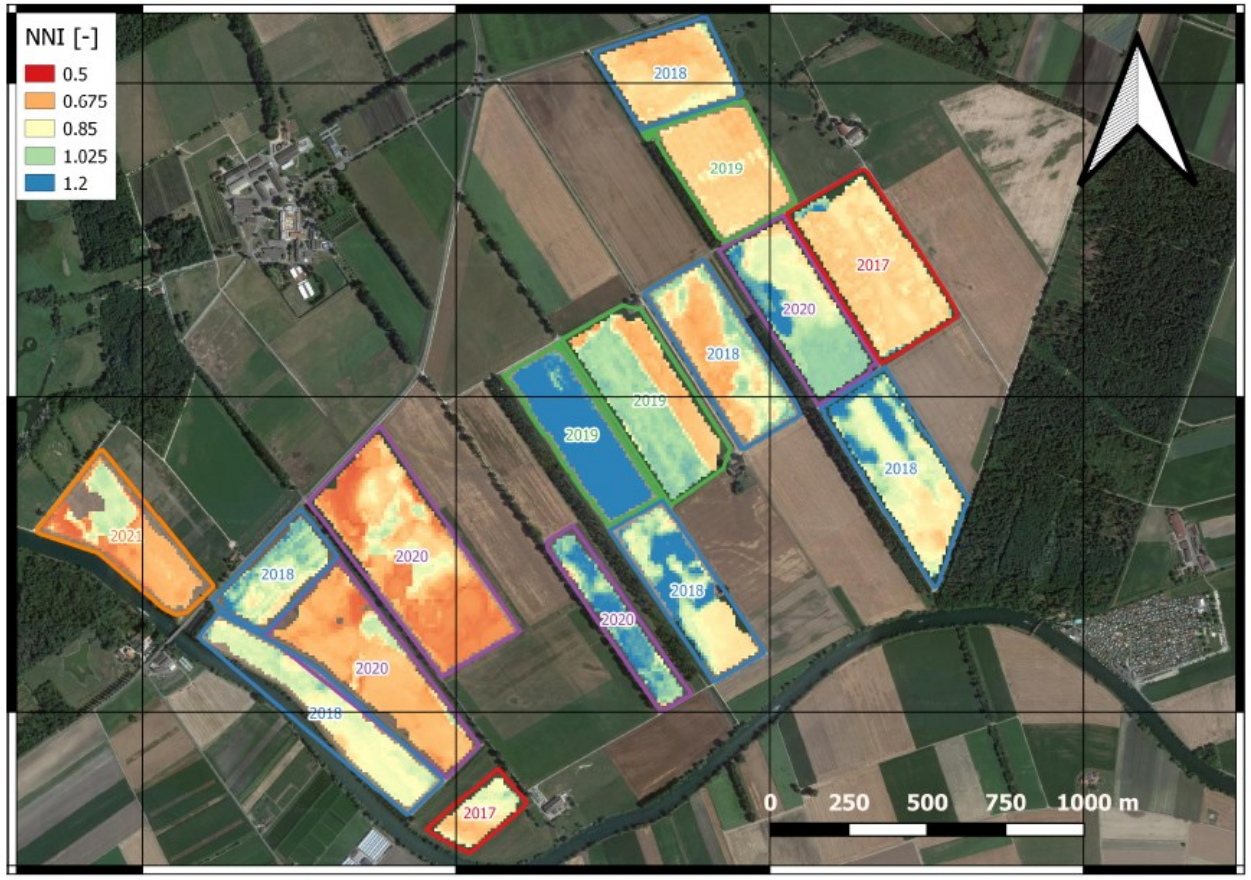


Figure 6: End of April composite of the N nutrition index (NNI) of all winter wheat fields from 2017–2021 of the example farm located in western Switzerland. The field borders are coloured according to the individual years.

Concept for satellite-based modelling of nitrogen status in winter wheat - under Review

Soil map not yet integrated

Agroscope

TERENSIS

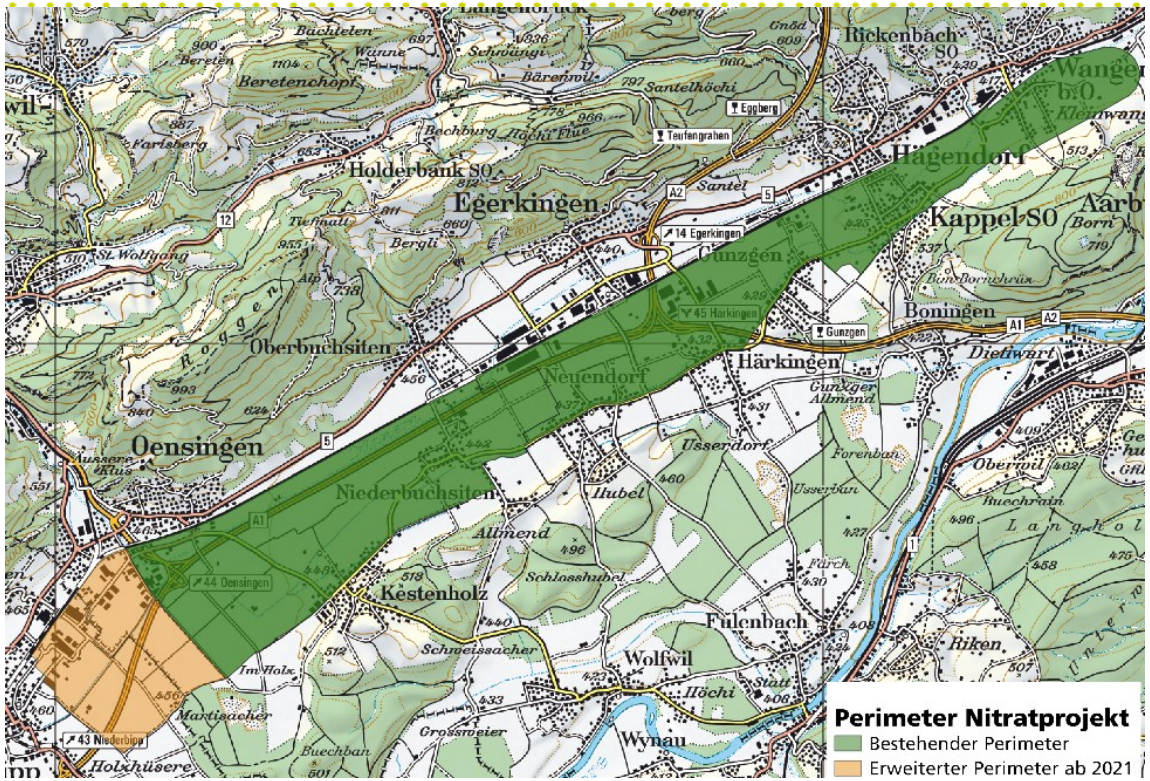
CriticalN

Groundwater-conserving, productive agriculture through site-adapted nitrogen fertilization

- Applied scientific support project in the Nitratprojekt NGO
- Demo trials and on-farm testing of current fertilization methods and increase knowledge / acceptance
- Legal integration, decision support tools
- **Reduce N losses into groundwater under the critical N load of 30 kg N ha^{-1} while maintaining productivity?**
  - Challenges: technical limitations in measurements, data quality from on-farm experiments

https://so.ch/verwaltung/bau-und-justizdepartement/amt-fuer-umwelt/wasser/grundwasser/schutz/das-nitratprojekt-niederbipp-gaeu-olten/das-forschungsprojekt-criticaln/

Largest Nitrate project in Switzerland (Nitrate vulnerable zone …)

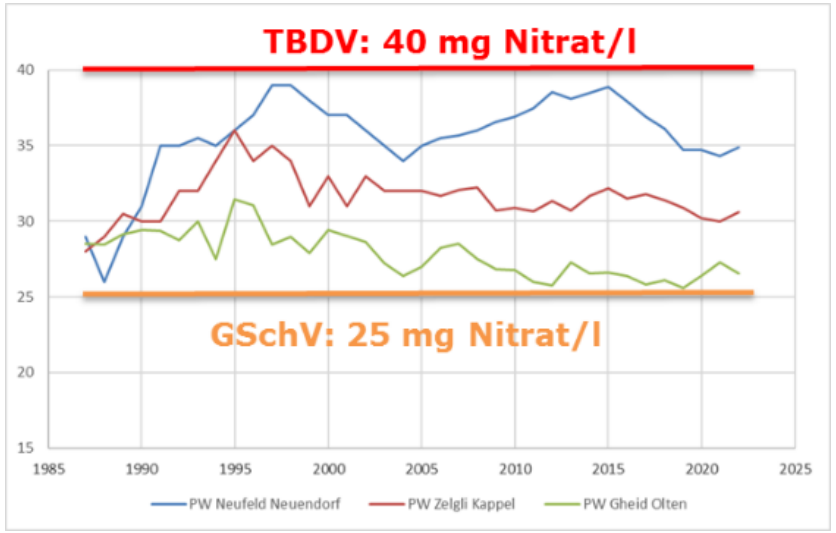


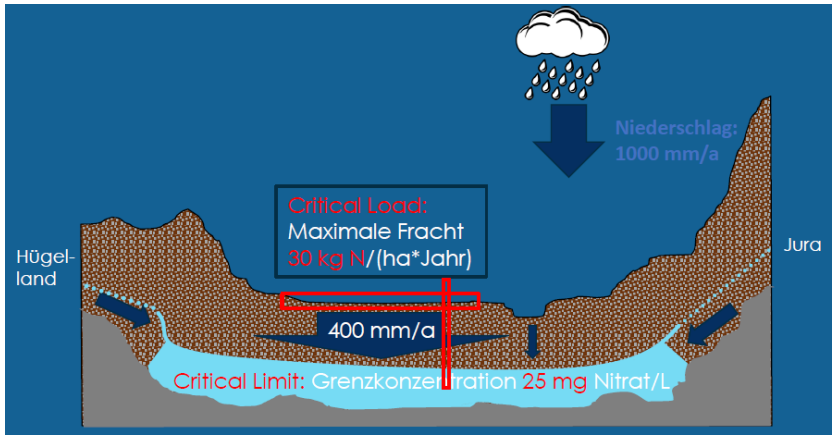
Perimeter 2000/2003

Erweiterung 2021

Flächen und Betriebe im Projektgebiet per Ende 2022			
	SO	BE	SO und BE
	total	total	Total
Landwirtschaftliche Nutzfläche im Projektgebiet [ha]	1124	259	1383
Davon am Nitratprojekt beteiligt (Vertragsflächen) [ha]	1031	52	1083
Anz. Betriebe im Projektgebiet	96	30	126
Anz. Betrieb mit Beteiligung am Projekt (mit Verträgen)	82	11	93

Used Measures are not sufficient

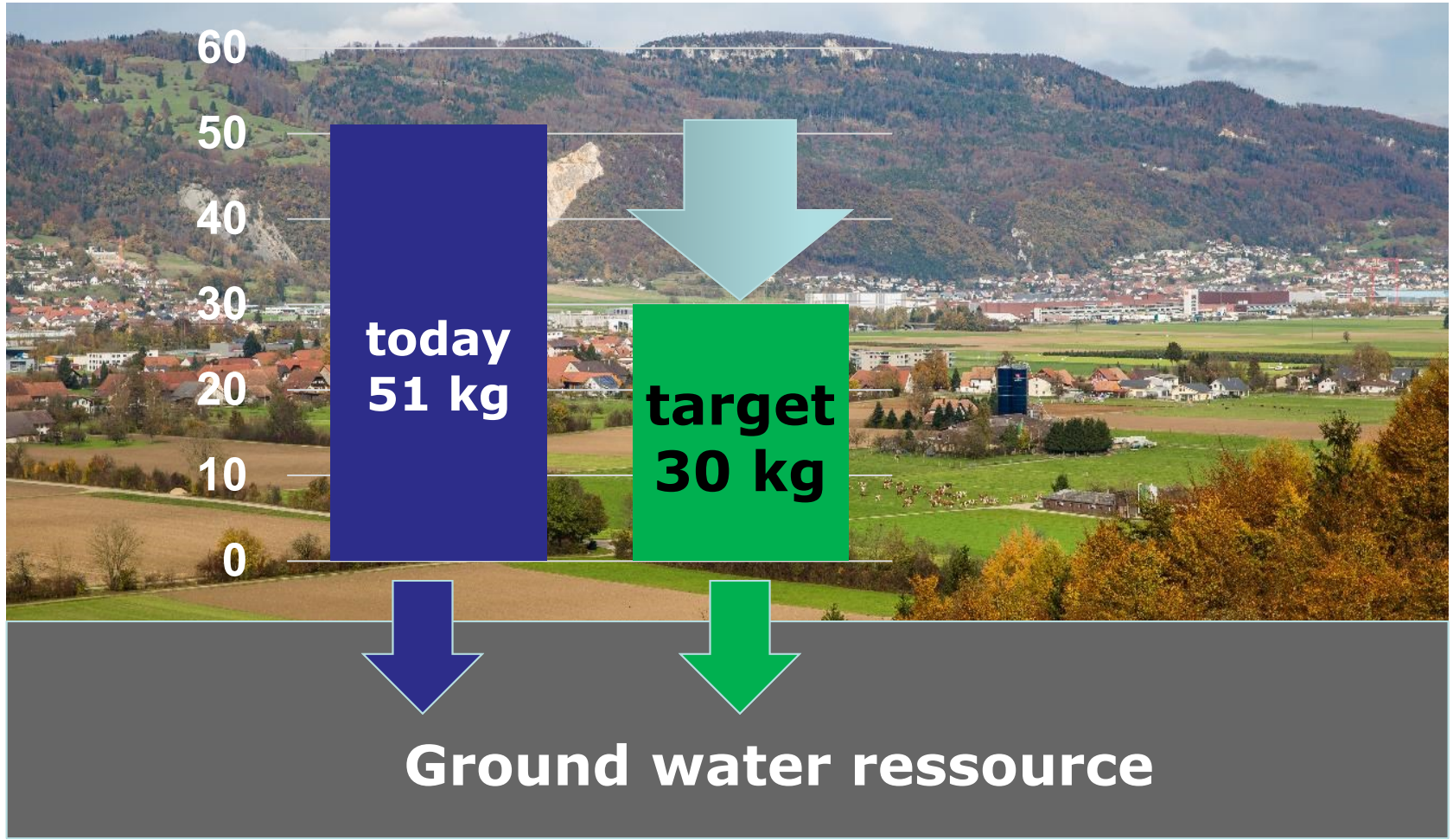




- Since 90ies above quality level
- Project aim: 25 mg Nitrat/l
- Todays measures und paricipation is right and important, but not sufficient

- **Max acceptable N-loss:**
  Ø 30 kg N / (ha*Jahr)
- Average loss today:
  Ø 51 kg N/(ha*Jahr)

Target N surplus acceptable

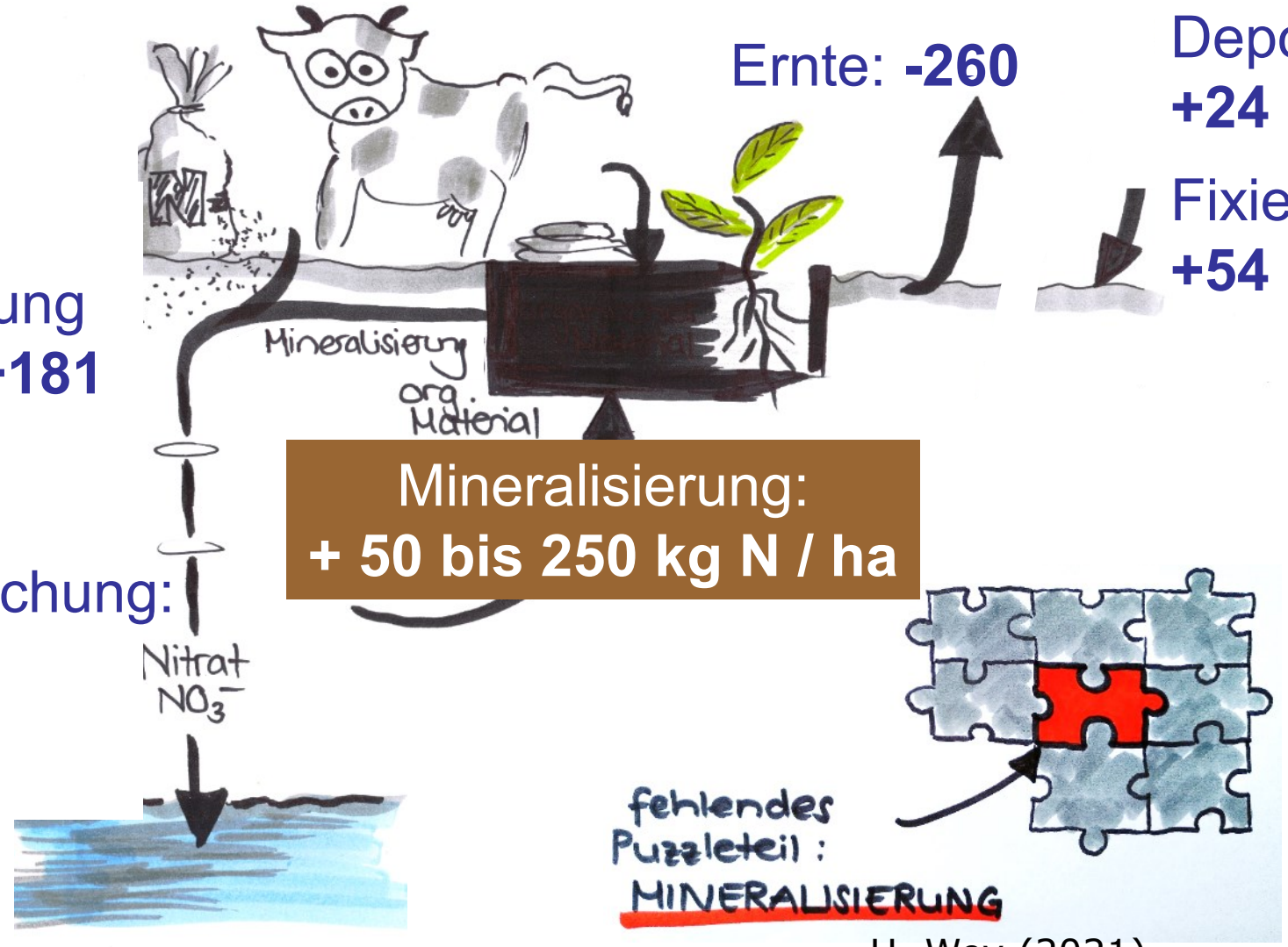


Ø 30 kg N /ha = Grundwasserschutz und Produktion

Liebisch et al. | April 2024

N-Balance arable crops

Zahlen in kg N ha^{-1} $Messperiode^{-1}$



H. Wey (2021)
Bünemann et al. (2022)

Project to innovate current nutrient managment system

- Test and teach fertilizer recommendation
- Develop a target oriented subsidy system
- Optimize processes (sampling and advice)
- Education of farmers and advisors
- Show case for agricultural policy makers

Conclusion for fertilizer recommendation in Switzerland, what should we do ?

- Regular revision with regard to yield, varieties, methods ….
- Binding and quantitative integration in legislation and law enforcment instruments
- Consequent digital transition (seamless data exchange between practice, federal and cantonal authorities … and research)
- Focus on knowledge exchange and education

Thank you!

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