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Swiss agricultural policy

SALCA life-cycle assessment Agri-environmental indicators

Peter Weisskopf and Thomas Nemecek
with Gérard Gaillard, Ruth Freiermuth Knuchel, Martina Alig, Daniel Baumgartner, Philippe Jeanneret, Hans-Rudolf Oberholzer

Mendel University, Brno

May 9, 2013

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Outline

Swiss agricultural policy

- Swiss agriculture: facts and figures
- Swiss agricultural policy today
- Agriculture policy 2014-2017

SALCA life cycle assessment (Swiss Agricultural Life-Cycle Assessment)

- The concept of life cycle analysis with SALCA
- SALCA emission models and impact assessment methods
- Examples of applications

Agri-Environmental Indicators (Agri-Environmental Monitoring)

- Basic concepts
- SALCA tools
- Examples of results

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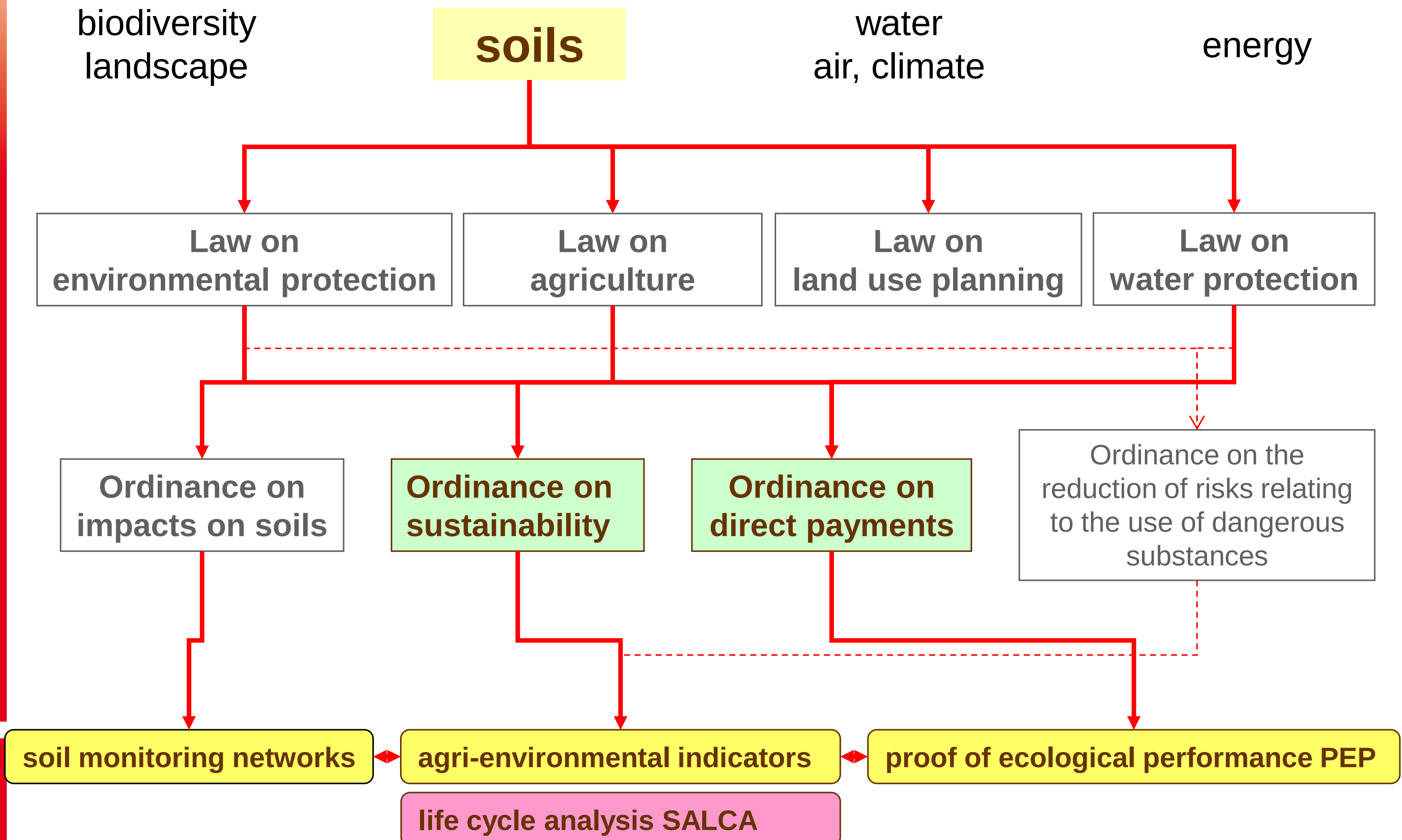
Coordination of agricultural and environmental policies: soil



SALCA: An integrated concept for agricultural life cycle assessment

SALCA = **S**wiss **A**gricultural **L**ife **C**ycle **A**ssessment

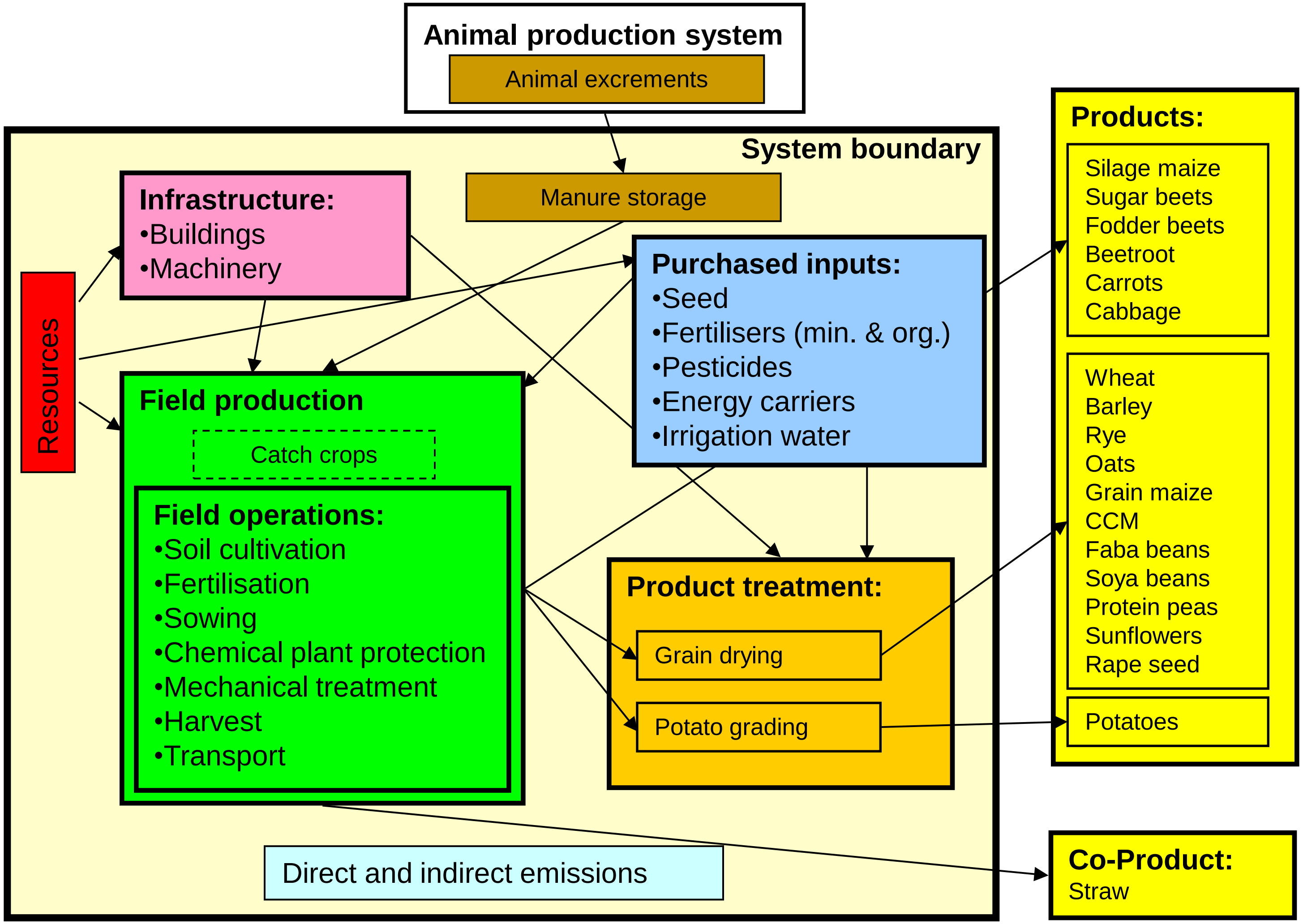
SALCA consists of the following elements:

- **Database for life cycle inventories** for agriculture (in collaboration with ecoinvent)

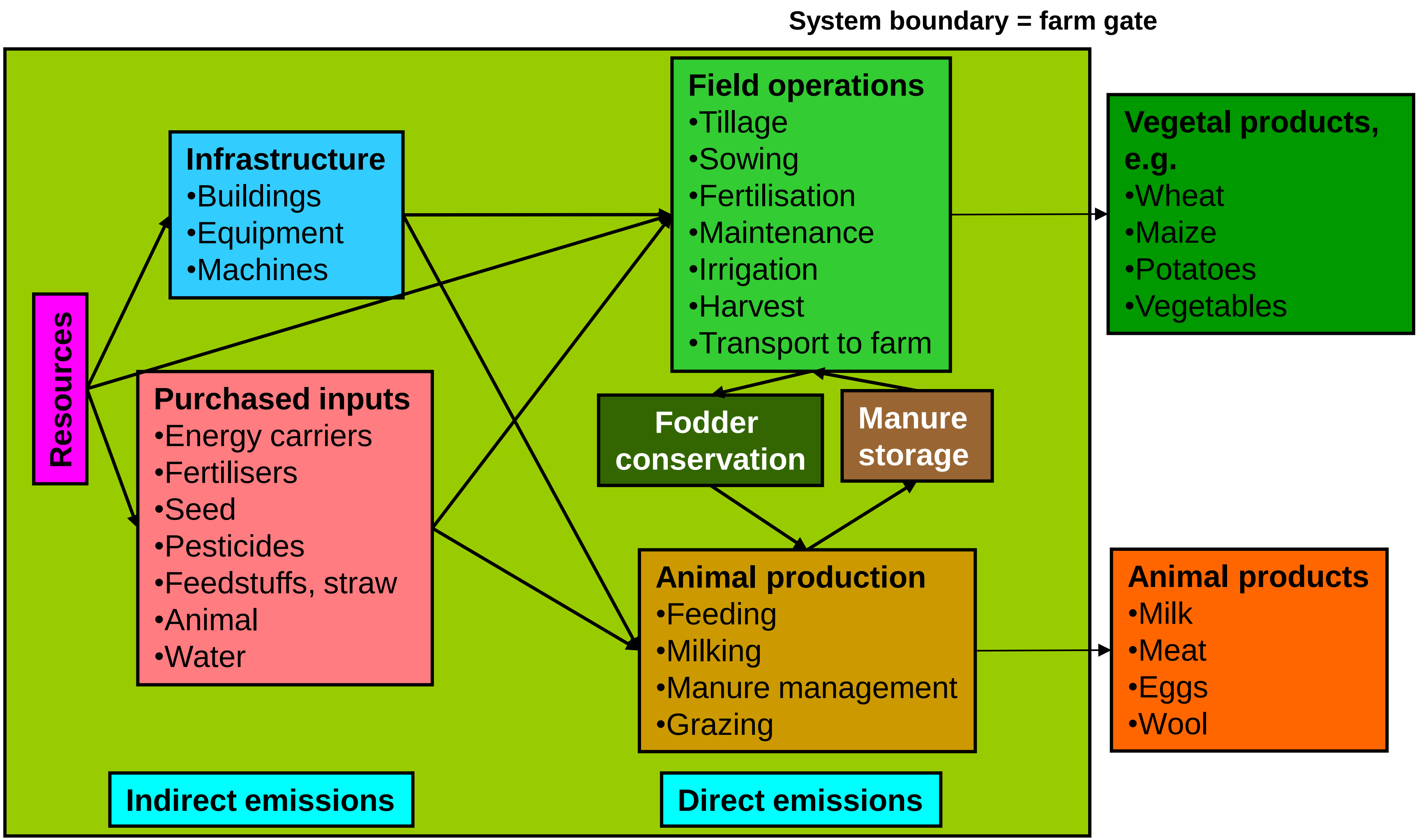
- Models for the calculation of **direct emissions from field and farm**
- A selection of **impact assessment methods** (midpoints)
- Methods for the assessment of **impacts on biodiversity and soil quality**

- **Calculation tools** for agricultural systems (farm, crop)
- **Interpretation scheme** for agricultural LCA

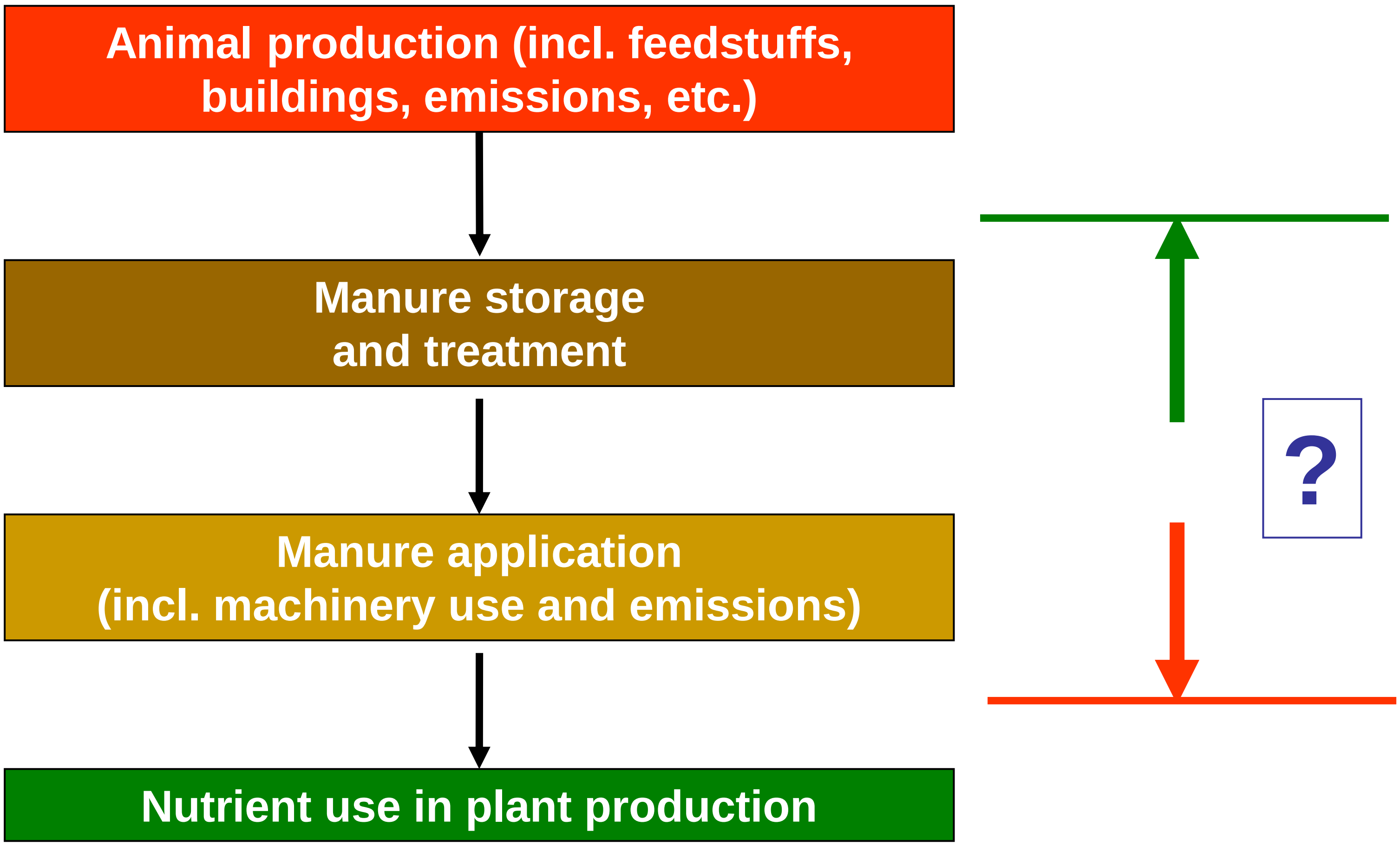
Defining system boundaries: crop production analysis



Defining system boundaries: whole farm analysis



Defining system boundaries: where to draw the line between animal and plant production?



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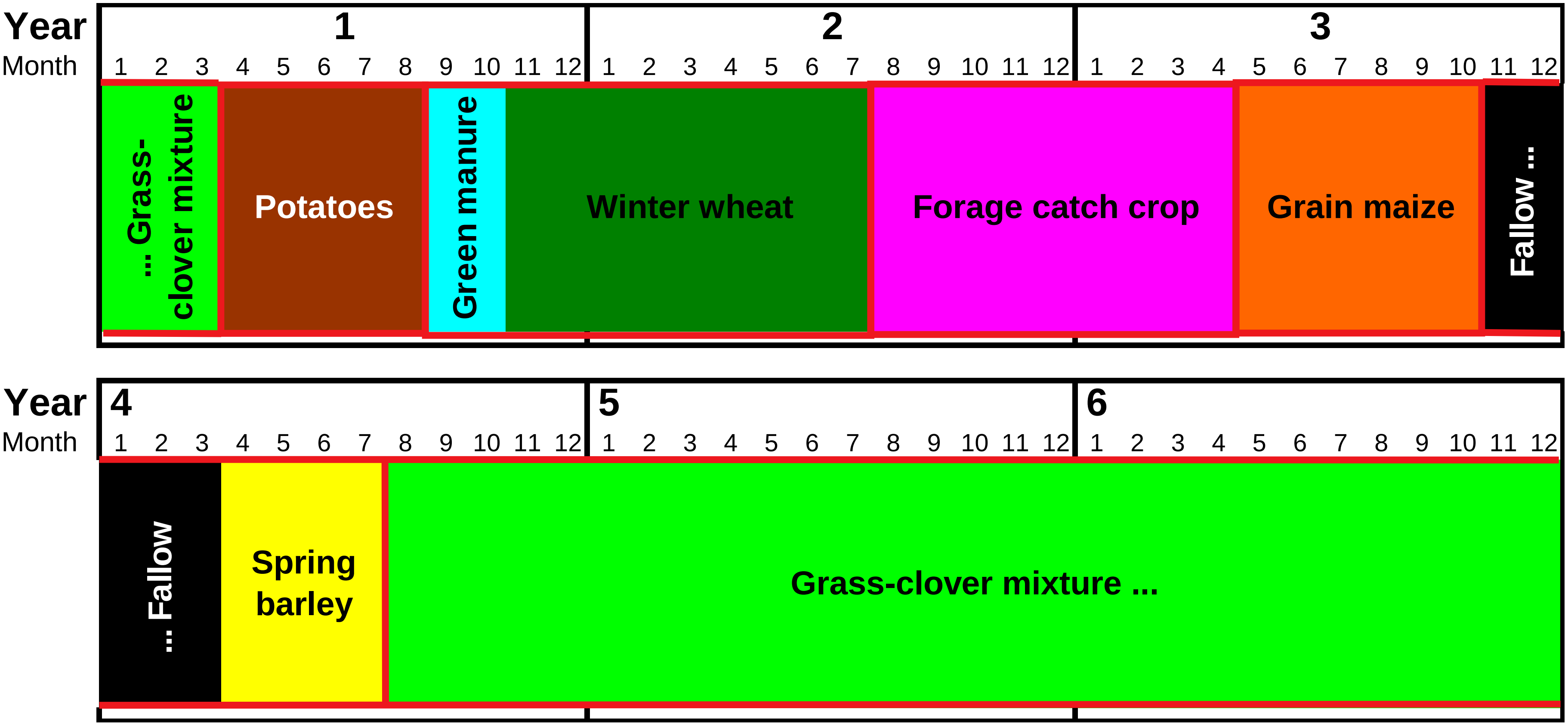
Defining system boundaries: single crop or cropping system?



Defining system boundaries: temporal system boundaries

Annual crops:

- Starting after harvest of previous crop (including fallow period or catch crop, if no product)
- Ending with harvest of the considered crop

Permanent crops:

- Annual basis (1st January to 31st December) or
- Multiannual cropping cycle (distinguishing different phases: planting, young plantation, main yielding phase, eradication)

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- **SALCA emission models and impact assessment methods**
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Estimating direct field and farm emissions

Ideal emission models should

- … reflect the underlying environmental mechanisms
- … be site and time dependent
- … consider the effect of soil and climate
- … consider the effect of management
- … be applicable under a wide range of different situations
- … should have a similar level of detail for the different models

- … **and**: should easily be usable:
  → Parameters are measurable
  → Data can be collected in a reasonable time
  → Calculation is feasible

A compromise is needed!

SALCA emission models

Emission	Description	Reference
Ammonia (NH_3)	Considers type of fertiliser, climate, time and technique of application	Menzi *et al*. (1997)
Nitrous oxide (N_2O)	Direct and indirect emissions	IPCC (2006)
Nitrate (NO_3^-)	Monthly balance, considering crop, sowing and harvest dates, soil tillage, timing and quantity of N fertilisation	Richner *et al*. (2006)
Phosphorus (P, PO_4^{3-})	Includes erosion, run-off and leaching, considers P fertilisation, soil characteristics, topography	Prasuhn (2006)
Heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn)	Field or farm level balance, considers inputs, harvest, leaching, erosion and change in soil concentration	Freiermuth (2006)
Methane (CH_4)	Enteric fermentation and manure management	IPCC (2006)

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SALCA emission models: ammonia (NH_3)

Four emissions paths are modelled:

1. **Application of farm manure** = f(fertiliser amount, NH_3 and NH_4-concentration, covered area, saturation deficit in the air in function of average monthly temperature)

2. **Application of mineral fertiliser** = emission factors according to fertiliser type (2-15%, Asman 1992)

3. **Emission from pasture** = 5% of total N in excrements emitted as NH_3

4. **Emission from stable** = emission factors dependent on animal category, housing system, farm manure type (liquid or solid)

Source: Menzi *et al*. (1997)

SALCA emission models nitrous oxide (N_2O)

N_2O in air:

adapted method according to IPCC 2006, under consideration of induced N_2O-Emissions:

- **Fertilisers**: Direct emissions: 1% of available N
- **Symbiotic N-fixation in legumes**: no emissions
- **Crop residues**: emission factor 1%
- **Storage of farmyard manure**: emission factors 0.1% for liquid manure and 2% for dung
- **Pasture**: emission factor 2%
- **Induced Emissions**: 1% of NH_3-N and 0.75% of NO_3-N

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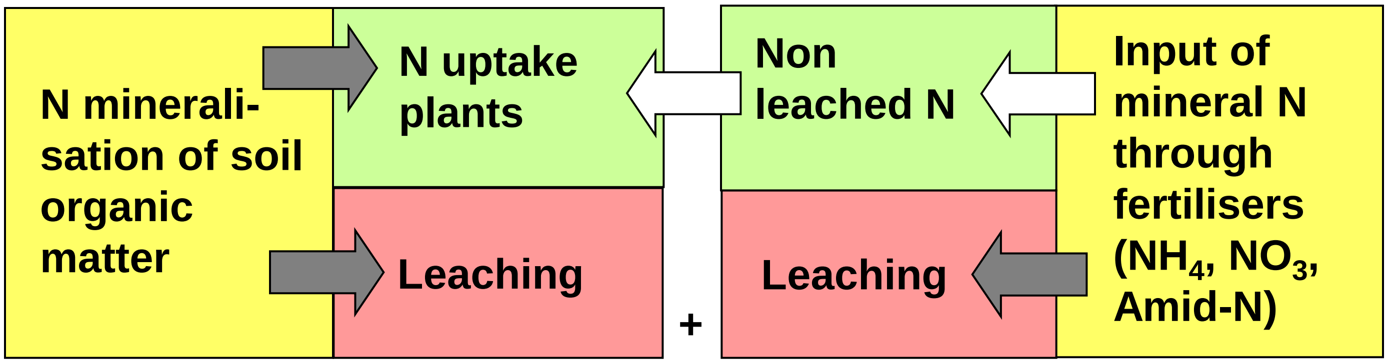
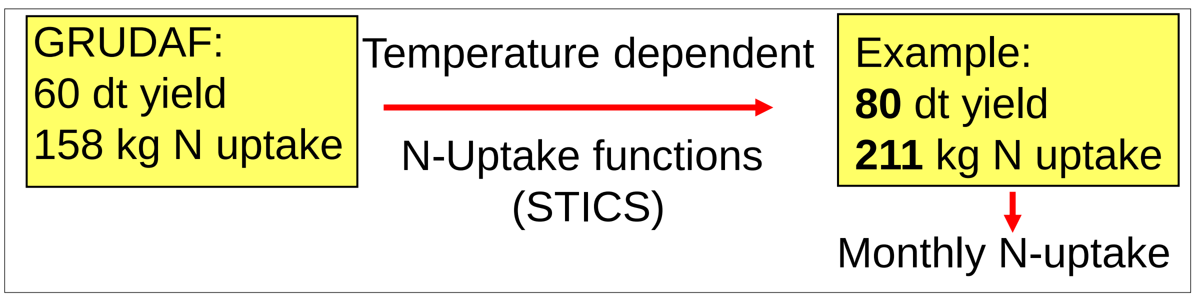
SALCA emission models: SALCA-nitrate





Source: Richner *et al*. (2006)

SALCA emission models: phosphorus (P)

Four kinds of P-emissions in water:

- **Surface run-off** in rivers (solved PO_4^{3-})
- **Drainage losses** in rivers (solved PO_4^{3-})
- **Erosion** in rivers (P bound to soil particles)
- **Leaching** in ground water (solved PO_4^{3-})

Emissions are dependent of:

- Soil characteristics (granulation, bulk density, soil water balance) and drainage
- Quantity of P-fertiliser
- Type of P-fertiliser (manure, compost, mineral)
- Field slope and distance to rivers
- Quantity of eroded soil
- Plant available P in upper soil

SALCA emission models: heavy metals

- **Input-Output-Balance per field** (caused by farming) for: **Cd, Cu, Zn, Pb, Ni, Cr, Hg**

- **Inputs:**
  → Fertilisers (mineral and organic)
  → Seed
  → Pesticides
  → Feedstuff and auxiliary materials for animal breeding

- **Outputs:**
  → Exported primary products (e.g. grains, meat)
  → Exported co-products (e.g. straw, animal manure)
  → Leaching to groundwater and drainage to surface water
  → Erosion to surface water

- Allocation for inputs caused by the farming
- The final balance can be negative!

Source: Freiermuth (2006)

SALCA impact assessment methods

Impact category	Reference	Remarks
Non-renewable energy demand	Ecoinvent (2007)	Fossil und nuclear energy resources
Global warming potential	IPCC (2007)	
Ozone formation potential	EDIP (2003)	With regionalisation
Eutrophication potential	EDIP (2003)	With regionalisation
Acidification potential	EDIP (2003)	With regionalisation
Aquatic and terrestrial ecotoxicity Human toxicity	CML (2001)	Complemented with characterisation factor for ca. 400 pesticide active ingredients
Biodiversity	Jeanneret et al. (2006)	11 indicator organism groups 2 characteristics
Soil quality	Oberholzer et al. (2006)	9 indicators for physical, chemical and biological soil properties

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SALCA methodology: method for biodiversity - framework

- **11 Indicator species groups**
  → ecological and LCA criteria: flora, birds, mammals, amphibians, molluscs, spiders, carabids, butterflies, wild bees, and grasshoppers

- **Two characteristics**
  → **overall species diversity** of the indicator species groups
  → **diversity of ecologically demanding species**

- **Extensive inventory data about agricultural practices**
  → occupation, emissions, farming intensity indicators (e.g. number of cuts) and process figures (e.g. herbicide type)
  → typical cultivated fields **and** semi-natural habitats

- **Characterisation based on scoring system**
  1) estimate every indicator species group's reaction to farming
  2) aggregation step resulting in scores

- **Aggregation and normalisation of scores**
  → biodiversity value and biodiversity potential

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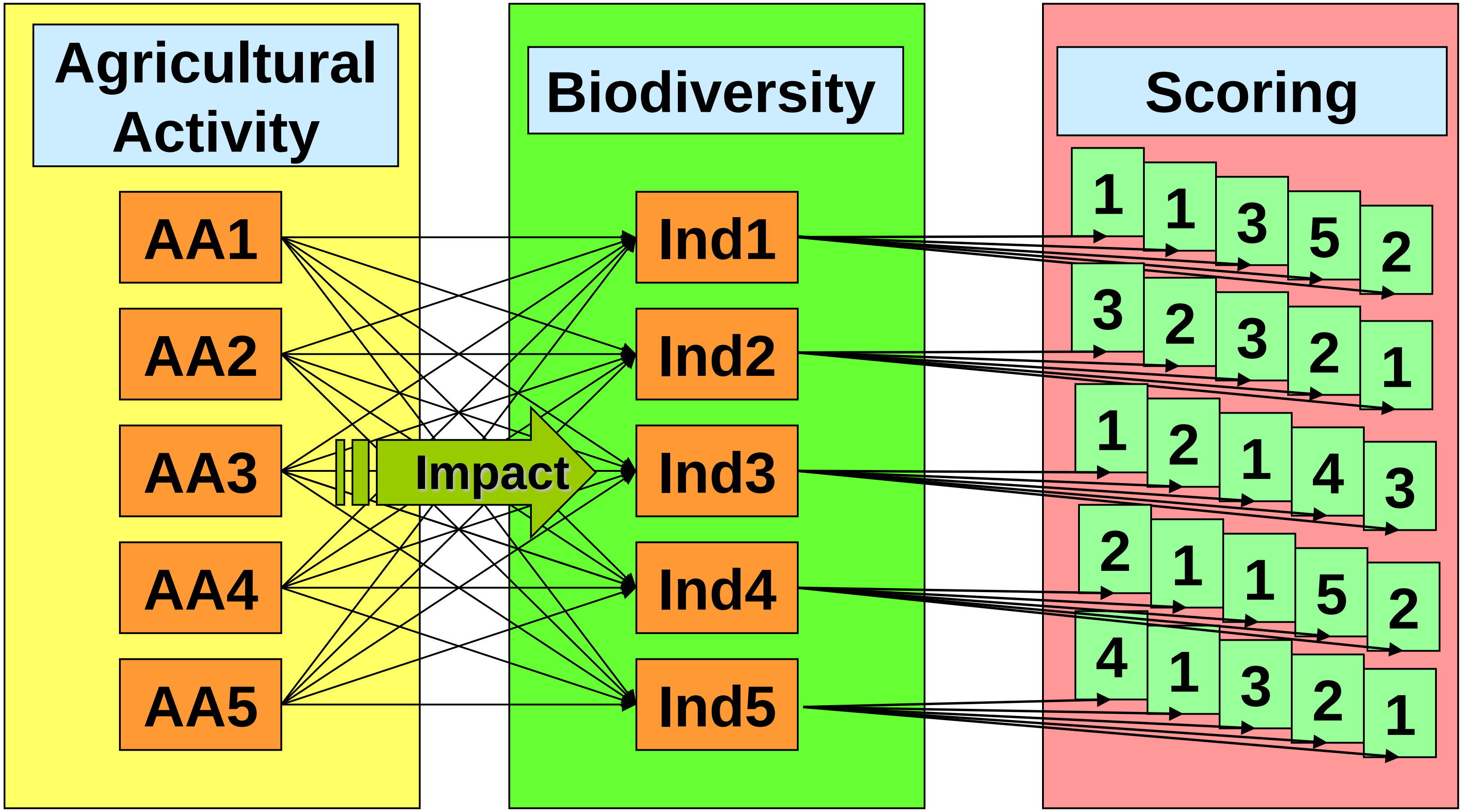
SALCA methodology: method for biodiversity - principle



SALCA methodology: example for biodiversity – case study

Biodiversity scores

Production system	Grassland (A)	Grassland (B)	Grassland (C)	Grassland (D)	Winter Wheat (A)	Winter Wheat (B)	Winter Wheat (C)	Winter Wheat (D)
Overall species diversity	**6.2**	**6.4**	**13.8**	**21.3**	**7.7**	**7.5**	**8.4**	**8.7**
Grassland flora	3.7	3.9	11.4	18.5				
Crop flora					15.2	15.1	16.0	17.3
Birds	6.4	6.7	13.8	22.0	5.3	5.0	6.2	6.4
Mammals	7.3	7.3	11.1	11.1	4.6	4.6	4.6	4.6
Amphibians	2.1	2.1	5.2	9.5	1.7	1.7	1.8	1.8
Molluscs	5.4	5.6	5.8	11.3	2.2	2.2	2.2	2.2
Spiders	9.1	9.3	15.8	22.4	8.2	8.0	10.5	10.7
Carabid Beetles	7.0	7.4	13.6	21.0	10.9	10.6	11.7	11.9
Butterflies	6.8	7.0	20.0	36.0				
Wild Bees	7.4	7.6	18.6	23.0	5.2	4.9	5.0	4.8
Grasshoppers	6.9	6.9	19.4	33.1				
Species with high ecological requirements								
Amphibians	0.8	0.8	2.9	4.8	1.5	1.4	1.6	1.6
Spiders	8.9	9.0	15.3	21.6	8.0	7.8	10.3	10.5
Carabid Beetles	7.0	7.3	13.4	20.6	10.6	10.1	11.2	11.3
Butterflies	6.7	6.8	19.4	36.0				
Grasshoppers	6.8	6.8	19.3	32.9				

- similar to the reference (95%<score<104%)
- better than the reference (105%<score<114%)
- much better than the reference (score >115%)
- no relevance for the considered system

Results of SALCA-biodiversity.
Biodiversity scores are given per ha cultivated crop.
A, B, C, D are management systems with main characteristics :

Grassland systems (hay production):

(A) 5 cuts/year, fertilised with slurry; 11t DM/ha
(B) 4 cuts/year, fertilised with slurry; 9t DM/ha
(C) 3 cuts/year, fertilised with solid manure; 5.6t DM/ha
(D) 1 cut/year, no fertilisation; 2.7t DM/ha

Winter wheat systems:

(A) Conventional production; 5.8t DM/ha
(B) Integrated production – intensive; 5.5t DM/ha
(C) Integrated production – extensive; 4.5t DM/ha
(D) Organic production; 3.5t DM/ha

Scores of grassland (A) and winter wheat (B) systems are set as **reference scores**. Color codes are given for rough comparison:

Source: Jeanneret et al. 2006

SALCA methodology: method for soil quality - framework

- **Spatial system boundary = farm**
- **Temporal system boundary = crop rotation period** (6-8 years)
- **Management data of all plots of a farm in a single year** are considered as representative for a whole crop rotation
- **Only influences of agricultural management practices are included**, no immissions
- **The development trend of soil properties is assessed, not absolute values**

Soil properties
Physical
Chemical
Biological

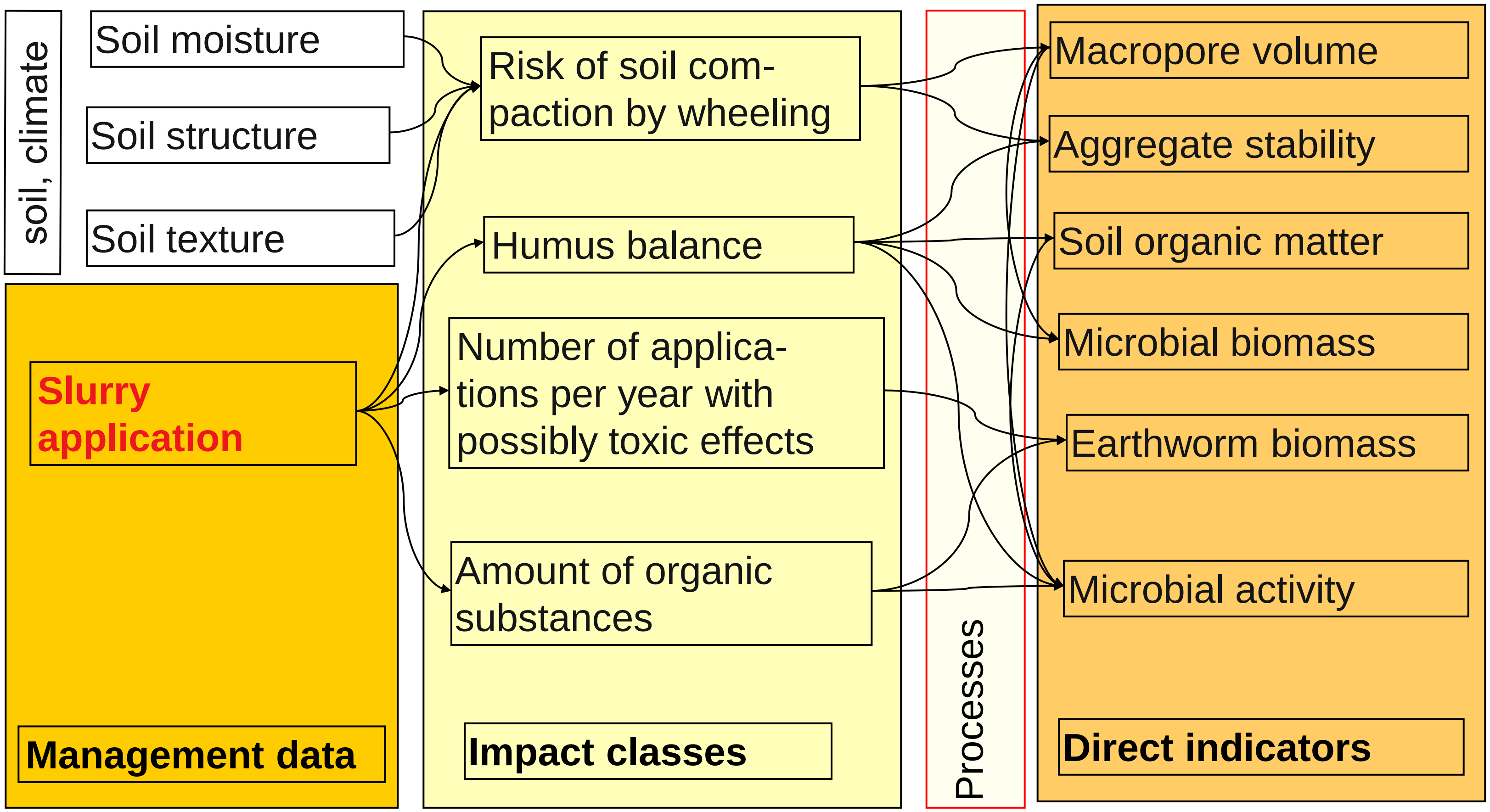
Criteria
According to ISO 14040 and ISO 14042
Depending on the needs of Life Cycle Assessment

9 Direct Indicators = measurable soil properties		
	Physical	**Rooting depth of soil**
		Macropore volume
		Aggregate stability
	Chemical	**Soil organic matter**
		Inorganic pollutants
		Organic pollutants
	Biological	**Earthworm biomass**
		Microbial biomass
		Microbial activity

Source: Oberholzer et al. (2006)

SALCA methodology: method for soil quality – impact assessment

Example: slurry application



Source: Oberholzer et al. (2006)

SALCA methodology: example for soil quality – results DOK

Results of SALCA-Soil Quality for the five DOC treatments

	Direct Indicators for soil quality	D0	D2	O2	K2	M
Physical	Rooting depth of soil	0	0	0	0	0
	Macropore volume	0	0	+	+	0
	Aggregate stability	-	+	+	+	-
Chemical	Corg content	--	+	+	+	--
	Heavy metal content	0	0	0	0	0
	Organic pollutants	0	0	0	0	0
Biological	Eathworm biomass	0	0	0	+	0
	Microbial biomass	-	0	+	+	-
	Microbial activity	-	0	+	+	-

- **Minor differences between the three farming systems**
  → most management practices are similar or equal regarding soil quality
  → some indicators do not show a positive effect in D2 because of slightly less organic input compared to O2 and K2.
- **D0 and M: impacts on soil quality by insufficient carbon supply**
  → no organic fertilizers, removal of crop residues
- **O2 and K2: positive effect of crop rotation on macropore volume**
  → not negated by a high compaction risk

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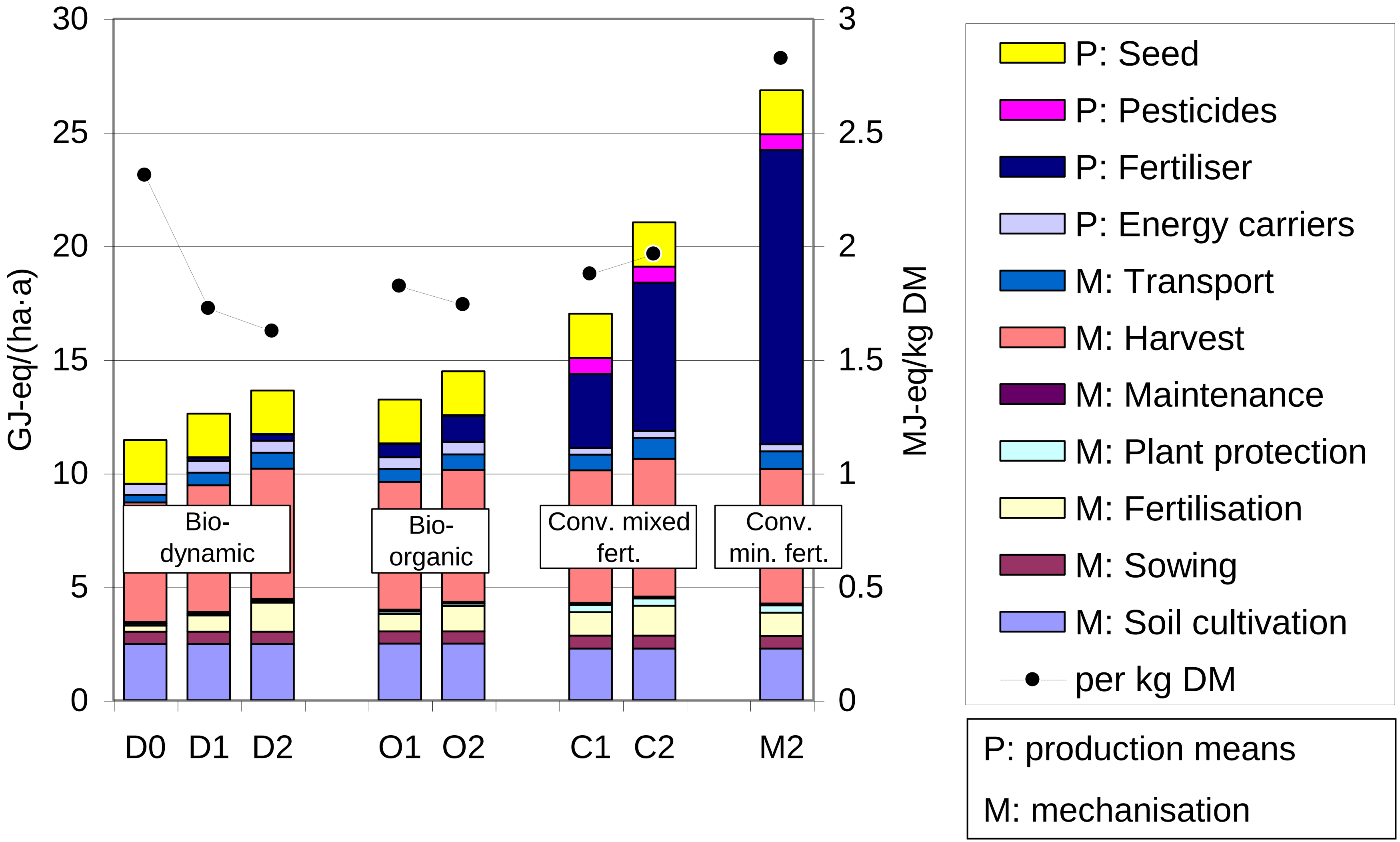
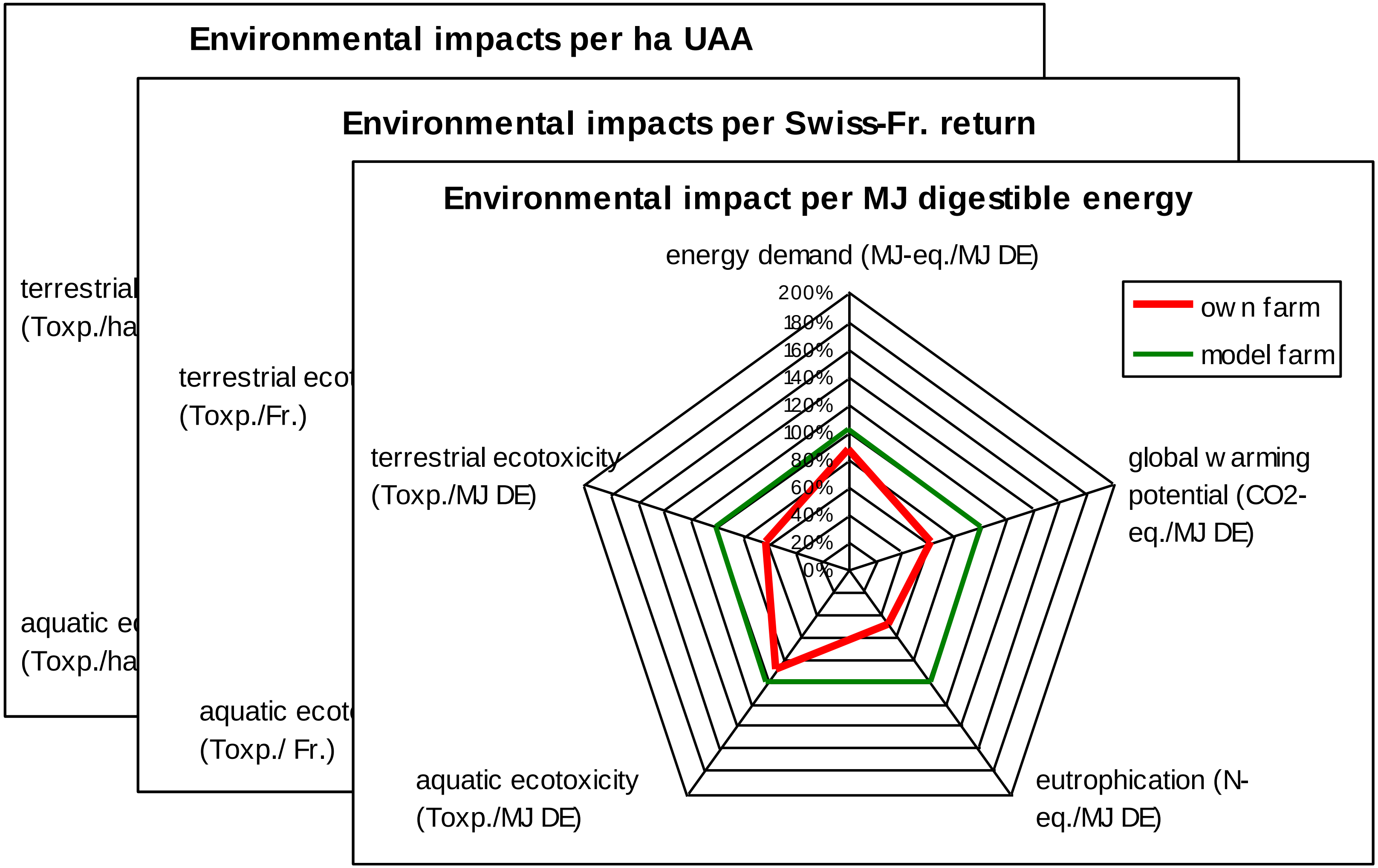
Cropping systems research

Example organic vs. integrated farming: energy demand in the DOC trial



Source: FAL report 58 (2006)

Communication of results to farmers: overview of environmental impacts



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Agri-environmental indicators: aims

- Based on Ordinance on sustainability in agriculture
- **Aim: assessment of the effects of agricultural policy and agricultural practices on environmental quality**

→ information on **national, regional and sectorial level**

→ information **for decision makers, for the general public, for comparisons** (with other countries)

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Agri-environmental indicator set

scope	**driving forces: agricultural practices**	**environmental effects: agricultural processes**	**environmental state**
nitrogen	• N-balance of agriculture	• potential N emissions (NO_3, NH_3, N_2O)	• nitrate pollution of groundwater
phosphorous	• P-balance of agriculture	• P content of soils	• P pollution of lakes
energy / climate	• energy consumption in agriculture	• energy efficiency • emission of greenhouse gases	
water	• use of pesticides • use of veterinary medicinal products	• risk of aquatic ecotoxicity	• pesticide pollution of groundwater
soil	• soil cover	• erosion risk • humus balance • heavy metal balance	• heavy metal content of soils
biodiversity / landscape	• ecological compensation areas	• potential effects of agriculture on biodiversity	• diversity of wild species • habitat diversity

Agri-environmental indicators: organisation

- **Start in 2009**; currently in implementation

  → **ART** responsible for driving forces and environmental effects
  → **Federal Office for the Environment** responsible for state indicators

- Organisation as **"Central assessment of environmental indicators (ZA-AUI)"**, analogous to "central assessment of farm accounting data (ZA-BH)"

- Data acquisiton in the same network (currently env. 450 farms) and with the same partners as for accounting data:
  → **data collection:** reference data for proof of ecological performance, PEP by farmers, state indicators by FOE
  → **data retrieval** by agricultural trustees
  → **data storage and management** by advisory service (AgroTech system)
  → **indicator calculation and interpretation** by ART

Agri-environmental indicators: production chain

farmers
→ data collection

Federal Office of Environment
→ data collection

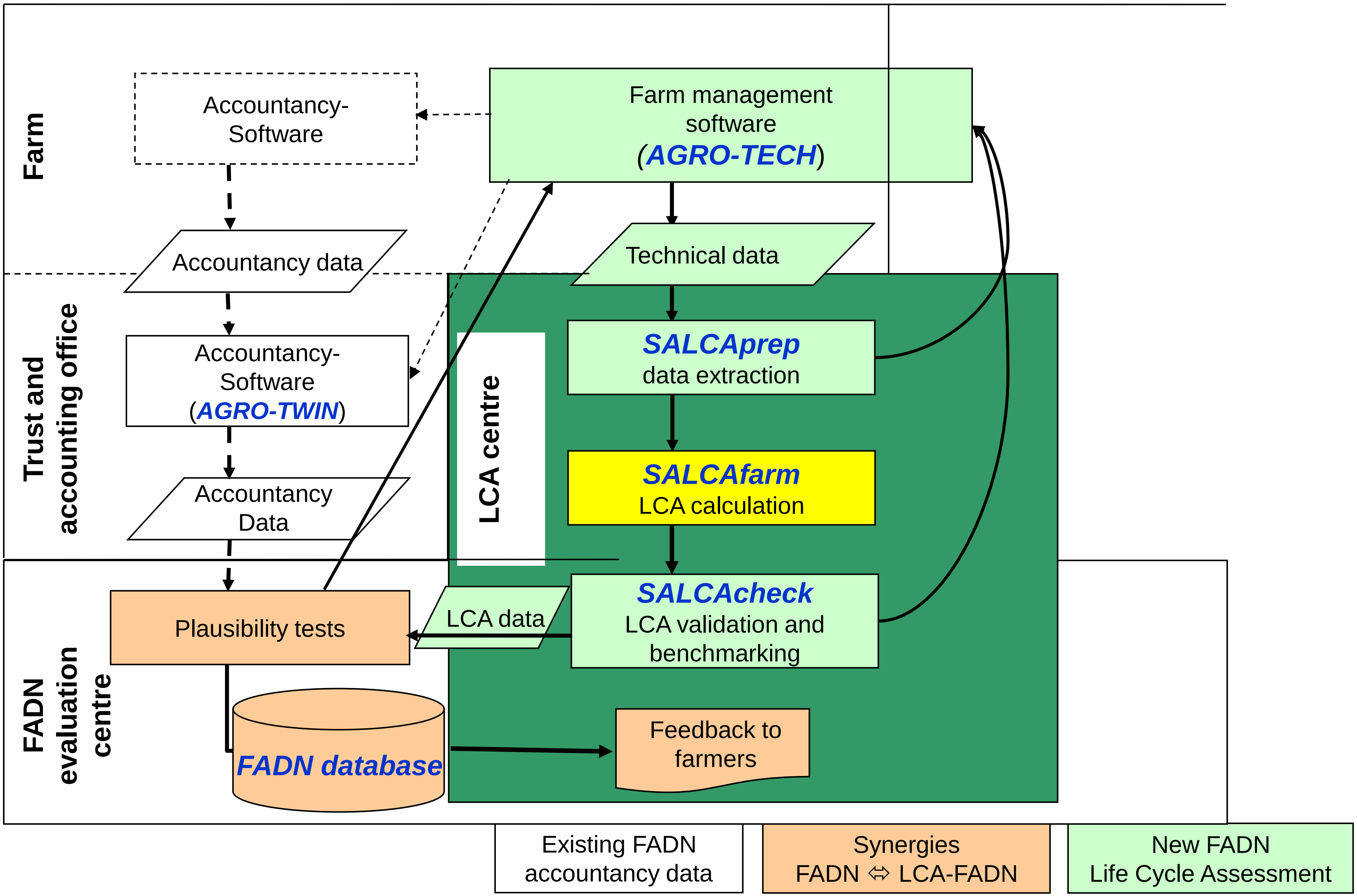
agricultural trustees
→ data acquisition, plausibility check, data storage

agricultural research station ART
→ data analysis and interpretation

Federal Office for Agriculture FOA
→ publication, conclusions, political measures

Workflow in the project LCA-FADN

(Farm Accountancy Data Network)



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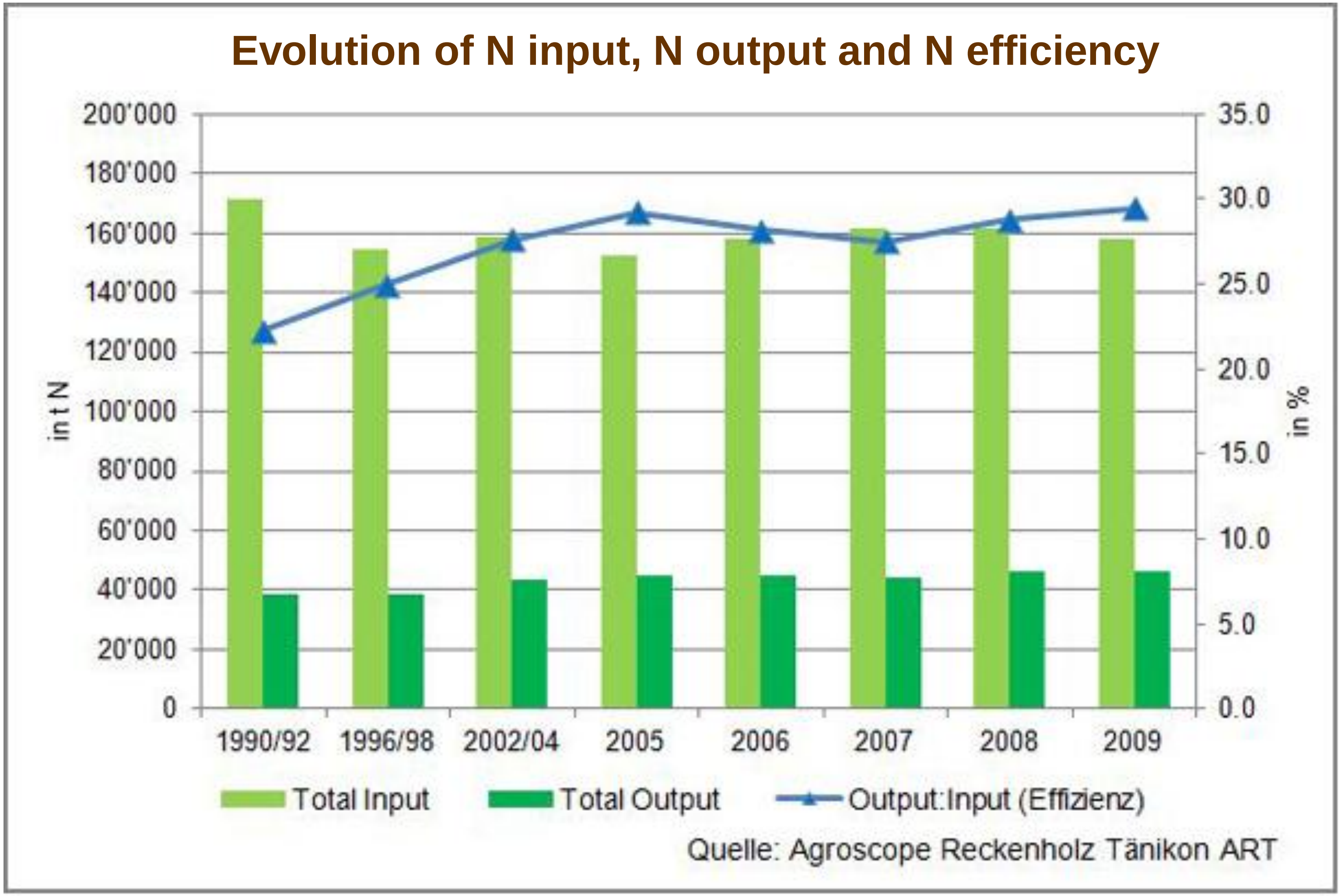
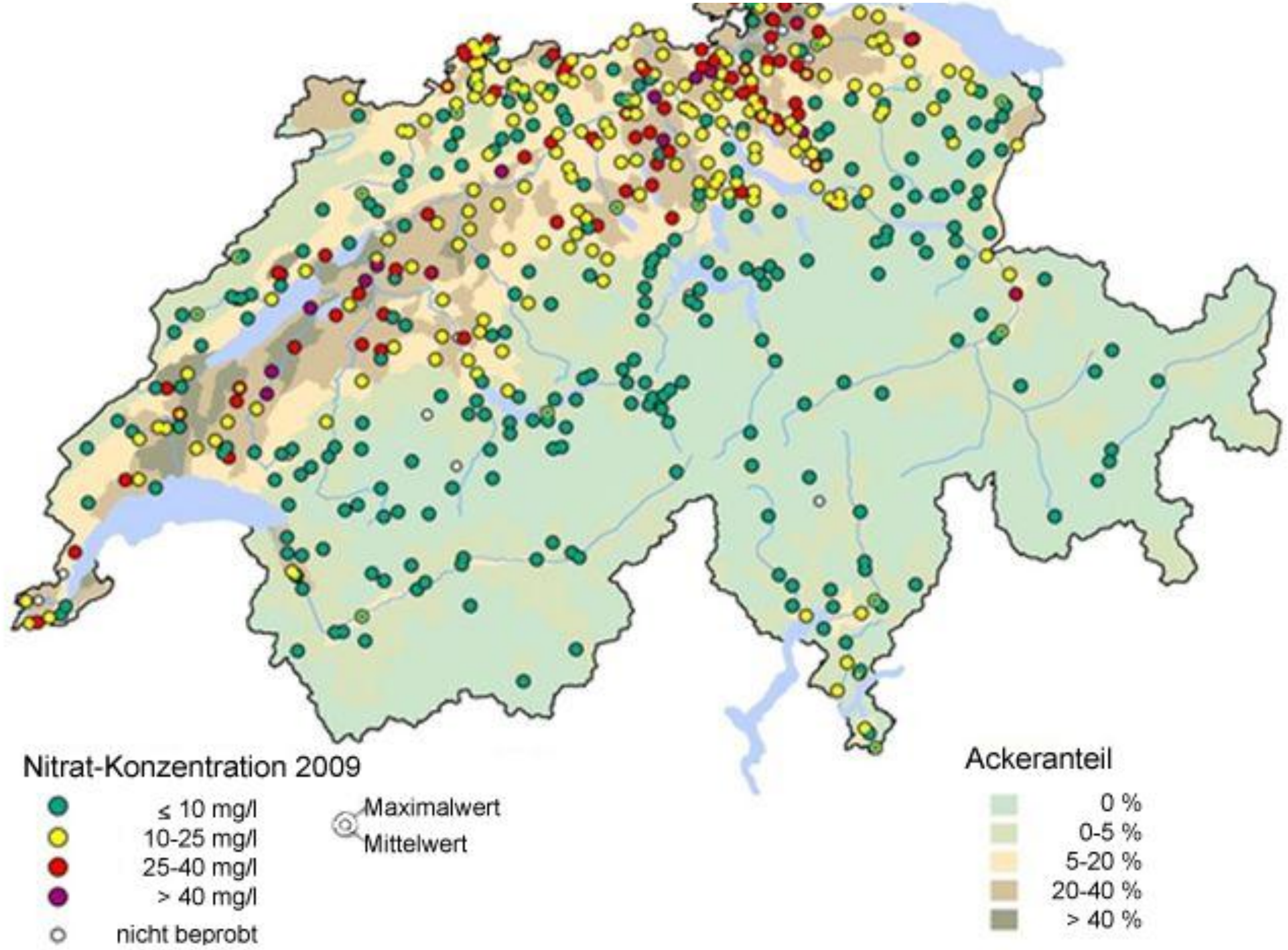
Examples for AEIs: nitrogen

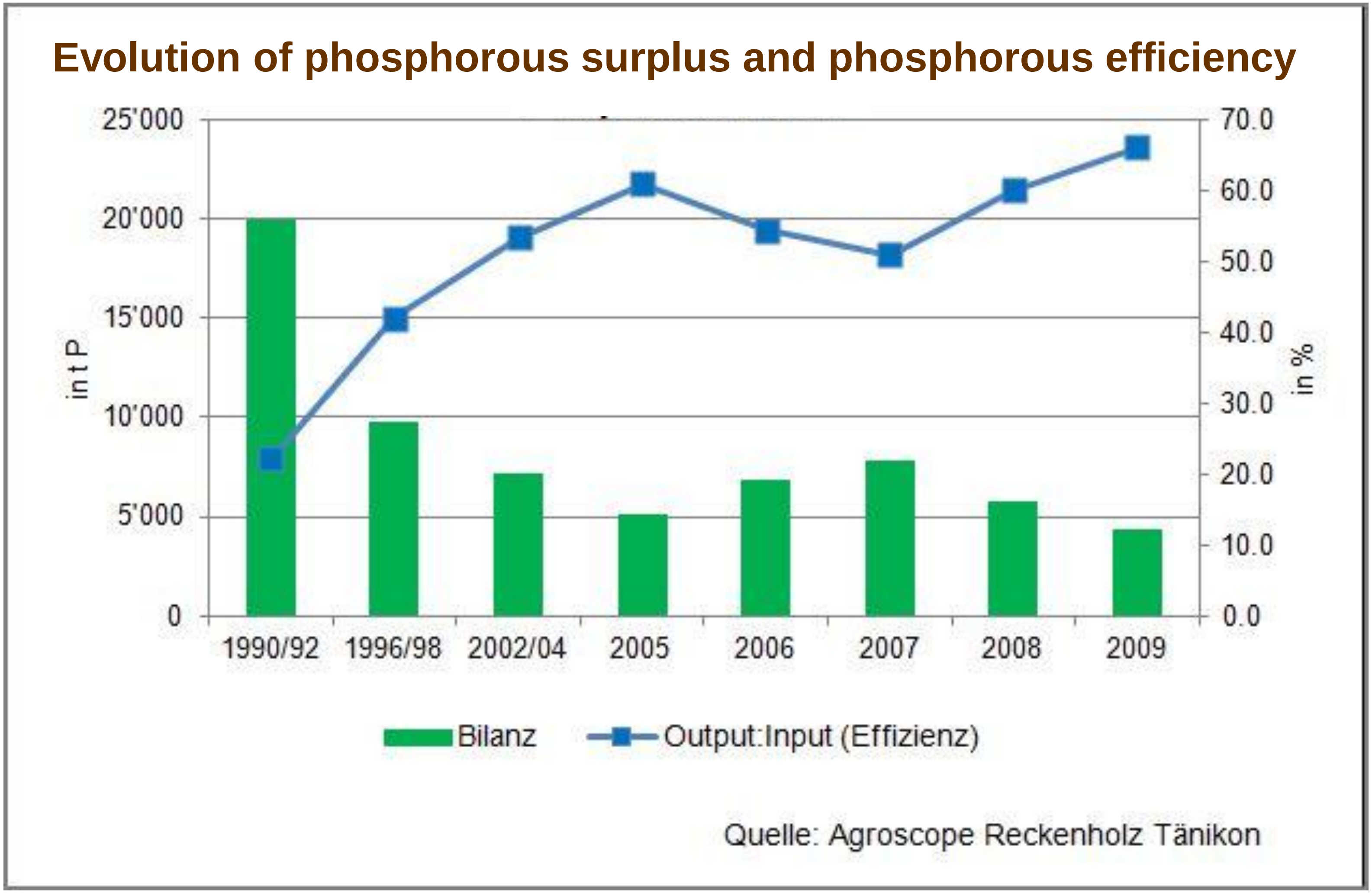


Examples for AEIs: nitrogen

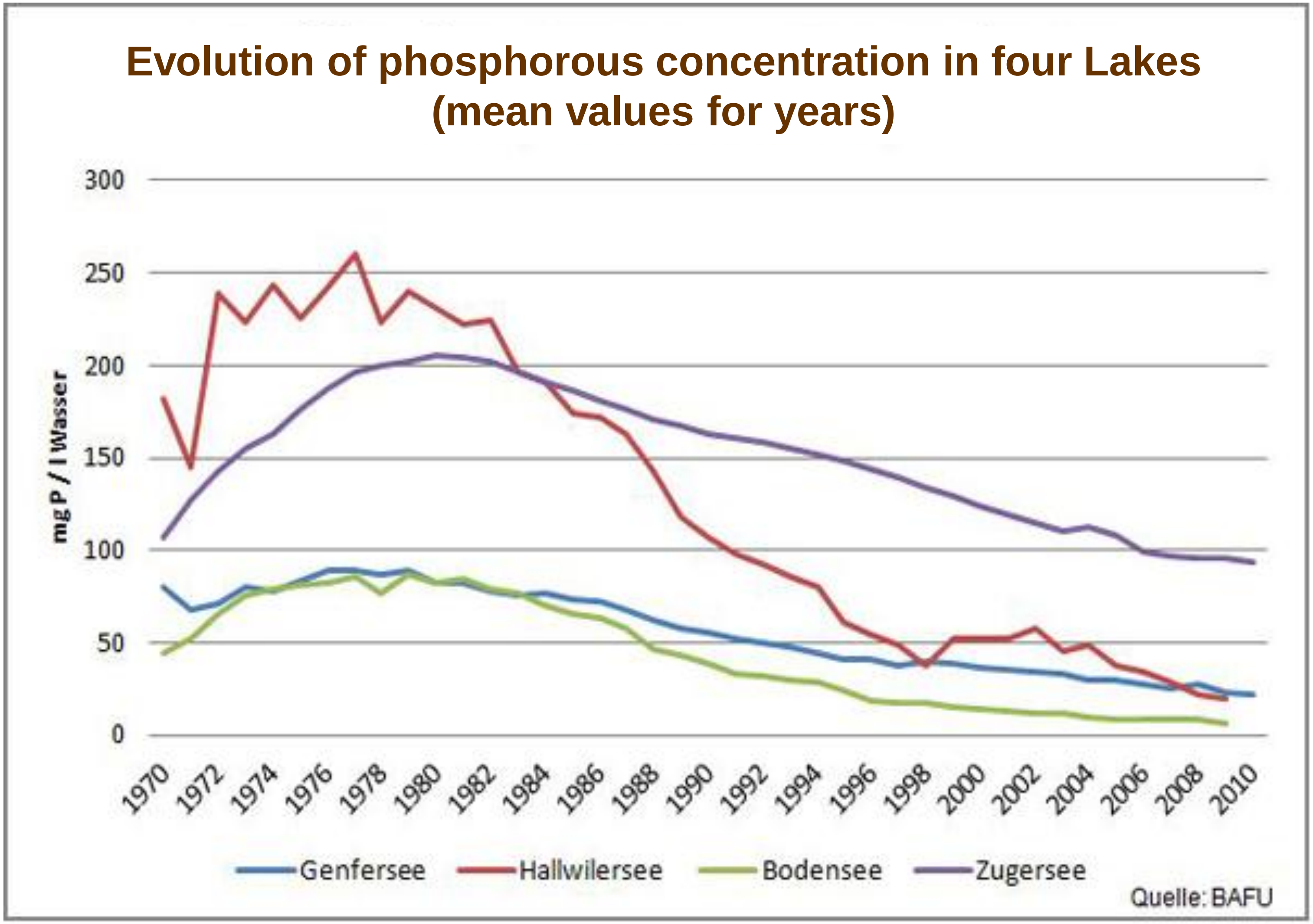
Nitrate concentration in groundwater, 2009



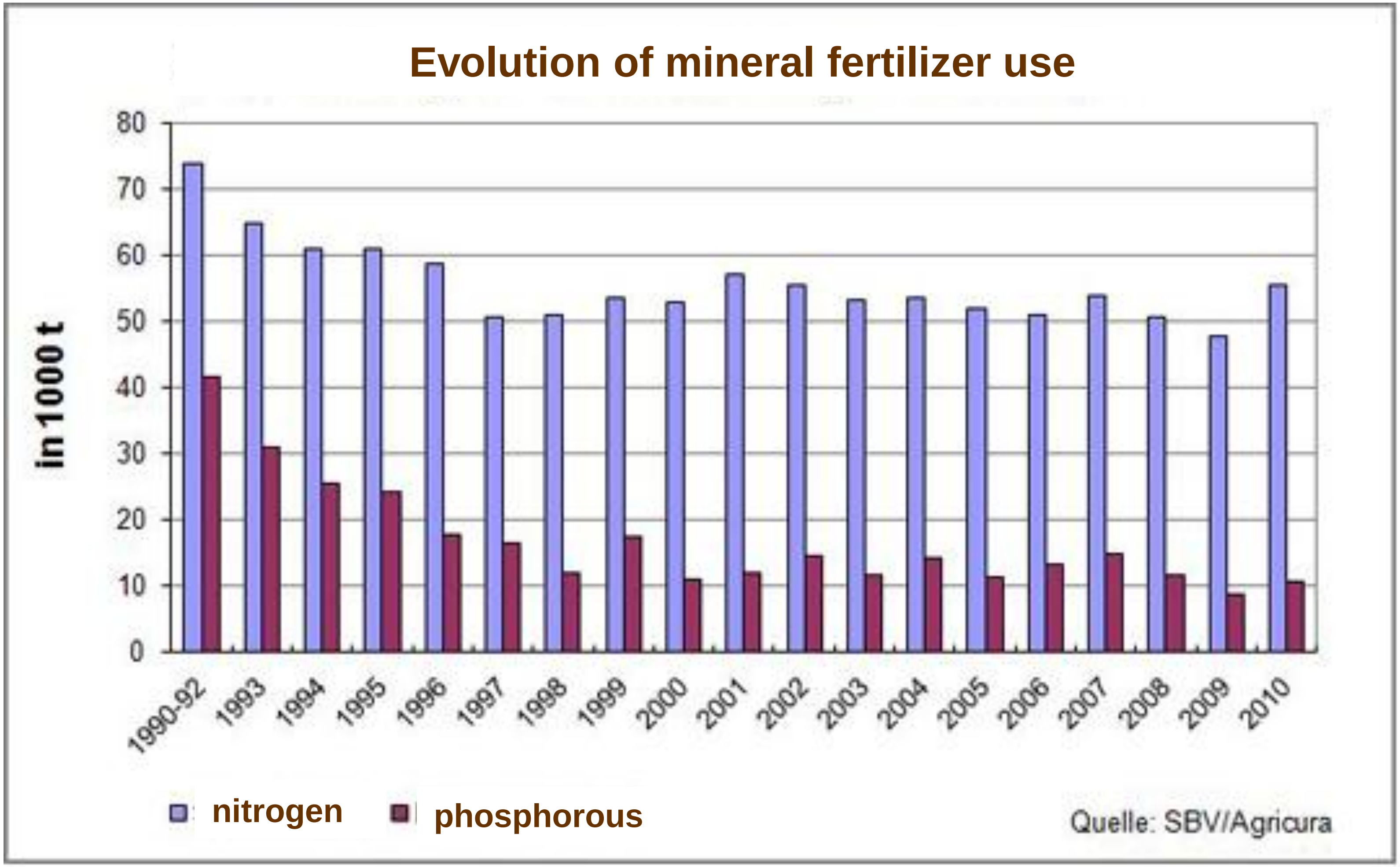
Examples for AEIs: phosphorous



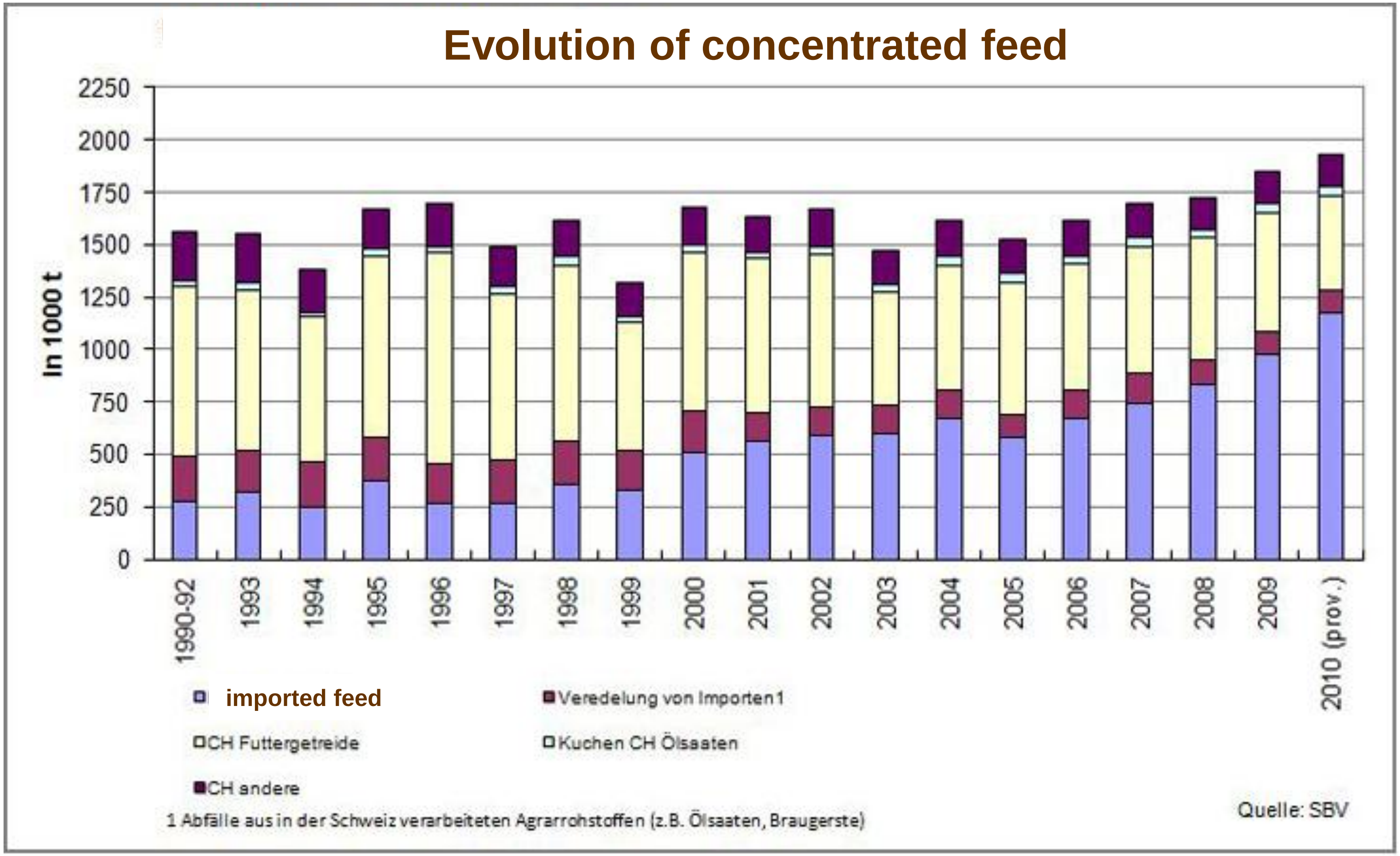
Examples for AEIs: phosphorous



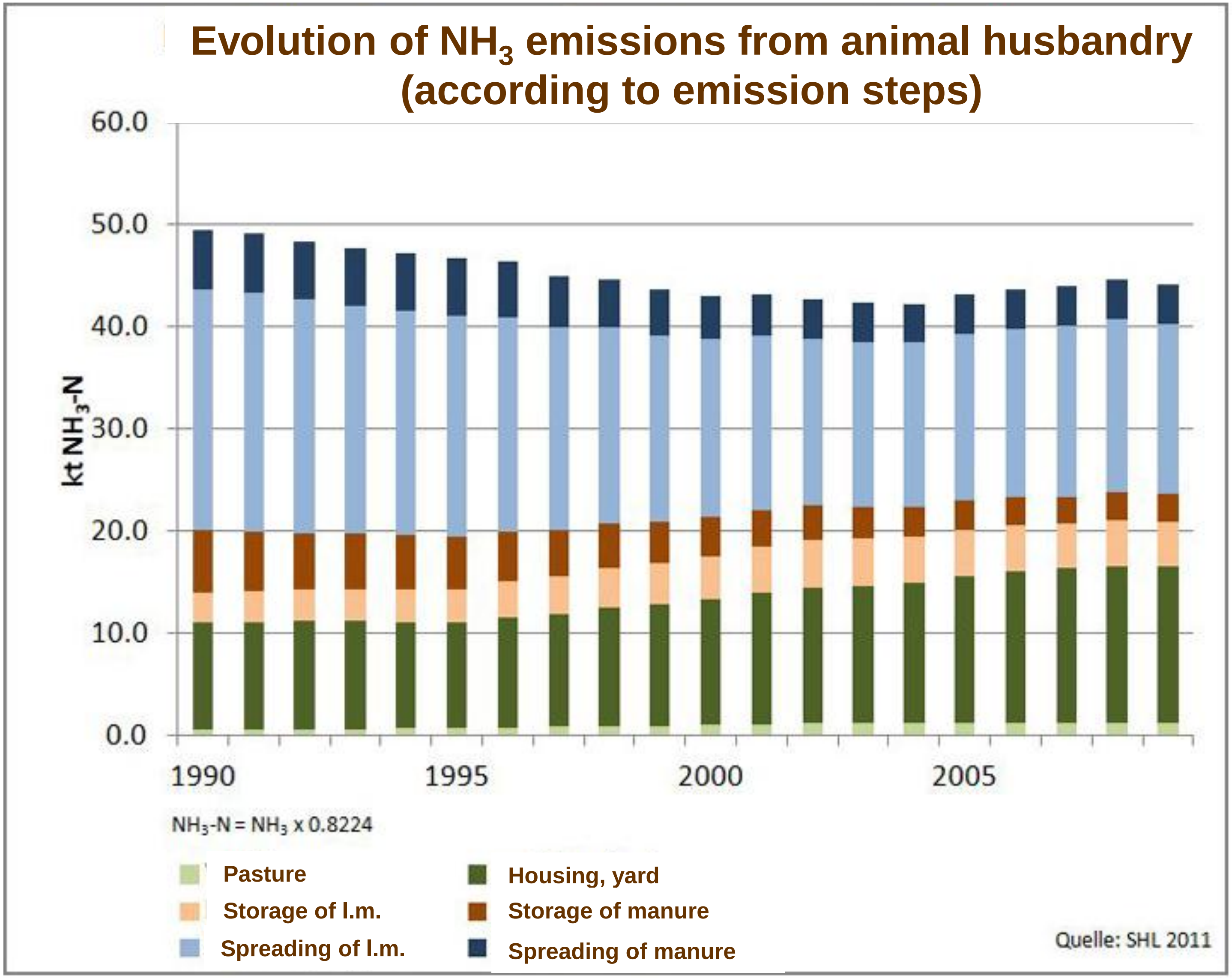
Examples for AEIs: nitrogen / phosphorous



Examples for AEIs: nitrogen / phosphorous

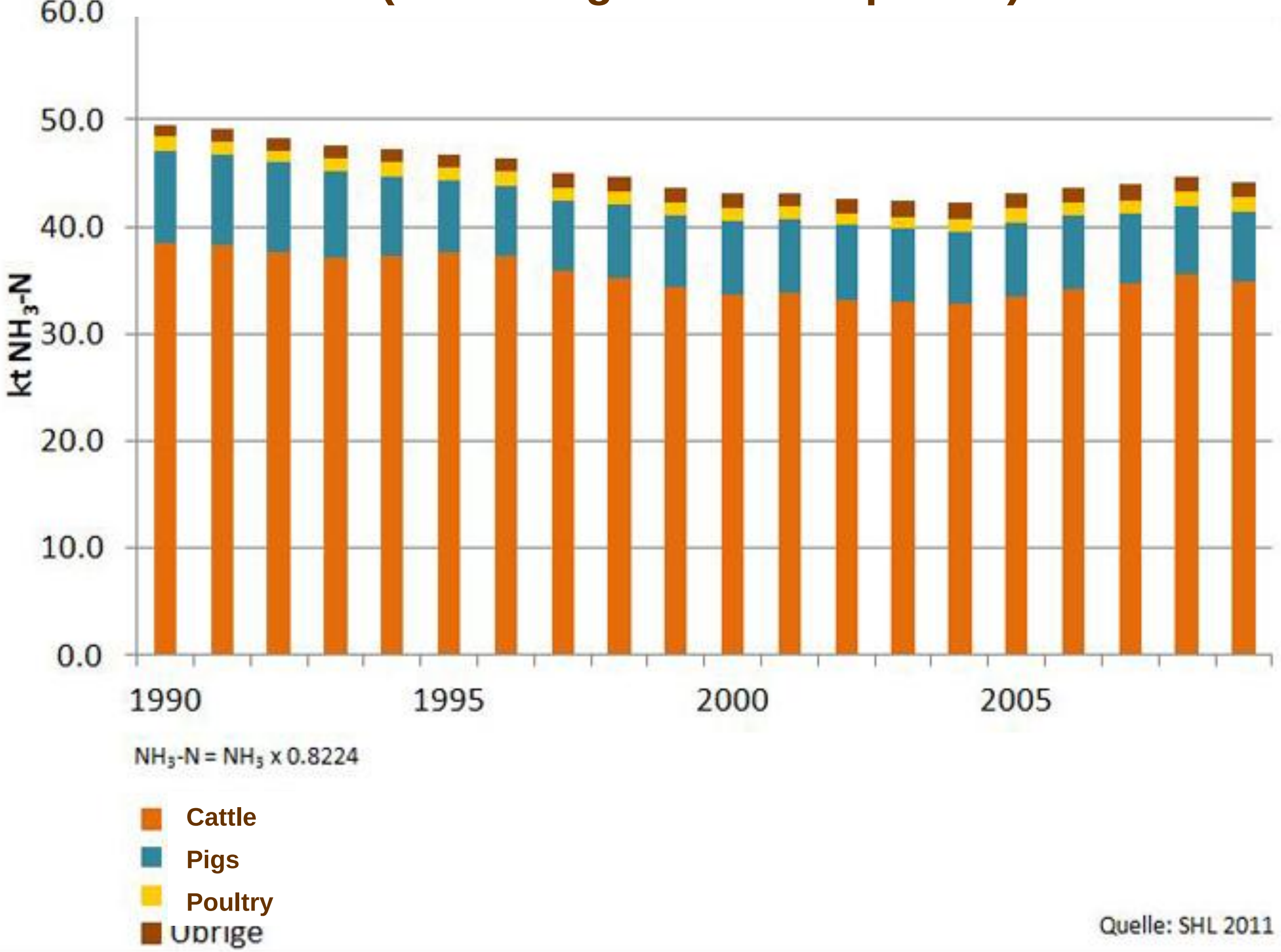


Examples for AEIs: energy / climate

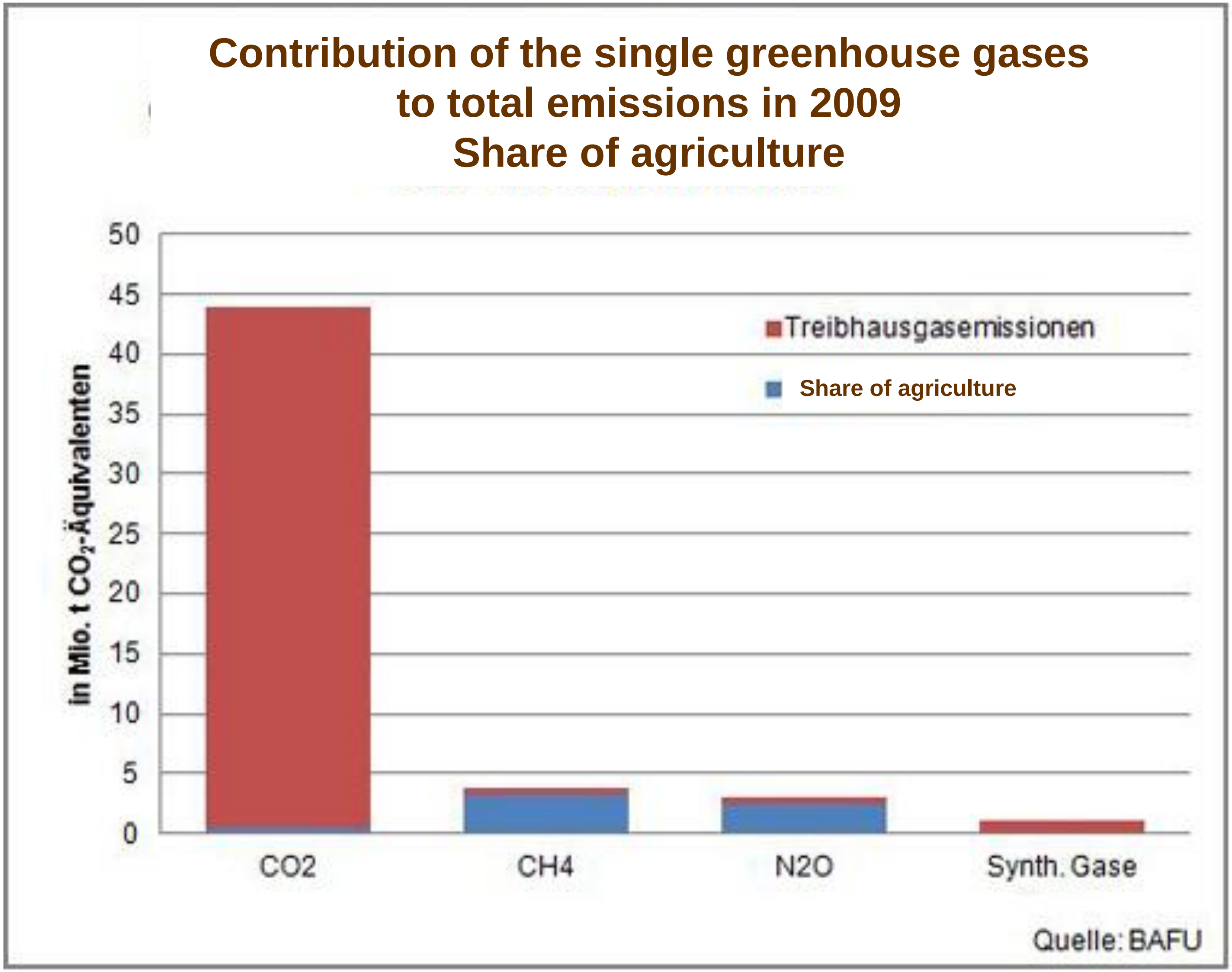


Examples for AEIs: energy / climate

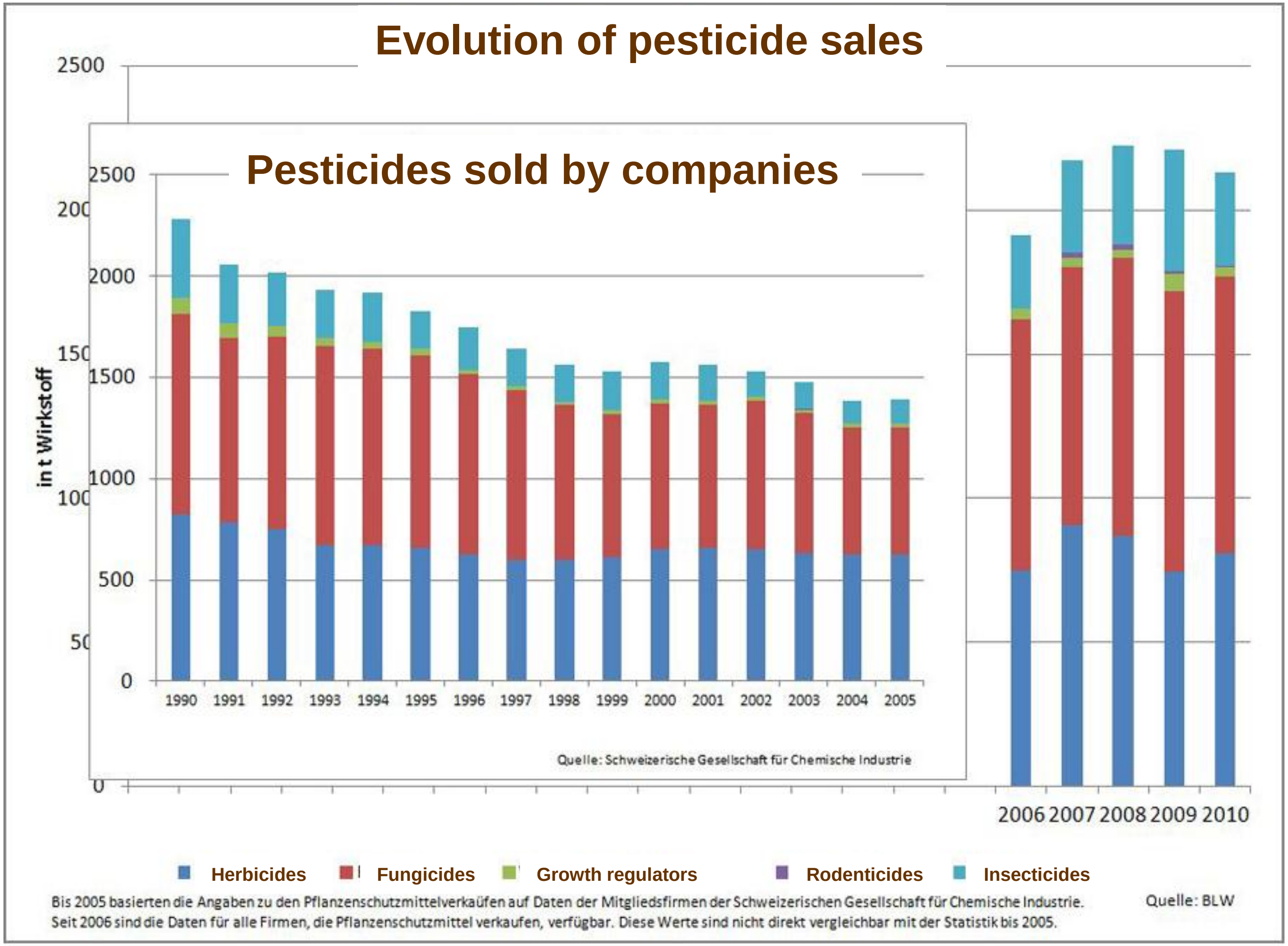
Evolution of NH_3 emissions from animal husbandry (according to animal species)



Examples for AEIs: energy / climate

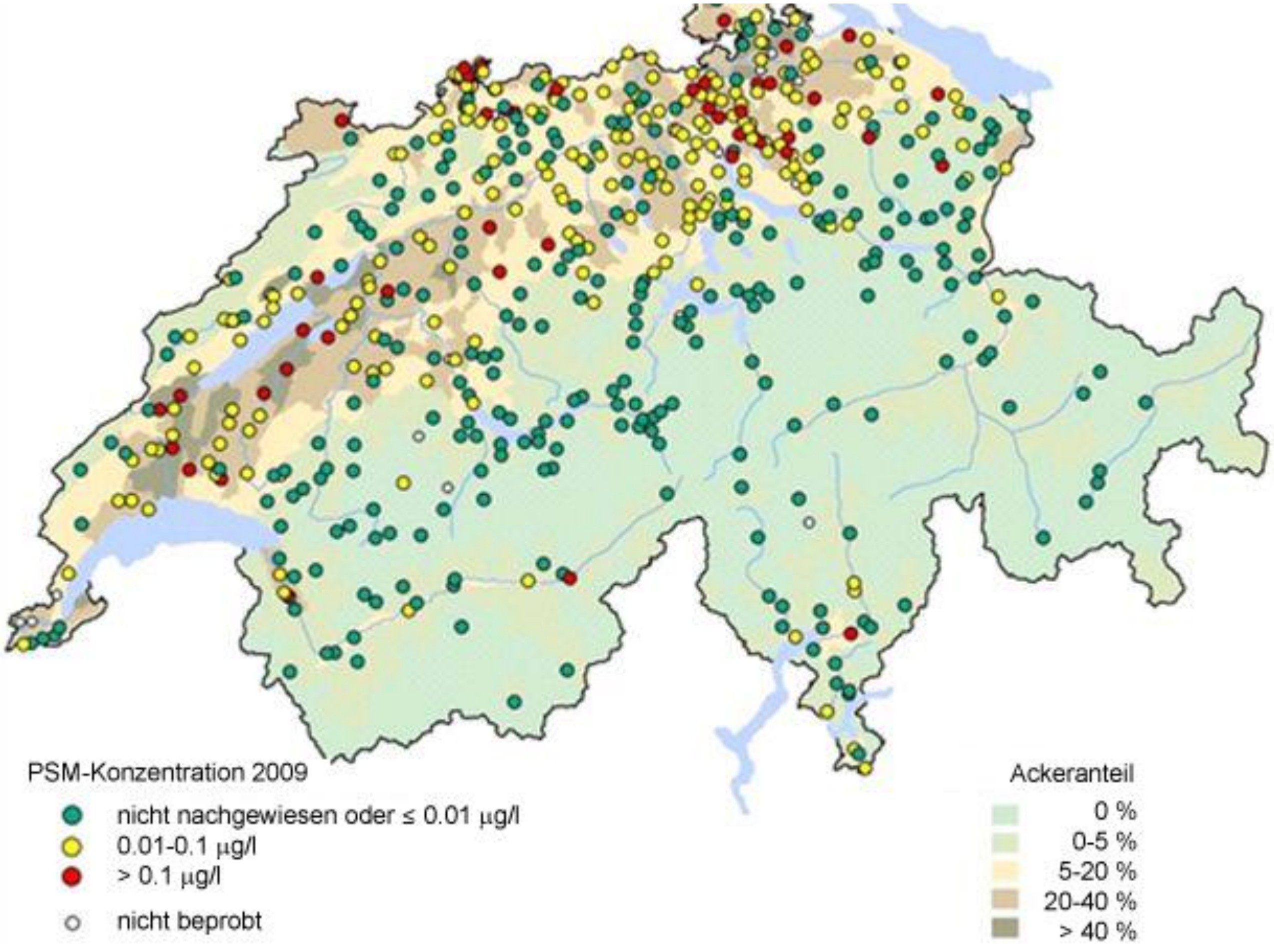


Examples for AEIs: water

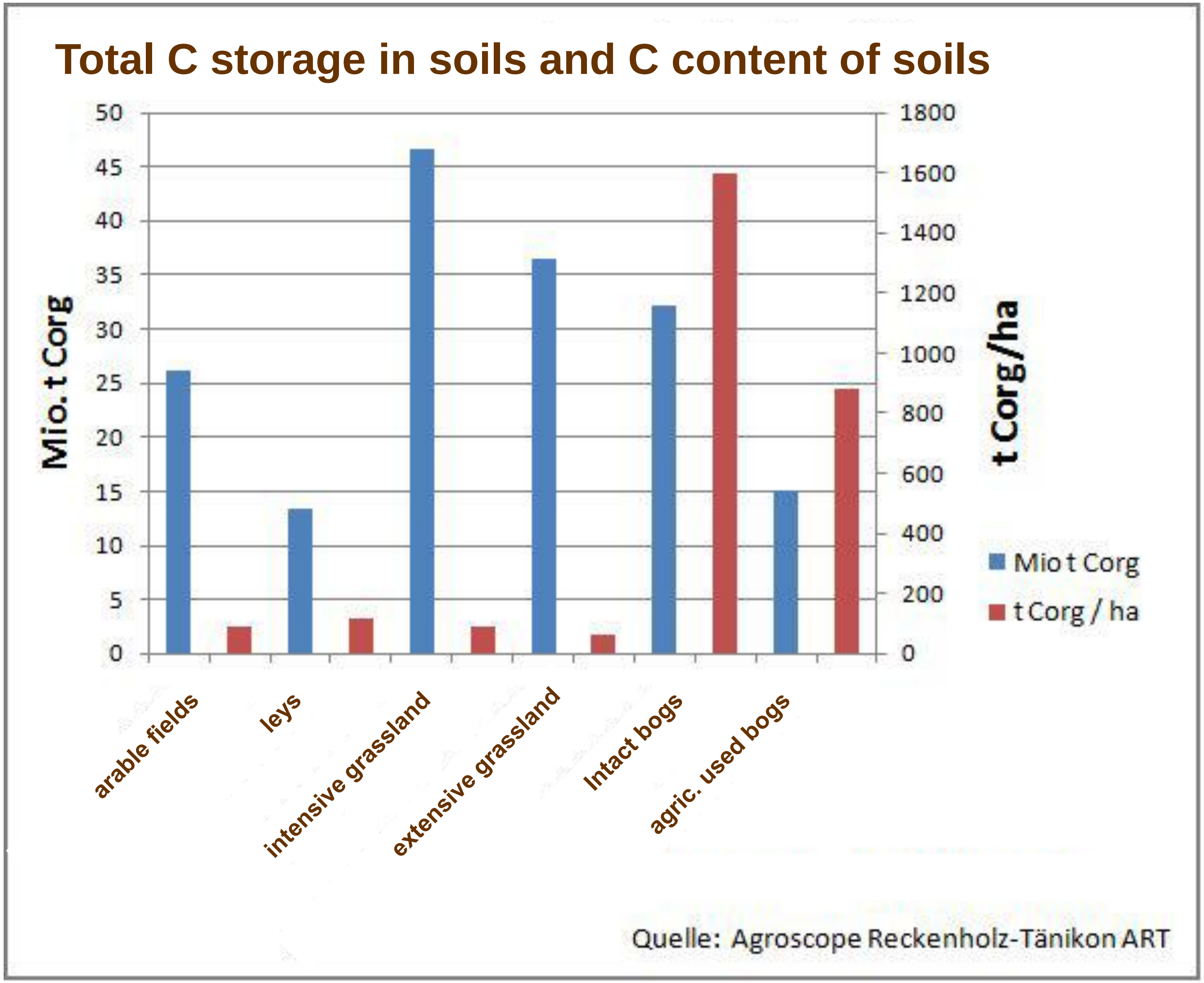


Examples for AEIs: water

Pesticide concentration in groundwater, 2009



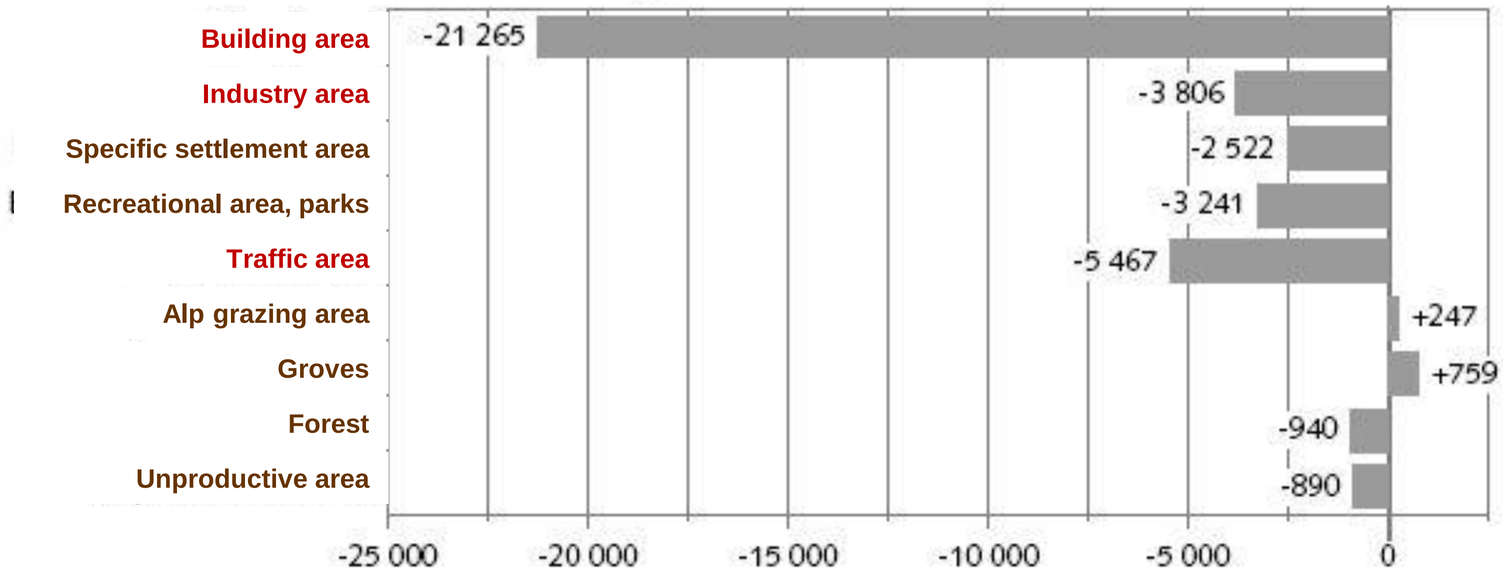
Examples for AEIs: soil



Examples for AEIs: soil

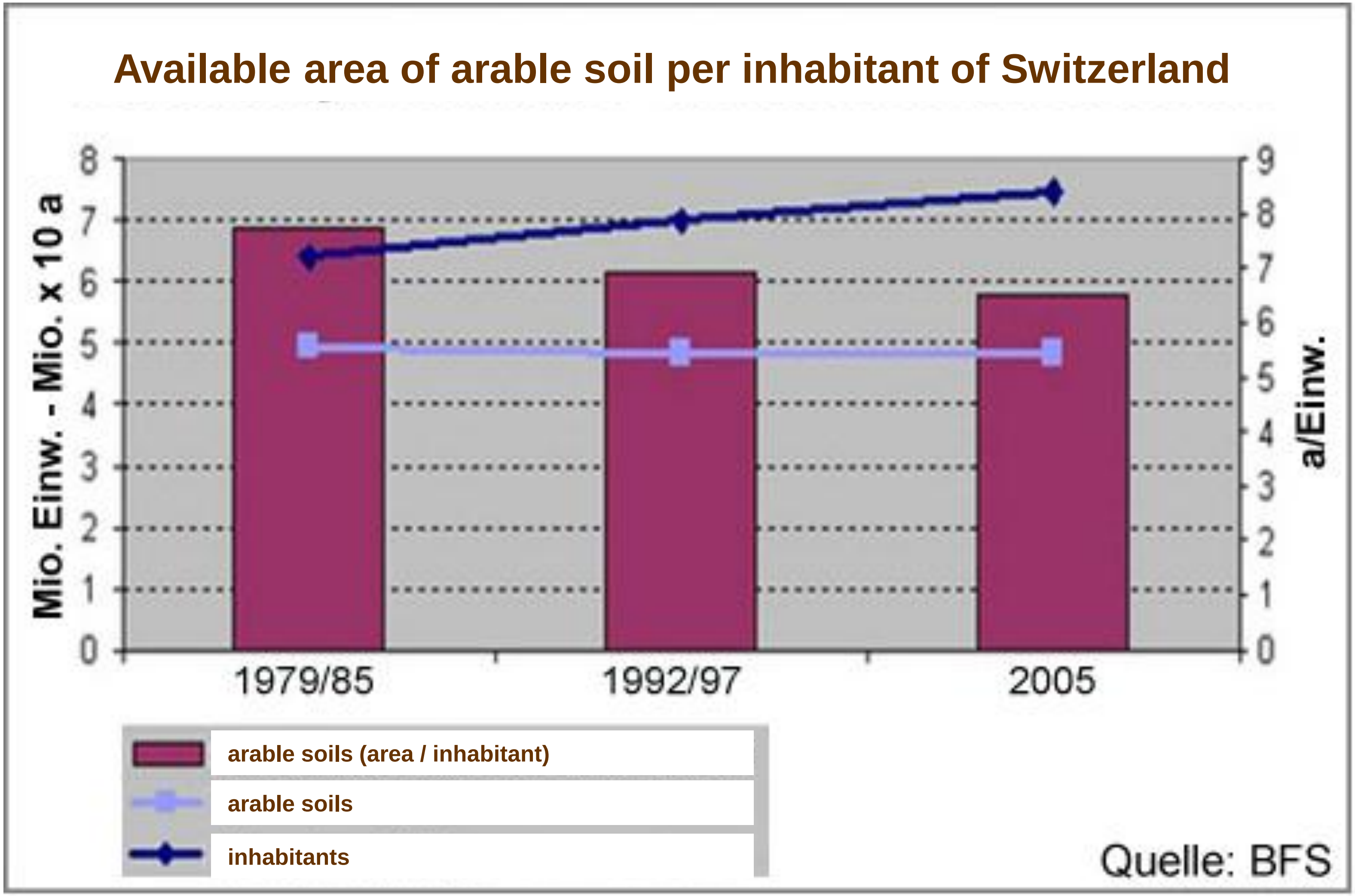
Changes in agricultural area 1979/85 – 2004/09

Auswertung von 16 Kantonen (ZH, BE, LU, OW, NW, ZG, FR, BS, BL, SO, SH, AG, VD, NE, GE, JU) mit einer Gesamtfläche von 2 004 130 ha oder 48,8% der Fläche der Schweiz, in Hektaren



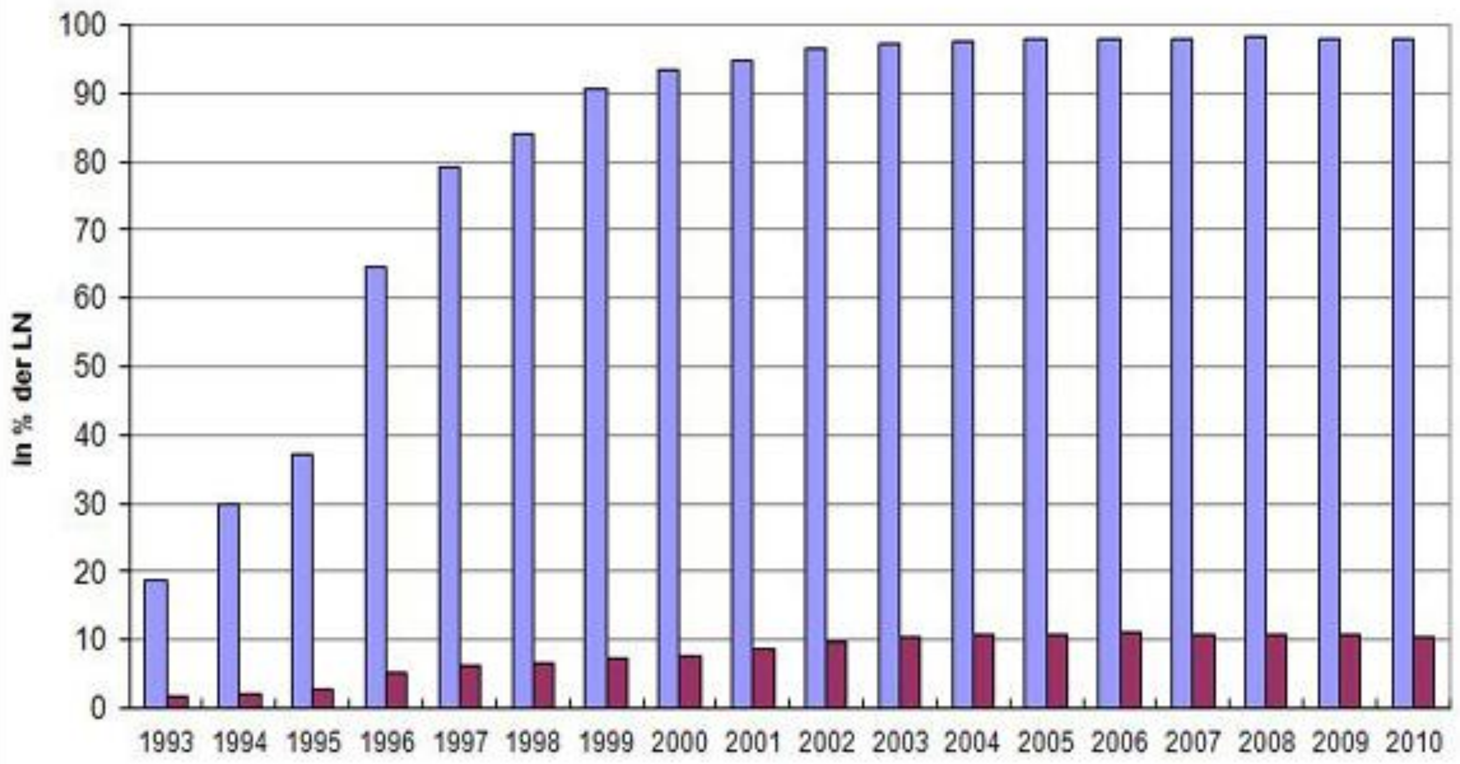
Quelle: Arealstatistik

Examples for AEIs: soil



Examples for AEIs: biodiversity / landscape

Evolution of area with environmental-friendly management



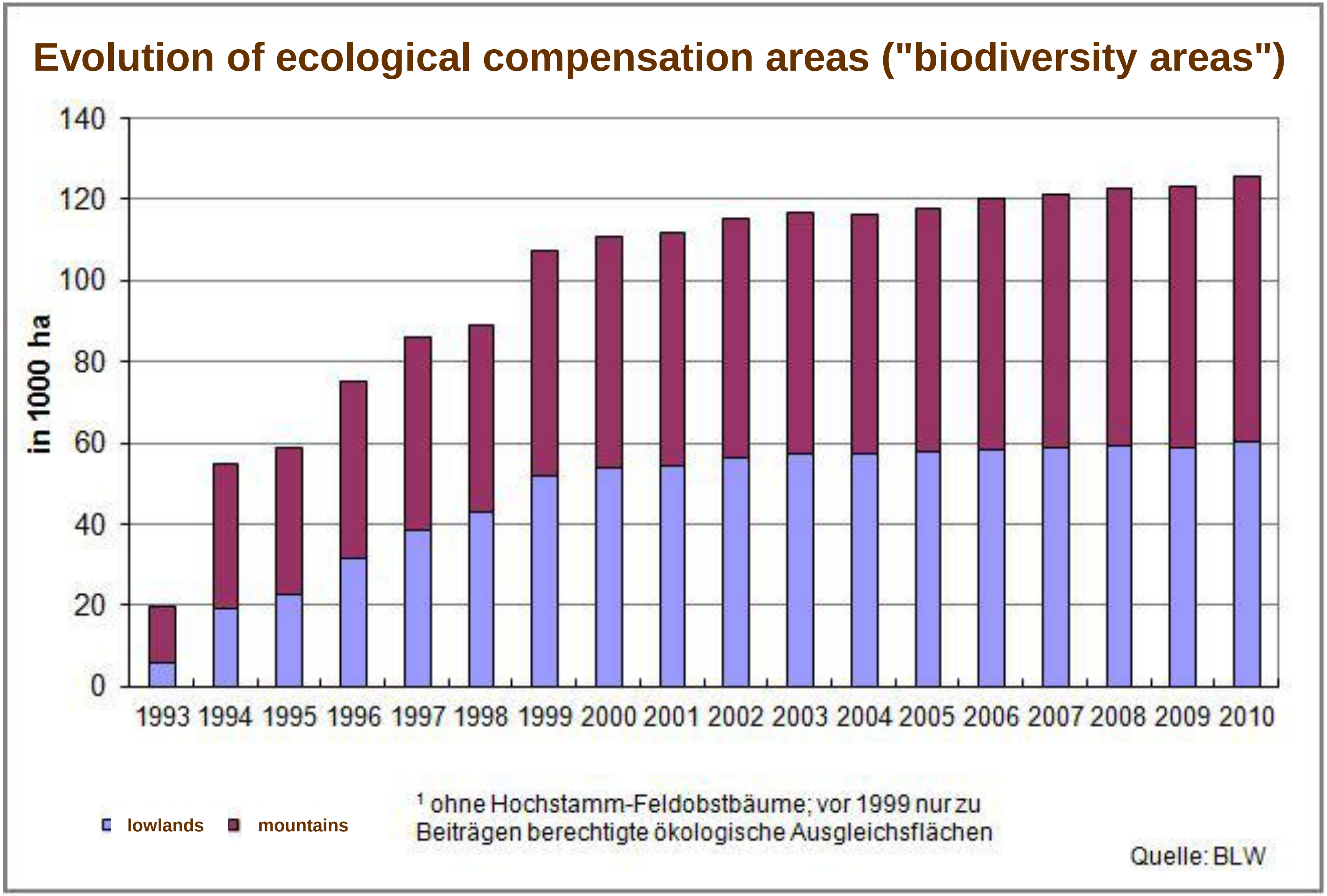
environmental friendly management

Organic farming

[1] 1993 bis 1998: IP+Bio; ab 1999: ÖLN

Quelle: BLW

Examples for AEIs: biodiversity / landscape



Thank you for your attention!

Agroscope