

# Integrated approaches to nitrogen management

## Some German experiences

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Air Pollutant Effects on Terrestrial Ecosystems*

# Outline

- The UBA strategy for the reduction of Nitrogen emissions
- What does „integrated“ mean?
- What is still missing?

## Why a strategy?

- N cascade not established as a concept
- N related environmental protection targets will not be reached
- They will be easier to reach when emitters and effects are treated in an holistic manner

## Customers

- Policy (NEC Dir. / Gothenburg Protocol; Nitrate & WF Directive; IPPC Directive; UNFCCC; CAP revision)
- NGOs and interested public
- European (NinE, COST729, TFRN, ...) & global N-networks

# Method and procedure

- UBA in-house working group and knowledge and publicly available / mostly official reported data
- external review via international status seminar (Nov 2008) and follow-up revision
- Report to MinEnv
- to follow: policy implementation by Environment and other Ministries

[www.uba.de/luft-e/index.htm](http://www.uba.de/luft-e/index.htm)

# Structure

1. Effects in relation to the N-Cascade

2. Nr related policies and quality targets

3. National Nitrogen budget

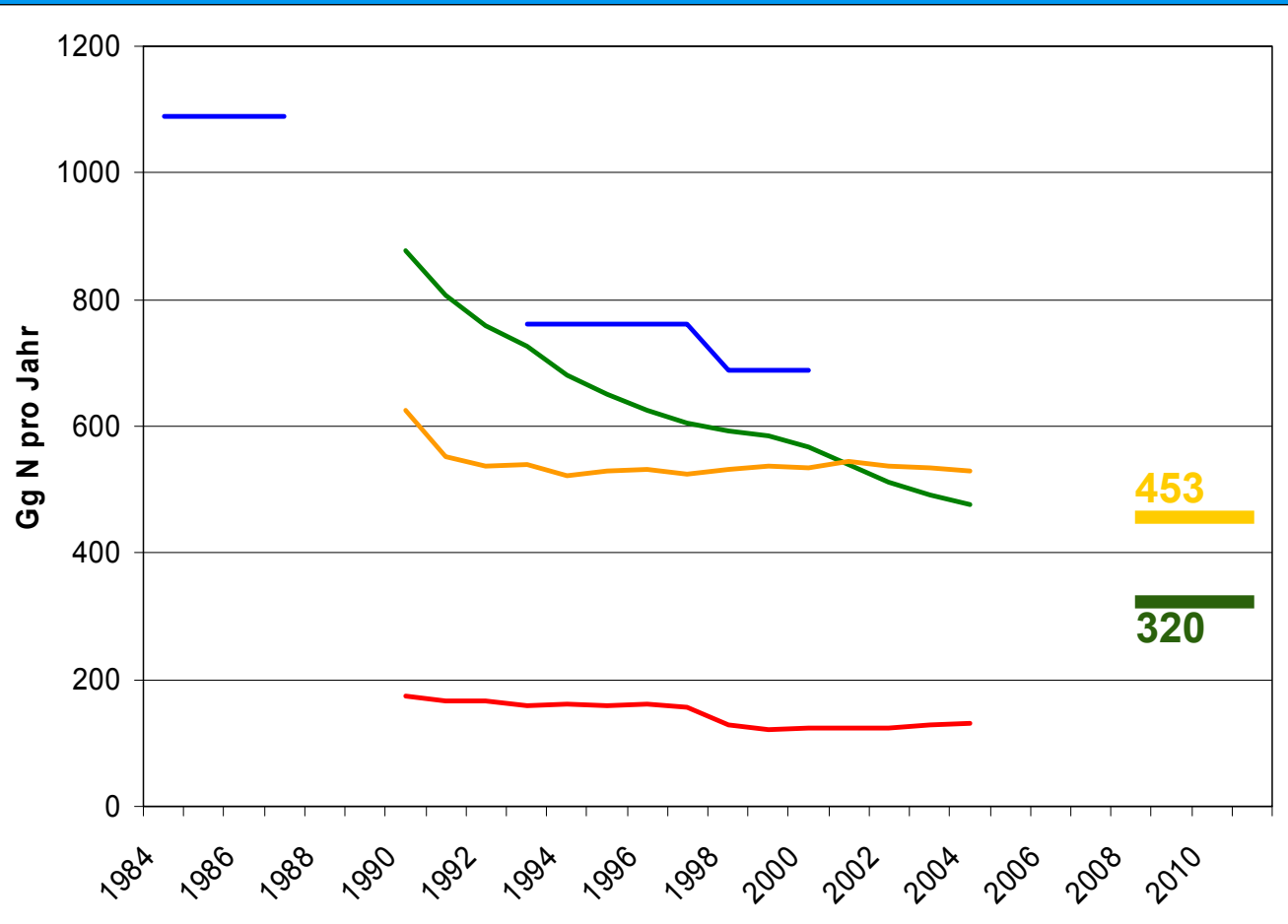
4. Evaluation of measures & instruments  
in relation to quality targets

5. Policy recommendations

INTEGRIERTE STRATEGIE  
ZUR MINDERUNG VON STICKSTOFFEMISSIONEN

Umwelt  
Bundes  
Amt   
Für Mensch und Umwelt

# German N emissions and targets



## Emissions

NO<sub>3</sub> / NH<sub>4</sub> to waters

NO<sub>x</sub> to atmosphere

NH<sub>3</sub> to atmosphere

N<sub>2</sub>O to atmosphere

## NEC Directive targets







NEC 2010 for NH<sub>3</sub>

NEC 2010 for NO<sub>x</sub>

453

320

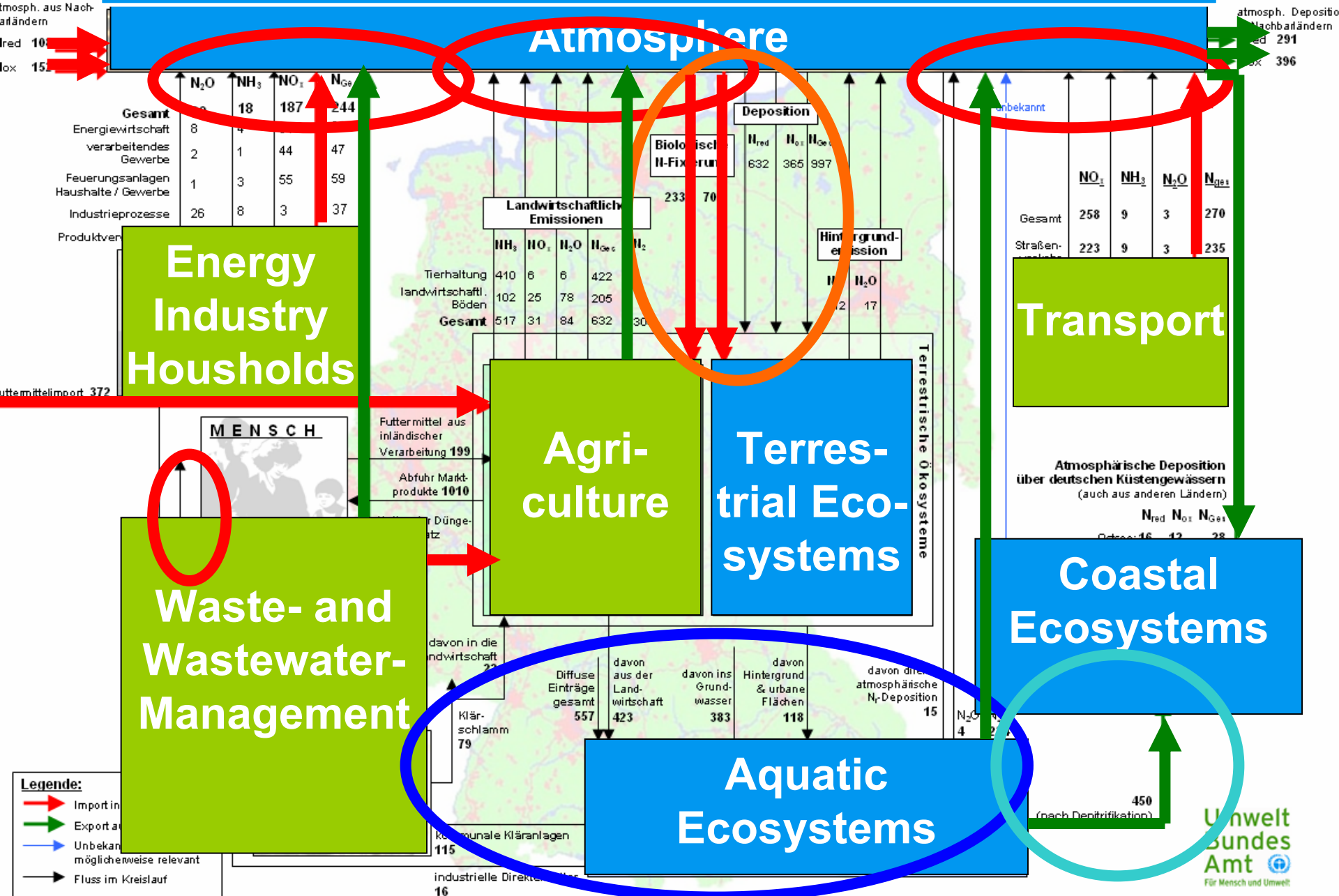
# N related environmental targets not reached

- Critical Loads for eutrophication and acidification exceeded on 95 % / 85 % of area 
- Insufficient reduction of N inputs into coastal waters 
- 14 % of measurement sites exceed nitrate concentrations limit values  / 
- PM10, ozone and NO<sub>2</sub> limit values partly exceeded  / 

# N-Budget for Germany

**IMPORT**

**EXPORT**



## N-Budget for Germany

### **import:**

- 1808 Gg mineral fertiliser
- 372 Gg feedingstuff import
- 300 Gg biological N fixation
- 514 Gg combustion
- 260 Gg transboundary atmospherical transport

**about 3200 Gg total**

### **quantifiable export:**

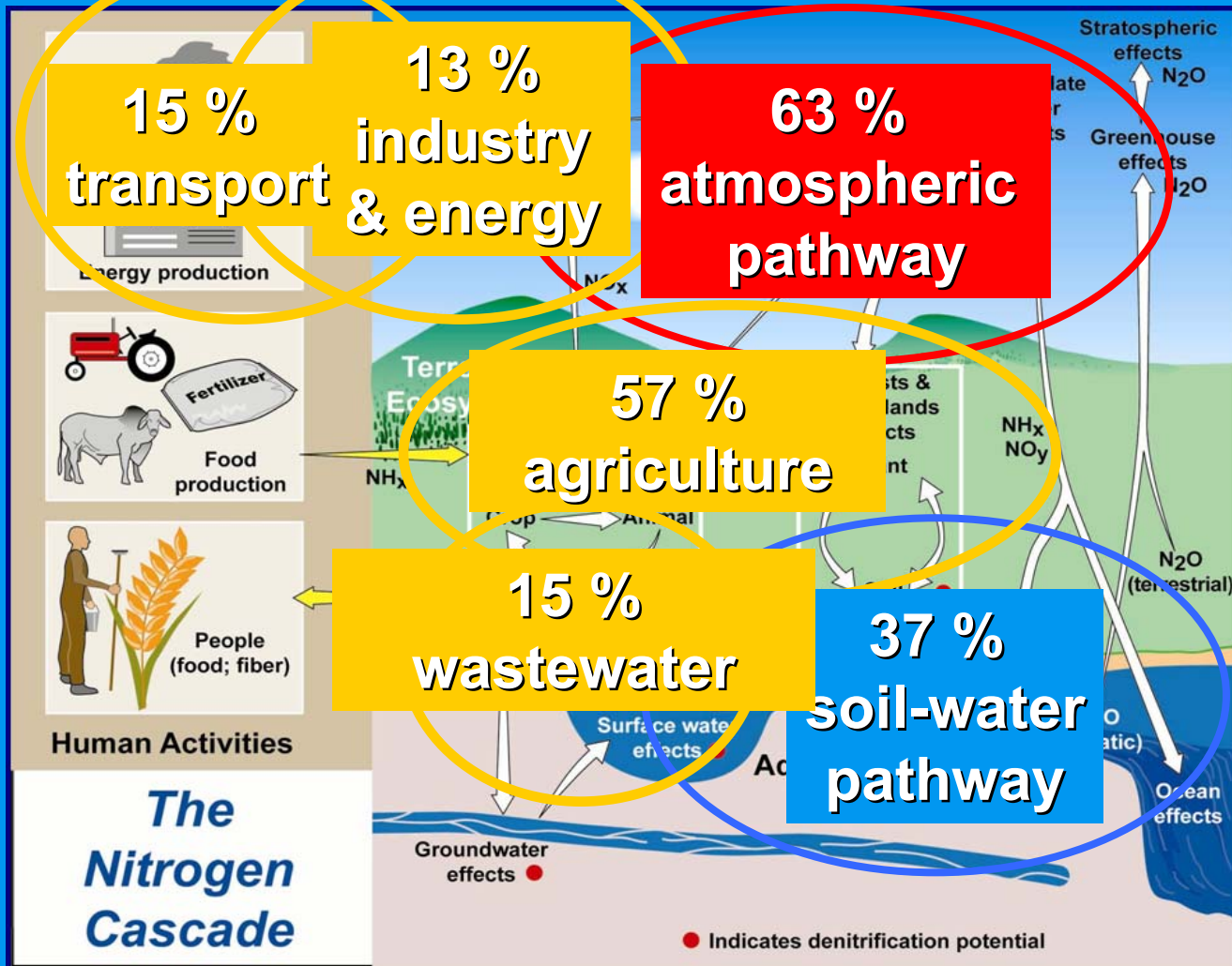
- 450 Gg river-based transport to sea
- 700 Gg transboundary atmospherical transport
- 830 Gg denitrification estimates:  
rivers, agriculture,  
wastewater management

**about 2000 Gg total**

## Uncertain fate of reactive N:

about 40 % of the anual import (accumulation? / loss? / export?)

# N-Budget for Germany



<u>Emissions [Gg]</u>	
agriculture	1062
transport	270
energy & industry	244
wastewater	270
waste	10
<b>total</b>	<b>1856</b>

van der Hoek et al., 1998

# Assessment of measures & instruments

- N-reduction potential [ $\text{Gg a}^{-1}$ ]
- cost-effectiveness [ $\text{€ / kg N}$ ]
- synergies & „pollution swapping“
- mandatory vs. optional

## Emission sectors

- agriculture
- transport
- energy & industry
- waste- & wastewater management

# Assessment of measures & instruments

- synergies & trade-offs so far not fully quantifiable
- largest reduction potential in agriculture, high cost-effectiveness
  - management measures & economical instruments are cheap and have high reduction potential
  - agricultural „m & i“ show large synergies
- within transport and energy sector a lot of cost-effective „m & i“ already implemented
- changed consumers' behaviour potentially effective

# Optional agricultural measures (examples)

Agricultural measures	NO <sub>x</sub>	NH <sub>3</sub>	NO <sub>3</sub> /NH <sub>4</sub>	N <sub>2</sub> O	reduction potential [Gg N]	cost effectiveness [€ / kg N]	Legal implementation
increased consultancy of farmers for use of fertilisers	°	++	++	+	45	high	„instructions of farmers by administrations, chambers of agriculture, consultants
quotation of mineral fertilizer due to fertilization plans (accredited experts)	°	+	++	+	n.q.	n.q.	Tightening of Fertilisation Ordinance Administrative consulting for fertilisation plans
Increased fertilisation efficiency	°	+	++	+	n.q.	n.q.	„administrative consulting for fertilisation; chambers of agriculture, consultants
N reduced feedingstuff adjusted to the N demand of the animals	°	++	+	+	14	high	Restoration and licensing of housing: certification of n-adjusted feeding (claim for TA Luft Nr. 5.4.7.1 c); consultation of the farmer by animal nutrition consultant
Air purification in pig housing	-	++	°	-	16	n.q.	Licensing TA Luft (Nr. 5.4.7.1 d); (instructions for farmers)
Covered storage (min. 6-8 month capacity) (pigs)	°	++	-	-	8	high	„Licensing, TA Luft Nr.5.4.7.1 h)“
Covered storage (min. 6-8 month capacity) (cattle)	°	++	-	-	2	medium	„Licensing, TA Luft Nr. 5.4.7.1 h)“

[www.uba.de/luft-e/index.htm](http://www.uba.de/luft-e/index.htm)

# Is the evaluation of measures and instruments integrated?

- Listing of „m & i“ for all relevant emitters ✓
- Evaluation w.r.t. abatement potential, abatement costs, synergies/antagonisms ✓
  - but costs and synergies/antagonisms not fully quantitative ✗
- Guidelines for generic assessment of „m & i“ ✓
- Realizability of „m & i“ (?)

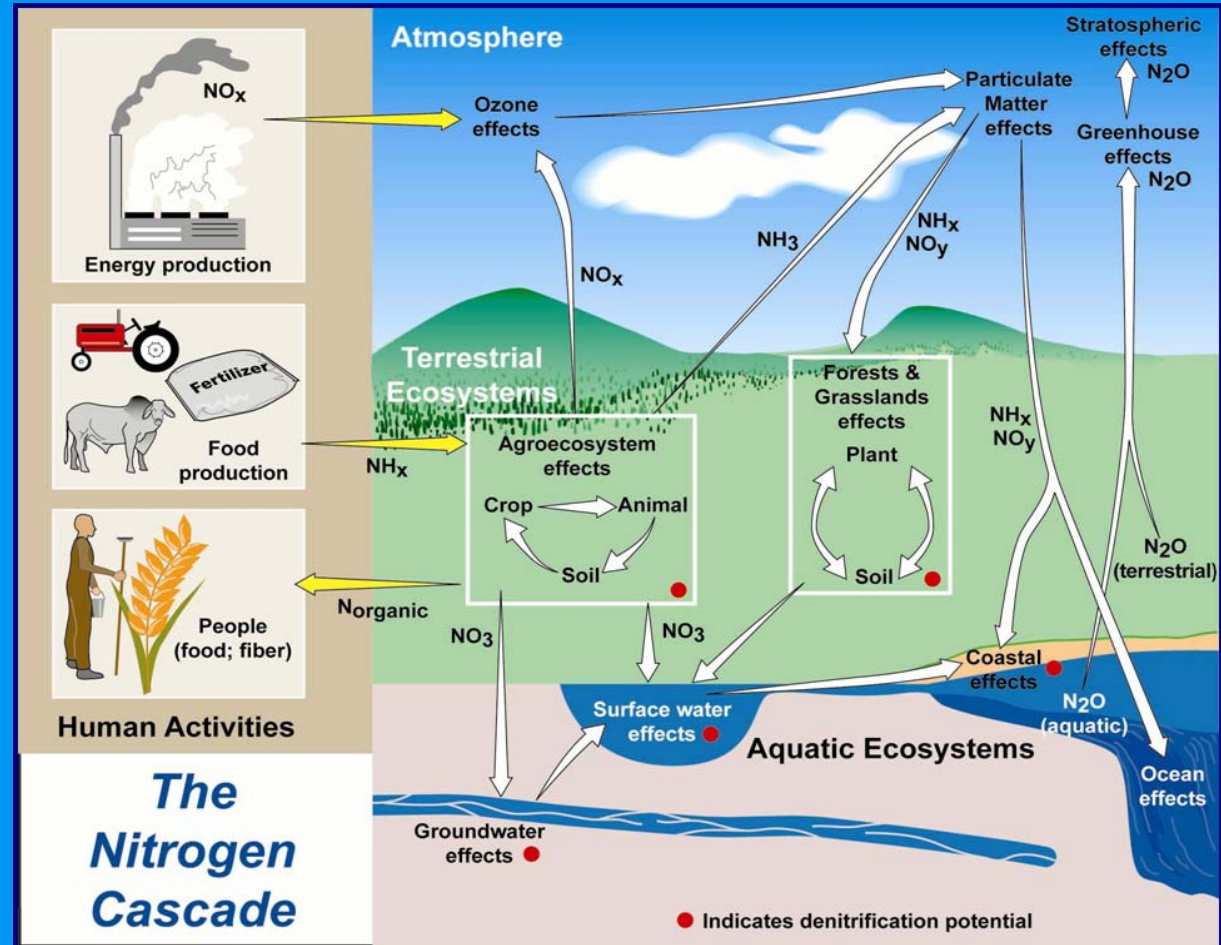
# Realizability of measures and instruments

- Regulated by law vs. optional ✓
- General criteria for success of m&i:

	<u>Combustion</u>	<u>Agriculture</u>		<u>Urban</u>
	<u>NO<sub>x</sub></u>	<u>NH<sub>3</sub></u>	<u>NO<sub>3</sub></u>	<u>N<sub>tot</sub></u>
Few stakeholders	x			x
Technology driven	x	x		x
Low costs			(x)	
Cost to consumers	x			x
Knowledge extensive		(x)		(x)
No yield loss	x	x		x

# Does the M&I evaluation take into account the N cascade ? (1)

- multi-source ?
- multi-effect ?
- multi-media ?
- multi-scale ?



# Multi-source

OK!

# Multi-effect, multi-media

- Evaluation takes into account
  - transfer between different N forms
  - cross-media effects (indirectly)

## BUT

- Synergies and pollution swapping not fully quantified
- There is no „evaluation currency“:
  - 1 kg  $\text{NH}_3\text{-N}$  = 1 kg  $\text{N}_2\text{O-N}$ ?
  - If not: how else?
- Evaluation target: eutrophication, climate change etc. or ecosystem services?

# Multi-scale

- “m & i” are defined on national/continental level but take effect locally / regionally
- “global perspective is critically important to public perception!”
- How to assess (spatial and temporal) scale of effects:  
N<sub>2</sub>O-N (global, 100 years) vs.  
NH<sub>3</sub>-N (local/regional, days to years)?

# Does the M&I assessment take into account the N cascade ? (2)

- multi-source ✓
- multi-effect, multi-media (✓)
- multi-scale ?

	General	Global	Transboundary	National	Local
Acidification from NH <sub>3</sub>	1	-	1	2	1
Eutrophication from NH <sub>3</sub>	1	-	2	1	1
NH <sub>4</sub> <sup>+</sup> aerosol as a global coolant	-	1	-	-	-
Effect of NH <sub>3</sub> on atmos. transport of SO <sub>x</sub> & NO <sub>v</sub>	-	2	2	3	-
Global warming from N <sub>2</sub> O	1	1	-	-	-
NO <sub>3</sub> <sup>-</sup> leaching	-	-	-	-	2

Results of DELPHI analysis by Angus et al. (J. Env. Man. 2003)

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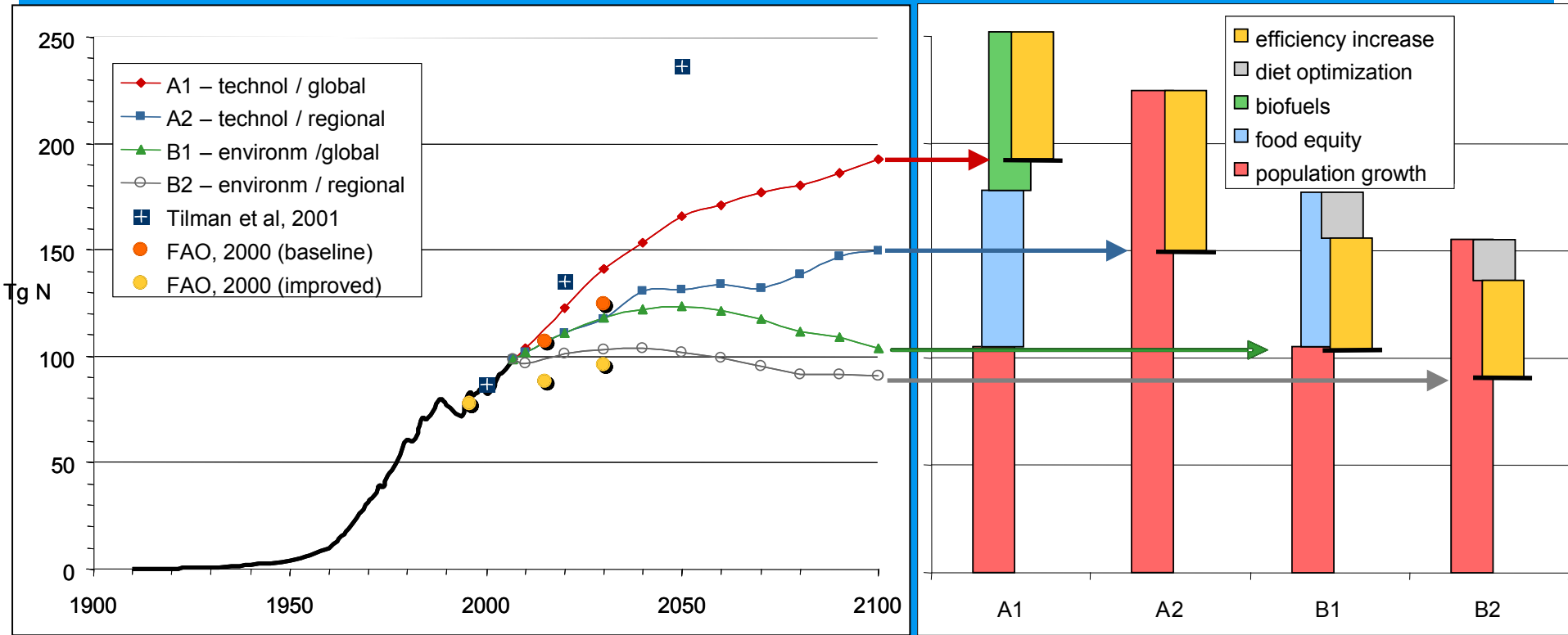
# N budgets are a useful policy instrument!

- **Communication and issue building**
- **Priorisation of fluxes for policy information**  
(e.g. air vs. water; agriculture vs. industry; ...as compared to EQOs)
- **Various scales:**
  - Sectoral (e.g. farm / field / soil budgets)
  - Local (NEU 4: Cellier et al)
  - National (NL, D, CH, ...)
  - Europe (ENA)
  - Global (e.g. Erisman et al 2008)
- **Optional coupling to C, P,... budgets** (Galloway&Gruber 2007)
- **Identification of control/intervention points** where
  - N efficiency can be improved (z.B. N efficient fertilization)
  - Nr losses are large (z.B. waste water treatment)

# Needed: Dynamic N Budgets

- **Dynamic flux / effect model** (after Galloway et al. 2008)
  - How much Nr enters the system?
  - How long does it stay in a compartment?
  - What are the effects?
  - What are the accumulation / loss rates?
  - How much Nr is transported where & in which form?
- **Aim: Prognoses, Scenarios** (ENA 5b)
  - How, where and when do m&i / policies change fluxes & accumulation rates?
  - How, where and when do m&i / policies change effects?
  - ... as compared to EQOs?

# Global Fertiliser Consumption 1900-2100

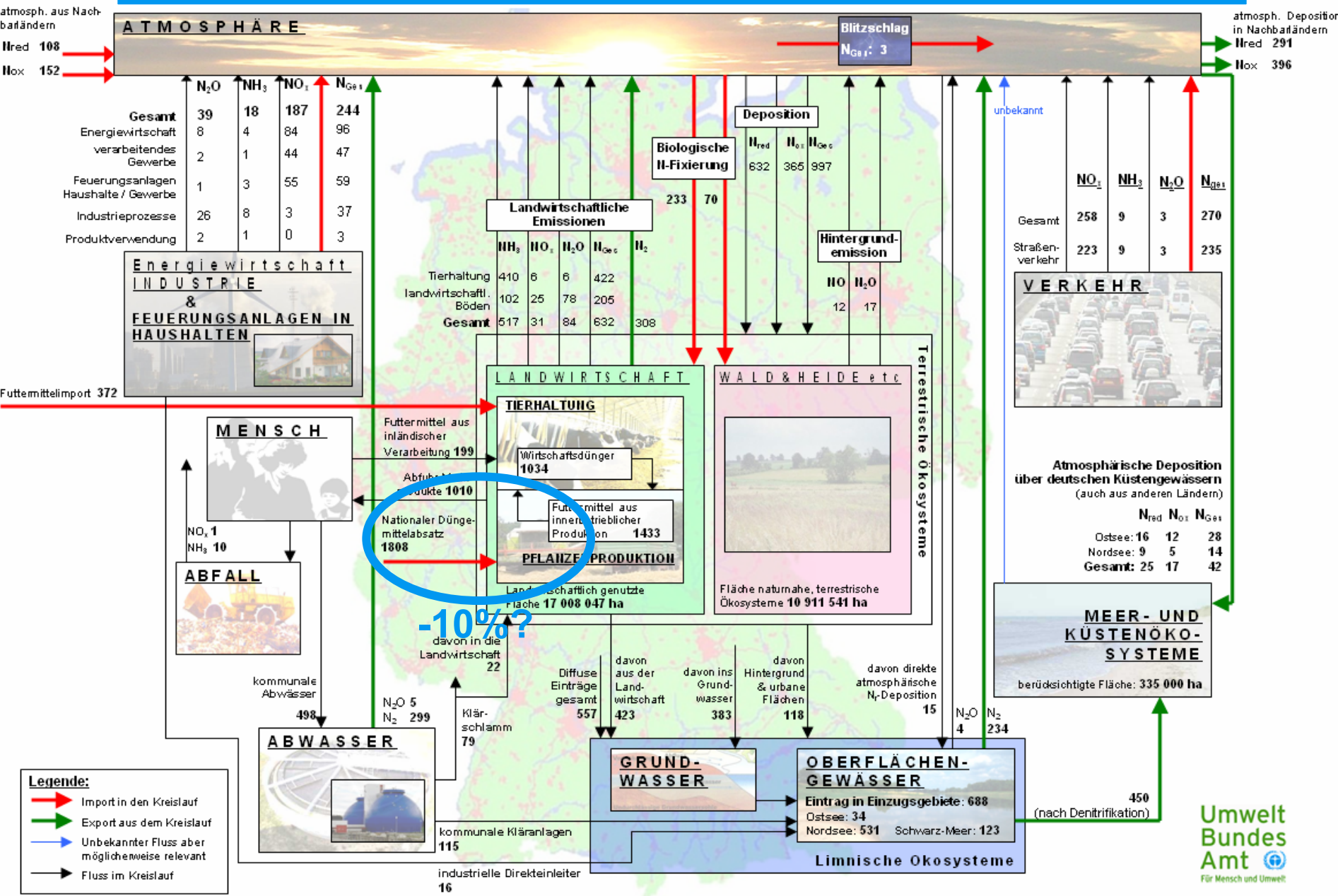


Erismann et al., Nature Geoscience (2008)

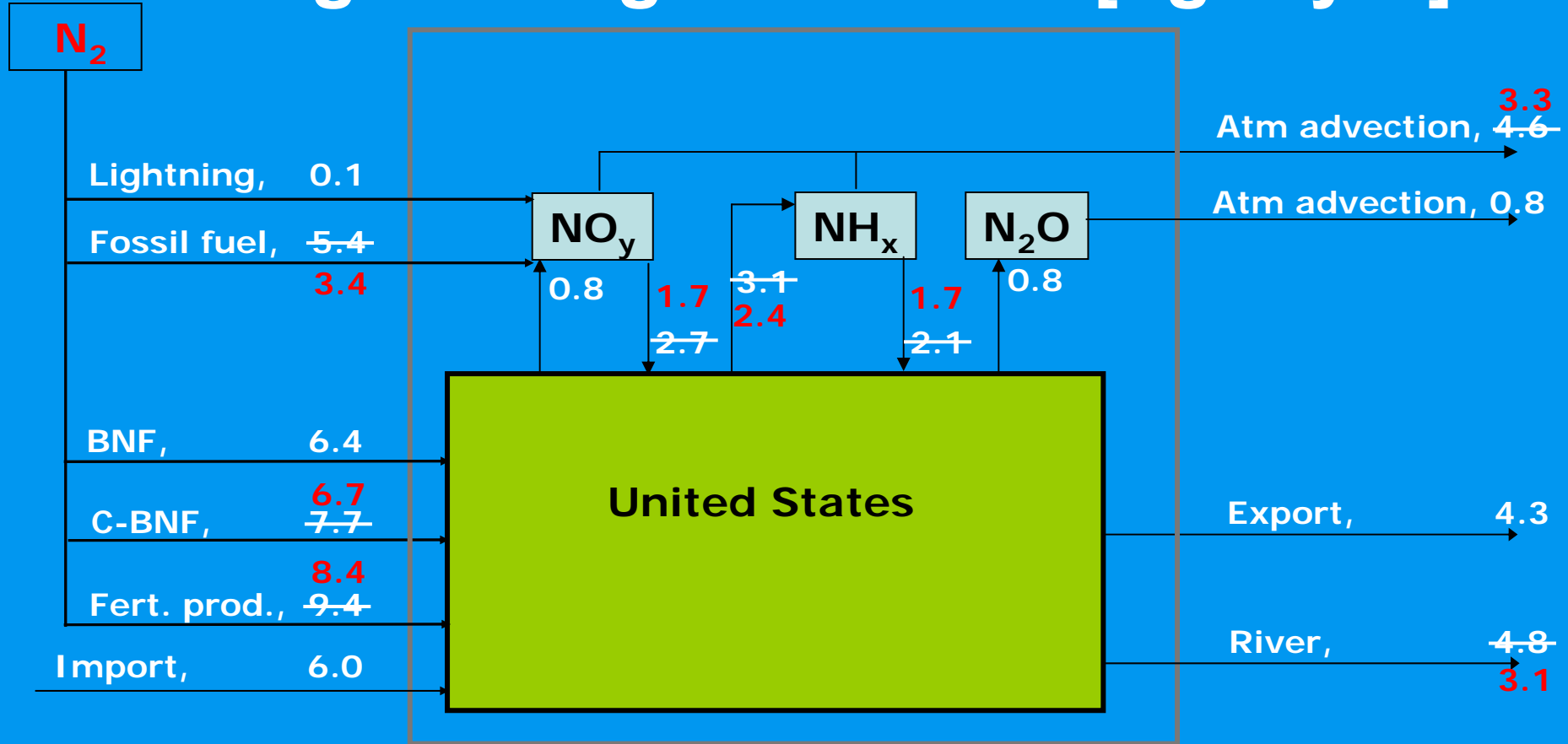
# Impact analysis of individual m&i

**IMPORT**

**EXPORT**



# US Nitrogen Budget: Revised [Tg N yr<sup>-1</sup>]

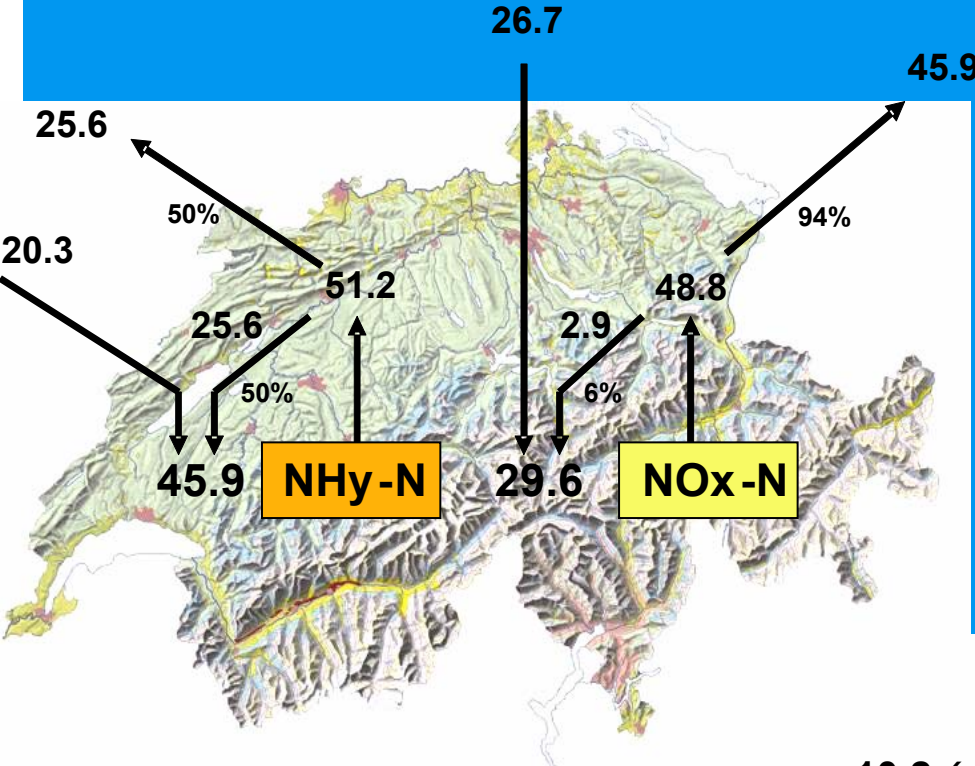


Nr Inputs: ~~35~~ **29** Tg N  
 Nr Outputs: ~~14~~ **11** Tg N

*The numbers on this slide have been modified, assuming the actions at control points were effective.*

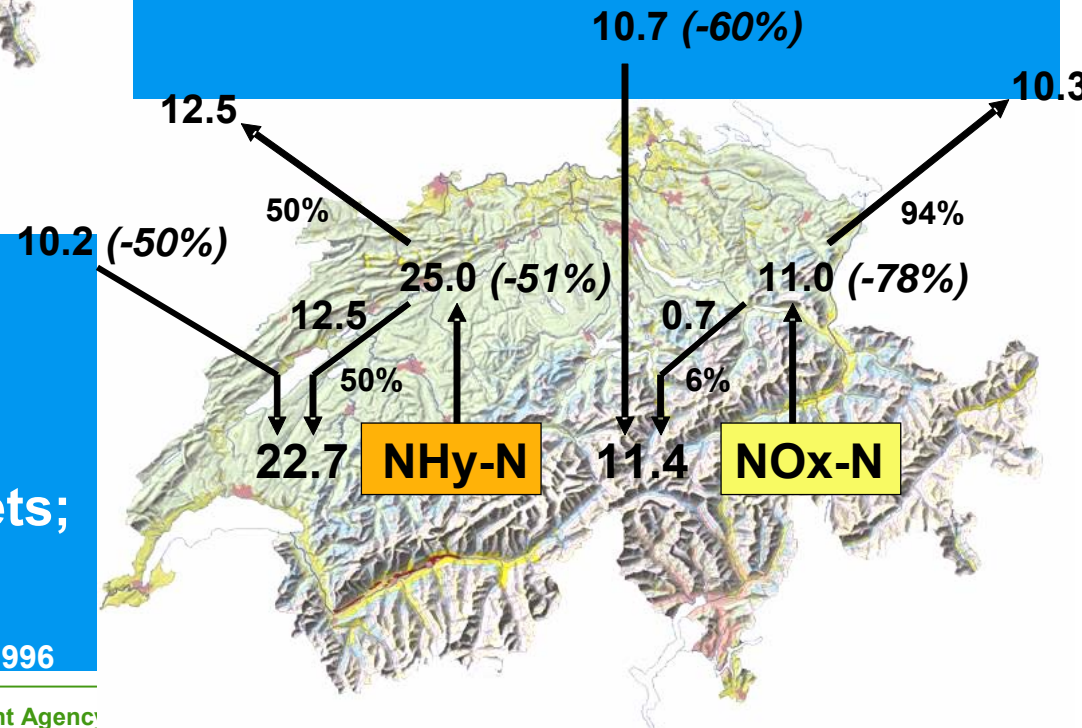
Galloway et al. (2008)

# Emission reduction towards sustainability: Swiss strategy I



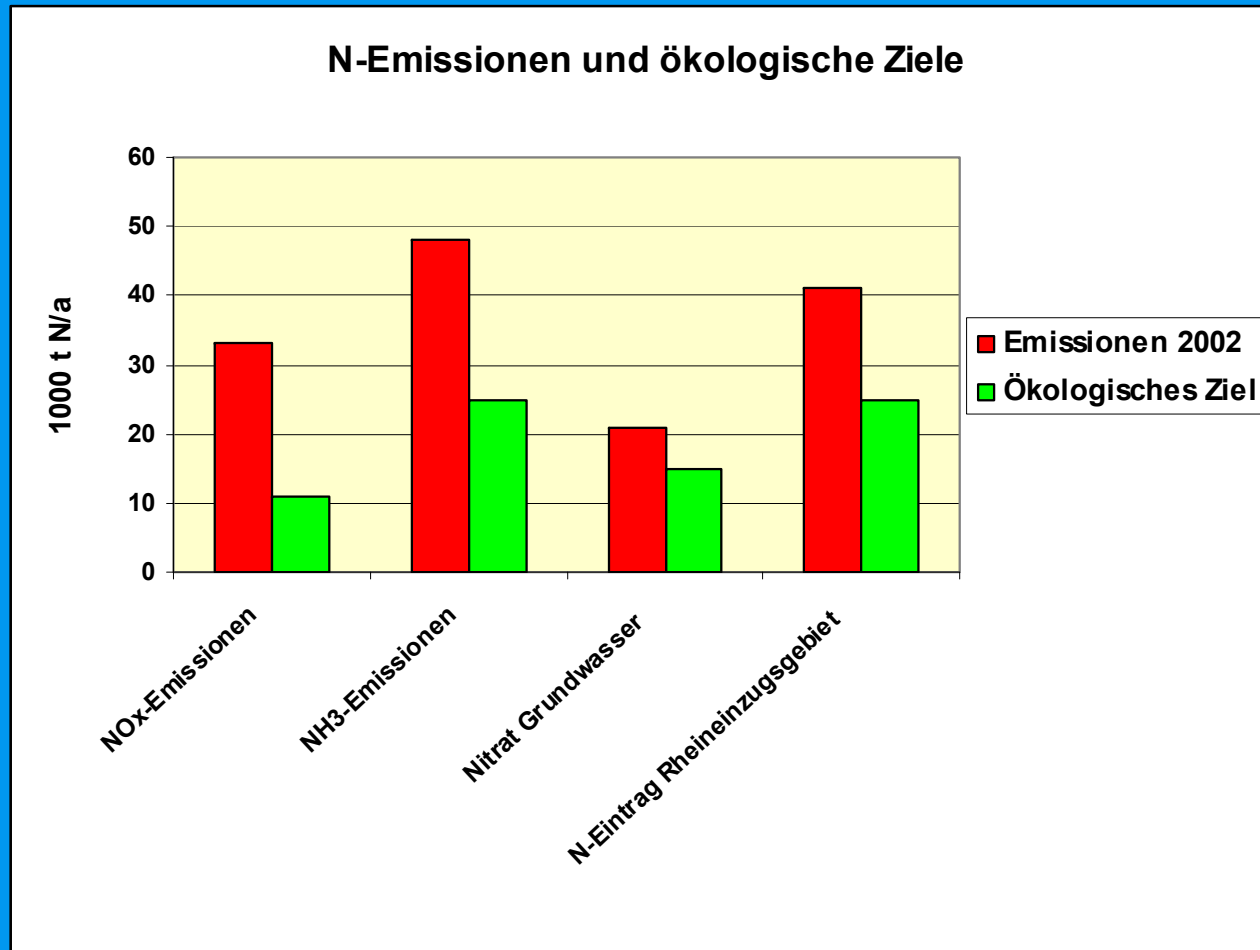
N fluxes Ø 1985-1995 [Gg N/a]

Sustainable N fluxes fulfilling O<sub>3</sub> and CL(N) targets; required reduction vs. 1990



Source: Projektgruppe N-Haushalt Schweiz/INFRAS 1996

# Swiss N emission reduction strategy II: emission reduction need vs. 2002



# International cooperation is indispensable!

- **Multilateral exchange of methods, data, M&I**
- **Europe: TFRN (fed by ENA et mult.al.) for CLRTAP; EU**
- **Global: UNEP / INI / CSD ...**
  - **Global policies on environment, agriculture, food security, sustainable development, climate, biodiversity, ...**

# Outlook

- **Spatial and temporal scales**
  - Methods to generalize and evaluate M&I / effects on various scales
- **Strengthen links between effects, targets and M&I**
  - Dynamize budgets
  - Links to ecological targets (e.g. WFD – good ecological state? Ecosystem services?)
  - Indicator development
    - Linking farm balances, national budget, CLexc, ...
    - regional / national Nr – emission caps?
  - Better cooperation with agricultural / food health and security policies
- **Adequate monitoring**
  - N budgets, N efficiency, biodiversity effects etc.
  - Link existing monitoring systems

# Summary

**Integrated approach aims at**

- 0. Issue building and communication**
- 1. Limiting Nr production, import and consumption**
- 2. Increasing N efficiency**
- 3. Increasing „unused“ Nr conversion to N<sub>2</sub>**

# Summary

**Integrated approach consists of**

- 1. EQO oriented analysis of effects**
- 2. N budgets**
- 3. M&I assessment**
  - a) Abatement potential
  - b) Synergies/pollution swapping
  - c) Abatement cost
- 4. Policy recommendations**
- 5. International cooperation**
- 6. Monitoring**

**Issue building and communication**

# Thank you for your attention!

[www.uba.de/luft-e/index.htm](http://www.uba.de/luft-e/index.htm)



from Oene et al.