UiO : Department of Chemistry
University of Oslo

Interdisciplinary Approach to Environmental Research

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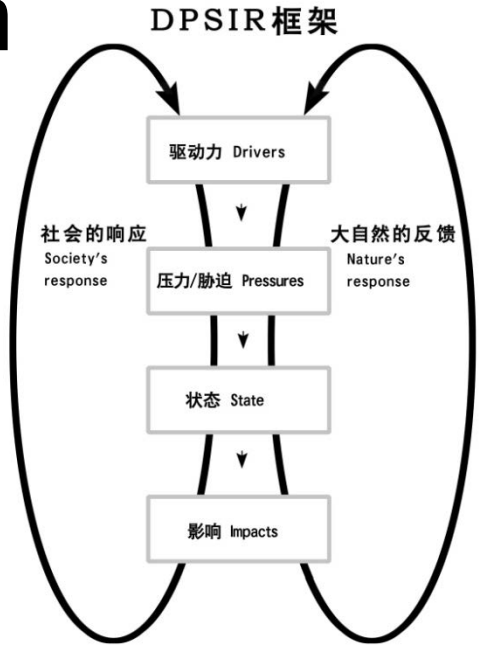
University of Oslo



Understand the links

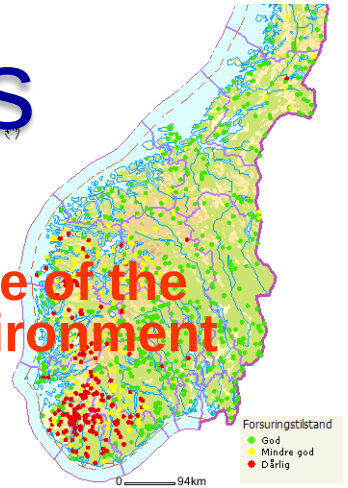
Drivers

Pressures

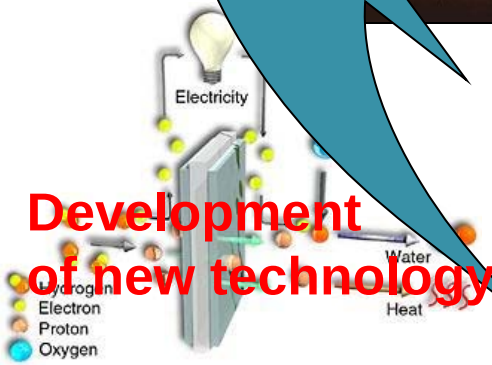
Dispersion

Long range transport

Transformation



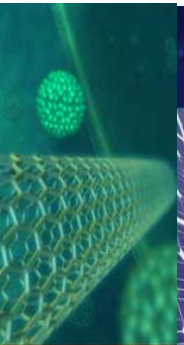
State of the environment



Development of new technology

Responces

Effects & Interactions



Abatement measures

Legislation

A **pollutant** has often multiple **effects** on different scales

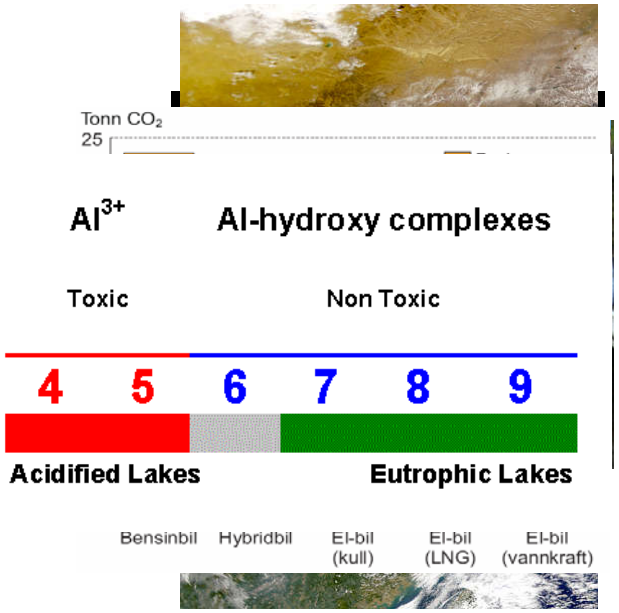
	GLOBAL Climate change	REGIONAL		LOCAL		
		Acid rain	Tropos-pheric ozone	Health	Vege-tation	Mat-erials
CO_2						
CH_4						
N_2O						
SO_2						
NOx	?					
NH_3						
NMVOC						
CO						
Aerosol					?	
Heavy metals						

An **abatement** measure has often multiple **effects** (Co-benefits/negative side-effects)

Abatement	**Main Target**	**Global**	**Regional**	**Local**
Increased energy efficiency	CO_2	**Climate**	**Acid rain, Eutrophication**	**Dust, Heavy metals**
Fuel substitution: Coal → Oil → Gas	SO_2, CO_2, NOx	**Climate**	**Acid rain, Eutrophication**	**Dust, Heavy metals**
Removal of black carbon emissions	PM	**Climate**	**Acid rain**	**Dust, Heavy metals**
Removal of SO_2 and/or particles	SO_2	**Climate**	**Acid rain**	
Renewable energy- biomass	CO_2	**Climate**		**Acidification**
Renewable energy- sun/wind/wave	CO_2	**Climate**		**Visual**

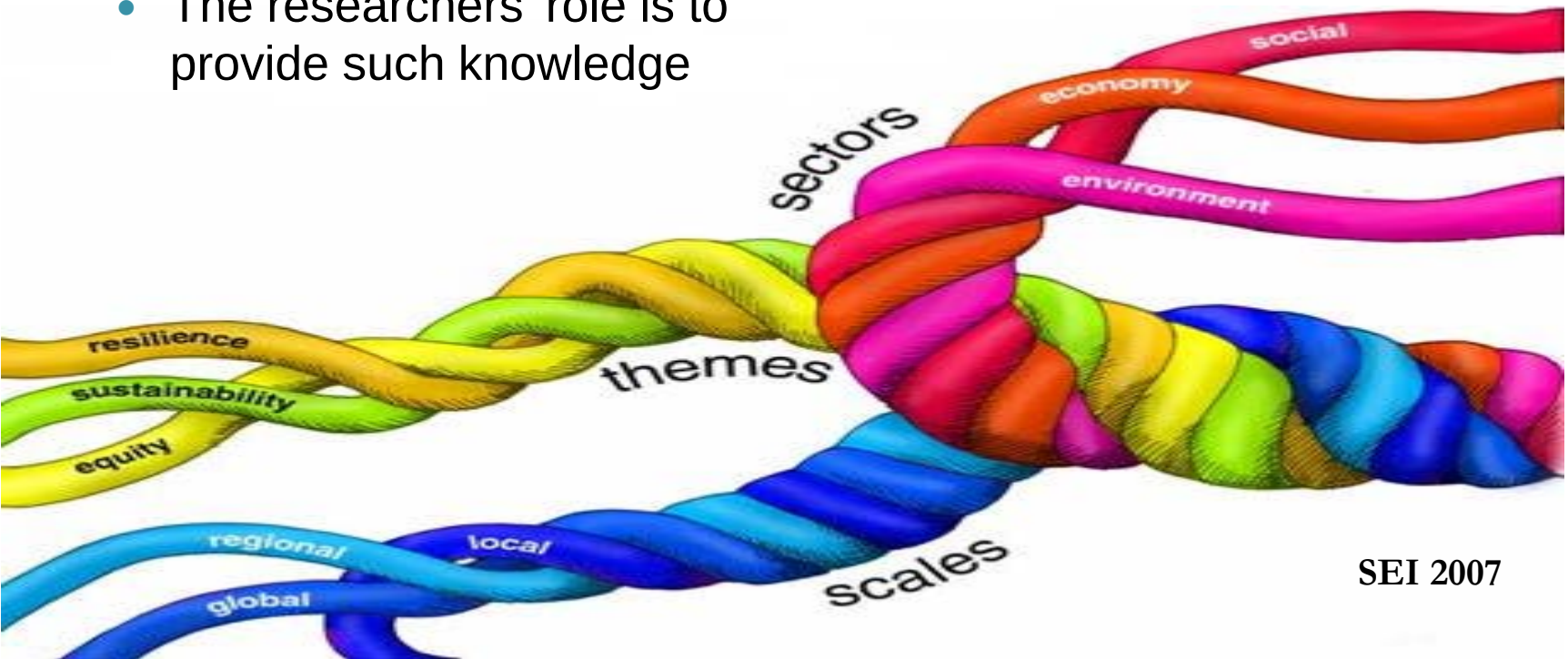
Most abatement actions have also **negative** side effects

- Many examples:
  - Freon in spaycans→ Hole in the ozonlayer
  - Biofuel → food shortage
  - Windpower
    → visual pollution, stakeholder conflicts
  - Removal of particles in fluegasses
    → increased acidification
  - Energy-saving light bulbs
    → emission of mercury
  - Electrical cars
    → increased global CO_2 emission?
  - Reduced acid rain
    → increased eutrophication
  - And so on..



Holistic approach

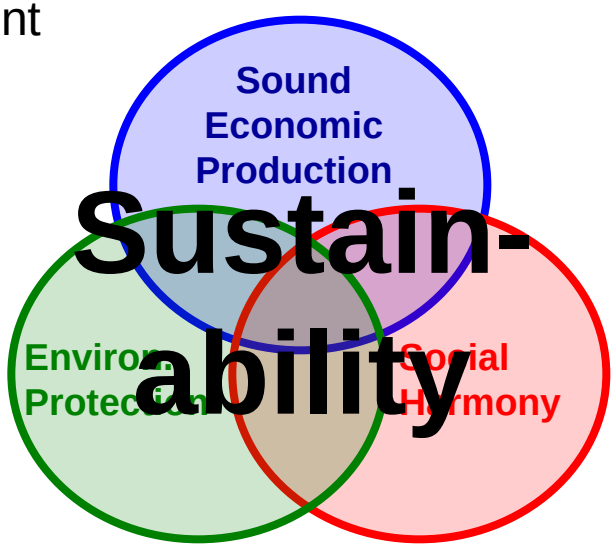
- A necessary basis for good decision-making and effective environmental policies on our increasingly complex and integrated environmental challenges
- The researchers' role is to provide such knowledge



SEI 2007

Sustainable development

- Enable decision makers
  to establish **knowledge** based abatement strategies
  on environmental challenges
  thereby **ensuring** a sustainable development



Sustainability implies
positive solutions for all components

Needs for environmental protection
are balanced against limitation
posed by social harmony and
economic production

- To obtain this knowledge, **integrated assessment studies**
  of the ways pollution and inadequate resource management
  affect the environment and humans are required.

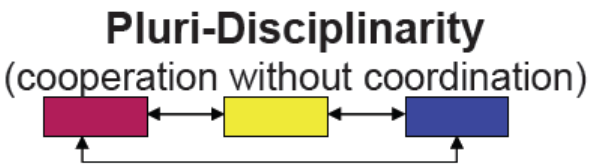
Call for Trans-disciplinary environmental knowledge assessment

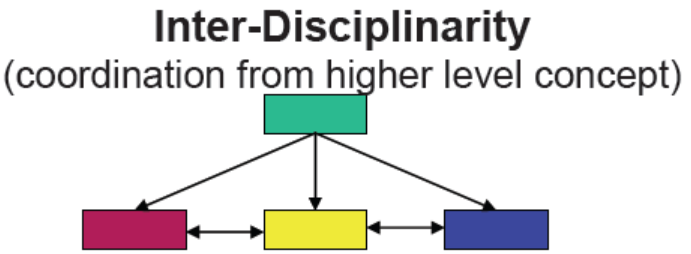
Types of Collaboration

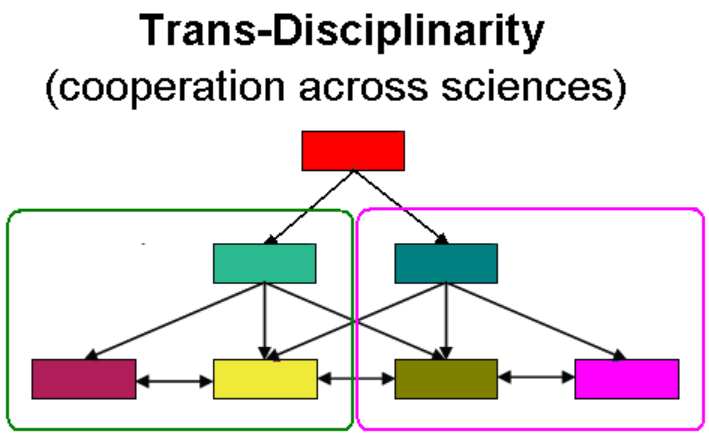
- **Multi- or pluridisciplinary**
  - The combination of several disciplines that are concerned with one problem, but without **intentional** integration

- **Interdisciplinary**
  - The **integration** of two or more disciplines to solve problems

- **Transdisciplinary**
  - Development of integrated knowledge and theory among **science and society**







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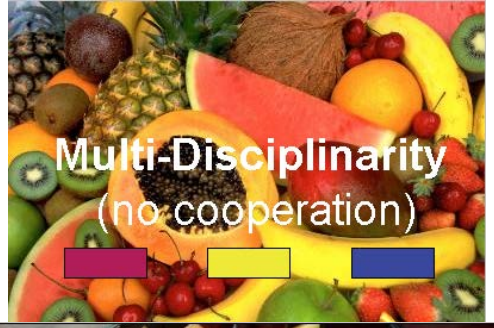
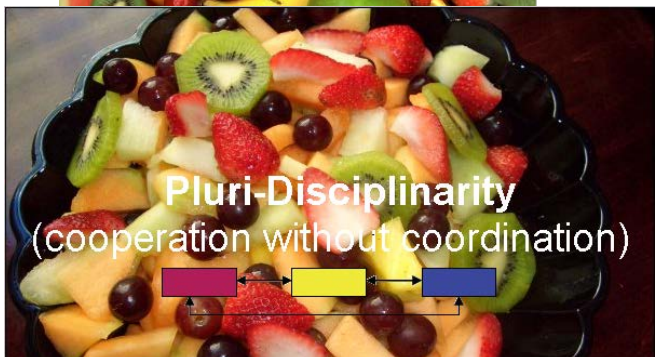
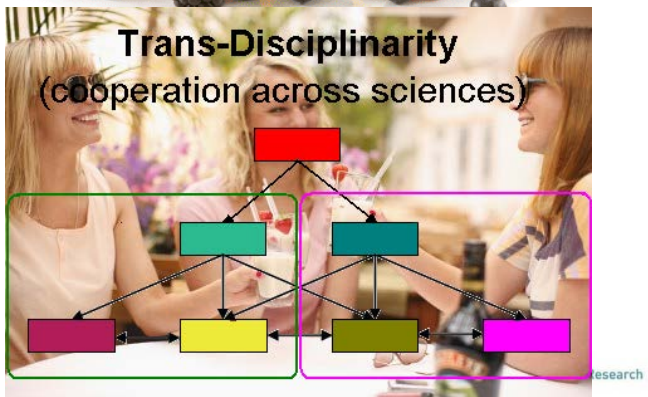
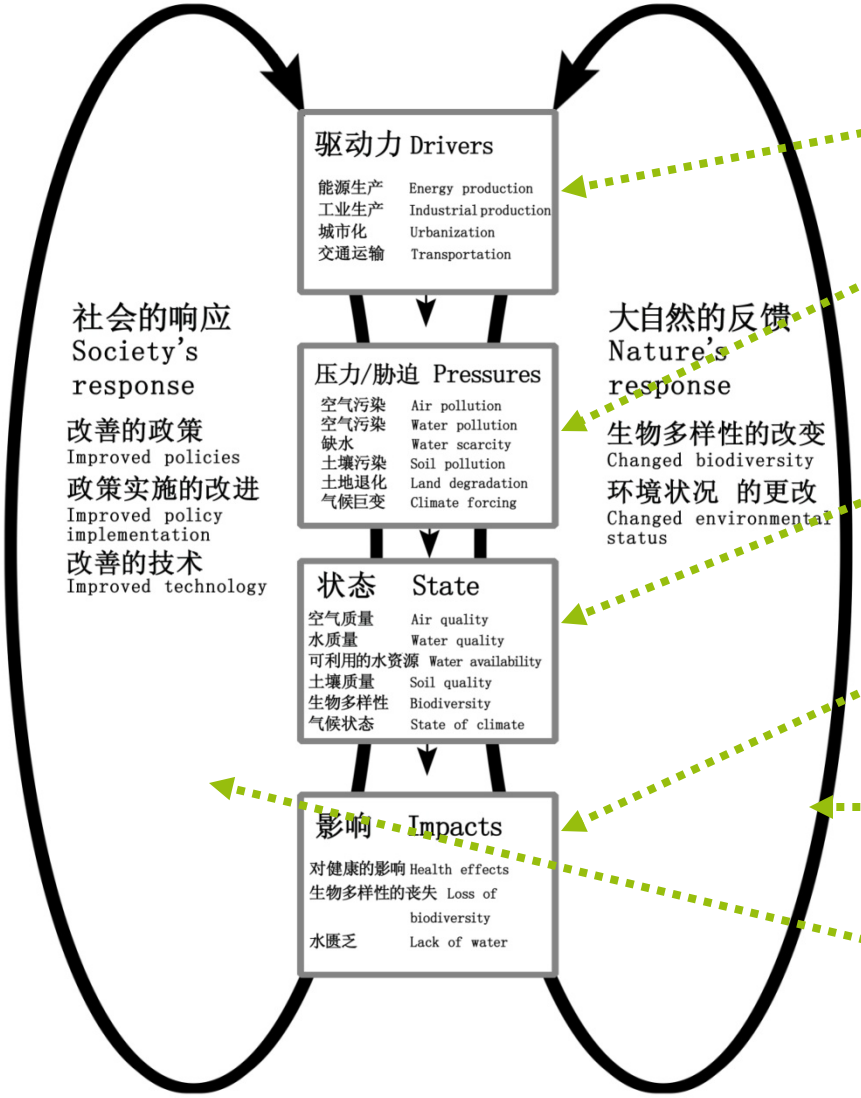






DPSIR框架理论模型



Drivers: Population growth, consumption, energy, travel

Pressures: Side effects of drivers (Emissions to air and water)

State: Resources, Pollution, Chemical & Biological state of Water, Air, Soil

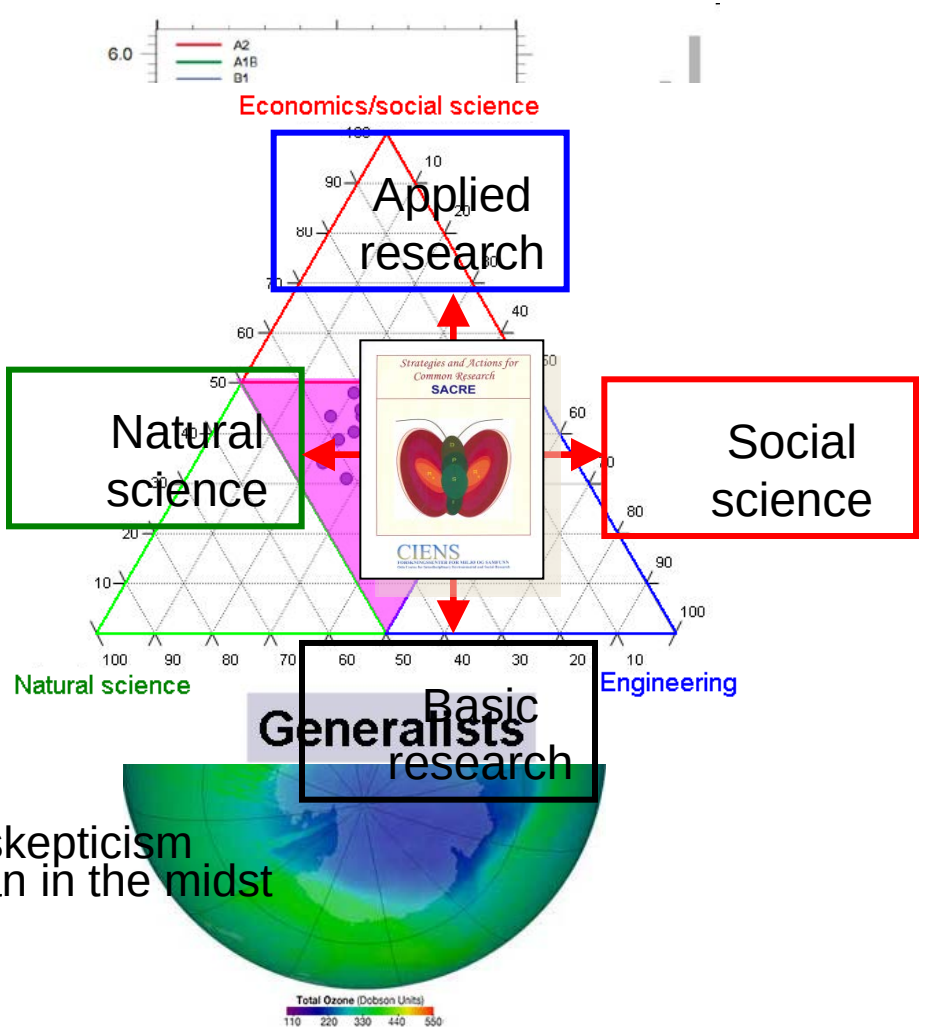
Impacts: Climate change, eutrophication, vegetation damage

Nature's Response: Changed biodiversity, change in eco-system services, feedback mechanisms

Society's Response: Adjustments, environmental protection, adaptation, environmental technology, policy, legislations, taxes

Drivers for Interdisciplinary in environmental knowledge development

- Increased societal legitimacy and improved research **relevance**
  - Environmental research must meet **societal** challenges
- Problems **discovered** by knowledge
  - Need to be solved with knowledge
- Problems **caused** by knowledge,
  - ”*can't be solved by using the same kind of thinking we used when we created them*”



- **Generates** opportunities for scientific innovation through cross-fertilisation and knowledge integration (the essence of inter-disciplinarity)
- Scientific curiosity is driven by scientific skepticism - **more prone** to be held by outsiders than in the midst of a disciplinary ‘hard core’

Building bridges

- Bridging disciplines
- Bridging approaches: modeling and observations – common research site
- Bridging spatial scales
- Bridging time scales and weather extremes
- Deterministic and probabilistic approaches

Science to policy interaction - Integrated assessment

Monitoring

Modelling

Assessment

Critical Loads

- Communication with decision makers facilitated by Critical Load maps

  "The deposition below which significant harmful effects do not occur according to present knowledge"

The12th. Five year plan

Scientific development

Ecological progress

Chart 10. A road-map for the 12th Five-Year Plan (2011-15)

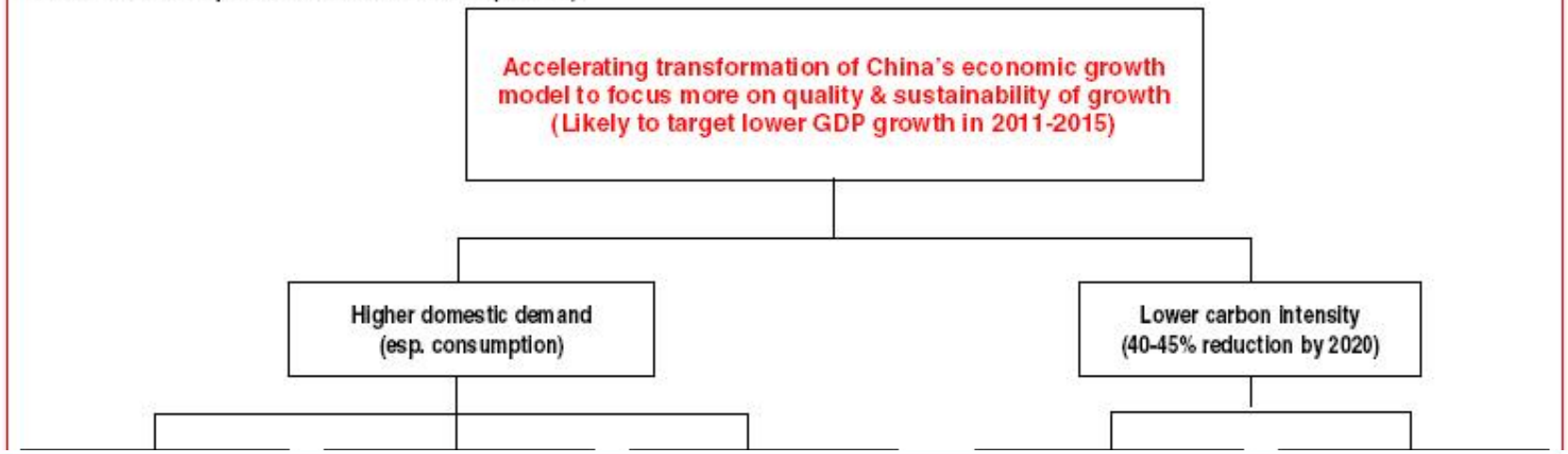


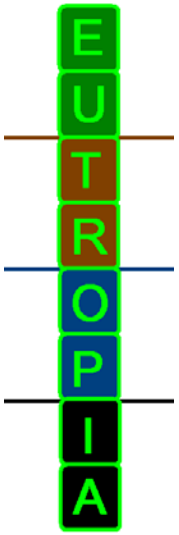
Table 35. The new Magic 7

Emerging strategic industries	Main content
Energy-saving and environmental protection	Energy efficiency, advanced environmental protection, recycling
Next generation information technology	Next-generation communications networks, Internet of things, network convergence, new flat panel display, high-performance integrated circuits and high-end software
Bio-technology	Bio-medicine, bio-agriculture, bio-manufacturing
High-end manufacturing	Aeronautics & astronautics, marine engineering equipment, high-speed rail, high-end smart equipment
New energy	Nuclear, solar, wind, biomass
New materials	Special function and high-performance composite materials
Clean-energy vehicles	Plug-in hybrid vehicles and pure electric cars

Source: State Council (http://www.gov.cn/ldhd/2010-09/08/content_1698604.htm)

Tidbits and experiences from our interdisciplinary research

- Acid rain
  - IMPACTS
- Eutrophication
  - Eutropia
  - SinoTropia
- SINCIERE



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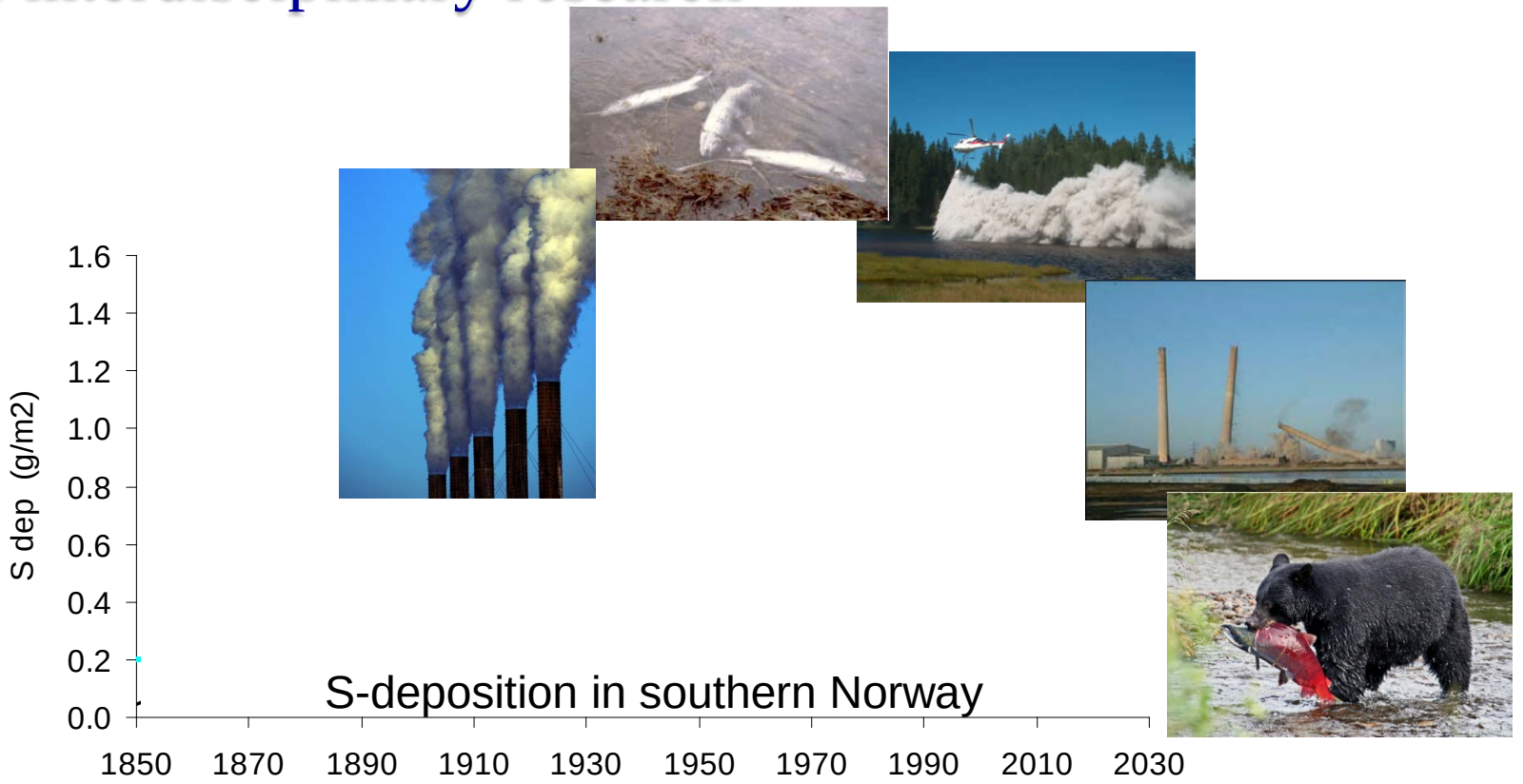
IMPACTS

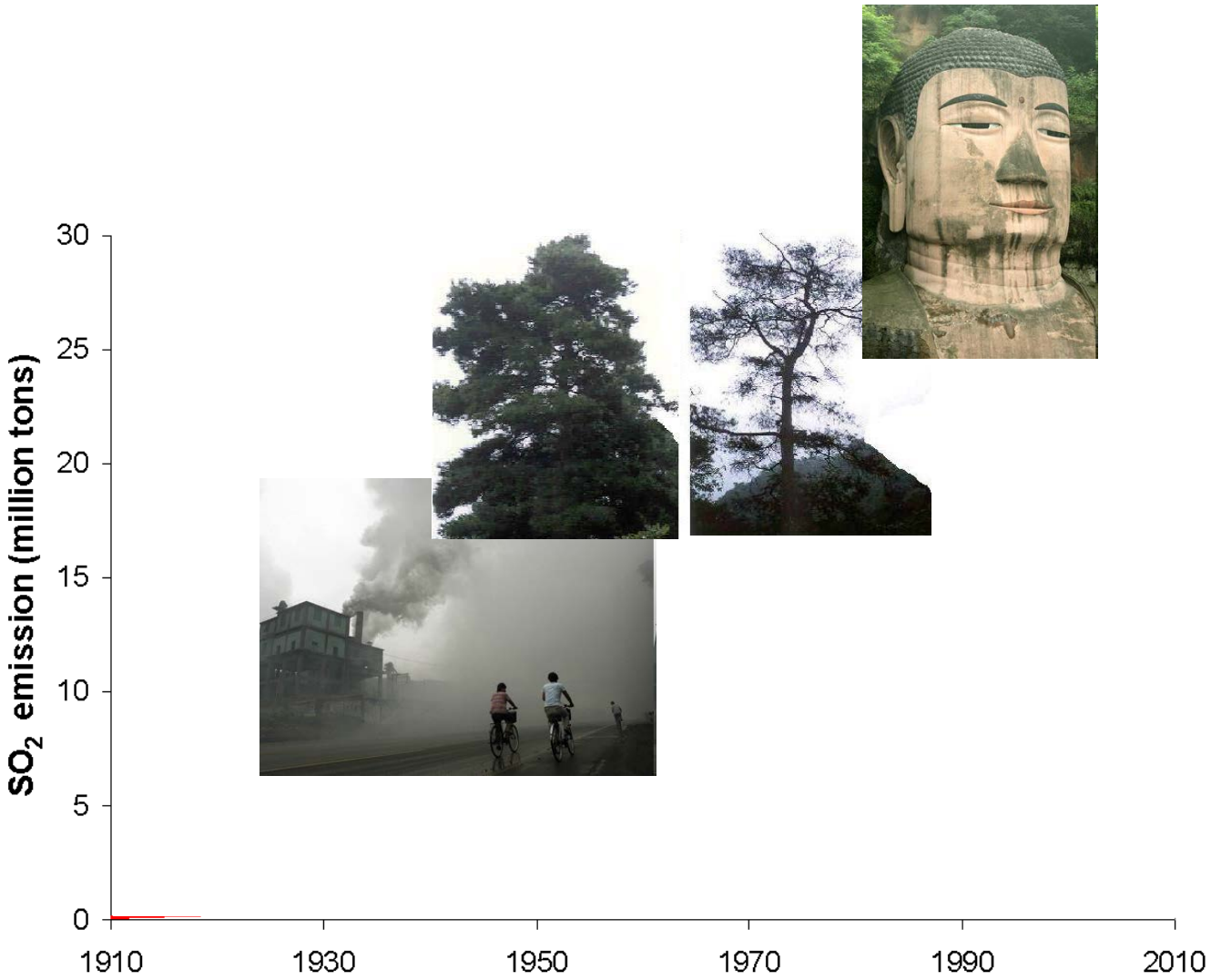
Integrated
Monitoring（监测）
Program on
Acidification of
Chinese
Terrestrial（陆生）
Systems

Acid rain – An European success story of interdisciplinary research



- Emission reduction **protocols** were developed as more **knowledge** was acquired from integrated **monitoring** programs
  - finalizing in the Gothenburg multi pollutant – multi effect protocol

What about China



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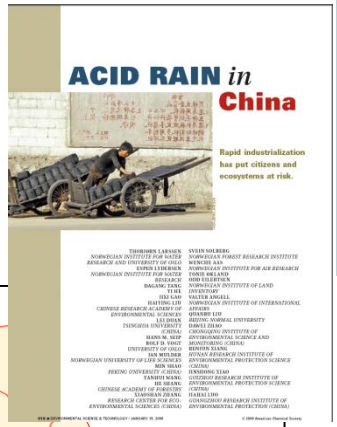
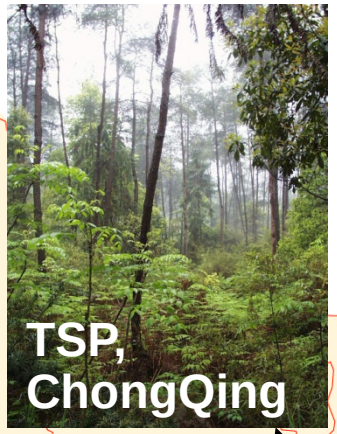
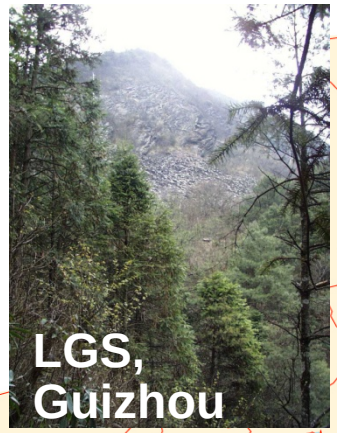
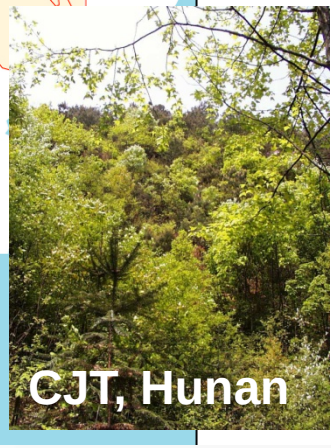
The IMPACT project: Integrated Acid rain research at 5 sensitive sites



IMPACTS







TSP
LCG
LGS
CJT
LXH

Precipitation pH isolines
- pH < 5.6
- pH < 5.0
- pH < 4.5
- pH < 4.0

Area of acid rain control zone

Location of the IMPACTS monitoring sites

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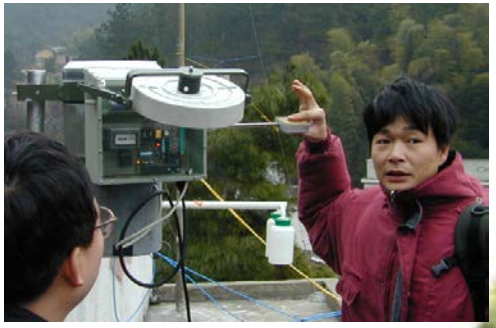
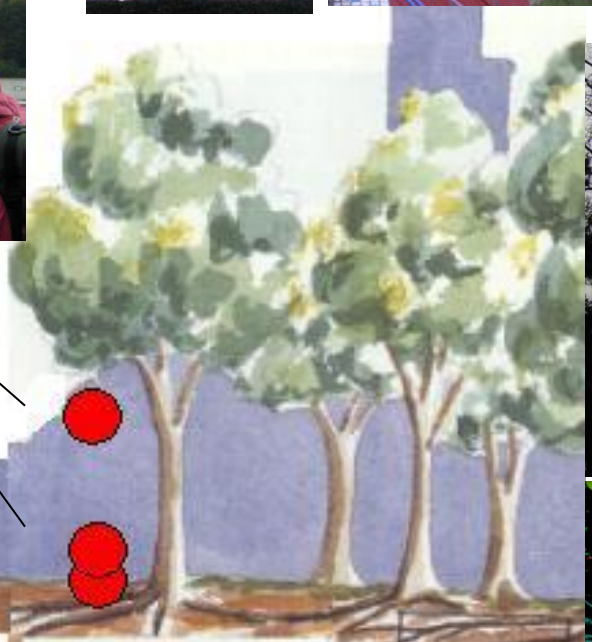
Integrated research

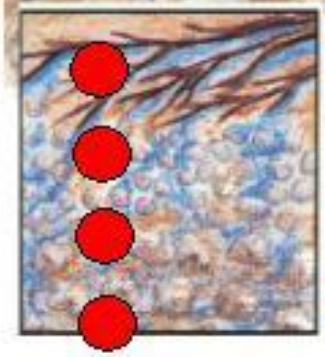
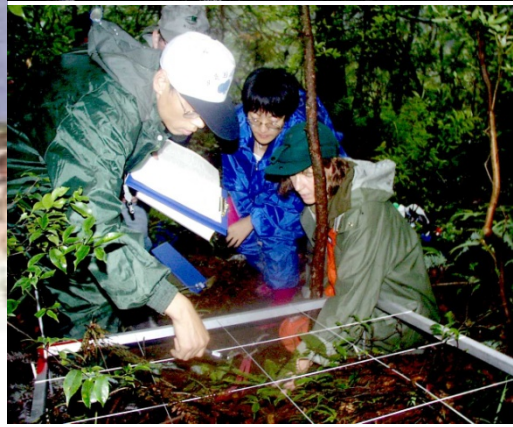
IMPACTS





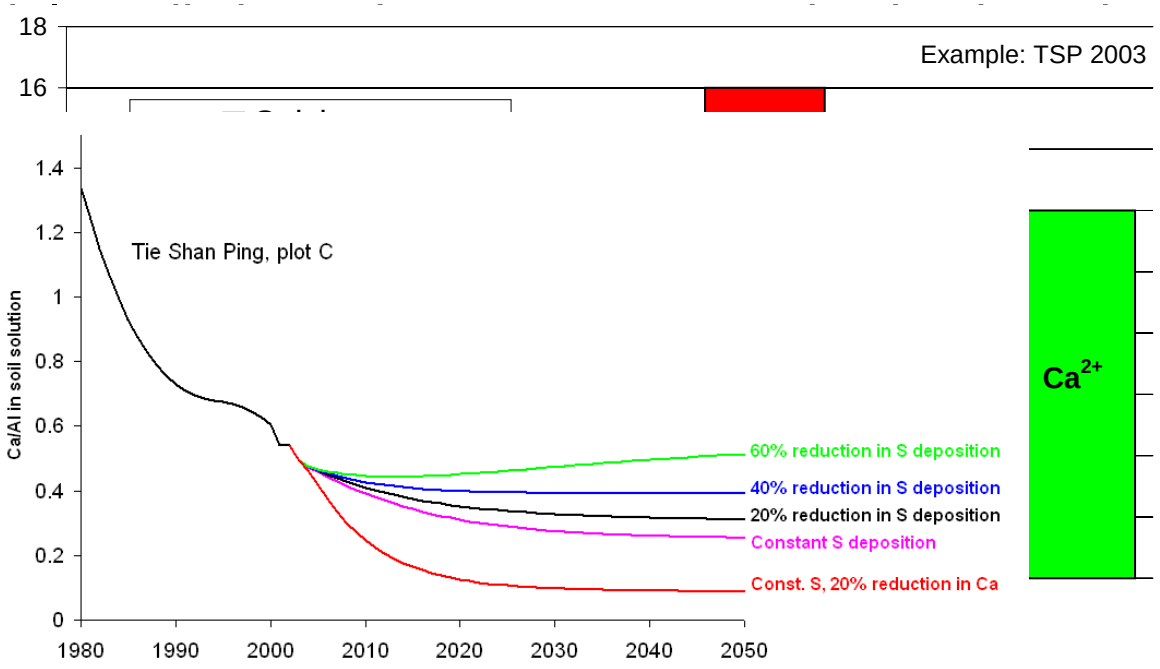



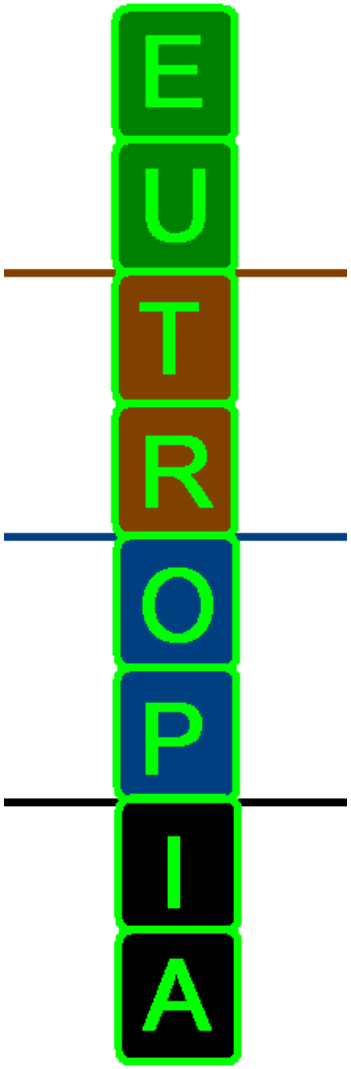


A few major findings from IMPACTS

- Substantial reactive Nitrogen emission and deposition
  - NOx contributes considerably to acidification
  - NH_3 increases the pH of precipitation though acidify the soil- and surface water
    - pH alone is not an indicator for acid rain
- Mo[illegible]osition ne[illegible]





Processes governing leaching of Phosphorus fractions to surface waters and effects of changing environment

RCN, Miljø2015 -Tvers
2009 – 2013

CIENS
Forskningssenter for miljø og samfunn
Oslo Centre for Interdisciplinary Environmental and Social Research

UNIVERSITY OF OSLO

NIVA
Norwegian Institute for Water Research

NINA

NIBR
Norsk institutt for by- og regionforskning

Bioforsk

Morsa

T. Andersen, A. Engebretsen R. Vogt et al.

O. Røyseth et al.

D. Barton

G. Orderud

E. Romstad

M. Beckman et al.

H. Gunnarsdottir

The problem

- **Eutrophication** is the **main** cause for poor water quality in agricultural districts

Miljostatus.no

Knowledge
– the key to collective action

- The **low hanging fruits** are already picked
  - Reduced fertilizing
  - No fall tilling
  - Vegetative buffer strips
  - Wetlands

- We now need to persuade the farmers to **step-up their efforts** on sub-optimal abatement actions

This can only be a
increased **knowle**
actions so far hav
any affect.. – this
science kicks in..

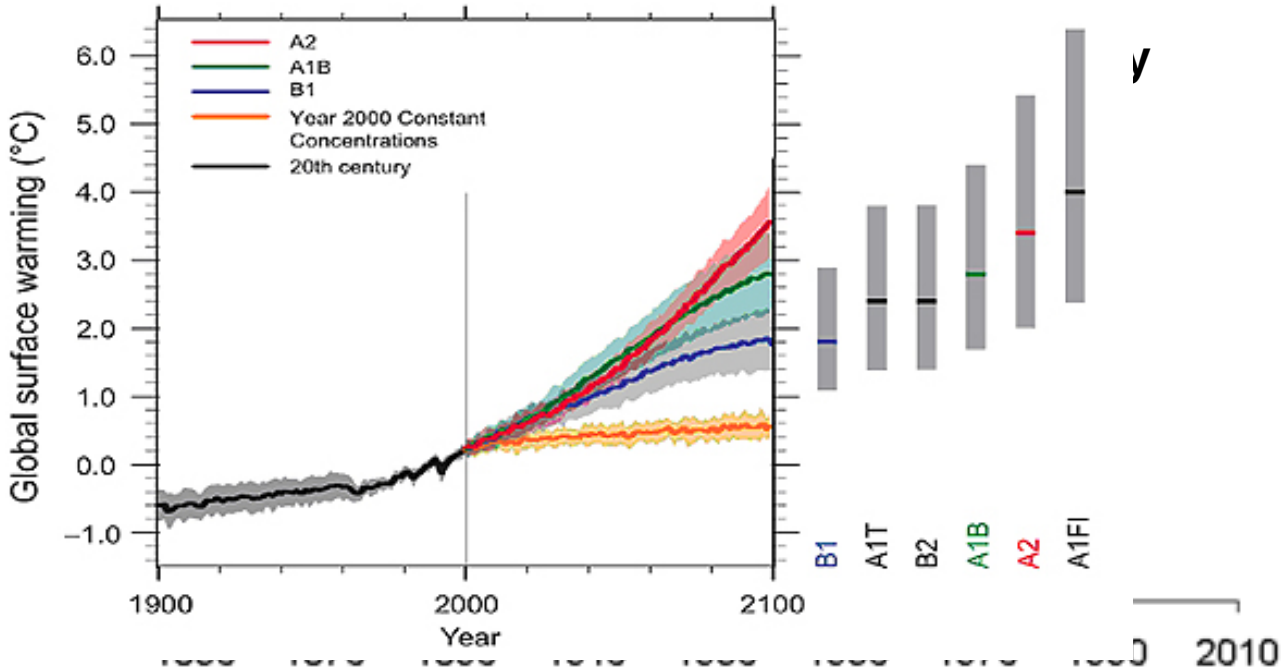
Sustainable management

- Abatement measures need to be assessed in regards to **cost-effectiveness** and an analysis of land **users'/farmers' response** to the these measures

  - Especially an assessment of **probability** of implementation is lacking from previous assessments of measures

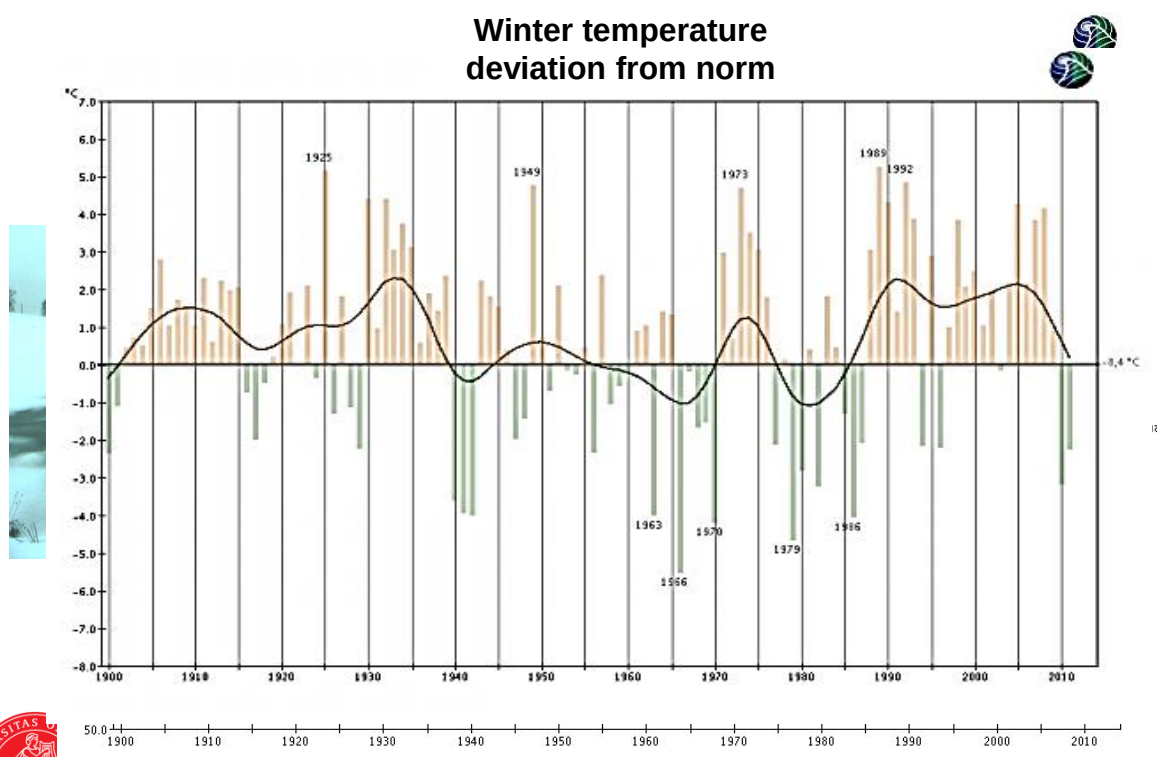
The **cause** for lack of effect of abatement actions is a changing environment

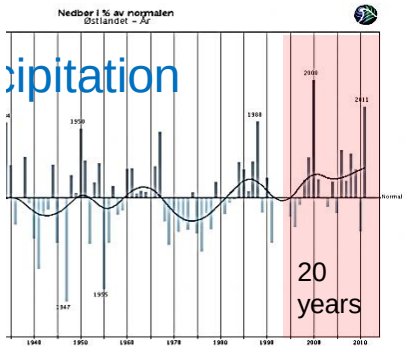
- The effect of abatement actions are disguised by the effect of changes in:
  - Climate
  - Decline in acid rain

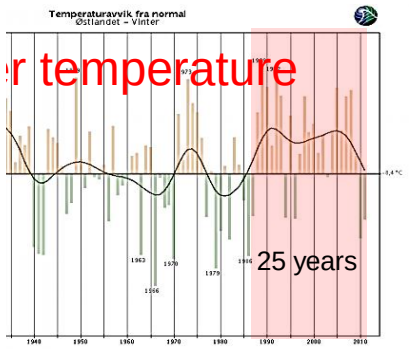


Changes in **climate** during the last 20+ years

- The amount of precipitation and the frequency of **heavy precipitation events** have increased and been above the norm during the past 20 years
  - Generates more surface runoff and flooded soils
- Average winter temperature has been **2ºC** over the norm during the last 25 years
  - Leads to more frequent **thaw** periods on barren and frozen soils

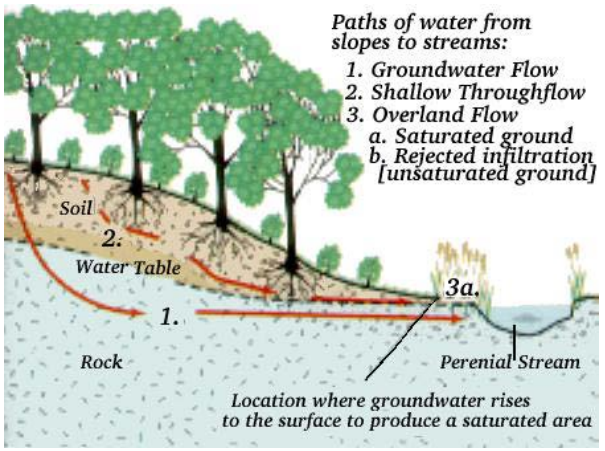




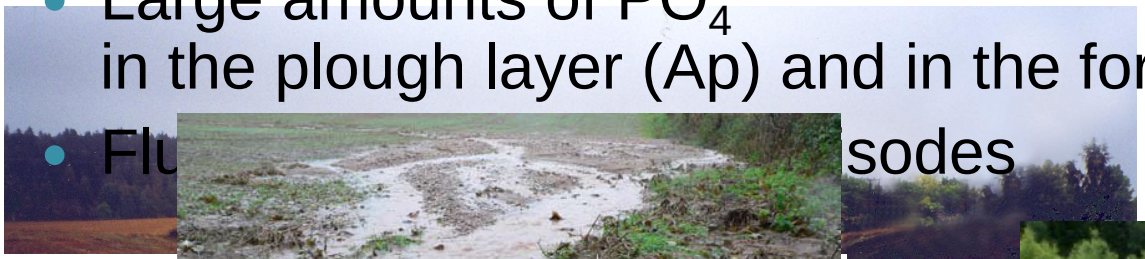


Met.no

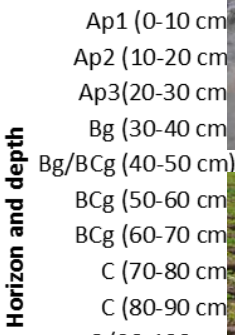
Increased surface runoff



- Increased erosion
- Large amounts of PO_4 in the plough layer (Ap) and in the forest floor (O)
- Flu… sodes



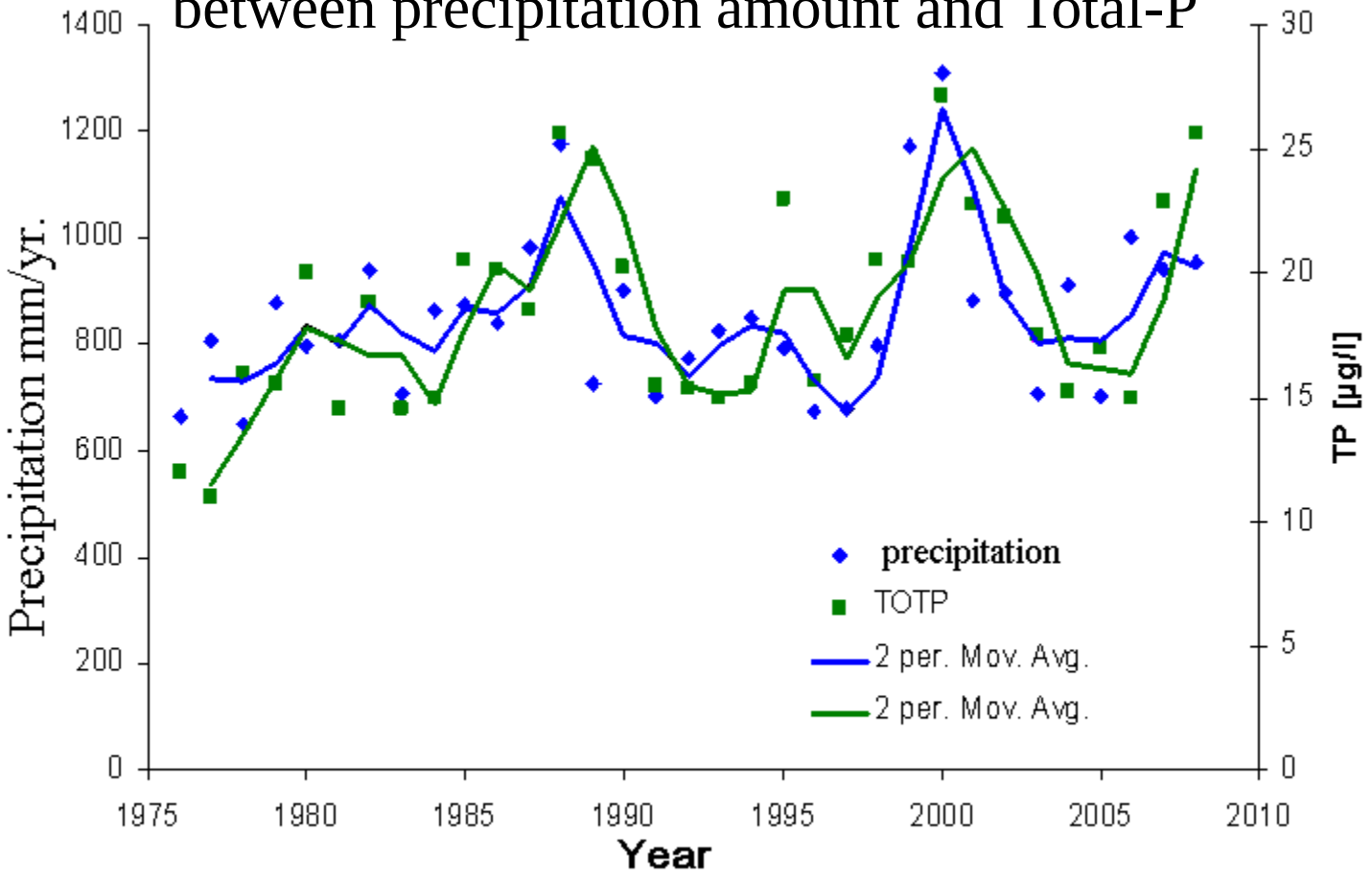
Agriculture



Desta, 2013

Effect of precipitation on P in Vansjø

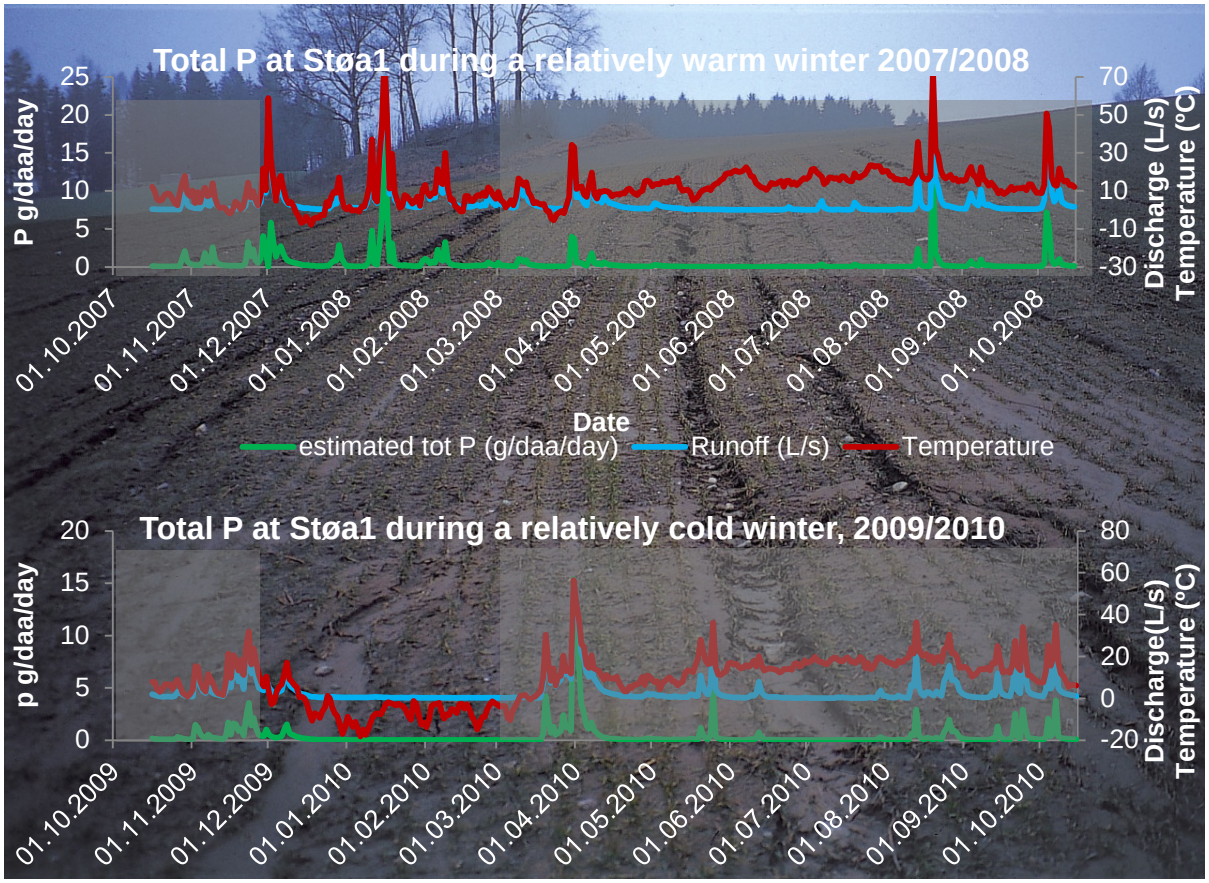
Good inter annual co-variation
between precipitation amount and Total-P



T. Rohlack, NIVA

Milder winters

- More frequent runoff periods during winter
  - Increased surface runoff and erosion due to soil frost and fall tillage

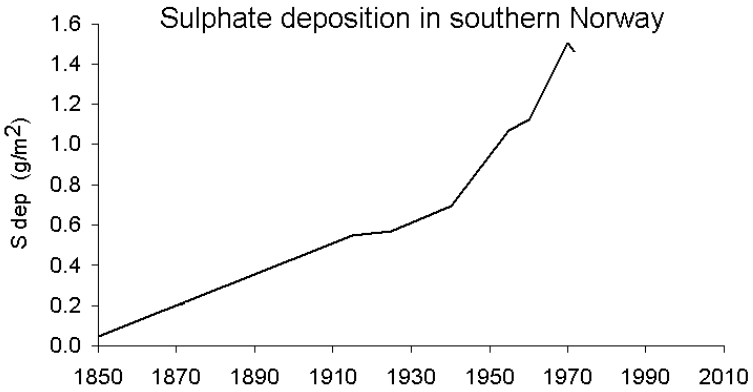


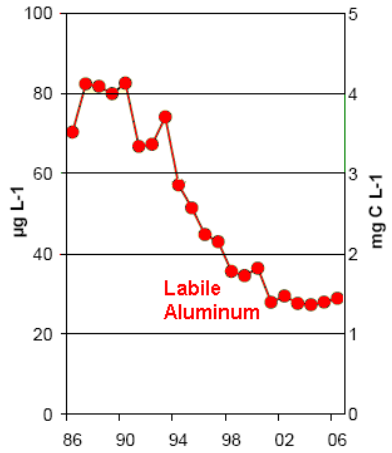
  - Large flux of bioavailable PO_4 due to no assimilation

Parekh, 2012

Reduced S deposition over the last 25+ years

- SO_4^{2-}, which in acid lakes in southern Norway constitutes the **dominant** anion charges, has **decreased by about 70%**
  - →This has led to a 66% decrease in labile **Al** leaching
  - →and an doubling in leaching of **DNOM**



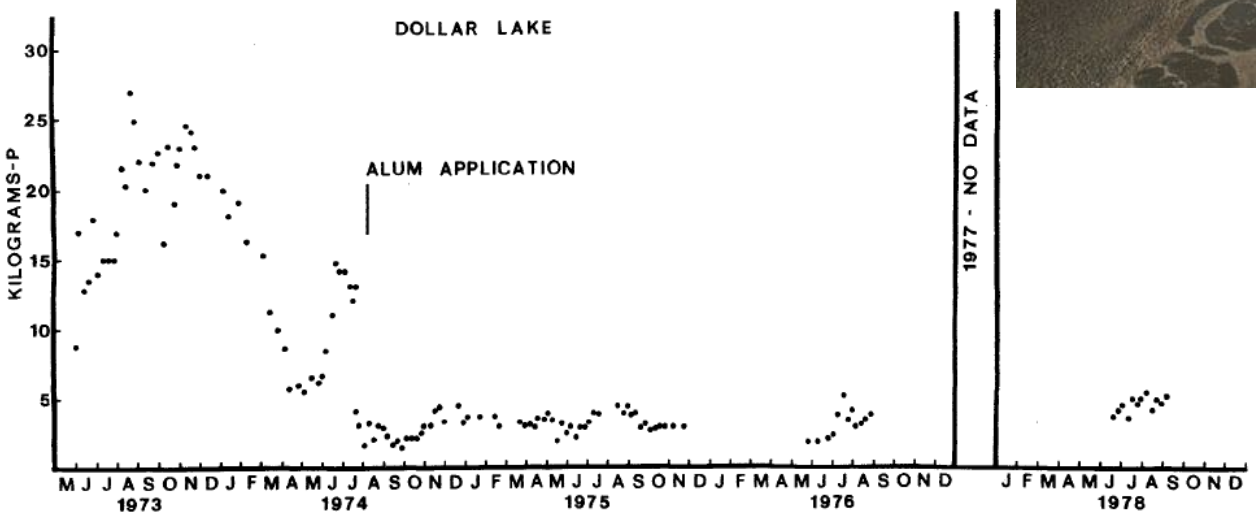


Skjelkvåle et al., 2007

Al^{3+} is used to remove PO_4

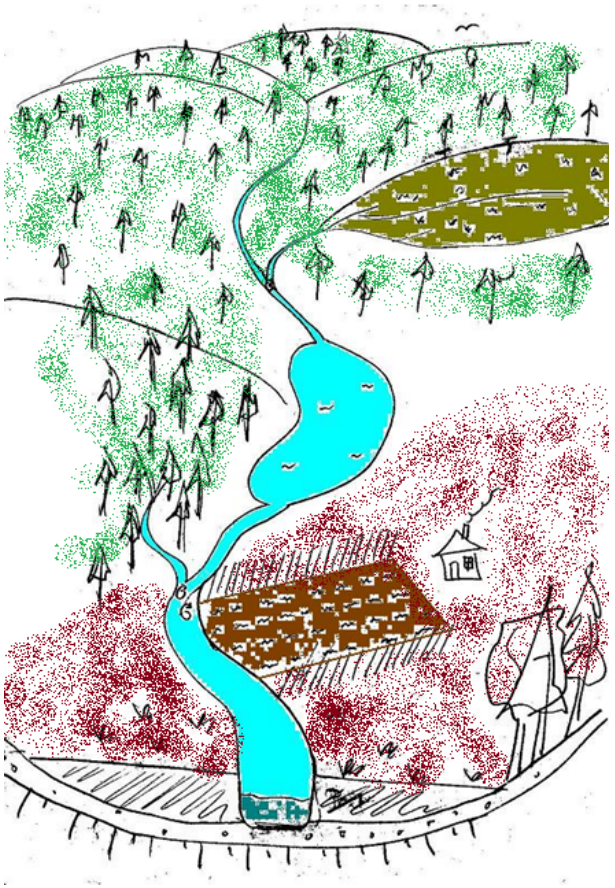
$$1.4Al^{3+} + PO_4{}^{3-} + 1.2OH^- \rightarrow Al_{1.4}PO_4(OH)_{1.2}(s)$$

- In sewage treatment plants
- In treatment of eutrophic lakes

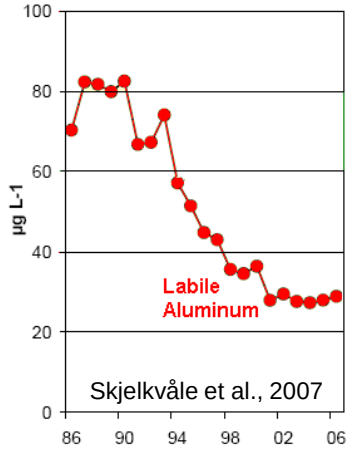


Distribution of land-use

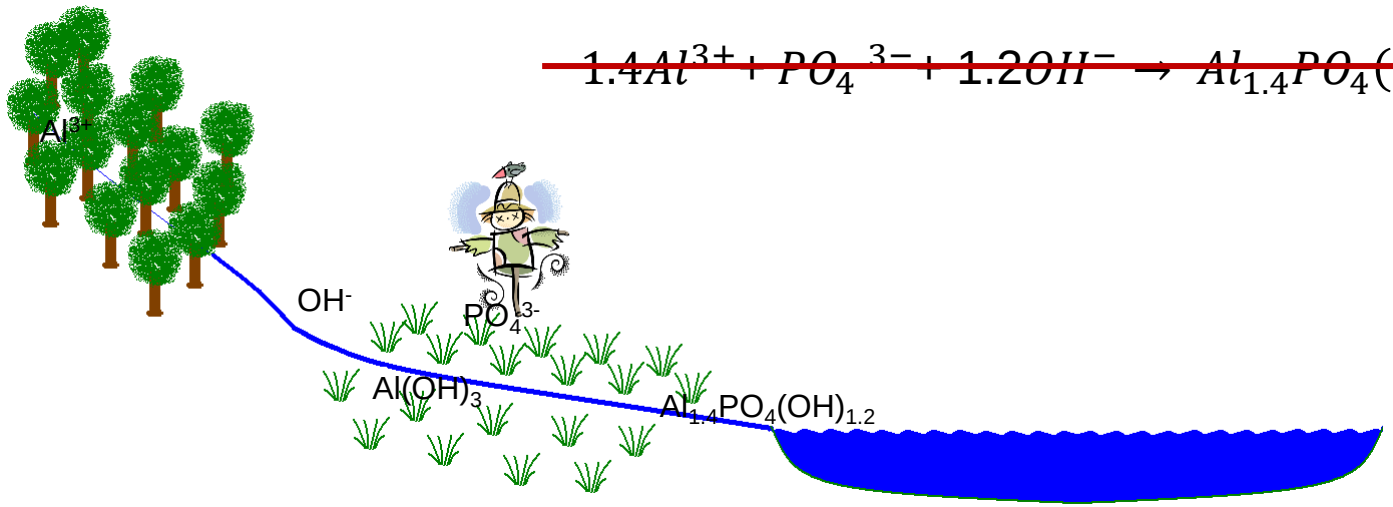
- Most watercourses drain forests areas and passes agricultural land downstream before entering the lake



Precipitation of PO_4 with Aluminium



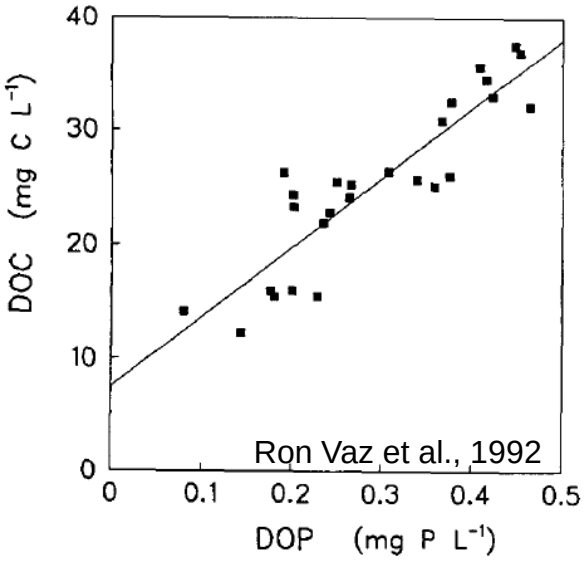
- Aluminium that was leached out of acid sensitive forests drained down into agricultural land where it mixed with PO_4 rich seepage with higher pH
- $Al(OH)_3$ precipitated and co-precipitated PO_4
- With the decline in acid rain
  we have lost an important mechanism for PO_4 removal

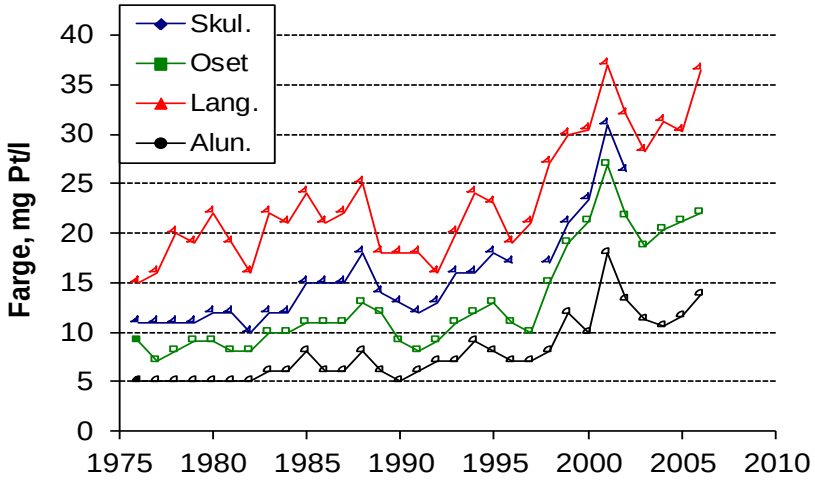


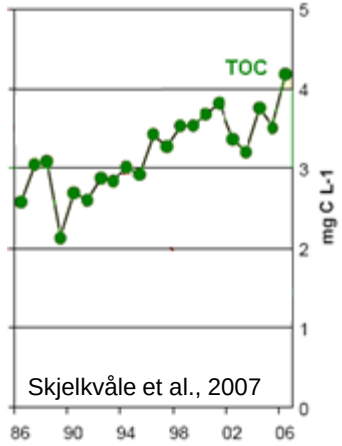
Transport of P with DNOM

- Background leaching of PO_4 accounts for 39% of the total P load
- PO_4 is in natural systems **transported** with DNOM
- There has been a doubling in the concentrations of DNOM

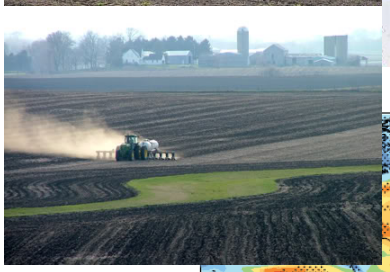
➢ **The background flux of PO_4 has thus likely doubled**

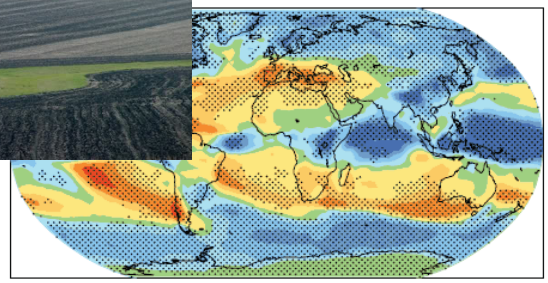


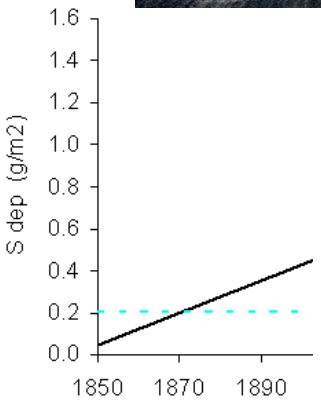


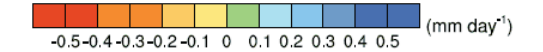


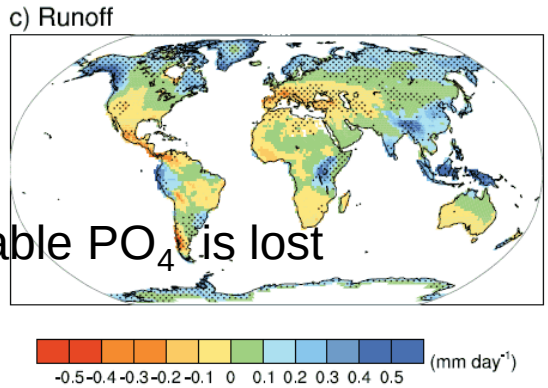
Important nature science knowledge











- More precipitation and milder winters have led to greater flux of P:
  - By increased surface runoff through only P rich surface soils
- Decline in acid rain has led to:
  - That an important precipitator (Al) of bioavailable PO_4 is lost
  - Increased background flux of DNOM-P

- **Conclusion: Without the abatement actions the conditions would today have been much worse!**

UiO : Department of Chemistry
University of Oslo

SinoTropia

Watershed Eutrophication management in China through system oriented process modelling of Pressures, Impacts and Abatement actions

- CAS/RCN Bilateral China – Norway Project
  2011 – 2014

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The main issue

- *60 - 70% of the surface water resources in China have too poor quality*
- *Eutrophication is the main cause for poor ecological quality*

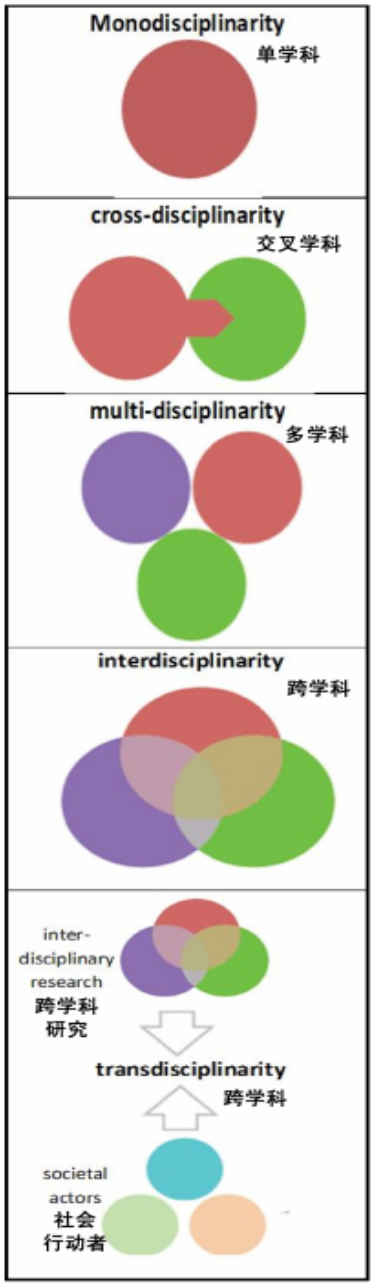
What is the solution..?

- Can we deal with eutrophication?
  - Are the abatement actions appropriate?
    - Are we targeting the right sources of nutrients and form of nutrients?
    - Are the effects of our abatement actions disguised by changes in other environmental pressures?
  - Are the abatement actions politically and/or socially feasible?
    - What barriers or thresholds in society hinder the implementation of abatement actions?
    - Is there sufficient knowledge of stakeholder interests?
    - What motivates collective action?
  - What can we do next, together?
    - We have already used the obvious abatement actions
    - What do we do next? How do we decide the best next step?

Thesis

- By adopting a **trans-disciplinary** approach to the eutrophication challenge, i.e. by integrating natural and social sciences with policy - we will improve:
  - Policy-making process
  - implementation of relevant policies

  In order to achieve water resource management that meets society's needs



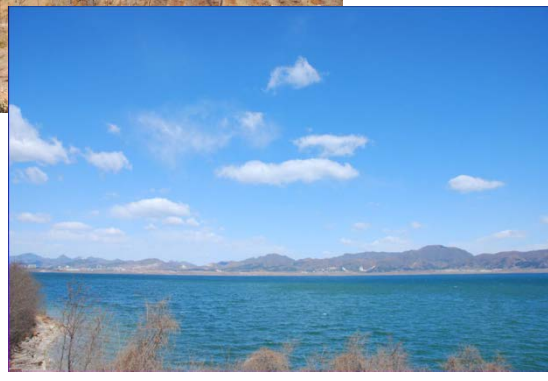
Hypothesis - Processes

- The role of **particle transport** of nutrients is likely overestimated. Most of this material is mainly buried in the sediments

- More frequent and intensive **rain episodes** enhance eutrophication due to increased erosion and leaching of nutrients

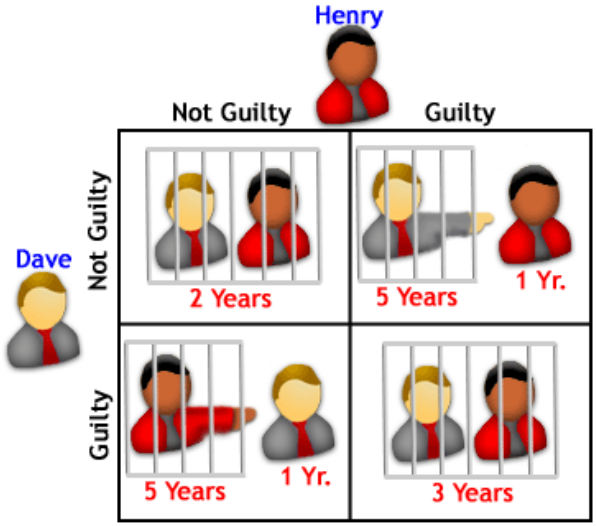
Hypothesis - Models

- Models need to be **adopted** to Chinese environments
  - The main governing processes may not be the same



Hypothesis – Societal response

- Knowledge -
  - Of stakeholder **interests** and learning processes are essential for the success of the public policies abating eutrophication
  - Constitute a necessary basis for sound environmental management through facilitating **collective** action and public policies



SinoTropia Research Strategy

- The hypotheses are tested through integrated works packages

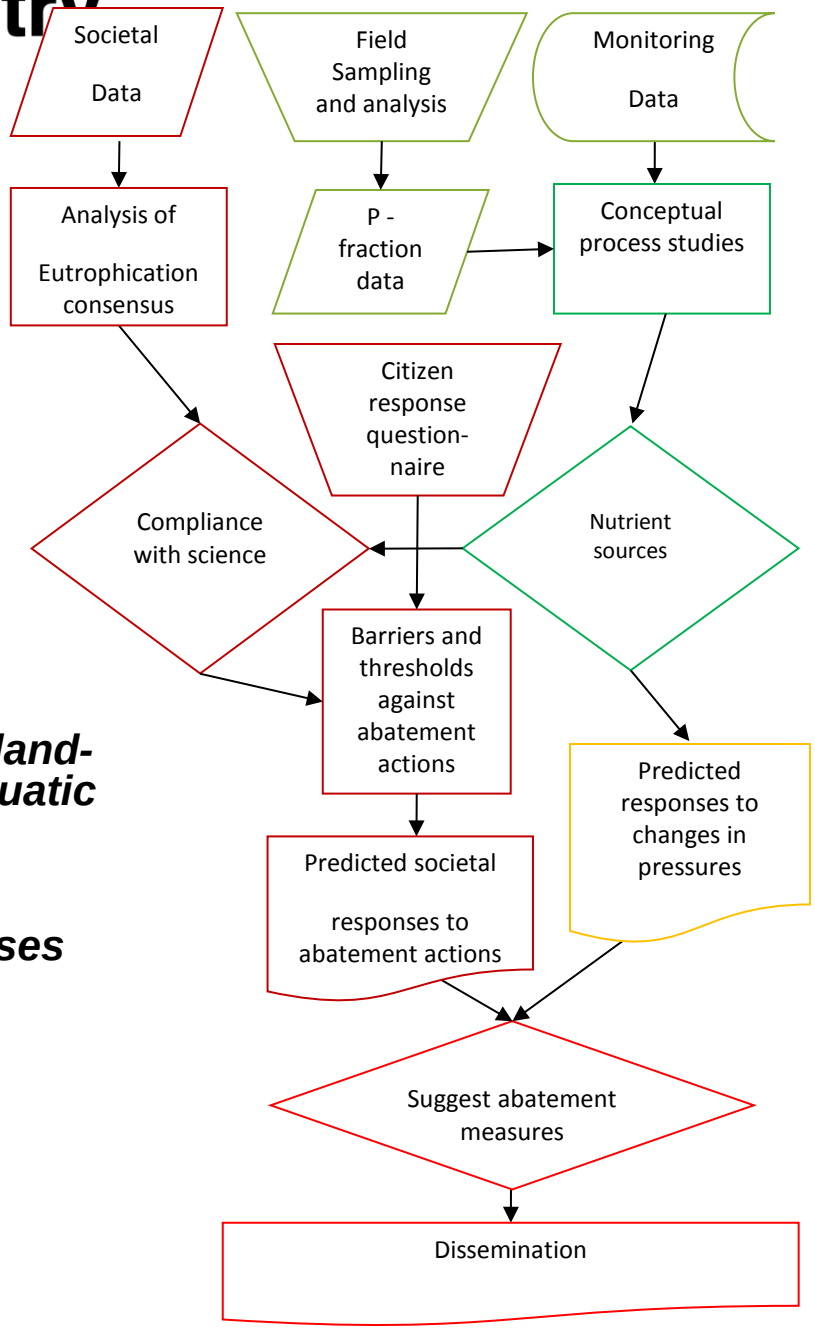
WP1 ***Field sampling and chemical analysis***

WP2 ***Catchment processes - the influence of land-use and climate on nutrient fluxes into aquatic systems.***

WP3 ***Modelling of catchment and lake processes***

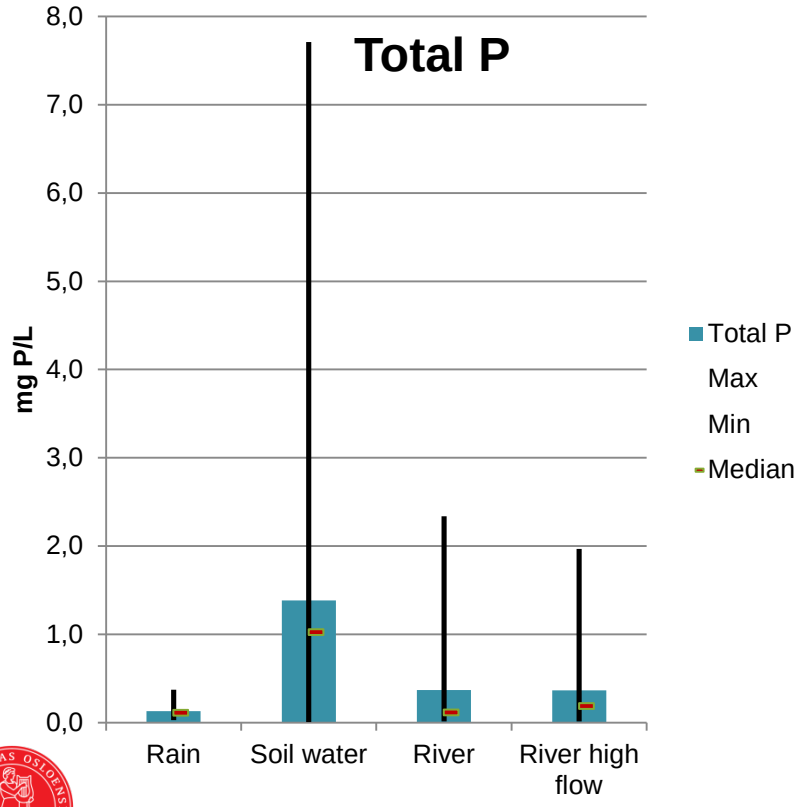
WP4 ***Societal processes and management procedures***

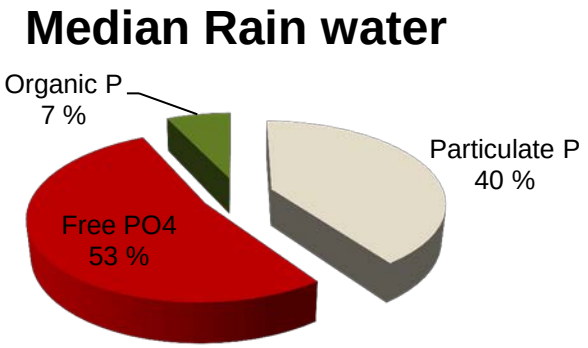
WP5 ***Nutrient management plan for Yuqiao reservoir***

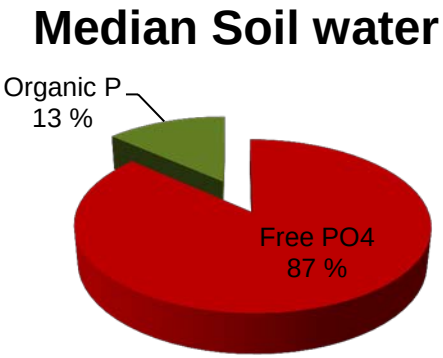


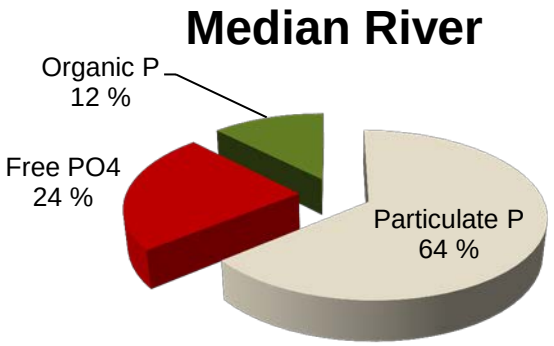
P fractions

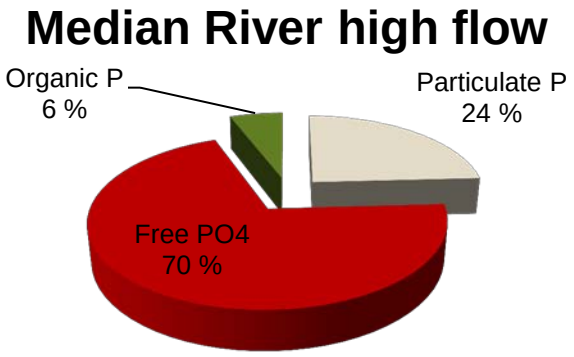
Large variation in soil water
Surpriced that P is not higher at high flow, especially the particle bound P





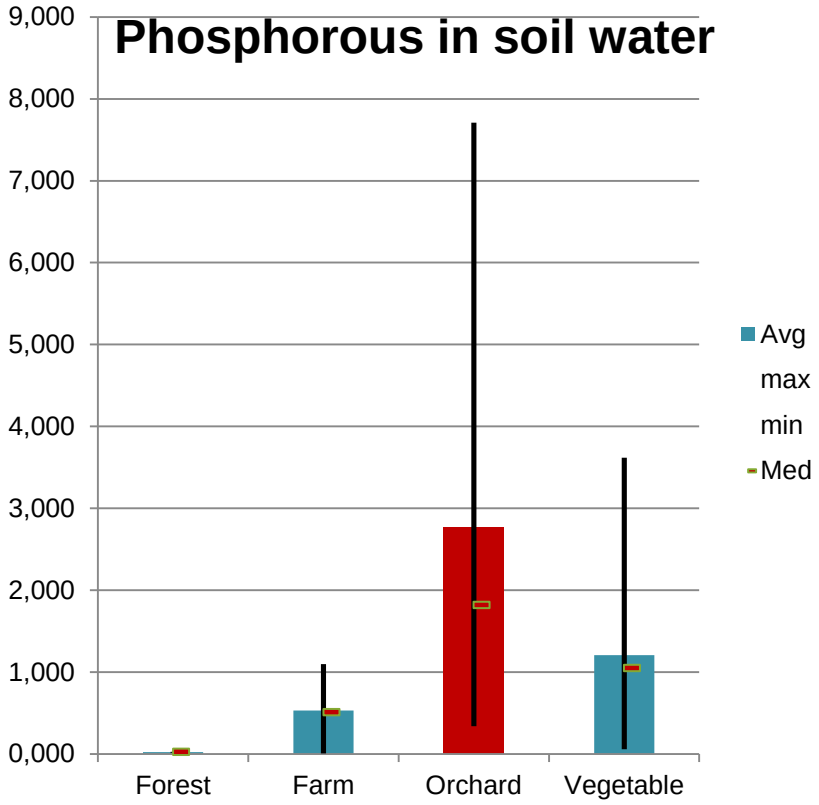




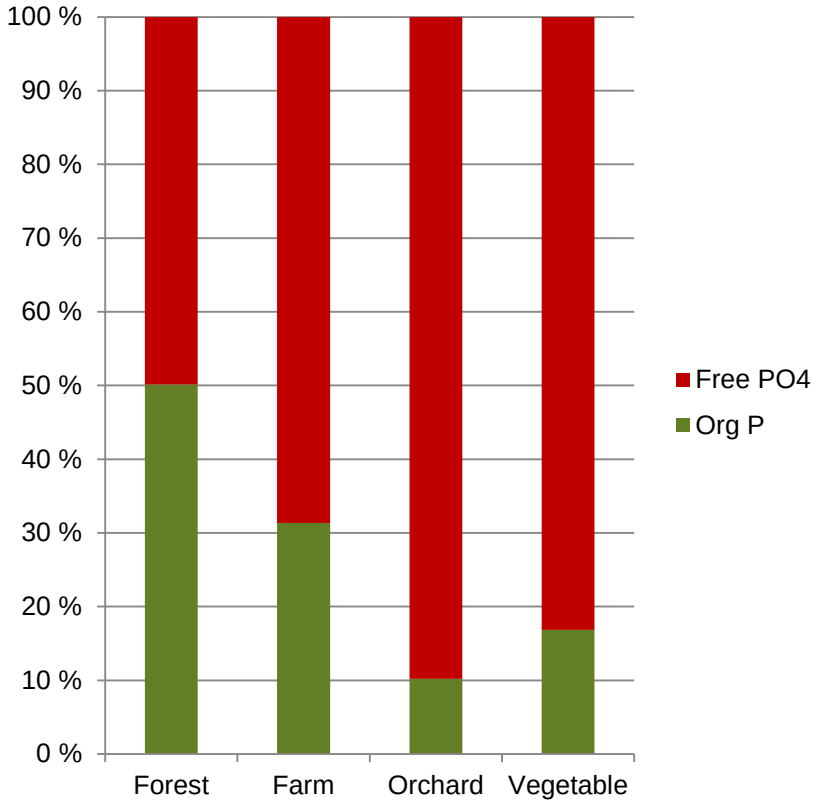


P in soil water

Surprising high values in orchards

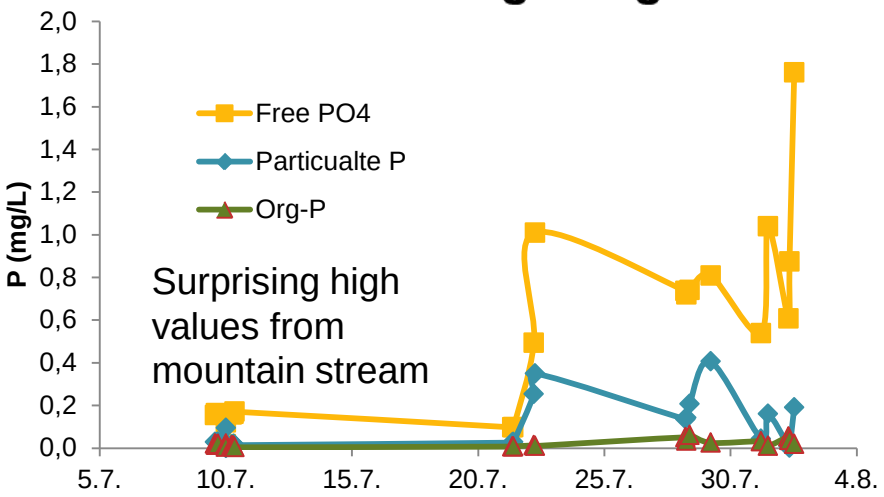


High Free PO_4 in Orchards
- Due to over-fertilization?

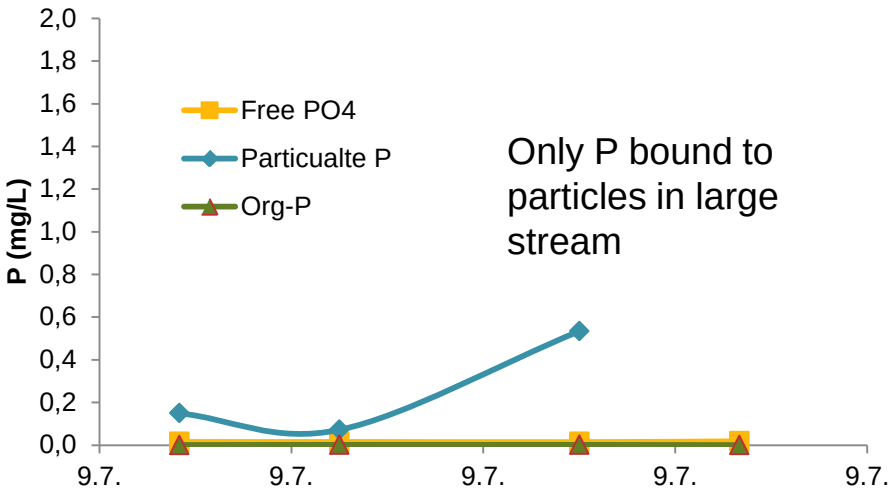


P fractions: Large differences between streams

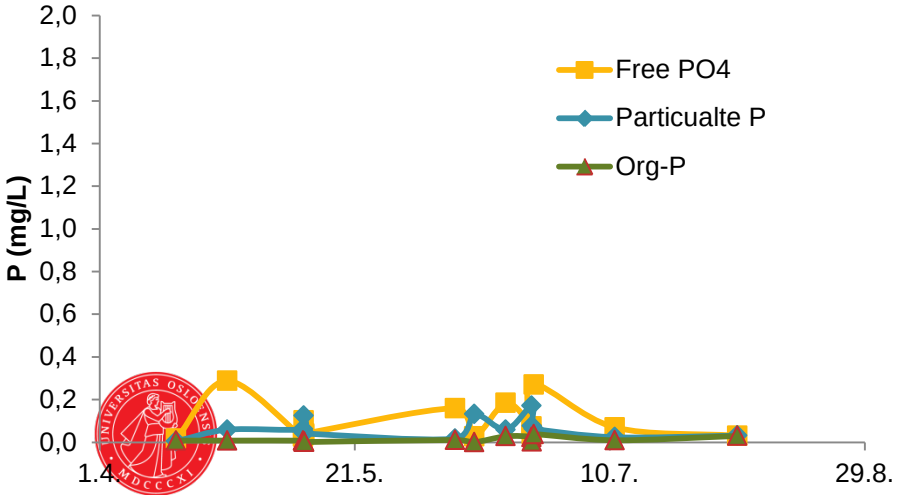
Beixinzhuang bridge



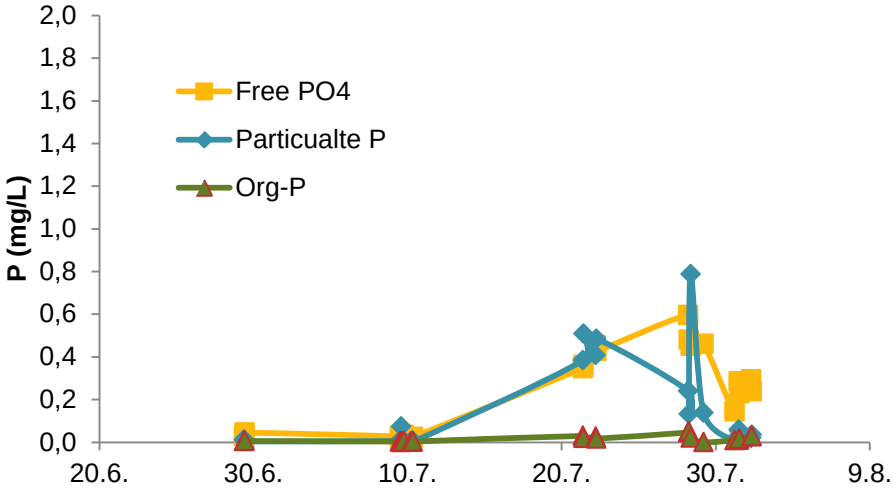
Lin river bridge



Liuxiangying river

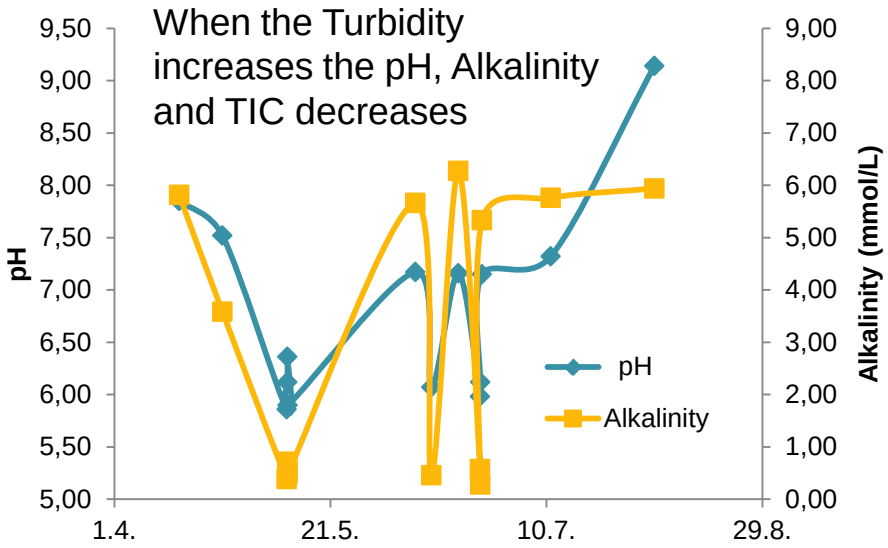


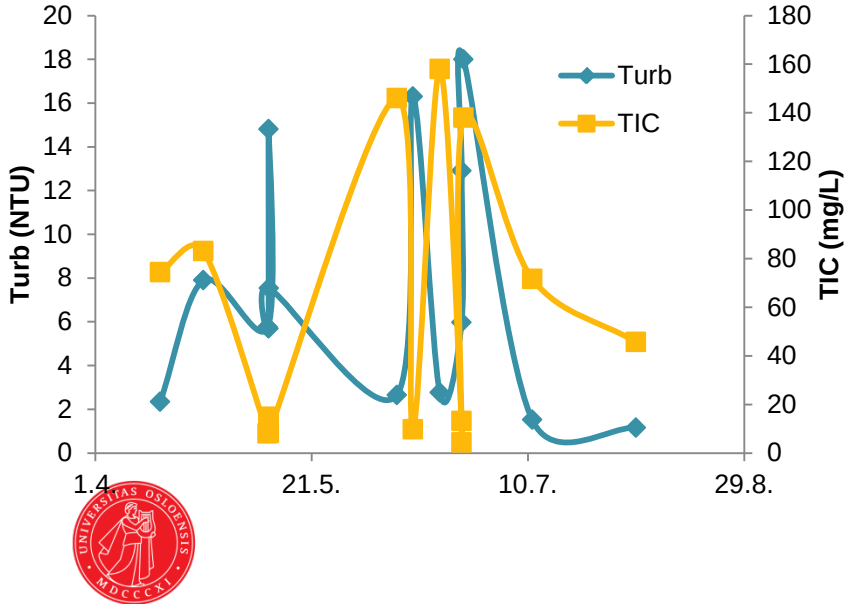
Xiaojugezhuang bridge

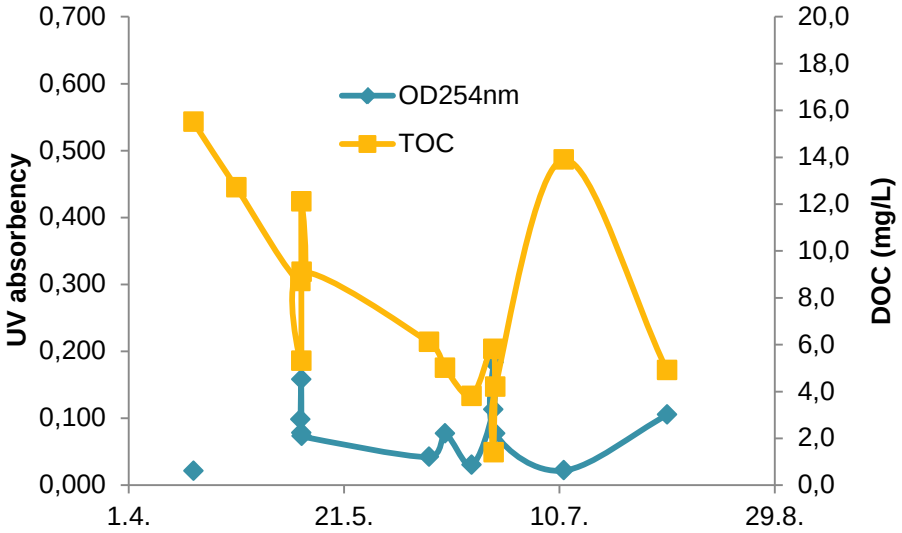


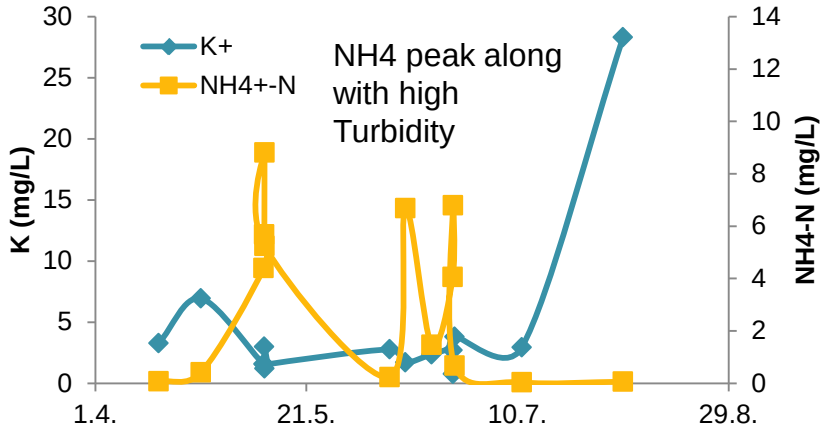
UiO

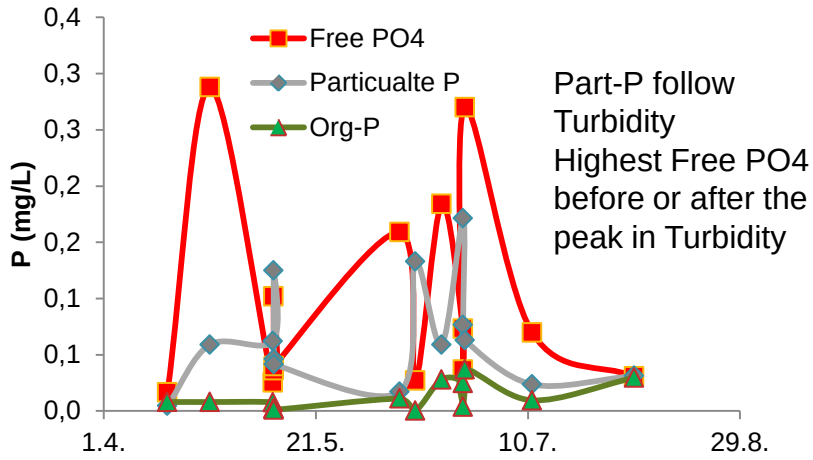
Liuxiangying river









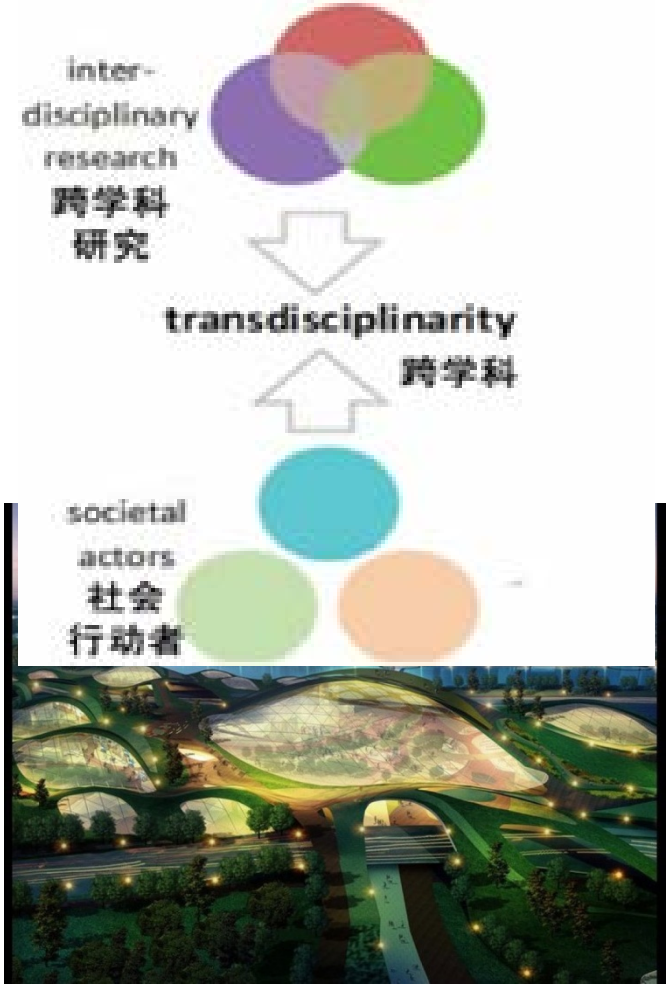


Planned output

- Nutrient management plan for Yuqiao reservoir
  - including a conceptual model for pre-warning of algal blooms and pollution control for blue-green algae – pilot implementation in two villages
- Improve public awareness regarding nutrient pollution

Working together?

- Preservation of water resources through precautionary principle
  - Solving the problem up-stream rather than end-of-pipe
- Partnership in a innovative and inclusive project with a trans-disciplinary approach
- Contributing to the Tianjin goal of scientific development and social harmony



SINCIERE

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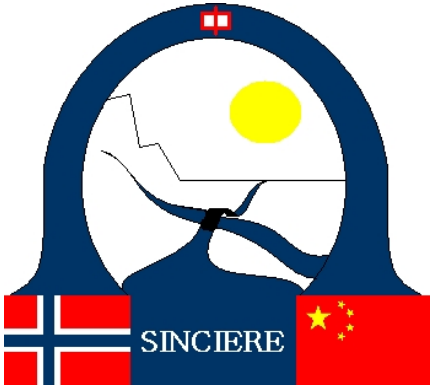

Our SINCIERE Vision:

To act as a catalyst and mediator for cooperation between China and Norway within the field of environmental research

- Facilitate interdisciplinary and policy relevant research and serve as a node for a broad network of associated institutions.

Some experience

- **Common goal** is necessary for good cooperation
  - **Modeling** promotes the interdisciplinary collaboration by concretizing the common goal
- Important to have clear **roles and respect** for the individual's academic integrity and platform
  - Respect for differences in approach: **Inductive – deductive**
- Interdisciplinarity requires participation outside your **comfort zone**
  - Time to establish **trust**
- **Polymath** hampered by lack of **polyglot**

Some experience cont.

- Cooperation is best achieved through **physical co-location**
  - **Common research site** make it possible to generate sufficient data
  - Easier to work together "**out there**" than in office
- Interdisciplinarity enables **cross-fertilization**
- **Coupling** Nature - Social Sciences and users:
  - Leads to that we are better able to ask the right **questions** and see the relevance of our studies
  - Facilitates the **practical** work in the field through collaboration with local stakeholders
  - Enable us to indentify the **relationship** between land use / activity and environmental parameters

Thank You

谢谢！