Combining biodiversity conservation with agricultural production – will the ecosystem service concept facilitate the emergence of multifunctional landscapes?

Henrik G. Smith

Centre of Environmental and Climate Research,
Lund University, Sweden

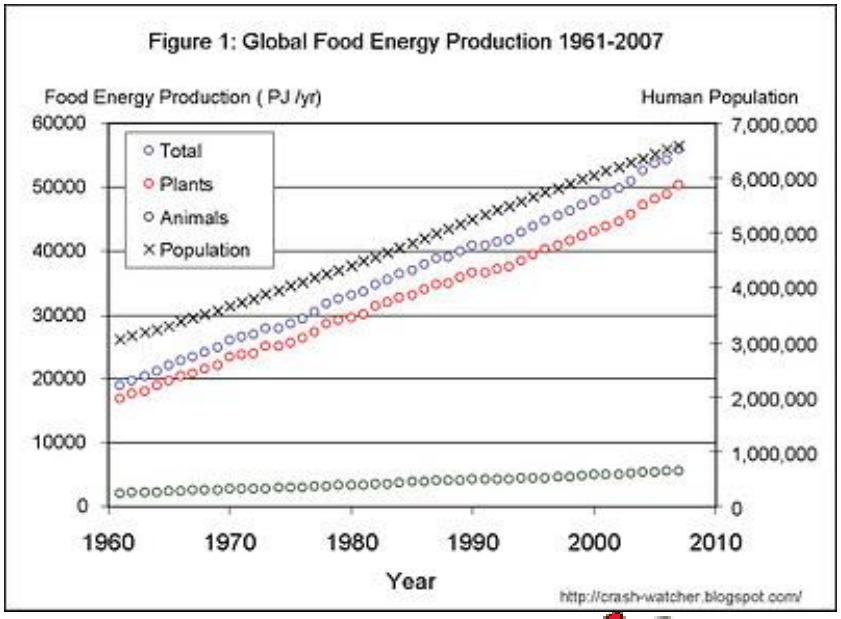
We expect multiple benefits from farmland:

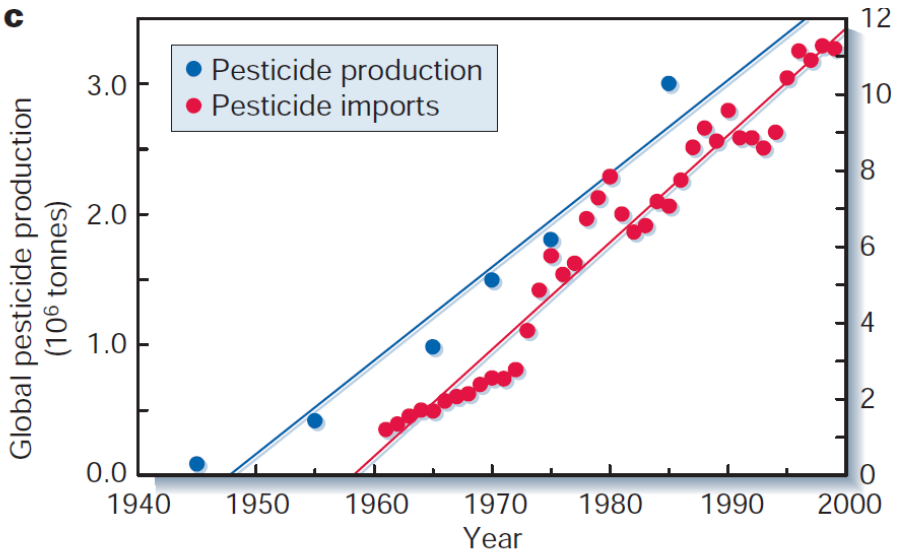
- Food production
- Biodiversity conservation
- Water regulation
- Nutrient retention
- Recreation
- Housing
- …

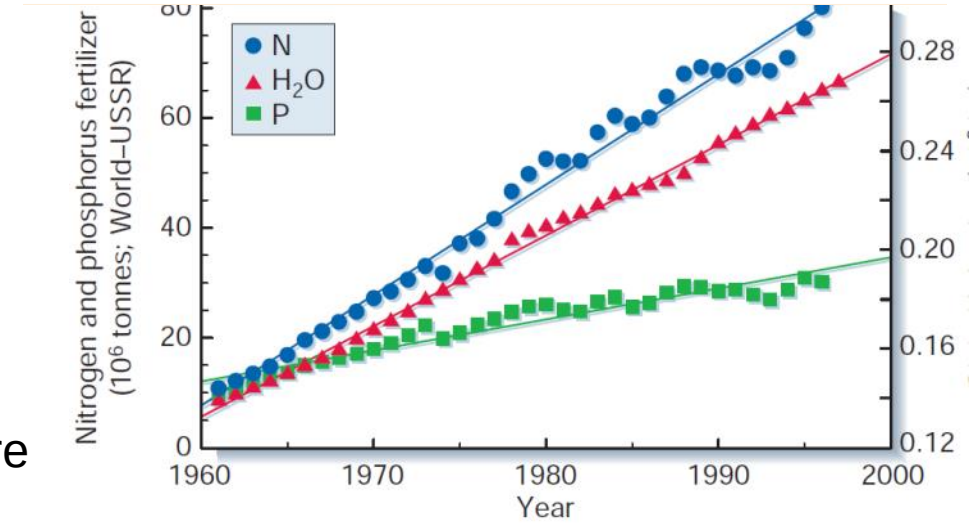
Landscape change puts multifunctionality at risk

- Intensification
  - Inorganic fertilizers
  - Pesticides
  - …
- Simplification
  - Loss of semi-natural habitats
  - Larger fields
  - Simplified crop rotations
  - ….

Production increased through agri-cultural intensification (and expansion)

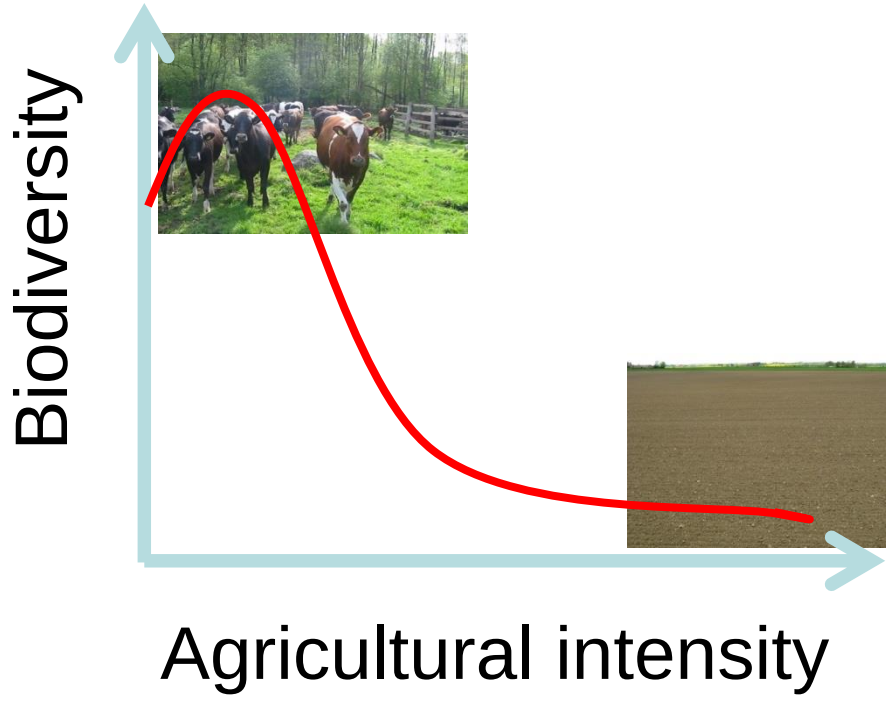


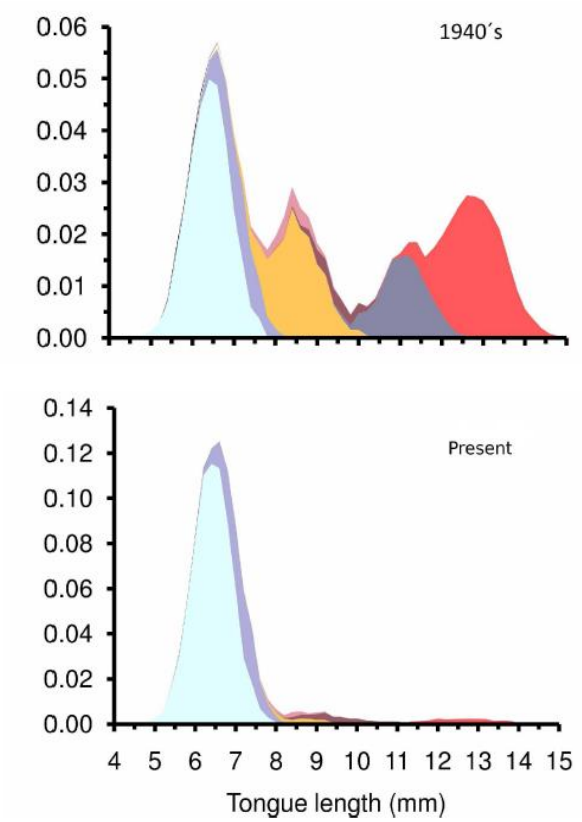


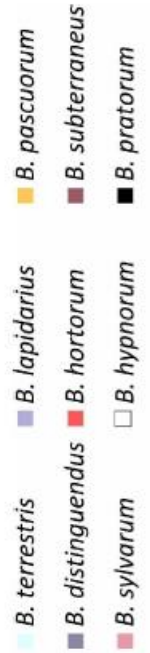


FAOSTAT; Tilman et al. 2002, Nature

Agricultural intensification has resulted in dramatic losses of biodiversity







Adapted from Hoogeveen et al. 2001; Bommarco, Lundin, Smith & Rundlöf 2011

How do we handle the tragedy of ecosystem services?

The Tragedy of the Commons

Garrett James Hardin (1915 – 2003) was an American ecologist and scientist who warned of the dangers of overpopulation.

Known for Hardin's First Law of Human Ecology: "You cannot do only one thing". This expresses the interconnectedness of every action.

"A finite world can support only a finite population; therefore, population growth must eventually equal zero."

Garrett Hardin

Mother Nature Network

The Tragedy of the Commons – By Garrett Hardin

Cheshire Region Biodiversity Partnership

Forum

The Tragedy of Ecosystem Services

CHRISTOPHER L. LANT, J. B. RUHL, AND STEVEN E. KRAFT

Derived from funds of natural capital, ecosystem services contribute greatly to human welfare, yet are rarely traded in markets. Most supporting (e.g., soil formation) and regulating (e.g., water purification, pest regulation) ecosystem services, and some cultural (e.g., aesthetic enrichment) and provisioning (e.g., capture fisheries, fuel wood) ecosystem services are declining because of a complex social trap, the "tragedy of ecosystem services,"

BioScience 2008

AI may threaten *both* private and public ecosystem services

Agricultural intensification

Loss of cultural service

Pollinator Diversity Declining in Europe

Several studies have suggested that particular pollinating insects might be in trouble—the domesticated honeybee in the United States, for example—but there has been little evidence for a large-scale problem. That is about to change: On page 351, a team led by Jacobus Biesmeijer and William Kunin of the University of Leeds, U.K., report a significant decline in pollinator diversity across the U.K. and the Netherlands since 1980. "They're going down, absolutely," says ecologist Jane Memmott of the University of Bristol, U.K. The study found that insect-pollinated plants in the two countries have also run into trouble, but the authors and others acknowledge that it's difficult to prove that the loss of pollinating only a few species of plants—were particularly hard hit. They experienced greater declines in distribution than less choosy pollinators in both countries. "Many of the rare species are now so rare that they will probably go extinct [in these regions] in the next decades," Biesmeijer predicts. The declines are probably due to destruction of habitat or agricultural changes; the team is analyzing the ALARM database for clues.

To see whether plants have been affected on a national scale by declines in pollinator diversity, Biesmeijer and his colleagues pored over botanical atlases. In the U.K., 75 wild plants that need insects for pollination had declined in distribution, whereas 30 that are pollinated by wind or water increased overall. In the Netherlands, where just the bees have declined, only bee-pollinated plants lost ground. "It seems too cozy to be coincidence," says Kunin.

Biesmeijer and Kunin suspect that there is a causal relationship between the pollinator and plant declines, although it's not clear which is driving the trend. Ecologist Jaboury Ghazoul of the Swiss Federal Institute of Technology in Zurich is skeptical that recent pollinator declines have affected plant populations; he thinks it's more likely that human disturbances, for example, favor weedy, wind-pollinated plants. Others fear that the loss of bees and other pollinators will have a clear agricultural impact. Says pollination ecologist Juliet Osborne of Rothamsted Research in Harpenden, U.K., "There is an economic reason to be worried."

–ERIK STOKSTAD

Rarer. In Britain and the Netherlands, wild bees, such as *Andrena gravida* (above), are declining.

?

Loss of pollination service

Science News ... from universities, journals, and other research organizations

Declining Bee Numbers Raise Concerns Over Plant Pollination

ScienceDaily (May 11, 2007) — A decline in bee diversity and abundance linked to habitat loss and disease in Europe together with a 50% drop in the number of managed honeybee colonies throughout North America are part of a global phenomenon known as the 'pollination crisis'.

Share This: Like 11 Tweet 0 +1 0 Share 27

Over 80% of crops in Europe are pollinated by insects and the contribution of bumblebees to Irish agriculture is often underestimated. Bees are responsible for most crop pollination and are often actively introduced by farmers into crops to improve production. Each year, Irish growers import hundreds of commercial bumblebee colonies from

Loss of ecosystem services contributing to crops and public goods

Food

Bio-energy

Fodder

Pollination

Bio-control

Nutrient retention

Ecosystem service providers

- Eutrophi-cation

Water regulation

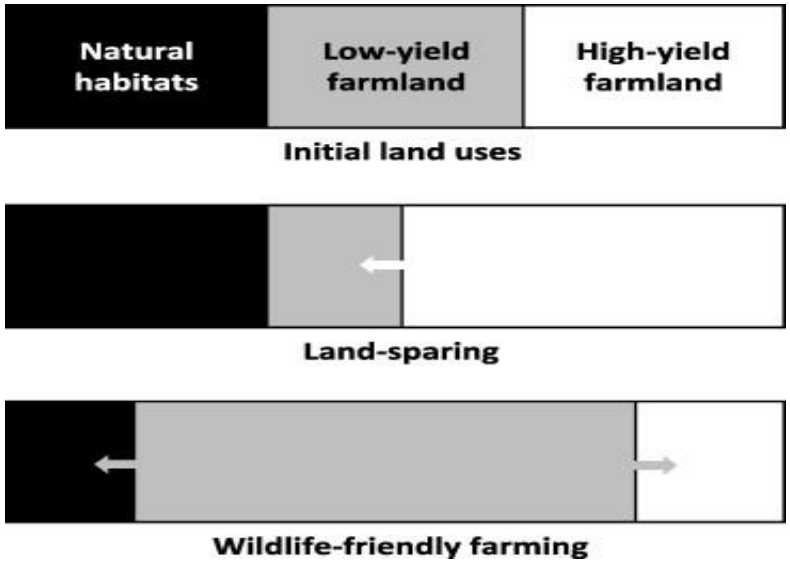
Recreation

Climate regulation

- Erosion

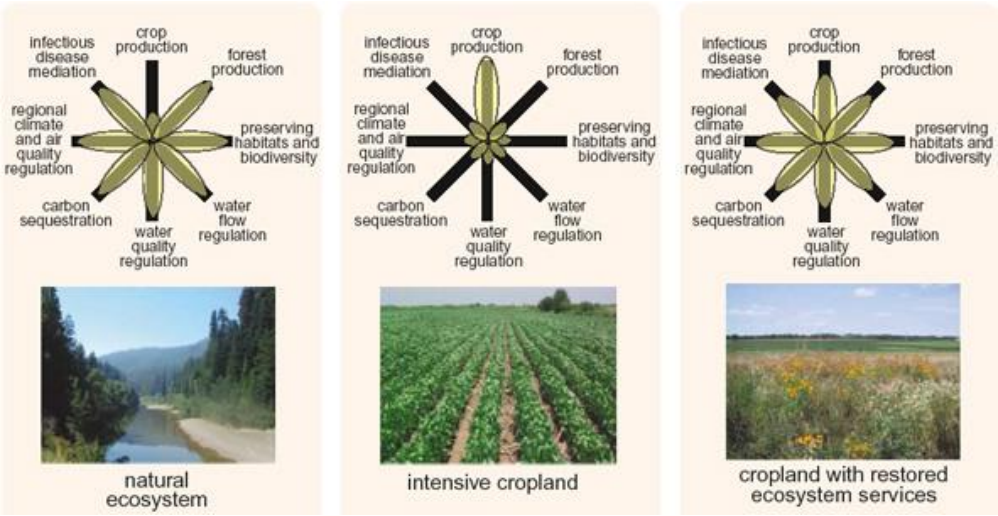
Should biodiversity conservation be integrated with production landscapes?

NO!



Phalan et al. 2011

YES!



Foley et al. 2005

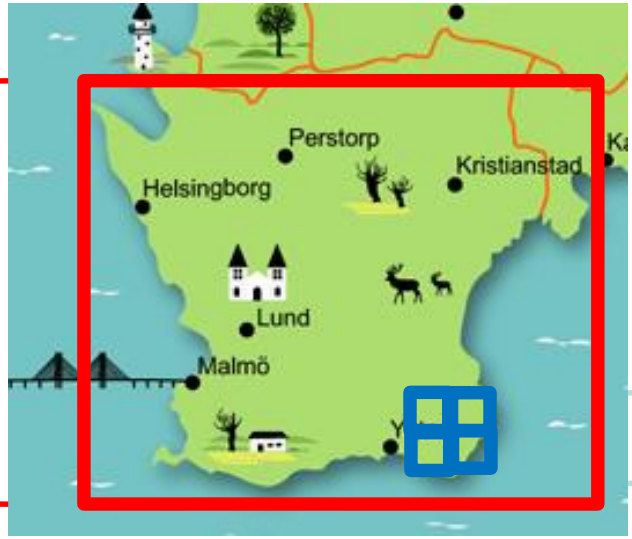
Problems when finding win-win between conserving biodiversity for ethical and utilitarian reasons

- Do the same measures benefit rare species and ecosystem service providers? (Identifying possible win-win solutions)

- How private are ecosystem services underpinning crop production? (Identifying incentives needed)

Conservation of ecosystem service providers and conservation of rare species are different objectives!

Rare species at regional scale

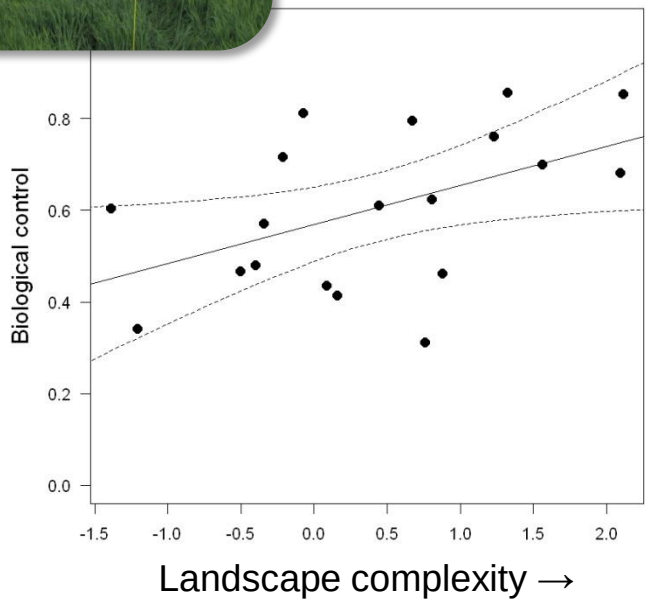


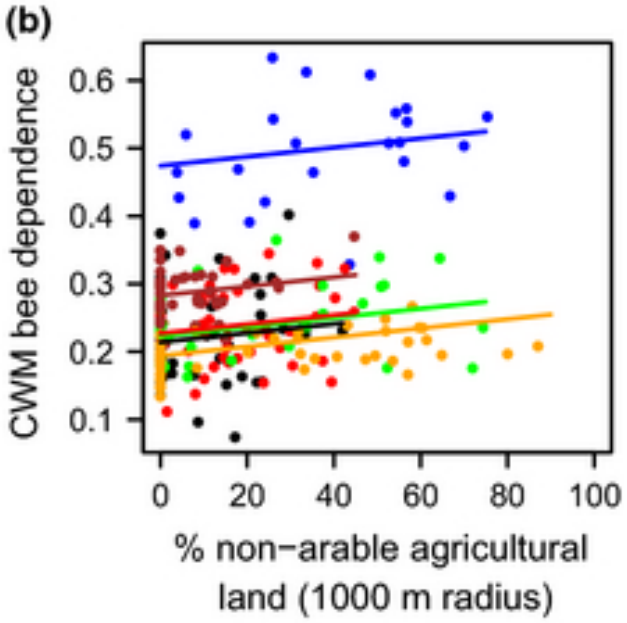
Ecosystem service providers at local scale

Ekroos, Olsson, Rundlöf, Wätzold, Smith, 2014

Identifying synergies

Preserving landscape complexity to benefit ecosystem services also benefit conservation



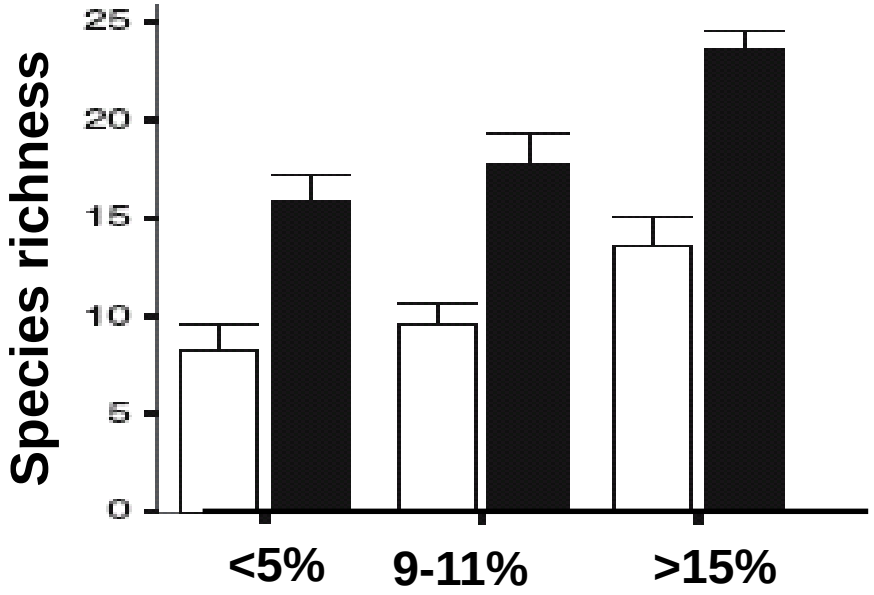


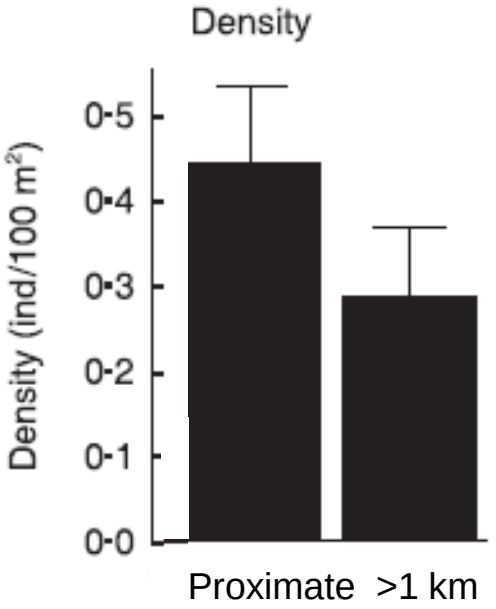
Rusch…Smith, Ekbom, 2013, J. Appl. Ecol.; Clough….Smith, 2014, Ecology Letters

Identifying synergies

Grassland conservation benefits rare species and ecosystem service providers

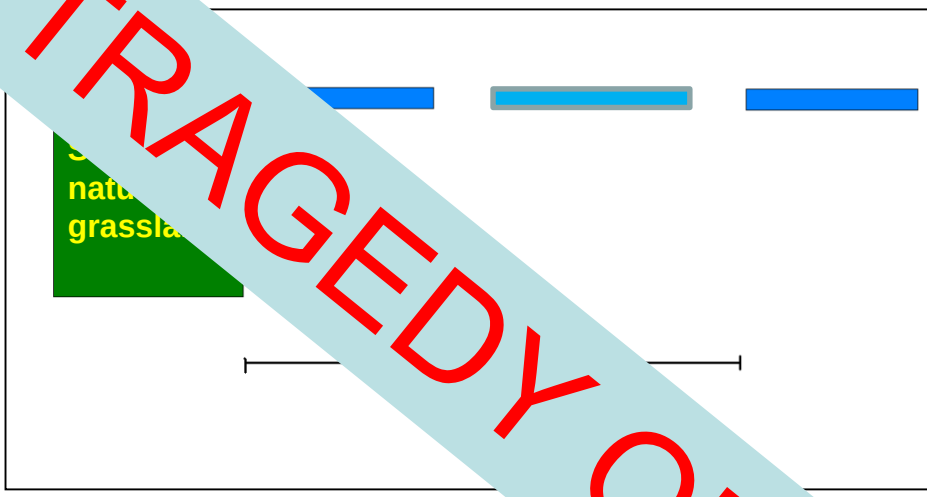
Small grassland
Large grassland

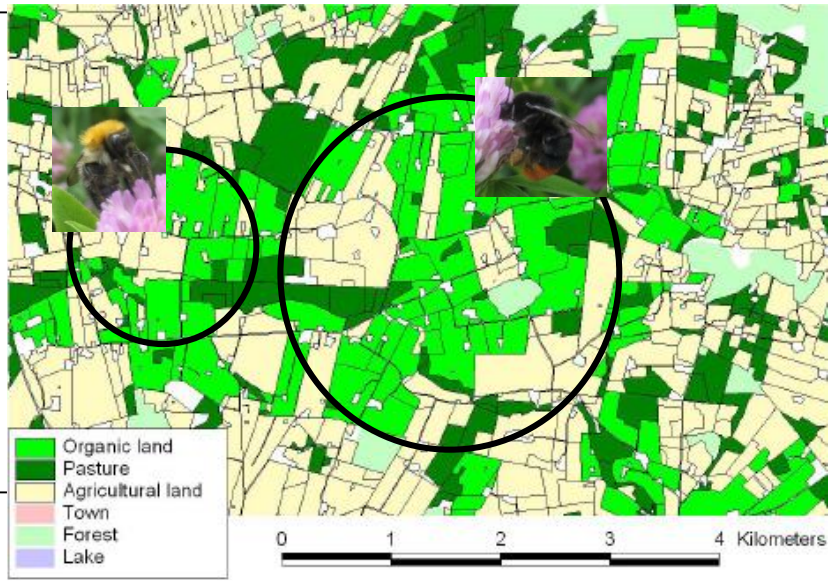


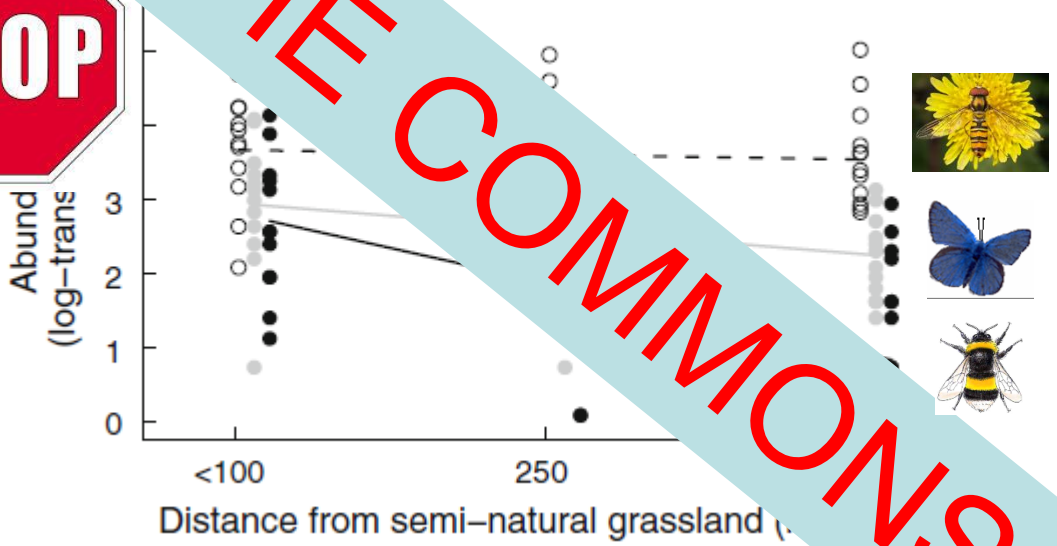


(Öckinger & Smith, 2006; Öckinger & Smith 2007)

TRAGEDY OF THE COMMONS

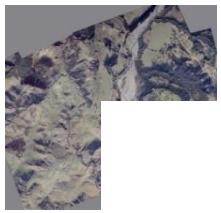






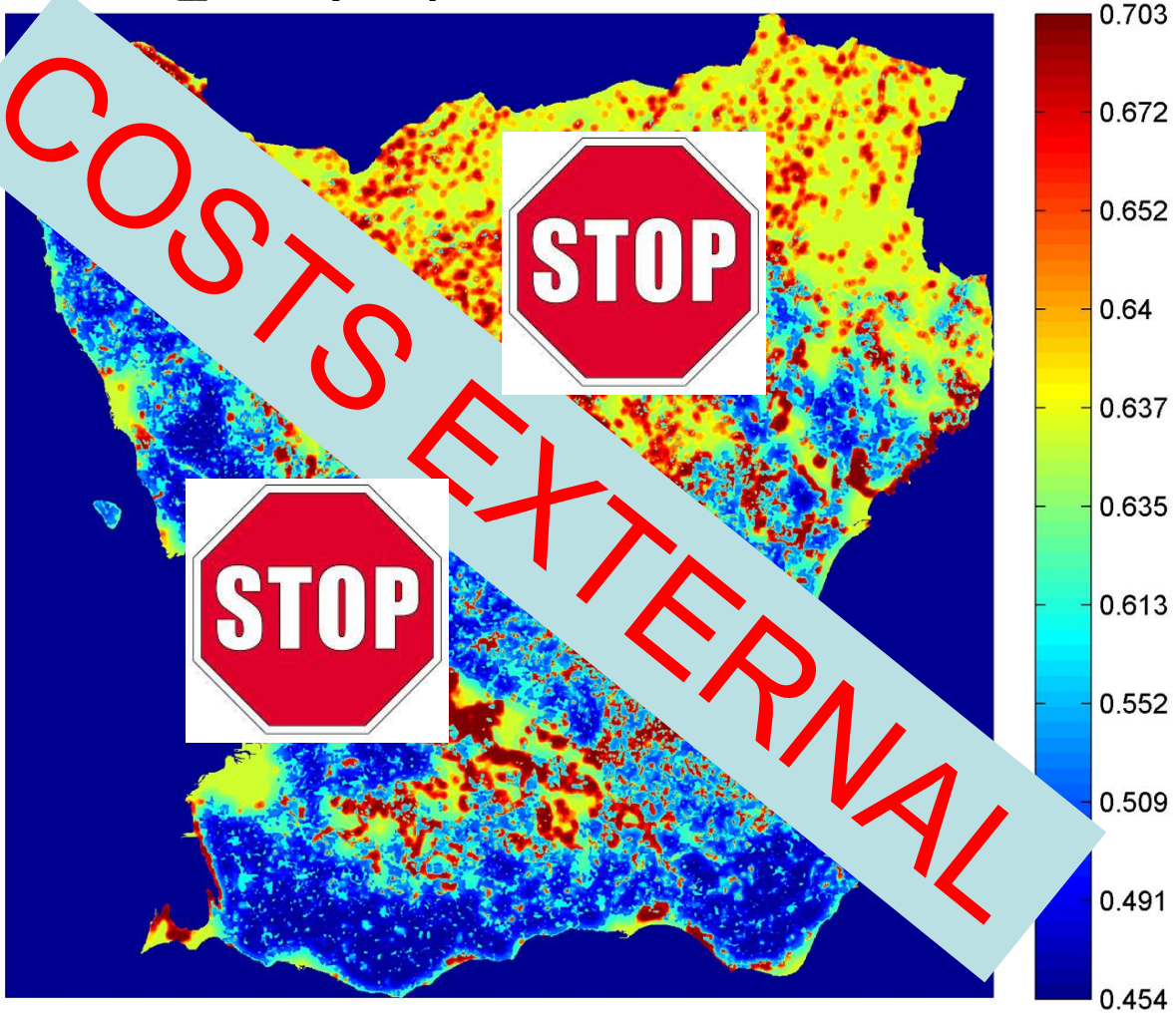
Ekroos, Rundlöf och Smith, 2013

Yield as a function of biocontrol of aphids birdcherry-oat aphids in barley



% non-arable, 135m

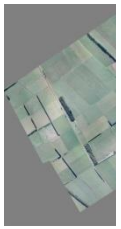
% non-arable, 1500m



Lands
compo

loss
ha)

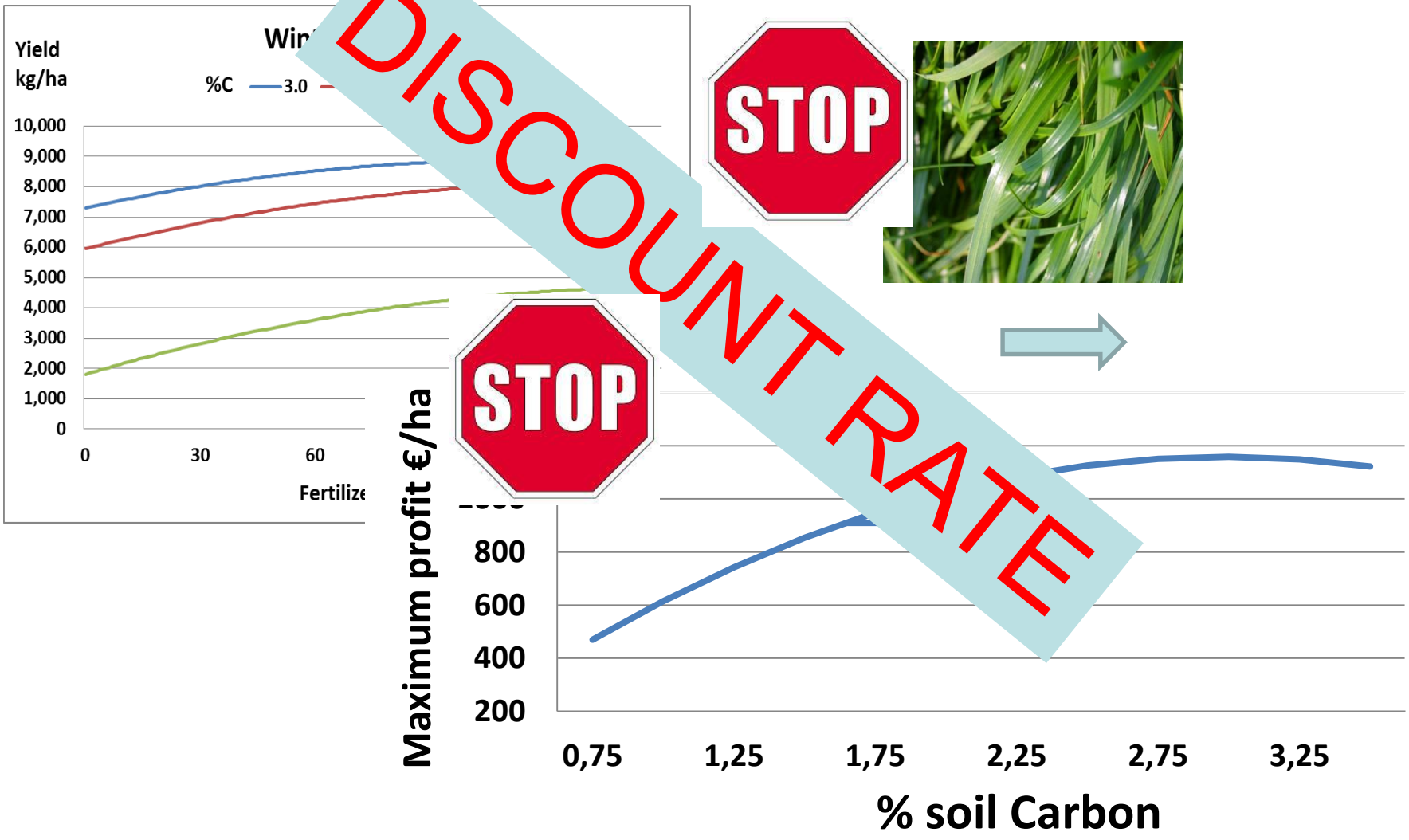
lue



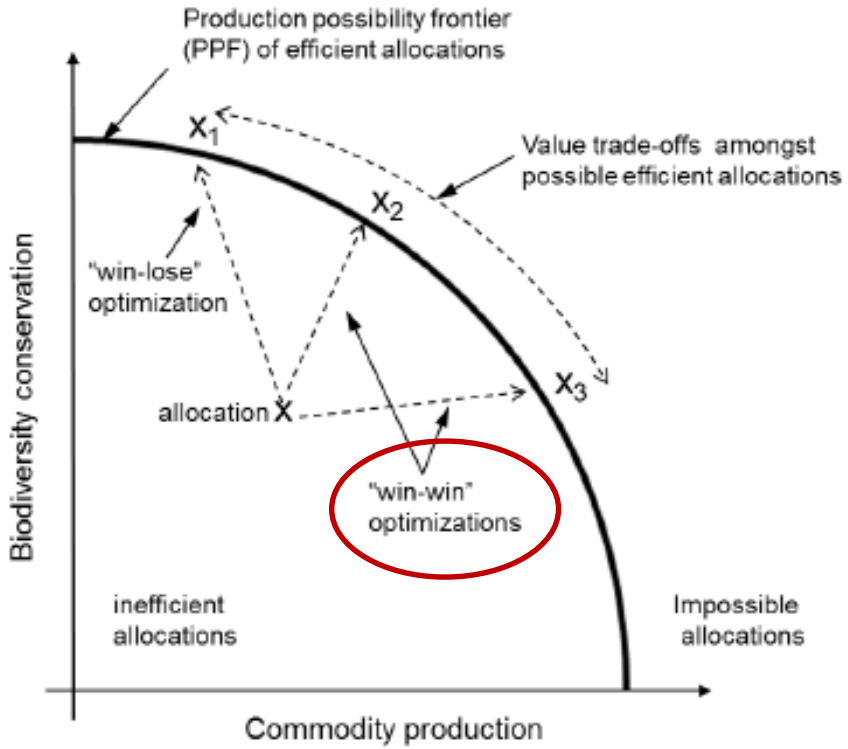
% non-arable, 500m

Jonsson…Smith…Olsson et al. 2014

Soil carbon affects the need for fertilizers, harvest and thus profit

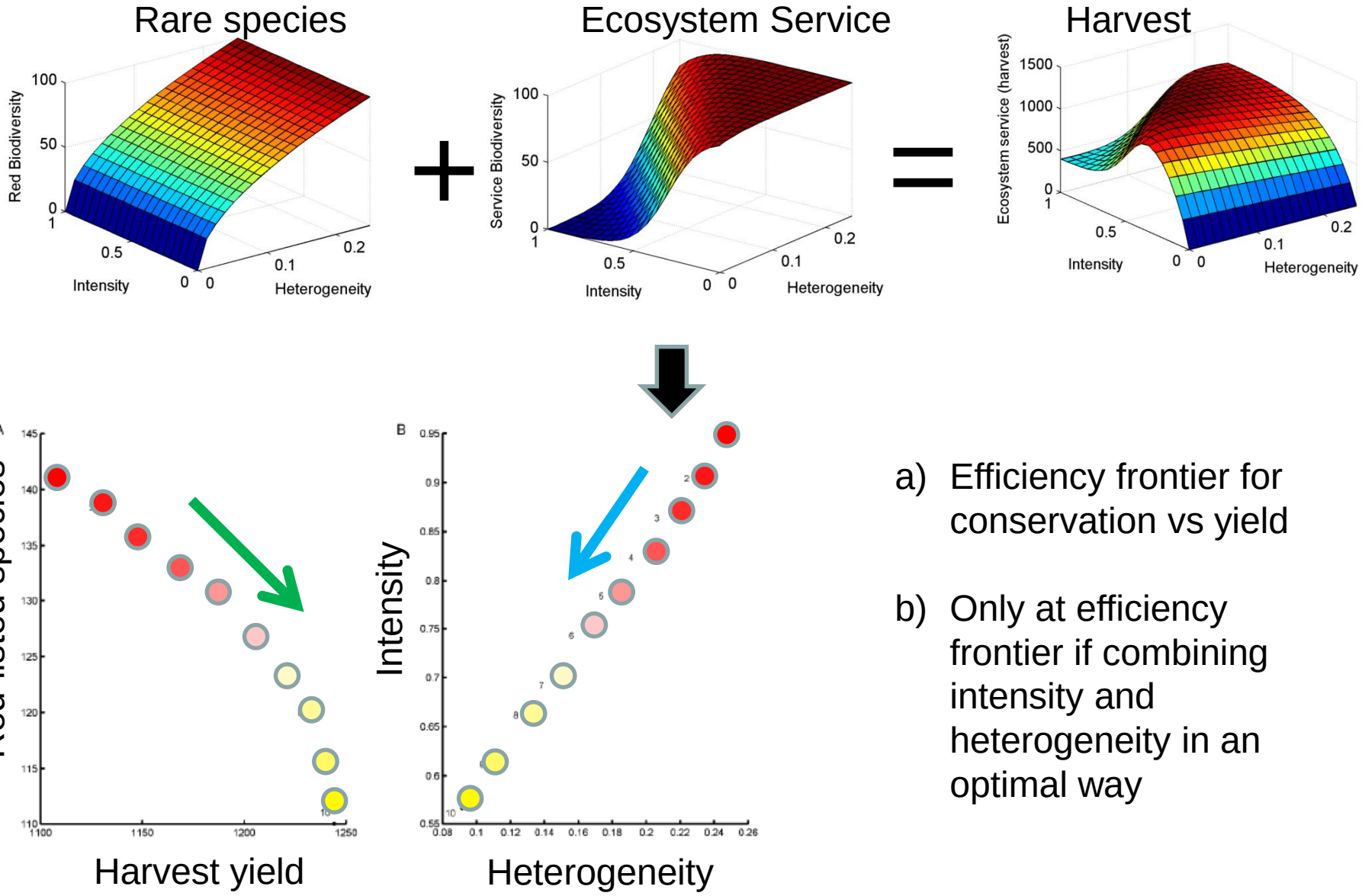


Avoiding trade-offs between agricultural production and biodiversity conservation



- Find win-win solutions reducing the distance to the efficiency frontier
- Handle the tragedy of ecosystem services (payment for ecosystem services, farmer collaboration, subsidies, regulations)

Fischer……Smith, Wehrden, 2014, Conservation Letters

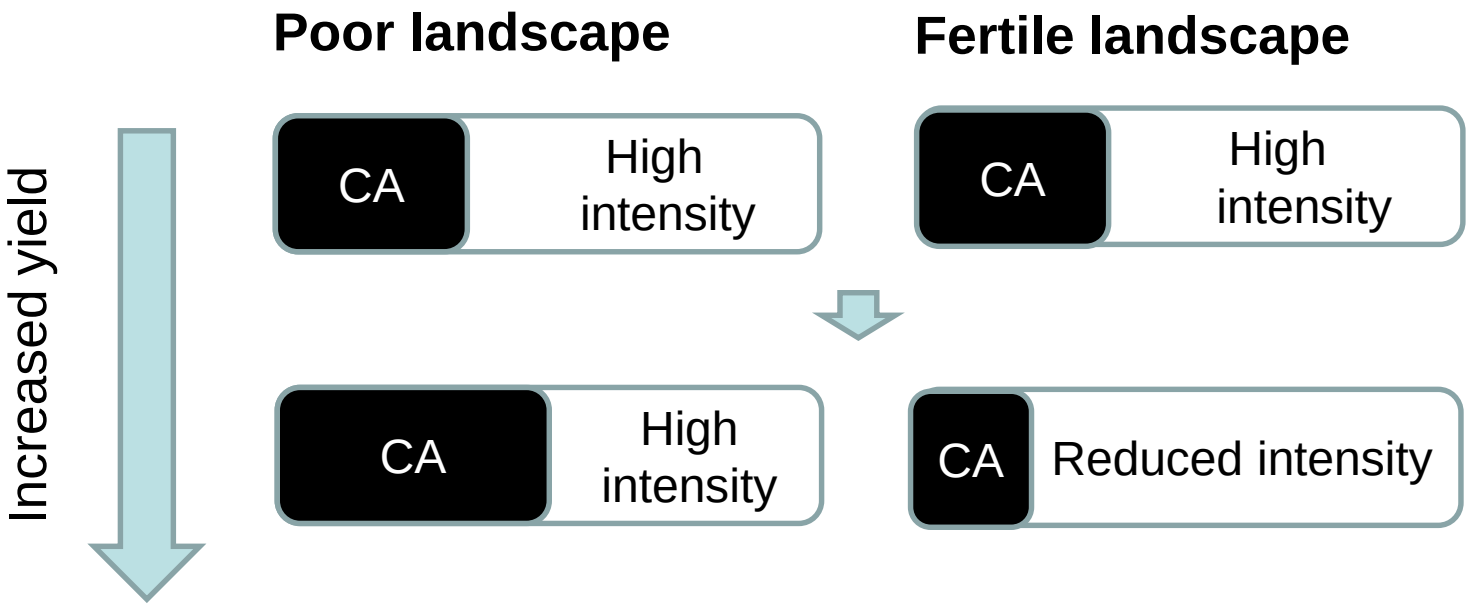


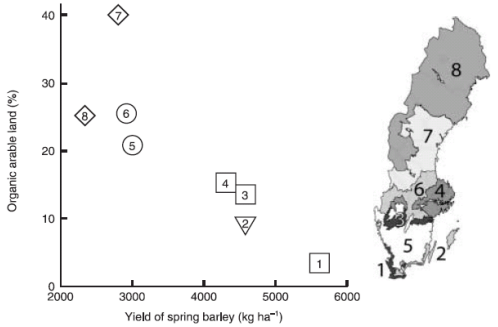
a) Efficiency frontier for conservation vs yield

b) Only at efficiency frontier if combining intensity and heterogeneity in an optimal way

Ekroos…Smith, 2014

Expanding efficiency frontiers to poor and fertile landscapes -> spare in the poor and share in the fertile landscape





Ekroos…Smith 2014, Biol. Cons.; Rundlöf & Smith 2006