Fast-growing tree plantations in the landscape – optimising several ecosystem services

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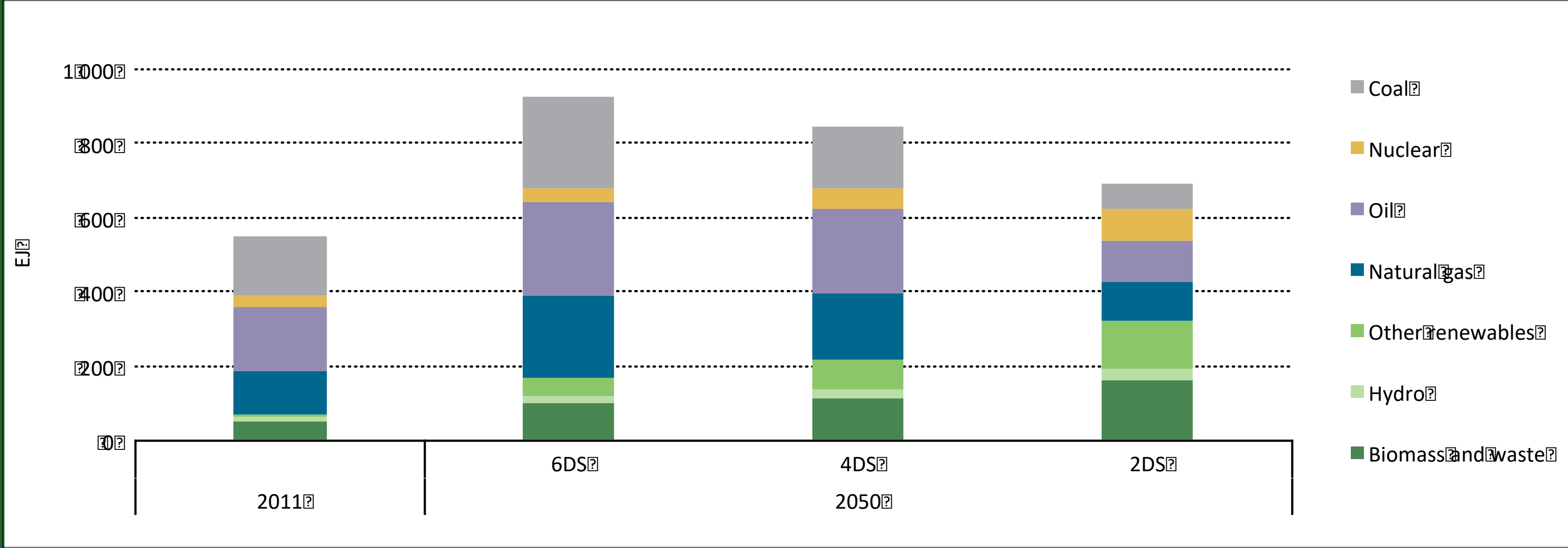
Bioenergy

- ***significant scope to make a greater contribution to secure and sustainable energy provision***



Global modelling results - Total primary energy supply

IEA Energy Technology Perspectives 2014

The Goal

How to go from today's *ca*. 50 to *ca.* 150 EJ/yr in 2050?

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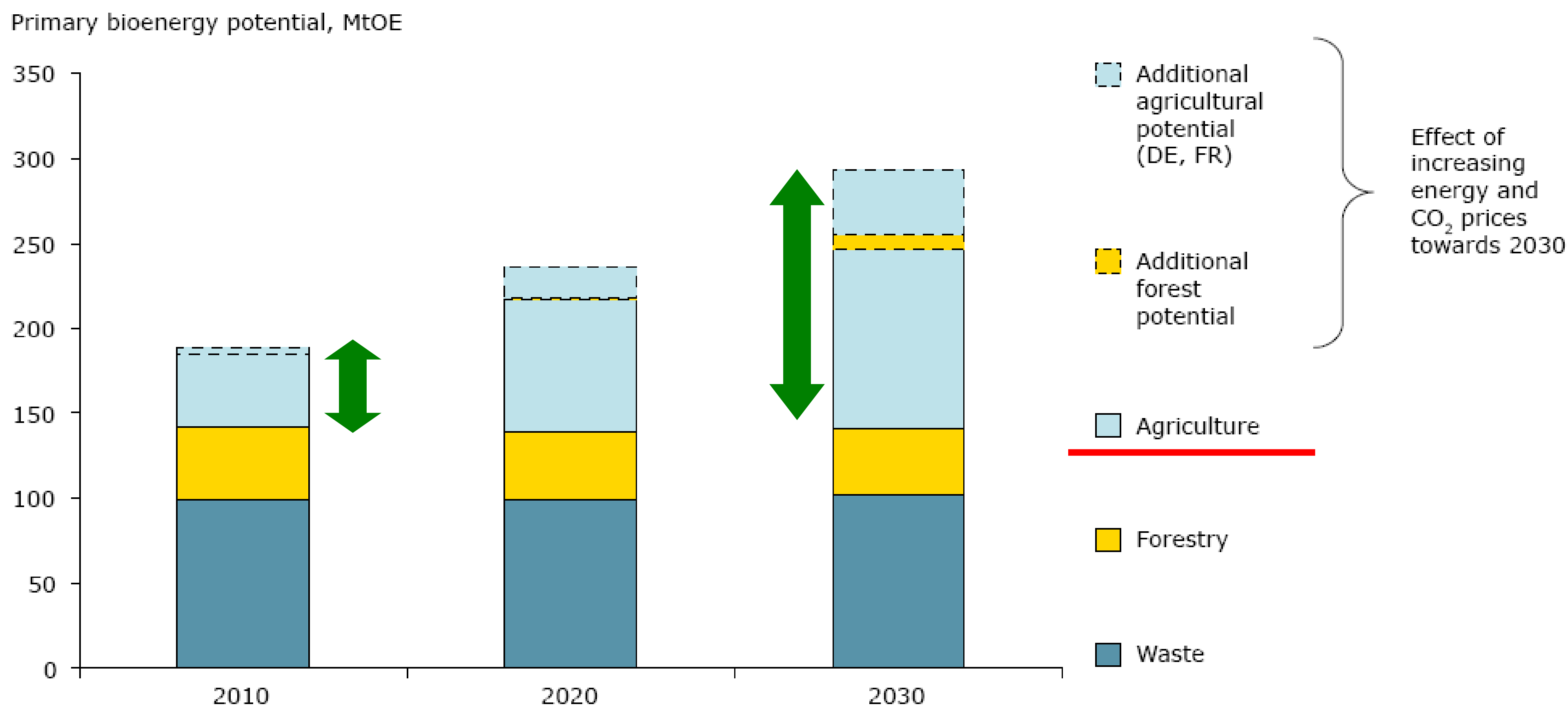
Figure 1 ***Environmentally-compatible* primary bioenergy potential in the EU**



Source: EEA (European Environmental Agency) 2006.

How much bioenergy can Europe produce without harming the environment?

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Some background

- biomass production in agriculture will have to increase tremendously
- organic waste and by-products from agricultural (and forest) industries can make important contributions but will not suffice to meet anticipated levels
- dedicated biomass production systems for energy will be needed

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Concerns raised

- potential disruption to food security
- raw material markets and rural livelihoods
- greenhouse gas (GHG) emissions
- displacement of small-scale farmers
- ecological impacts associated with land use change

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The Challenge

- how to integrate new bioenergy feedstock production systems into agricultural landscapes in ways that promote environmental, social and economic sustainability of the agricultural production

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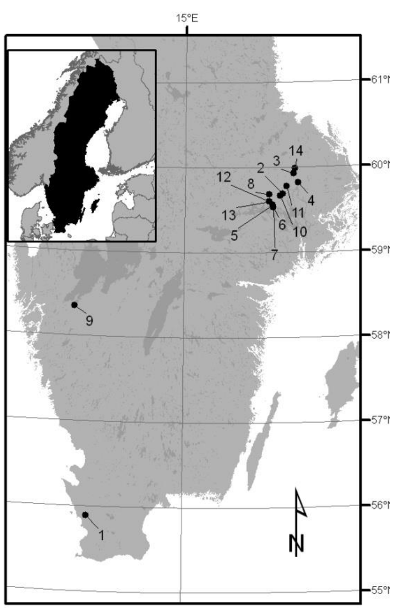
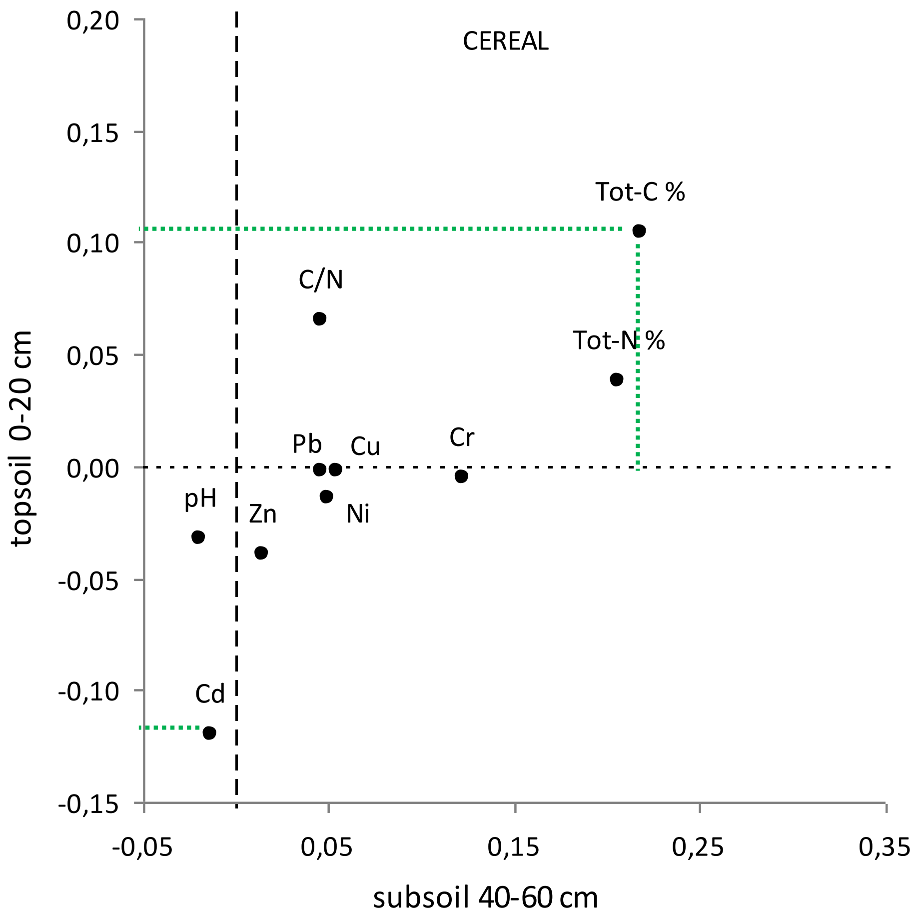
	Name	Year planted	Clone	Reference field	Sludge /Ash	Harvested	Inorganic fertilisation	Soil type (0-20 cm)	Biomass 2009-10	Previous use /before SRC
1	Billeberga I	2002	Sven	Cereals	Y/N (1)	2008	N	sandy loam	8.5**	Sugarbeet
2	Billeberga II	1994	Torhild	Cereals/rapeseed	Y/N (3)	Annually	N	loam	2**	Cereals
3	Djurby Gård	1990	78021	Cereals	Y/N (3)	2007/2011	N	silty clay	5.3	Cereals
4	Forkarby	1995	78112	Cereals	N/N	2008	Y (1)	silty clay	11	Cereals
5	French Trial	1994	78021	Cereals (eco)	N/N	2007/2010	Y (8)	clay loam	9.3	
6	Hacksta	1994	Jorr, Rapp	Peas/cereal	Y/Y (4)	2008	Y (1)	clay loam	4.2	Cereals
7	Hjulsta II	1995	Jorr	No ref	N/N	2008	N	clay	9.6	Oil crops/cereals
8	Kurths trial	1992	Ulv/Rapp	Cereals (eco)	N/N	2007/2010	N	clay loam	12.4	Cereals
9	Lundby Gård I	*2000	Tora	Cereals	Y/Y (1)	2005	Y (1)	clay	4.9	Cereals
10	Lundby Gård II	1995	78021	Cereals	N/N	2005	N	clay	2.5	Cereals
11	Puckgården	1992	78112	Cereals	N/N	2008	Y (4)	silty clay	10**	Cereals
12	Skolsta	1993	78021, Orm	Cereals	Y/Y (1)	2004	Y (2)	silty clay	4	Cereals
13	Säva	1993	Rapp, Orm	Grass	Y/N (2)	2007	N	silty clay	7.4	Cereals
14	Teda I	2000	Tora	Grass	Y/Y (2)	2009	Y (2)	silty clay loam	8	Cereals
15	Teda II	1993	78112	Grass	Y/Y (2)	2007	Y (2)	clay	1.7	Cereals/Set-aside
16	Åsby	1996	Tora	Cereals	Y/Y (1)	2008	Y (2)	silty clay	4.2	Cereals

Tab. 1. Description of the different locations where groundwater pipes were established. *

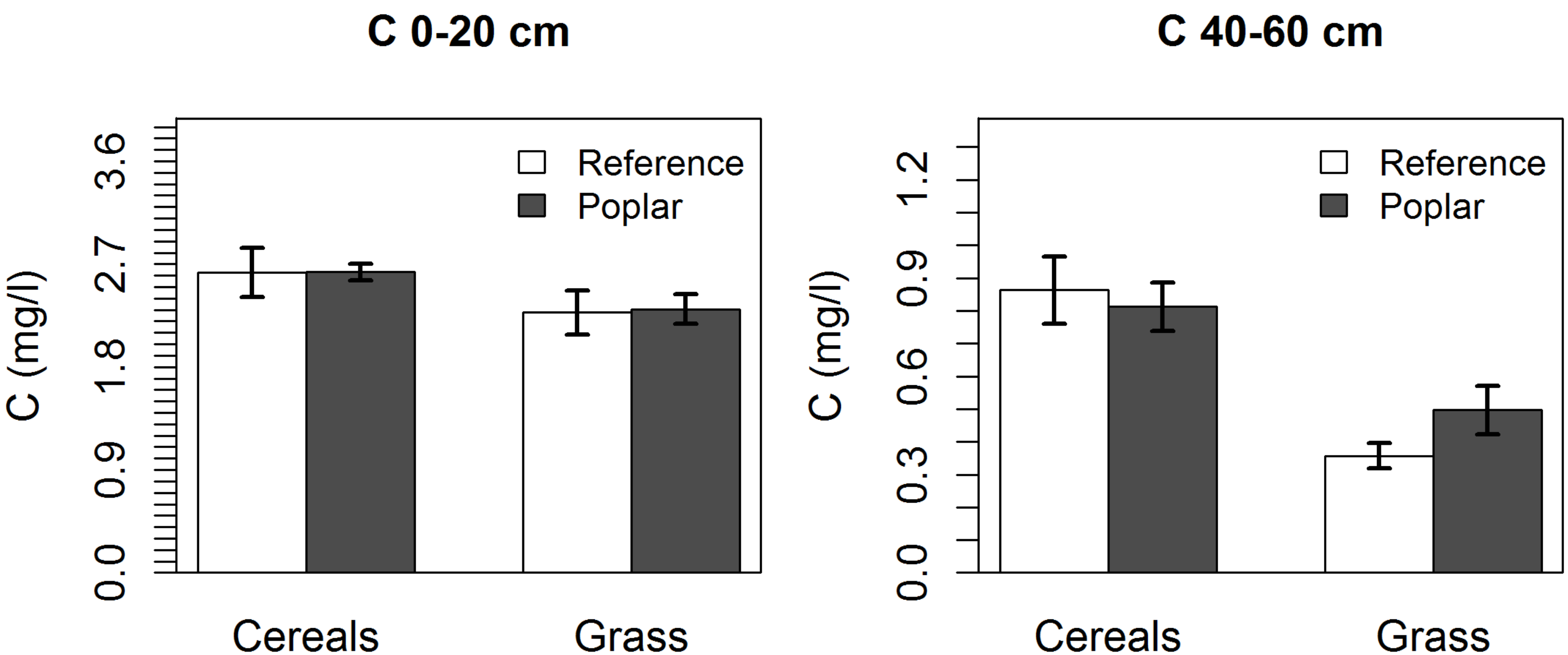




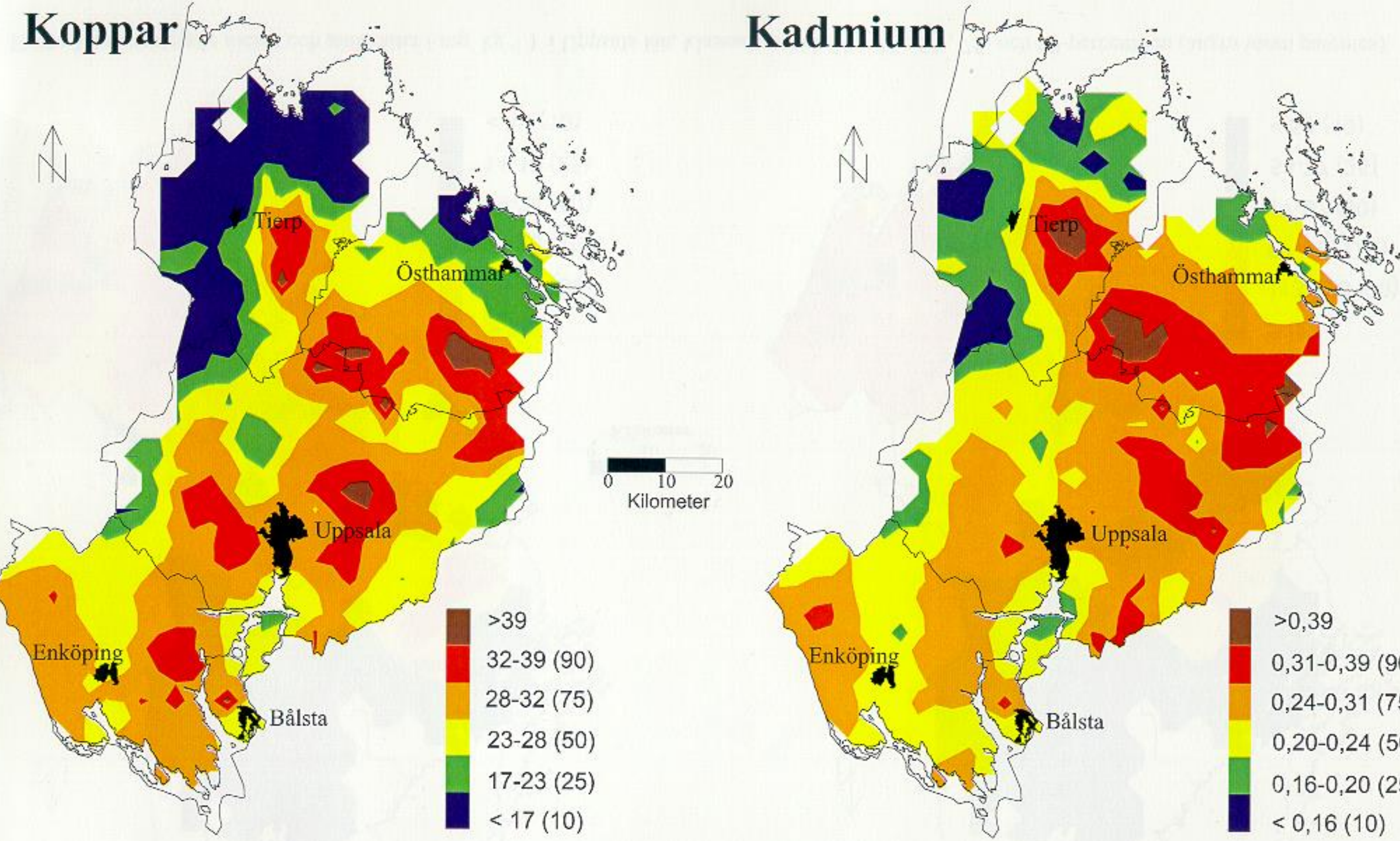
Relative differences between willow SRC plantations versus the reference. The values are the averages for all the locations of the different soil quality parameters investigated in topsoil (0-20 cm) and in subsoil (40-60 cm). Positive values represent higher observations of the studied parameter in the willow SRC plantations, in percentage (Dimitriou et al 2012, Bioenergy Research).

Impact of SRC vs ref on soil

- C storage in soil organic matter is higher under SRC than under conventional agricultural crops
- Soil organic matter stability is higher under SRC than under conventional agricultural crops and supports C sequestration in the soil
- Cd concentrations in the soil under SRC are lower than under conventional agricultural crops (ca. 12% lower in topsoil)
- Sludge applications did not affect the above differences of Cd in topsoil

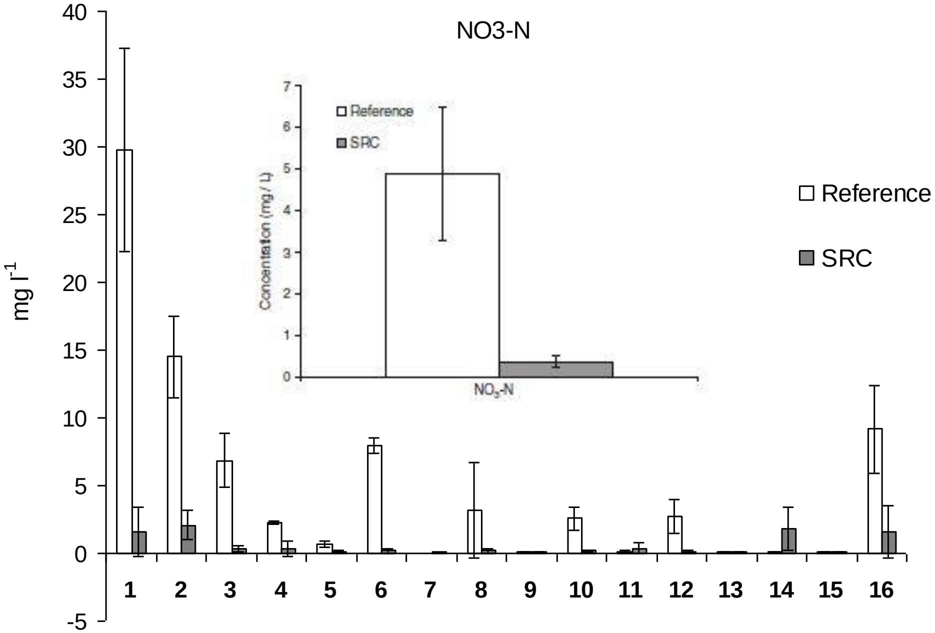


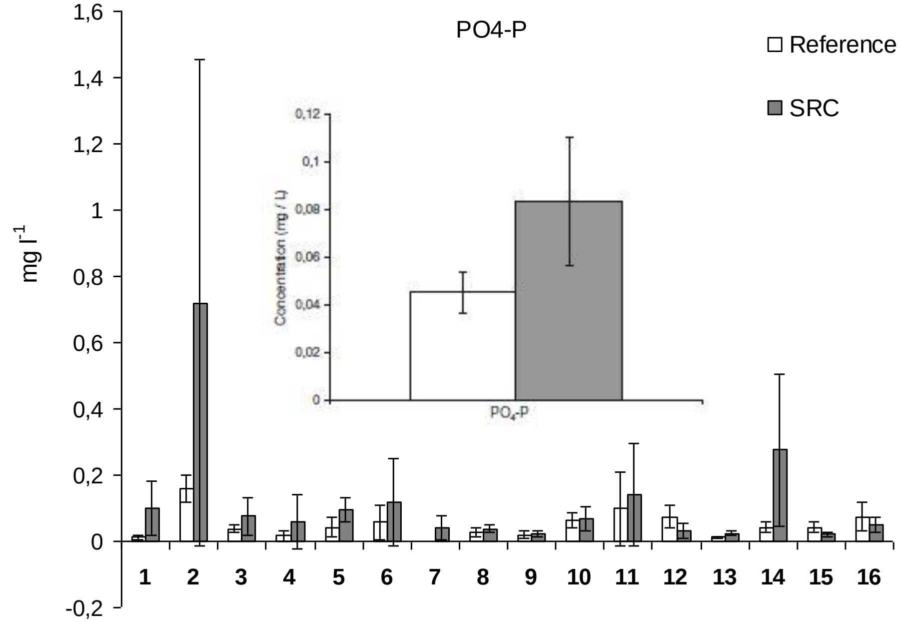
Differences in soil carbon (mg/l) at two depth levels (0-20 cm and 40-60 cm), for poplar plantations and the reference crops. Bars represent the standard error of the means (Dimitriou and Mola-Yudego, Forest Ecology and Management 2017)



Figur 4 Interpolerade koppar och kadmiumhalter (mg kg^{-1}) i Uppsala län, klassade utifrån10-, 25-, 50-, 75- och 90-percentilen (anges inom paren

Nutrient leaching





Means, averages and standard errors of NO3–N and PO4–P concentrations in the groundwater of willow short rotation coppice (SRC) plantations and reference fields (Dimitriou et al, 2012 - Bioenergy Research)

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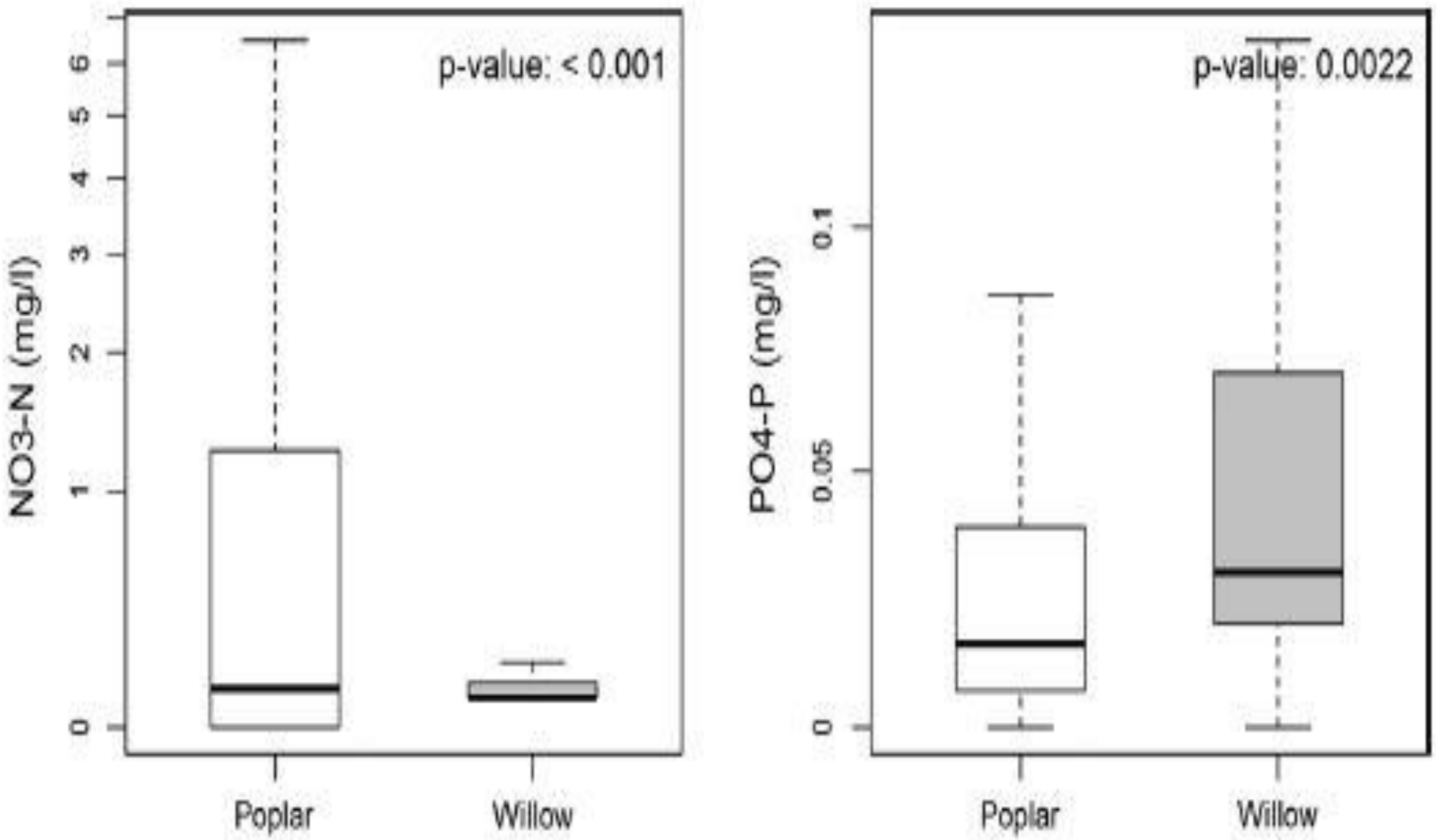
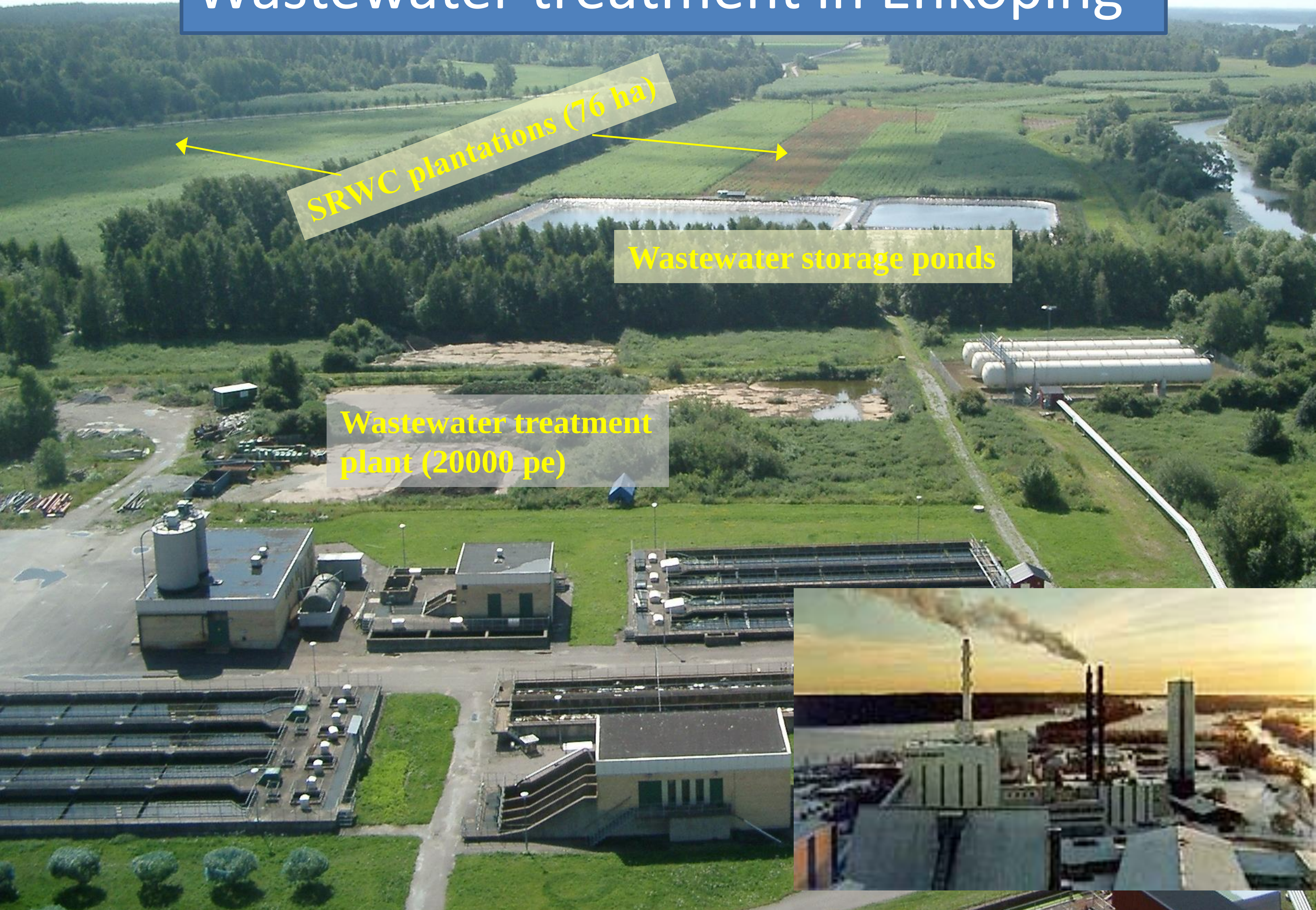
I. Dimitriou, B. Mola-Yudego / Forest Ecology and Management 383 (2017) 99–107



Total concentrations of NO3-N and PO4-P in the groundwater. Concentrations of NO3-N and PO4-P are presented in logarithmic scale. The boxes represent the median, upper and lower quartiles, and the bars the maxima and minima excluding outliers.

Riparian buffer zones and bioenergy production

Wastewater treatment in Enköping



Gross margins of SRC cultivation

Price (€/GJ)	Yield level (t DM per hectare)							
	5	6	7	8	9	10	11	12
2	-291	-306	-322	-337	-352	-368	-383	-398
3	-226	-228	-230	-233	-235	-237	-239	-242
4	-161	-150	-139	-128	-117	-107	-96	-85
5	-96	-72	-48	-24	0	24	48	72
6	-30	7	44	81	118	154	191	228
7	35	85	135	185	235	285	335	385

Gross margin of SRC (EUR/ha) for a range of yields and wood chip prices (for Swedish conditions in 2009; 1 MWh = 3.6 GJ, 1 t DM = 15.8 GJ). In: Dimitriou and Rosenqvist (Biomass and Bioenergy, 2011)

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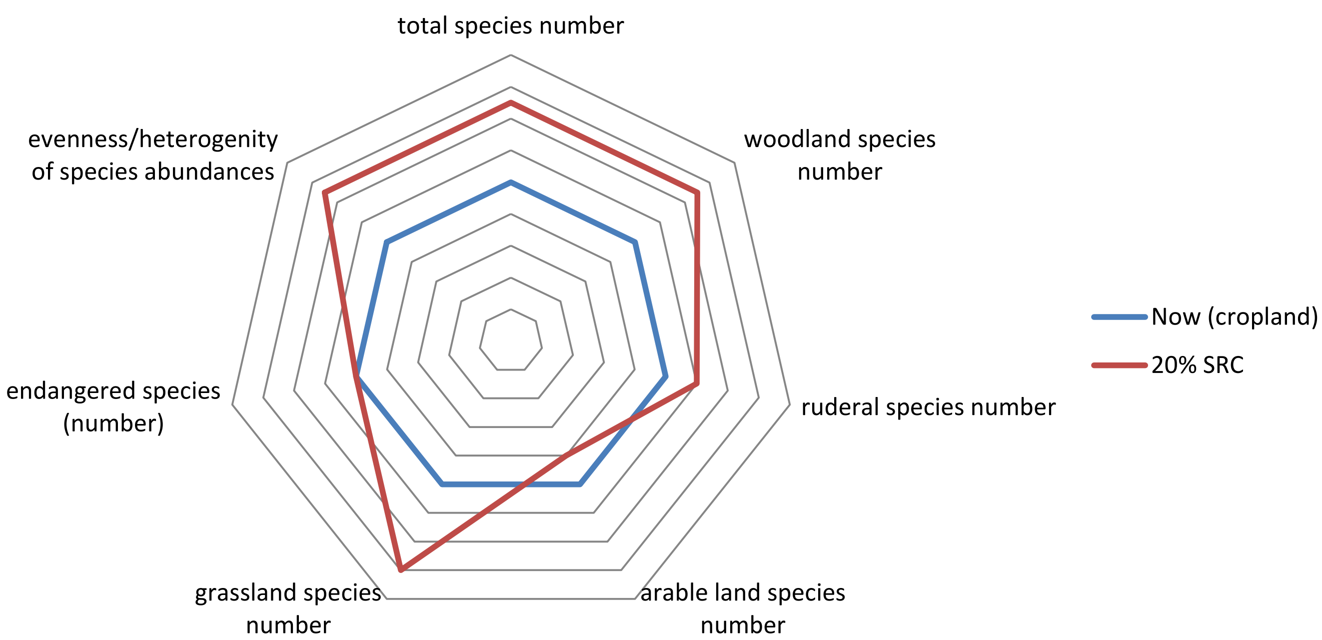
Soil salinization management

Oil Mallee, Australia – Picture: John McGrath

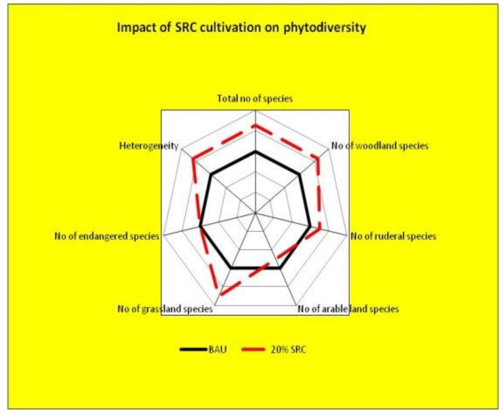
Trees and shrubs can be used to address soil salinity by reducing groundwater recharge, either by using water in the root zone and reducing 'leakage' to deeper aquifers; or by reducing saline or potentially saline groundwater levels (make them deeper beneath the ground surface) through roots directly accessing the water table and increasing discharge.

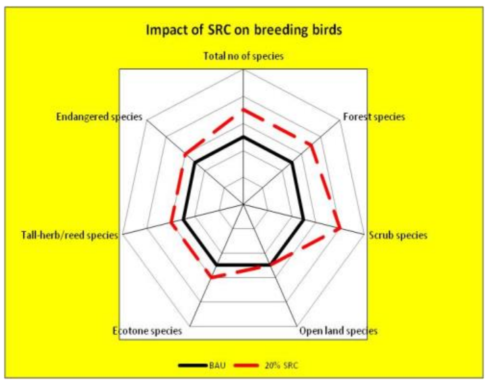
Biodiversity

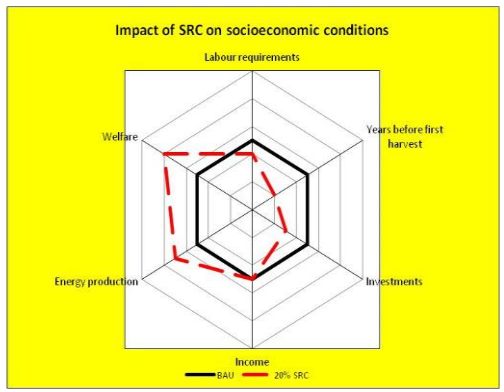
How would phytodiversity be afected by 20% willow in a landscape?

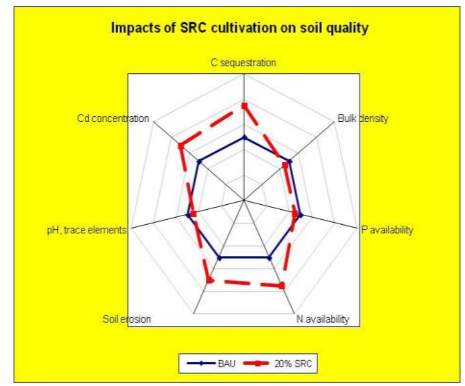


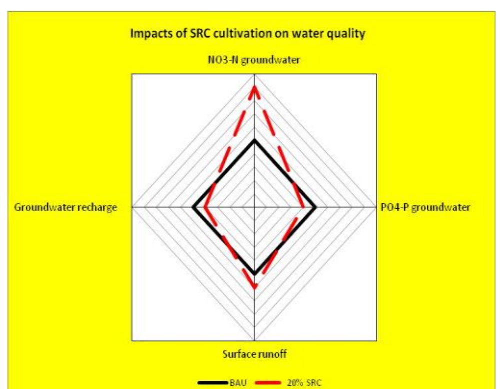
Langeveld et al 2012, Bioenergy Research











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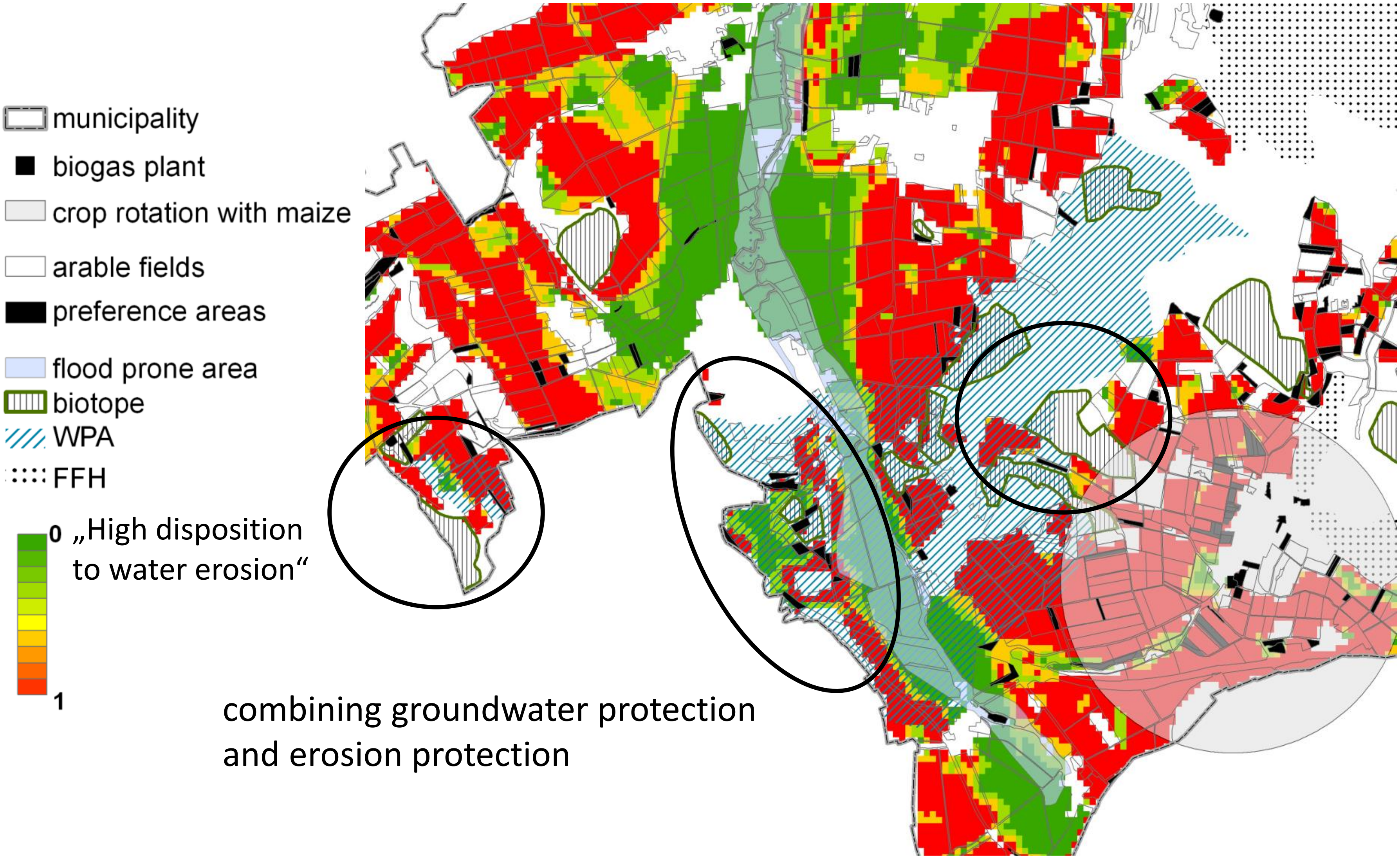
So, can we meet the challenge?

Consider bioenergy systems as an opportunity to design landscapes that add value…

Municipality of Friedland, DE – erosion, leaching



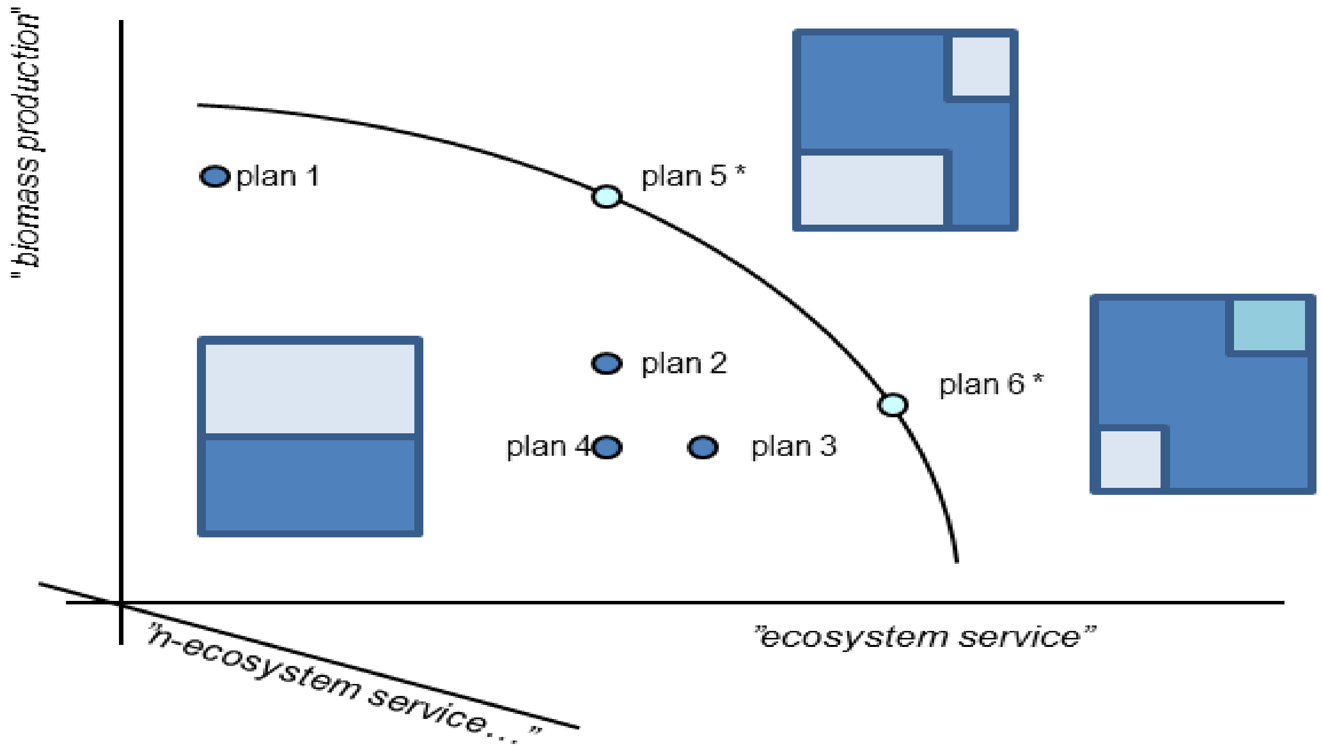
combining groundwater protection
and erosion protection

Case study: G Busch, BALSA

Consider bioenergy systems as an opportunity to design landscapes that add value…

… and use/develop participatory approaches to include stakeholders/decision makers!

Another example



Simplified illustration of pareto frontier efficiency between two hypothetical alternative services (biomass production for energy and water quality, bi-dimensional decision map) and 5 integrated land use and management schemes configuration alternatives. Plan 5 and 6 show pareto-efficiency. There can be additional service dimensions and a large number of management alternatives to be analysed.