RATING-SRC

Reducing environmental impacts of SRC through evidence-based integrated decision support tools

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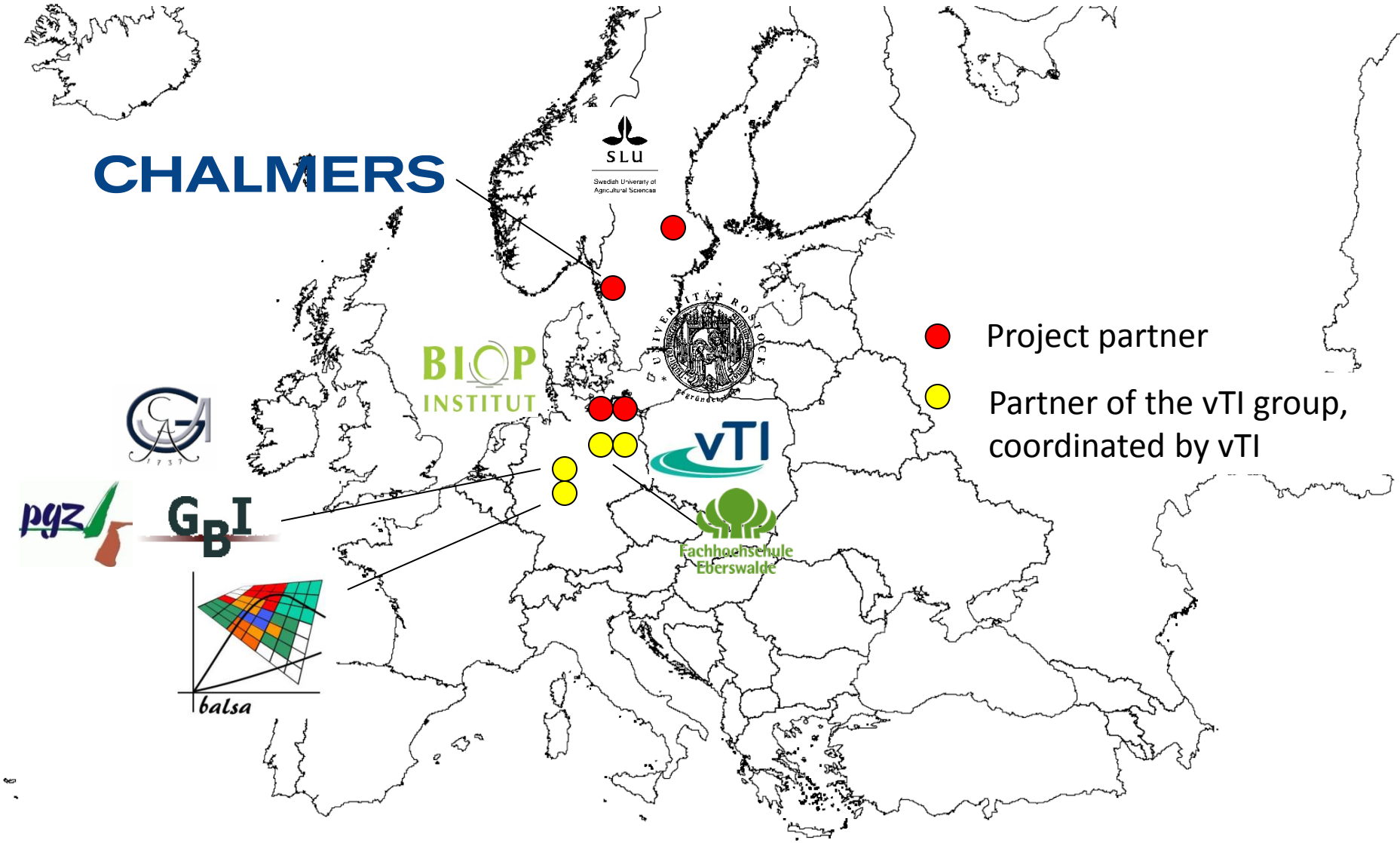
Presentation outline

- Project and partners description, background
- Effects on biodiversity
- Effects on soil
- Effects on water
- Conclusions and recommendations for SRC cultivation

General project description

- Title: **RATING-SRC** ("Reducing environmental impacts of SRC through evidence-based integrated decision support tools")
- ERA-NET Bioenergy Joint Call SRC focus area 3: **Environmental aspects of SRC**
- Duration: **36 months** (2/9/2008–31/8/2011) – prolongation until 29/2/2012
- 5 partners from 2 ERA-NET Bioenergy countries (**Sweden** and **Germany**)

Project consortium



Rating-SRC general objective

- to produce **scientific evidence** in order to **create** appropriate **decision-making tools** to **optimise impacts** of SRC on the environment

Why?

- A shift on agricultural land-use to SRC in areas adjacent to “wood-fuel” power stations (small or large) is anticipated…
- Implications (positive and negative) to environmental parameters (soil, water, biodiversity, landscape) in micro- (near the field) and macro- (regional) scale need to be evaluated (further use by decision-makers)
- Environmental advantages of SRC a means for balance to elevated grain prices
- SRC as sustainable energy generation system: recycling of wood-ash and sewage sludge should be considered

How?

- **Identification** → **Quantification** → **Evaluation** of potential environmental impacts (positive or negative)

⇒

- **Recommendations** to optimise SRC impact
- Filter **mapping** of appropriate SRC locations

PROJECT MANAGEMENT

WP 1 - Identifying the baseline: current knowledge of SRC impacts

1.1. Identification of decision-making and policy context for SRC in the ERA-Net countries
1.2. Analysis of perceptions related to SRC impact on landscape
1.3. Identification of potential effects of SRC cultivation on biodiversity (including effects of wood-ash recycling)
1.4. Identification of potential effects of SRC concerning soil aspects (including effects of wood-ash recycling)
1.5. Identification of potential effects of SRC concerning water issues

Phase 1: Current status, gaps in knowledge

WP 2 - Assessment of SRC impact on biodiversity

2.1. Synthesis of research results from biodiversity projects performed by consortium members

2.2. Impact of SRC on soil microbial diversity

2.3. Impact of wood-ash/sludge recycling on plant diversity in SRC

WP 3 - Assessment of SRC impact on soil issues

3.1. Impact of SRC on soil physical characteristics and composition of SOM

3.2. Impact of SRC on soil quality in terms of heavy metals

WP 4 - Assessment of SRC impact on water issues

4.1. Impact of SRC on water budgets

4.2. Assessment of SRC impact on water quality

Phase 2: Assessment

Field work

WP 5 - Evaluation of SRC impact on the environment and development of support tools for decision-making

5.1. Development of a sustainability framework appropriate for SRC establishment
5.2. Evaluation of SRC impact on the environment
5.3. Recommendations to increase the positive and mitigate the negative impacts of SRC on the environment
5.4. Filter mapping of appropriate SRC locations in case study areas
5.5. Dissemination of project results

Phase 3: Evaluation Recommendations Dissemination

WP 1 - Identifying the baseline: current knowledge of SRC impacts

Why?

- Current status of knowledge and research
- Gaps in knowledge

How?

- Detailed reviews on all environmental issues
- Analyses of reviews to identify gaps

WP1 – Special Issue in LBF

Special Issue in LBF – Published articles

Ioannis Dimitriou, Christel Baum, Sarah Baum, Gerald Busch, Ulrich Schulz,Jörg Köhn, Norbert Lamersdorf, Peter Leinweber, Pär Aronsson, MartinWeih, Göran Berndes und Andreas Bolte **The impact of Short Rotation Coppice (SRC) cultivation on the environment**

Sarah Baum, Martin Weih, Gerald Busch, Franz Kroiher und Andreas Bolte **The impact of Short Rotation Coppice plantations on phytodiversity**

Ulrich Schulz, Oliver Brauner und Holger Gruß **Animal diversity on short-rotation coppices – a review**

Christel Baum, Peter Leinweber, Martin Weih, Norbert Lamersdorf und Ioannis Dimitriou **Effects of short rotation coppice with willows and poplar on soil ecology**

Ioannis Dimitriou, Gerald Busch, Silvia Jacobs, Paul Schmidt-Walter und Norbert Lamersdorf **A review of the impacts of Short Rotation Coppice cultivation on water issues**

Gerald Busch **The impact of Short Rotation Coppice cultivation on groundwater recharge – a spatial (planning) perspective**

Jörg Köhn **Socio-economics in SRC – a review on concepts and the need for transdisciplinary research**

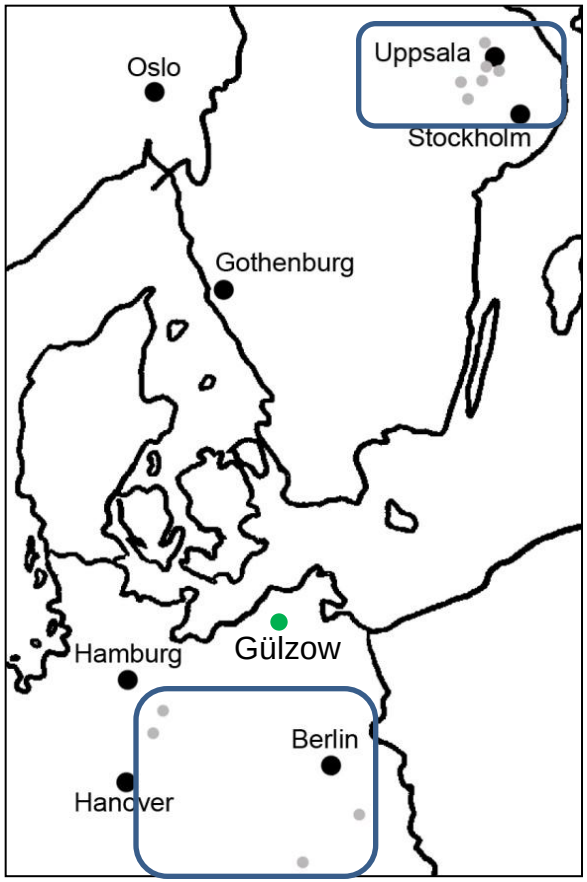
Assessment of SRC impact on biodiversity

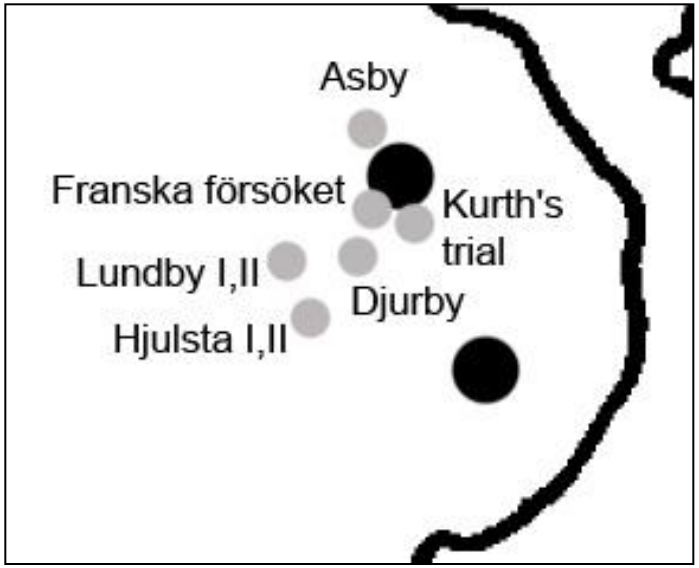
- **Considered components of biodiversity**
  - *Phytodiversity*: plant species diversity (vascular plants)
  - *Zoodiversity*: species diversity of ground beetles and breeding birds (indicator species approach)
  - *Soil biodiversity*: soil microbial population, ectomycorrhizal (EM) fungi

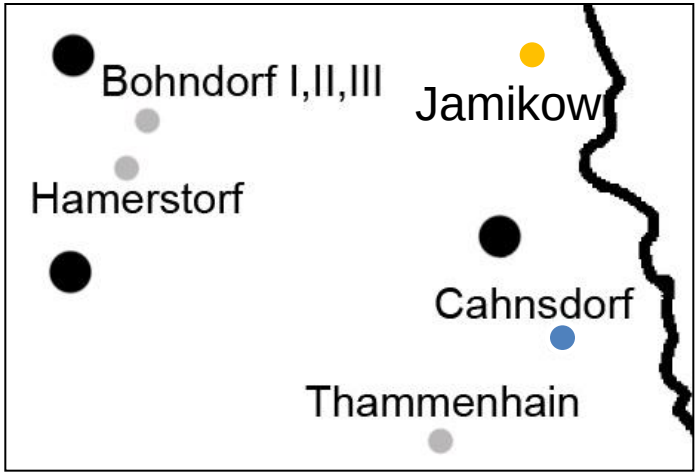
Assessment of SRC impact on biodiversity

- **Field studies**
  - *Phytodiversity*: 15 sites (poplar and willow) in Germany and Sweden (SRC, adjacent land-uses, landscape: 225 km² area)
  - *Zoodiversity*: 2 sites (poplar and willow) in Germany (SRC, adjacent arable sites)
  - *Soil biodiversity*: 2 sites (poplar/willow) in Germany (SRC, adjacent arable sites)

Biodiversity: location of study sites



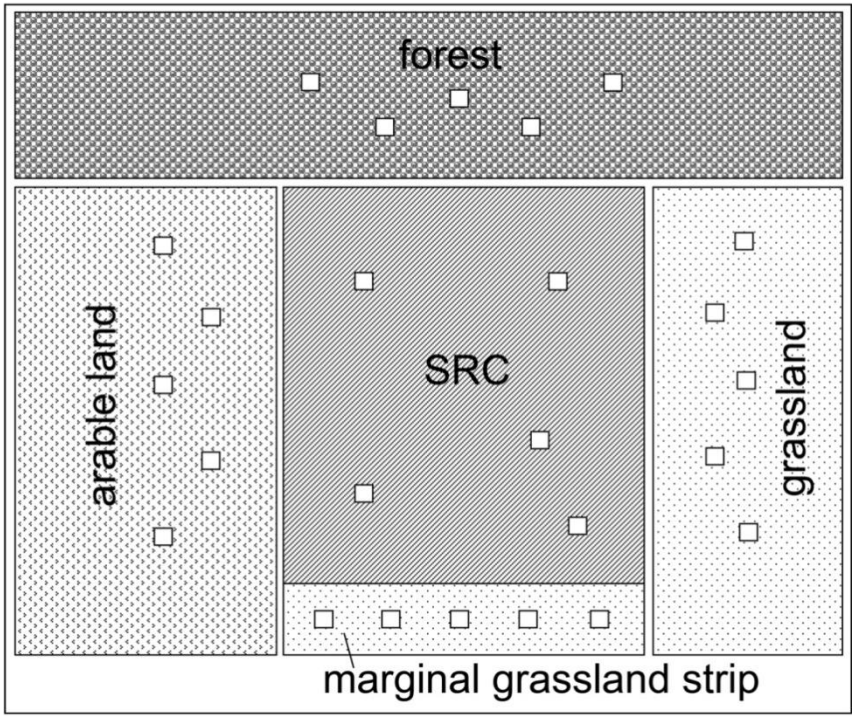




- Soil diversity (UoR: Rostock University)
- Phytodiversity (vTI)
- Zoodiversity (HNEE: Univ. Appl. Science Eberswalde)
- Zoodiversity, Phytodiversity, Soil diversity

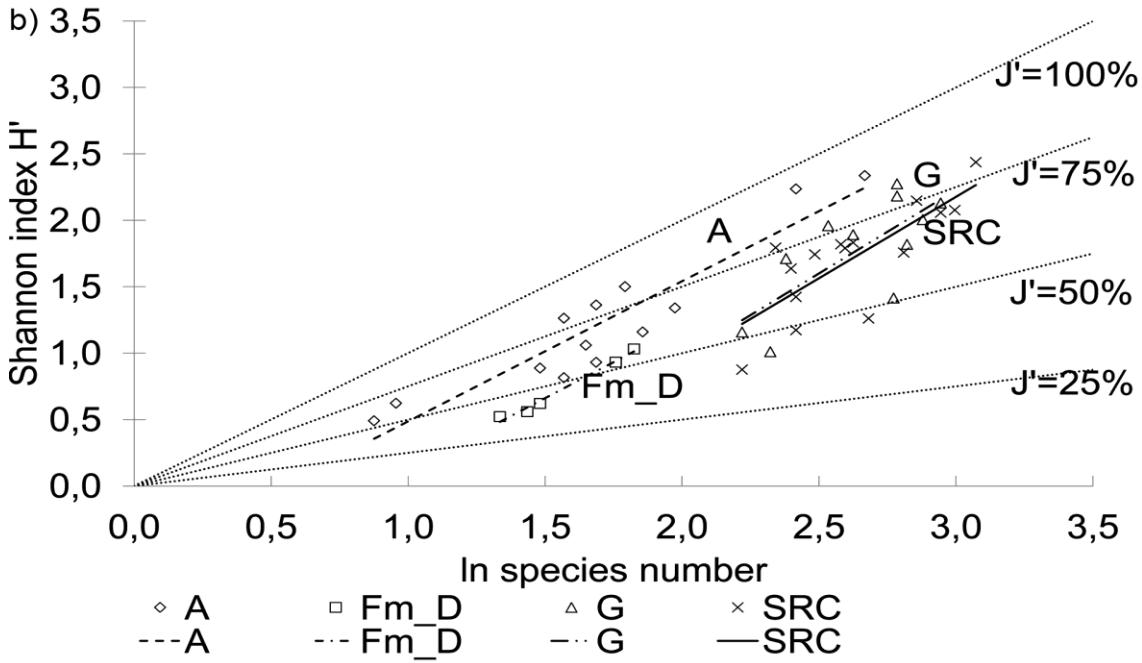
Biodiversity: Phytodiversity recordings

- Vegetation mapping and sample design:
  - Estimation of percentage cover of the layers
  - species lists with percentage cover
- SRC: 5 plots (3.3m x 6.7m): 111m² total area
- Other land uses: 5 plots (4m x 5m): 100m² total area
- In addition: soil seed bank sampling, radiation measurements



Source: Baum, Bolte and Weih, GCB Bioenergy (in press)

Biodiversity: Results phytodiversity

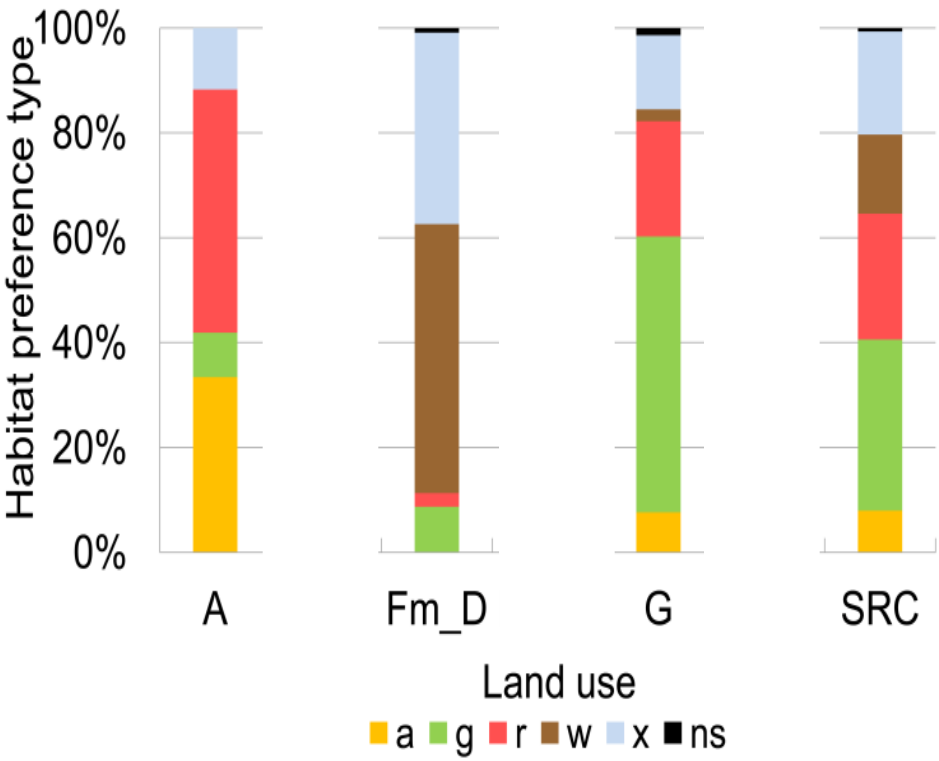


J‘ : Evenness

Source: Baum, Bolte and Weih, GCB Bioenergy (in press)

- High plant species number in SRC (> A: arable land, >Fm_D: mixed forest Germany, ≈ G: grassland)
- Species-rich SRC with more evenly distributed abundance of plant species

Biodiversity: Results phytodiversity

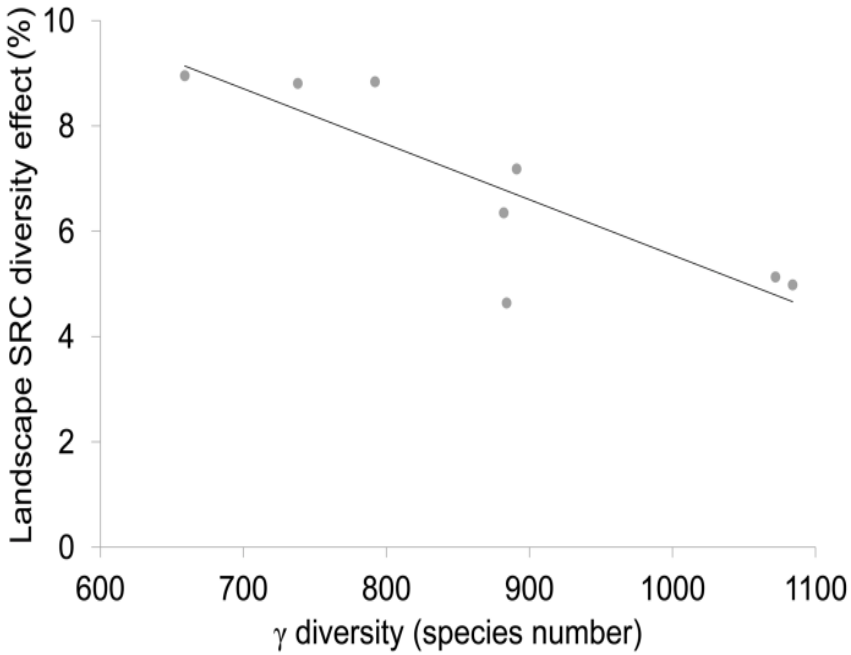


Proportions of species habitat preference. a: arable fields, g: grassland, r: ruderals sites, w: woodlands, x: indifferent, ns: not stated. A: arable land, Fm_D: mixed forest Germany, G: grassland

Source: Baum, Bolte and Weih, GCB Bioenergy (in press), modified

- SRC has the most balanced species distribution regarding habitat preferences
- Temporal variation of stand structures provides habitats for both light-demanding ruderal species and woodland species adapted to low light conditions

Biodiversity: Results phytodiversity



on landscape level (225 km²)

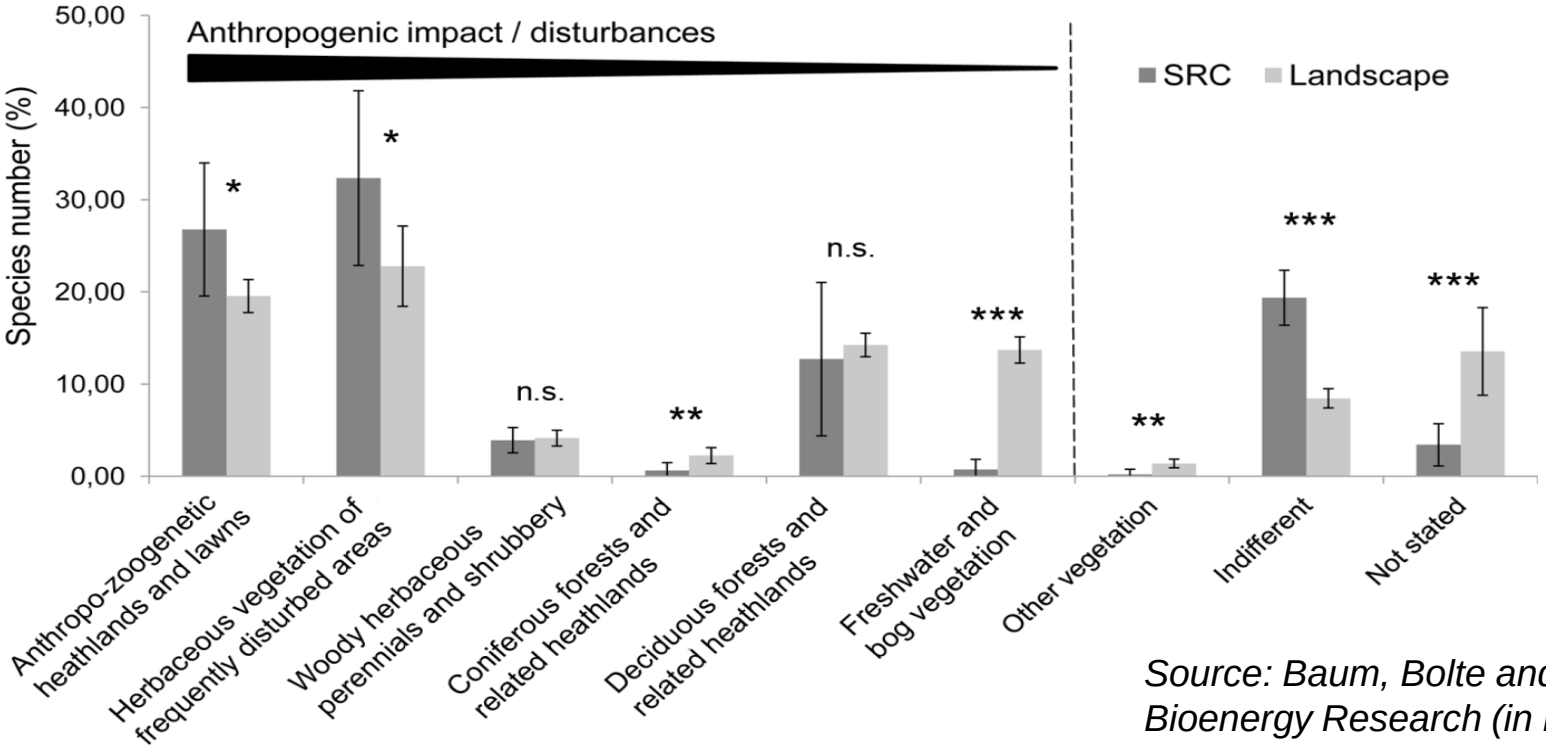
Multiple regression
(Overall model: R^2=0.71, p=0.0459)

Variable	Estimate	Standard Error	Pr > |t|
Intercept	16.347	2.846	0.0022
Number habitat types	-0.646	0.213	0.0291
SRC shoot age	-0.513	0.375	0.2296

Source: Baum, Bolte and Weih, Bioenergy Research (in review)

- SRCs' α diversity includes 4% to 9% of landscape γ diversity
- SRC diversity effect on landscape level increases with decreasing species richness of landscapes (→ most positive diversity effects in species-poor landscapes)

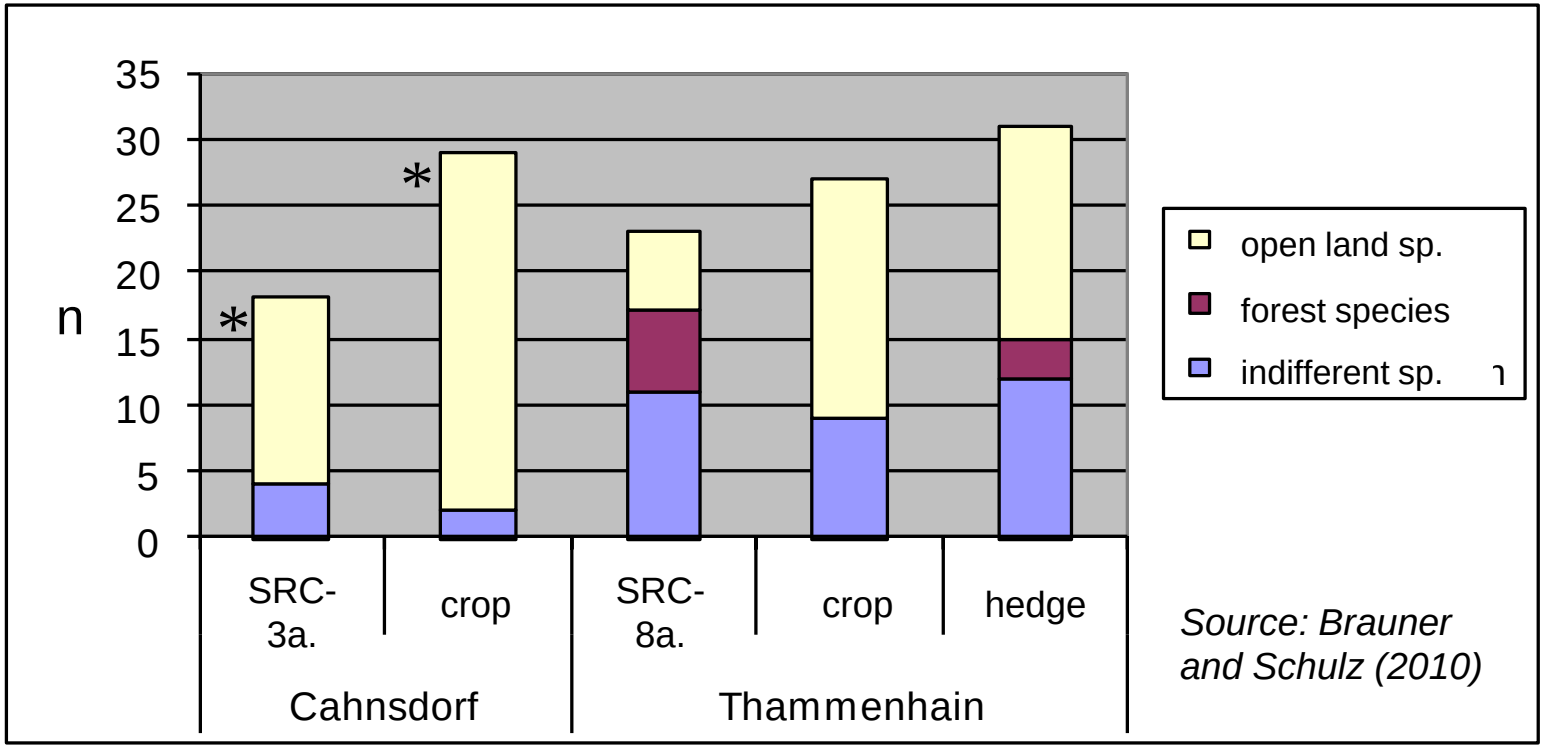
Biodiversity: Results phytodiversity



Source: Baum, Bolte and Weih, Bioenergy Research (in review)

- In landscape context SRC are important habitats for plant species of (anthropogenic) disturbed sites.
- Red list species are seldom found.

Biodiversity: Results zoodiversity



Spring occurence of ground beetles, recorded with pitfall traps

- High number of ground beetles in crops (arable fields).
- Forest species are only found in older SRC .

Biodiversity: Results zoodiversity

1. 2. 3.

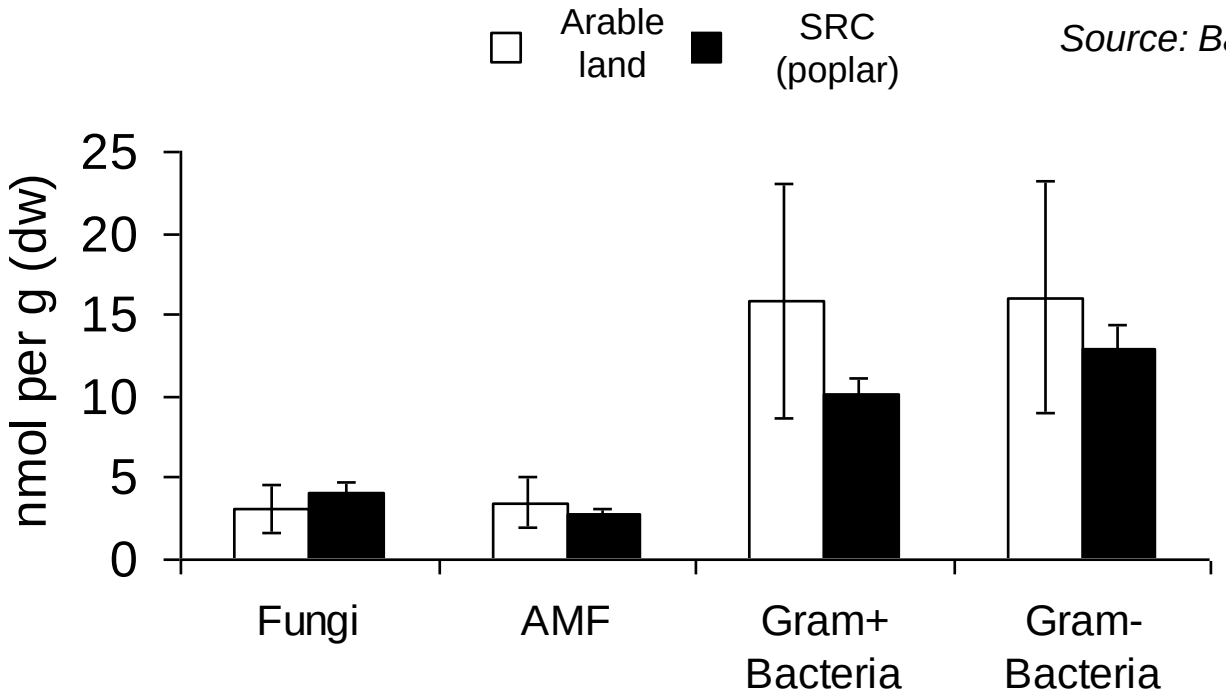
	Art	RL BRD	RL HE	RL S	RL BB	Anh. I VRL	KUP-Typen 01	02	03	04	05	06	07	08	09
1	Amsel (*Turdus merula*)									3,4	2,0	8,3	4,0	1,1	1,5
2	Bachstelze (*Motacilla alba*)						0,4								
3	Baumpieper (*Anthus trivialis*)	V	3	+	V			0,4		1,1	7,3		0,9		3,0
4	Blaumeise (*Parus caeruleus*)										1,3				
5	Braunkehlchen (*Saxicola rubetra*)	3	+	3	2			0,8							
6	Buchfink (*Fringilla coelebs*)									0,8	1,3		3,5	4,4	3,0
7	Buntspecht (*Dendrocopus major*)													1,1	
8	Dorngrasmücke (*Sylvia communis*)								4,8	2,2	1,3		0,3		
9	Fasan (*Phasianus colchicus*)										0,7				
10	Feldlerche (*Alauda arvensis*)	3	V	+	3		4,9	1,5	4,8						
11	Feldschwirl (*Locustella naevia*)	V	+	+	+					0,4	0,7				
12	Fitis (*Phylloscopus trochilus*)									8,2	2,6	14,2	2,3		0,8
14	Gartengrasmücke (*Sylvia borin*)									6,0	0,7	7,1	1,0		0,8
15	Gelbspötter (*Hippolais icterina*)	+	+	+	V										
39	Zaunkönig (*Troglodytes troglodytes*)											5,9	0,3	1,1	0,8
40	Zilpzalp (*Phylloscopus collybita*)									2,2		7,1	1,6		1,5
	Artenzahl						3	5	3	18	15	17	19	8	13
	Brutpaare insgesamt						14	9	4	120	41	67	151	21	32
	Gesamtsiedlungsdichte (in BP/10 ha)						5,7	3,4	19,3	44,9	27,1	79,4	22,1	22,9	24,2

• < 1,0 BP/10 ha ● 1,0 - 2,9 BP/10 ha ● 3,0 - 6,9 BP/10 ha ● 7,0 - 10,0 BP/10 ha ● >10,0 BP/10 ha

- Breeding bird diversity are promoted by variable SRC stand structures.
- Rare species are seldom found in SRC.

Source:
Gruß and Schulz (2011)

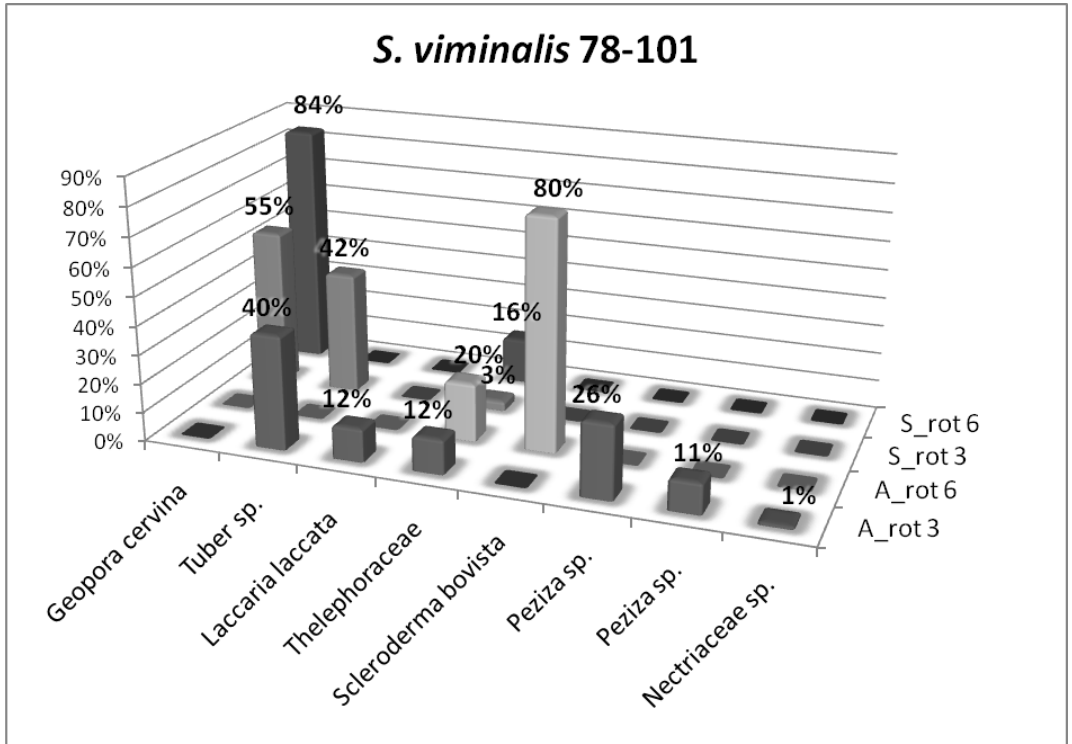
Biodiversity: Results soil biodiversity



Source: Baum et al. (in review)

- Changes of soil microbial population under SRC: increased ratio of fungal/bacterial and Gram-/Gram+ bacteria.
- Decreased colonisation density of all tested groups of microorganisms in SRC compared to wheat crop; → lower decomposition of SOM

Biodiversity: Results soil biodiversity



3- and 6-year rotation (rot 3 and 6) in spring (S) and autumn (A)

Source: Baum et al. (in review)

Diversity and relative abundance of ectomycorrhizal fungal taxa (%)

- Ectomycorrhizal fungis are introduced by willow SRC into arable soils.
- Increased accumulation of assimilates and SOM in the soils (latter also due to lower microbial decomposition).

Assessment of SRC impact on biodiversity

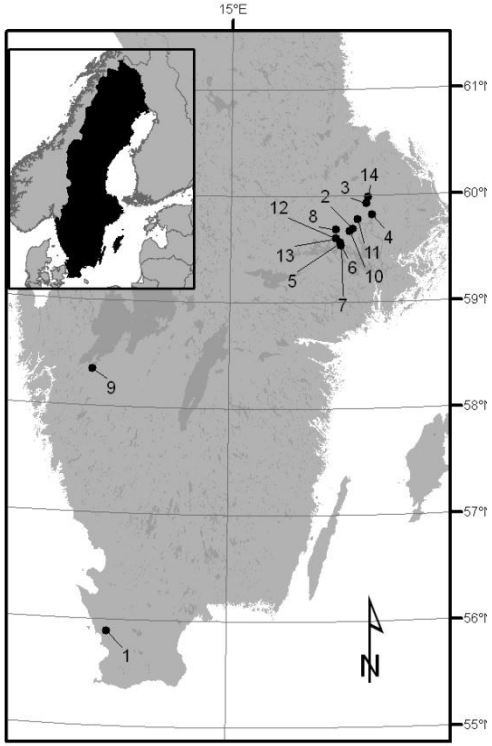
- **Main conclusions**
  - *Phytodiversity*: SRC are an important source for phytodiversity in the landscape. The diversity effect of SRC is highest in homogenous, species-poor landscapes. The temporal variation of SRC structure is an important reason for the positive phytodiversity effects.
  - *Zoodiversity*: SRCs are not habitats for rare species (ground beetles, breeding birds) and are often less populated than open landscapes. However, structural diversity in SRC can promote breeding bird diversity.
  - *Soil biodiversity*: Lower soil microbial population and the introduction of ectomycorrhizal (EM) fungi into soils seems to be the main reason for the accumulation of soil organic carbon in SRC sites compared to arable land.

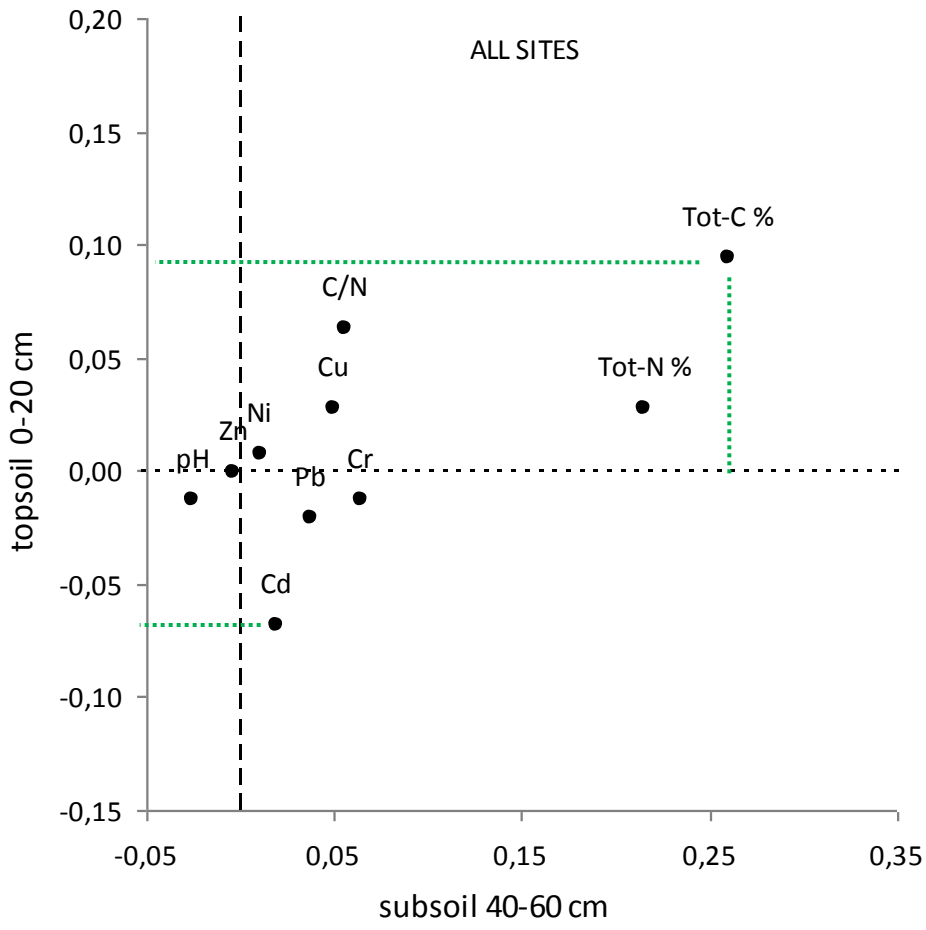
Assessment of SRC impact on soil issues

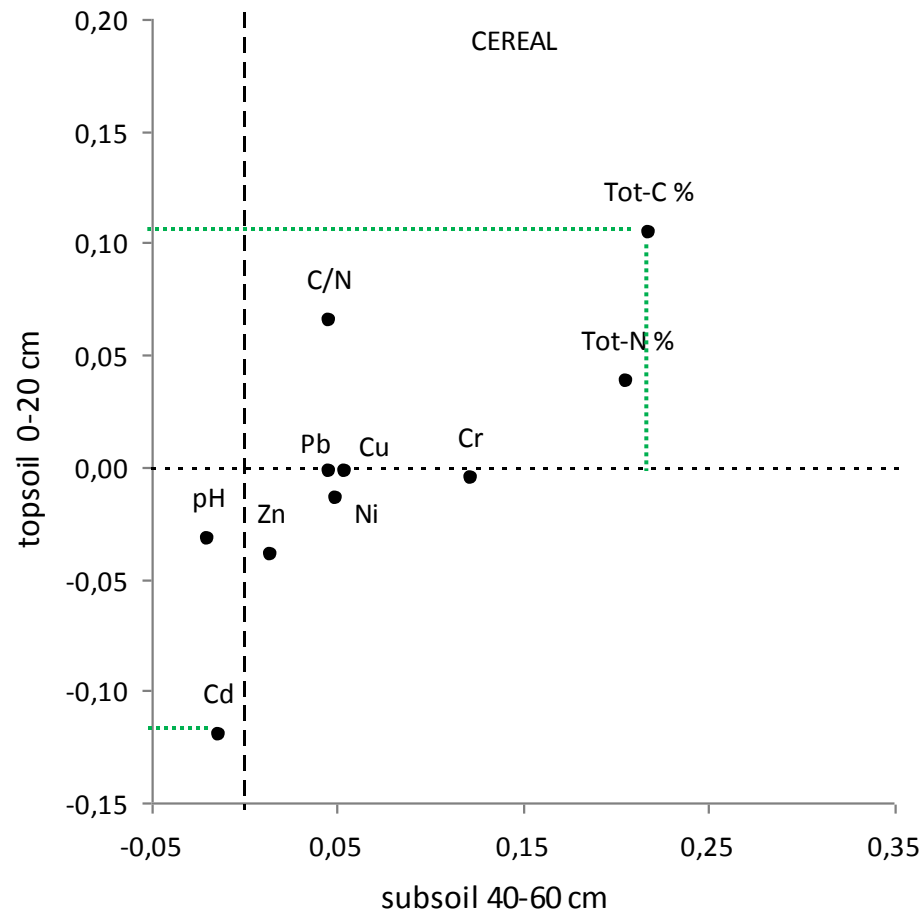
- SRC vs arable fields for tot. C and trace elements

- Soil organic matter quality under SRC

	Site	Year planted	Variety	Reference field crop	Sludge /Ash	Last harvest	Mineral fertilization	Soil texture (0-20 cm)	Biomass 2009	Previous use before SRC
1	Billeberga II	1994	Torhild	Cereals/rape seed	Y/N (3)	Annually	N	loam	2*	Cereals
2	Djurby Gård	1990	78021	Cereals	Y/N (3)	2007/2011 (5)	N	silty clay	5.3	Cereals
3	Forkarby	1991	78021	Cereals	N/N	2008 (5)	Y (2)	silty clay	11	Cereals
4	French Trial	1994	Mixture	Grass	N/N	2007/2010 (5)	Y (8)	clay loam	9.3	Cereals
5	Hacksta	1994	Jorr	Pea/Cereals	Y/Y (4)	2008 (3)	Y (1)	clay loam	4.2	Cereals
6	Hjulsta I	1995	Jorr	Cereals	Y/Y (2)	2008 (3)	N	clay	4.5	Oil crops/cereals
7	Hjulsta II	1995	Jorr	Cereals	N/N	2008 (3)	N	clay	9.6	Oil crops/cereals
8	Lundby Gård II	1995	78021	Cereals	N/N	2005 (2)	N	clay	2.5	Cereals
9	Puckgården	1992	78112	Cereals	N/N	2008 (4)	Y (4)	silty clay	10*	Cereals
10	Skolsta	1993	Orm	Cereals	Y/Y (1)	2004 (2)	Y (2)	silty clay	4	Cereals
11	Säva	1993	Rapp	Grass	Y/N (2)	2007 (3)	N	silty clay	7.4	Cereals
12	Teda I	2000	Tora	Grass	Y/Y (2)	2009 (2)	Y (2)	silty clay loam	8	Cereals
13	Teda II	1993	78112	Grass	Y/Y (2)	2007 (3)	Y (2)	clay	1.7	Cereals/Set-aside
14	Åsby	1996	Tora	Cereals	Y/N (1)	2008 (3)	Y (2)	silty clay	4.2	Cereals







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, unpublished).

Impact of SRC vs ref on soil

- C storage in soil organic matter is higher under SRC than under conventional agricultural crops
- 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

Introduction - soil organic matter quality under SRC

Effects of SRC on the organic matter of arable soils:

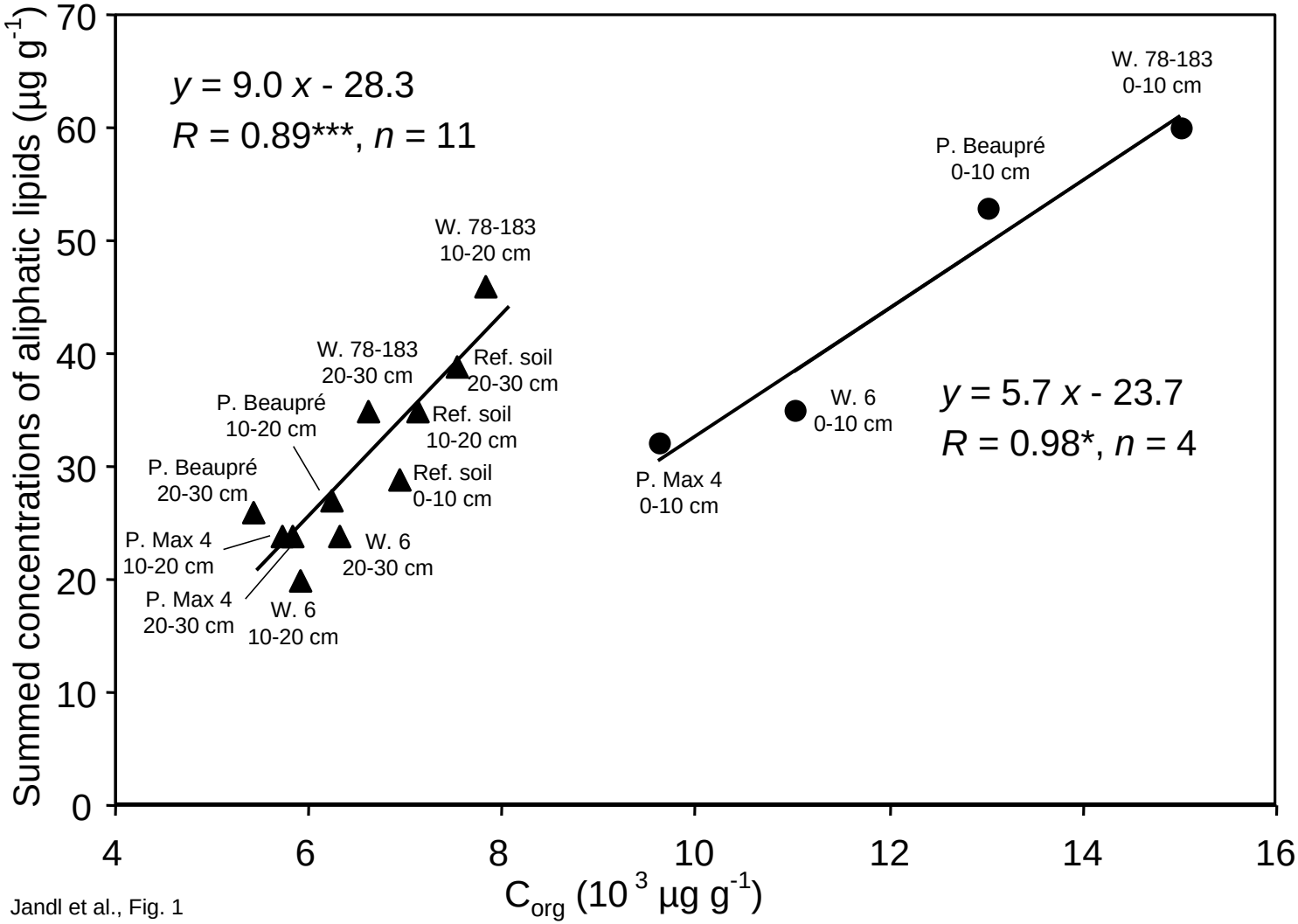
- potentials of SRC to increase the concentrations of organic matter in arable soils with initial low are moderate C_{org} concentrations were described by many authors

- the composition and stability control the decomposability of soil organic matter (SOM)

- changes in the SOM quality under SRC can be assumed by: changed litter composition combined with changes in the soil microbial community structure (introduction of ectomycorrhizal fungi by the host plants willows and poplar)

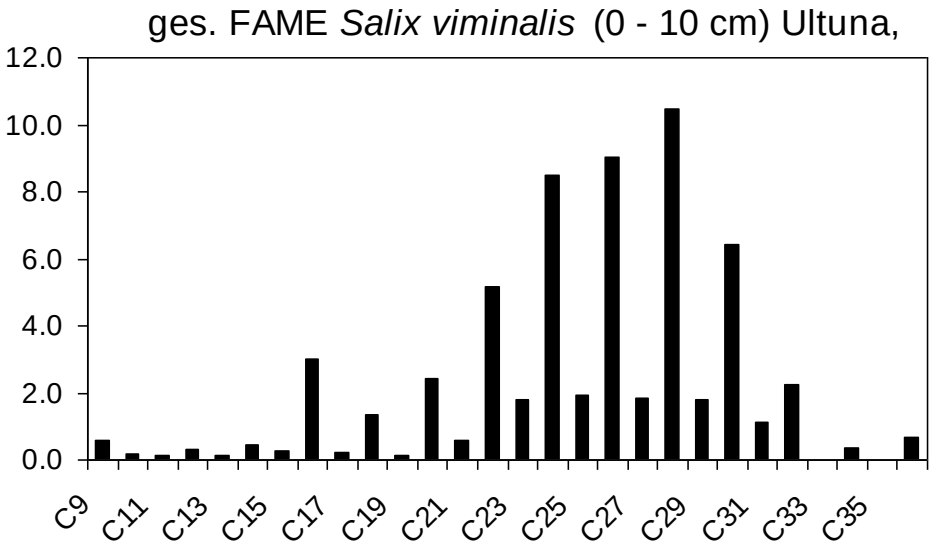
The quality of SOM indicates the sustainability of changes in the C_{org} concentrations in arable soils.

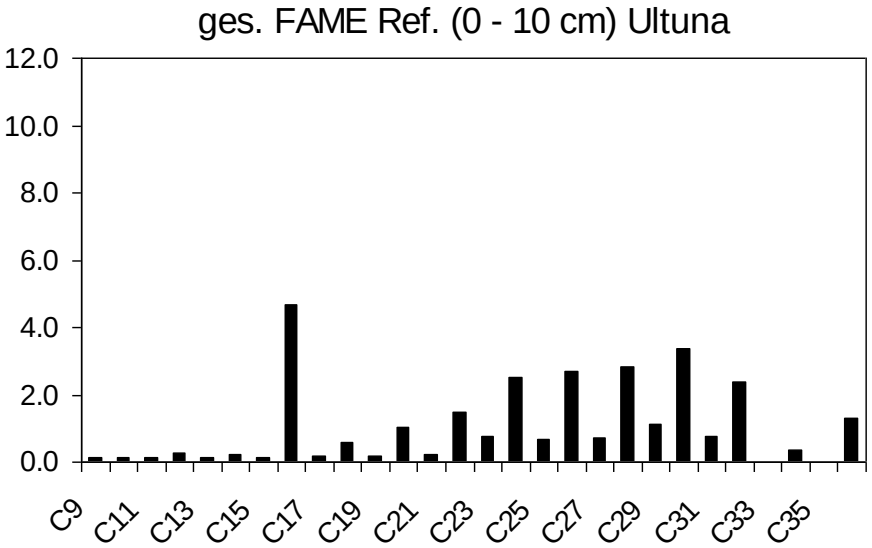
Correlation between the concentrations of aliphatic lipids and organic C in the soil (W - willow, P - poplar, Ref. - annual arable crops)



Jandl et al., Fig. 1

Increased concentrations (µg g^{-1}) of fatty acid methy ester (FAME) in the soil under willows compared to annual arable crops at the test site Ultuna (S) - indication of increased organic matter stability





FAME - fatty acid methyl ester

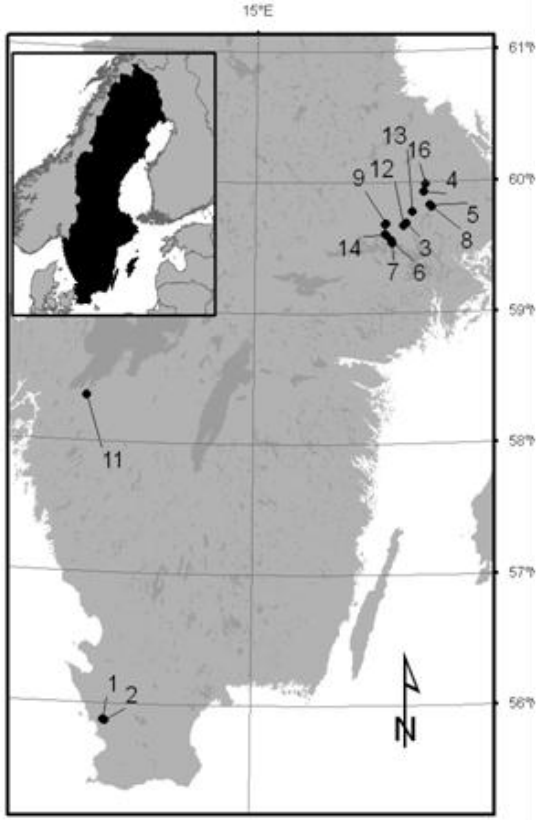
Summary and conclusions soil organic matter quality

-increased concentrations of long-chain fatty acids in the organic matter caused by the changed litter quality indicate a higher stability of SOM (lower decomposability) under SRC than under annual arable crops

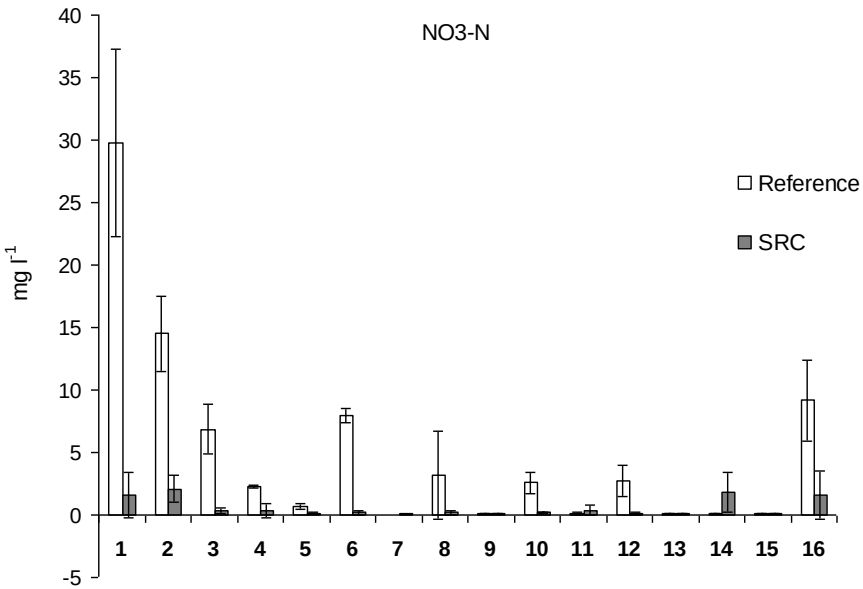
-higher thermal stability of the alkyl aromatics confirmed this tendency

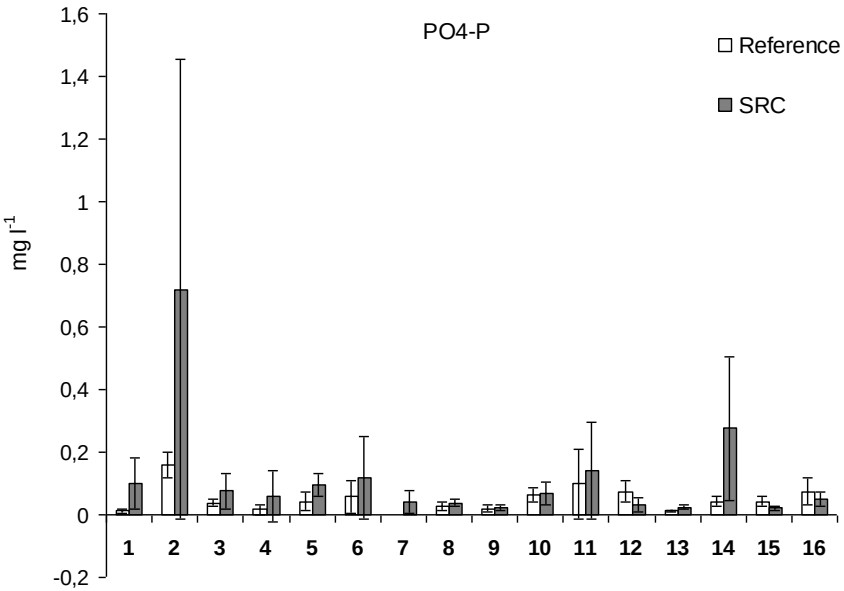
Sustainable increased organic matter concentrations in the soil under SRC can be assumed.

CODE	Name	Year Planted	Clone	Ref Field	Sludge/ Ash	Harvested	Mineral Fertilization	Soil type (0-20 cm)	Biomass 2009	Previous use
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	5.1	Cereals
4	Forkarby	1991	78021	Cereals	N/N	2008	Y (2)	silty clay	11.1	Cereals
5	French	1994	78021	Cereals (eco)	N/N	2007/2010	Y (8)	clay loam	9.3	Cereals
6	Hacksta	1994	Jorr, Rapp	Peas/cereal	Y/Y (4)	2008	Y (1)	clay loam	4.2	Cereals
7	Hjulsta	1995	Jorr	No ref	N/N	2008	N	clay	9.6	Oil crops/cereals
8	Kurth	1992	Ulv/Rapp	Cereals (eco)	N/N	2007/2010	N	clay loam	124	Cereals
9	Lundby Gård I	2000	Tora	Cereals	Y/Y (1)	2005	Y (1)	clay	4.9	Cereals/oil crops
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	4.1	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	8.1	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



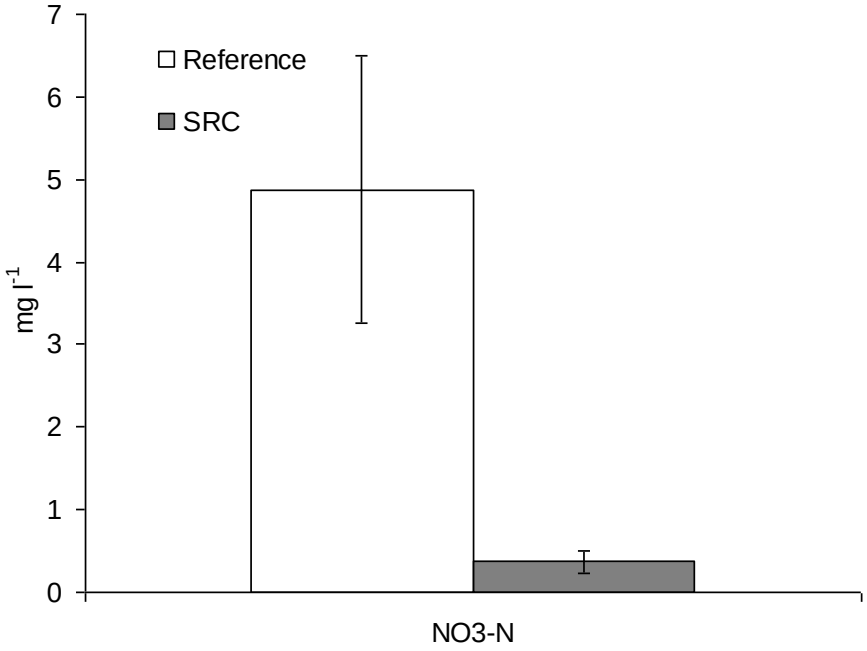
Willow SRC and water

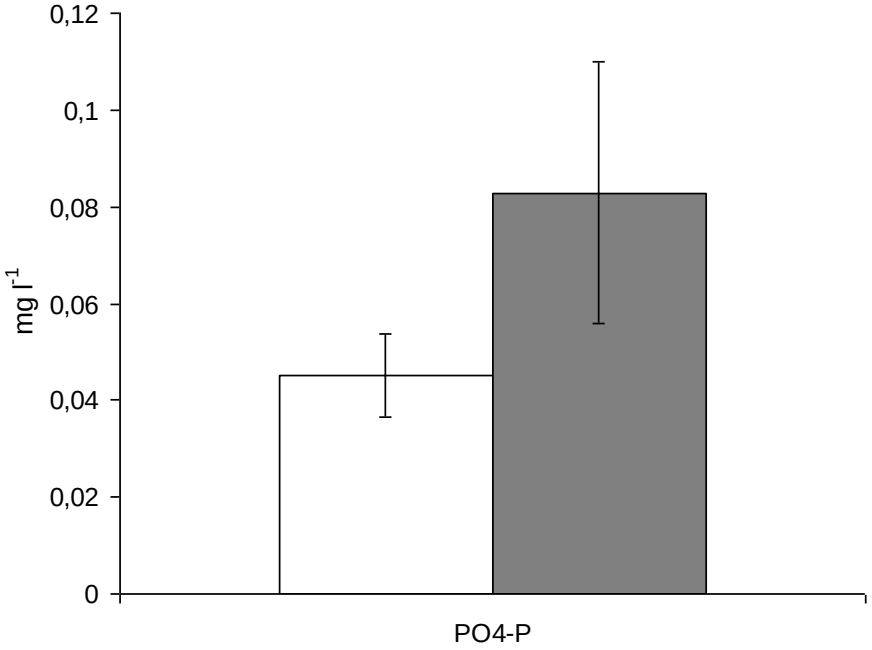




Averages of NO_3-N and PO_4-P concentrations in the groundwater of SRC and reference in each of the different locations throughout the whole experimental period. Numbers correspond to the locations as described in Tab. 1 (Dimitriou et al., unpublished).

Willow SRC and water





Averages of NO_3-N and PO_4-P concentrations in the groundwater of all fields pooled together for willow SRC and reference fields for the whole experimental period(Dimitriou et al., unpublished).

Treatment and N-dynamic

("Fuhrberger Feld")

- Soil treatment -

Control

Site P/2009

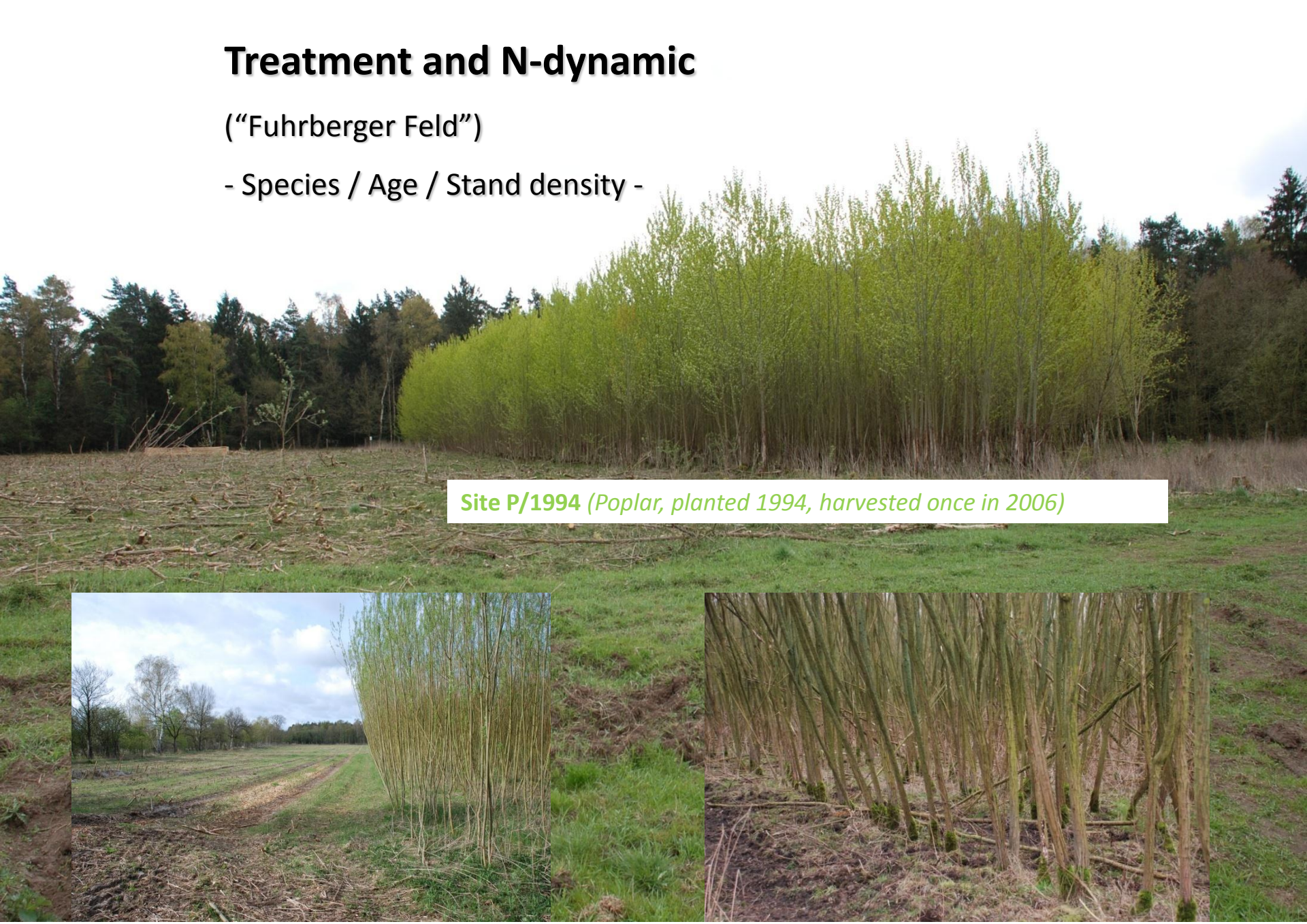
Site preparation for P/2009

Site P/2009 *(Poplar, planted 2009)*

Treatment and N-dynamic

("Fuhrberger Feld")

- Species / Age / Stand density -



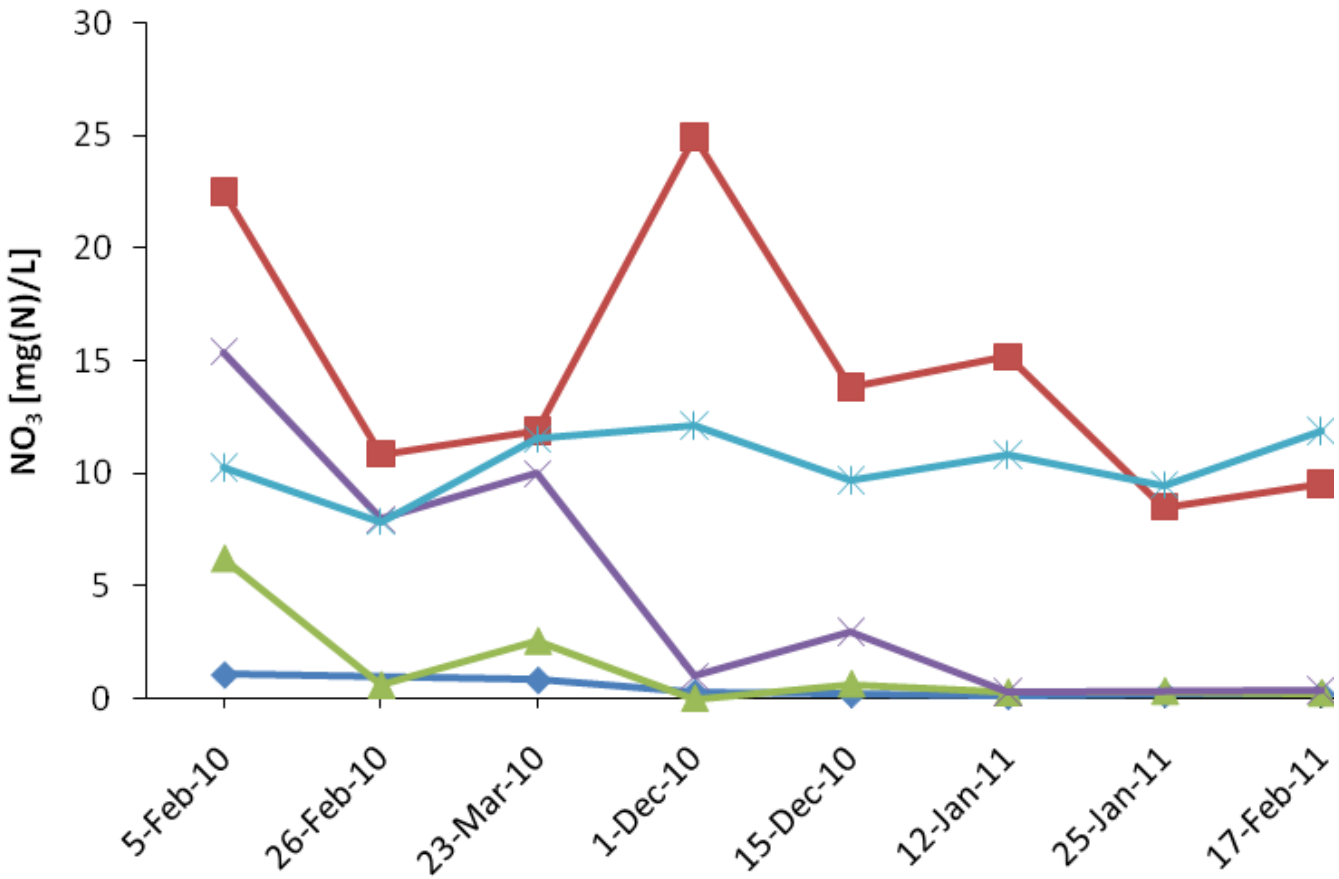
Site P/1994 *(Poplar, planted 1994, harvested once in 2006)*

Site W/2005 *(Willow, planted 2005, partly harvested 2010)*

Site W/1994 *(Willow, planted 1994, first harvested 2010)*

Treatment and N-dynamic (“Fuhrberger Feld”)

Nitrate in the soil solution, 100 cm soil depth



P/2009

W/1994

W/2005

P/1994

Observation period: Feb. 2010 – Feb. 2011

SRC and water quality - conclusions

- NO_3-N leaching from SRC was significantly lower than from reference fields
- NO_3-N leaching from SRC was not elevated during autumn or spring when most leaching from commercial fields occur
- Site preparation for SRC establishment and management (no harvest) can result in extensive N mineralisation
- PO_4-P concentrations in the groundwater of SRC were higher compared to reference
- Sewage sludge applications not responsible for the higher PO_4-P concentrations in SRC vs reference fields

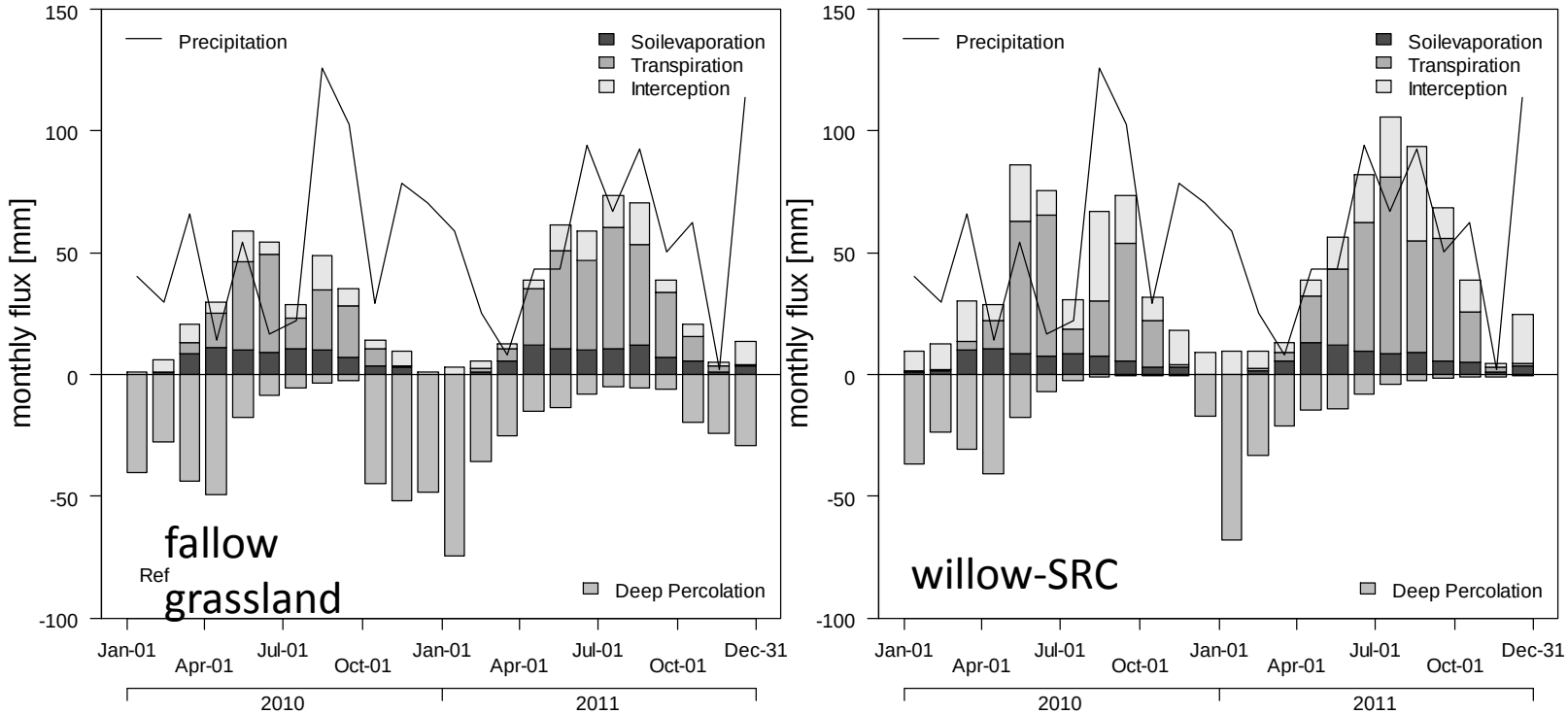
Water budgets – Study aims

1. Comparison of water budgets of two different land use types (Willow-SRC, fallow grassland) on sandy soils.
2. Evaluation of the influence of harvest operations on SRC's water budget partitioning.

Basic approach:

- Water budget simulations of study sites using a hydrological process model (CoupModel: „coupled heat and water transport model")
- Model parameterized, run and validated with measured field observations
  - Driving variables: climatic data
  - Input parameters:
    - Soil hydraulic properties → water storage capacity
    - stand characteristics (leaf area index [LAI], canopy height, root distribution) → pot. evapotranspiration and water uptake
  - Validation variables: Soil matric potential, stand precipitation

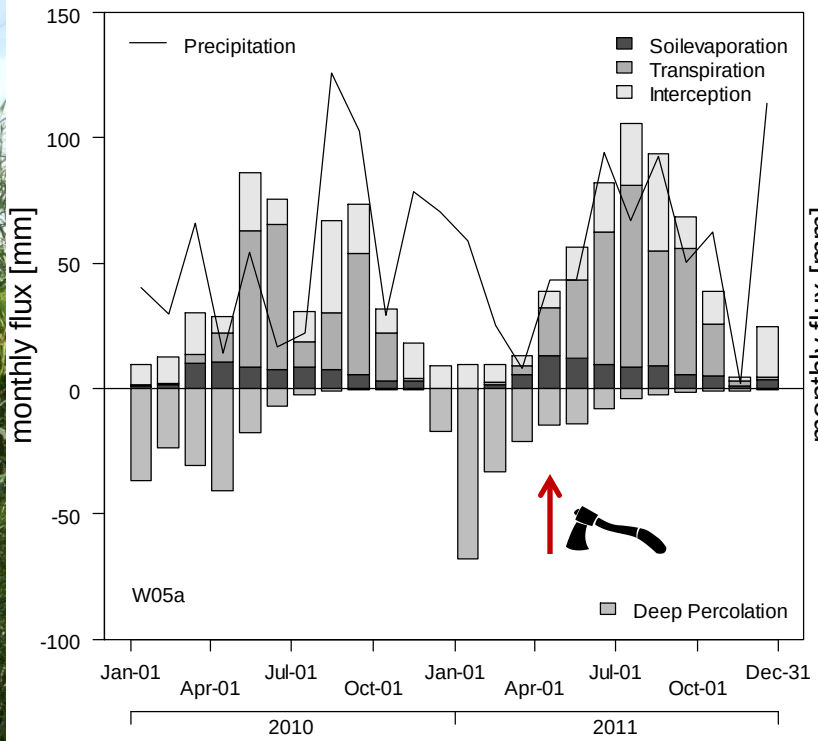
Results 1: fallow grassland vs. Willow-SRC

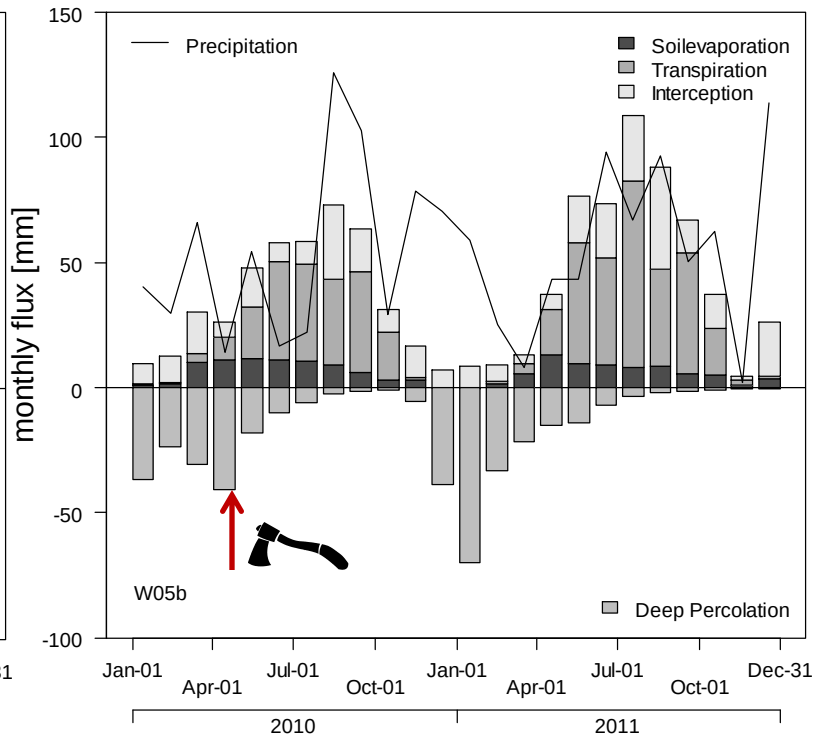


Higher transpiration and interception losses of willow stands result in reduced groundwater recharge.

	2010		2011	
	Ref	W05a	Ref	W05a
Precipitation	651	651	661	661
Interception	74	175	85	170
Transpiration	162	229	238	300
Soilevapoartion	73	68	80	76
DeepPerc	344	179	262	170

Results 2: harvesting effects 2010 & 2011





- Less interception and transpiration from the regrowing willow stand
- 2010: regrowth of W05b is slow because if dry period in June/July
- 2011: regrowth of W05a is fast, water budgets merely differ

	2010		2011	
	W05a	W05b	W05a	W05b
Precipitation	651	651	661	661
Interception	175	149	170	182
Transpiration	229	207	300	298
Soilevapoartion	68	79	76	71
DeepPerc	179	215	170	170

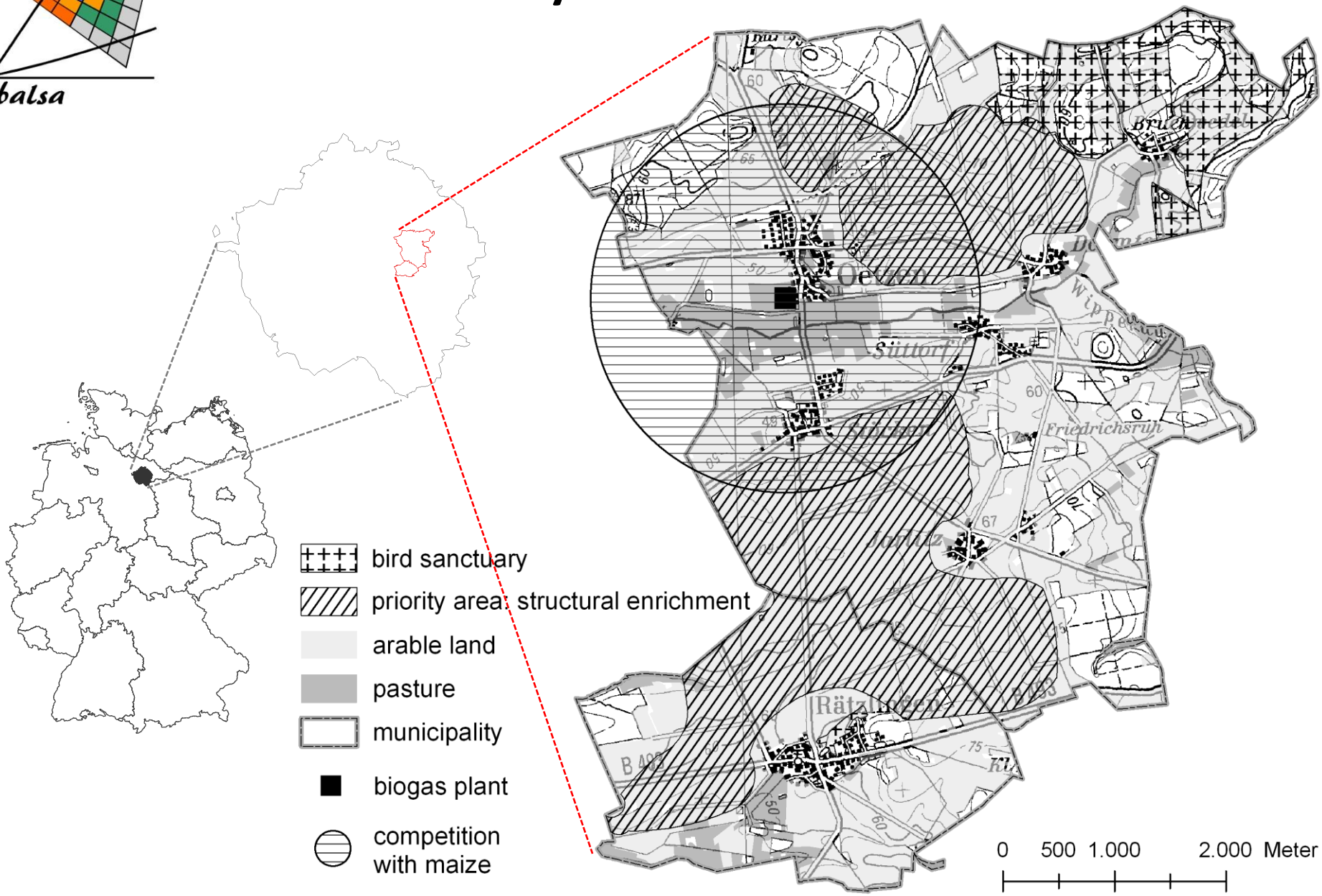
Conclusions water budget

- A shift from fallow grassland to willow-SRC reduces groundwater recharge due to higher evapotranspiration rates, however significant impact on catchment level not expected
- Interception and transpiration of a regrowing willow stand are comparatively small until canopy closure is achieved
- A short harvesting interval might thus reduce the negative effect of a land use shift towards willow SRC

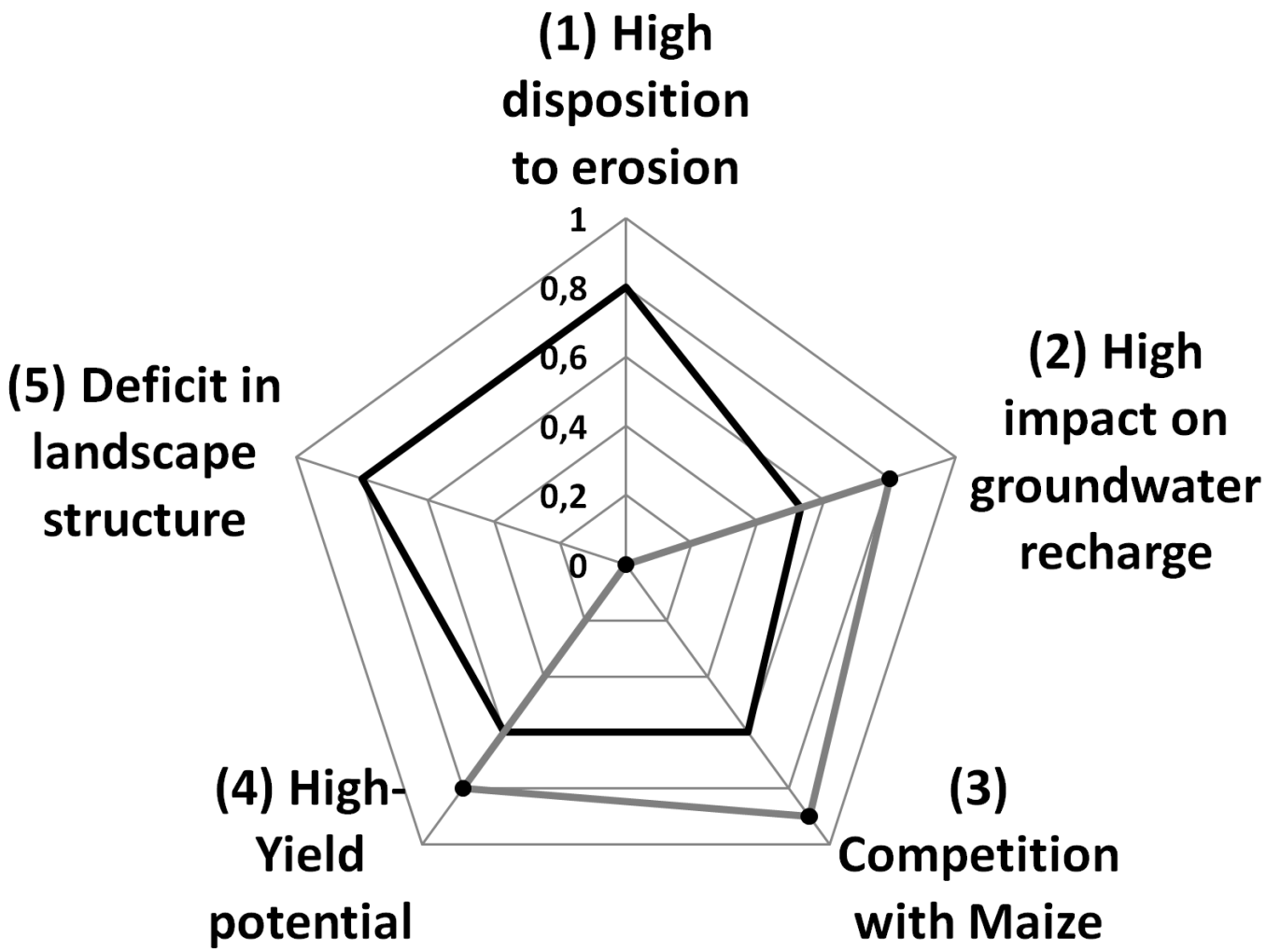
List of main recommendations for ”sustainably sound” SRC practice

- Establish SRC in homogenous arable landscapes to achieve highest positive effects on phytodiversity
- Variable SRC structures (shoot age, species/clones, area shape) and habitat diversity (intensive land use mixtures) to increase ecotone area and thus biodiversity (phyto- and zoodiversity)
- Cultivate SRC in fields located close to N sources (animal farms, wastewater treatment plants etc) to decrease N outflow to adjacent water bodies
- Cultivate SRC on fields with initial low C and high Cd soil concentrations to improve soil quality
- Harvest more frequently and cultivate SRC for at least 3 cutting cycles to achieve the above
- Recycle nutrients via municipal waste residues (no effect on groundwater and soil quality)

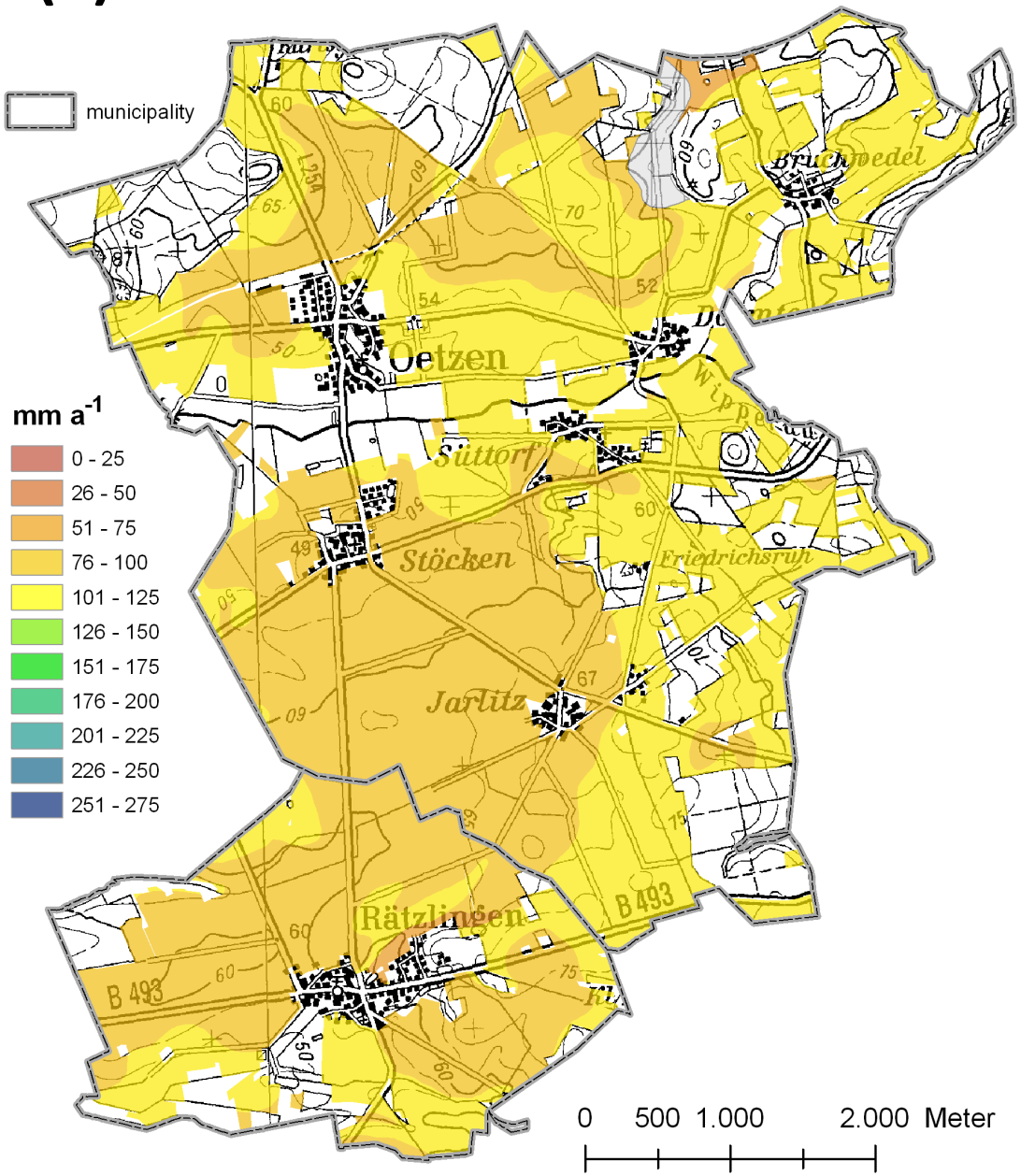
Study area


bird sanctuary
priority area: structural enrichment
arable land
pasture
municipality
biogas plant
competition with maize
0 500 1.000 2.000 Meter

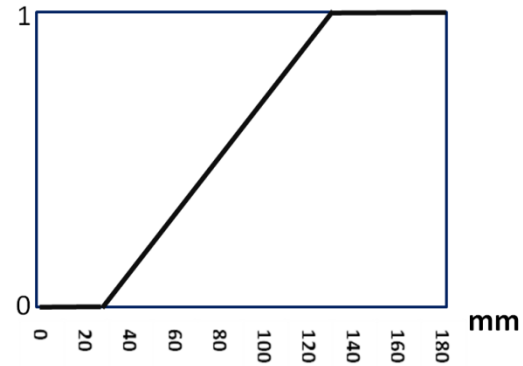
Fuzzy Multi-criteria analysis to show potential effects of goal-oriented allocation of Poplar SRC



(2) " High impact on groundwater recharge "

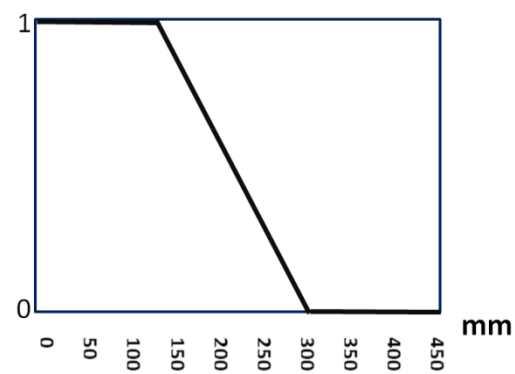


a) μ_1: High water abstraction



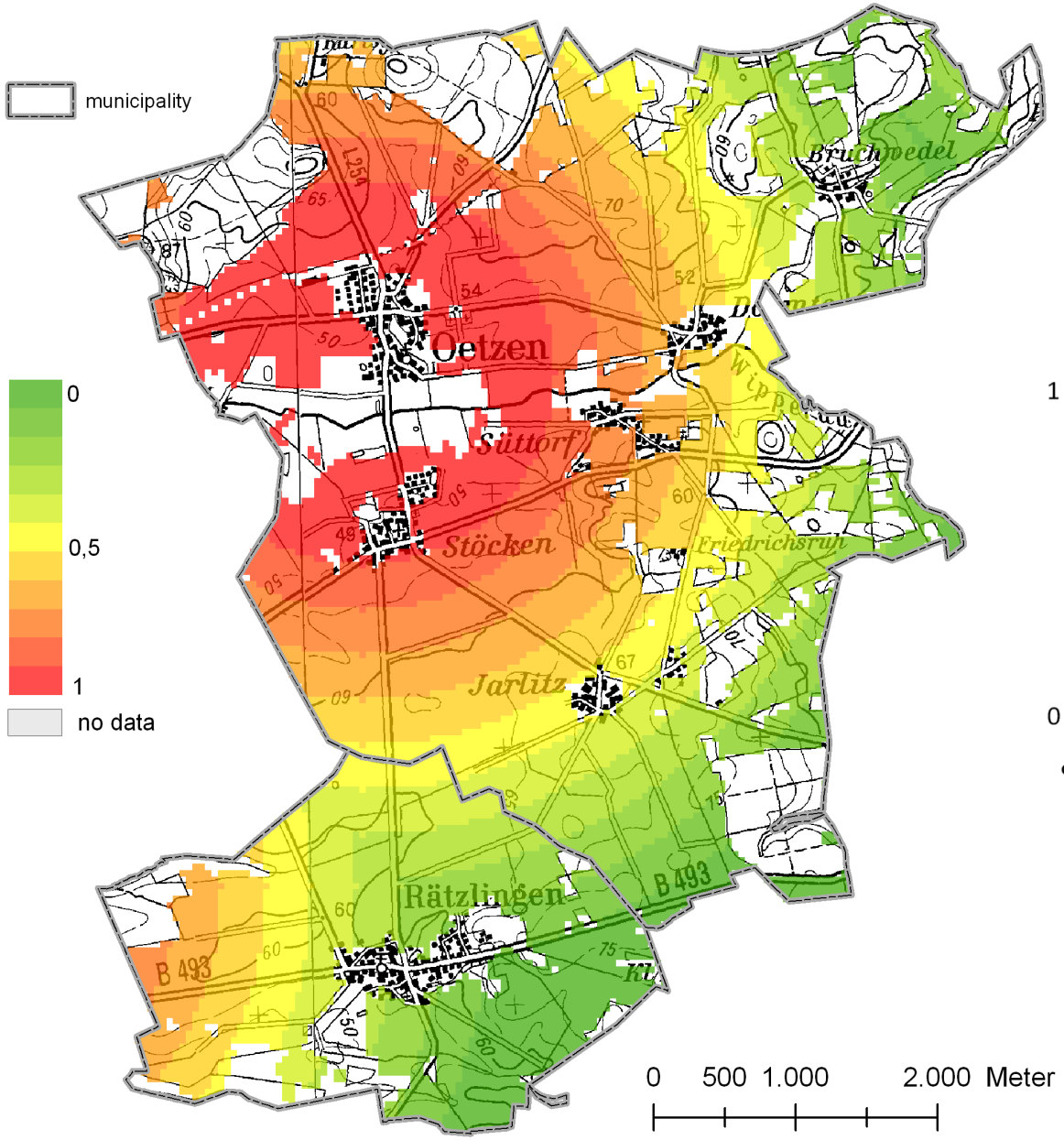
P_1: Annual decline in seepage water

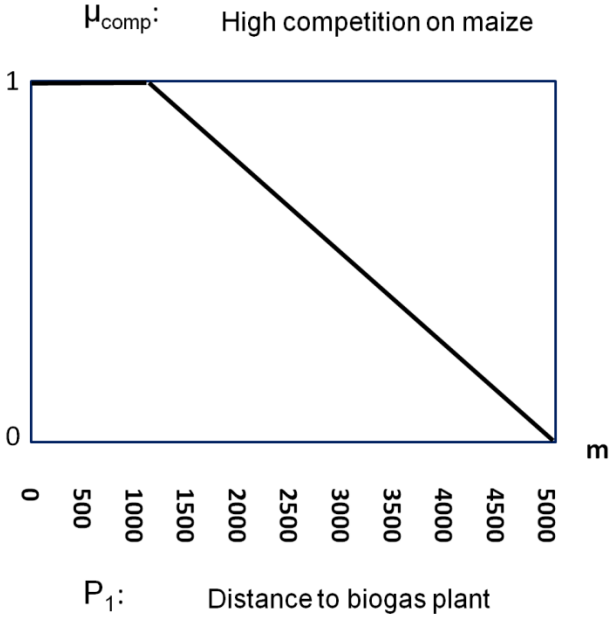
b) μ_2: Low potential of groundwater recharge



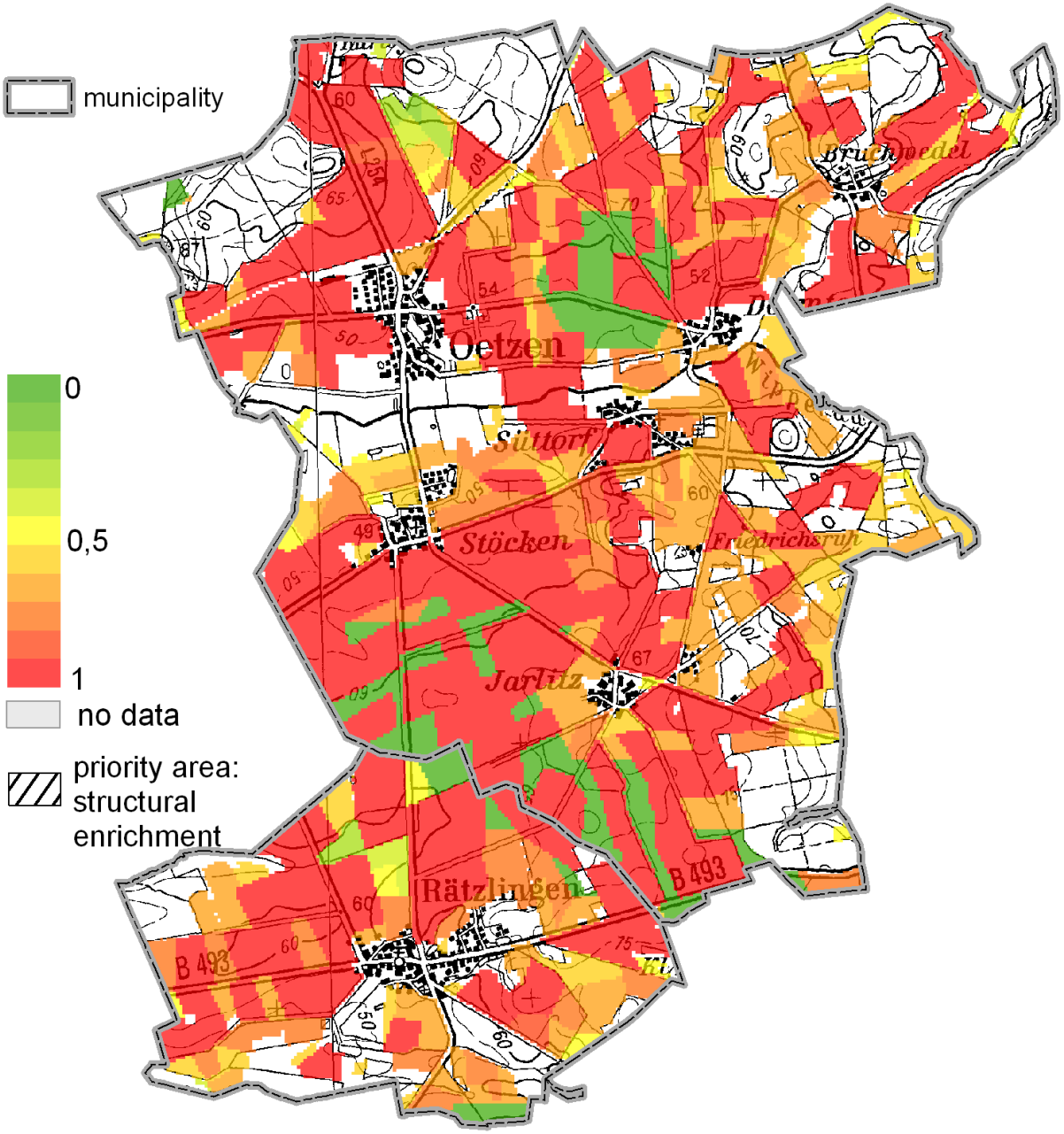
P_2: Annual groundwater recharge

(3) "Competition with maize"

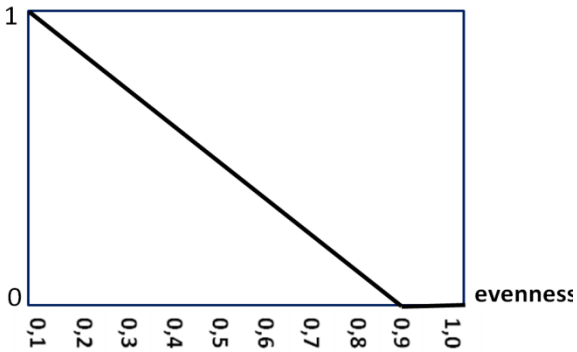




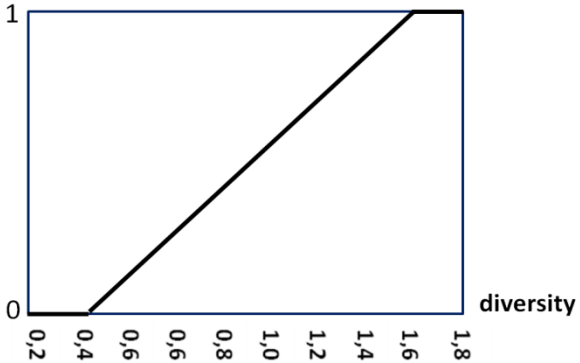
(5) "Deficit in landscape structure"



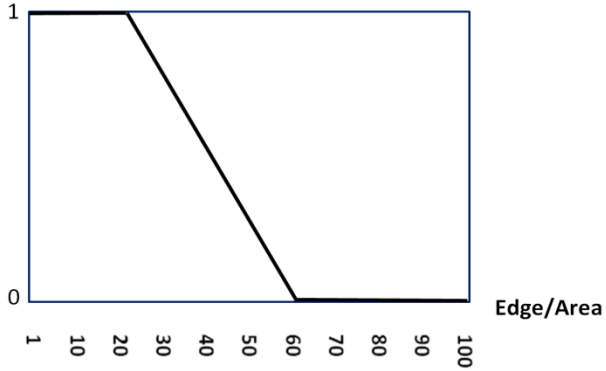
μ_{h_even}: High evenness



μ_{h_div}: High diversity

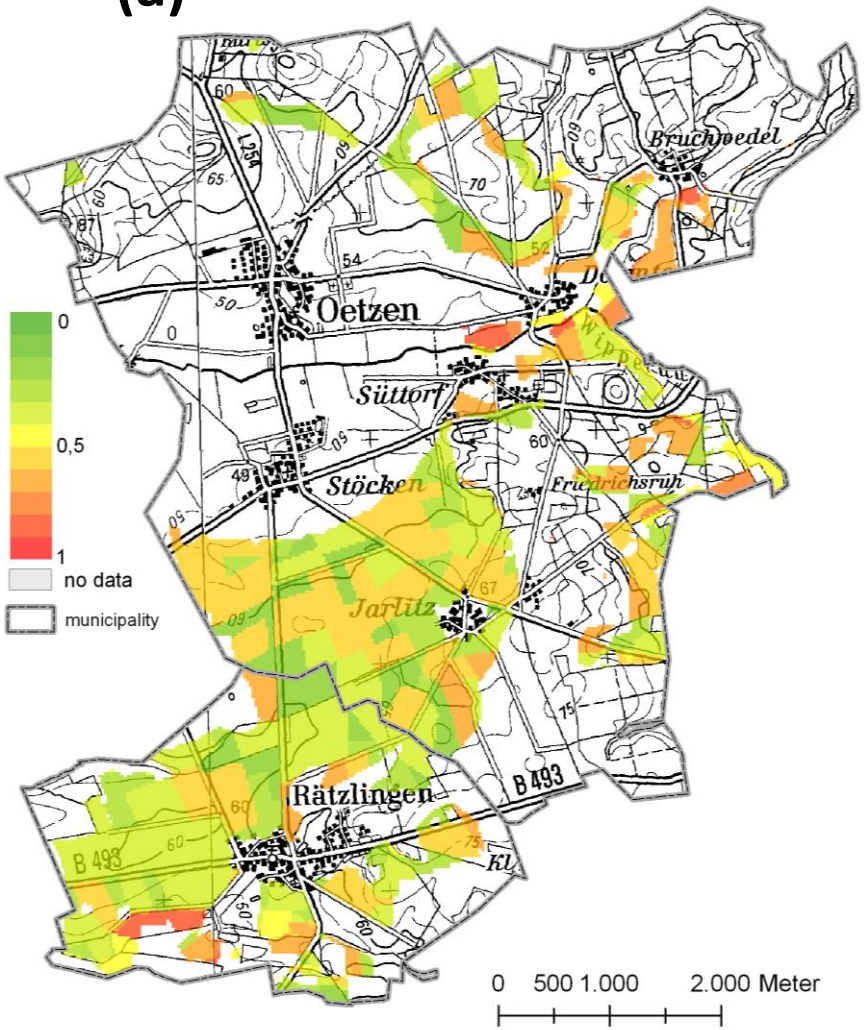


μ_{hpcplx}: High patch complexity



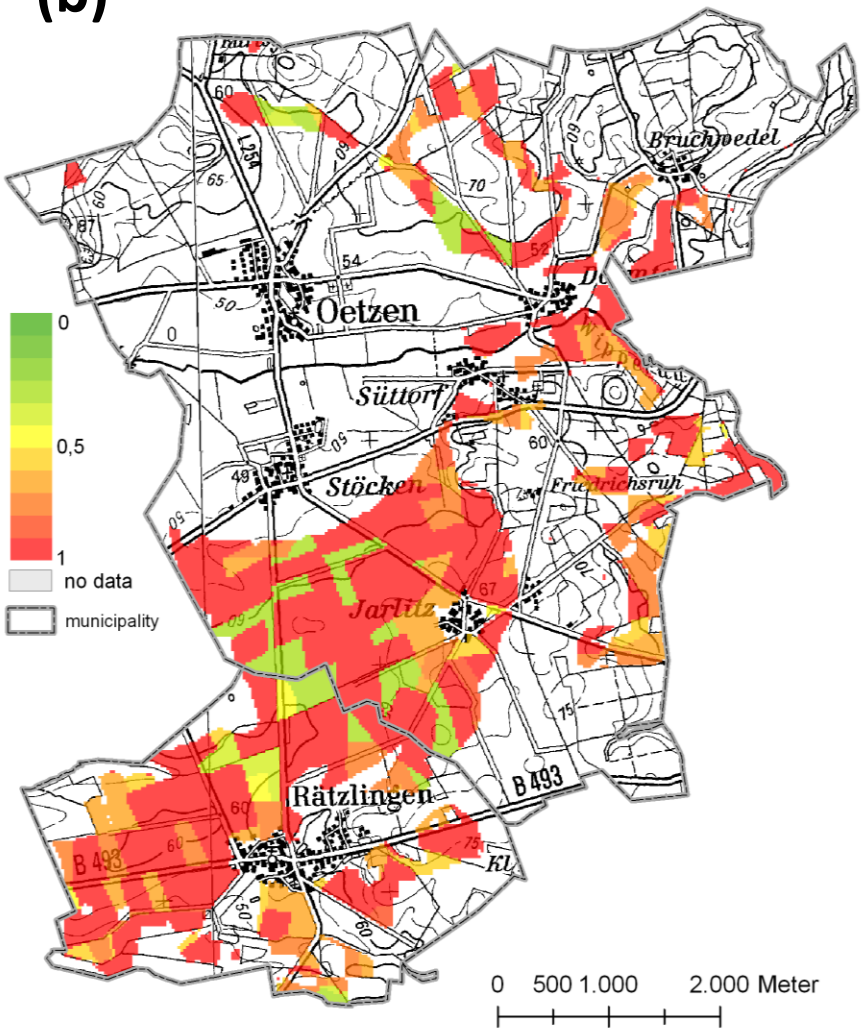
Pathway 2: Production-oriented SRC allocation with environmental goals as side-effects

(a)



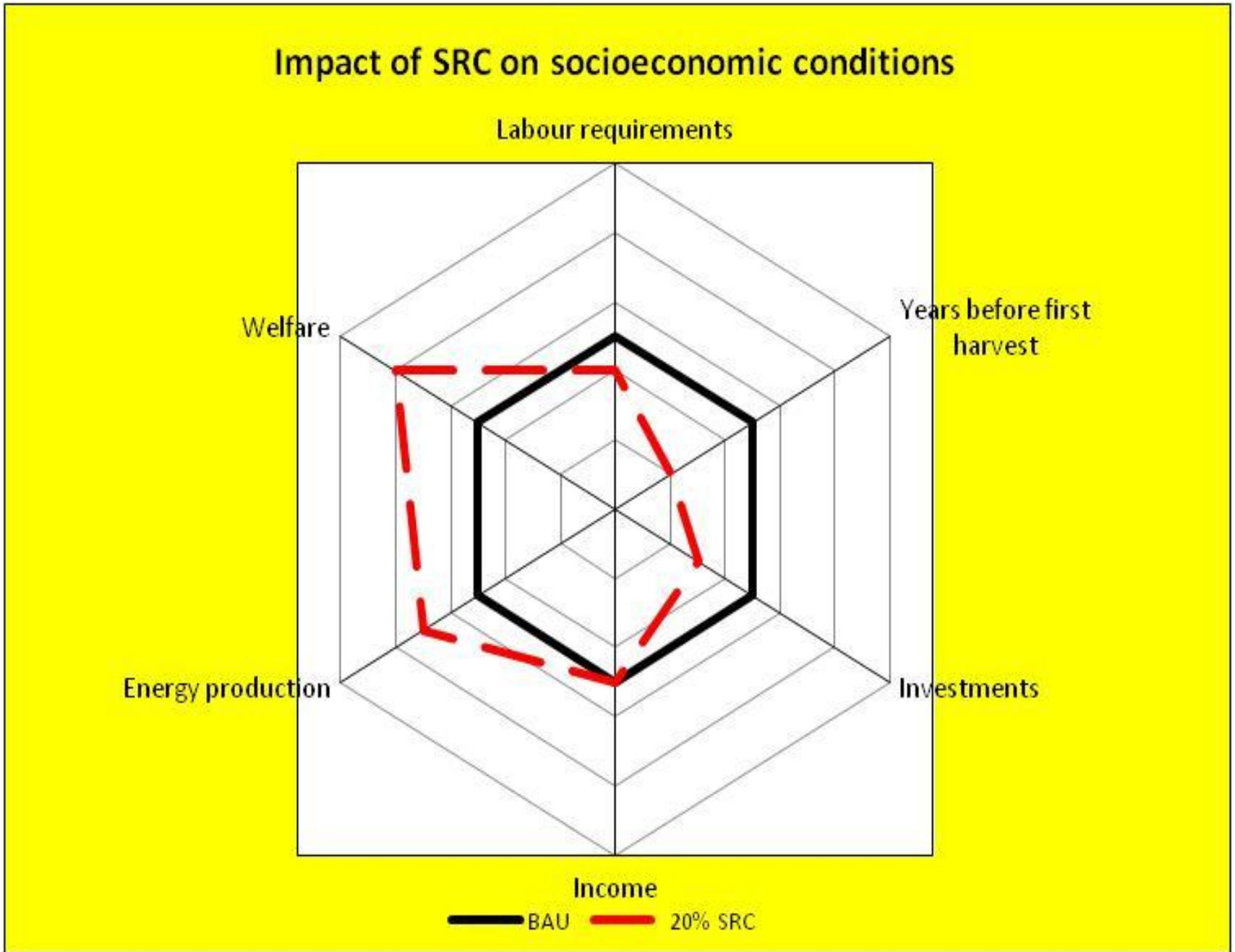
Average membership value of environmental dimensions
(wind-erosion, GWR, landscape structure)

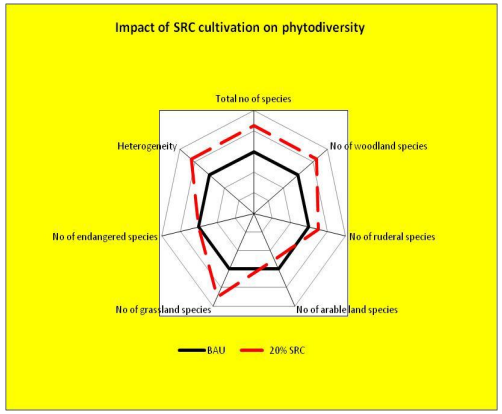
(b)

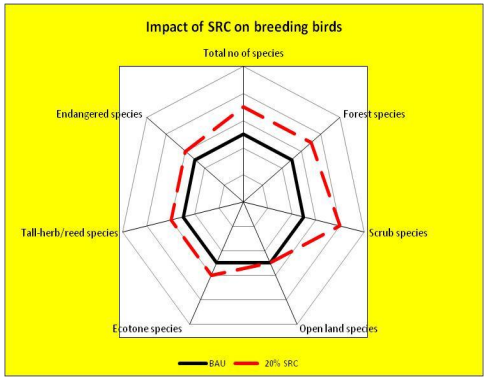


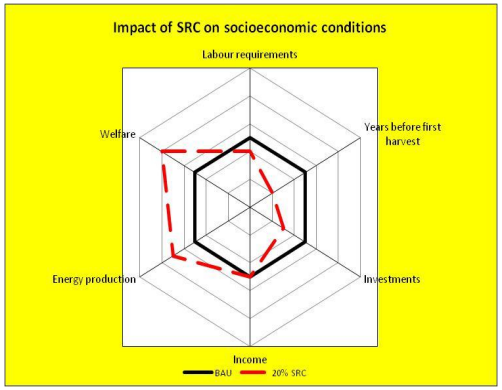
Maximum membership value of environmental dimensions
(wind-erosion, GWR, landscape structure)

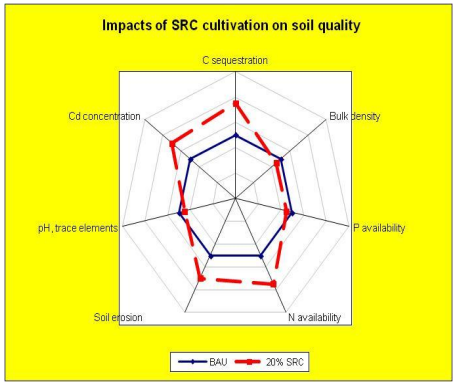
Decision support

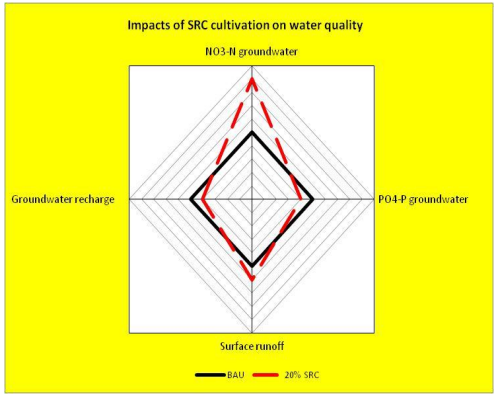



Impact of SRC cultivation on phytodiversity
Total no of species
No of woodland species
No of ruderal species
No of arable land species
No of grassland species
No of endangered species
Heterogeneity
BAU
20% SRC


Impact of SRC on breeding birds
Total no of species
Forest species
Scrub species
Open land species
Ecotone species
Tall-herb/reed species
Endangered species
BAU
20% SRC


Impact of SRC on socioeconomic conditions
Labour requirements
Years before first harvest
Investments
Income
Energy production
Welfare
BAU
20% SRC


Impacts of SRC cultivation on soil quality
C sequestration
Bulk density
P availability
N availability
Soil erosion
pH, trace elements
Cd concentration
BAU
20% SRC


Impacts of SRC cultivation on water quality
NO3-N groundwater
PO4-P groundwater
Surface runoff
Groundwater recharge
BAU
20% SRC

Energy crops and the new CAP

- Positive effects on water quality, soil quality and biodiversity (when compared to other arable crops) ⟹ Greening of Pillar 1

SLU
Swedish University of Agricultural Sciences

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BERE-431, Author: **Dimitriou** Impact of willow Short Rotation Coppice on water quality

BERE-438, Author: **Schmidt-Walter** Groundwater recharge of different aged willow short rotation coppices in a drinking water catchment

BERE-429, Author: **Lamersdorf** Nitrate seepage output under short rotation coppices (SRC) with poplar and willow in a drinking water catchment near Hannover, Germany

Soil

BERE-428, Author: **Dimitriou** Changes in organic carbon and trace elements in the soil of willow short-rotation coppice plantations

BERE-427, Author: **C. Baum** The impact of poplar growth on the composition of soil organic matter and on microbial communities in arable soils

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More information?

http://www.ratingsrc.eu/

4 Rating-SRC posters in the poster room!


THANK YOU VERY MUCH!