SRC – Environmental issues and multifunctional uses

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SRCplus Study Tour, 21-23 2015, Uppsala, Sweden
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Can the SRC area increase in the future when taking into account besides the economy other ecosystem services?

Yes! …

… but only if SRC 'value' improves!

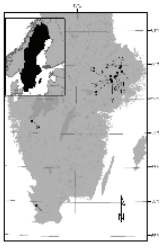
Additional values?

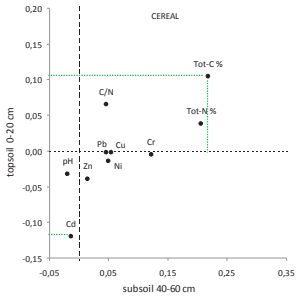
- via environmental impact/services?
- multifunctional uses of SRC

SRC impact on environment

- Soil
- Water
- Biodiversity

	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

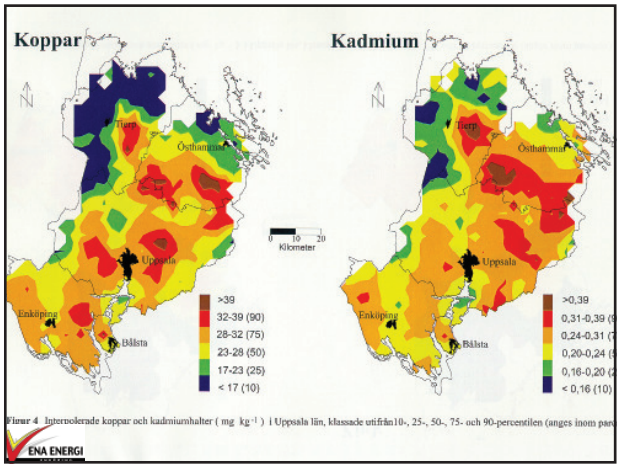




Relative differences between willow SRC plantations versus the reference. The values are the averages for all the locations of the different soil quality parameters investigated in topsoil (0-20 cm) and in subsoil (40-60 cm). Positive values represent higher observations of the studied parameter in the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



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

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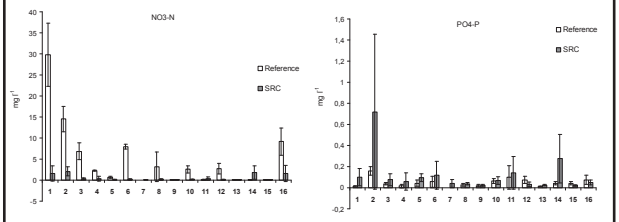
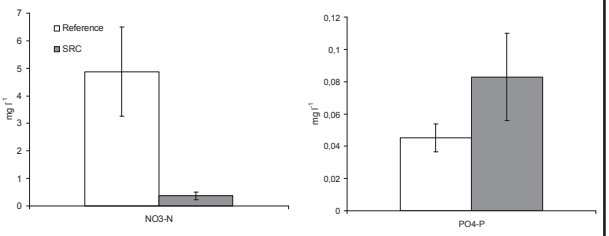
SRC impact on environment

- Soil
- Water
- Biodiversity

Impact of SRC vs ref on water quality



Willow SRC and water quality



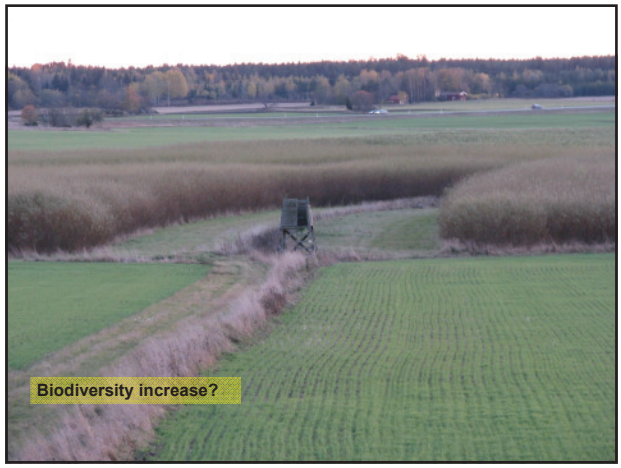
Averages of NO_3-N and PO_4-P concentrations in the groundwater of all fields pooled together for willow SRC and reference fields for the whole experimental period (Dimitriou et al., Bioenergy Research, 2012).

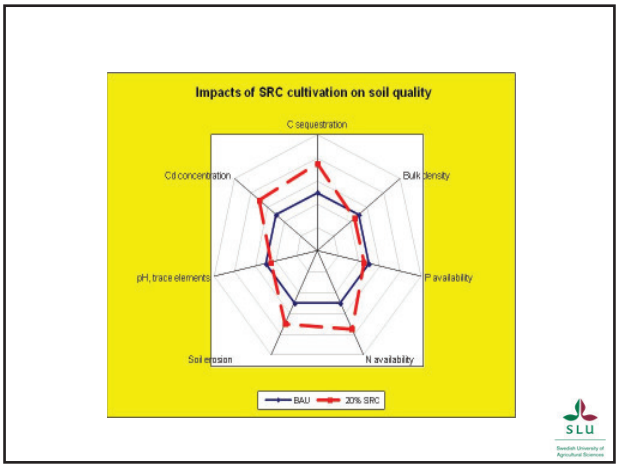
Impact of SRC vs ref on water quality

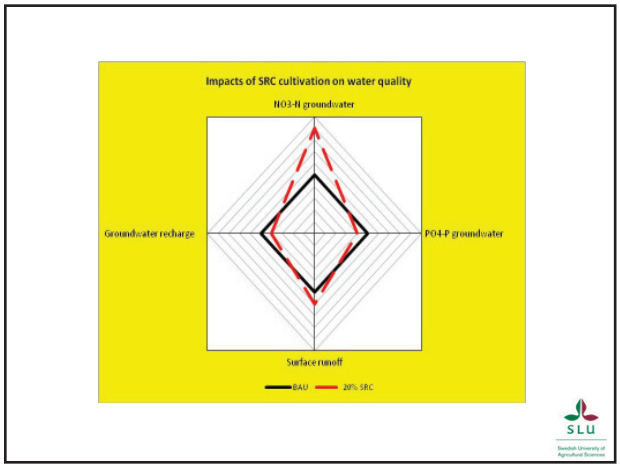
- Leaching of NO_3-N in the groundwater is substantially lower from SRC
- Leaching of PO_4-P in the groundwater is slightly higher from SRC
- Leaching of PO_4-P in the groundwater was not correlated to sewage sludge applications

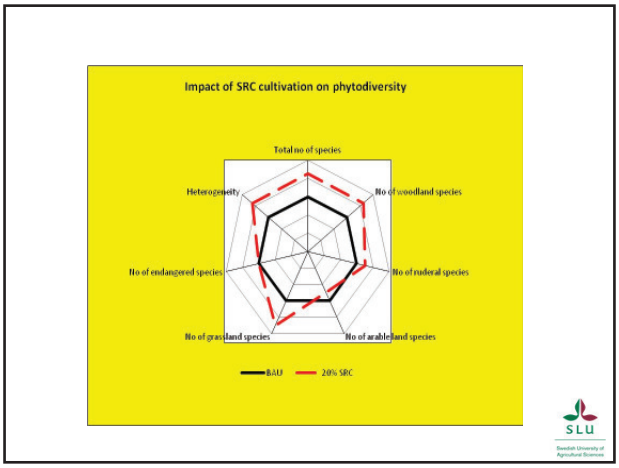
SRC impact on environment

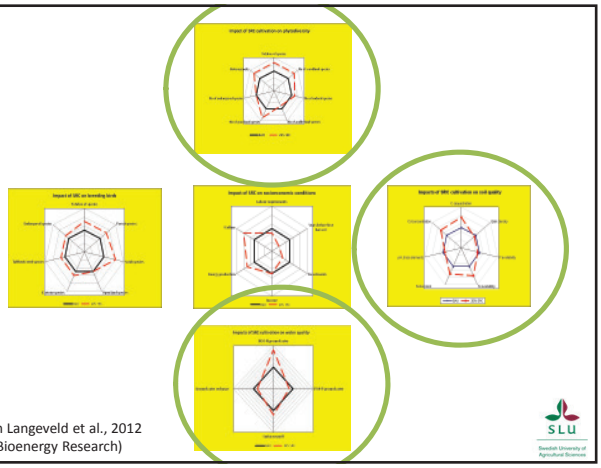
- Soil
- Water
- Biodiversity




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


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



In Langeveld et al., 2012 (Bioenergy Research)

Biomass production and environmental impact

- Replacement of fossil fuels ⇒ "THE" environmental service (macro-scale)
- Change of land uses in agriculture ⇒ affect (improve or deteriorate) environmental quality
- With careful design additional environmental benefits can be obtained

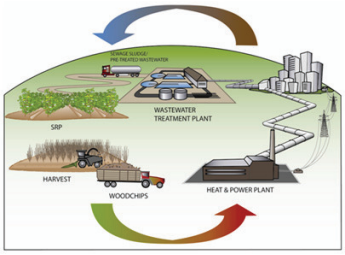
Additional values?

- via environmental impact/services
- multifunctional uses of SRC

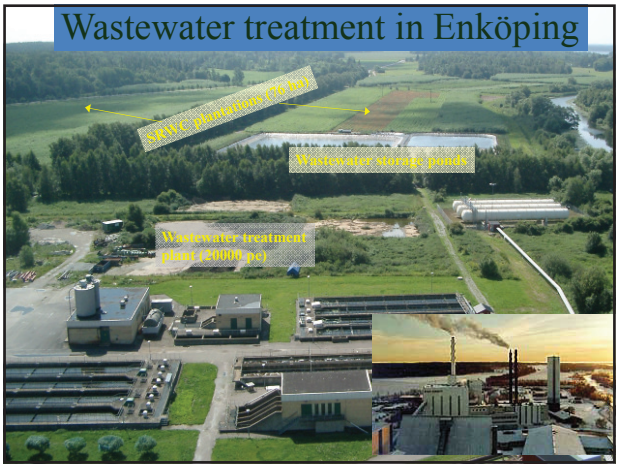
Treatment and utilisation of society's residues and biomass production as a part of the treatment system

The concept

- The safe use of nutrient-rich residues of society (as municipal wastewater and sludge) to fertilise fast-growing tree species (willows and poplars) to produce biomass for energy



Wastewater treatment in Enköping



Wastewater treatment in Enköping

- Need: 50% N reduction in outflow (Municipality)
- Solution : Reduced load of the WWTP through:

1. Septic-tank sludge to rural storage ponds

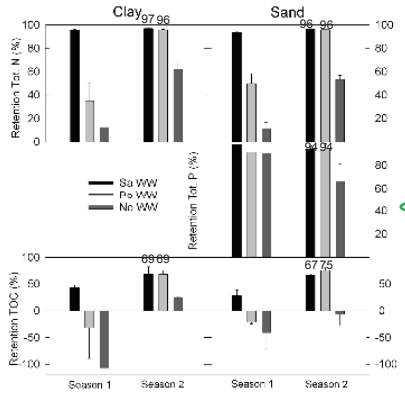
2. Diversion of wastewater from dewatering of sewage sludge….

Wastewater treatment in Enköping

…and irrigation of willows with “wet sludge” and treated wastewater

Wastewater and SRC research issues

- N, P, TOC leaching in groundwater
- Retention capacity vs maximum amounts applied
- Economic calculations and potential



Element	Wastewater conc. (mg/L)
Total N	34.7
Of which NH_4-N	*27.4*
NO_3-N	*0.2*
Org. N	*7.1*
Total P	4
TOC	7.5

	Tot. N load (kg/ha)	Tot. P load (kg/ha)
Season 1	262	21.2
Season 2	369	29.8

Relative retention (%) of Tot. N, Tot. P and TOC after wastewater application during two experimental seasons (Dimitriou and Aronsson, Biomass and Bioenergy, 2011).

Gross margins of SRC cultivation when wastewater is applied

Price (€/GJ)	Yield level (t DM/ha)							
	8	9	10	11	12	13	14	15
2	-242	-249	-256	-264	-271	-278	-286	-293
3	-137	-131	-126	-120	-114	-109	-103	-97
4	-33	-14	5	23	42	61	80	98
5	72	103	135	167	199	231	262	294
6	176	221	266	311	355	400	445	490
7	280	338	396	454	512	570	628	686

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) when wastewater is irrigated. In: Dimitriou and Rosenqvist (Biomass and Bioenergy, 2011)

	Population (Millions)	SRC area to be fertilised with all available ss (t ha)	SRC area to be fertilised with all available ww (t ha)	Arable land surface with SRC fertilised with ss (%)	Arable land surface with SRC fertilised with ww (%)	Energy produced from SRC if all ss applied (PJ)	Energy produced from SRC if all ww applied (PJ)
EU-27	495.13	35673	1505	34	1.4	5636.3	309.2
Austria	8.30	598	25	43	1.8	94.5	5.2
Belgium	10.58	635	28	75	3.3	120.5	6.6
Bulgaria	7.68	553	23	22	0.9	87.4	4.8
Cyprus	0.78	47	2	42	1.7	8.9	0.5
Czech Rep.	10.29	824	34	32	1.3	117.1	6.4
Denmark	5.45	436	18	18	0.7	62	3.4
Estonia	1.34	107	4	17	0.7	15.3	0.8
Finland	5.28	422	17	19	0.8	60.1	3.3
France	61.54	3411	162	19	0.9	700.5	38.4
Germany	82.31	5931	250	50	2.1	937.0	51.4
Greece	11.17	671	28	33	1.3	127.2	7
Hungary	10.07	604	25	17	0.7	114.6	6.3
Ireland	4.31	259	11	26	1.1	49.1	2.7
Italy	59.13	3550	146	50	2.1	673.1	36.9
Latvia	2.28	183	8	16	0.7	26	1.4
Lithuania	3.38	271	11	15	0.6	38.5	2.1
Luxembourg	0.48	34	1	56	2.4	5.4	0.3
Malta	0.41	24	1	305	12.6	4.6	0.3
Netherlands	16.36	1179	50	111	4.7	186.2	10.2
Poland	38.13	3052	116	26	1	434	23.8
Portugal	10.60	636	26	51	2.1	120.7	6.6
Romania	21.57	1295	53	15	0.6	245.5	13.5
Slovakia	5.39	486	19	37	1.5	61.4	3.4
Slovenia	2.01	161	7	93	3.8	22.9	1.3
Spain	44.47	3204	135	27	1.1	506.3	27.8
Sweden	9.11	505	23	19	0.9	103.7	5.7
Un. Kingdom	60.85	3634	150	60	2.5	692.7	38

Theoretical estimates of land required if all available sewage sludge (ss) and wastewater (ww) were applied to SRC, and consequent increases of the renewable energy amounts in the various EU countries. In Dimitriou and Rosenqvist (Biomass and Bioenergy, 2011)

Spreading of sewage sludge and wood-ash (when available) in SRC is very common in Sweden

Cadmium and SRC

		Treatments									
		sl+ash		(sl+ash)x2		sl		ash		control	
	Harvest interval (yrs)	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**3**
Cd	Supply	*1.2*		*2.5*		*1.2*		*1.3*		*0*	
	Potential output	5.6	5.2	8.9	7	8	5.7	6.9	7	6.7	5.2
	Change	**–4.4**	**–4**	**–6.4**	**–4.5**	**–6.8**	**–4.5**	**–5.6**	**–5.7**	**–6.7**	**–5.2**
Cu	Supply	*303*		*606*		*500*		*106*		*0*	
	Potential output	28	14	48	18	34	14	39	14	30	12
	Change	**275**	**289**	**558**	**588**	**466**	**486**	**67**	**92**	**–30**	**–12**
Ni	Supply	*18*		*38*		*13*		*25*		*0*	
	Potential output	12	7	15	6	12	5	11	5	10	6
	Change	**6**	**11**	**23**	**32**	**1**	**8**	**14**	**20**	**–10**	**–6**
Zn	Supply	*449*		*899*		*569*		*330*		*0*	
	Potential output	243	245	359	330	308	284	258	273	240	213
	Change	**206**	**204**	**540**	**569**	**261**	**285**	**72**	**57**	**–240**	**–213**

Table. Balance between supply via sludge–ash application and potential output via willow plantation harvest (in g ha^{-1} yr^{-1}), for the various treatments, if a potential harvest occurred annually or every three years. The potential output with a stem harvest was calculated for a 30:70 bark:wood ratio for year 1 and a 25:75 bark:wood ratio for year 3. Changes indicate potential changes in the soil pool (In: Dimitriou et al., 2006)

Assoc. Prof. Dr. Ioannis Dimitriou, Swedish University of Agricultural Sciences, Dep. of Crop Production Ecology
Course "Production and energy use of wood biomass" – Sustainability in bioenergy production: the SRF case
4/11/2011, Joensuu, Finland

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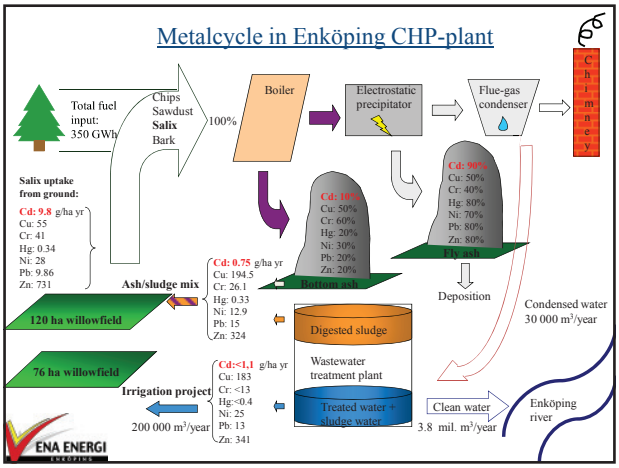
Metalcycle in Enköping CHP-plant



Gross margins of SRC cultivation when sewage sludge is applied

Price (€/GJ)	Yield level (t DM/ha)							
	5	6	7	8	9	10	11	12
2	-263	-276	-288	-301	-313	-326	-338	-351
3	-198	-197	-197	-196	-196	-195	-195	-194
4	-133	-119	-105	-92	-78	-65	-51	-37
5	-67	-41	-14	13	39	66	92	119
6	-2	38	77	117	157	196	236	276
7	63	116	169	221	274	327	380	432

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) when sewage sludge is applied. In: Dimitriou and Rosenqvist (Biomass and Bioenergy, 2011)

Assoc. Prof. Dr. Ioannis Dimitriou, Swedish University of Agricultural Sciences, Dep. of Crop Production Ecology.
Biomass cropping systems for multiple purposes - PhD course "Production of Biomass for Energy – quantity and quality aspects".
27/2/2012, Ecology building, Uppsala, Sweden.

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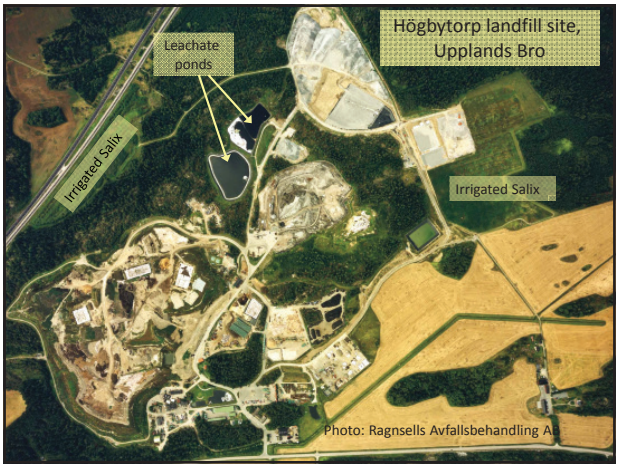


BEVATTNING!
ej dricksvatten


Energiskog
Snabbväxande energiskog planteras för att ta upp näringsämnen från lakvattnet. Träden avverkas och blir energi genom att bl a eldas som flis i pannor.