

Environmental impacts of SRC in Europe

Dr. Ioannis Dimitriou
Swedish University of Agricultural Sciences

Dr I. Dimitriou, Dep. of Crop Production Ecology, Swedish Univ. of Agricultural Sciences SLU



Overview of this presentation

- Short presentation of SLU
- Short description of the current situation for SRC in Sweden
- Aspects of environmental impact of SRC
- SRC and treatment/utilisation of residues
- Environmental impact of such practices

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Faculty of Forest Sciences
- **Uppsala**
Faculty of Natural Resources and Agricultural Sciences
- Faculty of Veterinary Medicine and Animal Science
- **Alnarp**
Faculty of Landscape Planning, Horticulture and Agricultural Science

SLU



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SLU facts (2006):

- Staff: 2900
- Annual turnover 256 M Euro
- 292 Professors
- 717 PhD students
- 3450 full-time students

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Dep. of Crop Production Ecology

- Research and teaching for all crops with economical interest in Sweden (food, fodder, energy)
- Section of Energy Crops
 - Mainly *Salix* but also *Populus* and other energy crops
 - Ecological characterisation
 - Stand dynamics
 - Management
 - System analyses
 - Economy
 - Multifunctional environmental uses of *SRF*

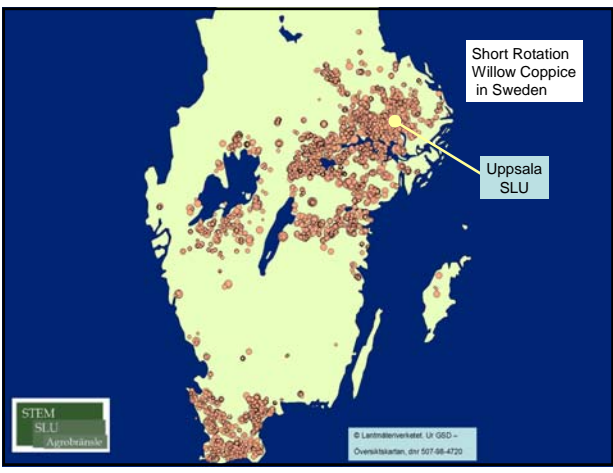
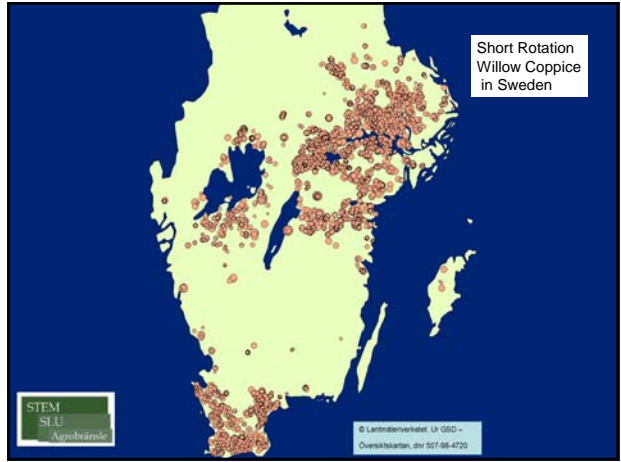
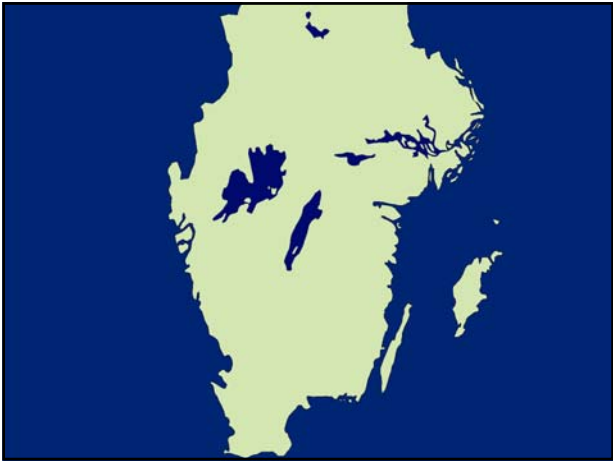
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Short-Rotation Willow Coppice for energy in Sweden

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Short Rotation Coppice in Sweden


- ❑ Ca. 16 000 ha are currently cultivated in Sweden for energy
- ❑ Predictions for rapid increase (Ministry of Agriculture, 2006)
- ❑ Grown on agricultural land
- ❑ Double-row system, fertilisation, weed control
- ❑ Harvested every 3-4 years, life span app. 25 years
- ❑ Average production: 6-10 t DM/ha/yr

Short Rotation Coppice in Sweden

- ❑ SRC cultivated area has remained almost stable during the last 10 years, the predictions have not become true...
- ❑ ...farmers do not usually fertilise and biomass production is therefore lower...
- ❑ ...the current high cereal prices give negative signs for area increase...
- ❑ ...in some cases SRC plantations did not get permission to be established due to landscape issues...

Environmental impact growing SRC plantations related to:

- Landscape


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Environmental impact growing SRC plantations related to:

- Landscape
- Biodiversity

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Photo: Nils-Erik Nordh



Photo: Nils-Erik Nordh



Photo: Nils-Erik Nordh

Environmental impact growing SRC plantations related to:

- Landscape
- Biodiversity
- Management
- Water
- Soil

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Management of SRC

- SRC is an agricultural crop but...
- ...lower input of herbicides and pesticides...
- Fertilisation is needed for high biomass production...
- ...and leaching losses are said to be lower...
- ...but at the moment biomass prices are low and do not compensate for the increased effect of fertilisation...
- ...therefore alternative fertilisation means are used when available

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SRC for treatment and utilisation of municipal and industrial residues in Sweden

- Municipal wastewater
- Landfill leachate
- Log-yard runoff
- Sewage sludge

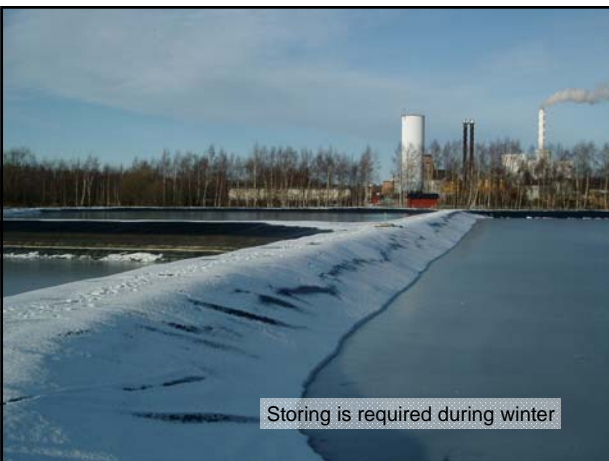
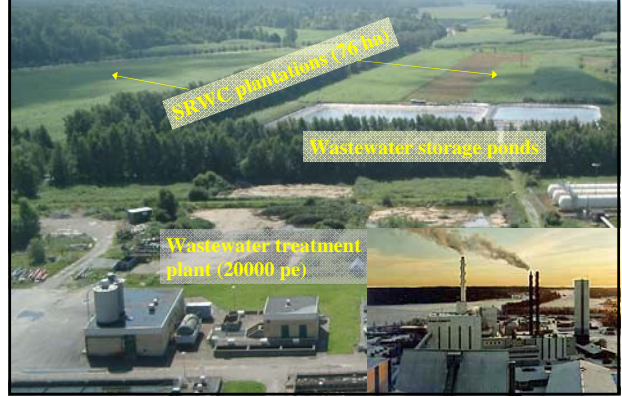
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Wastewater treatment in Enköping



Wastewater treatment in Enköping



Wastewater treatment in Enköping

Wastewater	N-tot (mg/l)	N-NH ₄ (mg/l)	P (mg/l)
Treated water	35	32	0.22
From dewatered sludge after sedimentation	925	639	21
From dewatered sludge after centrifuge	801	475	10.4

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Wastewater treatment in Enköping

- 25% of all N of the WWTP is N-rich wastewater from sludge dewatering
- Irrigation with around 2.5 mm per day for around 120 days on 76-ha SRWC
- Ca 150 kg N/ha yr
- N-rich wastewater is diluted by 75% with conventionally treated wastewater
- 11 t N and 0.2 t P are treated after irrigation with 20 000 m³ N-rich water after sludge dewatering, total irrigation: 200 000 m³

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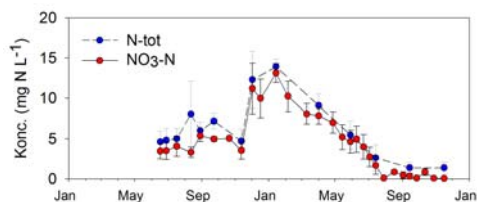
Potential environmental hazards and SLU research activities

- N-leaching to the groundwater
- Toxicity effects on willow plants (lower biomass production)
- Greenhouse gas losses (mainly N₂O) to the atmosphere
- Pathogens in the groundwater

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NO₃-N in the groundwater in Enköping

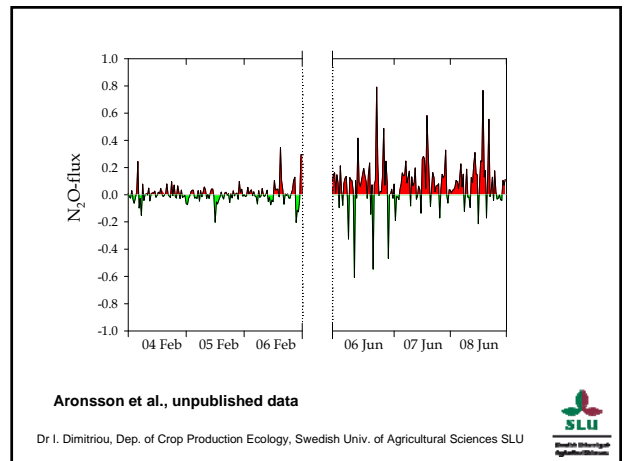
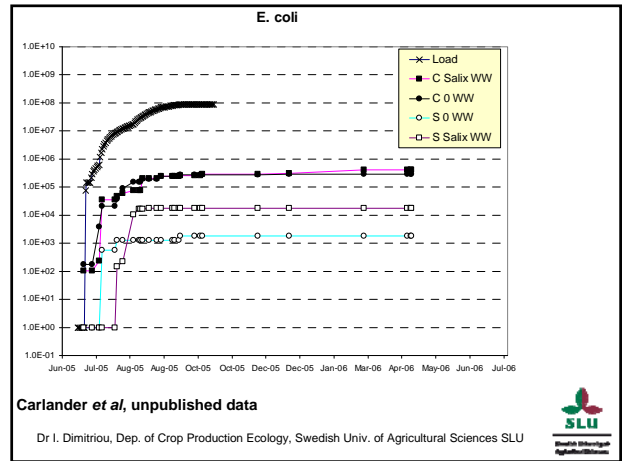
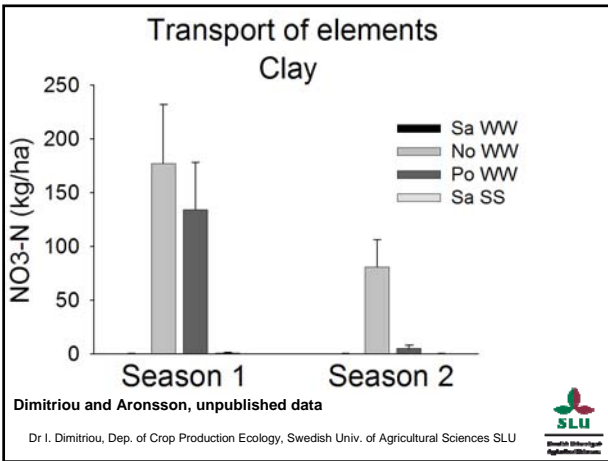
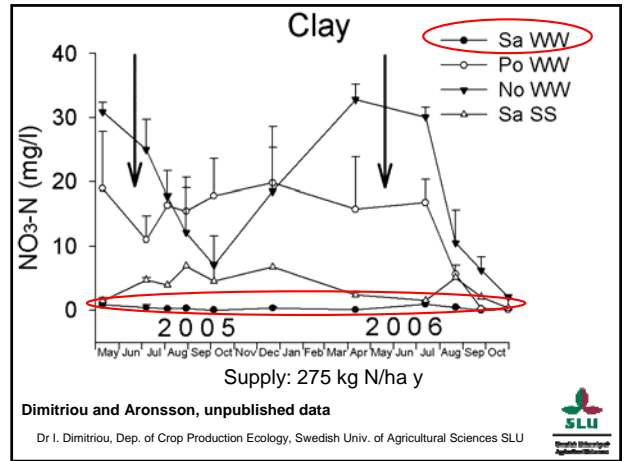


Supply: 150 kg N/ha y

Aronsson *et al*, unpublished data

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Research results

- N-leaching: negligible after the establishment year
- N amounts in groundwater very low due to high evapotranspiration
- N₂O emissions to the atmosphere occur, vary within a year but are low (10 kg ha⁻¹ yr⁻¹, Aronsson, unpublished data)
- Under worst-case conditions, pathogens were present in the groundwater but no pathogens were measured after the end of irrigation



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Spreading of sewage sludge in SRWC is very common in Sweden

Photo: Ragnsells Avfallsbehandling AB

Sewage sludge application on SRC

- Today 80% of the total SRC plantations (ca. 10 000 ha) are fertilised after harvest with sludge (mixed with wood-ash where available)
- The cost to the municipalities for sludge spreading on SRC varies from 9-32 Euro/ton (in comparison to 0 – 64 Euro/ton for green areas or ca. 500 SEK/ton for burning or ca. 55 Euro/ton for landfilling (for 2004, Svenskt Vatten)
- 22 or 35 kg P ha⁻¹ yr⁻¹ for a cutting cycle
- Willow is reported to efficiently take up metals, mainly Cd (ca. 10 g/ha/yr)



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Heavy metal regulations for sludge use in agricultural land

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Max. conc. in sludge (mg/kg DM) (1998:944)	2	100	600	2.5	50	100	800
Max. supply (g/ha/yr) (1994:2)	0.75	40	300	1.5	25	25	600
Max. conc. in soil (mg/kg DM)	0.40	60	40	0.3	30	40	100*
Normal conc. in topsoil (mg/kg DM)	0.22	16	15	0.10	9	16	77



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Sludge fertilisation on SRWC: Is it sustainable?

	Treatments											
	sl+ash		(sl+ash)x2		sl		ash		control			
Harvest interval (yrs)	1	3	1	3	1	3	1	3	1	3	1	3
Cd												
Supply	1.2		2.5		1.2		1.3		7		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		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		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		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



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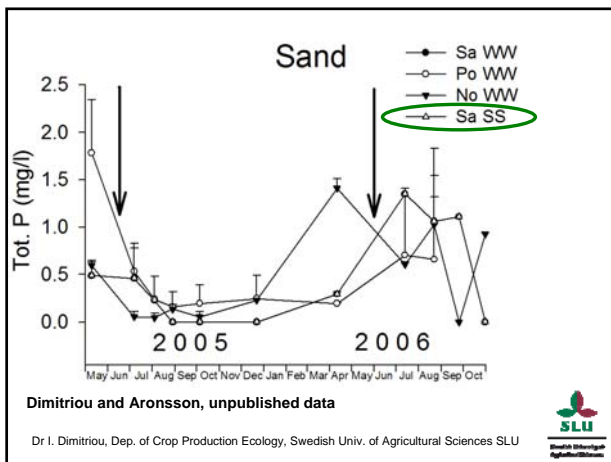
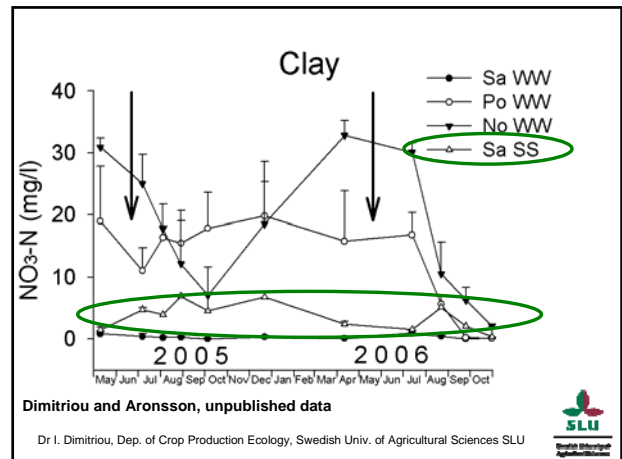
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	Total in 0–15 cm (kg ha ⁻¹)	Change in total metal amounts in soil after 25 years' application of 'sl+ash' (%)		Number of years to double the total amounts in soil after 'sl+ash'	
		no SRWC	with SRWC	no SRWC	with SRWC
Cd	0.36	+8.3	-26	+300	-95
Cr	92.6	+0.81	<+0.81	+3068	>+3068
Cu	59.1	+12.8	+12.2	+195	+204
Ni	53.4	+0.85	+0.51	+2966	+4854
Pb	43.3	+0.92	<+0.92	+2706	>+2706
Zn	225	+5	+3	+501	+833

Total metal amounts in the soil at Lundby, and the calculated increase (%) in the 0–15 cm soil layer after 25 years for 'sl+ash', without or with SRWC cultivation. The last two columns show the number of years required to double the total amounts of metal in the soil, if 'sl+ash' were applied at Lundby, without or with SRWC cultivation, respectively

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- ### Conclusions about environmental impact of SRC
- Landscape and biodiversity issues proved rather subjective, careful planning needed
 - Low input of pesticides and herbicides
 - Negligible leaching even under "worst-case"
 - Certain heavy metals as Cd reduced even after sludge application
 - Pathogens after wastewater in groundwater need to be considered
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