

Current investigations of N-balance in free range organic pig production in combination with short rotation coppice

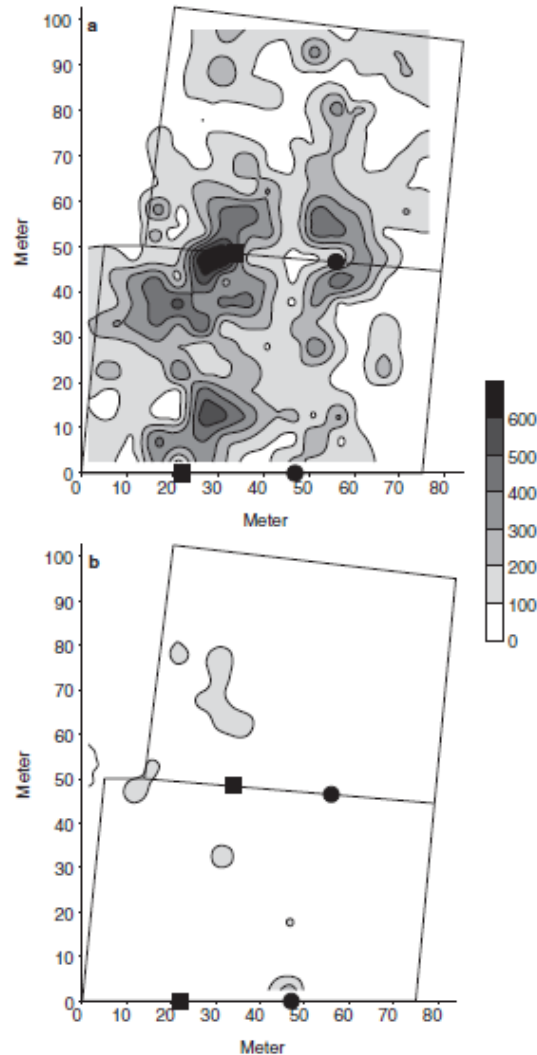
Uffe Jørgensen



AARHUS
UNIVERSITY

DEPARTMENT OF AGROECOLOGY

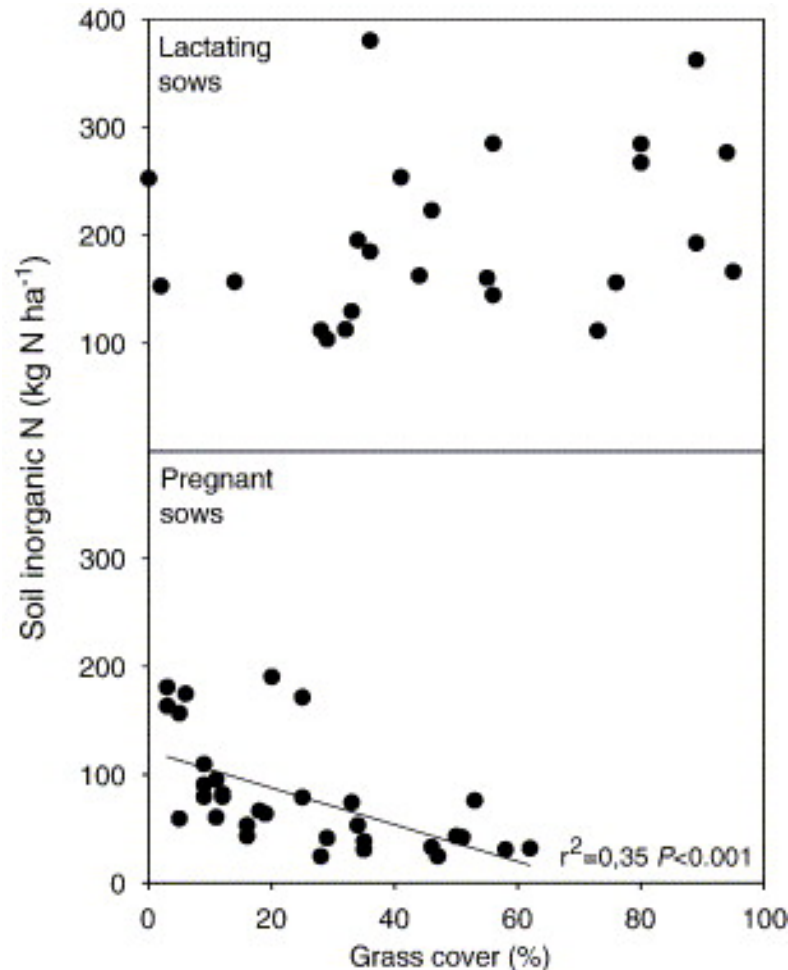
Earlier studies showed very high nitrogen loads in free range pig production – and very in-homogeneous distribution



Distribution of mineral N (kg/ha) at 0-40 cm depth in October (a) and April (b) following 32 lactating sows from April –October

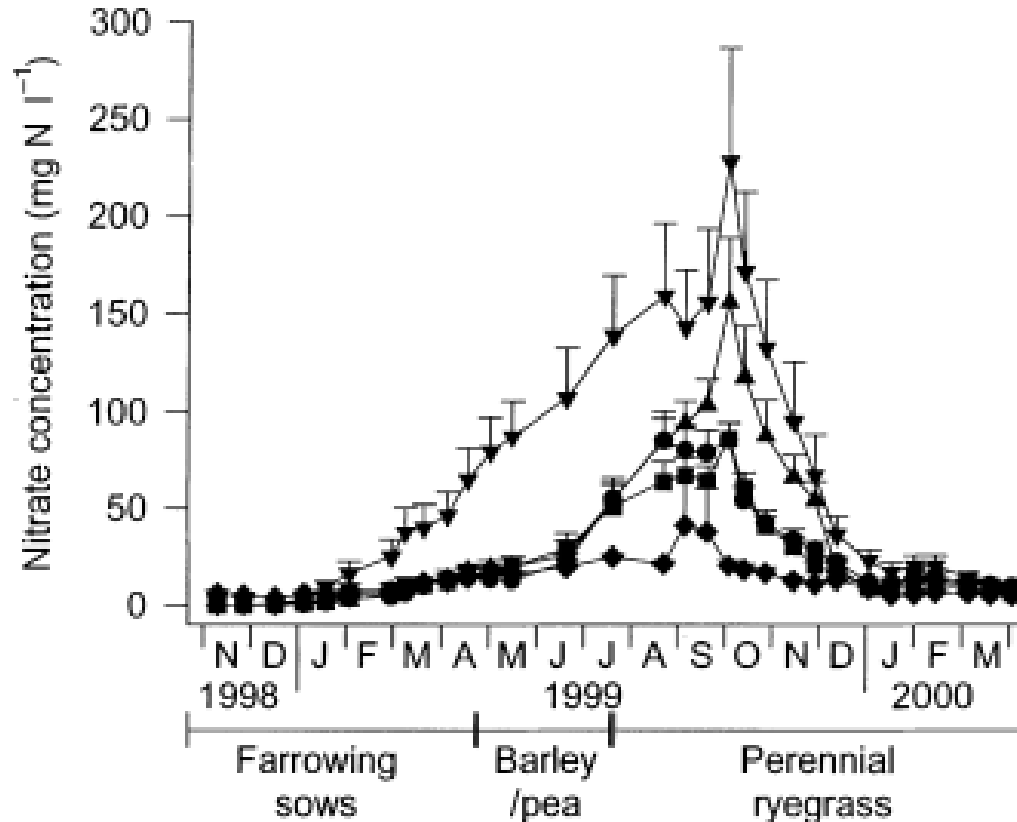
Eriksen, Petersen & Sommer, 2002

Grass cover can absorb N-loads if not too excessive



Relationship between grass cover and soil inorganic N in autumn (end of experiment) across lactating and pregnant sow paddocks

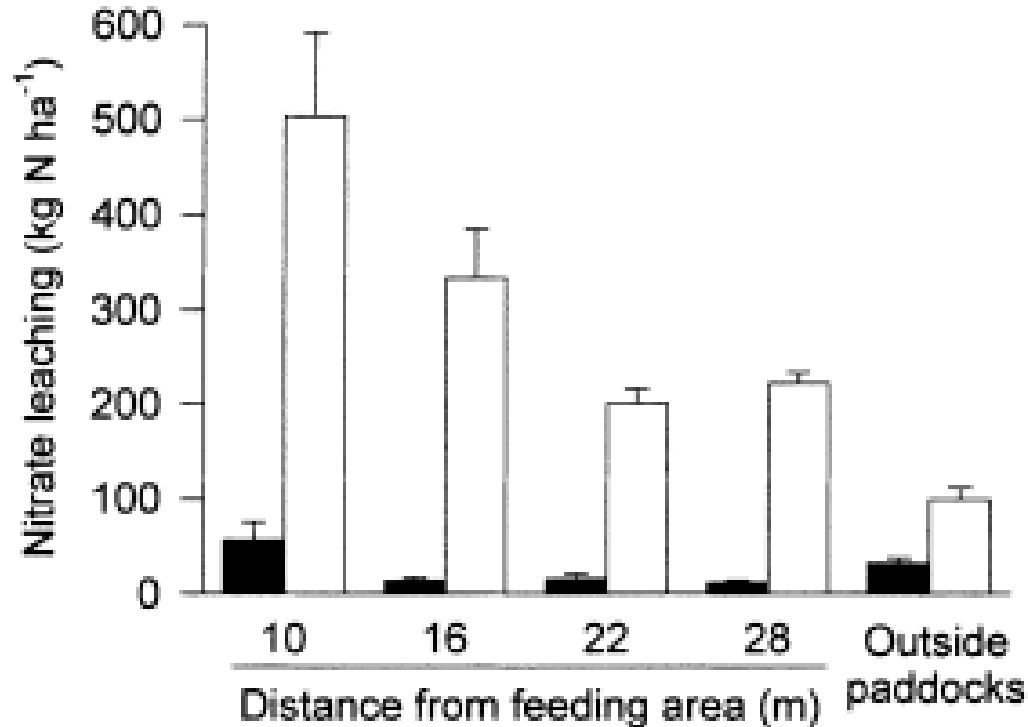
Very high nitrate concentrations have been measured below the root zone following a season of outdoor pigs



Four distances from feeding area and outside paddocks

Eriksen 2001. Grass and Forage Science [Volume 56, Issue 4](#), pages 317-322

And caused very high total leaching loss of nitrogen - at least close to feeding areas



Four distances from feeding area and outside paddocks – during (black) and after (white) grazing by lactating sows

Eriksen 2001. Grass and Forage Science [Volume 56, Issue 4](#), pages 317-322

N-balance for free range lactating sow system showed high losses

Table II. Tentative nitrogen mass balance for the piglet production system.

	kg N-ha ⁻¹	Output (% of feed input)
Input Feed	880	
Output Piglets	390	44
Ammonia volatilization	114	13
Denitrification	69	8
Nitrate leaching	141–308	16–35
Total	714–881	81–100

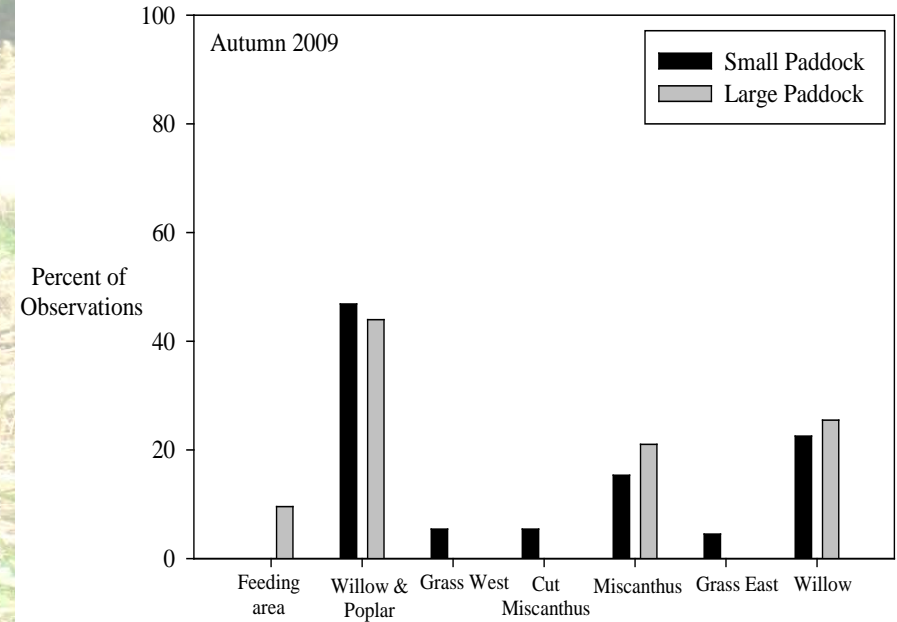
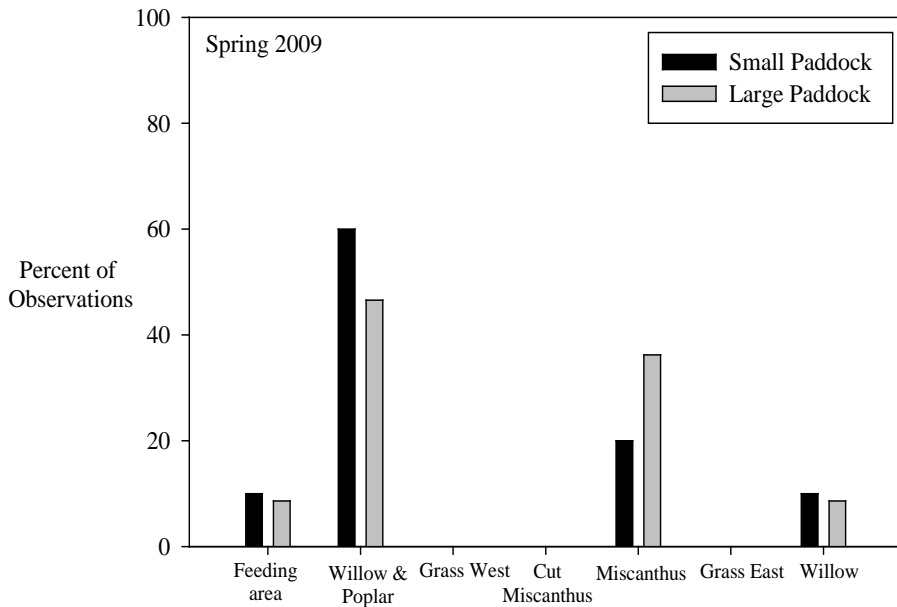
A combined system of free range pigs and perennial energy crops was tested with the hypothesis that a more persistent crop cover than grass could be secured

- Two groups of growing-finishing pigs were held during March – May and September – November 2009
- Two stocking densities
- Willow, poplar and miscanthus
- Crop damages insignificant and no plants were killed



Sørensen, 2010 & Horsted et al., 2012

High preference for excretory behaviour in energy crops and not on grass strips



Soil nitrate measurements showed low nitrate leaching – however difficult to integrate variability

Table 4 One year Nitrogen balance

System	Inputs (kgN/ha)			Outputs (kgN/ha)				
	Feed/Fertilizer ^a	Atmospheric ^b	Leaching ^c	NH ₃ -N losses ^d	N ₂ O-N and N ₂ emissions ^e	N retention in pigs ^f	Crop N off-take ^g	N accum
Small Paddock	765	14	30 (89 ^c)	37	63	230	87	332
Large Paddock	241	14	4 (11 ^c)	12	20	72	60	87
Willow Ref.	240	14	11 ^h	5	19	-	85	134

^a The value of feed is average feed-N given in spring (protein 16.9%) plus average feed-N given in autumn (protein 16.7 %).

240 kgN/ha mineral fertilizer was given to the Willow reference area

^b Estimated from the DEHM-model. The estimate is based on values from 2008 and Viborg was chosen as the municipal in the model

^c Estimated from soil N_{min} analysis in 0-75 cm depth

^d 7 % of N-content in manure and 2 % of N in NPK fertilizer (Andersen et al., 2001)

^e Estimated from SimDen in 0-100 cm soil layer

^f Average retention in each paddock. Retention of N is calculated as 30% of feed-N input

^g Crop off-takes comprise miscanthus and willow in the paddocks and only willow in willow reference area

^h NO₃ in soil water from 0-175 cm soil layer

Ongoing experiment at farmer Brian Holm – willow and poplar

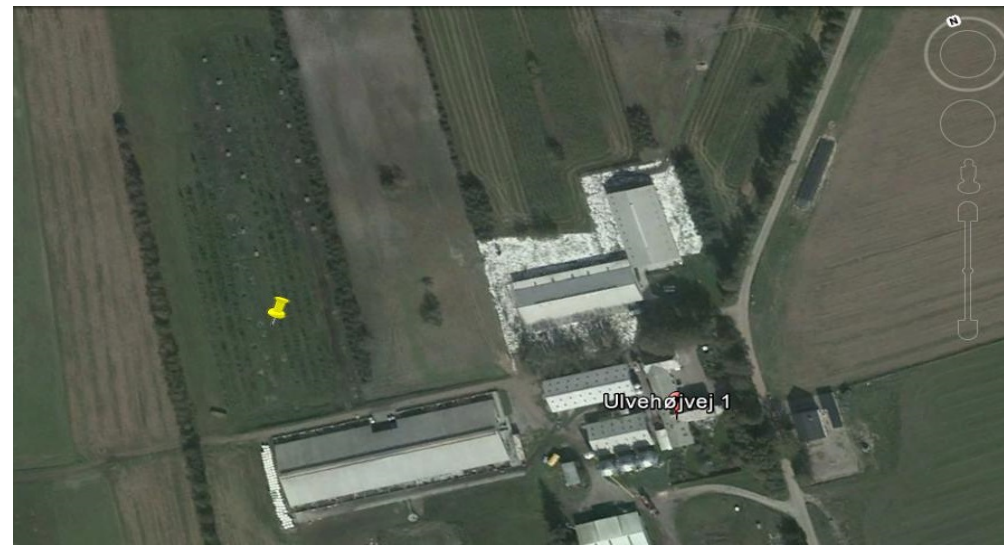
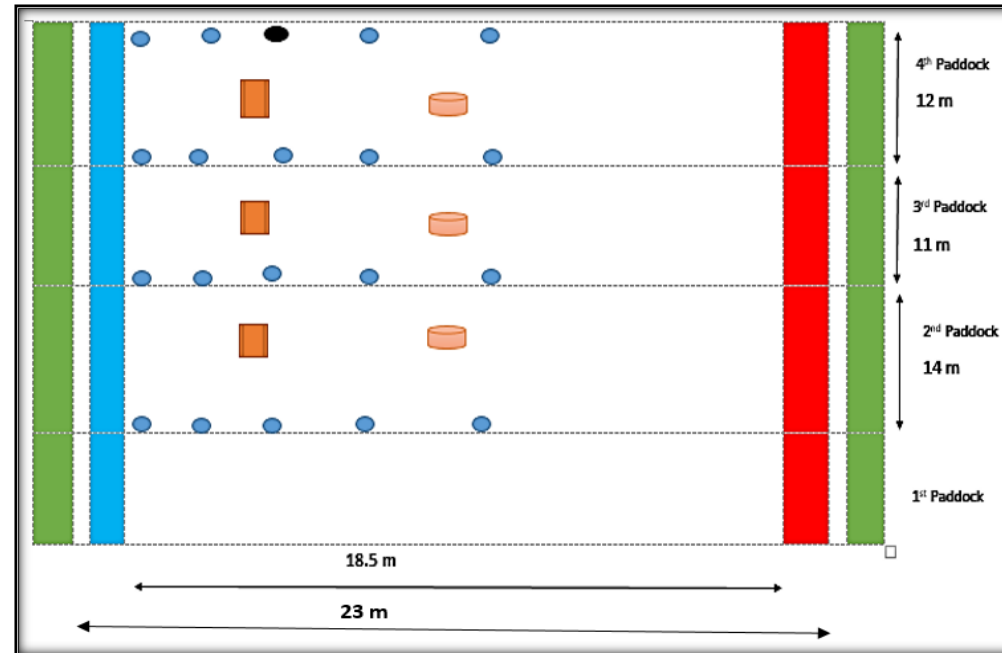
FARM BACKGROUND

- Hovborgvej Brorup, Region of Southern Denmark (Ulvehøjvej 1, 6650 Brørup)
- Location: 55° 34' 35" N, 8° 59' 30" E
- Among two biggest organic pig farms in DK with energy crops in pig paddocks
- Willow established in 2009
- 180 sows with weaning age of 8 weeks for piglets

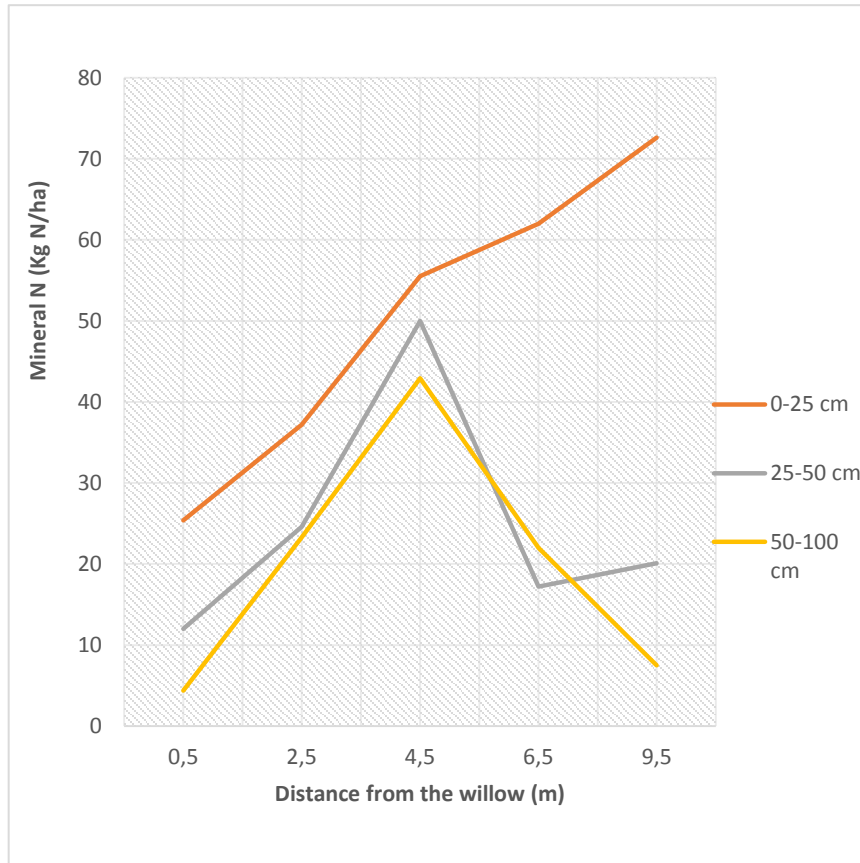
EXPERIMENTAL LAYOUT – willow

Master study by Emanuel Joel Lao

- Distance to willow row – five levels
- Soil depth – three levels
- Sampling time – 9 levels
- 4 replications



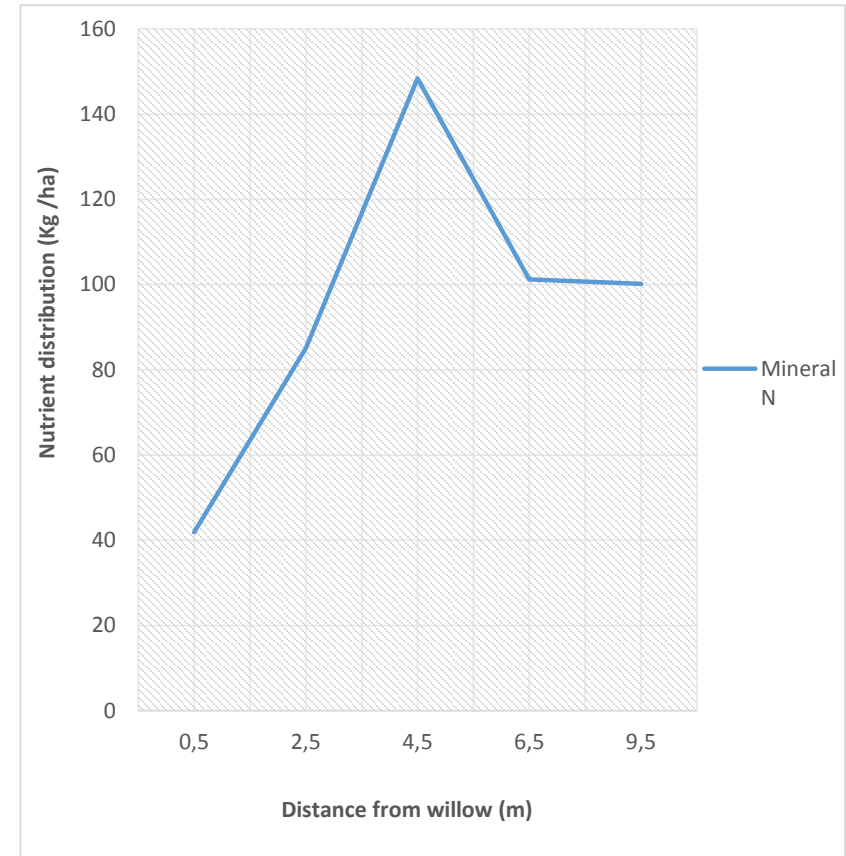
Soil Mineral N (NH₄-N & NO₃-N) in October following lactating sows since March



(a) Variations with depth and distance

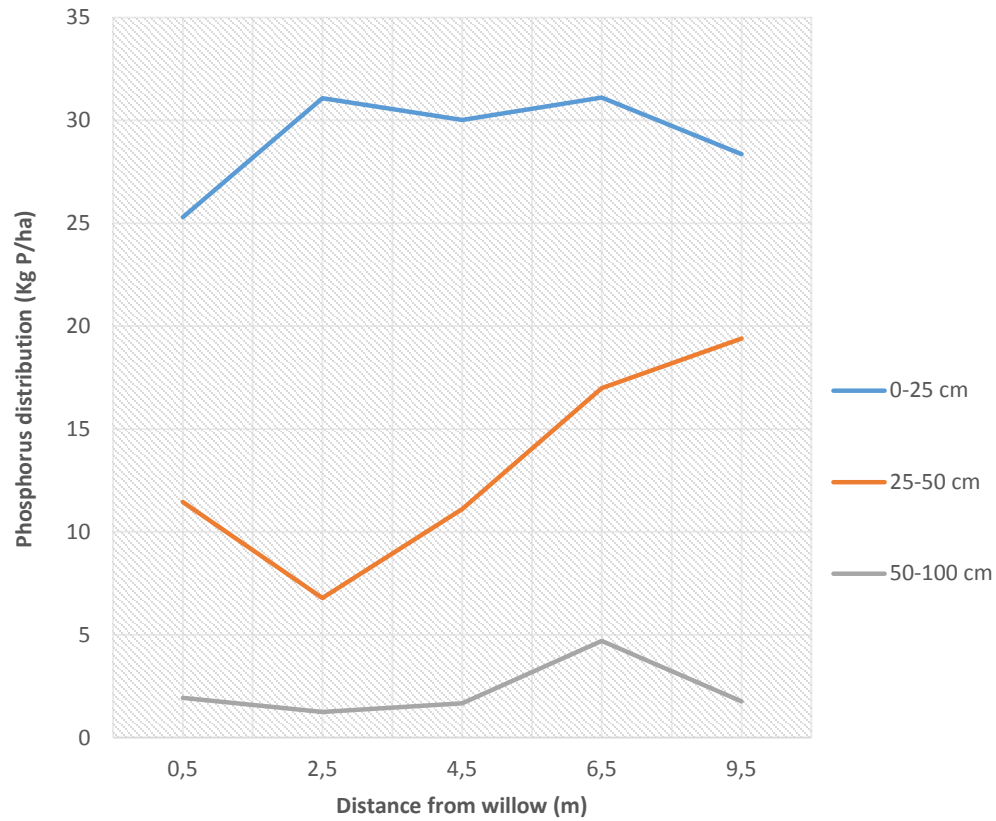
Depth effect - (DF=2, $p < 0.001$)

Distance effect - (DF=4, $p < 0.001$)

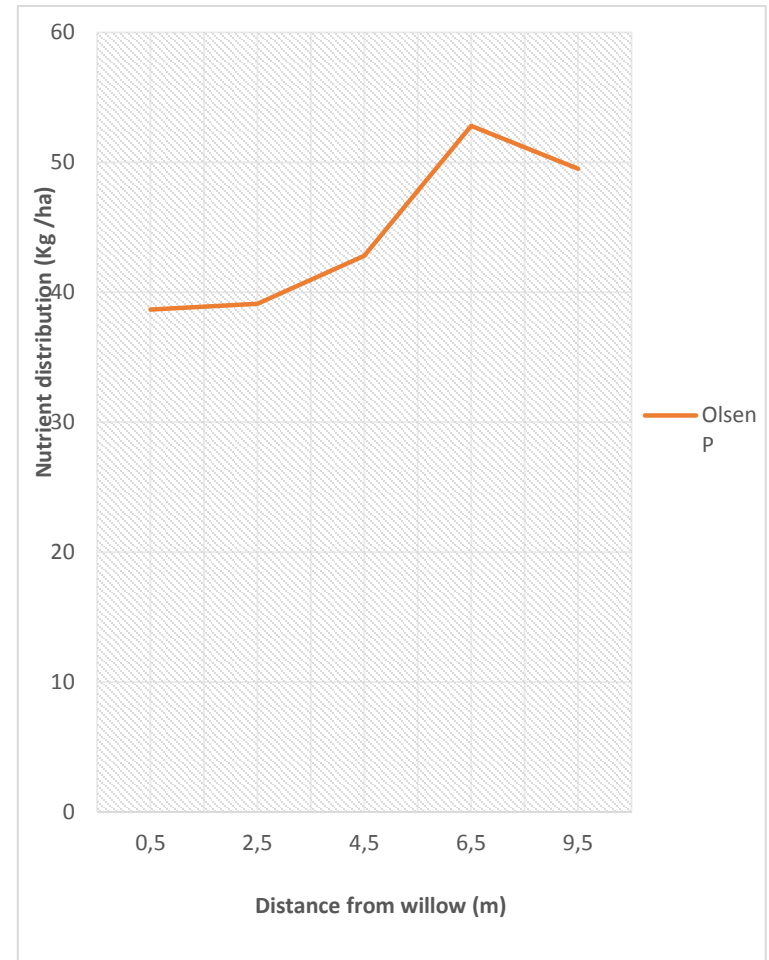


(b) Total Nmin in soil column

Phosphorous (Olsen-P) distribution



(a). Variation with depths



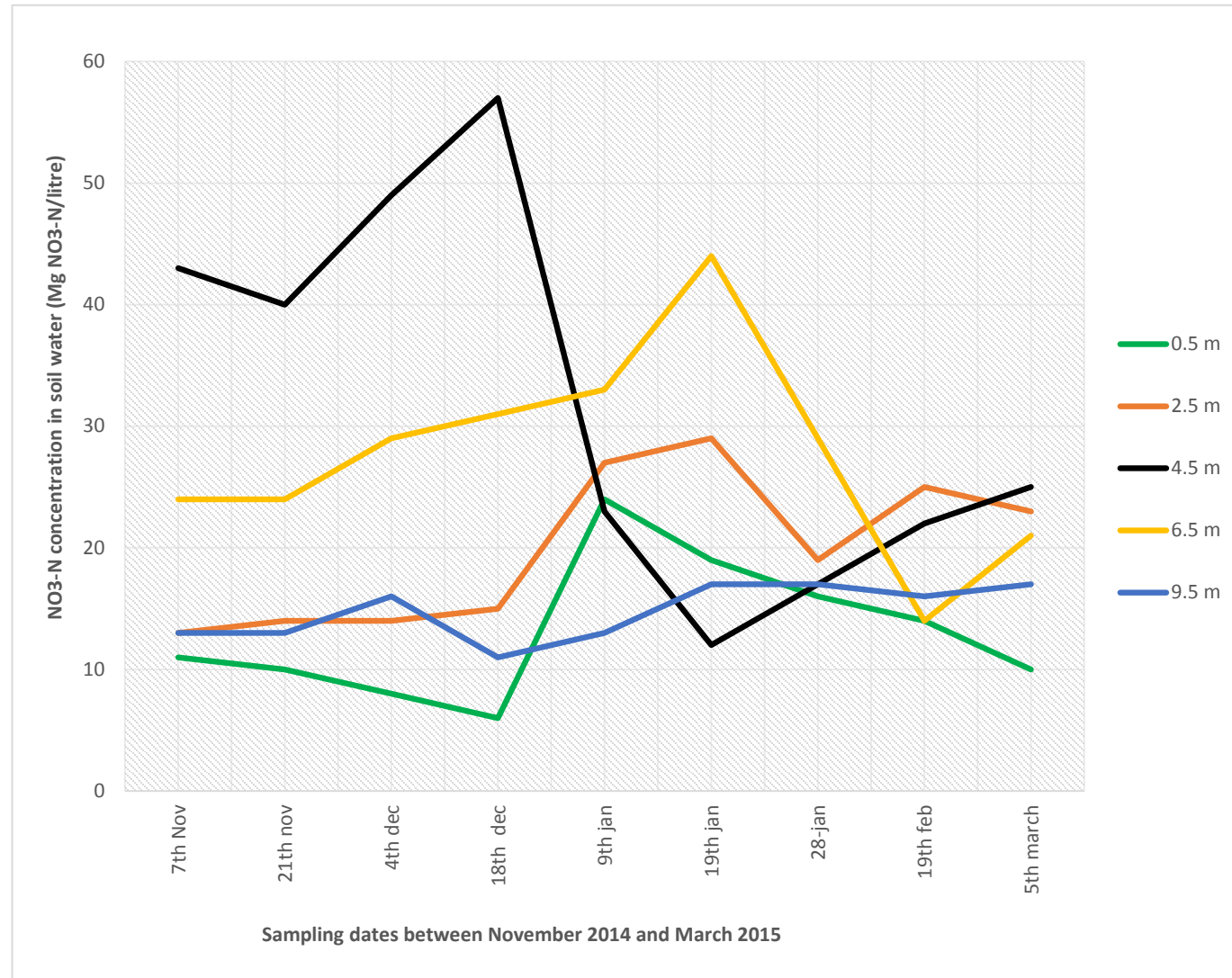
(b). Total P in soil column

Nitrate-N in soil water at 1.5 m depth during autumn-winter

- Interaction effect of distance and sampling time (DF=32, $p < 0.05$)
- Distance variations (DF=4, $p < 0.01$)
- Sampling time (DF=4, $p > 0.05$)

Average concentrations (mg NO₃-N/litre)

0.5 m - 13
2.5 m - 21
4.5 m - 37
6.5 m - 28
9.5 m - 15



Estimation of annual nitrogen balance for 3 rounds of lactating sows with willow borders – next year no pigs

N Balance estimation

Input		Kg N/ha	References
Grass yield		0	
Imported feed		1502	Brian farm document
N fixation		0	
Atmospheric Deposition		15	
Straws		5	Nielsen and Kristensen, (2005)
Seeds		0	
Loss of weight sows (30 kg/farrow period)		87	
Total N input		1610	
Output			
piglets		402	Eriksen et al., 2002
Uptake by Willow		39	Cavanagh et al., (2011)
N surplus		1168	
N in manure		1141	
Emissions		Emission Factor	
NH3 during grazing	0.07	80	Emission accounting Bioscience
Denitrification	0.1	117	IPCC standard
Potential NO3-N leaching and Soil Pool changes		972	Difference
N Efficiency (%)		27.4%	

But are standard estimations
correct in such a system?



Oct. 8th 2014

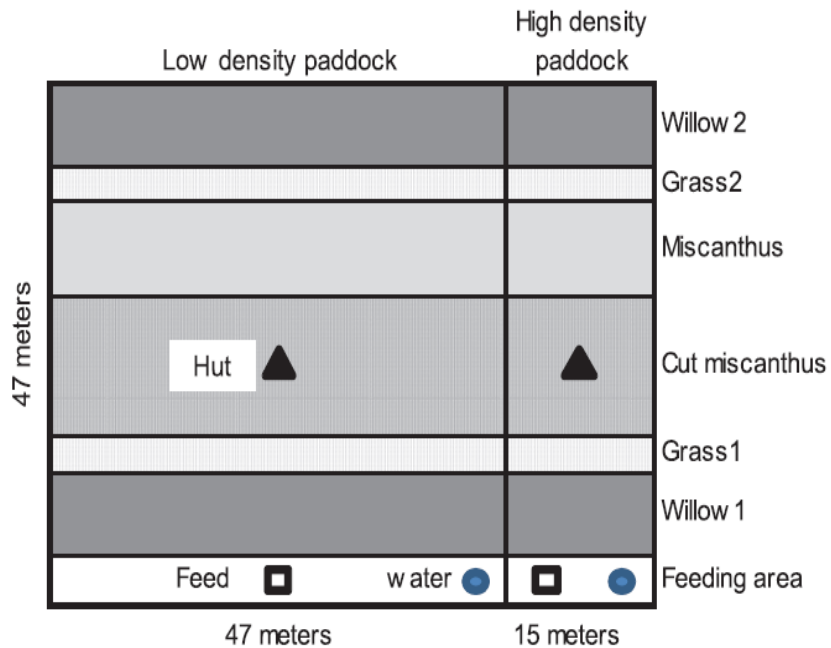
There seems to be large deviation between actual and potential nitrate leaching

- Potential nitrate leaching and soil pool changes 972 kg N/ha
- Rough nitrate leaching calculation willow area 76 kg N/ha
- bare soil area 179 kg N/ha

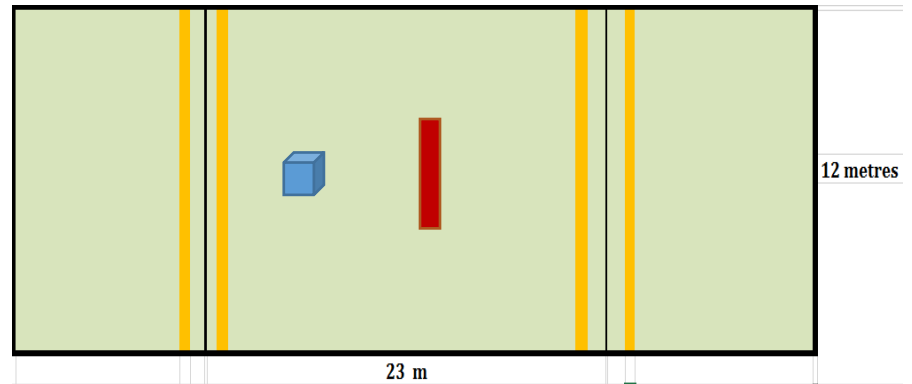
- Is denitrification much higher than estimated due to high mineral N and anaerobic conditions?
- Has much nitrate leached already in August?
- Is ammonia evaporation higher than estimated?
- Has the willow crop retained more than estimated?

Mineral N distribution may be manipulated by management, e.g. hut and feeder placement

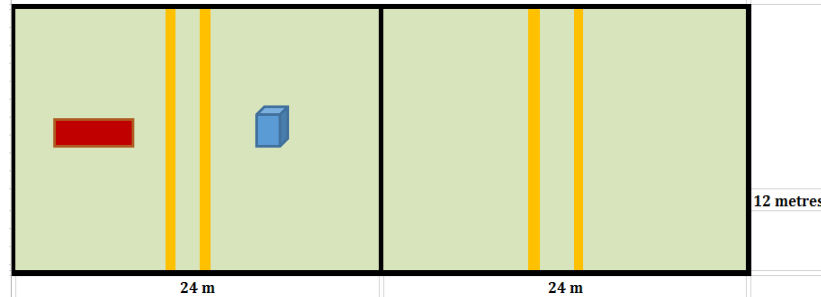
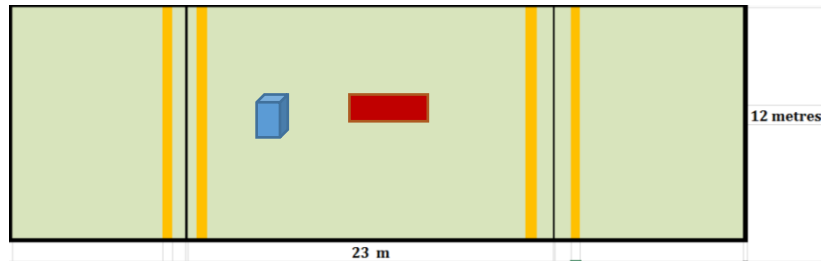
- **Horsted et al., 2012**



- **Lao, 2015**



Is the tree-grassland design appropriate to maximize the N-uptake by willow?



- Current design Brian Holm

- Proposed optimized design (Lao, 2015)

- But also stocking density, feeding efficiency, and willow density & harvest time should be considered
- Harvesting willow with leaves may remove 170 kg N/ha (Sørensen, 2010) if covering the whole area

2015: the willow paddocks were
sown with spring barley



New experiment with poplar rows and comparison with pure grass paddocks



Thank you

