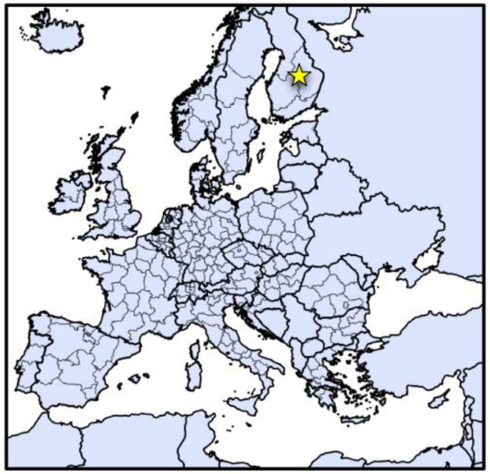


Finnish Pilot study: North Savo region

Luke Team:

Heikki Lehtonen, Reimund Rötter, Taru Palosuo, Xing Liu, Tuomo Purola, Jukka Höhn, Jarkko Niemi, Panu Korhonen, Perttu Virkajärvi, Olli Niskanen, Pellervo Kässi, Pirjo Peltonen-Sainio, Tapio Salo, Fulu Tao

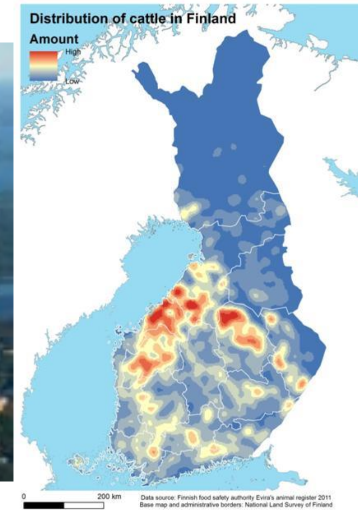
April 2015

Natural Resources Institute Finland (Luke)

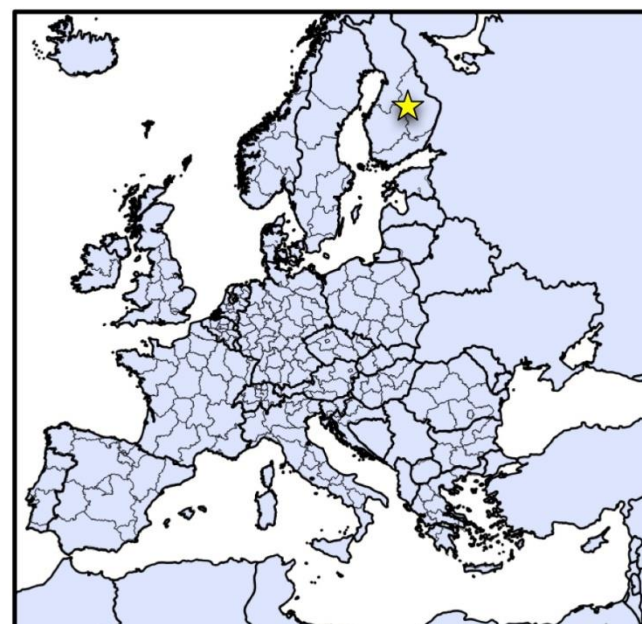
www.luke.fi

Firstname.lastname@luke.fi

North Savo region

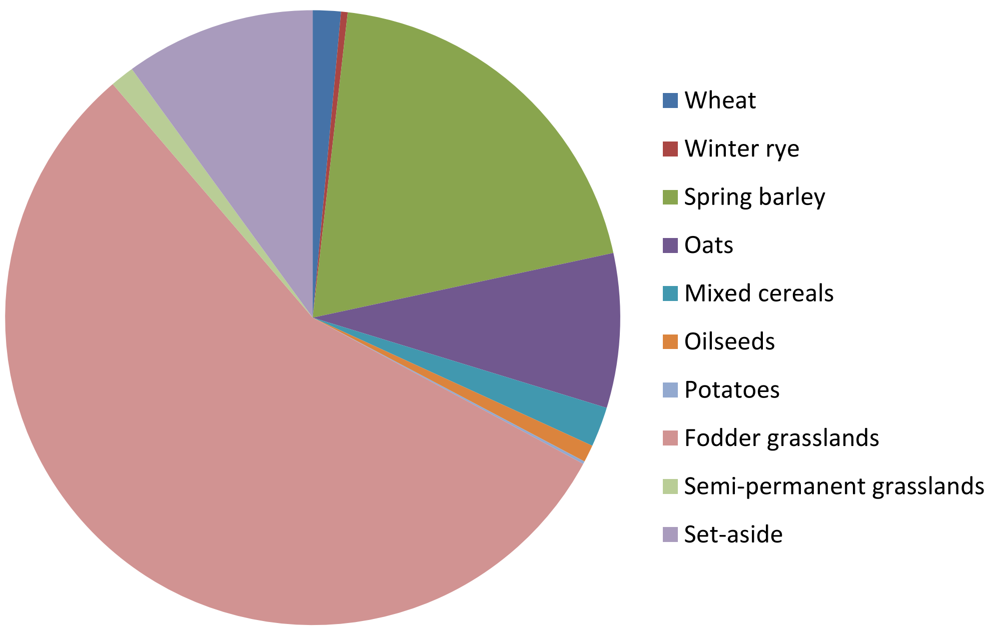


Total area 20 367 km2, 17.5% under water, beachline length 17000 km,
Population density 14.8 persons/km2 (Finland average 17.7)
247000 inhabitants (2010)
148000 ha farmland (8.8% of land area)
4200 farms
38000 dairy cows (10% out of whole Finland)
Cereals production becoming more popular, e.g. wheat, not only barley
Income/cap: 17000 eur (Finland average 18800 eur 2010)
http://www.pohjois-savo.fi/fi/pohjois-savo/



Agricultural activities

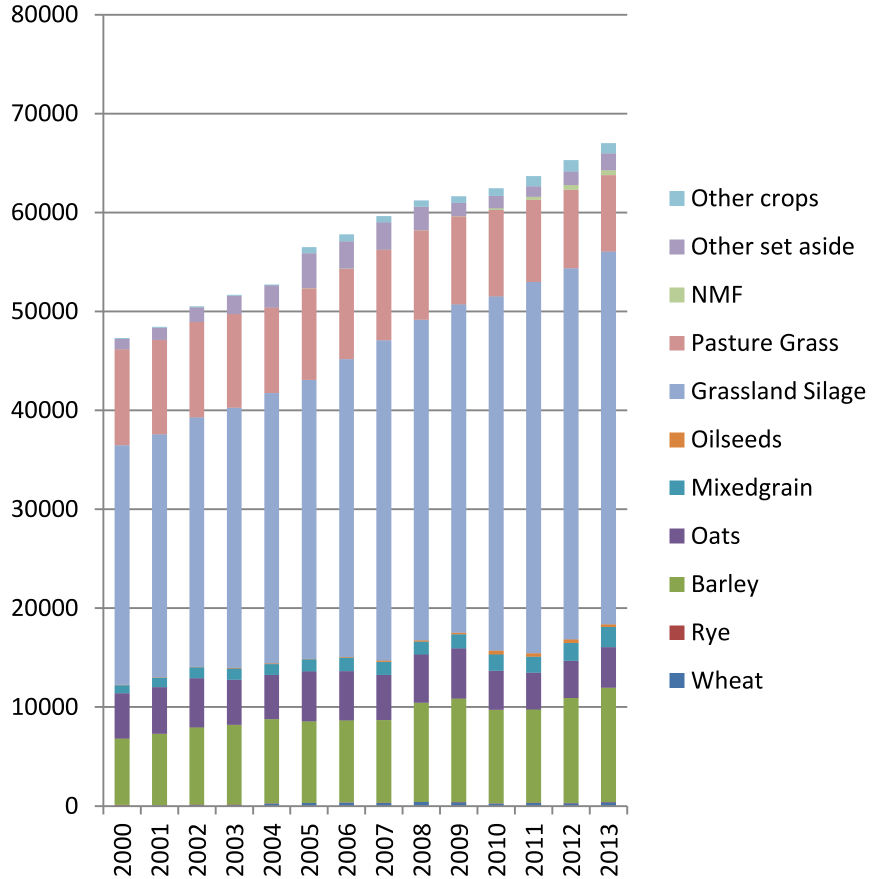
Land use distribution in North Savo (utilised agric. land 147,684 ha)

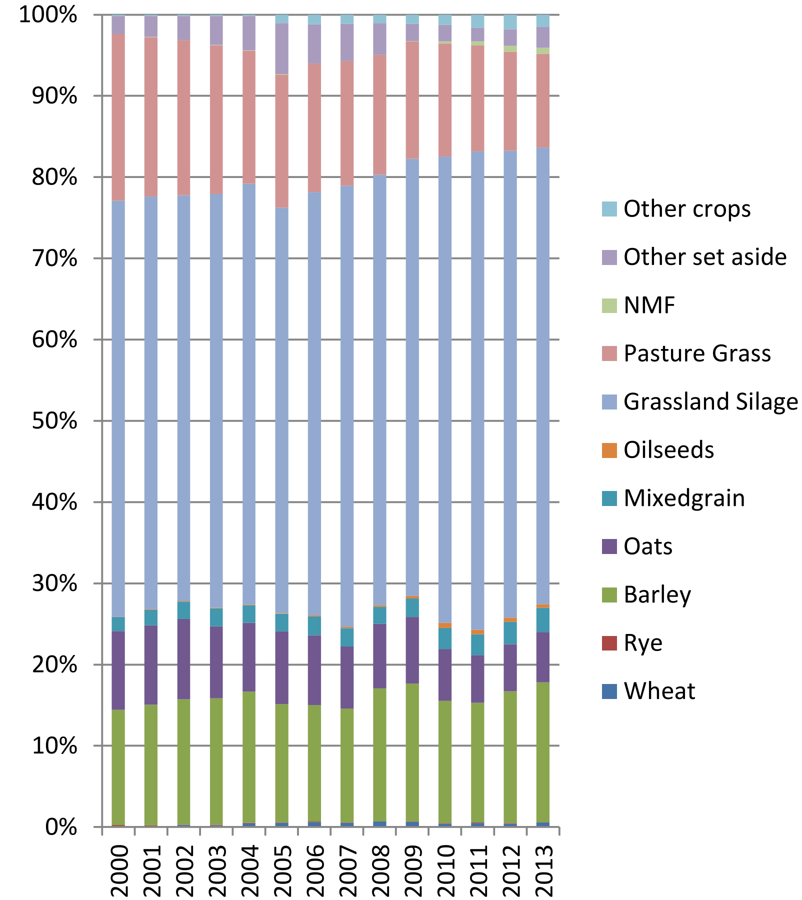


Number of livestock animals (1000 heads) in North Savo region 2011.
Source : Official farm statistics (www.mmmtike.fi)

	Pohjois-Savo
Dairy cows	38.1
Suckler cows	5.7
Bulls (>1 year)	14.4
Heifers	21.5
Calves	40.6
Cattle total	**120.3**
Fattening pigs	9.9
Pigs, 20-50 kg	7.1
Piglets	11.9
Sows	4.0
Pigs, total	**33.0**
Laying hens	18.2
Other poultry	4.6
Poultry, total	**29.5**
Sheep	3.4
Goats	0.3
Horses (at farms)	2.3

Land use (ha, %) at dairy farms





Projected climate change in Finland up to 2100, reference period 1971-2000

Source: Jylhä et al 2009, Ruosteenoja 2013

- Annual average temperature +2 - + 6 °C
  - In winter +3-+9 °C
  - **In summer +1-+5 °C**
- Annual precipitation + 12 - 22%
  - In winter +10 - 40%
  - **In summer + 0 - 20%**
- **Increased evapotranspiration during the growing period – threat of worsening early summer drought**

- Growing season length +30–45 days until 2100
- Temperature sum during growing period:
  - **Middle Finland 1100 -> 1600 degree days**;
  - Southern Finland 1300 -> 1900;
  - Northern Finland 900 -> 1200 degree days

- Increasing frequency:
  - rainy days, heavy rainfalls, dry spells
- **Decreased length of thermal winter**
- **Reduced snow cover and permafrost**
- Increased cloudiness

Median changes in selected agro-climatic indicators relative to 1971-2000

GISS-ER/**B1**

	2011-2040	2041-2070	2071-2100
Sowing date change (nr of days)	-3	-3	-4
Proportion of suitable sowing days	12	12	16
Date of the last spring frost (days)	-6	-5	-7
Effective radiation change (%)	13	9	14
Effective growing days (change in days)	20	26	41
Rain 3-7 weeks after sowing, change, mm	1,8	1,4	10,8
Proportion of dry days in AMJ, change (%)	0	1	-4
Proportion of dry days in JJA, change (%)	-6	-4	-14
Extreme high temp stress, change (days)	1	1	1
Temperature sum accumulation during grain filling, change, C	1,4	1,5	1

IPSL-CM4/**A2**

	2011-2040	2041-2070	2071-2100
Sowing date change (nr of days)	-9	-15	-17
Proportion of suitable sowing days	20	28	32
Date of the last spring frost (days)	-18	-24	-24
Effective radiation change (%)	5	-3	-13
Effective growing days (change in days)	7	31	52
Rain 3-7 weeks after sowing, change, mm	-6,4	-9,5	-12,3
Proportion of dry days in AMJ, change (%)	2	19	21
Proportion of dry days in JJA, change (%)	2	13	17
Extreme high temp stress, change (days)	1	4	6
Temperature sum accumulation during grain filling, change, C	2,3	3,7	5,4

Source: R. P. Rötter , J. G. Höhn & S. Fronzek (2012) Projections of climate change impacts on crop production: A global and a Nordic perspective, Acta Agriculturae Scandinavica, Section A – Animal Science, 62:4, 166-180, DOI: 10.1080/09064702.2013.793735

Indicators selected by Rötter et. al. (2010), Trnka (2011),

Climate (and management) related problems

- Spatio-temporal variability of crop yields (among field plots, years, etc.)
- Feed quality losses
- Winter time damages
- Soil compaction, wet conditions
- Plant pests becoming more frequent

Some climate related problems in North Savo region:

Ice encasement, due to warmer winters (hypoxia, frost). Photo: P. Virkajärvi (top),

Problems due to soil compaction. Photo: H. Mäkipää (middle),

Compacted soil, heavy axle loads. Photo: A. Mustonen (bottom, right);
Winter related damages (left, bottom. Photo P. Virkajärvi); effects of summer drought (bottom, middle. Photo E. Juutinen)

Adaptation solutions, cereals

- **Cereals cultivars requiring longer growing season**
  - Decrease vulnerability to (early summer) drought
  - More tolerant of heat stress
- **Earlier sowing times**
- **Improved / changed crop protection needed**
  - Currently no/little fungicide use => can be increased
  - More diverse crop rotations may relieve disease pressure
    - higher yielding oilseed /clover crops and cultivars => more protein production?
- **Adjusted fertilisation levels and timing/split applications**
  - Timely split applications according to development phases
  - According to yield potential of different crops and cultivars
- **Improved soil structure, soil pH, drainage**

=> resilience, extra costs…

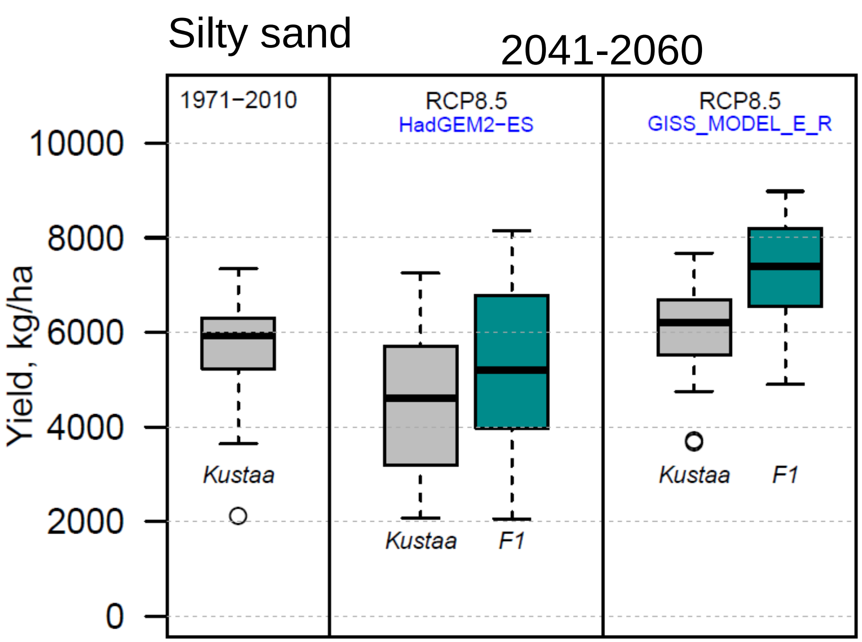
Assumptions used in WOFOST simulations, for evaluating changes in water-limited yields

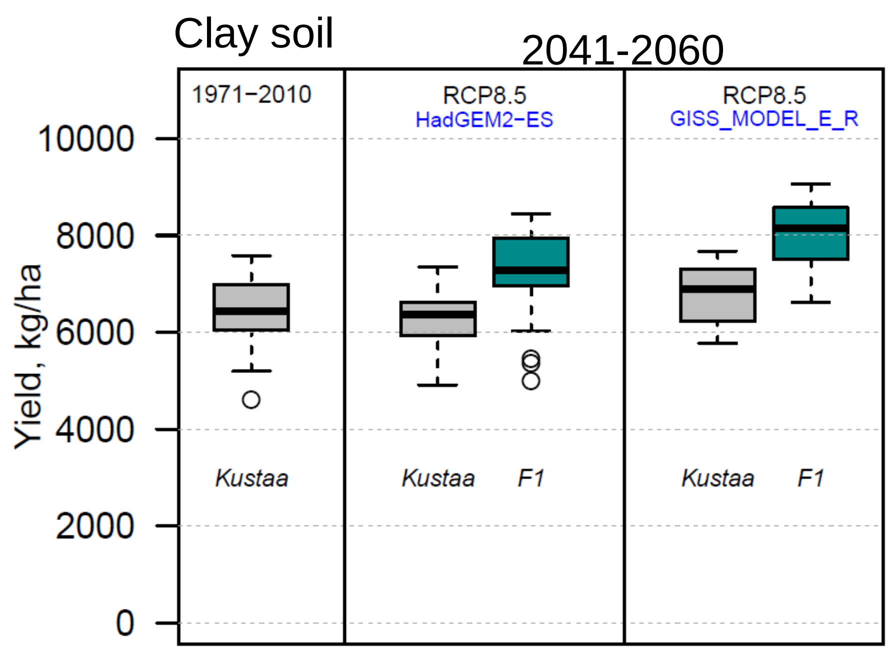
- Water-limited production situation – no nutrient limitations
- Sowing dates: calculated with a temperature threshold (8 °C) for the 10-day running mean.
  - Baseline period in Kuopio: mean 135 days (mid-May), std 9 days
  - 2041-2060 (RCP8.5, HadGEM2-ES): mean 119 days (late April), std 7 days
  - 2041-2060 (RCP8.5,GISS_MODEL_E_R): mean 135 days (mid-May), std 9 days
- No autumn cutoff other than maximum duration of 260 days
- Soil water content in spring assumed to be at field capacity

Future rainfed potential yields of barley in North Savo

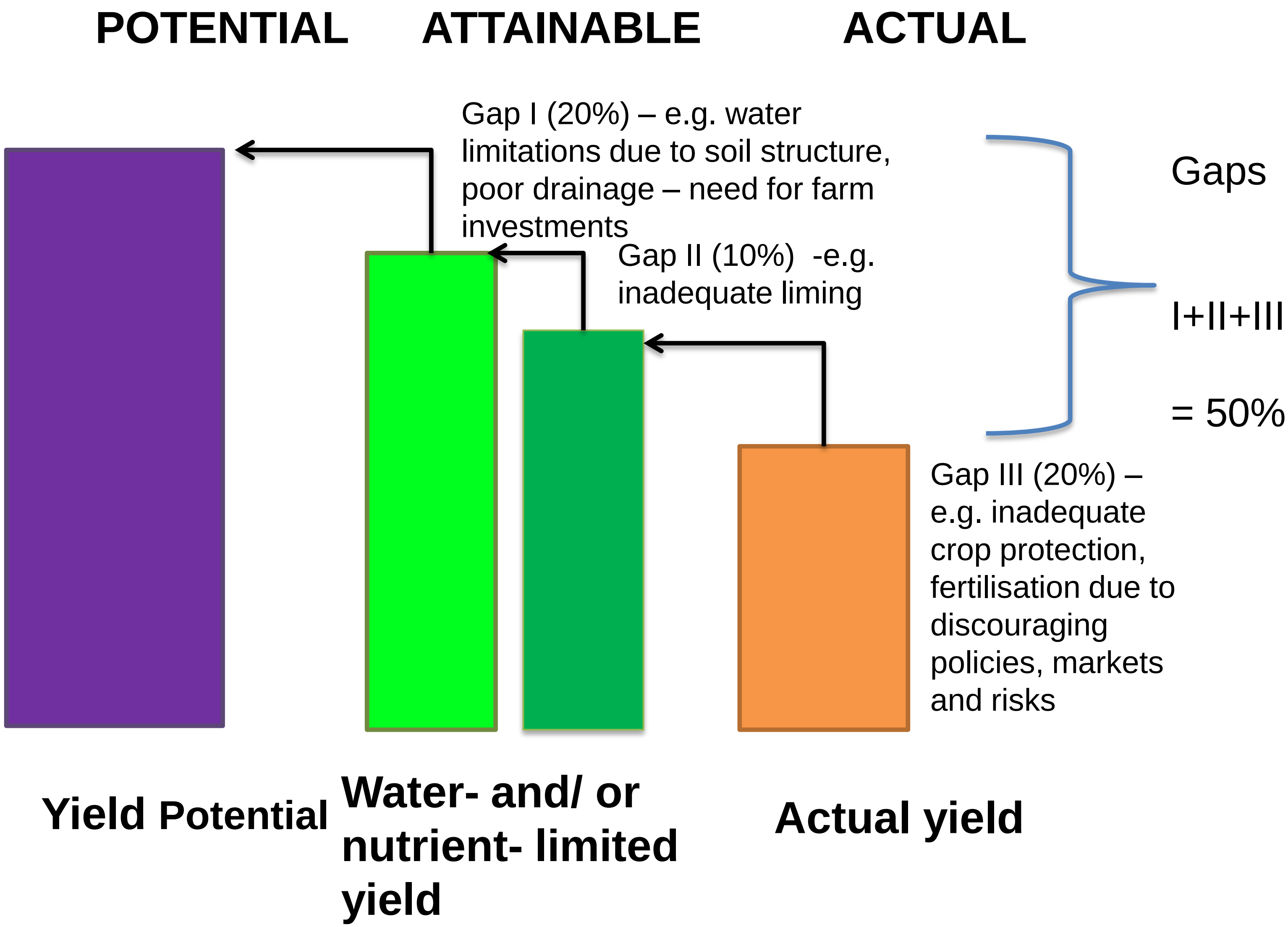
Water-limited yields simulated with model WOFOST using different emission scenario (RCP8.5) / climate model combinations for Kuopio (10 x 10 km grid)

- Current cultivar, Kustaa
- Possible future cultivar, ”F1” (only thermal requirement changed)





Yield gaps and their drivers



SIMULATE actual yields subject to different crop prices

Farm level economic analysis through dynamic optimisation over 30-40 years, adjusting
(1) N-fertilisation;
(2) soil improvements (liming, affecting soil pH value);
(3) fungicide use
(4) land use and crop rotation - monoculture implies increased disease pressure

… through production functions and crop yield responses
⇒Joint yield effects of N fertilisation, liming and fungicide use, crop rotation
⇒Yields, gross margins
Policies play a role: eligibility conditions, agri-environmental schemes

Peltonen-Sainio, P., Salo, T., Jauhiainen, L., Lehtonen, H. & Sieviläinen, E. 2015. Static yields and quality issues: Is the agrienvironment program the primary driver? AMBIO. ISSN 0044-7447. DOI 10.1007/s13280-015-0637-9
Lehtonen, H. & Rankinen, K. 2015. Impacts of agri-environmental policy on land use and nitrogen leaching in Finland. Environmental Science and Policy, Volume 50, June 2015, p. 130–144. doi:10.1016/j.envsci.2015.02.001

Simulated farm management and yields in 3 price scenarios for two farm types

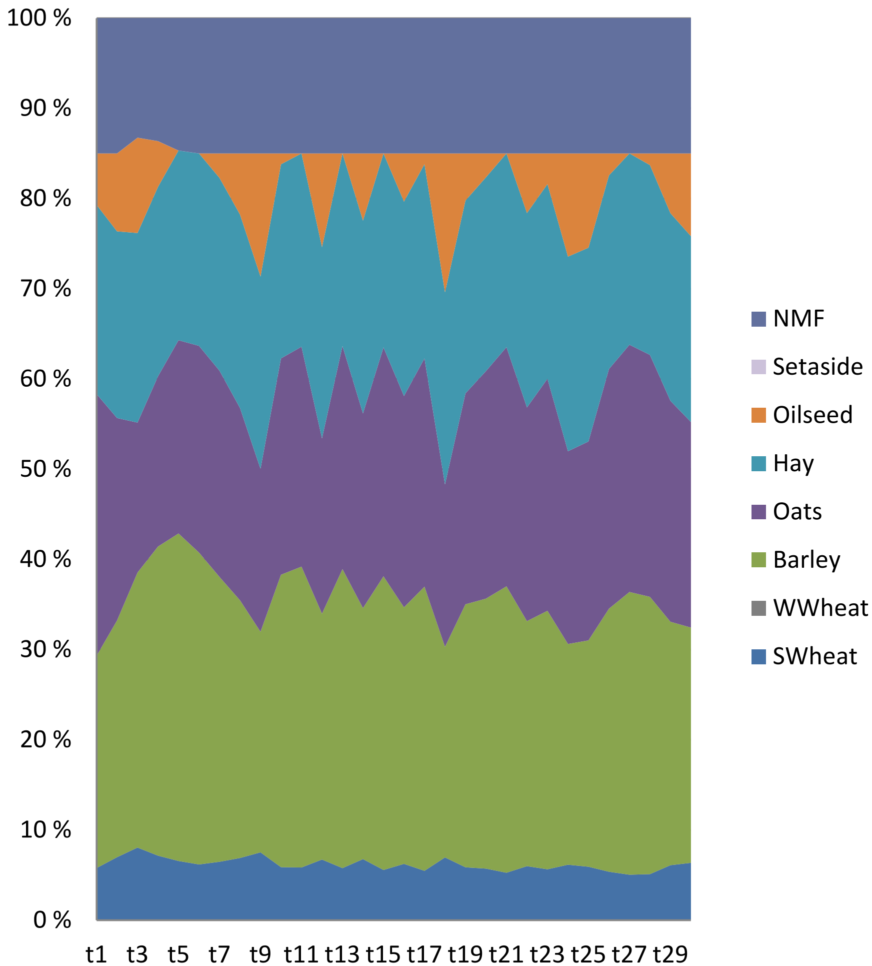
Simulated average yields, profit , soil pH and times of fungicide usage over the next 30 years under chosen scenario settings of crop prices with low (current) disease pressure setting

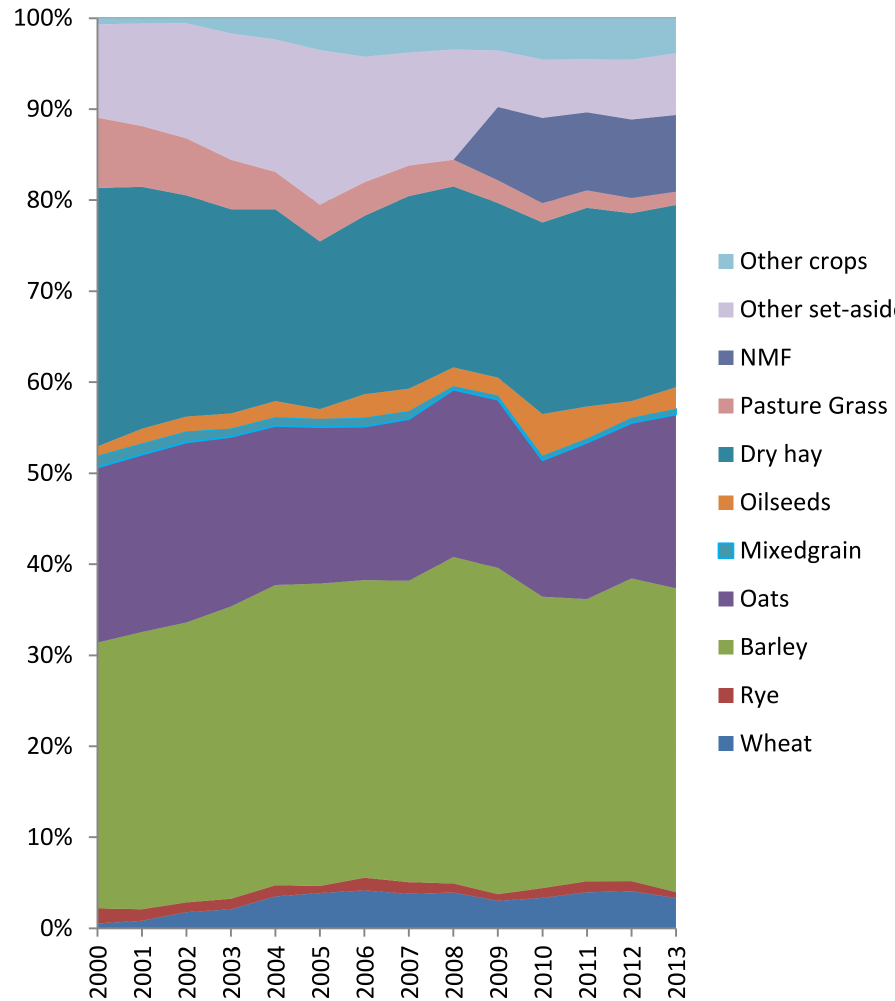
LP: Low price; MP: Moderate price; HP: High price. Moderate prices = 2008-2013 average prices; Low prices = -20%, High prices +20% from the MP level. Source: Lehtonen, H., Liu, X. & Purola, T. 2015. Balancing Climate Change Mitigation and Adaptation with Socio-Economic Goals at Farms in Northern Europe. Chapter 11 in book "Climate adaptation and food supply chain management in Europe", edited by A. Paloviita & M. Järvelä, to be published by Routledge

	Actual yield [kg/ha]	**Specialized cereals farm θ = 0.02**			**Other crop farm θ = 0.0165**		
		LP	**MP**	HP	LP	MP	HP
Average Yields	Spring wheat [3068]	2670 (-14.5%)	**3190 (3.8%)**	3364 (8.8%)	-	-	-
	Winter wheat [3066]	-	**-**	-	-	-	-
	Barley [3000]	2555 (-17.4%)	**2958 (-1.6%)**	3203 (7.9%)	2704 (-9.9%)	2942 (-1.9%)	3207 (6.9%)
	Oats [2786]	2469 (-12.9%)	**2898 (3.9%)**	3034 (8.2%)	2538 (-8.9%)	2855 (2.5%)	3036 (9.0%)
	Hay [3615]	3191 (-13.3%)	**3795 (4.7%)**	3963 (8.8%)	3138 (-13.2%)	3634 (0.5%)	3886 (7.5%)
	Oilseed [1305]	1106 (-18%)	**1368 (4.6%)**	1452 (10%)	-	-	-
Share of fungicide treated barley		0	0	116	0	0	97
Average pH		5.59	6.50	6.63	5.59	6.28	6.61
GHG emissions overall tons /year (normalized 10 ha)		23.49	28.75	31.52	16.90	22.00	24.34
GHG emission from organic soils (normalized 1 ha) /year		18.21	19.30	19.34	15.60	17.01	17.07

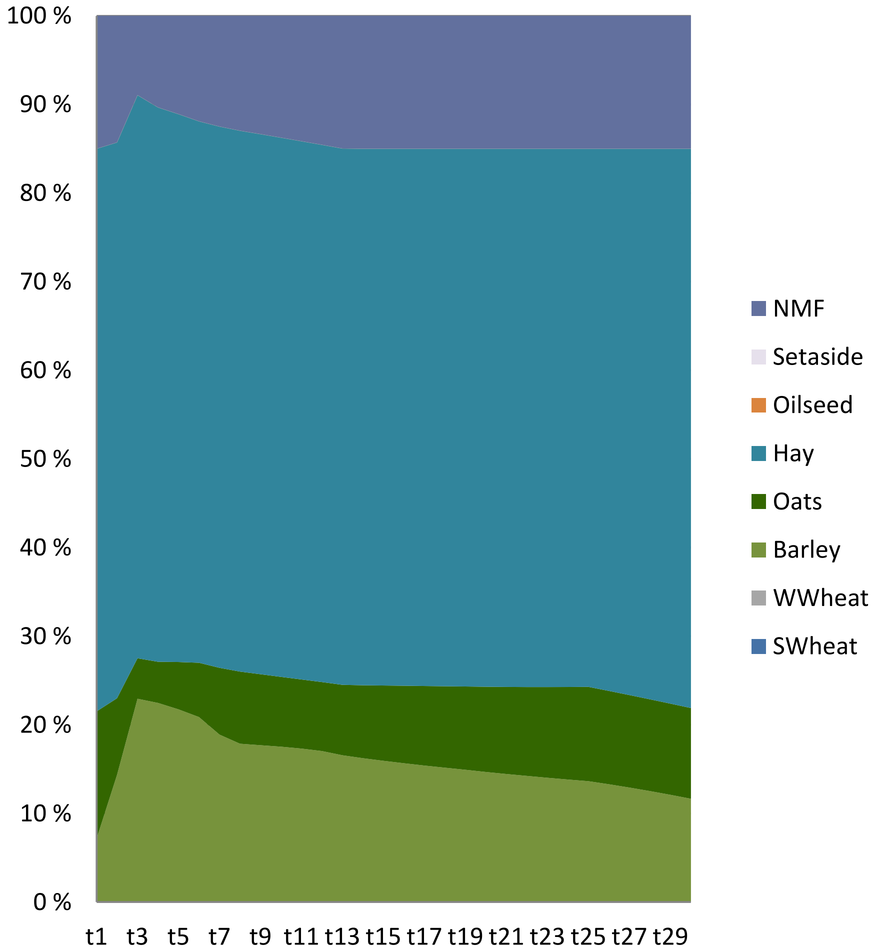
Note: [*] show the actual average yields (kg/ha) in North Savo of Finland 1995–2012 .

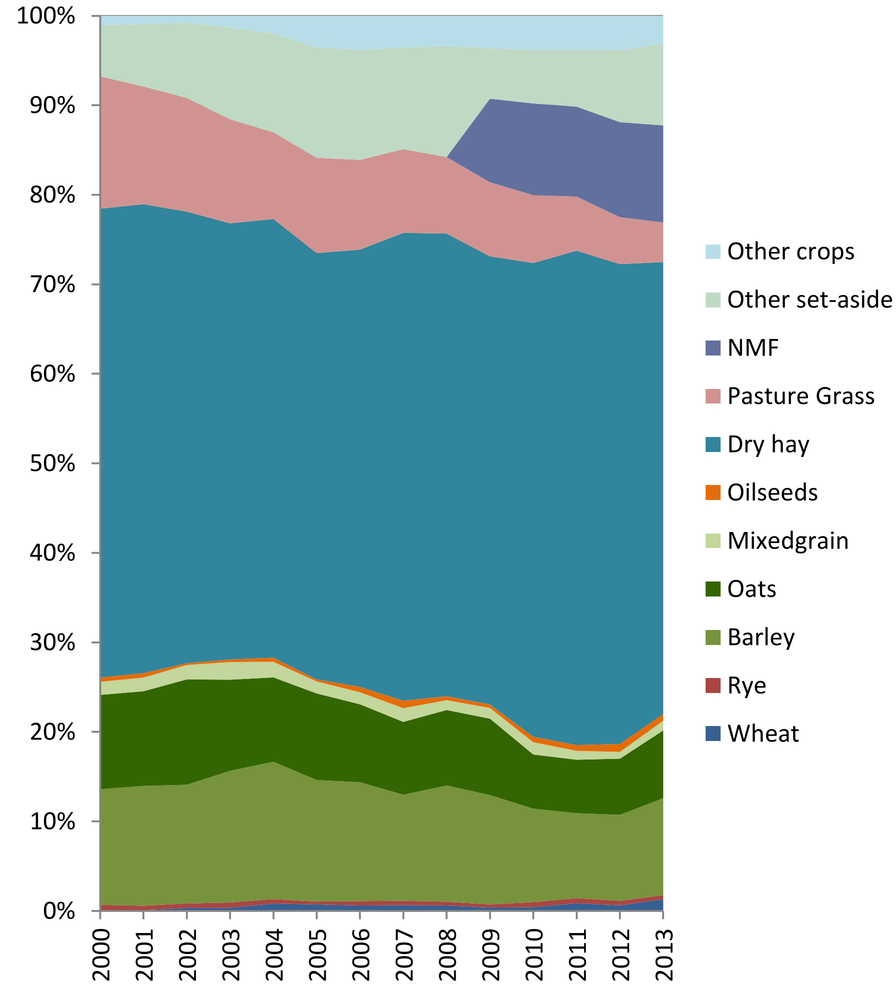
Simulated (low disease pressure, median price, left) land use over 30 years vs observed land use (right) on cereals farms in North Savo region Finland 2000-2013





Simulated land use over 30 years (left) vs observed land use on other crop farms in North Savo region (right) Finland 2000-2013





Adaptation solutions, grass

- Three cuts per year
  - Earlier cuts
- New grassland species and cultivars
  - More resistant to heat stress and drought
  - Better nutritive value
  - Sufficient winter hardiness
- Adjusted fertilisation levels
  - Proper timing, according to developmental phases
  - According to yield potential of different crops and cultivars
- Prevention of soil compaction
  - Drainage, sufficient
  - Development of machinery/use of machinery

The cost of managing farm level grass yield risk - Slightly decreasing in A1B!

- Excess silage grass area (own land + rented land) is kept to hedge against drought and silage deficit (buffer stocks of silage used)
- The mean yield of grass is gradually increasing from the baseline period up to middle-century
- Little change in the variation of grass yields in North Savo
- => The buffer stocks can be filled up more frequently in the climate scenario than in the baseline
- The average standard deviation of harvested yield decreases considerably in A1B, as well as the share of years of silage deficit
- Still the cost of risk remains significant – farmers need to keep sufficient grassland area and buffer stocks
  - Source: Kässi, P., Känkänen, H., Niskanen O., Lehtonen, H. & Höglind, M. 2014 Farm level approach to manage grass yield variation under climate change in Finland and North-Western Russia (submitted)

Farm level and regional perspectives

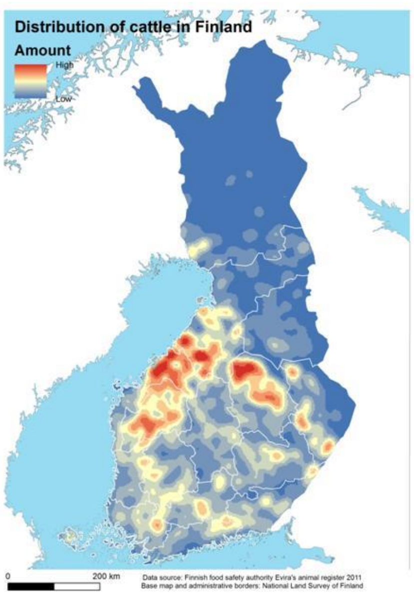
Stakeholder workshops revealed disappointments to current policies
”Policy schemes favor part-time farms, but are difficult /impossible for full-time, expanding farms”; ”It is easier to adapt to climate change than to EU and national policy changes”

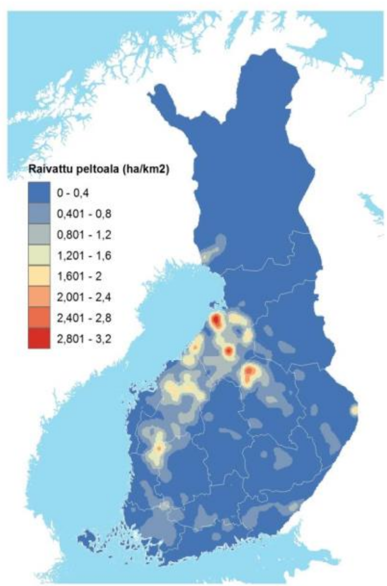
- “Some policy schemes discourage productivity growth, re-organisation and structural change”

- “Overall effect of many individual retarding effects accumulate, making ambitious farmers frustrated”

Now aver size of dairy farms 35 cows/farm. Fewer and larger dairy farms - Expanding dairy farms need land Frictions on land market => high land prices => intensive production, higher yields demanded

Left: Distribution of cattle
Right: Land clearance (ha/km2) 2000-2009



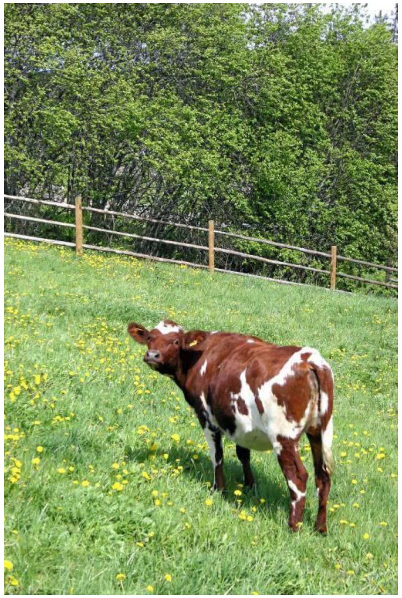


How to improve functioning of land markets? – short rental contracts, low commitments for land maintenance

How to improve ”land availability” for agricultural activities producing most value added in the region?
…while simultaneously decreasing GHG emissions ?

Land clearance has been a solution for some individual farms, despite high costs
This is due to incoherent policies

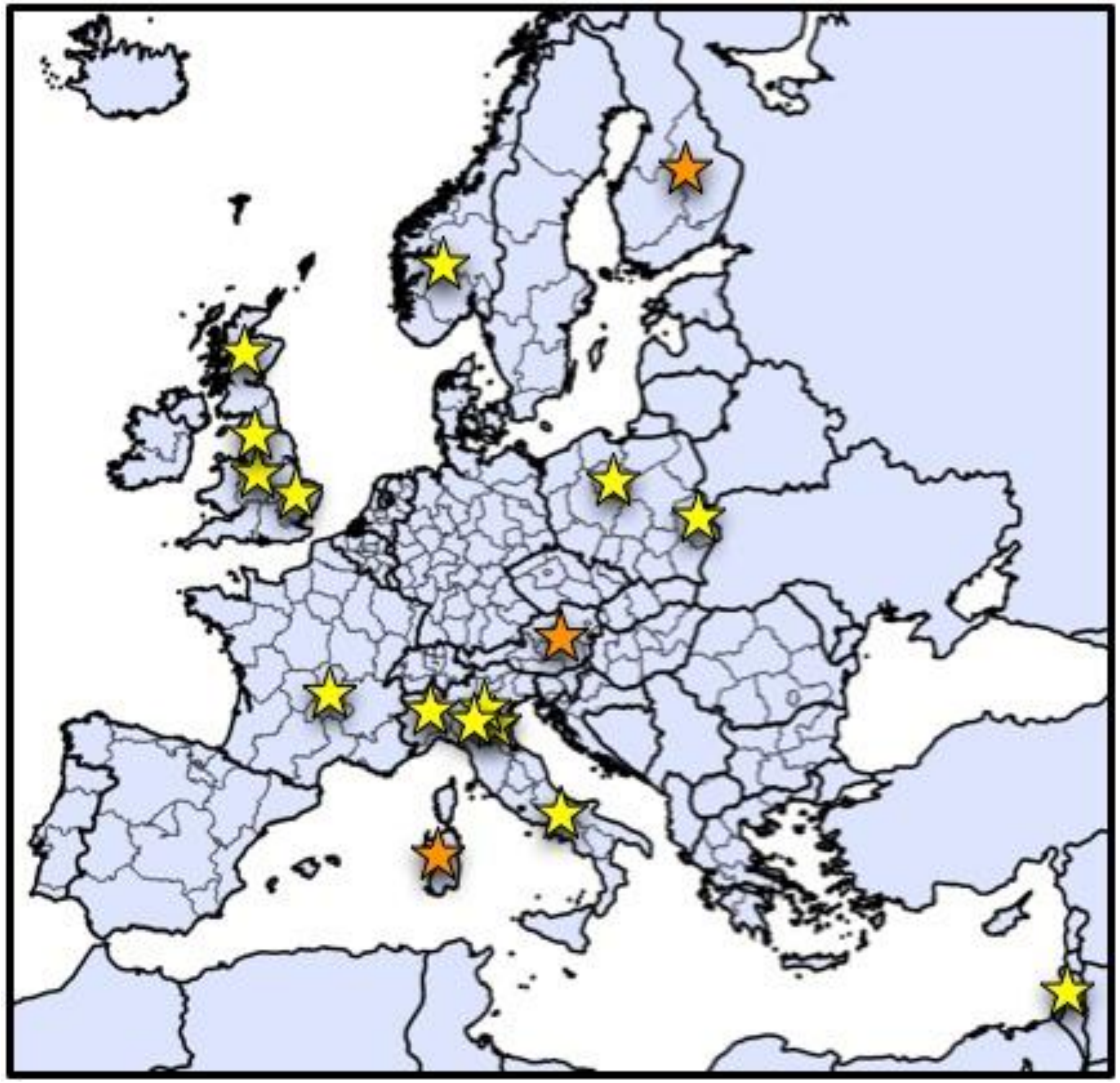
Summary on adaptation options in Northern Savo, Finland



Photos: Pentti Raiskio/Luke

- Increasing grass growth benefits dairy and beef
- Inter-annual volatility of grass yield increases
- Managing grassland yield variation: cost of drought risk relieved if moderate warming (e.g. A1B), but may increase if strong warming
- Increase in attainable yields of cereals and oilseeds is uncertain, more frequent droughts on sandy soils
  - New breeds such as heat/drought tolerant cereals cultivars, one important part of the solution!
  - More emphasis on maintaining soil quality!
- Positive market development + more flexible encouraging policies needed for medium/ long-term investments in:
- drainage, soil structure, lower axle loads, cultivars, crop rotation, manure spreading

Kiitos!
Thank you!



Contact:
Heikki.Lehtonen@luke.fi

http://macsur.eu/index.php/regional-case-studies/