Evaluating clover grass as a climate change adaptation measure in agriculture at the sector level

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Outline

- Introduction
- Different scales in modelling policy impacts
  - Crop and animal level
  - Farm level
  - Sector level
- Implementing clover grasses in sector models
- Impacts of climate change on grass production choices and land use
- Conclusive remarks

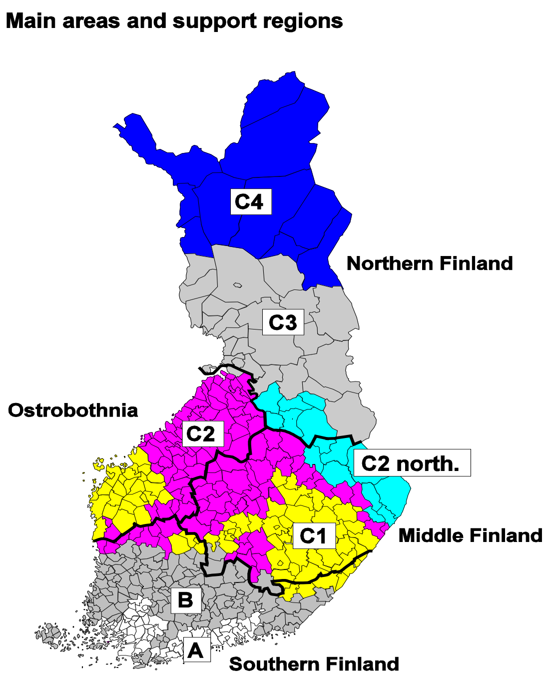
Impacts of CC on clover grass yields

- Based on a relatively large survey of literature on the clover grasses in climate change, one can conclude that clover grasses…
  - Benefit more on warmer springs than hay grasses
  - Benefits more on increased CO_2 concentration than hay grasses
  - Are more tolerant to drought than hay grasses
  - Produce lower dry matter yields than hay grasses
  - Produce higher protein content than hay grasses

Why sector level economic analysis of clover grasses changes?

- Grass production choices are linked to cattle feeding, manure spreading and regional level land use
- Links farm level changes with the markets – global prices
  - Can evaluate sensitivity of land use change on global prices
- Implied changes in farm size distrubution
  - Some farms are able to cope with the changes
  - => re-distribution of production between farms of different size, orientation, location
- Changed regional production allocation
  - Multi-regional point of view, comparative advantage
- Changed overall production and consumption of different products
  - Changed imports and exports

Main elements of MTT's DREMFIA model



Optimisation

MAX: producer and consumer surplus

- annual market equilibrium
- different yields and inputs in regions
- feed use of animals changes endogenously
- constraints on energy, protein and roughage needs of animals
- non-linear yield functions for dairy cows
- domestic and imported products are imperfect substitutes
- processing activities of milk and sugar
- export cost functions

Results/Initial values

production land use consumption prices
imports exports transportation

Policy scenarios

supports for farmers EU prices

Crop yield functions

- optimal level of fertilisation

Steering module

- bounds for land use variables; validated to observed data
- trends in consumption
- inflation
- increase in crop and animal yield potential

Model of technology diffusion

- endogenous sector level investment and technical change
- investments depend on relative profitability and accessibility of each technique
- gradual shifts of capital to best performing techniques

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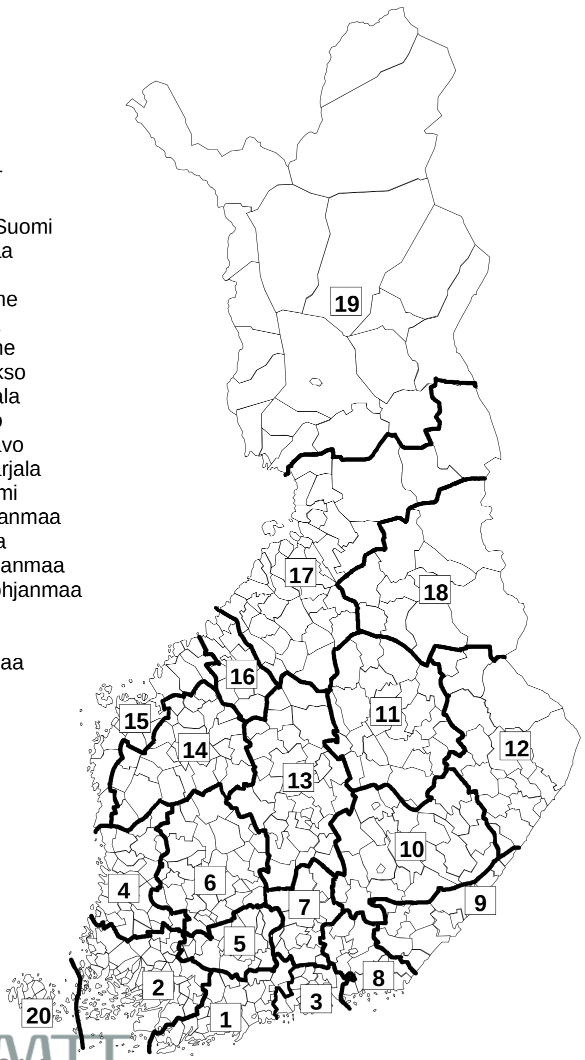
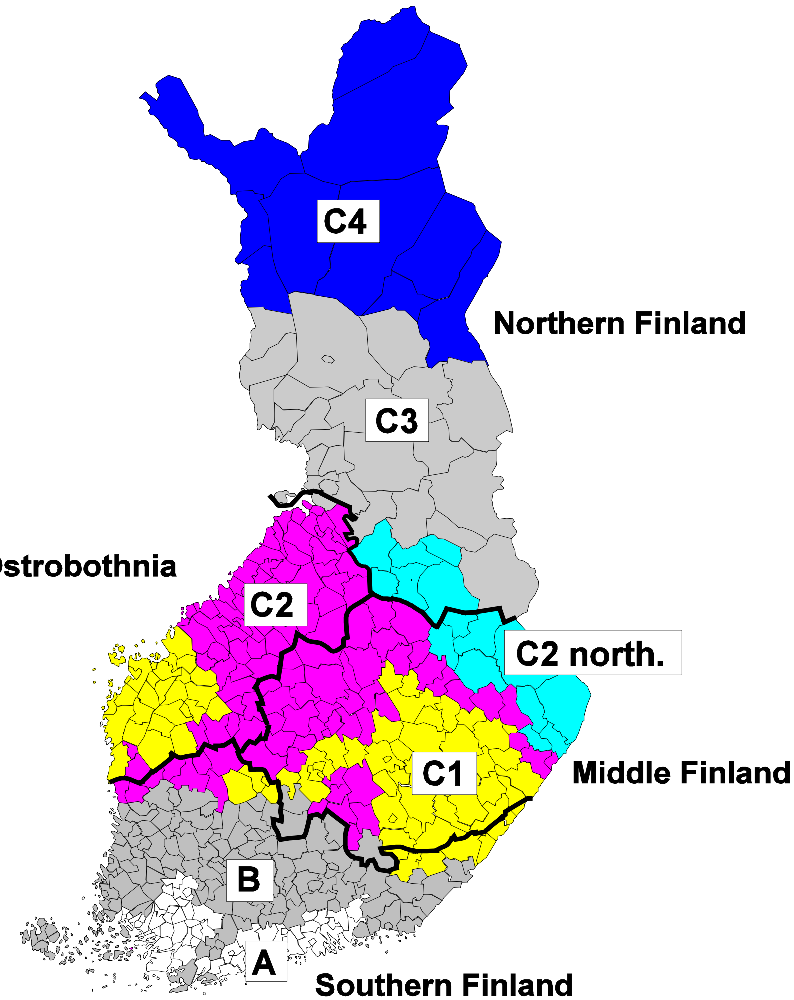
Lehtonen, H. 2001. Principles, structure and application of dynamic regional sector model of Finnish agriculture. Academic dissertation. Systems Analysis Laboratory, Helsinki University of Technology. Publisher: Agrifood Research Finland, Economic Research (MTTL). Publications 98. Helsinki. 265 pages. http://lib.tkk.fi/Diss/2001/isbn9512256894/

Regional disaggregation is a mix of provinces and agricultural support zones

MAAKUNNAT
1 Uusimaa
2 Varsinais-Suomi
3 Itä-Uusimaa
4 Satakunta
5 Kanta-Häme
6 Pirkanmaa
7 Päijät-Häme
8 Kymenlaakso
9 Etelä-Karjala
10 Etelä-Savo
11 Pohjois-Savo
12 Pohjois-Karjala
13 Keski-Suomi
14 Etelä-Pohjanmaa
15 Pohjanmaa
16 Keski-Pohjanmaa
17 Pohjois-Pohjanmaa
18 Kainuu
19 Lappi
20 Ahvenanmaa

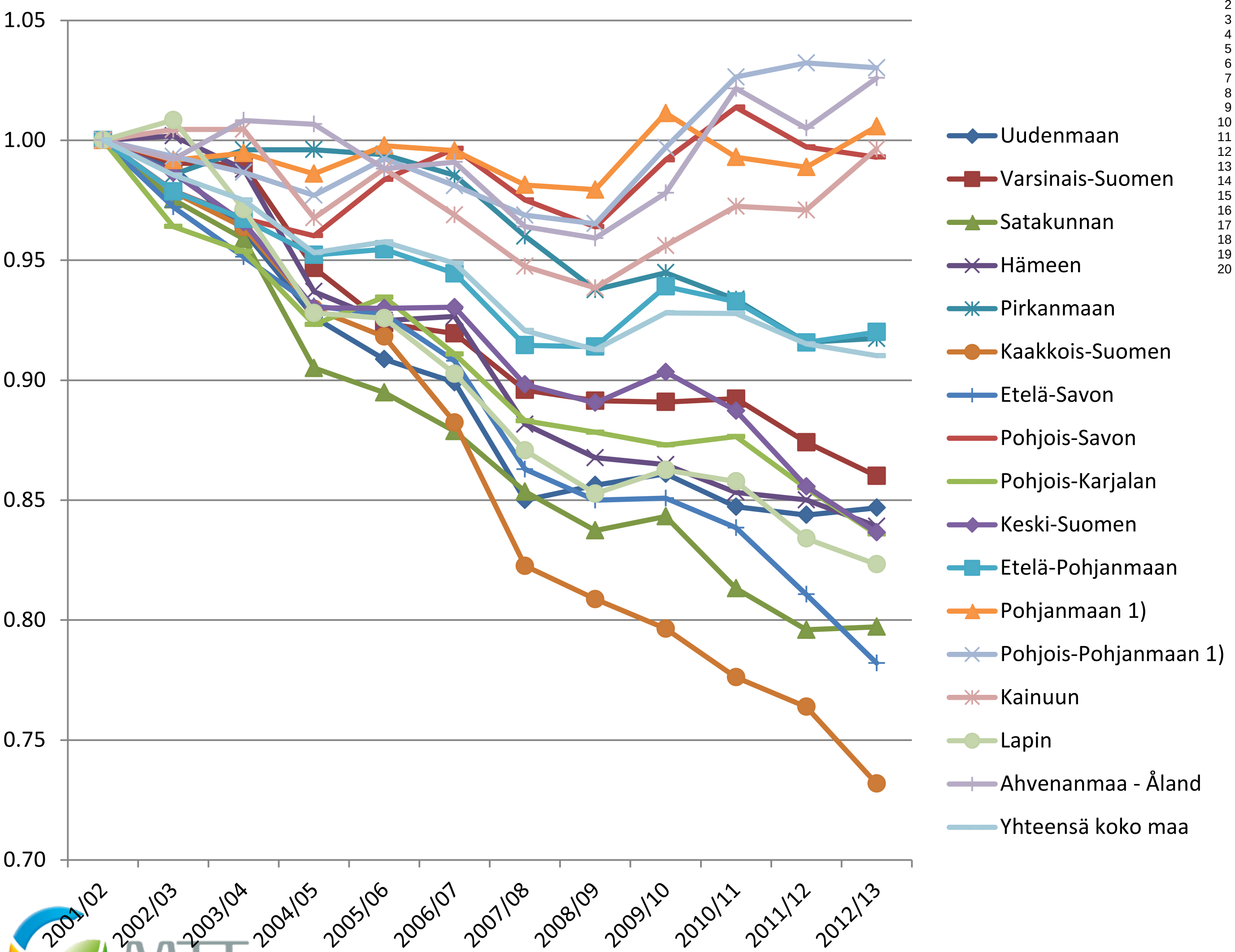


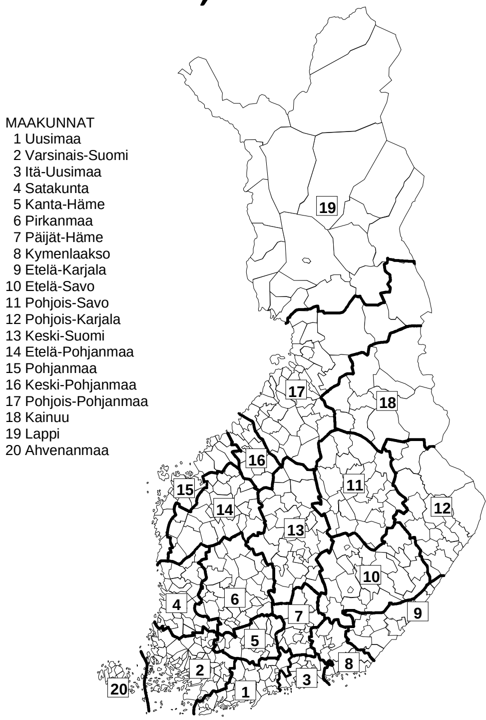
Main areas and support regions



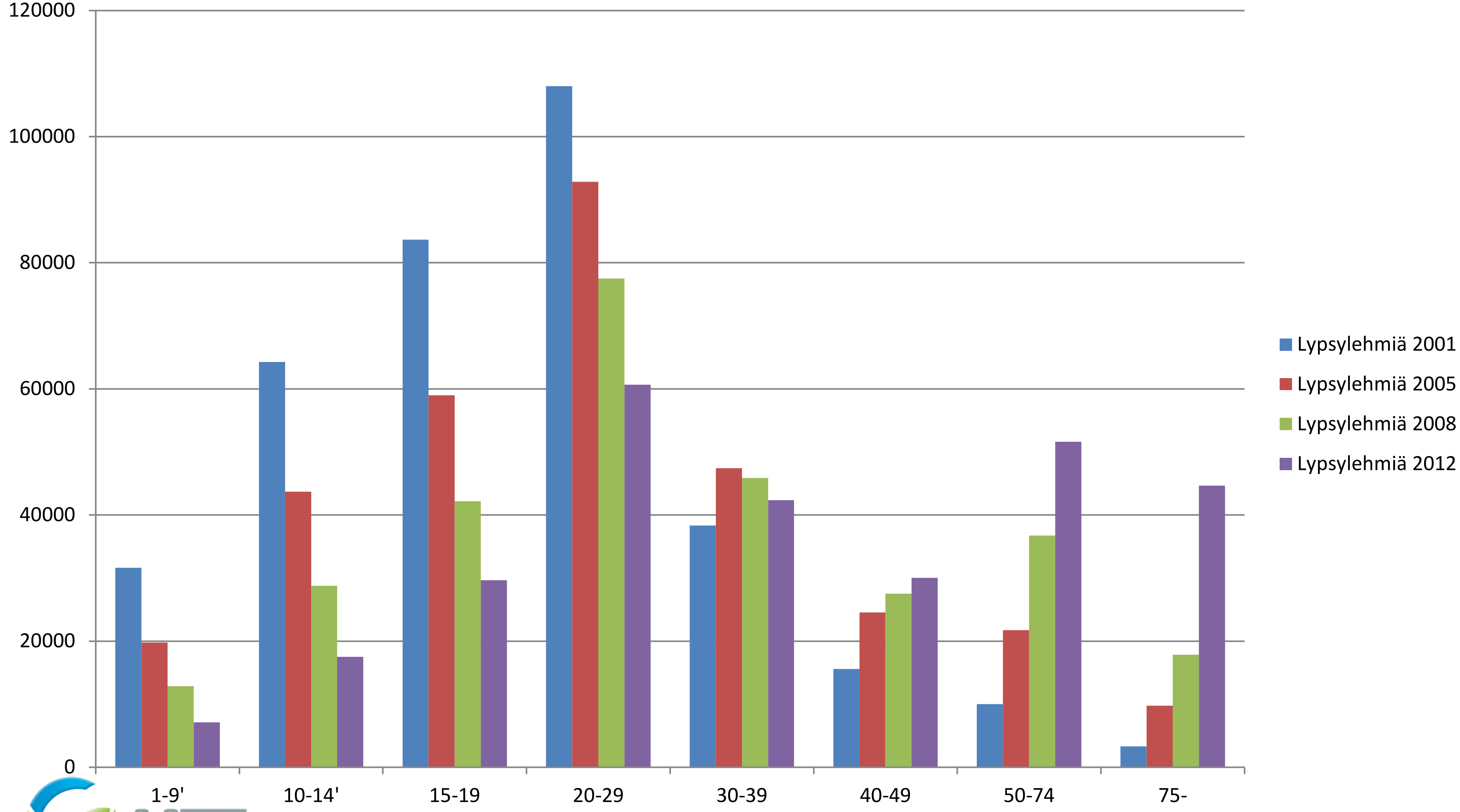
Development of milk production in different provinces, 2001/2002 = 1

Source: ww.mmmtike.fi



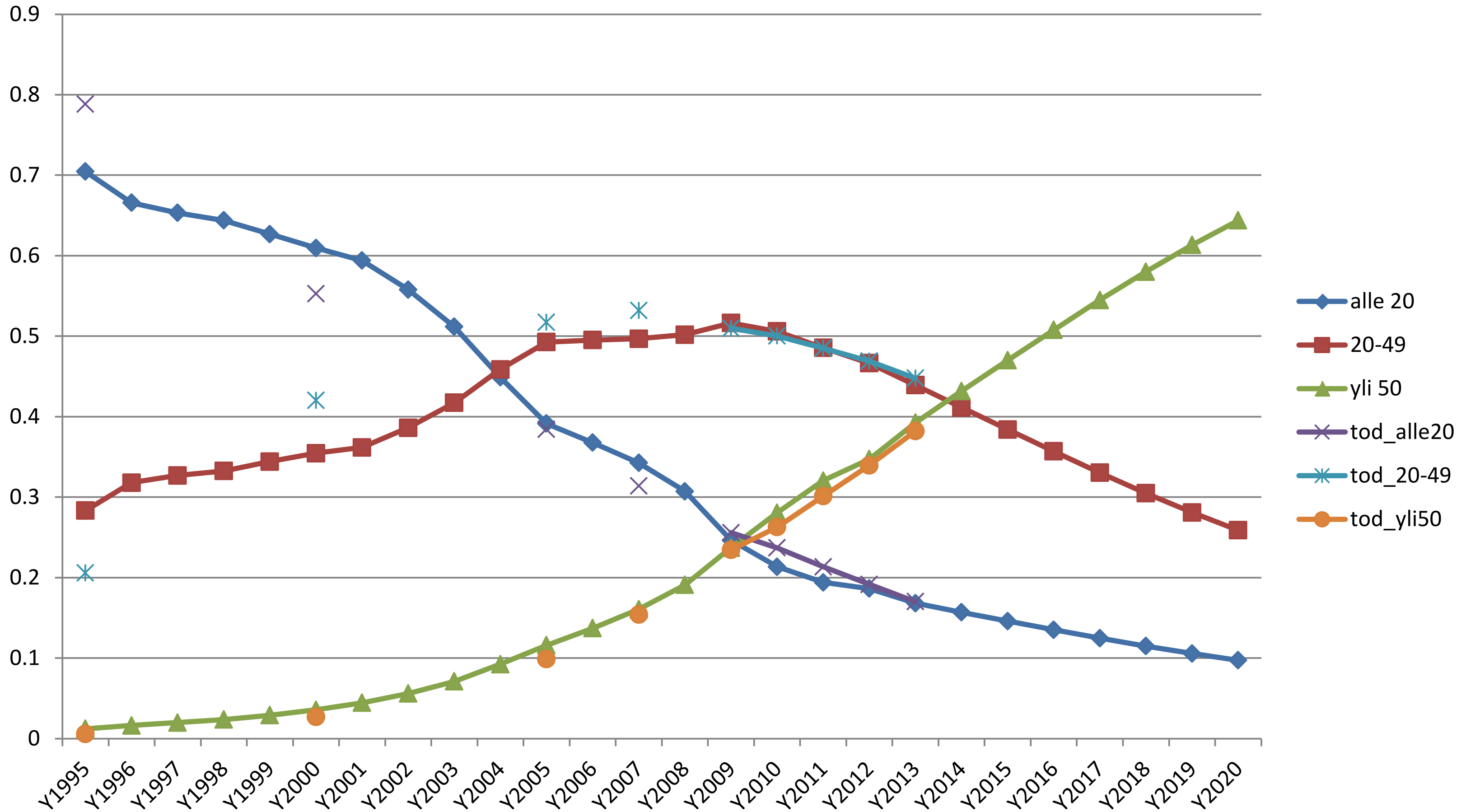


The number of dairy cows in different farm size categories

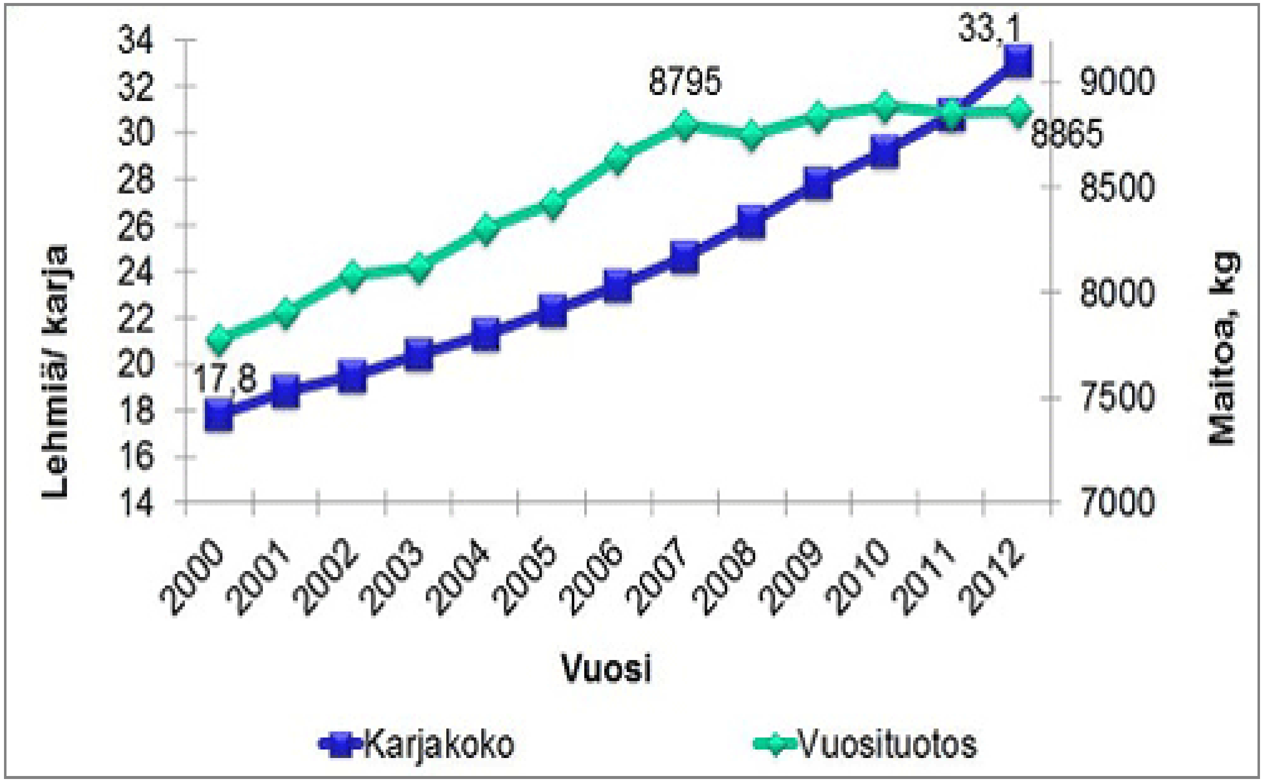


Dairy cows (1000) in different farm size categories (cows/farm) in the baseline

Source: MTT:n Dremfia-simulations, November 2013, reported most recently in: Niemi et. al. 2013. ”EU:n yhteinen maatalouspolitiikka vuosina 2014–2020 ja Suomen maatalous”. www.mtt.fi

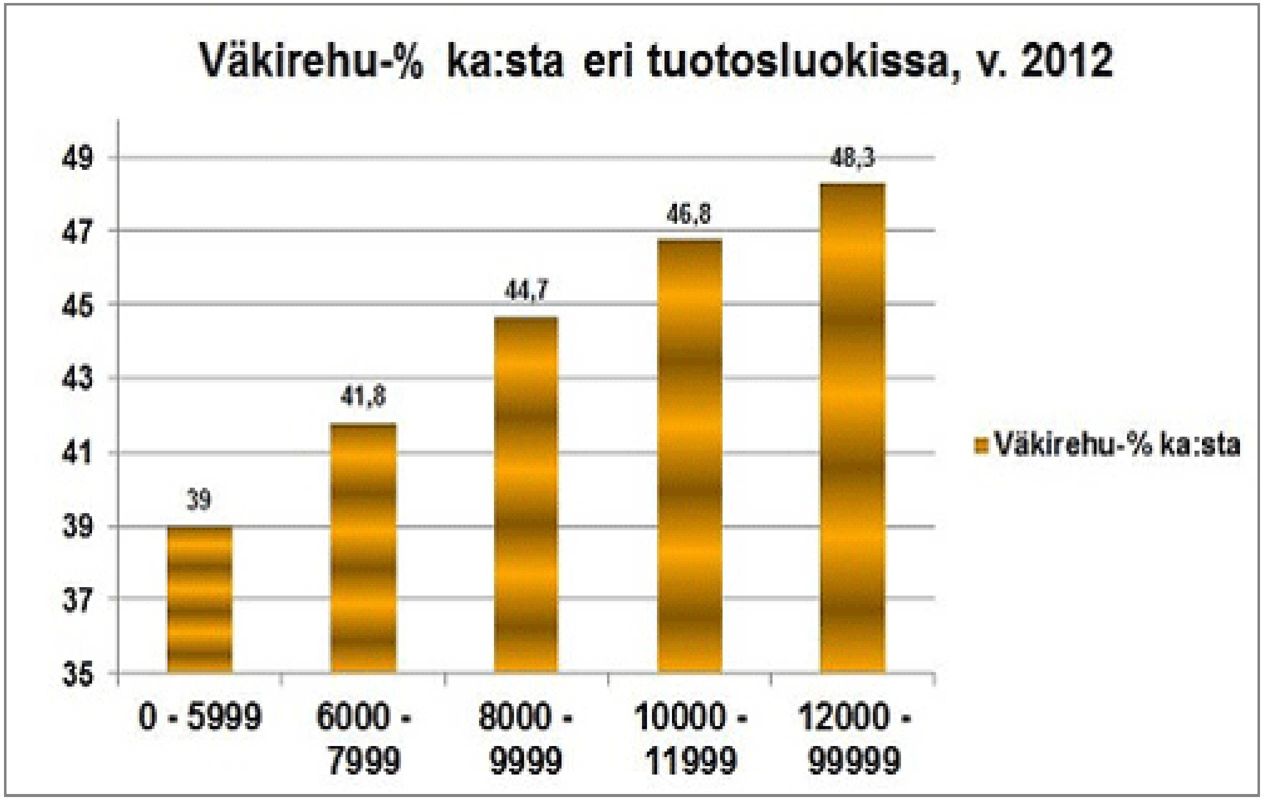


Average size of dairy farms, and milk yield per cow at milk recording farms (representing 84% of milk production)
- National average 8300 kg/cow 2013



Share of non-grass feeds, out of all dry matter, in the feeding of dairy cows 2012 (milk recording)

- close to the estimated quadratic yield response used in Dremfia



Low nitrogen fertilisation necessary for sufficient clover yields

- In northern European conditions, in the most northern countries such as Finland, 50 kg of soluble N fertilization is a maximum when aim is to have 50 % share of red clover in the sward (Saarela 1986, Nykänen et al. 2010)
- N uptake is most efficient in grass–legume mixtures due to mutual stimulation of nitrogen uptake from symbiotic and non-symbiotic sources (Nyfeler et al. 2011)
- 50-50 % of clover-grass yield proportion is therefore the most desirable to achieve best nutritional value, most efficient N fixing and least N leaching risk.

Red clover may provide significantly higher crude protein content, if low N fertilisation

	Metabolisable energy	Crude protein	Crude fibre	D-value
Feed	MJ/kg DM	g/kg DM	g/kg DM	g/kg DM
Average/early grass silage, weighted average of 1st (60%) and 2nd (40%) cut	10.8	158	328	674
Red clover silage (50%), average of 1st and 2nd cut	10.4	205	240	650

Source: MTT 2014. Feed tables and nutrient requirements. MTT Agrifood Research Finland.
https://portal.mtt.fi/portal/page/portal/Rehutaulukot/feed_tables_english

Technical characteristics of grassland as affected by the technique (conventional or with clover) in five regions

Source: Helming, J., Kuhlman, T., Linderhof, V., and Oudendag, D. 2014. Impacts of legume scenarios. Legume Futures Report 4.5. Available from www.legumefutures.de

		Fertilizer input (kg N per ha)	Production (t dm/ha)	Clover (%)	Net energy (MJ/kg dm)	Crude protein (g/kg dm)
Netherlands	Grass only	480	10	0	6.9	225
	With clover	130	9	46	6.6	223
Brandenburg	Grass only	197	8.2	0	5	130
	With clover	0	7.4	75	6.1	164
Sweden	Grass only	225	9	0	6.1	160
	With clover	110	9	30	6.2	160
Denmark	Grass only	350	9.7	0	6.6	170
	With small clover share	250	8.5	25	6.6	175
	With high clover share	65	8.1	60	6.6	190
Ireland	Grass only	504	12.5	6		219
	With clover	359	11.5	22		209

Clover fits well into the grassland – cereals –rotation of temporary grasslands typical in Finland (as well as in Sweden and Norway)

	Winter funguses	Basal root diseases	Clover rot	Clover root rot
Grasses	host	maintaining	detergent	host
Clover	detergent	detergent	host	host
Winter cereals	host	host	detergent	host
Spring cereals	maintaining	host	detergent	host
Pea	detergent	detergent	detergent	host
Rapeseed	detergent	detergent	detergent	host
Potato	detergent	detergent	detergent	host
Cumin	detergent	detergent	detergent	host
Linen	detergent	detergent	detergent	host
Buckwheat	detergent	detergent	detergent	host
Vegetables	detergent	detergent	detergent	host

Specific clover grass issues

- Assume grass-clover (50-50) seed mixes with max 50kg soluble (manure) nitrogen per ha
- Assume 10% (max 15%) higher protein content in grass-clover than in pure hay grasses
- Assume 10-15% lower yield of dry matter and undigestable fibre in grass-clover
  - These are based on a number of MTT and northern European studies

Fertilization level

- Agri-Environmental support scheme usually limits phosphorus fertilization to <20 kg/ha
  - P is the limiting factor for manure use/hectare for grains
  - For clover grass, nitrogen limits efficient fertilization to <50 kg soluble N/ha
  - Whole Finland is defined as nitrate vulnerable zone, which limits total nitrogen to 170 kg/ha
    - In most cases, P is limiting factor for manure fertilizer use in grass production as well

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Crops on Finnish dairy farms (2009)

- 63 % silage or pasture
- 34 % grains
- 3 % other
- Max 20 kg P/ ha

	Hectares	Percent	Manure use
Silage and dry hay	309394	53 %	P/N limits max use
Pasture	56947	10 %	Takes 1/12th of total
Barley	88710	15 %	P limits max use
Oats	81441	14 %	P limits max use
Other grain	30231	5 %	P limits max use
Other crop	9158	2 %	No manure
Set a side	3086	1 %	No manure
	578967	100 %	

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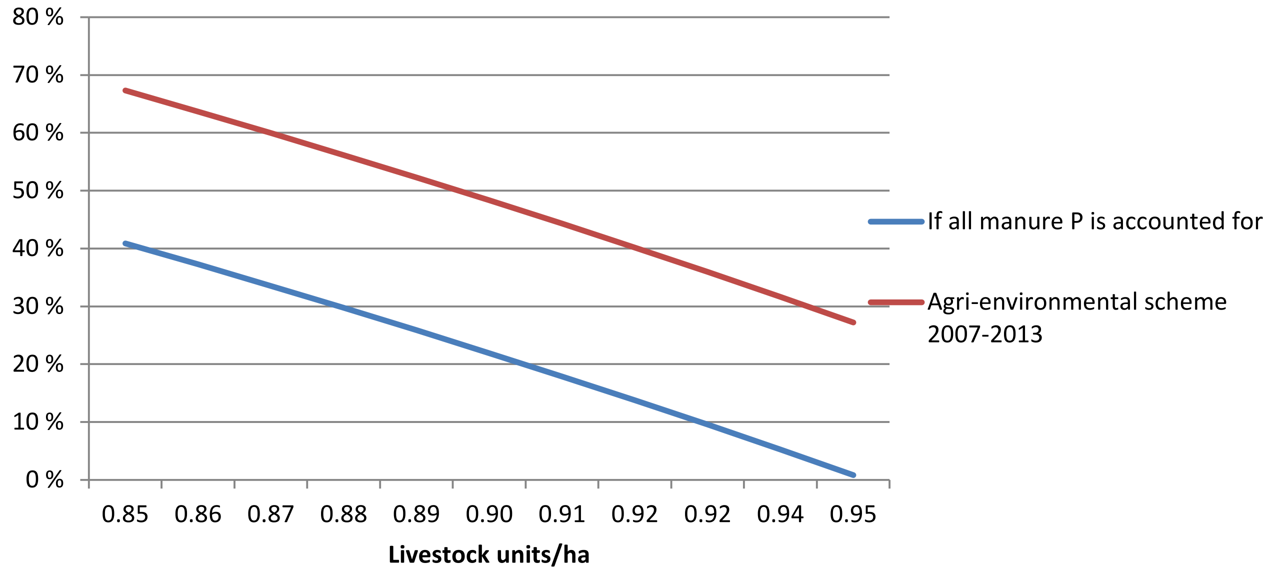
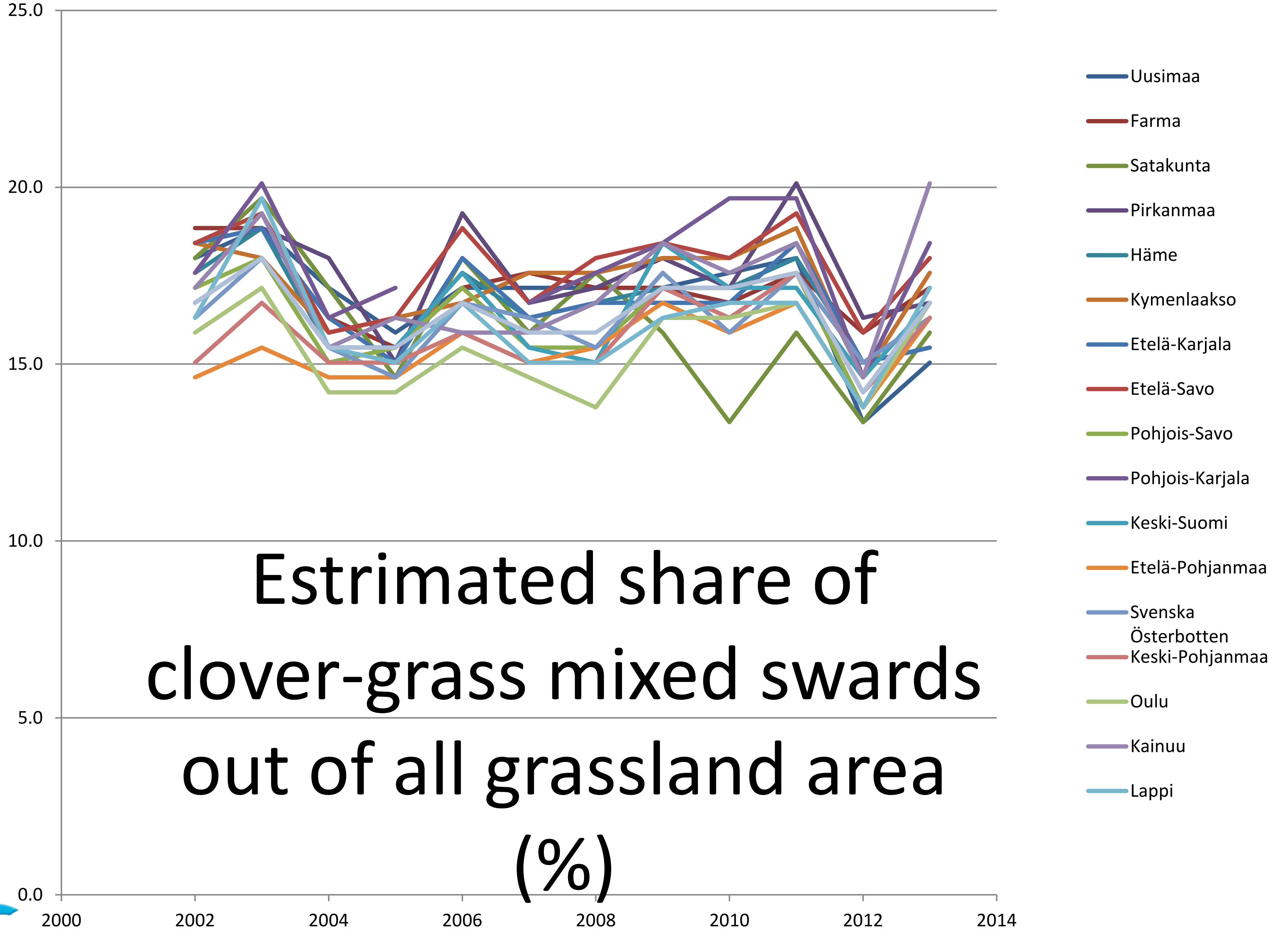
Limits for P fertilisation limit the use of manure per hectare => If all manure P is accounted for (as in below), little clover grasses on large and intensive farms



Important aspects of the DREMFIA sector model analysis

- Clover-grass is defined as a separate activity in the model, in addition to other crops and other grass types (intensive, extensive silage, dry hay, ”permanent” grassland)
  - Max 50 kg soluble N/ha for clover-grass
  - 10% more protein, 15% less dry matter and crude fibre
- Validate the model to reach 17% share of clover-grass out of the area of all grasses 2000-2012
  - Utilise regional differences in validation
  - The validation basis has been calculated in Solid
    - A separate document

Estrimated share of clover-grass mixed swards out of all grassland area (%)



Estimated share of clover-grass in regions (%)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Uusimaa	18,0	18,8	17,2	15,9	17,2	17,2	17,2	17,2	17,6	18,0	13,4	15,0	16,9
Farma	18,8	18,8	16,3	15,5	17,2	17,6	17,2	17,2	16,7	17,6	15,9	17,2	17,2
Satakunta	18,0	19,7	17,2	14,6	18,0	15,9	17,6	15,9	13,4	15,9	13,4	15,9	16,3
Pirkanmaa	18,4	18,8	18,0	15,0	19,3	16,7	17,2	18,0	17,2	20,1	16,3	16,7	17,6
Häme	17,6	18,8	15,5	15,5	17,6	16,3	16,7	17,2	17,2	18,0	15,0	15,5	16,7
Kymenlaakso	18,4	18,0	15,9	16,3	16,7	17,6	17,6	18,0	18,0	18,8	14,6	17,6	17,3
Etelä-Karjala	18,4	18,8	16,3	15,0	18,0	16,3	16,7	16,7	16,7	18,4	15,0	15,5	16,8
Etelä-Savo	18,4	19,3	15,9	16,3	18,8	16,7	18,0	18,4	18,0	19,3	15,9	18,0	17,8
Pohjois-Savo	17,2	18,0	15,0	15,5	17,2	15,5	15,5	17,2	17,2	17,6	13,8	16,3	16,3
Pohjois-Karjala	17,6	20,1	16,3	17,2		16,7	17,6	18,4	19,7	19,7	14,6	18,4	17,8
Keski-Suomi	16,7	18,0	15,5	15,5	17,6	15,5	15,0	18,4	17,2	17,2	14,6	16,7	16,5
Etelä-Pohjanmaa	14,6	15,5	14,6	14,6	15,9	15,0	15,5	16,7	15,9	16,7	13,8	16,3	15,4
Svenska Österbotten	16,3	18,0	15,5	14,6	16,7	16,3	15,5	17,6	15,9	17,6	15,0	16,3	16,3
Keski-Pohjanmaa	15,0	16,7	15,0	15,0	15,9	15,0	15,0	17,2	16,3	17,6	14,2	16,3	15,8
Oulu	15,9	17,2	14,2	14,2	15,5	14,6	13,8	16,3	16,3	16,7	13,8	16,7	15,4
Kainuu	17,2	19,3	15,5	16,3	15,9	15,9	16,7	18,4	17,6	18,4	14,6	20,1	17,2
Lappi	16,3	19,7	15,5	15,0	16,7	15,0	15,0	16,3	16,7	16,7	13,8	17,2	16,2
Åland		24,8	20,5	21,0	26,0	18,0	23,9	20,5	25,2	26,9	18,4	22,6	22,5
Koko maa	16,7	18,0	15,5	15,5	16,7	15,9	15,9	17,2	17,2	17,6	14,2	16,7	17,0

First findings based on the DREMFIA simulation results

- Difficulties in validating the model to replicate clover-grass areas 2002-2013, quite uniform across regions
- In DREMFIA, significant differences between regions
- Clover-grass is easily cultivated in less competitive dairy production regions with relatively little competition for land
  - Parts of central and eastern Finland, and some corners in southern Finland, clover grass areas increase rapidly if cost level is decreased
  - However, in the known regions with increasing production and increasing livestock density, little clover grasses
  - High subsidies per litre of milk in the very north incentivise intensive production and thus prevent clover-grasses
  - => Challenge of validating the clover-grass in the ”right regions”!

Subsidy for clover grasses?

- Clover-grass area and its use in feeding is responsive for a hypothetical ”clover-grass premium” in most regions
  - Take the money for this premium from CAP pillar 1 coupled / decoupled subsidies, keep consistency with the present CAP rules
  - However even in this hypothetical subsidy case the clover grasses do not easily reach 17 %
- The sector model with competitive markets uses clover grasses as a means of increasing the value of the sector by allocating clover-grasses in selected regions

Some solutions (on-going work)

- Implement the plant disease pressure matrix in a way that increase the benefits of clover grasses w.r.t. to cereals
- Clover grasses in better synergy with liming than hay grasses(?) => specify higher response for liming for clover-grasses
- However, liming is allocated first in competitive regions in the model
  – Challenge to validate both liming, clover-grasses and other land use simultaneously

Other observations from early simulations

- Clover-grasses are competing also with other low intensity grasslands in the model, not only with cereals and intensive grass silage
  - Low intensity grasslands accept more manure (appr. 120 kg N/ha) than clover-grass (50 kgN/ha)
- Manure spreading per m3 is more expensive for clover-grasses
- Low milk prices may promote clover grasses
  - Lower added value from concentrates at low milk prices
  - Changing subsidy per litre of milk to headage payment promotes clover grasses as well, at least slightly, depending on other prices
- High protein feed prices – median cereals prices –combination may also promote clover grasses
  - However cereals and protein feed prices tend to be somewhat coupled
- Clover grasses are also competing with imported crushed oilseed, used as protein supplement for dairy cows
- Increasing productivity of clover grasses in future climate may leads to larger share of clover grasses in forage (in areas as well?)
  - However this work is still restricted to A1B climate scenario – the relative yield development and competition between hay grasses and cereals

Next steps?

- First, the model must be properly validated
  - But this may not mean exact calibration of clover grass areas to ”observed” ones, in each and every region
  - May be some disease loss considerations help to realise more uniform use of clover grasses in all regions
- Define an upper limit for clover-grasses
  - i.e. 40% of land area? A limit based on manure spreading
- Consult experinced organic farmers / extension:
  - The role of clover pests and diseases, setting upper limits?
  - Other costs, risks and problems of clover-grass dominated strategy ? Some costs / benefits still missing?