Modelling mitigation effects on agricultural run off in the Morsa catchment

Developing of new tools for choosing strategies in the implementation of the WFD in Norway

Håkon Borch

Bioforsk – Institute for soil and environment

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Bioforsk

Norway how we like to present our land


Reality in many agricultural areas

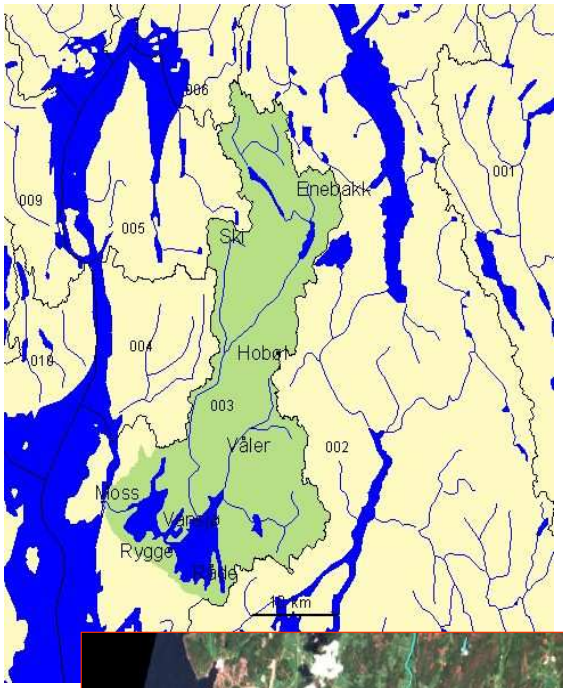
Main strategy for reducing agricultural run off

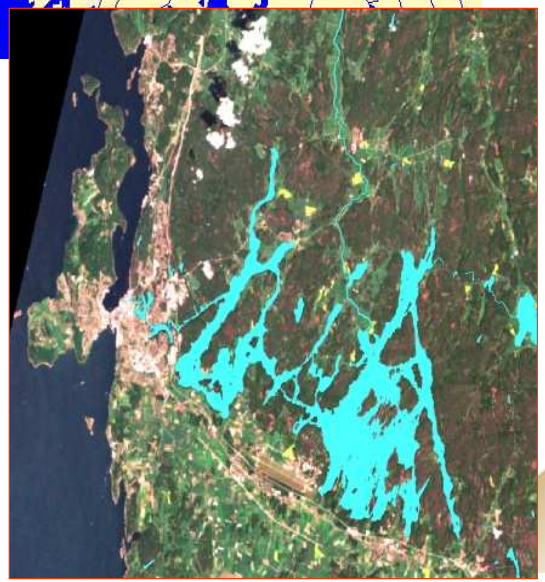
- Soil and P loss
  - Vegetation cover in the winter period (reduced tilling etc.)
  - Vegetation strips along water bodies
  - Sedimentation ponds
  - Fertilise with reduced P (P-AL limits etc.)
- Nitrogen
  - Optimised fertilising (low priority)
- Spread the manure
  - Spreading area
  - Storage of manure for 12 months and spreading in the growing season
- Pesticides
  - JOVA monitoring program (pesticides are not a big issue)

Reduced tilling and vegetation buffer strips

”The case Morsa”

- Drinking water for 60 000
- Recreation area
- Long term, systematic and massive effort to improve water quality
- ”Integrated” management:
  - Research, advisory, policy
  - Iinterdisciplinary approach
- Demanding problems





SUMMASUMMARUM P-reduction so far

2001

Calculated planned effects:

Reduced cultivation: 3,3 t P

Sedimentation ponds: 1,3-1,7 t P

Vegetation zones: 0,1-0,2 t P

+++

2001-06

Estimated achieved effects:

Reduced cultivation: 4,7 t P

Sedimentation ponds: 0,8 t P

Vegetation zones: 0,3 t P

+++++

Total reduction above 50 %

Model for soil- and phosphorus loss from agricultural areas - AGRICAT-P

Input data

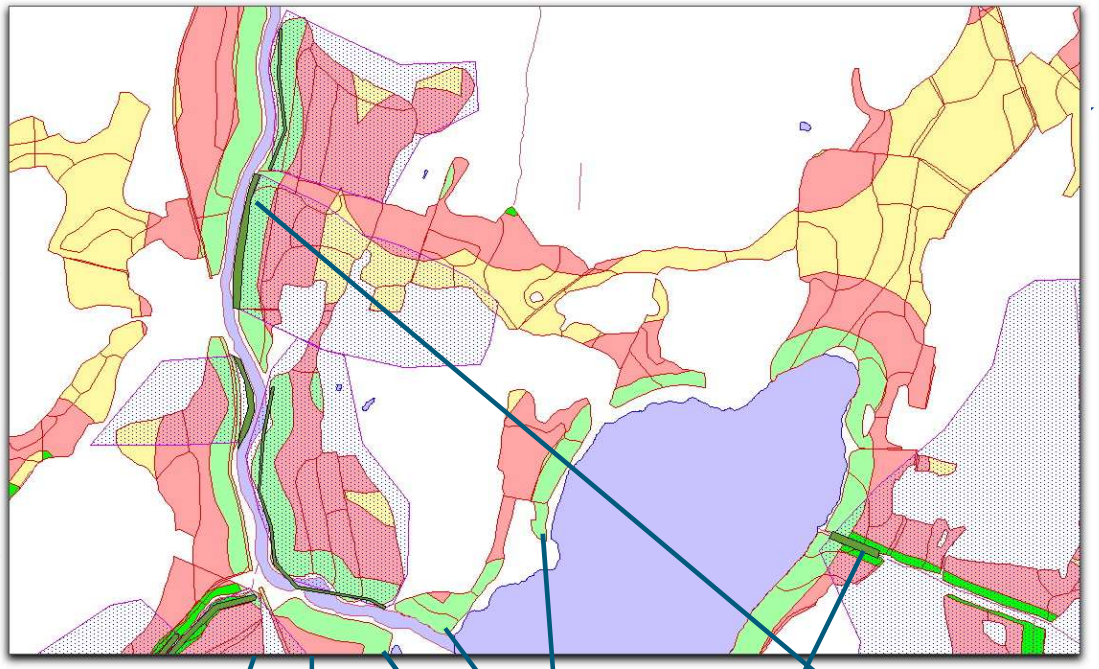
Norwegian soil map
- Erosion risk (USLE)
- Texture parameter
- Terrain levelling
- (slope)

Meteorological data
- R-factor

From GIS-program
- Watershed border
- Actual agricultural practices (where this is known)
- Buffers along rivers/streams
- Vegetation zones
- Sedimentation ponds
- Sedimentation ponds -watershed area

Government subsidy register
- Data about productions subsidies and environmental measures

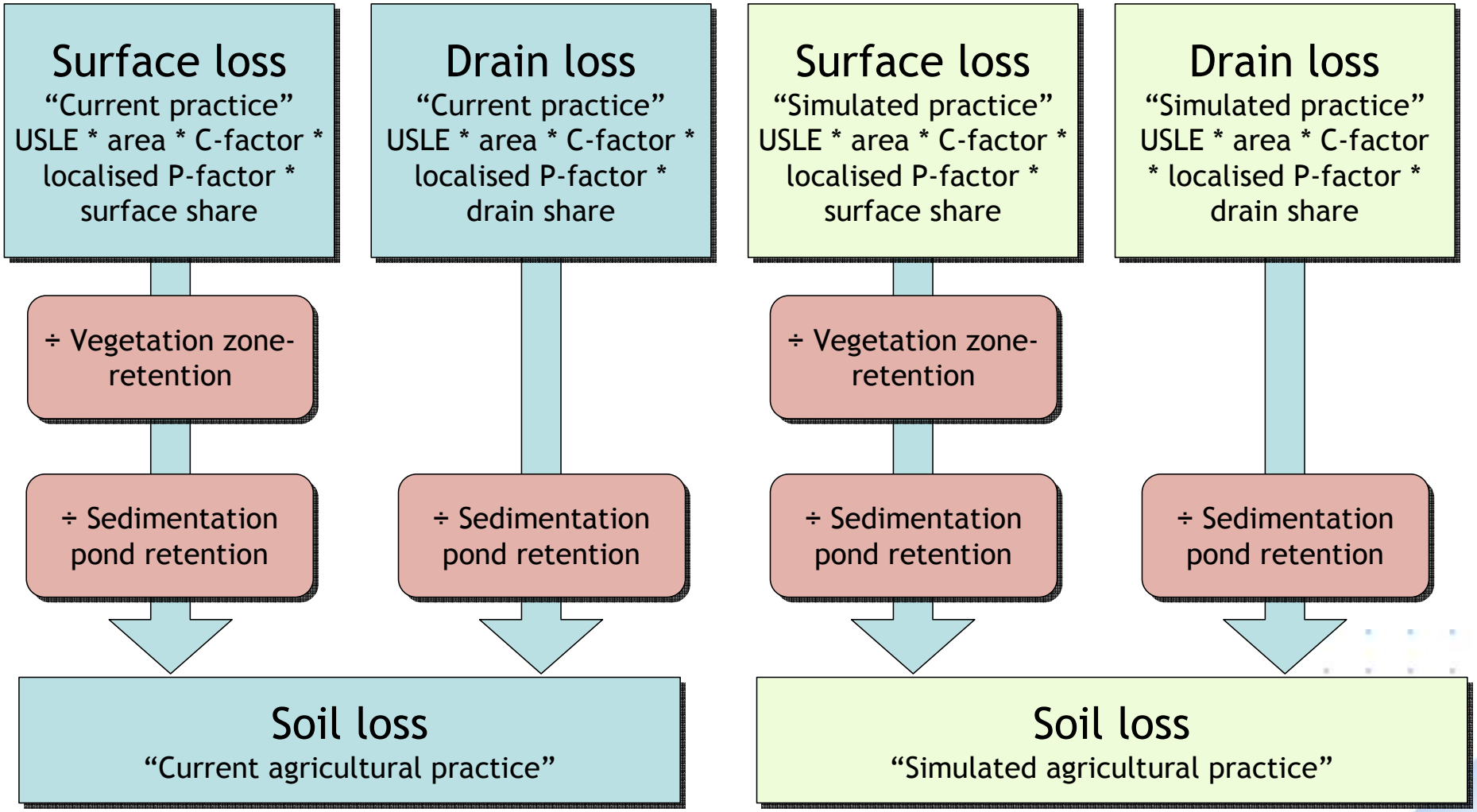
Soil database
- P-AL analyses the last 7 years



NEDBORFELT	DRIFTSENHET	EROSKLASSE	Jordtype	PALm...	PALTil...	ArealDaa	EHP	Buffer...	Faktdrift	Fangdam...	Vegsonereten...	VS bredde	ErDrifTotal
Hobølelva - øvre	Mangler info	3	Sandig silt		9	,571	291kg	100	Stubb + vårpløying	0%	0,00%		30,95kg
Hobølelva - øvre	Mangler info	3	Sandig silt		9	,404	291kg		Stubb + vårpløying	0%	0,00%		21,90kg
Hobølelva - øvre	0138/107/3	2	Sandig silt		9	3,113	58kg	100	Eng	0%	0,00%		24,64kg
Hobølelva - øvre	0138/107/3	2	Sandig silt		9	1,541	58kg	100	Høstpløyd	0%	0,00%		91,34kg
Hobølelva - øvre	0138/107/3	2	Sandig silt		9	4,354	58kg		Høstpløyd	0%	0,00%		258,07kg
Hobølelva - øvre	0138/101/1	3	Marin lettleire og		9	2,922	208kg	100	Stubb + vårpløying	0%	0,00%		123,39kg
Hobølelva - øvre	0138/101/1	3	Marin lettleire og		9	,182	208kg		Stubb + vårpløying	0%	0,00%		7,69kg
Hobølelva - øvre	0138/101/1	3	Marin lettleire og		9	6,529	208kg		Lett høstharving	0%	0,00%		670,28kg
Sæbyvannet, Svinna	0137/107/2	3	Marin lettleire og	15	15	,007	208kg	20	Stubb + vårpløying	0%	0,00%		0,30kg
Sæbyvannet, Svinna	0137/107/2	3	Marin lettleire og	15	15	,004	208kg	20	Stubb + vårpløying	0%	0,00%		0,17kg
Sæbyvannet, Svinna	0137/107/2	3	Marin lettleire og	15	15	1,158	208kg	20	Stubb + vårpløying	0%	0,00%		48,90kg
Sæbyvannet, Svinna	0137/107/2	3	Marin lettleire og	15	15	2,151	208kg	100	Stubb + vårpløying	0%	0,00%		90,83kg
Storefjorden	0135/64/1	1	Sandig silt		21	,068	23kg	20	Høstpløyd	42%	0,00%		1,14kg
Storefjorden	Mangler info	1	Sandig silt		21	,101	23kg	50	Høstpløyd	0%	0,00%		2,94kg
Storefjorden	0135/64/1	1	Sandig silt		21	5,17	23kg	50	Høstpløyd	0%	0,00%		150,55kg
Storefjorden	Mangler info	1	Sandig silt		21	,213	23kg	100	Eng	0%	0,00%		0,93kg
Storefjorden	0135/64/1	1	Sandig silt		21	8,612	23kg	100	Stubb + vårpløying	0%	0,00%		78,76kg
Storefjorden	0135/64/1	1	Sandig silt		21	,051	23kg	100	Høstpløyd	0%	0,00%		1,49kg
Storefjorden	0135/64/1	1	Sandig silt		21	,136	23kg	100	Høstpløyd	42%	0,00%		2,28kg
Storefjorden	0135/64/1	1	Sandig silt		21	,44	23kg	100	Høstpløyd	42%	0,00%		7,38kg
Storefjorden	0135/64/1	1	Sandig silt		21	4,128	23kg	100	Høstpløyd	42%	0,00%		69,24kg
Storefjorden	0135/64/1	1	Sandig silt		21	6,226	23kg		Høstpløyd	0%	0,00%		181,30kg
Hobølelva - nedre	0138/73/1	2	Sandig silt		8	3,547	169kg	100	Høstpløyd	0%	0,00%		501,47kg
Hobølelva - nedre	0138/73/1	2	Sandig silt		8	,309	169kg		Høstpløyd	0%	0,00%		43,69kg
Storefjorden	0135/65/1	1	Siltig sand		18	,402	42kg	50	Høstpløyd	0%	0,00%		18,51kg
Storefjorden	0135/65/1	1	Siltig sand		18	2,525	42kg	50	Høstpløyd	0%	0,00%		116,28kg
Storefjorden	0135/65/1	1	Siltig sand		18	2,405	42kg	100	Høstpløyd	0%	0,00%		110,76kg
Nedre Vansjø	Mangler info	1	Sandig silt		16	1,27	37kg	20	Høstpløyd	0%	0,00%		53,04kg
Nedre Vansjø	Mangler info	1	Sandig silt		16	,02	37kg	100	Høstpløyd	0%	72,00%		0,56kg
Hobølelva - øvre	0138/48/1	2	Marin lettleire og		5	,054	72kg	20	Stubb + vårpløying	0%	0,00%		1,07kg
Hobølelva - øvre	0138/48/1	2	Marin lettleire og		5	1,532	72kg	100	Stubb + vårpløying	0%	0,00%		30,29kg
Hobølelva - øvre	0138/41/1	3	Sandig silt		9	,878	354kg	50	Eng	0%	0,00%		23,97kg
Hobølelva - øvre	0138/15/1	2	Siltig sand		9	2,61	171kg		Høstpløyd	0%	0,00%		372,65kg
Mørkelva, Veidalselva	0137/63/1	2	Sandig silt		8	4,402	169kg	100	Stubb + vårpløying	0%	0,00%		159,66kg
Hobølelva - øvre	0138/39/1	4	Sandig silt		9	,219	1 256kg	20	Stubb + vårpløying	0%	0,00%		37,35kg
Hobølelva - øvre	0138/39/1	4	Sandig silt		9	,482	1 256kg	50	Potet	0%	0,00%		468,63kg
Hobølelva - øvre	0138/39/1	4	Sandig silt		9	5,035	1 256kg	100	Stubb + vårpløying	0%	0,00%		858,78kg
Hobølelva - nedre	0138/101/1	2	Marin lettleire og		8	,776	133kg	50	Høstpløyd	0%	0,00%		89,90kg

Calculation of soil loss

Calculations for today's agricultural practice and simulations for surface loss and loss through drainage pipes



Separate C-factors for surface and drainage system

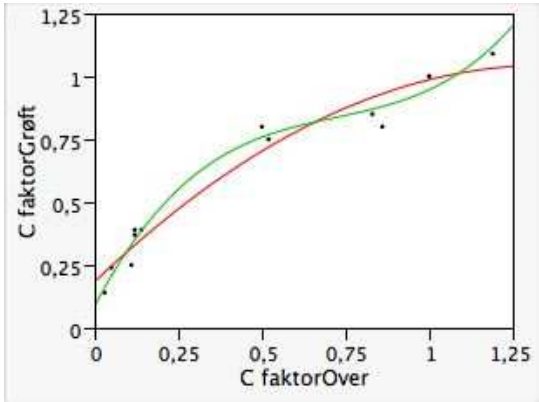
- C factor = effect of crop type (vegetation cover and amount of soil cultivation

Driftsform	C faktorOver	C faktorGrøft
Permanent beiteeng/vegetasjonsdekke eller ute av drift	0,03	0,14
Eng	0,05	0,24
Stubb pløyd og harvet om våren, korn m/ fangvekst	0,11	0,25
Vårharvet to ganger, korn	0,12	0,39
Direktesådd vårkorn	0,12	0,37
Vårpløyd og harvet, korn	0,14	0,39
Grønnsaker uten jordopptak	0,50	0,80
Lett høstharving og vårharving, korn	0,52	0,75
Høstkorn m/pløying	0,83	0,85
Tung høstharving, vårkorn	0,86	0,80
Høstpløying m/harving om våren, korn	1,00	1,00
Løk og rotgrønnsaker	1,00	1,00
Potet	1,19	1,09

- NB! Increasing soil cultivation gives more particle runoff in drainage systems, but the effect is not as much as for runoff from surface.

$$y = 1{,}4499187\,(x-0{,}49769)^3 - 0{,}9758528\,(x-0{,}49769)^2 + 0{,}5069296 + 0{,}5023361x$$

y = C-Factor for drain, x = C-Factor for surface, $R^2 = 0{,}980825$



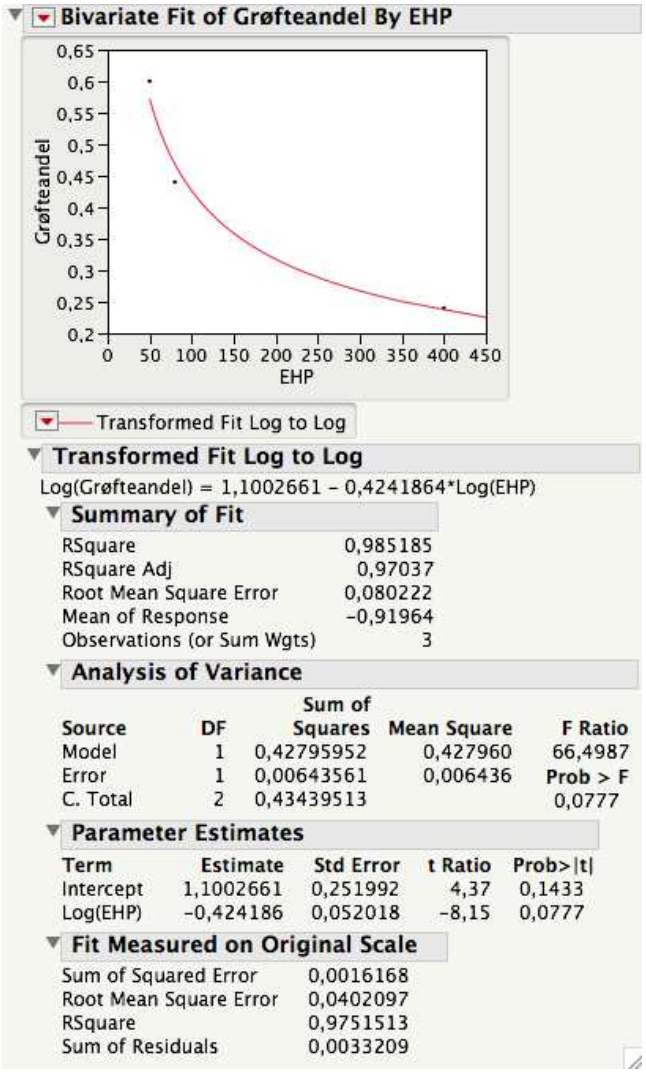
Drainage vs. surface runoff

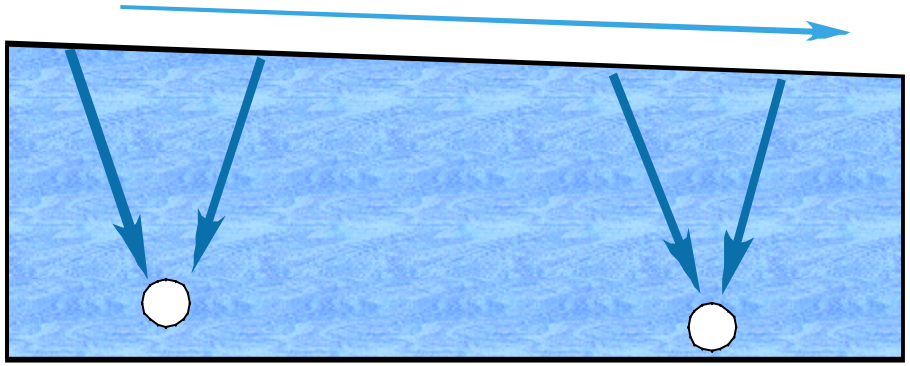
- Precipitation intensity, slope and soil texture is the main determinants for surface vs. drainage runoff
- Lack of precise data of this is solved with a coarse approach;

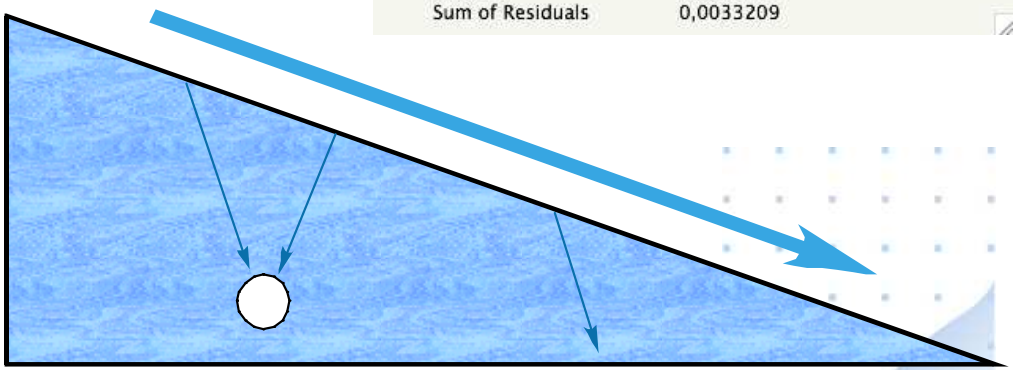
  Equation for this is based on a connection between erosion risk (USLE) as an expression of these parameters, and measured drainage run-off from test fields in Norway.

  Drain share of runoff =

  Case(e(1,1002661 - ,4241864*Ln(EHP)) > 1 ; 1 ; e(1,1002661 - ,4241864*Ln(EHP)) < 0 ; 0 ; e(1,1002661 - ,4241864*Ln(EHP)))

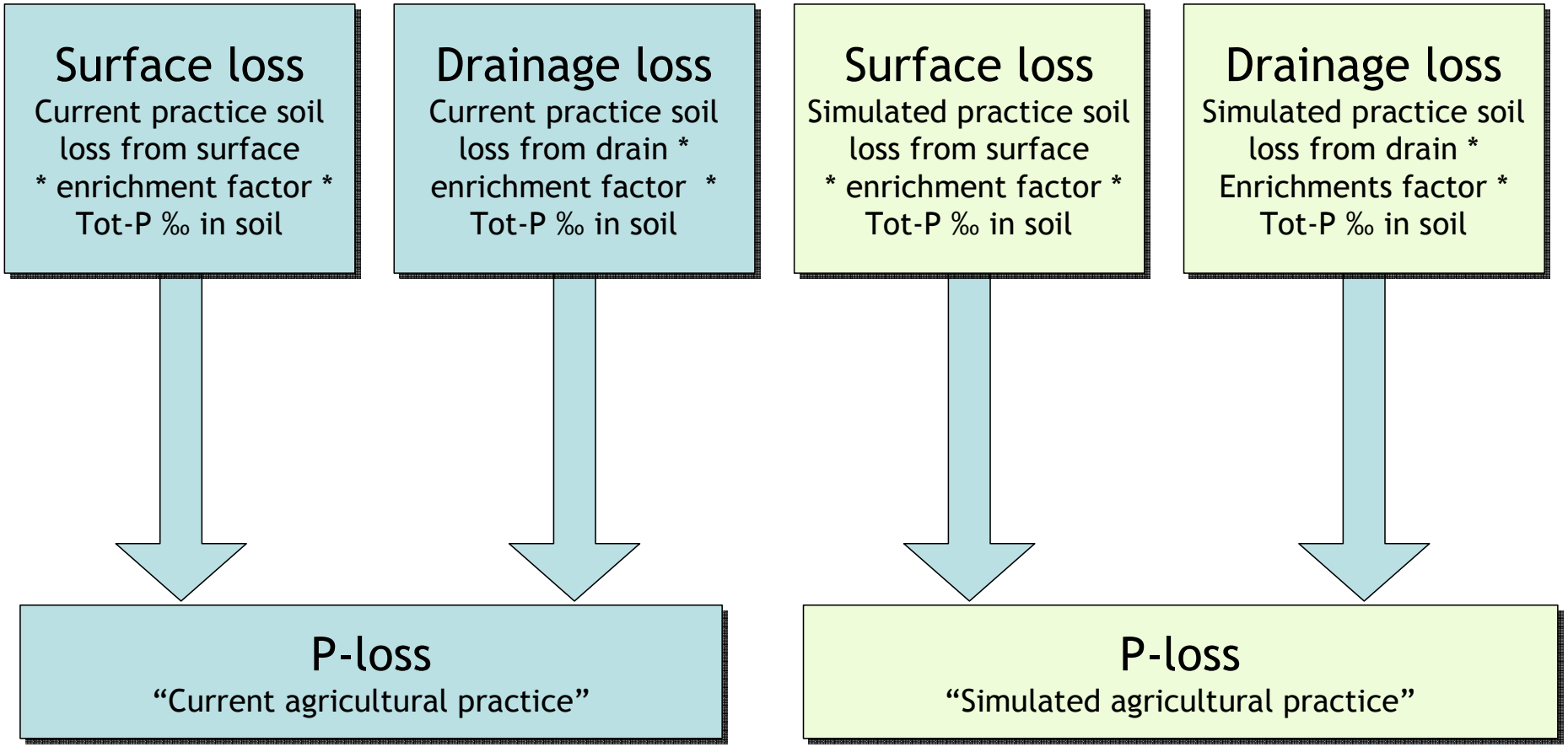






Calculations of P-loss

Calculations also done in 4 parallels



P-AL (Phosphorus available for plants) in soil is collected from several sources

I. From farmers P-AL maps

II. If no detailed P-AL maps are available; we use average of P-AL values from soil analyses from the last 7 years on the farm unit. Source national soil databank

Farm unit

III. If no information about the soil condition on the farm unit; we use average of other farm units in the watershed

Watershed

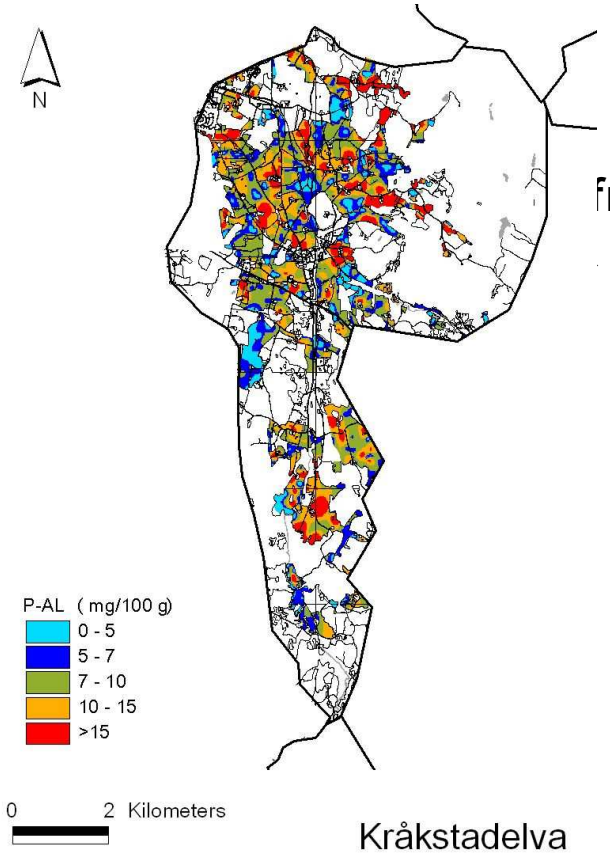
P-AL (Phosphorus available for plants) in soil is collected from several sources

I. From farmers P-AL maps

II. If no detailed P-AL maps are available; we from soil analyses from the last 7 years on the far databank

Farm unit

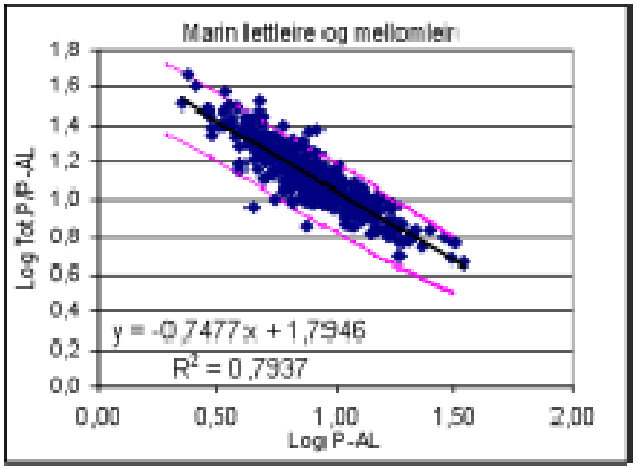
III. If no information about the soil condition c average of other farm units in the watershe



Watershed

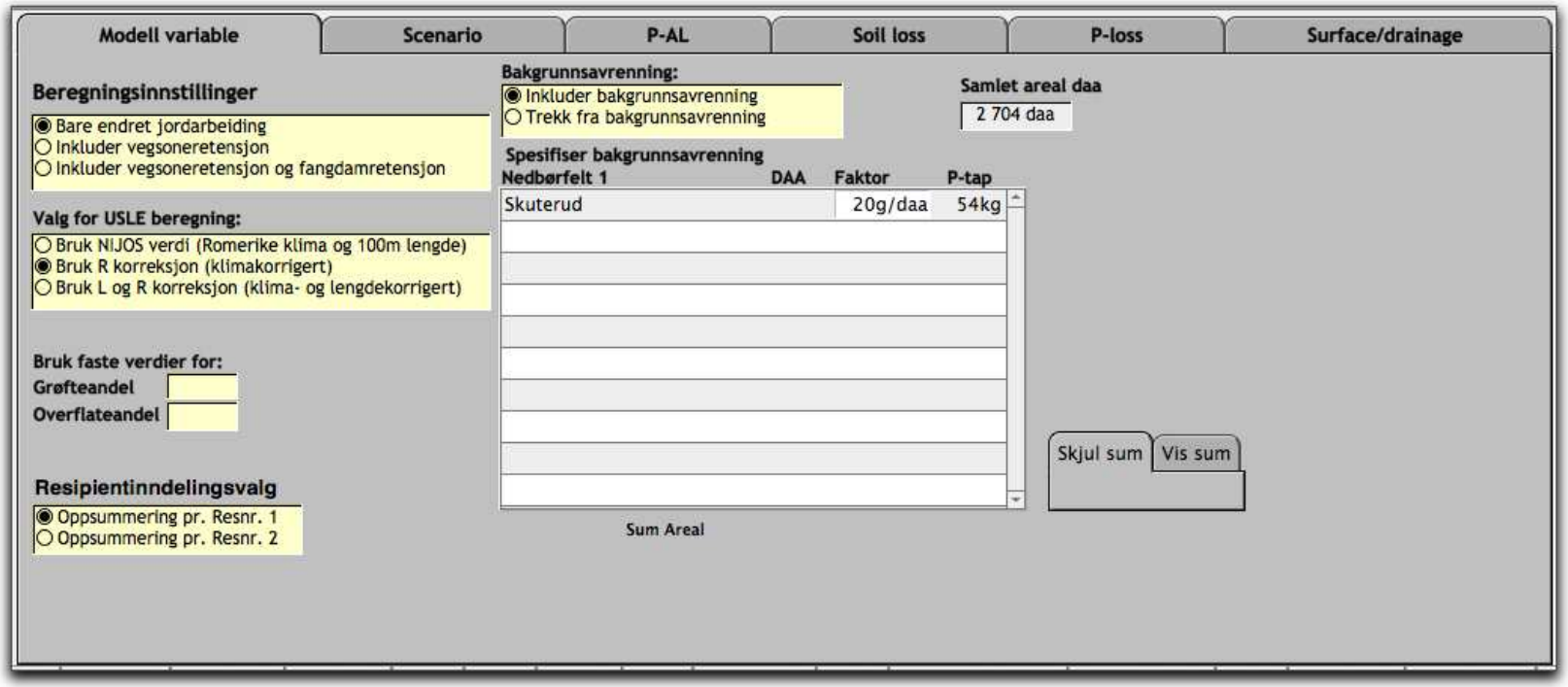
Total-P ‰ in soil is based on covariance between P-AL and Total-P

- Five equations for connection between P-AL and Tot-P is based on covariance in 562 soil samples where both parameters are analysed, separated in five soil types:



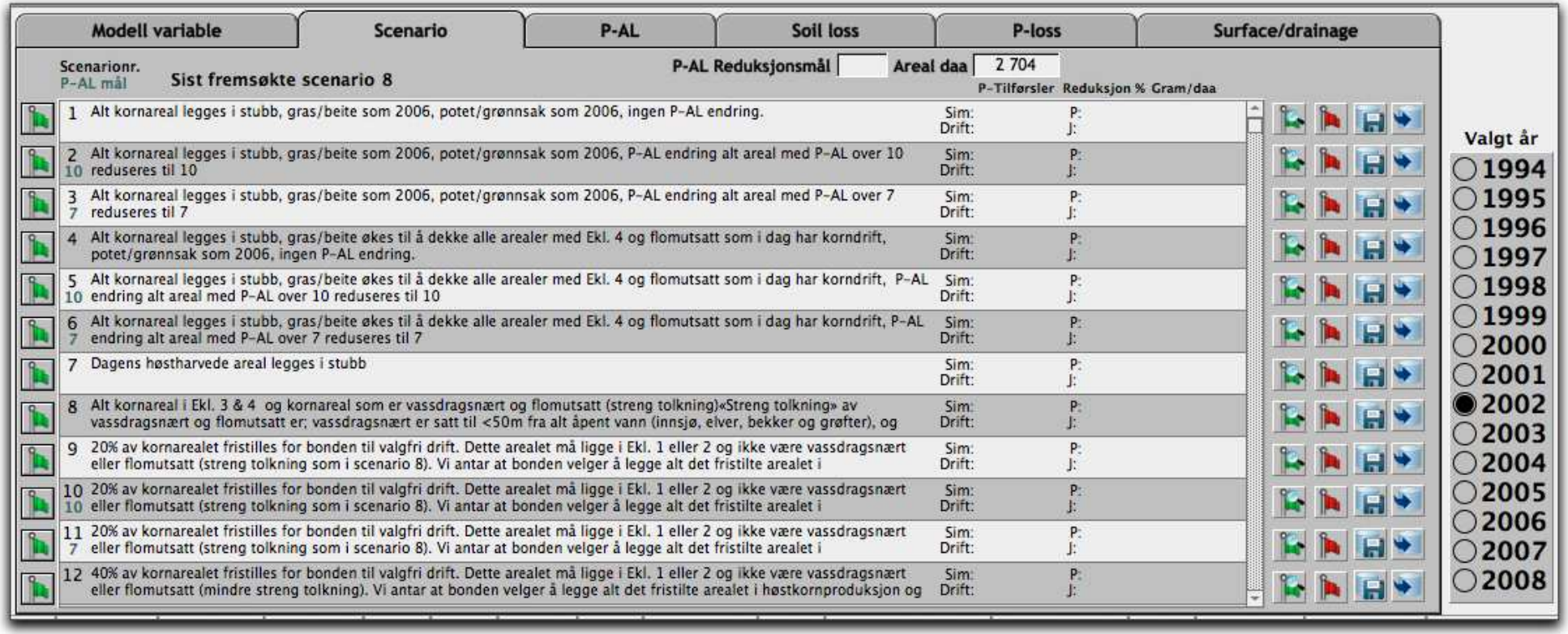
- Silty sand soil
- Sandy silt soil
- Light clay soil
- Heavy clay soil (marine sedimentation)
- Organic soil

We try to keep the user interface for the model as simple as possible.

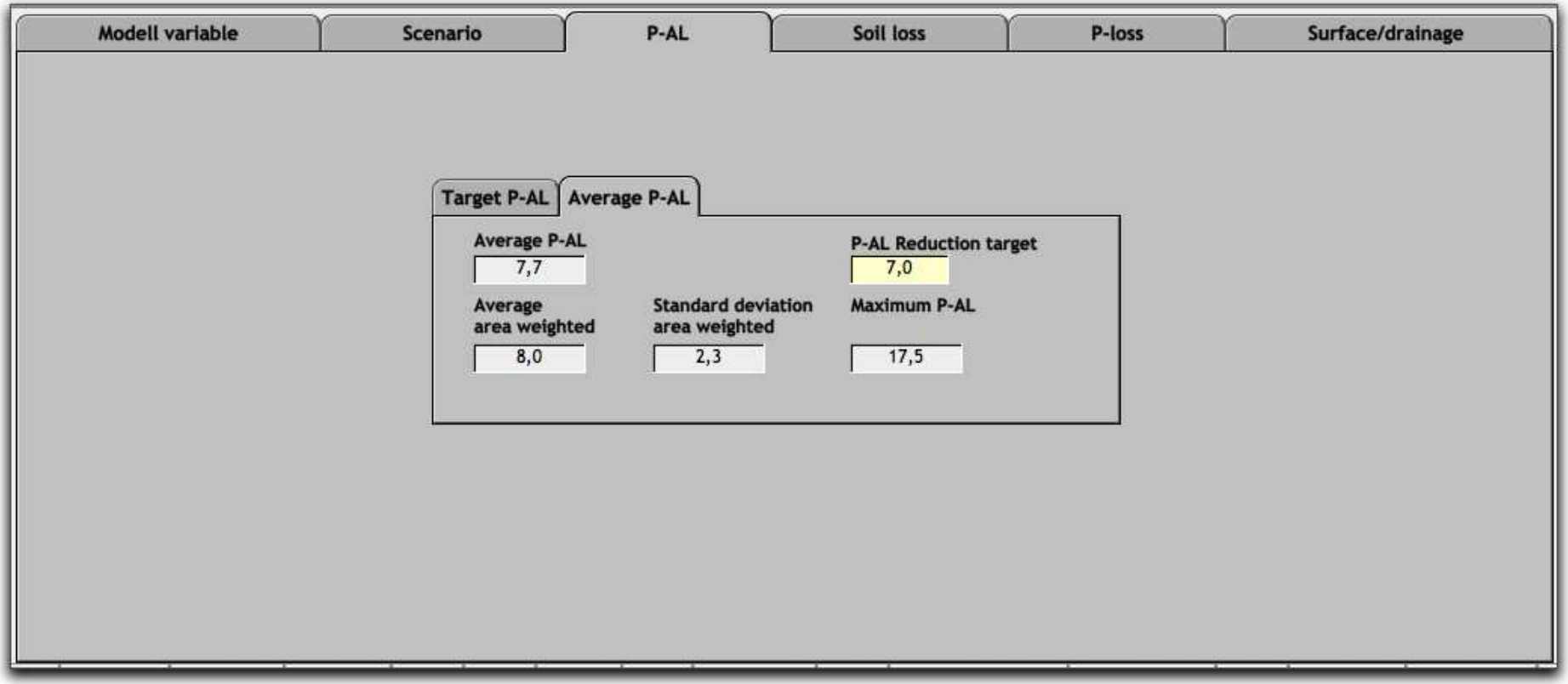


- **Built in FilemakerPro with an graphical GUI**

Flexible scenarios



Effects of P-AL reduction can be modelled



Results

Modell variable | Scenario | P-AL | **Soil loss** | P-loss | Surface/drainage

Actual agriculture practice

Sum soil loss: 113 122kg

Soil loss / daa: 41,8kg

Soil loss / haa: 418,3kg/ha

Simulated agriculture practice

Sum soil loss Sim	Reduction	% reduction
79 752kg	33 370kg	29,5%

Soil loss / daa: 29,5kg

Modell variable | Scenario | P-AL | Soil loss | **P-loss**

Actual agriculture practice

Sum P-loss: 229,1kg

P-loss / daa: 84,7g

Simulated agriculture practice

Sum P-loss Sim	Reduction	% reduction
176,5kg	52,6kg	23,0%

P-loss / daa: 65,3g

Modell variable | Scenario | P-AL | Soil loss | P-loss | **Surface/drainage**

Surface

	Actual practice	Simulated practice
Soil loss	56 957kg	29 665kg
P loss	109,2kg	64,7kg

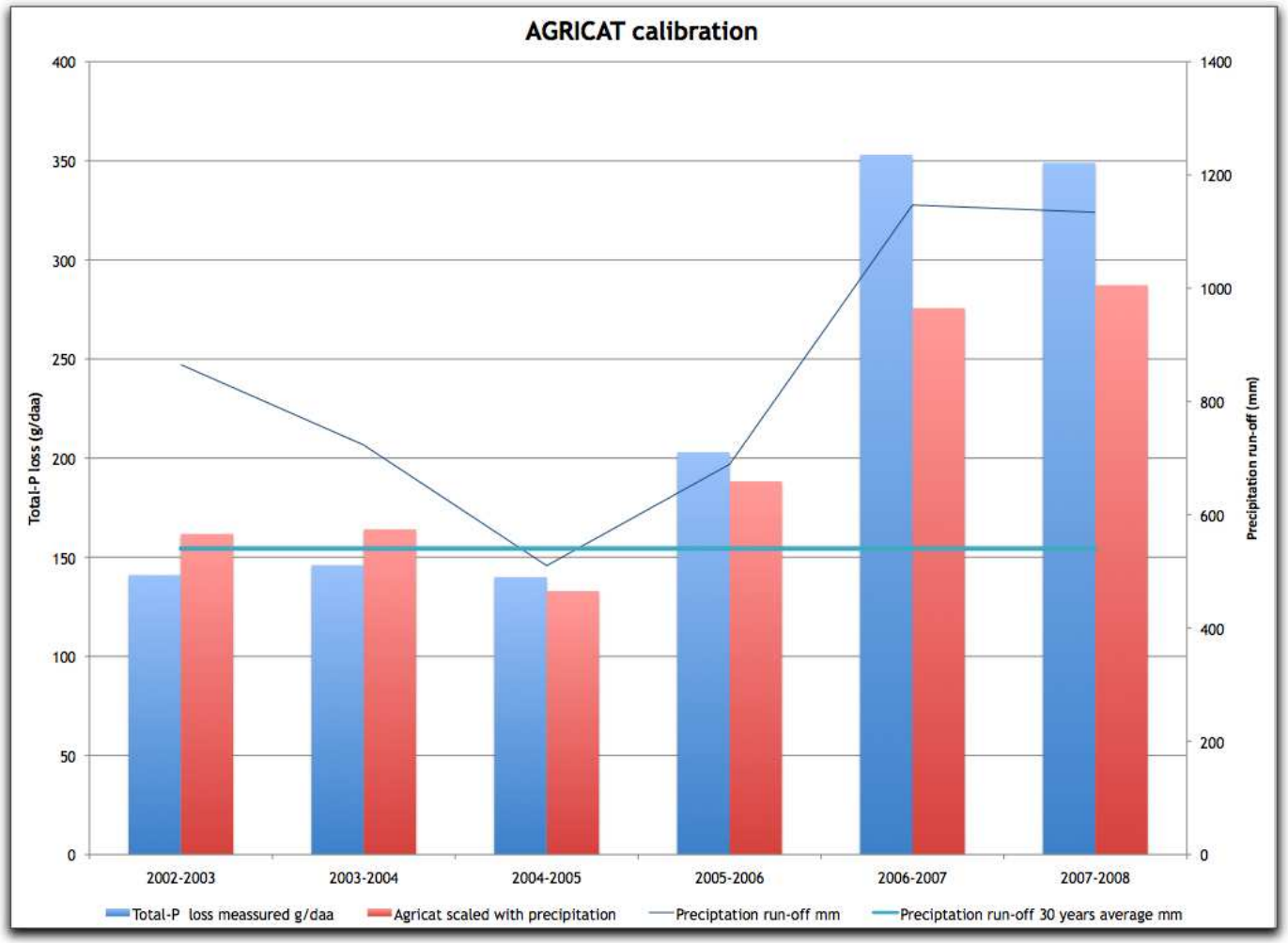
Drainage

	Actual practice	Simulated practice
Soil loss	56 164kg	50 086kg
P loss	119,9kg	111,8kg

Calibration on Skuterud catchment

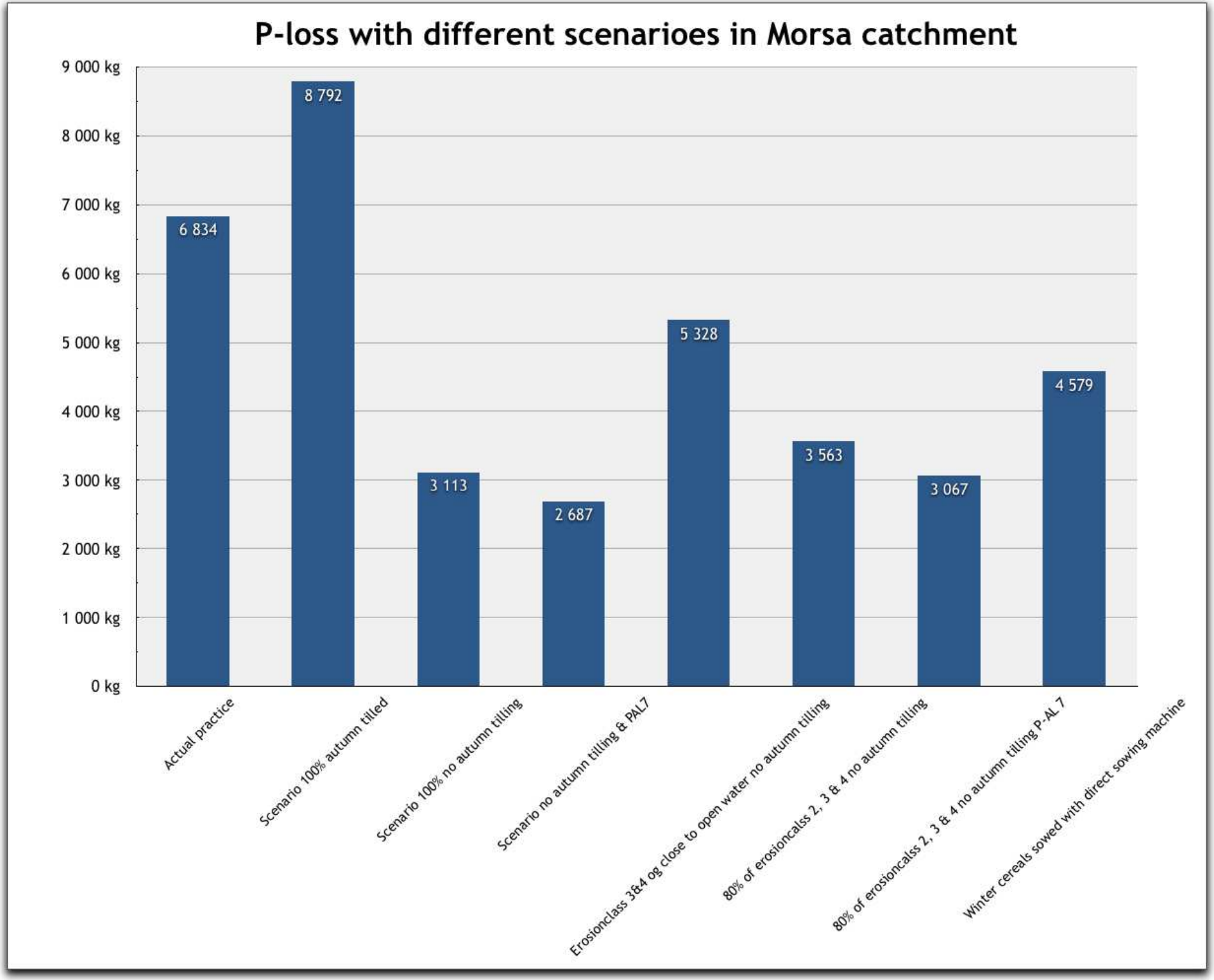
- «Reasonable fit on an annual basis»
- The model underestimates probably years with high annual rainfall
- We will do more calibration work on other test areas that we monitor

Year	Deviation
2002-2003	14,7 %
2003-2004	12,4 %
2004-2005	-5,0 %
2005-2006	-7,3 %
2006-2007	-21,9 %
2007-2008	-17,7 %
Average	**-4,1 %**

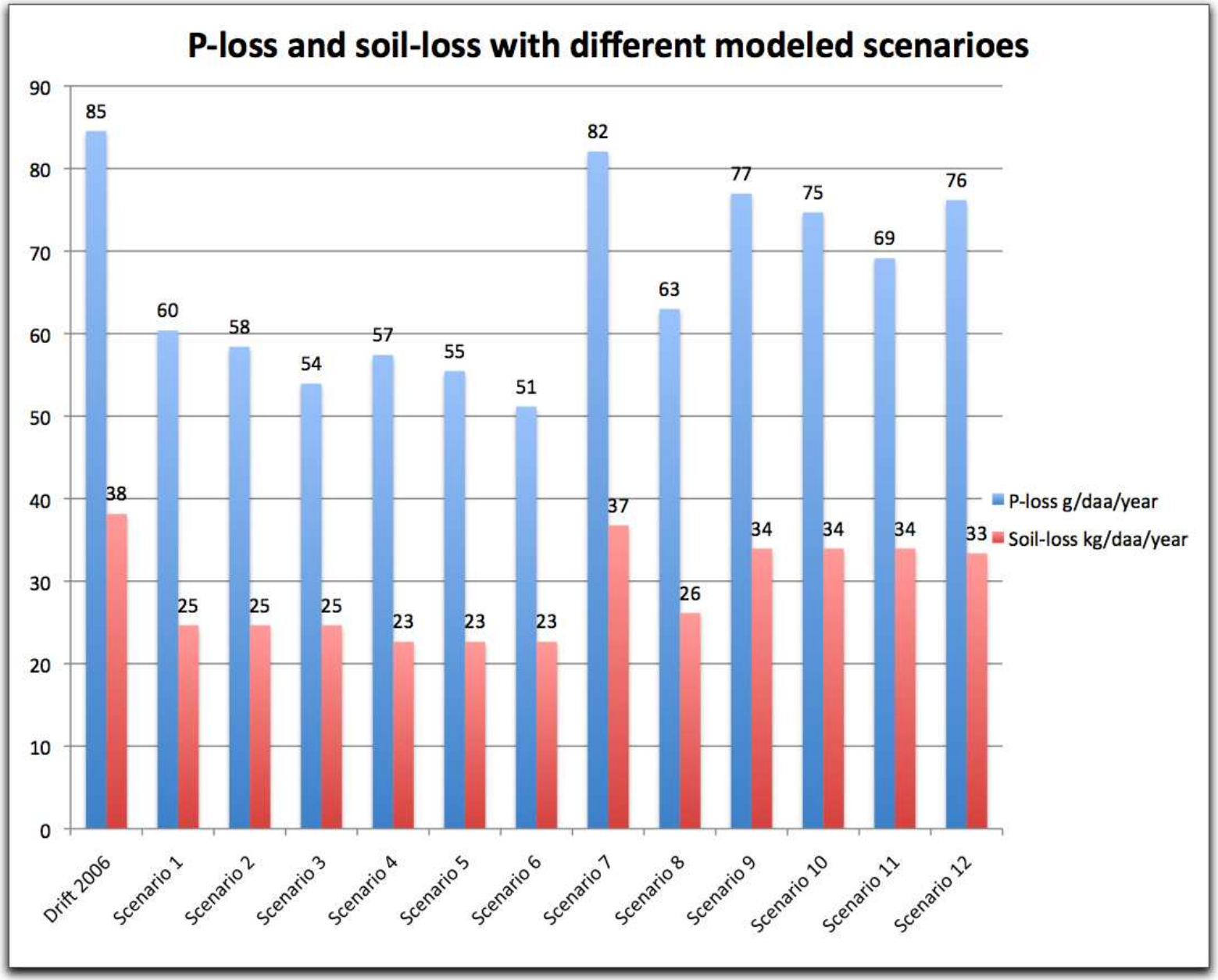


Type of scenarios that we run

- What if all cereal areas are tilled.
- What if no tilling on cereal areas.
- As above, but also no area with P-AL larger than P-AL 7.
- What if cereal areas closer than 30 meter from open water /streams /rivers) and areas in erosions class 3 and 4 are not tilled.
- What if 80 % of cereal areas in class 2, and 100% in class 3 and 4 and areas which is close to water (30 m) are not tilled and the three new sedimentation ponds are build.
- What if 40 % of farm areas have no restrictions, and 100% of cereal areas in class 3 and 4 and areas which is close to water (30 m) are not tilled.
- What if winter cereals are directly sowed and the rest is kept as in 2007.


P-loss with different scenarioes in Morsa catchment
9 000 kg
8 000 kg
7 000 kg
6 000 kg
5 000 kg
4 000 kg
3 000 kg
2 000 kg
1 000 kg
0 kg
6 834
8 792
3 113
2 687
5 328
3 563
3 067
4 579
Actual practice
Scenario 100% autumn tilled
Scenario 100% no autumn tilling
Scenario no autumn tilling & PAL7
Erosionclass 3&4 og close to open water no autumn tilling
80% of erosioncalss 2, 3 & 4 no autumn tilling
80% of erosioncalss 2, 3 & 4 no autumn tilling P-AL 7
Winter cereals sowed with direct sowing machine

Scenarios for the Morsa Catchment



What is the nest step for AGRICAT-P

- More calibration testing on our national monitored catchments with different climate and agricultural practise situation

- Improve the most vague founded parts of the model
  - the enrichment of P equation
  - division between drain and surface loss

- Cost effectiveness

- Carbon binding effects?