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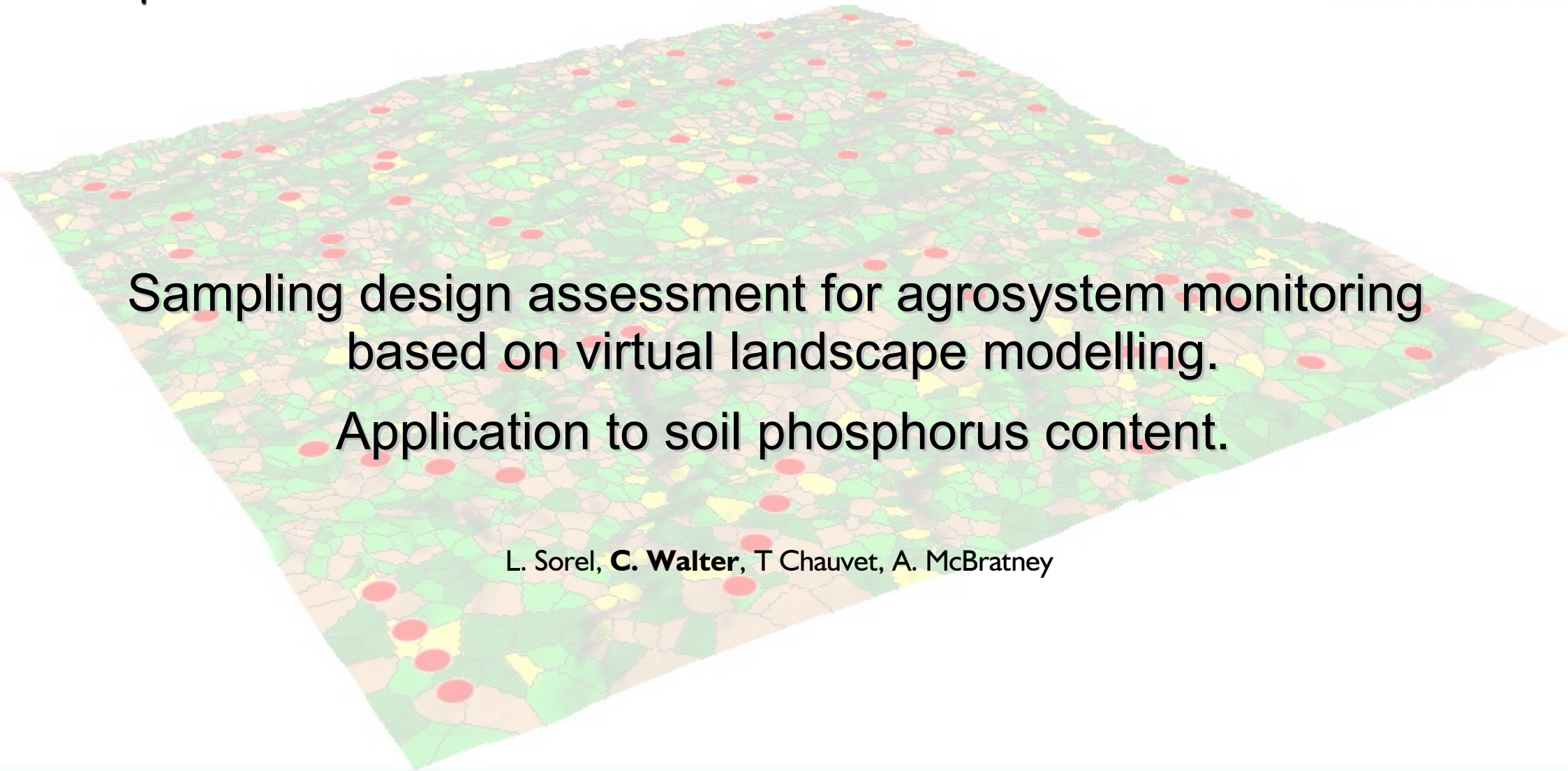


Sampling design assessment for agrosystem monitoring based on virtual landscape modelling.

Application to soil phosphorus content.

L. Sorel, **C. Walter**, T Chauvet, A. McBratney

Context

Survey programmes are necessary

- to monitor natural resources
- to assess the efficiency of environmental policies

> US: Environmental Monitoring Assessment Program — Lesser et al., 1997
> UK: Soil Action Plan — DEFRA, 2004
> Fr: Soil Quality Network — King et al., 2005

Design and implementation face financial cuts

> Simulation can be used to optimise the design of sampling programmes on virtual landscapes:

- subsampling existing databases (short chronicles, too local) — Fernández et al., 2005
- computed from spatial structure (irrealistic) — Papritz et al., 1995

Objectives

To create realistic virtual landscapes

- Initial spatial distributions
- Evolution processes

To implement different sampling strategies

To assess different sampling strategies

- Accuracy
- Trend detection ability

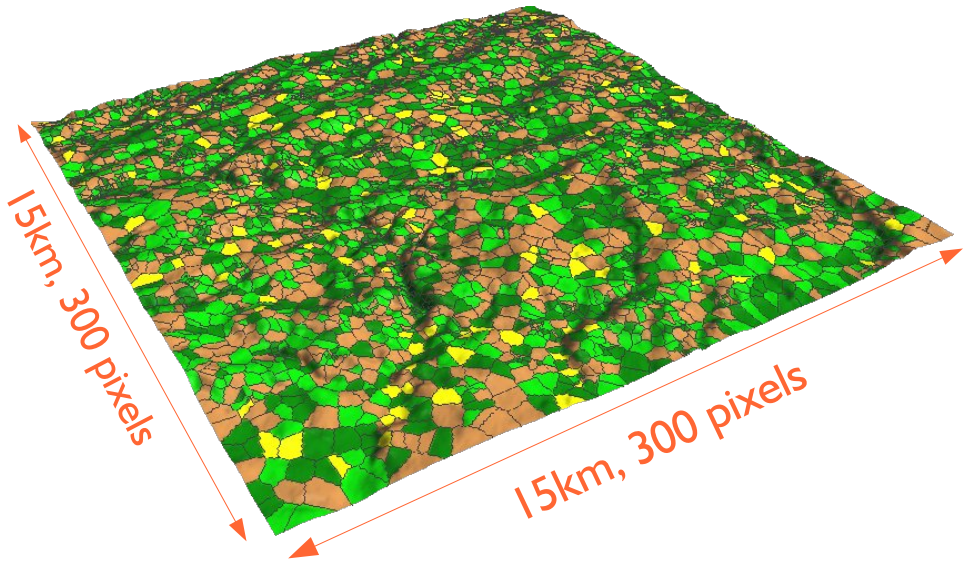
Soil phosphorus content

- Environmental issue
- Linked to agricultural practices

Virtual landscape, construction

Field contours generation

Walter et al., 2003



- 4153 fields, contours = f(DEM)

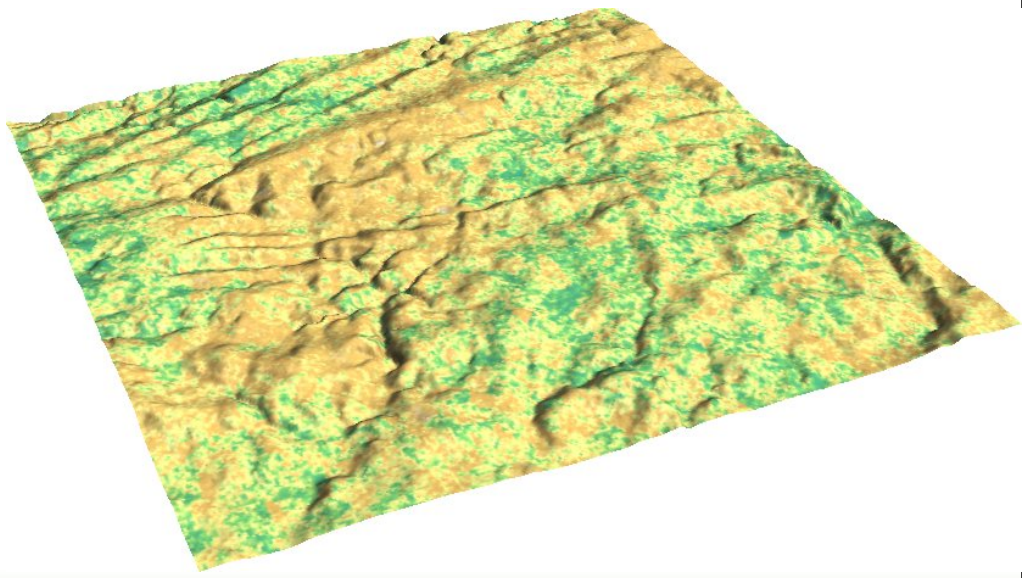
McBratney et al., 1999

- 4 landuses (perm/temp pastures, grains, maize), early 60's

Initial soil phosphorus content

3 sources of spatial variability:

- long distance variability
- crop induced variability
- short distance variability



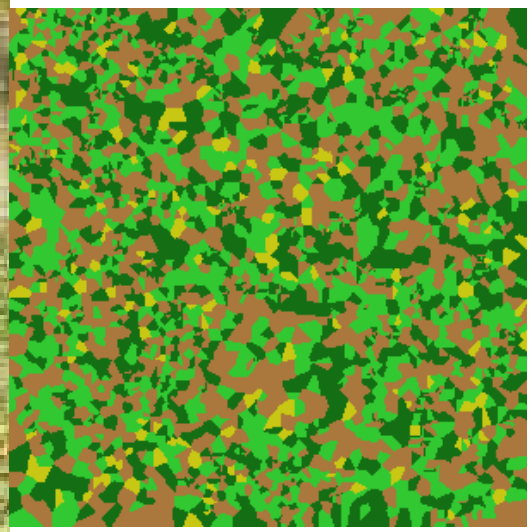
Virtual landscape, land use evolution

Walter et al., 2003

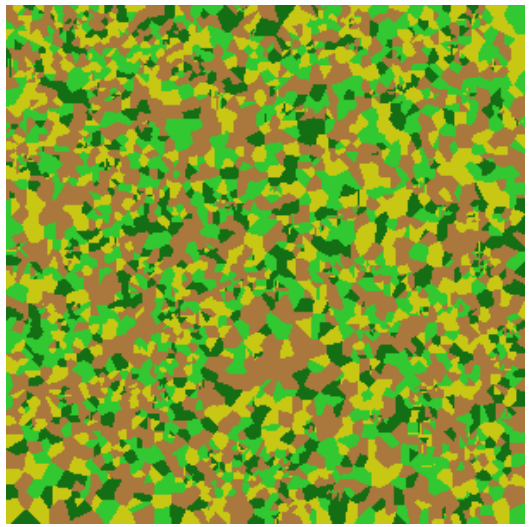
- stochastic transition matrix Cressie., 1991

- over 50 years

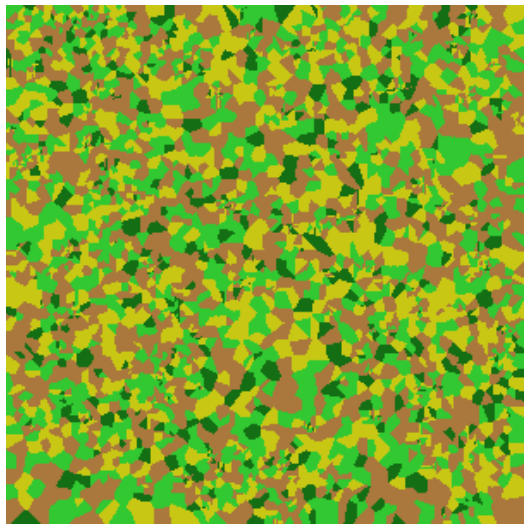
		Year Y+1			
		perm. pasture	temp. pasture	cereals	maize
Year Y	*perm. pasture*	95%	3,5%	1%	0,5%
	temp. pasture	1%	65%	24%	10%
	cereals	0%	20%	80%	0%
	maize	0%	9%	1%	90%



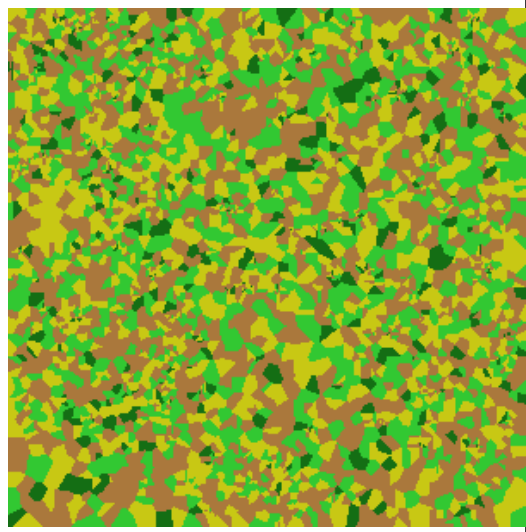
Year 1



Year 16



Year 30



Year 46

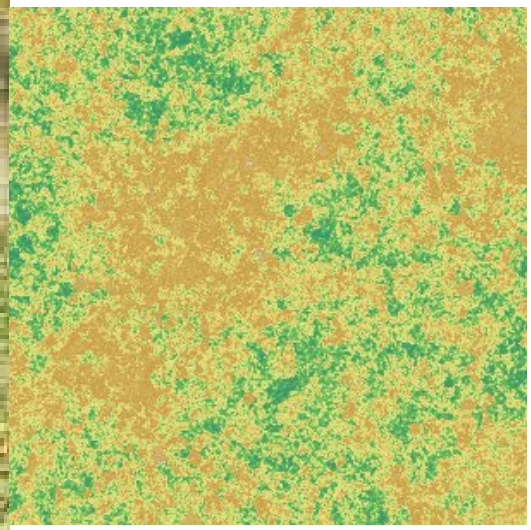
Virtual landscape, soil P content evolution

Fertilisation practices Schvartz et al., 2005

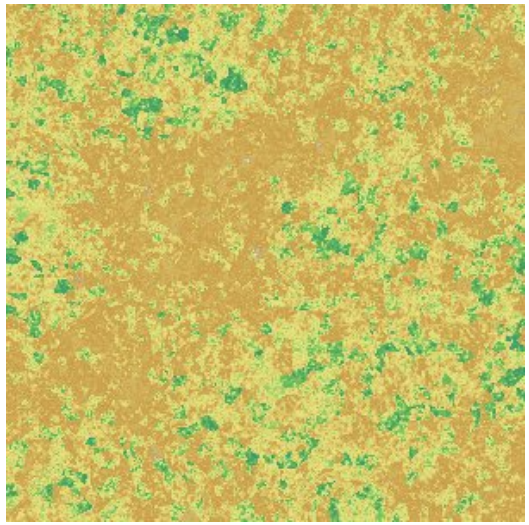
- 20 years : N-based fertilisation
- 30 years : P-based fertilisation

Crop intakes

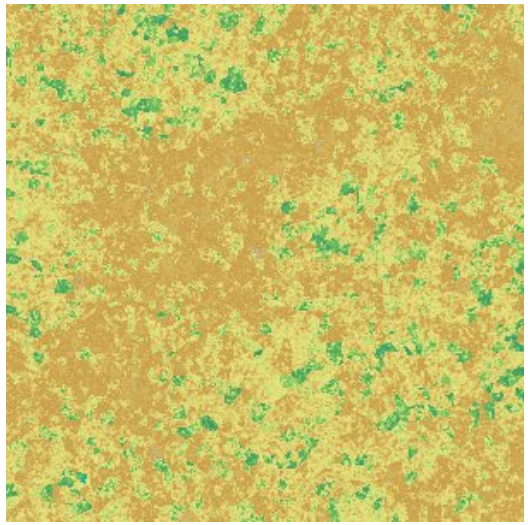
Soil P mineralisation Fardeau et al., 1994



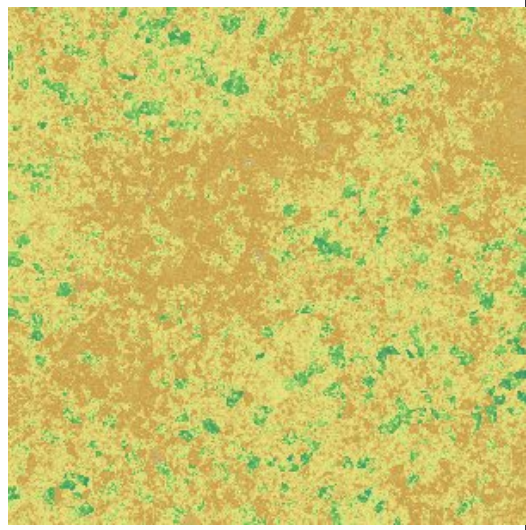
Year 1



Year 16



Year 30



Year 46

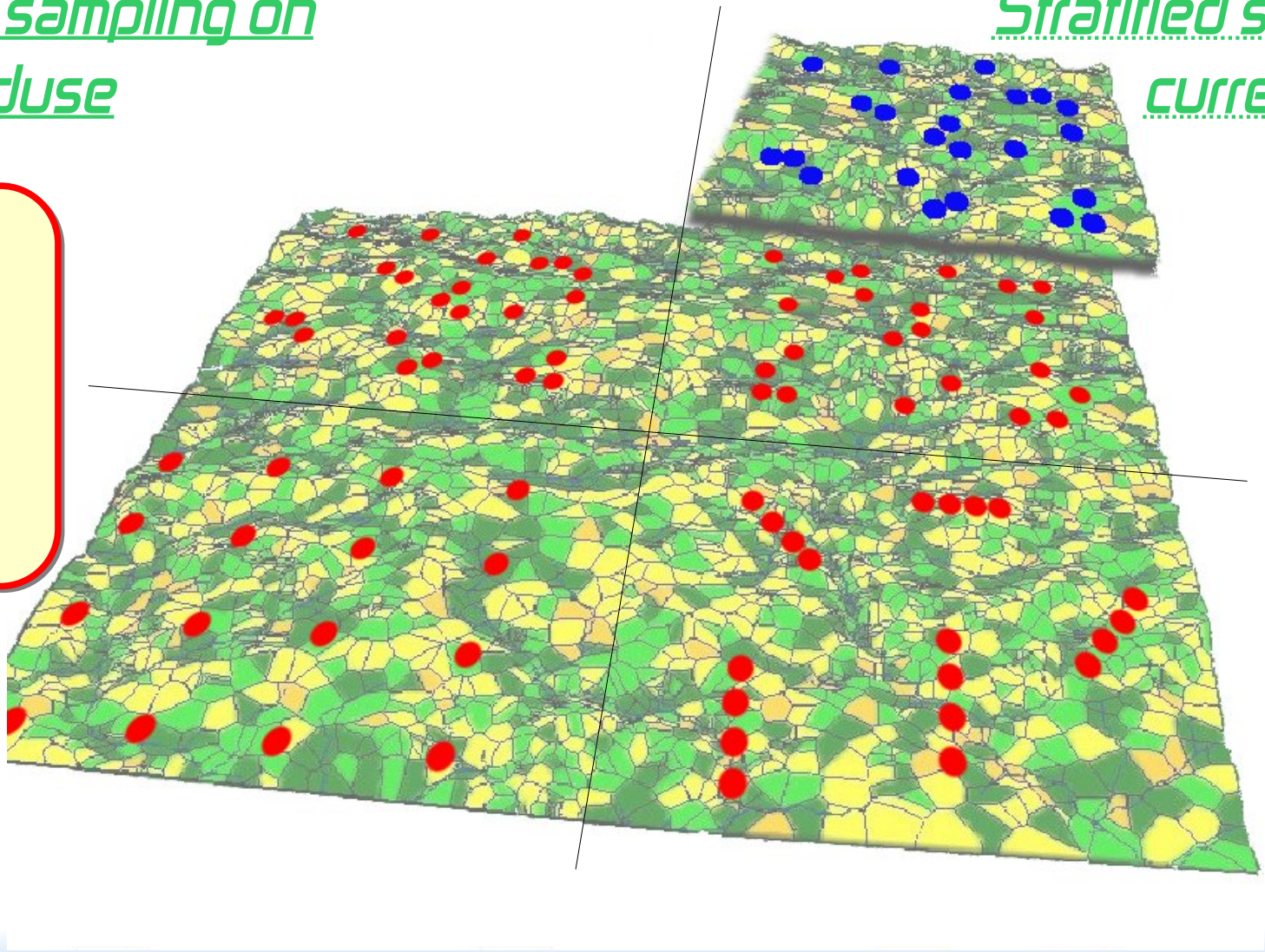
Sampling designs

Stratified sampling on initial landuse

Stratified sampling on current landuse

Sampling densities:

- 16 points
- 144 points
- 256 points
- 576 points
- 1024 points



Regular grid

Transects

Methods of comparison

Definitions

A strategy combines:

- a sampling design
- a sampling density
- 2-8 years interval

100 realisations per strategy
> 100 medians (soil P content)

Indicators

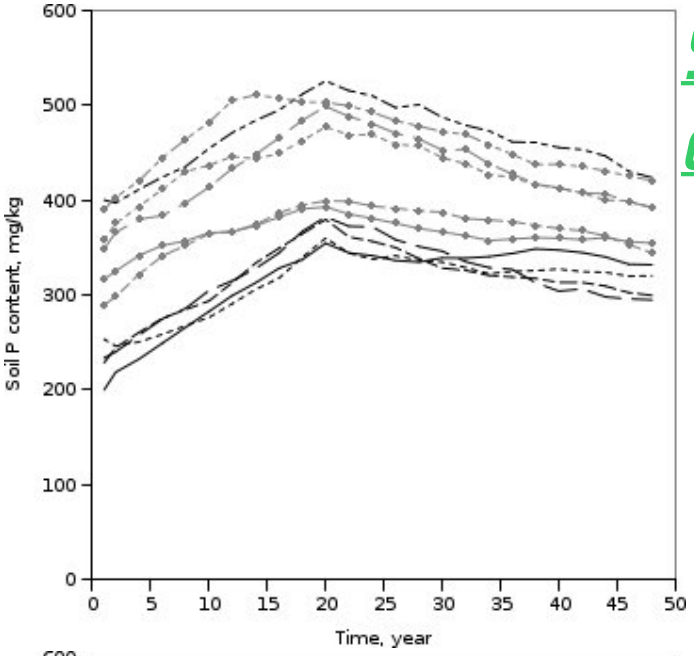
How accurate is the strategy?

- comparison of the actual and the sampled medians
- any sampling density influence?

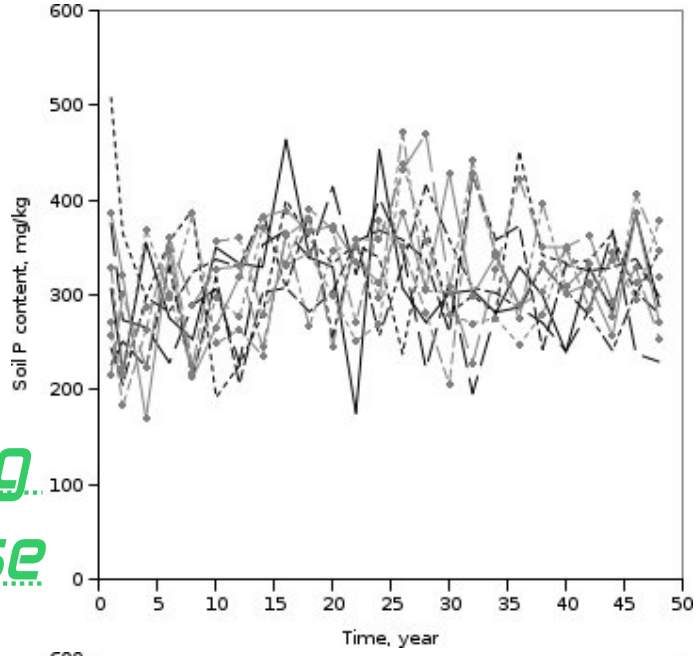
How well can the strategy detect an actual trend?

- any sampling density influence?
- any time interval effect?

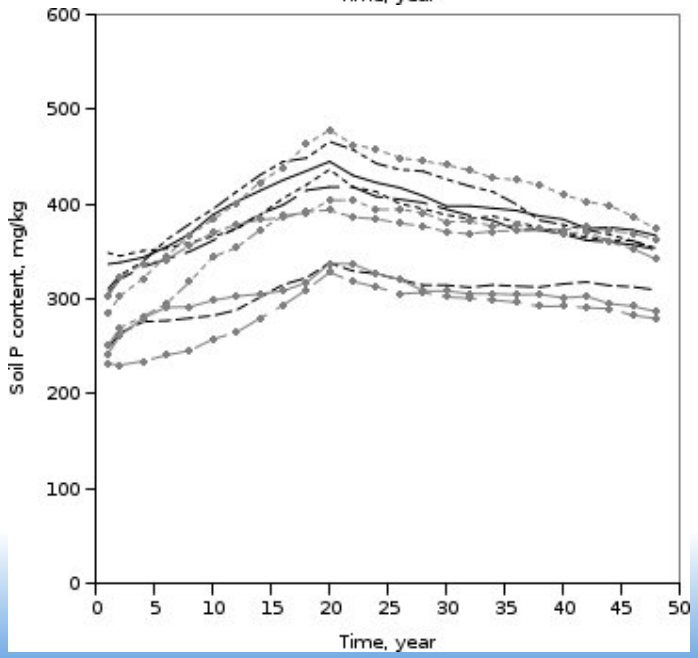
A few realisations



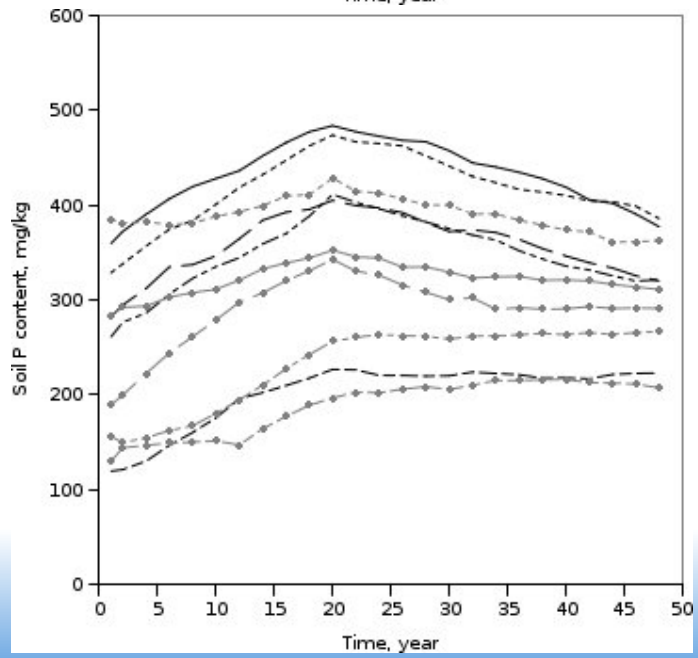
Stratified sampling on initial landuse



Stratified sampling on current landuse



Regular grid

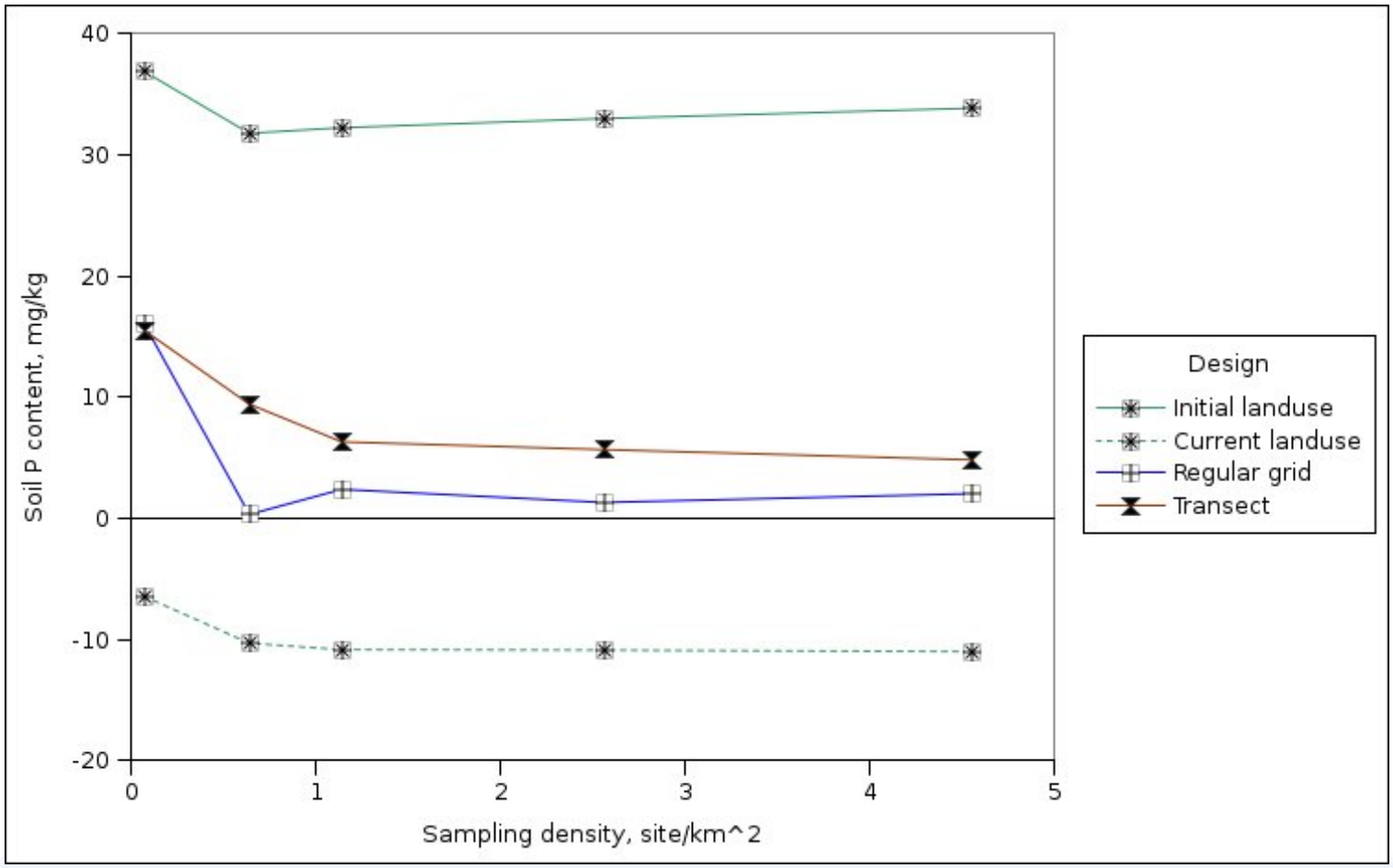


Transects

Accuracy

BIAS

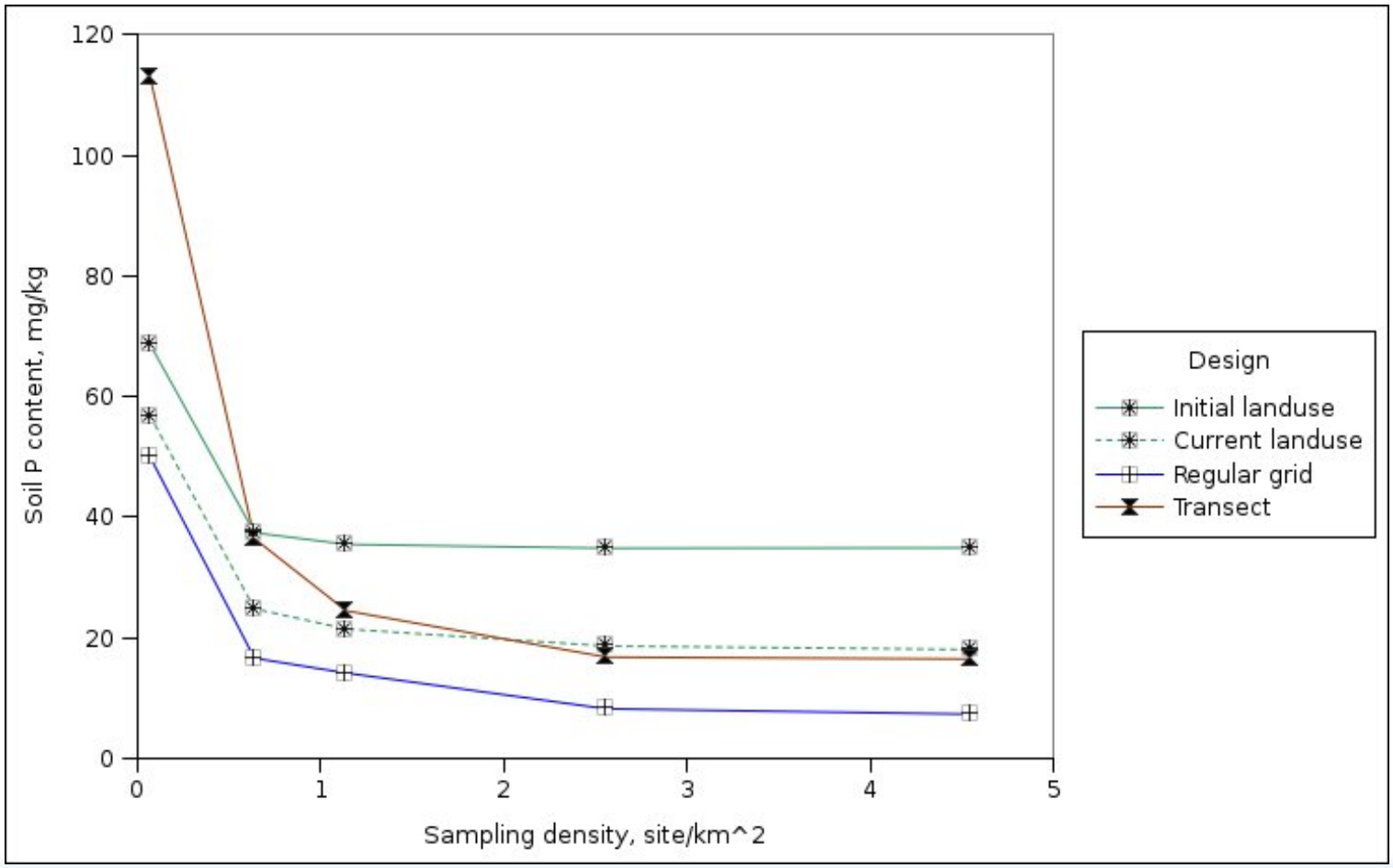
$$BIAS = \frac{1}{N_{Year}} \frac{1}{N_{Realisation}} \sum_{y=1}^{N_{Year}} \left[\sum_{r=1}^{N_{Realisation}} \left(Med_{y,r} - Med_{y,A} \right) \right]$$



Accuracy

RMSE

$$RMSE = \frac{1}{N_{Year}} \frac{1}{N_{Realisation}} \sqrt{\sum_{y=1}^{N_{Year}} \left[\sum_{r=1}^{N_{Realisation}} \left(Med_{y,r} - Med_{y,A} \right)^2 \right]}$$



Trend detection

Trend ratio

$$TR = \frac{(Med_{y,r} - Med_{y-t,r})}{(Med_{y,A} - Med_{y-t,A})}$$

Trend detection ability

$$TR \geq 0$$

Trend detection accuracy

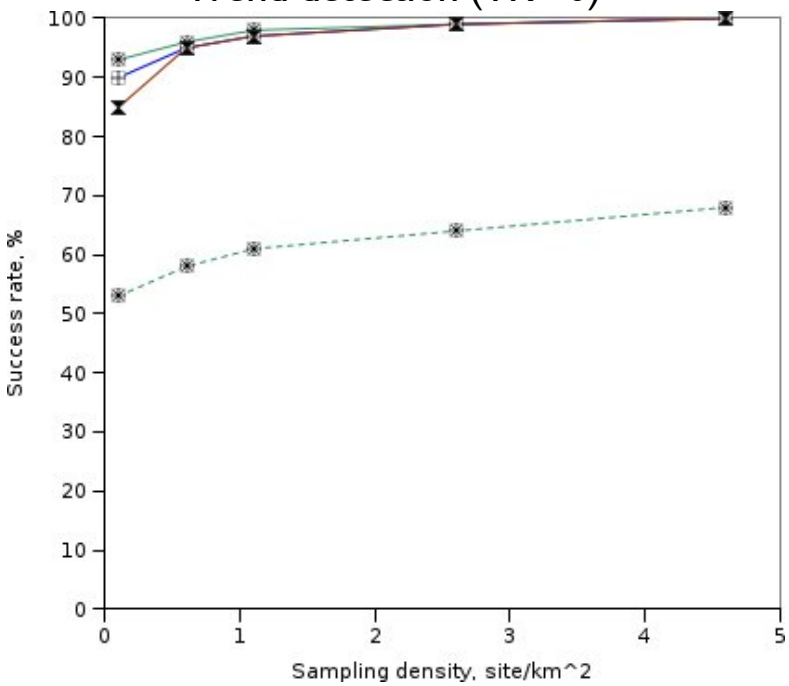
$$\frac{1}{k_{trend}} \leq TR \leq k_{trend}, \quad with \quad k_{trend} > 1$$

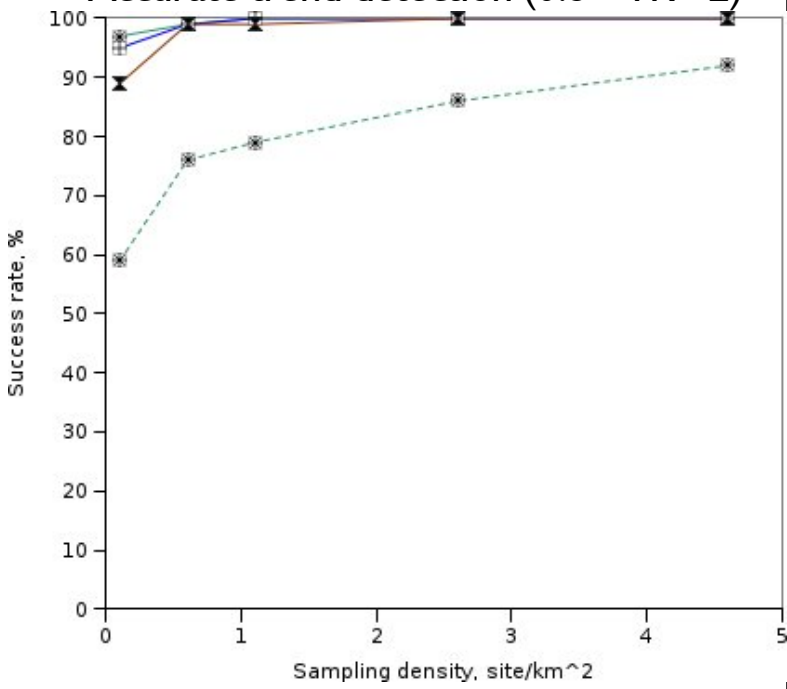
Success rates

Trend detection (TR>0)

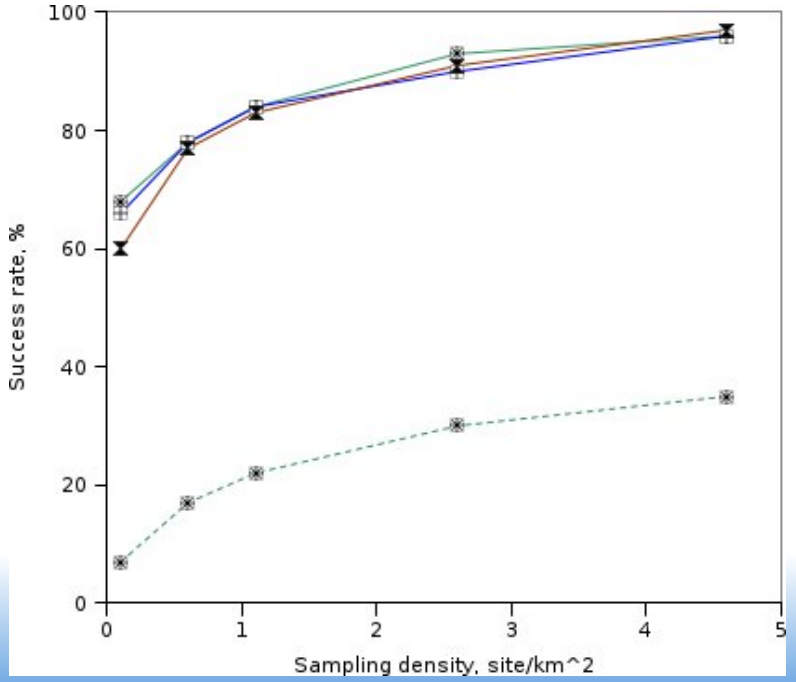
Accurate trend detection (0.5<TR<2)

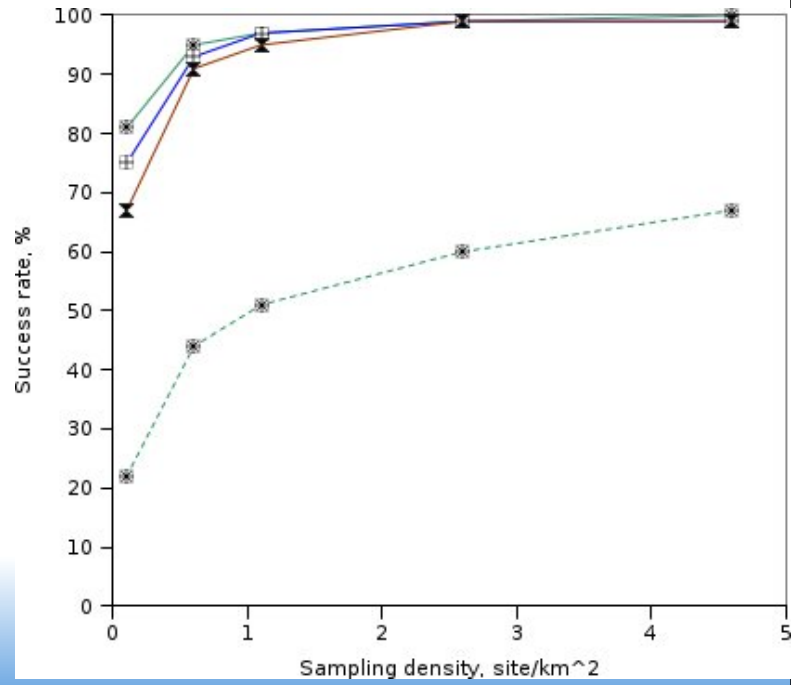
2-year interval





8-year interval





Conclusion

Sampling design assessment

	best design			*worst design*
BIAS	regular grid	transect	current landuse	initial landuse
ERROR	regular grid	current landuse	transect	initial landuse
TR success rate	initial landuse	regular grid	transect	current landuse

Virtual landscape modelling

- realistic
- flexible
- scenario evaluation

Perspectives

- joint evaluation on both soil and water quality
- integration of climatic and hydrological processes
- integration of the farm level of landscape organisation