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IALE World Congress 2007

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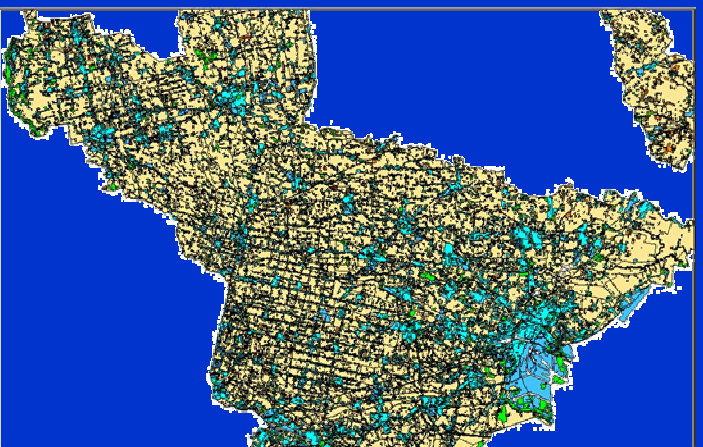
Multiscale analysis of the relationship among land use cover and streams water quality in the Venice lagoon watershed

8-12 July 2007 Wageningen



L. Favero[1], A. Zuin [1], E. Mattiuzzo [1], G. Zanetto[2], P. Ghetti[3], D. Franco[3]

[1] Planland – Cannaregio 3841, 30121 Venice (Italy)
[2] IDEAS – San Giobbe 873, 30121 Venice (Italy). e-mail: ideas@unive.it
[3] Università Cà Foscari – Dorsoduro 3246, 30123 Venice (Italy).

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The context

Venice lagoon = fragile habitat threatened by water pollution.

Regional plan to reduce nutrients inputs to 3000 t yr^{-1} for TN
300 t yr^{-1} for TP.

Relationships between
watershed Land Use (LU) ↔ surface water quality
= info for management and planning purposes.

Aims of the research

Literature:

LU patterns

simple % values

Metrics (landscape spatial patterns)

+

Natural watershed characteristics
= soil texture and permeability

↓

Water quality

Research objectives:

Analyses of

The relationships between streams nutrients concentrations
&
land use patterns

to verify

- role of soil properties
- role of landscape spatial pattern
- Scale effect

→ Next step: rural hedgerow network effect

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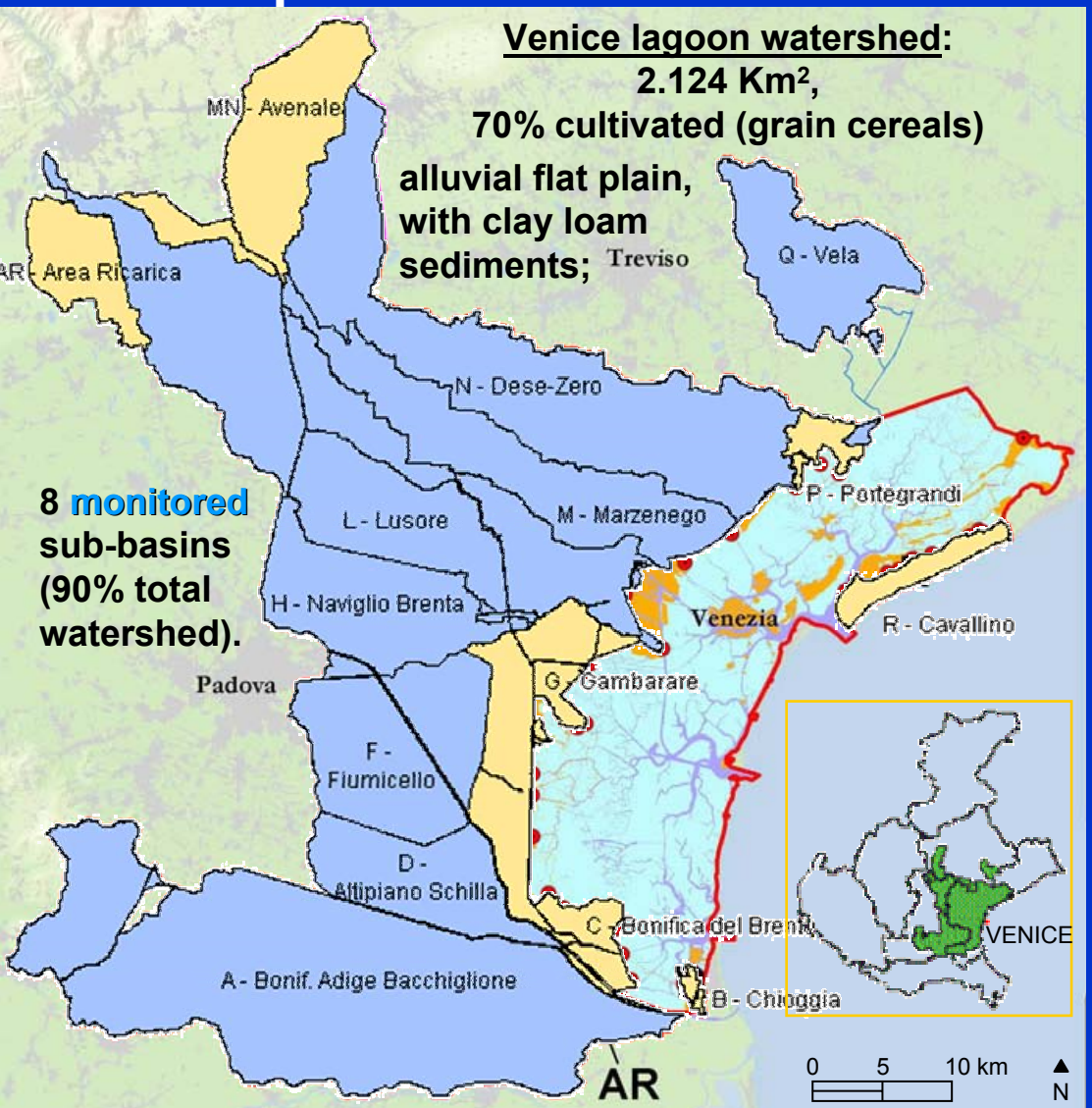
Dataset



Data from the "Veneto Regional Agency for the Environment Protection":

- $N\text{-}NH_4$ & $N\text{-}NO_3$ loads at the sub-basins outlets (2002-2004);
- digitised land use maps (satellite data 2001, 0.3 ha resolution);
- digitised soil characteristics maps;
- digitised streams and basins boundaries.

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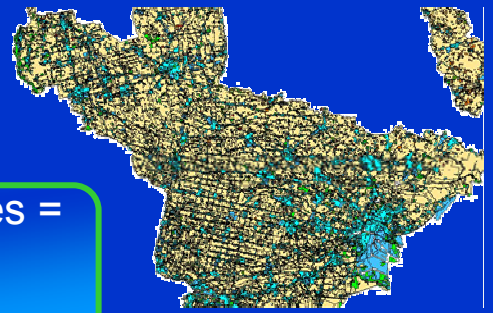
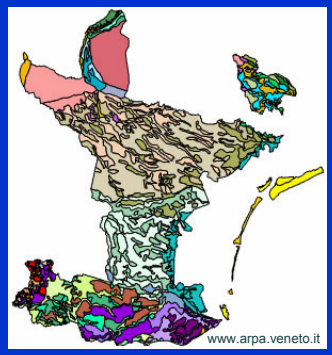
Data organization

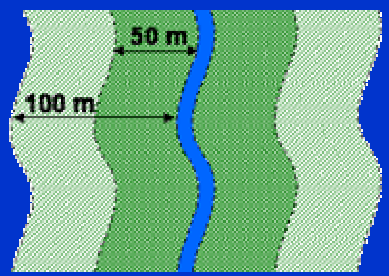


Explicative variables



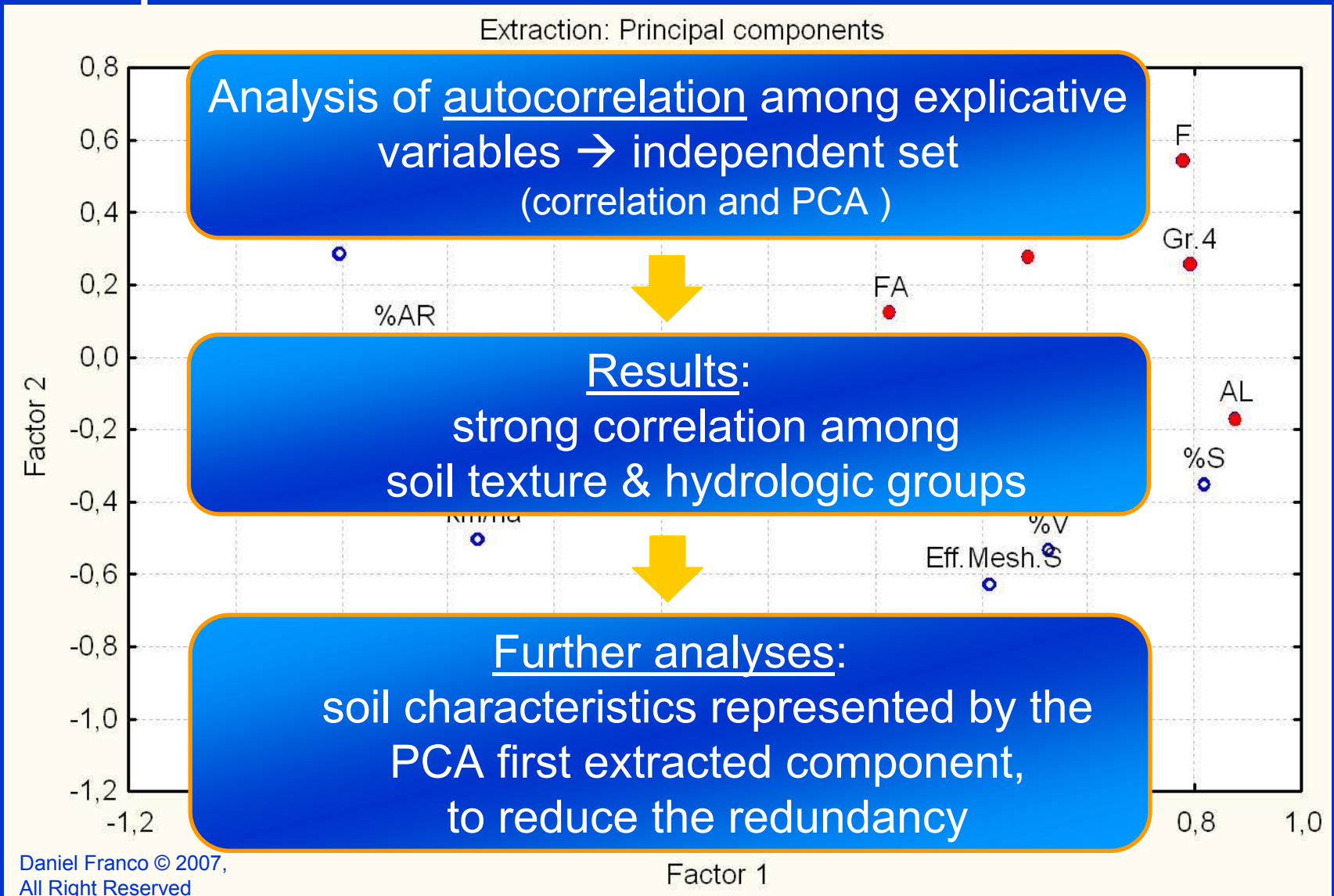
- Land Use types: 69 categories clustered into 7 classes =
  - urban, agriculture, industrial, zootechnics, tree farming and orchard, natural zones, vineyards.
- Soil characteristics:
  - soil texture classes; hydrologic soil groups; permeability.
- Landscape metrics (selected from literature studies):
  - the Shannon-Wiener index for heterogeneity (Franco, 2000),
  - the Effective Mesh Size index for fragmentation (Jaeger, 2000).

Landscape proximity analysis

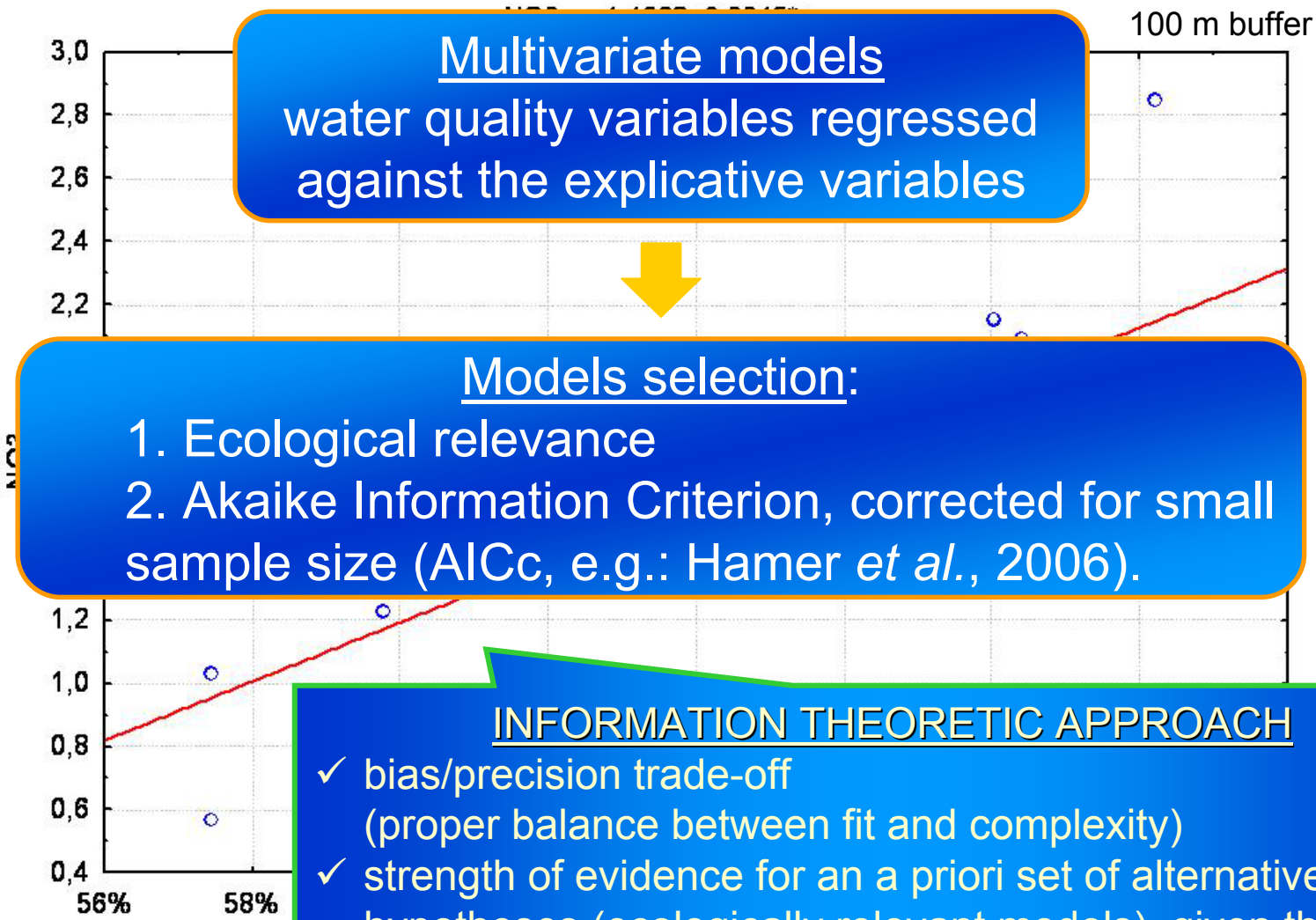


- = buffering concentric zones (0-50 and 0-100 m from streams) around the streams within each sub-basin.
- The 50m and 100m values were selected:
  - from literature analysis (distance at which the explicative variables and/or the relationships strength changes)
  - based on the sub-basins shape.

Analyses: first step



Analyses: second step



Multivariate models
water quality variables regressed against the explicative variables

Models selection:
1. Ecological relevance
2. Akaike Information Criterion, corrected for small sample size (AICc, e.g.: Hamer *et al.*, 2006).

INFORMATION THEORETIC APPROACH
- ✓ bias/precision trade-off (proper balance between fit and complexity)
- ✓ strength of evidence for an a priori set of alternative hypotheses (ecologically relevant models), given the data.

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Sub-basins selection

First regression results:

→ Peculiar behaviour of south sub-basins:

✓ High agricultural land use

✓ Low nitrogen loads

→ The whole stream network of this sub-basins is a reclaimed network

→ It is managed to reduce in-stream nutrients.

The reclaimed network management overrides the land use-water quality relationship:

→ The 3 south sub-basins were excluded.

Competing models selected

Nutrient	Variables	R^2	ΔAICc	Scale
$N\text{-}NH_4$	IND(+), F1(+)	0.8	0.00	W
	URB(+), F1(+)	0.8	1.72	50m

URB: urban;

IND: industrial;

F1: PCA factor (soil texture & permeability);

AICc: corrected Akaike Information Criterion.

W: watershed scale

In brackets the sign of the relationship.

NH_4 loads depend on

- industrial land use (watershed scale),
- urban land use (50m buffer scale),

→ higher concentration of sewage and waste disposal associated with urban & industrial areas (Jones *et al.*, 2001).

- soil characteristics: high $[NH_4]$ in fine textured, low permeable sub-basins

→ clay minerals and clay humics = large potential for nutrients adsorption

→ low permeability = overland flow → particulates & nutrients into rivers (Sliva & Williams, 2001).

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Competing models selected

Nutrient	Variables	R^2	ΔAICc	Scale
$N\text{-}NO_3$	AG(+)	0.7	0.61	W
	Shannon(-)	0.7	1.76	W
	AG(+)	0.7	0.00	100m
	AG(+)	0.7	1.78	50m

AG: agriculture;

Shannon: heterogeneity index;

AICc: corrected Akaike Information Criterion.

W: watershed scale

In brackets the sign of the relationship.

NO_3 loads dependent on:

- agriculture (at the three scales),

→ contribution of fertilizers to non-point source pollution (e.g. Sliva & Williams, 2001)

- heterogeneity (watershed scale, inversely dependent).

→ impact of ecotone density on NO_3 dynamic:

Ecotone density = ditches in this ancient reclaimed land;

Ditches are managed to enhance nutrients removal.

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Scale effect

LU near rivers is a better predictor of water quality than LU over the whole watershed?

- Literature:
  - contrasting results.
- Our study:
  - not significant differences among spatial scales

Venice watershed = highly impacted structure of the landscape:
agriculture 60-75%,
urban LU 9-28%
natural zones < 8%, even in the 50m buffer zone.

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Thanks for your attention