Identification of important spatial and temporal scales of ecological variables

Jonne Kotta, Ilmar Kotta and Helen Orav-Kotta

EESTI MEREINSTITUUT

Background

- Benthic communities have high variability at multitude of scales and this variability is closely linked with physical settings.
- Often the patterns have been specified at one or a few scales only ignoring all other possibilities.
- Identification of the important spatial and temporal scales helps us to unveil factors and processes generating the patterns of benthic communities.

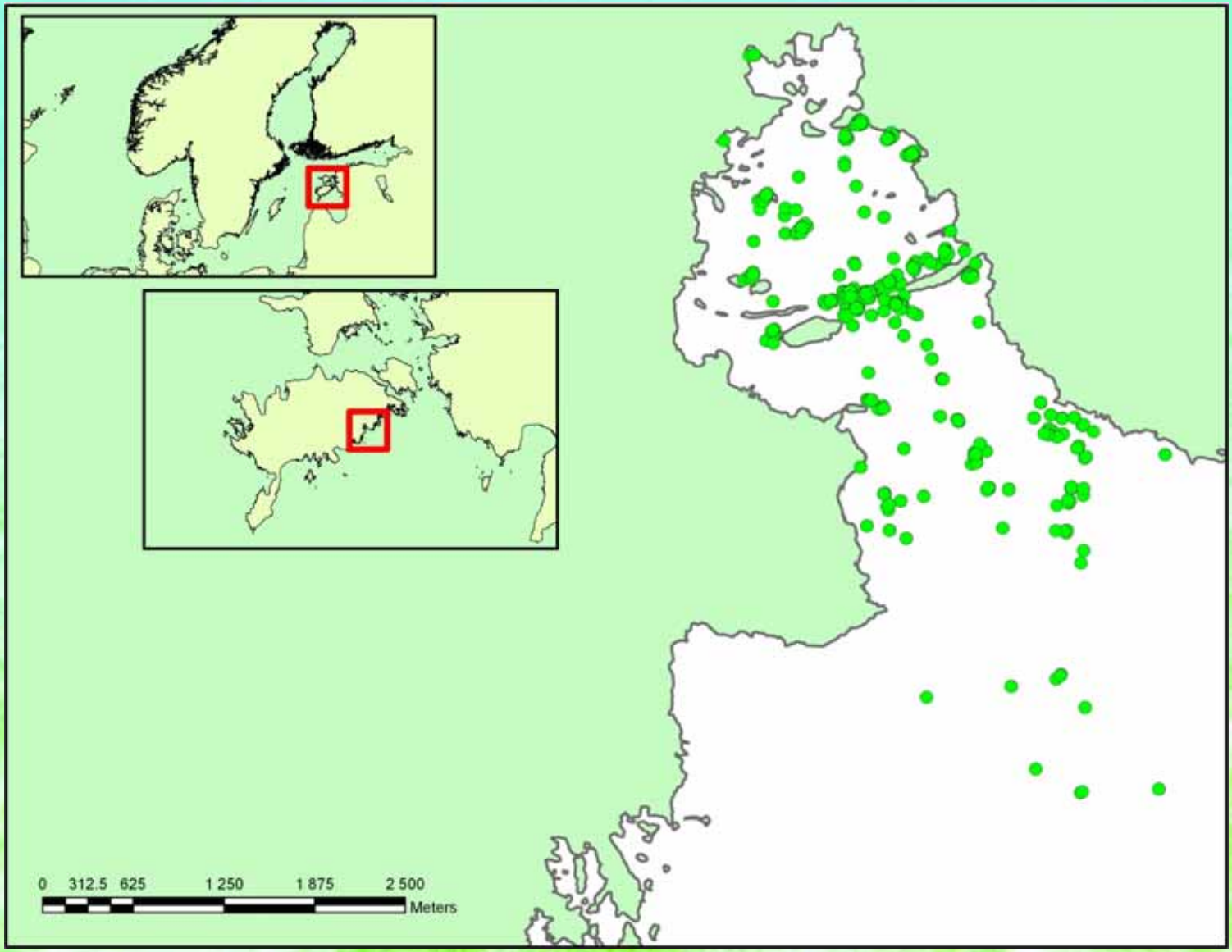
Background

- If environmental variables have large effects on benthic communities at certain scales then the communities have high spatial variance, i.e. communities are dissimilar at this scale.
- In the presence of small and large scale disturbances the community pattern may display scale invariance i.e. strong content of variability through all scales.

Objectives

- Does average similarity of benthic invertebrate communities change with geographical and temporal distances between communities?
- Whether the shape of such functional relationships varies among different invertebrate functional groups?

Study area



Study area

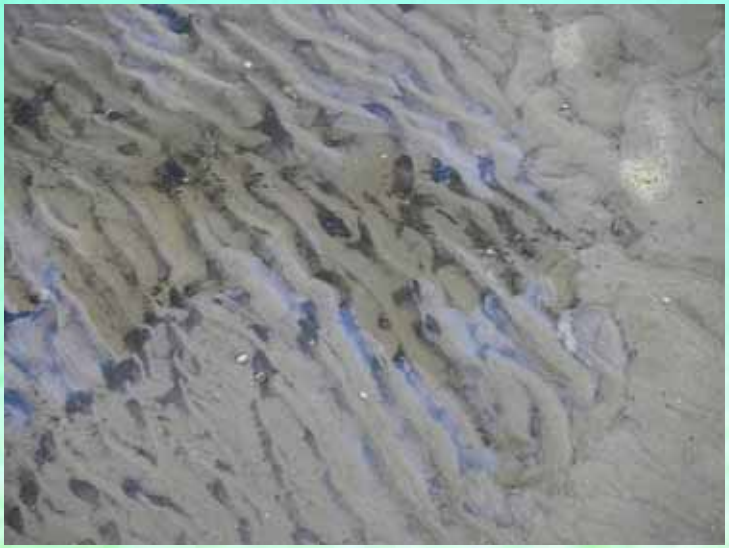
Salinity < 6psu

Strong temperature gradients (space, time)

Highly disturbed (waves, ice scour)

Moderately eutrophicated

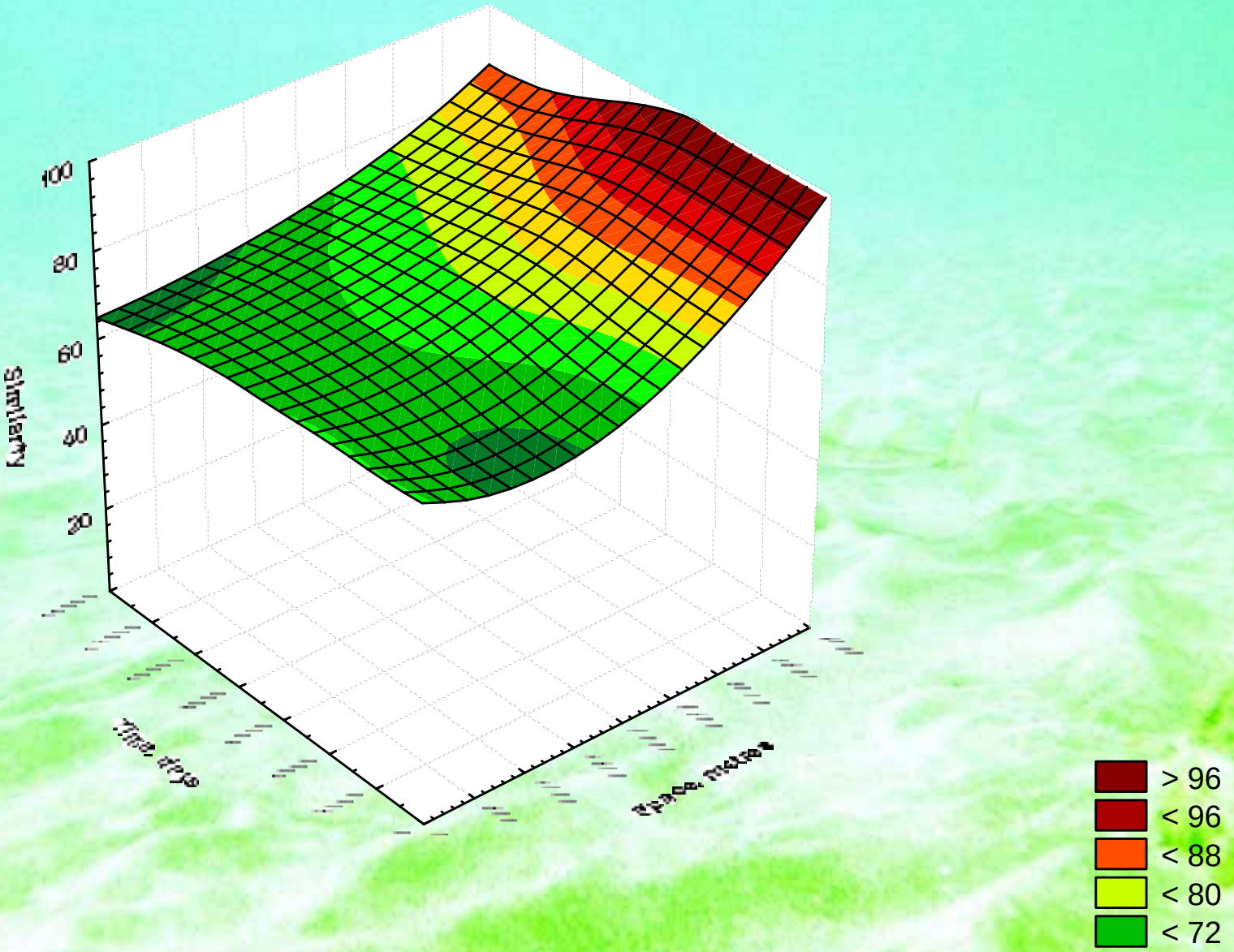
Great variation



Methods

- Grab samples collected seasonally during 1972-2007
- ArcGis point distance, slope tool
- PRIMER: Bray-Curtis similarity, Best permutation analysis

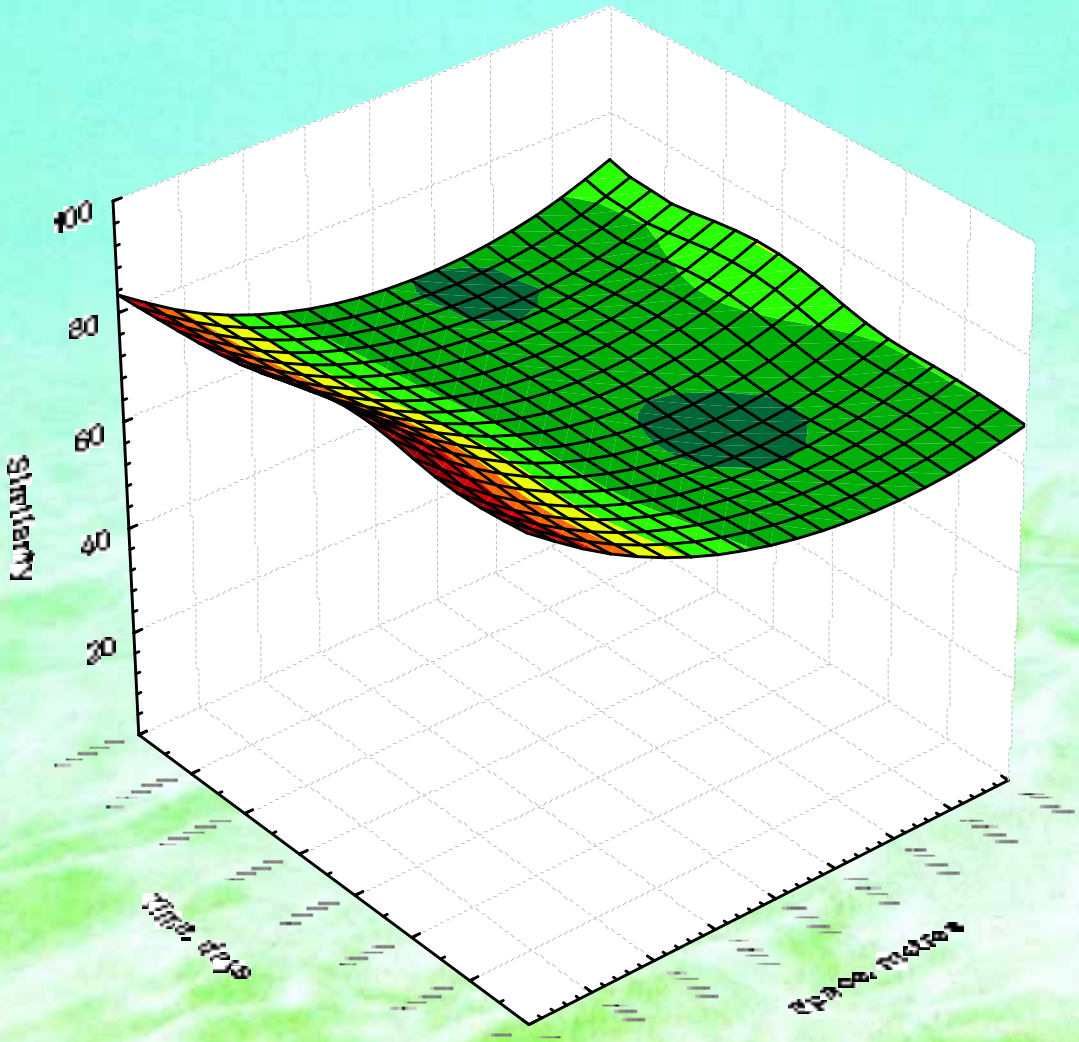
3D Surface Plot of Mobile deposit feeders against space and time



Mobile deposit feeders

- Temporal variability is not important.
- Spatial variability decreases with scale i.e. local variability is more important than landscape scale variability.

3D Surface Plot of Mobile carnivores against space and time

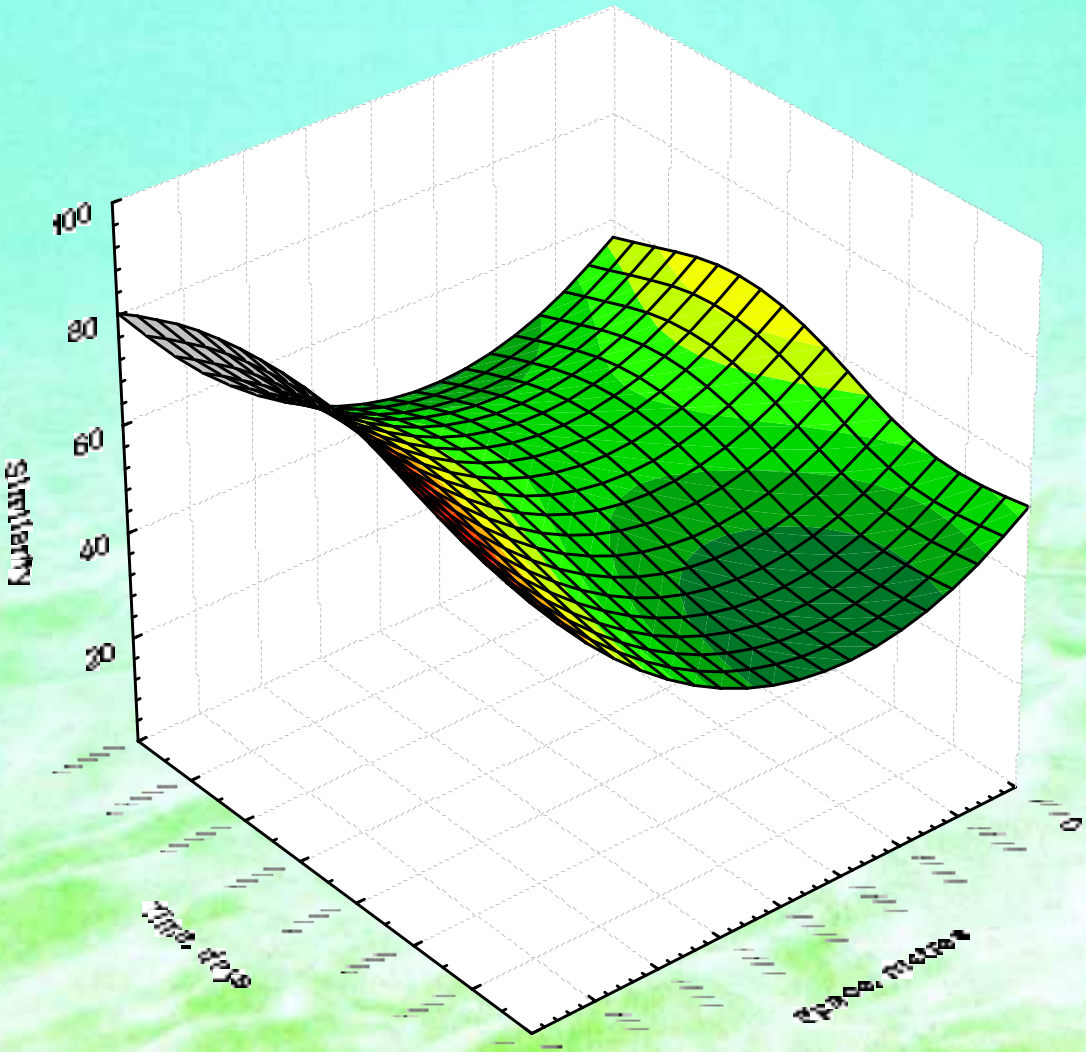


> 88
< 88
< 80
< 72
< 64

Mobile carnivores

- Temporal variability is not important.
- Spatial variability increases with scale i.e. landscape scale variability is more important than local variability.

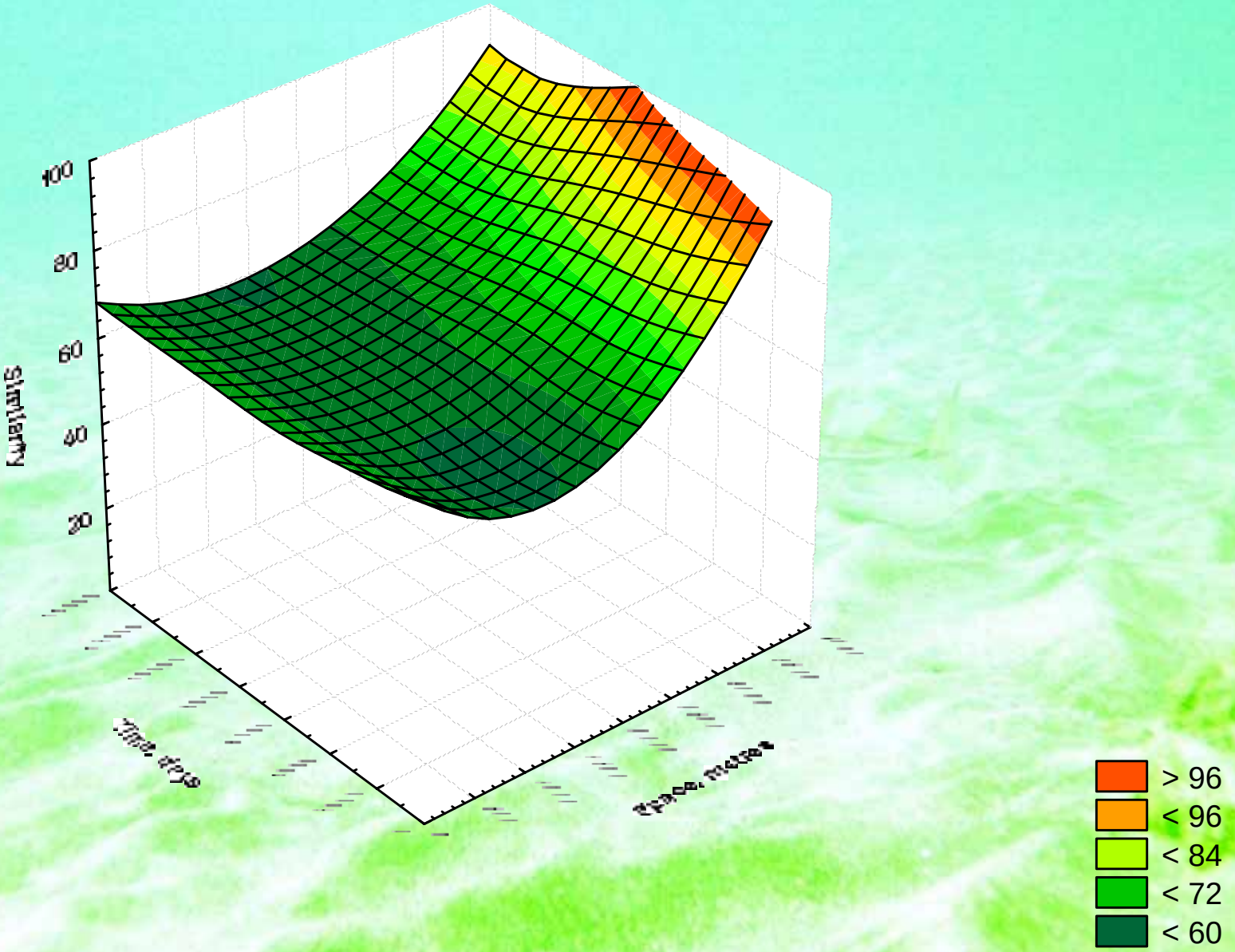
3D Surface Plot of Mobile herbivores against space and time



Mobile herbivores

- Temporal variability is important but less important than spatial variability
- Short term processes are more important than long term processes (decadal variability).
- Communities are very homogeneous at patch scale. Landscape scale variability is more important.

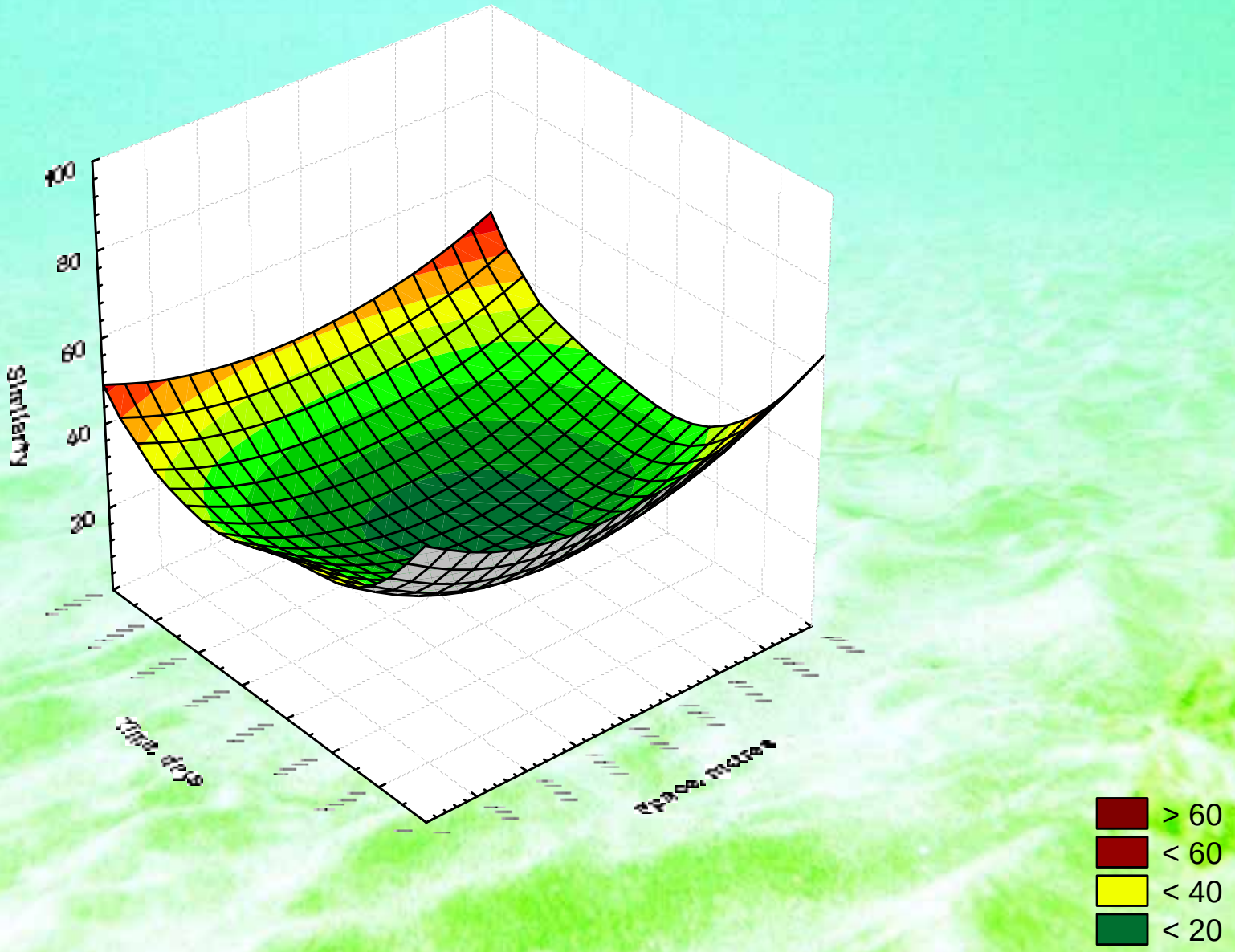
3D Surface Plot of Non-migrating deposit feeders against space and time



Non-migrating deposit feeders

- Temporal variability not important
- 1 km scale variability is more important than smaller or larger scale variability.

3D Surface Plot of Non-migrating herbivores against space and time



Non-migrating herbivores

- Decadal variability is very important.
- Spatial variability is not very important. Communities are slightly more heterogeneous at 1-2 km spatial scale.

Key questions

- Do environmental variables predict invertebrate communities the best at scales where highest dissimilarities between communities are observed?
- What is the relative contribution of climate variables to the overall variability?

Environmental variables

Sediment characteristics (local, landscape)

Inclination of coastal slope (10, 1000 m scale)

Total N and P loads

NAO winter index

Daily, monthly, seasonal wind pattern

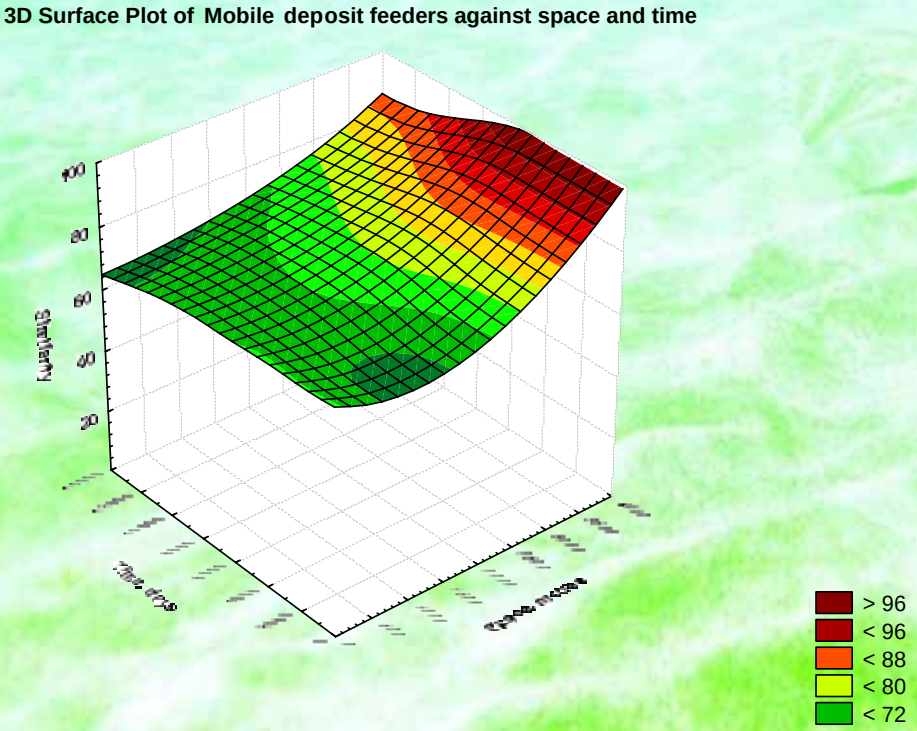
Frequency of storms

Daily, monthly, seasonal temperature pattern

Mobile deposit feeders

Important scale: patch scale

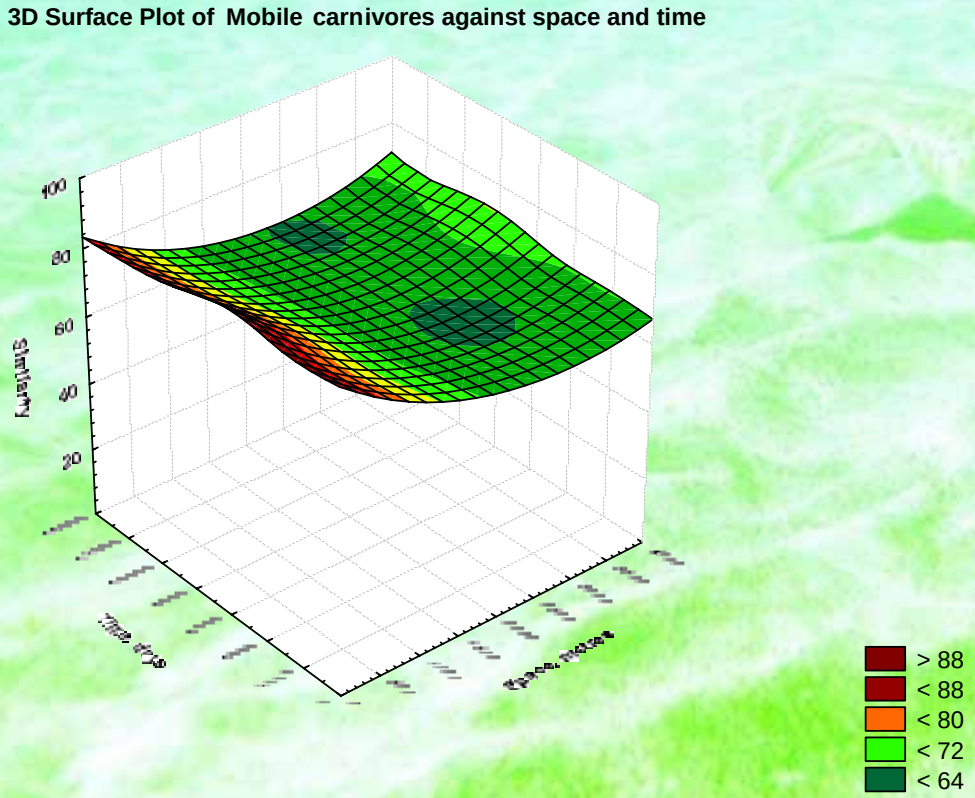
Explaining environmental factor: Slope 10m



Mobile carnivores

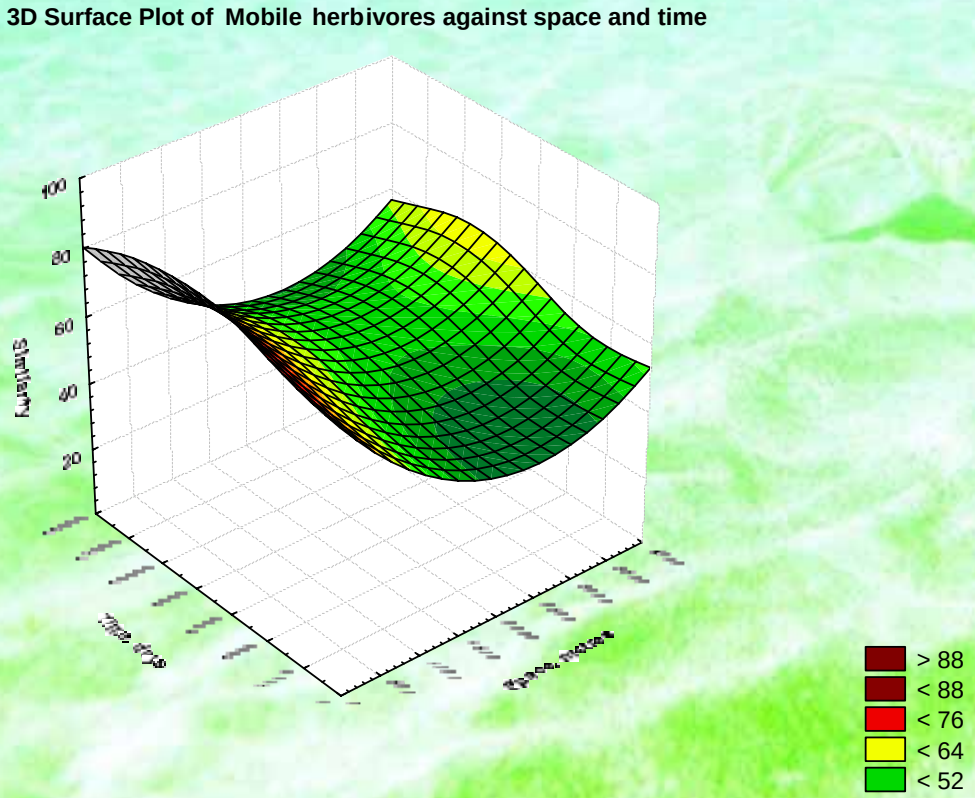
Important scale: landscape scale

Explaining environmental factor: Slope 1000m



Mobile herbivores

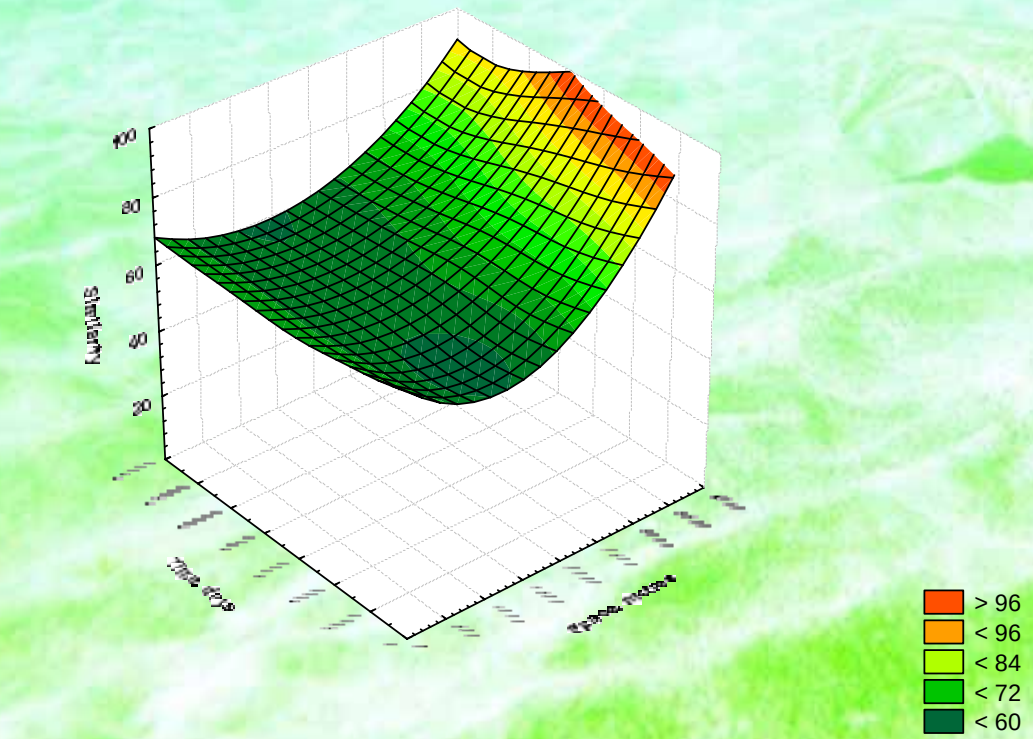
Important scale: patch scale, short-term variability
Explaining environmental factor: Slope 1000m



Non-migrating deposit feeders

Important scale: landscape (1 km) scale

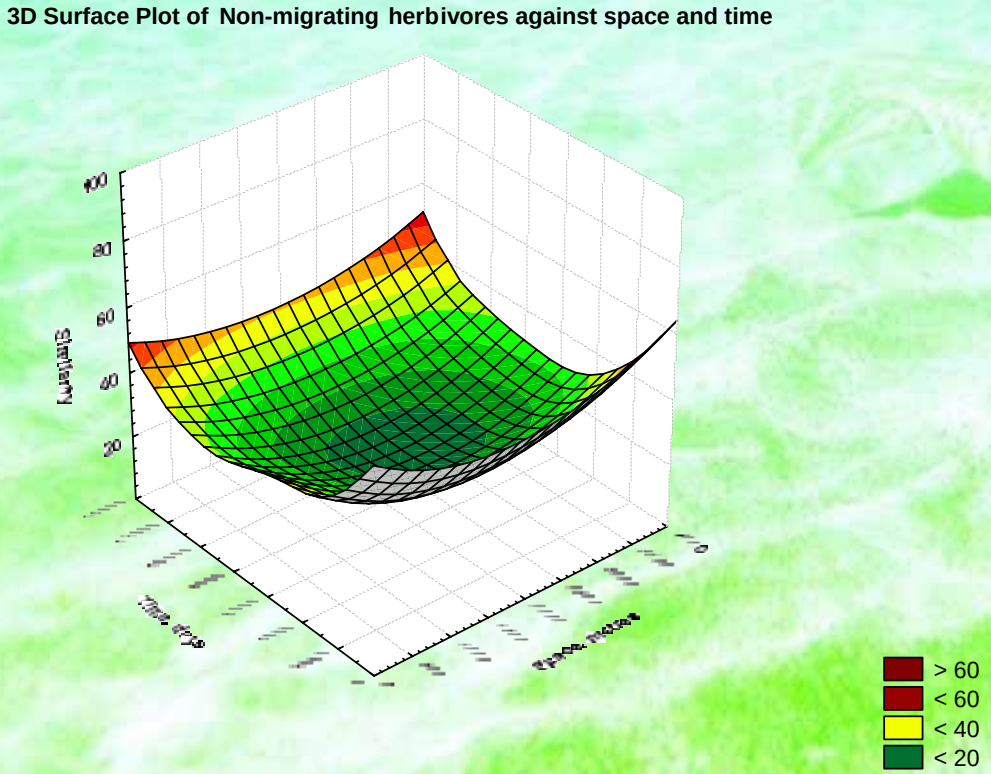
Explaining environmental factor: Slope 1000m



Non-migrating herbivores

Important scale: decadal scale

Explaining environmental factor: Total N load



Conclusions

- Benthic invertebrate communities varied in space and time and there were clear differences among invertebrate functional groups.
- Mobile deposit feeders varied mainly at local scale and non-migrating deposit feeders and carnivores at landscape scale. Temporal variability was not important.
- Mobile herbivores had seasonal and landscape scale variability opposing to the lack of spatial variability of non migrating herbivores.

Conclusions

- The variance spectra agreed amazingly well with the correlation scales between environmental and biological patterns.
- Majority of variability was due to spatial patterns of environmental variables across studied spatial scales.
- Temporal variability (eutrophication) was important only for non-migrating herbivores.
- Climate variables affected benthic communities through changes in nutrient loading only.

Acknowledgements:

Estonian Target Financing Program No SF0180013s08
Estonian Science Foundation grants Nos 6015 and 6016