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Scaling Patterns of Landscape Heterogeneity….

Presented by Curtis Bailey

Acknowledgments

- My head supervisor: **DR HELEN DE KLERK**, whose expertise, understanding, and patience, added considerably to my learning experience.
- **Prof Cang Hui** & **Mrs Zahn Munch**, my co-supervisors, for their valuable input, time and patience.

Table Of Contents ...

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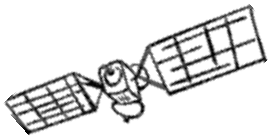
1. Introduction…



- **E**cology is a science that deals with the interrelations of organisms and their physical surroundings
- **S**ince its rise to prominence in the early 20th century, Ecologists have tried to understand and describe not only the relations between organisms but also the **processes and patterns** shaping their physical surroundings often referred to as Landscapes.

Landscapes

"Geographically spatially heterogeneous areas of interacting ecosystems or Patches with varying size, shape, composition, productivity"	**Wu (2000)**
"Area of land consisting of visually distinct Patches"	**Oxford**

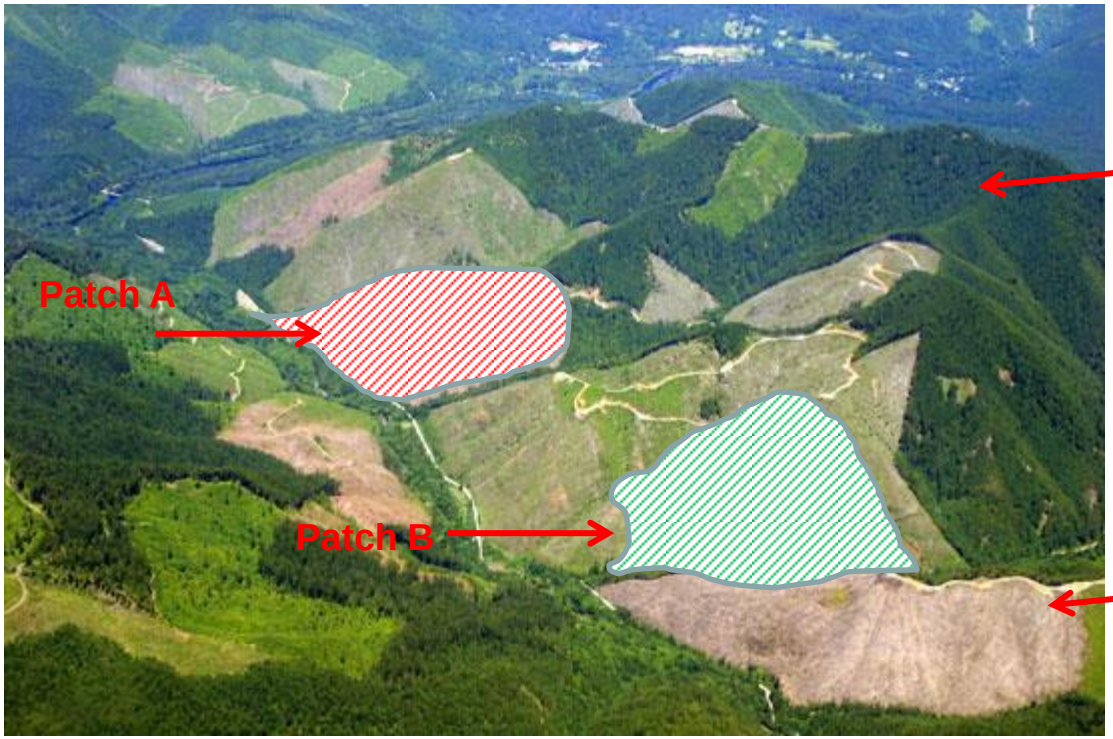
Introduction…

Patches

"Homogenous areas of habitat that differ from their surroundings"

- Each patch exists within a collage of other patches which together from landscape/patterns.
- These patterns are shaped by complex interaction between, climate, topography, soil ext.
- Multiple descriptive characteristics/metrics including; vegetation and animal density, resource availability and patch geometry
- Understanding the characteristic metrics of landscape heterogeneity is thus crucial for sustaining the provision of ecosystem service and better management of our natural capitals when facing future global climate and environmental change

Introduction…

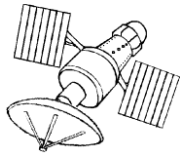


Heterogeneity In a Landscape Occurs:

A. Naturally
B. Induced by anthropogenic activity

C. Combination of A & B

Problem...?



Is **Scale**

- **Spatial Resolution/Pixel Size**
- **Extent/Area**

- Landscapes exhibit **different patterns** at **different spatial scales**, indicating a scale multiplicity relationship
- Two examples of scale problems in ecology include the identification of scales of landscape patterns and effects of changing scale on these patterns.

Aim...

- The following questions thus arise :
  1. What is the most appropriate or ideal pixel size to study ecological pattern-processes?
  2. Is it possible to predict and model changes in pattern-processes (i.e. heterogeneity in a landscape) across grain size?

AIM

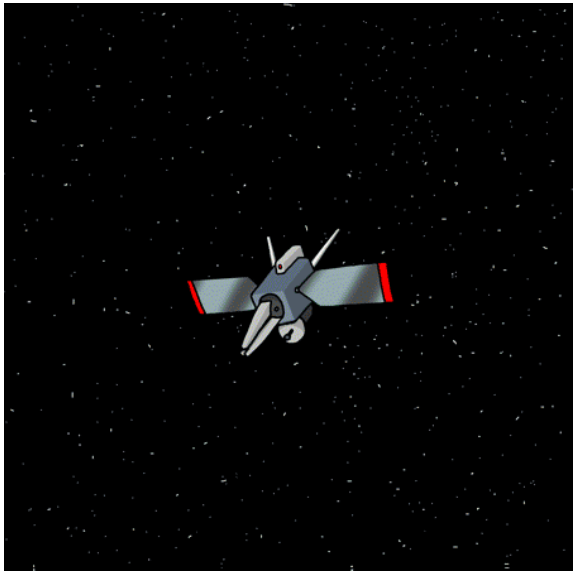
The overarching aim of this study was to compare the effect of changing scale (i.e. spatial resolution) on metrics describing heterogeneity in a landscape in order to create a model capable of cross scale heterogeneity predictions.

Objectives…

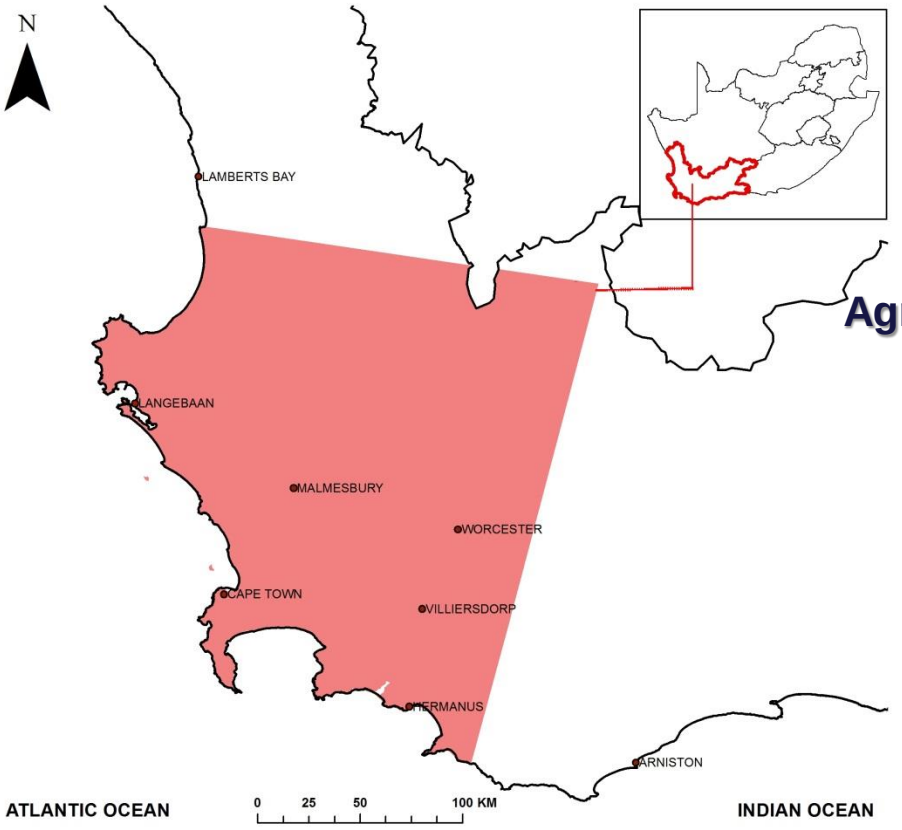
- Scale finer resolution data (Landsat 8) to coarser grain sizes using variety of aggregation algorithms to observe statistical influence across grain
- Calculate heterogeneity metrics for resultant image across scales
- Compare landscape metrics of coarsened fine scale data (Landsat 8) to coarse scale derived data (MODIS)
- Deduce scaling patterns for landscape metrics via regression models & test models statistically on independent study area

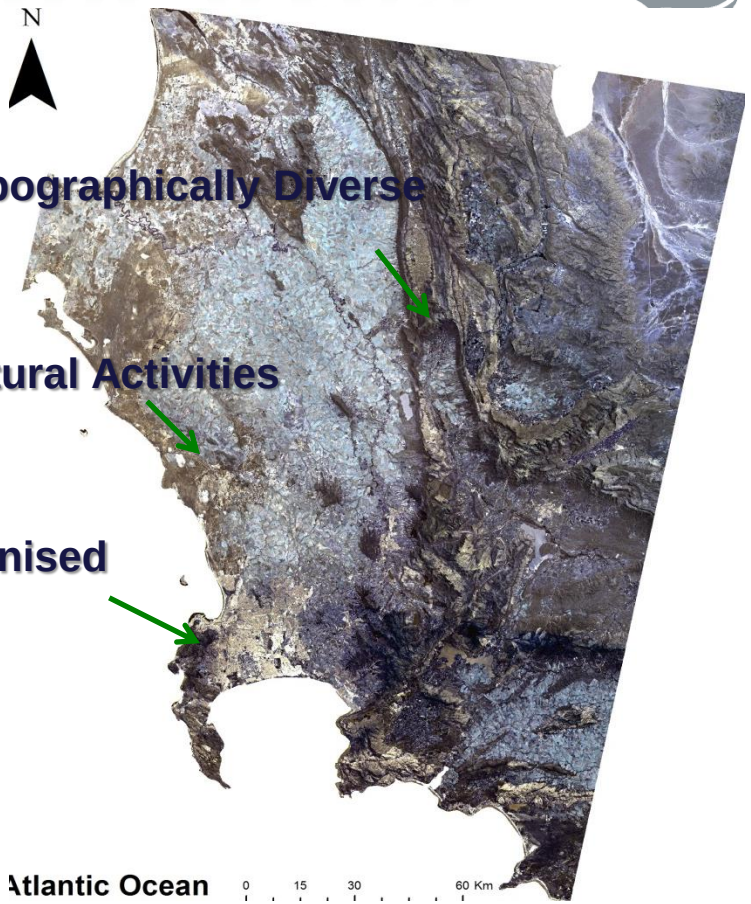
2. Materials & Methods: Data

- Raw Landsat 8 data at 30m resolution
- MODIS NDVI product at 480m resolution
- Software: Arcmap (v10.1), FRAGSTATS,



Materials: Study Area





Methodology…

2 Approaches Employed:

- **Direct approach**:
  used multi-scale statistical methods
- **Indirect approach**
  which used single scale methods with hierarchically resampled data

Methodology Pt.1:

Landscape Heterogeneity Surrogate, Metric & Algorithm Selection

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Surrogate

- Normalised Difference Vegetation Index (NDVI)

Metrics

- **Direct** = Summary Statistics vs grain
  - Min, Max, Mean, Variance (of NDVI)
- **Indirect** = Landscape Patch Metrics vs grain
  - Number of Patches, Patch Density, Patch Area, Patch Shape

Algorithms

- Bilinear interpolation, Cubic convolution, Mean & Max Aggregation
- 6 Scale/Spatial resolution (grain) sizes for each algorithm
  - 30,60,120,240,480,960 (m)
- Each algorithm changes pixel size & derives new pixel value differently
- Variety of selected to monitor statistical influence on metrics

Methodology Pt.2:

Processing, Cross Gain Pattern Calculation

- **Pre-processing:**
  - Data Atmospherically & Topographically corrected
- **Processing**
  - Landsat 8 images converted to NDVI equivalent (for all 4 algorithms)
  - Data log transformed to avoid distribution problems
  - Reclassified into 3 hierarchical classes i.e. low ,medium, high NDVI
- **Grain Pattern Calculation**
  - Summary Statistics & Landscape metrics calculated for each algorithm at each scale interval
  - Results of landscape metrics put as function of grain size
  - Compare to MODIS

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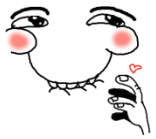
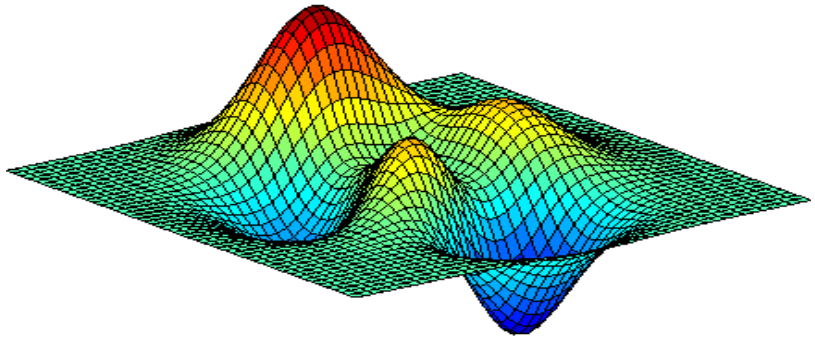
Methodology Pt.3:

Scaling Pattern deduction Via Regression models



Regression

- Regression equations derived from initial landscape metrics
- Non linear regression as suggested by Wu et al. (2004)
- Only Landscape metrics
- Tested on independent study site to test general model applicability
- R^2 values calculated for correlation



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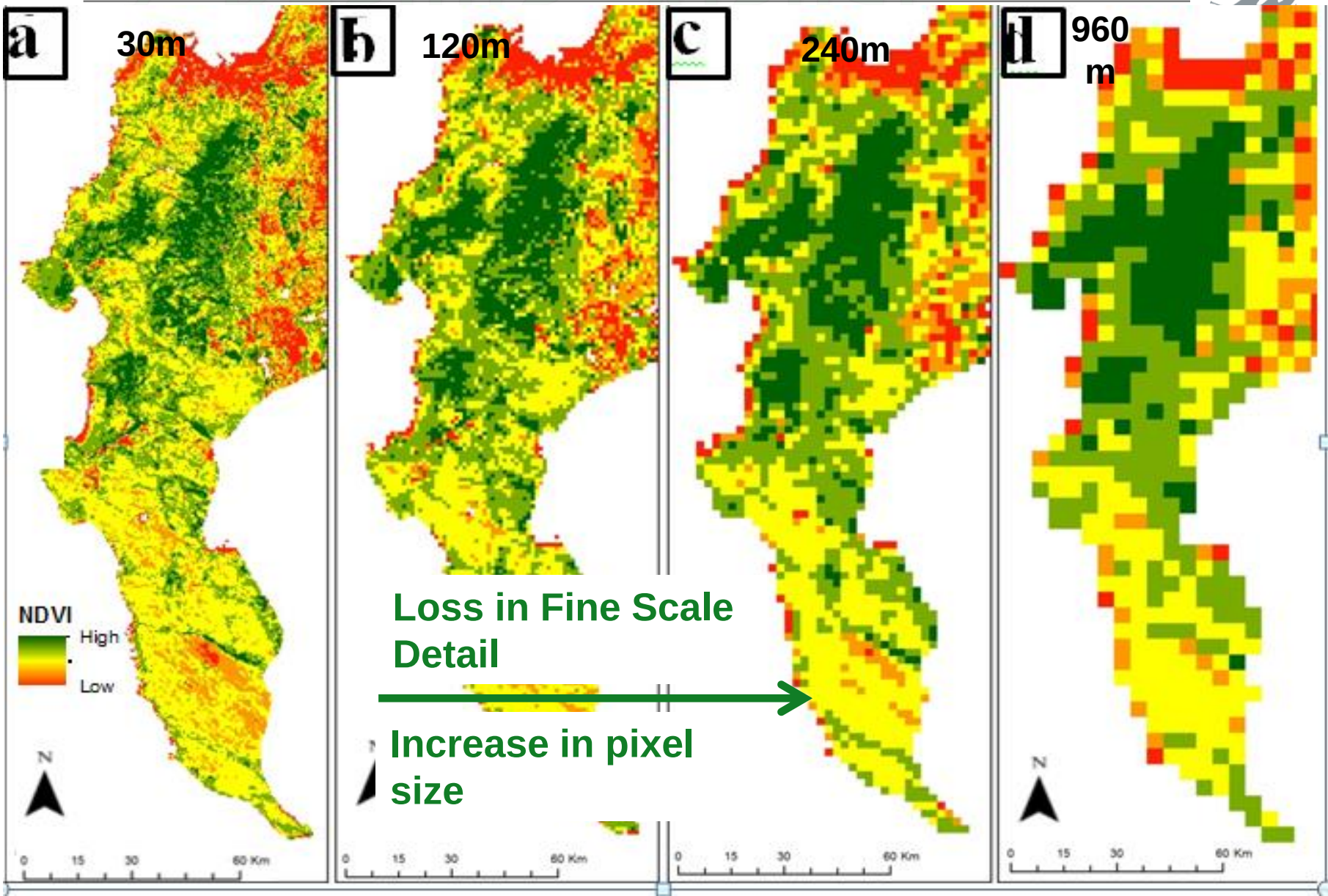
3. Results: Visual.....



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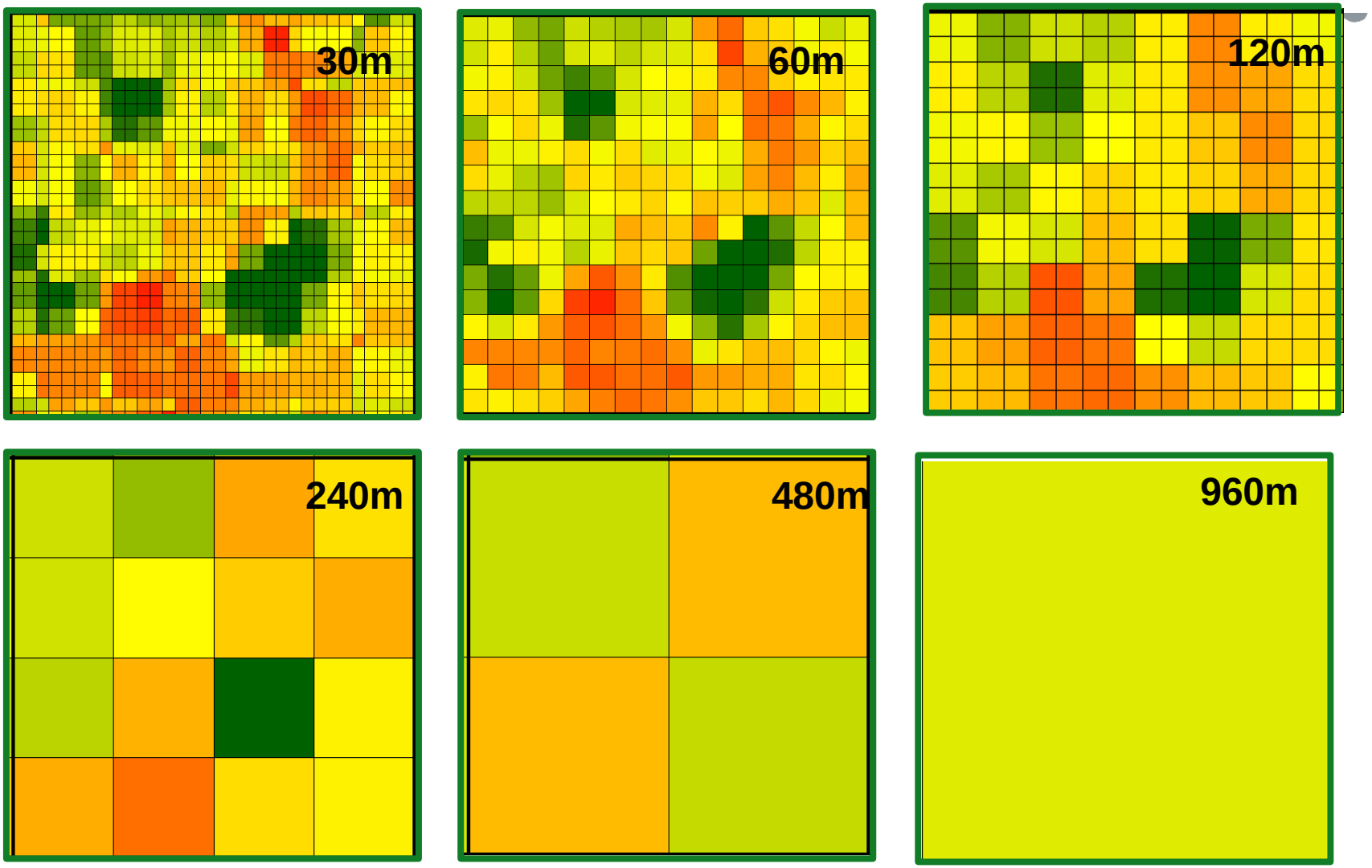
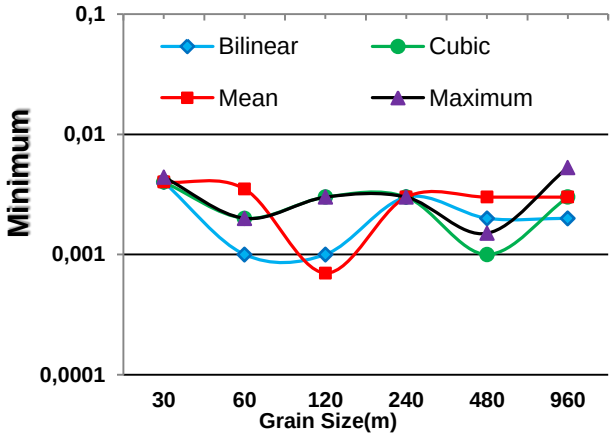
Loss in Fine Scale Detail

Increasing pixel size

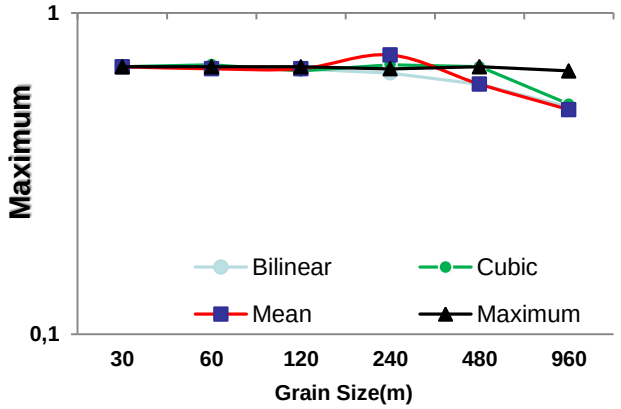


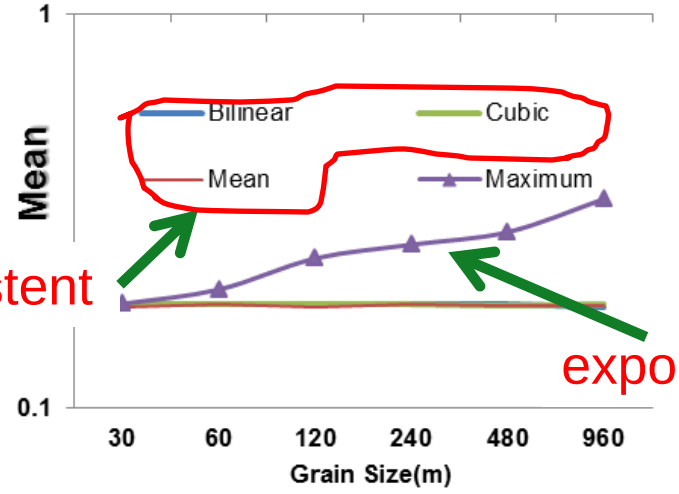
Results: Summary Statistics……

Erratic/Inconsistent



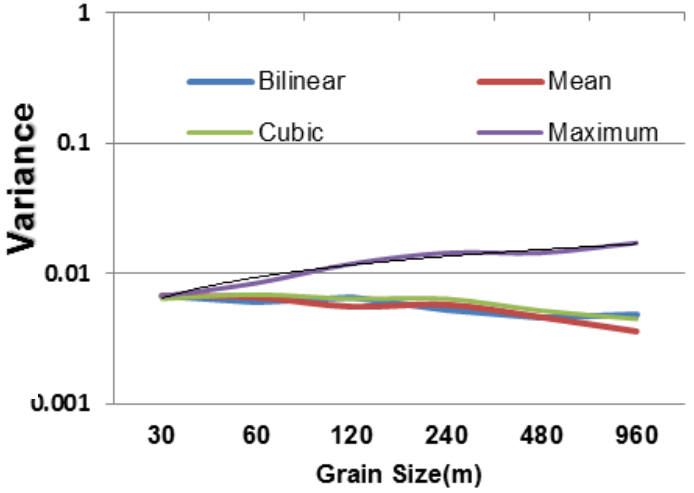
Linear, local variation



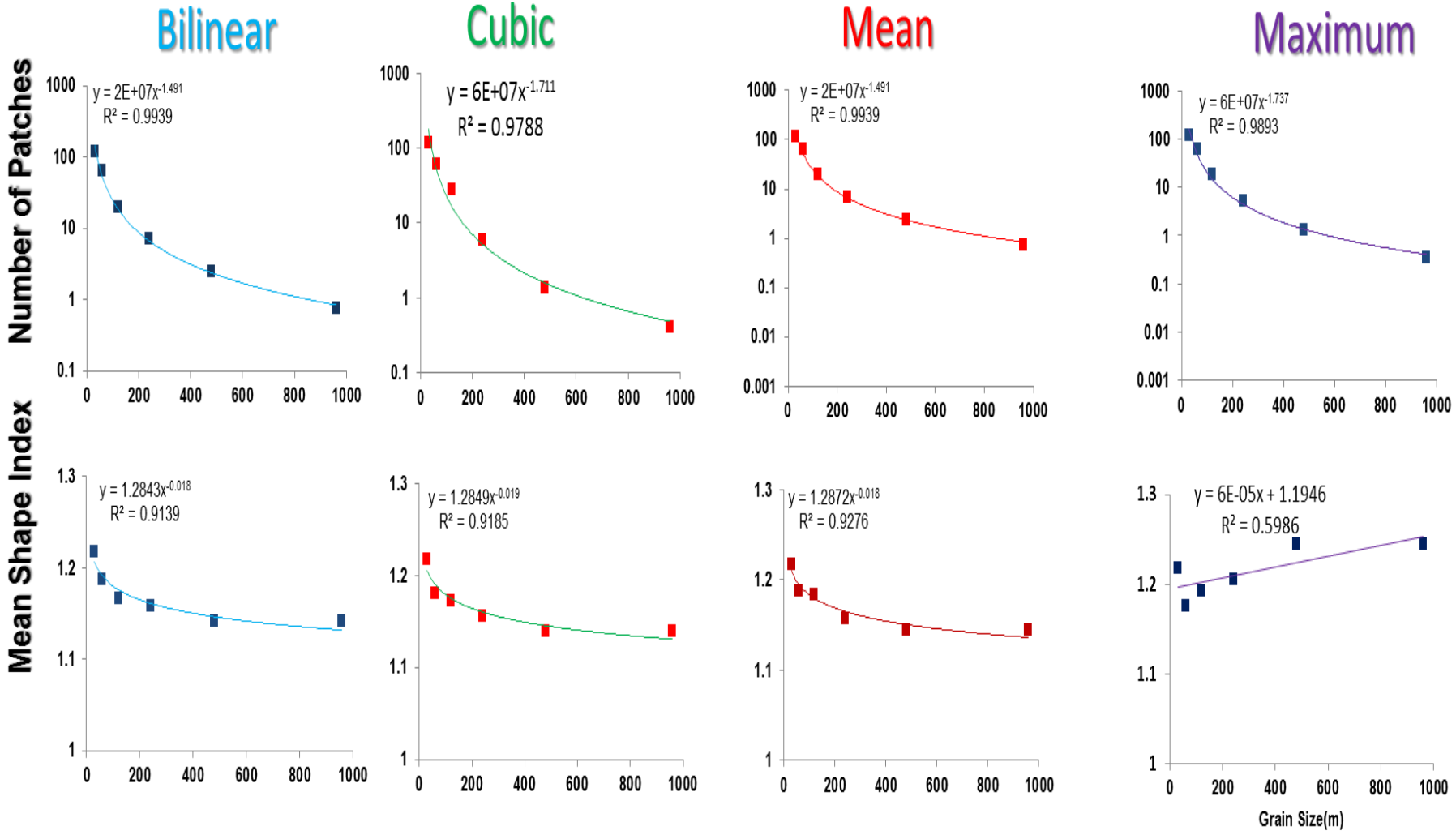


consistent

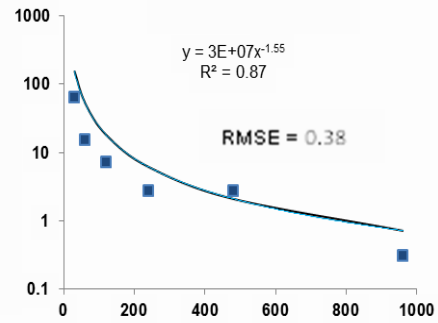
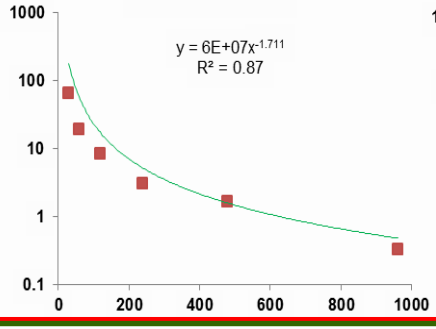
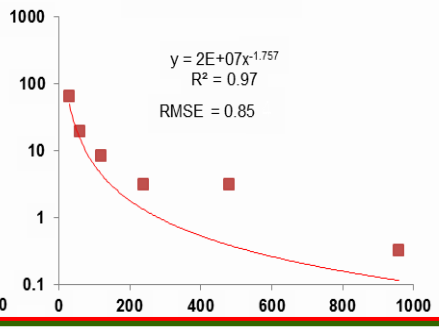
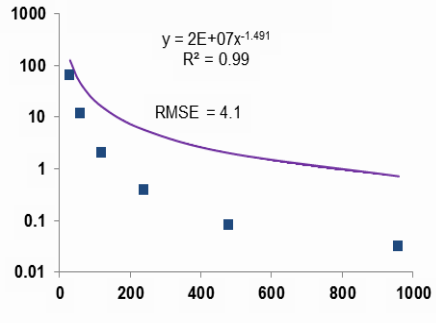
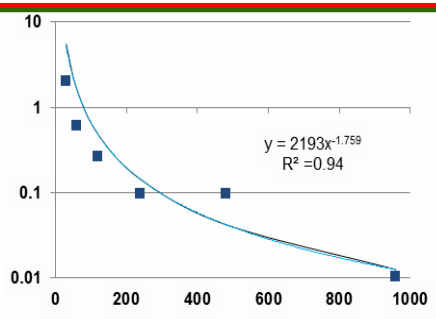
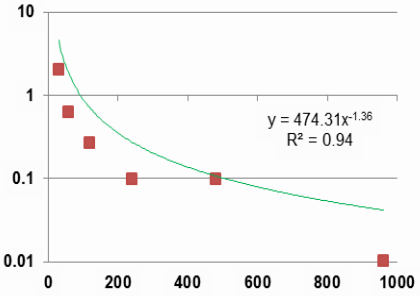
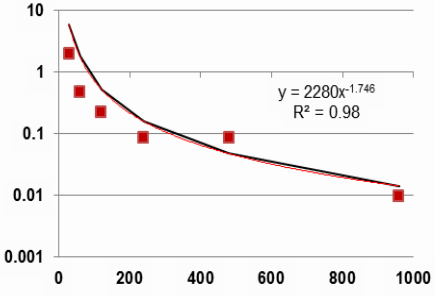
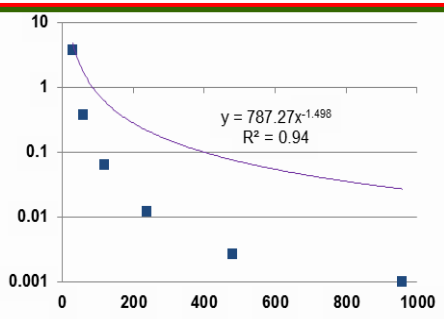
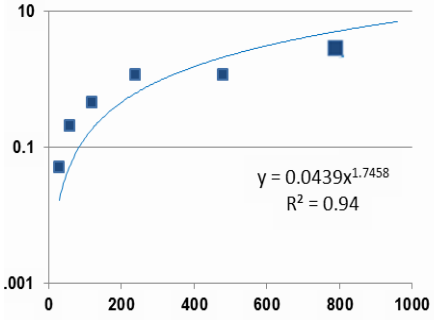
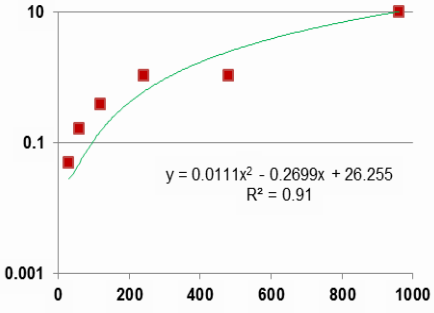
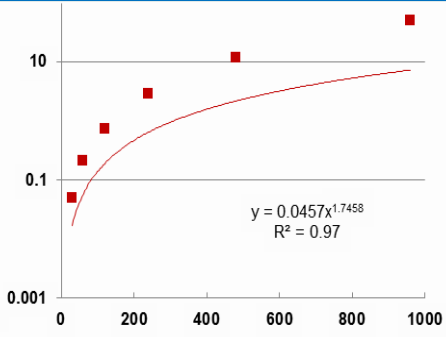
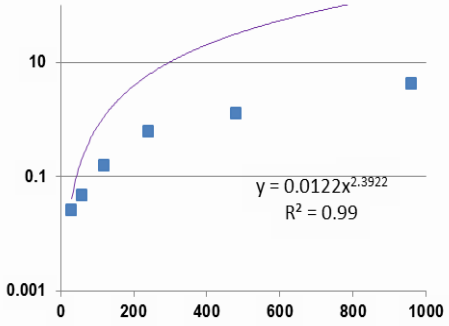
exponential



Results: Landscape Metrics……



Results: Landscape Metrics……

	Bilinear	Cubic	Mean	Maximum
Number of Patches				
Patch Density				
Patch Area				

Results: Scaled Landsat 8 Vs MODIS……

Landscape Metric		Algorithm								Average
	MODIS	Bilinear	Percentage Difference	Cubic	Percentage Difference	Mean	Percentage Difference	Maximum	Percentage Difference	Percentage Difference
Number of Patches	1284.00	1331.00	-3.66	1955.00	-52.26	1272.00	0.93	2436.00	-89.72	-36.18
Patch Density	0.04	0.04	0.00	0.06	-52.05	0.04	1.93	0.08	-87.23	-35.18
Mean Patch Area	2412.17	2328.39	3.47	1583.87	34.34	2454.99	-1.78	1287.63	46.62	20.66
Shape Index	1.25	1.14	8.55	1.14	8.68	1.14	8.29	1.24	0.28	6.45

4. Deductions……

1. Fine scale detail is lost as pixel size is progressively enlarged, hence spatial heterogeneity decreases as grain size increases. The relationship is thus inversely proportionate.
2. The amount of detail lost depends on the aggregating (scaling) algorithm employed, grain size and initial heterogeneity present in landscape.
3. Fine scale data are suited for local specialised studies while coarse scale data are better suited for generalised applications.
4. Variables describing heterogeneity behave in 3 ways:
   - Erratic/Inconsistent
   - Linear and consistent
   - Logarithmic, Power

   } Reflects notion that ecological process exhibit different patterns at different scales & are hierarchically established
5. Regression models show potential to model and predict cross scale changes, but this must be investigated further.

5. Conclusion…

Landscapes, in terms of their structure are complex and non-linearly organised, the behaviour of these processes-patterns at different scales cannot be described by a single model or statistical approach. Furthermore, although regression models show potential, complete models are nearly impossible to create since all relations between organisms, patches and ecosystems, are not yet discovered or fully understood. Thus more research need by done before we can truly grasp the effect of scale on ecological pattern-processes…

And with that I conclude..

Thank You...

6. References...

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Questions?...