Class Modelling; Behind the Scene

Analysis and Modelling (Remote Sensing)

Kiarash Pooladsaz

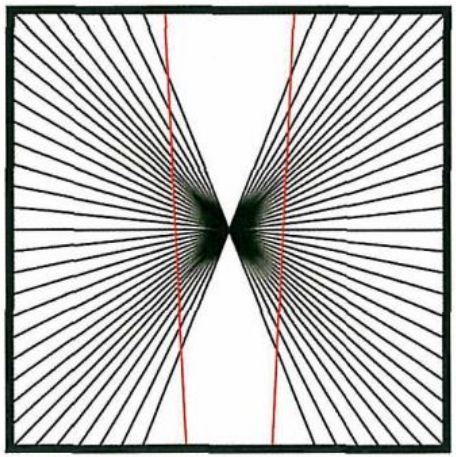
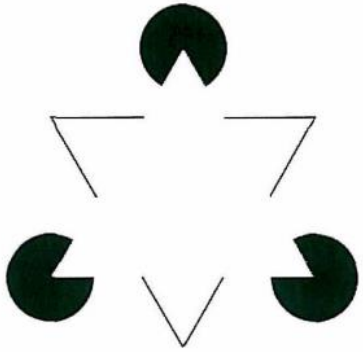
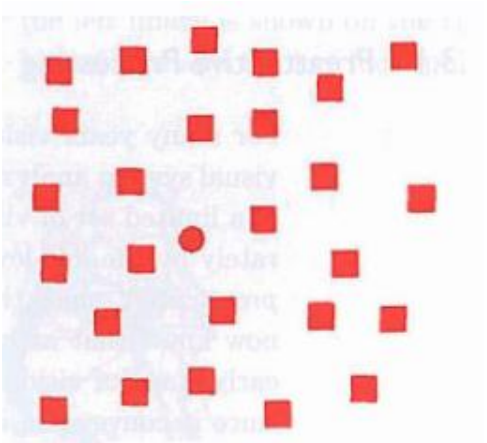
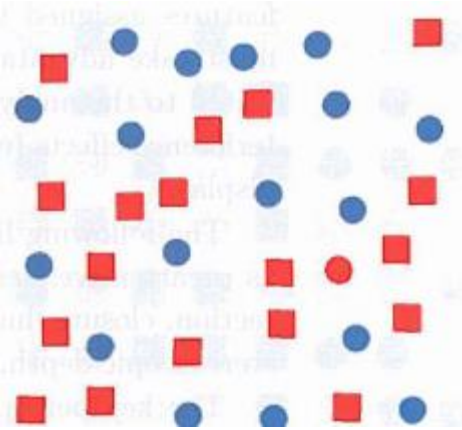
19.05.2022

- Image Perception
- Knowledge for Image Understanding
- Multi-Scale Classification

- Image Perception

Image Perception

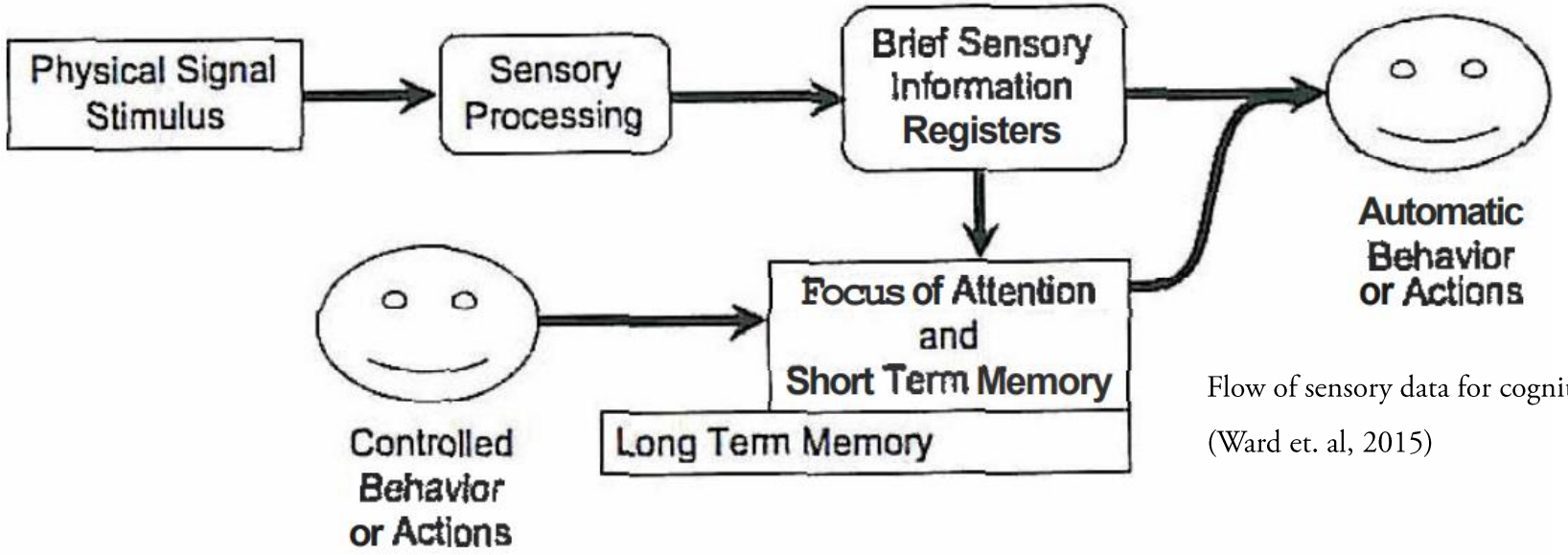
- Scattered light enables understanding the differences in our environment through colors, patterns, structures
- Perception as the process of recognizing (being aware of), organizing (gathering and storing), and interpreting (binding to knowledge) sensory information.
- Human senses receives signals from environment, and goes through forming a mental representation of environment

Visual perception (Ward et. al, 2015)

Image Perception

Preattentive perception is fast, some effects pop out as the result of preconscious visual processes. Attentive perception transforms early vision effects to low-level structured objects using short-term memory. It is selective and represents aggregate of what is in scene. Then, these low-level attributes are converted to higher-level structured ones for performing tasks. We first focus on low-level attributes, then turn to higher level-ones and finally put all together with memory models.

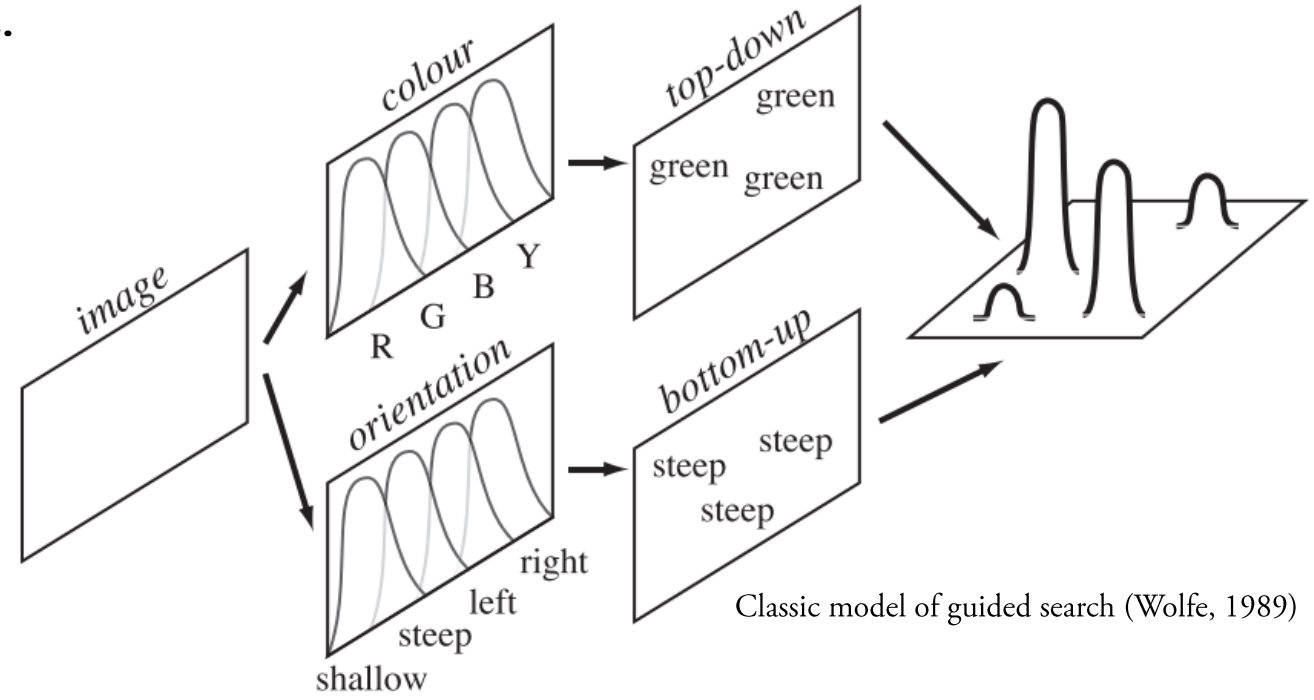


Flow of sensory data for cognition (Ward et. al, 2015)

Image Perception

Guided Search Theory by Jeremy Wolfe (1989)

Image divided into feature maps and within each map the feature is filtered into different categories. Bottom-up activation follows feature categorization; how different is a stimulus from its neighborhood objects. Top-down activation as a user-driven attempt to find a specific set of properties.

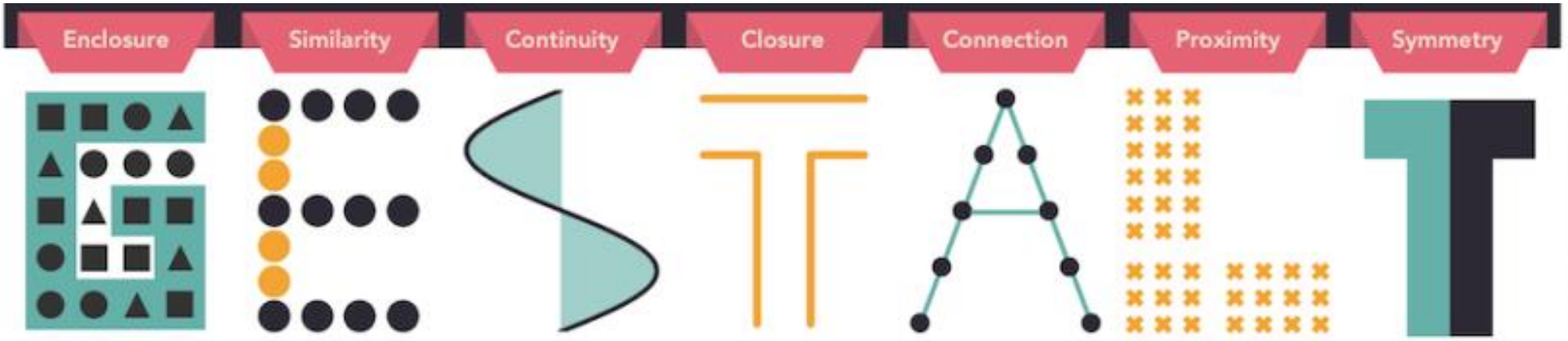


Classic model of guided search (Wolfe, 1989)

Image Perception

Gestalt principles by Wertheimer, Köhler and Koffka.

What human's eye perceive in the whole image results from set of interactions in the continuous space, in another term "Reification (objectification) of a complex set of relationships". However, these sets are not limited, where "the degrees of freedom for explaining perceptual phenomena are greater than the degrees of constraint offered by interactive principles".



Wadi As-Sirhan Basin, KSA

Palmanova, Italy


Barcelona, Spain


What helps?
Barcelona, Spain

- Knowledge for Image Understanding

Knowledge for Image Understanding

Knowledge helps interpreting the image, going from signals through Scene symbolic representation based on the domain of interest.

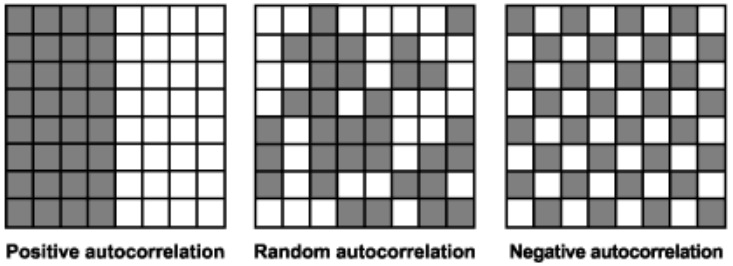
Spectral values behavior

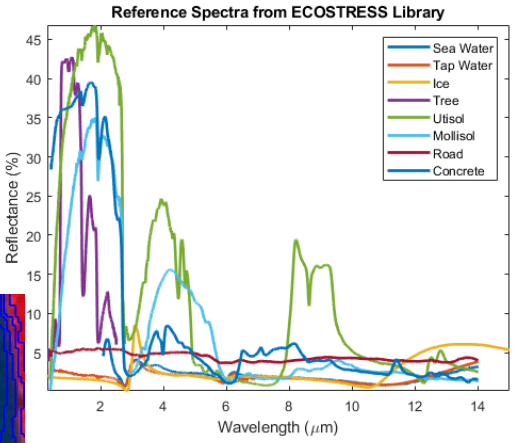
Spatial autocorrelations

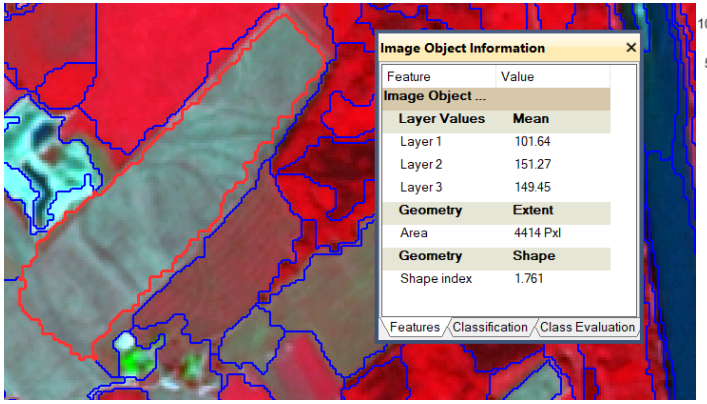
Physical laws and principles

……

Experience







Knowledge for Image Understanding

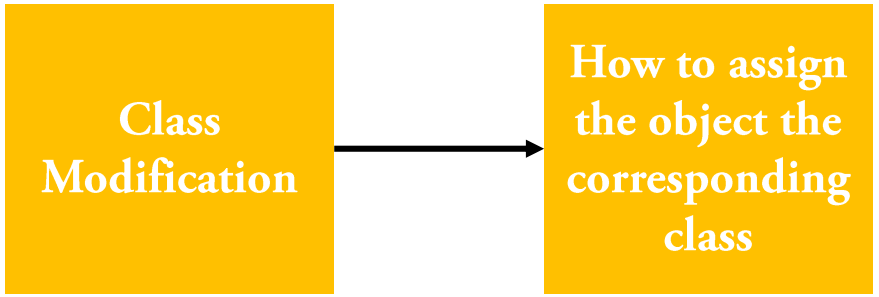
Heuristics Knowledge : Trial and Error

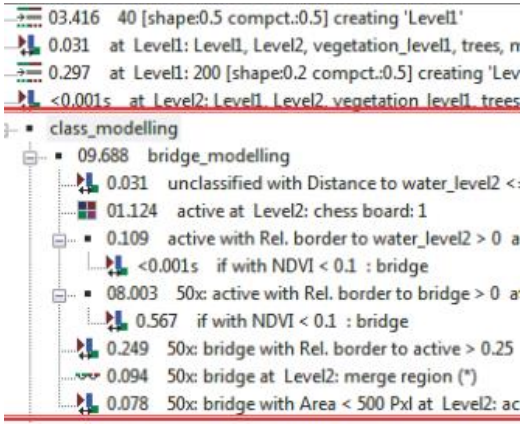
Structural Knowledge:

how concepts related to a domain are interrelated. Links between image objects and real-world geographical features.

Procedural Knowledge:

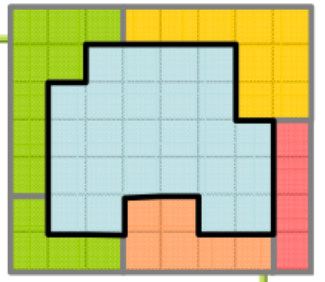
how to encode our structural knowledge through set of rules or through set of representative samples (usually ad-hoc manner).

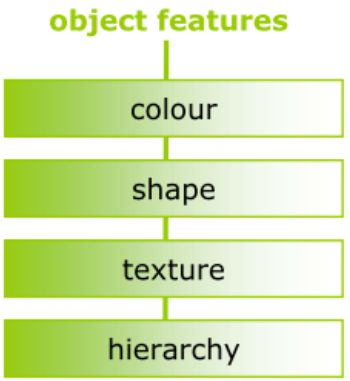




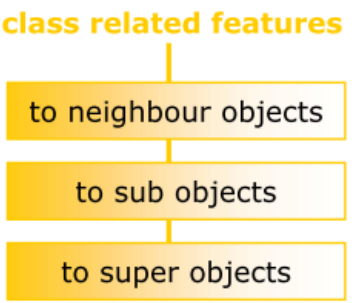
Knowledge for Image Understanding

- **layer values**
  - mean
  - std-dev
- **geometrical properties**
  - size, shape, …
- **textural properties**
  - layer value texture (e.g. mean of sub objects: std-dev)
  - shape texture (e.g. directions of sub objects)
- **hierarchical properties**
  - number of higher levels
  - number of super or sub objects





- **relations to classes of …**
  - neighbour objects
  - sub objects (relative area of …)
  - super objects
- **membership to …**



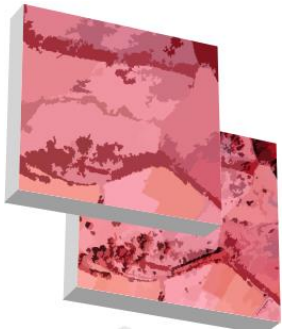
(Albrecht & Lang)

Knowledge for Image Understanding

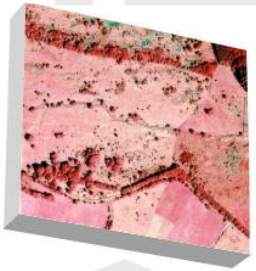
Planning of the image description outcome and segmentation

Domain of Interest

Segmentation problem



Complex image content



Targeting scale, objects and classes

Real world scene

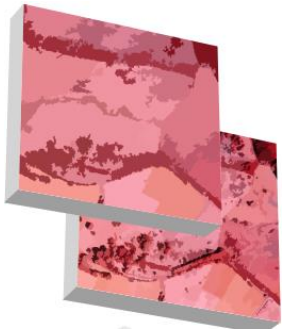
Progressive knowledge in image understanding (Lang & Blaschke, 2006)

Knowledge for Image Understanding

Planning of the image description outcome and segmentation ----- **Modelling (categorizing the image objects)**

Domain of Interest

Segmentation problem



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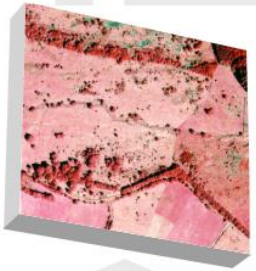
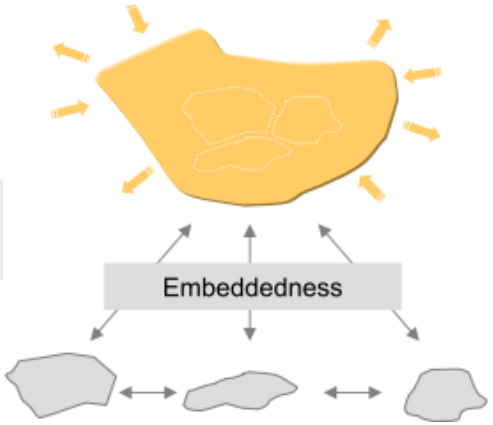


Real world scene

Targeting scale, objects and classes

Object Hypothesis



Class system in spectral, structural, semantic

Progressive knowledge in image understanding (Lang & Blaschke, 2006)

Knowledge for Image Understanding

Input: Class description, ORM rules, Labels

Knowledge Transformation

Output: Spatial distribution of known features

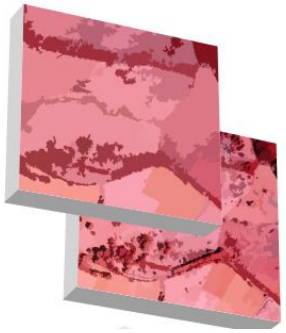
Planning of the image description outcome and segmentation

Modelling (categorizing the image objects)

Scene description as conceptual reality

Domain of Interest

Segmentation problem



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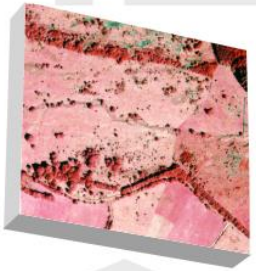
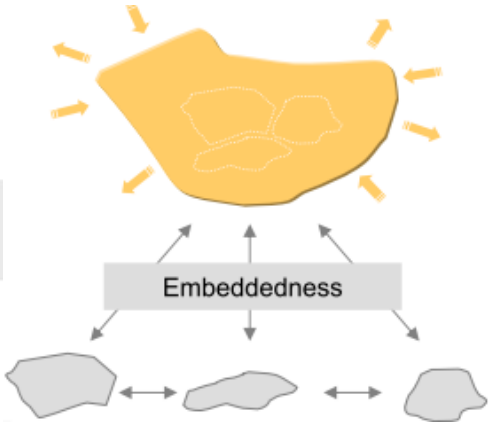


Real world scene

Targeting scale, objects and classes

Object Hypothesis



Object modelling

Class system in spectral, structural, semantic

Scene Description

Semantic system ⇔ conceptual reality

Spatial distribution of categorized objects

Transparency
Transferability
Objectivity

Progressive knowledge in image understanding (Lang & Blaschke, 2006)

Knowledge for Image Understanding

Input: Class description, ORM rules, Labels

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Planning of the image description outcome and segmentation

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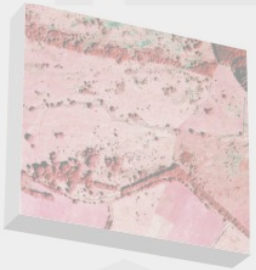
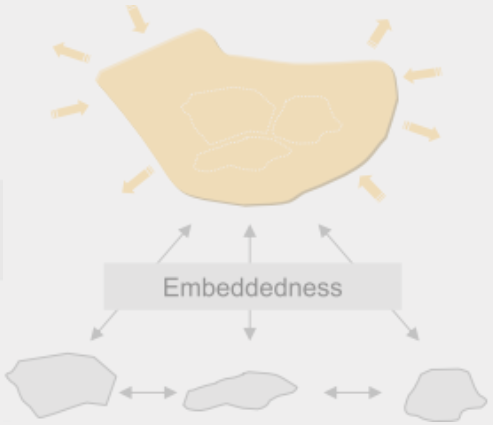


Real world scene

Targeting
sc
o
and
classes

How?

Object Hypothesis



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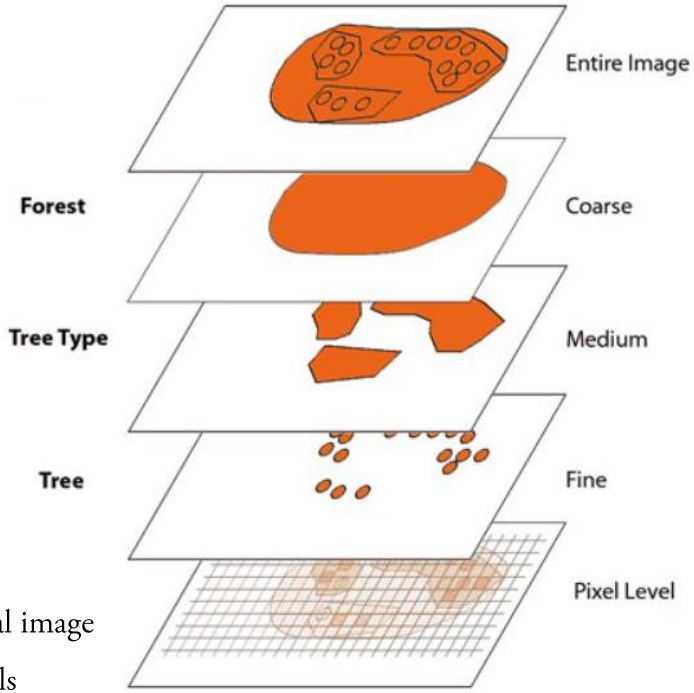
Progressive knowledge in image understanding (Lang & Blaschke, 2006)

- Multi-Scale Classification

Multi-Scale Classification

" Class modeling (Tiede et al. 2010) can be employed to topologically describe spatial constellations of a set of sub-units in a way that image information is structured into hierarchical divisions based on ontology-like rule sets that employ relational features."

A nested hierarchy, from internal spectrally homogenous elementary units to higher scale of functionally homogenous composite objects.



Hierarchical image object levels (eCognition documentation)

Multi-Scale Classification

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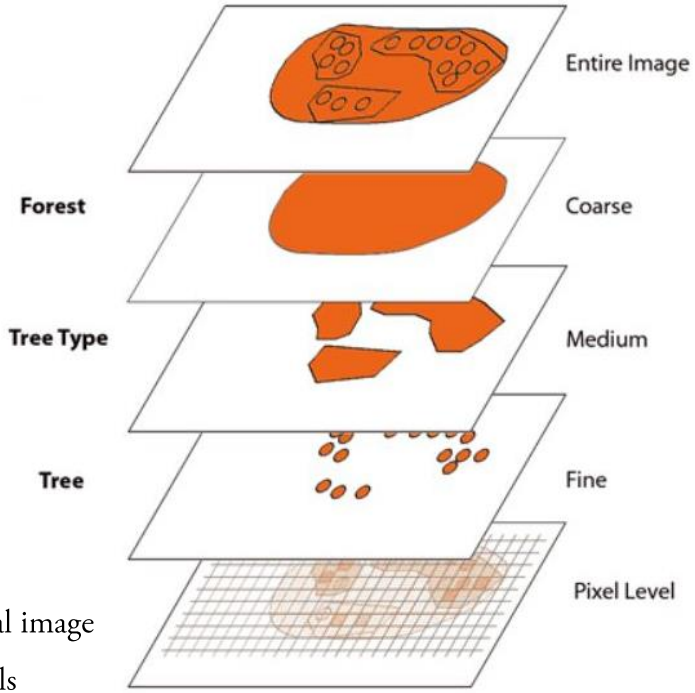
Why?



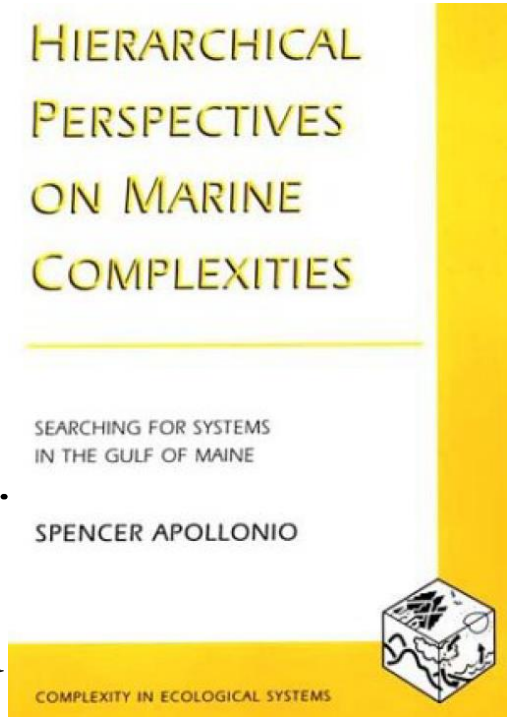
Hierarchical image object levels (eCognition documentation)

Multi-Scale Classification

- The world we observe demonstrates continuity. The complexity and interaction among components is inevitable. The whole is more than the sum of individual components.
- Human's perception of nature is hierarchical.

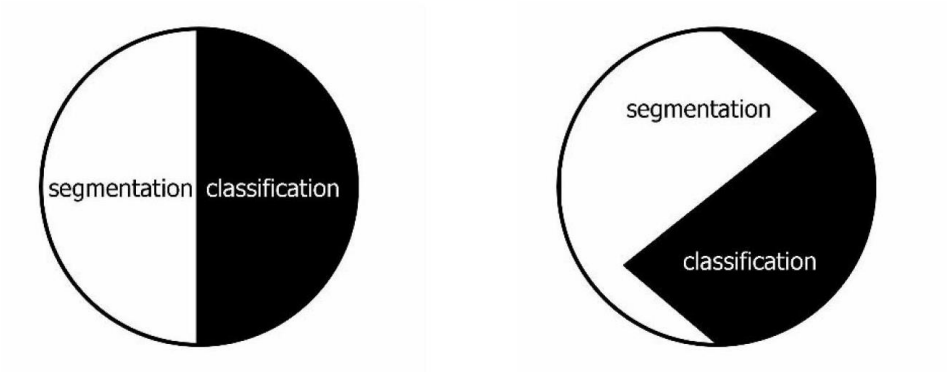
In hierarchical view the materials remain the same but the scale of observation and the perspective we bring to the issue change.

- Hierarchical view simplify uncertainty and complexity, providing meaningful inheritance hierarchy of objects based on the domain of interest.
- The hierarchy follows our need, priorities, perception and knowledge. Therefore, there is no final delineation.
- Understanding and explanation in science involves generalization and simplification, leading to amount of "loss of detail".

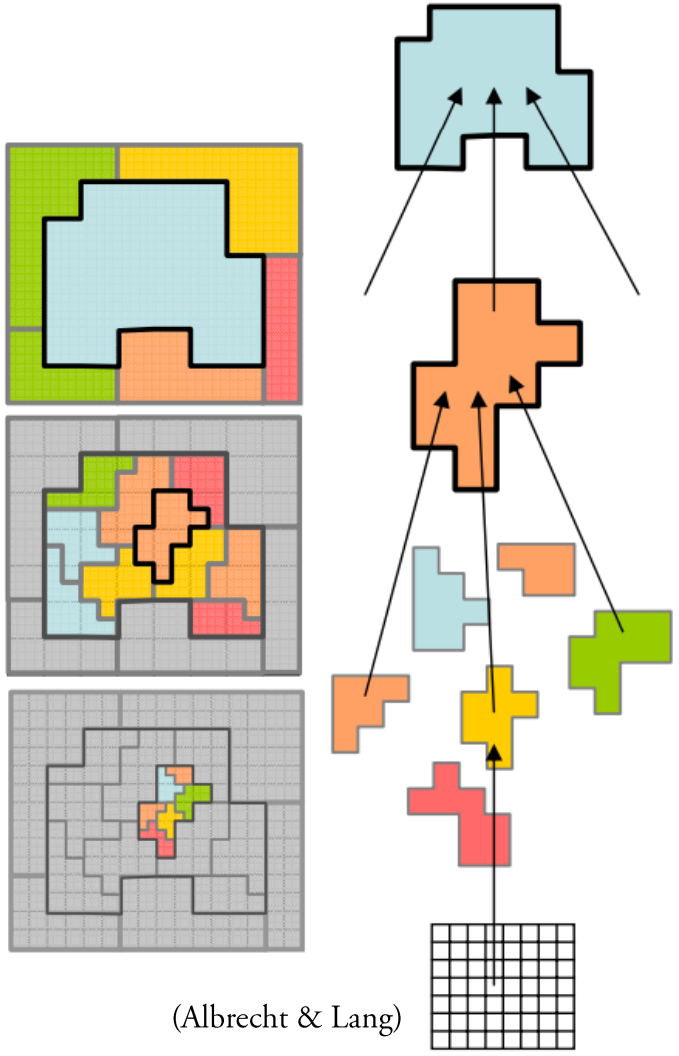


Multi-Scale Classification

Approaching composite classes by hierarchical multi-resolution segmentation and spatial modelling. From Initial segmentation and preliminary classification of elementary units, adding knowledge through rule-sets + auxiliary data, to a intuitive cyclic process of generating composite classes.

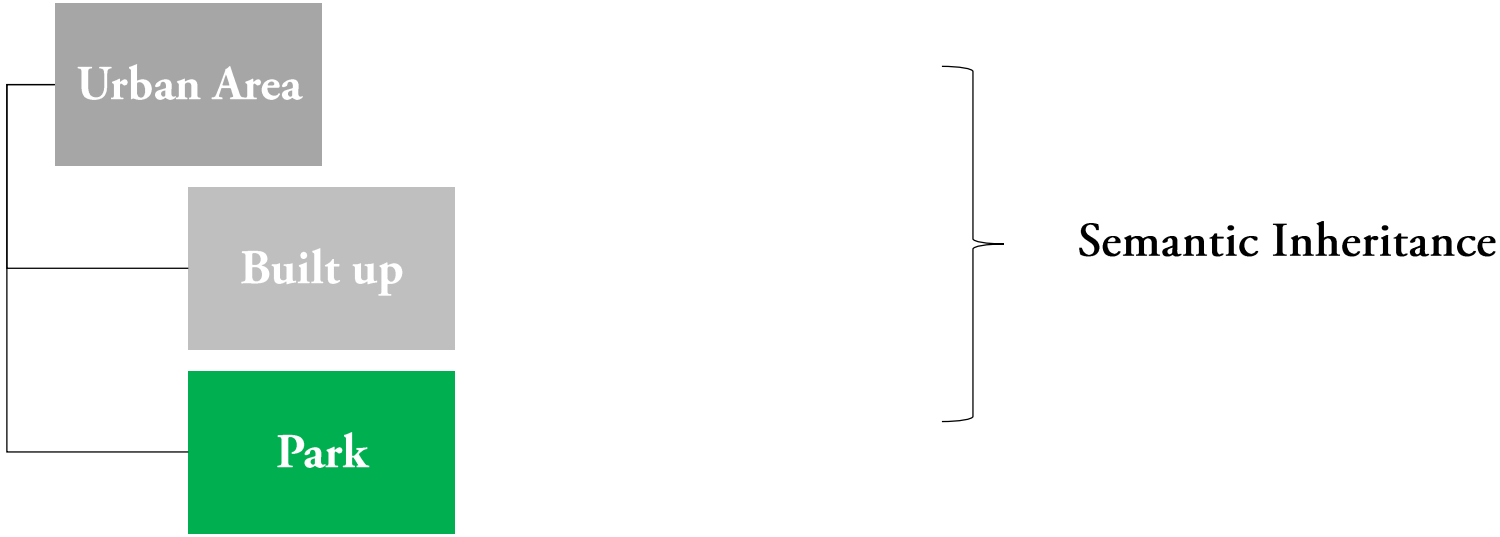


Two interrelated methodological pillars (Lang, 2008)

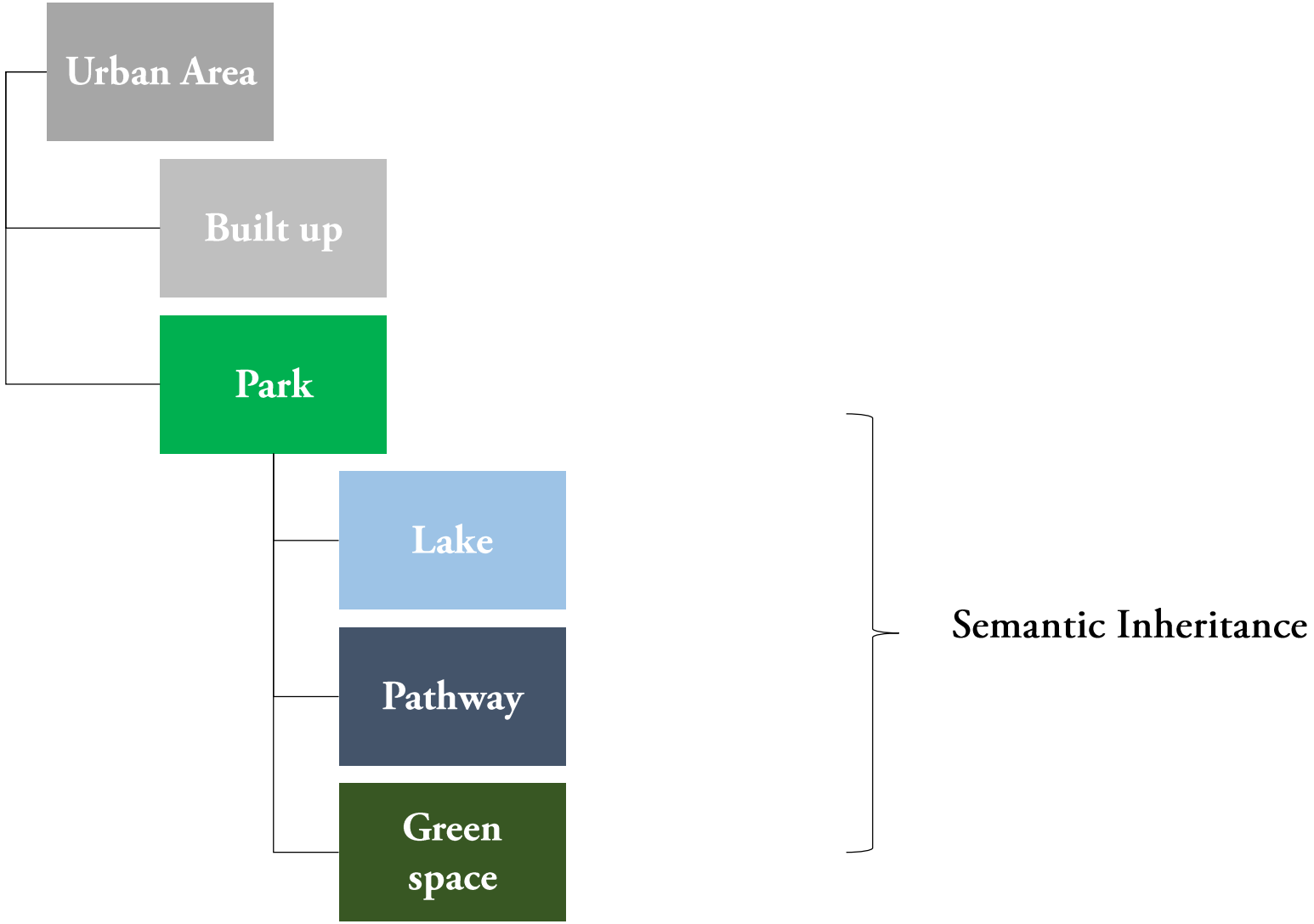


(Albrecht & Lang)

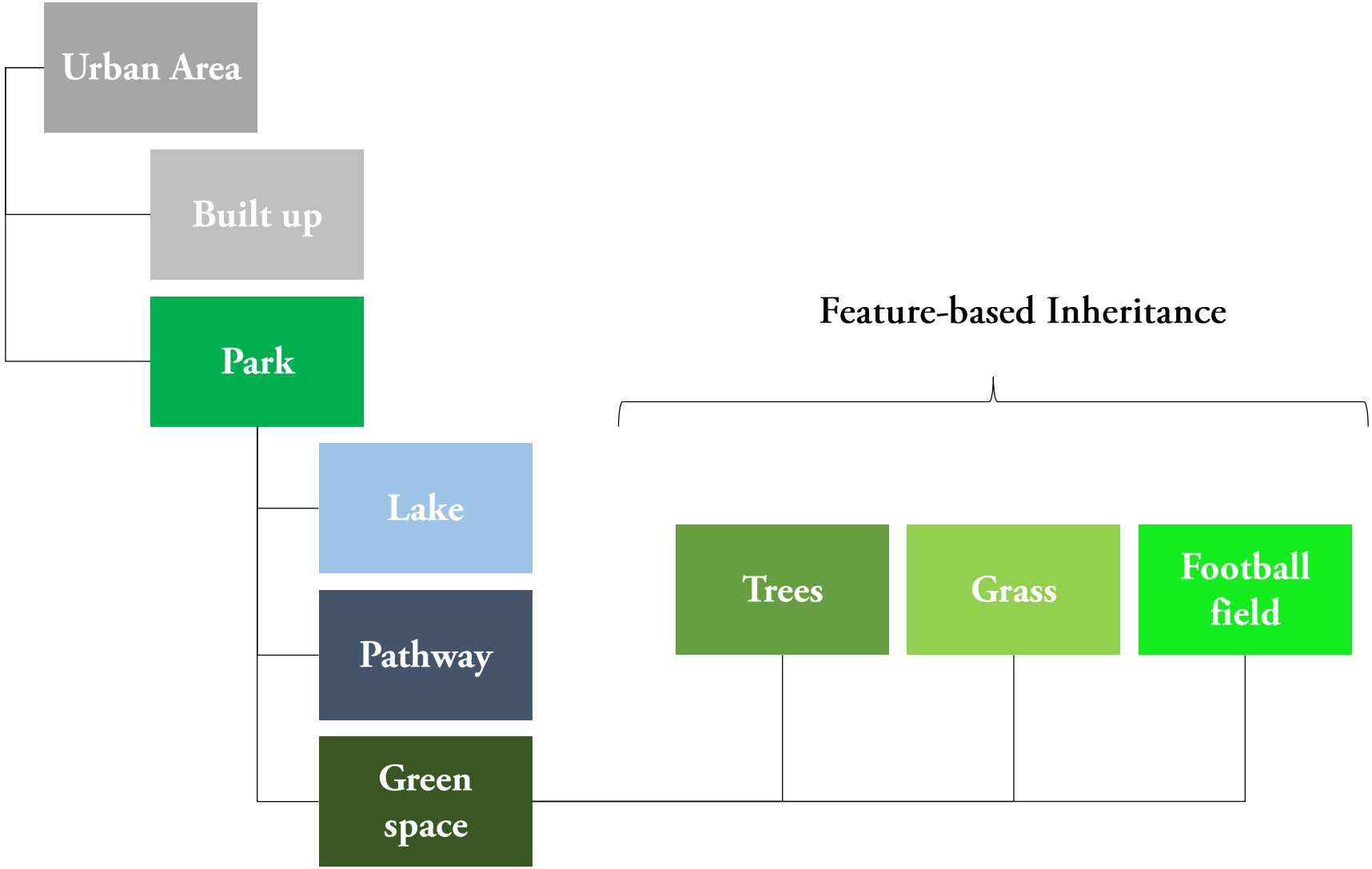
Multi-Scale Classification



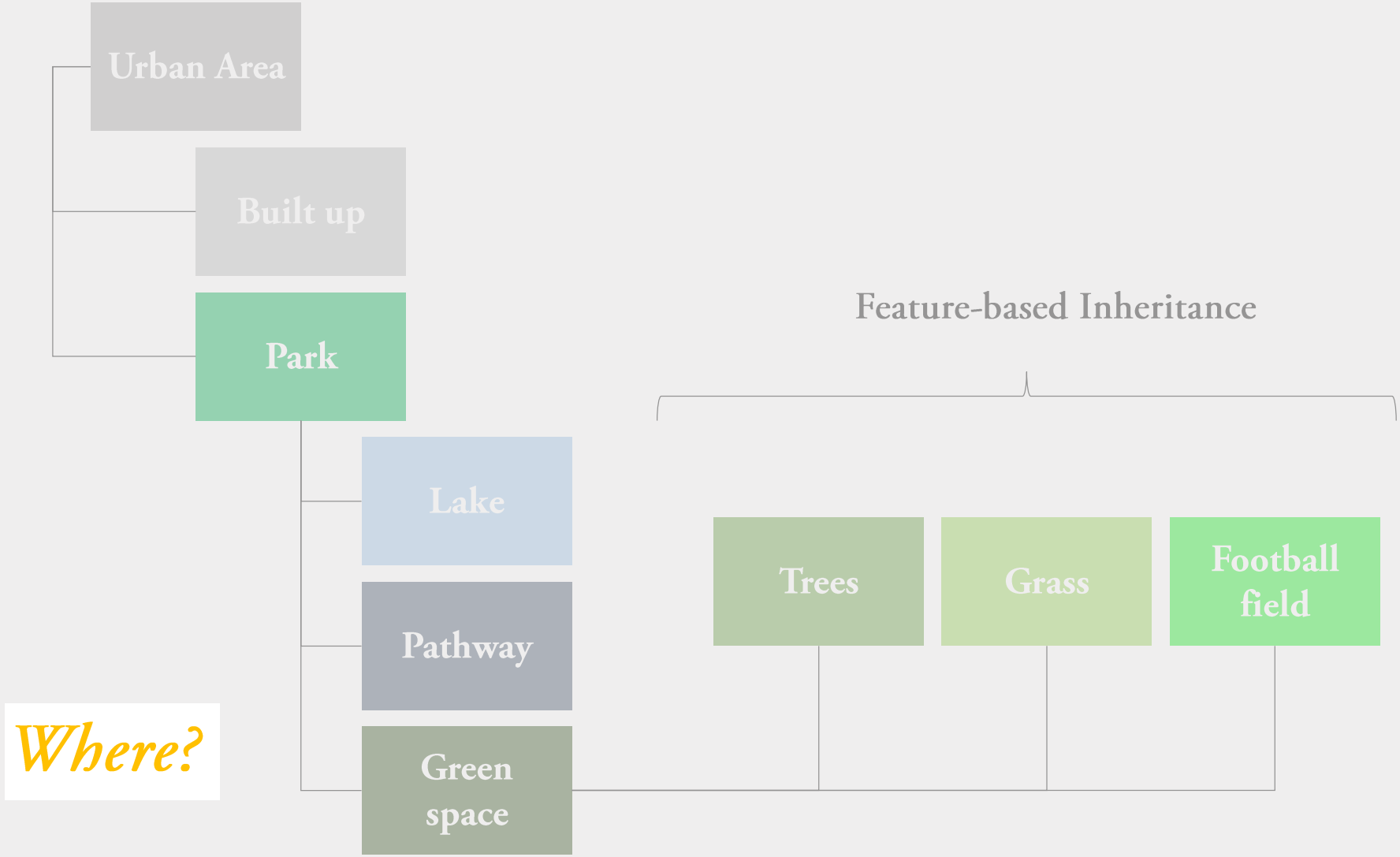
Multi-Scale Classification



Multi-Scale Classification

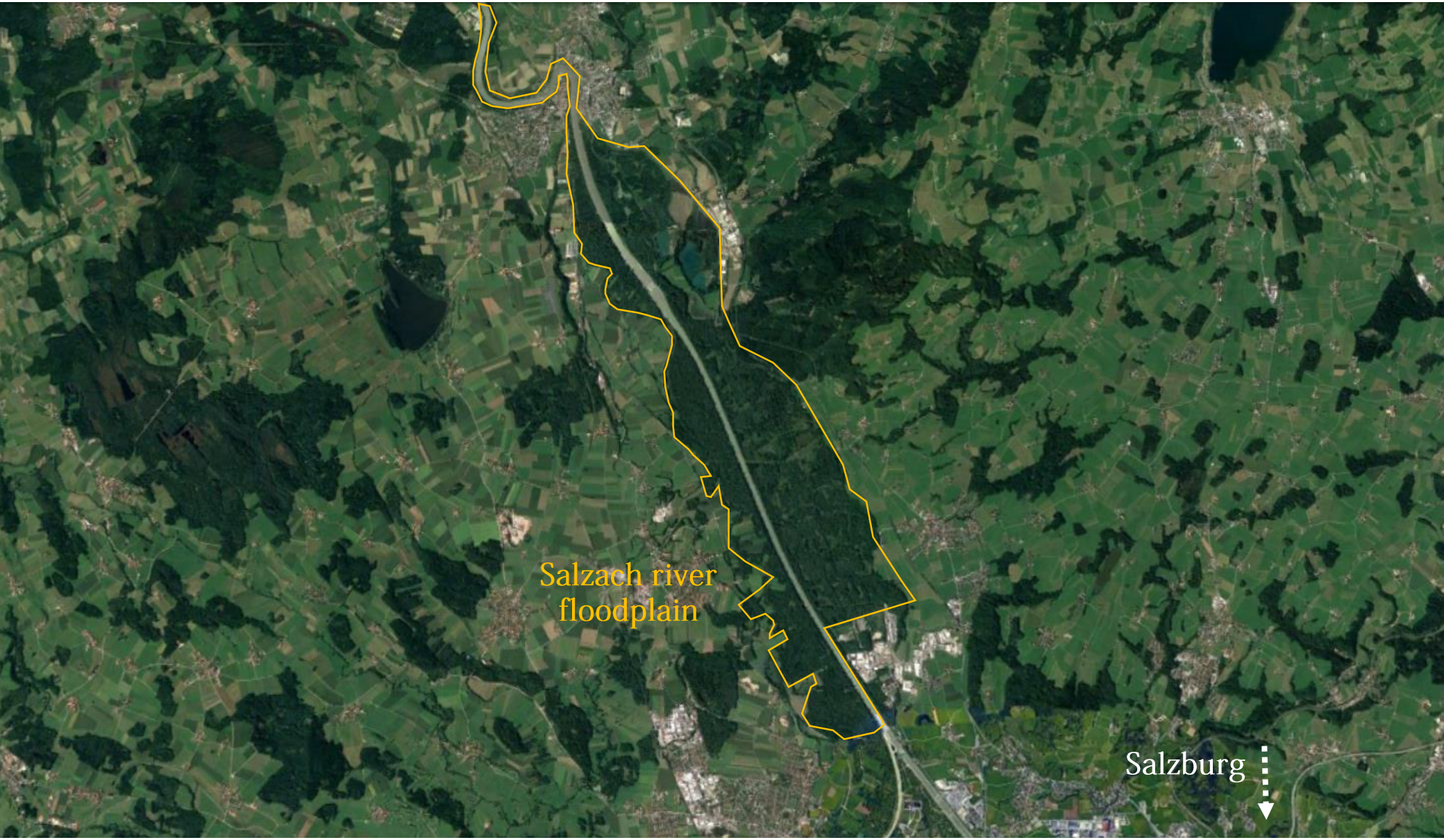


Multi-Scale Classification




Omdurman
Tuti Island
Khartoum


Parco delle Cave
Milan Centro

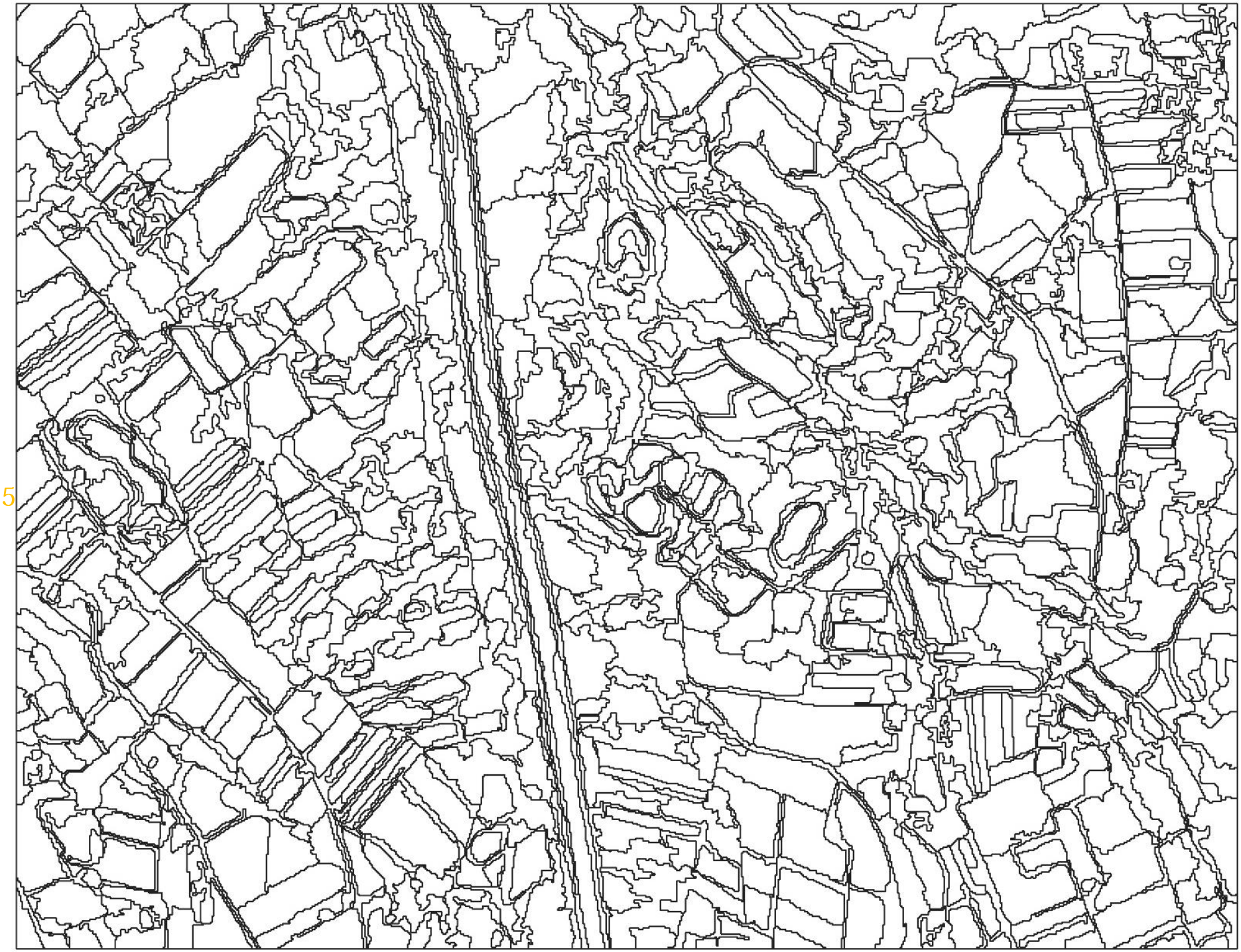


(Strasser & Lang, 2015)

And 100 of other cases…Let's get back.

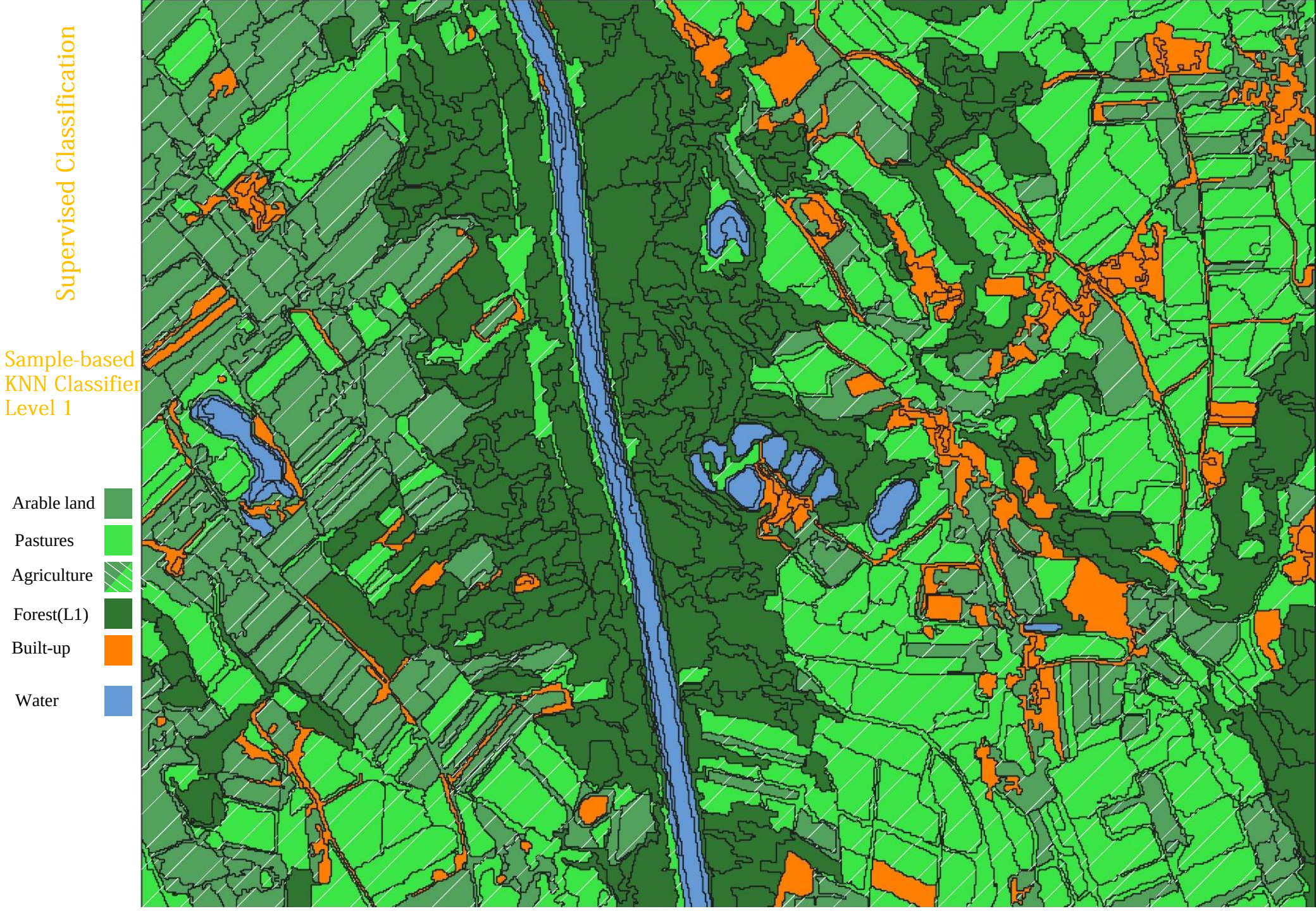
Multi-resolution Segmentation

Scale 30
Compact. 0.5
Shape 0.1



Supervised Classification

Sample-based
KNN Classifier
Level 1

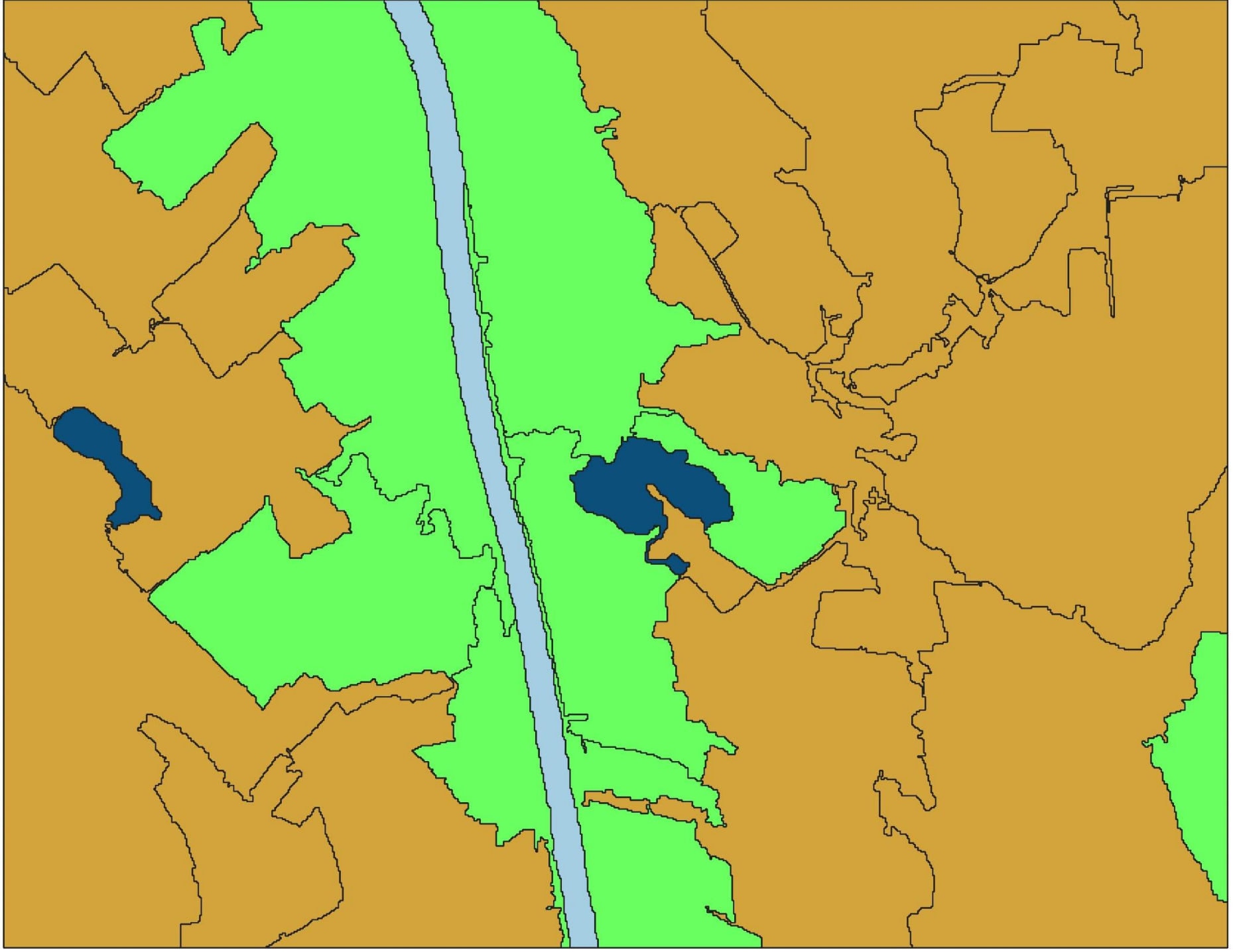


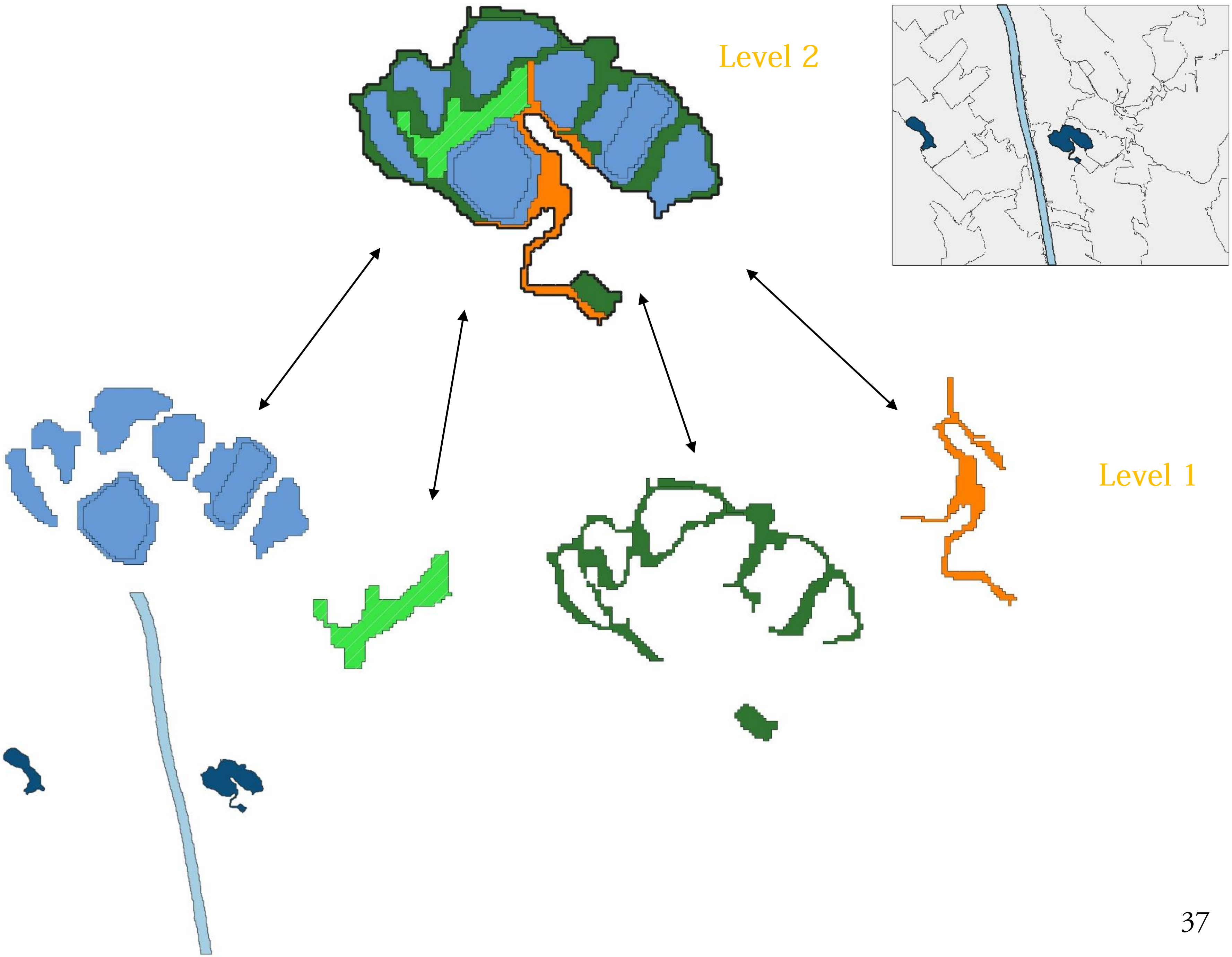
Object domain Multi-resolution Segmentation

Scale 200
Compact. 0.7
Shape 0.3

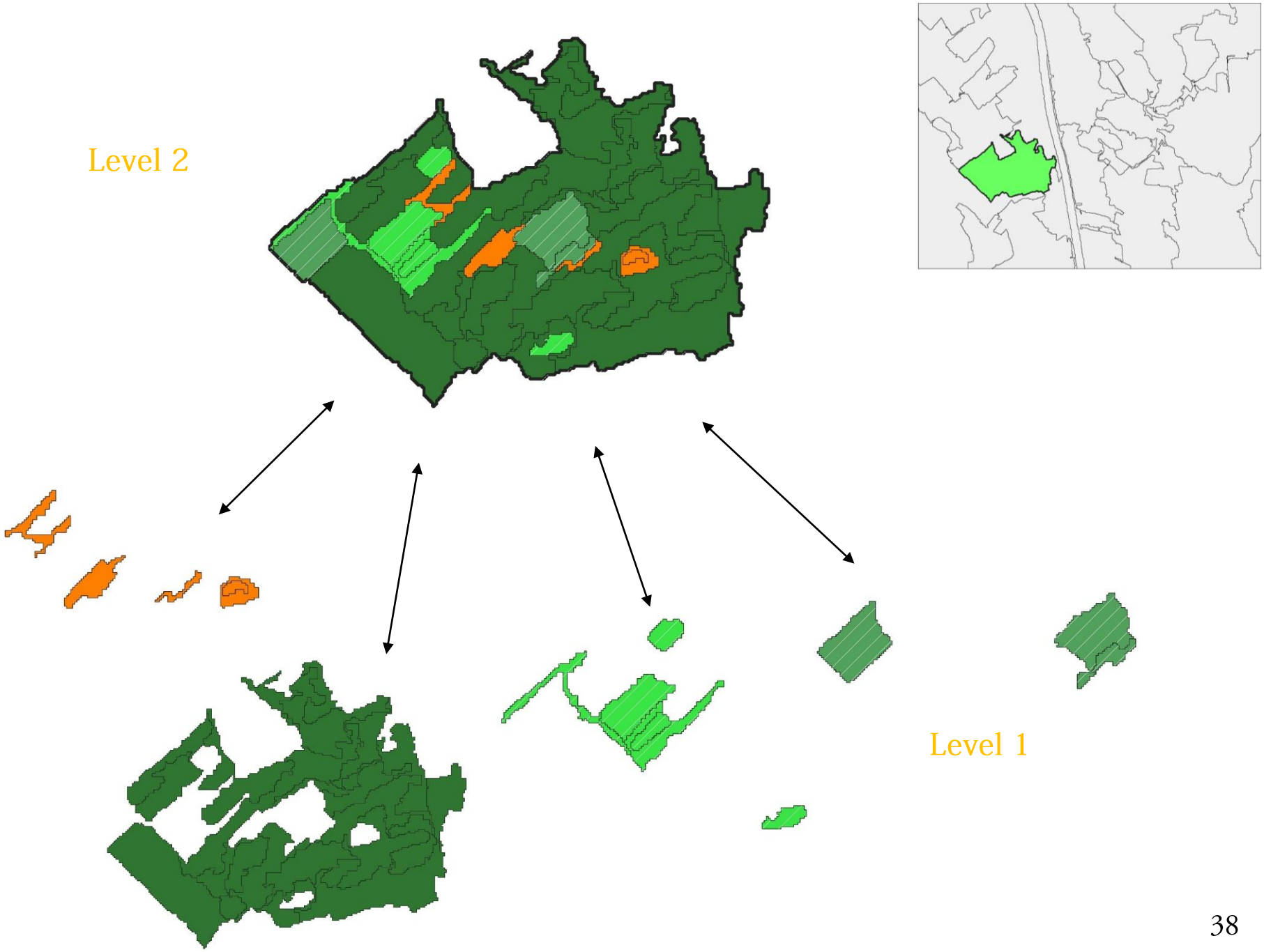
Knowledge-based Classification

Level 2



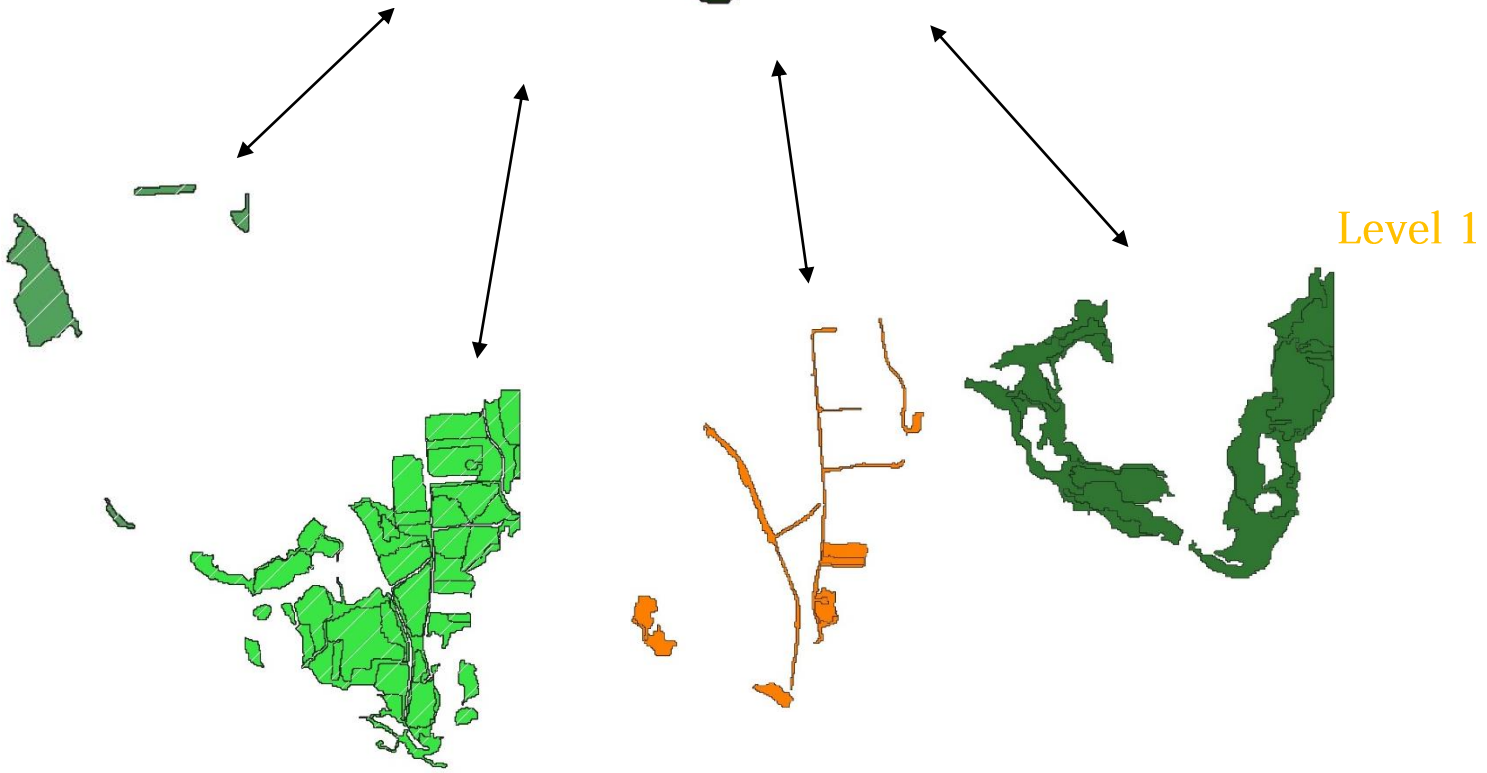

Rel. Area of Sub Objects
Water(L1) >= 0.4 ; L2: water
Level 2
Level 1
Shape Index >= 3 ; L2: river
Shape Index < 3 ; L2: lake area

Rel. Area of Sub Objects Forest(L1) > Rel. Area of Sub Objects Agriculture ; L2: Forest(L2)



Unclassified with Rel. Area of Sub Objects
Forest(L1) <= Rel. Area of Sub Objects
Agriculture ; L2: Open Land

Level 2



Level 1

The End…

- Image perception & Knowledge,
- The matter of Scale,
- Not merely focusing on exploiting comprehensive, but also effective image information,
- Conditioned Information (Lang et al. 2010a):

> "Conditioned information is the result of a process to fulfill the user demand in technological and conceptual sense and has undergone any kind of fitness check for operational use ('user validation')."

References

Articles

Lang, S. ; Blaschke, T. (2006). Bridging Remote Sensing and GIS - What Are the Main Supportive Pillars?

Lang, S. ;Tiede, D. (2015). Geospatial data integration in OBIA – implications of accuracy and validity. in Thenkabail, P., (ed.) Remote Sensing Handbook,New York: Taylor & Francis. pp. 295-316.

Strasser, T. ; Lang, S. (2015). Object-based Class Modelling for Multi-scale Riparian Forest Habitat Mapping. in International Journal of Applied Earth Observation and Geoinformation. Pp 29-37.

Books

Apollonio, S. (2002). Hierarchical Perspectives on Marine Complexities.

O.Ward, M. ; Grinstein ; Keim, D. (2015). Interactive Data Visualization. By Taylor & Francis Group, LLC.

Online Resources

eCognition Online Documentation:

https://docs.ecognition.com/v9.5.0/eCognition_documentation/User%20Guide%20Developer/4%20Basic%20Rule%20Set%20Editing.htm

Images at slides 8,9,10:

https://twitter.com/vincentlaforet/status/819952519124316160/photo/1 Barcelona

https://blogging-techies.com/estas-20-impresionantes-fotos-satelitales-cambiaran-su-perspectiva-de-nuestro-mundo/ other pics

Lang, S. (2021). Object-based Image Analysis, an Introductory Course. EO4Geocourses:

https://eo4geocourses.github.io/PLUS_OBIA-Introduction/#/

Advanced Remote Sensing Lectures

Lang, S. ; Tiede, D. ; Dabiri, Z. ; Augustin, H. Lecture 11, Knowledge Representation & Knowledge-based Systems.

Lang, S. ; Tiede, D. ; Dabiri, Z. ; Augustin, H. Lecture 12, Class Modelling.