

Geographic Objects and Their Categories



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Outline



- What is Ontology?
- Where Do Geographic Categories Come From?
- The Truth About Earth
- Objects and Fields: The Individuation Problem
- Data Standards and Cultural/Linguistic Relativism
- Some Empirical Results
- Summary

Ontology

- Ontology studies the constituents of reality
- An ontology of a given domain describes in formal terms the constituents of reality within that domain
- The ontology also describes the relations between these constituents, and also the relations between constituents of one domain and others

■ (Smith)

Ontology in Artificial Intelligence

- In Artificial Intelligence, an ontology is sometimes defined as a specification of a conceptualization

- (Tom Gruber <gruber@ksl.stanford.edu>)

Ontology of Geographic Things

- Geographic things are not merely *located* in space, they typically are *tied intrinsically* to space in such a way that they inherit from space many of its structural (mereological, topological, geometrical) properties
- The role and nature of boundaries is especially important

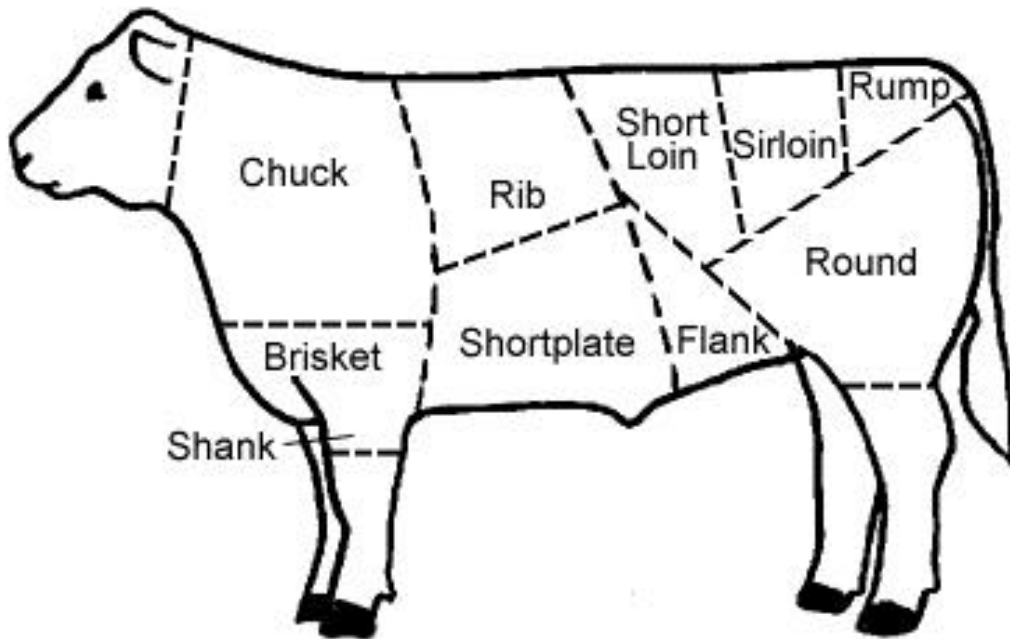
Kinds of Boundaries

- Bona fide boundaries - nature's joints
(but between tokens not types)
- Fiat boundaries - imposed explicitly by an authority
- Both of the above are crisp, but many geographic 'objects' have graded or indistinct boundaries

Bona Fide or Fiat?



Bona Fide or Fiat?



Geographic Things

- **Delimitation** criteria, for carving one individual from a continuum, are much more likely to be ambiguous, and to vary across individuals and cultures, and
- **Classification** (categorization) and delimitation probably are not independent

Some Truths about Earth

- The truth about Earth is that it is a roughly-spherical planet with a rocky crust



- With almost no loss of generality, the elevation of the Earth's surface can be modeled as a single-valued function of horizontal position, that is, as a continuous field of elevations

Mountains?



- If topography is (just) the rough surface of planet Earth, can mountains be ‘things’ (objects)?
- Topography is a mass noun, mountains and other landforms are countable ‘things’

How Many Mountains?



Objects and Fields: The Delimitation Problem

- Do mountains really exist?

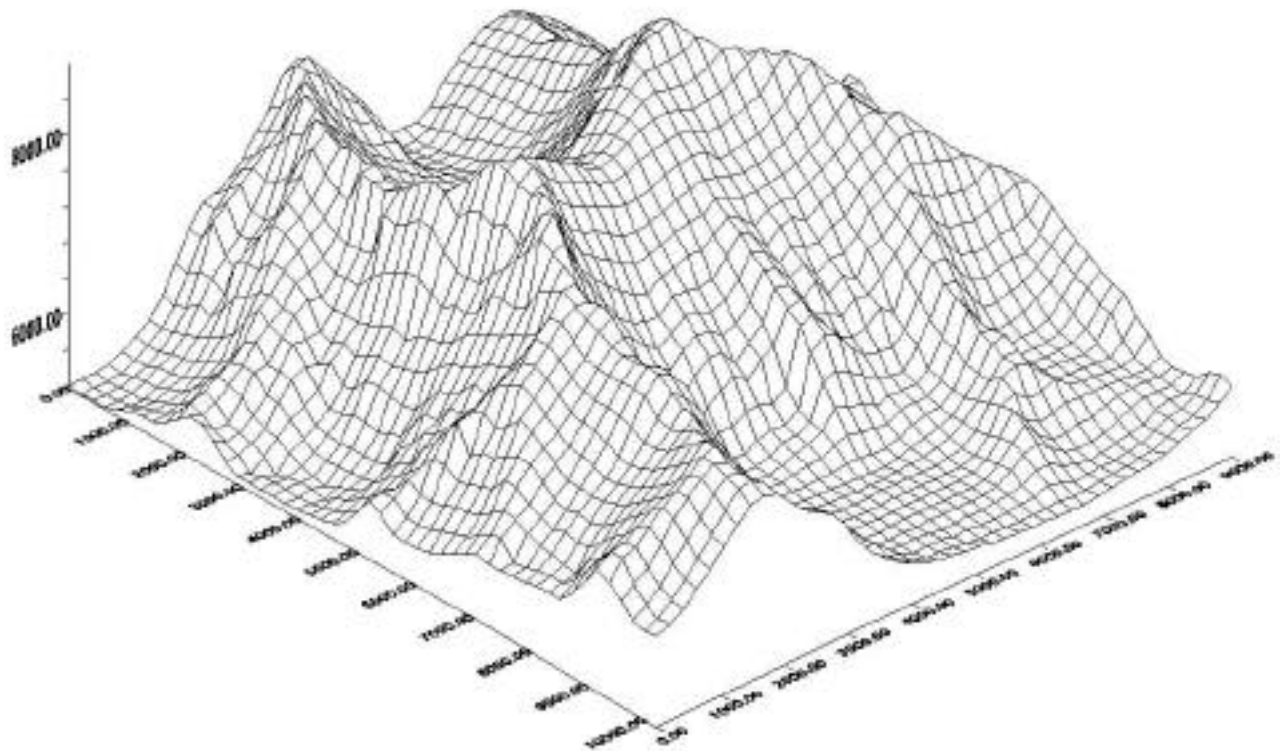


Do mountains really exist?

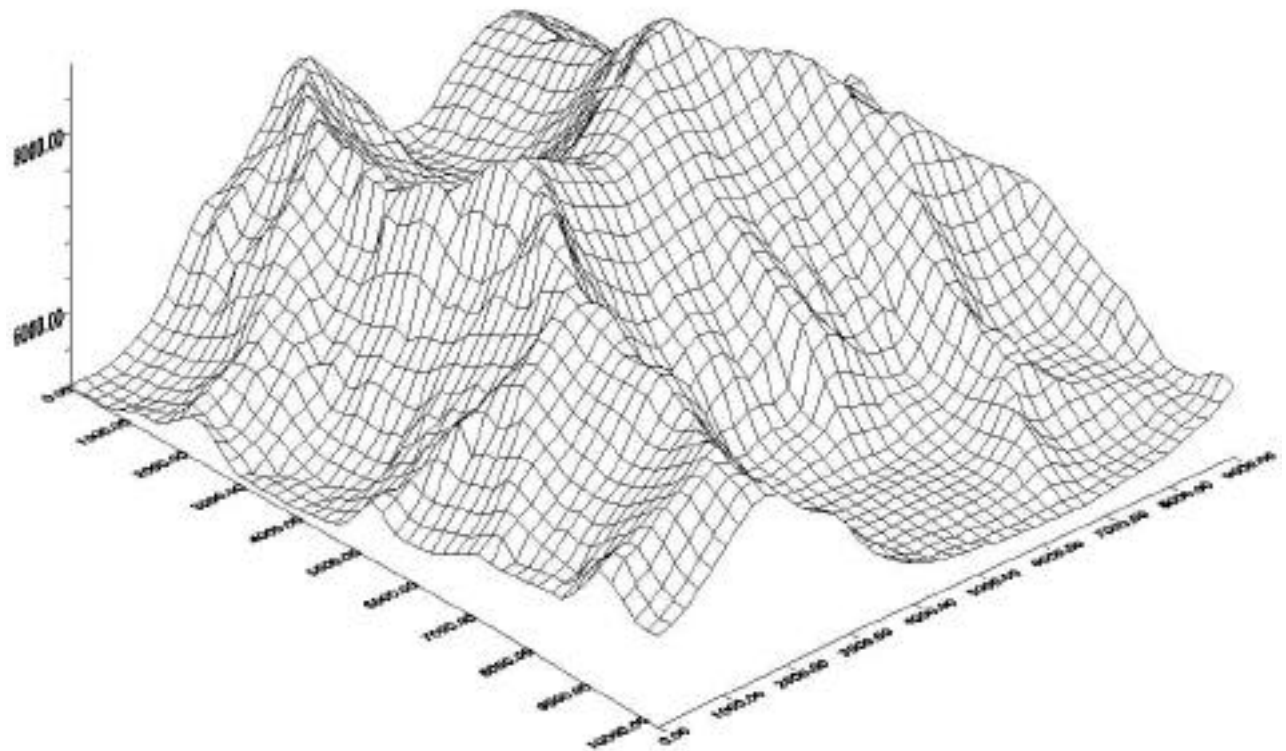


- Yes, obviously!
- But what does “exist” mean here?
- Do things (objects? entities?) exist that are members of the category “mountain”?
- Perhaps “mountains” are just convex parts of elevation fields

Perhaps mountains are just
convex parts of elevation fields...



Which part is Mount Everest?

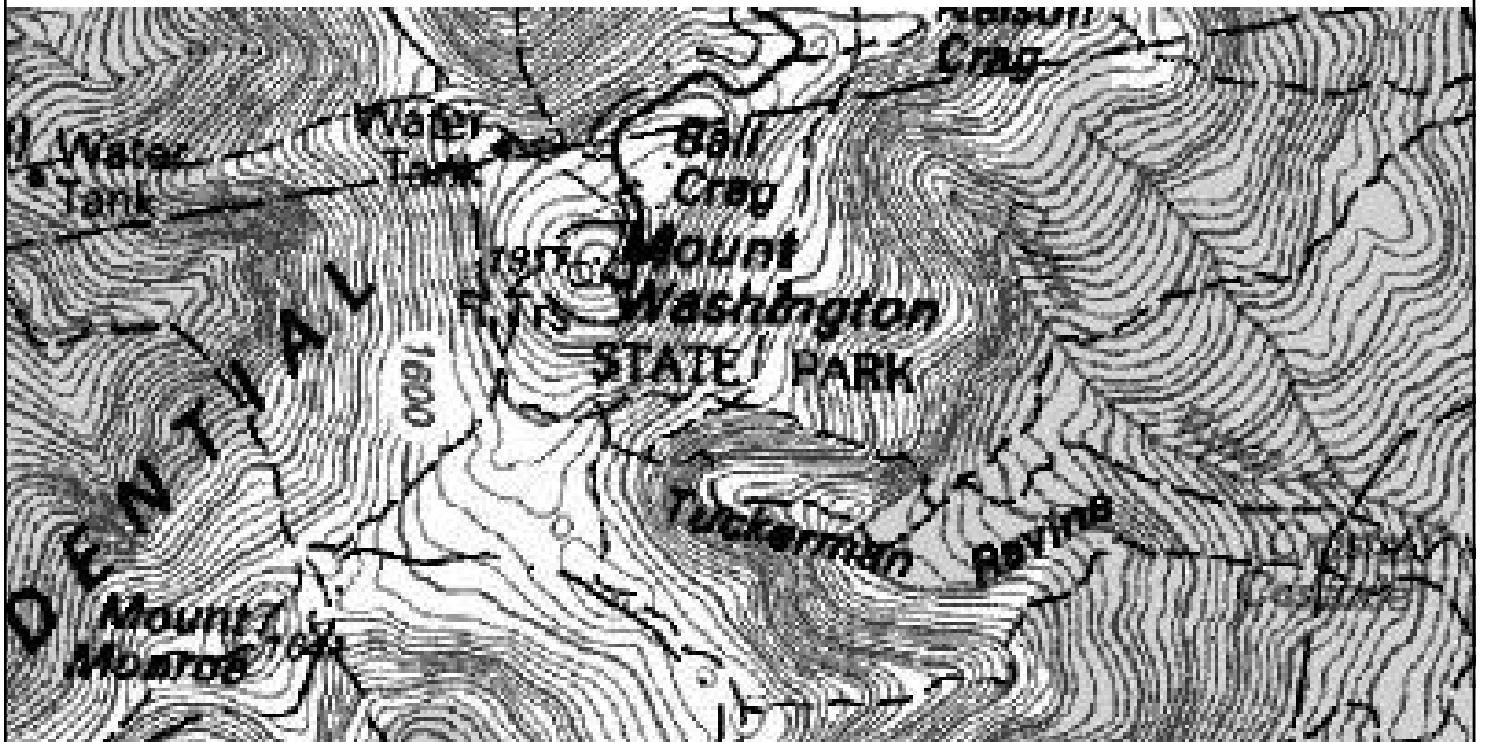


Mountains on Maps?



- You may think that mountains often are depicted on topographic maps

Where is Mount Washington?



Land Forms



- Overhanging cliffs are extremely rare, so the elevation of the Earth's surface can be conceptualized as a single-valued function of horizontal position, that is, as a continuous field
- Generally speaking, this is how science has modeled the geometry of the Earth's surface

Topography as Experienced



- The environment as experienced by people is very different from this world of fields and surfaces
- It is the same environment, of course, but experienced through human senses in the context of human activities and needs.

Topography Experienced

- When viewed from the surface of the Earth by a creature between 1 and 2 meters tall, the curvature of the geoid, of the horizontal, is almost imperceptible, whereas variations of surface elevation of tens, hundreds, or thousands of meters dominate the experienced landscape

Topography Experienced



- When people see, learn, and describe a landscape, they (apparently) consider it to be composed of objects or things, presumably based on some combination of gestalt visual perception and the perception of affordances

Affordances



- J. J. Gibson has provided a valuable account of the perceived world, which he presented as a prelude to his accounts of human visual perception
- A key part of his model is the concept of **affordances**

Affordances



- “The affordances of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or evil.”
- James J. Gibson, “The Ecological Approach to Visual Perception.”

Affordances



- “The verb to afford is found in the dictionary, but affordance is not. I have made it up.”
- “I mean by it something that refers both to the animal and the environment in a way that no existing term does.”
- “It implies the complementarity of the animal and the environment.” (p. 127)

Geographic Affordances

- Conjecture: Parts of the environment gain meaning, become things, mainly according to the activities that they afford.
- Parts of the Earth's surface that afford more or less the same activities may be considered to belong to the same category.

Geographic Affordances

- Mountains afford climbing by experts
- Mountains also afford navigation when they serve as landmarks
- Lakes afford fishing, the obtaining of drinking water, swimming, travel by boat
- Forests afford wood gathering, hunting, hiding from enemies
- Etc.

Data Exchange Standards and Linguistic Relativism

- Standard Facilitate Data Exchange
- Common Ontology facilitates Semantic Interoperability
- But what about cultural or linguistic differences in categories?
- An Example: Étangs

Semantics for Geospatial Data Exchange

An Example from the DIGEST standard
(Digital Geographic Information Working Group, DGIWG)

BH080: A body of water surrounded by land

US Lake / Pond

FR Lac / Étang

GE See / Teich

IT Lago / Stagno

NL Meer / Plas / Vijver

SP Lago / Laguna

UK Lake / Pond

Semantics for Geospatial Data Exchange

Are “ponds” in English the same as
“étangs” en Français?

BH080: A body of water surrounded by land

| | |
|-----------|-----------------------------|
| US | Lake / Pond |
| FR | Lac / Étang |
| GE | See / Teich |
| IT | Lago / Stagno |
| NL | Meer / Plas / Vijver |
| SP | Lago / Laguna |
| UK | Lake / Pond |

Étang de Berre



- Avec ses 75 km de périmétrie et une profondeur ne dépassant pas 9 mètres, cet étang gigantesque est relié à la Méditerranée par un canal à l'ouest, et par un souterrain à l'est, en direction de Marseille

Things are not always what they say they are ...



Étang de Berre



■ *Ceci n'est pas un «pond»!*

Étang de Berre



■ So, is it a lake?

Étang de Berre



■ No! In English it would be called a “lagoon”!

Another Kind of Water Body: Lagoon

BH190: Open body of water separated from the sea by sand bank or coral reef

| | |
|-----------|----------------------------|
| US | Lagoon / Reef Pool |
| FR | Lagon / Lagune |
| GE | Lagune |
| IT | Laguna |
| NL | Lagune / Strandmeer |
| SP | Albufera |
| UK | Lagoon / Reef Pool |

Conceptual Model for Water Bodies



- | “A body of water surrounded by land”
- | “Open body of water separated from the sea by a sand bank or coral reef”

■ Kinds of water bodies may be distinguished by

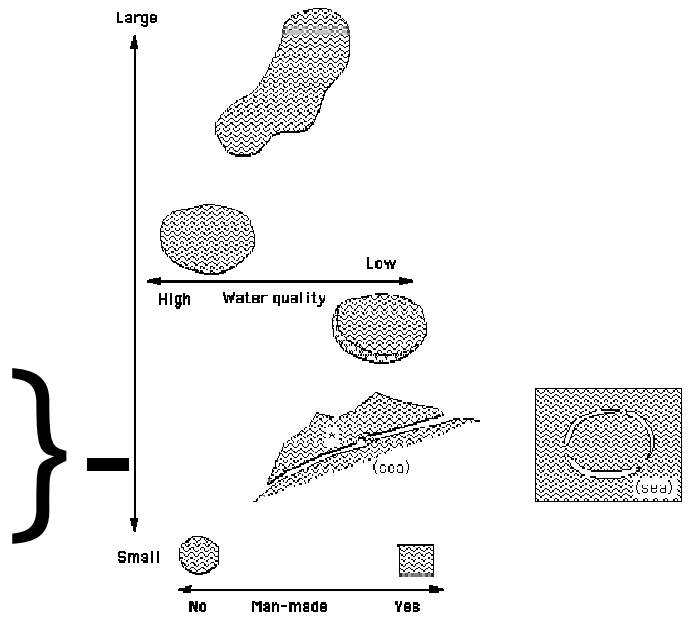
- Size
- Origin
- Water quality
- ...

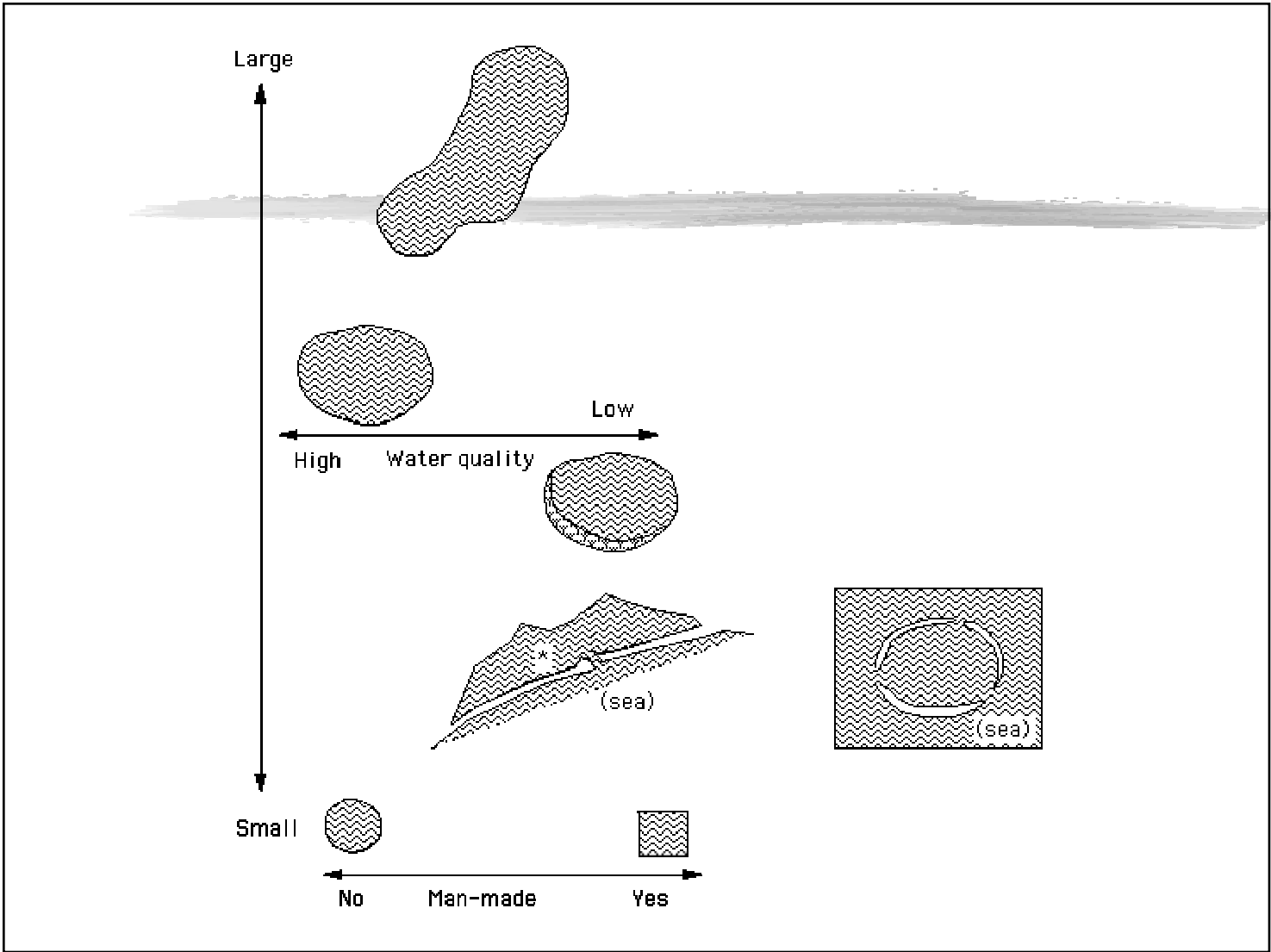
Different Languages

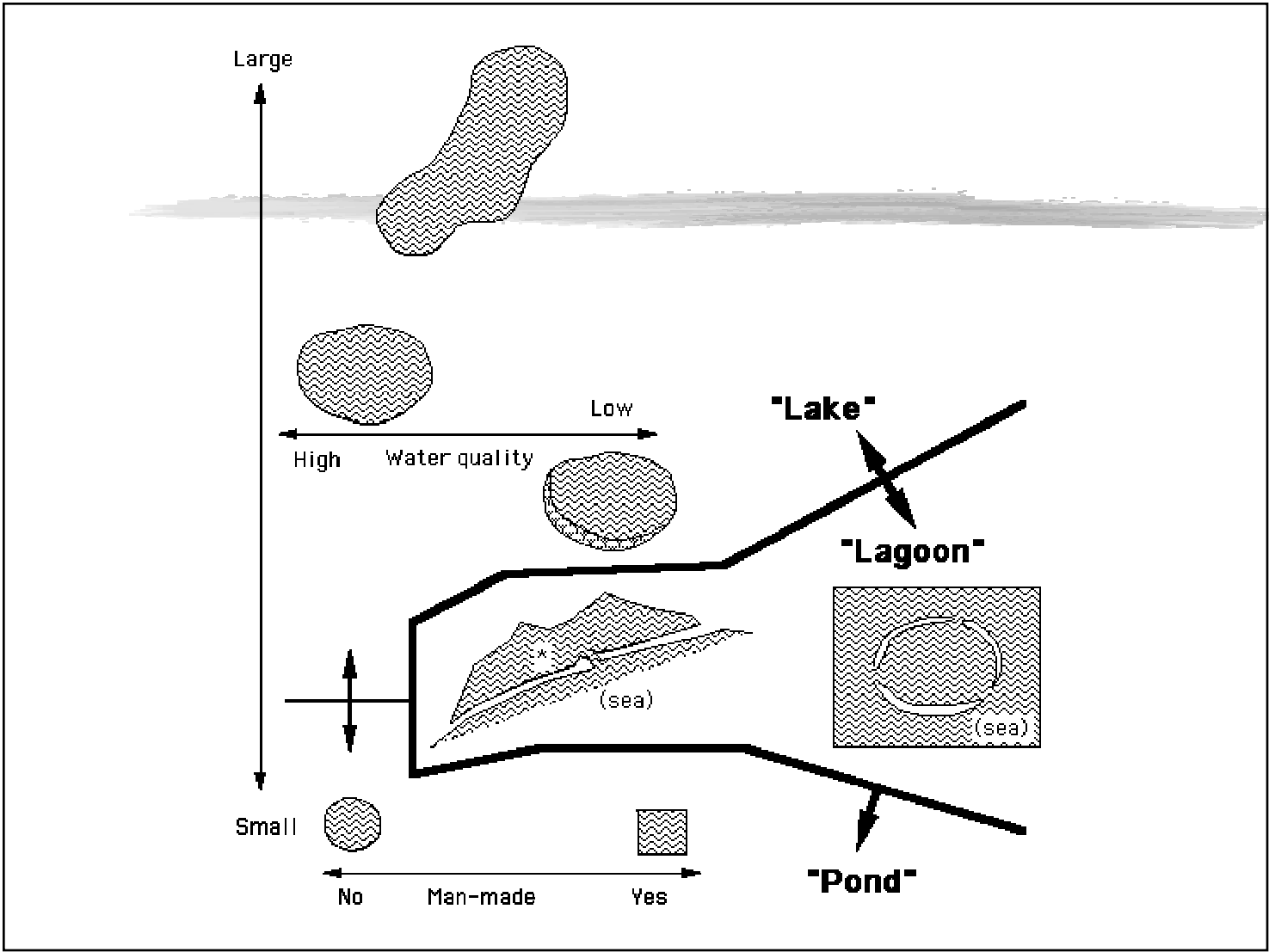


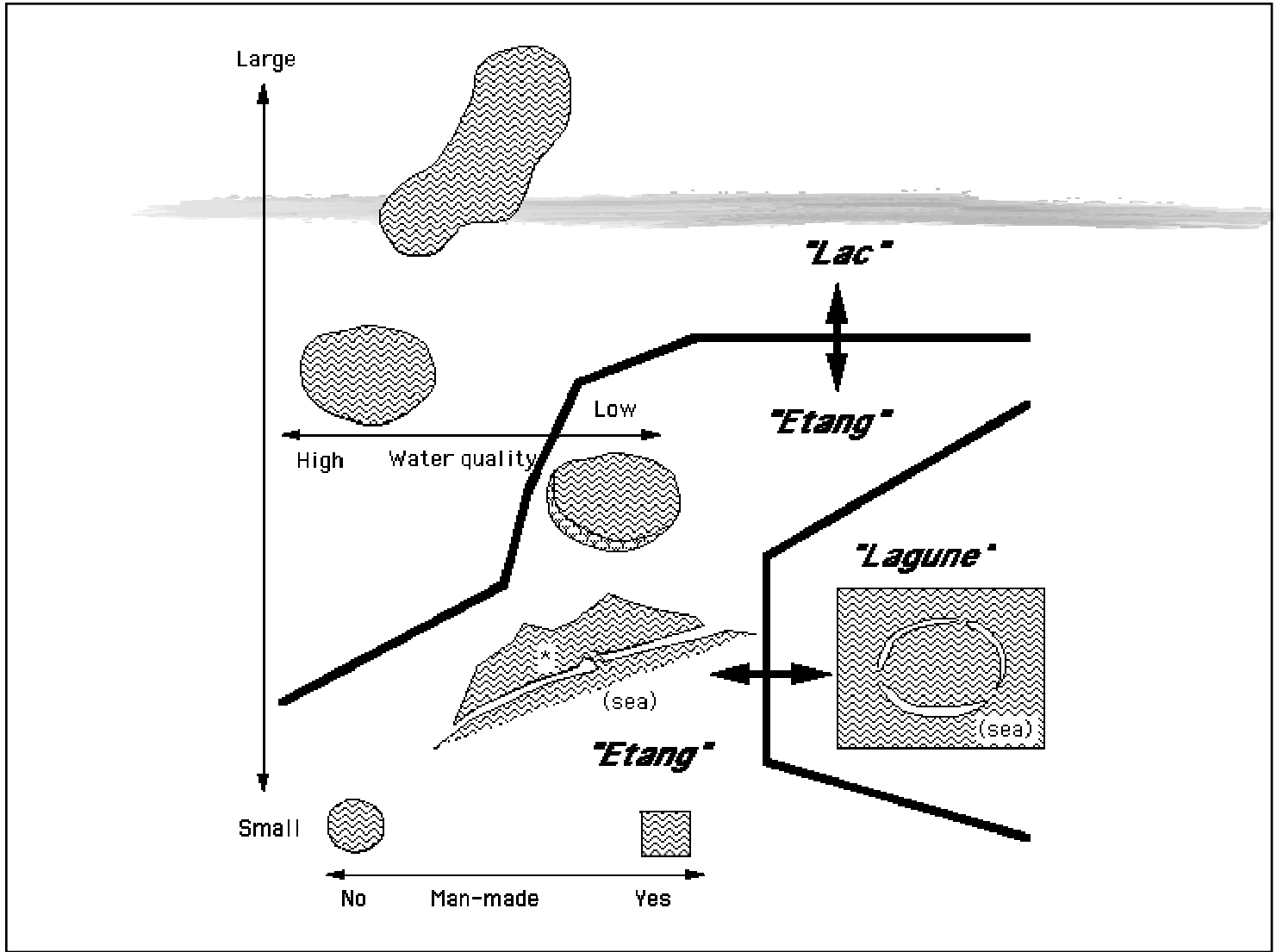
- Different languages may give different weights to these factors
- Consider English and French

Conceptual Model for Water Bodies









Geographic Categories



■ Some Empirical Results

Category Norms

(following Battig and Montague, 1969)

- “For each of the following categories, please write down as many items included in that category as you can in 30 seconds, in whatever order they happen to occur to you”
- Subjects were then given a series of category labels

“a kind of geographic feature”

(COSIT'99 paper)

| | | |
|----|------|----------|
| 31 | 1.65 | mountain |
| 19 | 4.79 | lake |
| 17 | 4.00 | ocean |
| 17 | 4.82 | plain |
| 16 | 4.44 | river |
| 15 | 4.00 | hill |
| 12 | 6.83 | desert |

Subject Matter of Geography

- Almost all are part of the natural (physical) environment
- *Borders, field, park, and road* were the only built features mentioned, just once each!
- This was a surprise, since modern academic geography is a more social science than an environmental one
- Was the word “feature” responsible?

General Ontological Terms

- *Feature, object, entity, item, thing, something, term, unit, being, individual, instance, token, phenomenon, ...*
- These terms are not exactly synonymous, but the distinctions in meaning are not obvious either, at least in everyday English
- It is difficult to translate the distinctions into other languages

What Difference Does the Exact Question Make?

- a kind of geographic feature
- a kind of geographic object
- something that could be portrayed on a map
- (concept, entity, phenomenon)

Subjects

- 263 students from the “World Civilization” general education course at UB, Fall 2000
- Additional subjects in Finland, Croatia, Poland, Guatemala, and England

English Norms

| term | feature | object | map- pable | total F |
|-----------|-----------|--------|---------------|---------|
| mountain | 48 | 23 | 25 | 96 |
| river | 35 | 18 | 31 | 84 |
| lake | 33 | 13 | 21 | 67 |
| ocean | 27 | 16 | 18 | 61 |
| city | 1 | 4 | 30 | 35 |
| country | 2 | 6 | 23 | 31 |
| road | 1 | 2 | 27 | 30 |
| hill | 20 | 9 | 0 | 29 |
| valley | 21 | 7 | 0 | 28 |
| plain | 19 | 6 | 1 | 26 |
| continent | 1 | 10 | 12 | 23 |
| plateau | 17 | 4 | 0 | 21 |

English Norms, 'feature' highest

| term | feature | object | map- pable | total F |
|----------|-----------|--------|---------------|---------|
| mountain | 48 | 23 | 25 | 96 |
| river | 35 | 18 | 31 | 84 |
| lake | 33 | 13 | 21 | 67 |
| ocean | 27 | 16 | 18 | 61 |
| hill | 20 | 9 | 0 | 29 |
| valley | 21 | 7 | 0 | 28 |
| plain | 19 | 6 | 1 | 26 |
| plateau | 17 | 4 | 0 | 21 |
| desert | 14 | 6 | 0 | 20 |
| volcano | 10 | 4 | 0 | 14 |
| stream | 6 | 2 | 1 | 9 |

English Norms, 'object' highest

| term | feature | object | map- pable | total F |
|-----------|---------|-----------|---------------|---------|
| map | 0 | 17 | 0 | 17 |
| globe | 0 | 11 | 0 | 11 |
| peninsula | 8 | 10 | 1 | 19 |
| compass | 0 | 8 | 2 | 10 |
| land | 2 | 6 | 0 | 8 |
| rock | 1 | 6 | 0 | 7 |
| atlas | 0 | 6 | 0 | 6 |

English Norms, 'mappable' highest

| term | feature | object | map- pable | total F |
|-----------|---------|--------|---------------|---------|
| city | 1 | 4 | 30 | 35 |
| road | 1 | 2 | 27 | 30 |
| country | 2 | 6 | 23 | 31 |
| state | 0 | 5 | 15 | 20 |
| continent | 1 | 10 | 12 | 23 |
| town | 0 | 5 | 8 | 13 |
| street | 0 | 1 | 8 | 9 |
| highway | 1 | 0 | 7 | 8 |
| park | 0 | 0 | 6 | 6 |
| county | 0 | 2 | 5 | 7 |
| building | 0 | 1 | 5 | 6 |

Non-geographic things

| term | feature | object | not map- pable | total F |
|-----------------|-----------|-----------|-------------------|---------|
| | 54 | 57 | 50 | 161 |
| NO ENTRY | 13 | 8 | 2 | 23 |
| house | 9 | 8 | 6 | 23 |
| building | 13 | 6 | 1 | 20 |
| car | 4 | 14 | 8 | 26 |
| pen | 1 | 11 | 0 | 12 |
| chair | 1 | 9 | 1 | 11 |
| book | 0 | 8 | 1 | 9 |
| pencil | 0 | 8 | 1 | 9 |
| desk | 0 | 8 | 0 | 8 |
| person | 6 | 6 | 16 | 28 |
| animal | 1 | 4 | 7 | 12 |

Physical things

| term | feature | object | some- thing | entity | phenom- -enon |
|-------------|---------|--------|----------------|--------|------------------|
| N= | 17 | 21 | 18 | 18 | 19 |
| weight | 4 | - | 1 | 1 | - |
| height | 4 | - | - | 1 | - |
| pen | - | 6 | 1 | - | - |
| table | - | 4 | 3 | - | - |
| chair | - | 4 | 2 | - | - |
| mountain | - | 2 | 6 | 2 | 1 |
| rock | 1 | 2 | 2 | 2 | - |
| tree | - | 1 | 4 | - | - |
| no response | 3 | 3 | - | 5 | 4 |
| hurricane | - | - | - | - | 4 |

Weather Phenomenon (263 subjects)

| | |
|------------------|------------|
| hurricane | 225 |
| tornado | 214 |
| rain | 100 |
| snow | 85 |
| blizzard | 75 |
| hail | 67 |
| lightning | 65 |
| earthquake | 57 |
| typhoon | 56 |
| flood | 49 |
| sleet | 42 |
| monsoon | 41 |
| thunder | 41 |
| wind | 38 |
| thunder storm | 33 |

Weather Phenomenon, Finnish

(60 subjects) (“säätmiö”)

| | | |
|---------------------|-----------------------|----------|
| sade | rain | 45 |
| myrsky | storm, tempest | 34 |
| tuuli | wind | 28 |
| ukkonen | thunder and lightning | 22 |
| lumisade | snowfall | 20 |
| auringonpaiste | sunshine | 15 |
| pouta | dry weather | 11 |
| helle | heat, hot weather | 10 |
| pakkanen | cold | 10 |
| hurrikaani | hurricane | 8 |
| tornado | tornado | 8 |
| pyörremyrsky | tornado | 7 |
| räntäsade | sleet | 5 |
| vesisade | rain | 5 |

Weather - the phrasing

| term | kind of weather | kind of weather phenomenon | total |
|--------------|-----------------|----------------------------|-------|
| N= | 18 | 19 | 37 |
| rain | 14 | 8 | 22 |
| snow | 15 | 6 | 21 |
| sleet | 7 | 5 | 12 |
| sunny | 11 | 0 | 11 |
| cold | 9 | 1 | 10 |
| cloudy | 7 | 2 | 9 |
| windy | 5 | 4 | 9 |
| hot | 7 | 0 | 7 |
| thunderstorm | 5 | 5 | 10 |
| tornado | 6 | 15 | 21 |
| hurricane | 6 | 13 | 19 |

Geographic Waters

| Mean US English N=261 | Mean Finnish N=60 | Mean Croatian N=34 |
|---------------------------|----------------------|-----------------------|
| 0.83 ocean | 0.04 valtameri | 0.21 ocean |
| 0.42 sea | 0.66 meri | 0.78 more |
| 0.81 river | 0.63 joki | 0.73 rijeka |
| 0.80 lake | 0.75 jarvi | 0.55 jezero |
| 0.57 creek, brook, stream | 0.15 puro | 0.14 potok |
| 0.38 pond, pool | 0.30 lampi | 0.00 ribnjak |
| 0.17 bay, gulf, inlet | 0.17 lahti, poukama | 0.00 saljev, zaton |
| 0.14 waterfall, rapids | 0.07 koski | 0.05 slapovi |
| 0.12 canal, channel | 0.21 kanava | 0.00 kanal |
| 0.10 swamp, bog, marsh | 0.22 suo | 0.29 mocvaram, bara |

Summary



- Geographic things are special
- Some phenomena are more like fields
- People apparently conceptualize most phenomena as objects
- Formalizing geographic ontologies should be difficult, and fun!

Thanks for your Attention!



