Introduction to Geographic Information Systems – GIS

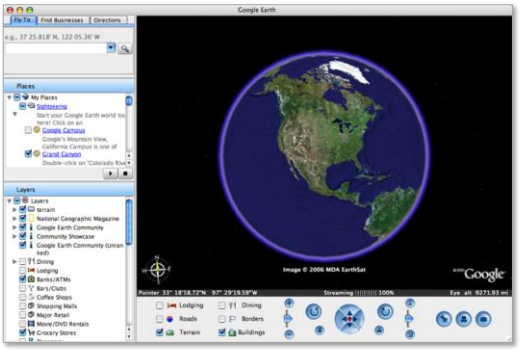
Basic mapping and GIS

Hans Skov-Petersen
hsp@ign.ku.dk
35 33 18 16

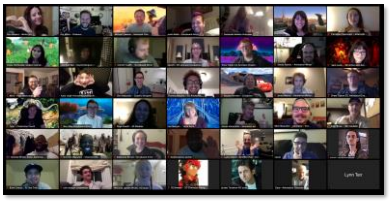
As a courtesy to those in the audience who are not (yet) acquainted with GIS ….

… and, as *a friendly and collegial gesture* for those who are

I will start by sharing *my personal trick to explain what I am doing* for a living



What? Where? (When?)



… who's talking?
… for what purpose?
… to who?
… … at what scale?

René Magritte,1928–29

Immanuel Kant (born 1724) made clear the distinction between

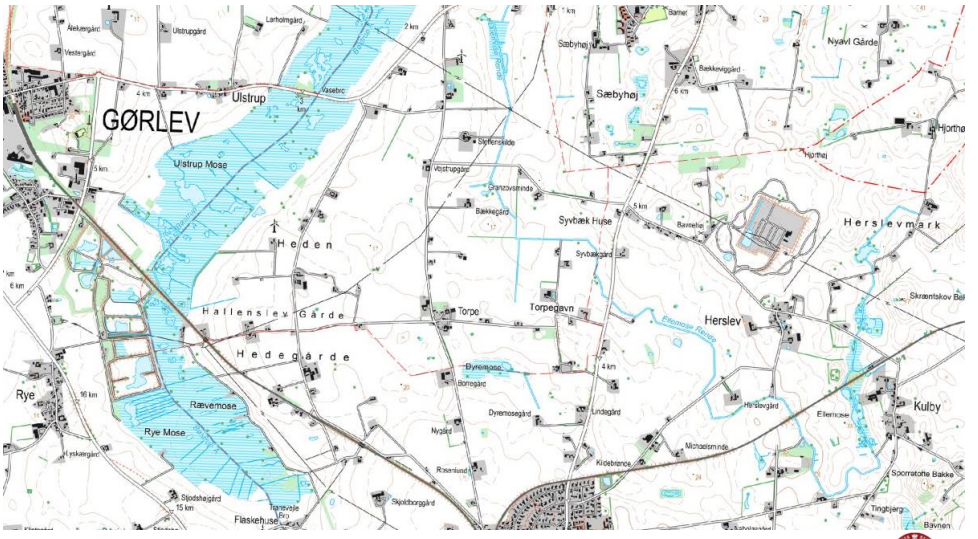
- the thing as it is **by itself** ('das ding an sich') and
- things are **to 'us'** ('das ding für uns')

GIS deals with

- **Representations of** the Real World
- Not, the Real World **per se**

The core demand, when doing 'good GIS', is to understand and **take into account the premise's** of the representations.

What is a wetland?



What is a wetland?

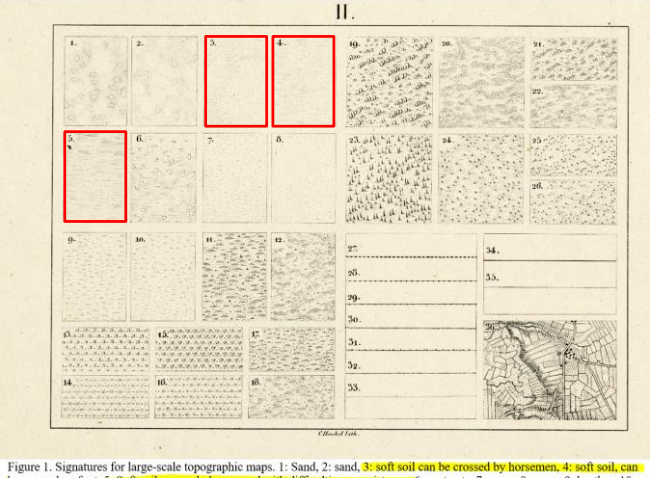
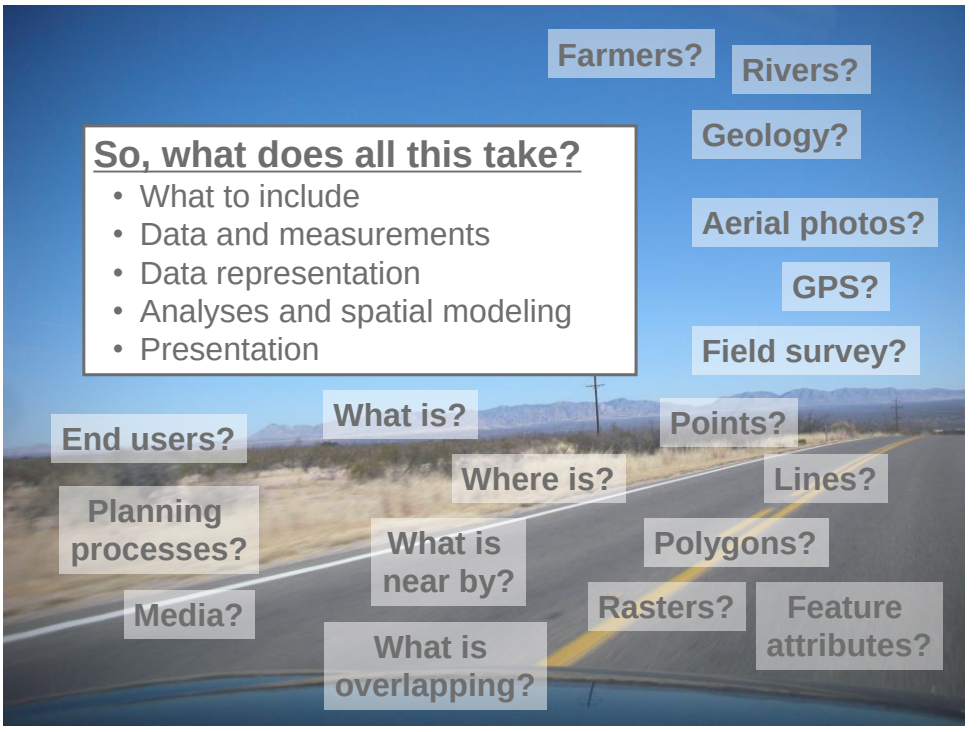


Figure 1. Signatures for large-scale topographic maps. 1: Sand, 2: sand, 3: soft soil can be crossed by horsemen, 4: soft soil, can be crossed on foot, 5: Soft soil, can only be crossed with difficulties or assistance, 6: peat cuts, 7: grass, 8: grass, 9: heather, 10: heather, 11: scrubland (perspective), 12: scrubland (plan), 13: Plantation, 14: plantation, 15: orchard, 16: orchard, 17: scrubs, 18: scrubs, 19: Deciduous trees, 20: Deciduous trees, 21: Deciduous trees, 22: Deciduous trees, 23: Coniferous trees, 24: Coniferous trees, 25: Coniferous trees, 26: Coniferous trees.

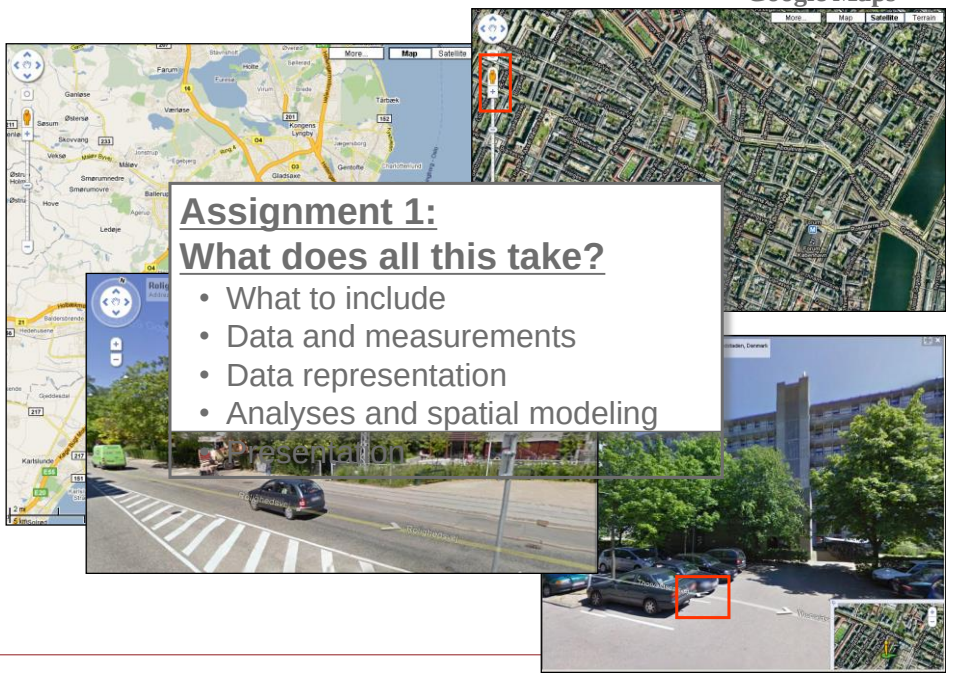
Danish
1800 century
topographic map

Svenningsen, S., Perner, M. L., Levin, G., & Groom, G. (2021). Investigating land area categories in largescale historical topographic maps in relation to analysing land use and land cover changes. In *Annual Conference Digital Approaches to Cartographic Heritage–Proceedings, Greece* (pp. 164-178).


What will happen to water availability in the San Pedro basin?


So, what does all this take?
• What to include
• Data and measurements
• Data representation
• Analyses and spatial modeling
• Presentation
Farmers?
Rivers?
Geology?
Aerial photos?
GPS?
Field survey?
Points?
Lines?
Polygons?
Rasters?
Feature attributes?
What is?
Where is?
What is near by?
What is overlapping?
End users?
Planning processes?
Media?

Google Maps



Assignment 1:
What does all this take?

- What to include
- Data and measurements
- Data representation
- Analyses and spatial modeling

Presentation

KØBENHAVNS UNIVERSITET

What goes in ..

So what is .. **GIS** ..?

What comes out ..

Data acquisition and automation

Data storage and management

Data analysis and modeling

Data presentation and dissemination

Or, to be slightly more formal: GIS is…

Bourrough, 1986, p. 6:

A powerful set of *digital tools for collection, storing, retrieval, transforming and displaying spatial data* from the real world

Huxhold and Levinsohn, 1995, p. 5:

A set of geographical information processing concepts and principles that define a broad model of the real world *within which an organization functions*

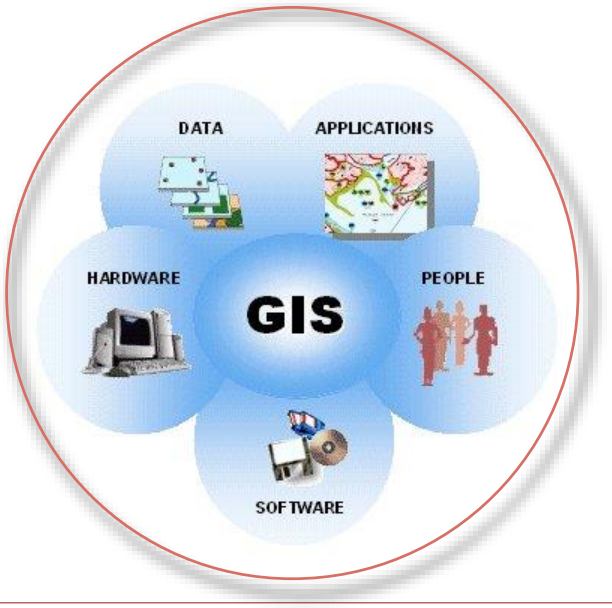
Sui and Goodchild, 2001, p. 387:

… the complex relationship between GIS and society can be better understood if one conceives of *GIS as new media*

Skov-Petersen ☺…, 2003, p. 272:

GIS is a mass-media centred on handling and communicating geographic information

A contextual view to GIS?



Society
Organisations
Processes
Stake holders
Target groups

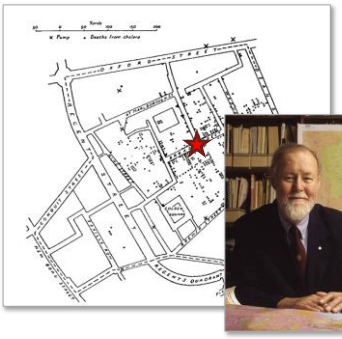
Planning
Design
Management

Discourse
Ethics
Power
Equity
Privacy

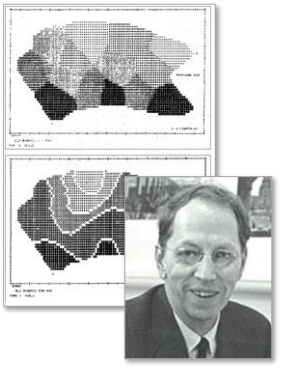
GIS and Geoscience thorough time

As Technology

1840 John Snow | **1964** CGIS | **1966** SYMAP | **1970th** CAD | **1979** ESRI | **1989** WWW | **1990th** GIS hits the PC | **2001** PostGIS and WMS | **2002** QGIS | **2006** WFS | **2004** GMap | **2010->** GIS is everywhere



Canadian GIS
Roger Tomlinson



SYMAP
Howard Fisher

ESRI
Jack Dangermond

GIS and Geoscience thorough time

As Technology (data capturing)

1840 John Snow | **1964** CGIS | **1966** SYMAP | **1970th** CAD | **1979** ESRI | **1989** WWW | **1990th** GIS hits the PC | **2004** GMap | **2010->** GIS is everywhere

Manual coordinate entry

Drum scanning

Manual digitizing (tablets)

Digital satellite imagery

GPS/GNSS

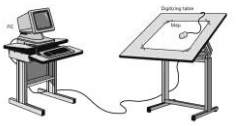
Digital ortophotos

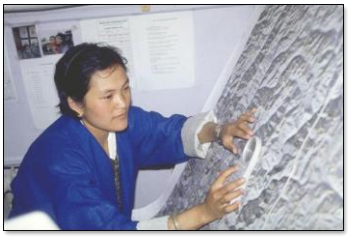
Light detection and ranging (LIDAR)

Web-based 2.0 GI (PPGIS, VGI)

Video-based tracking

Social media

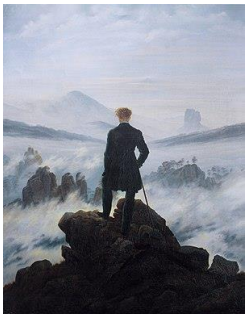




And so what?

We are at point in time where…

- Data production is hidden to its end-users
- Analytical techniques are well developed (and not a prime concern of most GIS-users)
- Storage and distribution of (massive amounts) of data is becoming increasingly important
- Dynamic – and often real-time – data are becoming more prominent
- Data and spatial analysis are used more and more in the (mass-) media
- … and we don't know who we are talking to, and what the information is used for.



Content of the course… never the less

It is expected that you during the course will learn to comfortably handle and understand the basics:

- How you get the real world into the computer (data automation)
- How to acquire existing data sets and assess their quality
- How data are stored and handled (data management)
- How to combine and analyze data (spatial analysis and modeling)
- How to present and disseminate results (digital cartography)

But it is not all about pressing buttons on the computer keyboard… an understanding of the principles 'behind' the scene is a fundamental necessity.

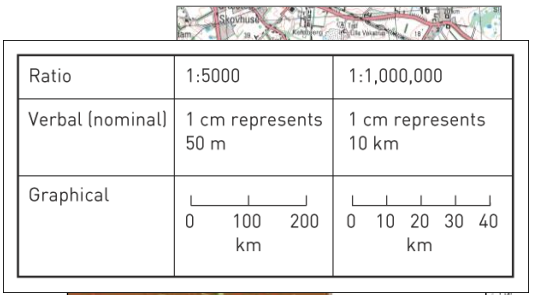
We will teach you how to *'drive the car'* – the interface to the technology

…. but hopefully also how to *'cope with, and behave in, traffic'* – that is, how to deal with GIS (as data, analysis and as a means of communication) in true combat

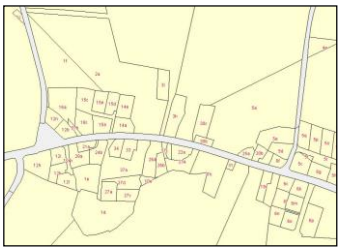
Pause

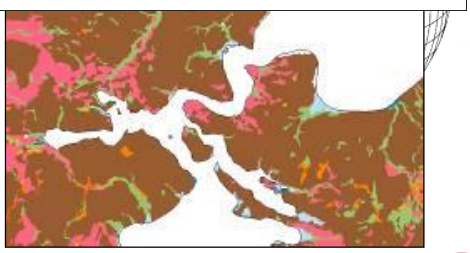
Cartographic concepts

- Scale
- Projections/SR
  - The sphere and the flat
  - Coordinate systems
  - Units
- Map types
  - Topographic maps
  - Thematic maps
  - 'Legal' maps



Ratio	1:5000	1:1,000,000
Verbal (nominal)	1 cm represents 50 m	1 cm represents 10 km
Graphical	0 100 200 km	0 10 20 30 40 km





Notions of Spatial scale

Relative representation
- E.g. 1:25.000

Magnitude, Size, Extend
- 'Global scale'
- 'Local scale'
- 'Landscape scale'
- 'Large/small scale'

Quality, Trustworthiness
- Detail/generalization
- Resolution
- Precision/Accuracy

The DNA string is 2.3 nm wide in reality
It is represented by a 0.5 m wide model
Accordingly **the scale is** 1:0,000.000.000.001.51

KØBENHAVNS UNIVERSITET IGN

Notions of Temporal scale

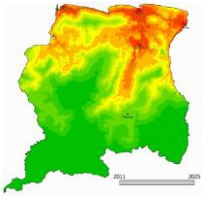
Relative representation
Animations
- Time laps/speed-up
- Slow motion

Magnitude, Size, Extend
Periods
- The Holocene
- My childhood
- My coffee at Joe's

Quality, Trustworthiness
- Detail/generalization
- Resolution
- Precision/Accuracy

Scale: 1:1.510.000.000.000
(10 sec vs 175 Mill Years)

Scale: 1:0.001
(10 sec vs 0.01)



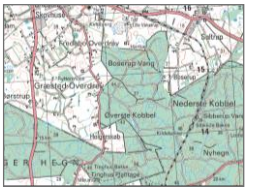
Geodata is...
data that has a *geographic dimetion*.

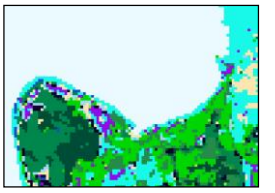
In 2D GIS…
we normally we distinguish:

Vector data (features)
- Points
- Lines
- Polygons

Raster data
- Images
- Tematic data

Tabels
- Attributes
- Geo coded information





Attributes of Als-Camping

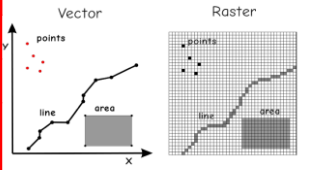
OBJECTID *	NAVN	ADR_1	ADR_2	POSTNR	BY_
1	Solholm Camping	Osvej 17	Bjerge Strand	4480	Store Fuglede
2	Vene Camping	Klitten 10	Vene	7600	Struer
3	Bovbjerg Camping	Juelsgårdvej 13	Ferring	7620	Lemvig
4	Fladbro Camping	Hedevej 9		8900	Randers
5	Trelde Næs Camping	Trelde Næsvej 297	Trelde Næs	7000	Fredericia
6	FDM Nordstrand Camping	Nordstrandsvej 107		4500	Nykøbing S
7	Strandparkens Camping	Skydebanevej 20		9000	Aalborg

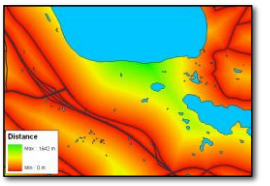
Record: 1 Show: All Selected Records (0 out of 590 Selected) Options

Raster or Vector GIS.

Characteristic	Raster	Vector
data structure	usually simple	usually complex
storage requirements	larger for most data sets without compression	smaller for most data sets
coordinate conversion	may be slow due to data volumes, and require resampling	simple
analysis	easy for continuous data, simple for many layer combinations	preferred for network analyses, many other spatial operations more complex
spatial precision	floor set by cell size	limited only by positional measurements
accessibility	easy to modify or program, due to simple data structure	often complex
display and output	good for images, but discrete features may show "stairstep" edges	maplike, with continuous curves, poor for images

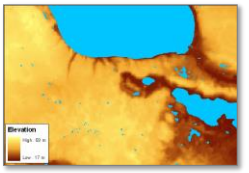
Bolstad: Table 2.2, p 56

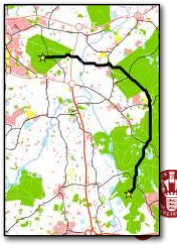




Some data-sources directly supply data in raster formats
- The prominent example is data from Remote sensing/Digital Image processing.
- The majority of global, environmental organisations supply data in raster-format

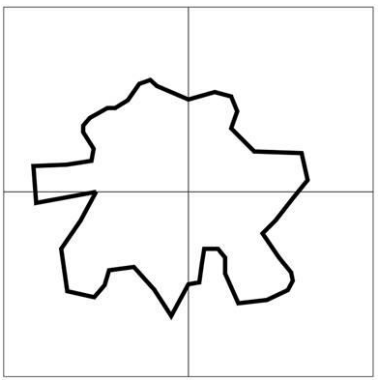
But to me... it is very much a question of what to model:
- Spatially, discreet phenomena (e.g. land parcels) are well represented by vector/feature
- Continuous phenomena (e.g. noise) requires a raster representation



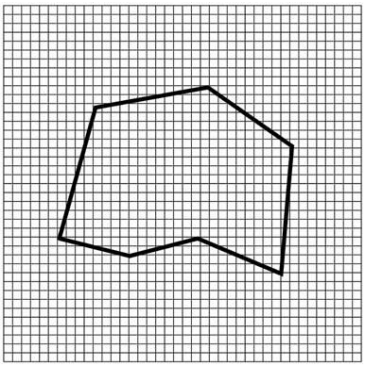


Raster or Vector GIS
Storage requirement, revisited

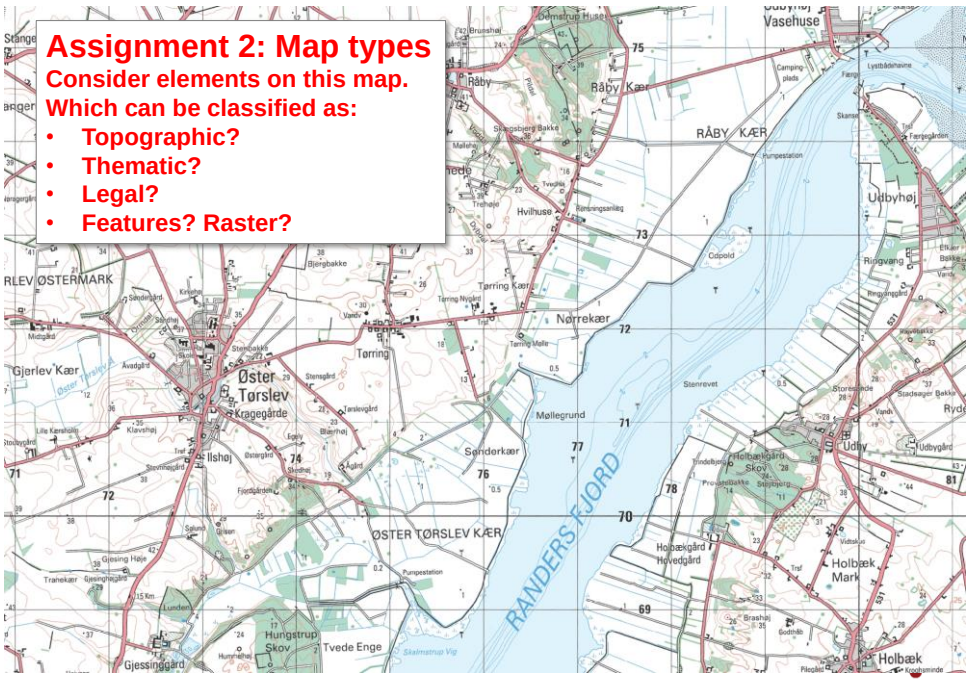
So, as always…
It's a matter of scale
… and accordingly, resolution



2x2 raster. God-only-knows how many vertices.



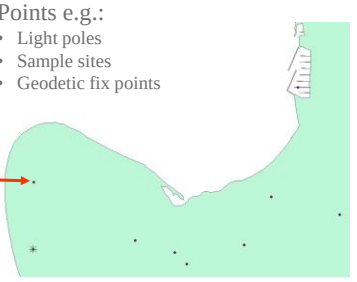
40x40 raster. Polygon with 7 vertices



Basic concepts of vector GIS

Points e.g.:

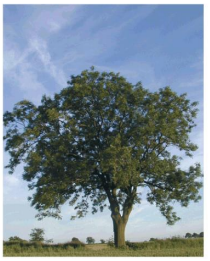
- Light poles
- Sample sites
- Geodetic fix points



Attributes:

Material	Heigth	Owner
Steel	8	ELRO
Wood	6	Æbeltoft municipality
….		

(a) Postbox



(b) Tree

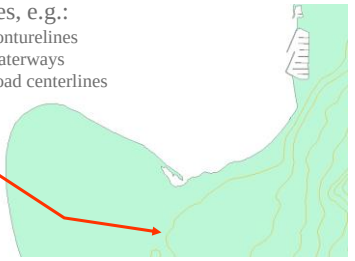
(c) Lamp post

Source: Heywood et al.

Basic concepts of vector GIS

Lines, e.g.:

- Conturelines
- Waterways
- Road centerlines

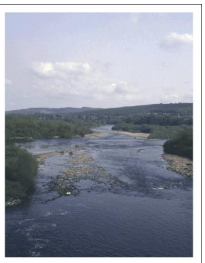


Attributes:

Index	Elevation	Source
0	5	KMS
1	10	KMS
….		

(a) Road

(b) Power line



(c) River

Source: Heywood et al.

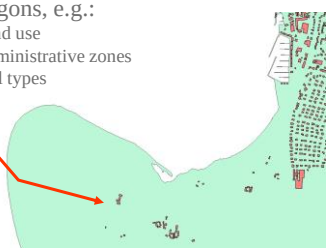
Basic concepts of vector GIS

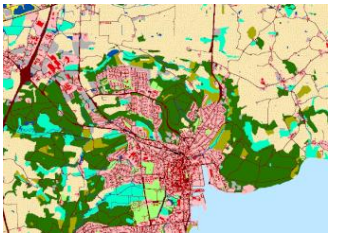
Attributes:

Type	Use	Number of floors
Brick	Dwelling	2
Steel	Shed	1
….		

Polygons, e.g.:

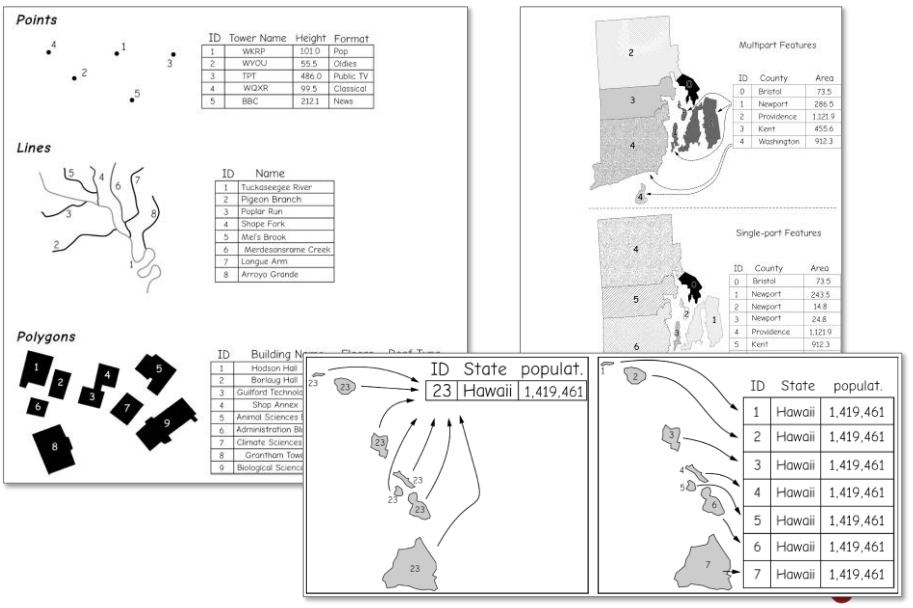
- Land use
- Administrative zones
- Soil types





Source: Heywood et al.

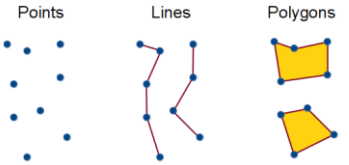
The feature model, revisited



Different feature type -> different options

You can do different things to different data types:

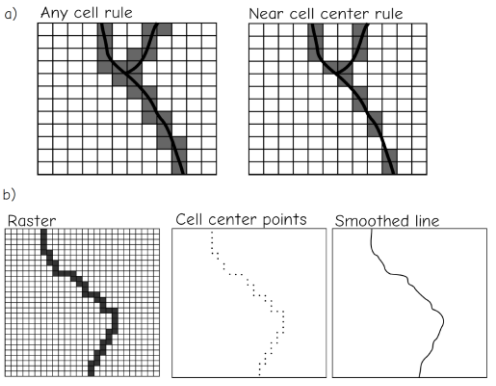
- Areas (and peripheries) from polygons
- Inside buffers to polys
- Length from lines
- Network analysis from lines (with network topology)
- Crossings of line
- Distances between points
- … and even lines and areas



You can transform from complex to simpler forms:

- Polygons to lines and points
- Lines to point

The opposite is more difficult



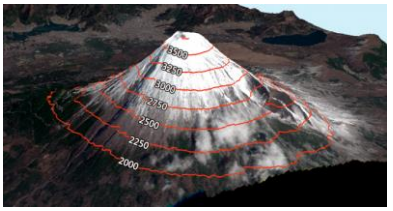
Raster to vector conversion

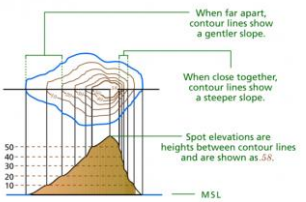
Conversion between feature types and raster/vector is indeed possible

But… every time you do so you degrade the information

Rules of thumb:

- Keep data in its original form as long as possible
- Consider wisely the scale (magnitude/resolution) your present application requires
- Think of what your 'end user' might require





Source: https://gisgeography.com/contour-lines-topographic-map/

Assignment 3

Spend 3 minutes discussing examples of what on this picture that could be represented as:

- Points (attributes?)
- Lines (attributes?)
- Polygons (attributes?)
- Raster's

Almost there… but please remember

It is not all about pressing buttons on the computer keyboard… an understanding of the principles 'behind' the scene is a fundamental necessity.

We will teach you how to *'drive the car'*

…. but hopefully also how to *'cope with and behave in traffic'*

…. and may be even *be able to find your way* ☺

That's it...

Thank you for now