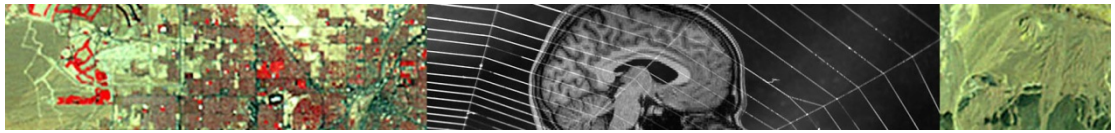
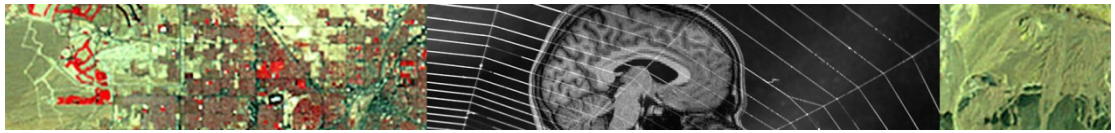
spatial@ucsb
perspectives for teaching and research



The Changing Face of GIS

Michael F. Goodchild
University of California
Santa Barbara

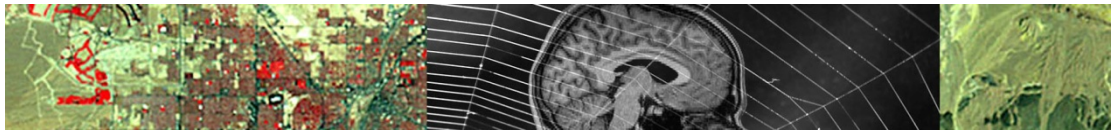
spatial@ucsb
perspectives for teaching and research



Two topics

- New data sources
- Critical spatial thinking

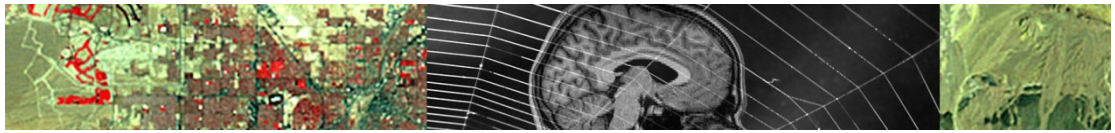
spatial@ucsb
perspectives for teaching and research



How is geographic information created?

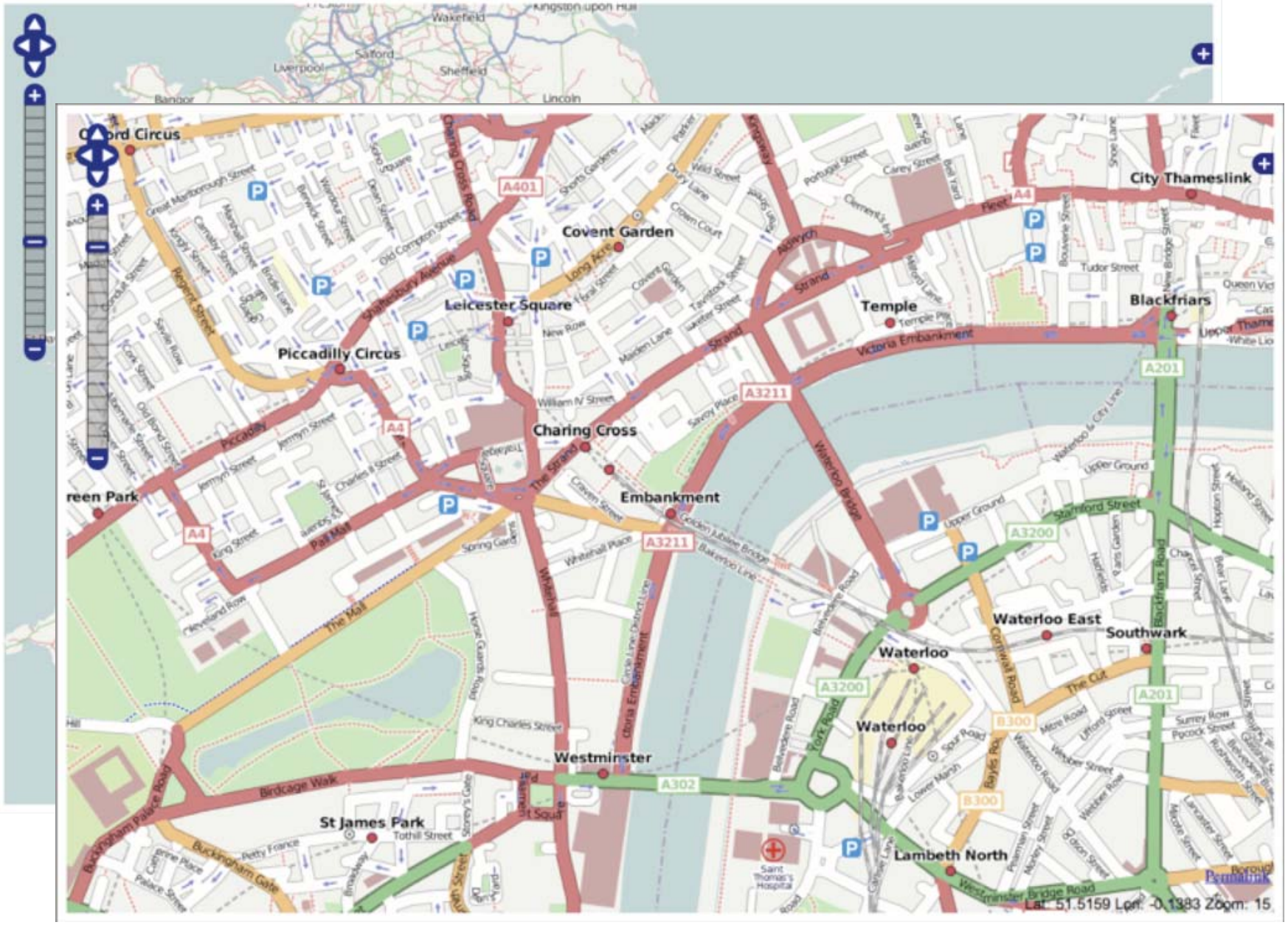
- By authorities and their experts
  - USGS
  - NGA
  - Ordnance Survey
  - military in many countries
  - state and local governments
- Disseminated to non-expert users
  - with restrictions
  - at cost of production or reproduction?
  - restrictions since 9/11

spatial@ucsb
perspectives for teaching and research

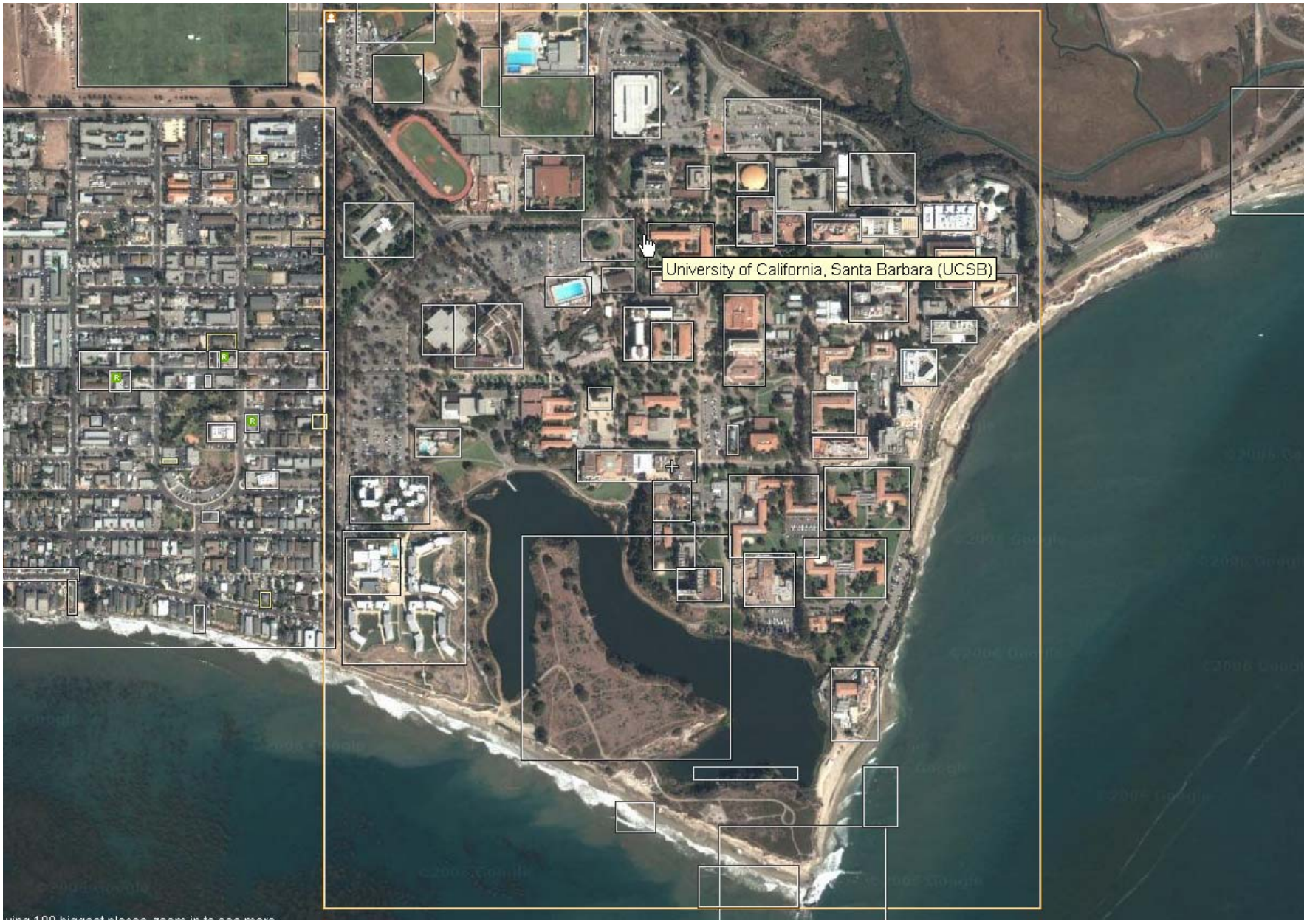


Volunteered geographic information (VGI)

- A phenomenon of the 21st Century
  - recent months
- *User-generated content*
- *Collective intelligence*
- *Crowdsourcing*
- *Asserted information*
- The empowerment of millions of private citizens
  - largely untrained
  - no obvious reward
  - no guarantee of truth
  - no authority



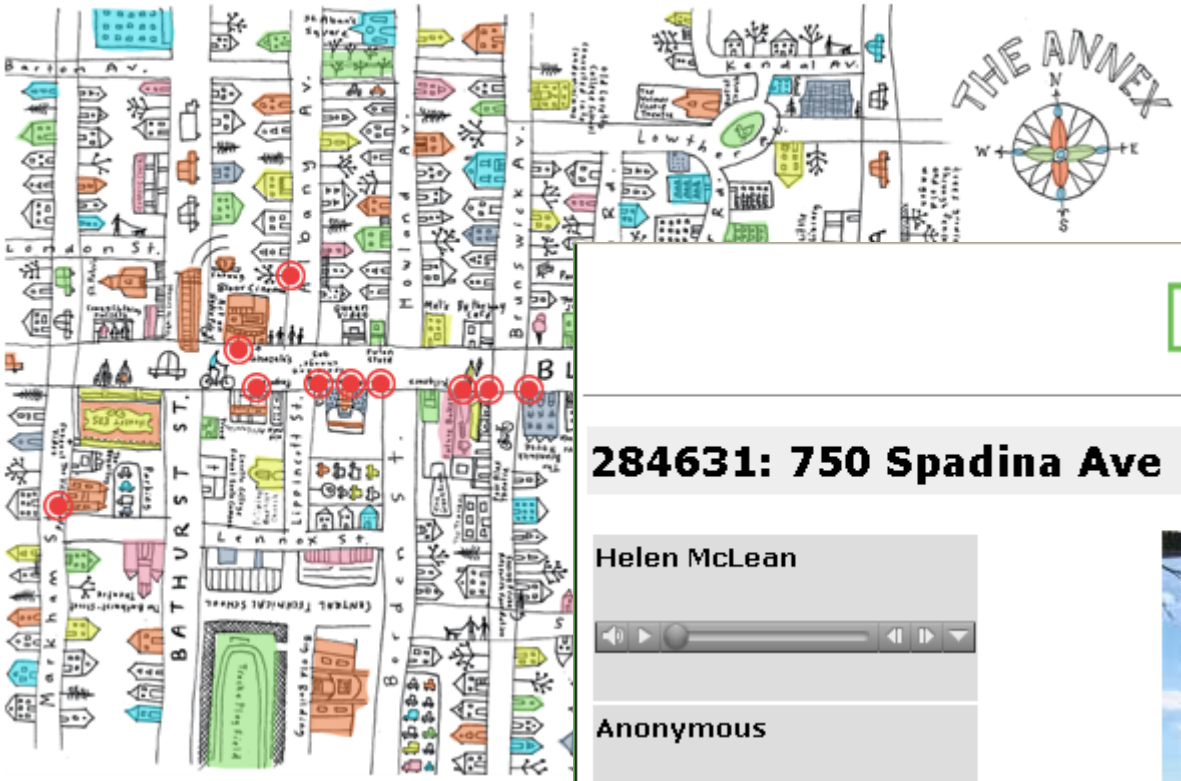
www.openstreetmap.org



www.wikimapia.org

www.flickr.com

murmur



murmur

284631: 750 Spadina Ave

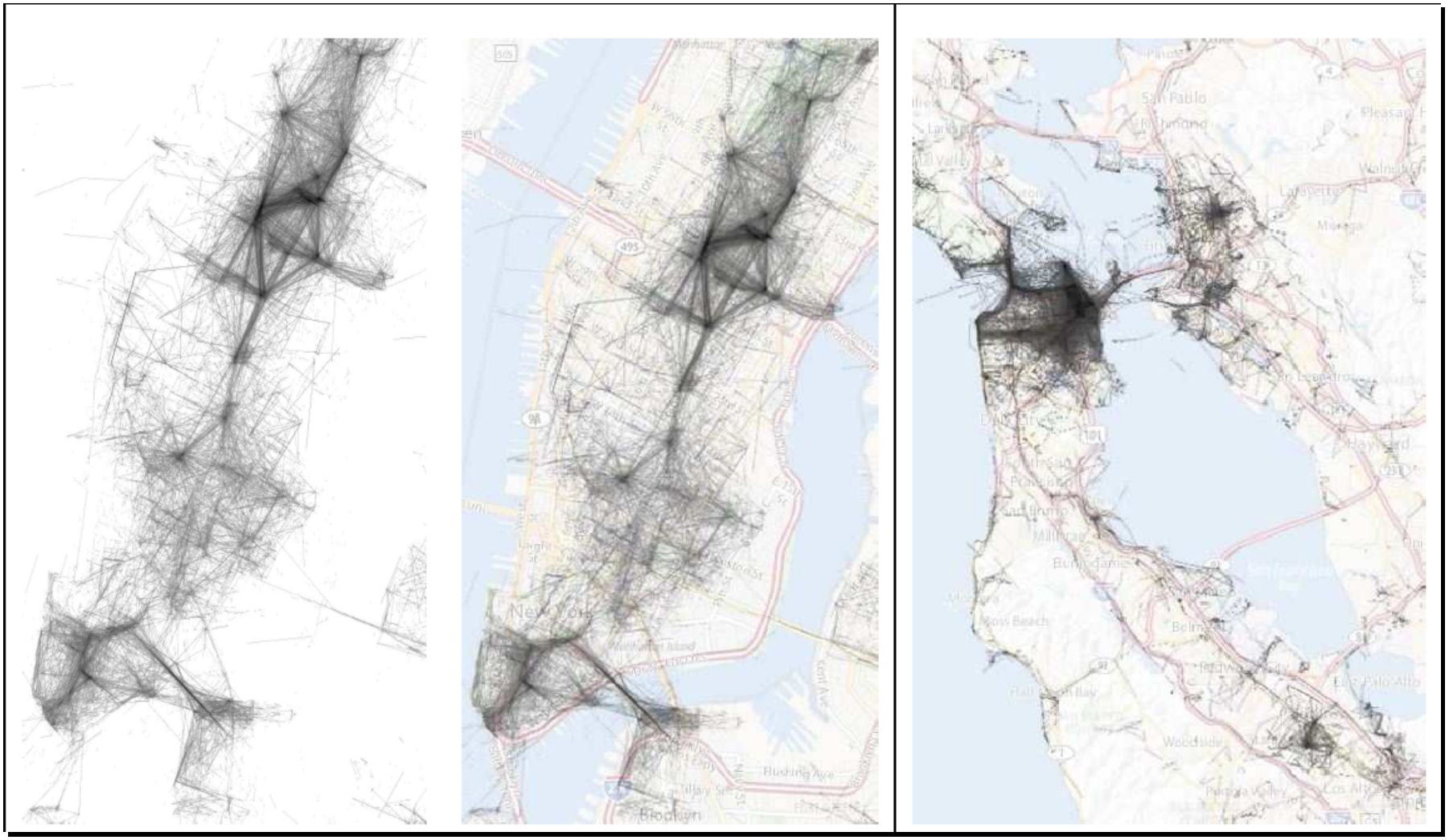
Helen McLean

Anonymous

Eva MacDonald

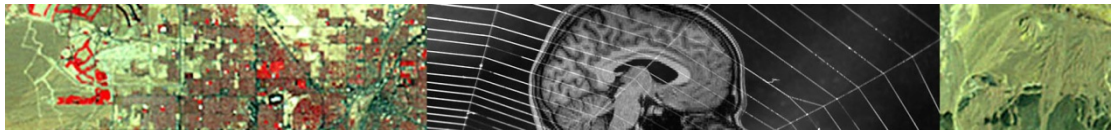
- info@murmurtoronto.ca -

CASA UCL, http://www.casa.ucl.ac.uk/capableproject/maps/home.asp



Tracks inferred from Flickr postings
(http://www.cs.cornell.edu/~crandall/papers/mapping09www.pdf)

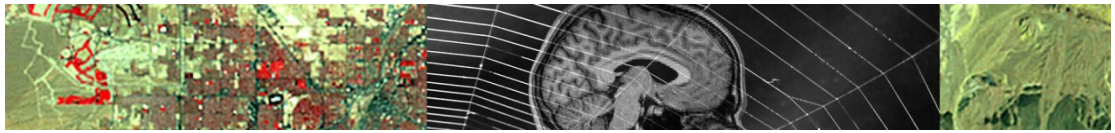
spatial@ucsb
perspectives for teaching and research



Giving attributes to tracks

- Socioeconomic characteristics
- Inferred speed, activity
- Environmental sensors
  - atmospheric quality
- User-supplied information
  - 3G Smartphone apps
  - *participatory sensing*
- Attributes (field-like) from GIS
  - LifeLines
  - André Skupin, socioeconomic data

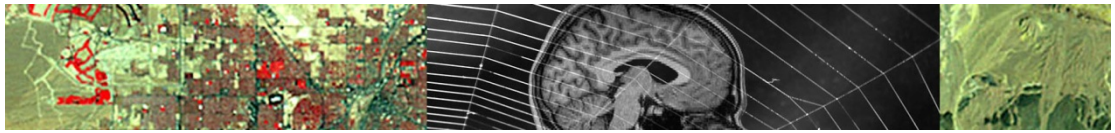
spatial@ucsb
perspectives for teaching and research



Future prospects

- Knowing where everything is (at all times)
  - every mobile phone
  - every vehicle
  - every farm animal
  - every item in a store
  - every construction beam
  - every asset for emergency response
  - every victim of a disaster

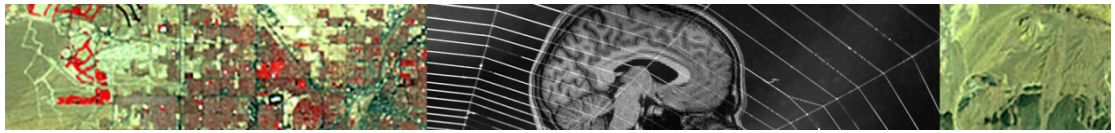
spatial@ucsb
perspectives for teaching and research



"A spate of burglaries in a Buckinghamshire village had already put residents on the alert for any suspicious vehicles. So when the Google Street View car trundled towards Broughton with a 360-degree camera on its roof, villagers sprang into action. Forming a human chain to stop it, they harangued the driver about the "invasion of privacy", adding that the images that Google planned to put online could be used by burglars."

http://technology.timesonline.co.uk/tol/news/tech_and_web/article6022902.ece

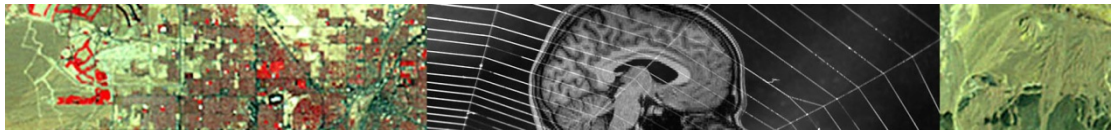
spatial@ucsb
perspectives for teaching and research



Securing access

- All of these technologies raise issues of privacy
- The danger of over-reaction
  - by IRBs
  - by communities
- Traditional responses:
  - limit access to a select few
  - aggregate or blur to remove identity
    - migration and commuting flows
    - cultural assets
  - the Census Data Center approach

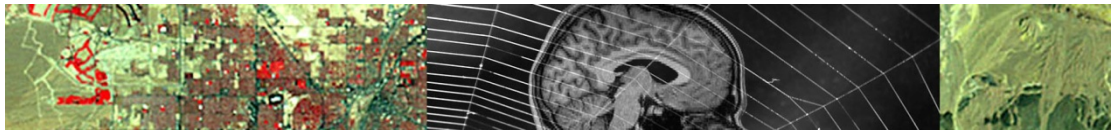
spatial@ucsb
perspectives for teaching and research



Types of VGI

- Asserted or authoritative
  - hybrids
    - Tomtom
- Egocentric or allocentric
  - whose location?
    - location-based social networking
    - http://vgi.spatial.ucsb.edu/inventory
- Structured or unstructured
  - accuracy

spatial@ucsb
perspectives for teaching and research



Emergency management

- Recent fires in Santa Barbara
  - Zaca Fire (July 07)
    - burned for 2 months
    - no houses lost
  - Gap Fire (July 08)
    - burned for 7 days
    - no houses lost
  - Tea Fire (November 08)
    - burned for 2 days
    - 230 houses lost
  - Jesusita Fire (May 09)
    - burned for 2 days
    - 75 houses lost

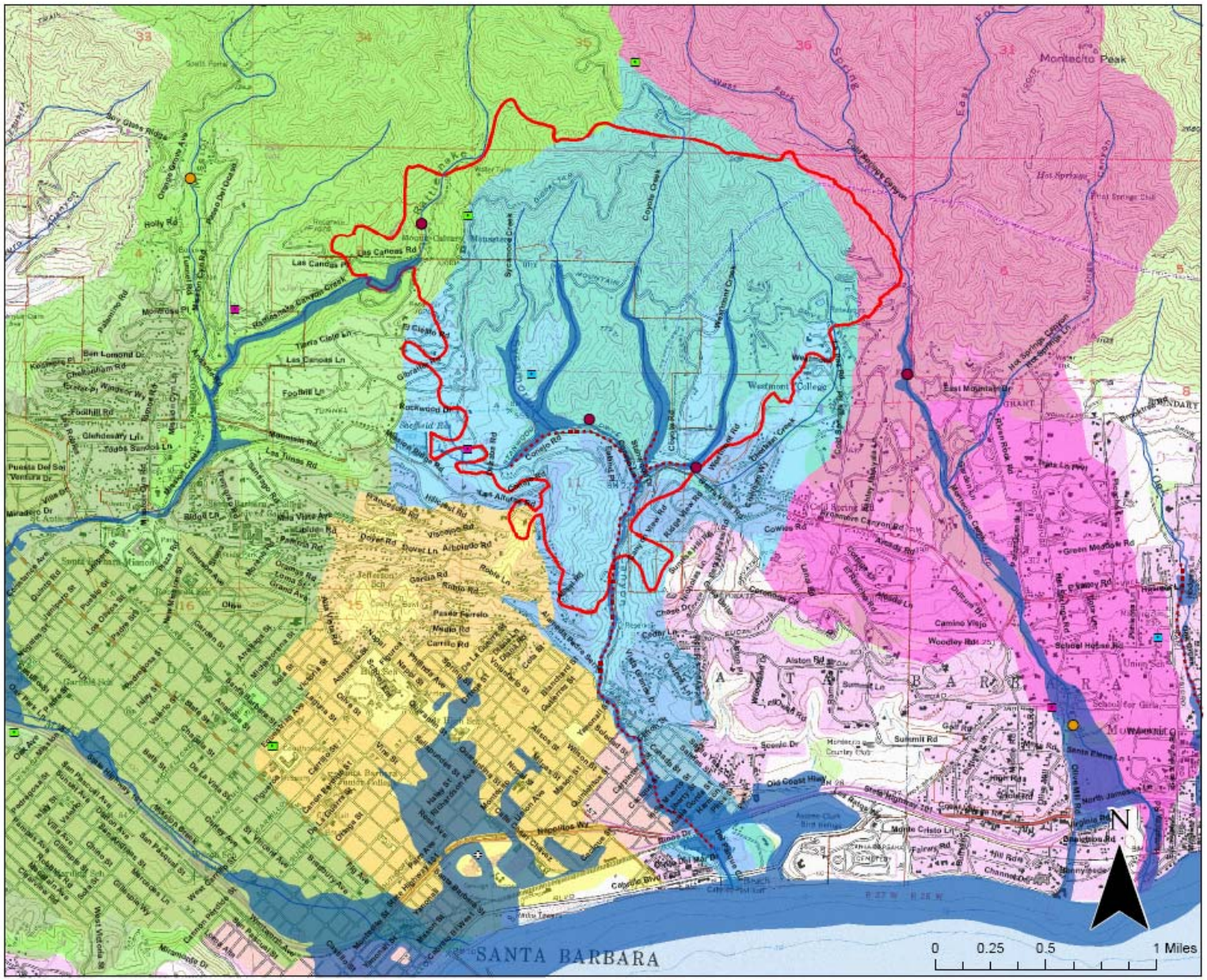
Tea Fire

Legend

- Debris Basin
- Debris Basin to be Cleaned
- Self-Recording Station
- Alert Station
- Observer Station
- Channel Clearing
- Sand Bags - 401 E. Yanonali St.
- Tea Fire Perimeter

Watersheds	Acres Burned	% of Watershed
Mission Canyon	183	2%
Laguna	8	1%
Sycamore Canyon	1,686	67%
Montecito Creek	64	1%

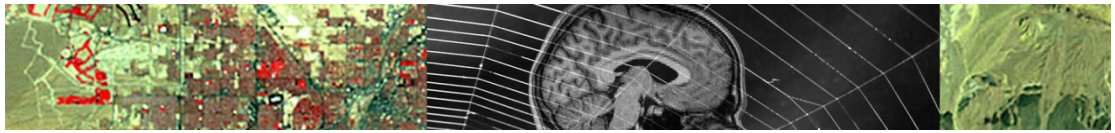
- City Boundary
- 100 year flood plain




Timeline
Flipbook
List
Map
Full Screen
Embed Widget
Share:
Follow
FEMA: California Tea Fire
Nov 13, 2008
tea fire santa barbara | VPNewsLog
Nov 13, 2008 7:48 PM
The Tea Fire
Nov 13, 2008 11:24 PM
Fire destroys 80+ houses in Montecito, Santa ...
Nov 13, 2008
Santa Barbara "Tea" Fire
Nov 13, 2008 9:44 PM
Canned Spam in high demand - Crime Scene
Nov 13, 2008
Las Alturas Fire Montecito 2008 Tea Fire
Nov 13, 2008 8:42 PM
Wildfire Today: Update on Tea fire near Monte...
Nov 13, 2008
Lal Masjid of Bradistan « Pak Tea House
Nov 13, 2008 9:50 PM
BREAKING NEWS
MONTECITO
Tea Fire Westmont College
Nov 14, 2008 3:11 AM
Tea Fire (Santa Barbara & Mon...
Nov 14, 2008 7:39 AM
Tea Fire SB fr
Nov 14, 2008
Oprah's house Montecito: Oprah's house fire '...
Nov 13, 2008
Tea Fire Montecito/Santa Barbara pt. 1
Nov 14, 2008 12:00 AM
Santa Barbara Tea Fire Time Lapse
Nov 14, 2008 5:46 AM
Water Fill Up Helicopter Tea Fire Santa Barb...
Nov 14, 2008 10:51 AM
Montecito Fire (See Pic and Video Footage) - ...
Nov 13, 2008
Tea Fire Santa Barbara Helicopter Water Drop
Nov 14, 2008 1:55 AM
365 days: Abwarten und Tee trinken
Nov 13, 2008
Santa Barbara "Tea Fire" Helicopter
Nov 14, 2008 2:00 AM
3 pm
4 pm
5 pm
6 pm
7 pm
8 pm
9 pm
10 pm
11 pm
Nov 14, 2008
2 am
3 am
4 am
5 am
6 am
7 am
8 am
9 am
10 am
11 am
12 pm
1 pm
2 pm
SHOW SOURCES

Hits	Source
595673	Jesusita Fire (Ethan)
188308	SBC Jesusita Fire Santa Barbara, CA (Robert O'Connor - fire news blog)
89214	Jesusita Fire Map (Randy - Independent.com)
67525	Jesusita Fire in Santa Barbara - LA Times map (Los Angeles Times)
27777	Map of burned homes in Santa Barbara (Los Angeles Times)
26330	Jesusita Fire Evacuation Areas: Approximation (COSB)
25454	Santa Barbara 'Jesusita Fire' (ABC7 Eyewitness News)
19592	Jesusita Fire - Santa Barbara (lanewspace)
2446	Santa Barbara Damaged Homes 2008 (Los Angeles Times, note: mapped for comparison with Jesusita)
2048	Jesusita Fire (longhairedhippy)
1314	Santa Barbara Fire Evacuation (Gary);
962	Jesusita Fire in Santa Barbara (ABC30 Action News)
788	Wildfire ~ Santa Barbara (Buffalo)
505	Closure map - Jesusita Fire in Santa Barbara (Los Angeles Times)
461	Untitled (Matthew, note: discovered via google.com.mx);
396	Jesusita Fire Structure Damage (Paul Bartsch);

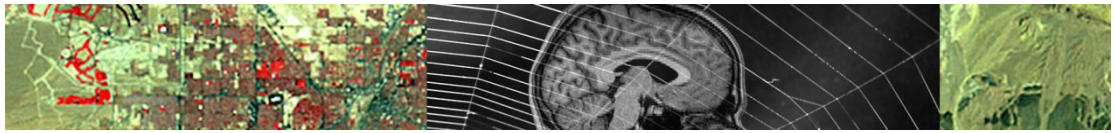
spatial@ucsb
perspectives for teaching and research



VGI

- Important in all four cases
  - first photographs of Tea Fire appeared on Flickr in minutes
  - first Twitters about Jesusita Fire in minutes
  - maps, text accounts
- Search engines (Google) take a finite time to catalog
  - too long for Tea and Jesusita Fires
- Flickr and other site-specific catalogs work much faster
  - after Zaca Fire people knew where to look for rapidly available information

spatial@ucsb
perspectives for teaching and research



Lessons learned

- Authoritative information
  - must be verified by officials
  - too slow for the Tea and Jesusita Fires
- Asserted information
  - carries risk of false positives
    - false rumor of Tea Fire in Mission Canyon
    - some unnecessary evacuations
  - people are willing to accept false positives
  - lack of authoritative information amounts to false negatives
  - false negatives are far less acceptable than false positives
    - there were some posted false negatives

Luck, readiness pay off in Santa Barbara's Mission Canyon

Spencer Weiner / Los Angeles Times

Smoke from the Jesusita fire darkens the sky along Holly Road above Mission Canyon near Santa Barbara today.

Hundreds of homes are set in a narrow canyon downwind from brush-covered wildlands, but evacuation drills, brush clearance and reverse 911 calls all help avert a major disaster.

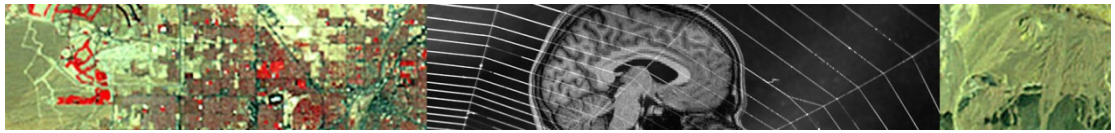
By Bettina Boxall and Catherine Saillant
May 8, 2009

Reporting from Santa Barbara -- Everyone in Mission Canyon knew these days of flame and smoke would come. It was just a matter of when and how bad it would get.

They had staged evacuation drills, set up phone trees and put herds of brush-munching goats to work. They had cut down clusters of eucalyptus and bought metal shutters to protect against flying embers.

LA Times May 8 2009

spatial@ucsb
perspectives for teaching and research



Critical spatial thinking

- Larger than GIS
  - now that the technology is easier to use
- What every Google Earth user needs to know
- Focus on fundamental spatial concepts
  - from simple, acquired in early childhood
  - to advanced, acquired in college
- One of Gardner's seven types of intelligence
  - almost entirely neglected in education

“**1. Linguistic**

Children with this kind of intelligence enjoy writing, reading, telling stories or doing crossword puzzles.

2. Logical-Mathematical

Children with lots of logical intelligence are interested in patterns, categories and relationships. They are drawn to arithmetic problems, strategy games and experiments.

3. Bodily-Kinesthetic

These kids process knowledge through bodily sensations. They are often athletic, dancers or good at crafts such as sewing or woodworking.

4. Spatial

These children think in images and pictures. They may be fascinated with mazes or jigsaw puzzles, or spend free time drawing, building with Lego or **daydreaming**.

5. Musical

Musical children are always singing or drumming to themselves. They are usually quite aware of sounds others may miss. These kids are often discriminating listeners.

6. Interpersonal

Children who are leaders among their peers, who are good at communicating and who seem to understand others' feelings and motives possess interpersonal intelligence.

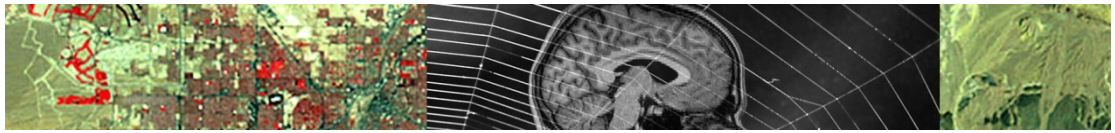
7. Intrapersonal

These children may be shy. They are very aware of their own feelings and are self-motivated.”

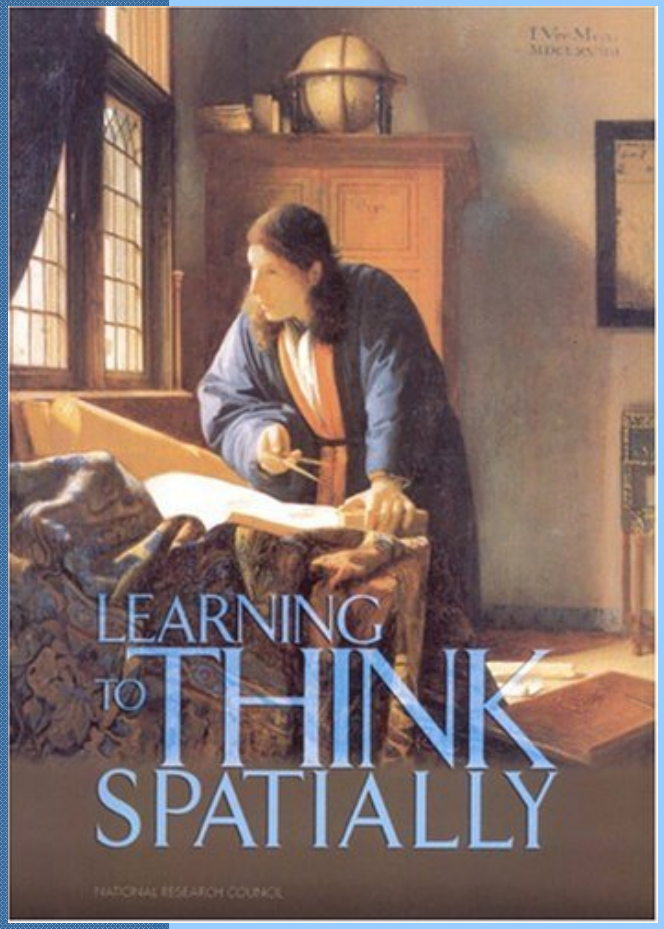
Howard Gardner

http://www.professorlamp.com/ed/TAG/7_Intelligences.html

spatial@ucsb
perspectives for teaching and research



What is spatial thinking?

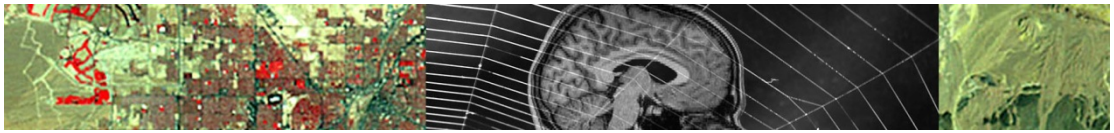


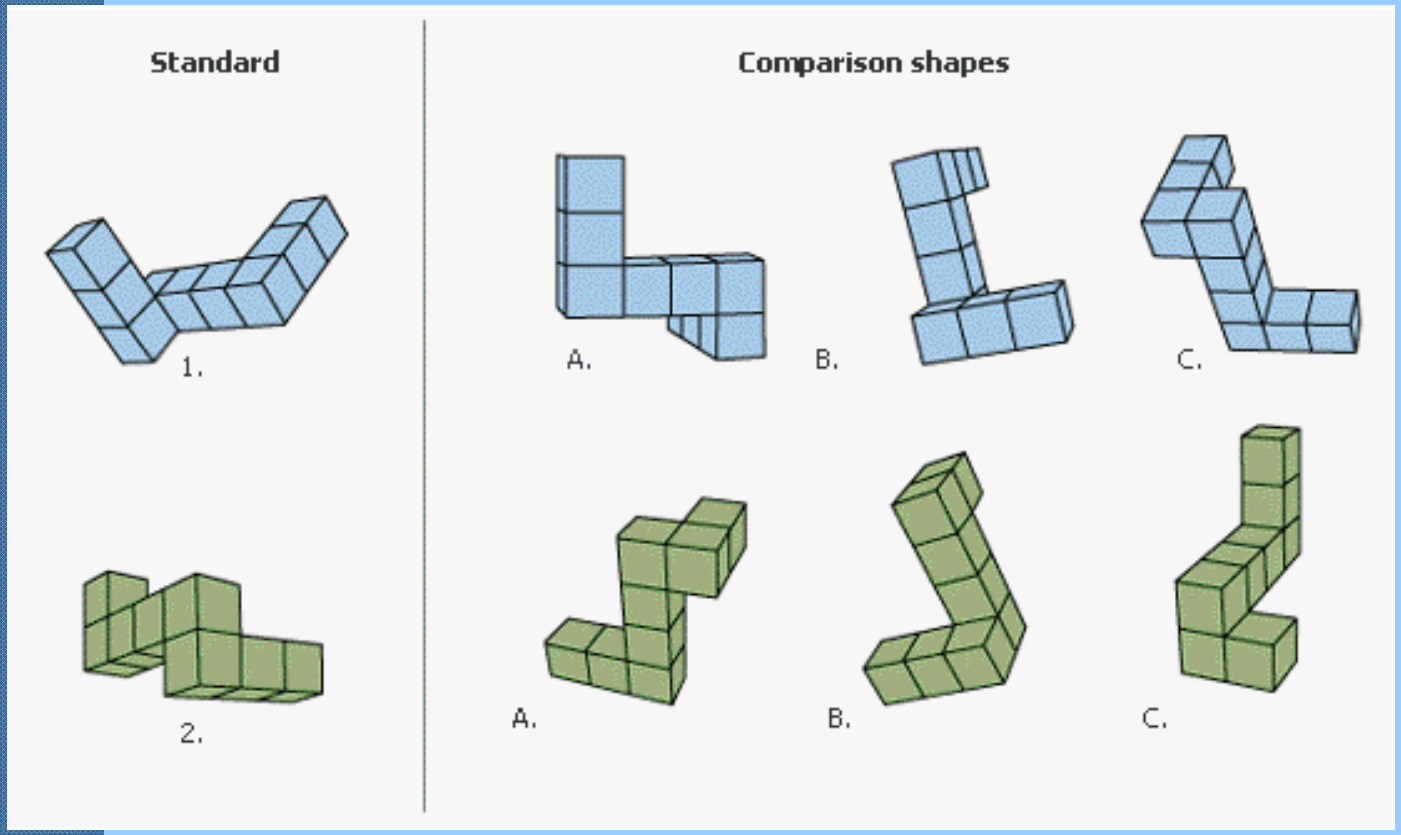
"Three aspects of spatial ability:

- Spatial knowledge
  - symmetry, orientation, scale, distance decay, etc.
- Spatial ways of thinking and acting
  - using diagramming or graphing, recognizing patterns in data, change over space from change over time, etc.
- Spatial capabilities
  - ability to use tools and technologies such as spreadsheet, graphical, statistical, and GIS software to analyze spatial data"

http://www.nap.edu/catalog/11019.html

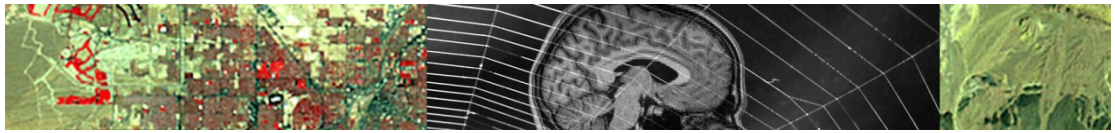
spatial@ucsb
perspectives for teaching and research





Which is further west, San Diego or Reno?

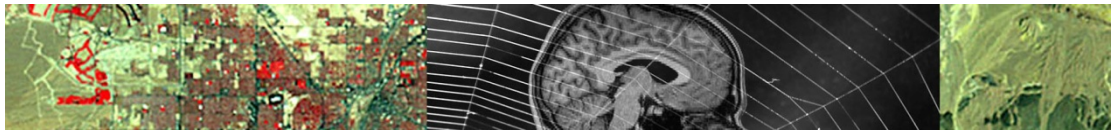
spatial@ucsb
perspectives for teaching and research



What fundamental concepts exist in spatial intelligence?

- Are they sophisticated and abstract enough to warrant a place in the curriculum?
  - like mathematics, statistics, language, music
  - can spatial intelligence gain more respect?
  - where in the curriculum?
- Are they an appropriate basis for improved GIS user interface design?
  - does the interface need improvement?

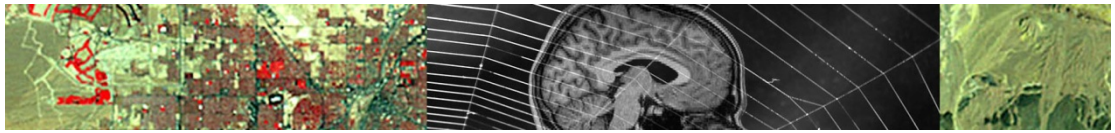
spatial@ucsb
perspectives for teaching and research



A complex set of tools

- A GIS is capable of virtually any conceivable operation on spatial data
  - how many conceivable operations are there?
- ArcGIS 9.2 toolkit
  - 510 operations
  - 10 headings, up to 4 levels of hierarchical organization
  - headings include:
    - Analysis, Spatial Analyst, 3D Analyst, Geostatistical Analyst, Spatial Statistics
    - Data Management, Conversion

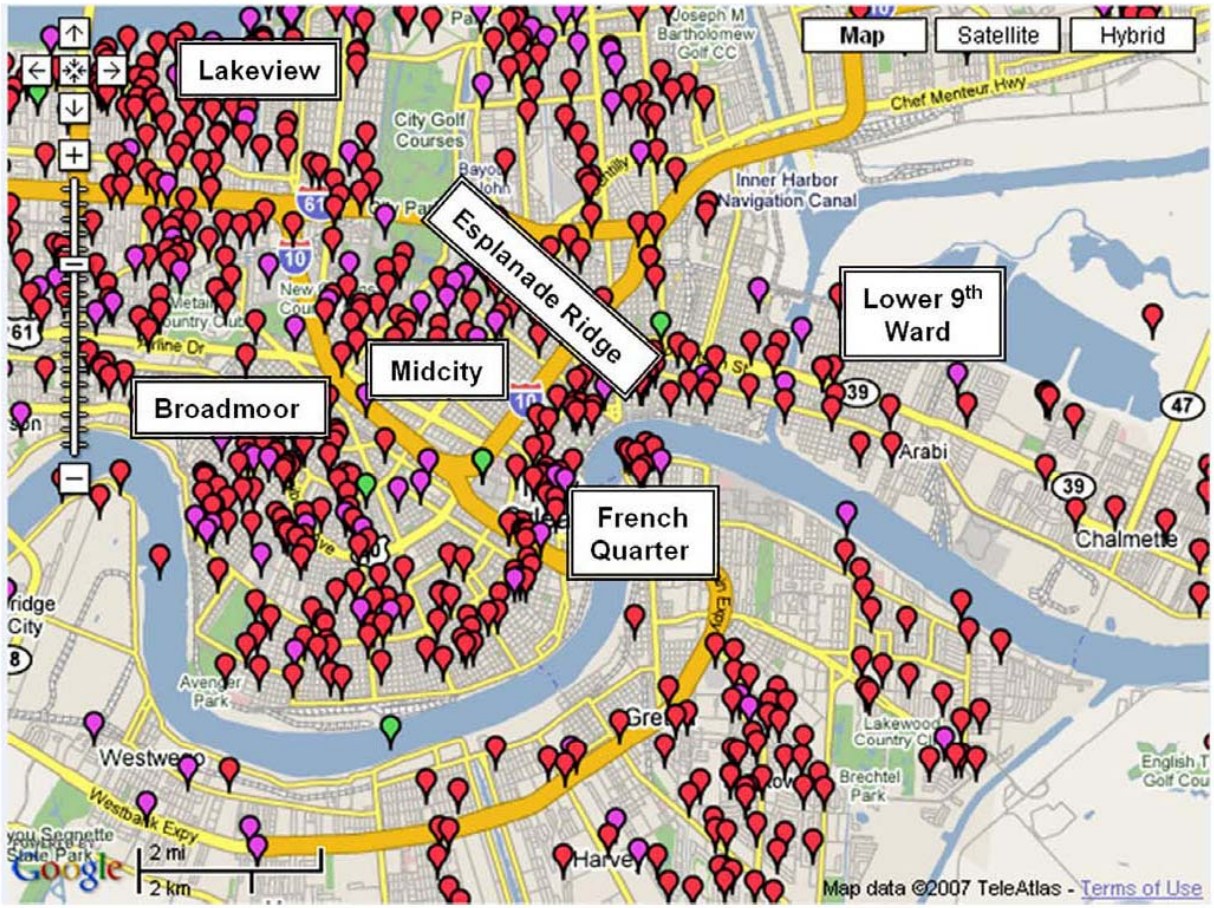
spatial@ucsb
perspectives for teaching and research



1. Location

- Defining and measuring location
  - the impossibility of exact measurement
- From infinitesimal point to extended area
- Place
  - how many places are there in the U.S.?
- Location as context
- Location as common key
- It is important to know *where* events occur

Cyberscape: Placemarks in post-Katrina New Orleans

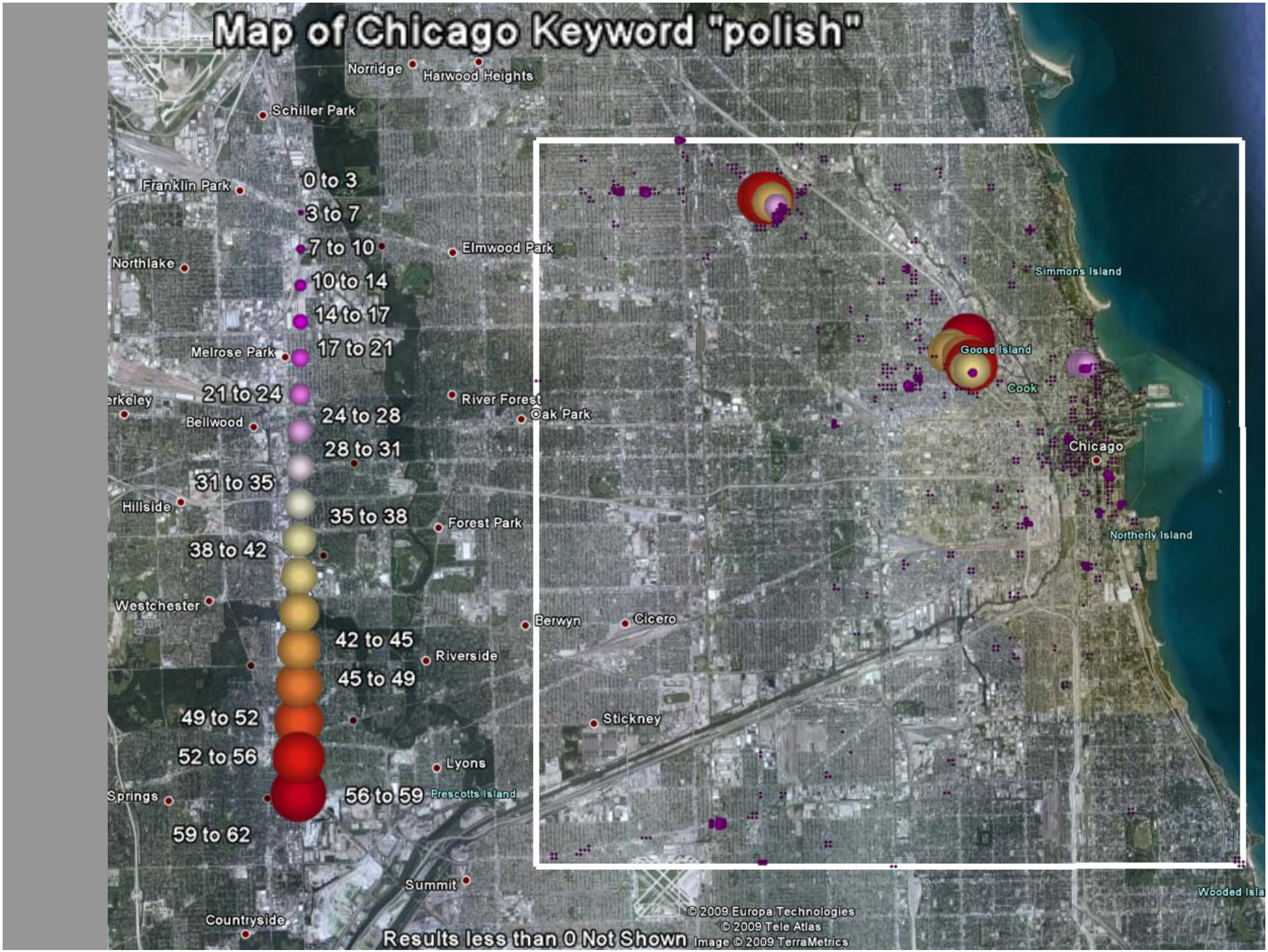


Flooding Reports (via Scipionus) in New Orleans, Sept. 2005

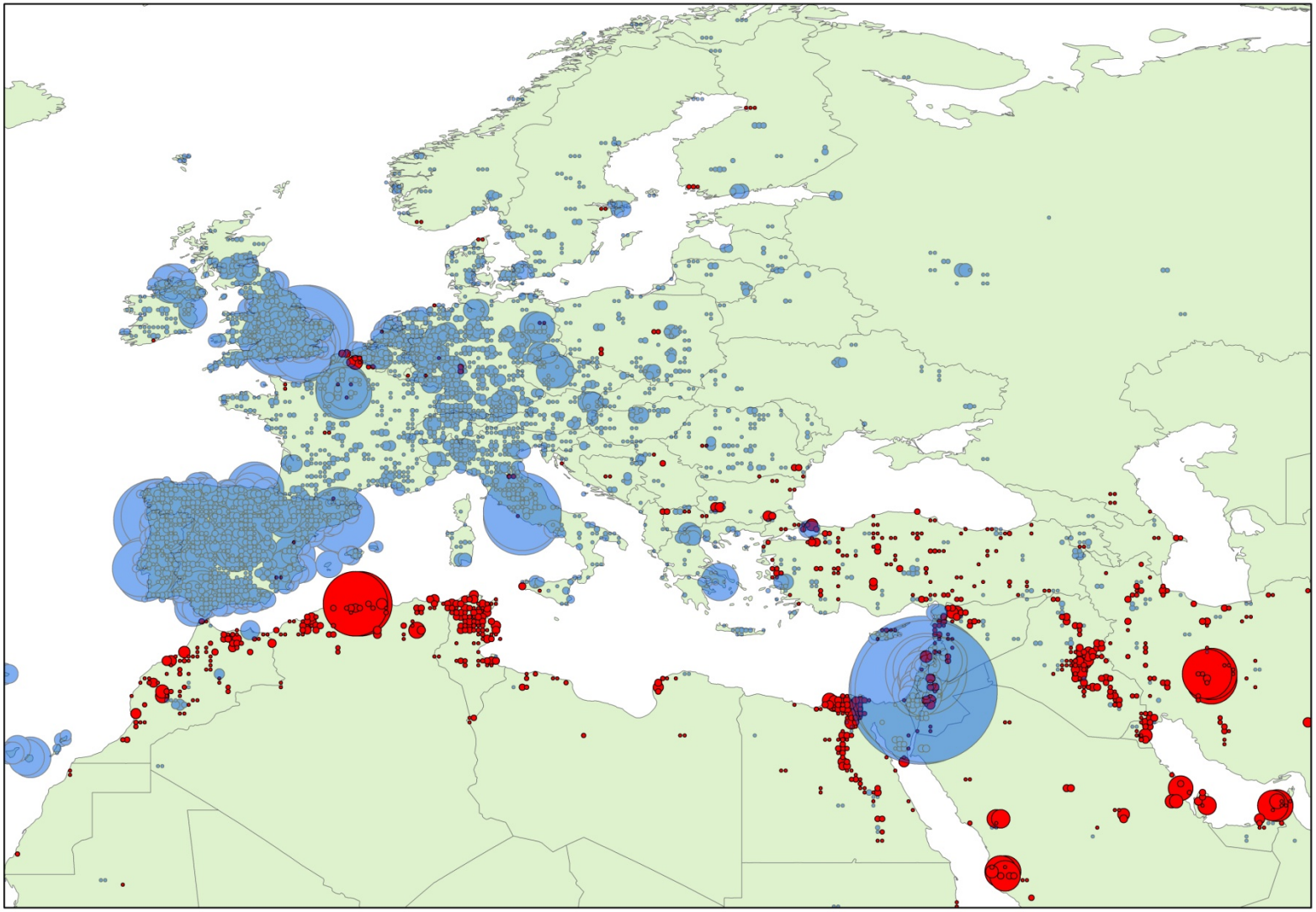
Who was able to or interested in using this new technology?

Which places were they interested in?

Crutcher and Zook. 2009. *GeoForum*

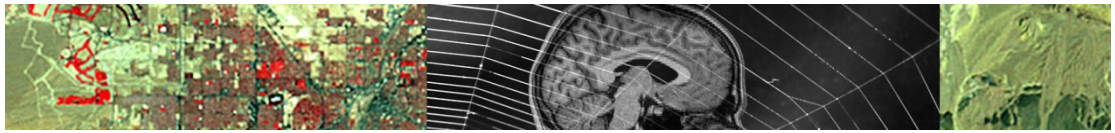

Map of Chicago Keyword "polish"
Norridge
Harwood Heights
Schiller Park
Franklin Park
0 to 3
3 to 7
7 to 10
10 to 14
14 to 17
17 to 21
21 to 24
24 to 28
28 to 31
31 to 35
35 to 38
38 to 42
42 to 45
45 to 49
49 to 52
52 to 56
56 to 59
59 to 62
Elmwood Park
Northlake
Melrose Park
River Forest
Oak Park
Bellwood
Hillside
Forest Park
Westchester
Berwyn
Cicero
Riverside
Stickney
Lyons
Prescotts Island
Springs
Summit
Countryside
Simmons Island
Goose Island
Cook
Chicago
Northerly Island
Wooded Isla
© 2009 Europa Technologies
© 2009 Tele Atlas
Image © 2009 TerraMetrics
Results less than 0 Not Shown

Jesus and Allah



BLUE = (more Jesus than Allah); RED = (more Allah than Jesus).
Size of the bubble show the magnitude of the difference

spatial@ucsb
perspectives for teaching and research



2. Distance, direction

- Measurement
  - plane, globe
  - buffers
- Distance decay
  - decline of interaction with distance
  - cost, time impediments
  - footprints of human behavior

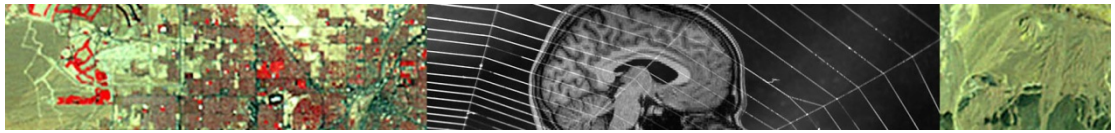
North Korea's missile threat

Type	Maximum range	Payload	Status
Nodong	1,300 km (810 miles)	700 kg (1,550 pounds)	Currently deployed
Taepodong-1	Up to 10,000 km	Several hundred kg	Test failed 1998, not yet operational
Taepodong-2	10,000–15,000 km	Several hundred kg	Not yet tested

Source: Task Force for US Korea Policy, Centre for International Policy

The Economist, May 17th 2003

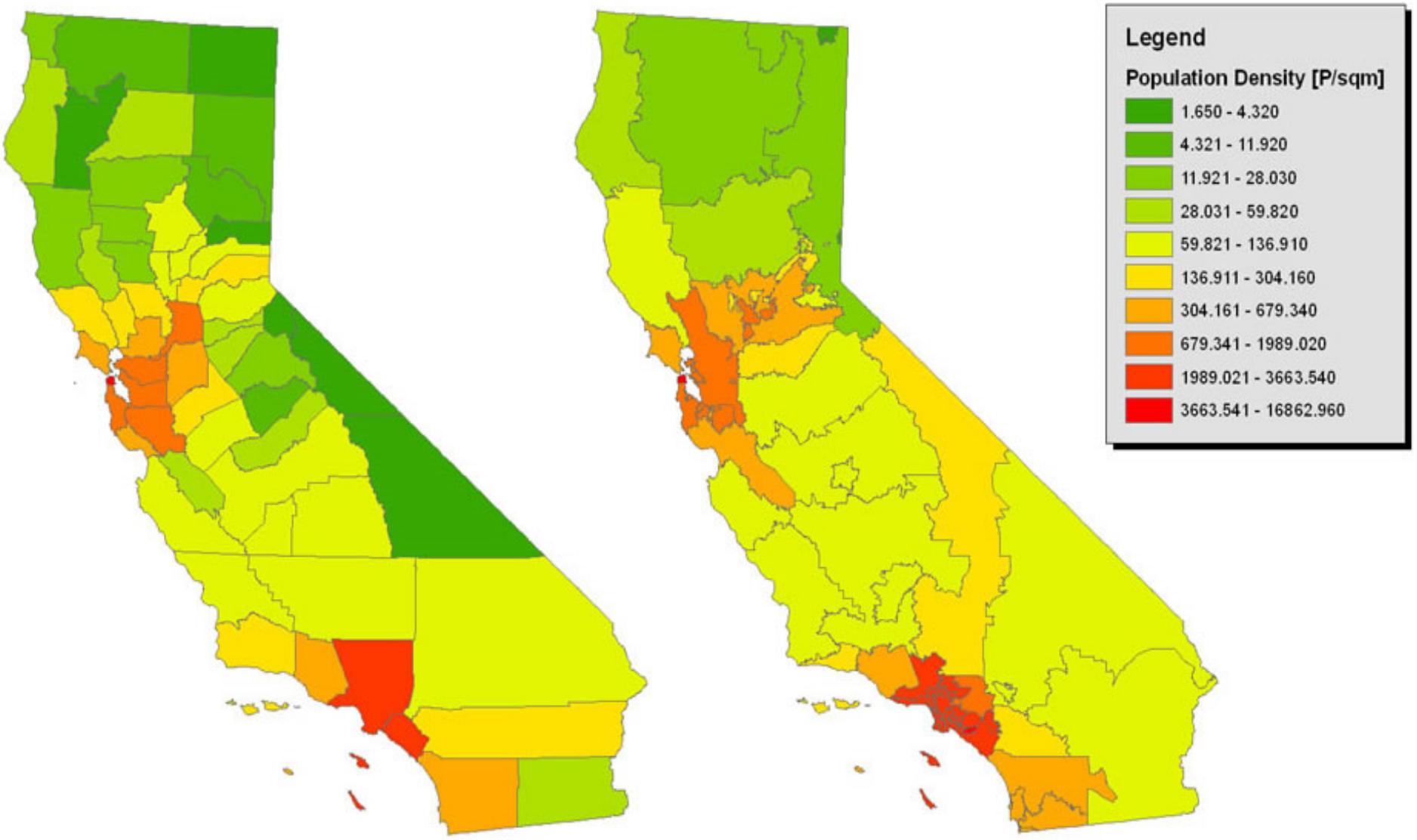
spatial@ucsb
perspectives for teaching and research



3. Neighborhood/region/territory

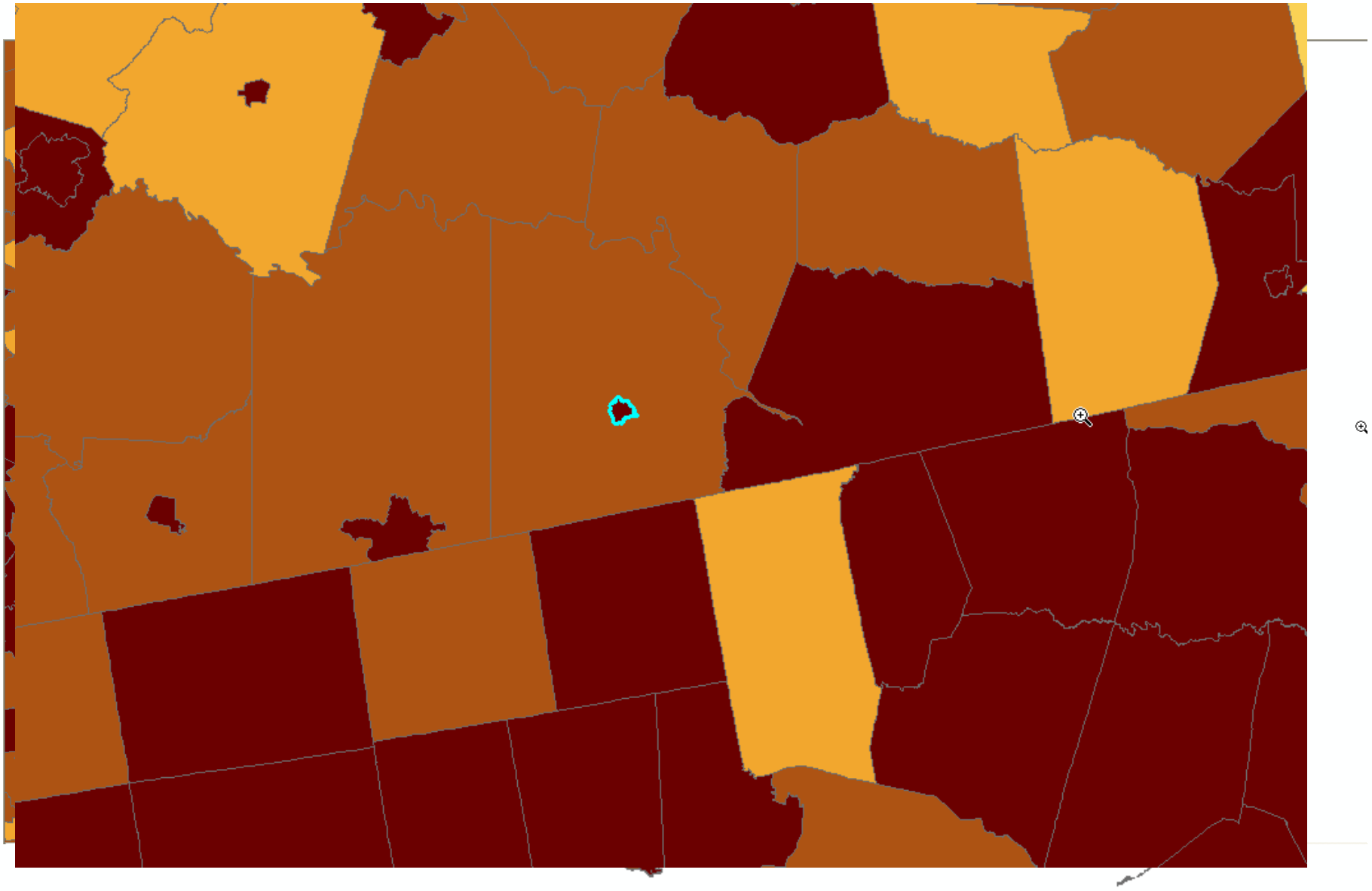
- The context of individuals
  - action space
- Homogeneous areas
- The reporting zone containing the individual
  - arbitrarily imposed on a continuous Earth
- The ecological fallacy
  - the modifiable areal unit problem
- Competition for space
  - trade areas, bird territories
  - functional regions

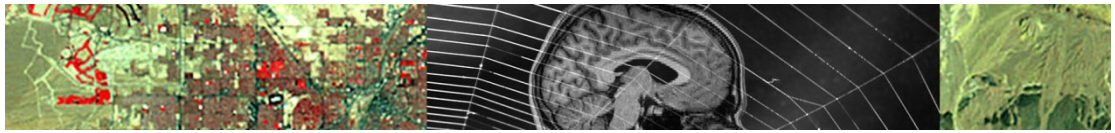
Areal Interpolation Example: Population Density in California



Original dataset
Population density by county

After areal interpolation
Population density 3-digit zip code regions





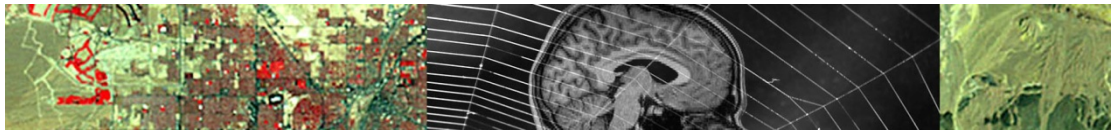
4. Scale

- Level of detail
  - the inevitability of generalization
- Extent

2700	http://www.asprs.org/resources/grids/08-2005-italy.pdf
7600	http://en.wikipedia.org/wiki/List_of_countries_by_length_of_coastline
9225.8	http://earthtrends.wri.org/text/coastal-marine/variable-61.html

- Scale is always important
  - many properties cannot be defined independently of scale
    - length of a coastline
    - slope of a topographic surface
    - land use class
    - “the flattest spot in the US”

spatial@ucsb
perspectives for teaching and research



Conclusions

- Web 2.0 is creating novel sources of geospatial information
  - that can complement traditional sources
  - that can play a key role in time-critical situations
- It is possible to enumerate the fundamental concepts of a spatial approach
  - four broadly defined concepts
  - 27 in De Smith, Goodchild, and Longley (2006) *Geospatial Analysis*
    - www.spatialanalysisonline.com
  - 177 in www.teachspatia.org ontology

teachspatial.org

Concepts | Schemas | Resources | Discussions | Events | About

Navigation

- TeachSpatial Blog

User login

Username: *

Password: *

Log in

- Create new account
- Request new password

recent blog posts

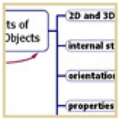
- Analyzing the Spatial Distribution of Class Participants
- Teaching spatial concepts about current weather using desktop GIS and current imagery
- Teaching Spatial Concepts using Ski Areas and GIS
- Executive Summary: Symposium on a Curriculum for Spatial Thinking
- a 'spatial concept' concept space
- "spatial _____": collocated words by discipline

> "...**spatial thinking** is pervasive: it is vital across a wide range of domains of practical and scientific knowledge; yet it is underrecognized, undervalued, underappreciated, and therefore underinstructed."

National Research Council 2006 report: *Learning to Think Spatially* [Read Excerpts]

teachspatial.org is a collaborative, interactive web site devoted to improving our understanding of how spatial thinking contributes to science and society, and to providing resources that promote applications of spatial concepts and spatial tools in teaching and learning. The site features three parts:

Part 1 enumerates and defines **core concepts** of spatial thinking, presented in the original words of authors from 18 source documents. Users of the site are invited to read the original publications to appreciate the contextual frameworks used by these authors. Please contribute to expanding the range of disciplines and specializations represented by suggesting additional source documents for inclusion.



Part 2 presents **schemas** that interpret, synthesize, and model aspects of spatial thinking that draw on and interact with selected concepts from part 1. Please submit your own schema and explanatory text; and please join others with commentary and questions for online discussion.

Part 3 will provide an archive of **user-contributed resources** for teaching and learning. Please share your pedagogic strategies, exercises, demonstrations, and course syllabi for use and consideration by others in their efforts to enhance spatial literacy.

Karl Grossner

www.teachspatial.org

place

[OED]: 3. a. A space that can be occupied; 5. a. A particular part or region of space; a physical locality, a locale; a spot, a location. Also: a region or part of the earth's surface; 12. a. A proper, appropriate, or natural position or spot (for a person or thing); 13. b. The space or position previously or customarily occupied by another person or thing

place

in place

Source: Tversky (2005)
Constituents of the space of navigation include places, which may be buildings or parks or piazzas or rivers or mountains, as well as countries, planets or stars, on yet larger scales. Places are interrelated in terms of paths or directions in a reference frame (p 9). Places [are] configurations of objects such as walls and furniture, buildings, streets and trees...(p 10).

Read more

place

in place

Source: de Smith, et al. (2008)
The divisions of the world, recognized. e.g., as place names, landmarks, rasters, polygons, reporting zones, tessellations, etc. 'At the centre of all spatial analysis is the concept of place. The Earth's surface comprises some 500,000,000 sq km, so there would be room to pack half a billion industrial sites of 1 sq km each (assuming that nothing else required space, and that the two-thirds of the Earth's surface that is covered by water was as acceptable as the one-third that is land); and 500 trillion sites of 1 sq m each (roughly the space

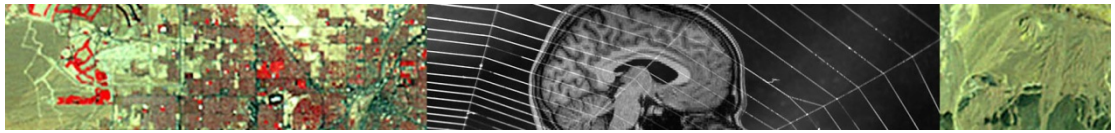
Read more

place

in place

Source: Kaufman (2004)
(an object) exists at some absolute place or position within the latitude and longitude coordinates shown, and at a place relative to other objects or areas (p 174)

spatial@ucsb
perspectives for teaching and research



Conclusions (2)

- Critical spatial thinking is more than GIS
  - an enveloping conceptual framework for many new technologies and disciplines
  - phenomena embedded in space and time
  - many drivers
- One of a minimal set of intelligences
  - part of everyone's education