The Case for an Enduring Spatial Science

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Outline
- Spatial roots
  - Geography
  - Landscape architecture
  - Computer science
- The (current) opportunity
- Guiding principles
  - Spatial as an enabling discipline
  - Core concepts & distractions
  - Role of collaboration
  - Changing character of spatial data in a fast changing world
  - Role of geodesign | actionable science
- Final Thoughts

Spatial roots | geography
- Representation
- Classification
- Analysis
- Visualization

Spatial roots | landscape architecture

Spatial roots | computer science

The opportunity
- Spatial turn
  - Rapid spread of spatial thinking & GIS throughout sciences
  - Snow's 19th century work on cholera
  - Scholten's new book
  - ACM GIS conference series
  - Swept through social sciences and humanities as well
    - All human action literally takes place somewhere
    - Spatial dimension of social interaction key for understanding all of the classic questions about the human condition
- New academic units
- New academic programs
Five guiding principles

- Spatial as an enabling discipline
- Core concepts | distractions
- Role of collaboration
- Changing character of spatial data
- Geodesign | actionable science

Spatial as an enabling discipline

- Cf. with statistics
- Need small number of fundamental spatial scientists, larger numbers of translational scientists?
- Know ourselves, our role in the knowledge discovery process
  - GIS&T Body of Knowledge projects
- Learn how to connect & collaborate with others

Core concepts | Duckham 2014

Spatial structure
Dynamism
Uncertainty
Cognition
Design
Scale

Dynamism

Catalina Island Fox, Photo: Courtesy of Tim Coonan
Mission Blue Butterfly, Photo: Courtesy of Travis Longcore

Uncertainty

Cognition
Design Maps Technology

Scale | complexity

Global
- Cloud cover and CO2 levels control primary energy inputs to climate and weather patterns

Meso
- Prevailing weather systems control long-term mean conditions; elevation-driven lapse rates control monthly climate; and geological substrate exerts control on soil chemistry

Topo
- Surface morphology controls catchment hydrology; slope, aspect, horizon, and topographic shading control surface insulation

Macro
- Vegetation canopy controls light, heat, and water for understory plants; vegetation structure and plant physiognomy controls nutrient use

Nano
- Soil microorganisms control nutrient recycling

(Slide: Courtesy of Michael Hutchinson)

Distractions

Role of collaboration

- Work with scientists in other domains
- Tackle “big” questions in new and important ways
  - Use of taxi, cell phone & social media data to explore form and function of metropolitan regions, cities, etc.
- Key criteria for success ...
  - Collaboration needs to involve more than spatial scientists
  - Sum of the parts must be greater than the parts themselves

Urban form | function

Economic organization

Placemaking, neighborhoods, active living

Industry in Motion: Using Smart Phones to Explore the Spatial Network of the Garment Industry in New York City
Sarah Williams
Elizabeth Currid-Halkett
2014
Melanoma risk ... 

- One of most rapidly increasing cancers among white population in U.S.
- Studies consistently point to UV exposure as most important risk factor
- Individual sun exposure has proved difficult to quantify
- Initial research question ...
  - How well can we model spatial variations in UV radiation given measurement network & interpolation techniques available?

Collaborative work with Myles Cockburn (USC Keck School of Medicine) & Zaria Tatalovich (National Cancer Institute)

Radiation data correlations

Thiessen error map

Kriging error map

Spline Error Map
Model differences

- Spline predictions 11 & 2.2 times better than Thiessen polygon & kriging predictions
- ANUSPLIN...
  - Smallest RMSE, MAE & VE
  - Highest R (observed / predicted)
  - Smallest R (observed / error)

Case control dataset

- Los Angeles County Cancer Surveillance Program
  - 820 melanoma cases among white, non-Hispanic residents < 65 yrs
  - Cases older than 65 yrs excluded to minimize recall bias of events occurring in young age
  - Controls included 877 individuals who lived nearby and that were matched to cases for ethnicity, age, and gender
- Structured interviews
  - Residential history from birth to time of interview recorded as county or county of residence (if outside USA)
  - Time spent at each residence reported in years
  - Time spent in outdoor activity (average number of days per year of outdoor activity during age periods 15-24, 24-44, >44 yrs of age)

Statistical analysis

- Second research question...
  - How is incidence of melanoma connected to place of residence and time spent outdoors?
- Conditional logistic regression used to estimate odds ratios for melanoma
  - Cumulative lifetime exposure: 4 classes (<150,000, 150-200,000, 200-250,000, >250,000 Wh/m²)
  - Analysis of time spent in outdoor activity in 3 age-specific classes because exposure at young age is important?
  - Self-reported time spent in outdoor activity: 4 classes (0-50, 51-100, 101-200, >200 days per year)
  - Examined 45+ year age group because younger adults have less chance for exposure and we controlled for matching variables of age, sex and socio-economic status

Cumulative UV exposure

<table>
<thead>
<tr>
<th>Cumulative exposure (Wh/m²)</th>
<th>Case-control</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 150,000</td>
<td>118/143</td>
<td>1.2</td>
</tr>
<tr>
<td>150,000-200,000</td>
<td>160/174</td>
<td>1.82</td>
</tr>
<tr>
<td>200,000-250,000</td>
<td>168/201</td>
<td>2.64</td>
</tr>
<tr>
<td>&gt; 250,000</td>
<td>215/191</td>
<td>6.01</td>
</tr>
<tr>
<td>p-Value</td>
<td>&lt; 0.0001</td>
<td></td>
</tr>
</tbody>
</table>

UV adjusted time spent outdoors

<table>
<thead>
<tr>
<th>Exposures</th>
<th>Case-control</th>
<th>OR</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV adjusted outdoors, 15-24 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 558,800</td>
<td>90/121</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>558,800-1,042,671</td>
<td>123/124</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>&gt; 1,042,671</td>
<td>122/122</td>
<td>1.55</td>
<td>0.0955 (0.0333)</td>
</tr>
<tr>
<td>UV adjusted outdoors, 25-44 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 294,330</td>
<td>110/120</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>294,330-645,333</td>
<td>125/125</td>
<td>1.91</td>
<td></td>
</tr>
<tr>
<td>&gt; 645,333</td>
<td>105/121</td>
<td>0.99</td>
<td>0.74 (0.61)</td>
</tr>
<tr>
<td>UV adjusted outdoors, 44+ years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 299,720</td>
<td>123/121</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>299,720-609,600</td>
<td>99/120</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>&gt; 609,600</td>
<td>116/127</td>
<td>0.91</td>
<td>0.74</td>
</tr>
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Changing character of spatial data

- Finer granularity in terms of both space and time...
  - Digital terrain modeling
  - Exposure modeling
- 3D
- Crowdsourcing | Volunteered Geographic Information
- Social media
- Sensing systems
- Changing role of government

Digital terrain modeling

- Sources
  - National Map
  - LiDAR
  - IFSAR
  - GPS
- Types
  - Contour and stream line data
  - Remotely sensed elevation data
  - Surface specific point elevation data

Topographic attributes

- Elevation \( z \)
- Slope gradient \( \alpha \)
- Slope aspect \( \omega \)
- Curvatures \( \kappa \)
- Distance to the nearest ridge
- Downslope length
- Upslope area

Sparse data | spatial interpolation

- Pre-processing decisions
  - Need to focus on fundamental science as well as tools
  - Source and granularity of DEM used
  - Presence and handling of spurious pits (interpolation)
  - Choice of drainage enforcement option (if any)
  - Choice of flow routing algorithm
  - Dynamic character of key variables and processes
  - Depiction of topographic shape matters most!

LiDAR | spatial filtering

- Light Detection And Ranging
- Measures distance to, or other properties of a target by illuminating target with light, using pulses from a laser
- Three components
  - Airborne scanning laser rangefinder
  - Differential GPS
  - Internal Navigation System
- Generates millions of points at relatively low cost...
Geodesign

- Focuses on spatial thinking
  - New field built on spatial sciences base
- Leverages geospatial technologies
  - Sketching
  - Computation
- Focuses on the future
- Focuses on design as a force for good and precursor to action
- Focuses on collaboration
  - Multi-disciplinary
  - Stakeholders and general public
  - Special role for Web

Small- and big-D design

- Small D design
  - Simple optimization problem
- Large D design
  - Varying goals among stakeholders
  - Feedback loops that modify objectives
  - Inclusion of new constraints and data as the process proceeds
  - Uncertainties about implementation
  - Messy!

Source: Goodchild (2010)

Six stages of geodesign

- Simple | Complex Models
- Key Participants
  - The people of the place
  - Experts (i.e. technically competent people)
  - All will need to take more active roles
- Drivers of change
  - Political attitudes
  - Information technologies

Source: Steinitz (2012)

Reality Check LA (2002)

http://www.youtube.com/watch?v=-aHgIh6m3ns

Role of the Web

- UCSB | Marine Science Lab
  - SeaSketch
    - Specify geographic area of interest
    - Upload map services from ArcGIS Online
    - Create and invite users and groups to participate in projects
    - Define sketch classes for marine management zones
    - Create map-based discussion forums
    - Create simple surveys to collect data on human uses of ocean
  - MarineMap
  - Spatial marine planning
**Final thoughts**

- Spatial as an enabling discipline
- Core concepts | distractions
- Role of collaboration
- Changing character of spatial data
- Geodesign | "actionable" science

**Our past work ...**

- Focused on terrestrial environments
- Focused on space (less about time)
- Focused on what is or what has been
- Ignored most of the world ...
  - Oceans – cover 70% of Earth’s surface
  - Buildings – people spend 85% of their lives indoors & dense urban areas have far more interior space than land area
- Not well aligned with everyday places & non-expert users
- Not connected to sketch & recording needs of design disciplines

**Spatial education**

- Geographic information
  - Tells us "what is where when"
- Spatial science ...
  - A visual science (maps)
  - An "enabling" science like statistics
- Supported by rapidly expanding suite of geographic information technologies
- High entry cost has been & still is a barrier to widespread adoption and use
- Esri’s new $1 billion ArcGIS Online gift to U.S. schools

**Spatial @ USC ...**

- New undergraduate programs
  - GE courses (incl. "Numbers & Maps")
  - Spatial Studies Minor
  - GeoDesign B.S. degree
- New progressive degree programs
- New graduate programs
  - GIS&T M.S. degree
  - GIS&T Graduate Certificate
  - Geospatial Intelligence Graduate Certificate
  - Geospatial Leadership Graduate Certificate
  - GeoHealth track in Master of Public Health degree

**Geodesign | placemaking**

- Spatial thinking
- Geospatial technologies
- Focus on the future
- Design as a force for good
- Collaboration

- Capacity building
- Human well-being
- Sustainable development
- Spatial leadership
- Professional ethics

**Close | Questions?**

- Placemaking 101
  - Lighter
  - Quicker
  - Cheaper
  - http://www.pps.org/

- John Wilson
  - jpwilson@usc.edu
  - http://spatial.usc.edu

- Project for Public Spaces
  - Placemaking plans
  - City-wide strategic plans
  - Capacity building and cultural change