Four Methodological Themes in Spatial Health Science

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0. Spatial & computational turns in public health

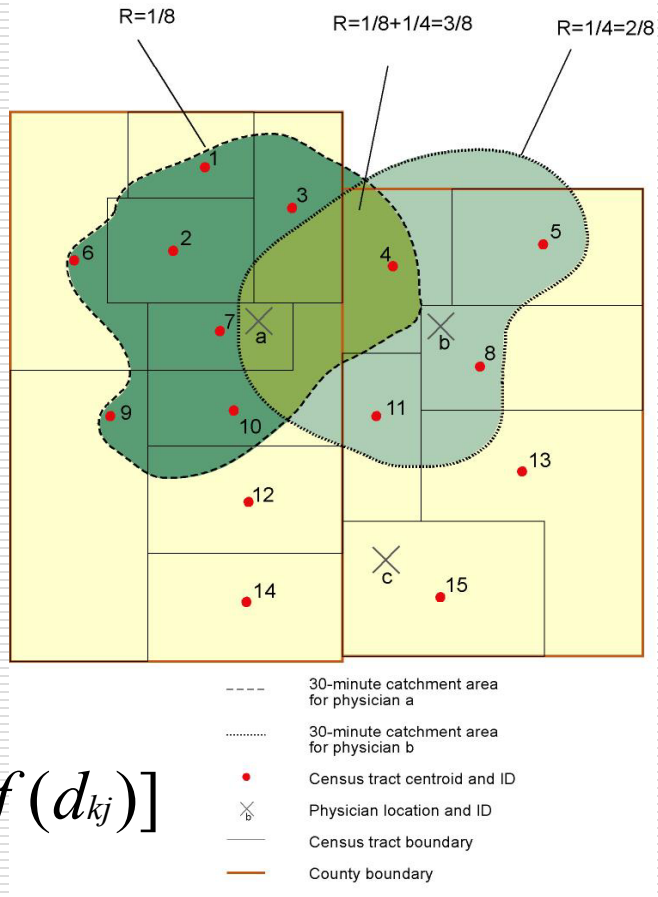
- Computational turn: data analytics
- Spatial turn: precision & area-adaptable
- Bridging quantitative & qualitative divide via GIS
  - Hybrid (mixed)

1. Spatial Accessibility for 4As

- Accessibility as a classic location issue
- Spatial vs. aspatial in accessibility
  - 5As in access to healthcare: Approachability, Acceptability, Availability, Affordability, Appropriateness
- 2SFCA for spatial access in residents
- i2SFCA for crowdedness in facilities
- 2SVCA for telehealth
- Applications of spatial accessibility in 4S

Spatial Accessibility by 2SFCA

- Scale availability at each supply location
- Sum up accessible supplies around each demand (residents)



$$A_i = \sum_j R_j f(d_{ij}) = \sum_j [S_j f(d_{ij}) / \sum_k (D_k f(d_{kj})]$$

From 2SFCA to i2SFCA

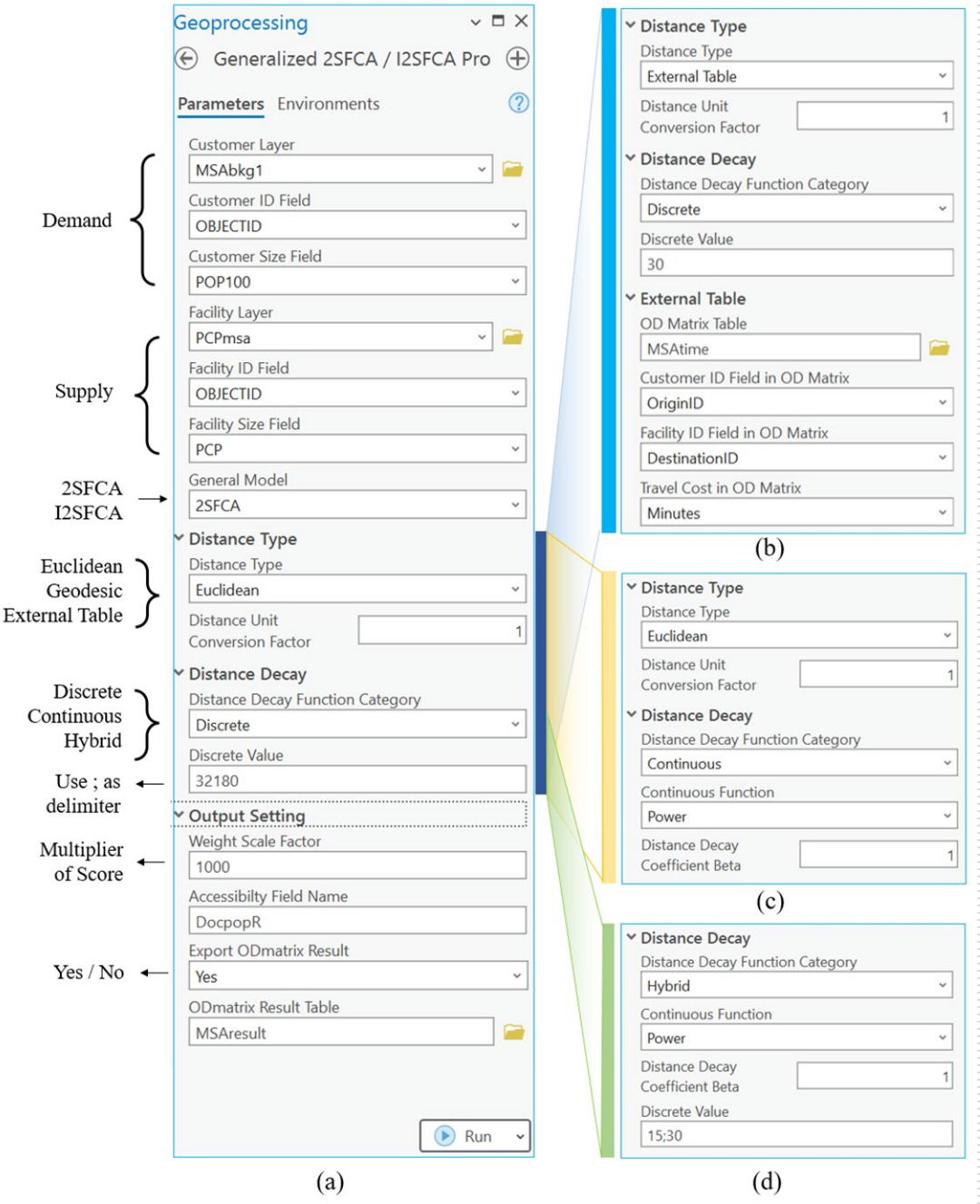
- Capture availability at each supply: $S/\Sigma P$
- Sum up accessible supplies around each demand: $\Sigma(S/\Sigma P)$

Resident accessibility

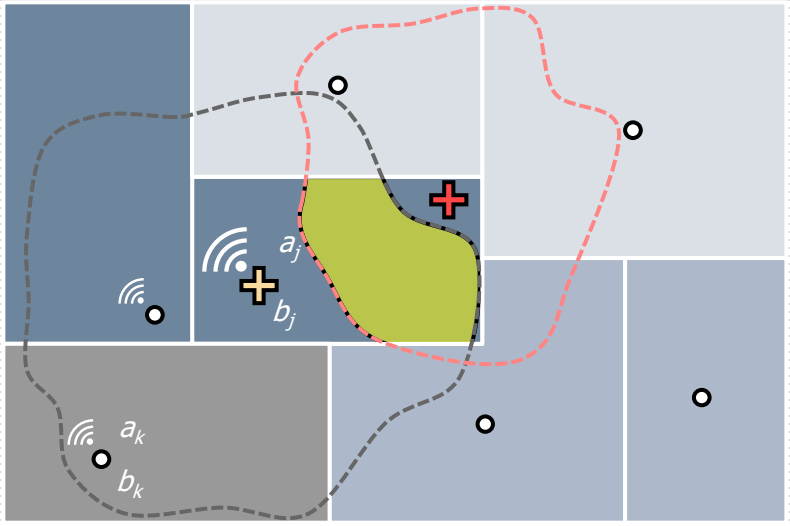
Facility crowdedness

- Capture competition intensity at each demand: $P/\Sigma S$
- Sum up reachable demands around each supply: $\Sigma(P/\Sigma S)$

2SFCA/i2SFCA



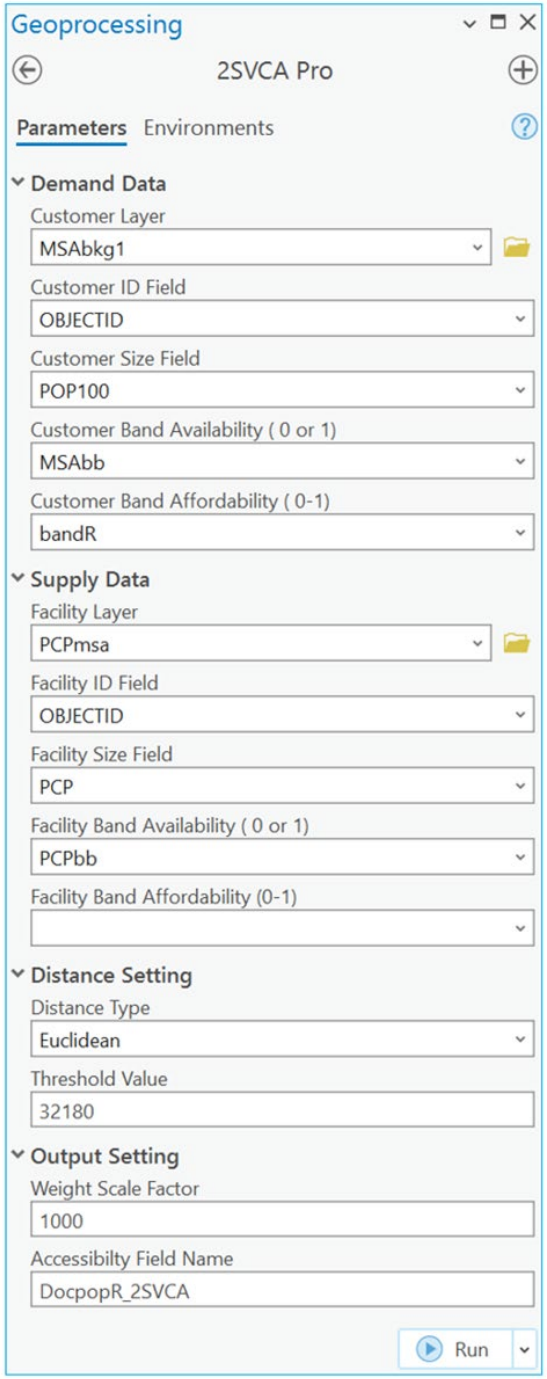
Virtual accessibility by 2SVCA



Captures effects of broadband availability *b* vs. affordability *a*

- $VA_i = a_i \sum_{j \in (d_{ij} \leq d_0)}^{n} \left[a_j S_j f(b_j) / \sum_{k \in (d_{kj} \leq d_0)}^{m} (a_k D_k f(b_k)) \right]$

2SVCA



Demand
Point or Polygon Feature

(if using Euclidean or Geodesic for Distance Type, it MUST be in Projected Coordinate System, and the centroid of Polygon will be used)

If blank : use 1 for default value

Supply
Point Feature

(if using Euclidean or Geodesic for Distance Type MUST be in Projected Coordinate System)

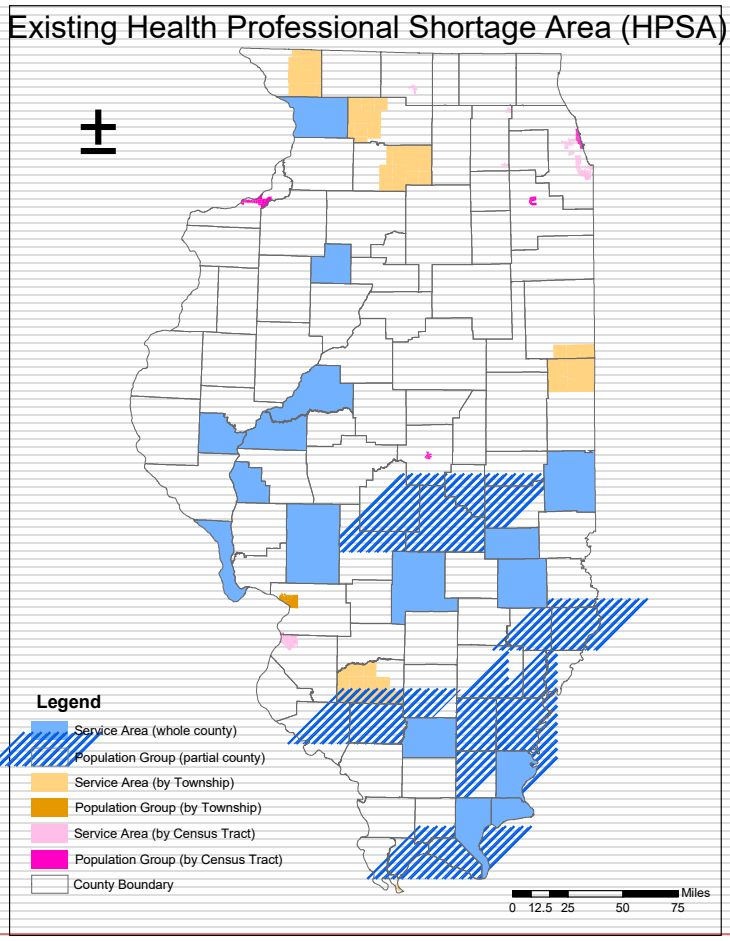
If blank : use 1 for default value

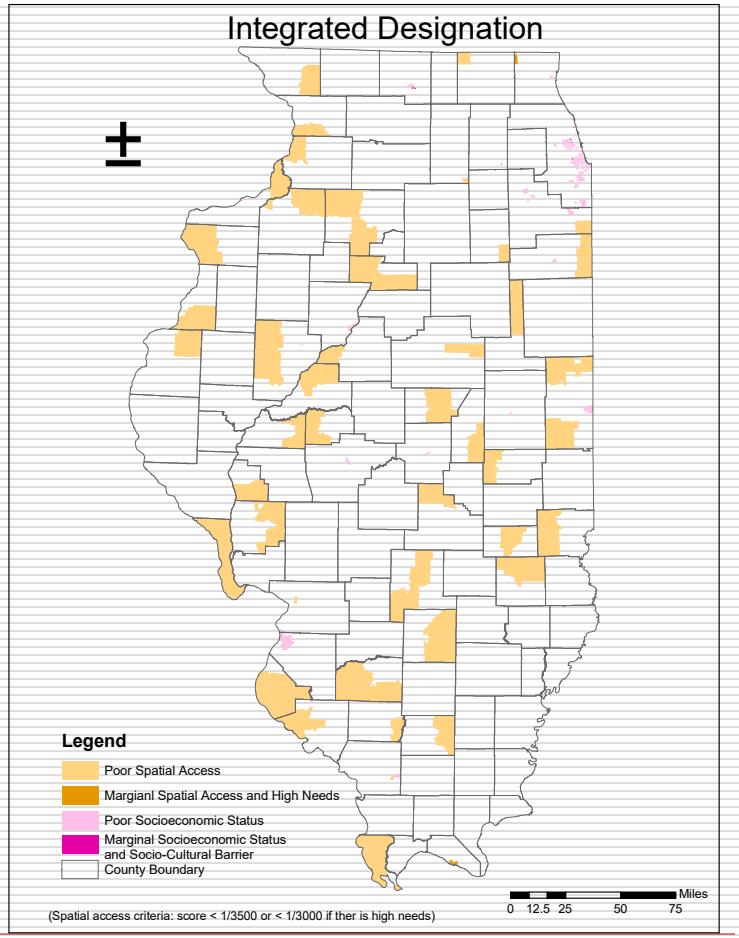
Euclidean
Geodesic
External Table

Unit
meters for Euclidean /Geodesic

Multiplier of Score

Defining HPSAs





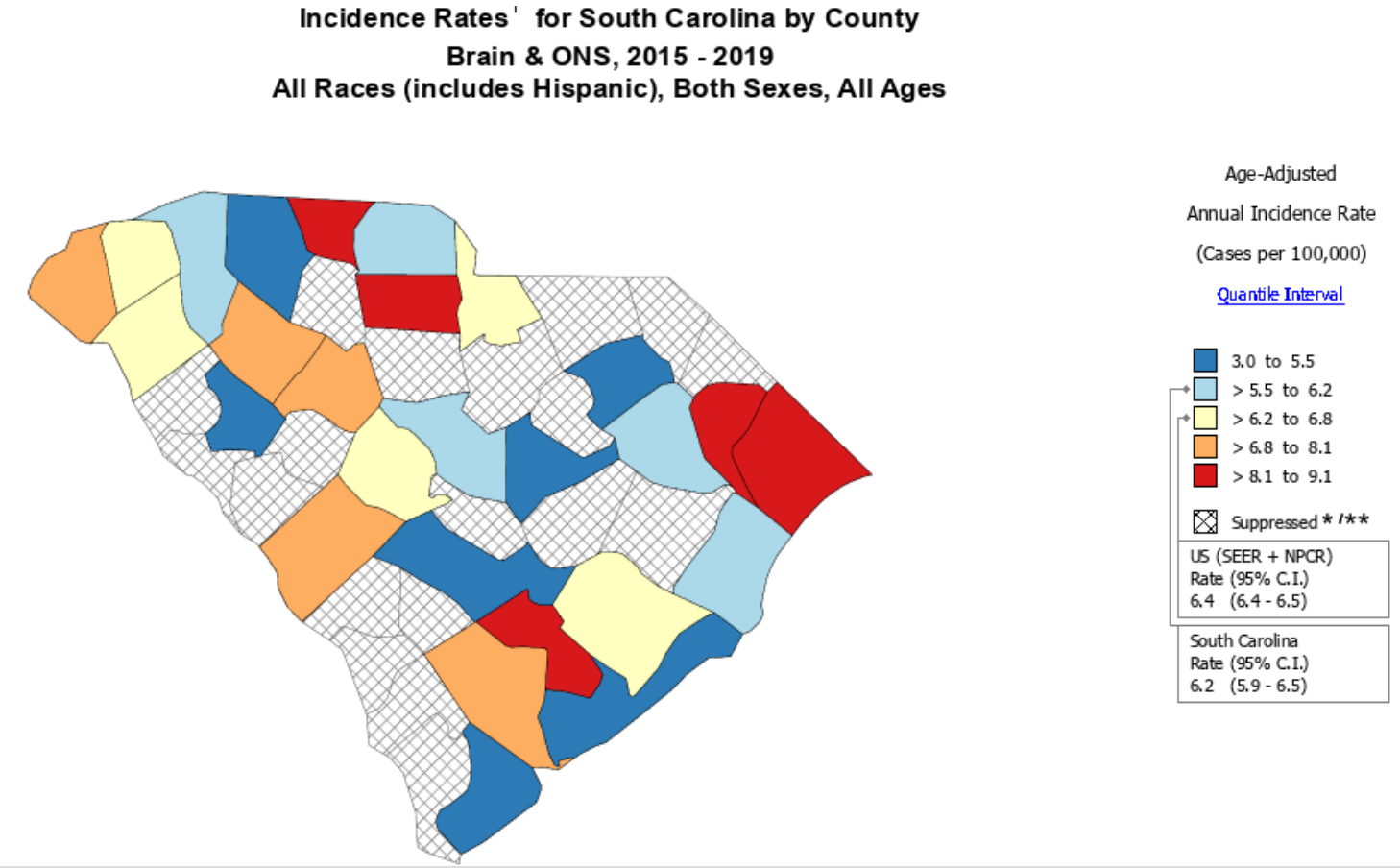
Accessibility matters for "4As"

1) for anything (e.g., healthcare, job, education, recreation, food),
2) to anyone (e.g., on disparity in access between socio-demographic groups),
3) by any means (e.g., via different transportation modes, challenges by the handicapped), and
4) at any time (e.g., accounting for temporal variability of supply, demand, and transportation between daytime vs. nighttime, seasonally, normal vs. natural disasters)

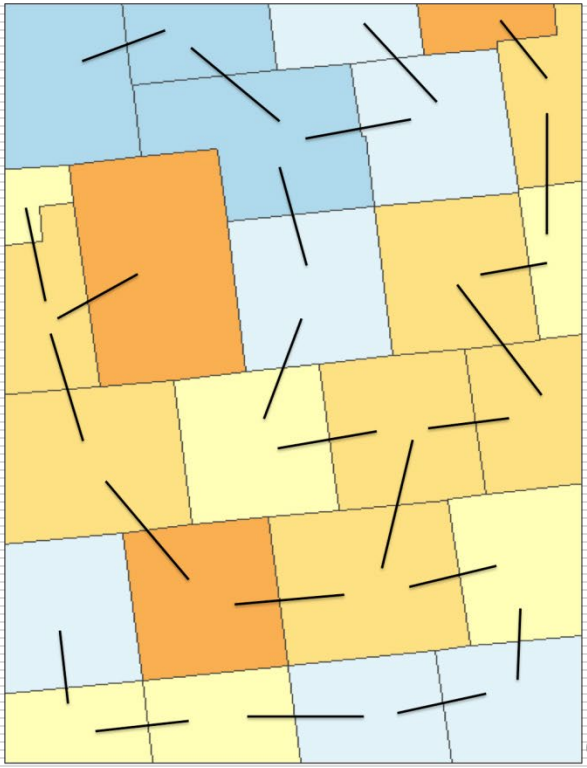
Recap

- Captures proximity, availability & complexity of S-D interaction
- Theoretical derivation
- Empirical validation
- Popularity aided by intuitive interpretation & GIS automation
- Starting point of tackling disparity

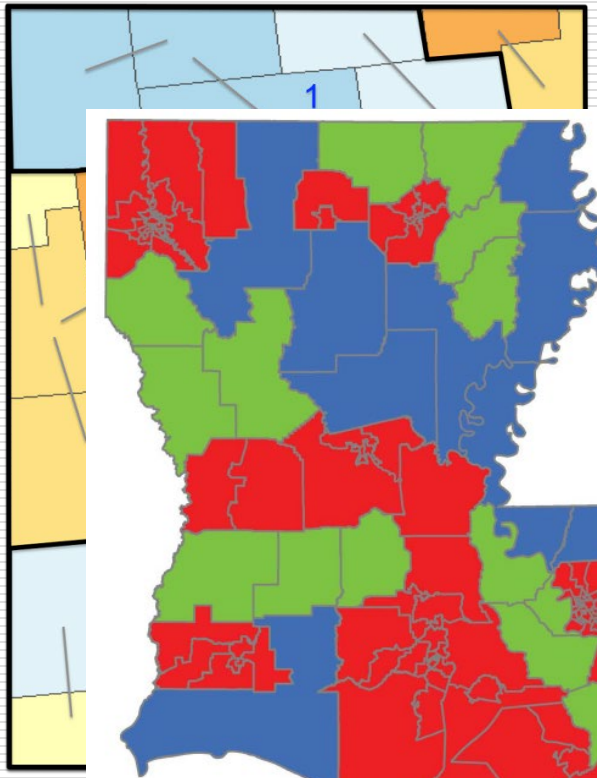
2. Constructing areas for cancer data dissemination



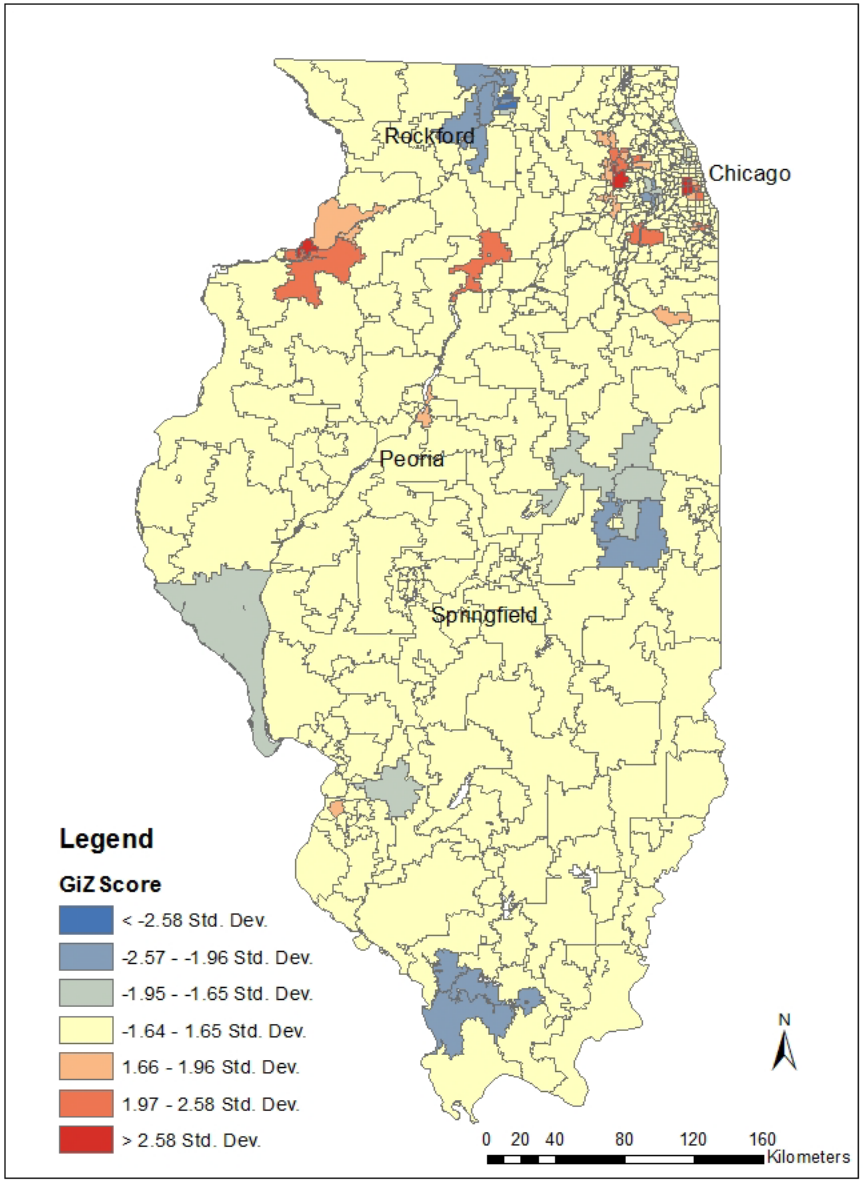
Spatial clustering for homogeneous regions: From REDCAPc to MLR



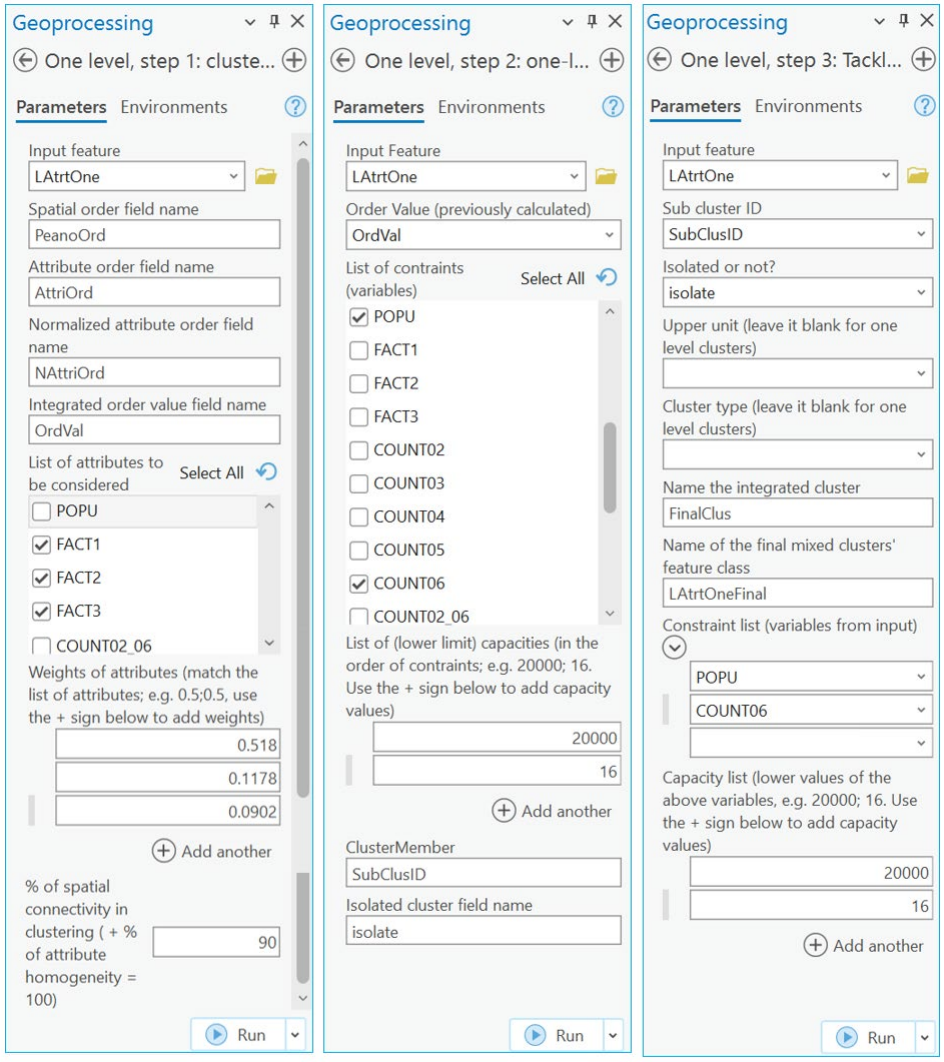
(A)



Cluster of late-stage breast cancer rates in Illinois 2000



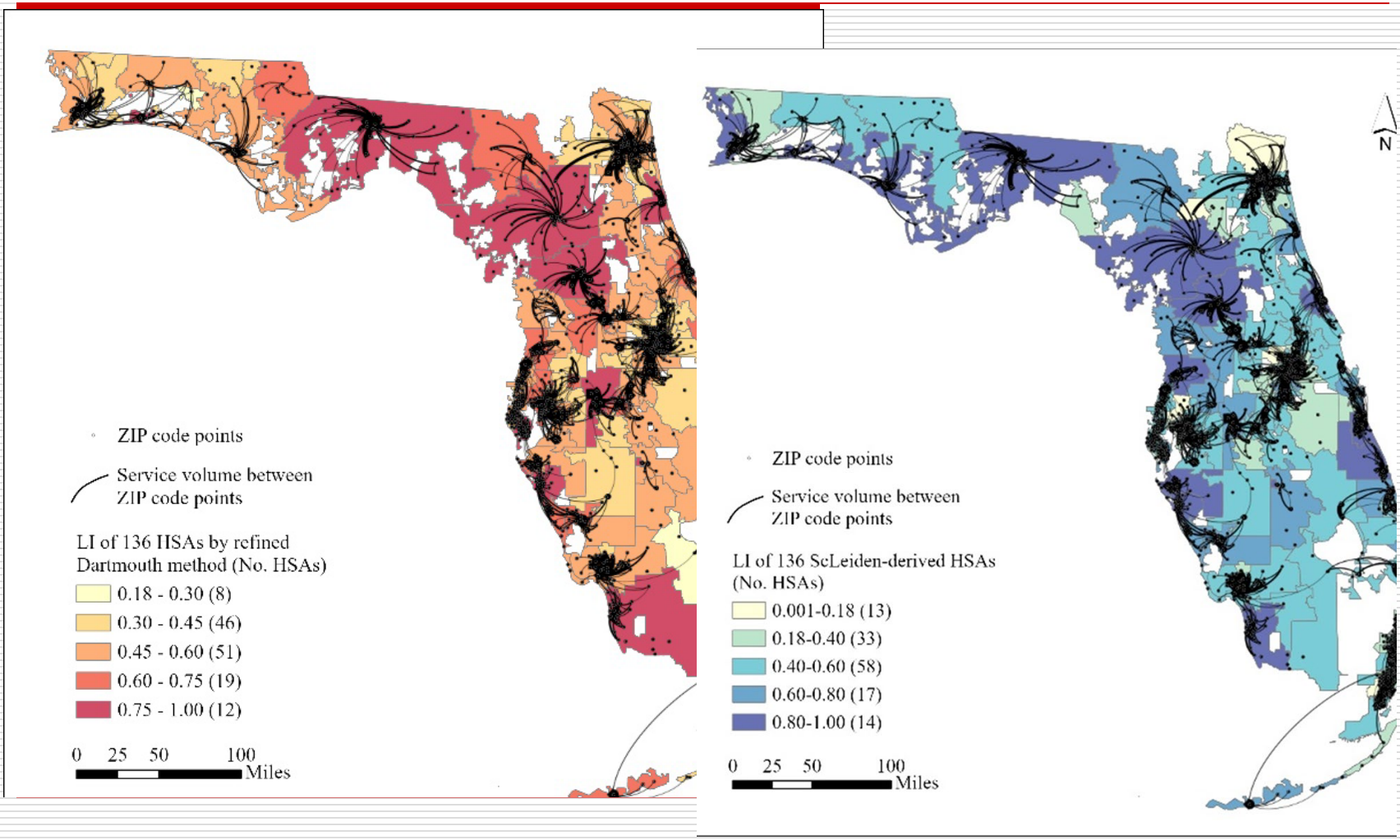
MLR


Geoprocessing
One level, step 1: cluste...
Parameters
Environments
Input feature
LAtrtOne
Spatial order field name
PeanoOrd
Attribute order field name
AttriOrd
Normalized attribute order field name
NAttriOrd
Integrated order value field name
OrdVal
List of attributes to be considered
Select All
POPU
FACT1
FACT2
FACT3
COUNT02_06
Weights of attributes (match the list of attributes; e.g. 0.5;0.5, use the + sign below to add weights)
0.518
0.1178
0.0902
Add another
% of spatial connectivity in clustering (+ % of attribute homogeneity = 100)
90
Run
Geoprocessing
One level, step 2: one-l...
Parameters
Environments
Input Feature
LAtrtOne
Order Value (previously calculated)
OrdVal
List of contraints (variables)
Select All
POPU
FACT1
FACT2
FACT3
COUNT02
COUNT03
COUNT04
COUNT05
COUNT06
COUNT02_06
List of (lower limit) capacities (in the order of contraints; e.g. 20000; 16. Use the + sign below to add capacity values)
20000
16
Add another
ClusterMember
SubClusID
Isolated cluster field name
isolate
Run
Geoprocessing
One level, step 3: Tackl...
Parameters
Environments
Input feature
LAtrtOne
Sub cluster ID
SubClusID
Isolated or not?
isolate
Upper unit (leave it blank for one level clusters)
Cluster type (leave it blank for one level clusters)
Name the integrated cluster
FinalClus
Name of the final mixed clusters' feature class
LAtrtOneFinal
Constraint list (variables from input)
POPU
COUNT06
Capacity list (lower values of the above variables, e.g. 20000; 16. Use the + sign below to add capacity values)
20000
16
Add another
Run

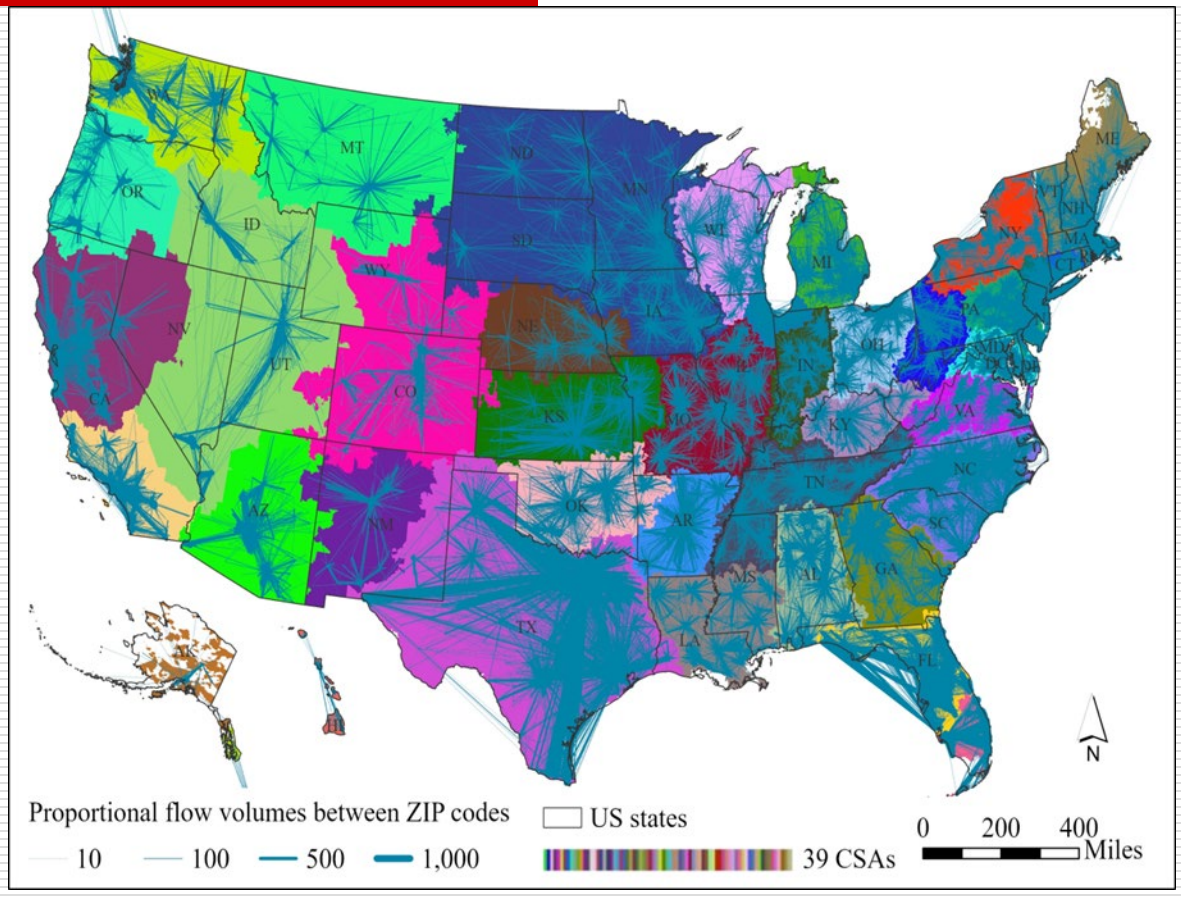
3. Defining hospital service areas (HSAs)

- HSA is a functional region
- Other terms
  - Hospital Referral Regions (HRRs)
  - Catchment areas for NCI Cancer Centers
  - Pediatric surgical areas (PSAs)
  - Primary care service areas (PCSAs)
  - Cancer service areas (CSAs)
- Spatializing network community detection methods (e.g., ScLeiden)
  - Maximize flows within HSAs & minimize flows between HSAs

Delineating functional regions: HSAs from Dartmouth to ScLeiden



Cancer Service Areas in the U.S.



ScLeiden

Geoprocessing

Network Community Detection Meth...

Parameters | Environments

Input Polygon Layer: ZIP_Code_Area

Unique ID Field: ZoneID

Population Field (Optional): POPU

Input Edge File: OD_All_Flows

Origin ID Field: PatientZipZoneID

Destination ID Field: Hosp_ZoneID

Service Flow Field: AllFlows

Distance (or Travel Time) Field (Optional): Total_Time_min

Delineation Method: ScLeiden

Input Resolution (>0): 29.64

Impose Spatial Contiguity: Yes

Input Spatial Adjacency Matrix File: E:\CMS_GISV3\Case04Au\FLplgnAdjUp.npz

Threshold Size (Optional): 1000

Output Polygon Layer: Sd_HSAs

Run

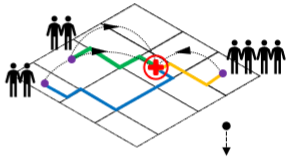
Input Polygon

Projected coordinate system

ID Field

Population

Input Edge File



Origin ID	Destination ID	Service Flow	Distance

ScLouvain method
ScLeiden method

Default value of 1： global maximal modularity

Spatial Constraints

IF YES for Spatial contiguity, need provide Spatial Adjacency Matrix

Threshold size refers to population size of each derived community

Dissolved input polygon layer with Several indices

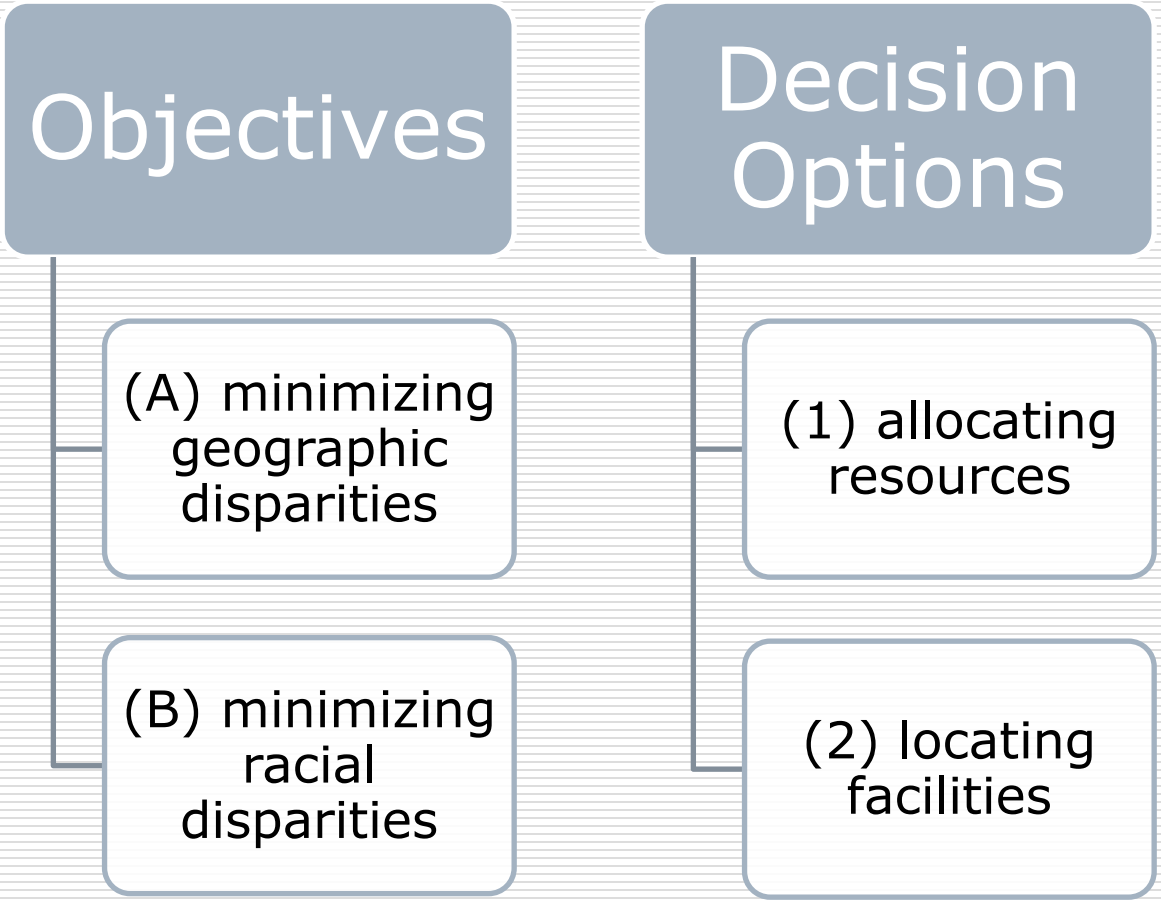
Recap for 2&3

- Explicitly optimize an objective
  - Eliminates uncertainty & enables replication
- Automated in GIS
- Flexible scale enables studies of MAUP & UGCoP
- Homogenous regions are comparable, with reliable rates, free of spatial autocorrelation
- Functional regions are used for management & planning

4. Spatial optimization: location-allocation problems

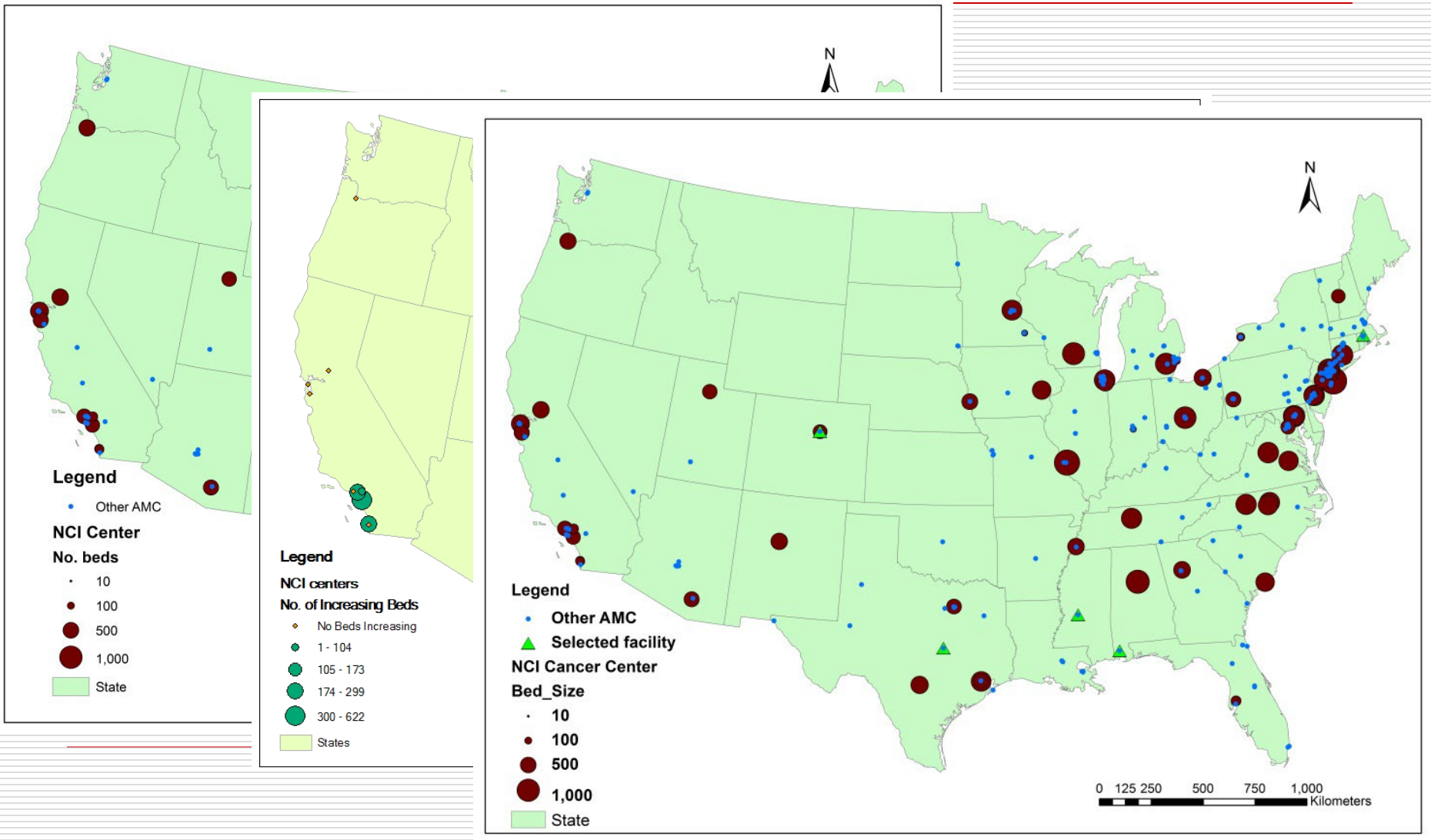
Model	Objective	Constraints
p-median problem	Minimize total distance/time	Locate *p* facilities; cover all demands
Location set covering problem (LSCP)	Minimize the number of facilities	Demand must be within a specified distance/time
Maximum covering location problem (MCLP)	Maximize coverage	Locate *p* facilities; cover demand if within a specified distance/time
Center model (Minmax)	Minimizes the maximum distance	Locate *p* facilities; cover all demands

The Maximum Accessibility Equality Problem (MAEP)

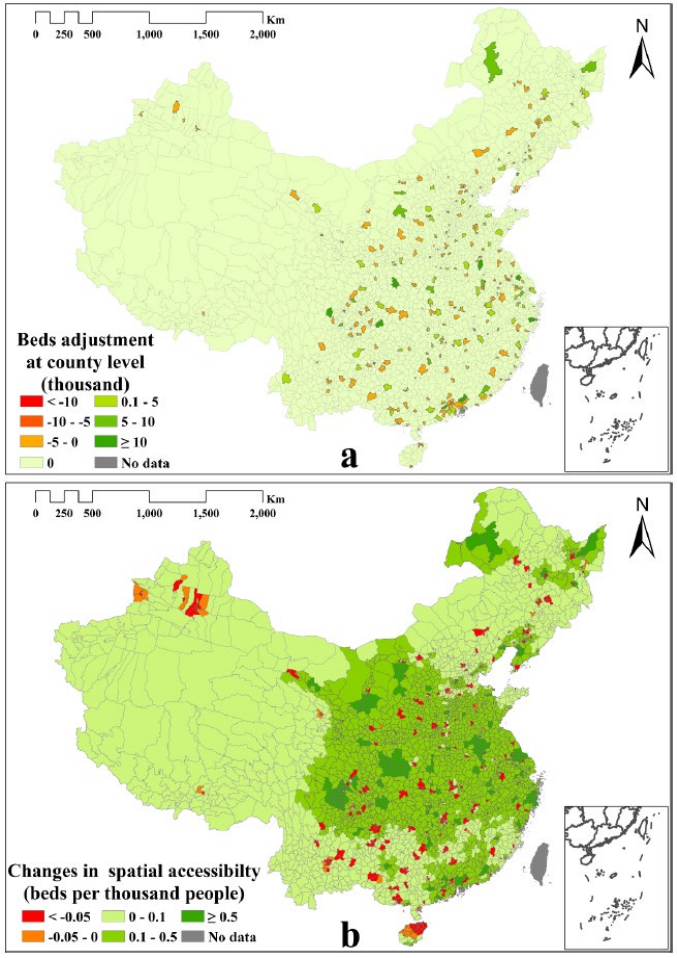


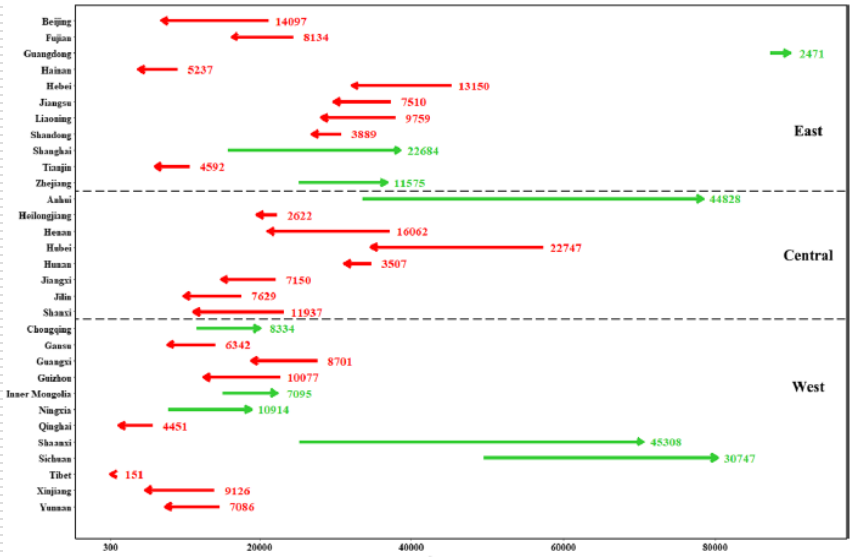
Scenarios:
A1
A2
B1
B2

Planning NCI Cancer Centers in the U.S.



Planning top-tier hospitals in China



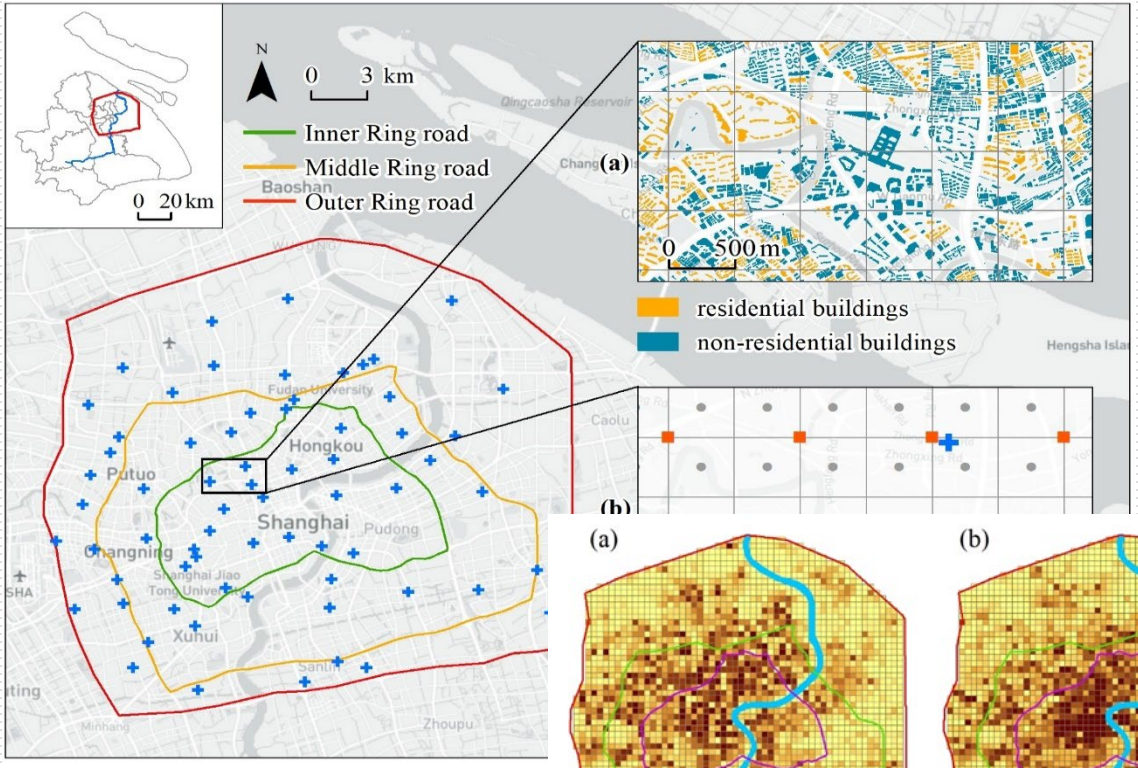


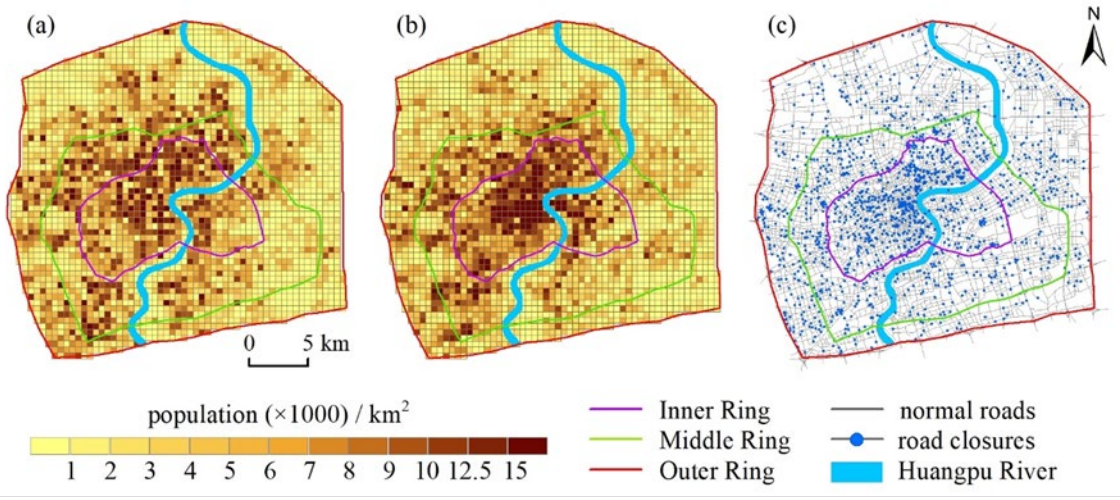
Current and optimized spatial allocation of top-tier general hospital beds.

		Counties	Number of beds	Weighted SD of spatial access[1]	Weighted median spatial access[2]
Current	(1)	2,853	802,168	1.03	0.15
Optimized	(2)	2,853	802,168	0.49	0.38
Ratio	(2)/(1)	100.00%	100.00%	47.57%	253.33%

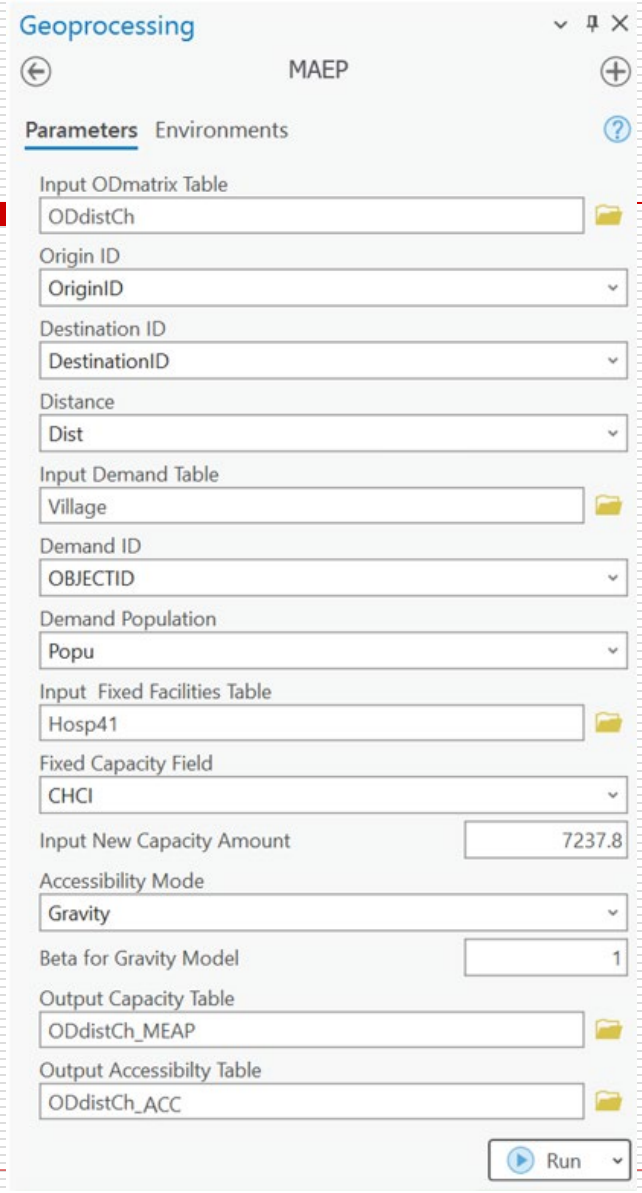
Note: 1 and 2 refer to the population-weighted SD of spatial accessibility and the population-weighted median spatial accessibility, respectively.

EMS planning in Shanghai





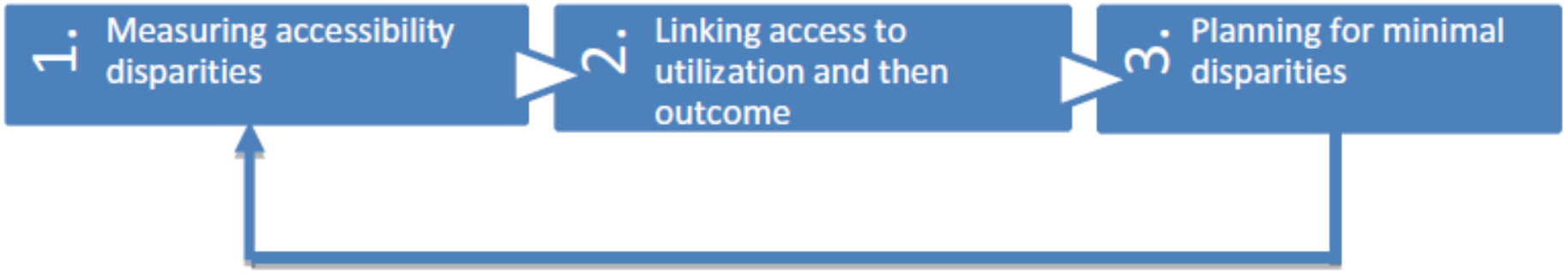
MAEP


Geoprocessing
MAEP
Parameters
Environments
Input ODmatrix Table
ODdistCh
Origin ID
OriginID
Destination ID
DestinationID
Distance
Dist
Input Demand Table
Village
Demand ID
OBJECTID
Demand Population
Popu
Input Fixed Facilities Table
Hosp41
Fixed Capacity Field
CHCI
Input New Capacity Amount
7237.8
Accessibility Mode
Gravity
Beta for Gravity Model
1
Output Capacity Table
ODdistCh_MEAP
Output Accessibilty Table
ODdistCh_ACC
Run

Recap

- A new paradigm in location-allocation
- A rich set of MAEP in various *stages of disparity*, various *measures*, various *applications*
- Complexity in formulating objective function, decision variables and constraints
- Computational efficiency in algorithms

Integrating as easy as 1-2-3



Overall Reflections

- GIS made a name with integrating data & visualizing spatial pattern/process
- Spatial simulation & optimization are the frontiers
- Precision public policy & planning attracts funding
- GIS automation brings down the barriers
- Geography is the reality of complexity we live in. Survive & *thrive* in it!

Thank You!

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