Using Spatial Analysis Tools in Implementation Science

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Cyberseminar Outline

- **Introduction:** ***Bauer***
- **Overview of spatial analysis with emphasis on relevance to implementation methods:** ***Penfold***
- **Examples of applying spatial tools to implementation issues:** ***Cowper Ripley***
- **Q&A:** ***Presenters & Audience***

Question:

“Who’s out there anyway?”

Why Pay Attention to Geographic Factors in Implementation Efforts?

Pre-Implementation (assessment):

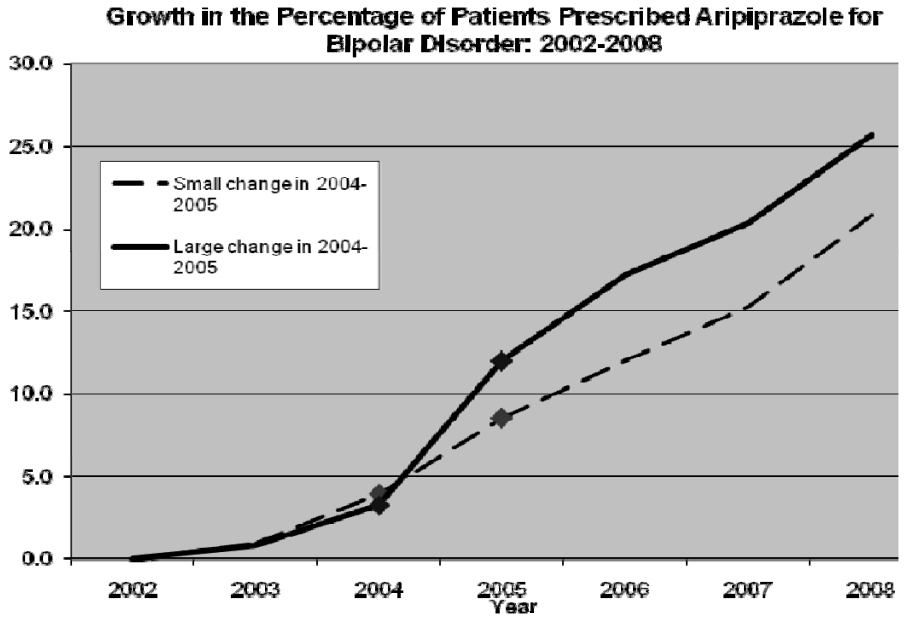
- Is VHA an hermetically sealed, top-down, hierarchically driven healthcare system?
- Or do local factors play a role in provider (and system) behavior at the VISN and VAMC level?
- Are these factors explainable solely in terms of administrative structural features?
- Or do local social/spatial context factors play a role in provider/patient/system behavior?

Why Pay Attention to Geographic Factors in Implementation Efforts?

Implementation (strategy design):

- Social context factors
- Resource availability & distribution
- Travel & communication issues
- Maintenance & sustainability of implementation strategies
- Information & influence flow—*intended and unintended*

Spread of Newer Antipsychotics for Bipolar Disorder & PTSD HSR&D IIR 10-314 (2011-2014)

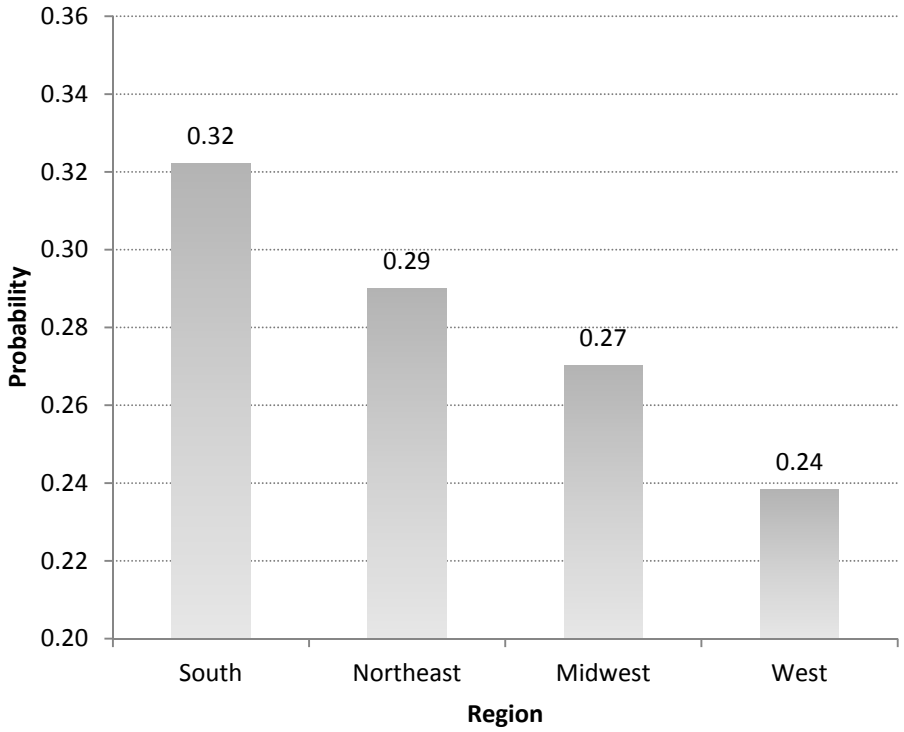


We hypothesize that both geographic factors, consistent with classic diffusion theory, and organizational factors, as articulated in more recent applications of diffusion theory to dissemination within healthcare organizations, will shape SGA spread and, therefore, identify opportunities for intervention.

Regional Variability in Use of Newer Antipsychotic Prescribing for PTSD

(n=705,085)

Fig 1. Estimated Probability of Being Prescribed with Any of Five SGAs for PTSD Patients (FY2003 to 2010)



(Analyses courtesy of Austin Lee, PhD)

Spatial Analysis Tools in Implementation

- Site-specific customization
- Social context often defined geographically
- Geographic units as policy boundaries

- Specific tools
    - Location-allocation
    - Minimum set coverage
    - Spatio-temporal cluster analysis (hotspots)
    - Geographically weighted regression

Site Customization

- Implementation of interventions and/or policies generally requires customization to local resources or circumstances
  - Capacity constraints
  - Differences in workplace culture/procedures
  - Aggregate differences in patient needs

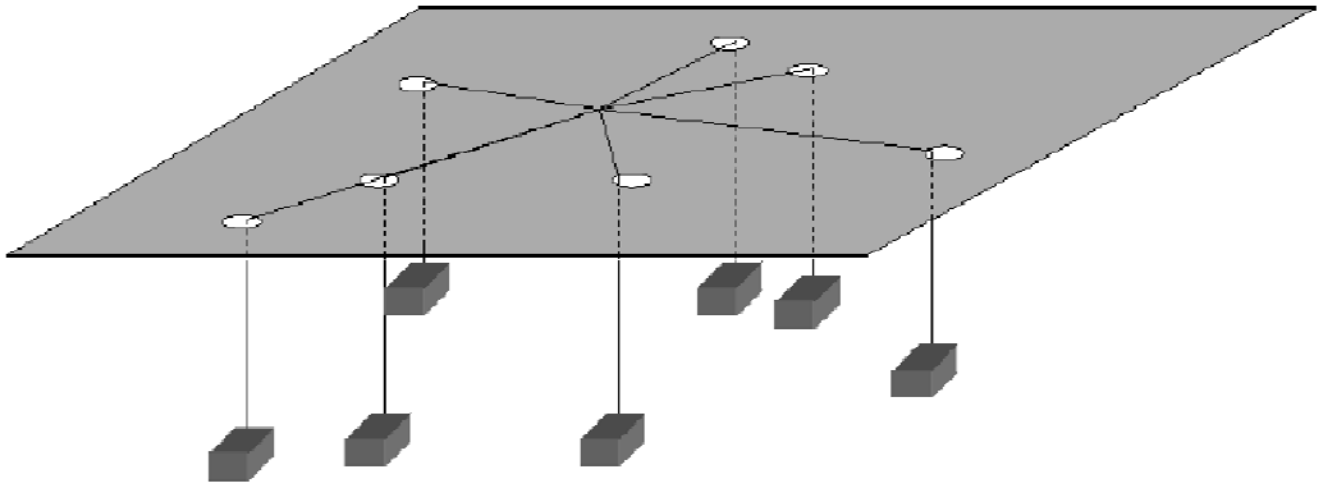
- Location-allocation (p-median) implementation
  - Optimal location of new facility or site of service
  - Optimal re-allocation of resources given a known set of service points

Intervention: improve “access”

- Increase the number of sites
- Increase capacity at existing sites
- Subject to budget constraints

- Location-allocation problem
  - How many sites should be added and where to achieve the accessibility goal(s)?
    - “P-median problem”
  - What should the capacity (e.g., # clinicians) be at each site given the distribution of demand?

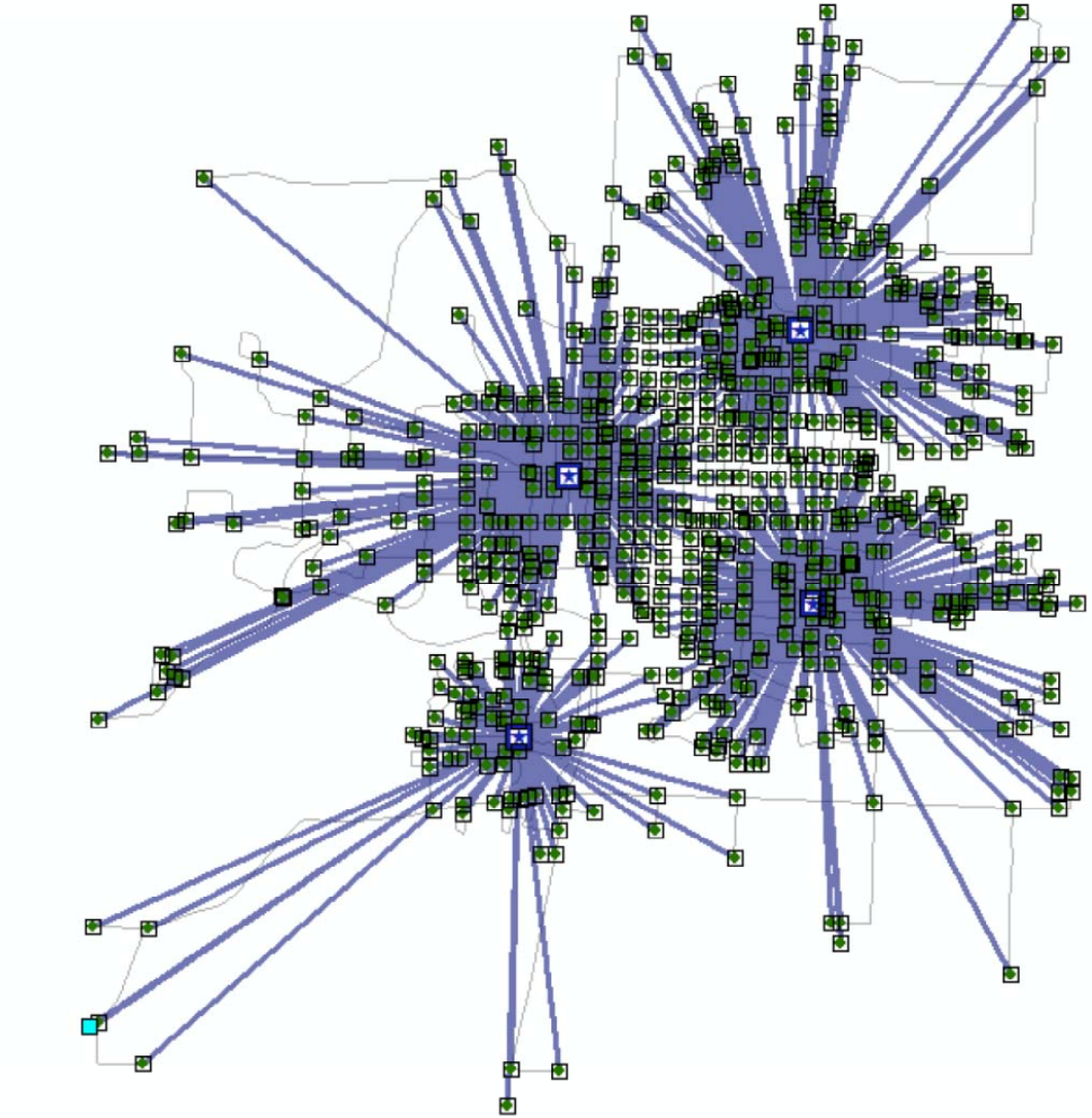
Minimize distance to a central site



1-median problem

Source: Schietzelt & Desnham, 2003

Location-Allocation with 4 sites



Minimum Set Coverage Problems

- What is the minimum number of service points required to cover a geographic area with “service”
  - E.g., how many CBOCs would be required such that no veteran must drive more than 30 minutes to reach one.
  - How many broadband internet access points are needed to implement remote telehealth access for a population of veterans “fairly”?

xDSL coverage in Franklin County, OH

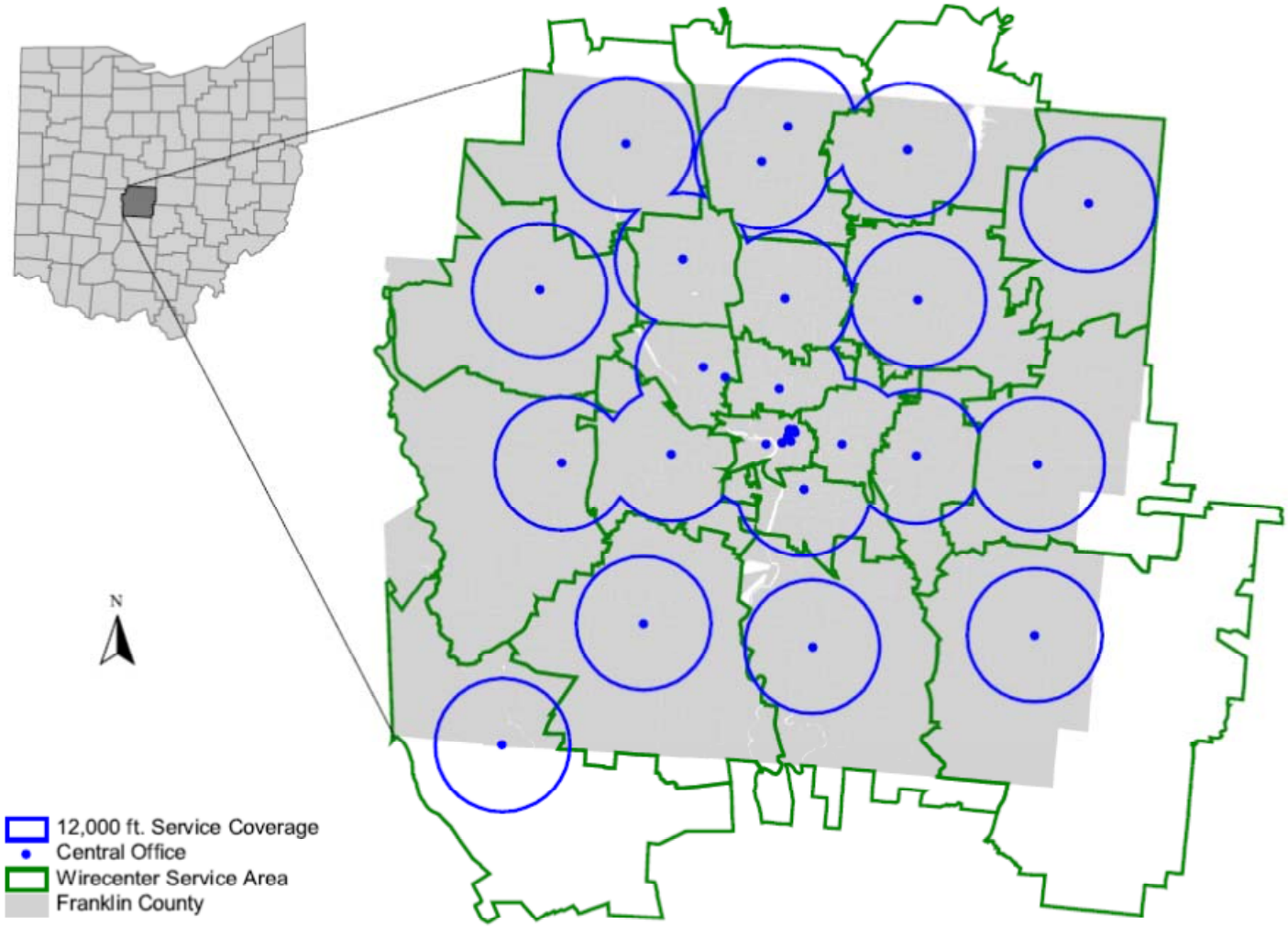


Fig. 3. Wire centres and potential xDSL coverage

Grubesic and Murray, 2002

Various Tradeoff Solutions

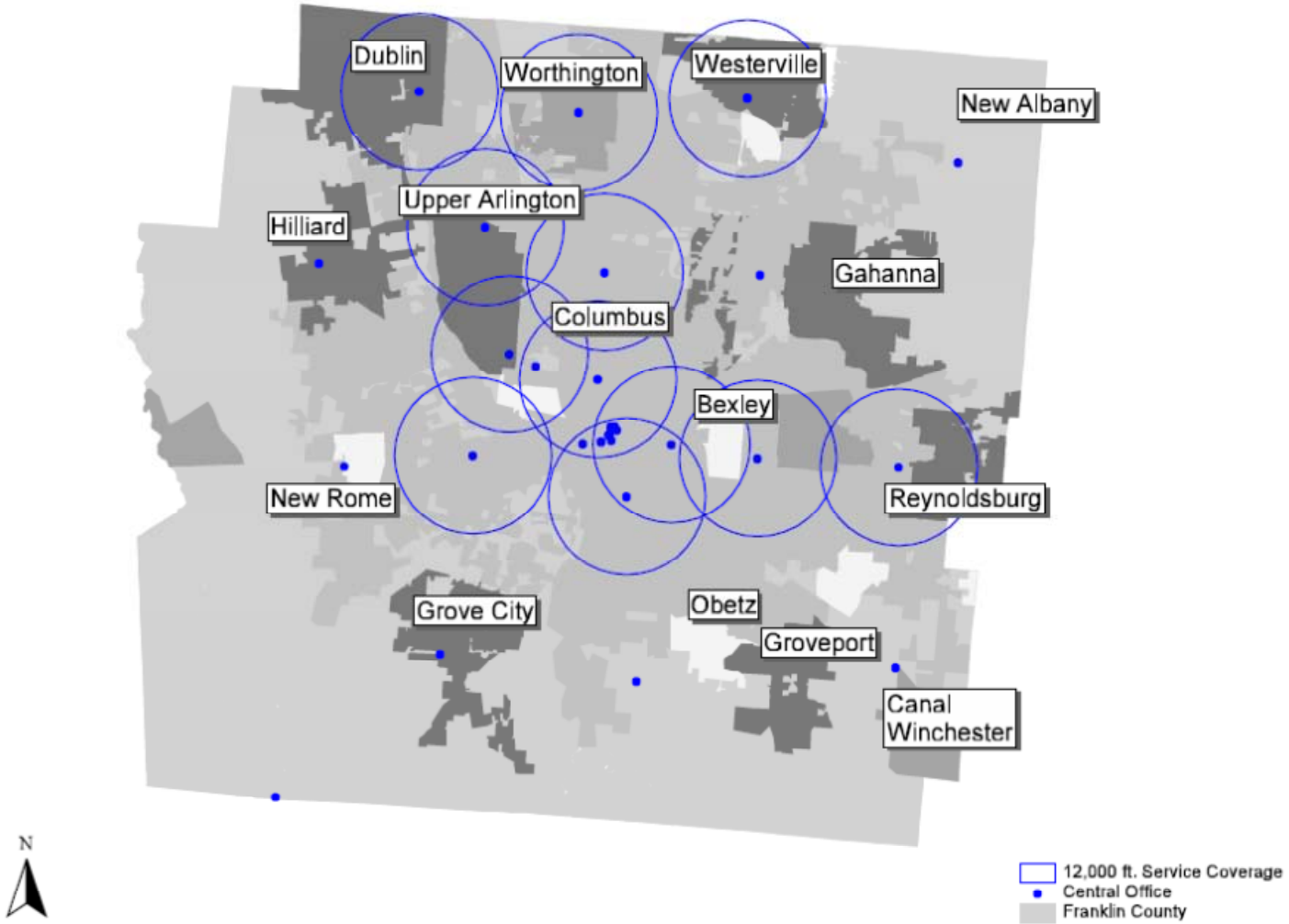


Fig. 8. Non-dominated tradeoff solution #3 for $p = 12$

Social Context & Networks

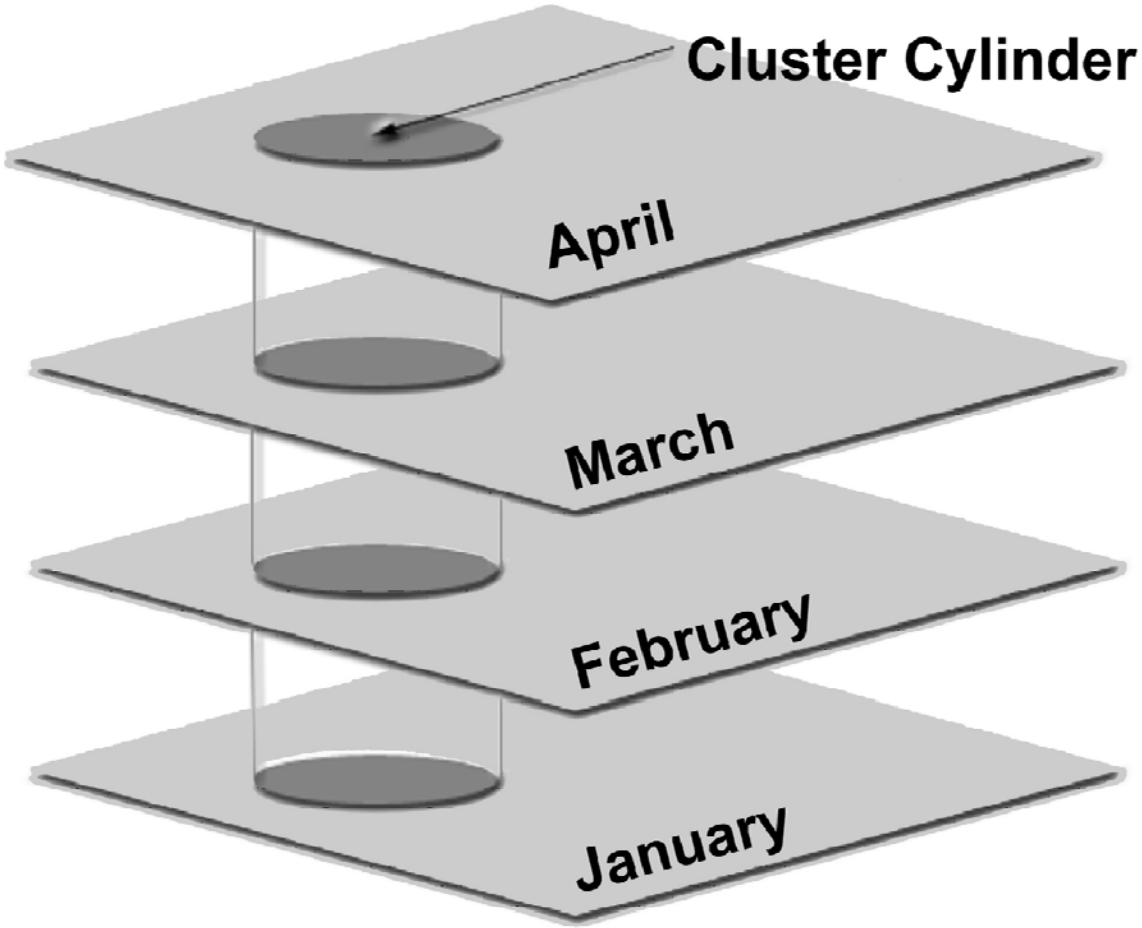
- Social context is often geographically defined (homophily)
  - VAMC vs. VISN, rural vs. urban, county vs. state, state vs. region
  - Various levels of spatial aggregation associated with different cultures/norms
- Social context often implicated in the success/failure of interventions
- Social networks often defined/constrained geographically because people interact with their local colleagues/patients/neighbors more often
  - Spatio-temporal cluster analysis is one approach to defining the spatial extent of social interaction

Space Time Scan Statistic

- Uses
  - Geographical and temporal surveillance of a process to detect clusters of events (e.g., Rx of a new drug)
  - Test whether a process is randomly distributed over space, time or space-time
  - Evaluate the statistical significance of clusters

- Multiple types of scan statistic for different distributions
  - Poisson-based, Bernoulli, space-time permutation, multinomial, ordinal, exponential, normal.

Space-time Cluster of “adoption”



Source: Penfold et. al., 2009

Interpretation/Significance

- Who are the clinicians or patients within the space-time cluster?
  - How do the resources, people, etc within clusters differ from those outside the cluster?
  - Do clusters occur in the same places across multiple interventions/policies?
- Target dissemination/implementation resources to clusters with LOW uptake of a desired change

Policy Boundaries

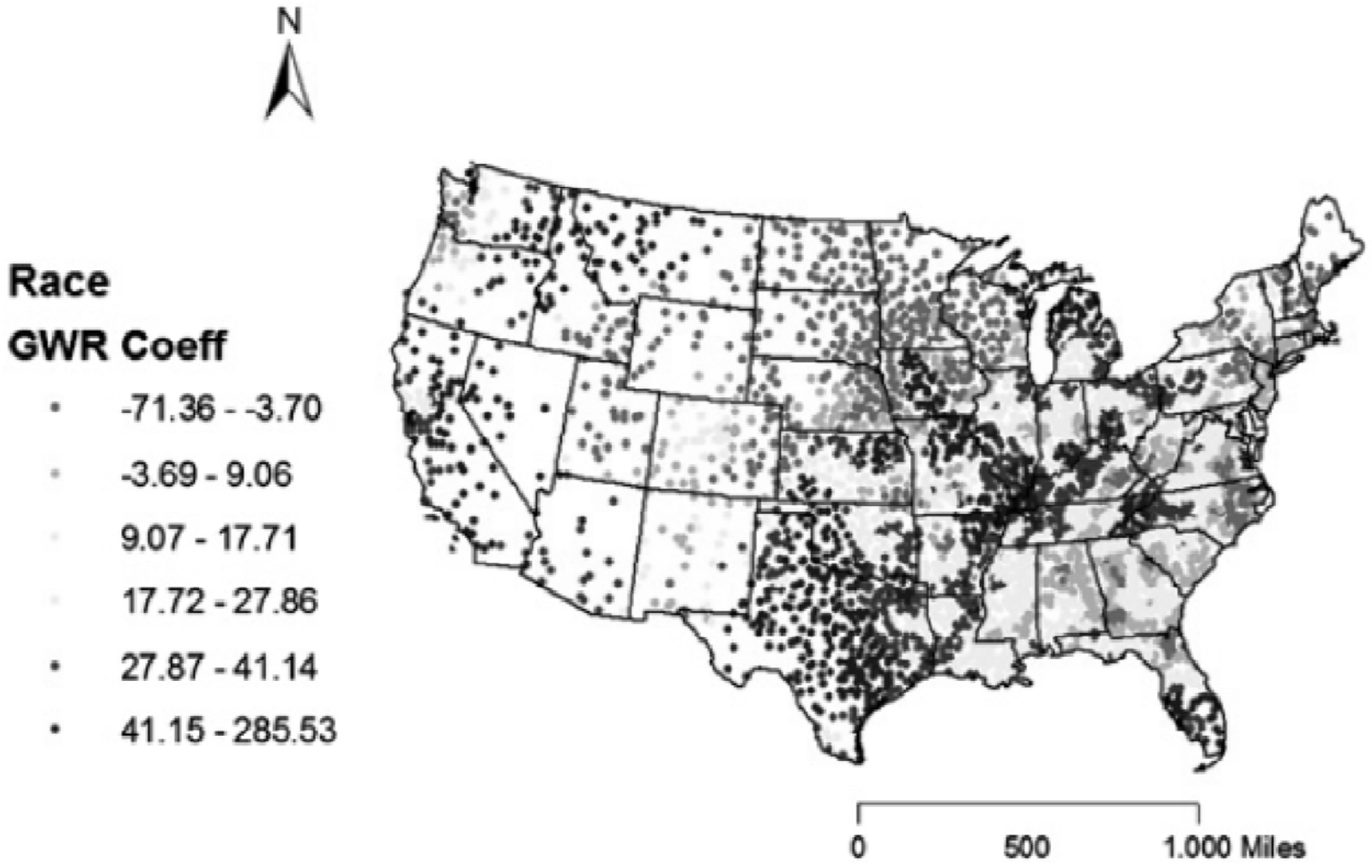
- Most policy interventions are implemented for a specific jurisdiction and these are often geographically defined
  - VAMC, VISN, state
- Geographic entities become convenient units for evaluating the impact of policies
  - intervention versus control units
  - E.g., impact of state-level Medicaid policies on veterans' use of VHA services
- Approaches
  - Geographically Weighted Regression
  - Conditional Autoregressive Models

Geographically Weighted Regression

- Version of “multi-level” or “mixed” modeling where regression coefficients vary across sub-groups in the population
  - Coefficients vary with geographic units in GWR

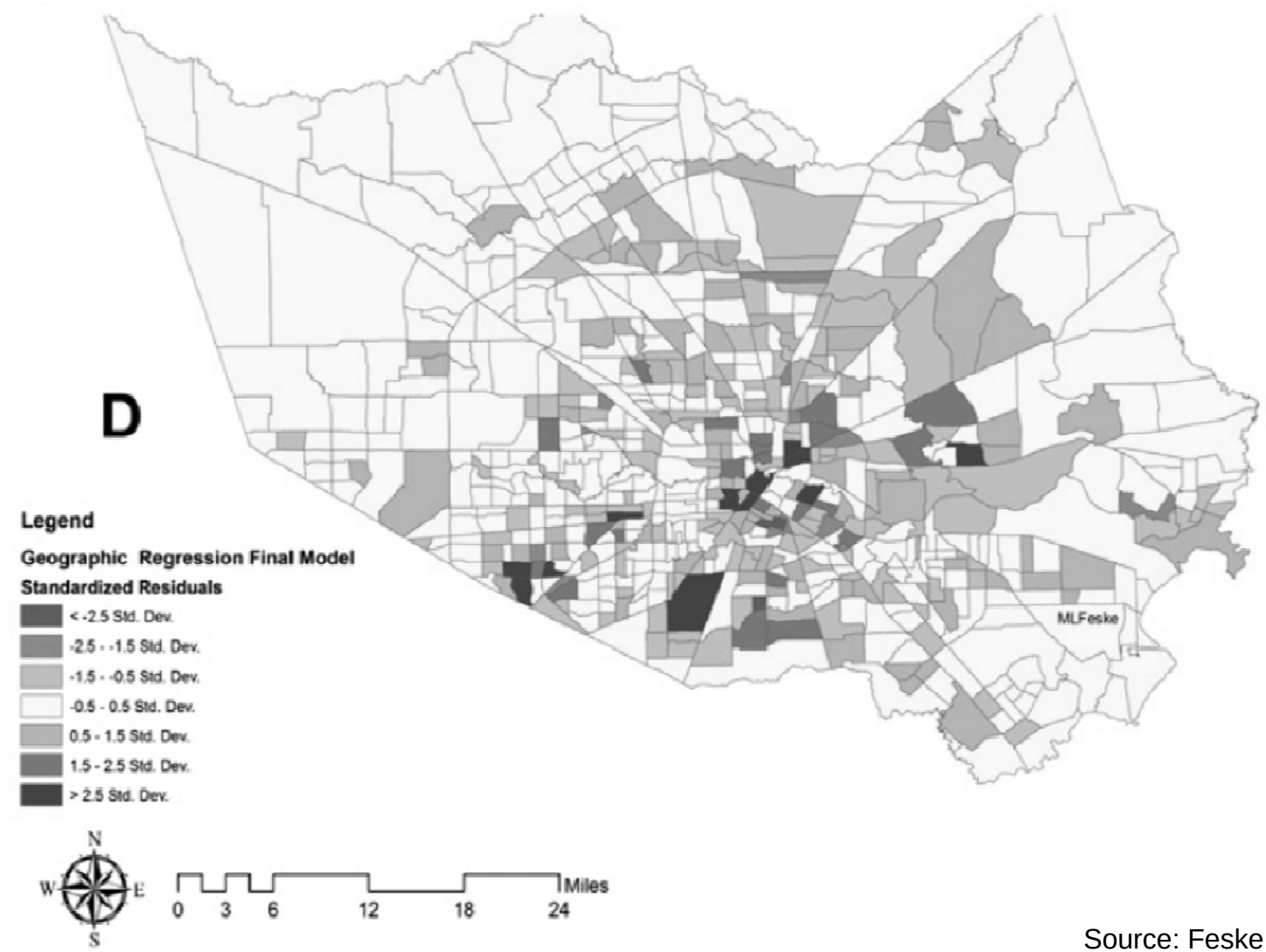
- GWR allows the investigator to model “tailoring” factors that may optimize the implementation of interventions
  - E.g., neighborhood variation in racial/ethnic composition, socio-economic status
- GWR also facilitates evaluation of spatial variation in the impact of an intervention
  - Spatial analysis of regression model residuals

Effect of Race on CHD Mortality



Source: Gebreab and Diez Roux, 2012

GWR hotspots for TB in Houston, TX



Source: Feske et. al., 2011

Summary

- Geography plays a prominent role in implementation
  - Often receives little consideration however
- There are a host of “off-the-shelf” tools
  - SatScan: www.satscan.org (freeware)
  - P-median java applet: http://www.hyuan.com/java/
  - GWR SAS macro:
    - Chen VY and Yang TC. SAS macro programs to geographically weighted generalized linear modeling with spatial point data: applications to health research, *Computer Methods and Programs in Biomedicine* 2012;107:262-273
  - ArcGIS

Using Spatial Analysis Tools in Implementation Science

Diane C. Cowper Ripley, PhD

Overview: Two Examples

- Access to Acute Stroke Care in VHA
  - RRP (PIs: Glenn Graham, Huanguang Jia)
- Expansion of Telehealth
  - Office of Rural Health

Example 1: Acute Stroke Care

- The National Institute of Neurologic Disorders and Stroke and Advanced Cardiac Life Support guidelines recommend "door to treatment" of one hour for persons who are candidates for thrombolytic therapy
- The most commonly used drug for thrombolytic therapy is tissue plasminogen activator (tPA)
- Timely and effective tPA administration after stroke onset can improve patient survival, limit functional deficits, and improve quality of care
- **Time lost is brain lost**

Objectives

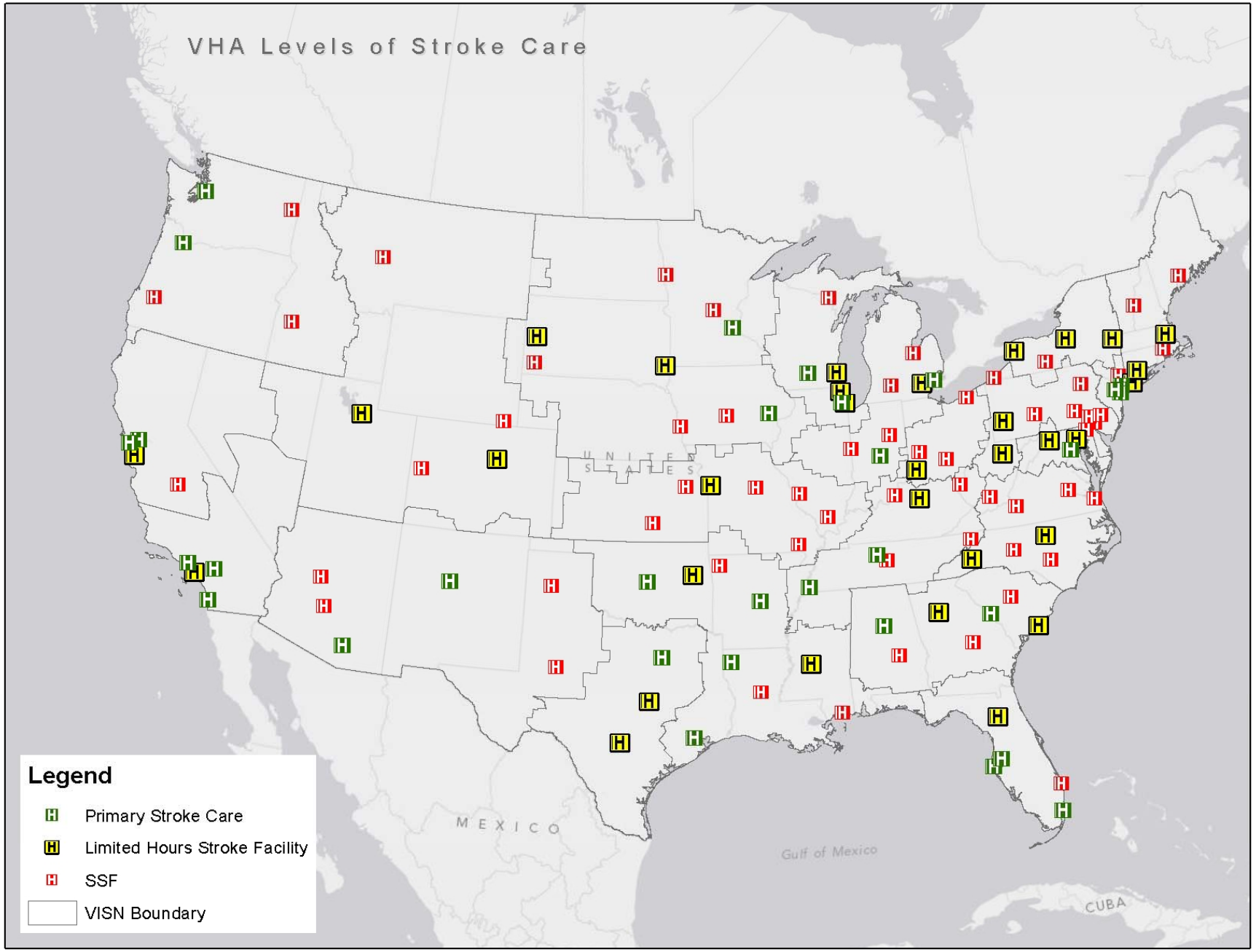
- We wanted to get a look at the big picture of acute stroke care within the VHA
  - Look at both ischemic and hemorrhagic stroke
  - Travel time analysis to acute stroke care (shorter travel time=better patient outcomes)
    - **60 Minutes to stroke care was the bench mark in this study**
  - Partnership with Non-VHA entities to reduce overall travel time to obtain acute stroke care

Methods

- Identify VHA patients with acute stroke by ZIP code for FY06-FY10
  - Used ICD-9 Codes 431-437
  - Aggregated patient locations up to the ZIP code level
- Identify VHA facilities that have specialized stroke care
- Identify Non-VA stroke center locations
- Draw travel times around all VHA and Non-VA stroke care locations

Methods (cont.)

- From the VACO (VA Central Office) Neurology Office - 113 VHA facilities could deliver 3 different levels of stroke care
  - Primary Stroke Care (PRC) *30 VHA locations
    - 24/7/365 stroke care
  - Limited Hours Stroke Care (LHSC) *28 VHA locations
    - 9-5 M-F stroke care
  - Supporting Stroke Facility (SSF) *55 VHA locations
    - Limited resources for stroke care
- From VACO identified 1074 Non-VA stroke care centers across the nation

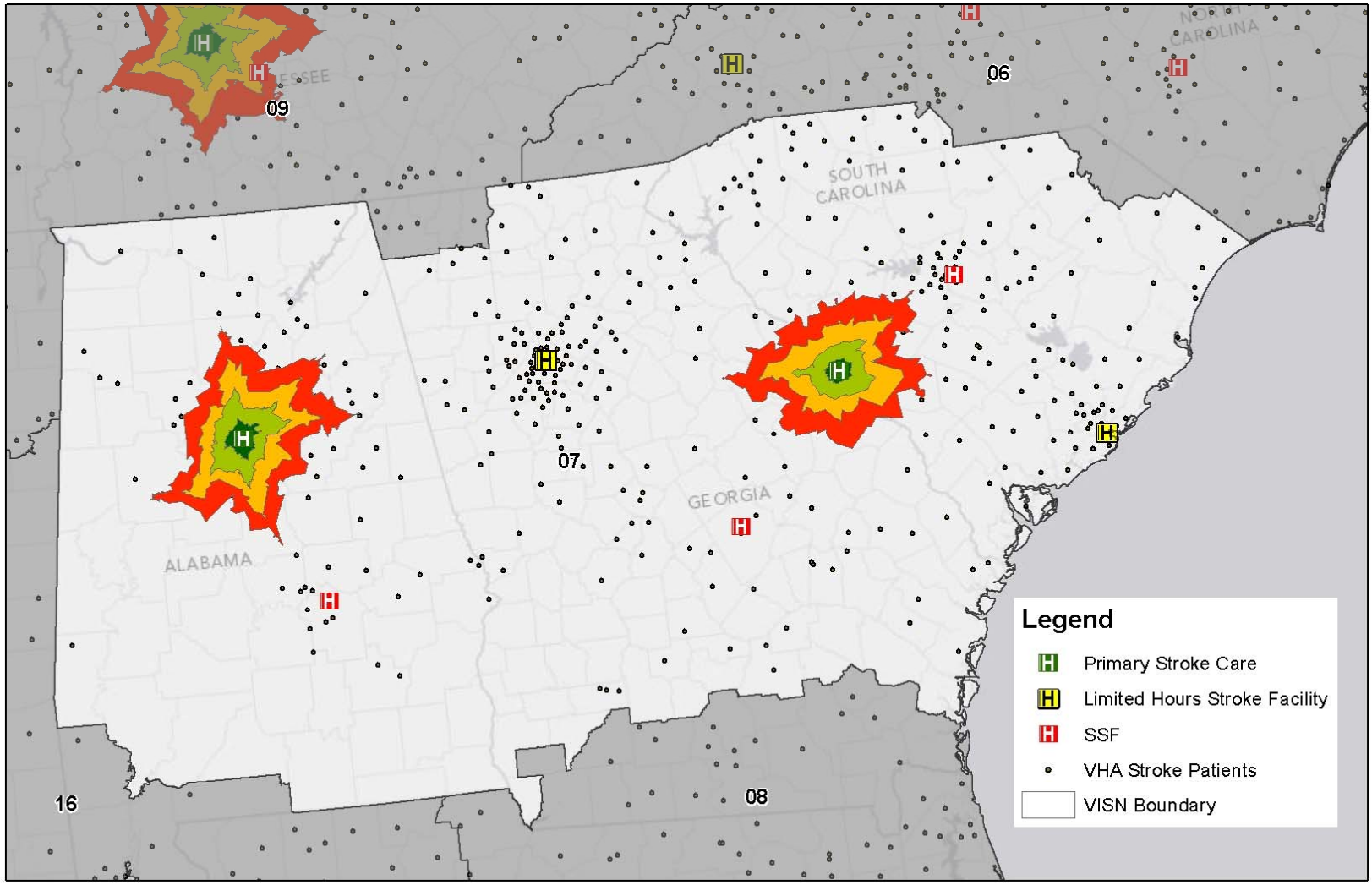

VHA Levels of Stroke Care
Legend
Primary Stroke Care
Limited Hours Stroke Facility
SSF
VISN Boundary
MEXICO
Gulf of Mexico
CUBA

Scenarios

- Stroke coverage – current
  - Scenario 1 (upgrading 1 Limited Hours facility)
  - Scenario 2 (Maximum VA capacity)
  - Scenario 3 (VA Stroke Centers + top 3 non-VA Stroke Centers)
  - Scenario 4 (Maximum VA + Non-VA Capacity)
  - Example is for VISN 7, but can be done in all VISNs
    - 742 patients with stroke FY06-FY10

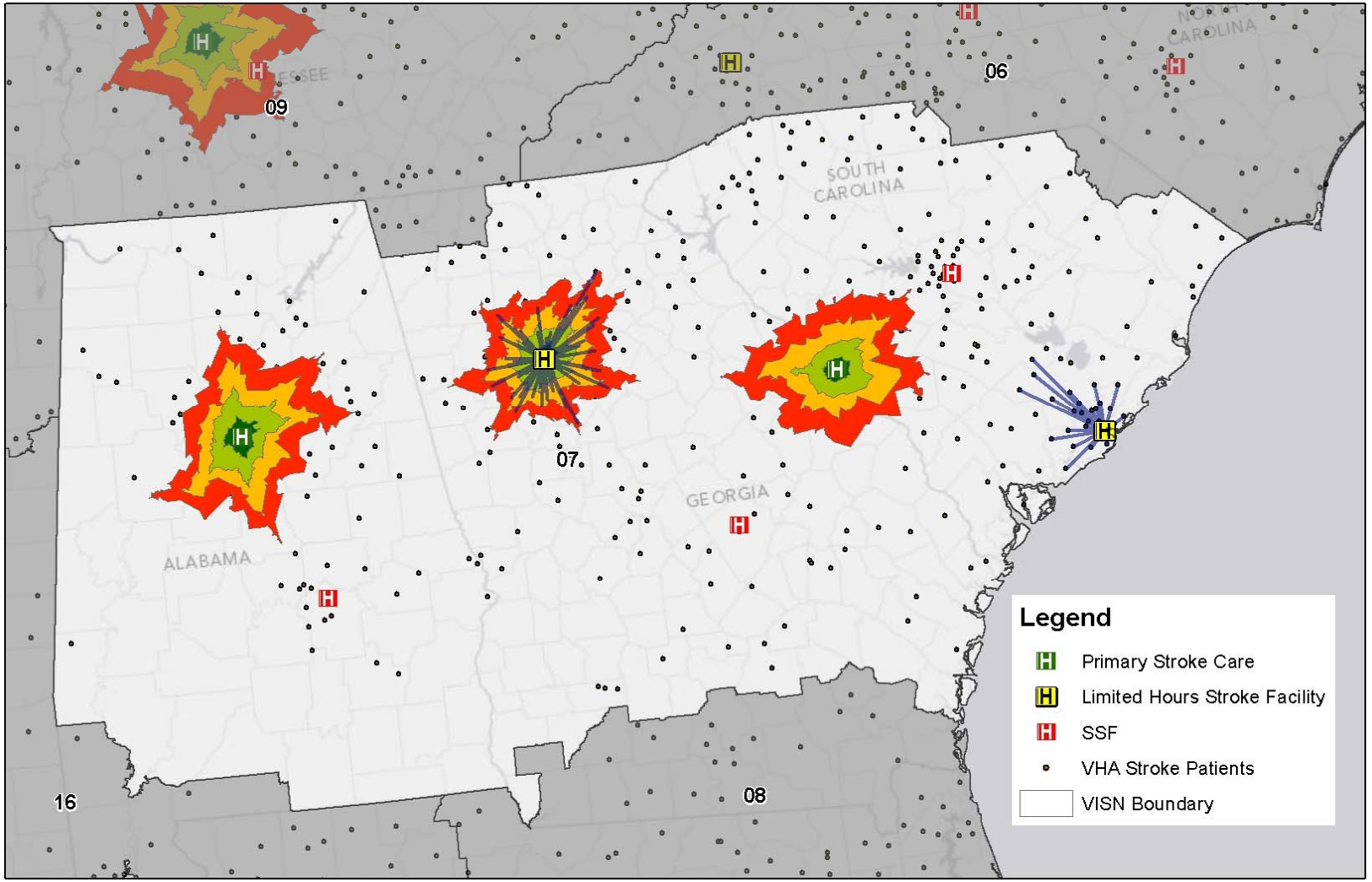
136 (18.3%)

60 Minute Travel Time Around VHA Primary Stroke Care
Veterans Integrated Service Network 7



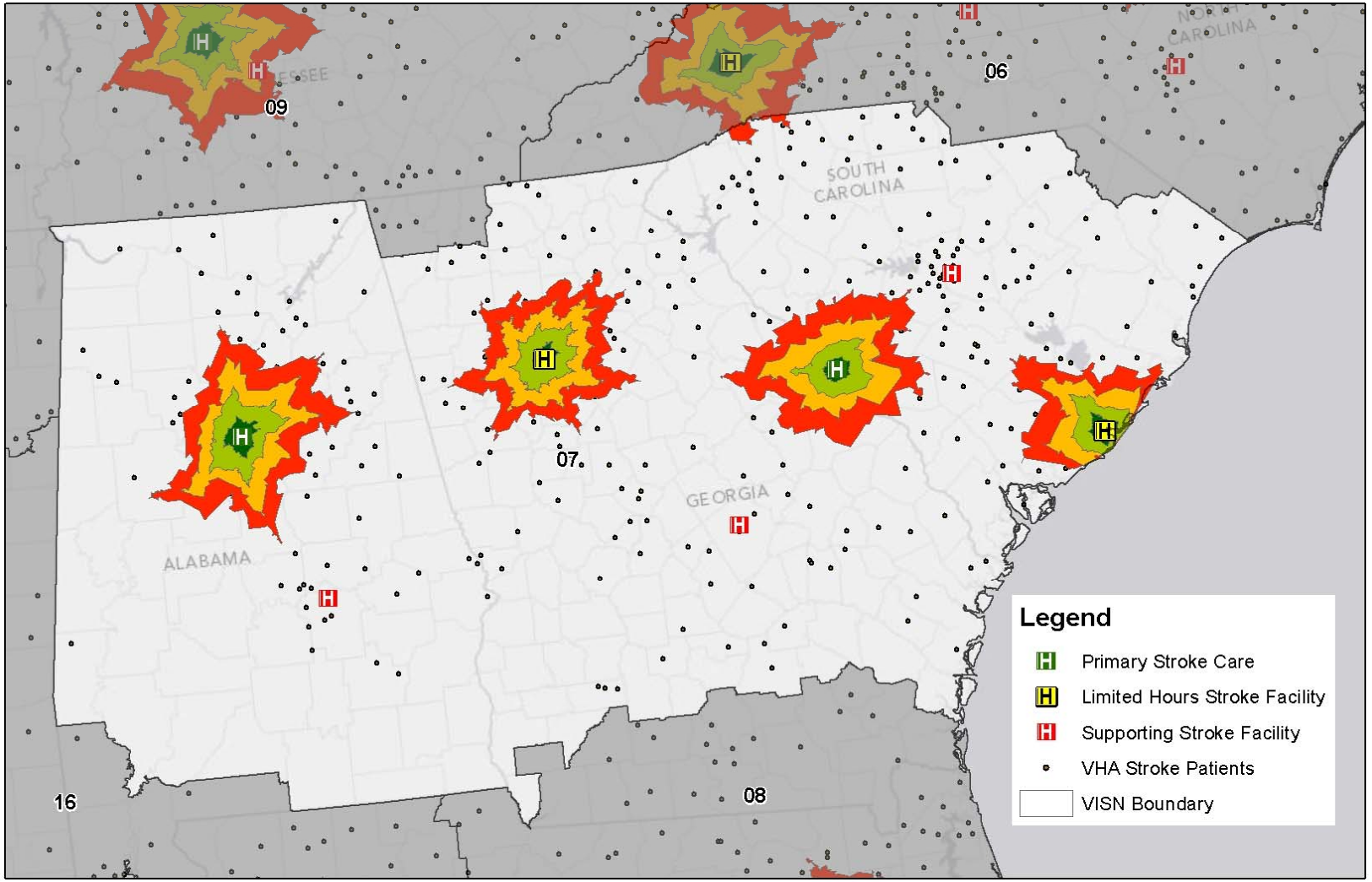
273 (36.8%)

60 Minute Travel Time Around VHA Primary Stroke Care
Veterans Integrated Service Network 7

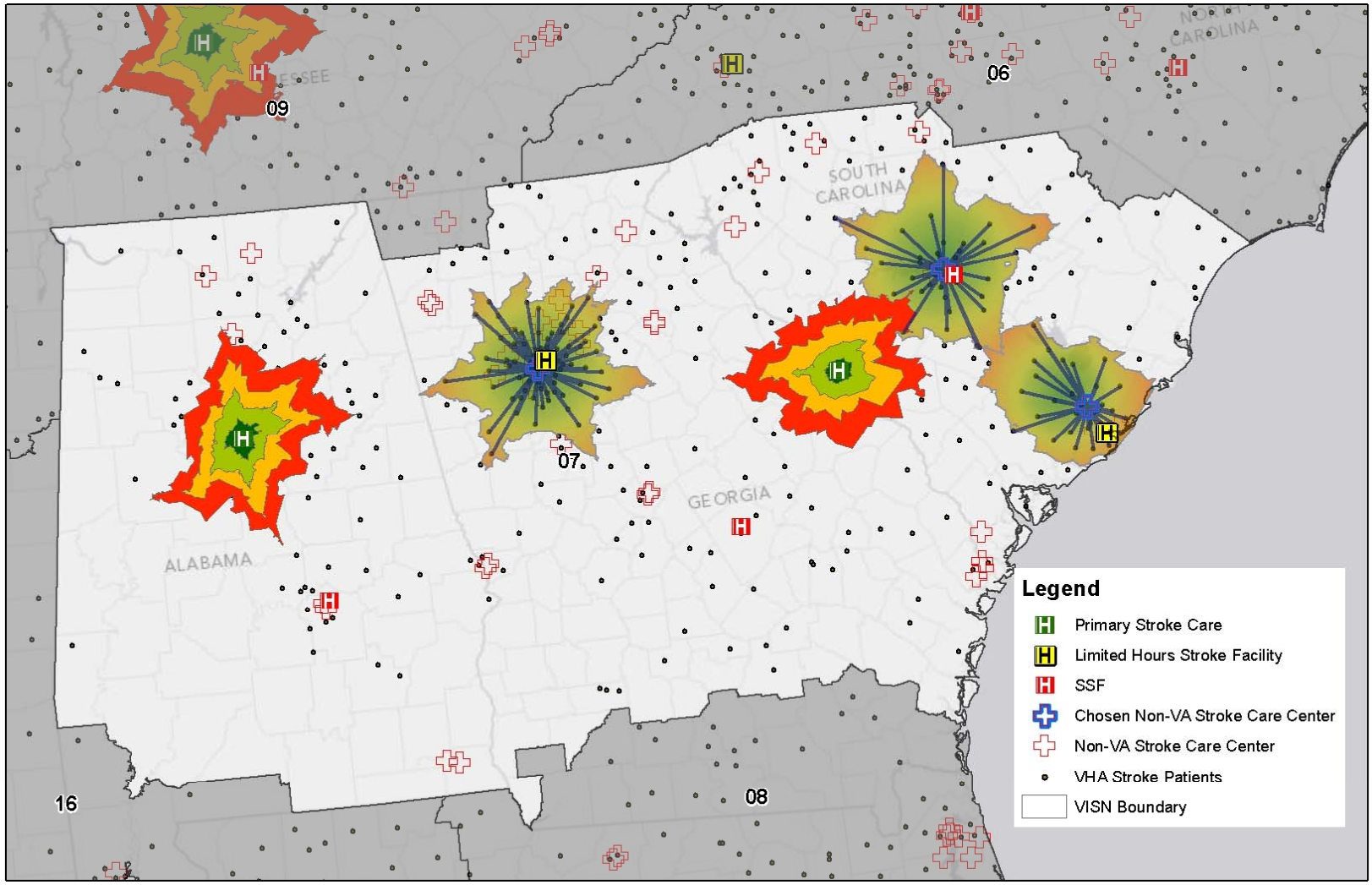


339 (45.7%)

60 Minute Travel Time Around VHA Primary Stroke Care and Limited Hours Stroke Facilities (Maximum VA Capacity) Veterans Integrated Service Network 7

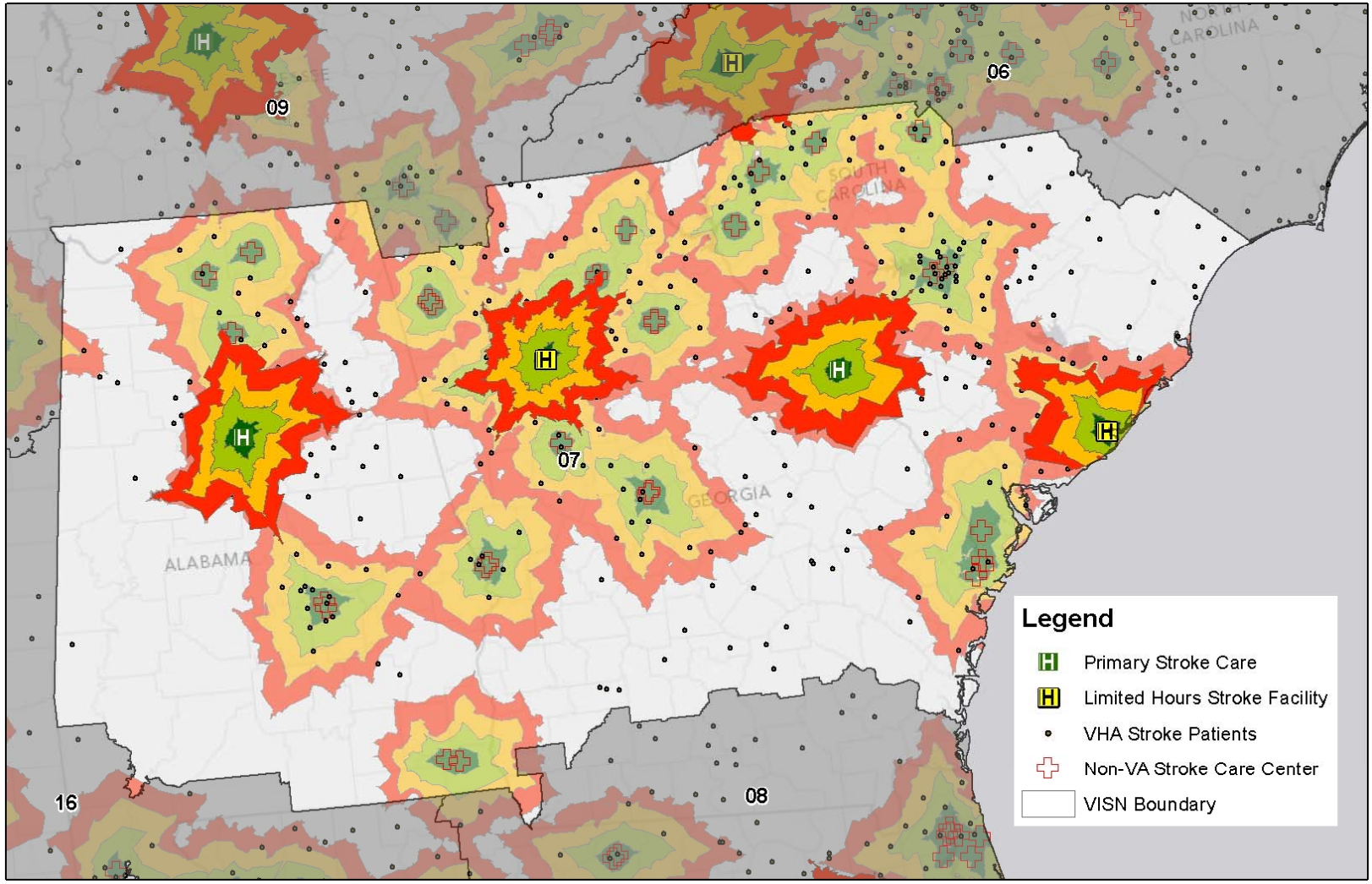


60 Minute Travel Time Around VHA Primary Stroke Care and 60 Minute Travel Time Around Top Three Choices of Non-VA Stroke Care Center Veterans Integrated Service Network 7



615 (82.9%)

60 Minute Travel Time Around VHA Primary Stroke Care, VHA Limited Hours Stroke Facilities and Non-VA Stroke Care Facilities (Maximum Capacity in VISN) Veterans Integrated Service Network 7



Coverage Under Different Scenarios

- Baseline: 136 (18.3%)
- Scenario 1 (upgrading 1 VAMC): 273 (36.8%)
- Scenario 2 (Maximum VA capacity): 339 (45.7%)
- Scenario 3 (VA Stroke Centers + top 3 non-VA Stroke Centers): 303 (40.8%)
- Scenario 4 (Maximum VA + Non-VA Capacity): 615 (82.9%)

Implications

- Facilities and patients are not distributed the same in all VISNs
- GIS can help identify access gaps to specialty care
- Assist in "build or buy" decisions
- Show current maximum capacity in VISN
- Assist in where new tele-specialty CBOCs would be most beneficial

Example 2: Broadband Coverage

- Expansion of Telehealth in VHA
  - VAMC to CBOC
  - VAMC to Patients' Home
  - CBOC to Patients' Home
- Move care closer to where rural Veterans reside
- Office of Rural Health

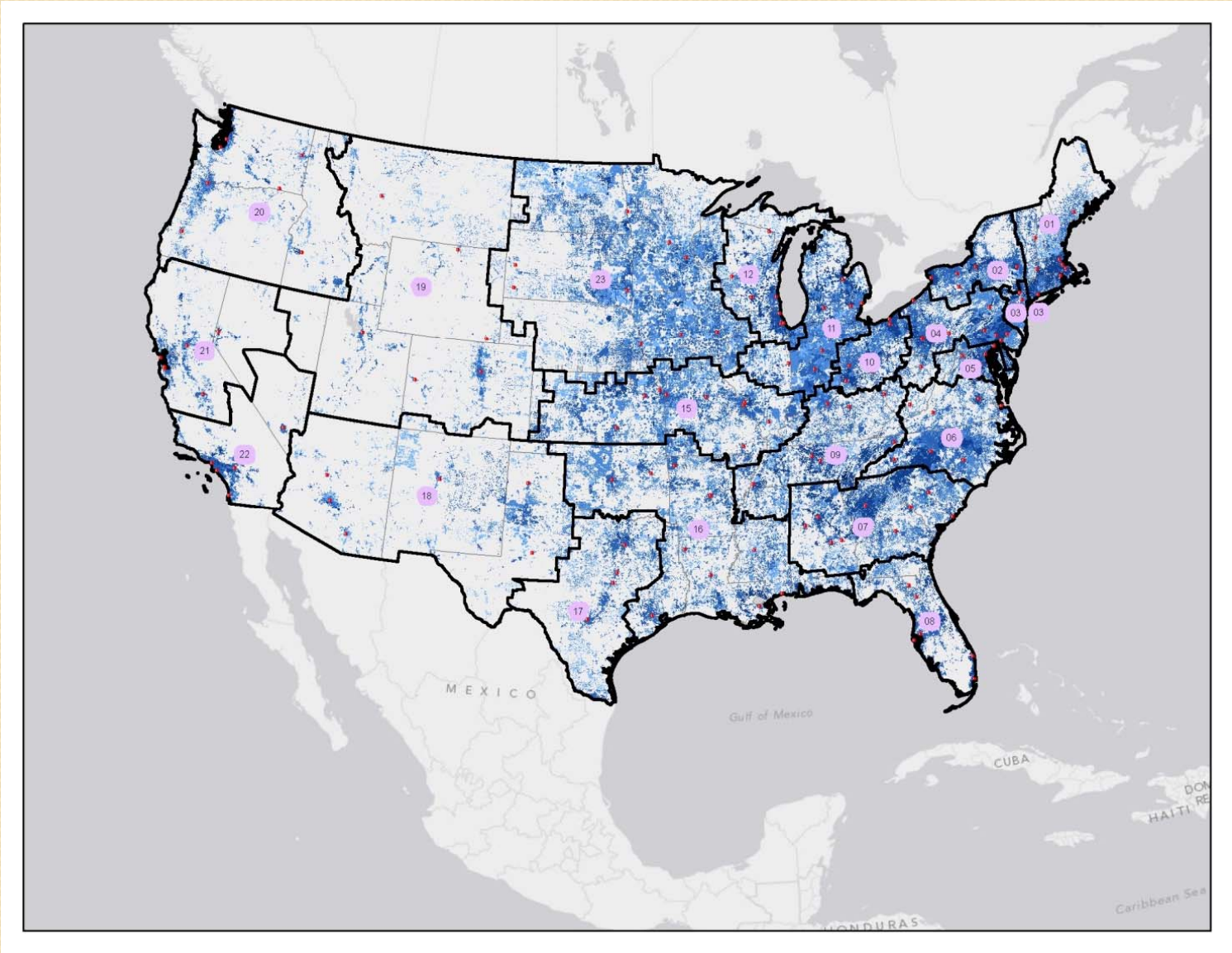
Broadband Coverage

- Assemble database
- The National Broadband Map is a tool to search, analyze and map broadband availability across the United States.
  - Created and maintained by the NTIA, in collaboration with the FCC, and in partnership with 50 states, five territories and the District of Columbia.

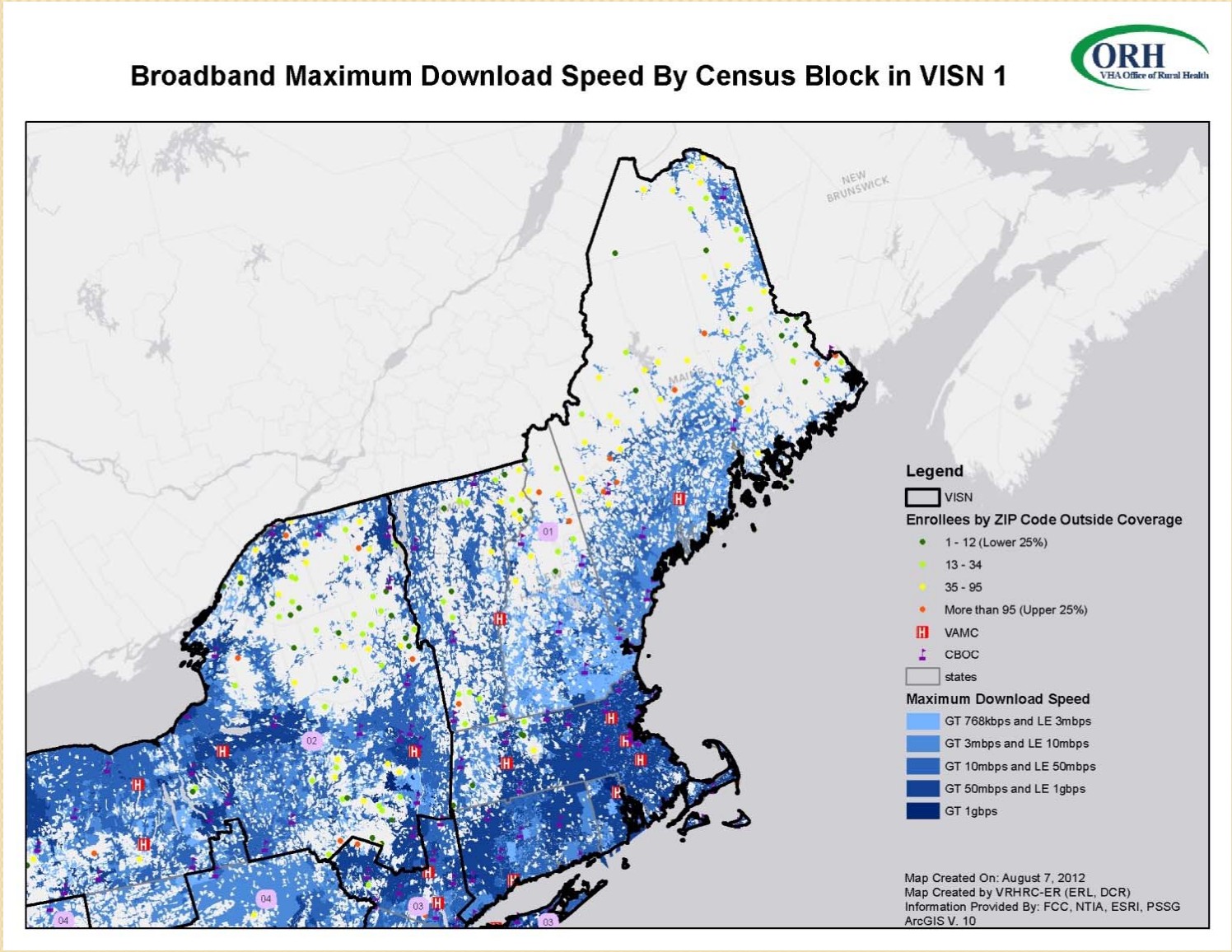
Broadband Coverage

- Downloaded data from http://www.broadbandmap.gov/data-download
- National shape file not available, so downloaded and merged each state file
- Mapped national coverage
- Mapped VISN coverage
- Identified enrollees outside of coverage

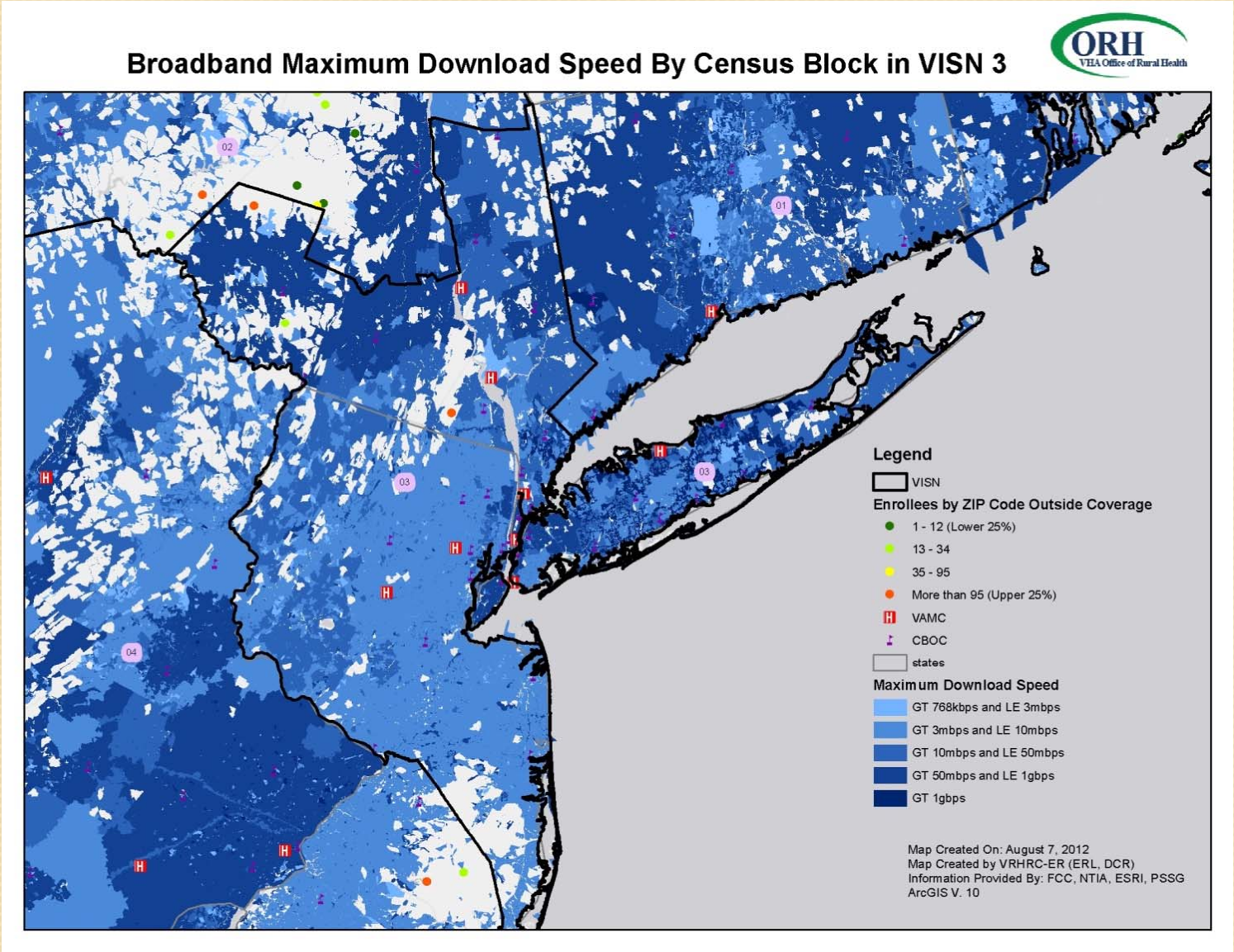
BROADBAND COVERAGE - NATIONAL



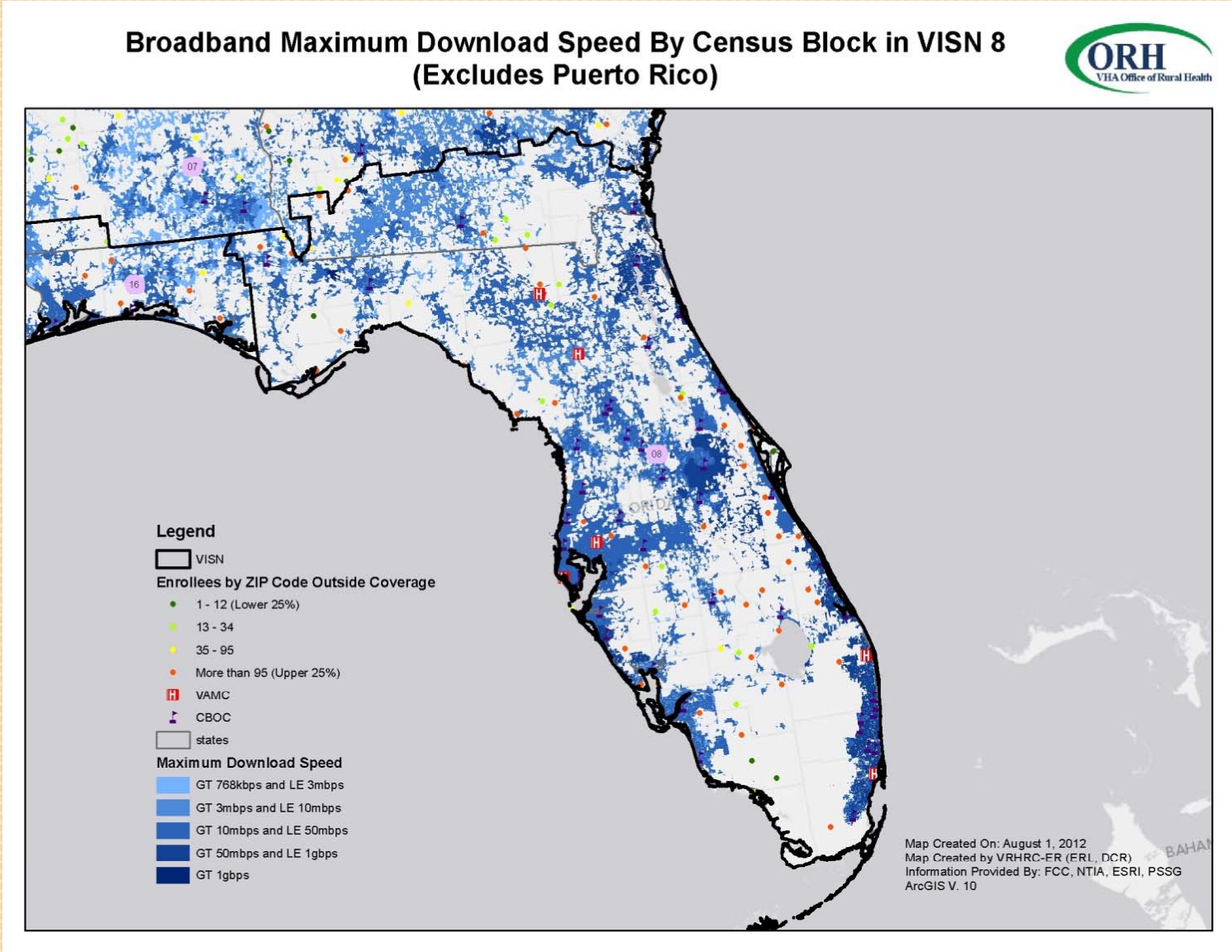
Broadband Coverage – VISN 1



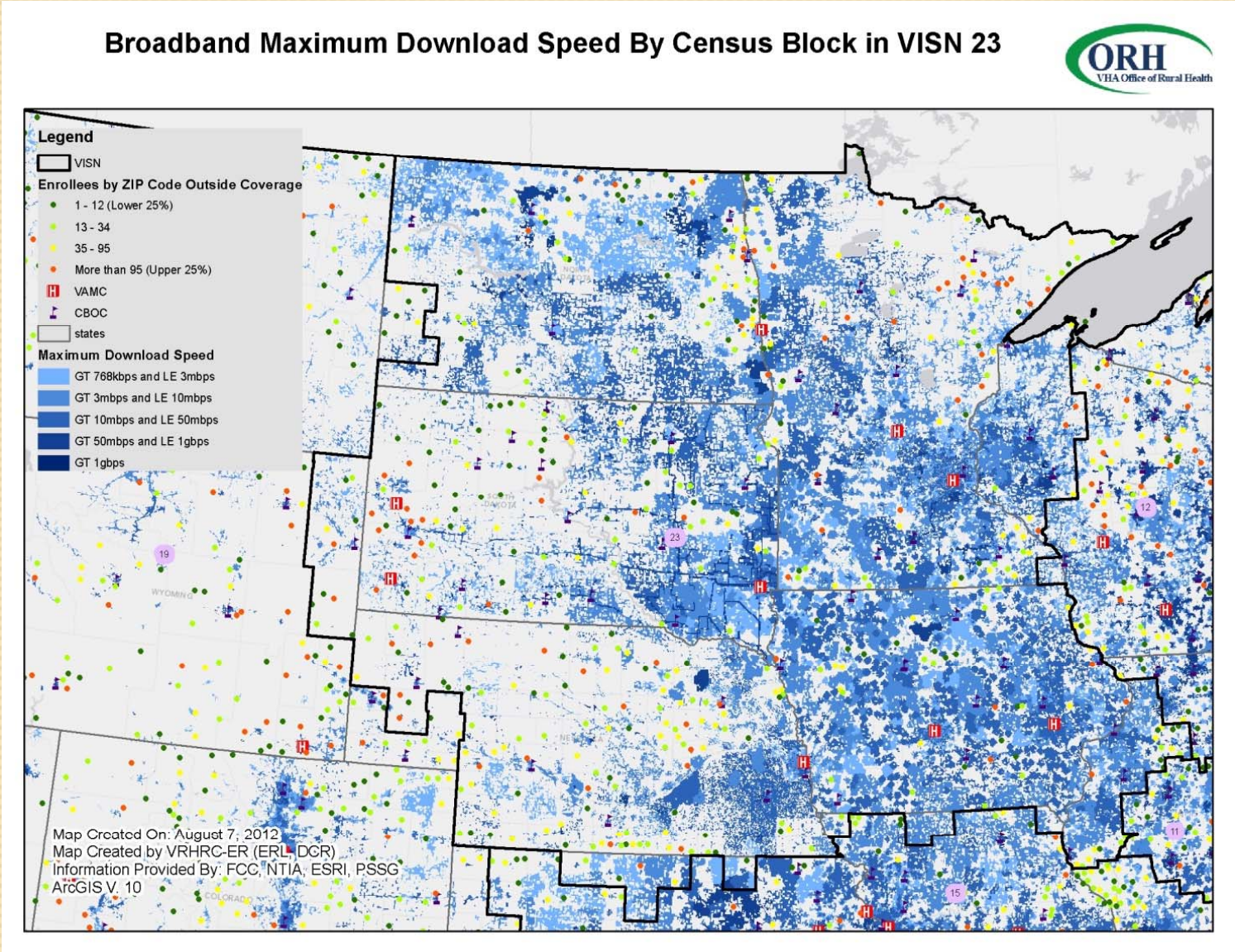
Broadband Coverage – VISN 3



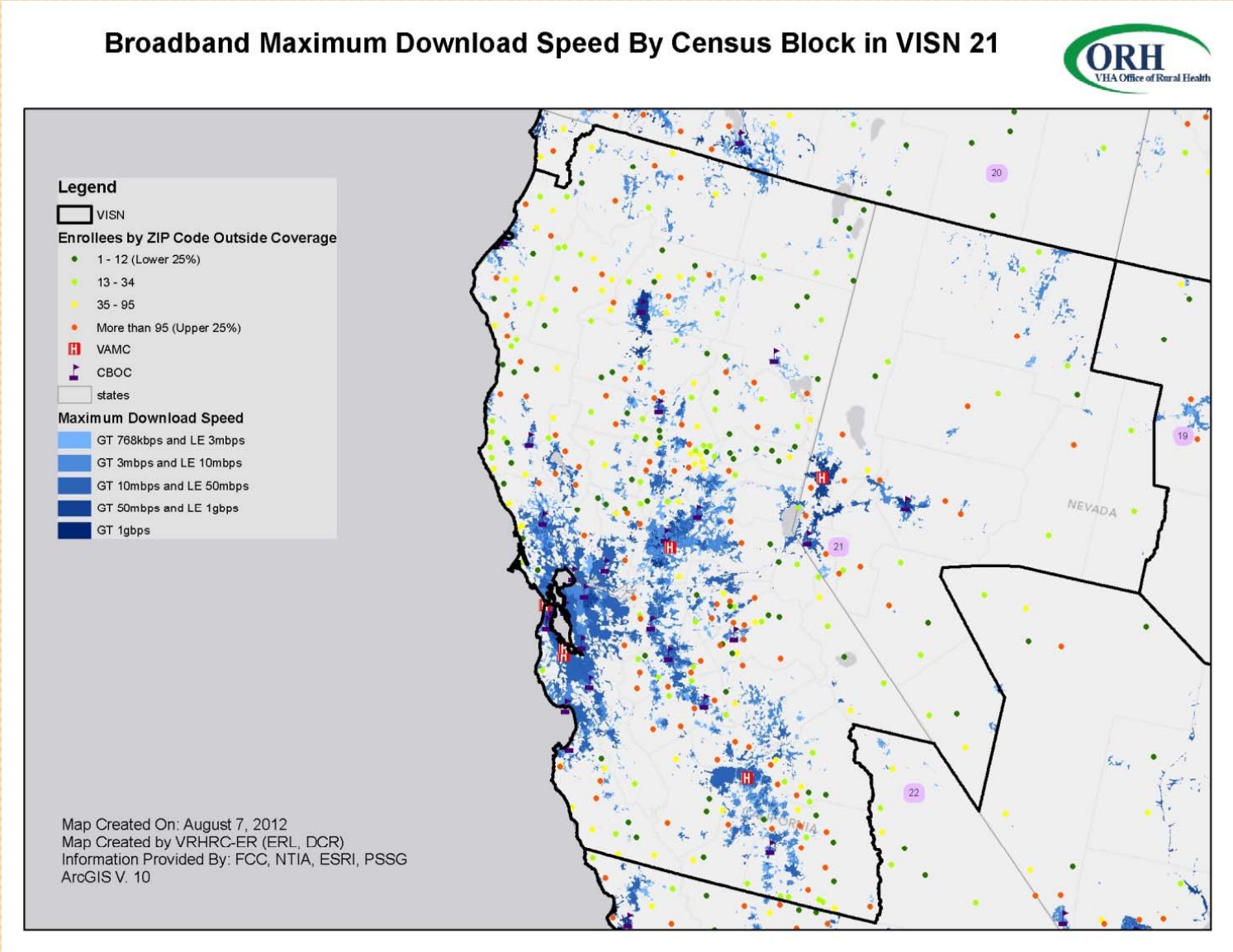
Broadband Coverage – VISN 8



Broadband Coverage – VISN 23



Broadband Coverage – VISN 21



Implications

- May have a tele-medicine program that shows promise in pilot phase
- To roll out, need to see if roll out is even feasible
- GIS can help with understanding spatial capacity for new technology
- In addition to broadband, have also downloaded and can map wireless coverage

Contact Information

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VA GIS Users Group

- VA GIS Users Groups includes employees from across the VA, not only in VHA
- SharePoint: http://vaww.dwh.cdw.portal.va.gov/Regions/gis/SitePages/Home.aspx
- GIS Day is November 14 – This year VA is participating… join us!

Questions?