Exploring and regionalizing geographic distributions of rare causes of mortality

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Purpose:

- Experiment with different spatial and population weighting techniques that can be used to create both comprehensible maps and meaningful regions from county level data.
- Use spatial autocorrelation techniques to evaluate statistically the resulting maps and regions.

In this presentation…

- I will use two publicly available programs Head-Bang and GeoDa.
- The county rates/events (mortality) will be laryngeal cancer and silicosis, 1995-2004. Those 25 years and older comprise the study population. The data are from the NCHS Compressed Mortality Files (1989-1998, 1999-2004).

Learning Objectives:

- Identify smoothing and borrowed strength methods used in exploring spatially referenced data.
- Discuss global and local spatial autocorrelation techniques and their role in cluster delineation.
- Recognize the role of dependence, scale, and spatial context in regionalizing mortality.

Purpose of Regionalizing Mortality:

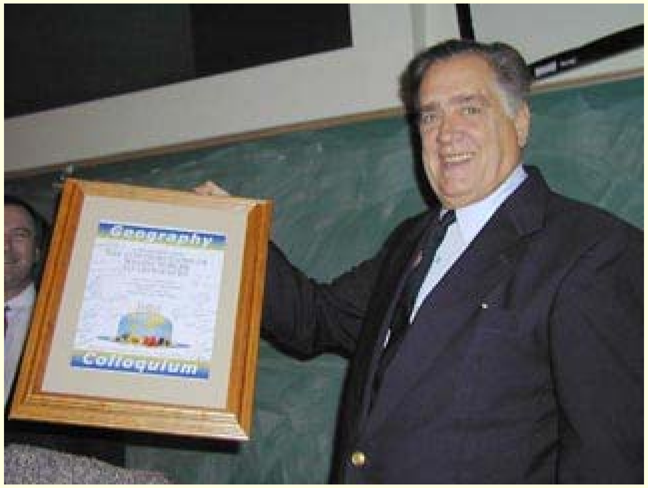
- Focusing our attention and resources on the problem.
  - financial and human resources, education, policy

- Formulating hypotheses about associations, causes, and etiology.
  - social, biological, and physical determinants

Methods used to create regions:

- Filtering and Smoothing (reducing noise, increasing stability).
    - aggregating spatially and temporally
    - borrowing strength

- Identification of statistical and visual clusters (determining similarity and relatedness).
    - global spatial autocorrelation
    - local spatial autocorrelation



Waldo Tobler’s First Law of Geography:

"Everything is related to everything else,
but near things are more related than distant things." [Tobler, 1970, p.236]

TOBLER, W. R. (1970). "A computer model simulation of urban growth in the Detroit region". Economic Geography, 46(2): 234-240.

Implications?

- Scale, Dependency, and Context:
  - processes occur at different scales
  - degree of thematic similarity among spatial units of analysis will vary with S-T distance
  - continuous or discontinuous process?
  - smaller spatial units more thematically homogeneous than larger ones

Smoothing and Borrowed Strength

- Why?
  - noisy (choropleth) maps as a result of small numbers or inappropriate (S-T) scale of analysis
  - smoothing enables better discernment of patterns, if any

- How?
  - change S-T scale of analysis by aggregating over spatial and/or temporal units
  - use or <u>borrow</u> external information to get closer to a “true” value

- The Price?
  - aggregation can cause information loss, increases heterogeneity (and can affect associations among variables if modeling)
  - borrowing strength can increase dependency among spatial units and change interpretation as it relates to scale

- The Benefit?
  - with increased spatial dependency the scope and scale of a region may be more effectively delineated, especially with rare occurrences

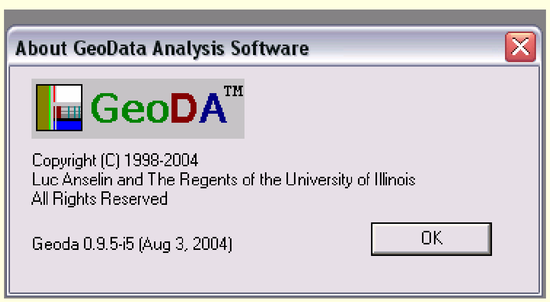
For smoothing choroplethic maps of rare causes of mortality:

Headbang

Non-parametric smoothing using neighboring median values and population weights.

Hansen, Simonson,and Statistical Research and Applications Branch, NCI. Headbang software (srab.cancer.gov/headbang) version 3.

GeoDA



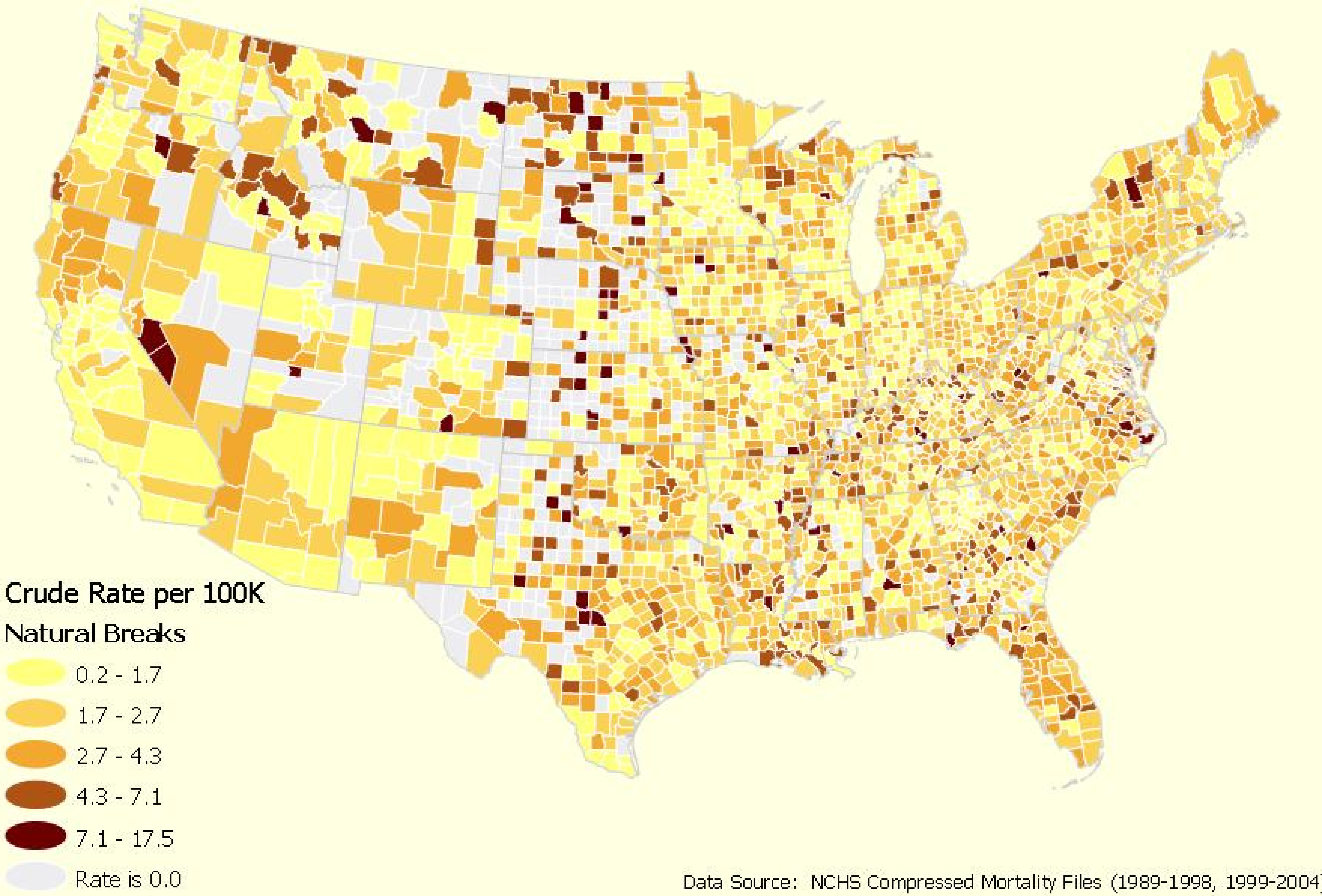
An exploratory geographic data analysis program: using spatial empirical bayes

Spatial Autocorrelation

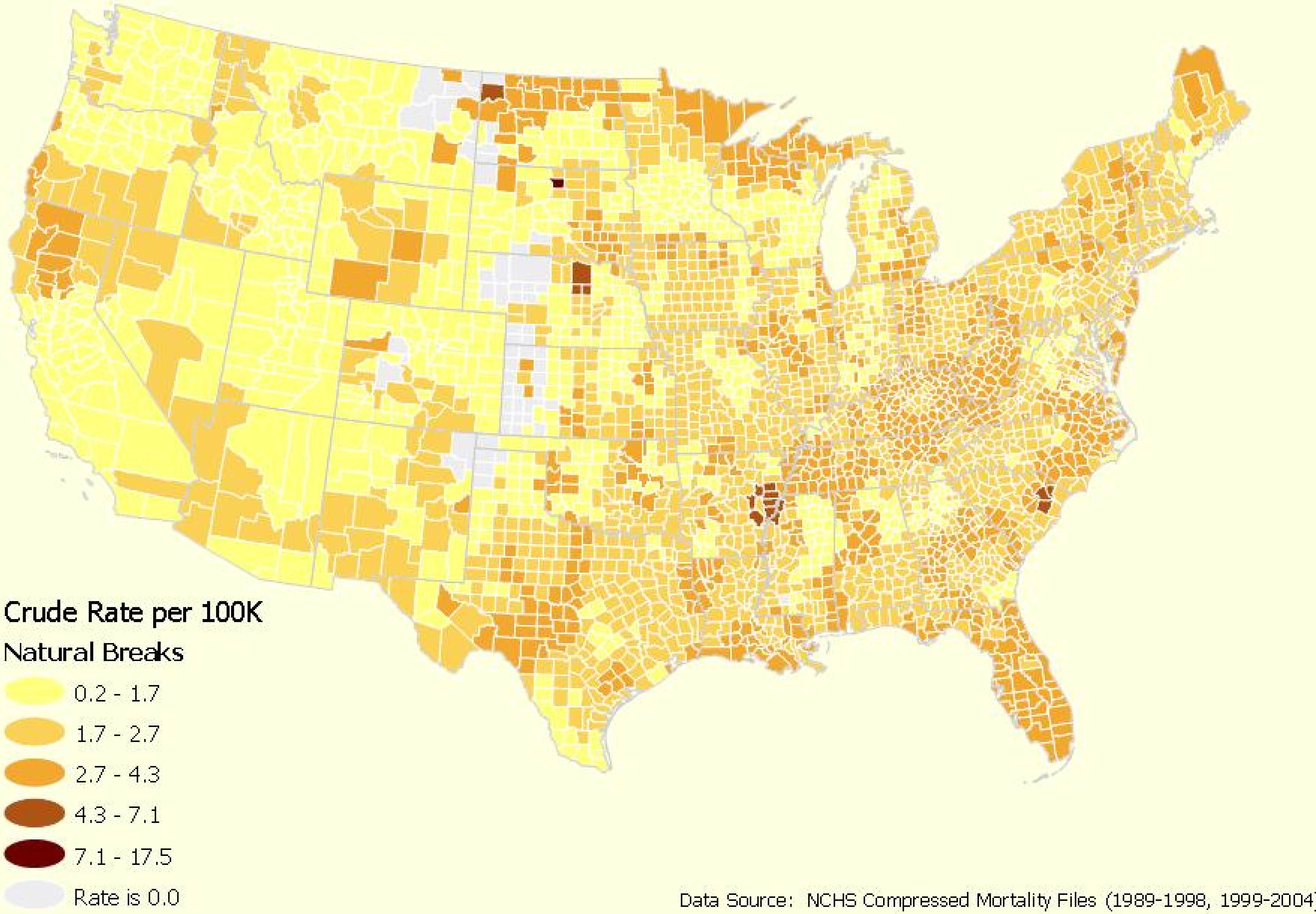
- Why?
  - measures the degree of relatedness of values (observed or smoothed) based on spatial relationships
  - many different methods provide some sort of statistical evaluation of the relationships
- Global
  - determines if there is positive (clustered), negative (checkerboard), or no spatial autocorrelation (Moran's I or Getis-Ord's General G)
  - can be used to measure the effects of smoothing, assessing dependence—useful for modeling where the assumption of independence of spatial units of observation is assumed
- Local
  - determines and locates clusters statistically based on spatial and thematic attributes
  - can be used to locate, measure, and delineate the type of clustering occurring (Local Moran's I (LISA) or Hot Spot/Getis-Ord Gi*)

Note: LISA (univariate) from GeoDA will be used in this presentation. "I" is a measure/statistic of similarity or likeness—recall the first law of geography.

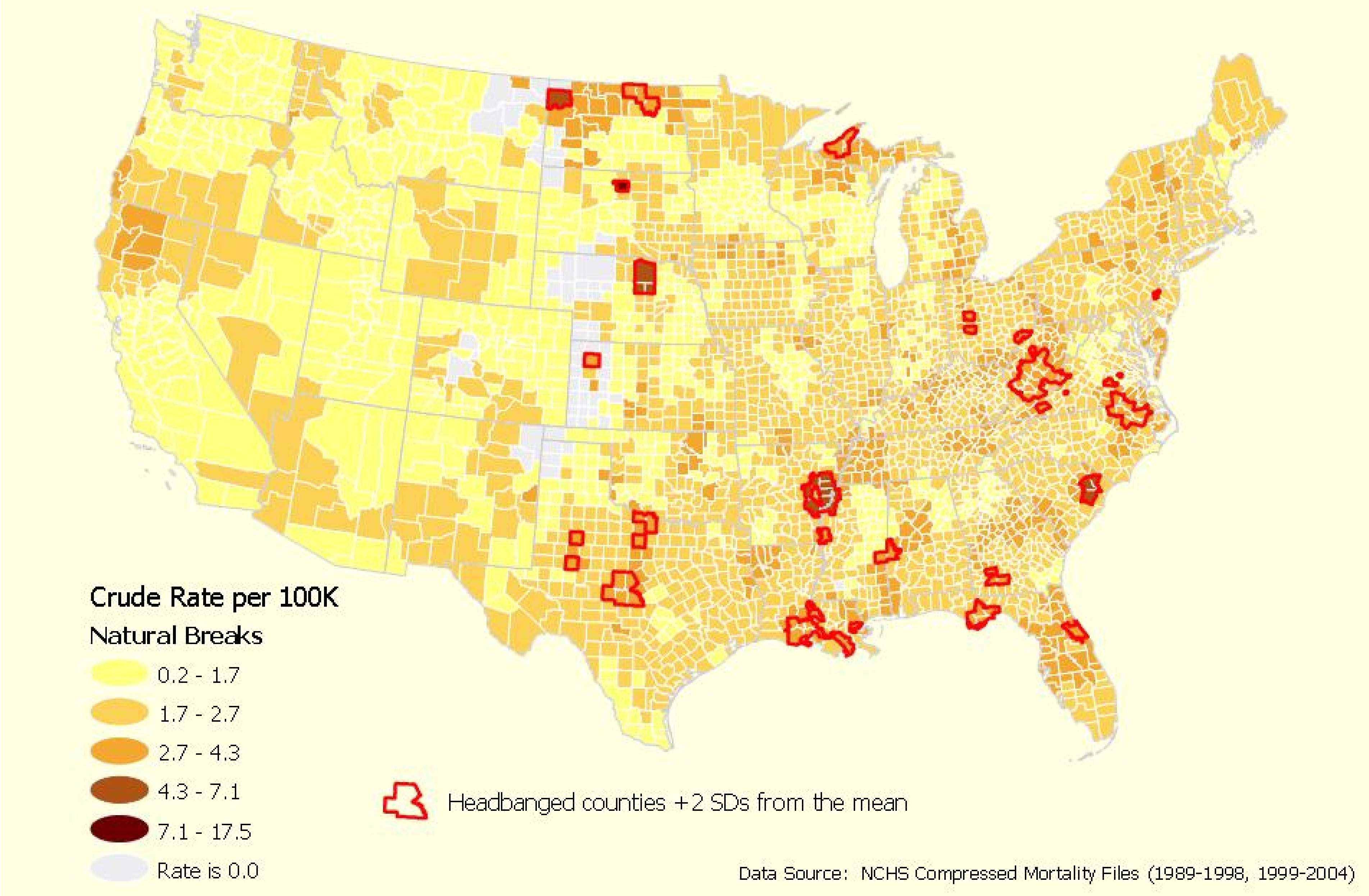
Observed Laryngeal Cancer Mortality 95-04



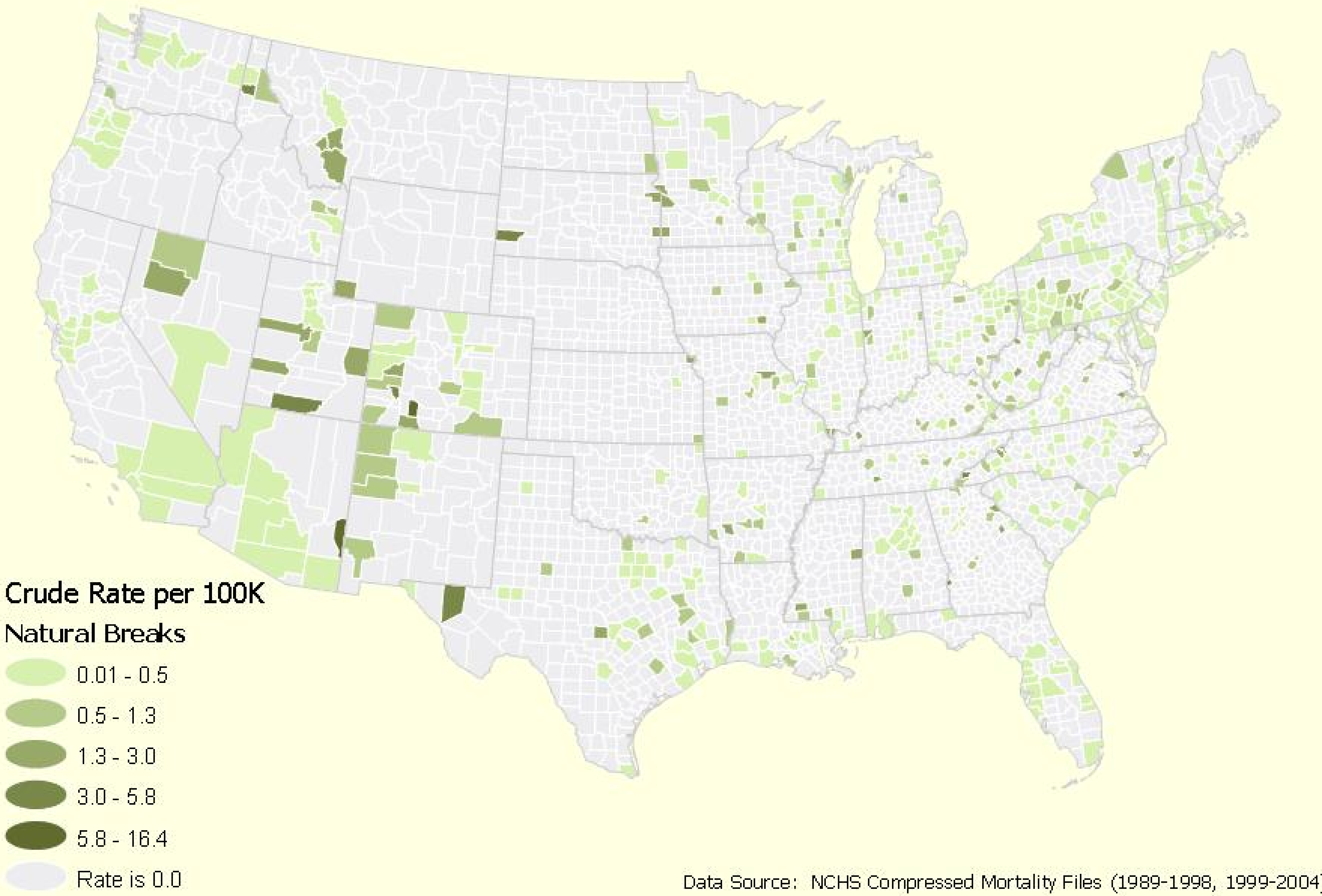
Head-Banged Laryngeal Cancer Mortality 95-04

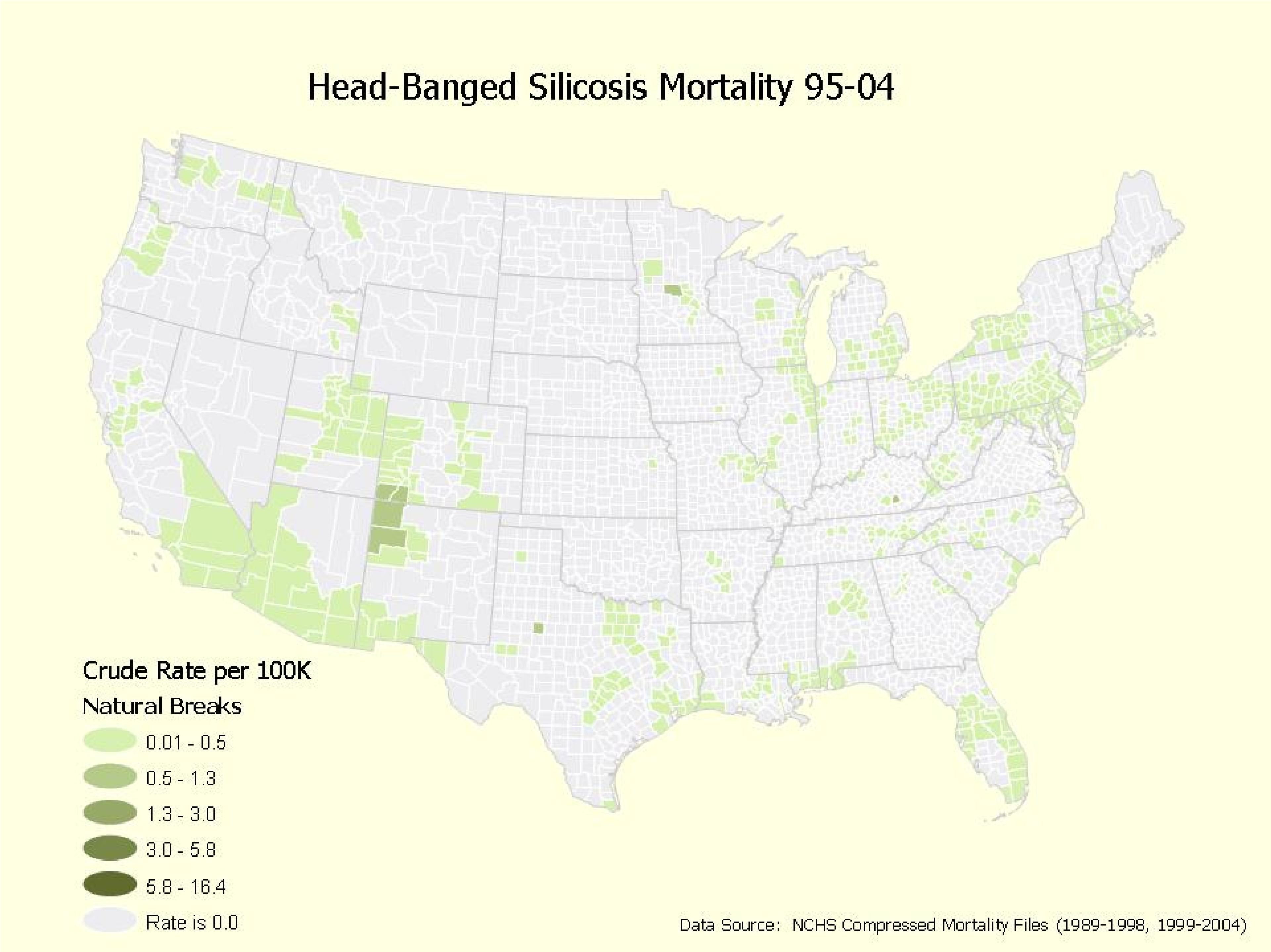


Head-Banged and Regionalized Laryngeal Cancer Mortality 95-04

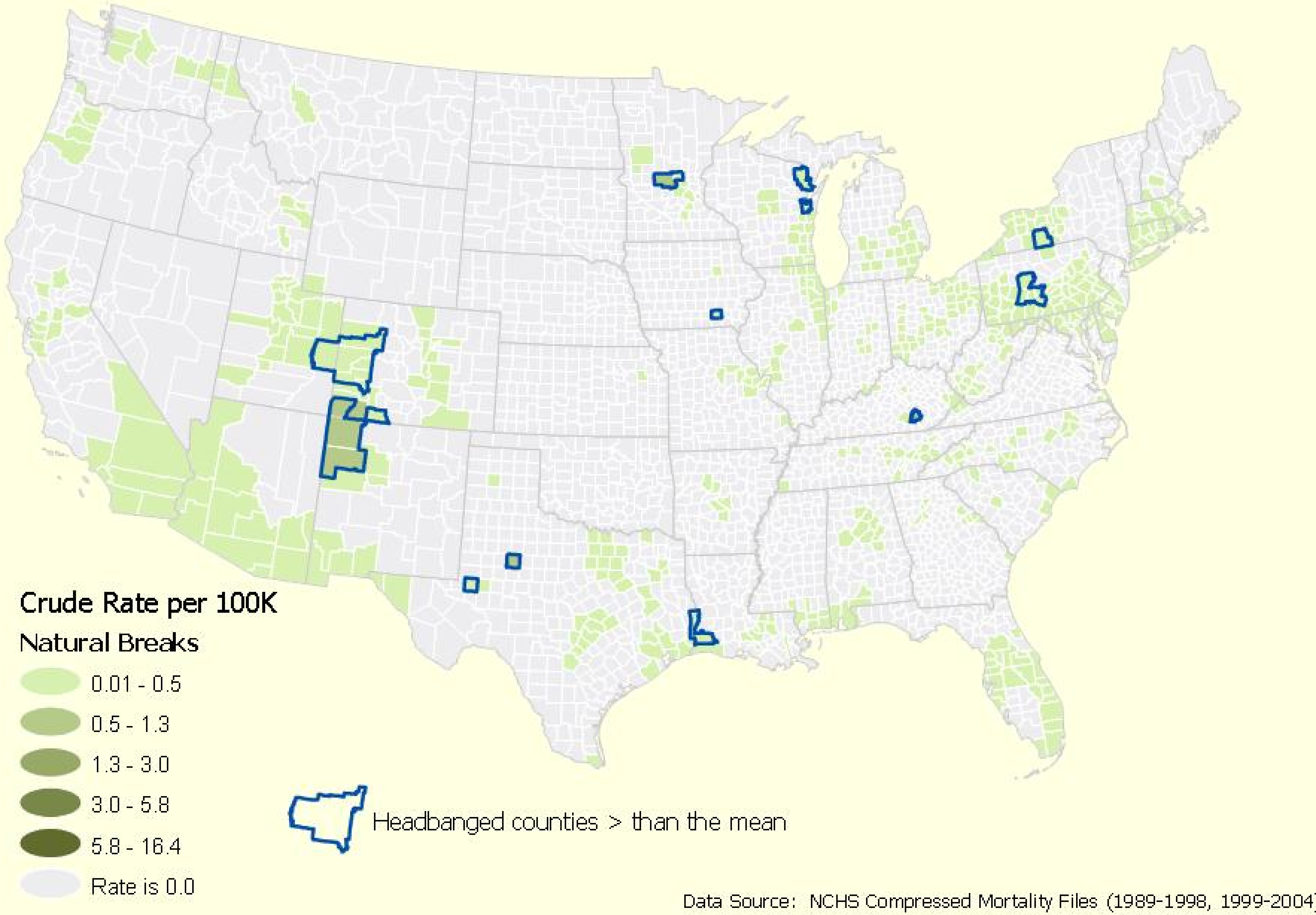


Observed Silicosis Mortality 95-04

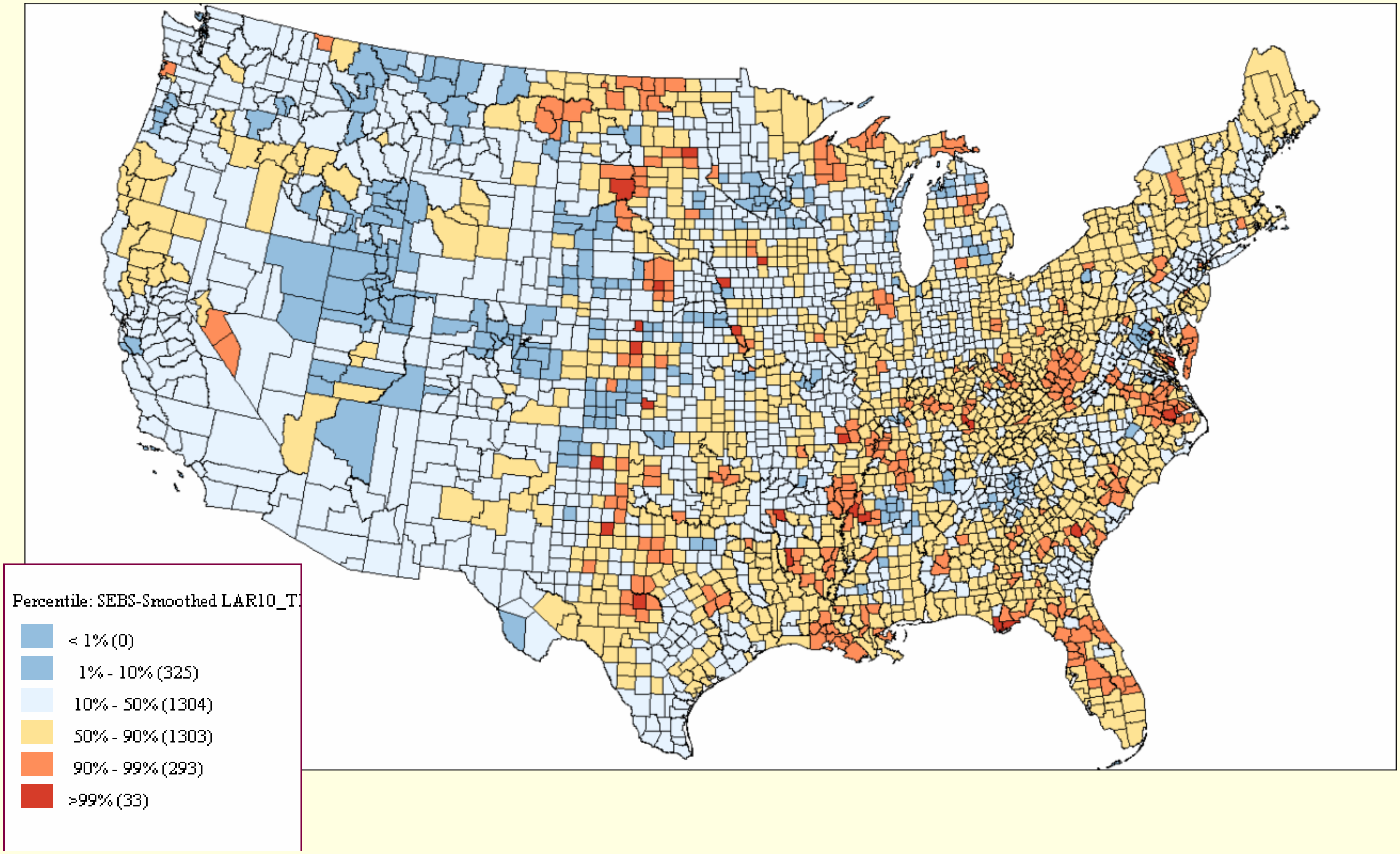



Head-Banged Silicosis Mortality 95-04
Crude Rate per 100K
Natural Breaks
0.01 - 0.5
0.5 - 1.3
1.3 - 3.0
3.0 - 5.8
5.8 - 16.4
Rate is 0.0
Data Source: NCHS Compressed Mortality Files (1989-1998, 1999-2004)

Head-Banged and Regionalized Silicosis Mortality 95-04



Laryngeal Cancer Mortality Crude Rates Smoothed Using Spatial Empirical Bayes (GeoDA) Rook's Case, 1st Order



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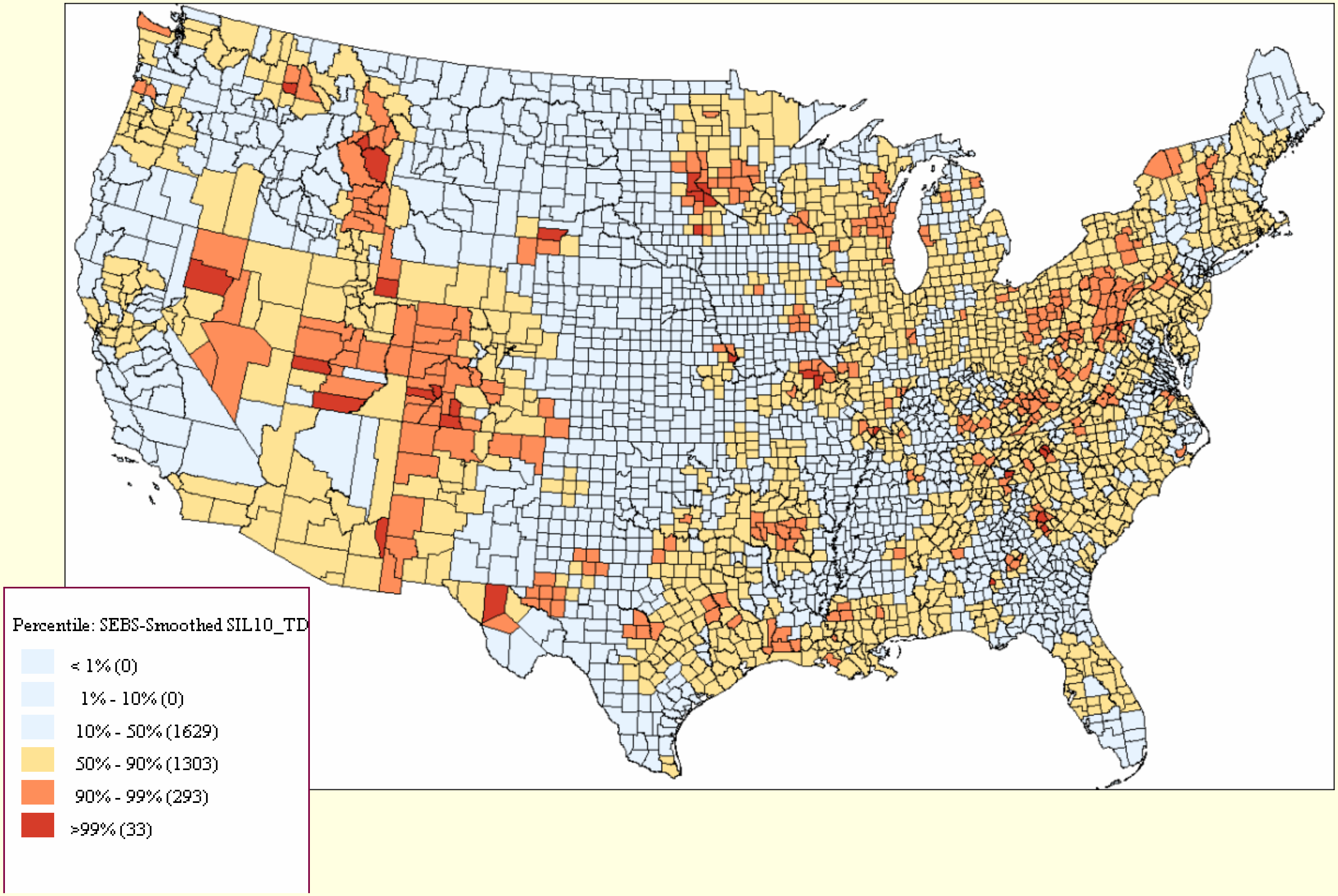
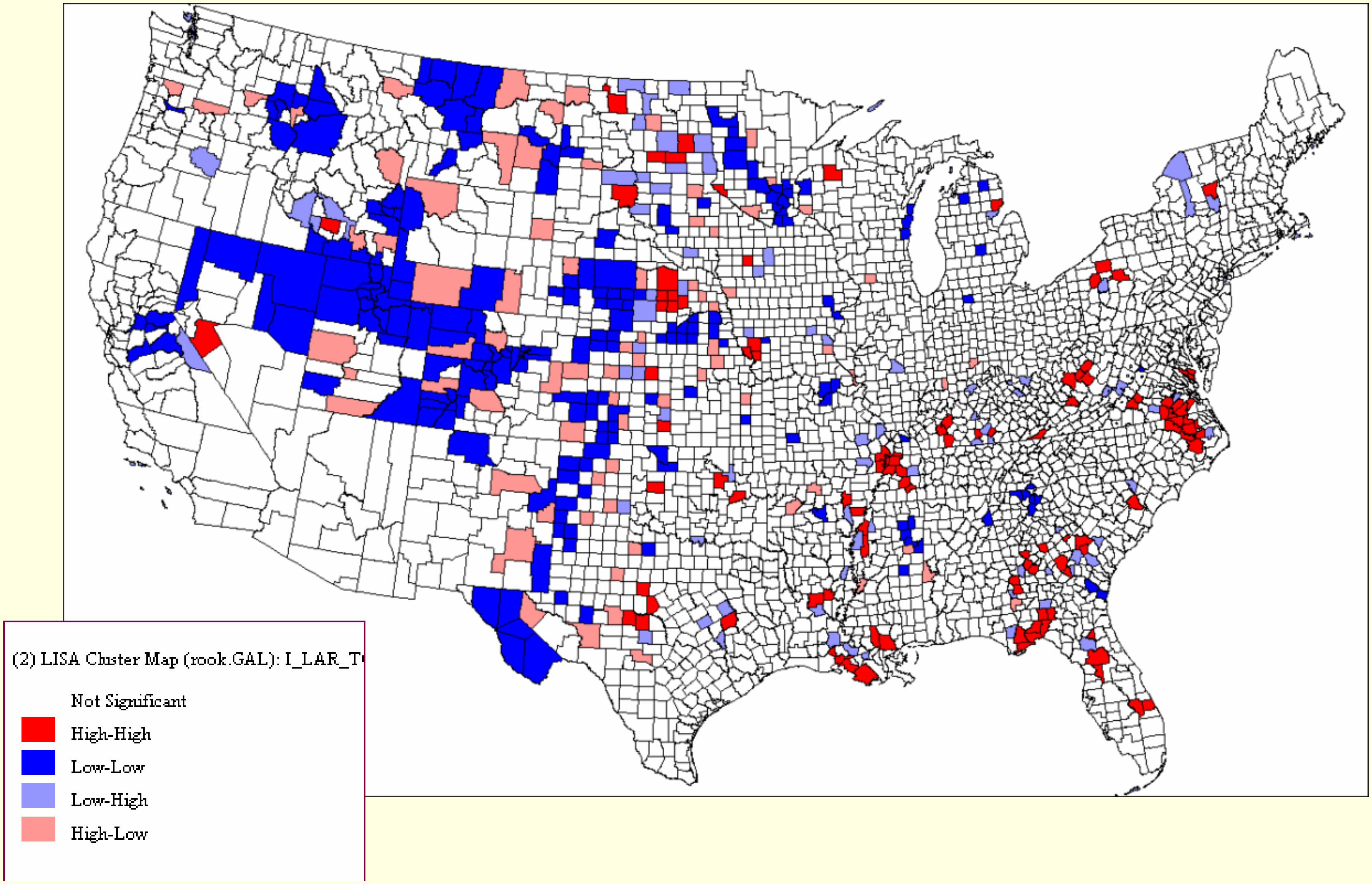
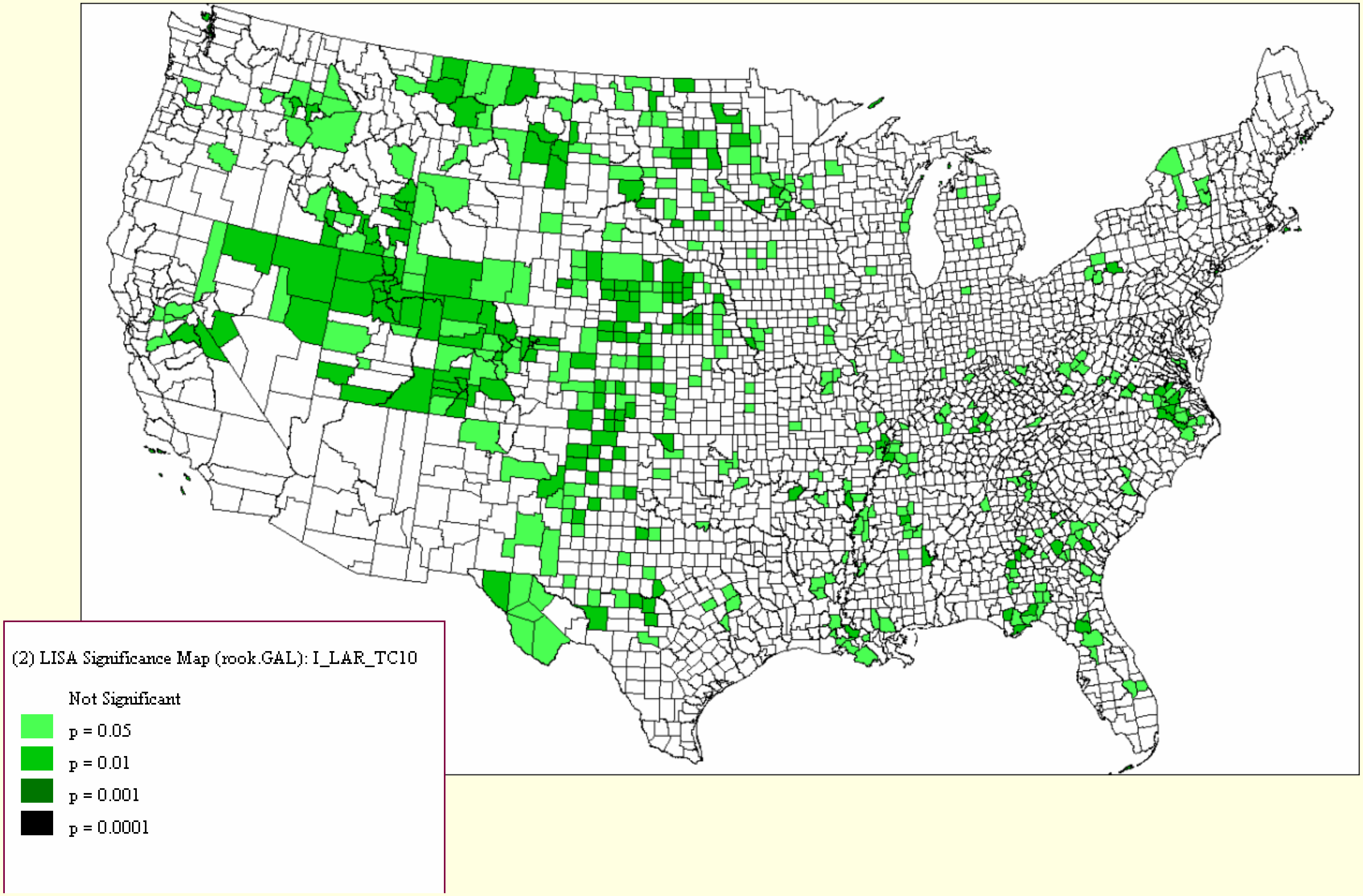


Laryngeal Cancer Mortality Crude Rates Results of LISA Application
Rook's Case, 1st Order



Laryngeal Cancer Mortality Crude Rates Significance of Patterns (H-H, L-L, L-H, H-L)
Rook's Case, 1st Order



Laryngeal Cancer Mortality Head-Banged Crude Rates Results of LISA Application
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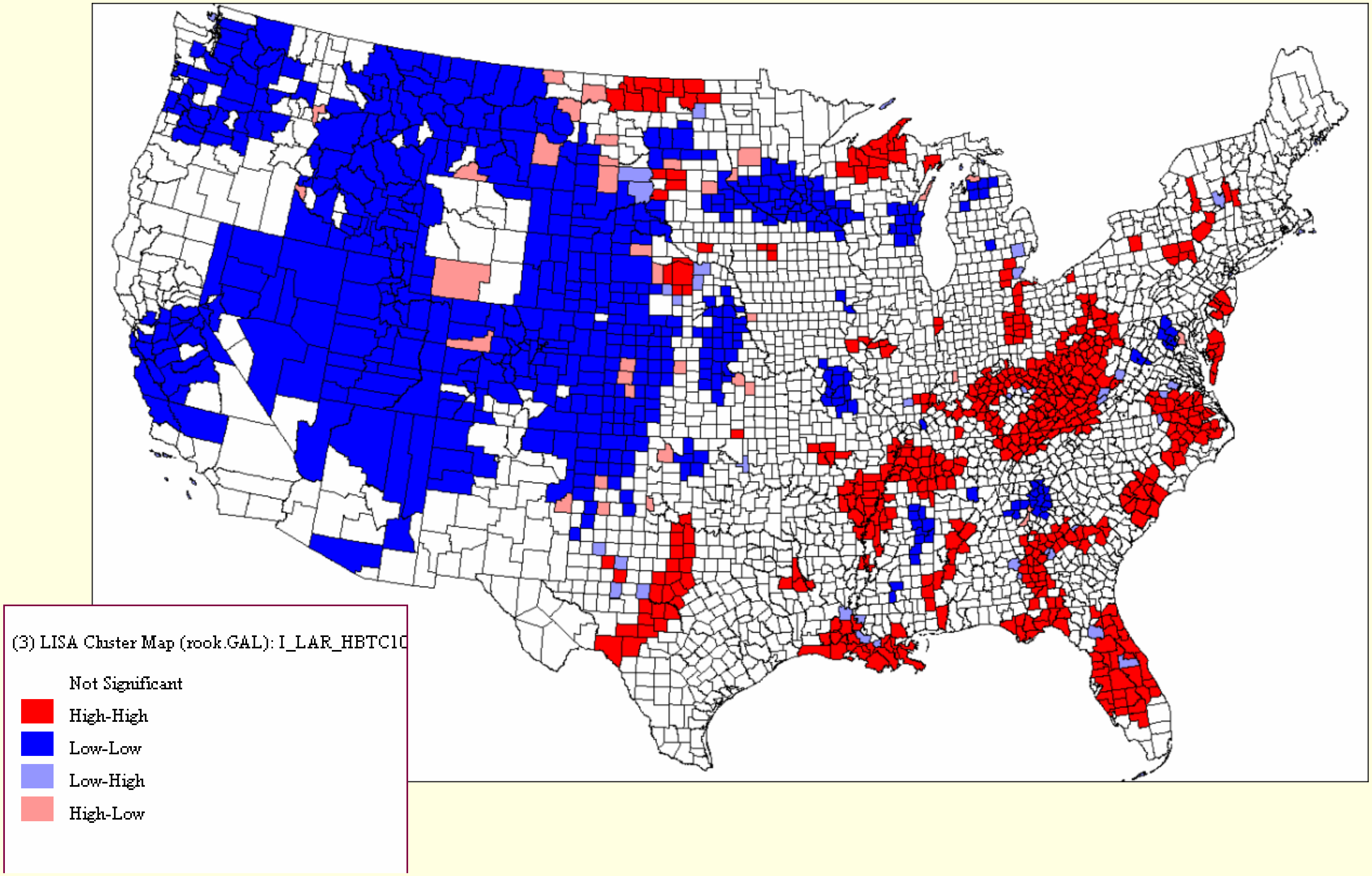

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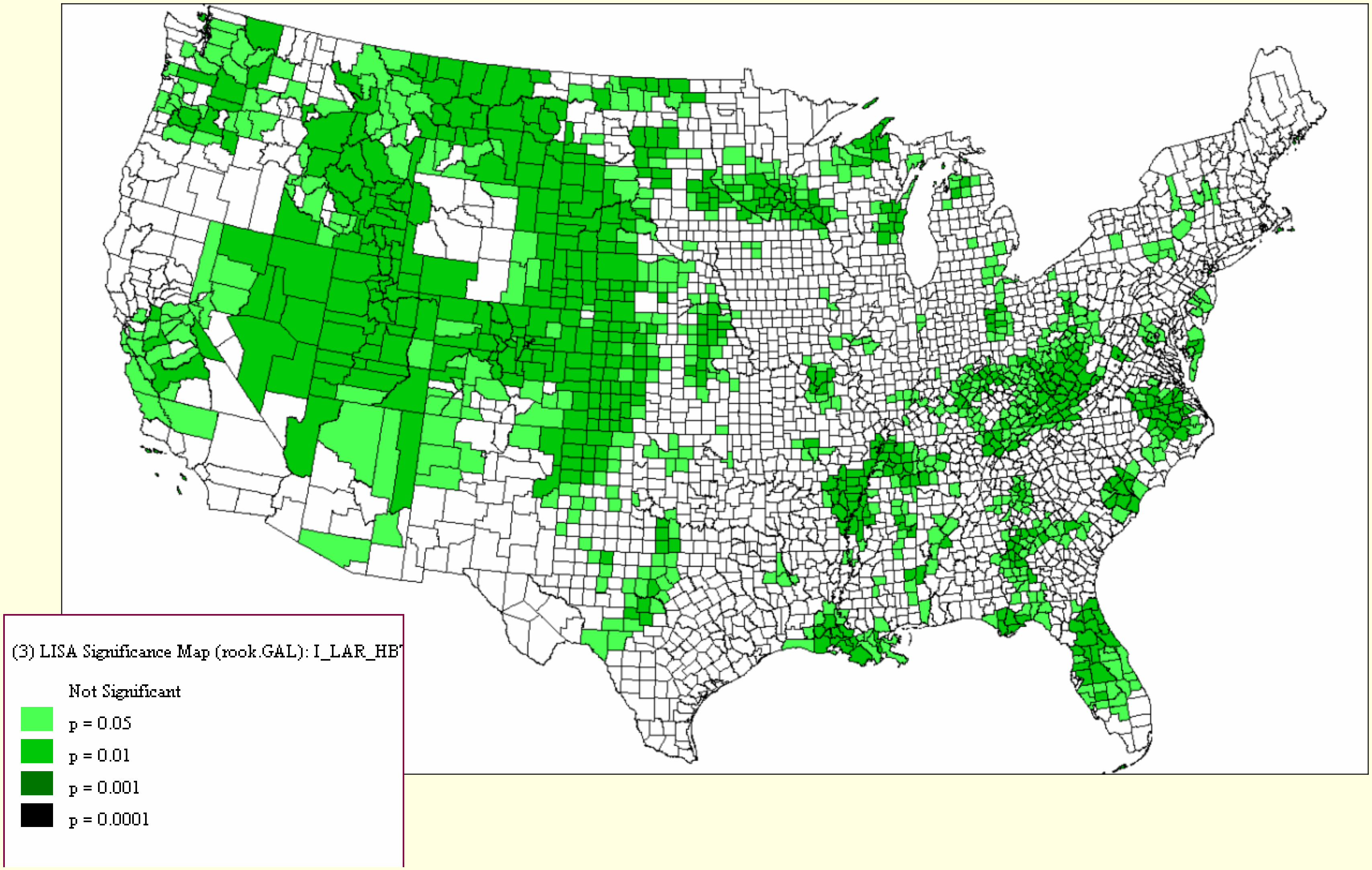

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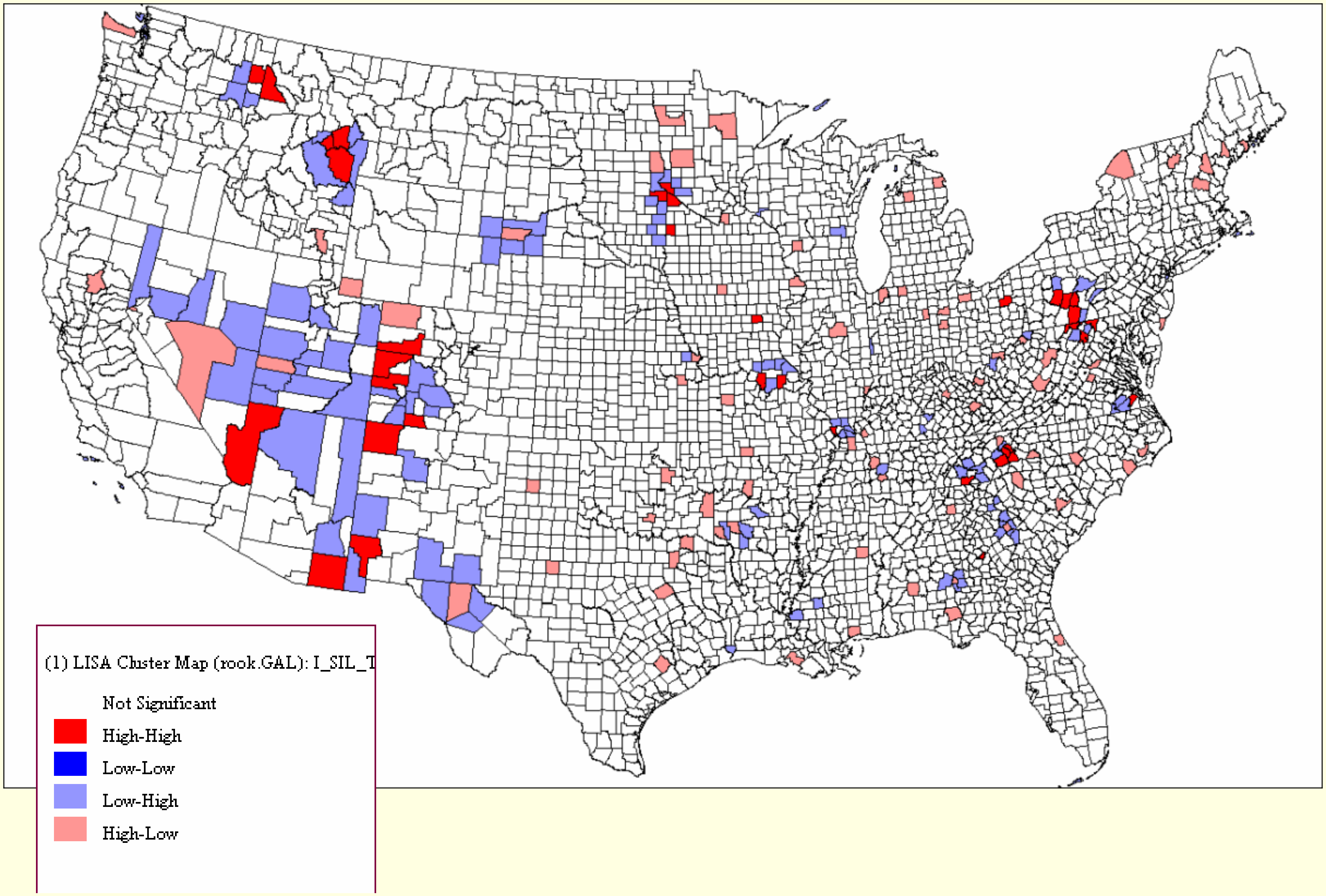

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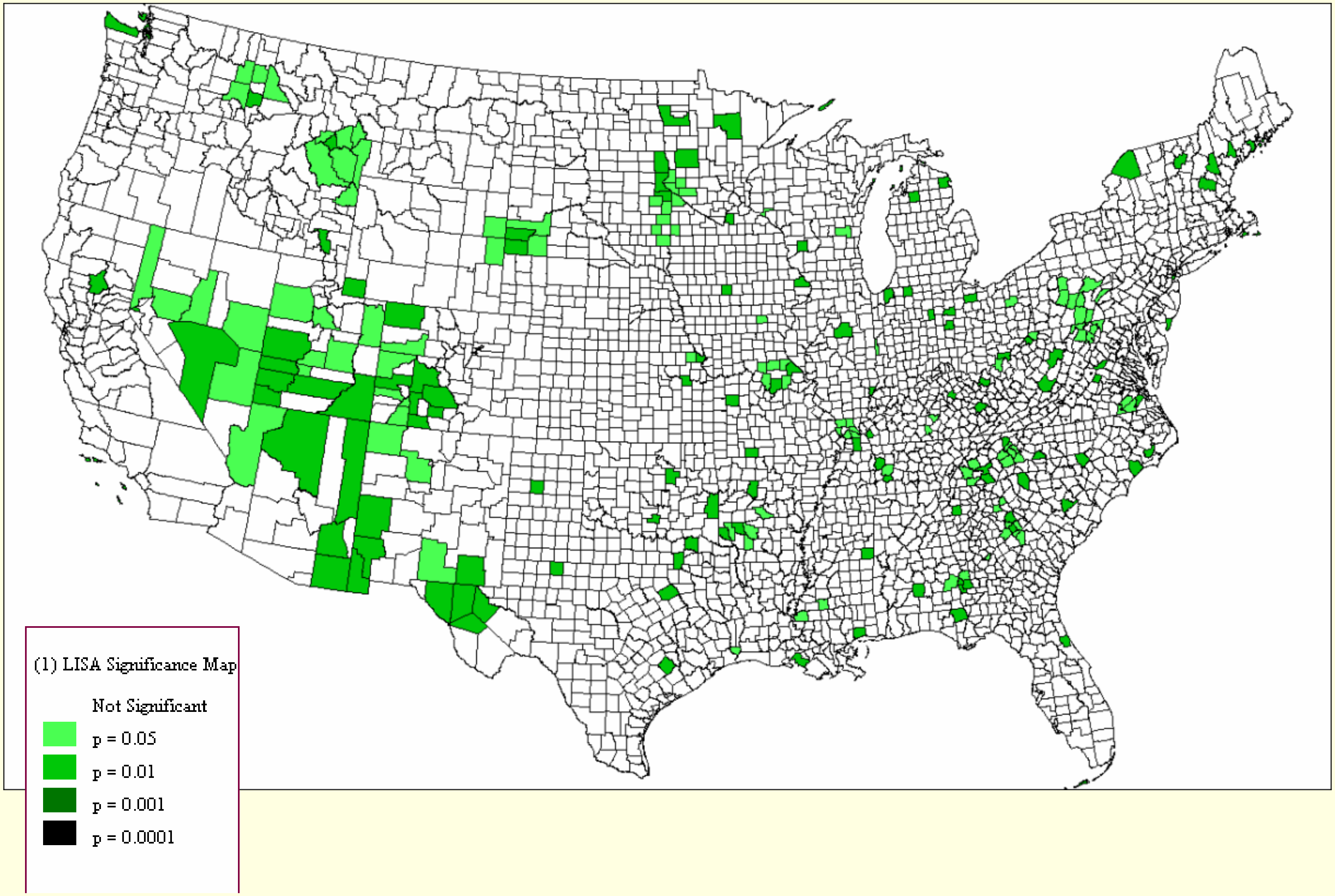

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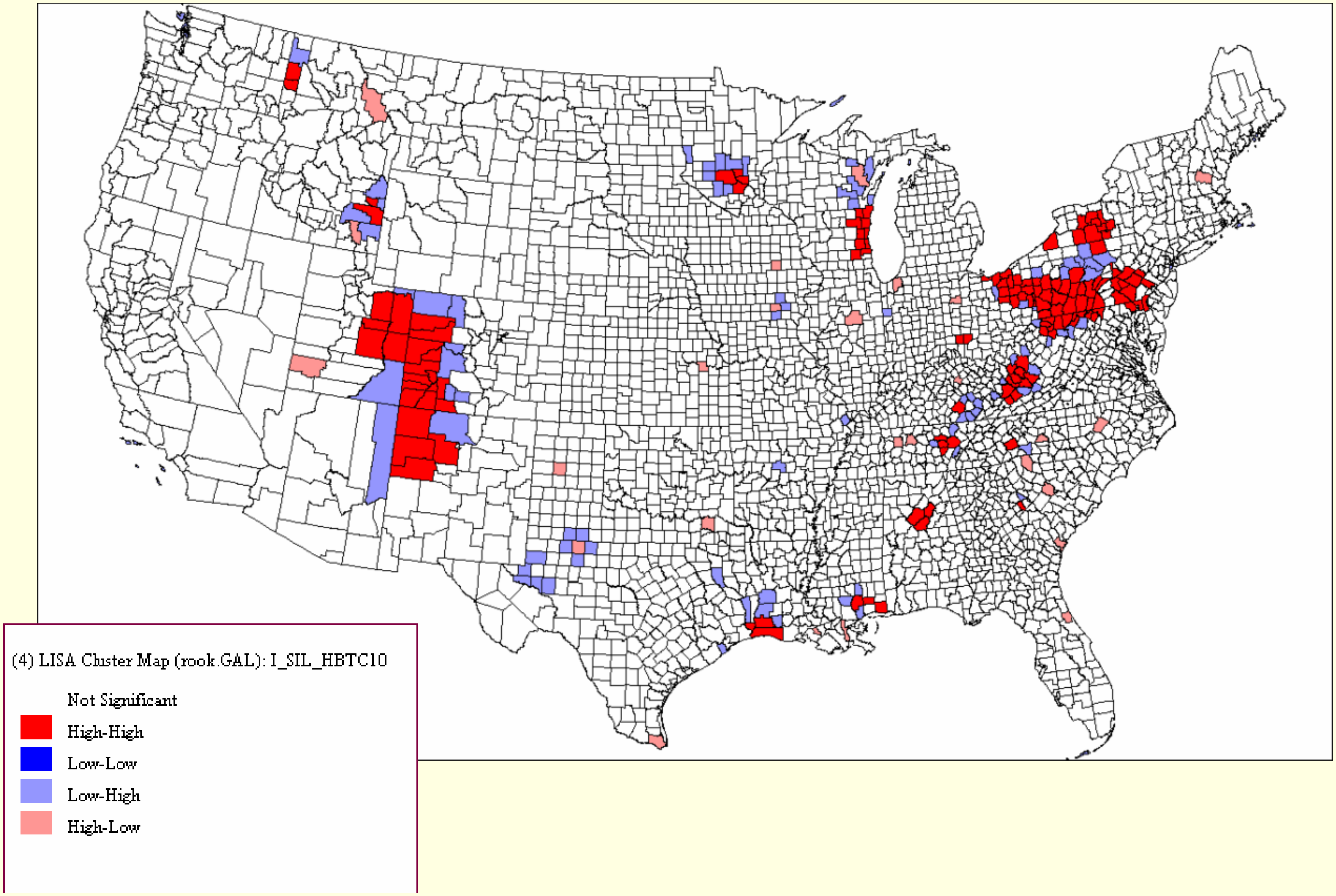

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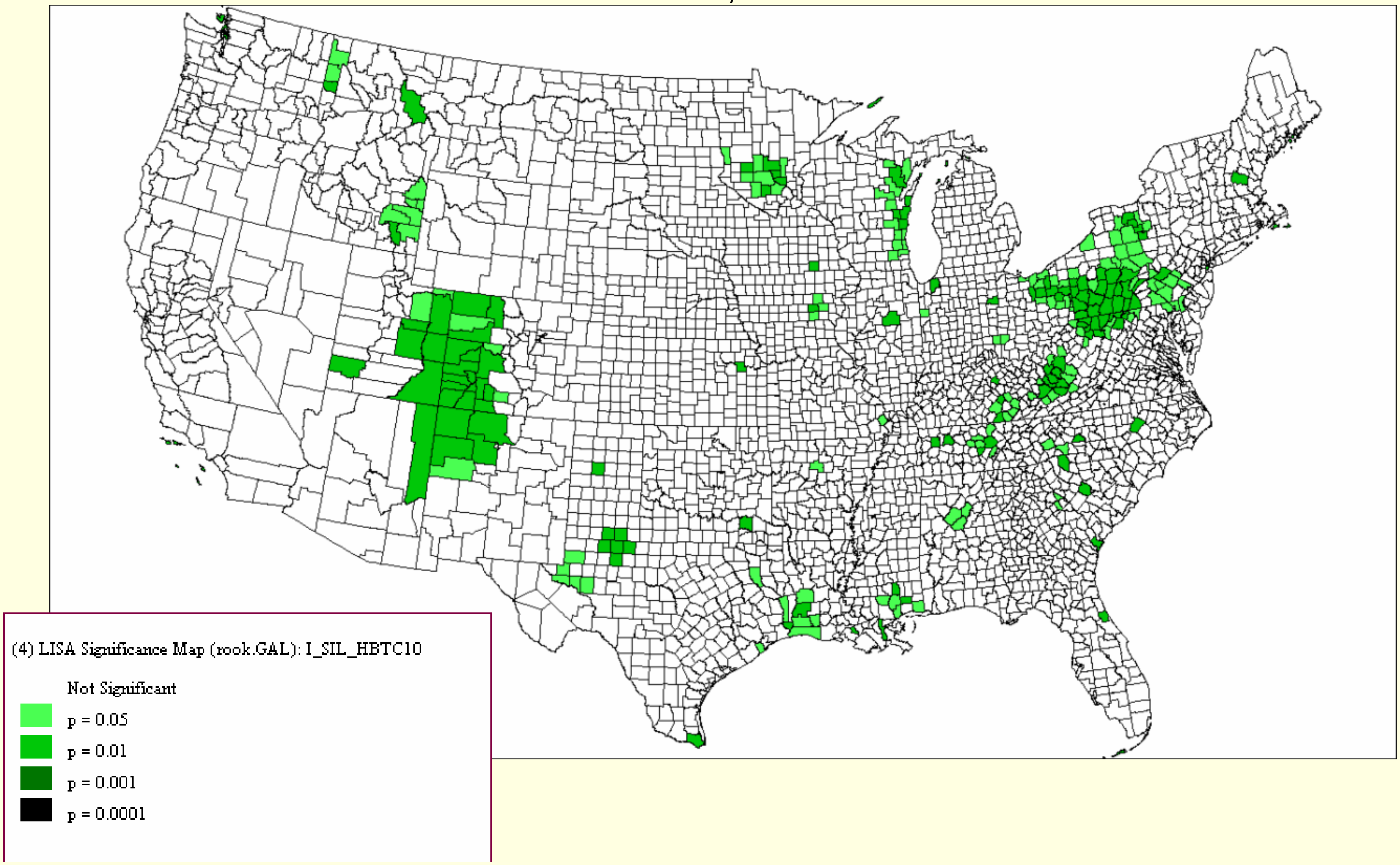

Summary and Conclusions:

- Smoothing reduces noise in both mortality maps—especially for laryngeal cancer. Silicosis mortality is rare and appears more localized (many zero rate counties) and scattered, but smoothing sharpens the focus.
- The danger of smoothing is the creation of artifactual or apparent visual clusters with newly dependent relationships with surrounding areas. (This may not be desirable.) Rules can be devised to delineate meaningful clusters like not using counties with zero rates and employing threshold criteria.
- Global spatial autocorrelation methods can be used to determine if clusters exist within a map. Smoothing can reveal inherent clusters and introduce apparent clusters. The degree to which this occurs can be measured in a relative way by these methods.
- Local spatial autocorrelation can delineate spatially and statistically meaningful clusters, including the type of cluster (H-H, L-L H-L, L-H). This ability helps demarcate regions in a more objective manner, but common sense should always be applied.
- The map is not the territory. Smoothing and spatial autocorrelation techniques operate on geometric representations or real world phenomena and processes. They can be effective tools for gaining insights into the scope and scale of the processes being mapped.

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