

# Snyder's GS50 Projection for the Mapping of all 50 United States

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# Map projection

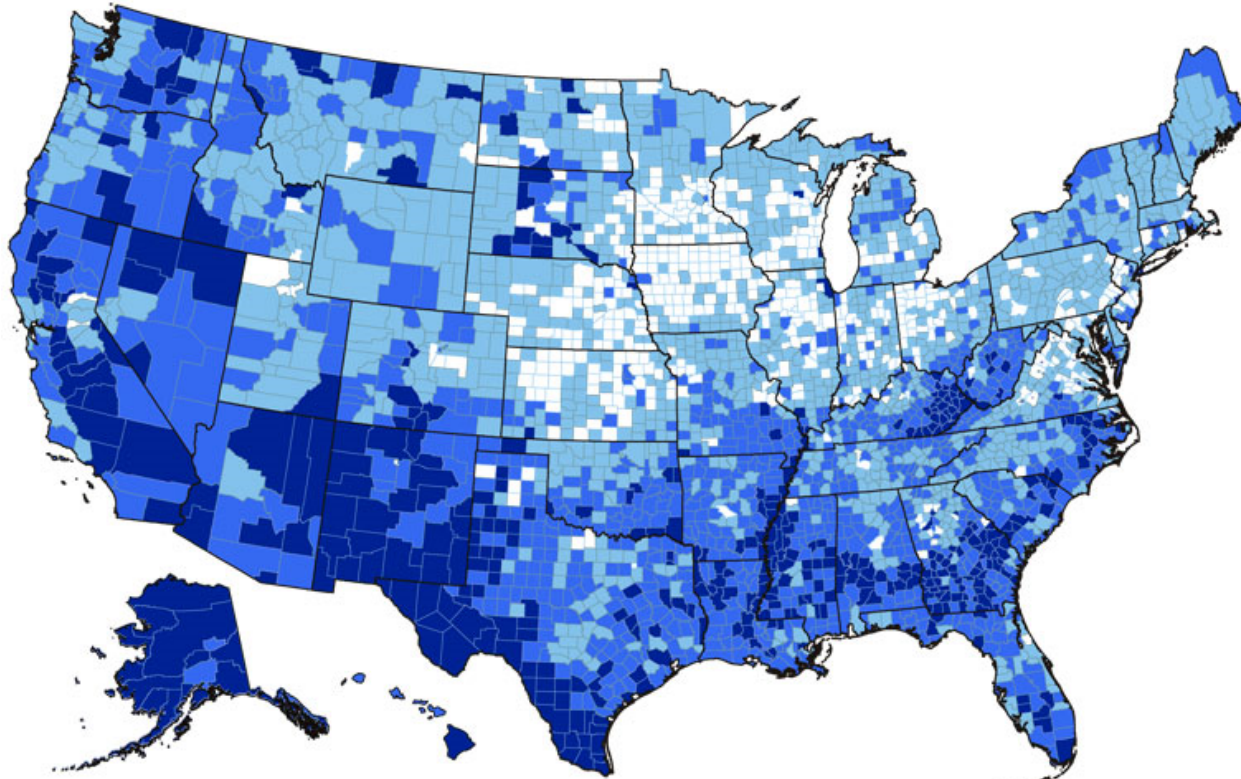
- “a transformational method used in cartography to represent a three dimensional surface of earth or other body as a plane.”
- Many variants, a function of model (sphere, spheroid, ellipsoid), invertibility, aspect, secancy, form etc.
- Classic trade-off: conformality, equivalence and equidistance
- Snyder’s “Flattening the Earth” notes trend toward conformal projections for global grids and coordinate systems
- Snyder creates 2 new classes: optimal and space

# National projections for thematic cartography

- Many nations adopt standard projections for use in national mapping of demography, health etc.
- Projection choice by nation covered in *Understanding Map Projections* (Kennedy, 1994-2000) and Snyder (1987) *Map Projections: A Working Manual* USGS Professional Paper 1395.
- US contradicts general recommendations: Lower 48 works well on Lambert Conformal Conic, but Hawaii is remote and small, and Alaska large and covers huge longitude range
- Census and some other agencies also include the territories

# The standard: LCC with insets

## Hard-to-count counties



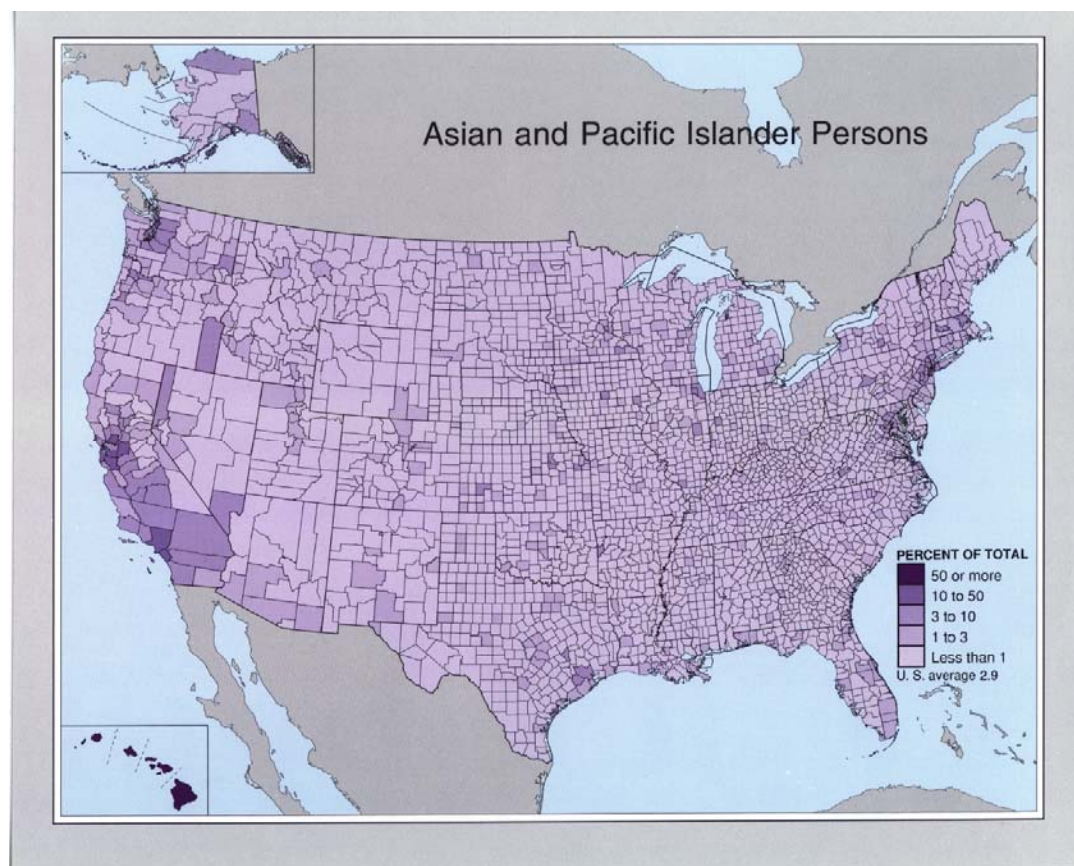
The Census Bureau has scored each neighborhood in the USA on the likelihood of its residents mailing back the Census 2010 form next spring. The score, shown here as a county average, is based on 12 factors such as rates of poverty, English-speaking ability and homeownership. Higher scores indicate a lower likelihood.

Likelihood of returning Census form  
(maximum score 132)

- Most likely (0-15)
- Likely (16-30)
- Less likely (31-45)
- Least likely (46-82)

Source: Analysis of Census Bureau data by Paul Overberg, USA TODAY

# The standard: LCC with insets!



# Alaska & Hawaii

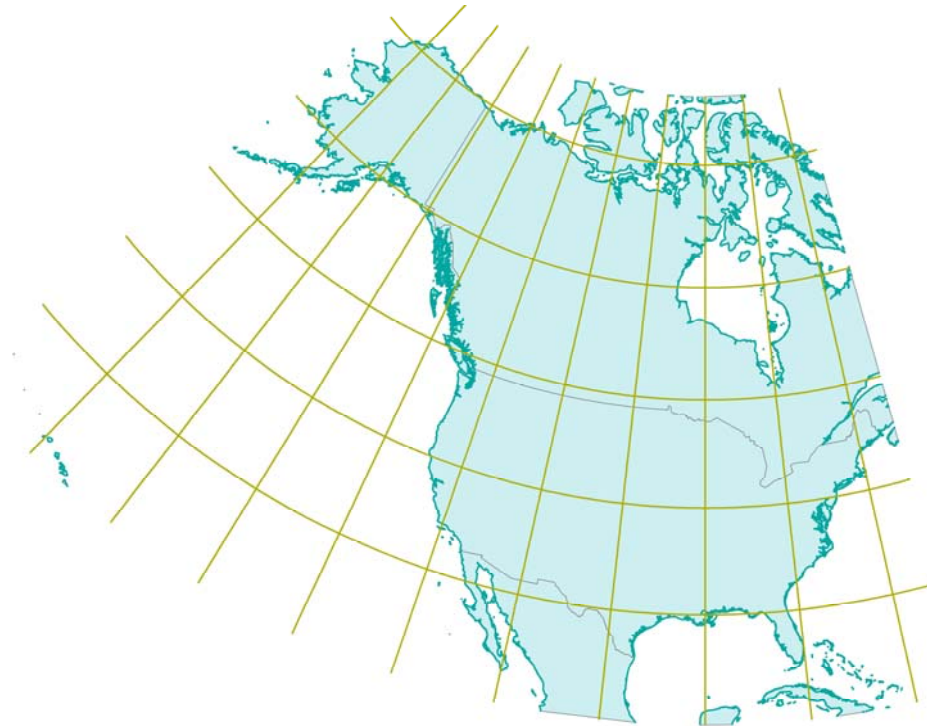
“A small group of islands just off of San Diego”

“A small state just north and west of British Columbia.”

“And I can see Russia from my house.”



The standard: LCC without insets



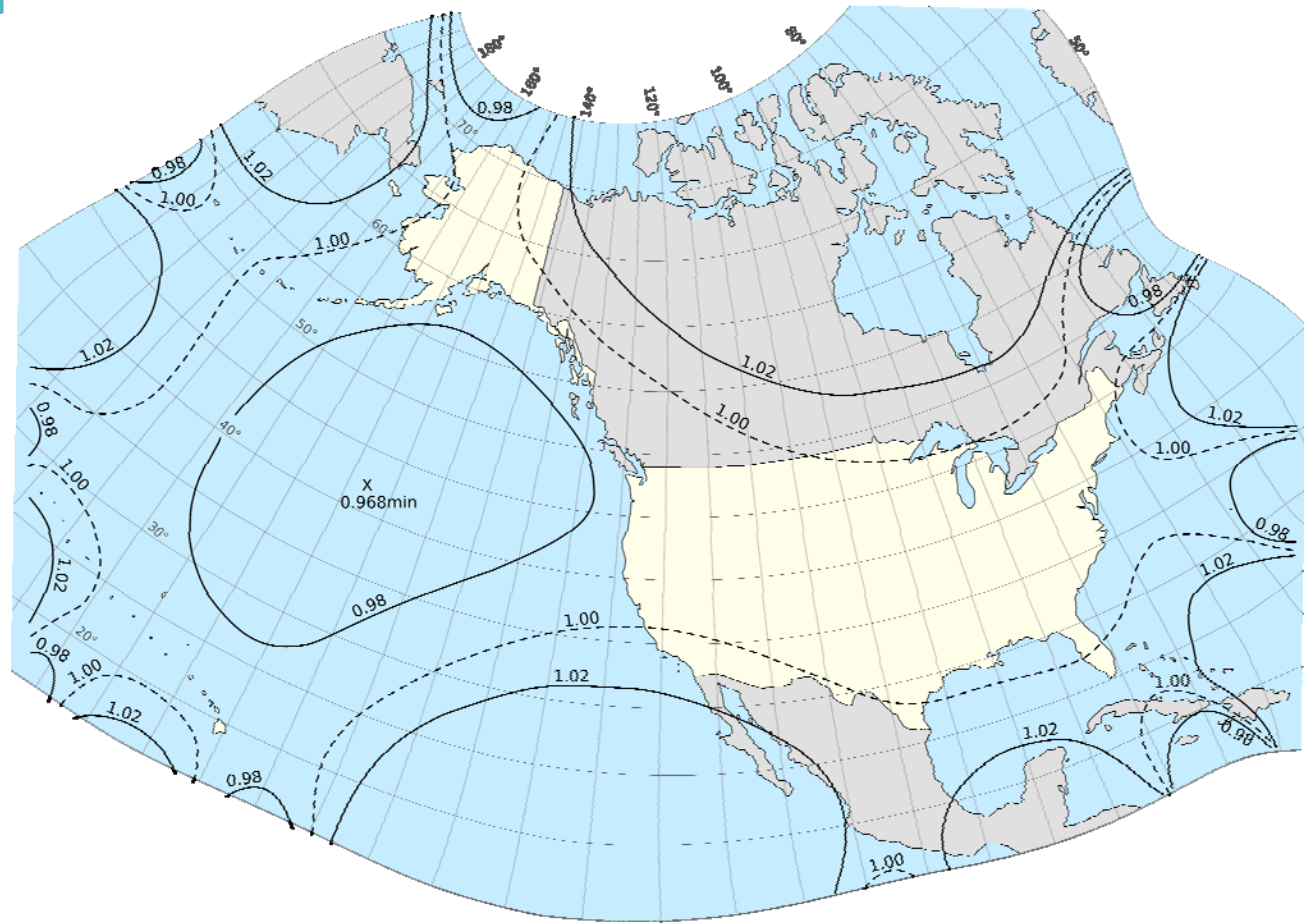
# Optimal Map Projections

- A class of projections noted by Snyder that attempts mathematical treatment to balance distortion properties
- Early example is the Winkel Tripel—a modified azimuthal map projection, the arithmetic mean of the equirectangular projection and the Aitoff projection
- The name Tripel (German for "triple") reflects Winkel's goal of minimizing distortion of area, direction and distance together
- Many optimizations involve framing, orientation (e.g. Alaska State Plane Zone 5001 (AK\_1), or creative secancy
- Few attempt mathematical optimization

# The GS50

- GS50 is a conformal projection, custom-designed to contain less than 2% scale variation across all 50 United States, and optimized to minimize the sum of geometric distortions
- An oblique stereographic projection forms the base
- An algorithm then empirically minimizes the overall distortion using 10<sup>th</sup> order complex polynomials, rather than simple geometric forward and inverse transformations
- The complexity of the projection transformation has meant that few map projection software tools have included it among those supported

# Distortion



# Software Resources

Software support for GS50 (all via PROJ.4)

GRASS GIS

QGIS

MapServer

PostGIS

Thuban

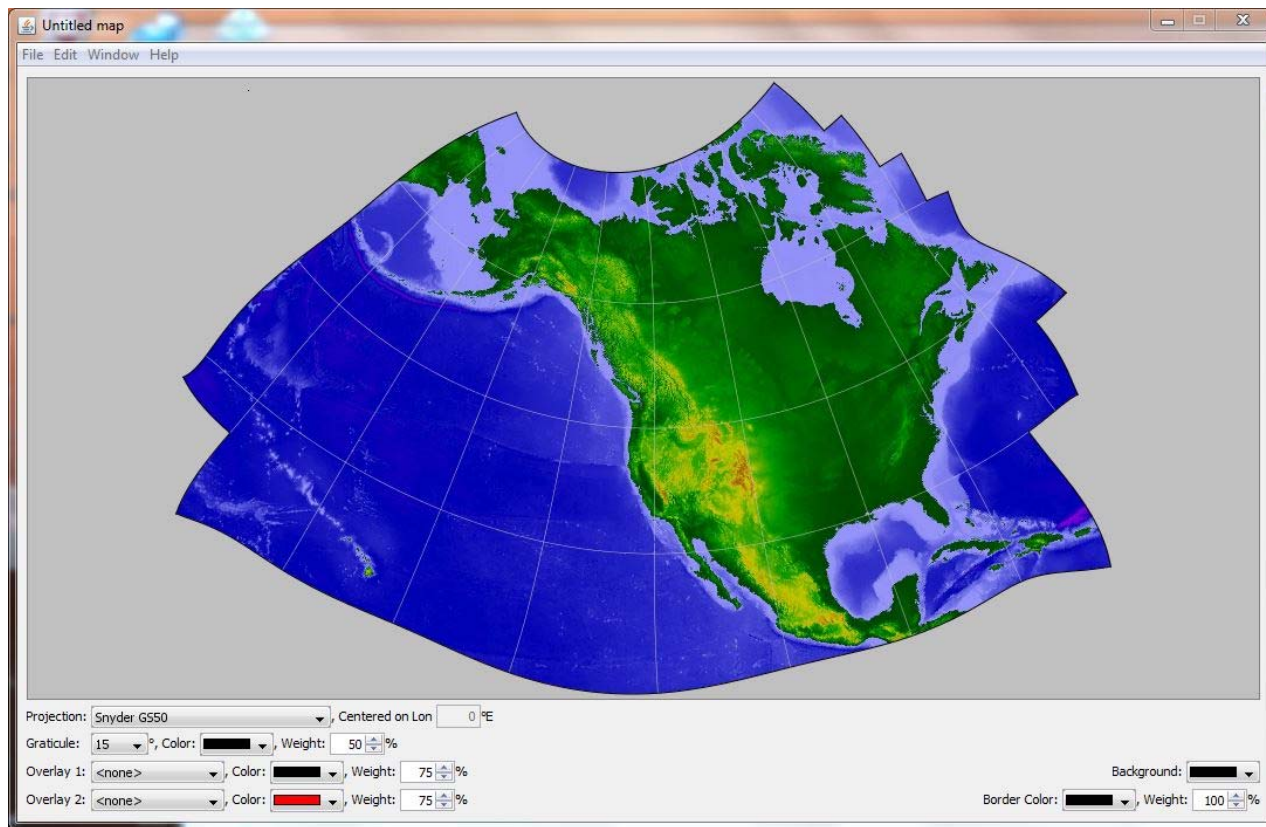
OGDI

Mapnik

TopoCad

OGRCoordinateTransformation

# NASA: G.Projector—Global Map Projector (Raster only)



# Libraries: Mostly C, C++ and Java

PROJ4JS - Javascript projections implementation.

PROJ4PHP - PHP projections implementation.

GMT - Generic Mapping Tools

GCTPC: The other widely used projection package from the USGS.

Geotrans: a projections and datum shift program from NGA.

GeographicLib: C++ class for projection, geodesic and geoid calculations by Charles Karney.

JHLabs Java Map Projection Library: Loosely derived from PROJ.4 with similar syntax.

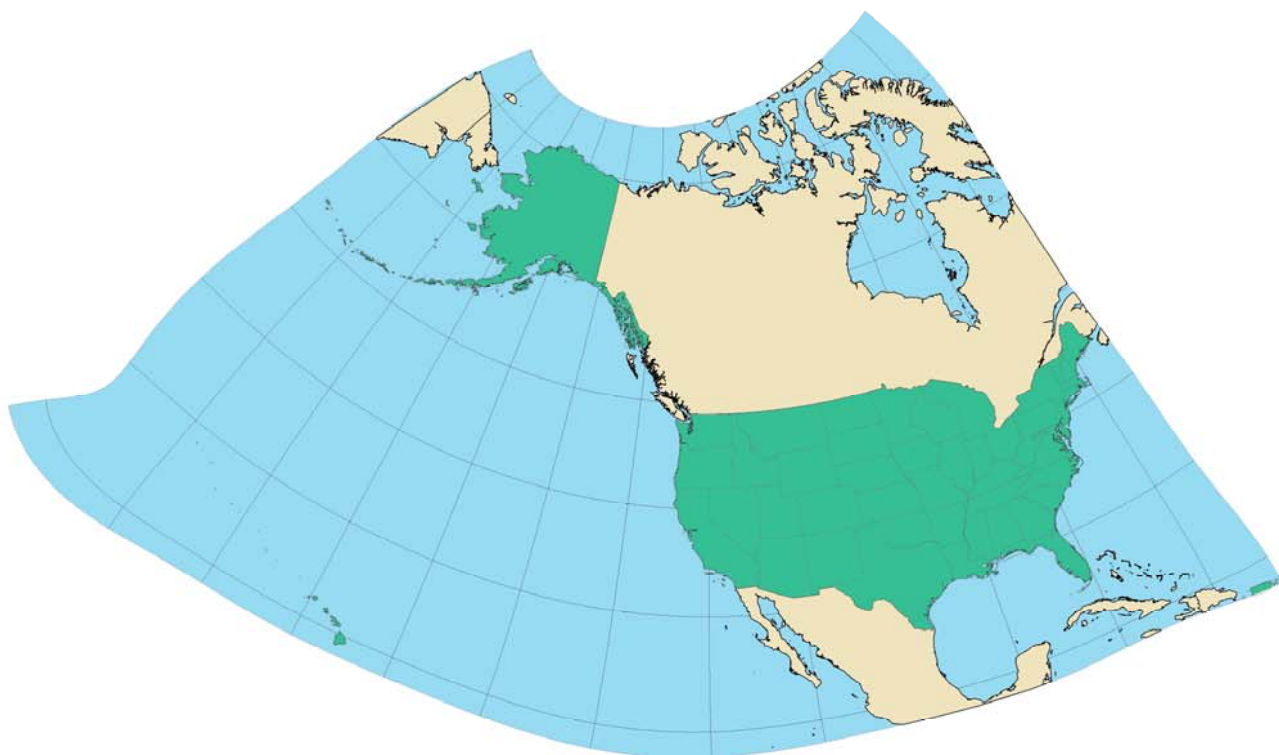
GeoTools: GeoTools is a Java GIS library that includes sophisticated projections support.

GDAL: Geospatial Data Abstraction Library

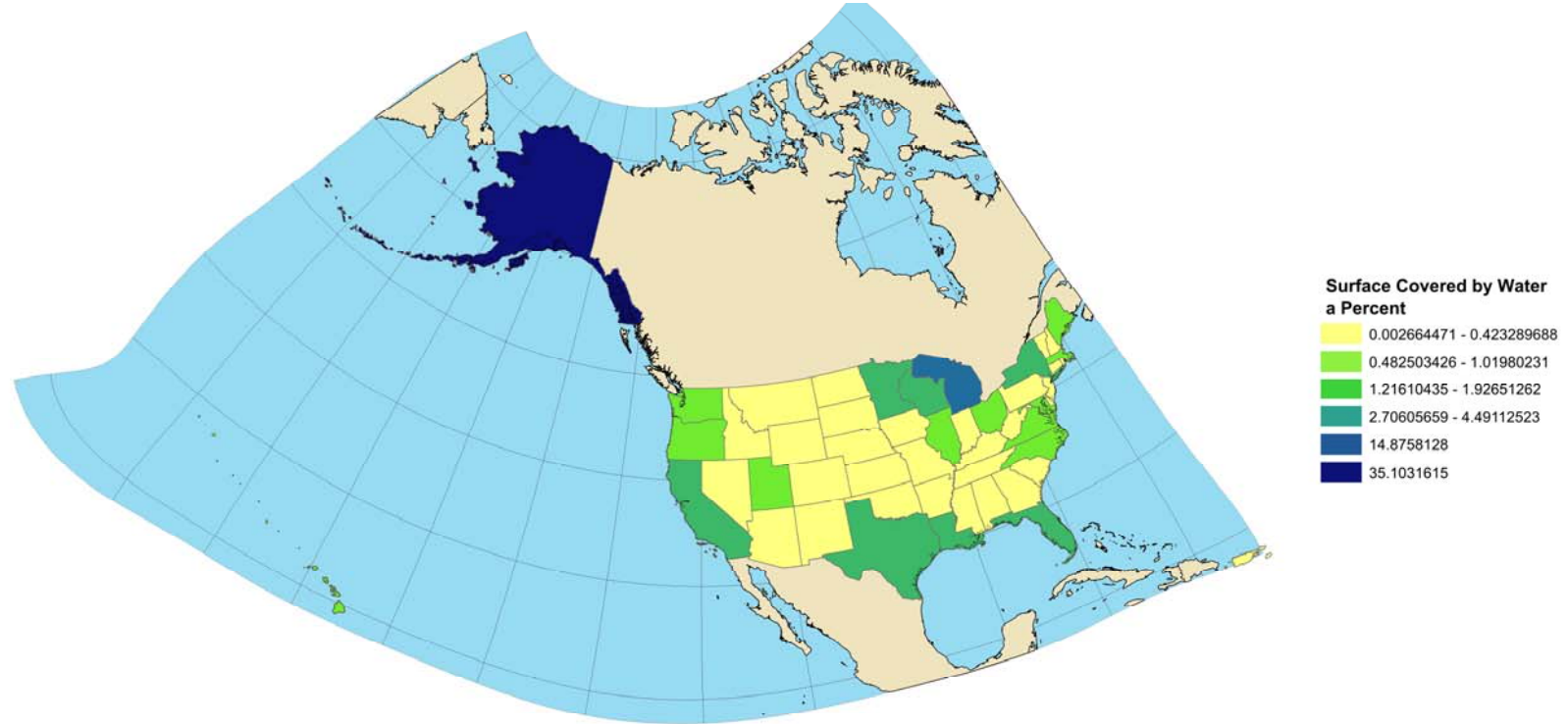
# But, use has lagged

- GS50's use in thematic mapping is hampered by it not being supported by the major GIS and automated mapping packages
- GRASS GIS and QGIS a notable exception, but dependent on PROJ.4
- Federal Government can help promote with use by USGS, Census, NGA, NOAA etc.
- One issue is probably the lack of readily-available ESRI shape files
- Using NACIS' Natural Earth as a model, I have converted national, state and county outlines using PROJ.4, the opensource Shapelib and some C code
- Maps in ESRI Shapefile format available from:  
<http://www.geog.ucsb.edu/~kclarke/Public/GS50USA.zip> (129MB)
- Two versions--with and without clip to bounding rectangle
- Bounding box matters—include all US vs. choose major parallels/meridians

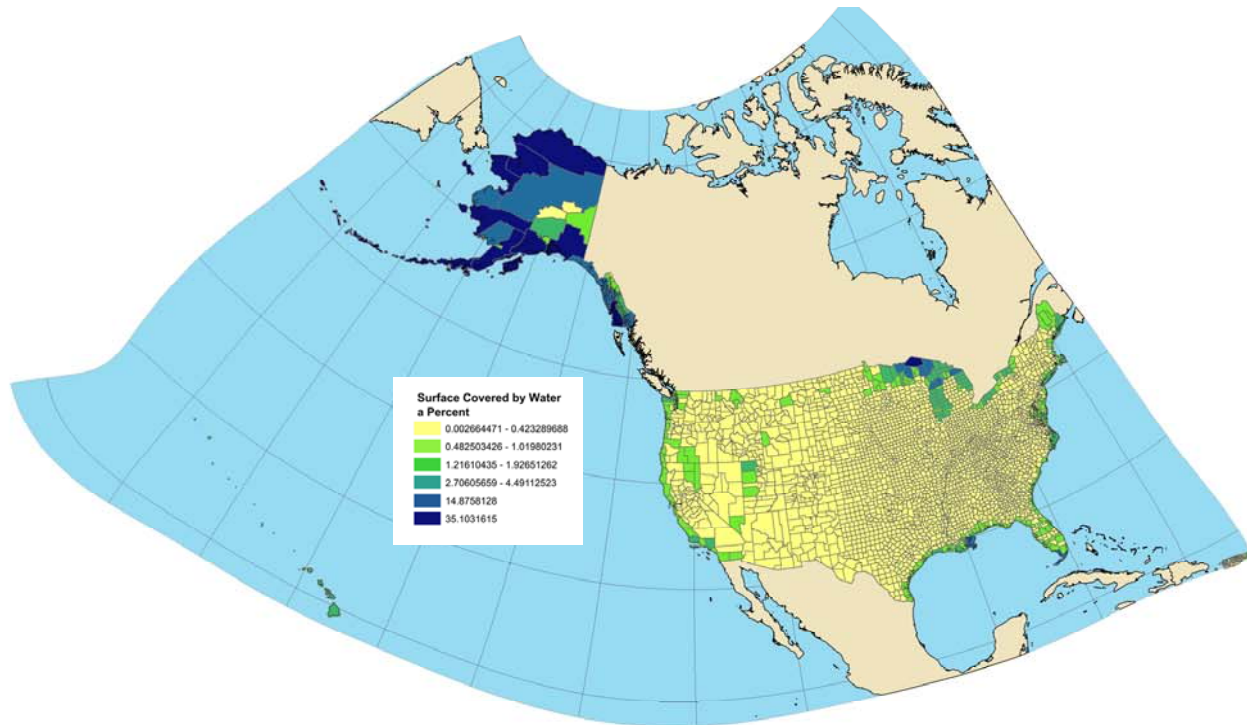
# Natural Earth: Administrative--Nations



# Census Bureau 2014 TIGER files with FIPS codes: States (Percent water in State area)



# Census Bureau 2014 TIGER files with FIPS codes: Counties (Percent water in County area)



# GS50

- GS50 has admirable simplicity and inclusiveness—showing all 50 states accurately, and not just the lower 48
- Less than one-fourth the variation in scale of the best standard projections
- Use should be encouraged, for example in new media, the World Wide Web, and in education
- Optimal projections worth exploring for different countries, regions and the globe
- Possible to optimize on perceptual properties in addition to cartometric
- Makes projection obvious, and promotes 3D thinking

# J. P. Snyder



*“It is more important that cartographers, for whom use of map projections is only one of many skills involved in map work, be brought closer to the projections already available than that still more projections be developed.” (Flattening the Earth, p. 276.)*

# Pertinent references

Snyder, John Parr (1985). *Chapter 5a A low-error conformal projection for a 50-State map of the United States; Appendix 9 Derivation of formulas for a low-error conformal projection for the 50 States*“ Computer-assisted map projection research”. *Bulletin* (United States Geological Survey) 1629: pp.79–92; 147–51.

Snyder, John Parr (1987). *26 Modified-Stereographic Conformal projections* "Map Projections: A Working Manual". *Professional Paper* (United States Geological Survey) 1395: 203–212.

Evenden, G. I. (1990) *Cartographic Projection Procedures for the UNIX Environment—A Users Manual*. USGS Open file report 90-284 (plus 2 appendices)