Geospatial Data Visualization

Introduction

- **Topic Overview**: Many datasets link information to physical locations.
  - Example: Ecological studies, socioeconomic data, infrastructure maps.
- **Importance**: Visualizing data in its geospatial context enhances understanding and interpretation.
- **Goal**: Learn about map projections, layers, and methods like choropleth maps and cartograms.

Geospatial Data Examples

- **Ecological Studies**: Mapping plant and animal locations.
- **Socioeconomic Contexts**: Mapping population data, income, education levels.
- **Infrastructure**: Mapping bridges, roads, and buildings.
- **Key Takeaway**: Geospatial visualization brings clarity to spatial relationships and distributions.

Challenge of Map Design

- **Challenges**: Correct map projections and accuracy.
- **Critical Elements**:
    - *Map Projections*: Preserving angles or areas.
    - *Distortions*: Projections cannot represent a spherical surface perfectly on a flat map.
- **Visualizing geospatial data requires careful design choices.**

Understanding Map Projections

- **What is a Projection?**
  - Flattening Earth’s spherical surface onto a flat map.
  - Distortions: Angle or area (cannot preserve both simultaneously).
- **Projection Types**:
  - *Conformal*: Preserves angles.
  - *Equal-area*: Preserves areas.
  - *Compromise*: Balances both distortions.

Orthographic projection of the world

This projection shows Europe and Northern Africa as seen from space. The lines emanating from the North Pole are called meridians, and the lines perpendicular to them are called parallels. All meridians are the same length, but parallels shorten as they approach the poles.

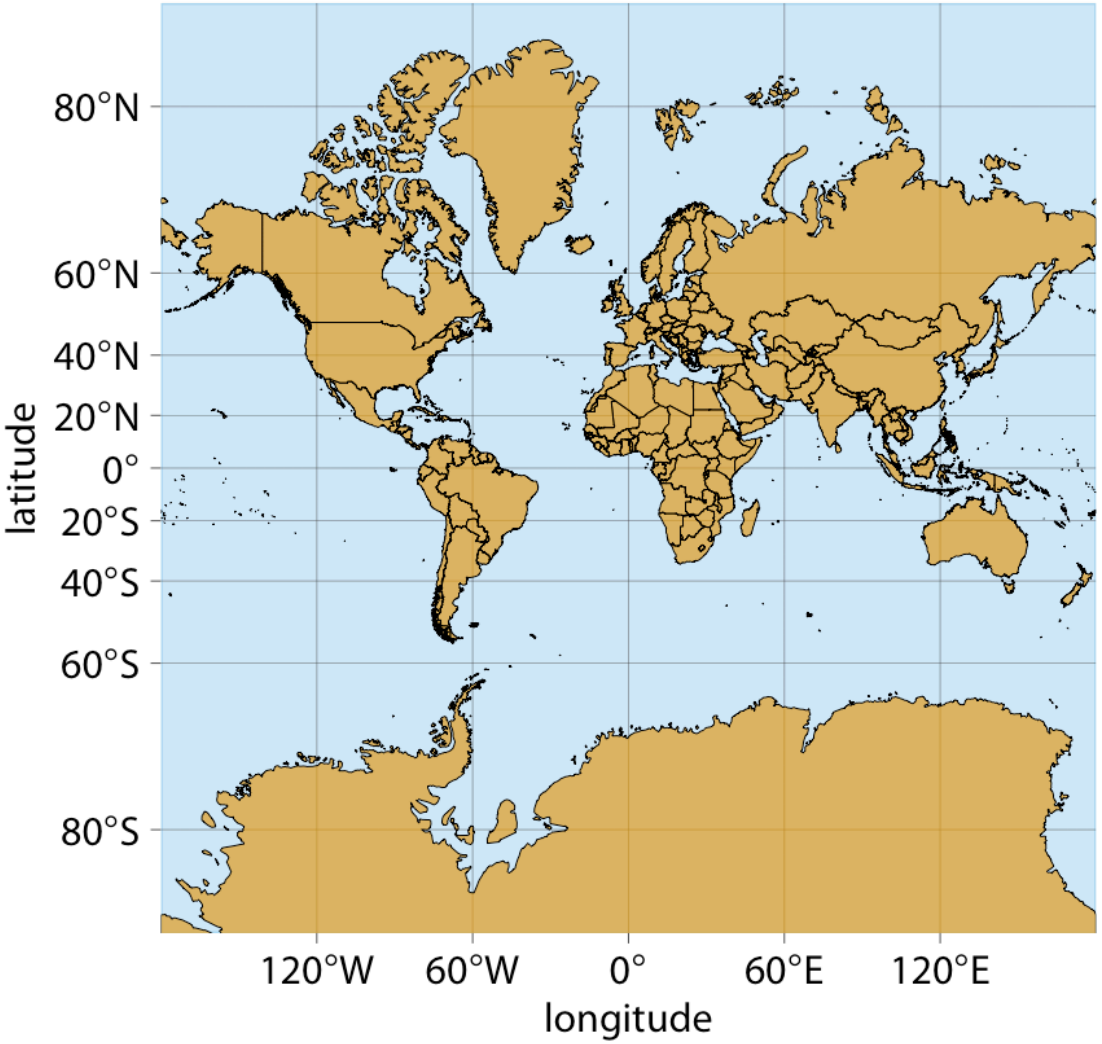
Common Map Projections

- **Mercator Projection**:
  - *Conformal*—accurately preserves shapes but distorts areas near the poles.
  - Example: Greenland appears larger than Africa, though Africa is 14 times larger.
- **Goode Homolosine Projection**:
  - *Equal-area* projection, minimizes angular distortions but sacrifices continuity.
  - Useful for displaying global data accurately.

Mercator Projection Example

- **Characteristics**:
  - Preserves local angles.
  - Distorts areas (e.g., Greenland vs. Africa).
- **Usage**: Historically used for navigation but no longer preferred for global maps.

Mercator projection of the world

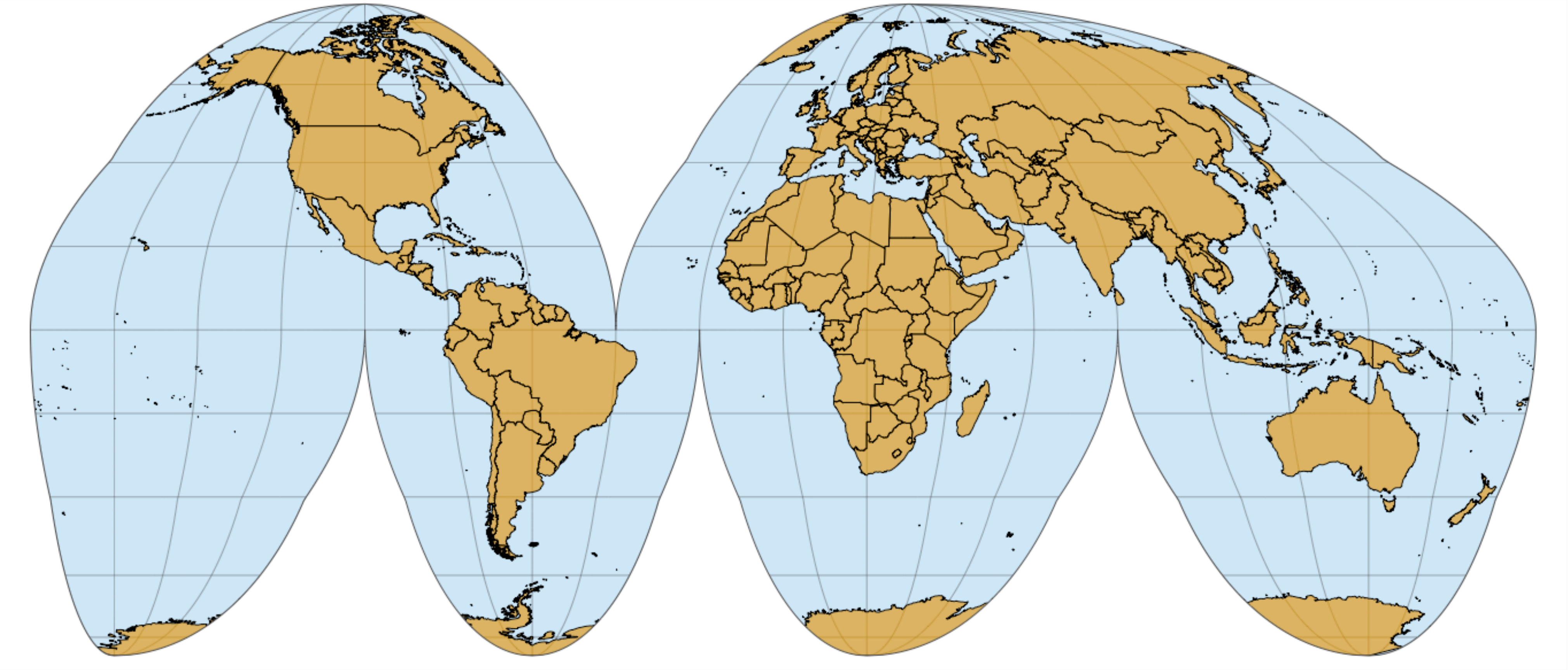


In this projection, parallels are horizontal and meridians are vertical. It’s a conformal projection preserving local angles but distorts areas near the poles. For example, Greenland appears larger than Africa, despite Africa being 14 times bigger.

Goode Homolosine Projection

- **Preserves Area**: Offers a more accurate representation of global size relationships.
- **Aesthetic Trade-offs**: Landmasses like Greenland and Antarctica appear disjointed.
- **Practical Use**: Ideal for mapping global data where area accuracy is critical.

Goode homolosine projection of the world



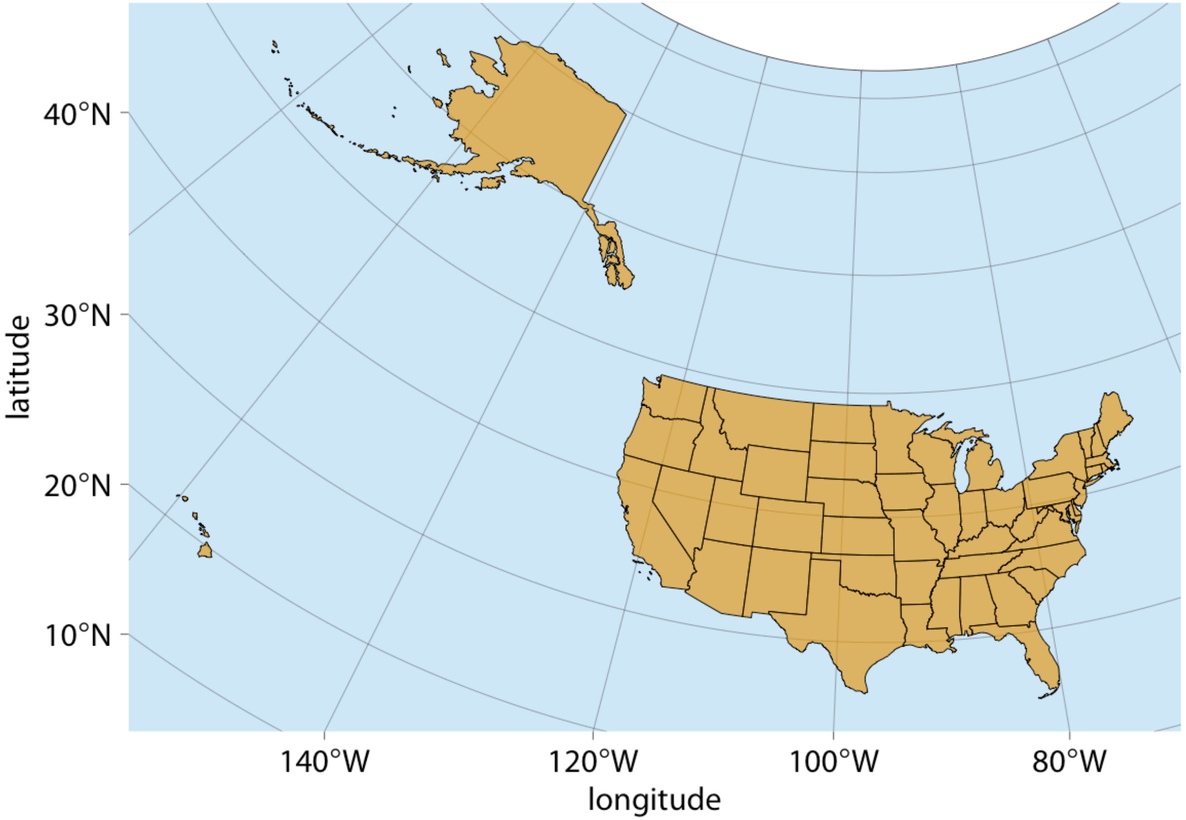
This projection accurately preserves areas while minimizing angular distortions, at the cost of showing oceans and some land masses (Greenland, Antarctica) in a non-contiguous way.

Projecting Large Areas

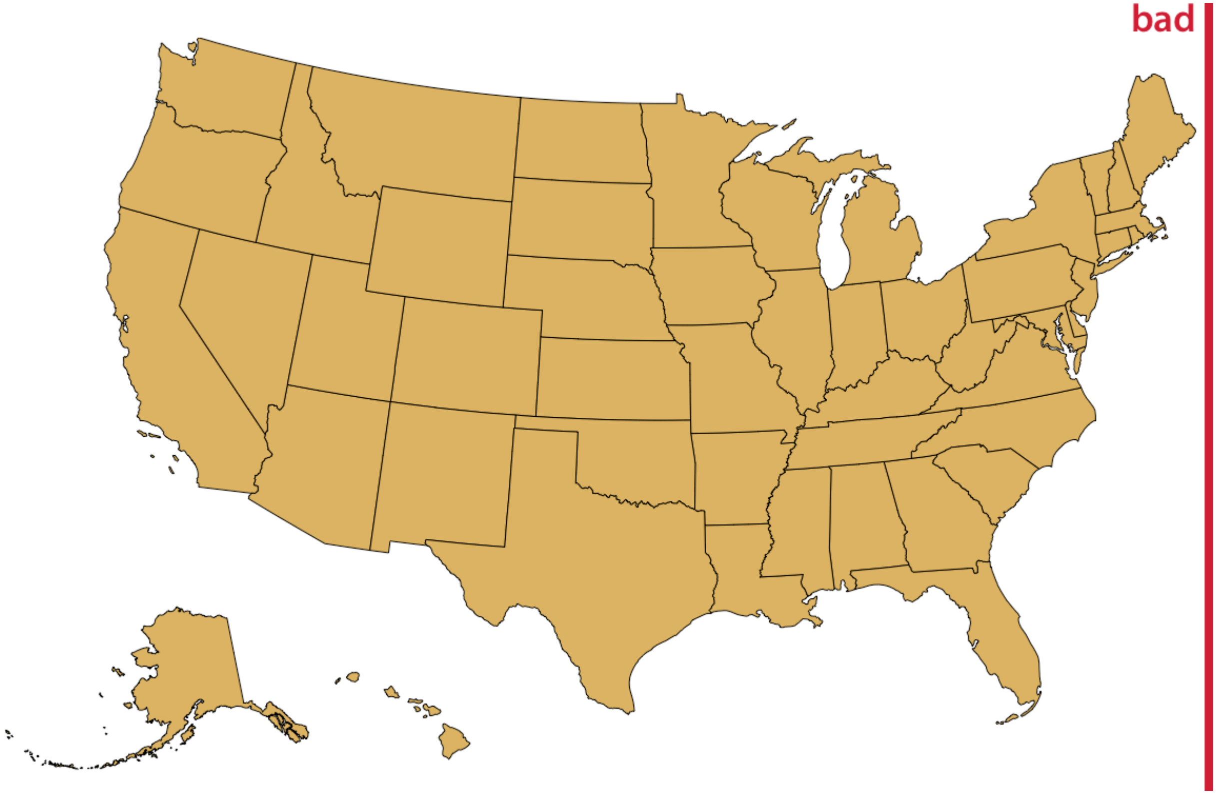
- **Challenges**: Projecting a whole country like the U.S.
  - Alaska and Hawaii’s spatial relationships can appear misleading.
  - Example: Misleading size distortion in “bad” visualizations (Alaska made to appear smaller).

Relative locations of Alaska, Hawaii, and the lower 48 states shown on a globe.

Visualization of the United States



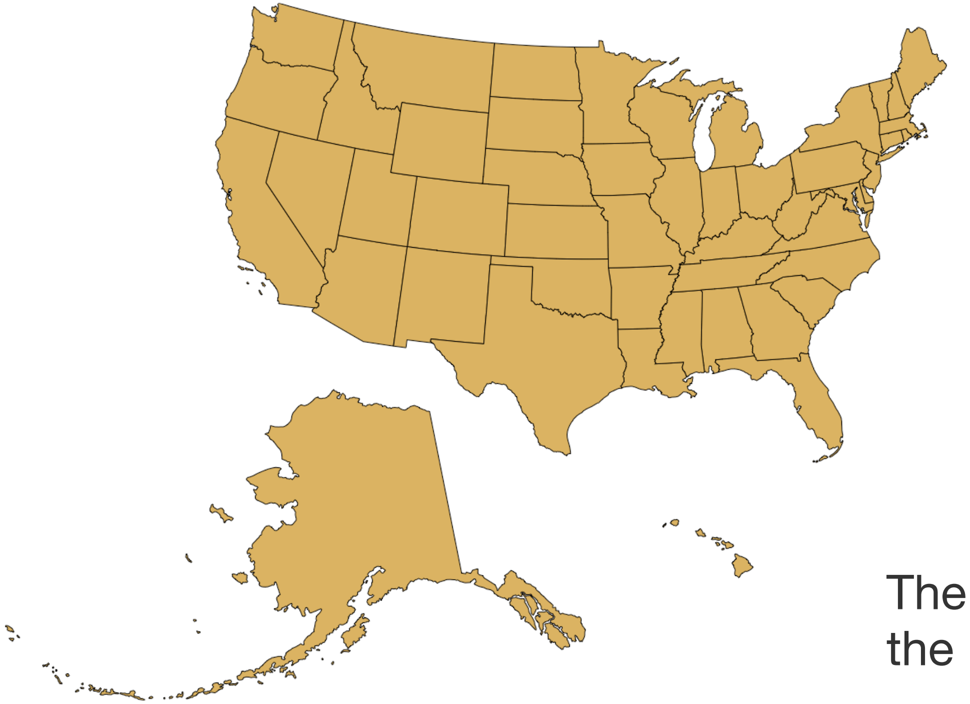
Area-preserving Albers projection. Alaska and Hawaii are shown in their true locations.



Alaska and Hawaii moved beneath the lower 48 states. Alaska scaled to 35% of its true size.

Handling U.S. States Projection

- **Example**: U.S. states visualized with correct relative sizes.
  - Alaska should not be scaled down to fit aesthetically into the map.
  - Better visualization: Move Alaska and Hawaii without scaling.



The states of Alaska and Hawaii moved to lie underneath the lower 48 states.

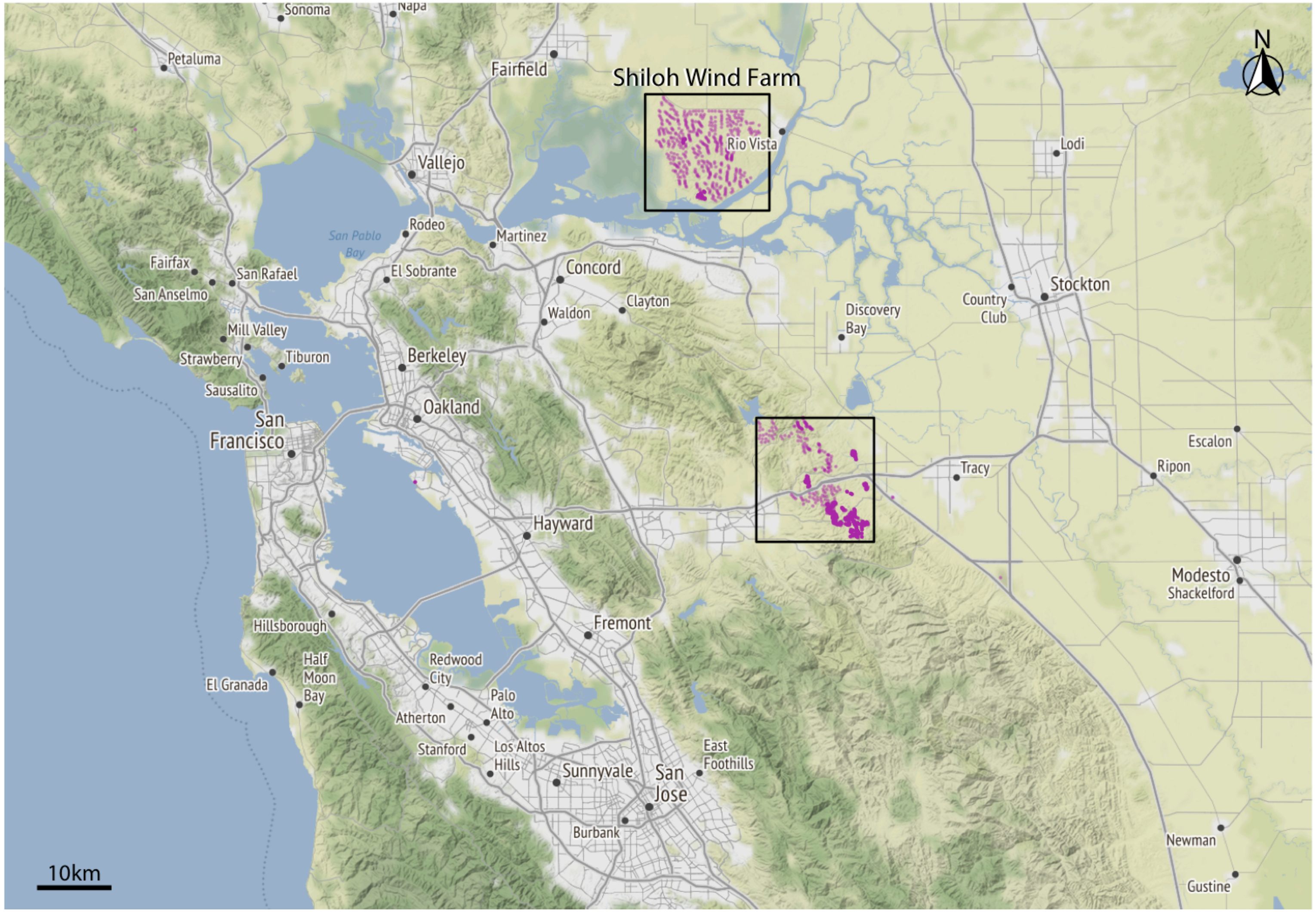
Layers in Geospatial Visualization

- **Concept**: Maps can have multiple layers of information.
  - *Layer 1*: Terrain (hills, valleys, water).
  - *Layer 2*: Roads and infrastructure.
  - *Layer 3*: Wind turbines (locations marked as dots).
  - *Layer 4*: Cities with labels.
- **Key takeaway**: Different data types and layers add contextual richness to maps.

Wind Turbine Visualization in San Francisco

- **Example of Multi-Layer Mapping**:
  - Layer 1: Terrain.
  - Layer 2: Road network.
  - Layer 3: Wind turbine locations.
  - Layer 4: Cities and additional map details.
- **Usage**: Helps identify spatial patterns of energy sources in relation to geography.

Wind Turbine Visualization (continued)



Wind turbines in the San Francisco Bay Area. Individual wind turbines are shown as purple-colored dots. Two regions with a high concentration of wind turbines are highlighted with black rectangles. Wind turbines near Rio Vista collectively are referred to as the Shiloh Wind Farm.

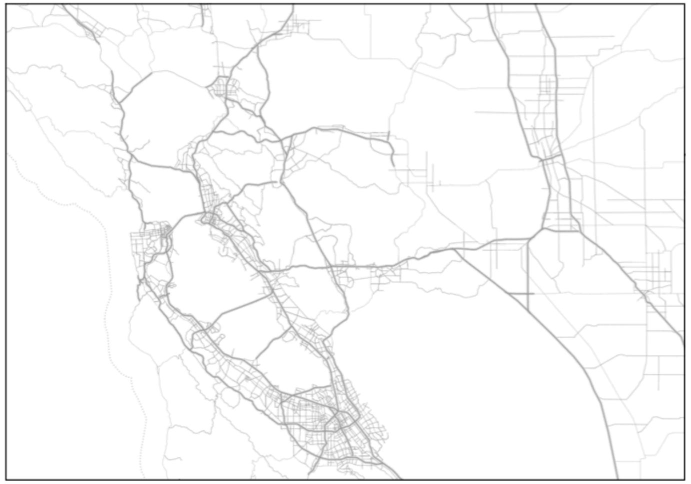
Enhancing Map Aesthetics and Information

- **Aesthetics**: Data points can show multiple dimensions using colors and shapes.
  - Example: Wind turbines color-coded by construction date and shaped by project.
- **Takeaway**: Mapping is not just about placing dots on a map; it is about using visual features to communicate multiple data aspects effectively.

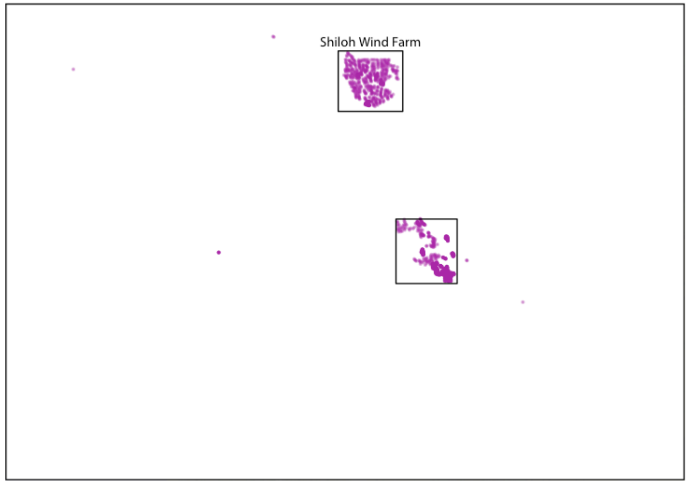
Individual layers

terrain

roads



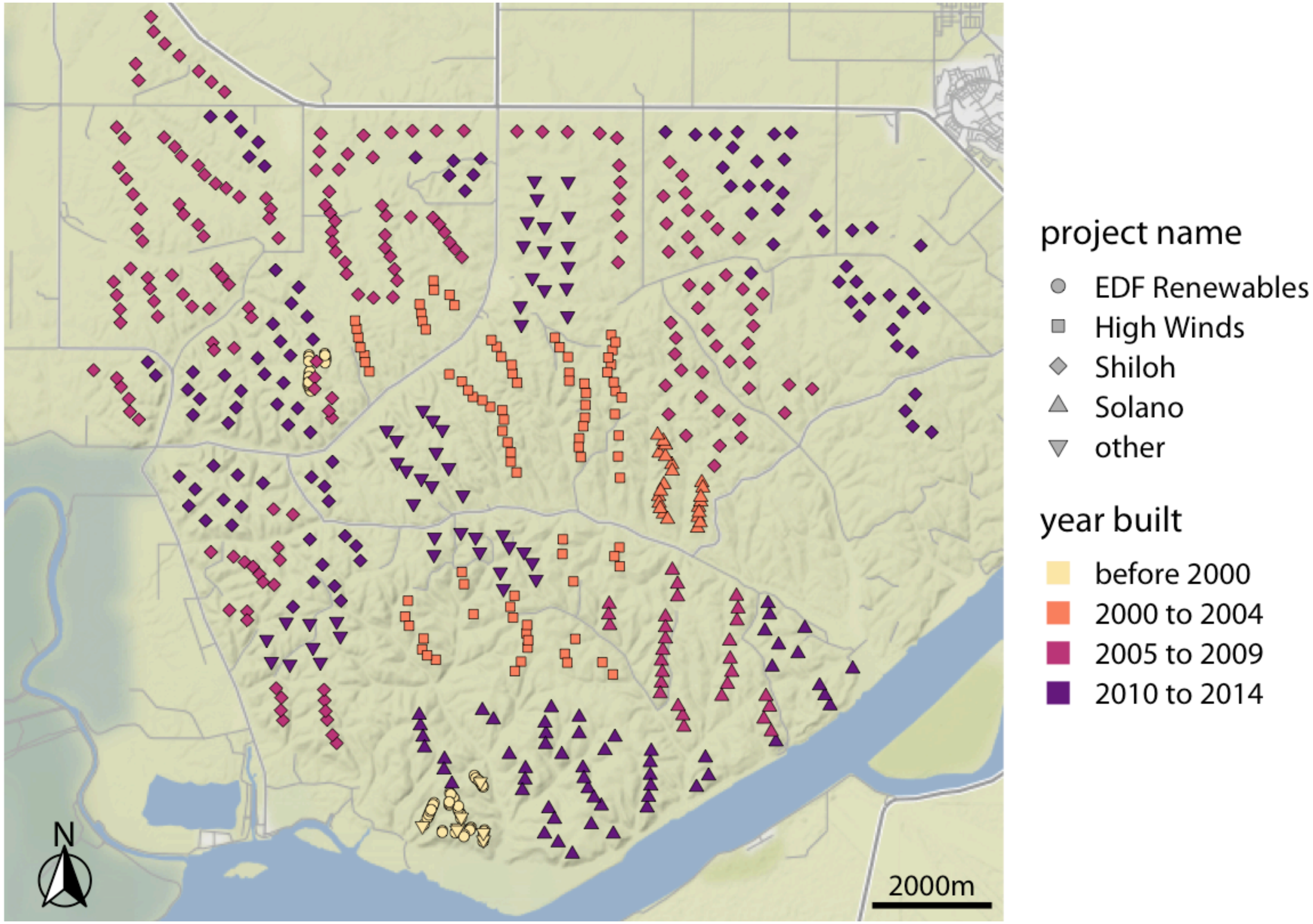
wind turbines



city labels, scale bar

From bottom to top, the figure consists of a terrain layer, a roads layer, a layer showning the wind turbines, and a layer labeling cities and adding a scale bar and north arrow.

Location of wind turbines

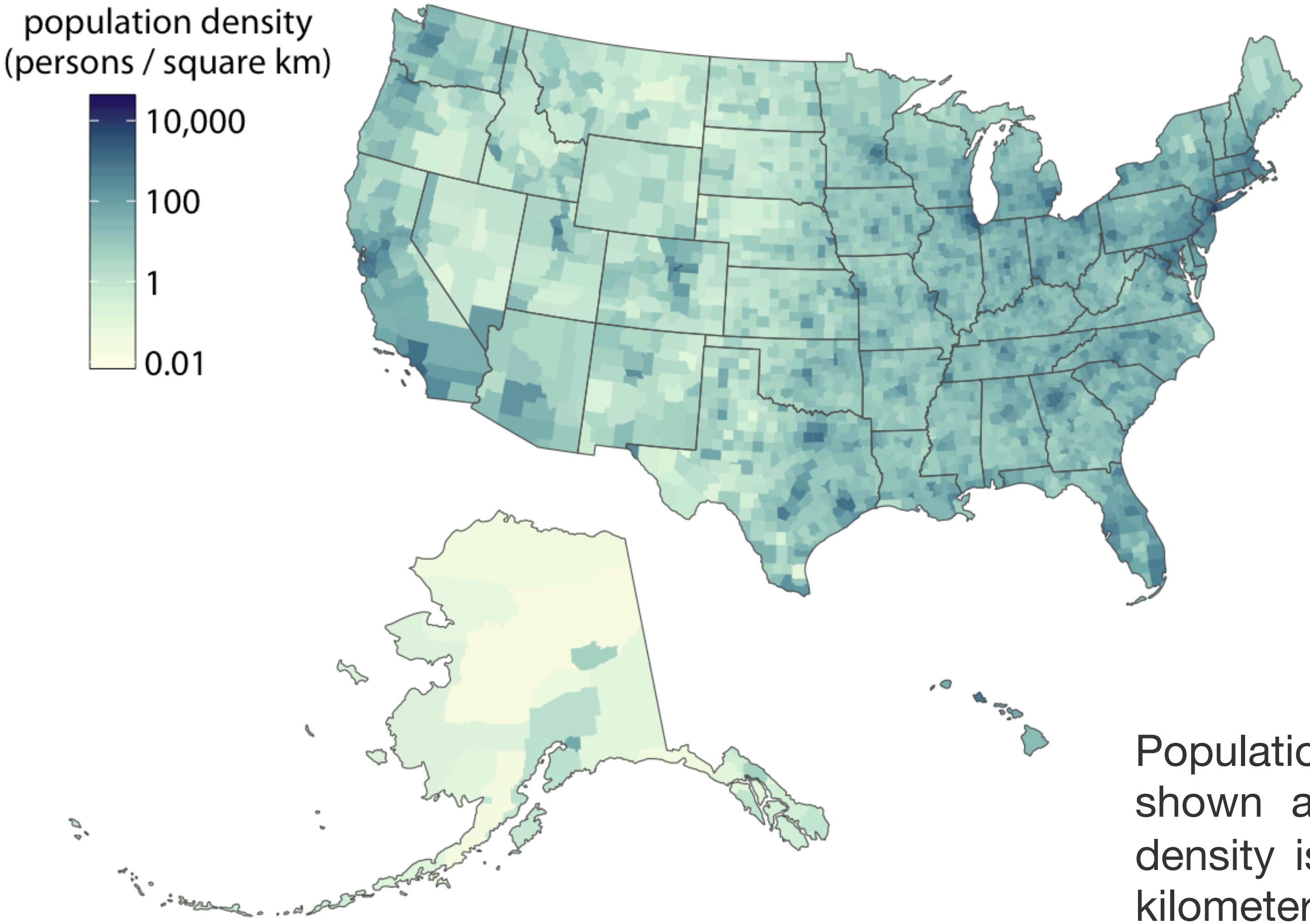


Location of individual wind turbines in the Shiloh Wind Farm. Each dot highlights the location of one wind turbine. Dots are colored by when the wind turbine was built, and the shape of the dots represents the various projects to which the individual wind turbines belong.

Choropleth Mapping

- **Definition**: Choropleth maps are used to display how a quantity varies across locations by coloring regions based on data dimensions.
- **Example**: Population density (persons per square kilometer) across U.S. counties.
  - Areas with higher population densities are shown with dark colors, while lighter colors represent lower densities.
  - Light colors represent high density, while dark colors represent low density.

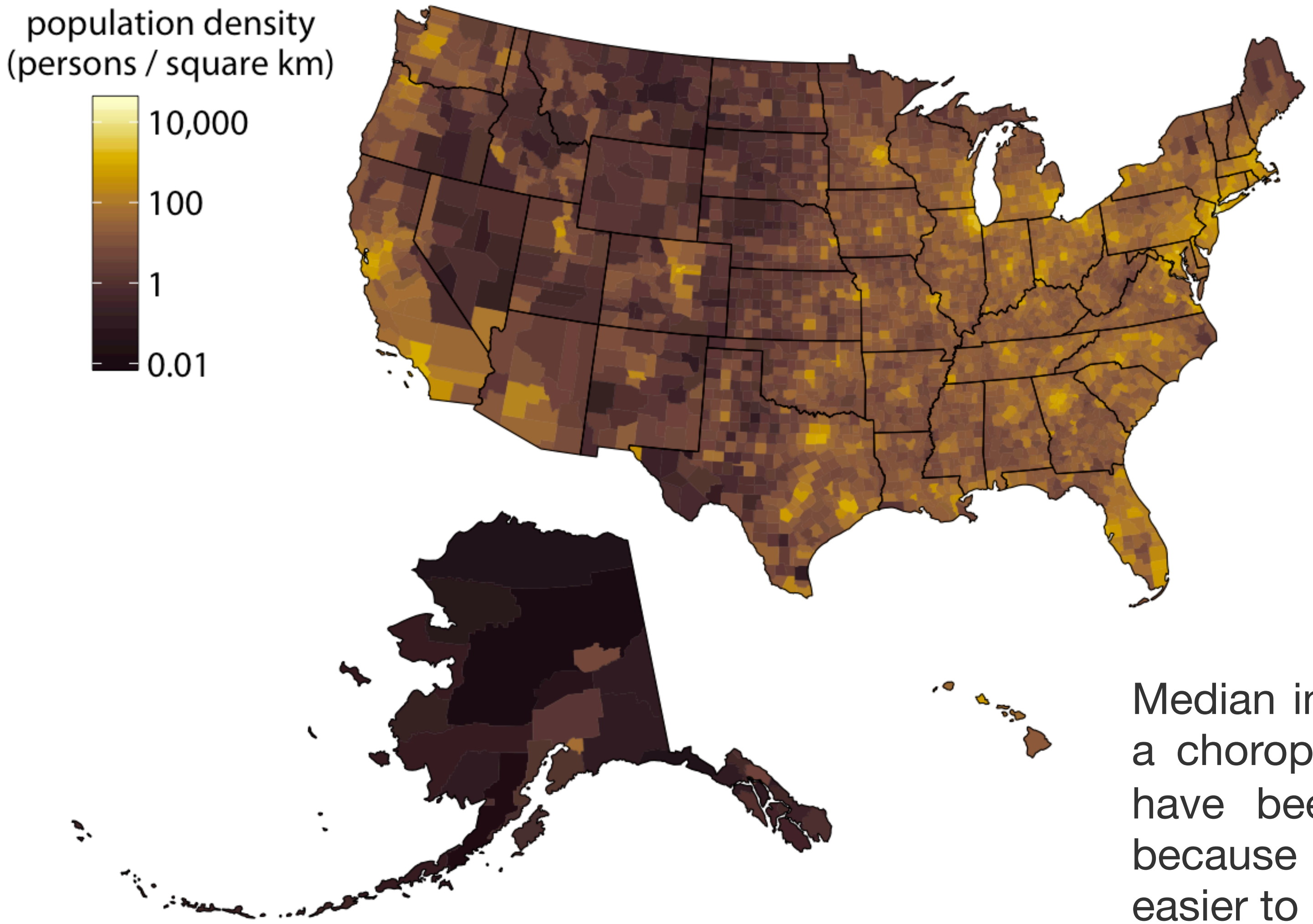
U.S. county population density



Population density in every U.S. county, shown as a choropleth map. Population density is reported as persons per square kilometer.

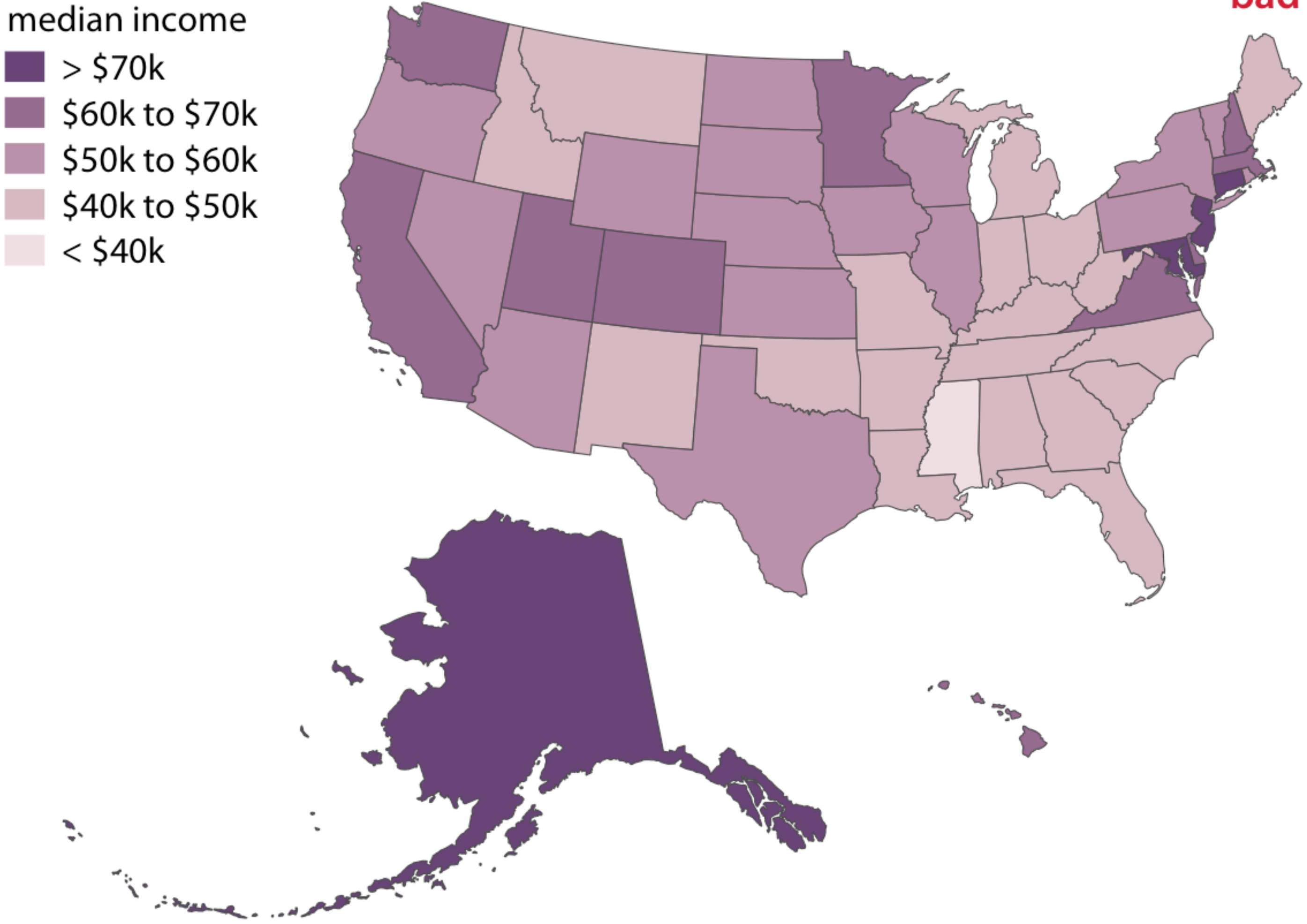
- **Best Usage**: Choropleths work best when the coloring represents density. Considerations include:
    - **Uniform size/shape** of areas.
    - **Relative size** of areas to avoid disproportionate attention due to size.
- **Continuous vs Discrete Colors**:
    - Continuous color scales are visually appealing but harder to interpret.
    - Binned color scales (e.g., 4-6 bins) are easier to read but sacrifice some detail.
- **Limitations**: Maps may be dominated by larger states like Alaska, leading to a poor representation of income distribution.

U.S. county median income - Choropleth



Median income in every U.S. county, shown as a choropleth map. The median income values have been binned into five distinct groups, because binned color scales are generally easier to read than continuous color scales.

U.S. state median income (continued)



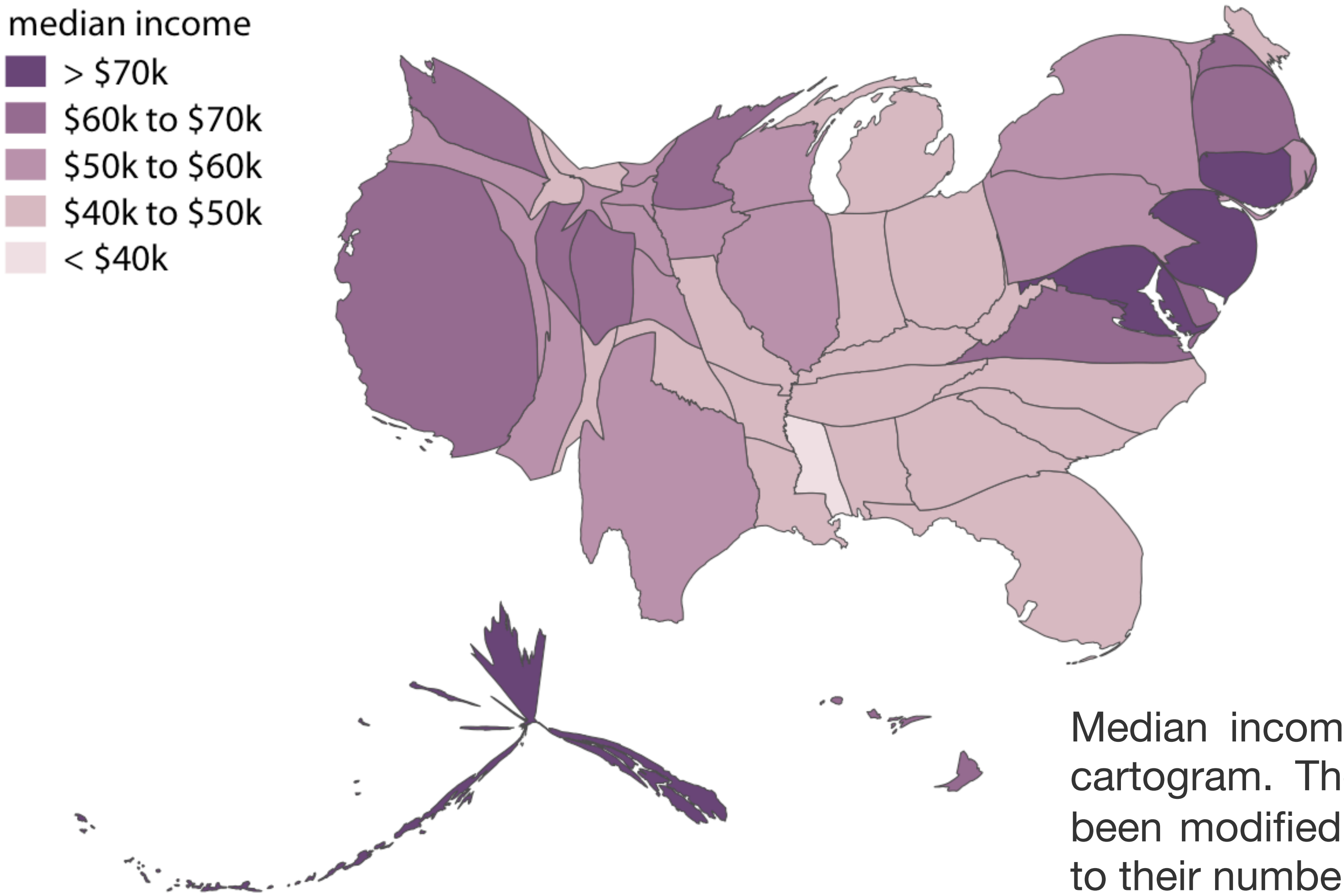
bad

U.S. state median income shown as a choropleth map. Alaska's large size and low population density distort the visualization, making it a poor representation of income distribution.

Cartograms

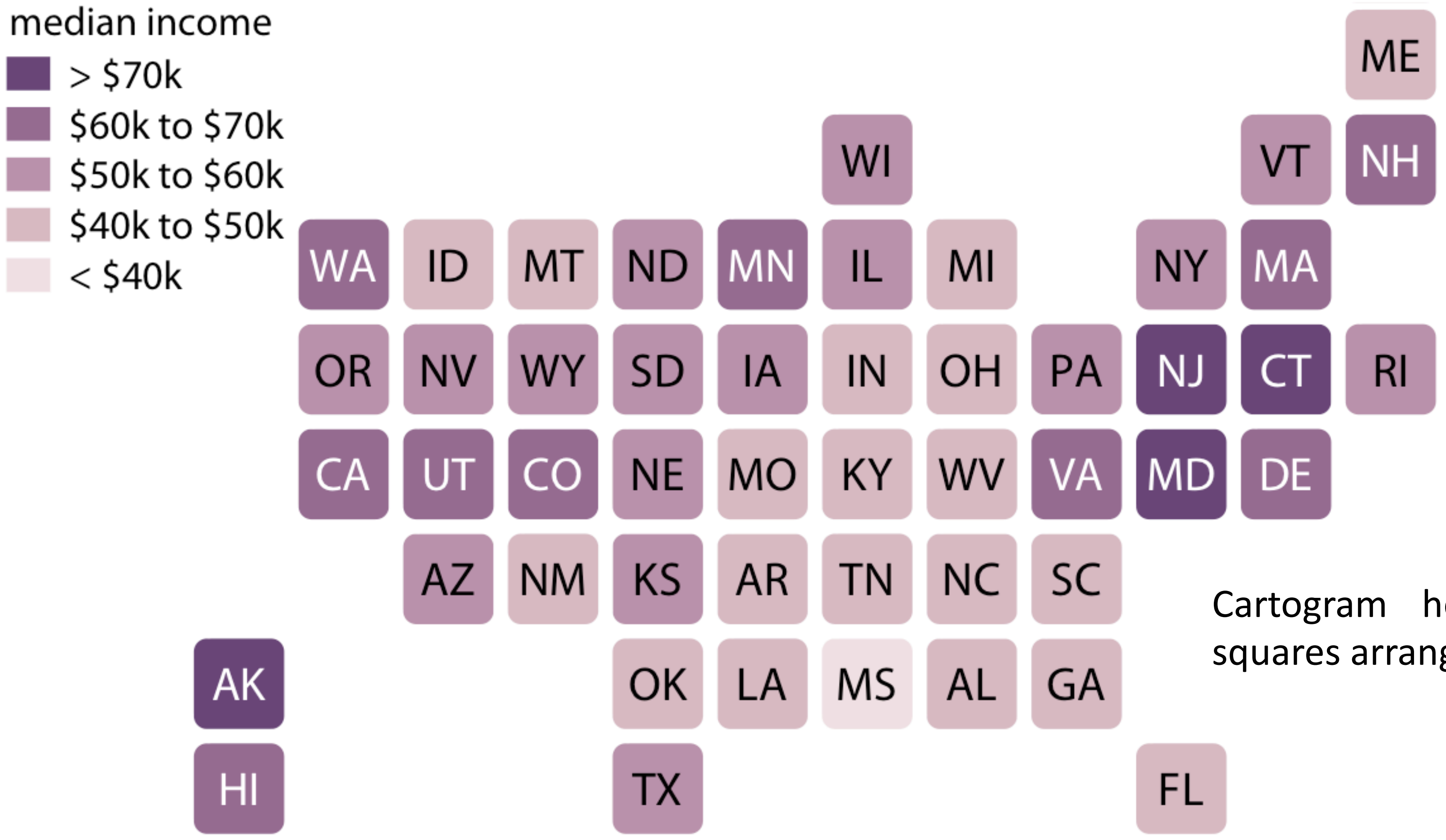
- **Definition**: Cartograms adjust the size of regions to reflect a quantity, such as population.
  - Example: U.S. states modified to reflect population size.
- **Cartogram Heatmap**: Each state is represented by a colored square to maintain equal visual weight for each state.
- **Complex Cartograms**: Display individual plots for each state, showing trends over time (e.g., unemployment rate trends).

U.S. state median income - Cartogram



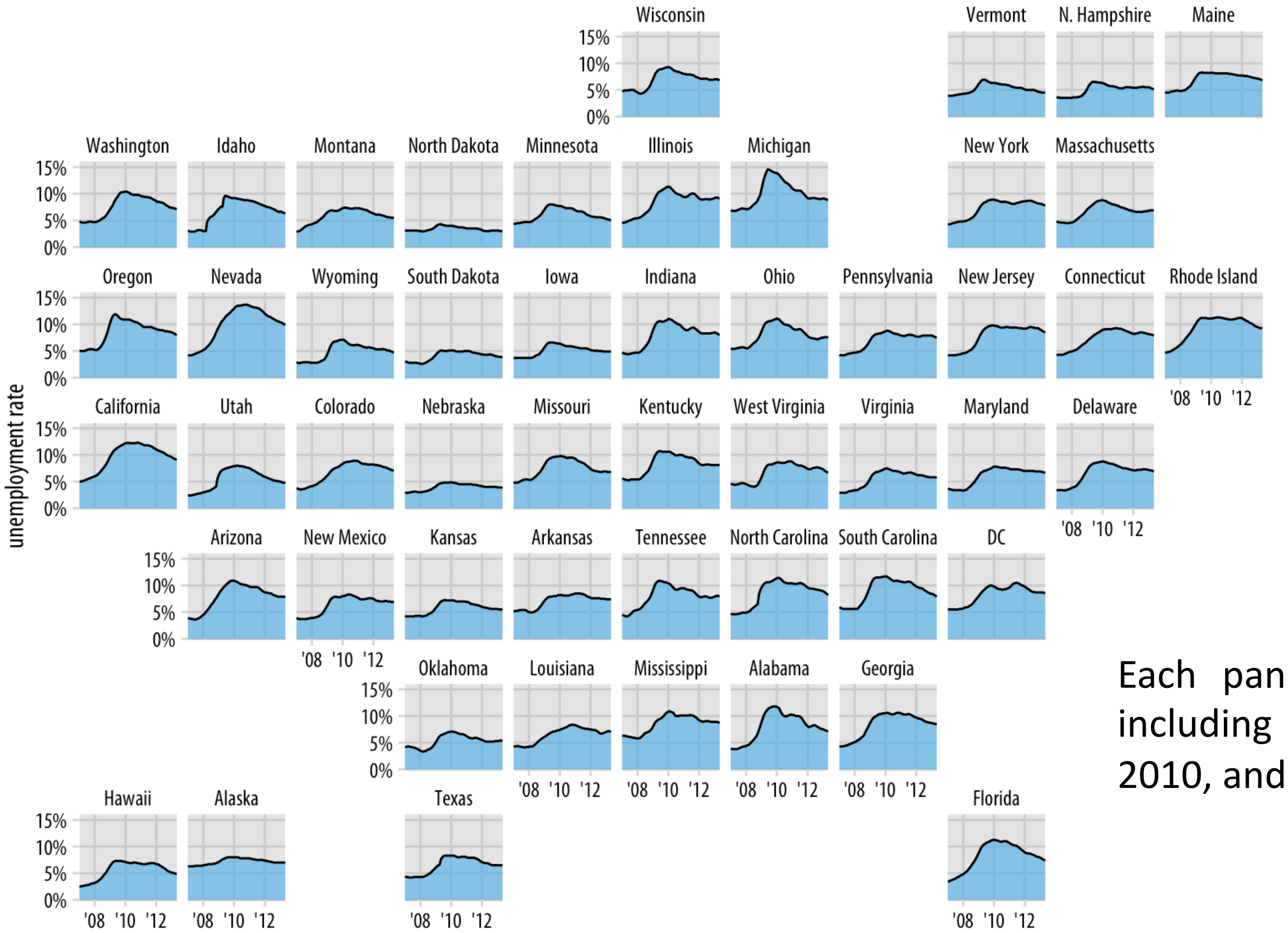
Median income in every U.S. state, shown as a cartogram. The shapes of individual states have been modified such that their area is proportional to their number of inhabitants.

U.S. median income - Cartogram heatmap



Cartogram heatmap with equally sized squares arranged by relative state positions.

State unemployment rates (2007–2013)



Each panel shows a state's unemployment rate, including D.C. Vertical lines mark January 2008, 2010, and 2012. Nearby states exhibit similar trends.

Conclusion and Key Takeaways

- **Geospatial Visualizations**: Enhance understanding of complex spatial relationships.
- **Map Projections**: Always choose the right projection based on your needs (e.g., accuracy vs. aesthetics).
- **Layering**: Combine multiple layers for richer, more informative maps.
- **Practical Applications**: Geospatial data visualization is essential in ecological studies, urban planning, economics, and many other fields.