Cartography and Visualization in GIS

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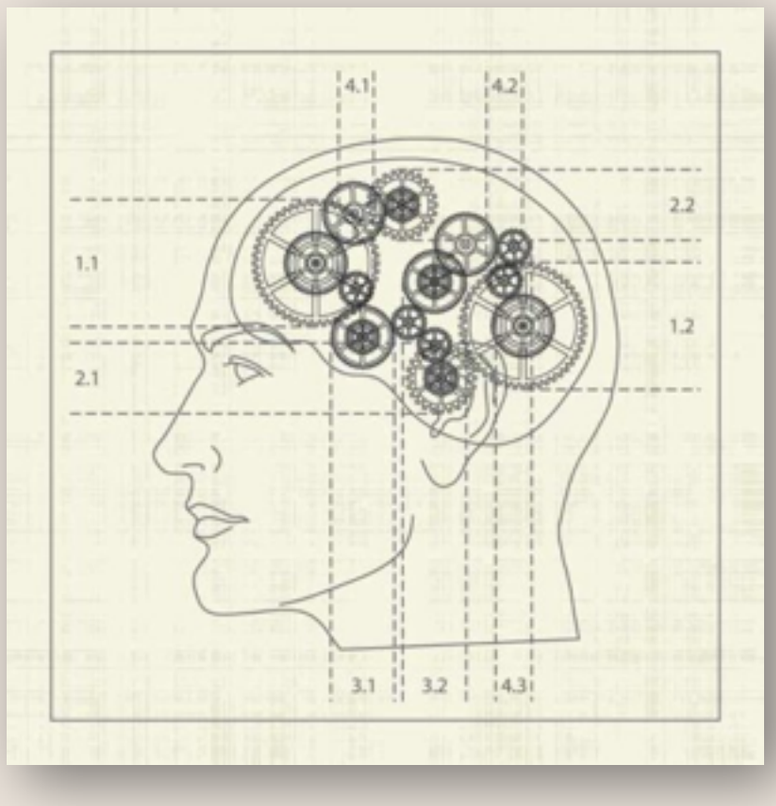
bit.ly/sgccart

Image: http://bklynr.com/block-by-block-brooklyns-past-and-present/

Map roles in GIS

- Maps are **representations**
- Visualize complex information
- Simplification, aggregation, symbolization

- Maps are tools for **spatial thinking**
- Explore and analyze spatial data
- Make decisions based on spatial information



Friday, September 18, 15

Our use of GIS at Stanford is primarily for academic research, using GIS and maps to answer spatial questions.

Maps are representations
We use maps to represent complex geographic data and phenomena.
We rely on representations to simplify and focus spatial information and to make the invisible visible.

Maps are tools for spatial thinking
We use maps explore and analyze spatial data.
Maps are often the basis for spatial decision-making processes.

Maps are a form of visual communication.
Fundamentally all map use is based on a visual communication function.
The map holds spatial information and the map user reads the map to absorb that information.
The map is a tool for communication between the map author and the map reader, as well as between the data and the researcher.

Effective communication process usually involves evaluation and feedback.

Map reading is a cognitive process
Maps (especially in GIS) are not just containers for raw data, they are tools for thinking spatially.
We use maps to explore, interpret, and analyze spatial data.
Most GIS maps are the basis for spatial decision-making processes.

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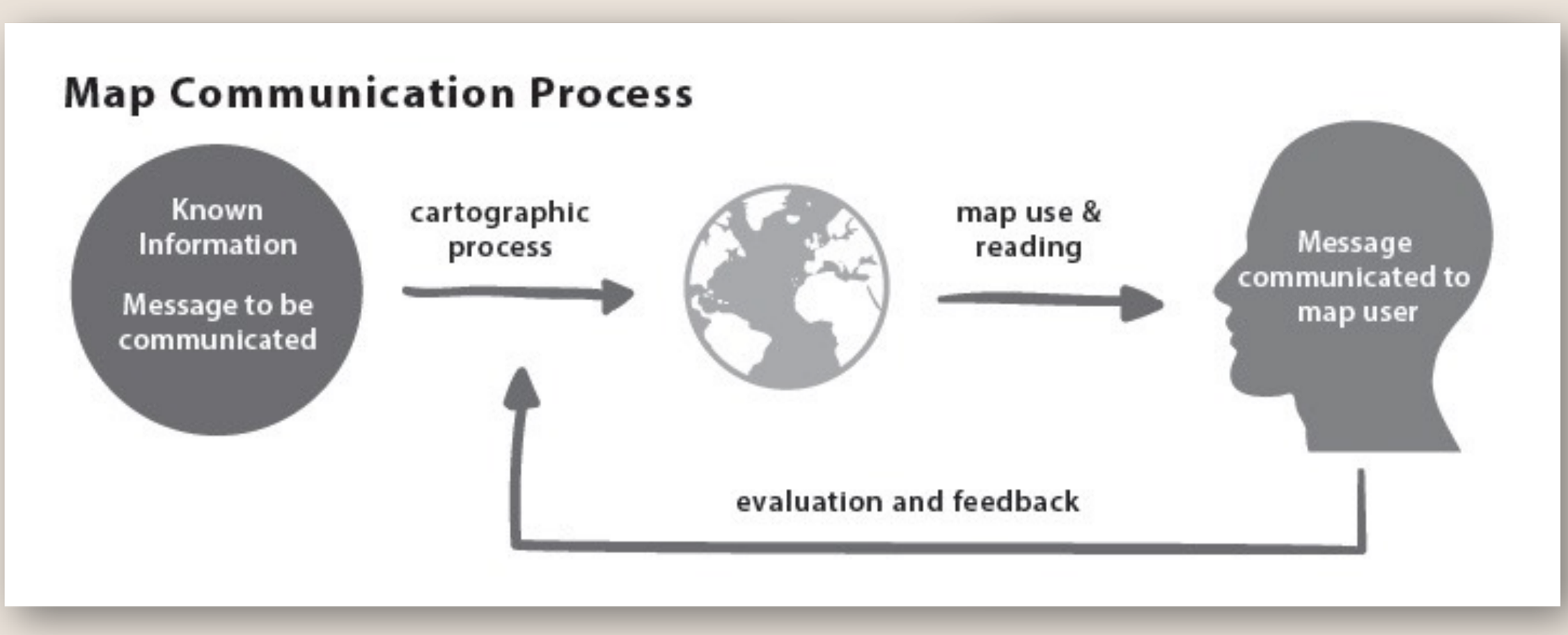

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Why design matters?

- Maps have communication goals
- Effective communication supports our goals
- Good design enhances communication
- Poor design breaks down communication

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Maps have communication goals and messages.
Most maps are not passive containers for spatial facts but carry an implied message or are created to meet a specific communication goal.
Communication is not a uniform process, all maps differ in their effectiveness at delivering visual information.
Effective communication should be the goal of any map or map maker.
Good design enhances communication, poor design breaks down communication.
Design is what enables us to tailor a map to meet its specific communication goals.
Design allows us to focus the map users attention. To reduce visual distractions. To create a visual story and deliver our message.

Effective communication is the goal, design is how we archive it.

There is a difference between ‘making’ a map, and ‘designing’ one.

Our ultimate goal is a map that is clear, elegant, simple to understand, designed for its message and its audience.

Once we all agree that effective communication is a critical feature or goal of almost any publication map we need to look at how design effects visual communication in maps.

Design is what happens between the “known info” and the “map user” and it has a direct effect on how maps are read or interpreted.

What do we risk when we don’t take the time to communicate effectively?

Communication breakdown
Poor quality cartography can obscure the point of your work and send misleading or incorrect messages to the map reader.

Perception of quality
Visual design quality can directly effect the perception of work quality in your project.
Poorly designed visuals suggest poorly designed analysis.

Capture attention
Project visuals may be the best chance to engage with your audience, if they fail, the opportunity for communications is lost.
Poor design drives away the reader.

Engaged thinking
To look at a well-designed map is to think about its content, not merely observe it.
Good maps tell stories, they both answer questions and prompt new ones.

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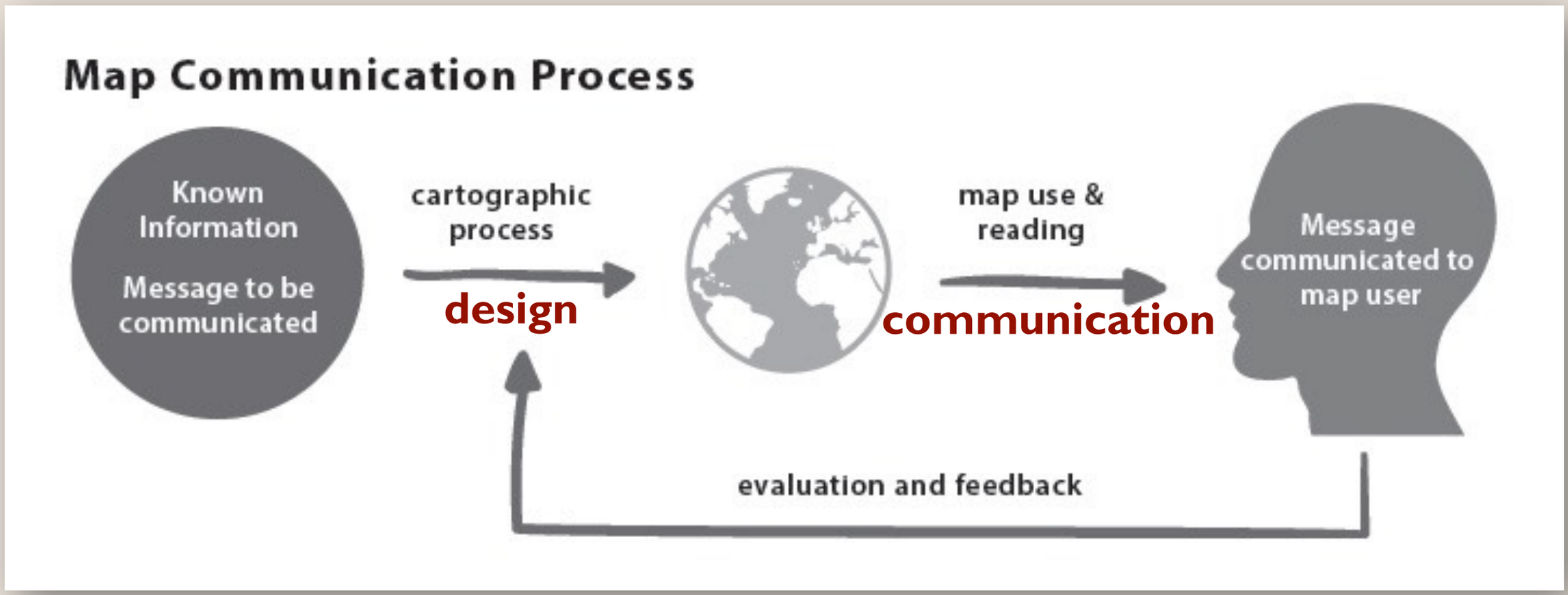

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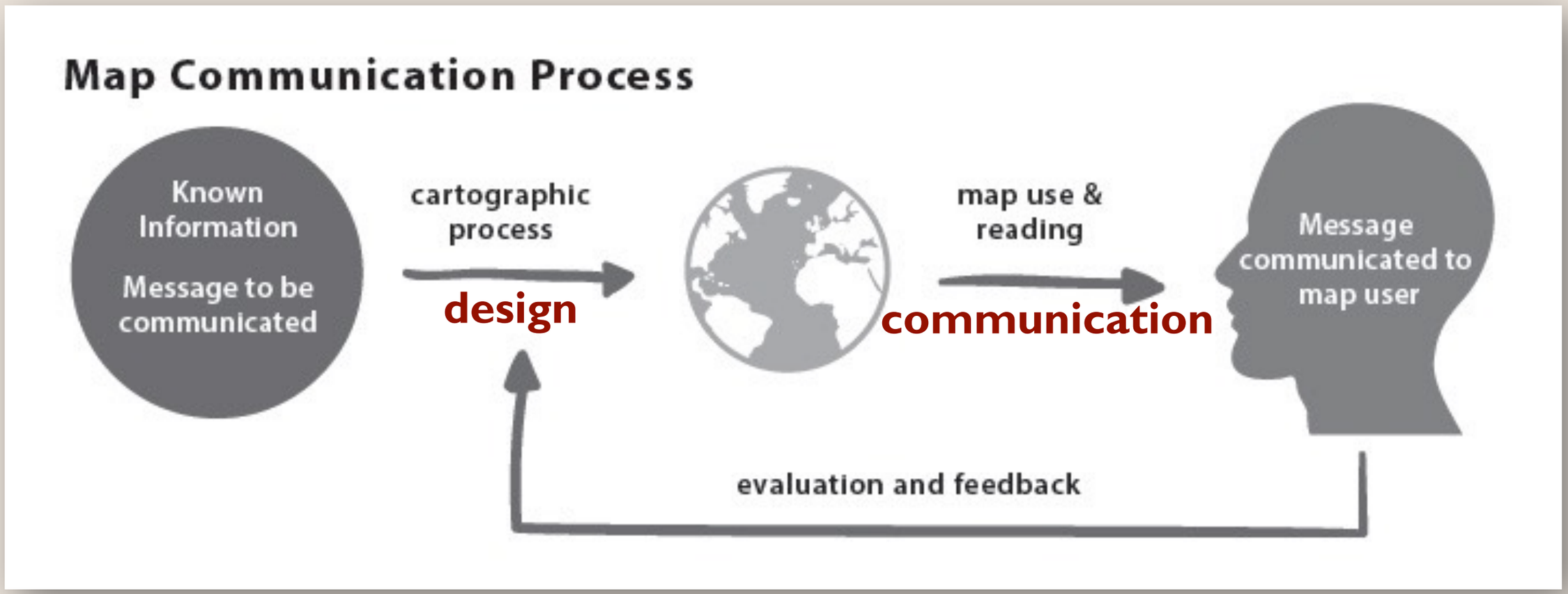

Your map is only as useful as it is used.

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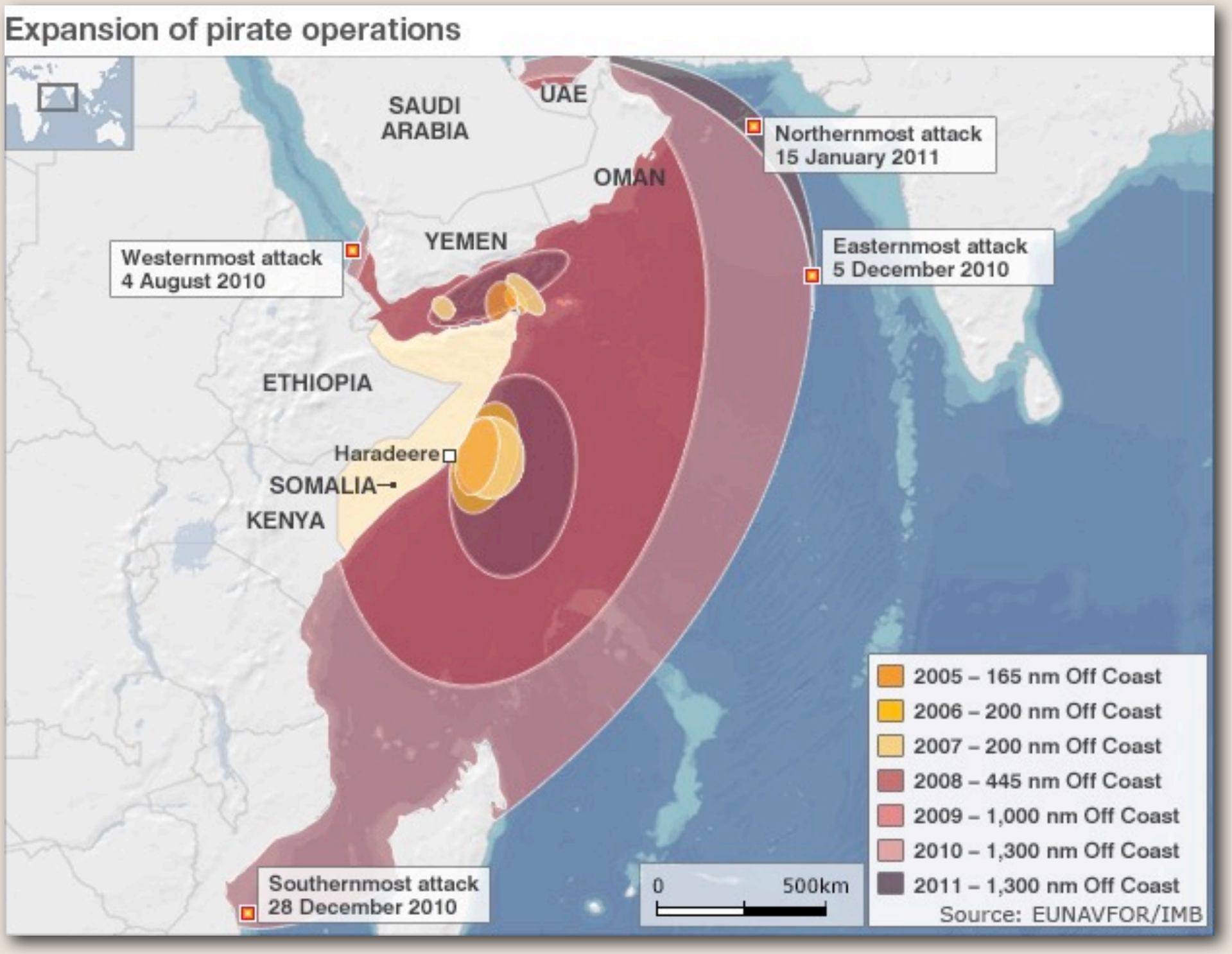

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Discussion of how design effects a maps ability to communicate a story.

Design Comparison – Pirate Maps
Map 1: what's the message in this map? How is its design affecting that goal?

What do you notice about the area symbols? Are they doing a good job of modelling expansion (or just concentration)?
These are SD circles, not ranges, they don't really model a progression of activity.

What do the colors tell you is the most important feature on this map? Now what does the title tell you is most important?

Without the legend could you tell what polygon came first or last? Why is the most important area the least visible (darkest color, bottom of visual order)?

Map 2: compare that to 2nd map of the same topic. How did they improve the map through design?

Polygons now cover only water (important for ocean going pirates).

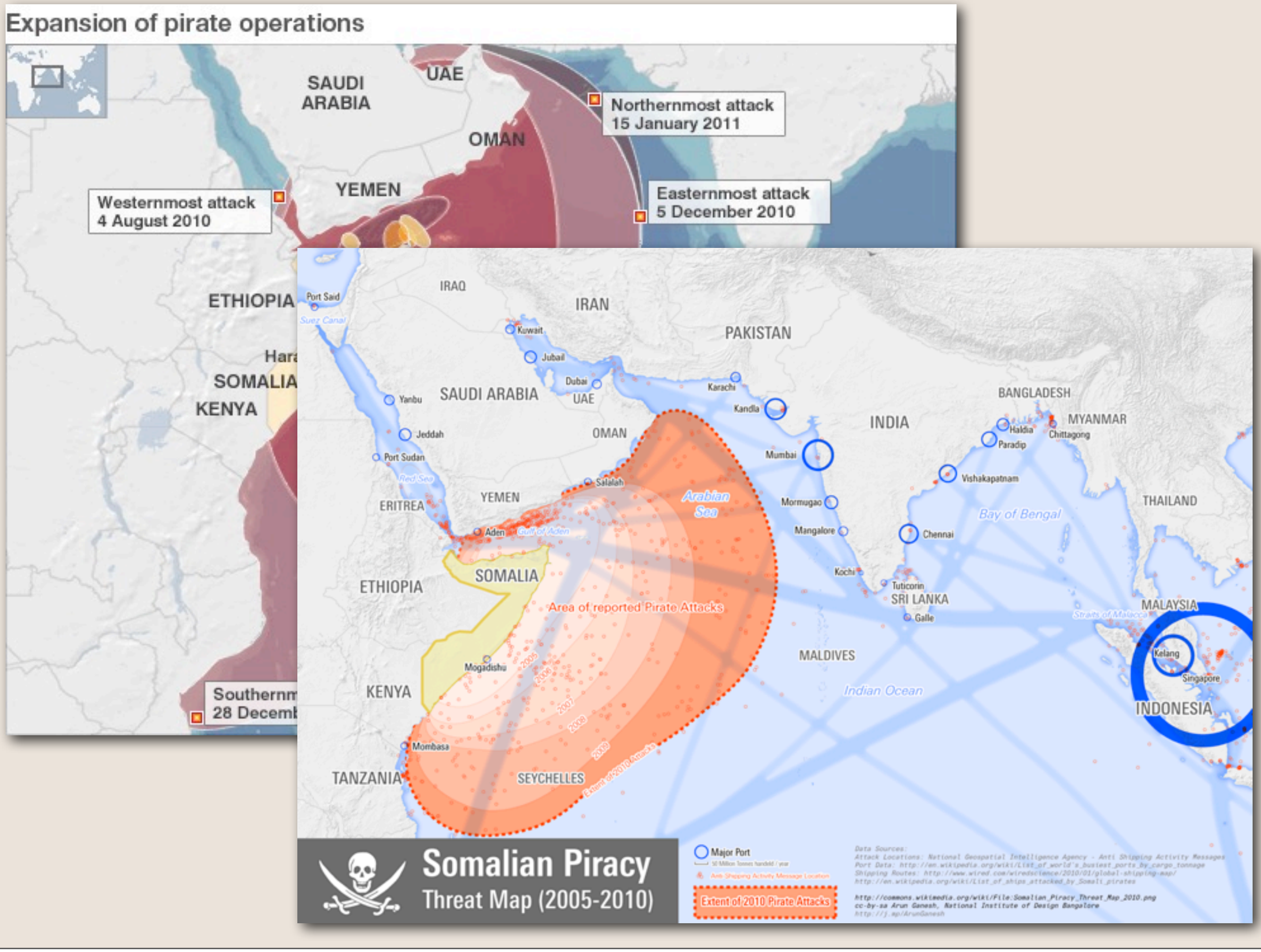
There is a clear progression from oldest to most recent in the symbology.
The area colors now mean something, clearly telling me which data is the most important while still relating all the data to each other (same color family).

The map labels are doing the work of the legend.

Added point data over aggregate ranges for extra detail.

Improved the context by adding ports and shipping lanes. This context does something very important for the 2nd map that's missing from the 1st map. Can anyone tell me what that is? It invites the map viewer to imagine the actual flow of shipping traffic over this area, it suggests the victims, it creates a story.

Map 1 is the cartographic equivalent of what Homer Simpson would call, "punching someone in the dark, it's a victimless crime". No victims, no story, not an engaging map.



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purpose and audience

- What is the maps purpose?
    - Purpose drives decisions about content, style, and layout.
- Who is the map for?
    - Experts can handle more complex information
    - Non-experts may require a simplified map message

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All map design starts with understanding who you are making the map for and why.
The nexus of audience and purpose create a communication goal for each map.

Purpose:
Your maps purpose drives the decisions you will make about what goes on the map, and how it looks.

Audience:
Knowing who the intended map reader is allows you to speak directly to them, in language and symbology they understand or expect.

Communication with experts allows maps to be more technical and dense, we can assume the map readers are familiar with the underlying material.
Communication with non-experts means we need to work harder to clearly express our message so it can be understood by someone outside of our field.

Knowing the maps Purpose and Audience combine to create your Communication Goal for the map.

Map1: who is this map for? Experts, geo scientists.
It's busy, complex, distracting color scale, has an unlabeled legend, unlabeled map features. This map was designed for people who already know about the science behind earthquakes.
(research model of ground shaking - http://www.bssaonline.org/content/98/2/1012.figures-only)

Map2: who is this map for? Non-experts. People who only learn about earthquakes from the newspaper, or when things fall on them.
It has a simplified classification scheme, less distracting colors. The relationship between scientific data and how it effects the reader is spelled out.
Fewer map details like roads and epicenter points, more labels. Clear title, a stated communication goal (this is a map of the 1906 earthquake shaking)
(New York Times article on 1906 quake - http://www.nytimes.com/imagepages/2006/04/10/science/20060411_QUAKE_GRAPHIC.html)

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Purpose + Audience
= Communication Goal

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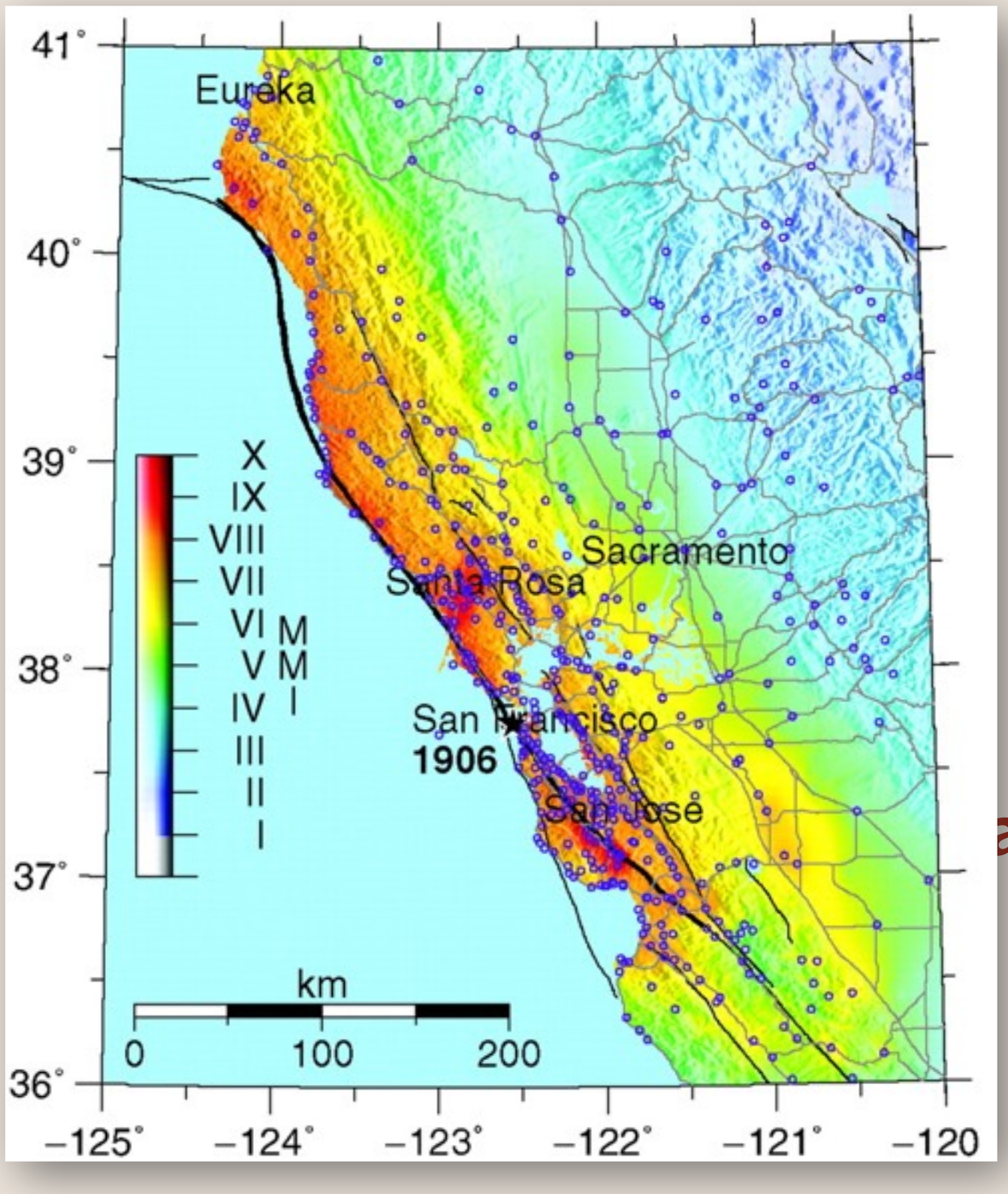

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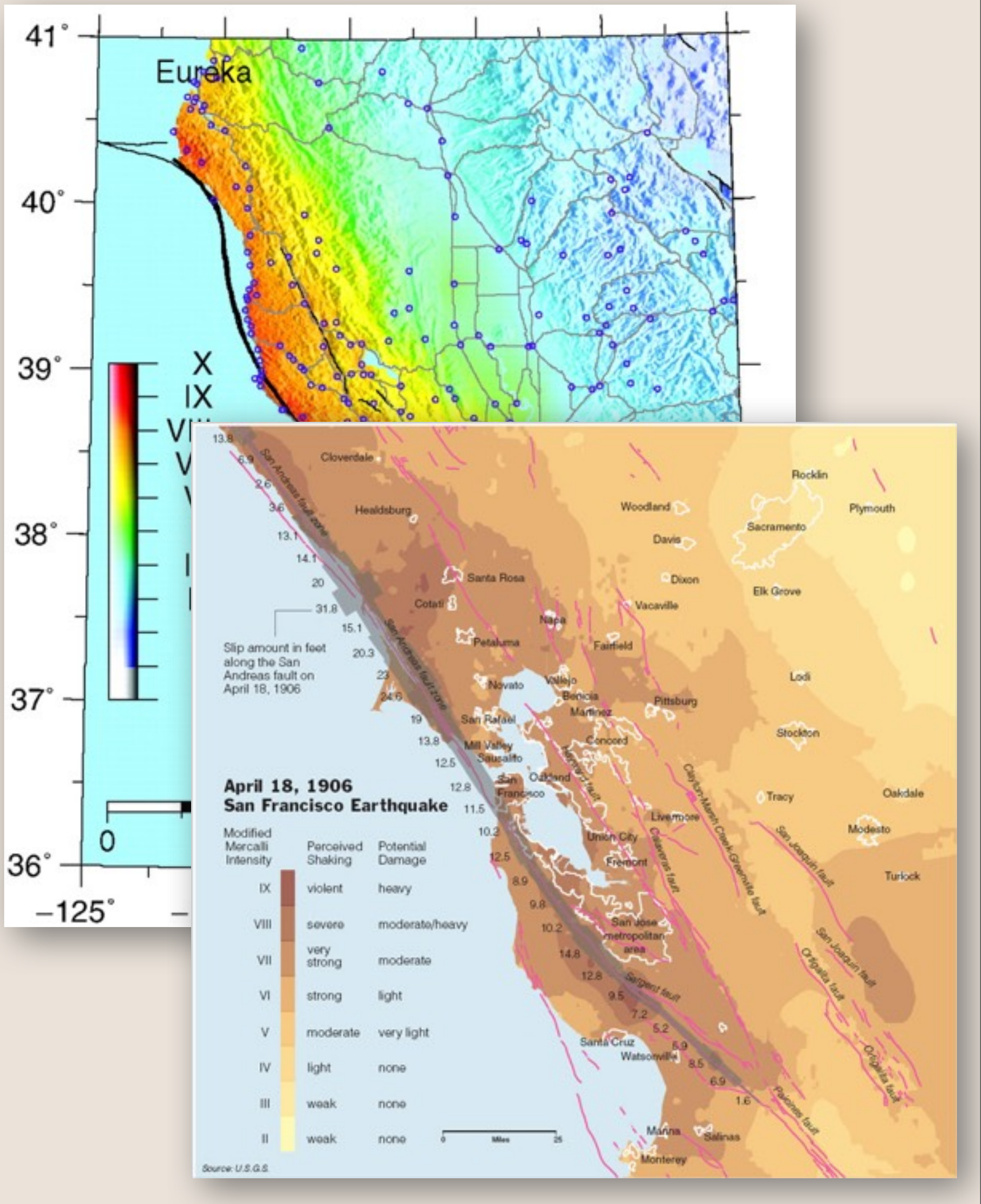

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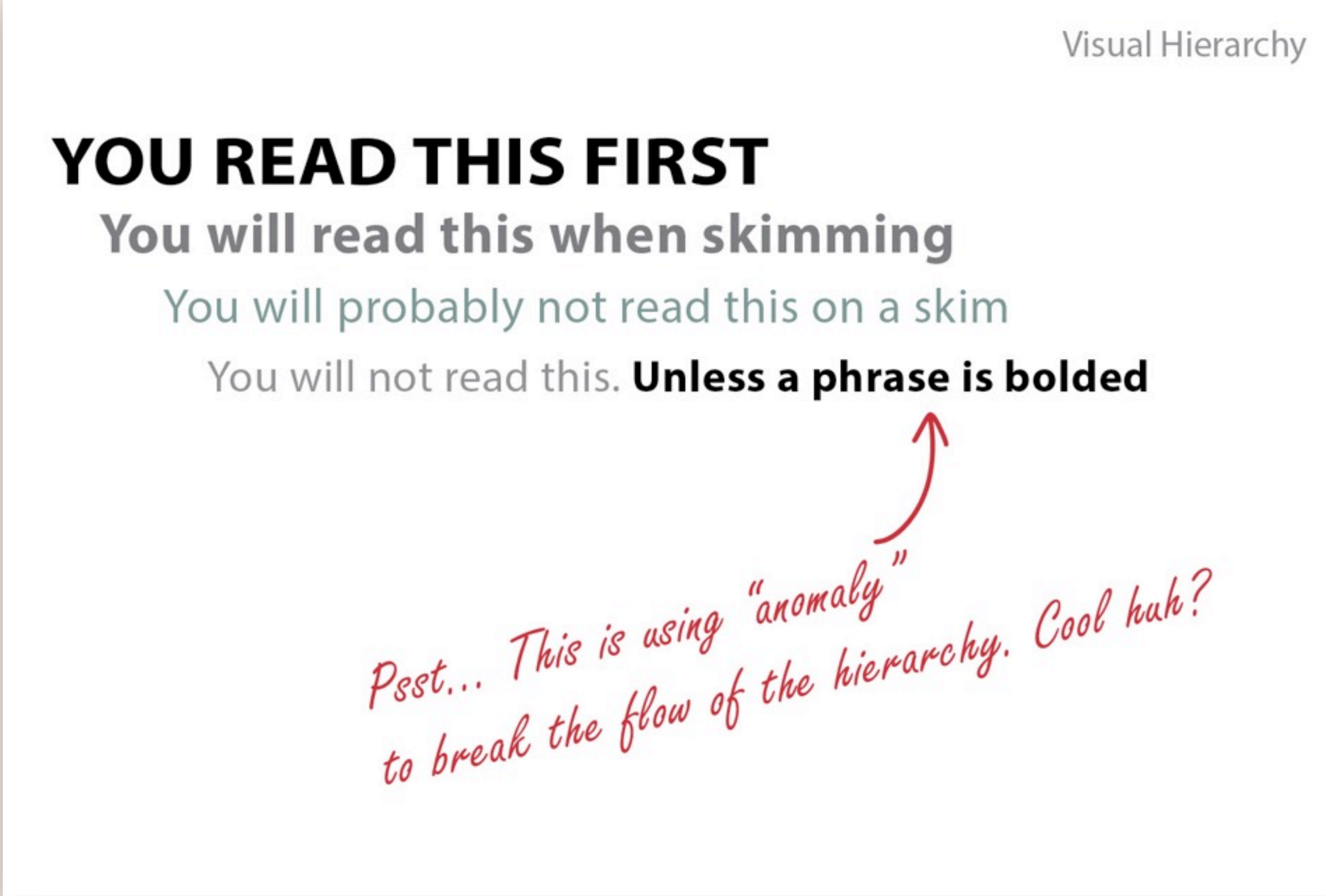

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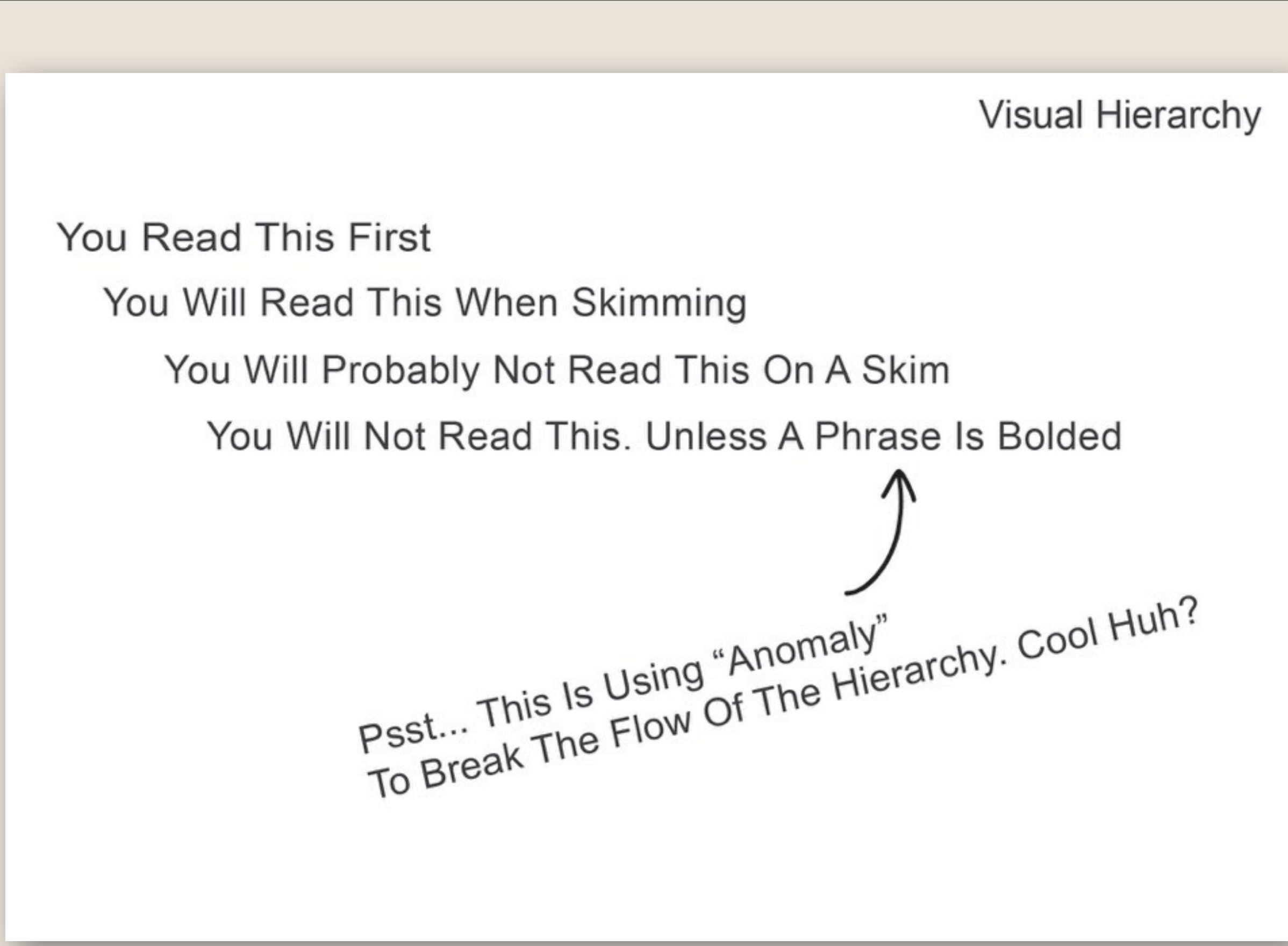
A fundamental technique for good design in map making is establishing a solid visual hierarchy.

The VH tells the reader what information is most important in an image, what's supporting or contextual, and what is just background.

The VH helps direct the readers eye around the image in a planned and deliberate way.

Compare the VH type slide with the same information and no VH. Which is more effective? Which is the most like what you get by default out a GIS?



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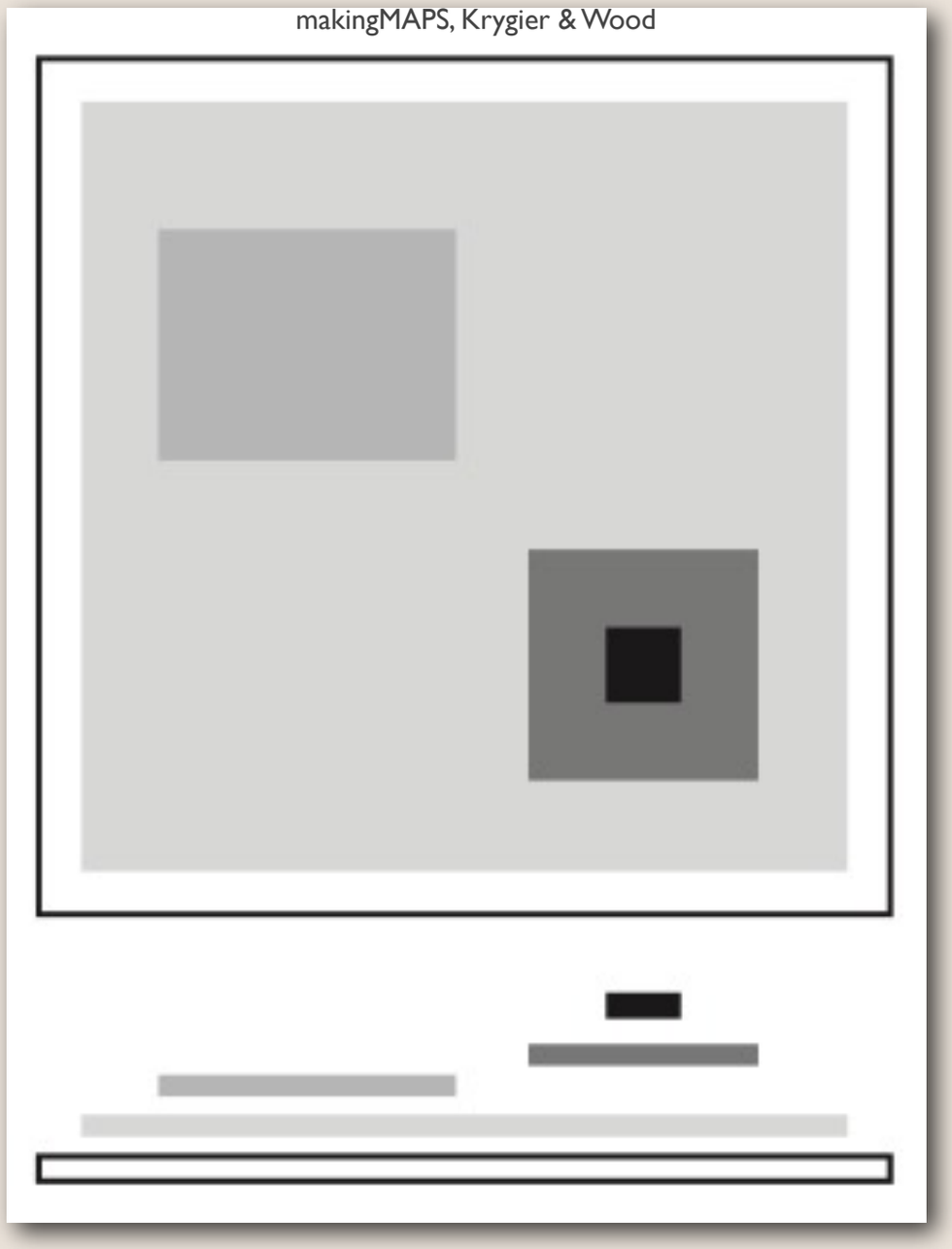
create a visual hierarchy

- Some elements of an image stand out, others fall back
- Design choices effect visual order
- Separate and layer information in rough proportion to their relevance
- Visual hierarchy follows the intellectual hierarchy



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VH is possible because all images have a visual order or depth from background to foreground.

A features position in the visual order suggests its relative importance in the map (important features sit at the top, and less important features recede into the background).
VH is not the same as drawing order in the map, although it can be affected by it.

The distance between features in the hierarchy suggests their relationship to one nother (close features are more alike, features further apart are more dissimilar).

VH follows your intellectual hierarchy for the map - you need to know what your maps goals are and what's the importance of each map layer to those goals.
Use the VH to separate and layer features in rough proportion to their relevance.

VH is established through changes in symbology, style, and layout.
The perceptual effect of figure-ground drives the perception of a VH (VH is the concept, FG is the mechanism that helps us see depth in images).
We take it for granted that when we look at an image, we know instinctively what part of the picture is important and what is just background.
What is the figure and the ground in this image? How do we know that?

Anything that creates strong contrast or visual difference helps establish the figure-ground relationship. Objects that stand out from the background become figural.
Figure-ground on a map will fail if the map is too visually homogenous.

** open VH slider: http://www.mapbliss.com/MedeCart/map-sliders.html

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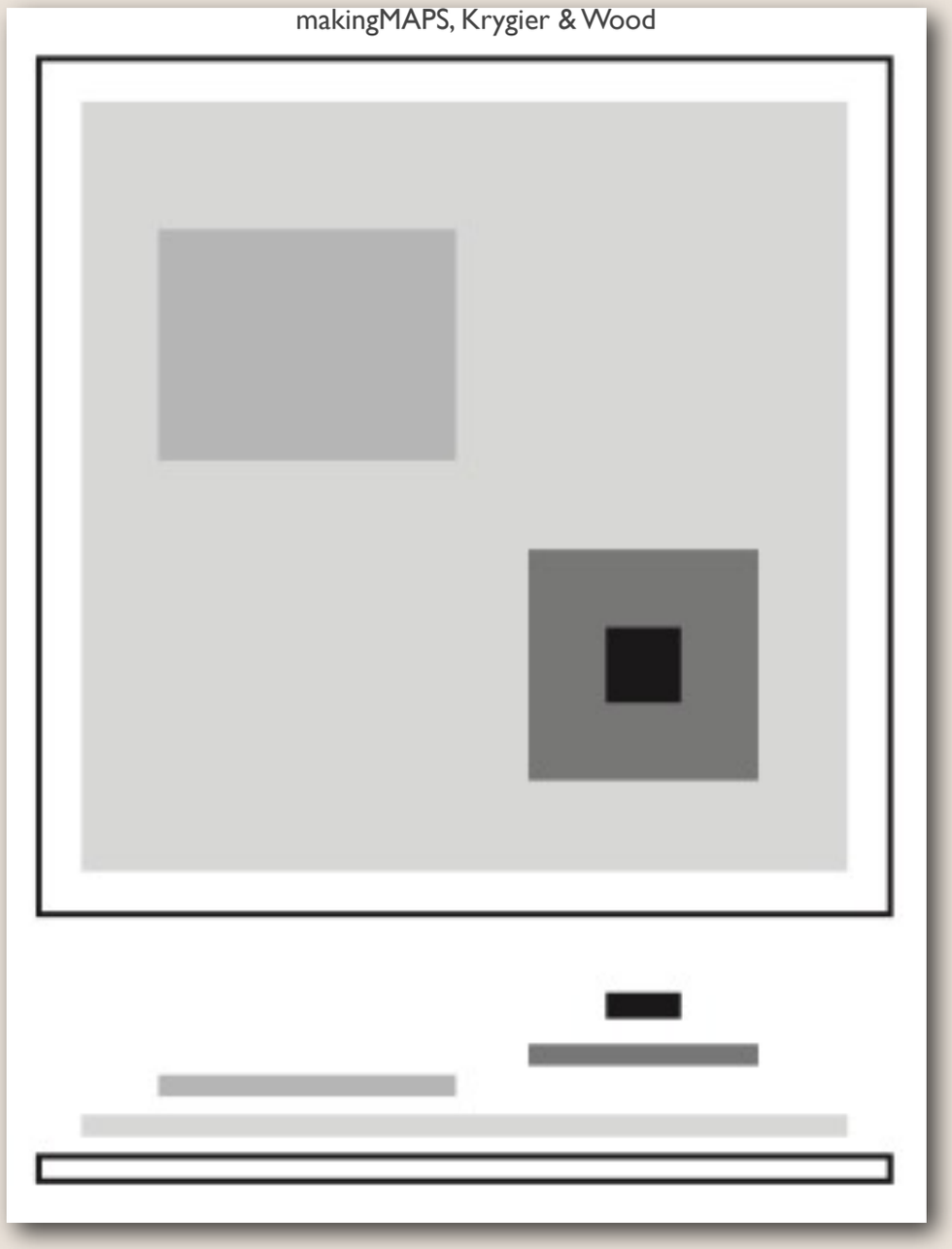

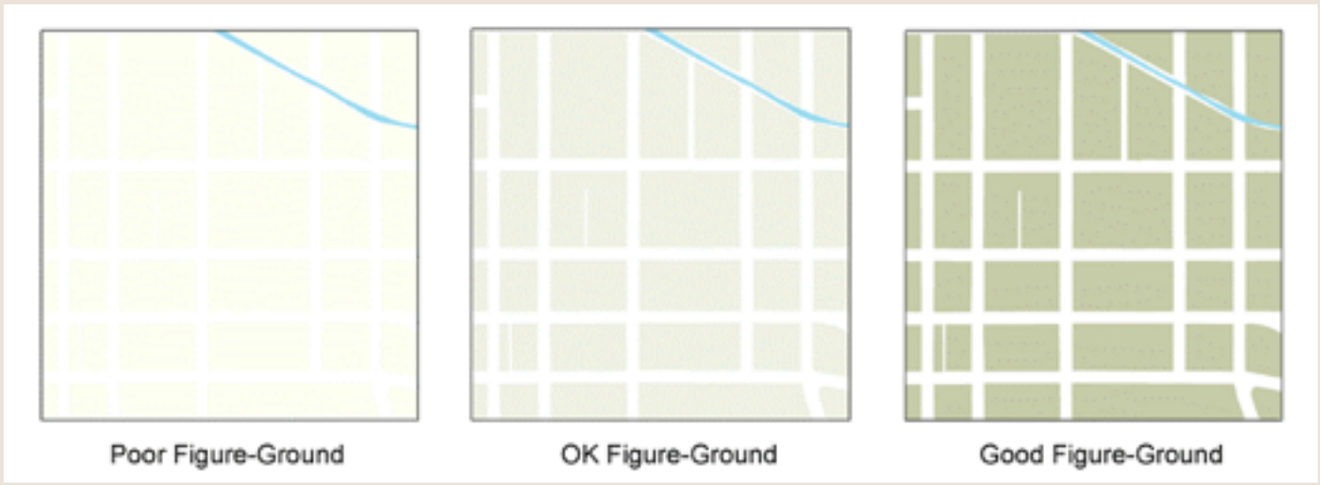

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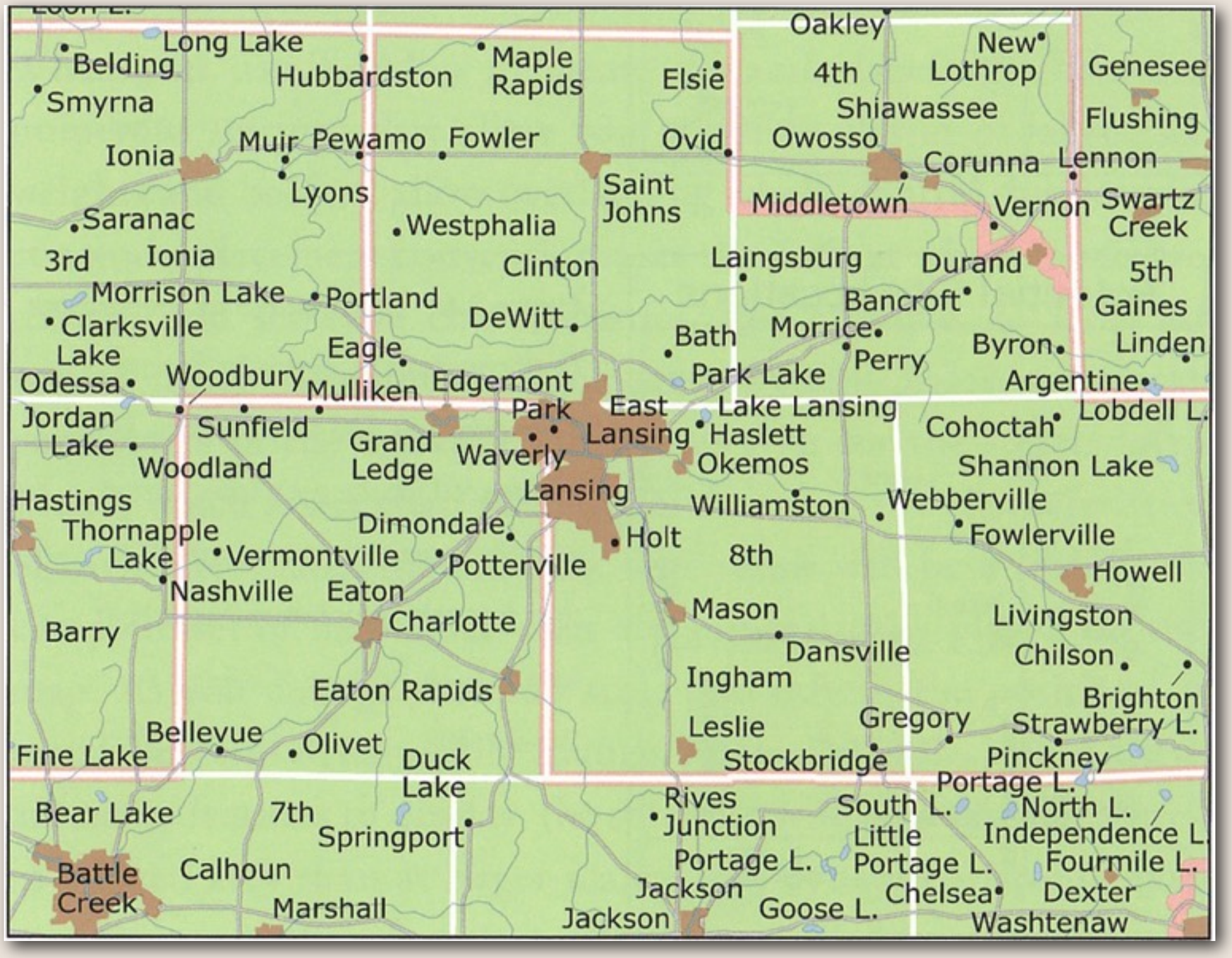

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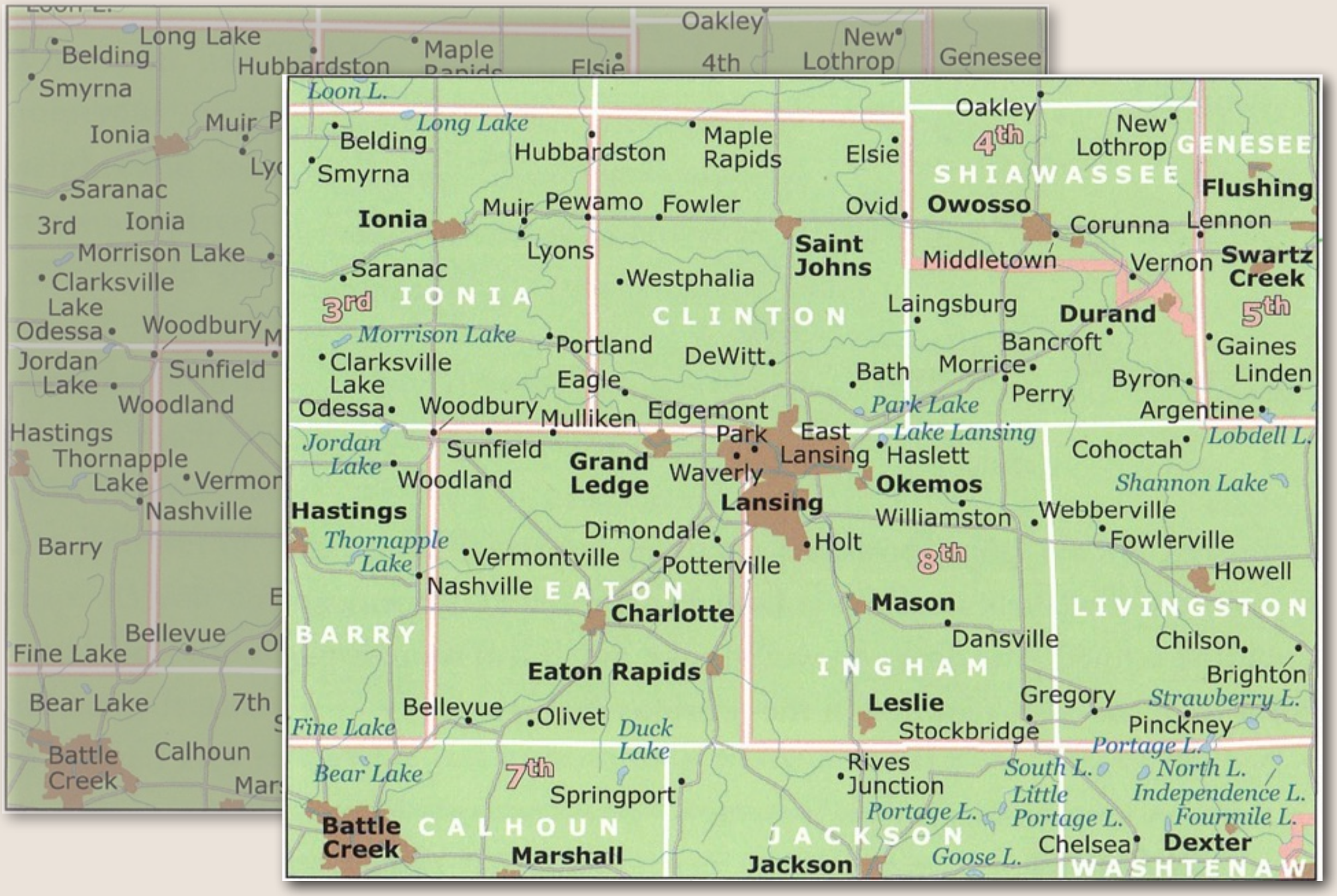
8 seconds, count the number of lakes on the map BY LABEL. How many did you get? (21?)

How much easier is it to see the lakes in the 2nd map?
What cartographic concept is this an example of?
How was that achieved?

Label symbology can reinforce the visual hierarchy of map.

Don’t treat map labels as an afterthought.
Labels are features too, they describe by what they say but also by how they look.
A labels appearance should compliment it meaning (blue italics for water, small regular for towns, large bold for cities…)

label hierarchy



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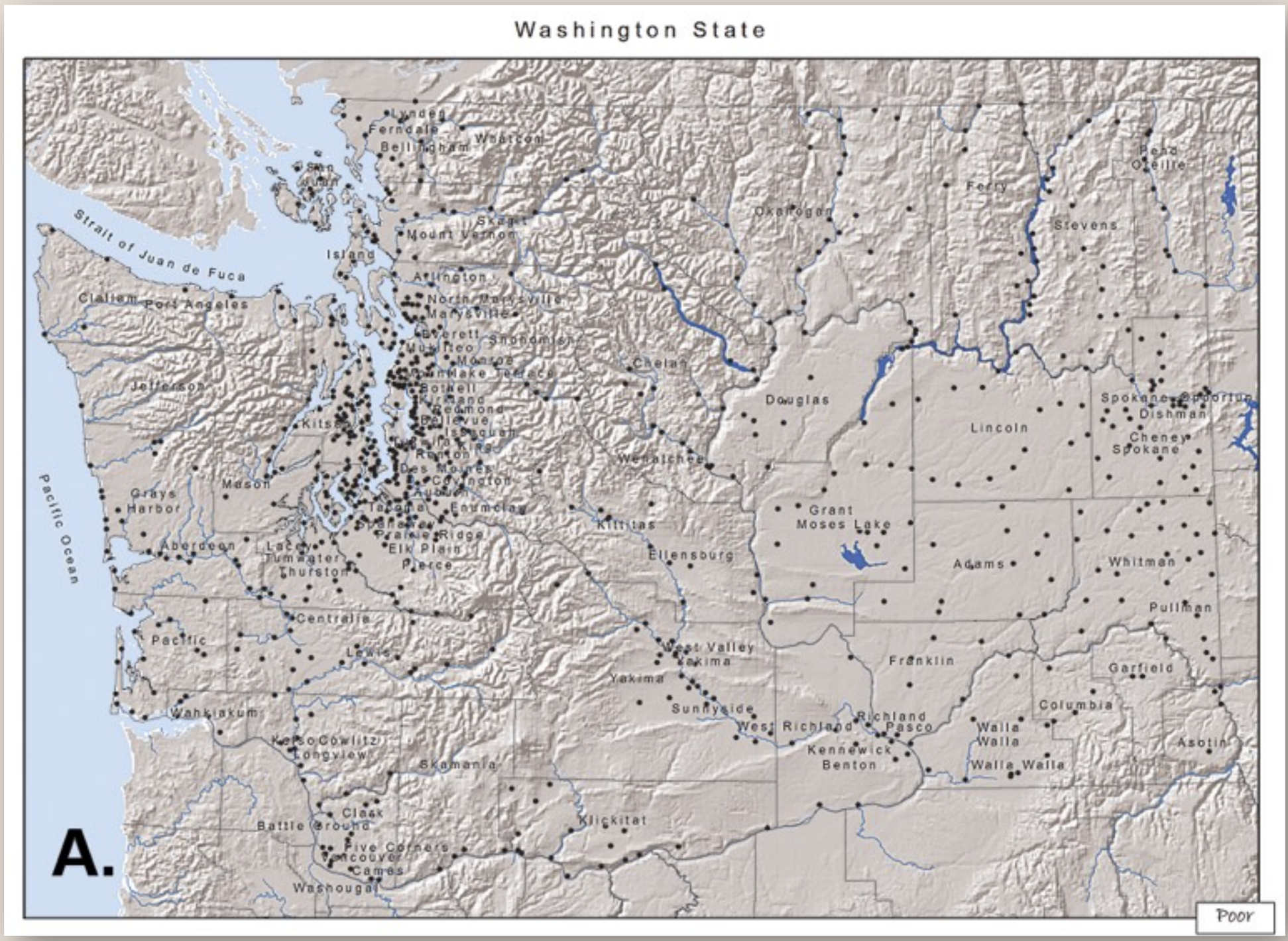
"Great design tends towards simplicity" (Jacques Bertin)

design for simplicity & clarity



Friday, September 18, 15

Anything you can do to separate the figure from the ground in your map will help establish the VH and focus the readers attention.
Designing for simplicity and clarity will allow you to focus your remaining map elements on what's important about your message or data.

Techniques for simplicity & clarity are:
Remember clutter is not a characteristic of complex data, but a failure of design. Simple and clear maps can represent very complex data.
Remove unnecessary detail or data (remove extra data and simplify what remains).
Leave on contextual information but use masks and subdued symbology to move it further back in the VH.

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Take away what is not needed; subdue what is only for reference.

Emphasize what is important.

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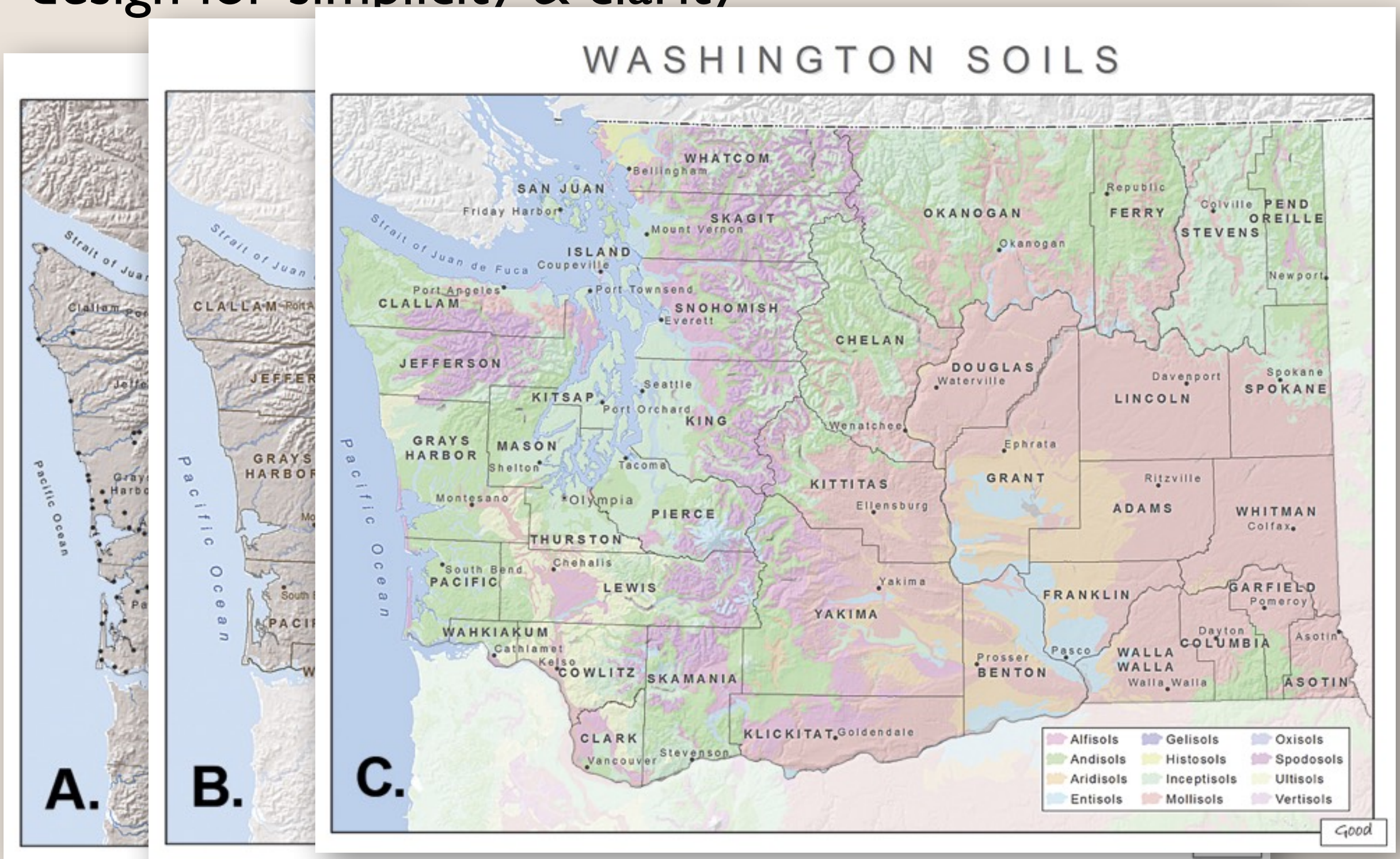

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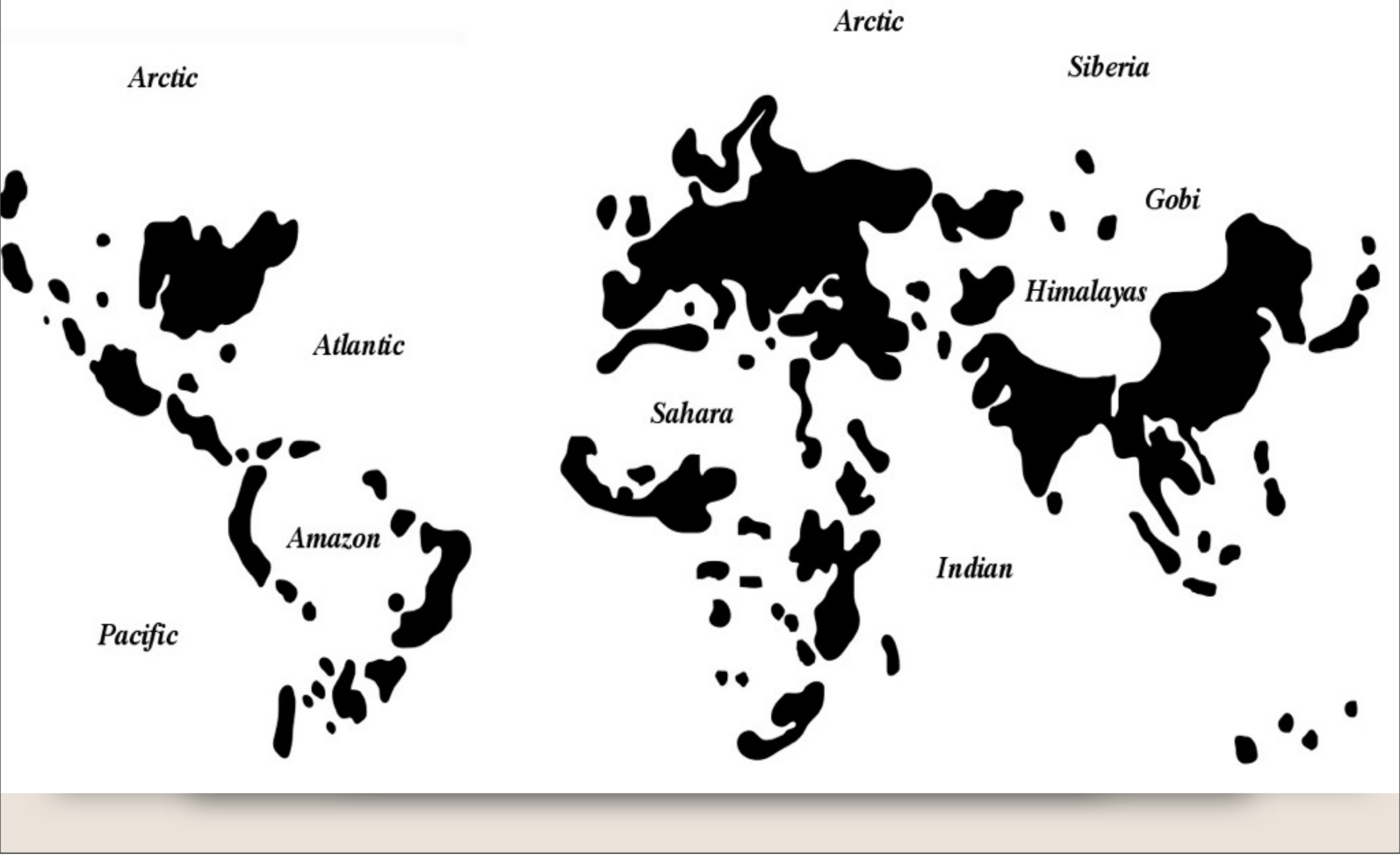

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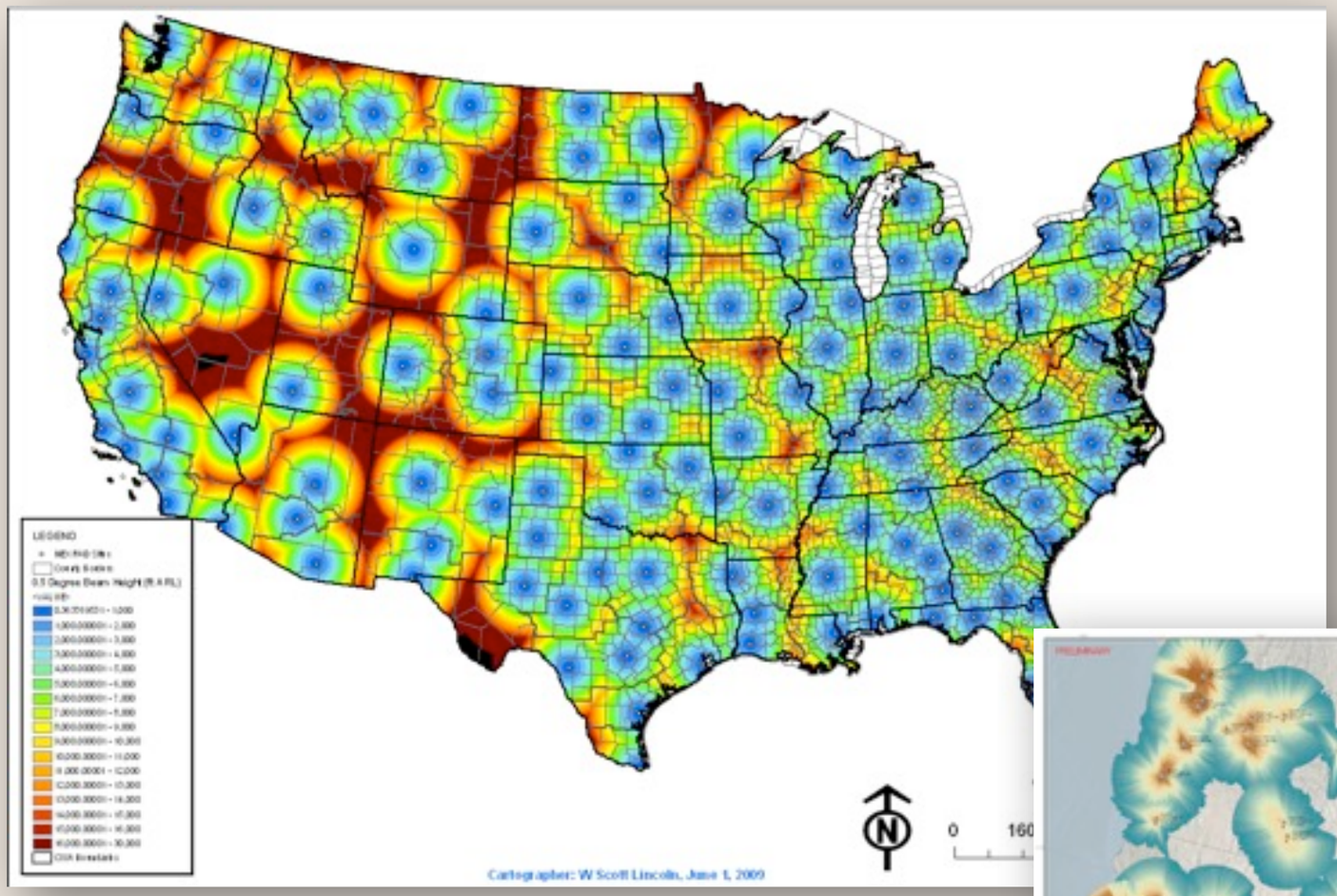

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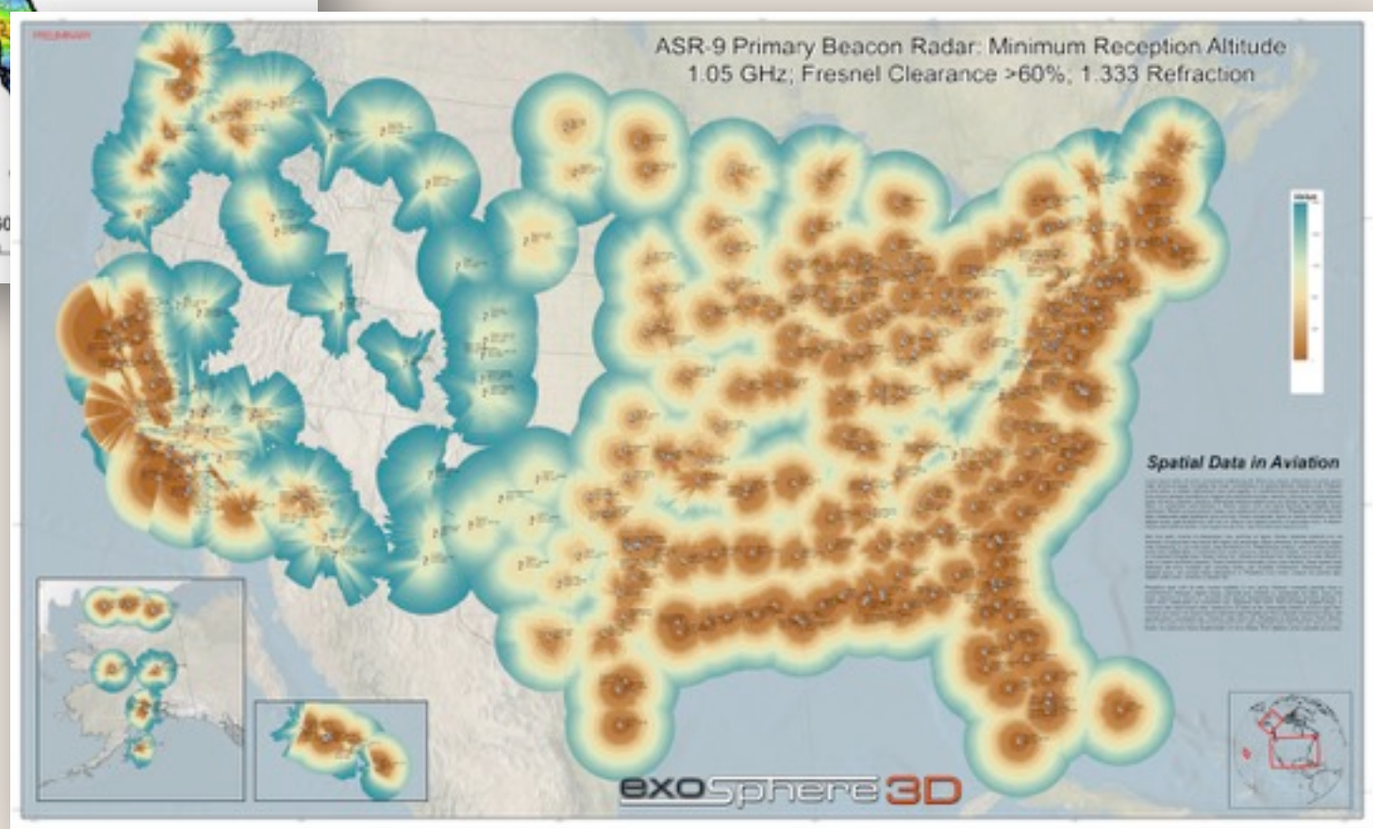
- Connect color choices to feature type
- Avoid over use of bright, oversaturated colors

- Match color symbology to data type.
- Diverging color schemes should have a critical value.



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A common design failure in many GIS maps is the incorrect use of color.
Color is deeply connected to meanings for many people and cultures and ignoring those connotations can confuse the map reader.
Color is a natural quantifier. Use color intensity changes to signal data value changes. Use color hue changes to signal data type changes.

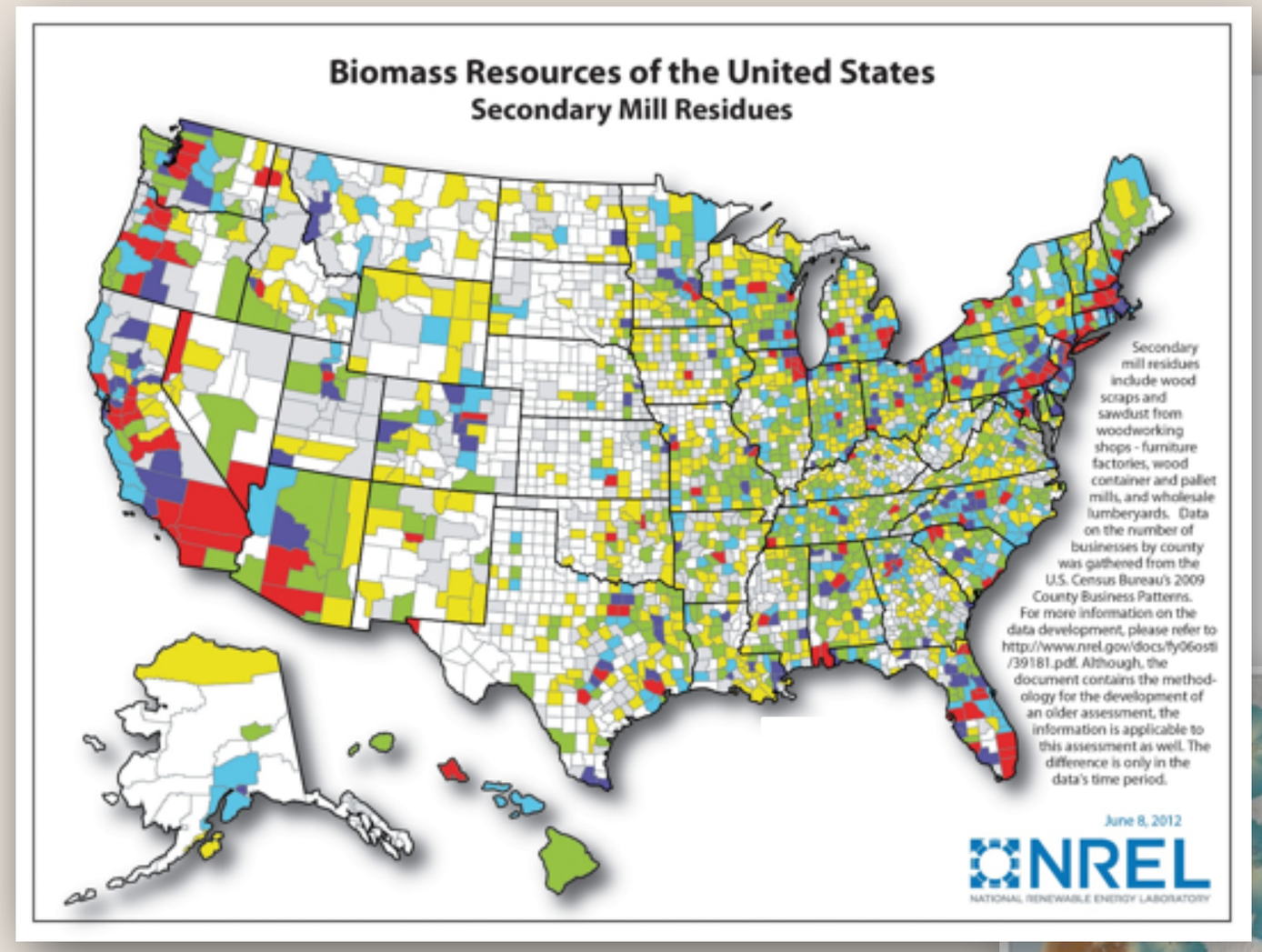
Make smart color choices:
Color is visually very powerful and often over used in GIS.
Color brings impact & attention to our maps; but over doing it can turn readers away.
Using color incorrectly can misinform or confuse.

Compare radio map A to map B; good or bad color choices?
Map A dark areas stand out but represent lowest signal strength, compare to map B where low signal strength has no color at all.
Visual weight of the map shifts from the west to the east.

Use colors that match your data type.
NREL: without a legend, what color would you guess is the lowest value? Or the highest?
Is color hue a good choice for mapping value changes? What would work better?
Does the color ramp for income make more sense with regard to the data? Why?

Watch out for diverging color schemes, best when used with a meaningful critical value.

make smart color choices



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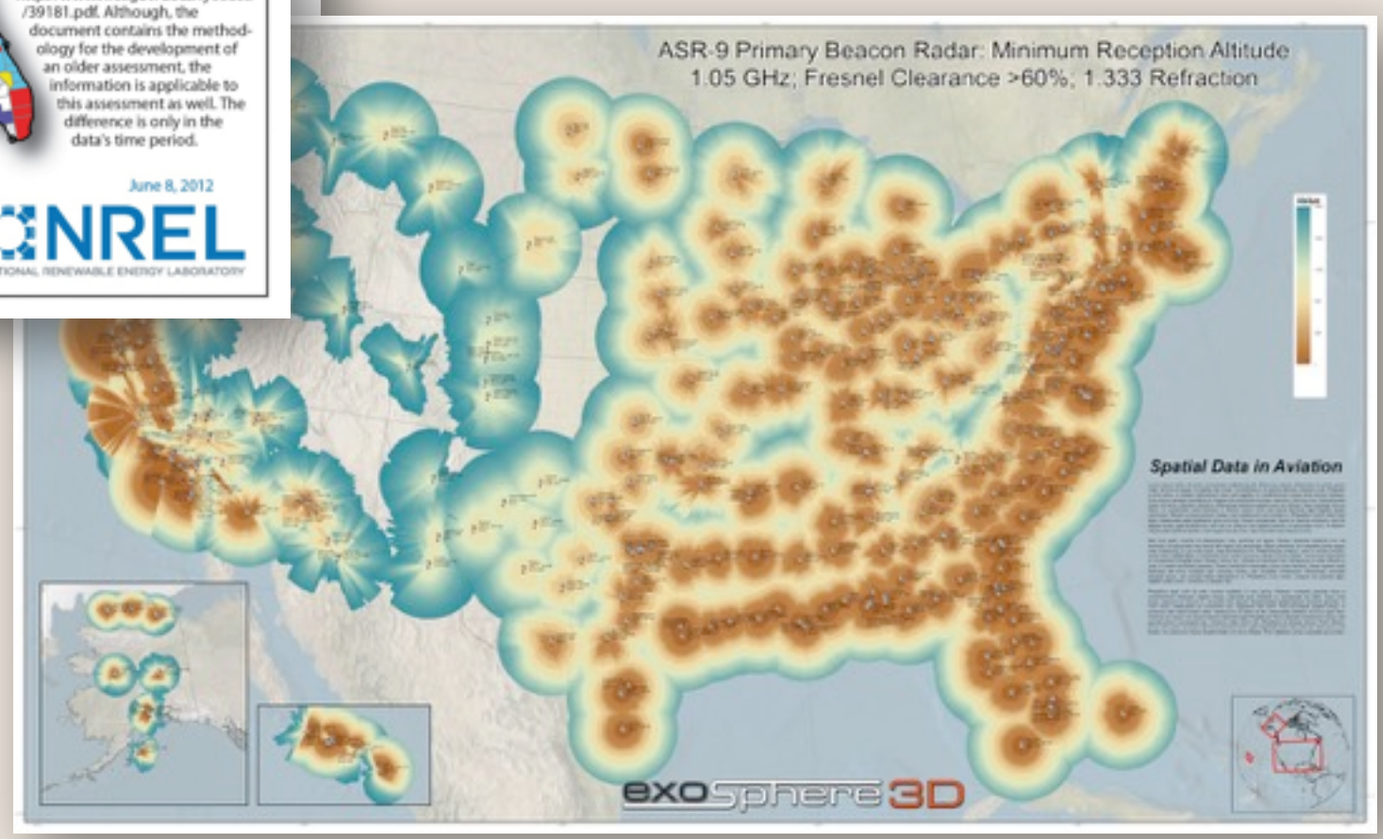

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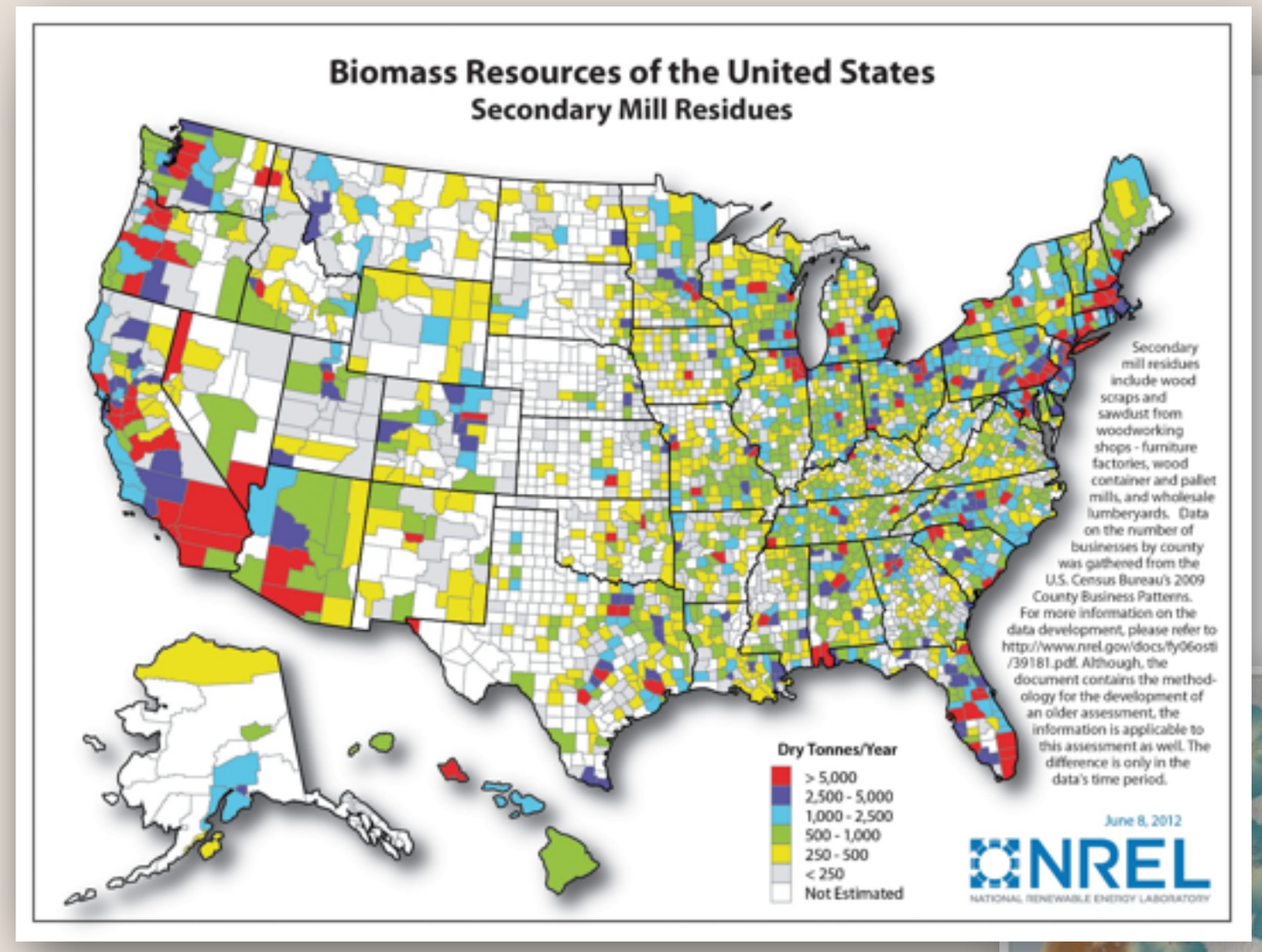

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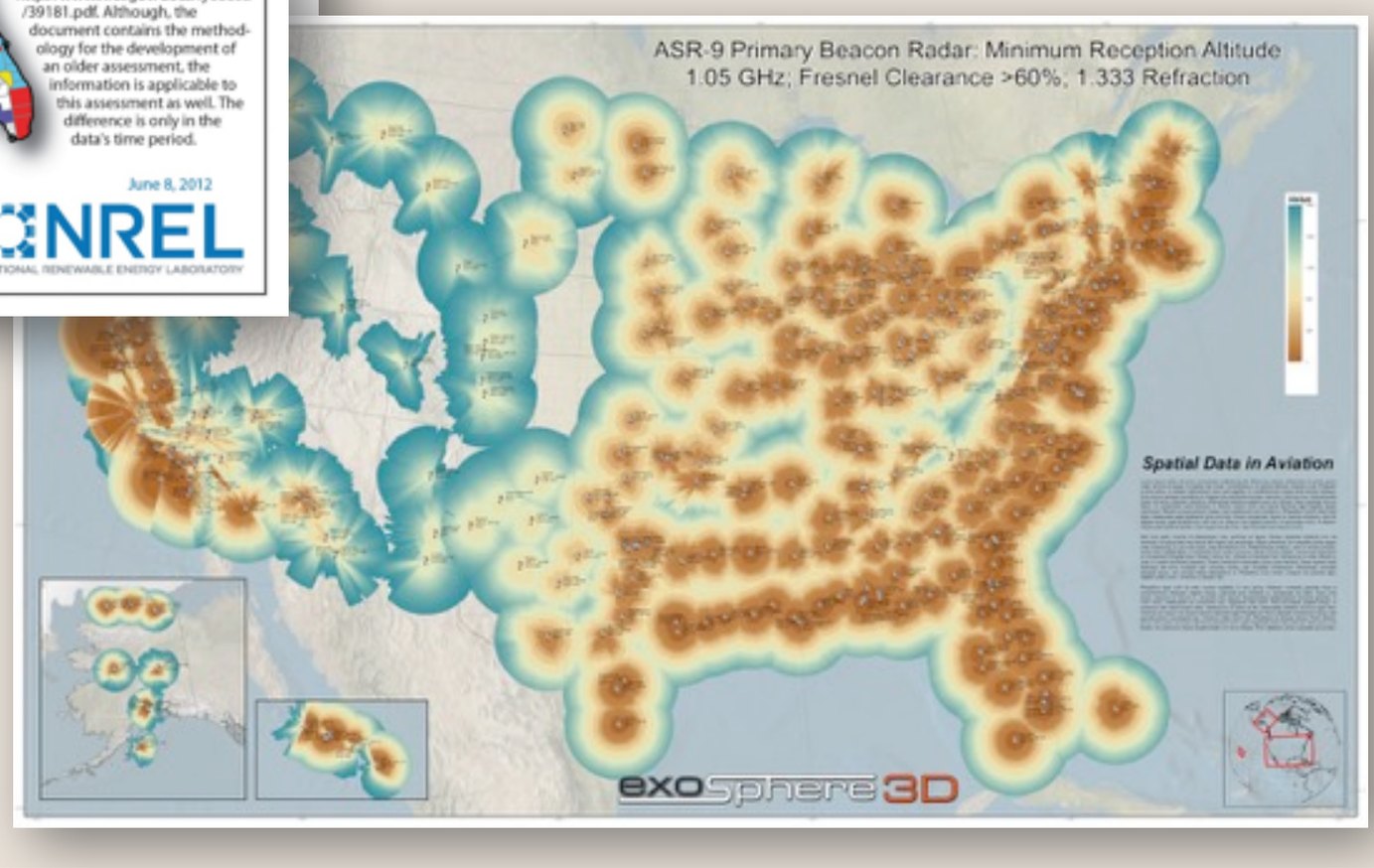

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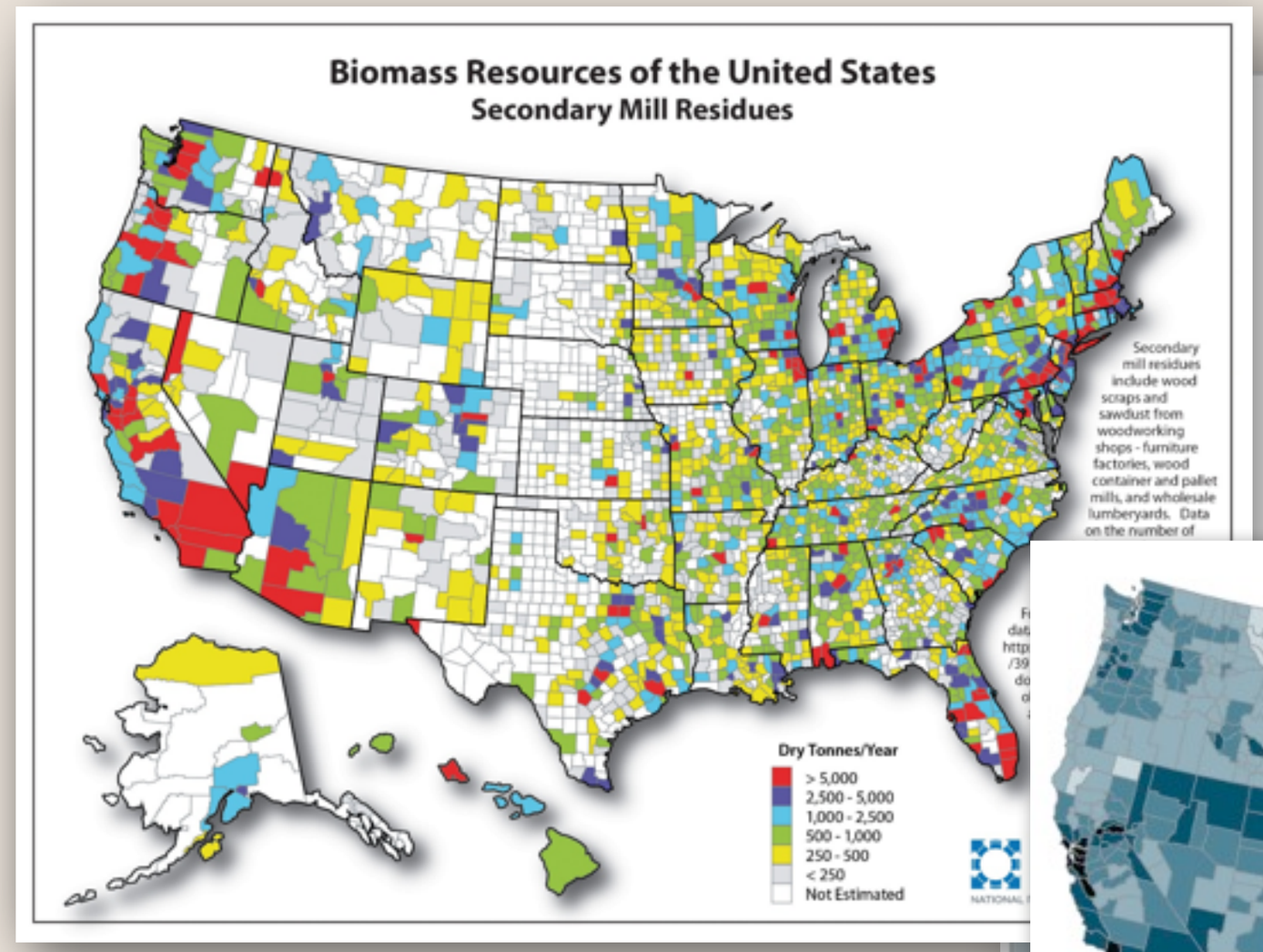

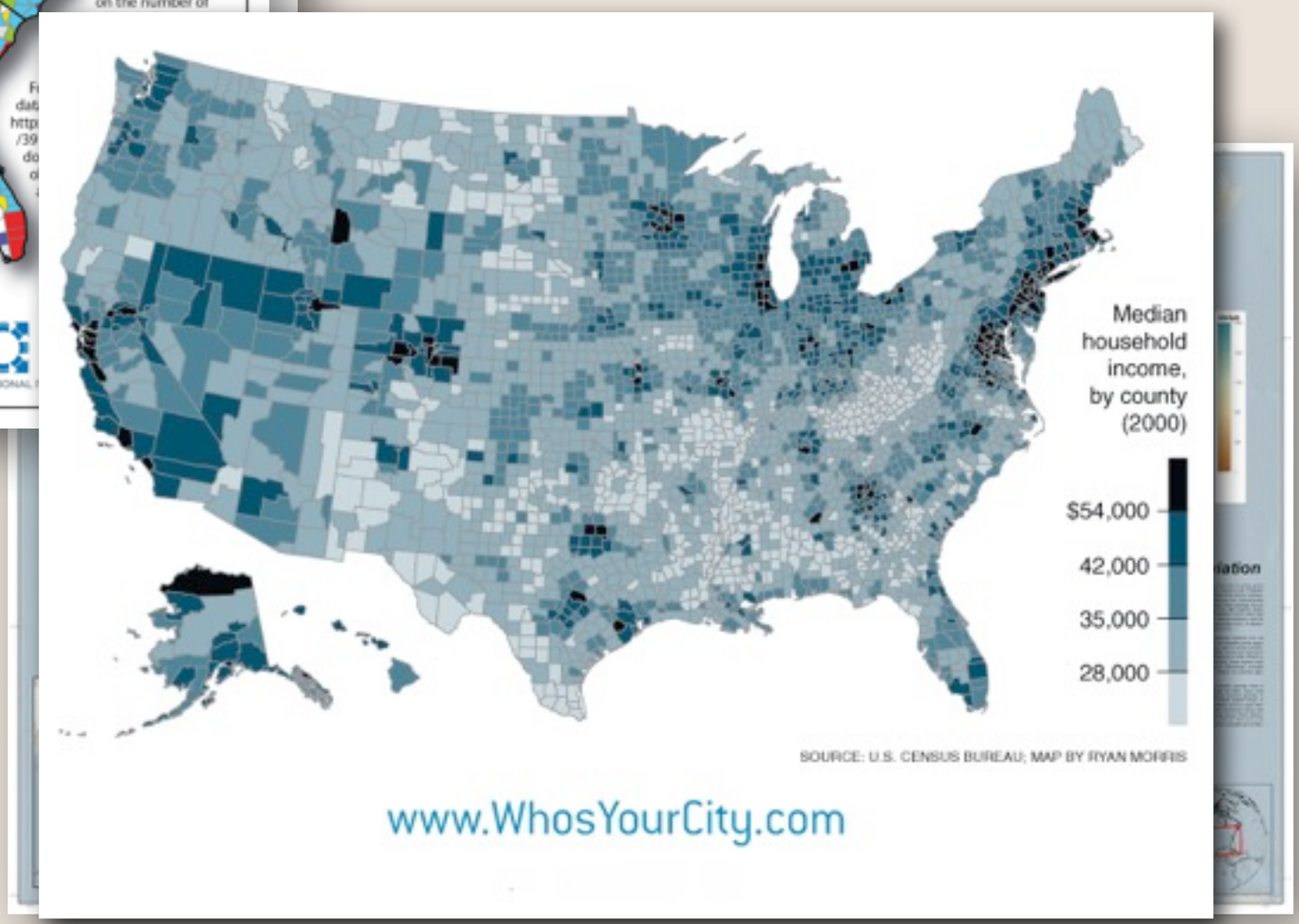

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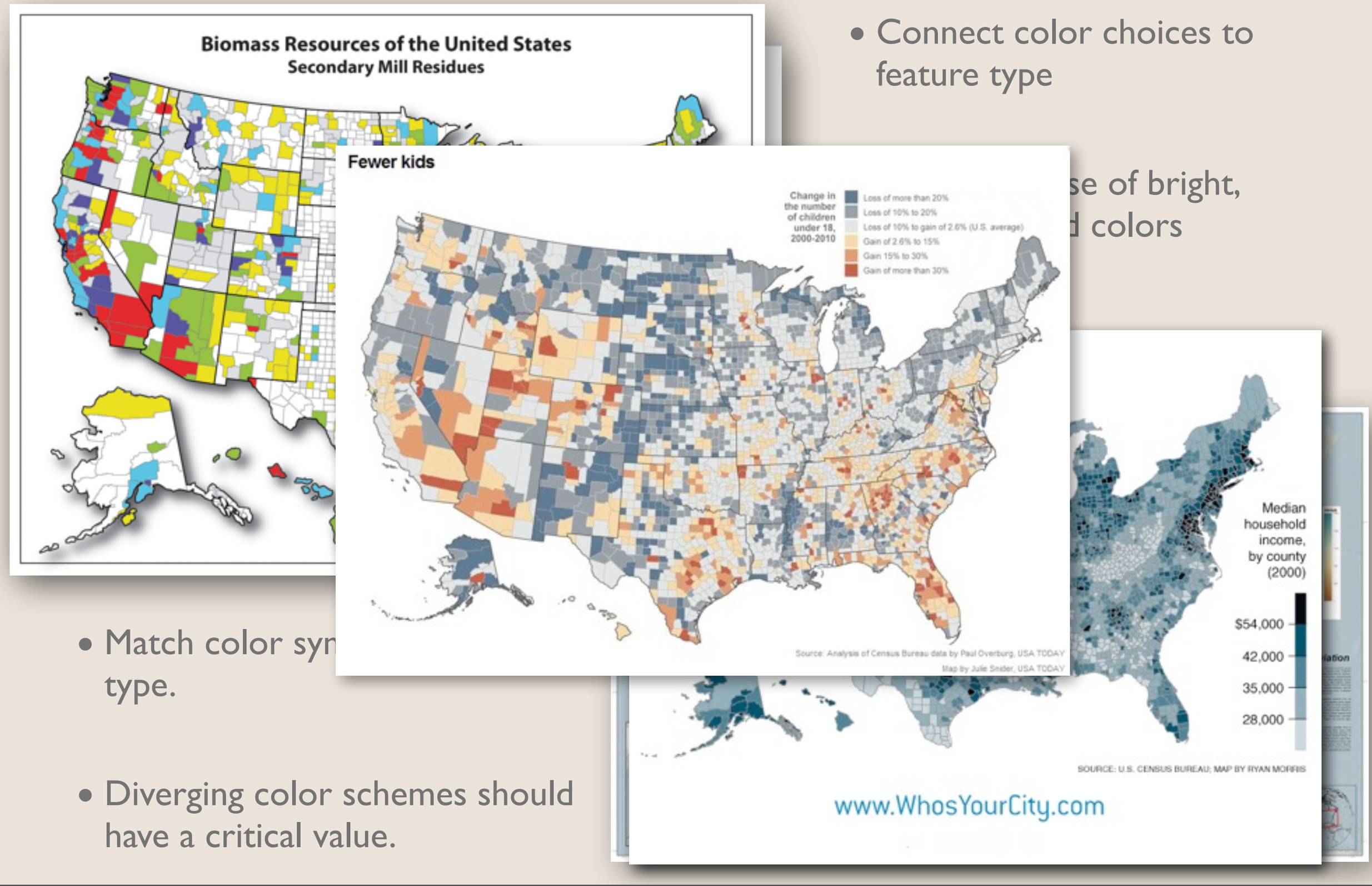

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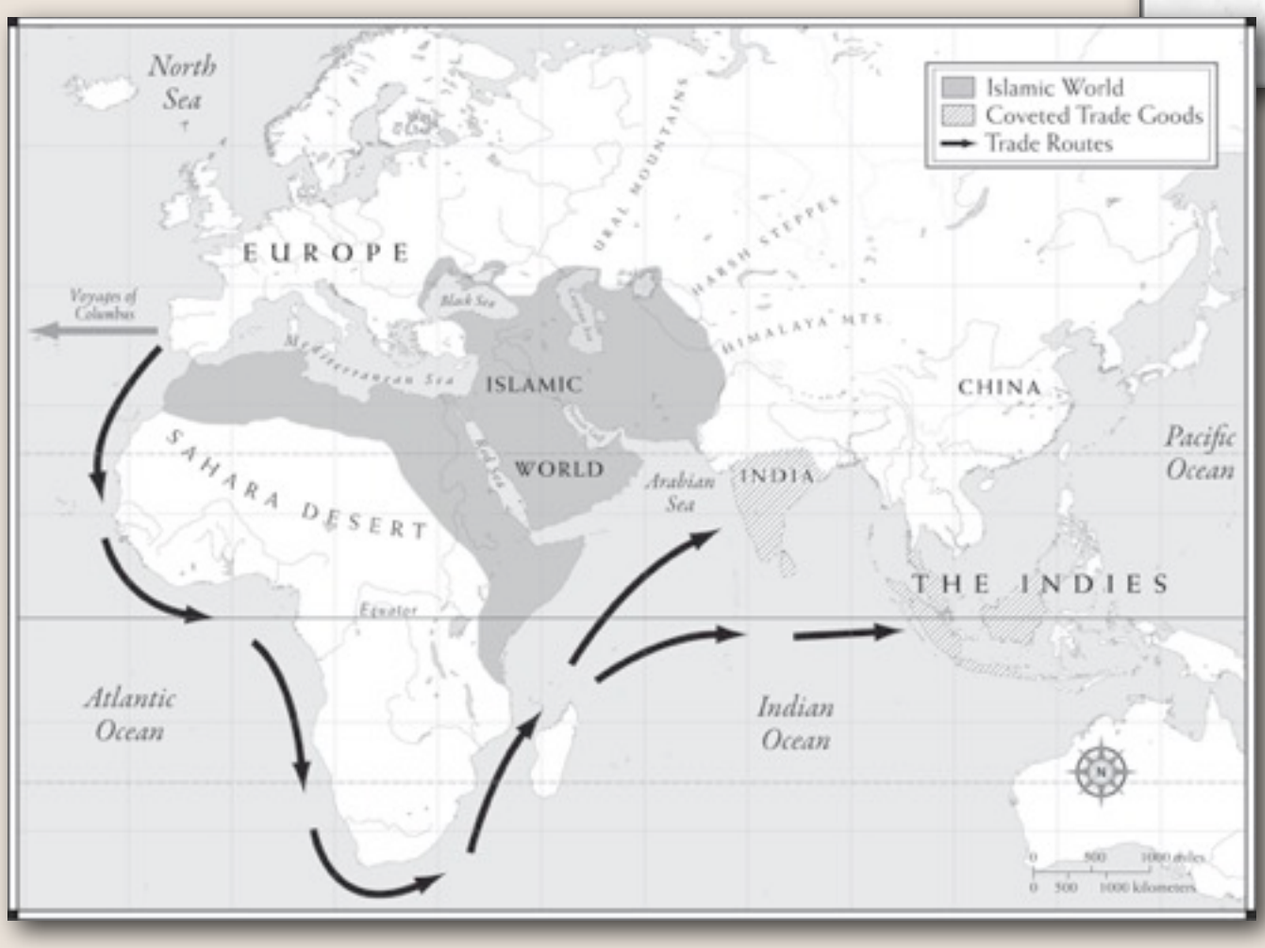
reduce color dependency

- Does your map need to be in **color**?
- Gray scale maps can be very effective



- Avoids cultural associations
- Best for b&w reproductions

Friday, September 18, 15

Reduce color dependency:
Do you even need color on your map?

GIS maps have a tendency to over use color (everything in color, heavy use of bright saturated colors)

Greyscale maps can be very powerful. Solid black become the figure on grey background.

Limits cultural associations and issue with color blind map readers.

Adding small amount of color to greyscale map creates strong VH & clear data emphasis.

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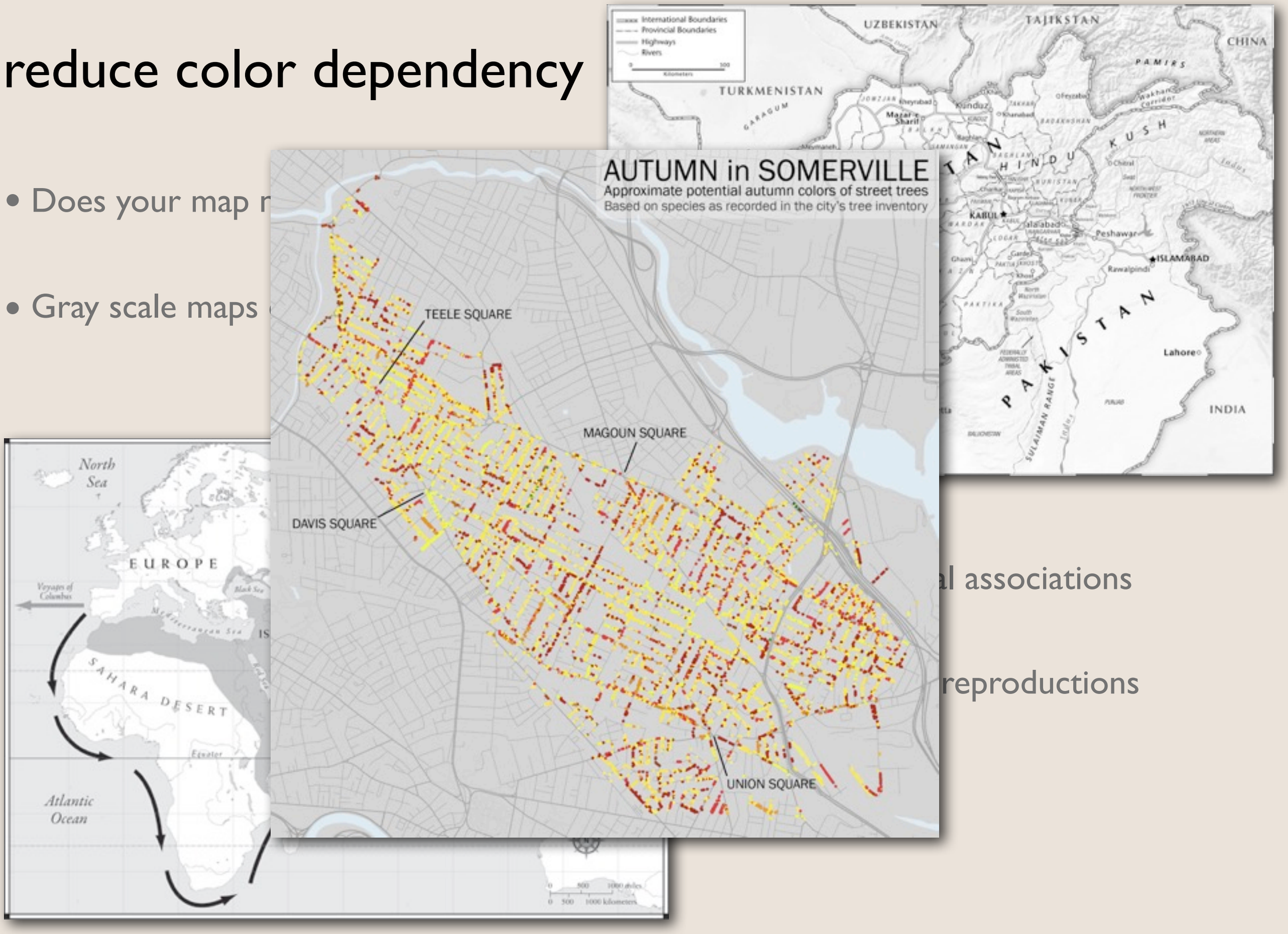

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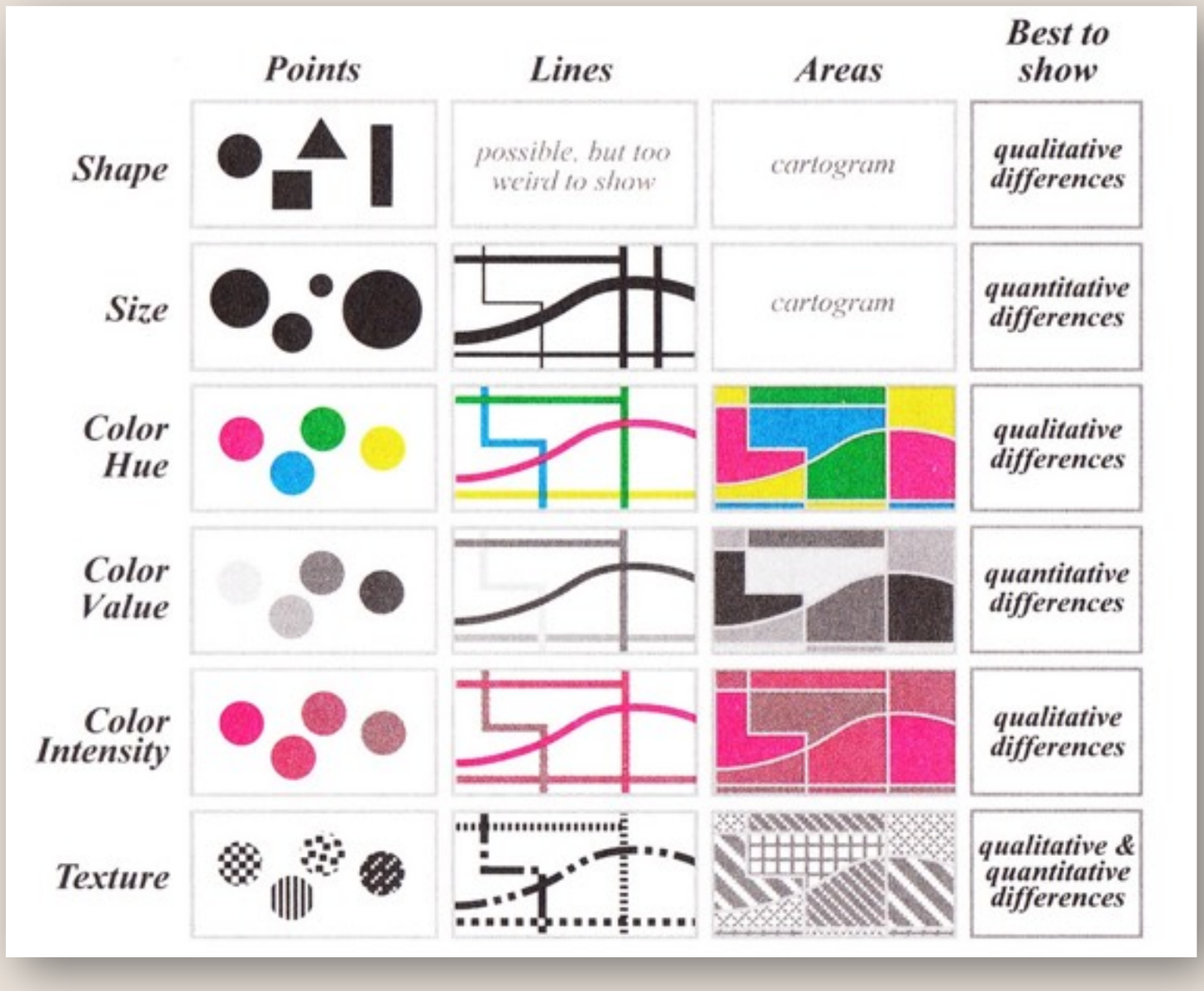
the visual variables

- visual variables guide map symbol choices
- identify the type of data and the feature geometry
- symbolize by shape or color hue for qualitative data
- symbolize by size or color value for quantitative data

Visual Variables



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The visual variables
Visual variables help guide basic map symbology by suggesting the best ways to change symbols based on the data they represent.

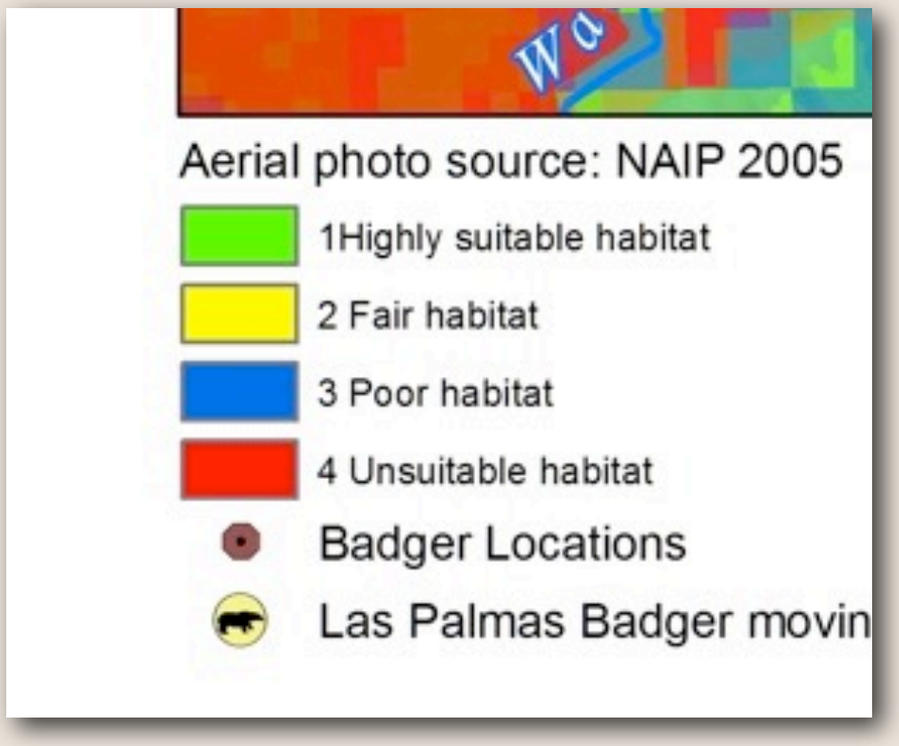
Use the guide by looking at the type of feature you are symbolizing and the type of data it represents.

So if I have points for wells w/ value for pollution levels? What about displaying the type of well?

If I have areas for political party affiliation? What about % of vote?

What about % of vote by party? (we just saw that right?).

Symbology is very subjective, use the VV to help guide you away from making critical mistakes in representation, but don't limit yourself to its rules.



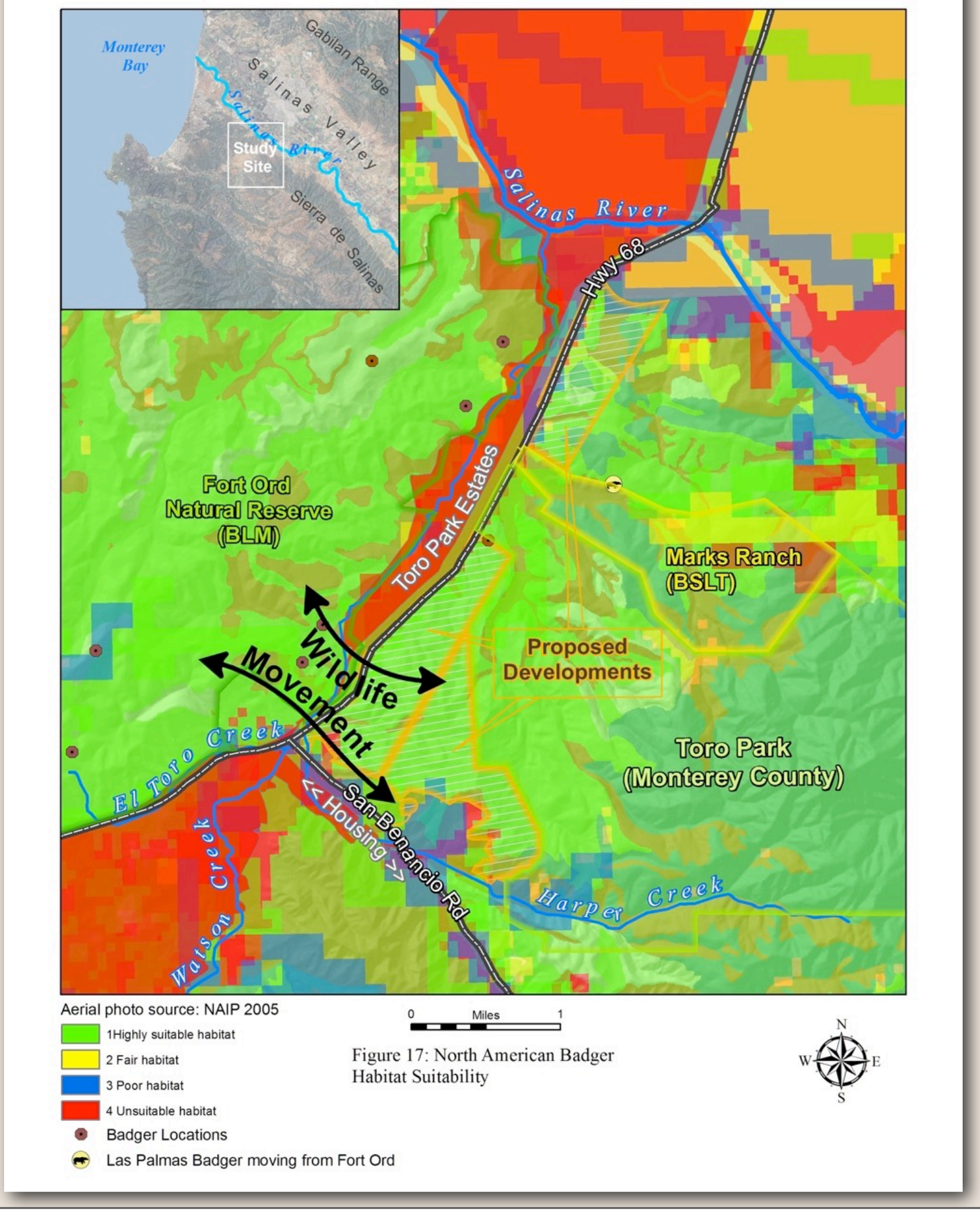


Figure 17: North American Badger Habitat Suitability

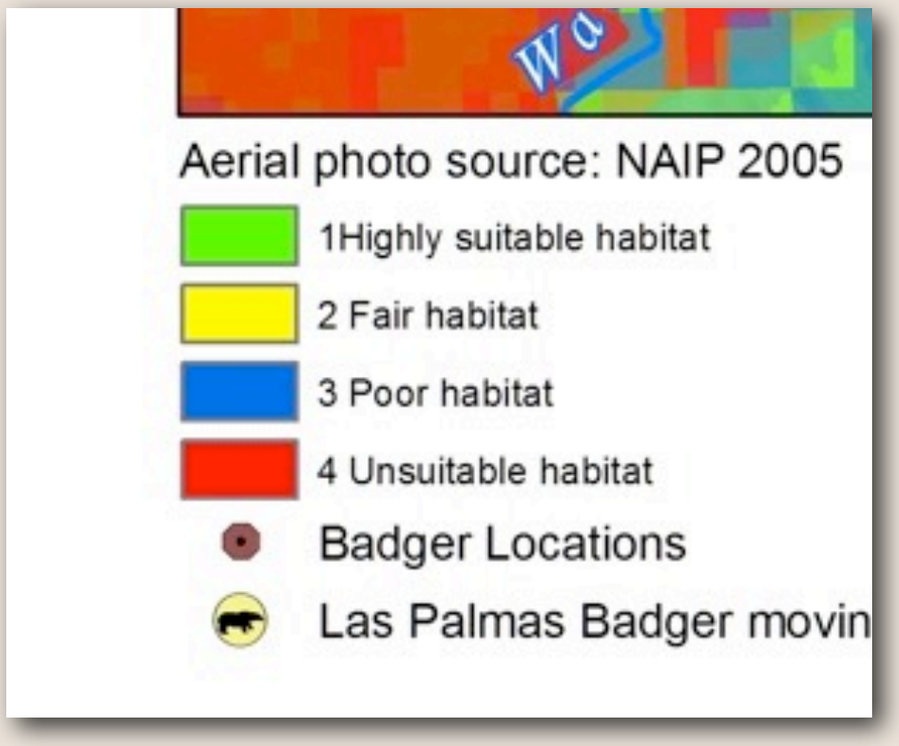
Friday, September 18, 15

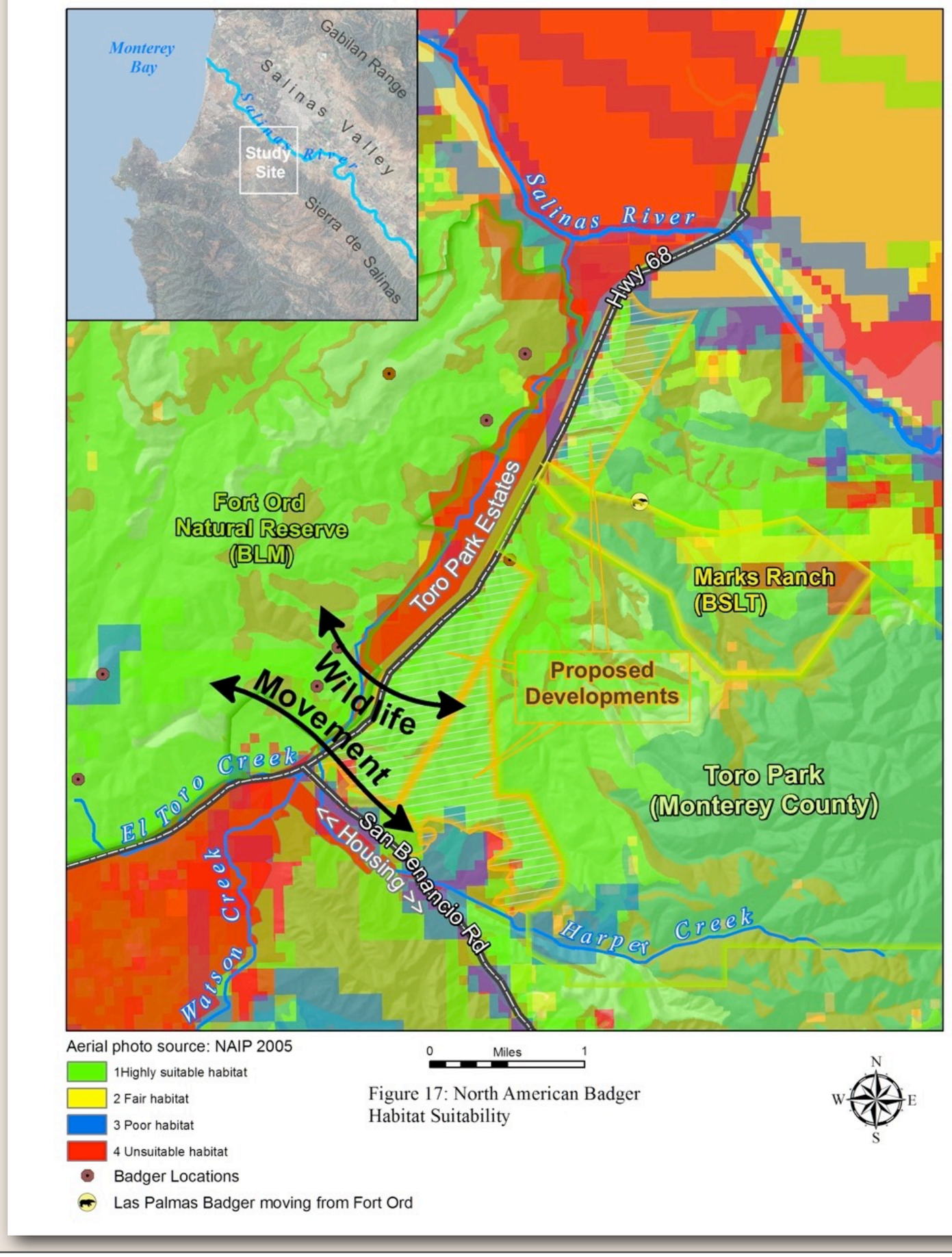
Visual Variables quiz:

What can you tell me about the visual variable choices in this suitability map?

Is this the correct classification symbology for this kind of data?

Describe an al ternate symbology that might work better?





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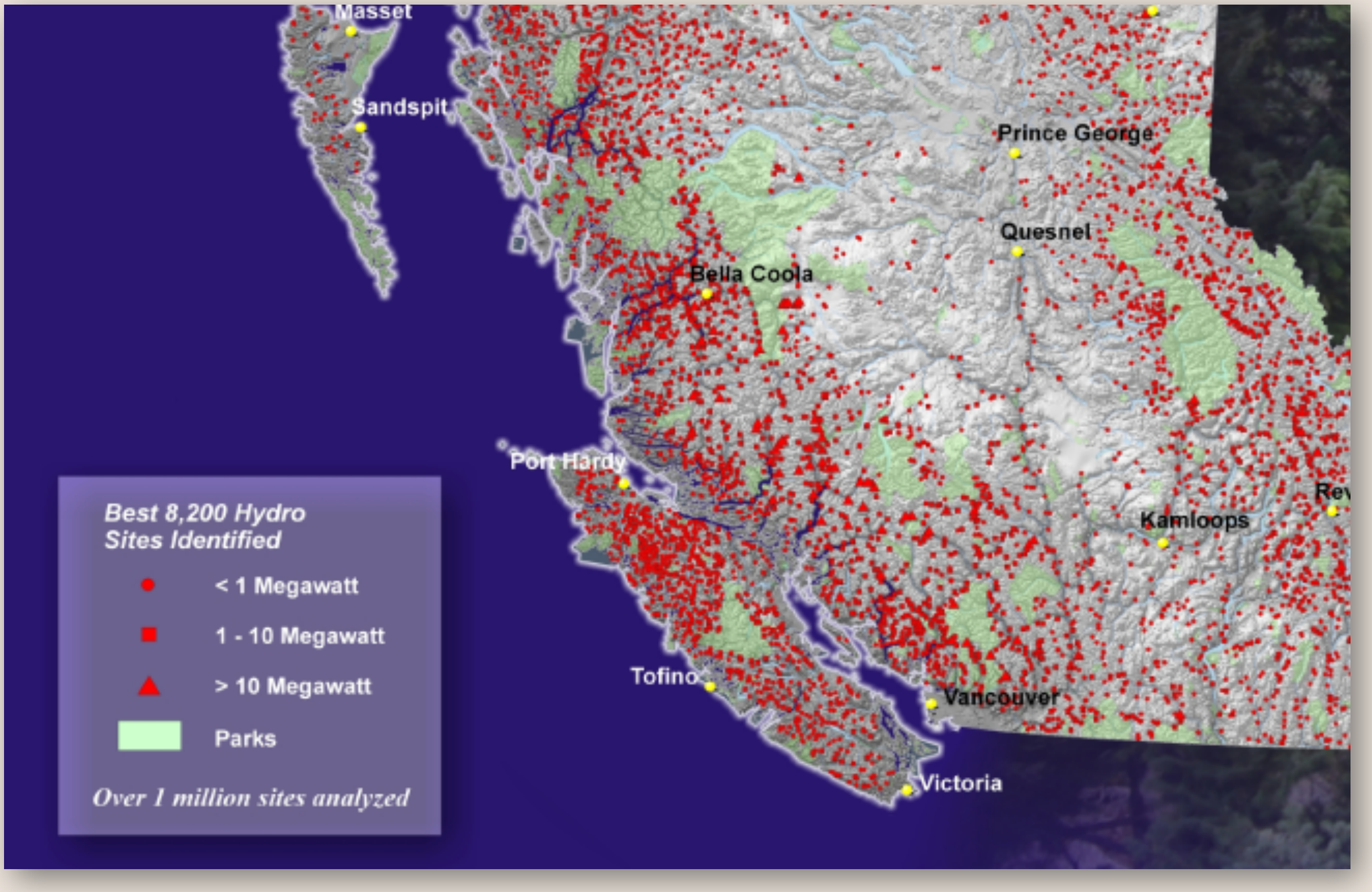

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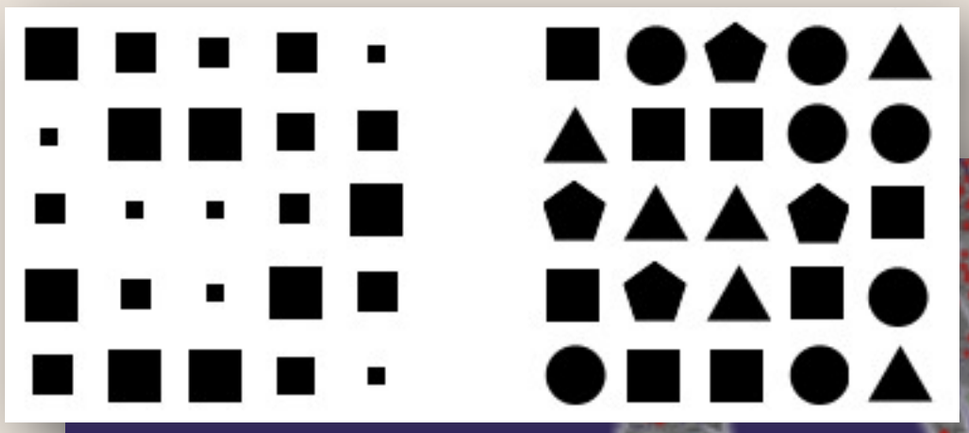
What about this visual variable choice? What is more, a triangle or a square?

What would have been a better choice for this data?

If the reader has to look at the legend to understand the gist of the data distribution, the map symbology has failed.



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The 15 Minute Review

aka "eat your vegetables"!

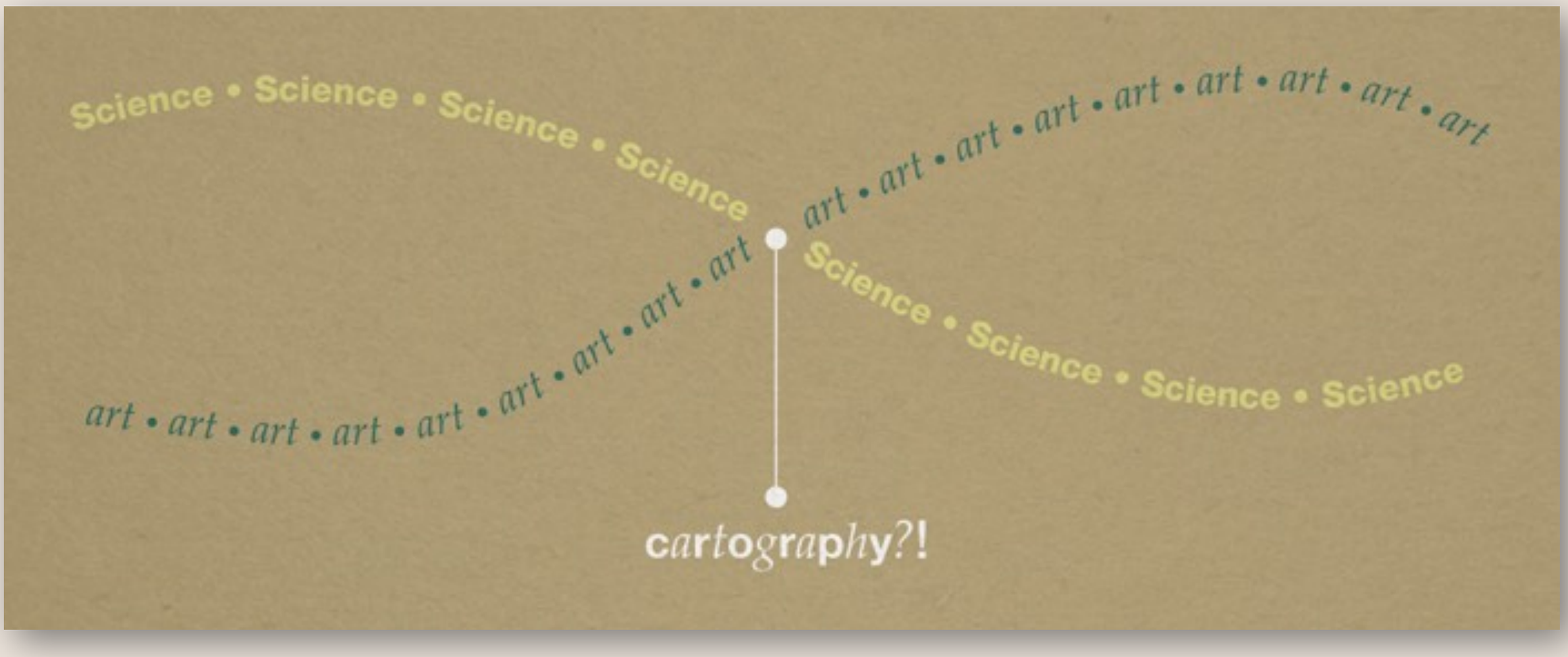
- Map title - is it brief and directly related to the map?
- Map scale - is it correct?
- Scale units rounded? (eg 5km, not 4.85km)
- Do legend symbols match the map?
- Do symbol classifications match the data type? (qualitative or quantitative)
- Can anything be removed?
- Does your map include Title, Source, and Author information?
- Will the map fit the page or screen?
- Does it reproduce ok in b&w?
- Check your spelling
- Have a colleague review it
- Proof it in its final media!

Friday, September 18, 15

Cartography in GIS can sometimes be a bit like eating your vegetables or getting more exercise…
…we know it's good for us, but we just don't have "time".

And not every map needs full design, and not every organization or supervisor is on board with spending time and money or what they may see as "dressing up" the data.

At a minimum we should all be able to run a quick design review check list like the 15 minute review looking for the most basic design issues.



David Medeiros
Stanford Geospatial Center
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bit.ly/sgccart