

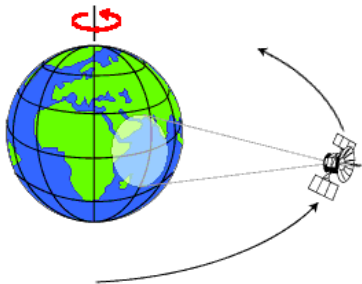


NICHOLAS SCHOOL OF THE
ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY



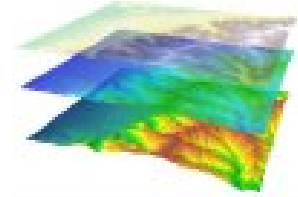
Fundamentals of Geospatial Analysis

Cartographic Design

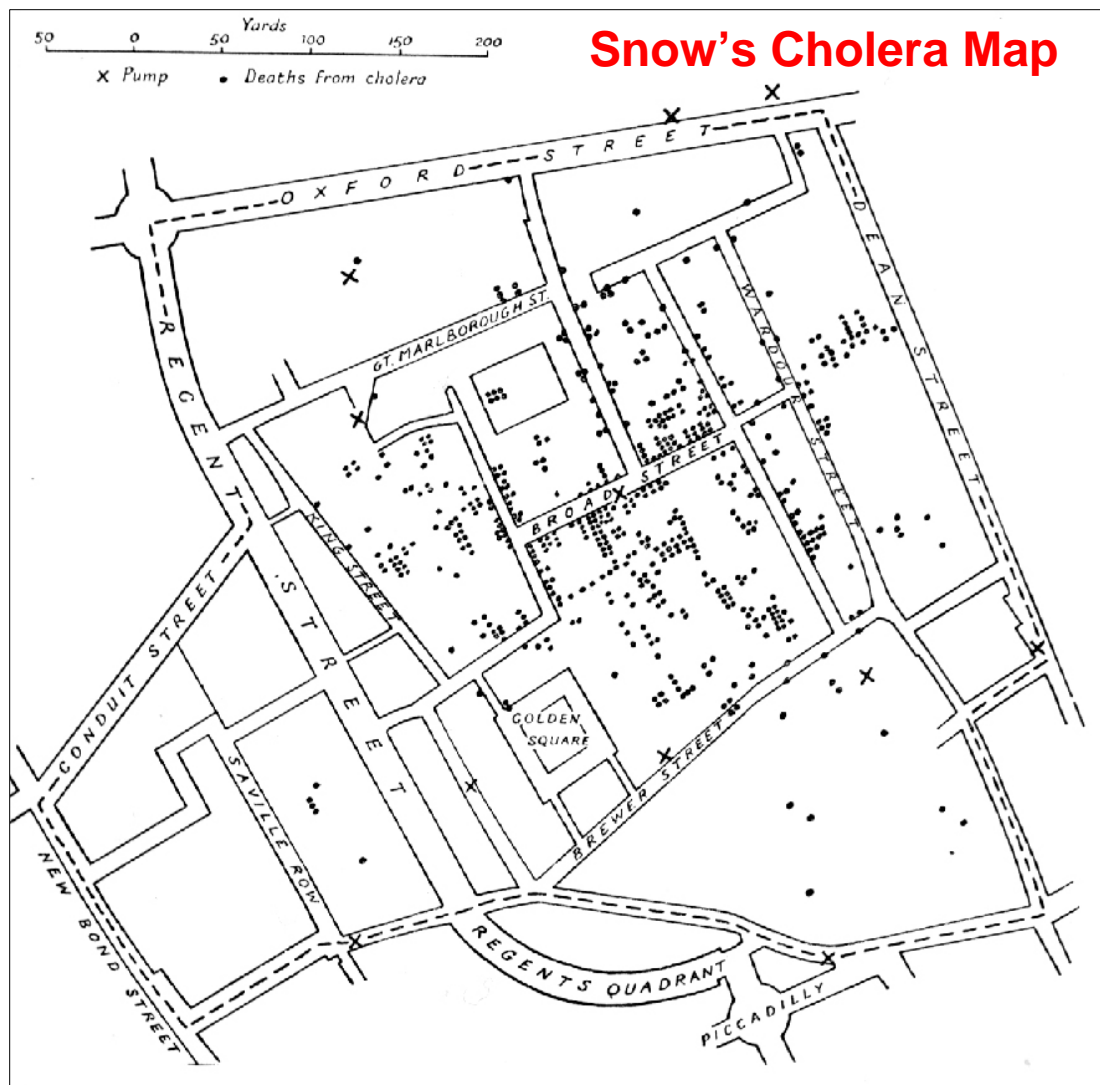


John Fay & Patrick Halpin

With materials from ESRI's Virtual Campus cartography course



Importance of Maps



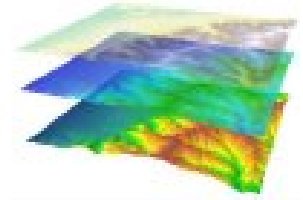
From: Tufte (1997) *Visual Display of Quantitative Information*

Good maps...

... speak a universal language

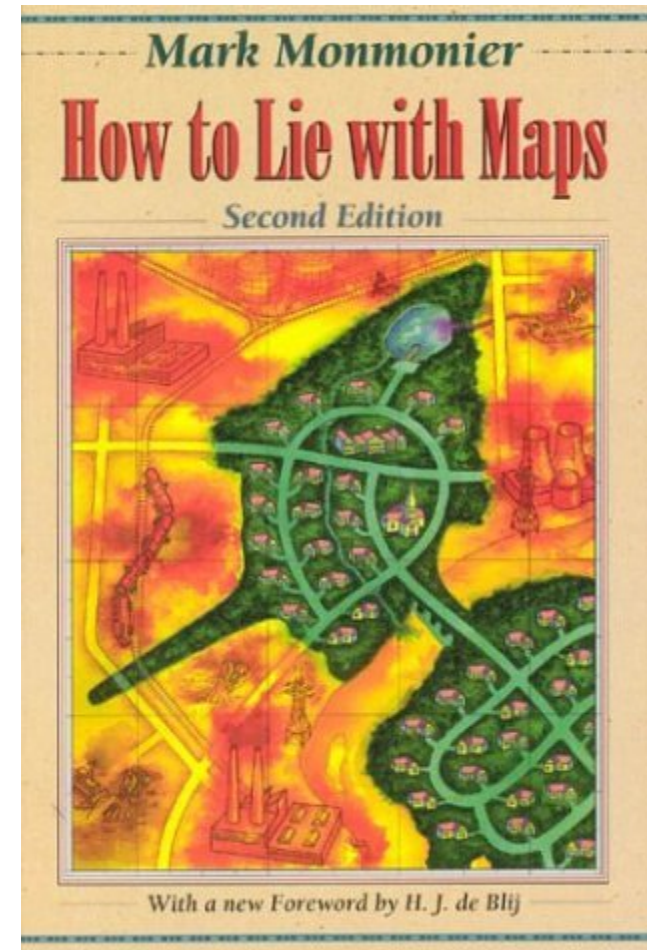
... facilitate decision making

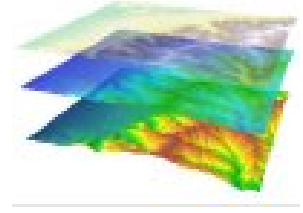
... convey information aesthetically



Designing Maps with Purpose

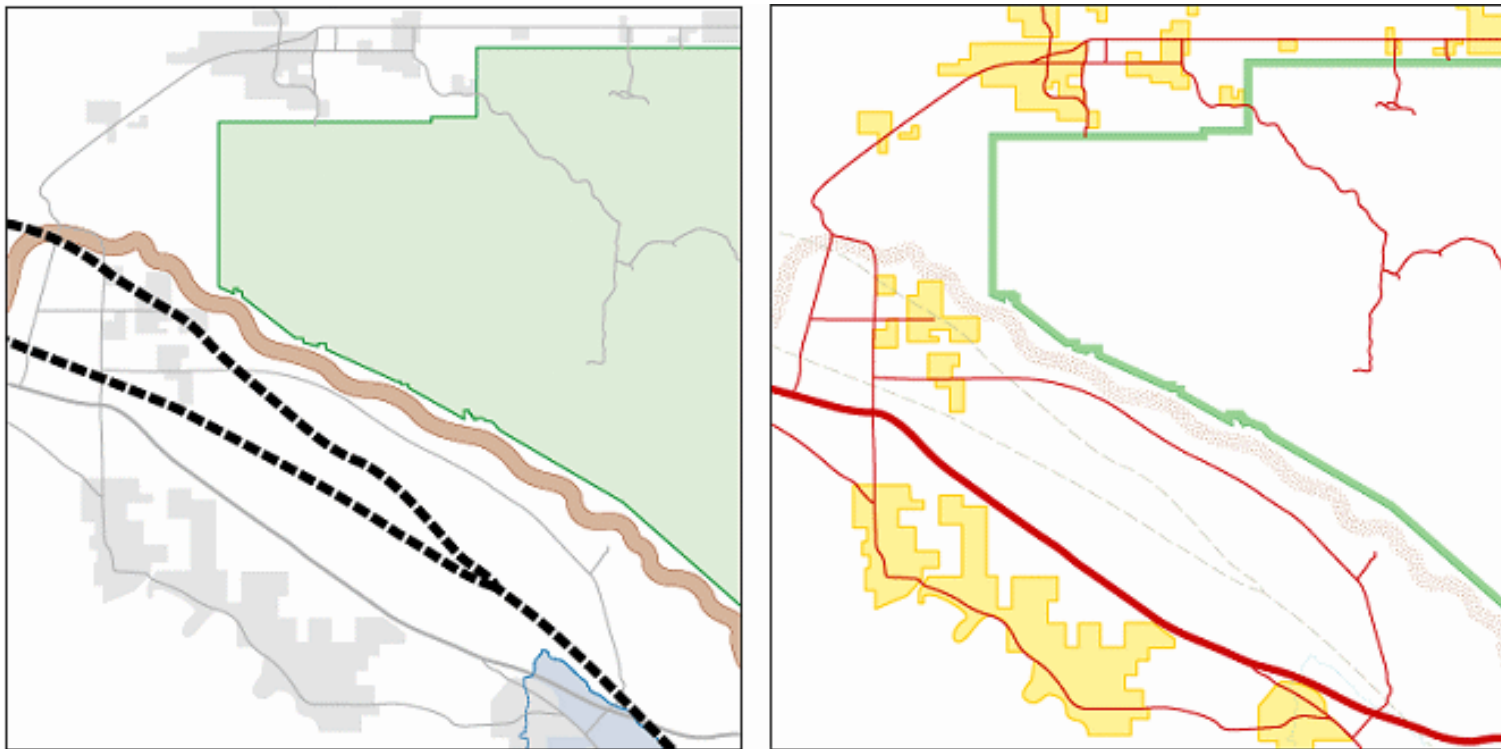
- What information is being mapped?
- Who will be reading the map?
- Is map content being coordinated with written text?
- What size will the map be?
- In what media will the map be used?
- What are the time and budget constraints?





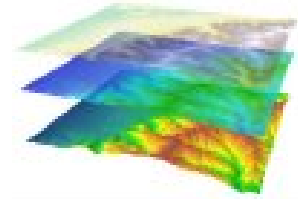
Designing Maps with Purpose

- What information is being mapped?



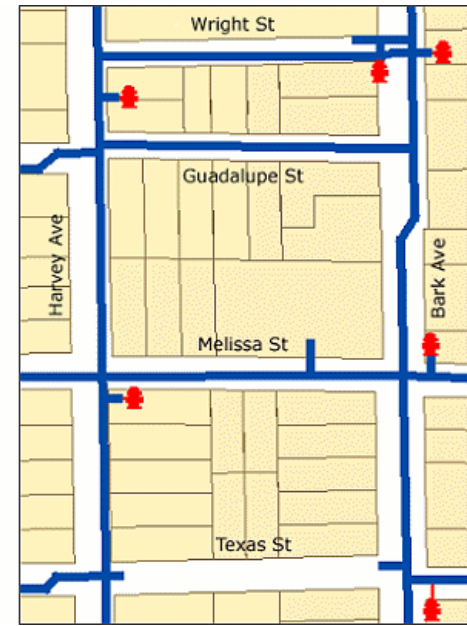
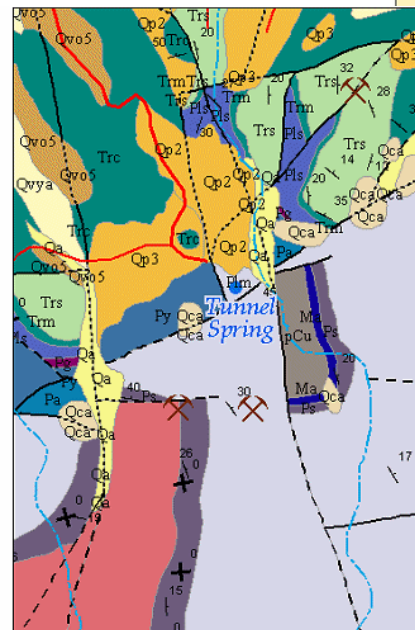
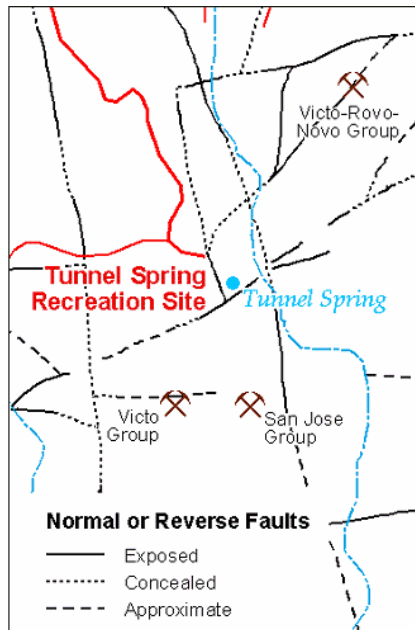
Two maps of Joshua Tree National Park. The map on the left emphasizes physical features, while the map on the right emphasizes cultural features.

Every map should have a purpose. What is it? Does your map speak to that purpose?

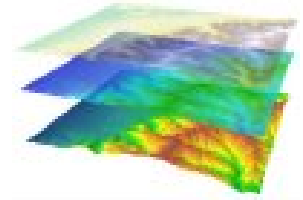


Who will be reading your map?

Design maps to meet the level of expertise of your reader...



The more knowledge and time the audience brings to the task of reading your map, the more information you will be able to include.

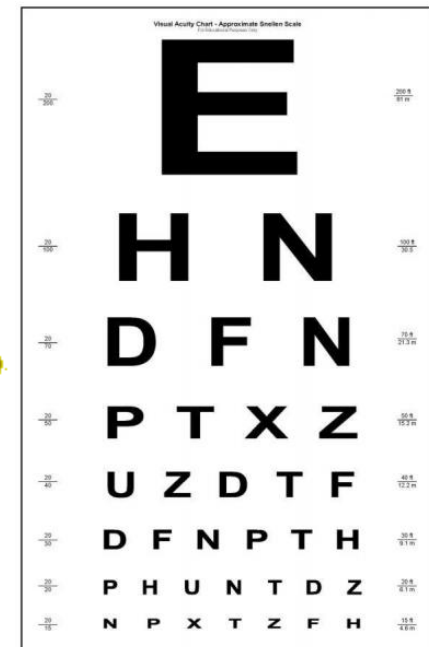
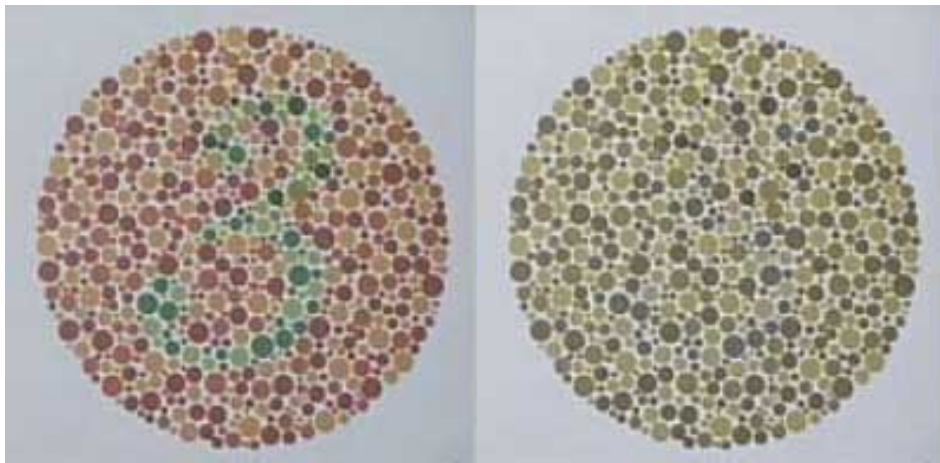


Who will be reading your map?

Special needs of audience...

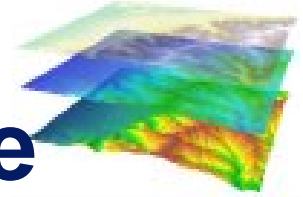


Color blindness



Small print

Resolution and Viewing Distance

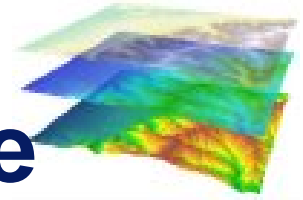


Numerous media options:

- Computer screen
- Computer projected display
- Color laser prints
- Black & white laser prints
- Poster sized plots
- Professional glossy magazine
- Huge backdrop for trade show
- Supporting info on a TV show
- FAX sent to emergency response
- In-line display on a PDA or GPS
- Web page

...each has its own resolution/display constraints

Resolution and Viewing Distance

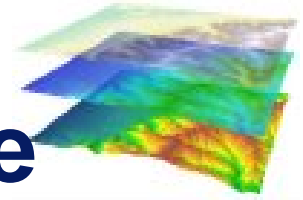


Consider final media when setting resolution...

Approximate DPI (dots per inch) of various media:

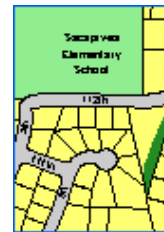
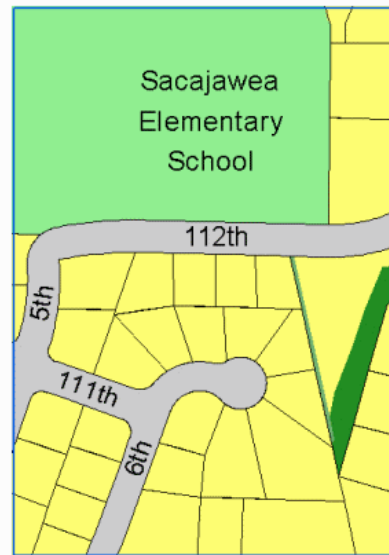
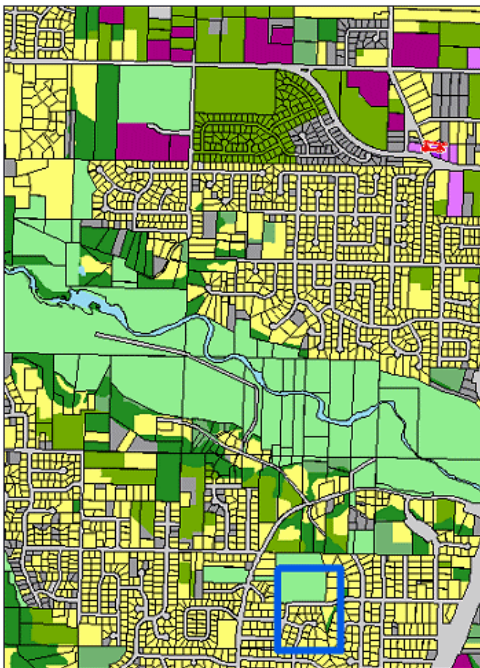
Household TV (27"):	26
Computer screen:	72
Laser printer:	1,200
Litho plate/offset printer:	12,000

Letters 2" high seen from 14' away are roughly equivalent to viewing 10-point type from 1' away.

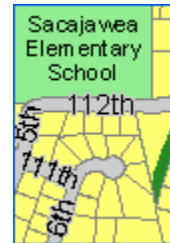


Resolution and Viewing Distance

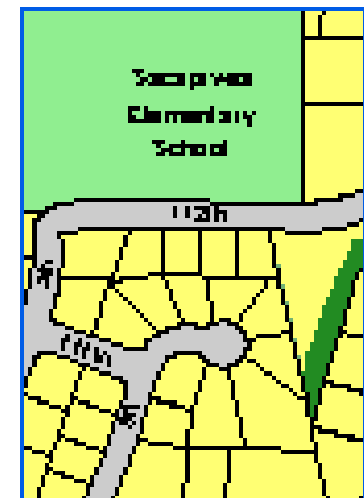
Design your graphics for the size of the final output...



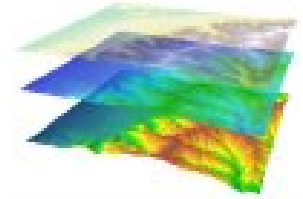
Not enough DPI on monitor to view at smaller size



Adjusted for smaller size/DPI



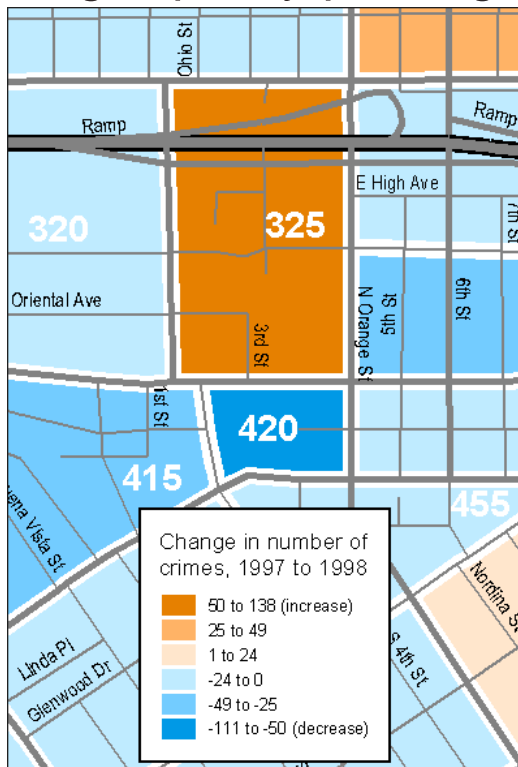
Enlargement of coarse image loses resolution



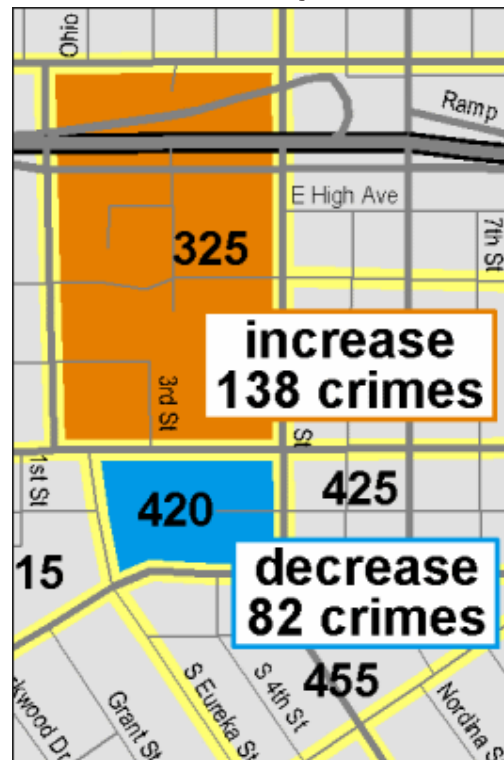
Color & Contrast

Set colors and contrasts for your different media...

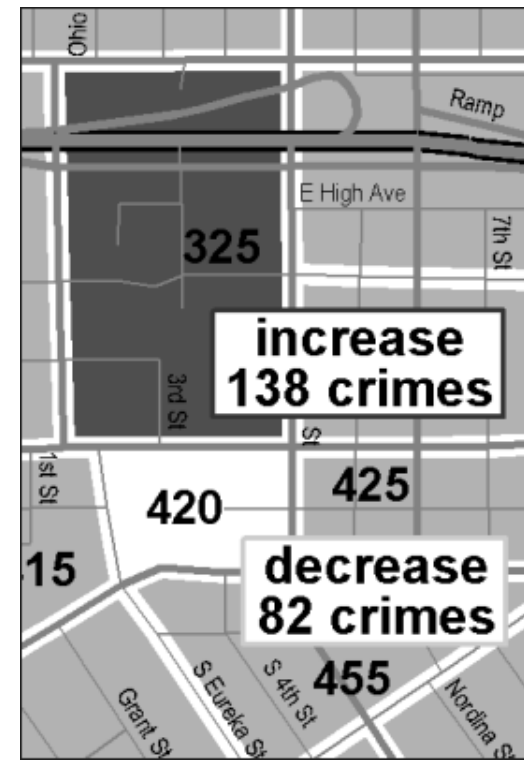
High-quality printing

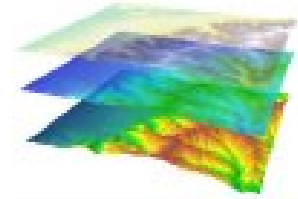


LCD Projection

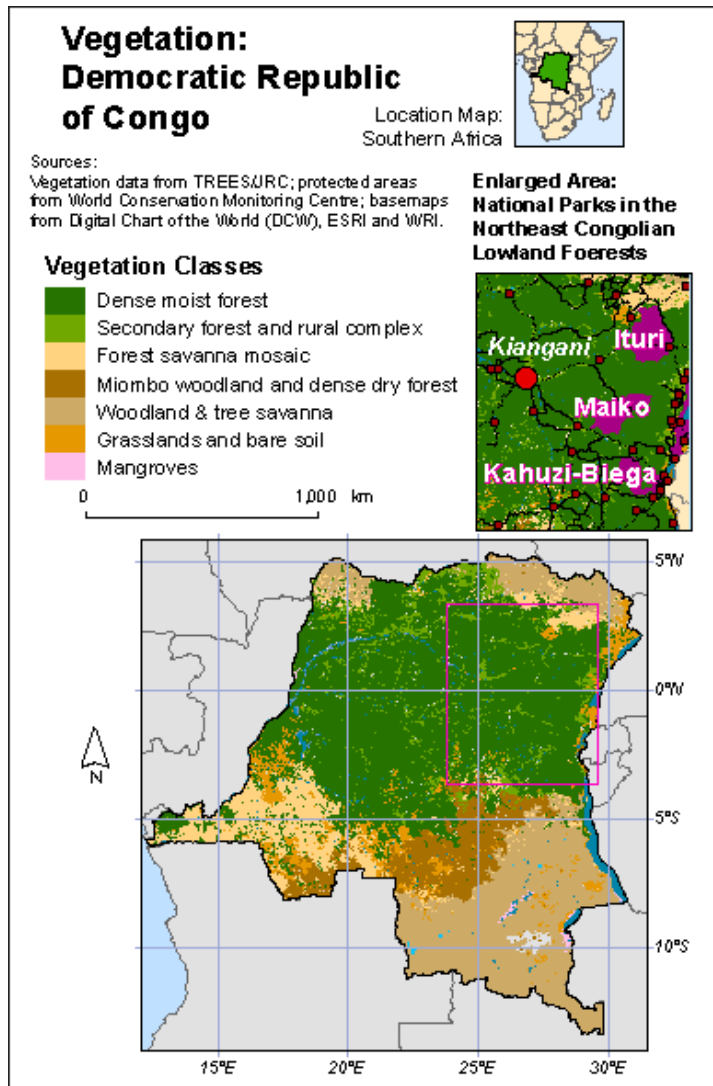


Photocopying



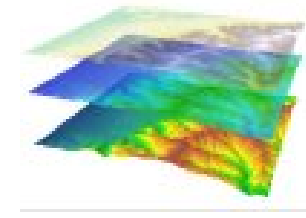


Visual Hierarchy

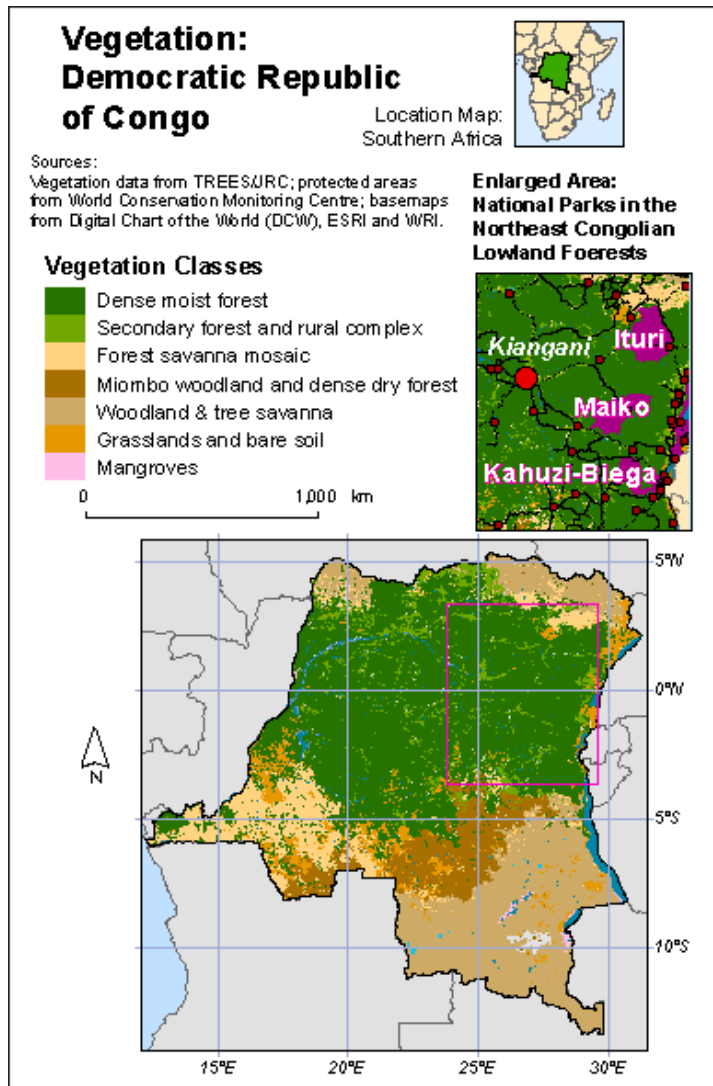


Make most important features most prominent by adjusting:

- Position
- Size
- Surrounding open space
- Color contrast
- Line weights and detail



Visual Hierarchy



Map Elements

Main map

Smaller-scale inset maps showing location

Larger-scale inset maps showing detail or locations outside the area of the main map

Titles

Subtitles

Legends

Scale indicators

Orientation (direction) indicators

Graticule

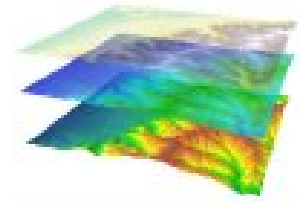
Explanatory text notes

Source note

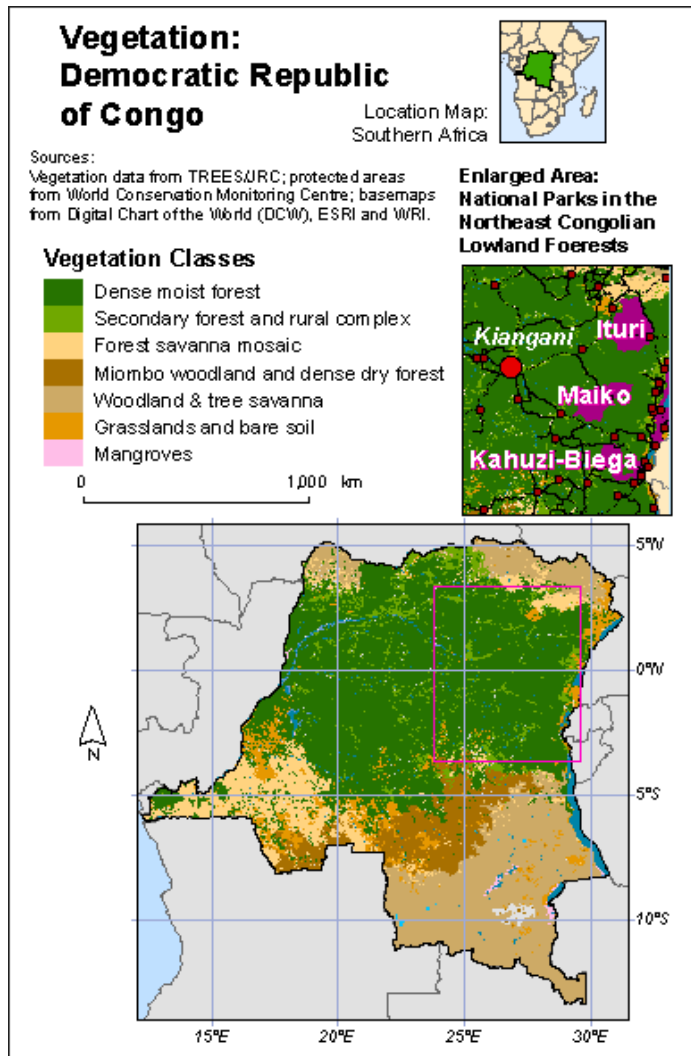
Neatline

Photos

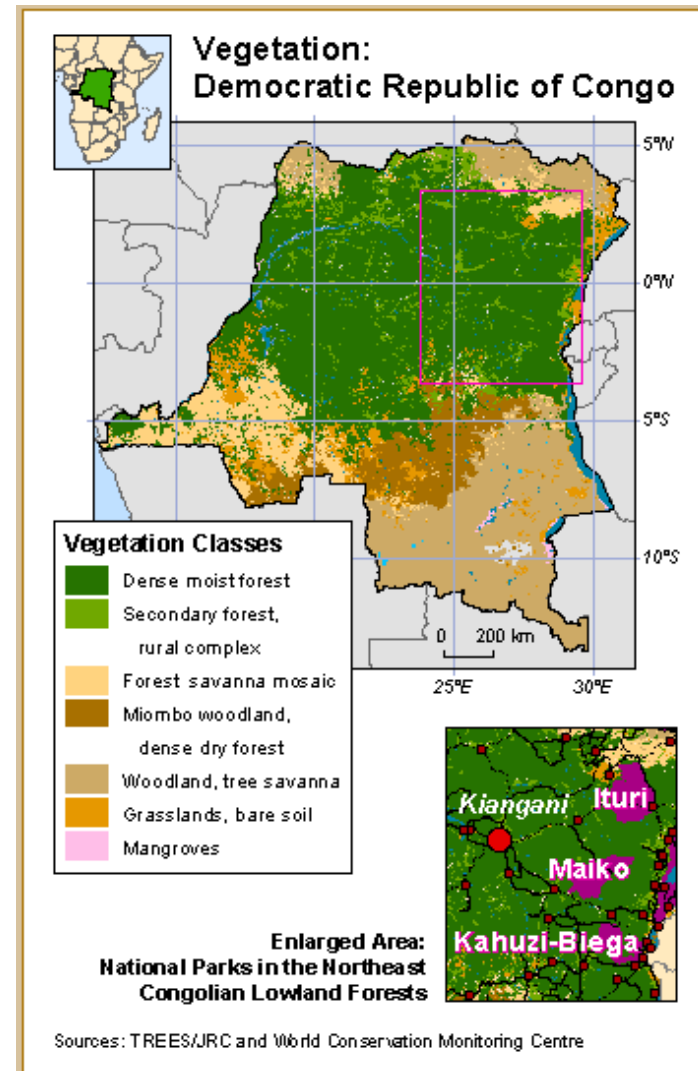
Graphs



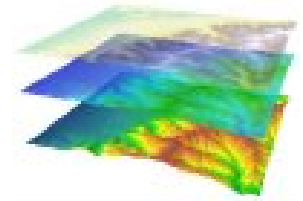
Visual Hierarchy



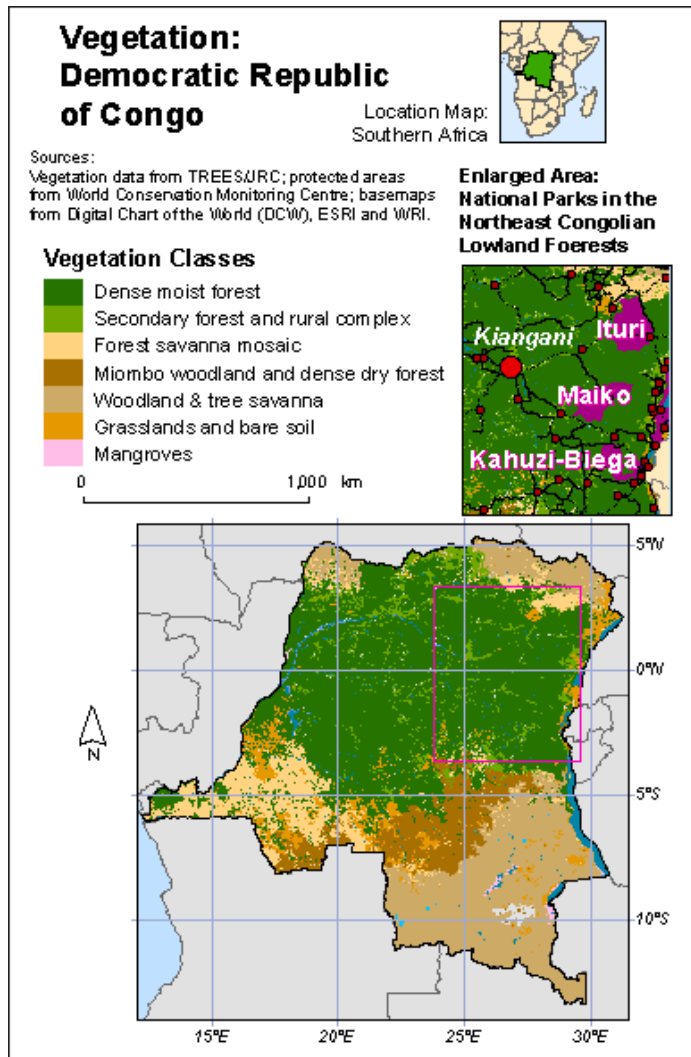
Original



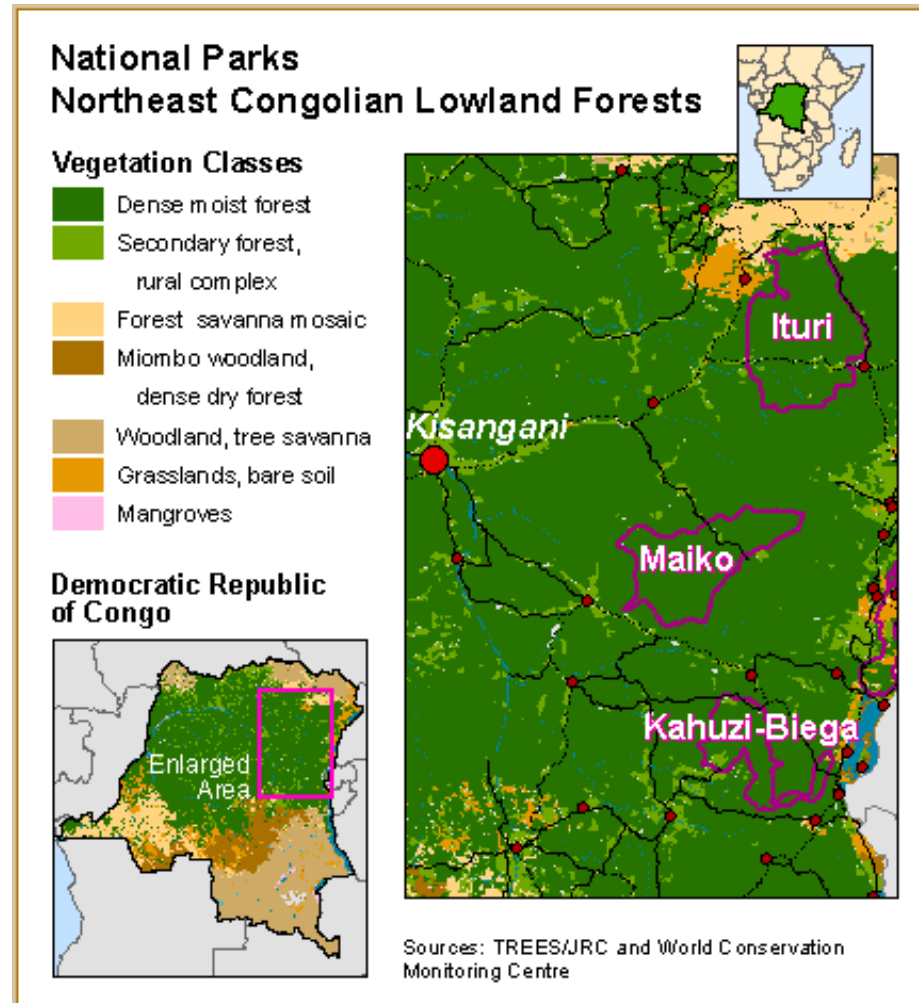
Emphasizes Congo Vegetation



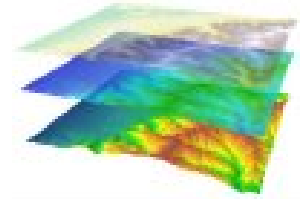
Visual Hierarchy



Original



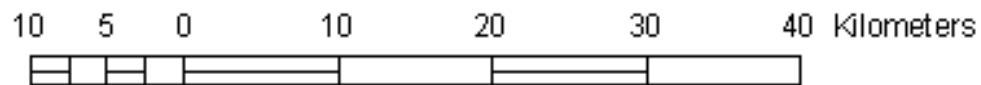
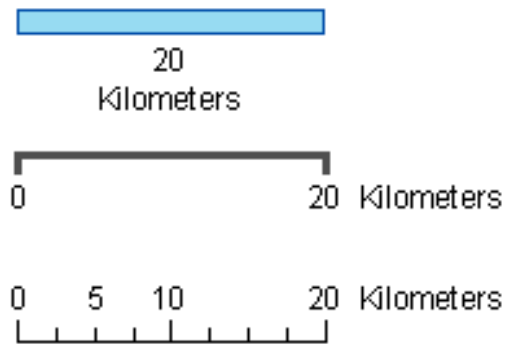
Emphasizes parks in Congo forest



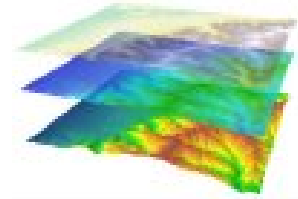
Design Elements

Scale bars:

Thematic maps



Reference maps

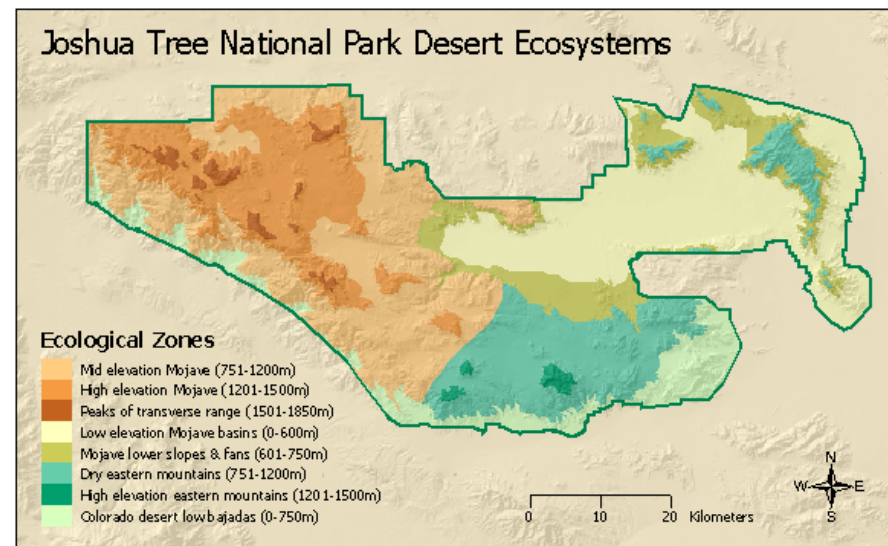
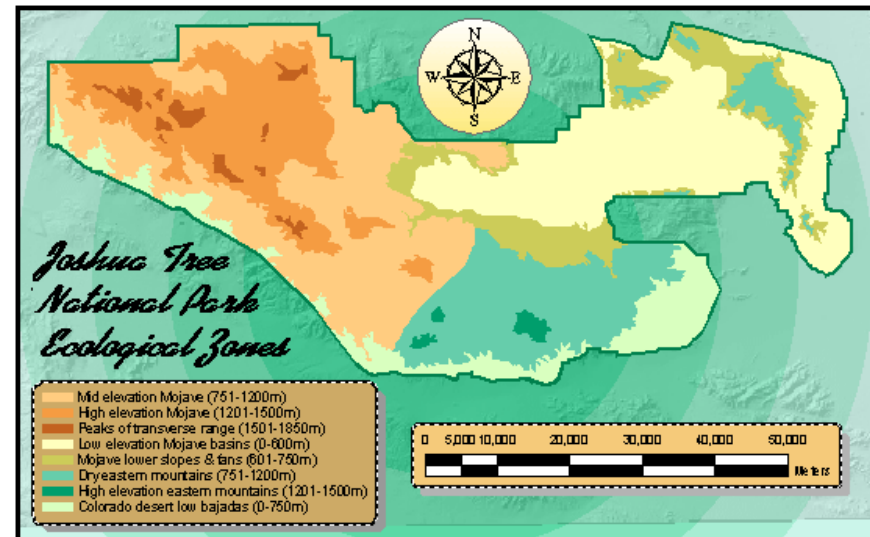


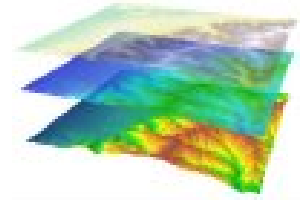
Design Elements

Decorative Elements:

- Drop shadows
- Line styles for frames
- Background patterns
- Compass rose
- Zoom lines
- Colorful logos
- Decorative type fonts

These features tend to distract. Use purposefully!

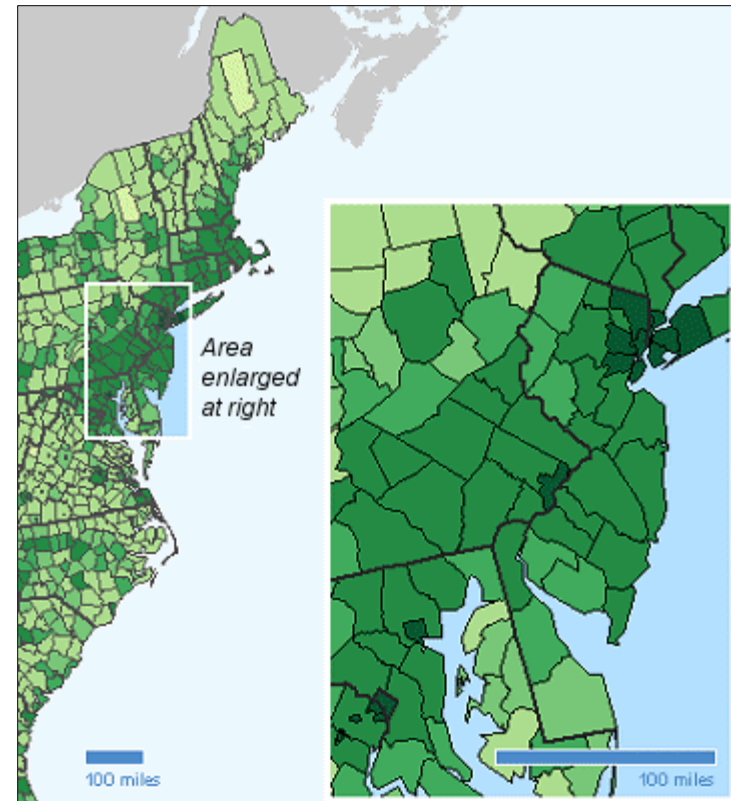
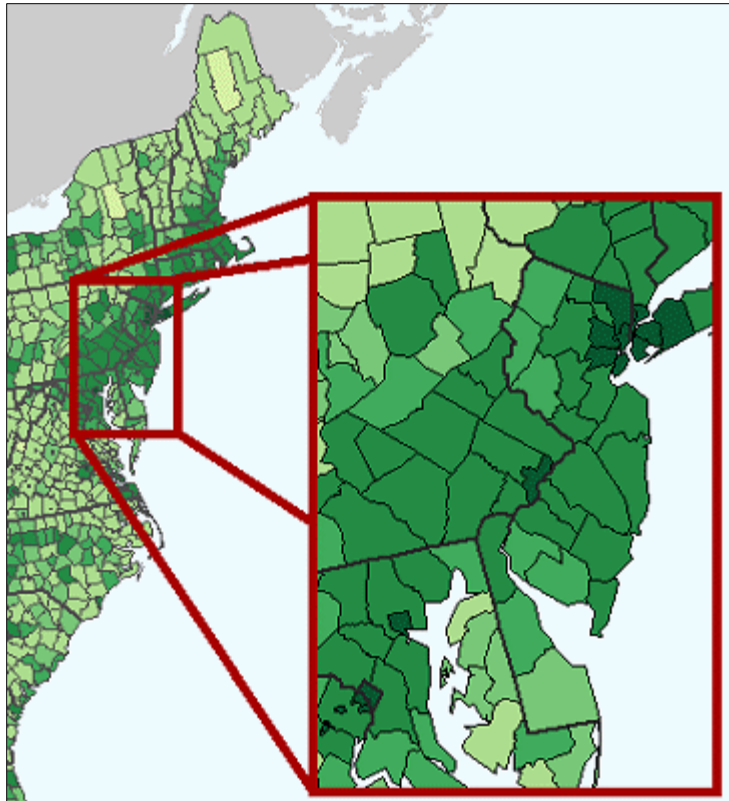


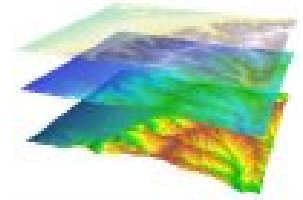


Design Elements

Decorative Elements

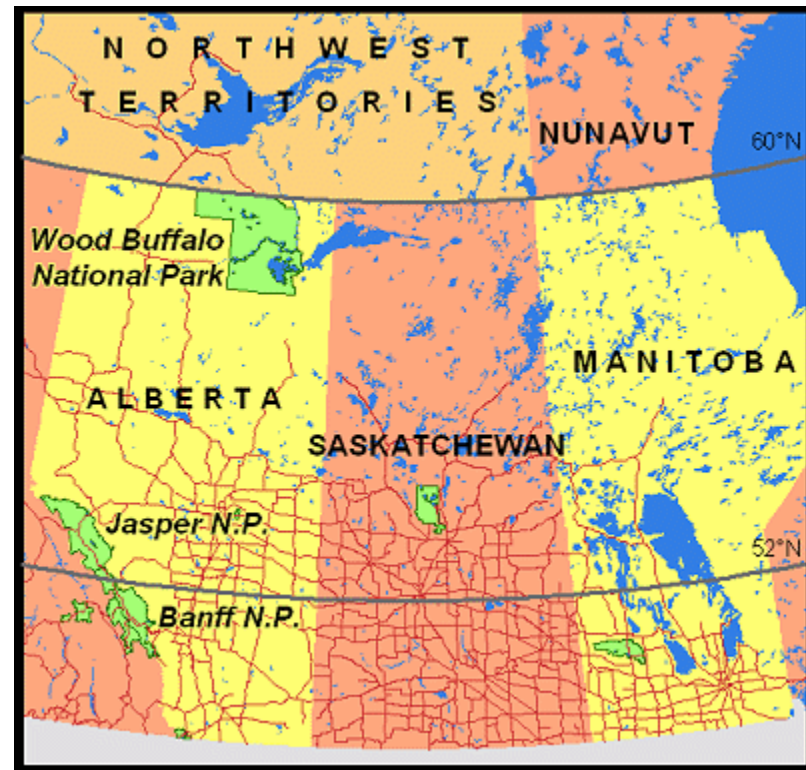
Keep focus on information, not element...



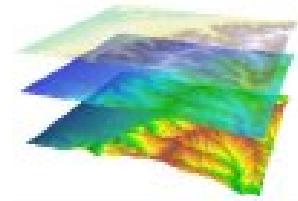


Choosing Map Projections

Which projection element to preserve:
Area? Shape? Distance?

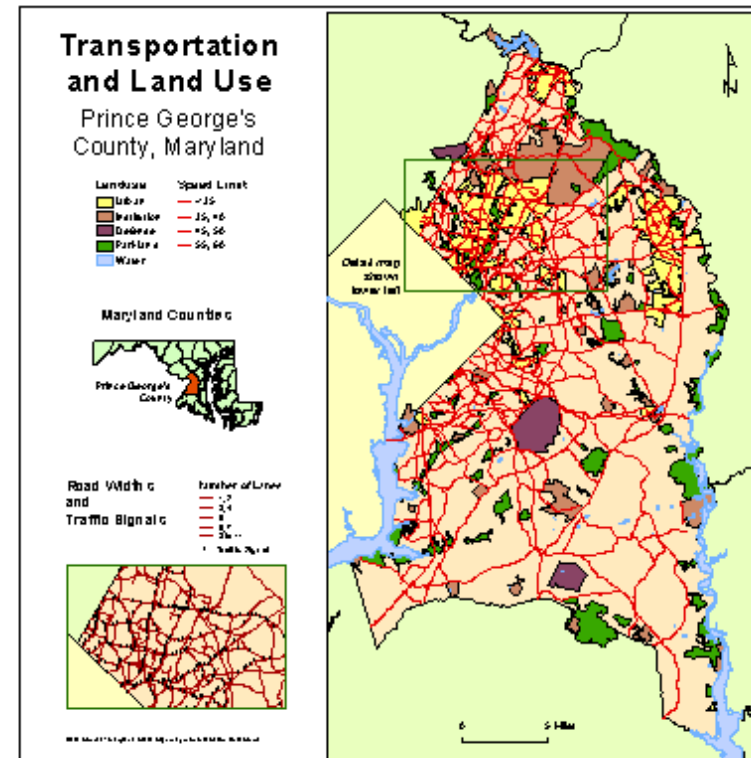
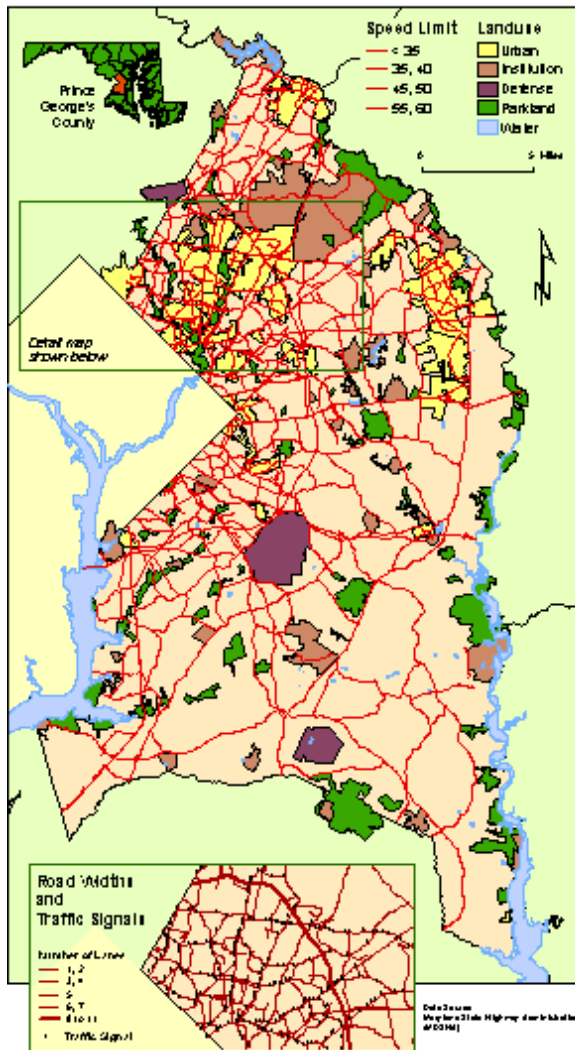


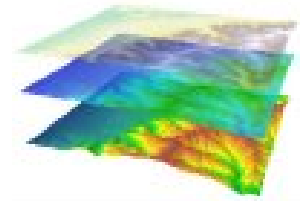
Preserving area is required for density presentations



Balancing Empty Spaces

Transportation and Land Use Prince George's County, Maryland

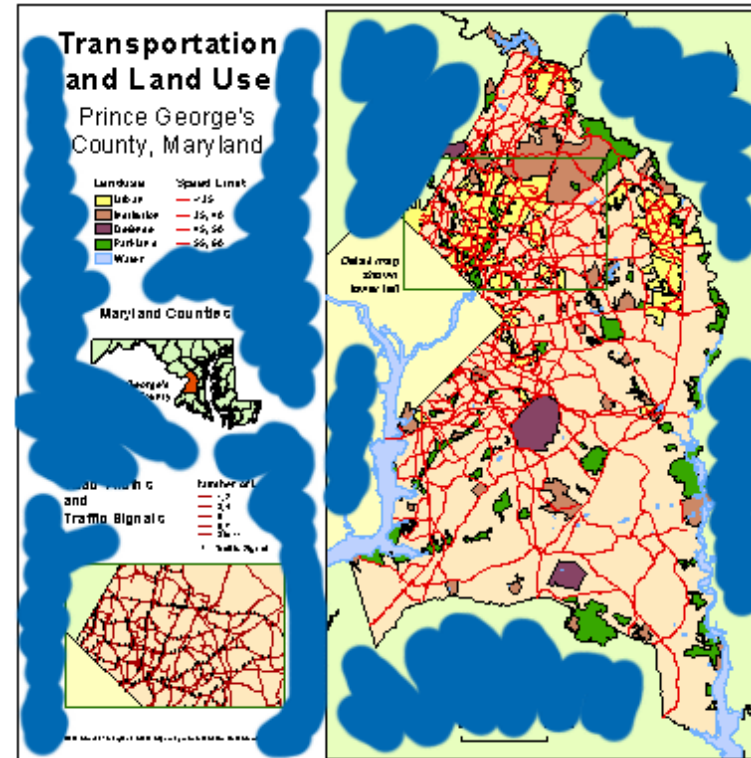
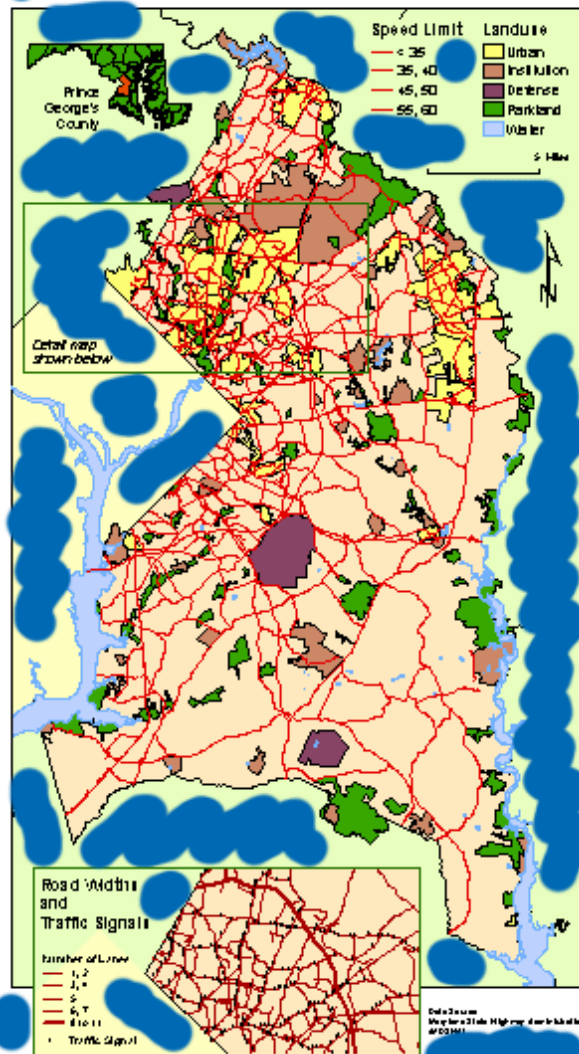


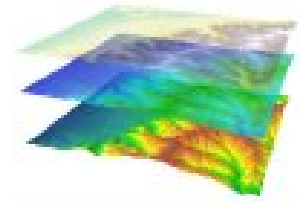


Balancing Empty Spaces

Transportation and Land Use Prince George's County, Maryland

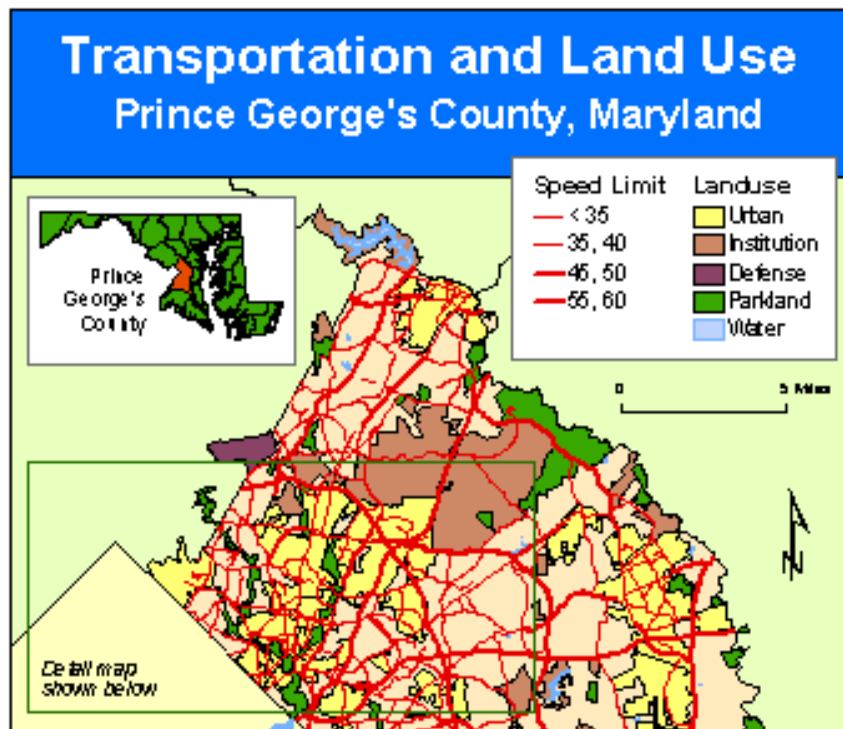
Learn to identify & balance white space. Use it as a design element.

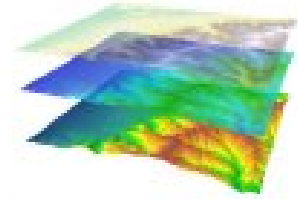




Balancing Empty Spaces

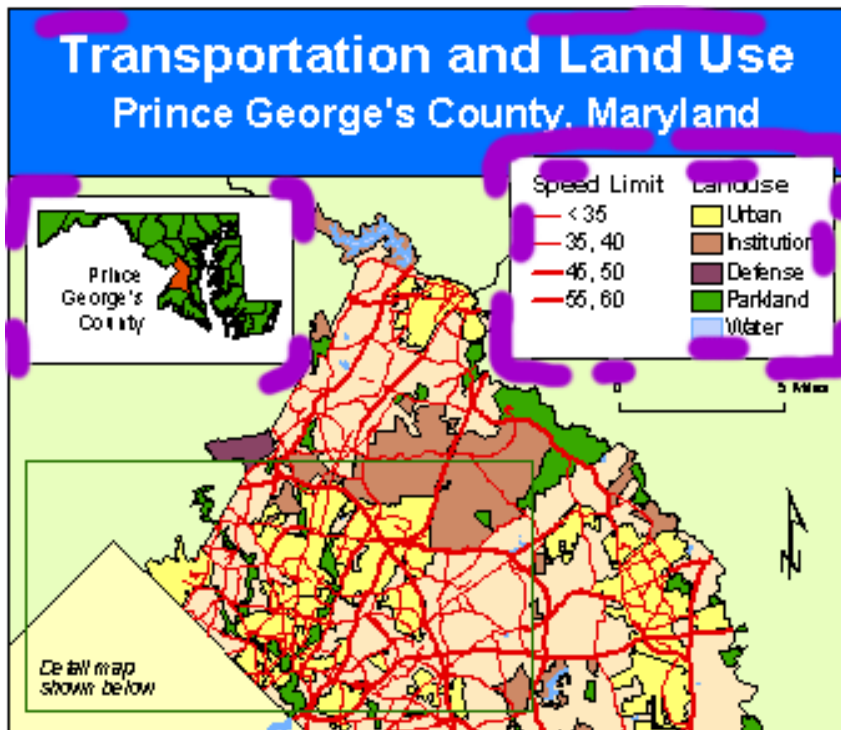
Boxes



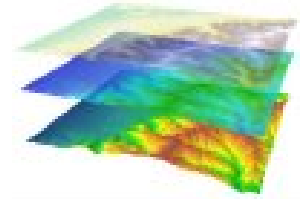


Balancing Empty Spaces

Boxes

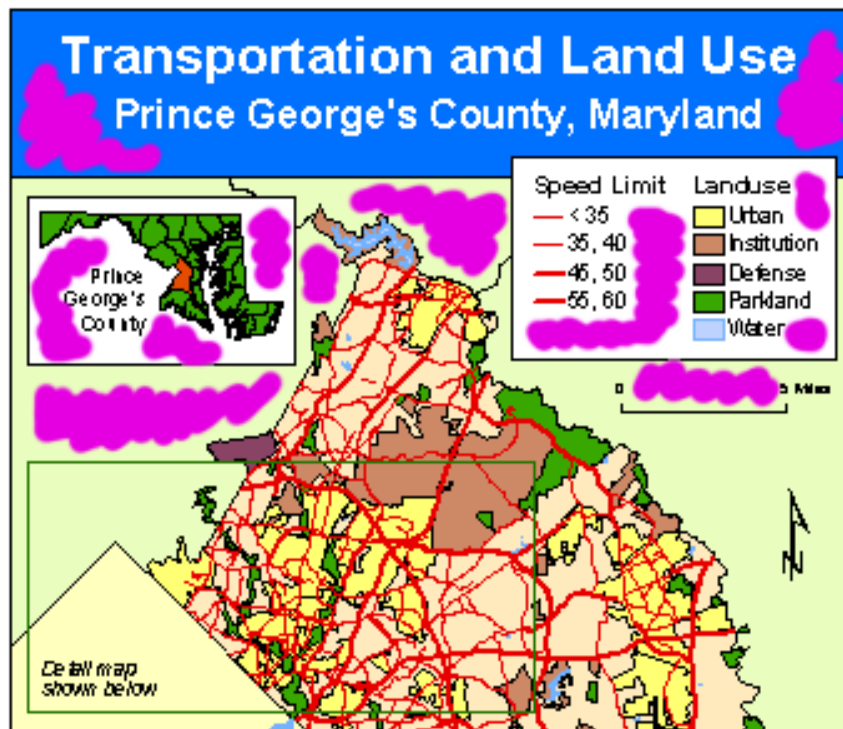


...chops fluid open areas into areas inside and outside the box making more tight spaces...

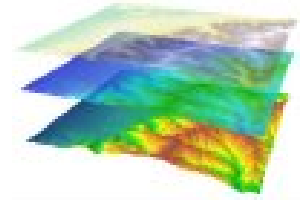


Balancing Empty Spaces

Boxes



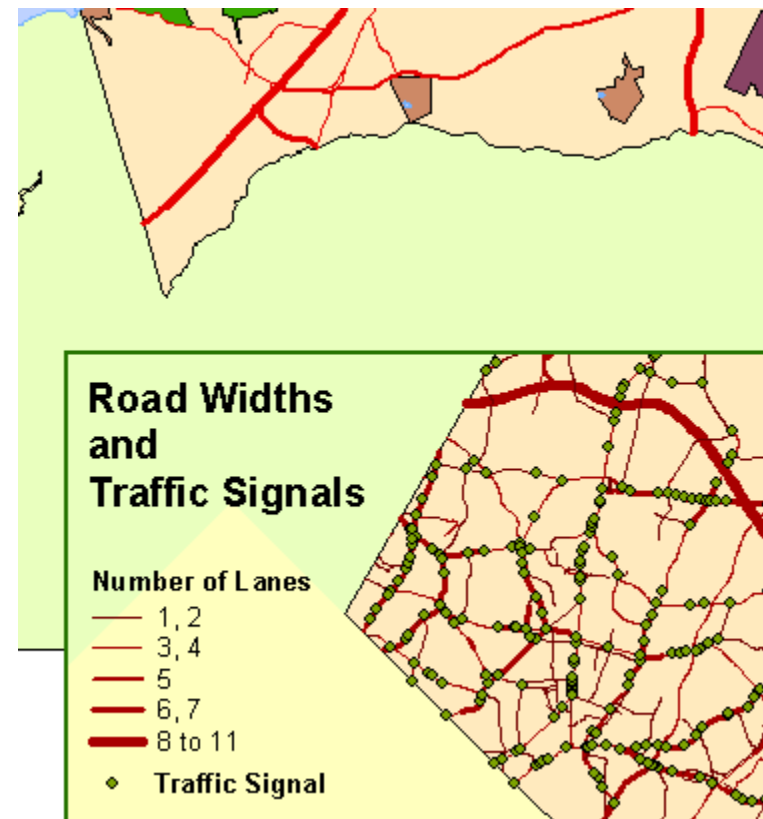
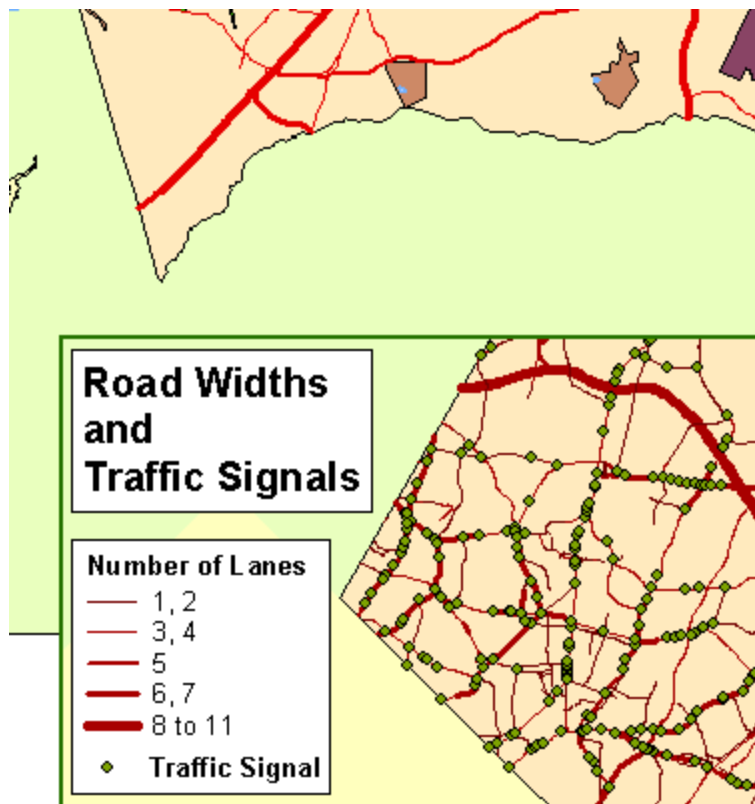
...makes maps appear more crowded with less fluid use of empty spaces...



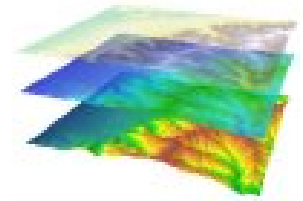
Balancing Empty Spaces

Boxes

...create a difficult and distracting set of pinched angles. Let empty spaces flow into each other.



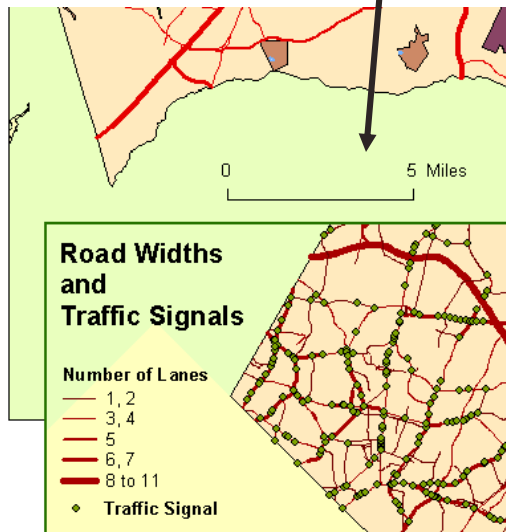
Boxes elevate the visual hierarchy of the elements it surrounds



Minimizing Ambiguity

Space objects so that related items are closer together...

To what maps are the scale bar referring??



Prince George's County, Maryland

Landuse	Speed Limit
Urban	< 35
Institution	35, 40
Defense	45, 50
Parkland	55, 60
Water	

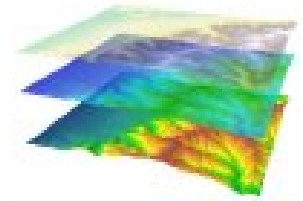
Maryland Counties



Prince George's County

0 5 Miles

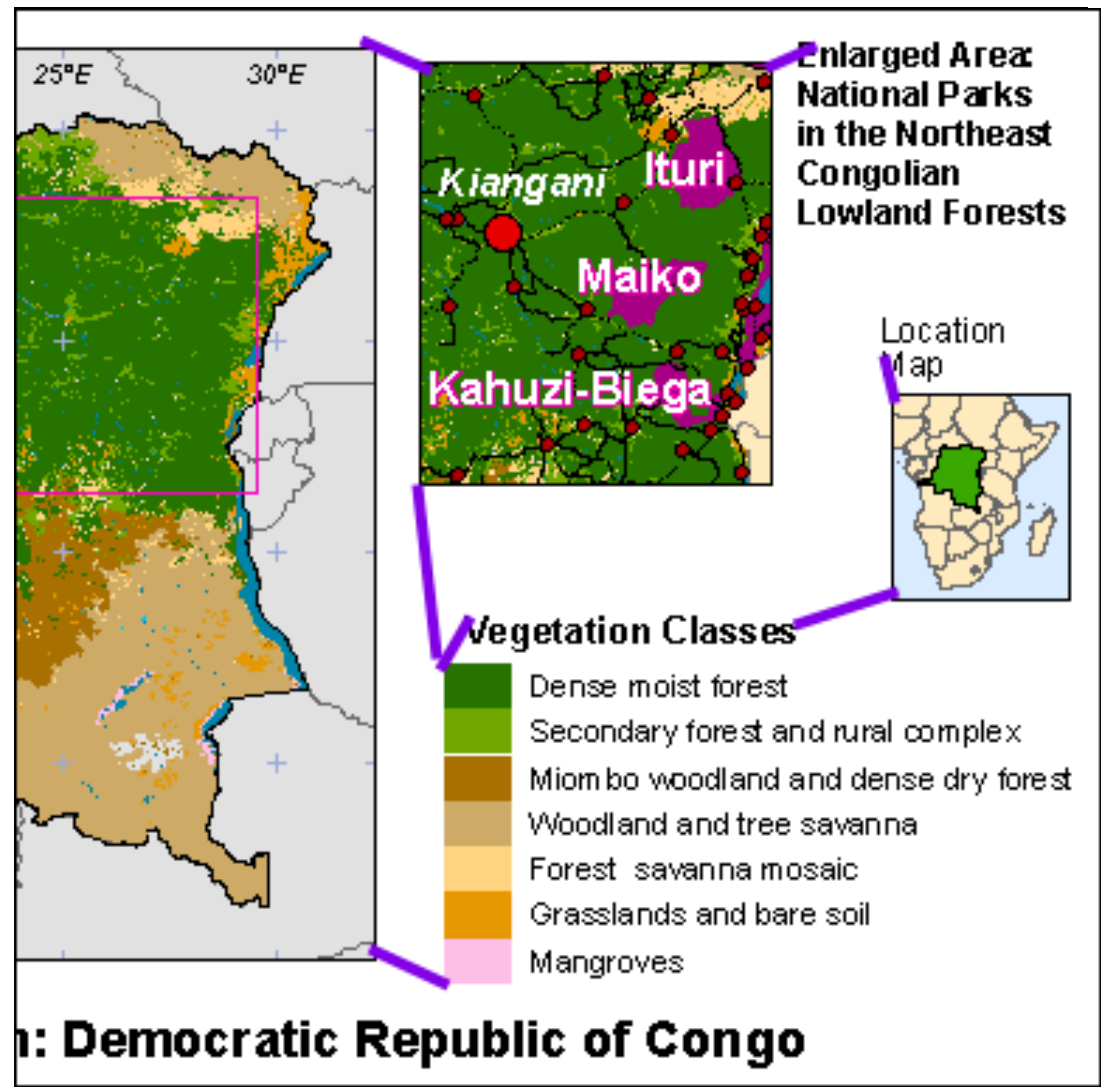


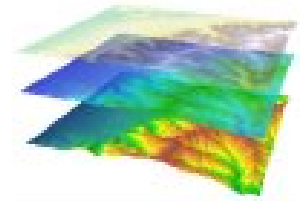


Element Alignment

Aligning all elements to each other creates an over-structured map.

Haphazard alignment creates a sloppy map.



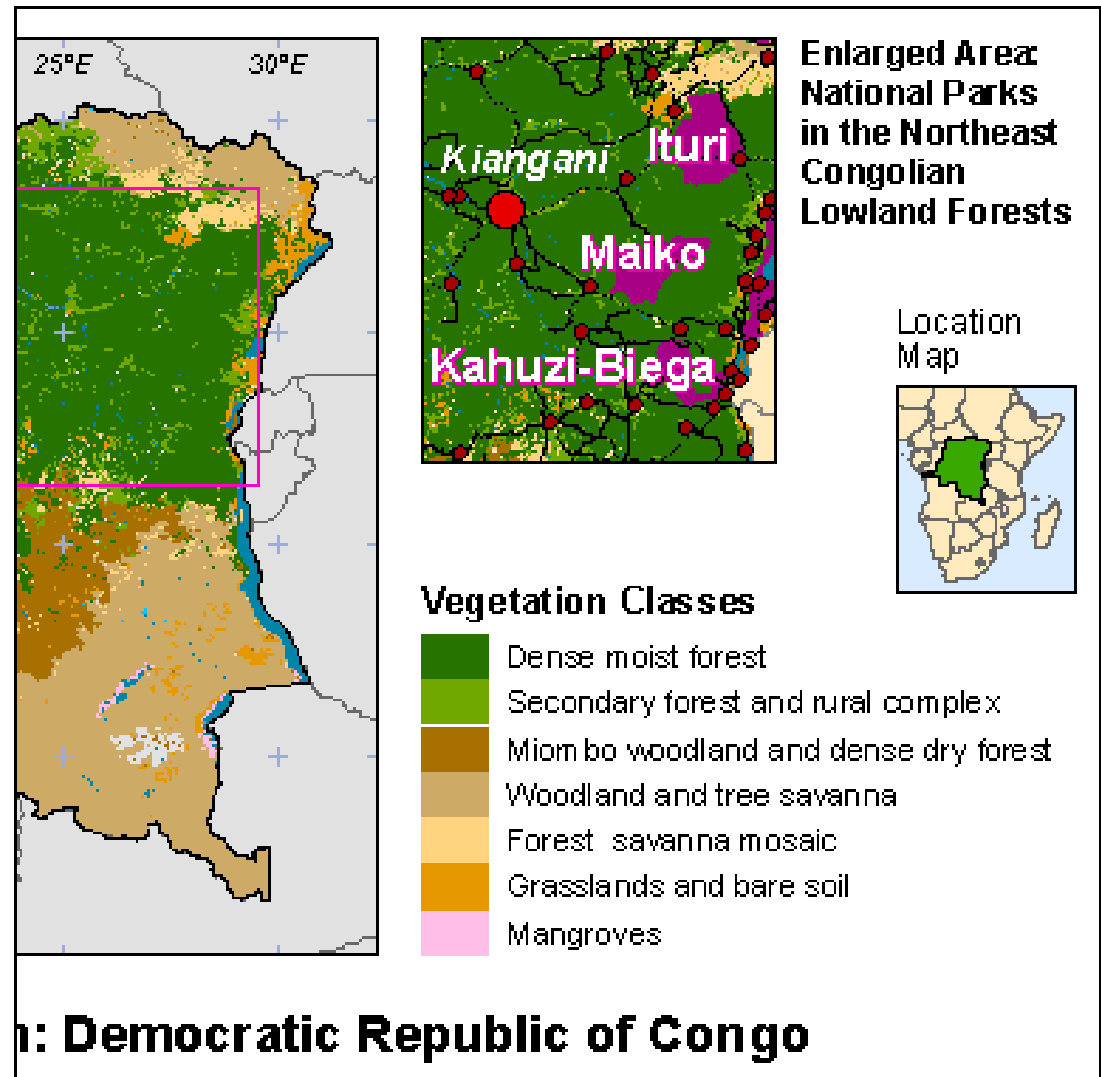


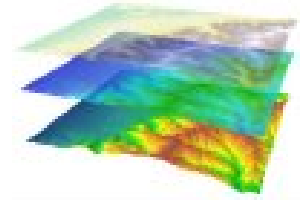
Element Alignment

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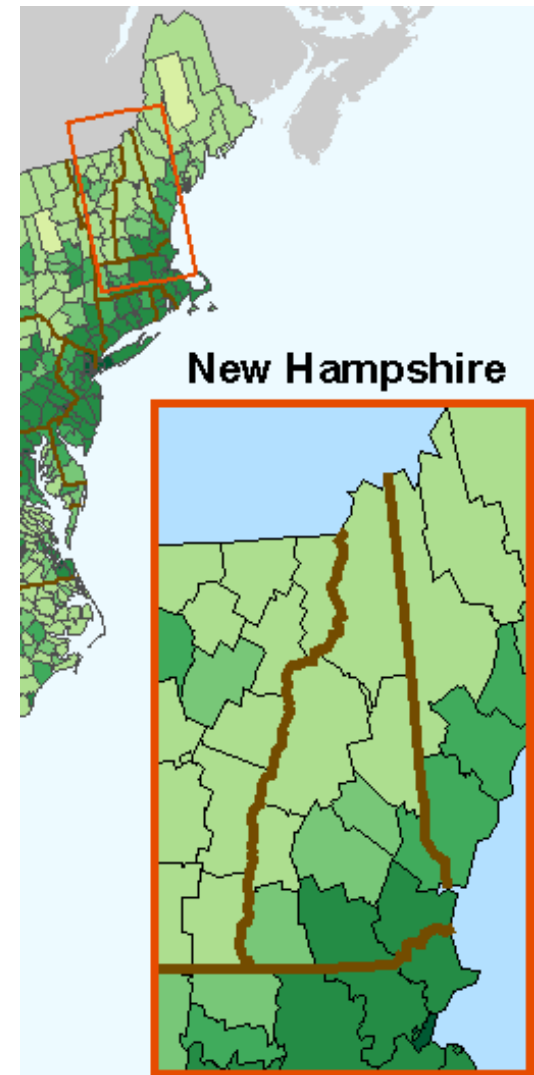
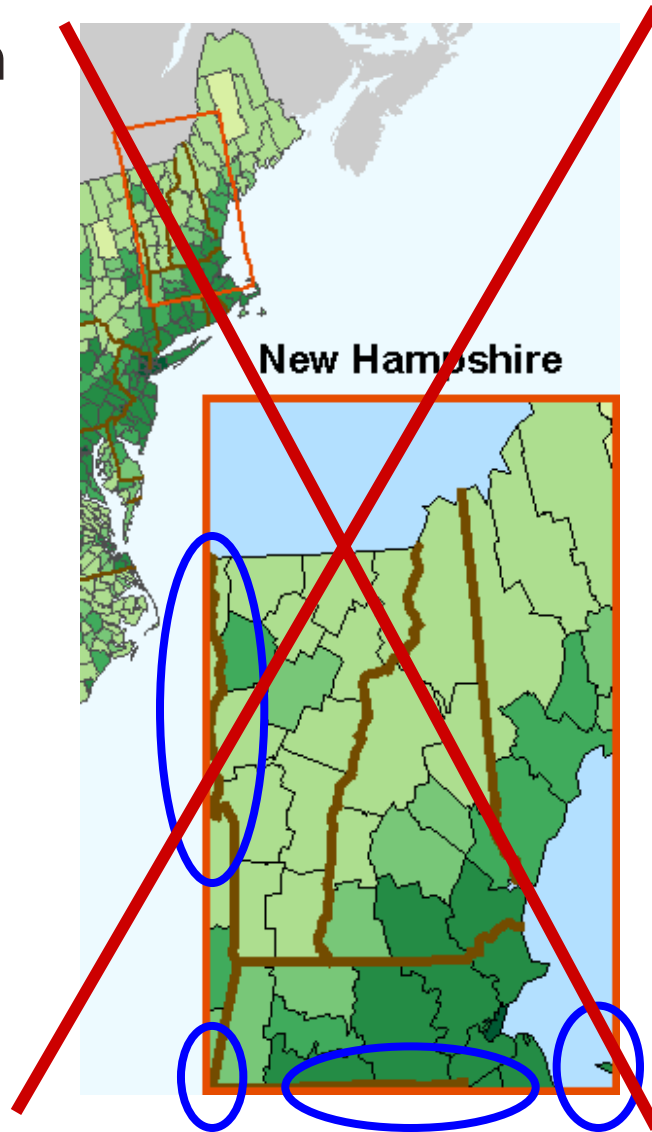
Selective alignment shows intention and can link elements.

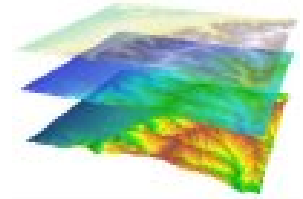




Frame Positioning

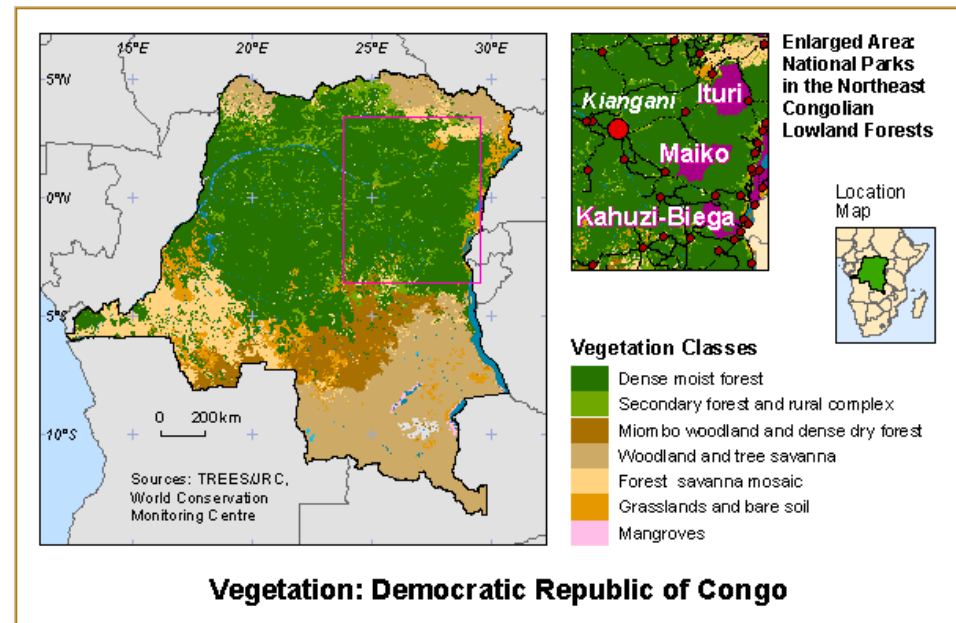
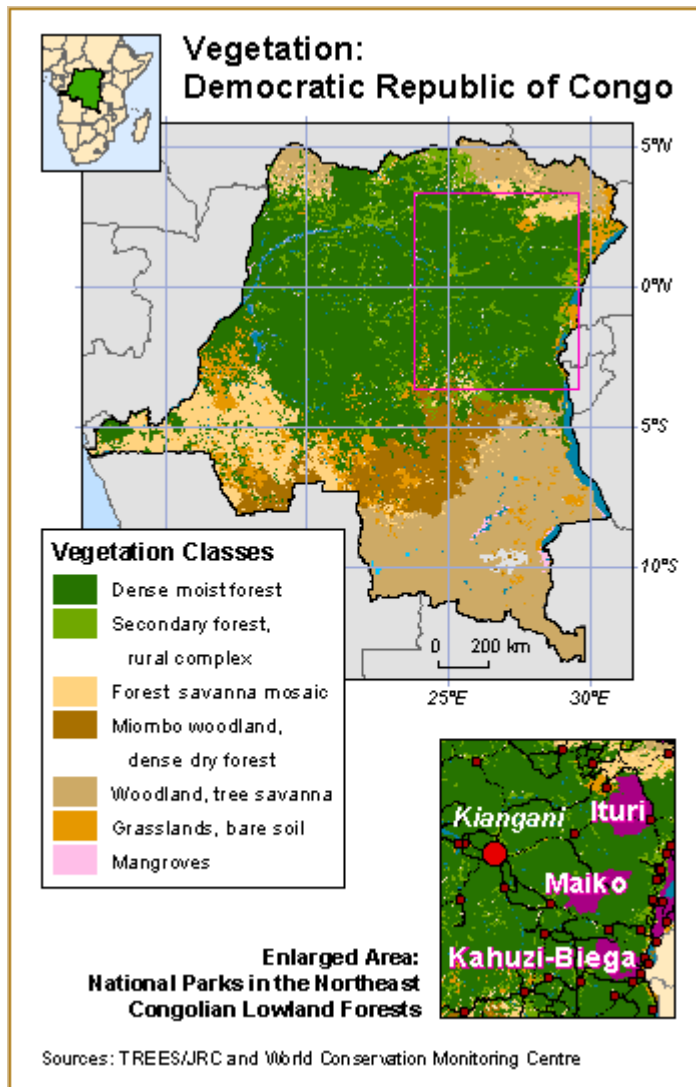
Avoid confusion between layout elements and geographic features

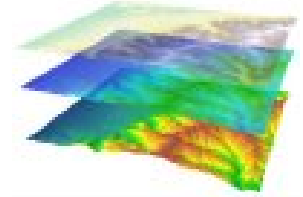




Experimentation/Critique

1. Create your map
2. Consider radically different layouts
3. Refine map
4. Invite critique

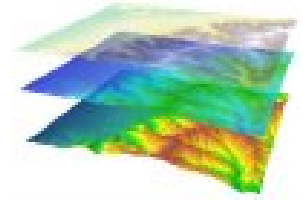




Exporting Maps

Raster export formats:

- Bitmap (.bmp)
- Tagged Image File Format (.tif)
- Joint Photographic Experts Group (.jpg)
- Portable Network Graphics (.png)
- Graphics Interchange Format (.gif)



Exporting Maps

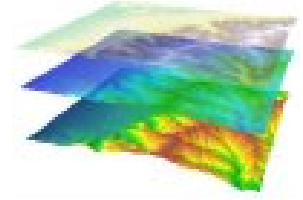
Raster export formats:

- Produce pixel-by-pixel renditions of map (*WYSIWYG*)
- User sets height & width (pixels) and resolution (dpi).
- Larger, more resolute images are higher quality, but require more disk storage space.



— 3x →
resolution

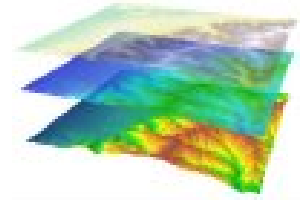




Exporting Maps

Vector export formats:

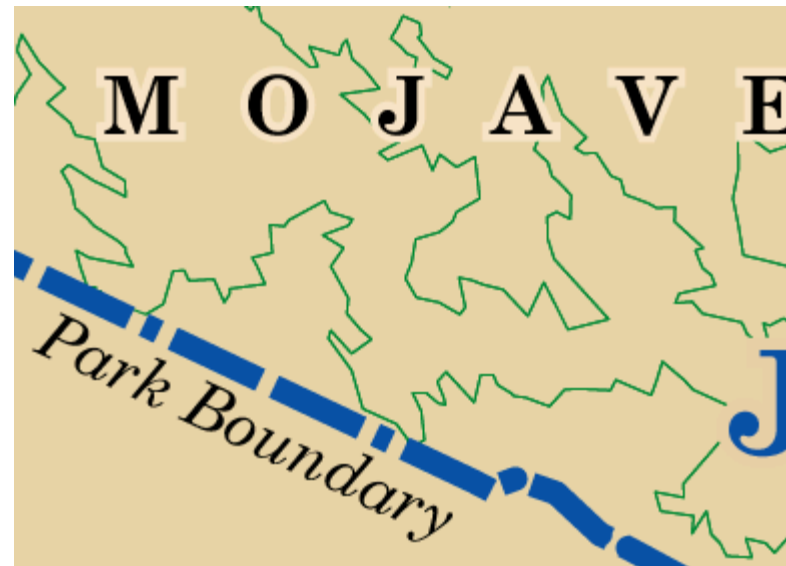
- Enhanced Metafile (.emf)
- Encapsulated Postscript (.eps)
- Adobe Illustrator (.ai)
- Scaleable Vector Graphics (.svg)
- Portable Document Format (.pdf)

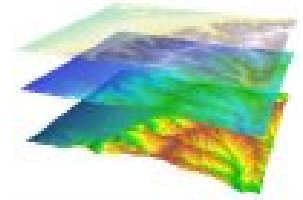


Exporting Maps

Vector export formats:

- Contain instructions on how to redraw elements.
- Elements may be editable after export.
- File size is much smaller, but can take time to draw.
- Reconstruction is not always exact; post editing often required.

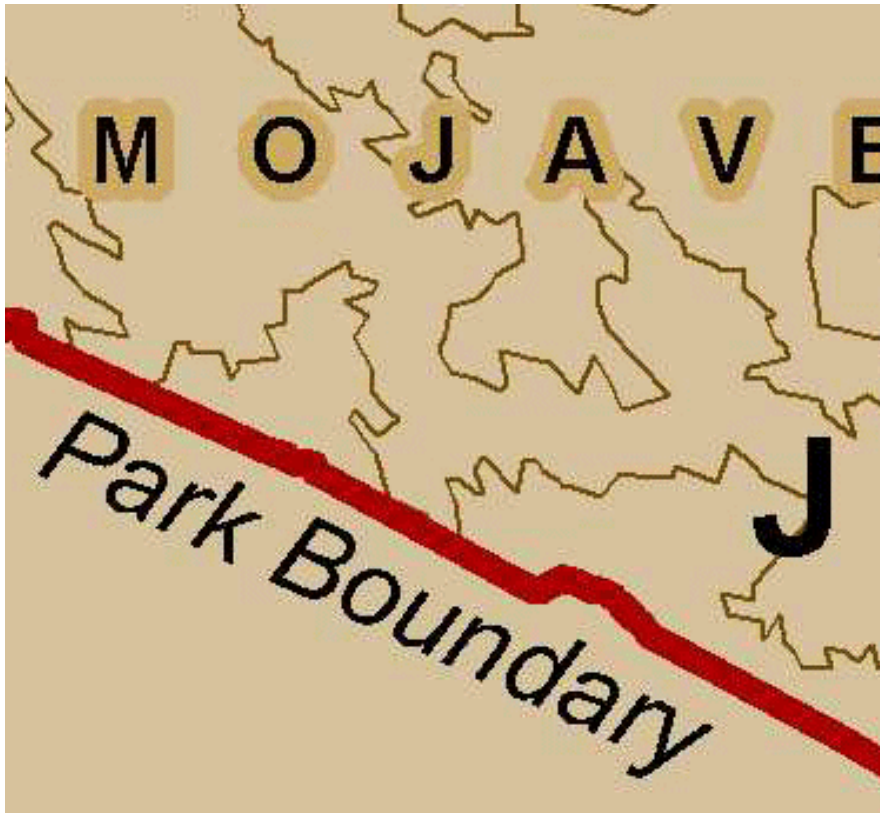




Exporting Maps

JPEG format:

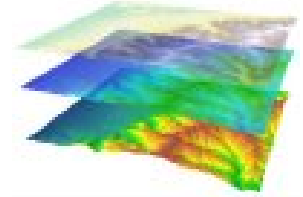
- Size, resolution, and **quality** (compression) are specified



Low quality



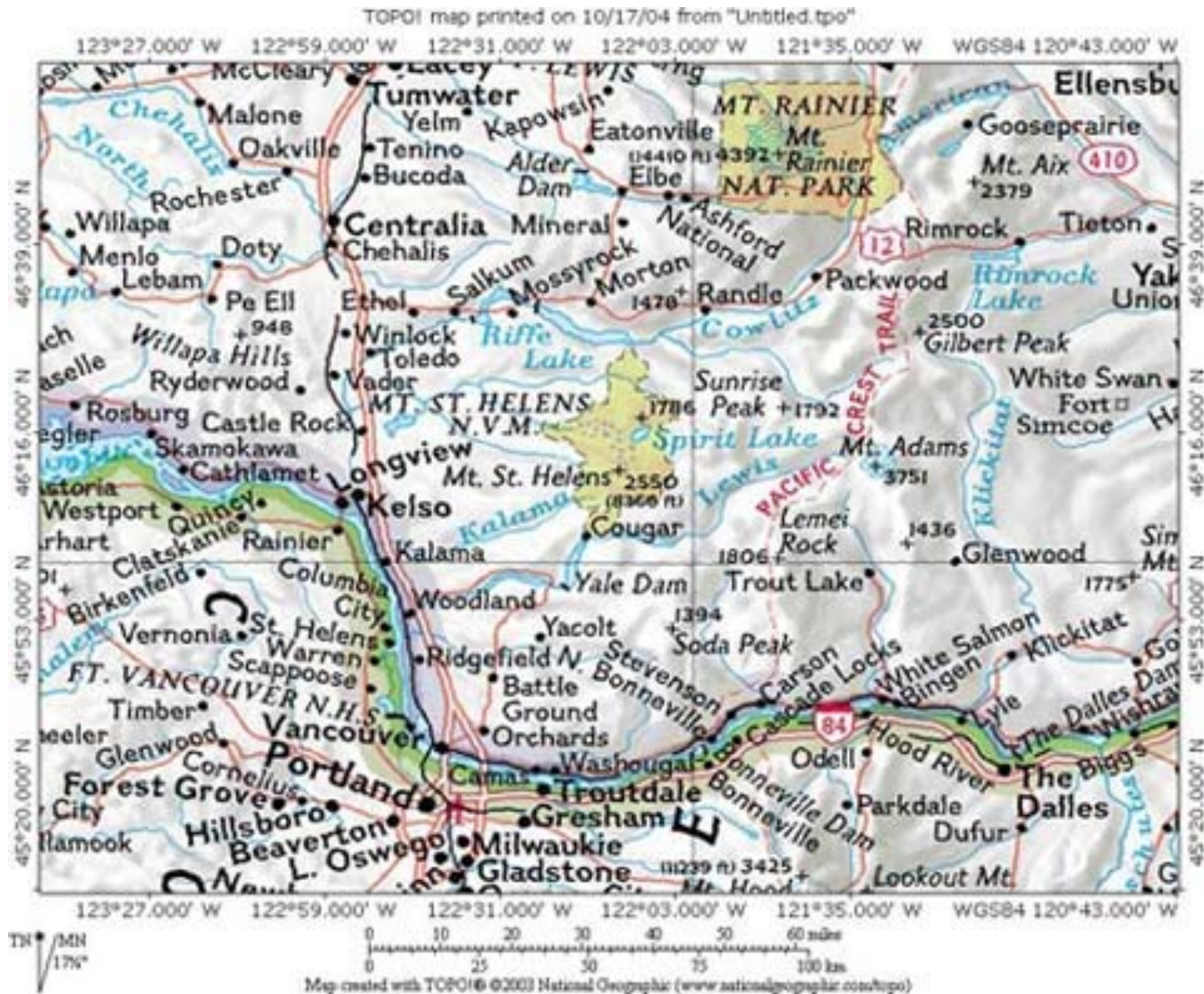
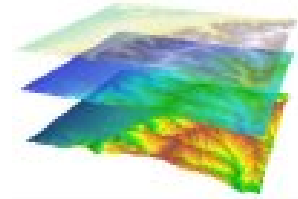
High quality

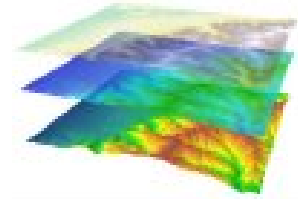


Map Design: Review

- A map's design is guided by its purpose, audience, and viewing medium
- High resolution media can support fine lines and subtle colors. Low resolution media requires big print and contrasting colors.
- Visual hierarchy is set to promote the most important map features.
- Map projections should be chosen to minimize distortion of the main map feature.
- The balancing and alignment of map elements should maximize flow and minimize ambiguity.
- Different export file formats have unique requirements

Type Basics





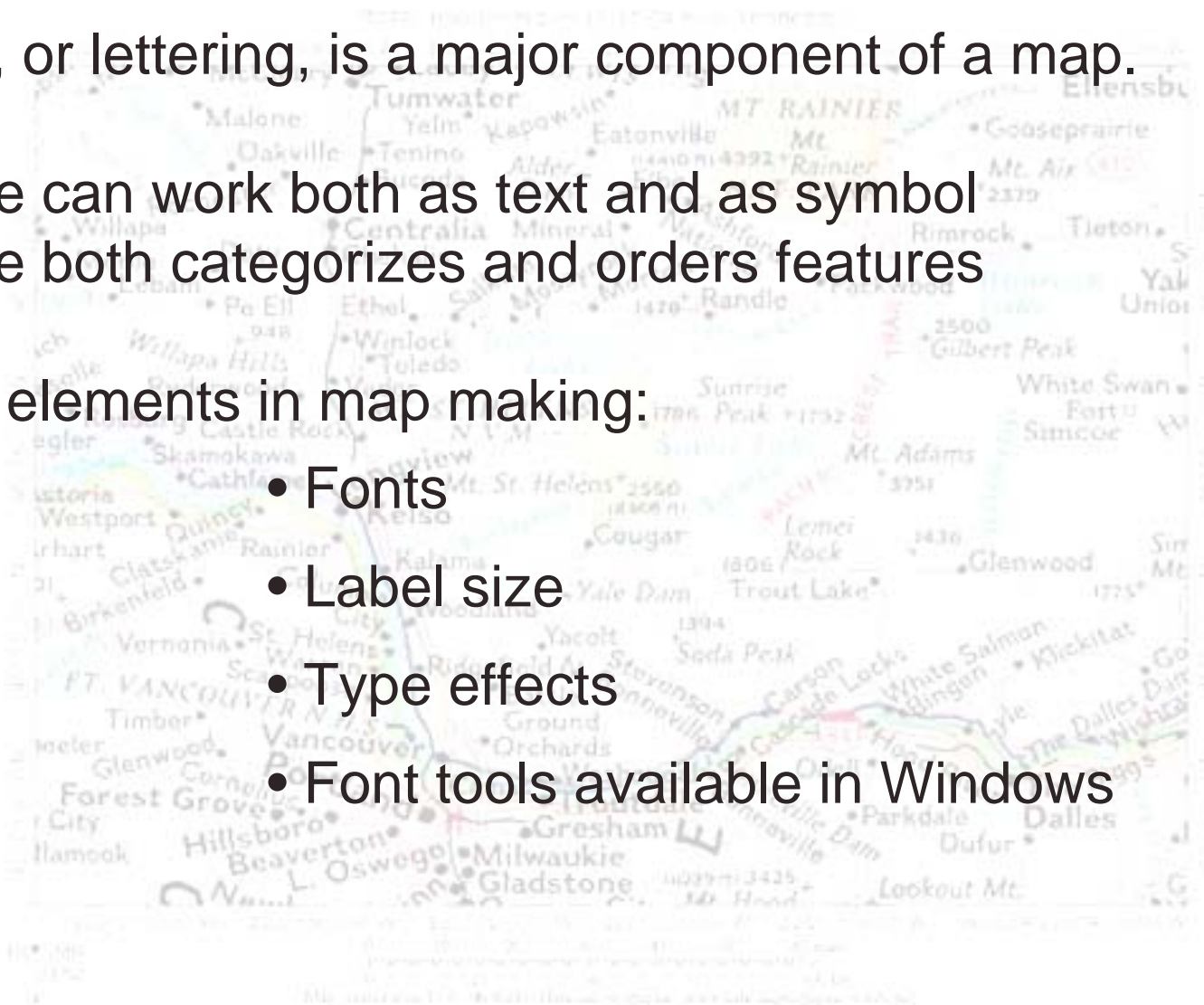
Type Basics

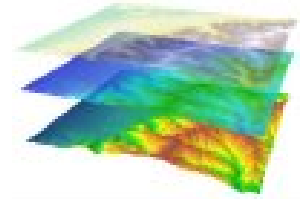
Type, or lettering, is a major component of a map.

- Type can work both as text and as symbol
- Type both categorizes and orders features

Type elements in map making:

- Fonts
- Label size
- Type effects
- Font tools available in Windows





Categories of Fonts

- **Serif**

small finishing strokes on letters

gqabj GIQWB &?147,
Times New Roman

gqabj GIQWB &?147,
New Baskerville

gqabj GIQWB &?147,
Courier New

- **Sans serif**

no finishing strokes

gqabj GIQWB &?147,
Arial

gqabj GIQWB &?147,
Tahoma

gqabj GIQWB &?147,
Futura

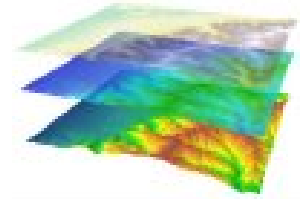
- **Display Fonts**

Distinctive or
decorative letter
forms

gqabj GIQWB &?147,
Tiffany

**gqabj GIQWB &?147,
Impact**

*gqabj GIQWB &?147,
Kaufmann*

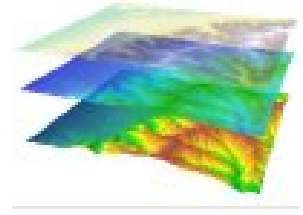


Categories of Fonts

Maps usually contains only two font types.

- A *serif* font is often used for water or other physical features
- A *sans serif* font is used for towns and other cultural features





Font x-height and legibility

- x-height describes the height of the letter 'x' for a font
- x-height and thinness of letters are important considerations when small text size is used on maps

palouse palouse
Garamond Palatino

Bell Gothic Font (phonebook)

AaBbCcDdEeFfGgHhIiJjKk

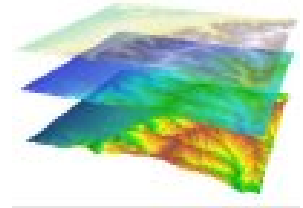
- Some fonts also angle better than others

minimum
Times
New Roman
Italic

minimum
Verdana
Italic

minimum
Georgia
Old Style
Italic

minimum
Arial
Italic



Type styles and font families

Regular... Bold... Italics... Bold italics...

Arial Regular

Arial Bold

Arial Italic

Arial Bold Italic

Arial Narrow Regular

Arial Narrow Bold

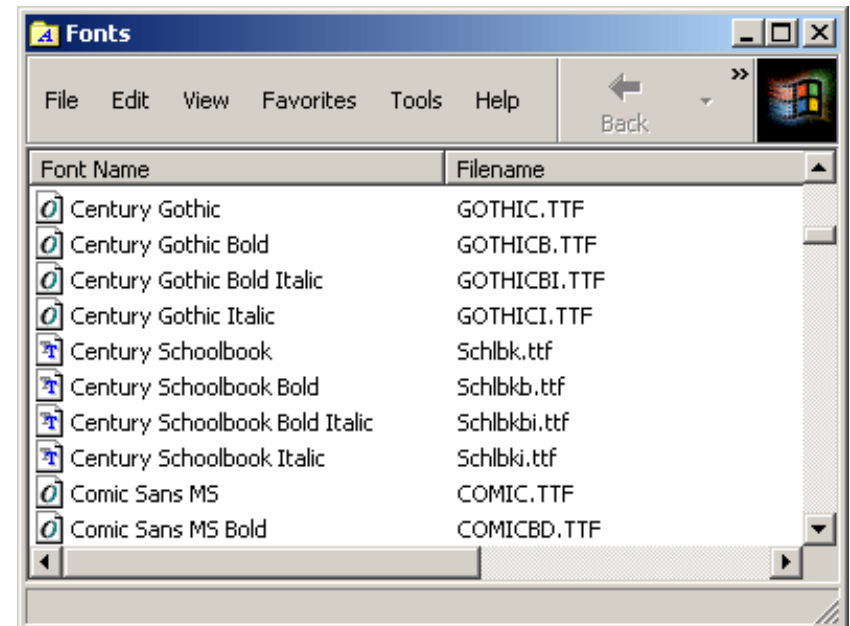
Arial Narrow Italic

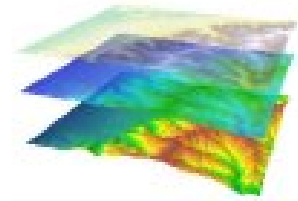
Arial Narrow Bold Italic

Arial Black Regular

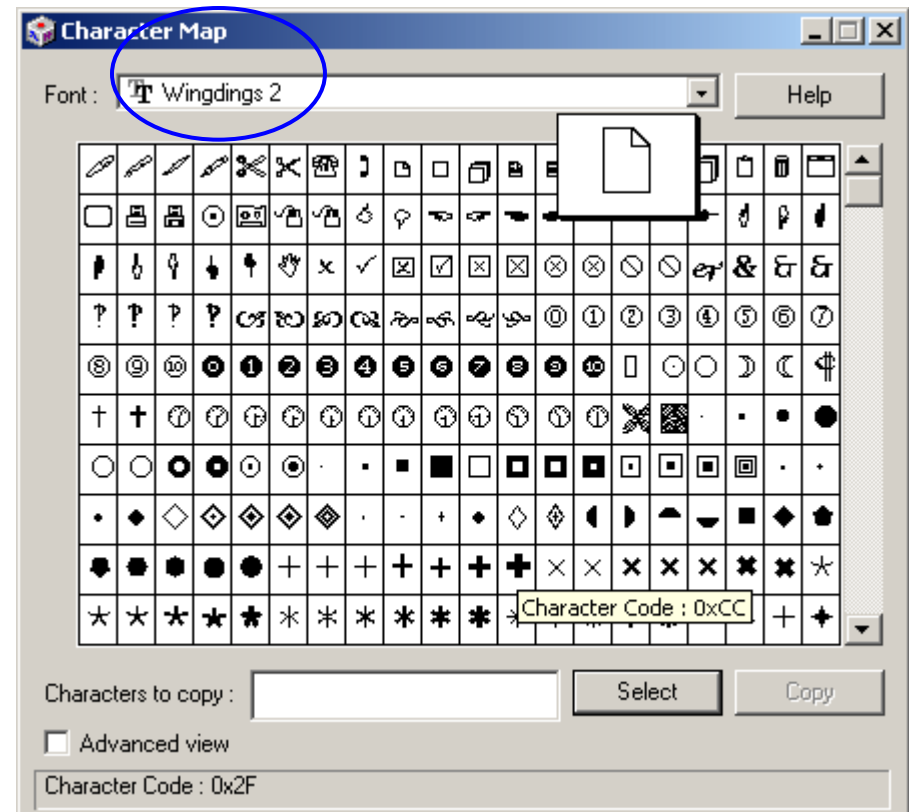
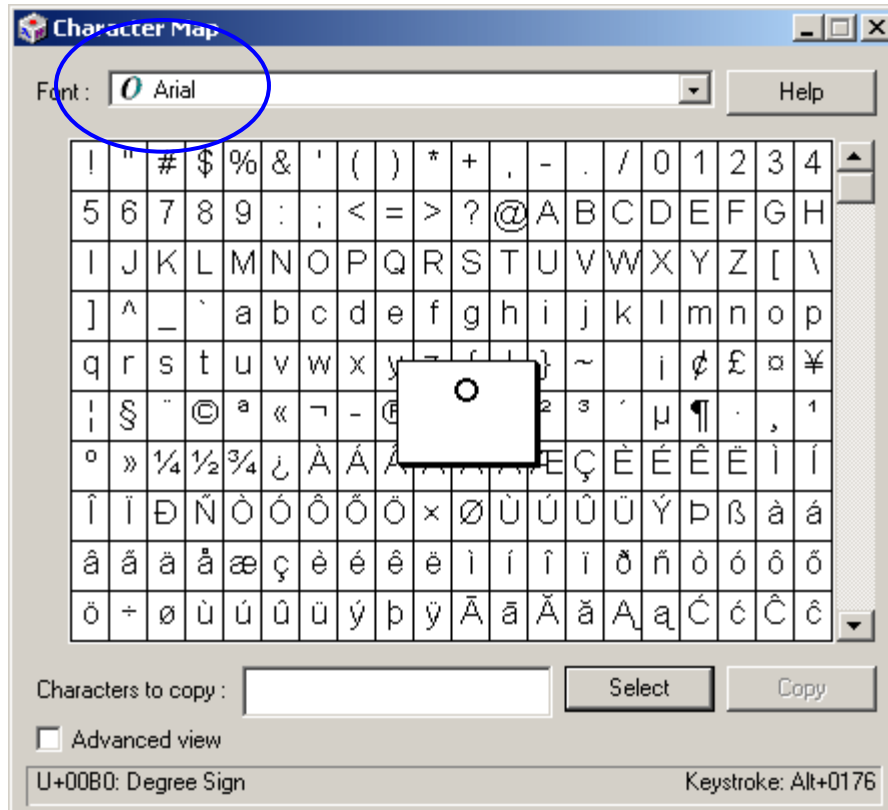
Arial Black Italic

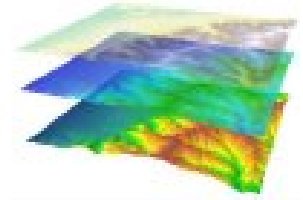
C:\WINDOWS\Fonts\





Special Characters





Type Size

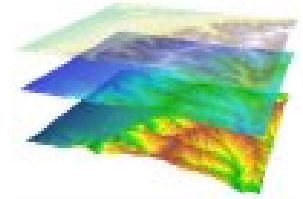
Font size is measured in *points*:

One point is approximately 1/72 of an inch

However, different fonts can vary markedly in size even for a given point setting...

Albany	Albany	Albany
Airport	Airport	Airport
Times	Batang	Haettenschweiler

So, label placement may change if fonts change...



Character Spacing

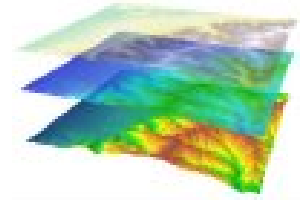
Units of character spacing are percent of point size.

D E A R B O R N
H E I G H T S

200% character spacing

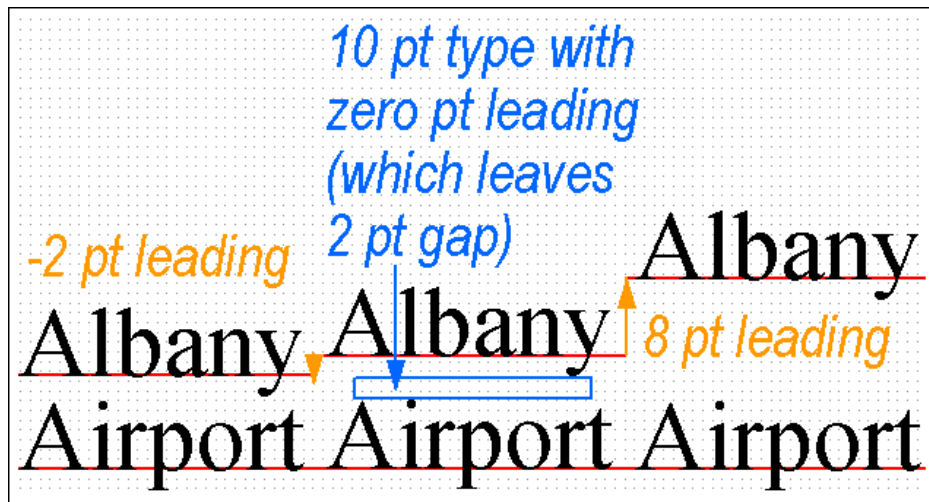
Spacing increases legibility
of curved text.





Line Spacing

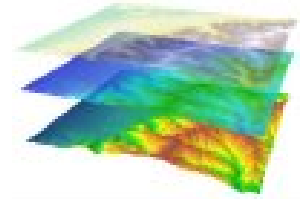
Leading is the spacing between lines



The default leading is 120% of letter height

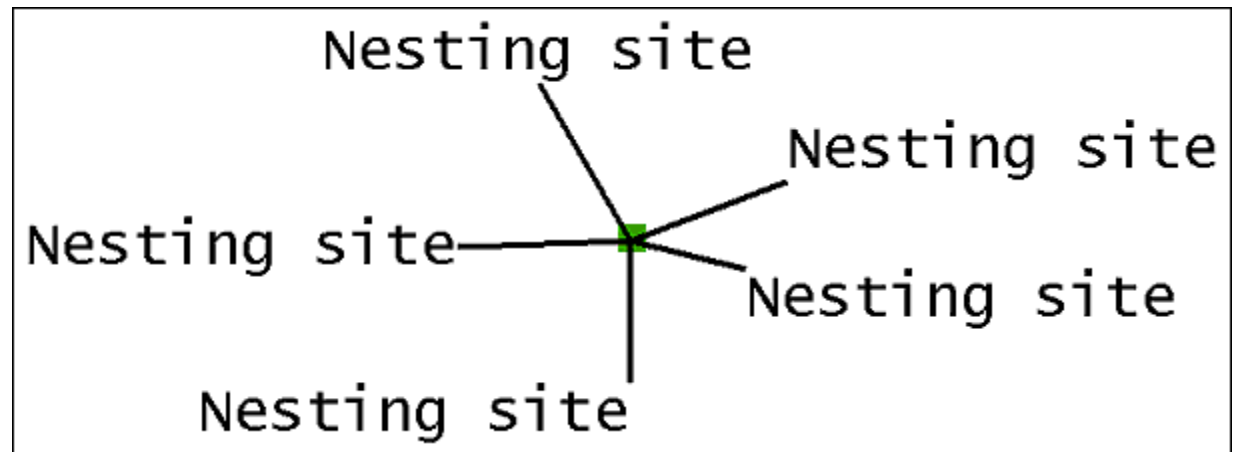
Line spacing can reduce ambiguity



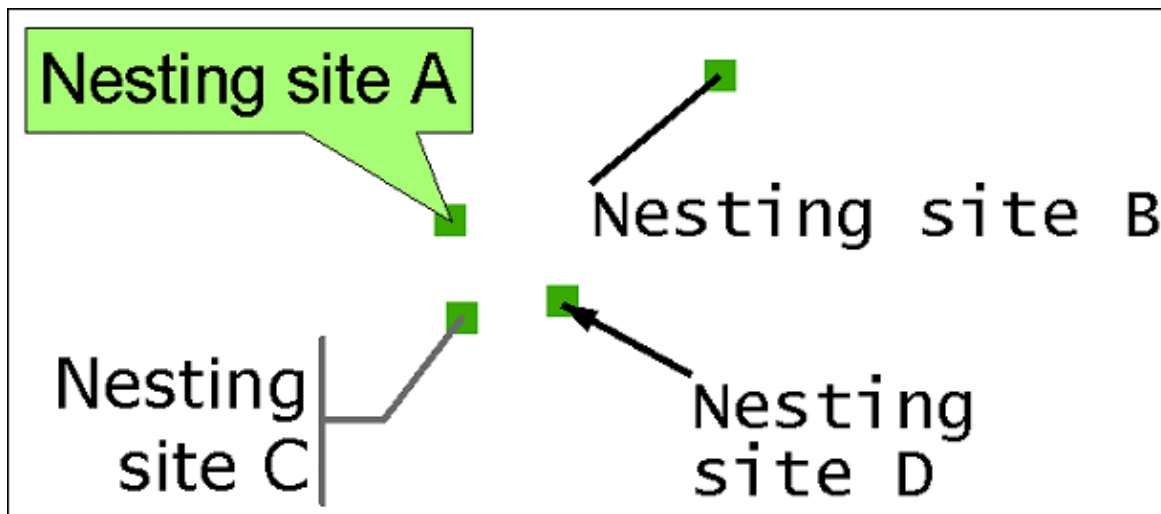


Callouts

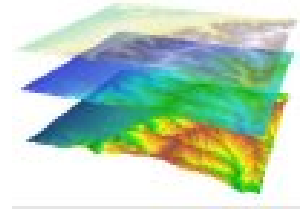
Callouts clarify the link between location and its label



Callout placement options...



Callout design options...

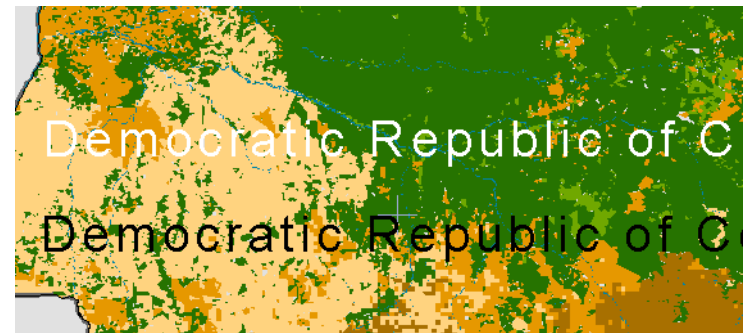


Shadows

Shadows can increase the legibility of text on maps.

**REVISED
ZONING**

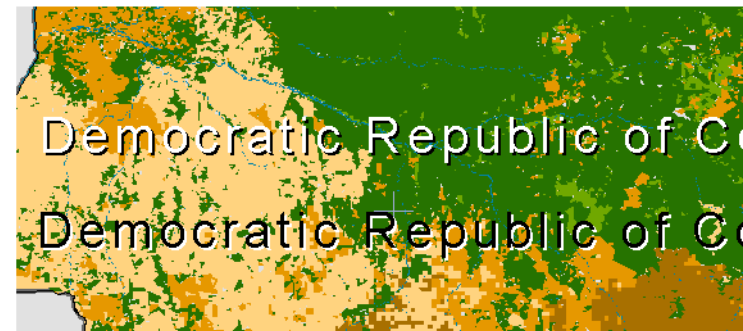
Large offset:
floating text...

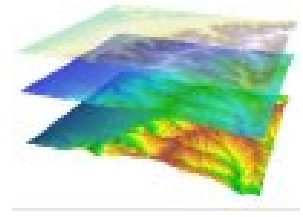


Adds contrast/clarity
on colored backdrops

**REVISED
ZONING**

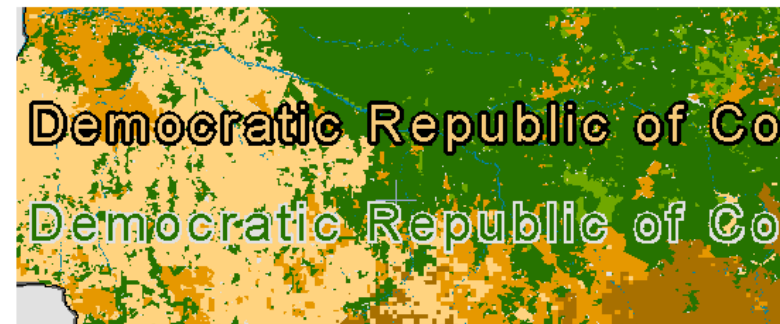
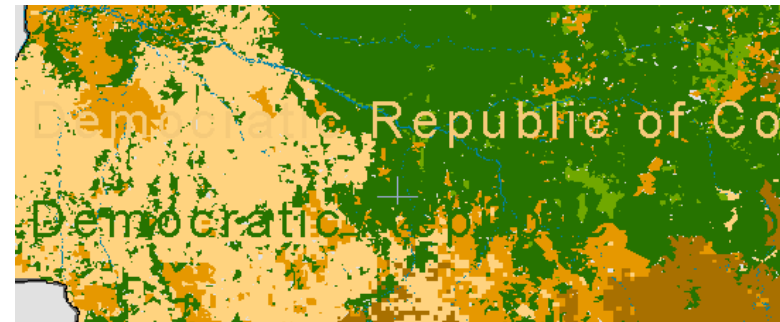
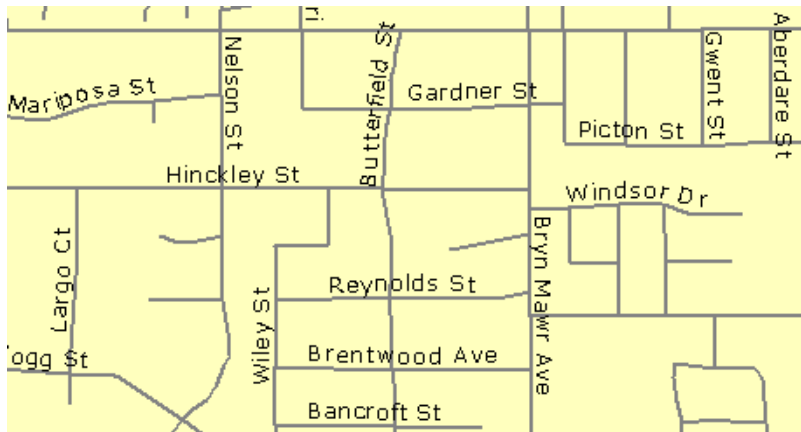
Small offset:
subtle effect...



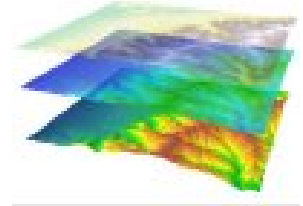


Halos

Like shadows, halos can increase legibility

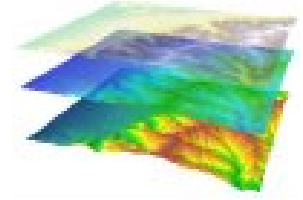


Halos should mask as little underlying map as possible, but enough to minimize ambiguity



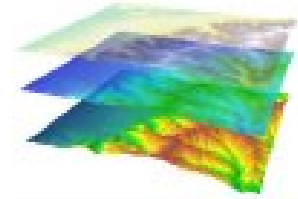
Type Effects: Review

- Well designed type adds clarity and professionalism to a map.
- Font types can be used as text and symbols simultaneously.
- Serif and Sans Serif fonts are often used to label physical and cultural objects, respectively.
- Decorative fonts should be used very sparingly. Good maps can often be drawn with as few as two font types.



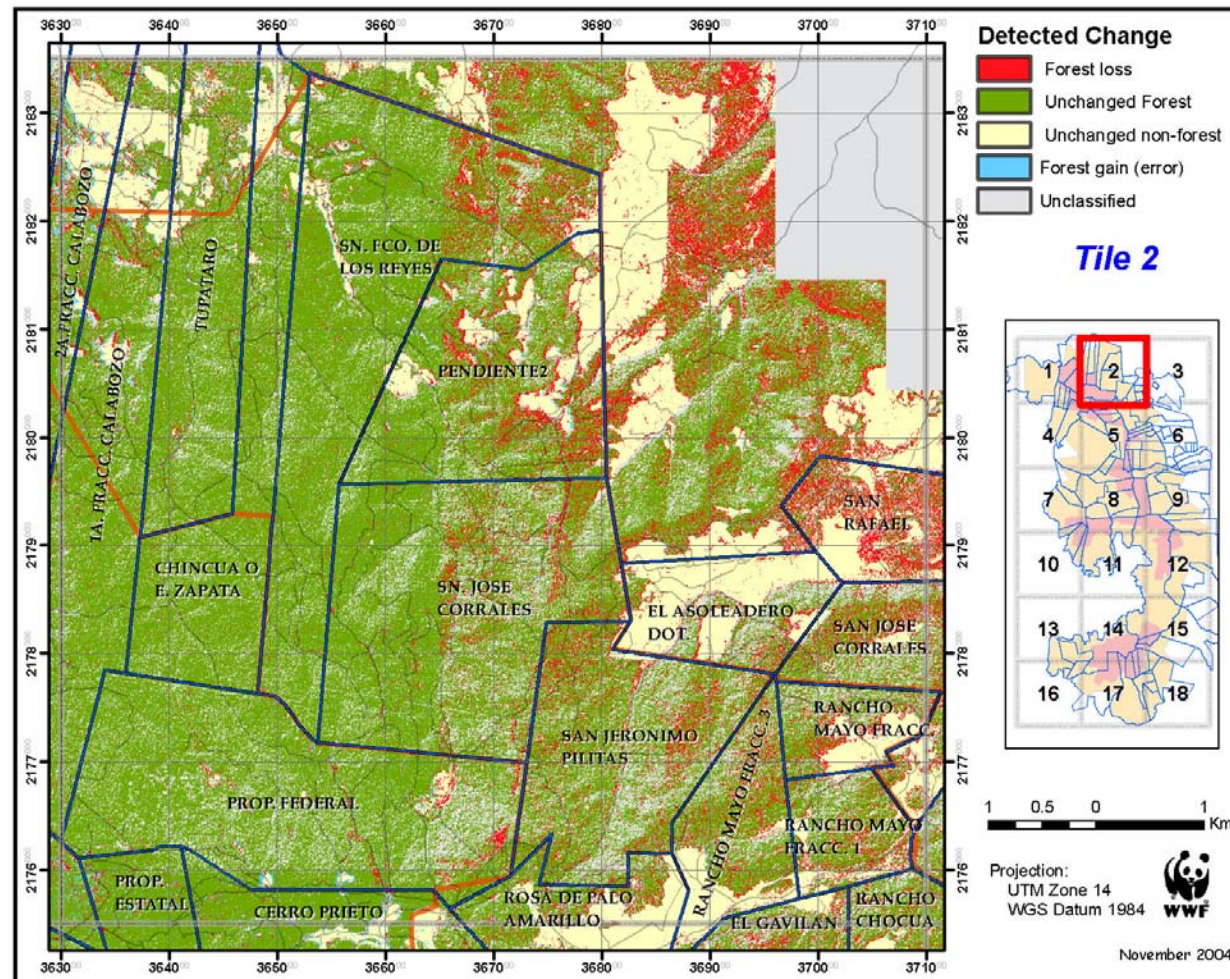
Type Effects: Review

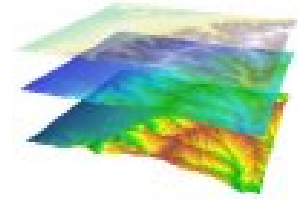
- Text point size, character spacing, and leading offer three ways to adjust the size of a text element on a map.
- Callouts, shadows, and halos are type effects that, when used appropriately, increase clarity and enhance map design.
- All text effects should be used with purpose. When used merely to decorate a map they often detract from the map's message.



Effective Type in Map Design

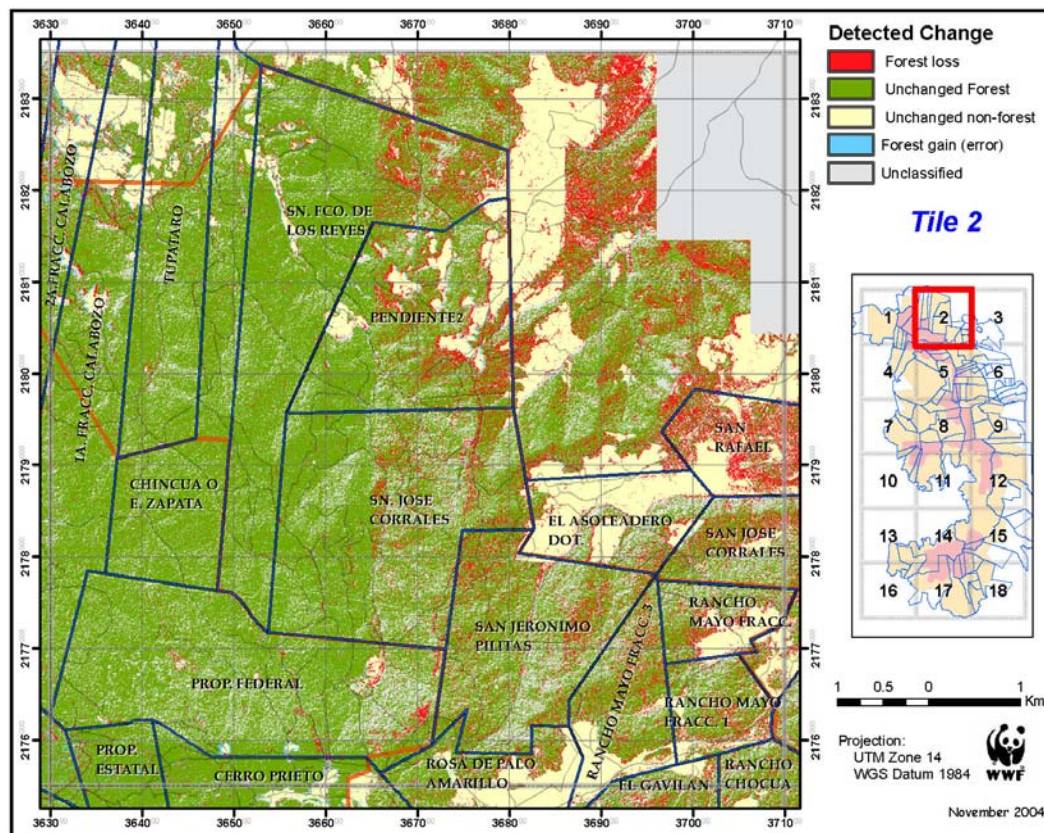
When and where to use the many type effects available in ArcMap.



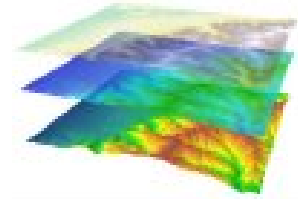


Strategies for Map Text

Graphic Text



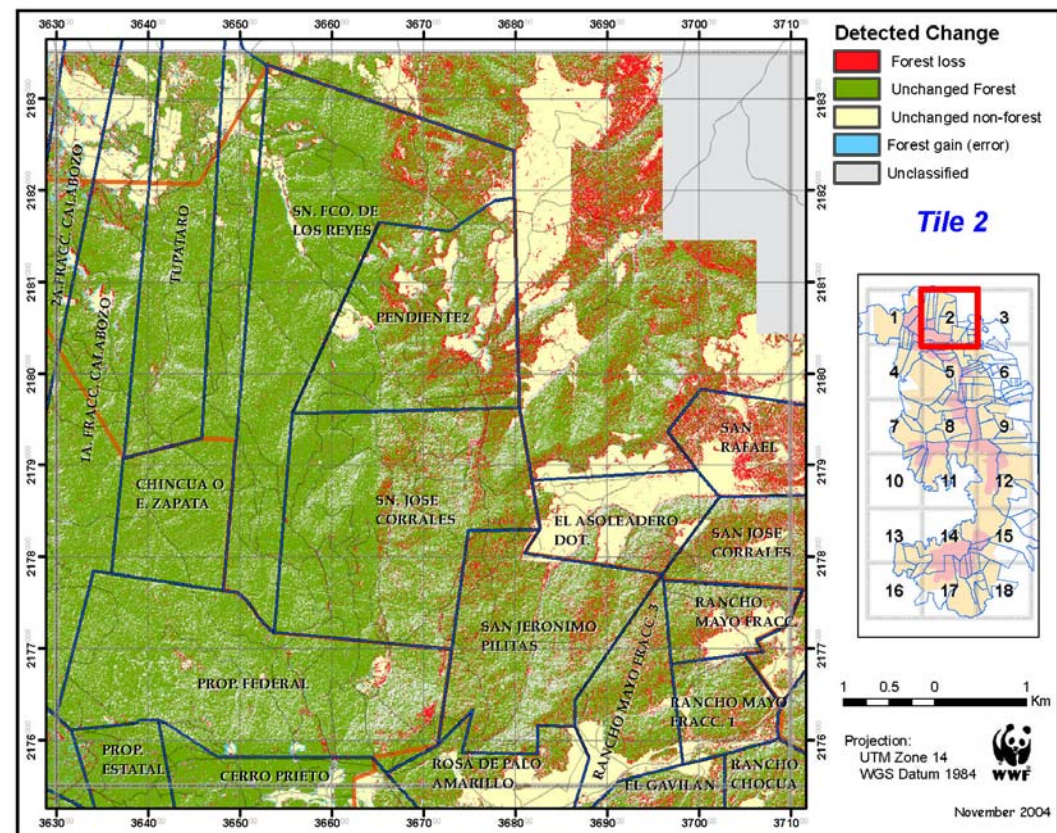
- Manually placed in ArcMap's Layout view (not seen in Data view)
- Text is not linked to spatial features or data frames
- Text remains static; position is unchanged by scale or extent
- Good for titles, subtitles, sources, or notes

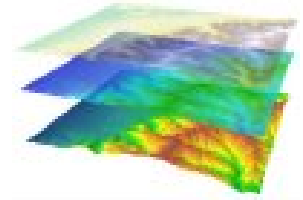


Strategies for Map Text

Dynamic Feature Labels

- Label text from a feature layer's attribute table
- Added in ArcMap Data view. Viewable in both Data and Layout views.
- Text characteristics can be set for many labels at once
- Size & position change dynamically with scale and extent changes to map

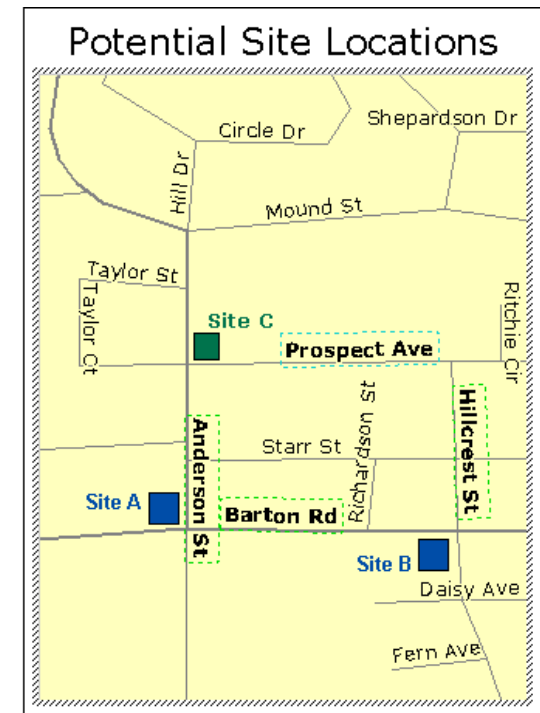
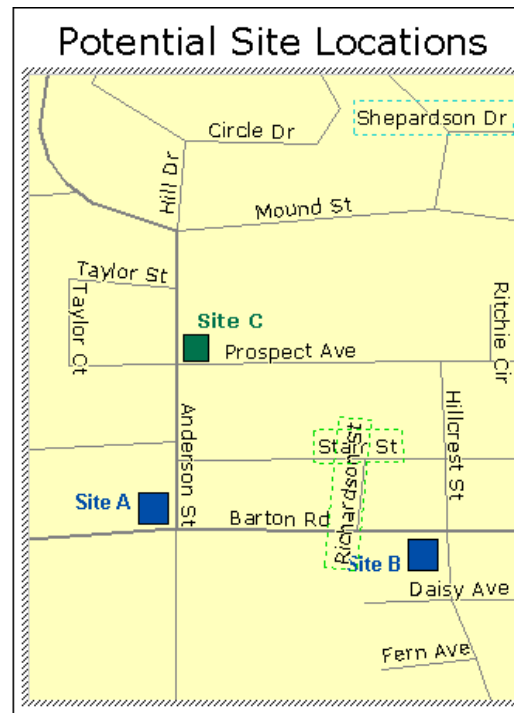


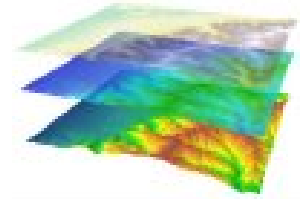


Strategies for Map Text

Annotation

- Text associated with a data frame
- Created as individual text elements or by converting dynamic feature labels
- Stored either in the map document or in an annotation feature class
- More flexible than dynamic feature labels

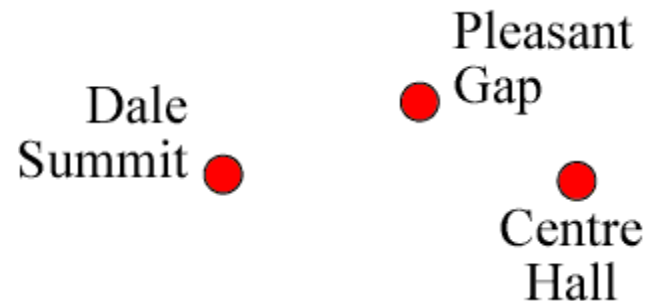




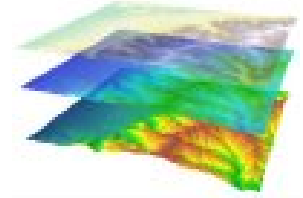
Labels as indicators of location

Labels as indicators of location

- Labels can name AND help locate map features



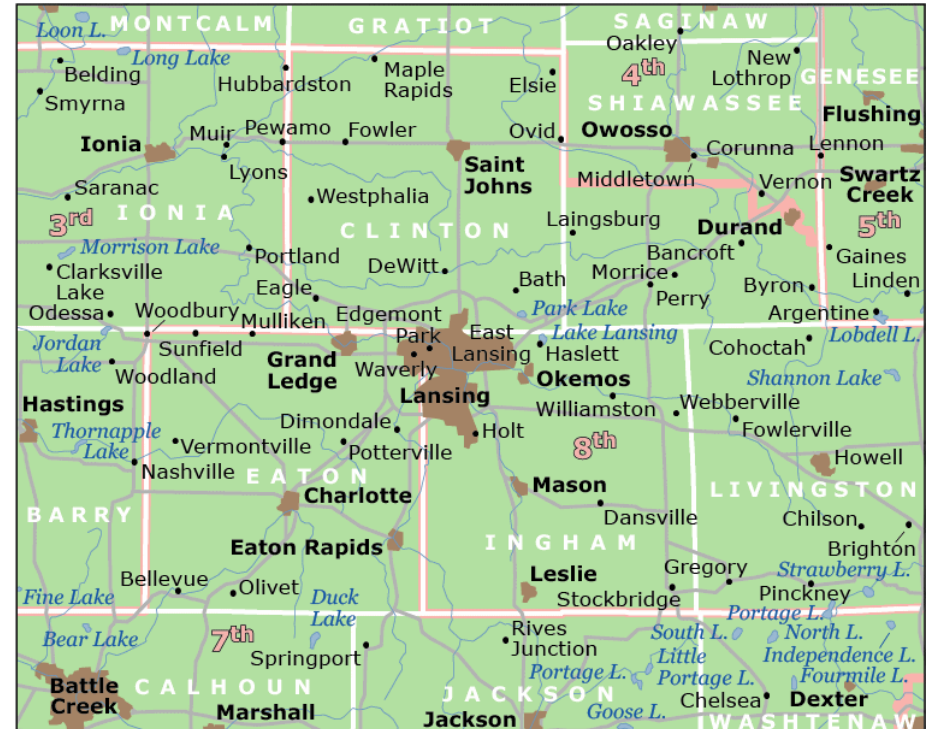
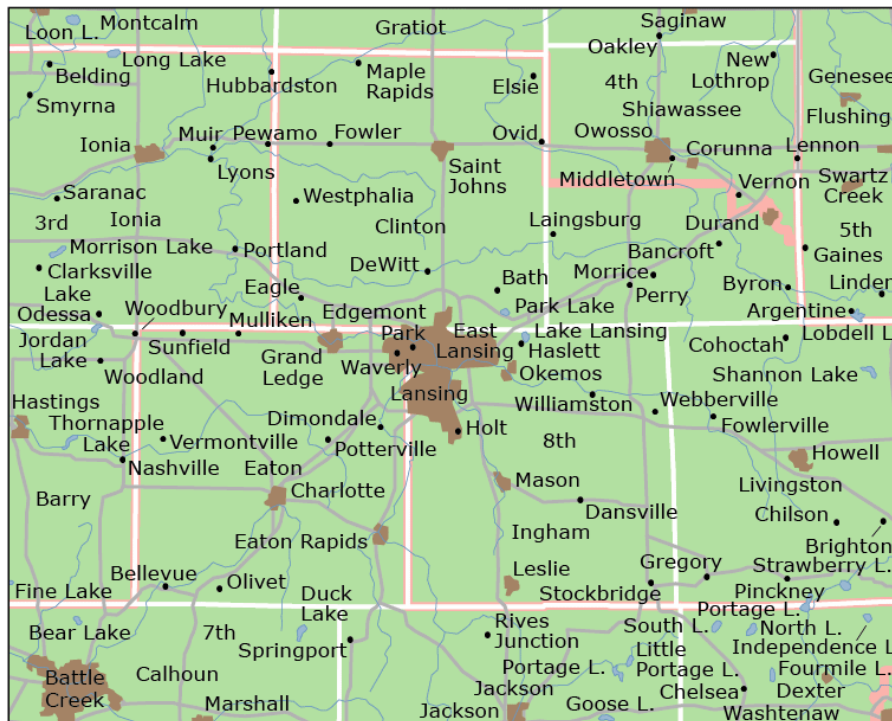
- Whenever possible, the relationship between location and label should be predictable.



Labels as Symbols

Labels as indicators of feature category

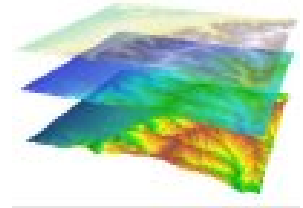
Categorizing features reduces the labels readers must search through



Categorize by:

Font, Posture (Roman v *Italic*), **Color hue**,

Arrangement



Labels as Symbols

Distinguishing label categories

Different fonts

Nittany Mountain

Penn State

Different posture

S. Water Street

Spring Creek

Different arrangement

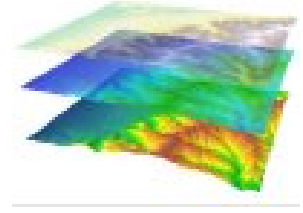
Harrisburg

Susquehanna

Different hue

Harrisburg

Susquehanna



Labels and Feature Hierarchy

Labels can be used to differentiate cities of different sizes or streams of different flow magnitudes

The type characteristics that help establish feature hierarchies:

Pittsburgh

State College

Boalsburg

Point size

Bellefonte

Pleasant Gap

Weight

Philipsburg

Port Matilda

Scaling

FERGUSON PATTON

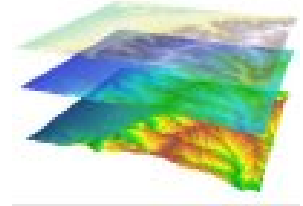
CENTRE

Lightness

PENN STATE

Walker Building

Case



Labels and Feature Hierarchy

Category v. Hierarchy

The largest spatial features aren't necessarily the most important in a map, so sometimes large labels need to be demoted in the map hierarchy.

Label character spacing can lower feature hierarchy...

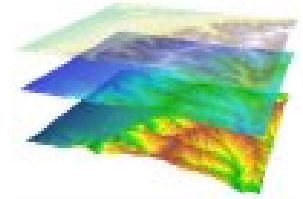
P E N N S Y L V A N I A
CENTRE COUNTY

...as can label lightness...

PATTON
FERGUSON
CENTRE

...as can label contrast.

PATTON
FERGUSON
CENTRE



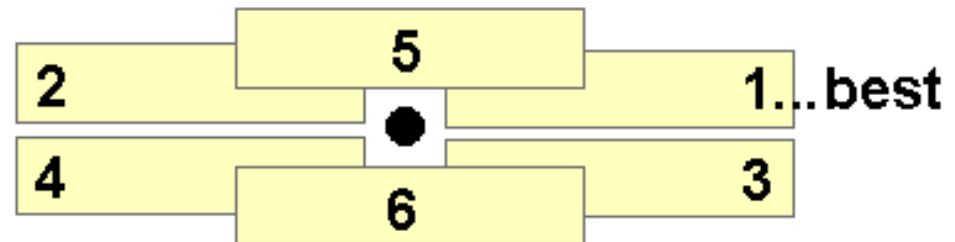
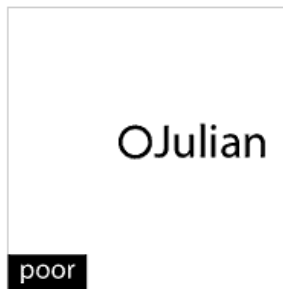
Label Placement: Points

Point label placement

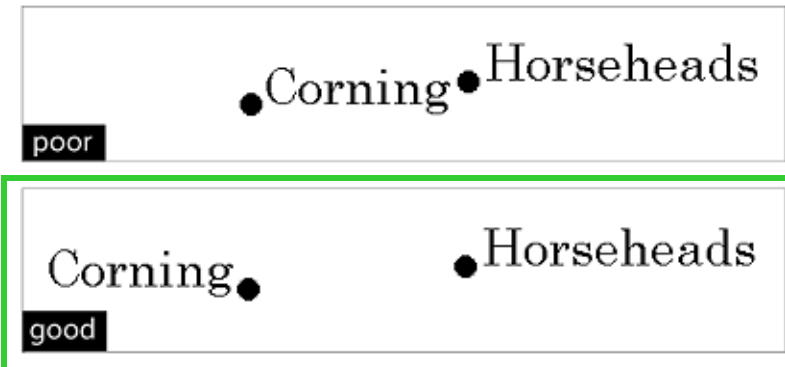
Predictable, unambiguous point label placement makes life easier for the map reader.



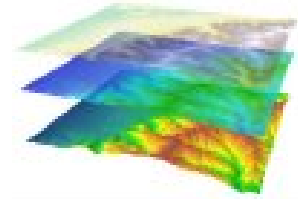
Slight shifts minimize confusion



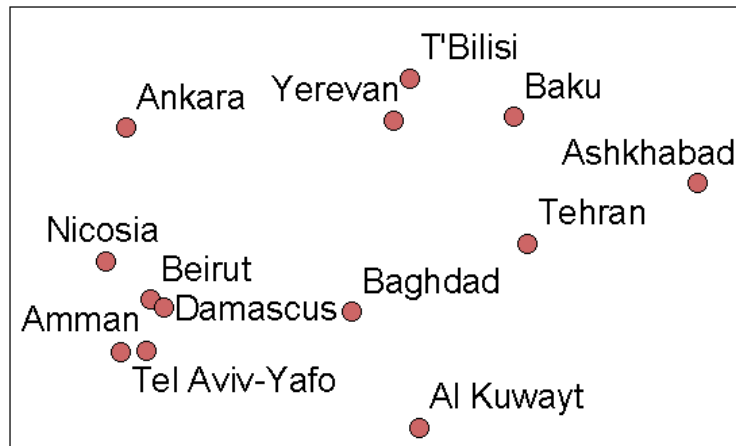
Order of preferred label placement



Proper placement reduces ambiguity

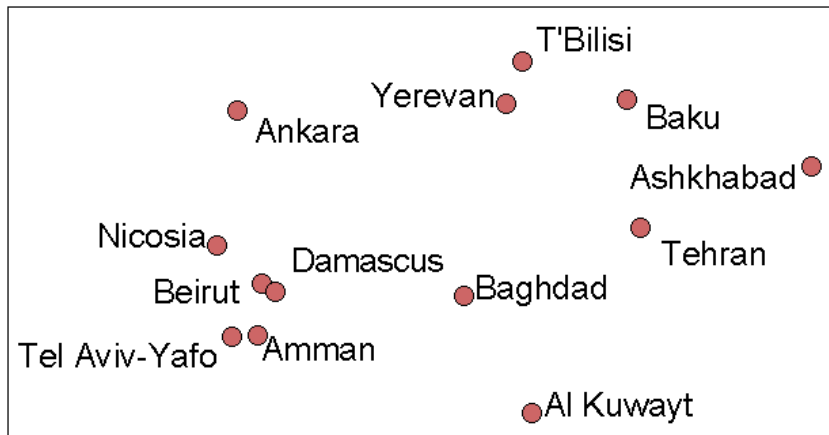


Label Placement: Points

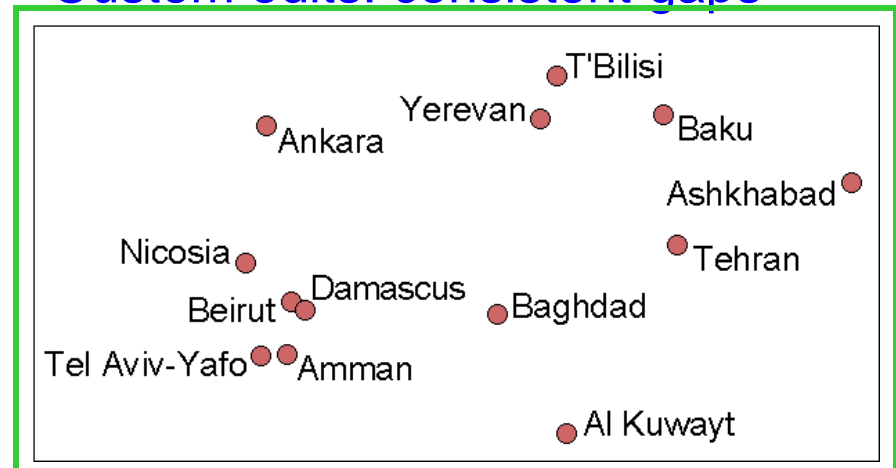


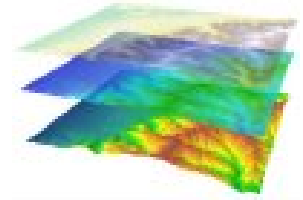
ArcMap
default
labeling

Custom edits: inconsistent gaps

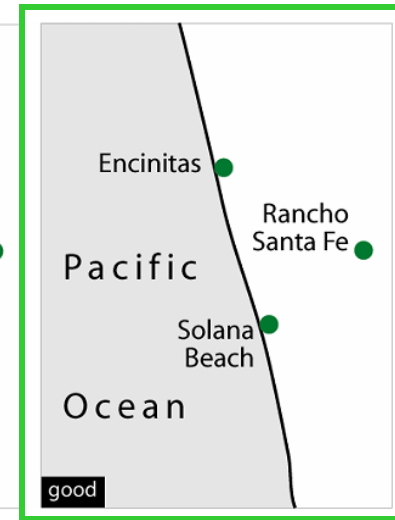
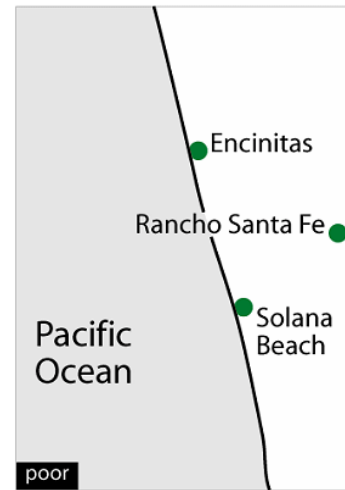
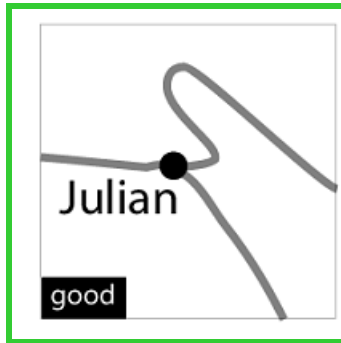


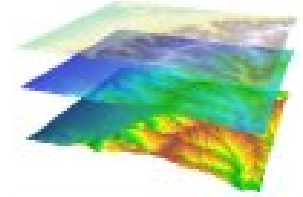
Custom edits: consistent gaps





Label Placement: Points

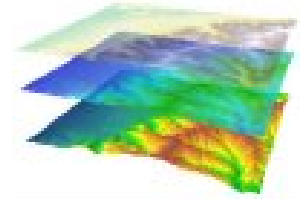




Label Placement: Points

SUMMARY: Point label placement

- The best positions are next to and shifted up (right or left) from the point.
- Maintain a consistent distance between labels and points throughout the map.
- Break lines for type, but minimize the frequency of breaks.
- Position labels on the same side of a line feature as the point.
- Position labels for coastal features in water.
- Do not span land and water with a label.

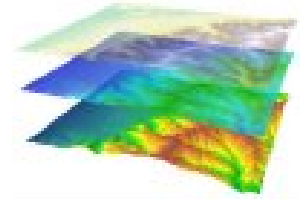


Label Placement: Lines

Line label placement



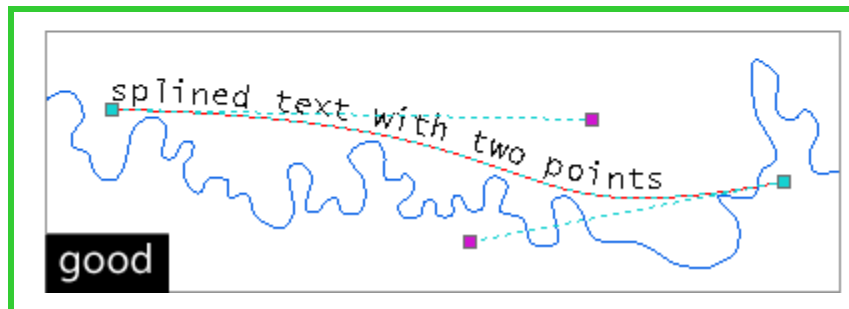
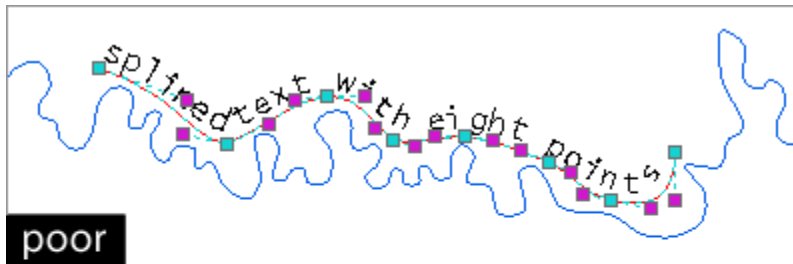
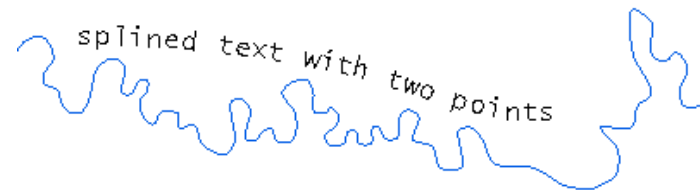
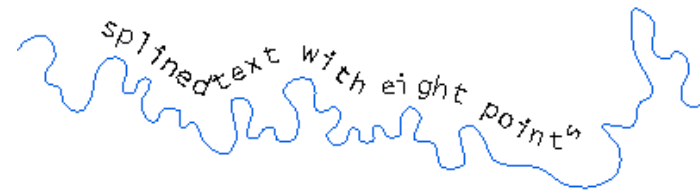
What's wrong with these labels?

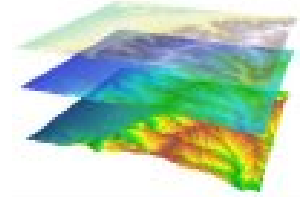


Label Placement: Lines

Curves/Splines

Splines should be smooth approximations of the feature's shape

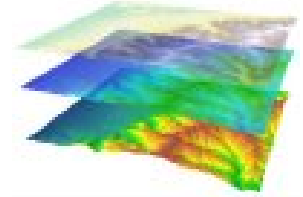




Label Placement: Lines

SUMMARY: Line Label Placement

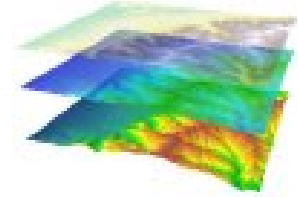
- Position labels to follow lines.
- Use default character spacing.
- Repeat labels for long line features.
- Place labels at the straightest and most horizontal portion of a line.
- Break lines that run across text, but minimize the frequency of breaks by choosing positions carefully.



Label Placement: Lines

SUMMARY: Line Label Placement (cont'd)

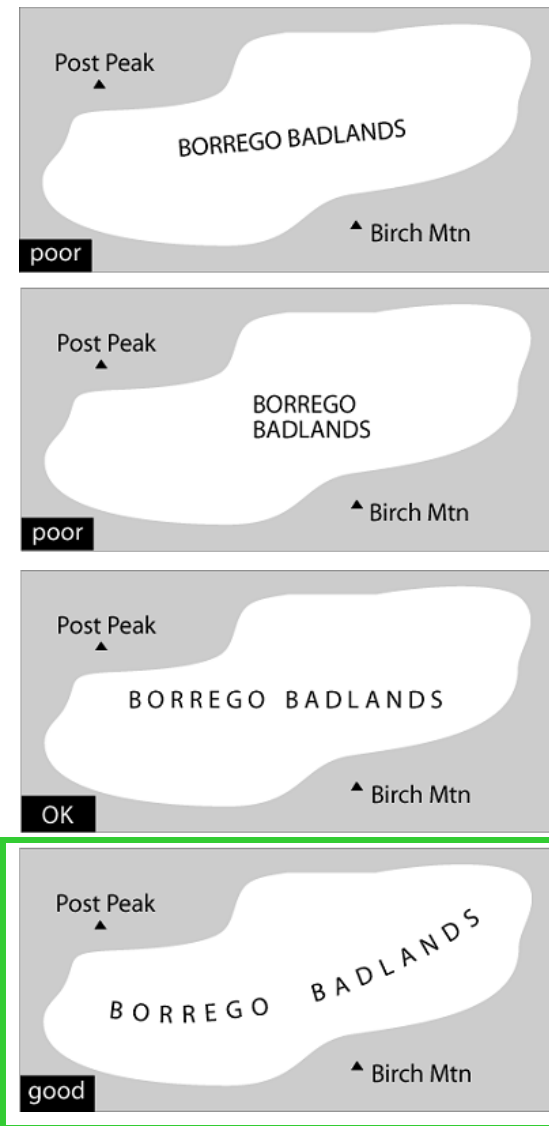
- Position labels above lines when practical.
- Do not allow any portion of a label to tilt upside down.
- Use simple curves for labels so they fit loosely to lines with complex curves.
- Maintain a small and consistent gap between labels and lines throughout the map.

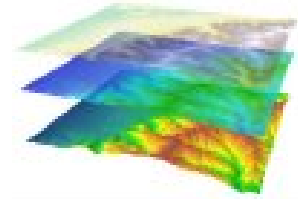


Label Placement: Areas

Area Label Placement

- Area feature labels indicate the extent of the feature by positioning.
- Use spacing, not size to show extent (size is for importance).
- SIMPLE curved type can be used for irregularly shaped areas.





Label Placement: Areas

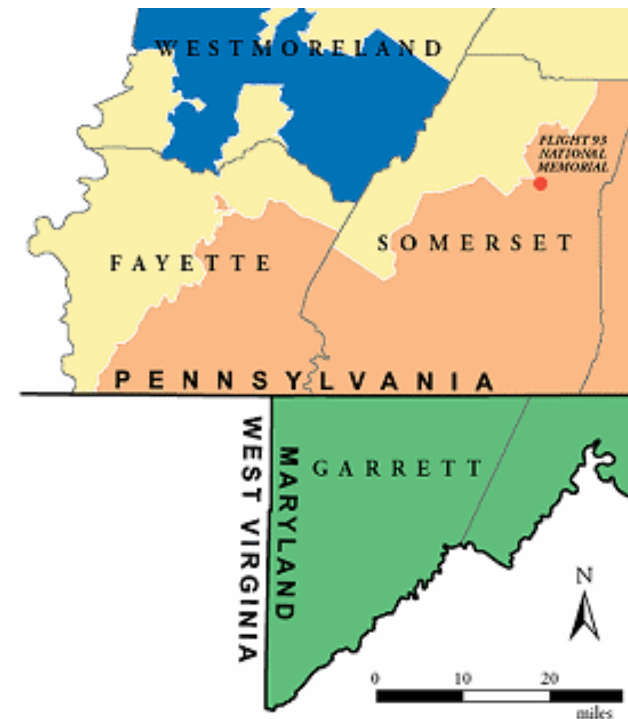
Spacing is better suited to uppercase lettering.



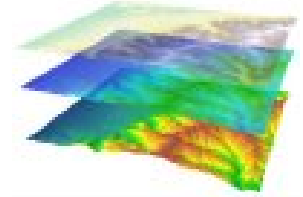
Find natural spots to place labels



Allow lettering to cross lines to avoid crowding



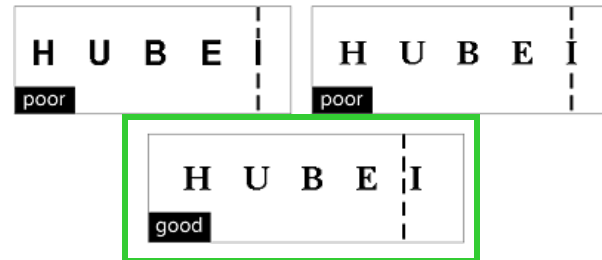
When showing a portion of a feature, placement along a boundary may work

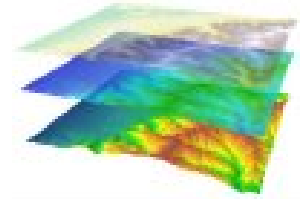


Label Placement: Areas

SUMMARY: Area Label Placement

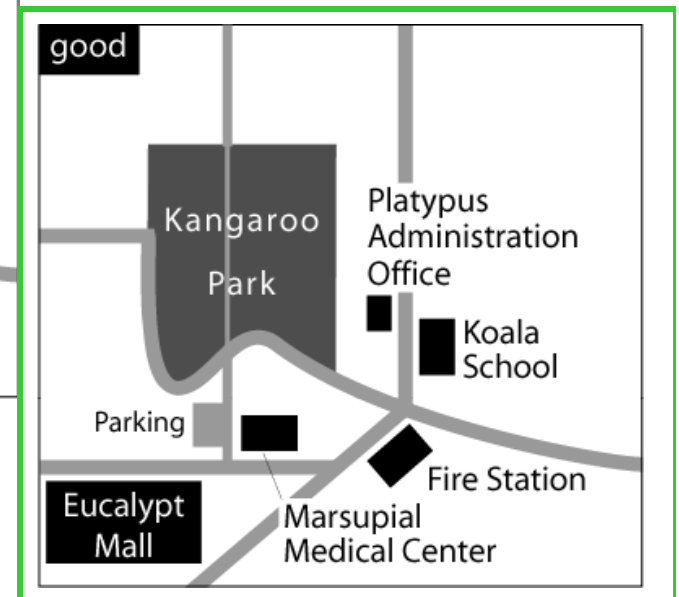
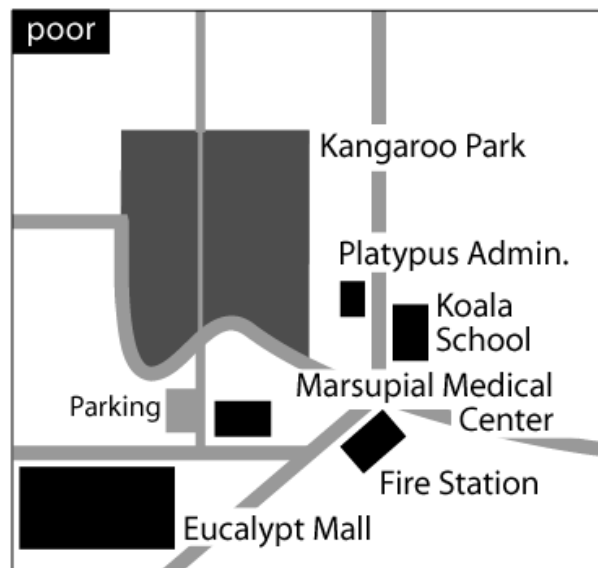
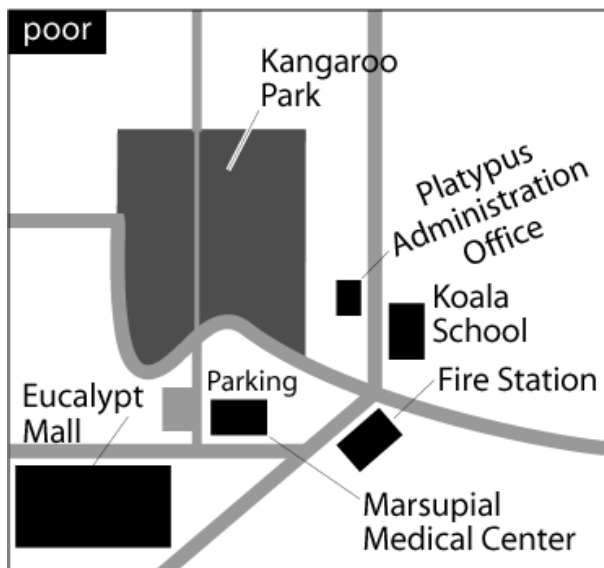
- Suggest the area's extent by label position, character spacing, line spacing, and simple curves.
- Use uppercase letters when spacing characters.
- Do not adjust text point size to fit labels into small areas or to fill large ones.
- Stagger horizontal alignments.
- Adjust label position so gaps fit across features (adjust gaps by small amounts if needed).
- Ensure that individual letters are not mistaken for symbols especially a sans serif I).



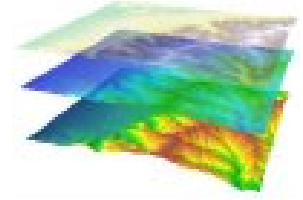


Label Placement: Dense Labels

Dense maps require simplification and rule breaking

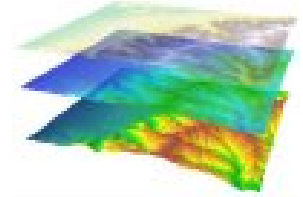


Strive to reduce ambiguity
and maximize readability



Effective Type: REVIEW

- Three Text types: Graphic text, Dynamic Feature Labels, Annotation
- When labeling many features, it's best to set type characteristics of dynamic feature labels and convert to annotation to customize individual labels.
- Labels indicate location and group features into categories and hierarchies.



Effective Type: REVIEW

- Consistency in label position reduces ambiguity and enhances a map's information content.
- Area feature labels should indicate the extent of the feature.
- Dense maps will require you to simplify categorizations and break placement conventions.