

# Mastering Map Scale: Formalizing Guidelines for Multi-Scale Map Design

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a.k.a. Cindy and babs

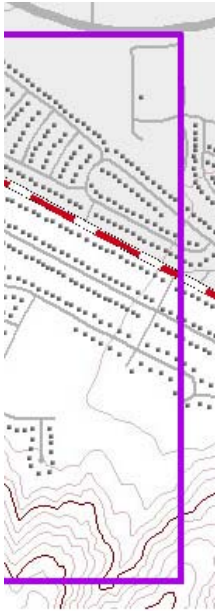
# Collaborators

## **PSU cartography seminar students:**

Tanuka Bhowmick, Steve Gardner, Adrienne Gruver,  
Tania del Mar López Marerro, Sohyun Park,  
Anthony Robinson, Steve Weaver

## **ESRI:**

Charlie Frye and Aileen Buckley;  
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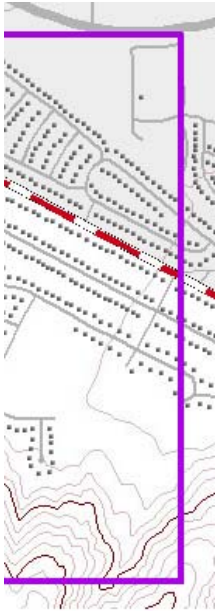
# Overview

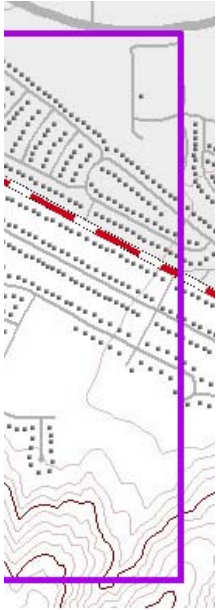
Studying mapmaking through wide range of scales, isolating **symbol design, selection** and **elimination** from processing that changes feature geometry

Topics:

- "ScaleMaster" exercise, with grads
- Related research by others
- General concept of workload balancing

*Preliminary...invite critique, inspiration, reaction*





# ScaleMaster Exercise: Work with Grad Students

a.k.a. do the impossible

# ScaleMaster exercise in seminar

Multiple map scales

1:10K to 1:5M

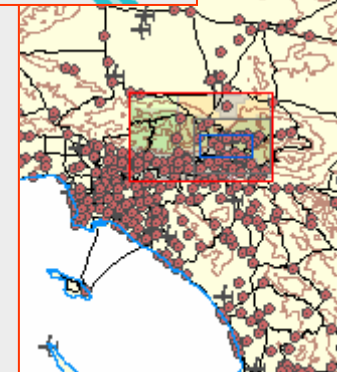
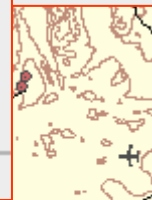
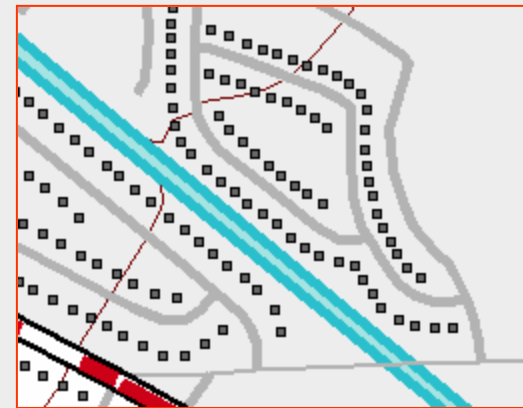
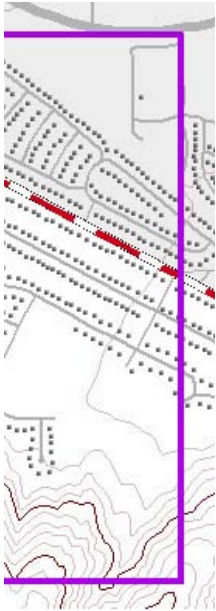
Multiple databases:

Three USGS sources

One map purpose and media:  
topographic, on screen

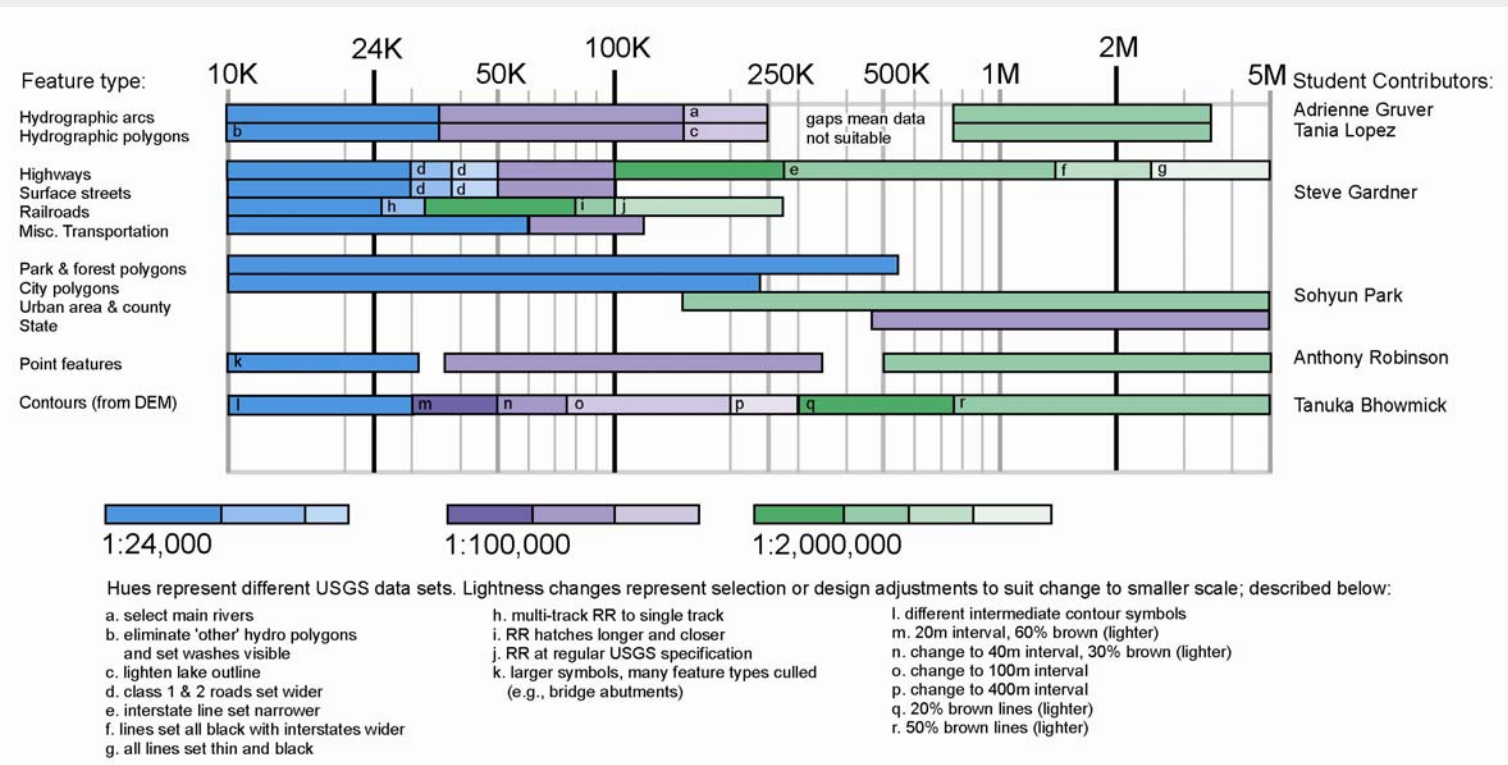
Iterative redesign and selection/elimination

Goal was acceptable map at any scale

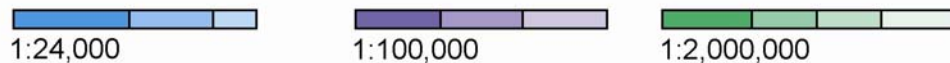
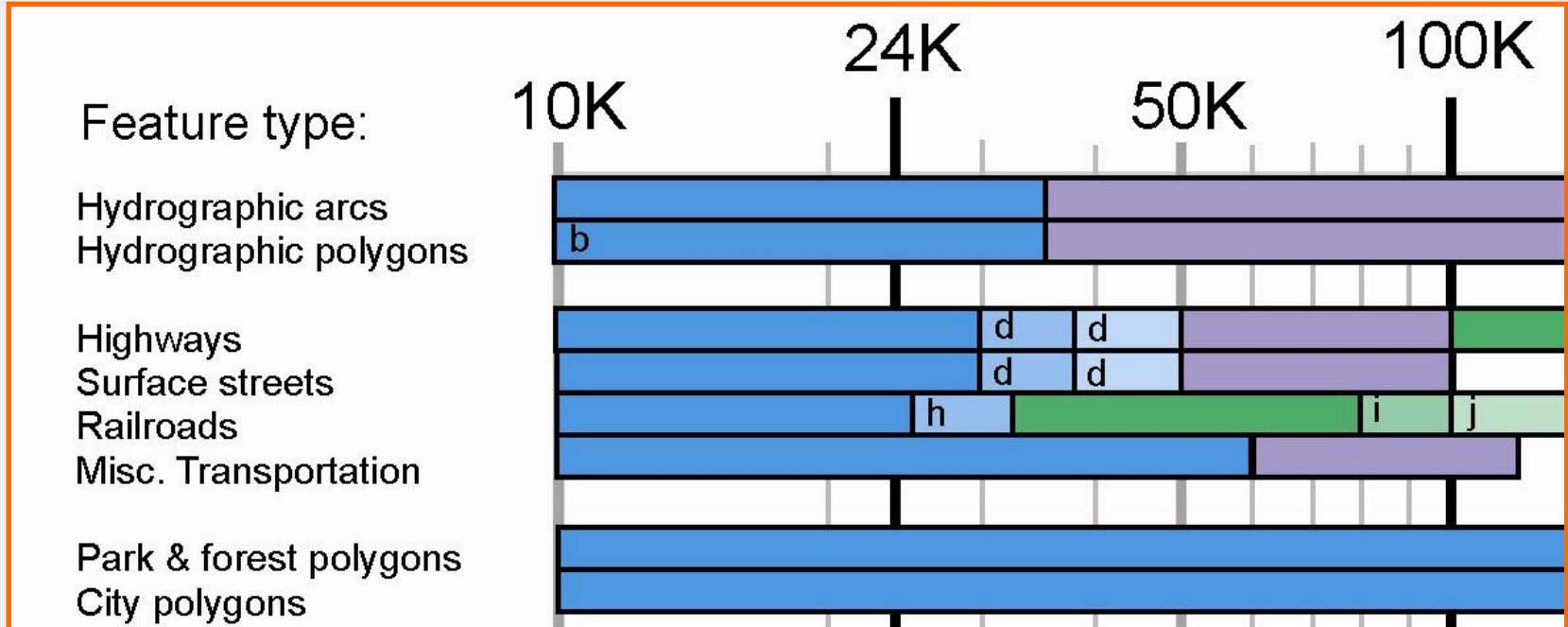


# ScaleMaster with grad students

## Diagram form



# ScaleMaster with grad students



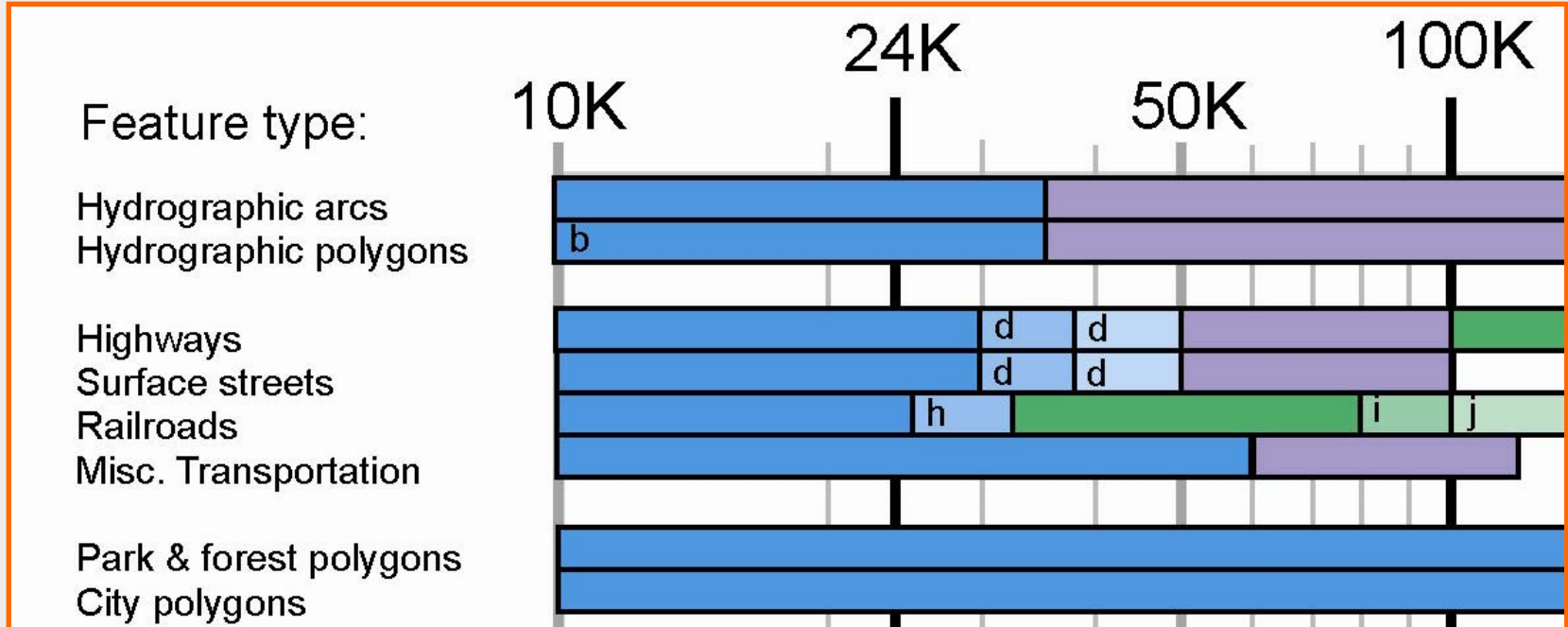
Hues represent different USGS data sets. Lightness changes represent selection or design adjustments to suit change to smaller scale; described below:

- a. select main rivers
- b. eliminate 'other' hydro polygons and set washes visible
- c. lighten lake outline
- d. class 1 & 2 roads set wider
- e. interstate line set narrower
- f. lines set all black with interstates wider
- g. all lines set thin and black

- h. multi-track RR to single track
- i. RR hatches longer and closer
- j. RR at regular USGS specification
- k. larger symbols, many feature types culled (e.g., bridge abutments)

- l. different intermediate contour symbols
- m. 20m interval, 60% brown (lighter)
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- o. change to 100m interval
- p. change to 400m interval
- q. 20% brown lines (lighter)
- r. 50% brown lines (lighter)

# ScaleMaster with grad students



1:24,000      1:100,000

Hues represent different USGS data sets. Lightness changes represent select

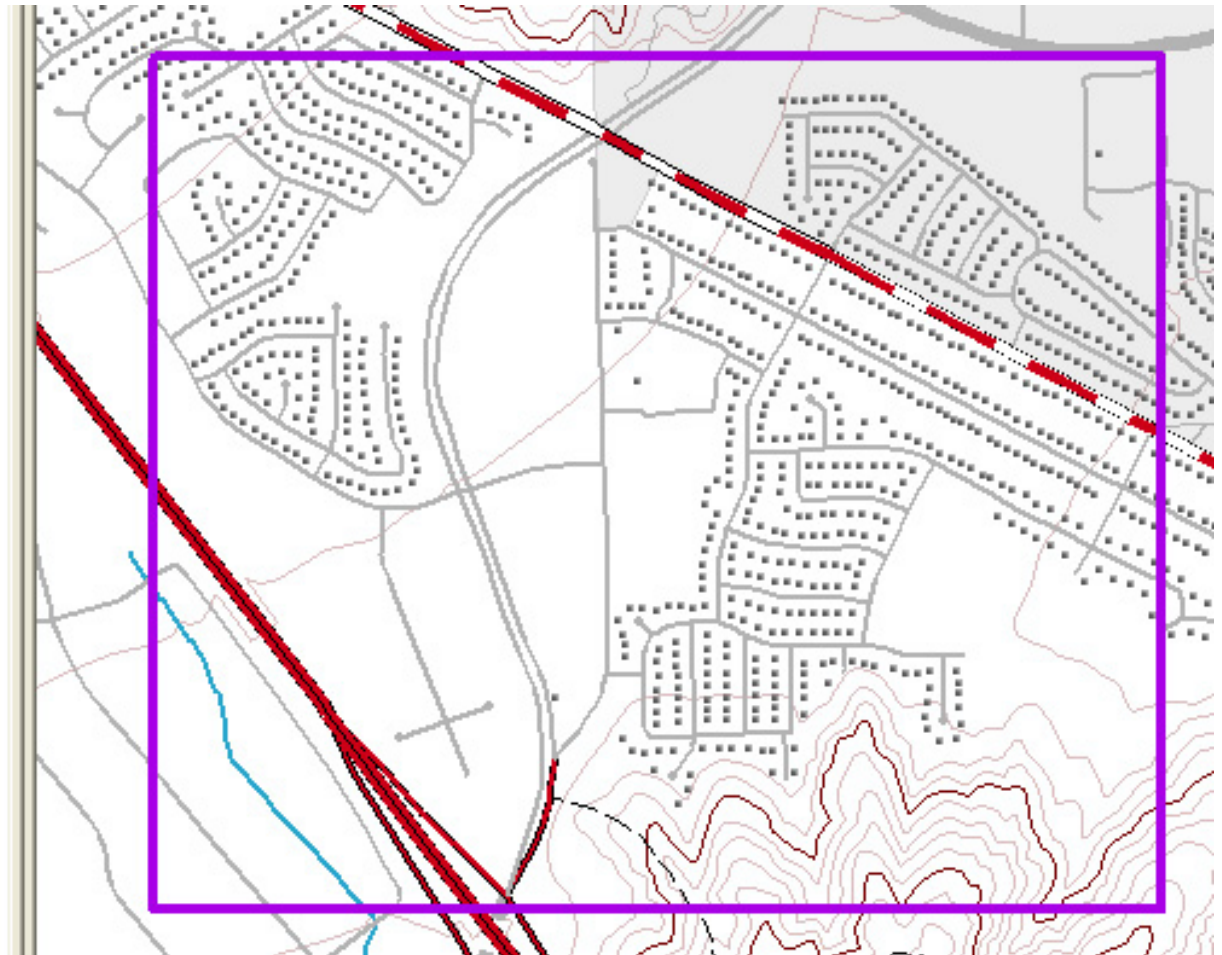
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# ScaleMaster map at 1:15,000



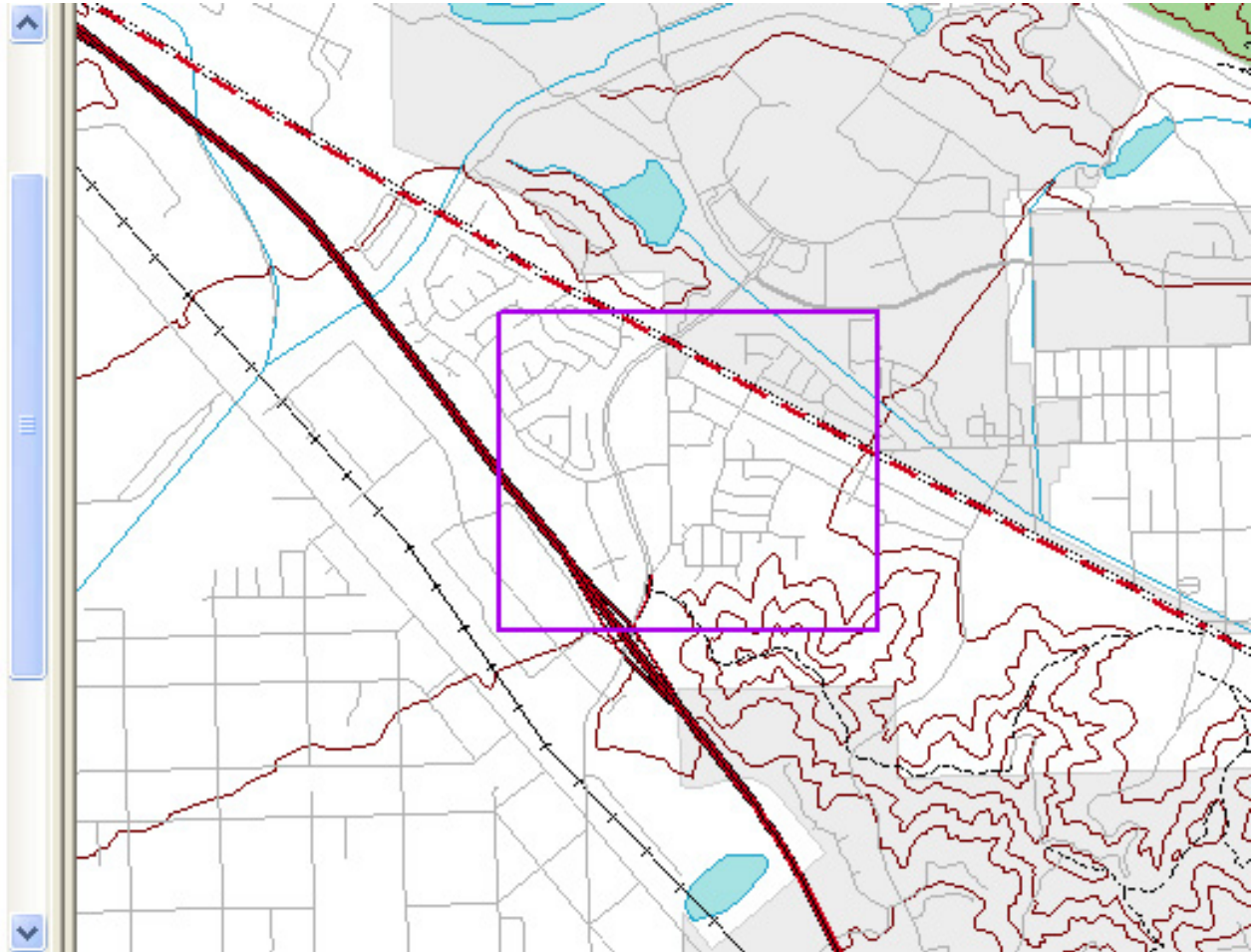
- Layers
- Coastlines
- Point symbols
- Roads
  - road\_arcs\_30K
  - road\_arcs\_30-38K
  - road\_arcs\_38-50k
  - road\_arcs\_50-100K
  - road\_arcs\_100-275k
  - road\_arcs\_275k-1.5M
  - road\_arcs\_1.5M-2.5M
  - road\_arcs\_2.5M-5M
- Railroads
- Misc. Transportation
- Hydrography
- Hypsography
- Boundaries










# ScaleMaster map at 1:40,000

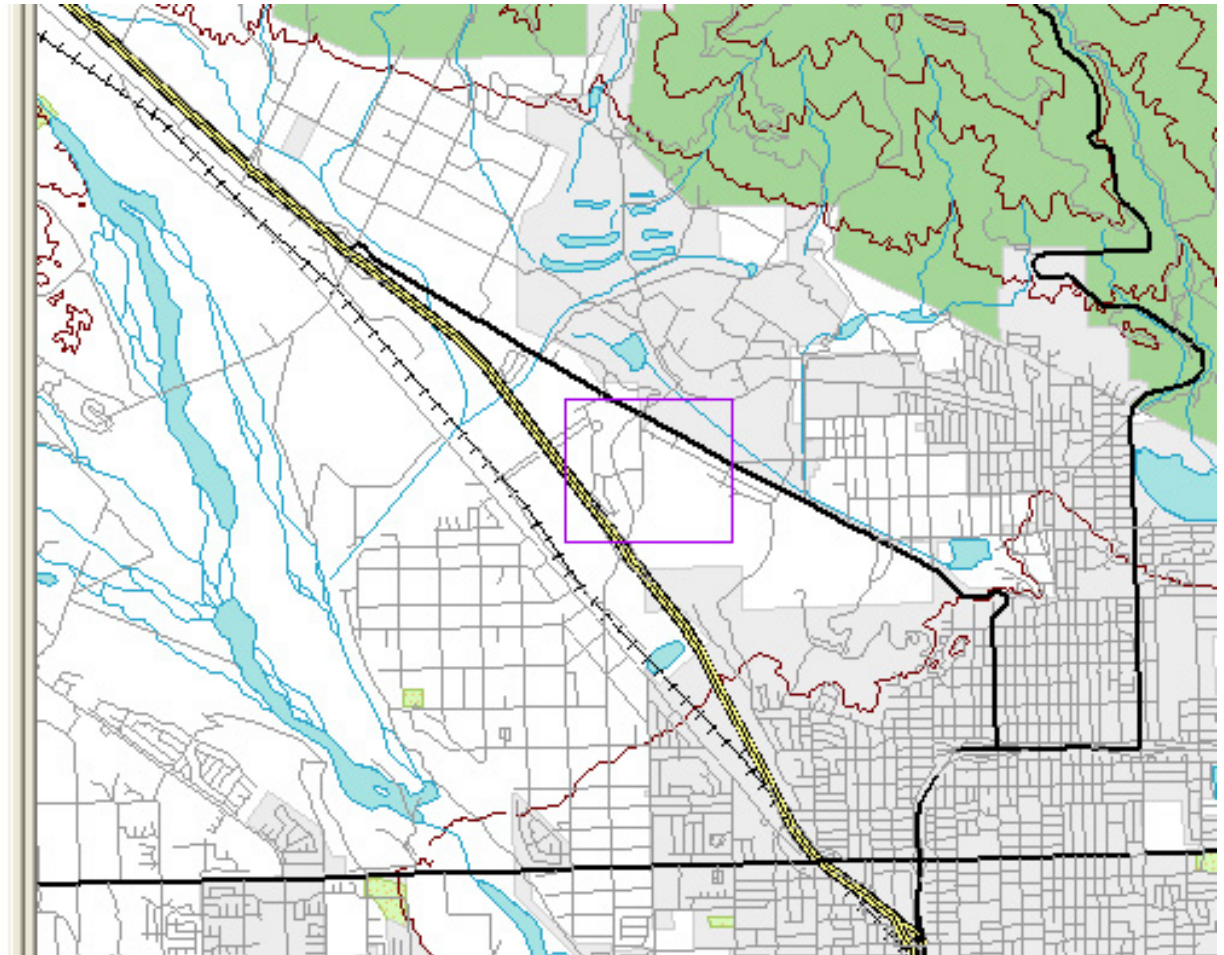
- road\_arcs\_38-50k
  - <all other values>
  - symbol\_name
  - Class 1 Road
  - Class 1 Road, Ramp
  - Class 1 Road, Ramp, Underpass
  - Class 1 Road, Underpass
  - Class 1 Road/.025
  - Class 1 Road/Divided, Underpass
  - Class 1 Road/Divided/.045
  - Class 2 Road/.030
  - Class 2 Road/.030, Overpass
  - Class 2 Road/.030, Underpass
  - Class 2 Road/Divided, Overpass
  - Class 2 Road/Divided/.045
  - Class 3 Road
  - Class 3 Road, Overpass
  - Class 3 Road, Traffic Circle
  - Class 3 Road, Underpass
  - Class 3 Road/.040
  - Class 4 Road
  - Class 4 Road, Underpass
  - Class 5 Road
  - Trail
- road\_arcs\_50-100k









# ScaleMaster map at 1:90,000

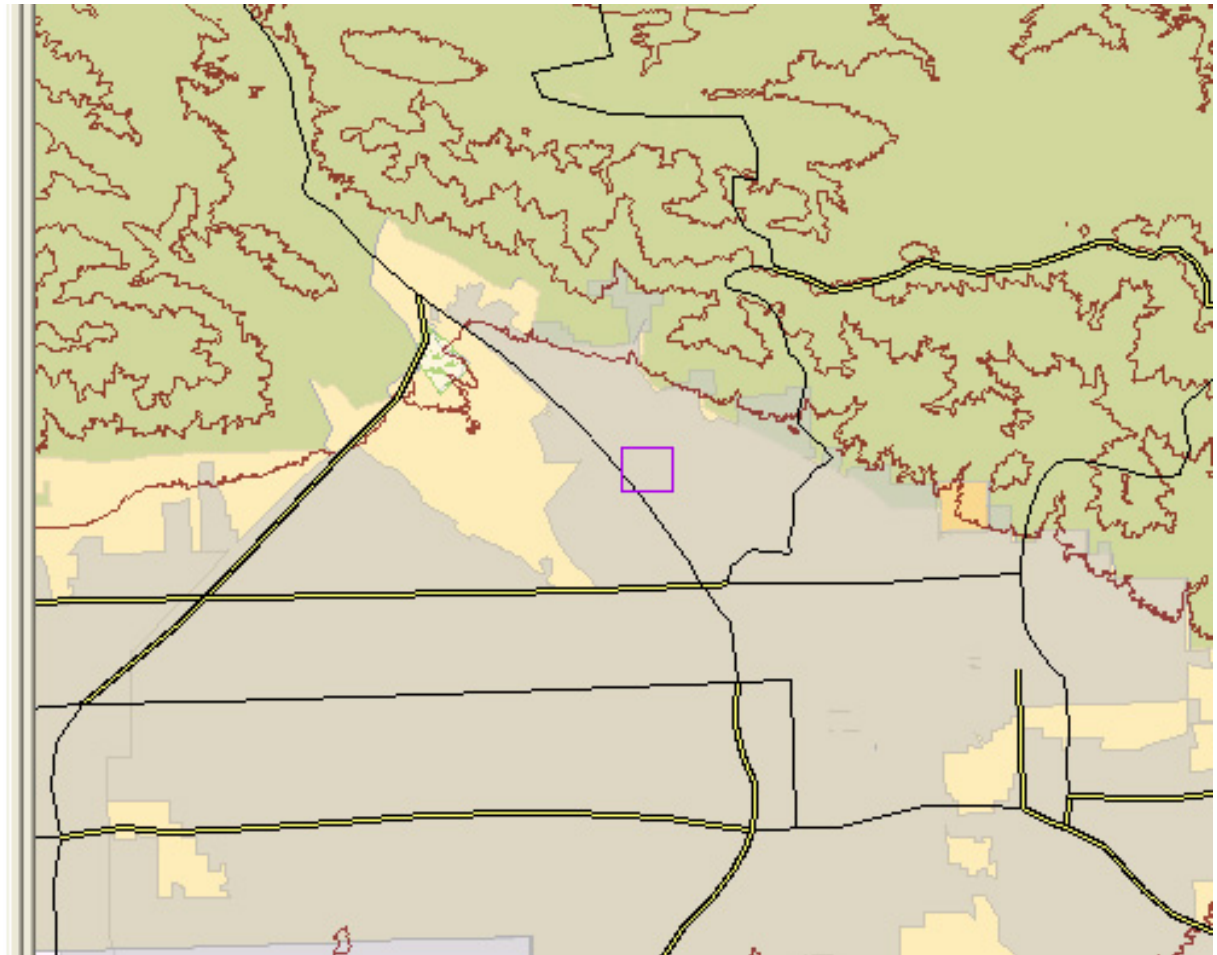
- [-]  **Layers**
- [+]  Coastlines
- [+]  Point symbols
- [-]  Roads
  - [+]  road\_arcs\_30K
  - [+]  road\_arcs\_30-38K
  - [+]  road\_arcs\_38-50k
  - [-]  **road\_arcs\_50-100K**
- ROUTE\_TYPE
  -  Interstate
  -  US Route
  -  State Route
  -  Other roads
- [+]  road\_arcs\_100-275k
- [+]  road\_arcs\_275k-1.5M
- [+]  road\_arcs\_1.5M-2.5M
- [+]  road\_arcs\_2.5M-5M
- [+]  Railroads
- [+]  Misc. Transportation
- [+]  Hydrography
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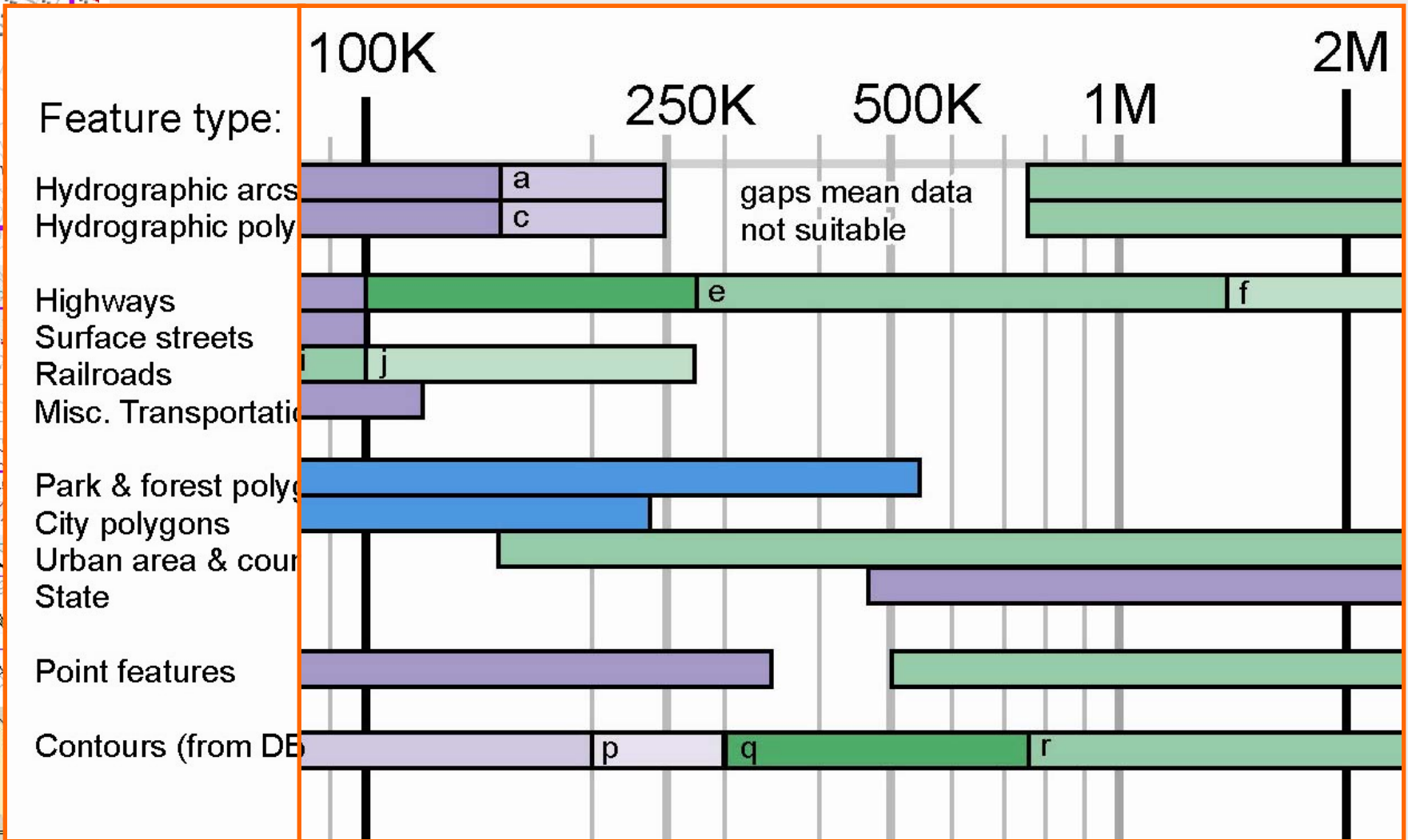


# ScaleMaster map at 1:300,000

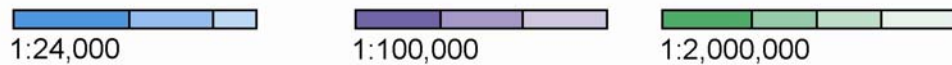
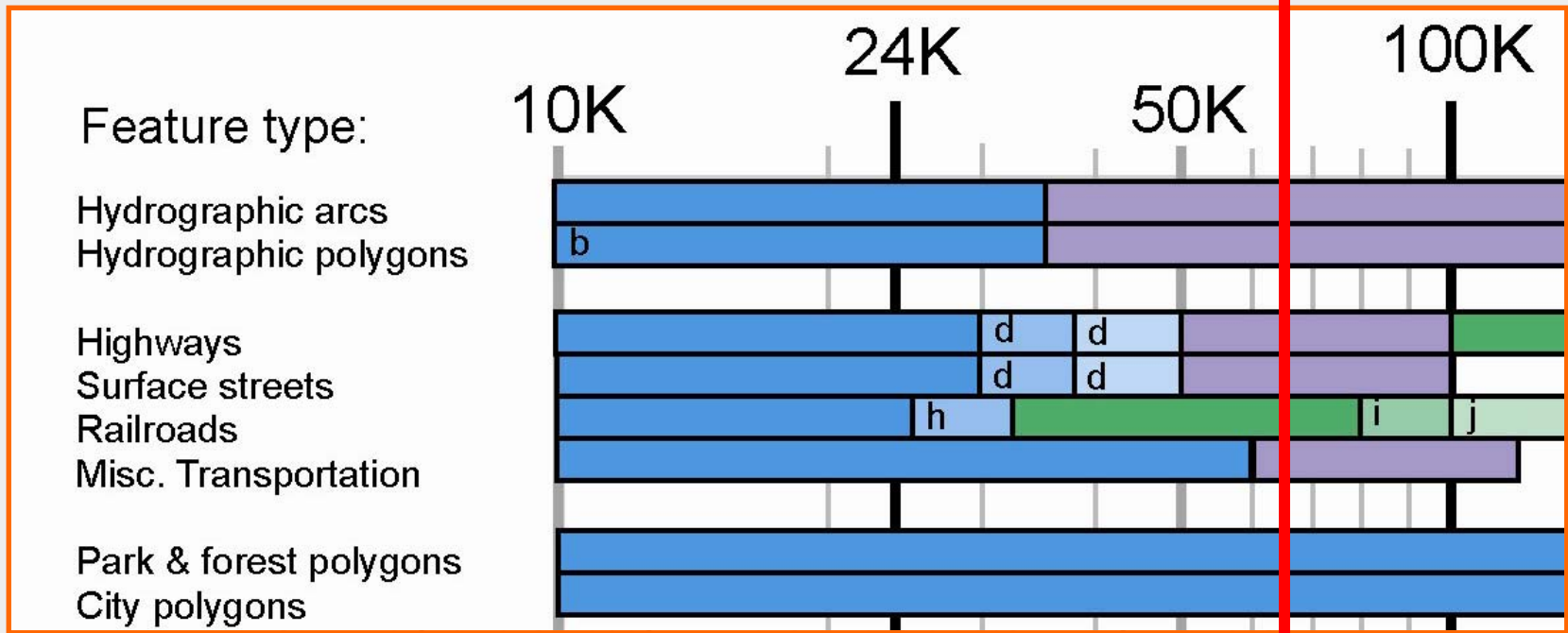
-  **Layers**
- Coastlines
- Point symbols
- Roads
  - road\_arcs\_30K
  - road\_arcs\_30-38K
  - road\_arcs\_38-50k
  - road\_arcs\_50-100K
  - road\_arcs\_100-275k
  - road\_arcs\_275k-1.5M
- ROUTE\_TYPE
  -  Interstate
  -  US Route
  -  State Route
- road\_arcs\_1.5M-2.5M
- road\_arcs\_2.5M-5M
- Railroads
- Misc. Transportation
- Hydrography
- Hypsography
- Boundaries



# ScaleMaster with grad students



# ScaleMaster with grad students



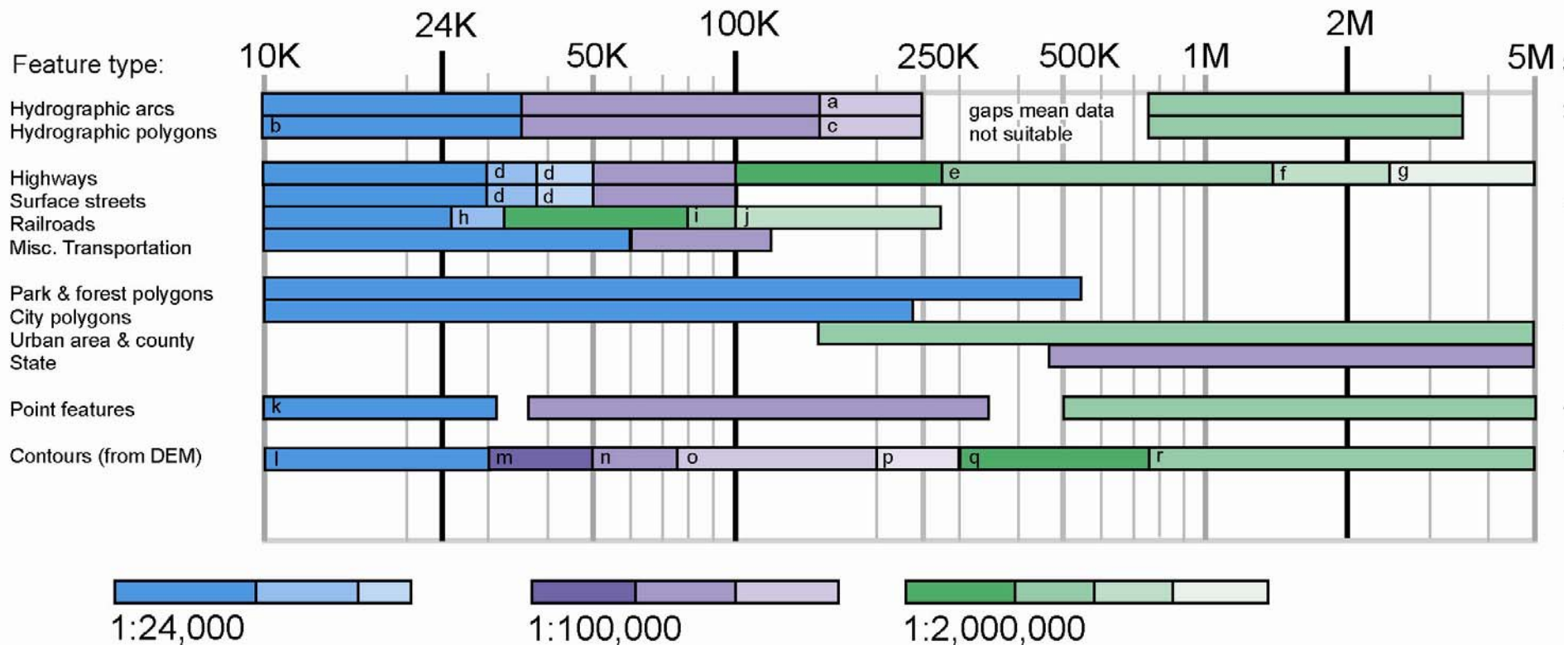
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Make a map at 1:65K



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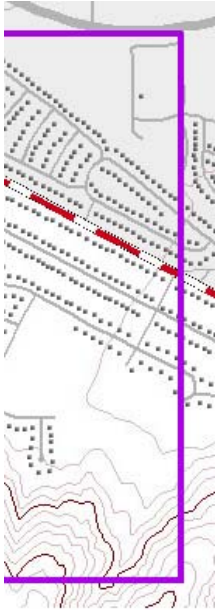


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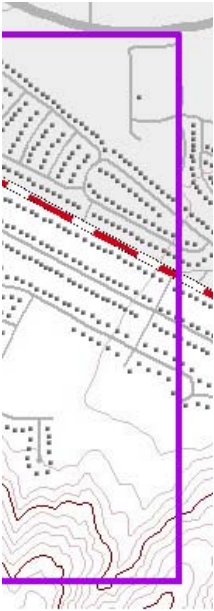


## Related Work by Others

# Context

Decisions for high-quality products balanced against data processing workloads for:

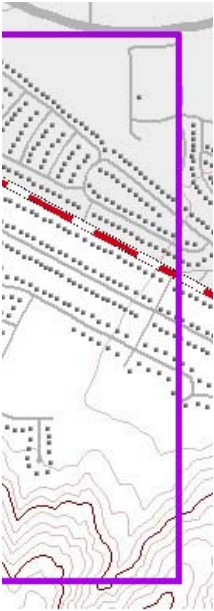
- on-demand and on-the-fly multi-scale mapping for the Web (Torun et al. 2000; Cecconi and Gallanda 2002; Cecconi et al. 2002)
- mobile devices (Harrie et al. 2002; Hampe et al. 2004)
- in-car navigation (Li and Ho 2004; Ulugtekin et al. 2004)
- adaptive zooming (Cecconi and Gallanda; Harrie et al.; Hampe et al.)



# Context

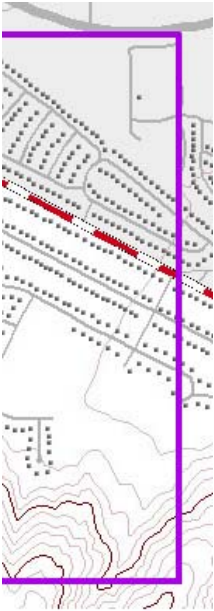
In past decade, generalization work has formalized:

- knowledge-based rules (Kilpelainen 2000)
- context-sensitive algorithms (Jones et al. 1995; Burghardt and Cecconi 2003)
- data modeling (Buttenfield 1995; Ruas and Lagrange 1995)
- software agents (Galanda and Weibel 2003; Regnaud, 2003)
- online progressive vector transmission (Buttenfield 1999; Paiva et al. 2004; Zhou et al. 2004)



# Context

- Now, European national mapping agencies producing databases containing linked multiple representations of detailed, high-resolution objects:
- Multi-resolution or multi-representation databases (MRDB) (Kilpelainen 1997; Spaccapietra et al. 2000)
  - Updates autonomously propagate to all resolutions, reducing work of updating maps (Dunkars 2004; Haunert and Sester 2004; Stoter et al. 2004; Bobzien et al. 2005)





# Symbolization set at beginning

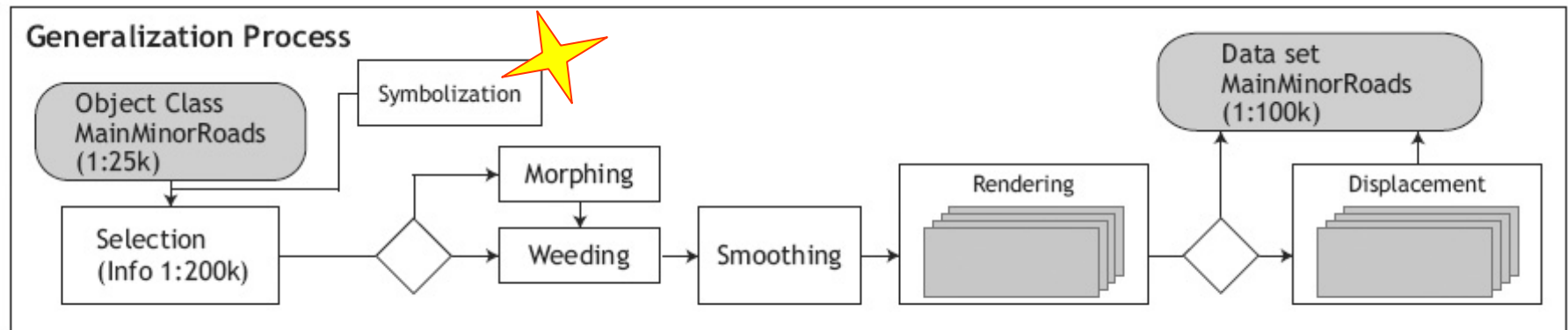
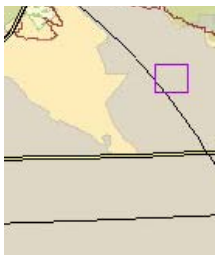


Fig. 5. Generalisation process for the object class “main and minor roads”

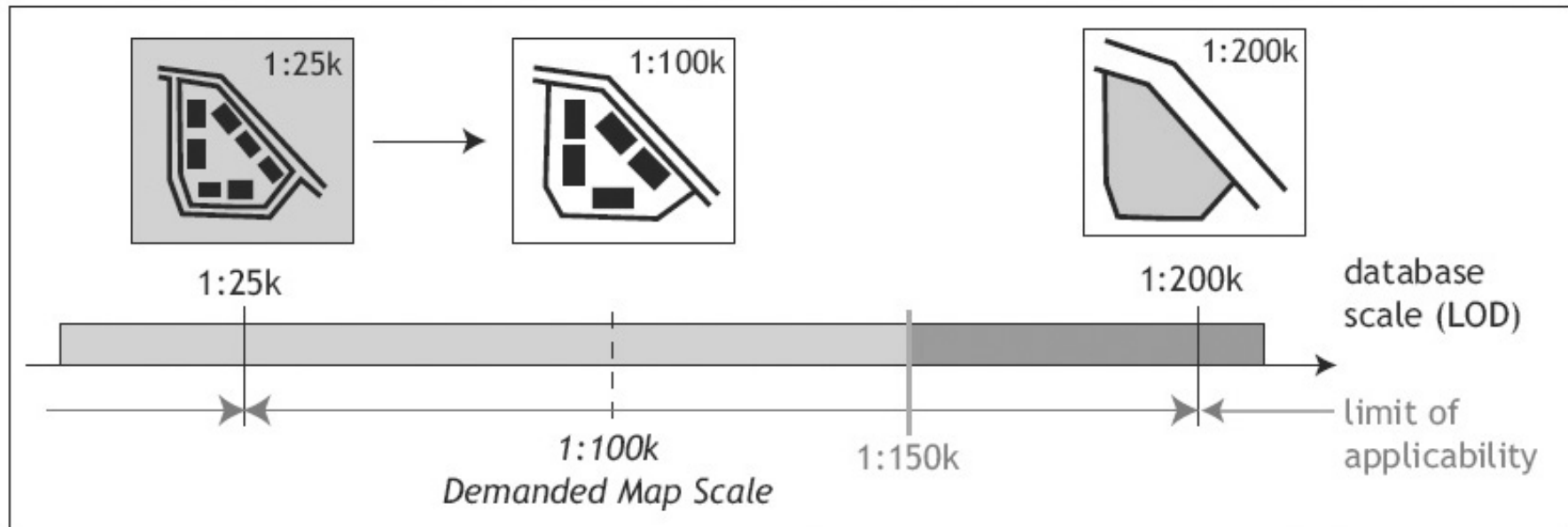
Cecconi et al. 2002



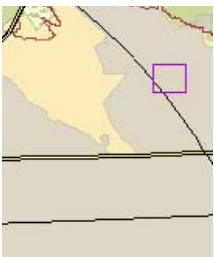




# Select database used at each scale



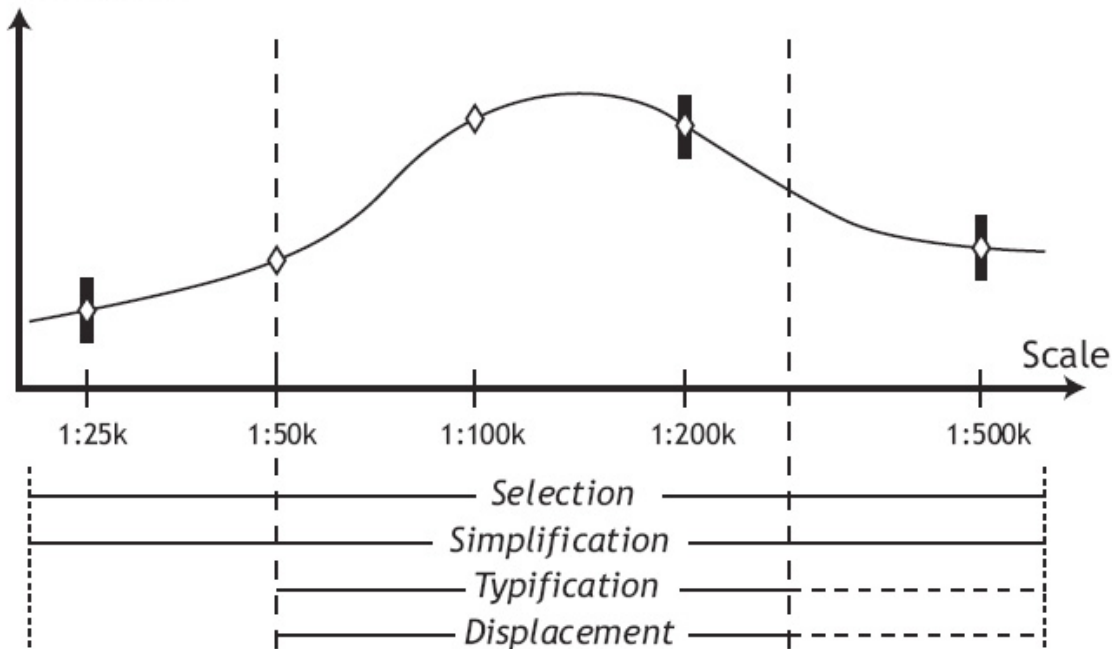
Cecconi et al. 2002





# Cecconi et al. model of workload

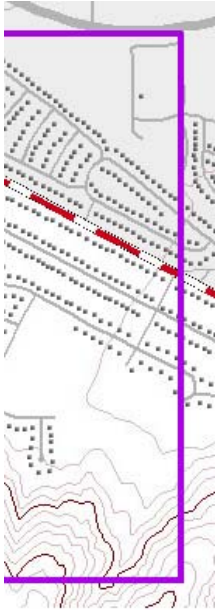
Road network  
Generalization  
Complexity



- ┆ Limits of operator application
- ┆ Map scale range
- ▬ Levels of detail (LoDs)
- ◇ Map scales

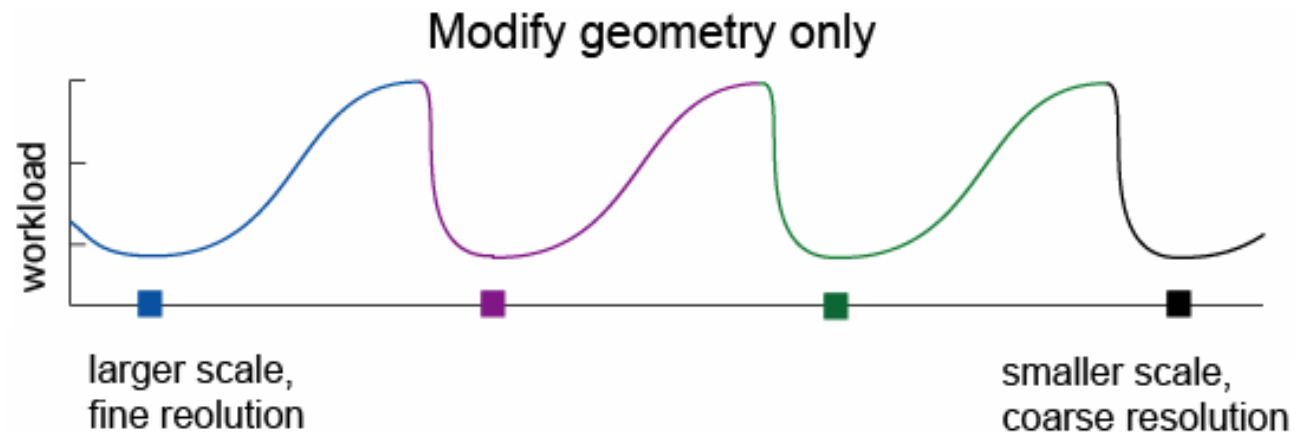
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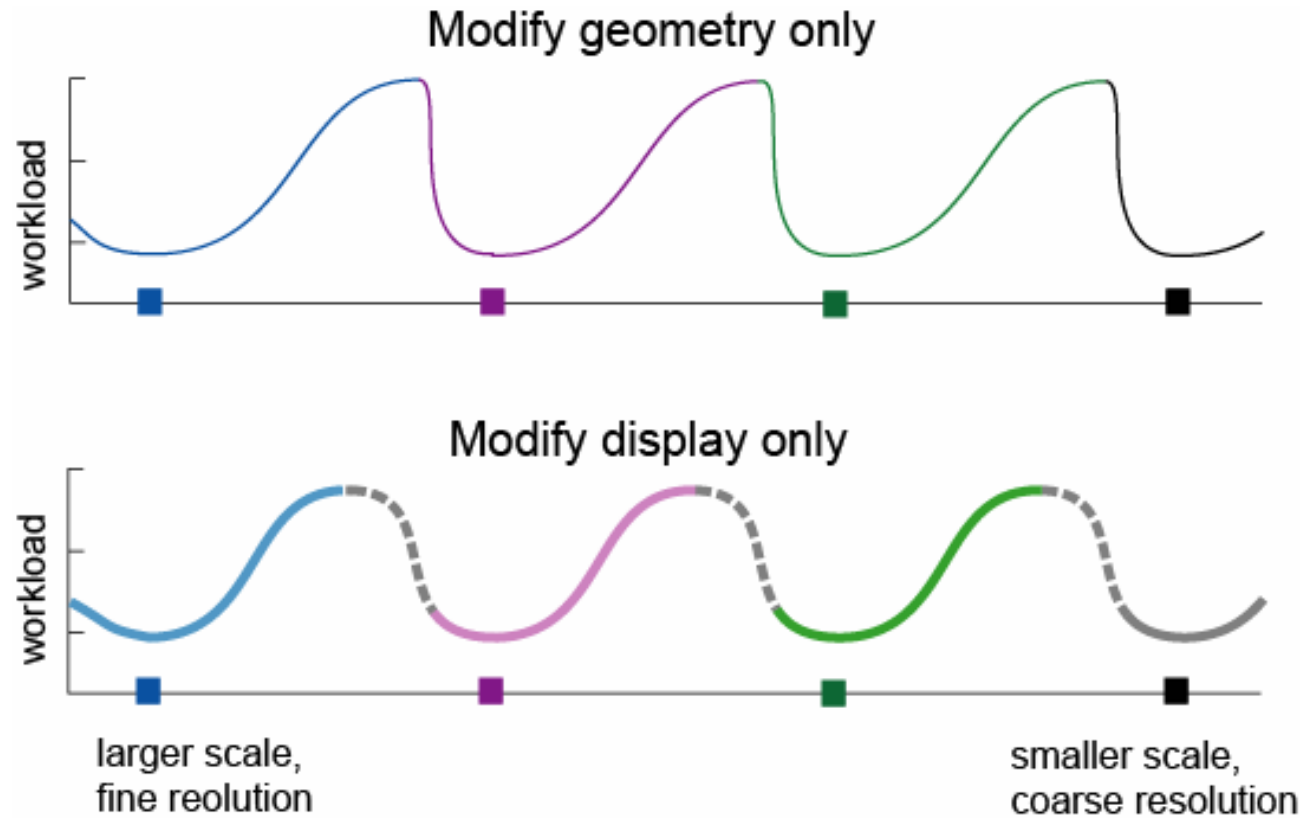
# Balancing Workloads

# Workloads for single solutions



Workload includes processing complexity, time, skill level, tool sophistication...all increase cost

# Workloads for single solutions

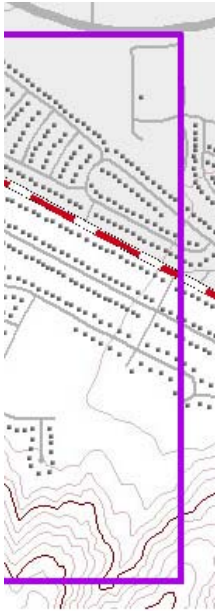


Schematized, hypothetical...what should shapes be?

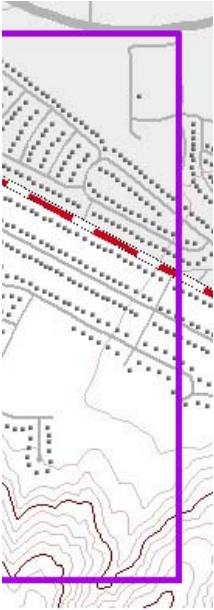
# Display vs. geometry change

Modifications to feature **display** may include:

- Changing to colors over which type is readable
- Increasing spacing in boundary dash to reveal underlying roads
- Changing marker symbol size, shape, hue, and lightness to not obstruct adjacent features
- Adding line casings to place labels inside roads
- Removing polygon outlines so lines do not obscure polygon fills
- Replacing features with labels



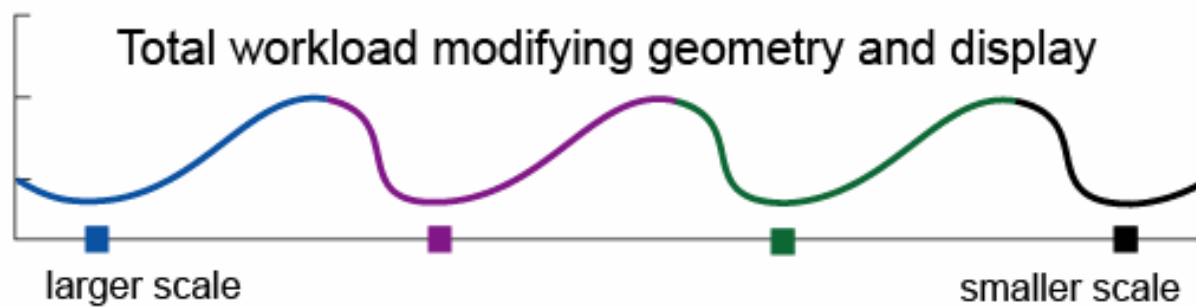
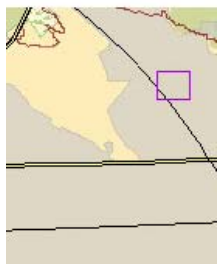
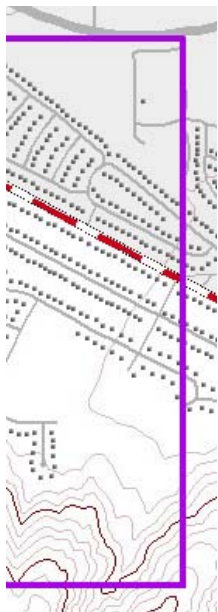
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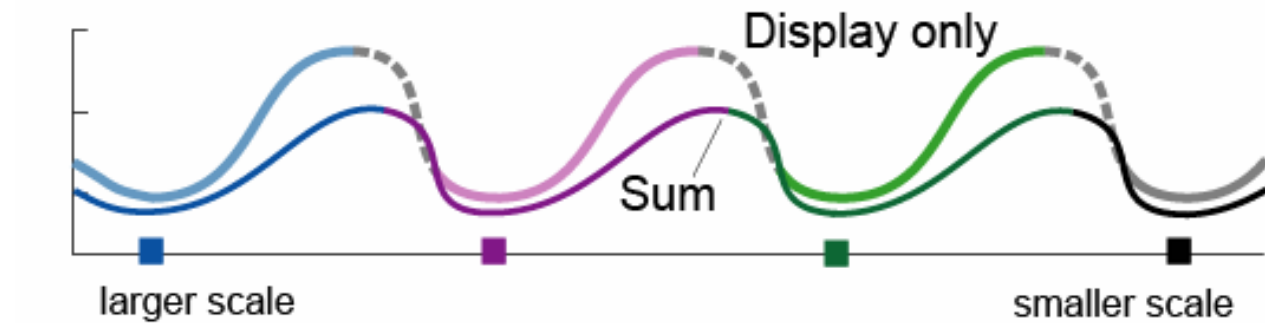
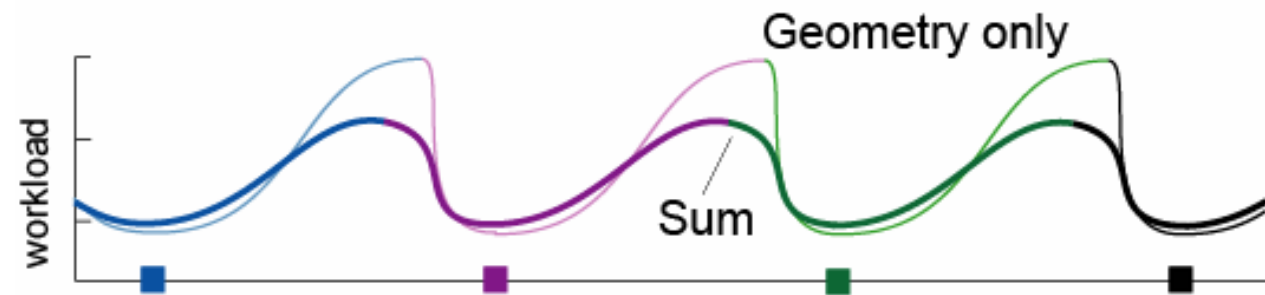
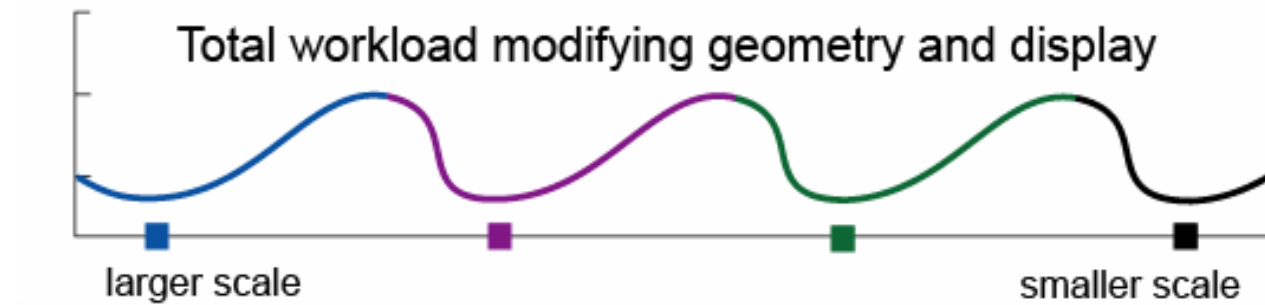
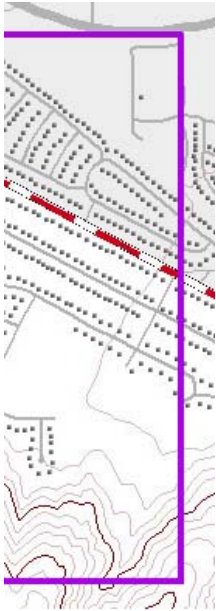
Modifications to feature **geometry** may include:

- Resampling geometry  
(e.g., DEM resampling for smoother relief shading)
- Interpolating new isolines from a DEM  
(e.g., changing from a 3m to 20m contour interval)
- Changing dimensionality  
(e.g., collapsing building footprints to point features)
- Simplifying lines  
(e.g., reducing coordinates along an intricate coastline)
- Summarizing many small features with larger one  
(e.g., aggregating many small ponds to 'wetland area')

# Sum less than a single approach

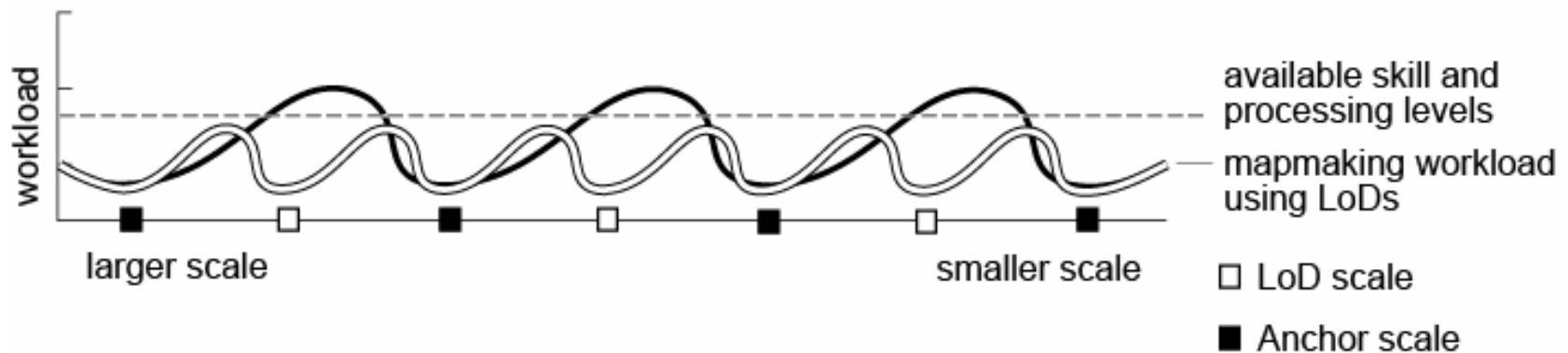


# Sum less than a single approach



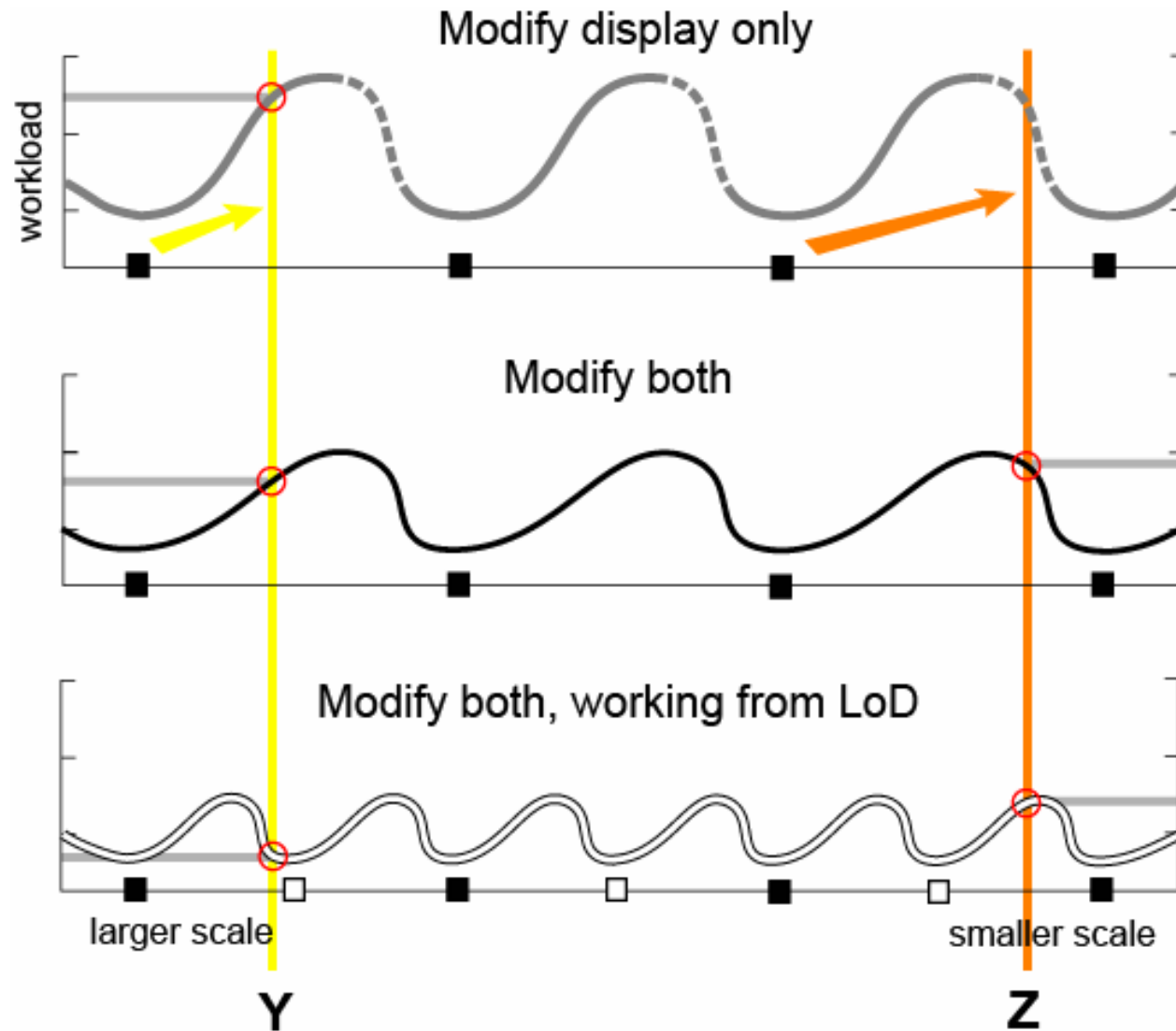


# Reduce workload using LoDs

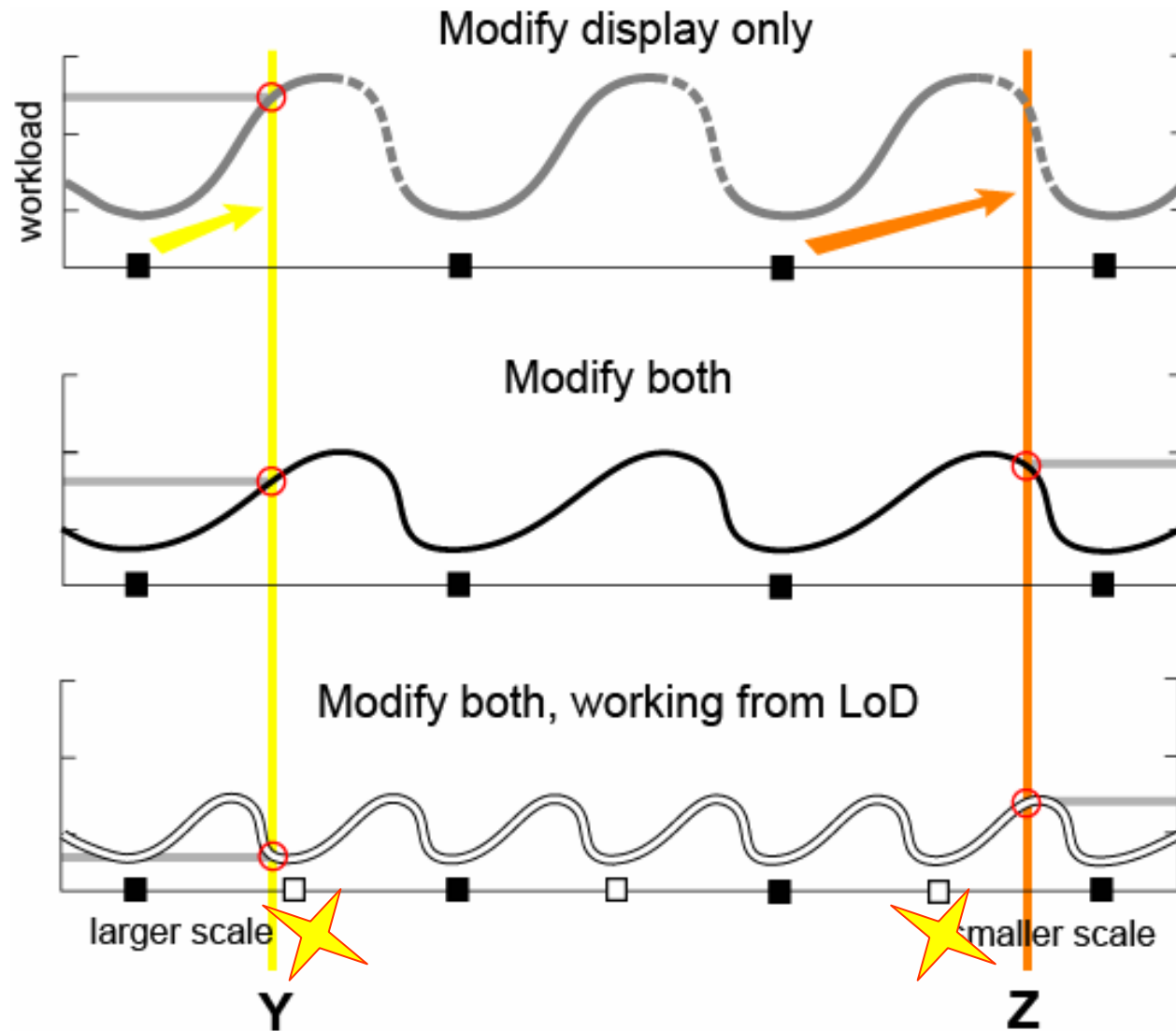


LoD: Level of Detail, preprocessed database

# Reduce workload using LoDs



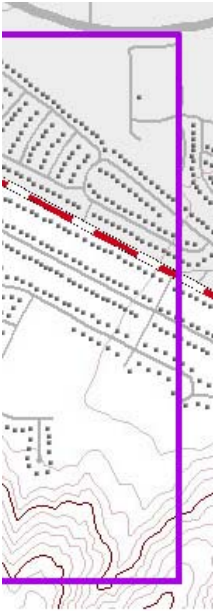
# Reduce workload using LoDs



# Concluding comments 1

Potential...

- Formalize cartographers' decisions about changing map scale
- Maintain consistency among multi-scale design outcomes
- Guide organizations lacking a staff cartographer on design and data selection



## Concluding comments 2

Potential...

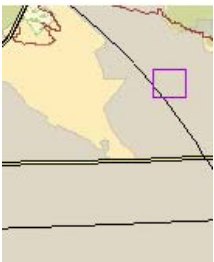
- Guide systematic production of a minimum number of LoDs derived from larger scale data
- Identify additional intermediate-scale datasets suited to mapping needs



# Concluding comments 3

Potential...

- Guide minimized download from databases for specific map purpose and scale
- Assist integration of databases at varied scales and different ownership



# Concluding comments 3

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- Assist integration of databases at varied scales and different ownership

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**[www.personal.psu.edu/cab38](http://www.personal.psu.edu/cab38)**

