a synoptic view of multi-scale mapping operators

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"We actually made a map of the country on the scale of a mile to a mile!" [said Mein Herr]

"Have you used it much?" I enquired.

"It has never been spread out, yet," said Mein Herr: "the farmers objected: they said it would cover the whole country and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well."

-Lewis Carroll, *Sylvie and Bruno Concluded*

abstraction

power (useful and usable)

abstraction

power (useful and usable)

abstraction

certainty

power (useful and usable)

abstraction

generalization (ways we abstract)

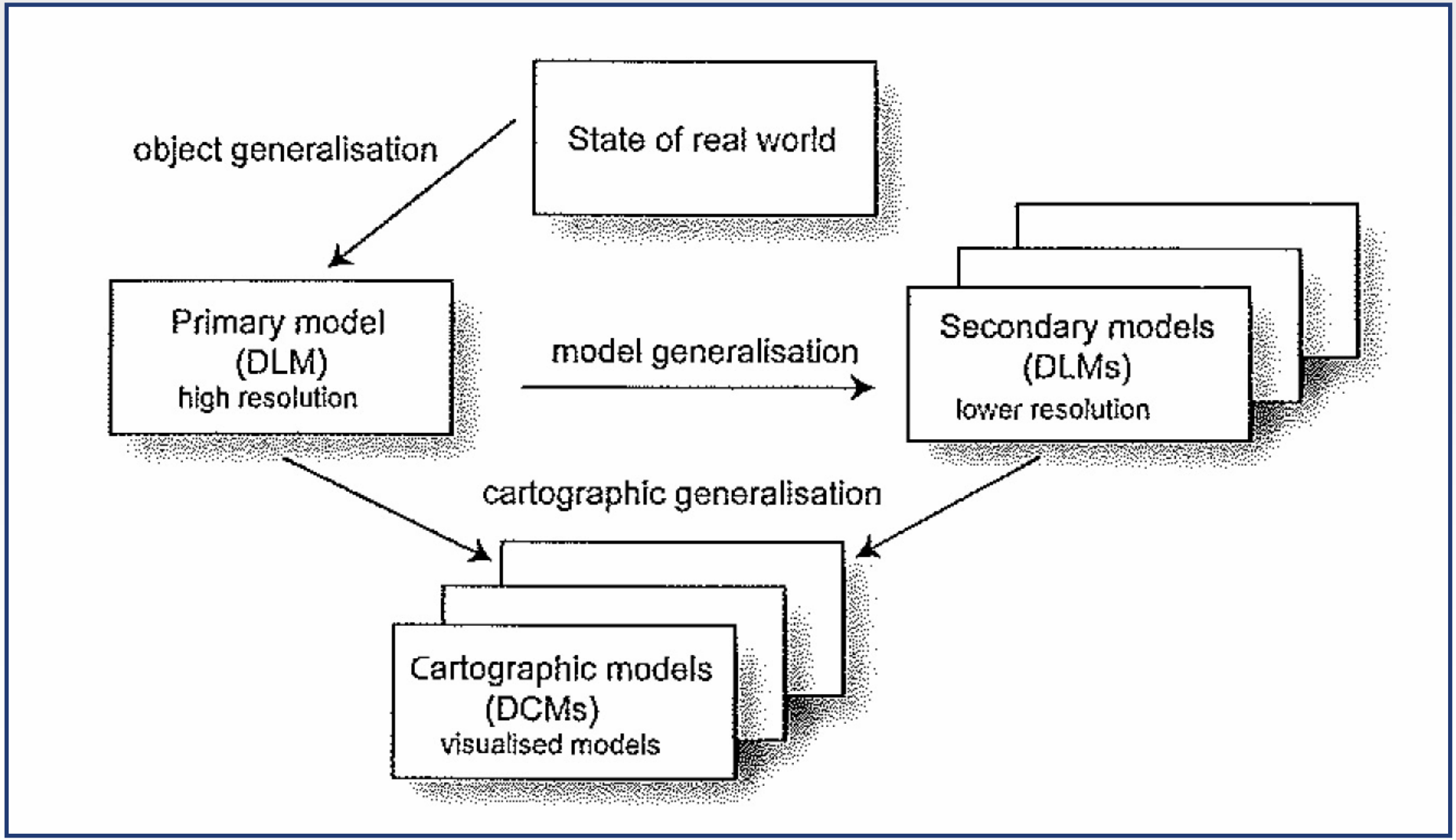
agenda

one: a primer on generalization, multi-scale mapping, and MRDB

two: description of a schematic for capturing multi-scale mapping design specifications

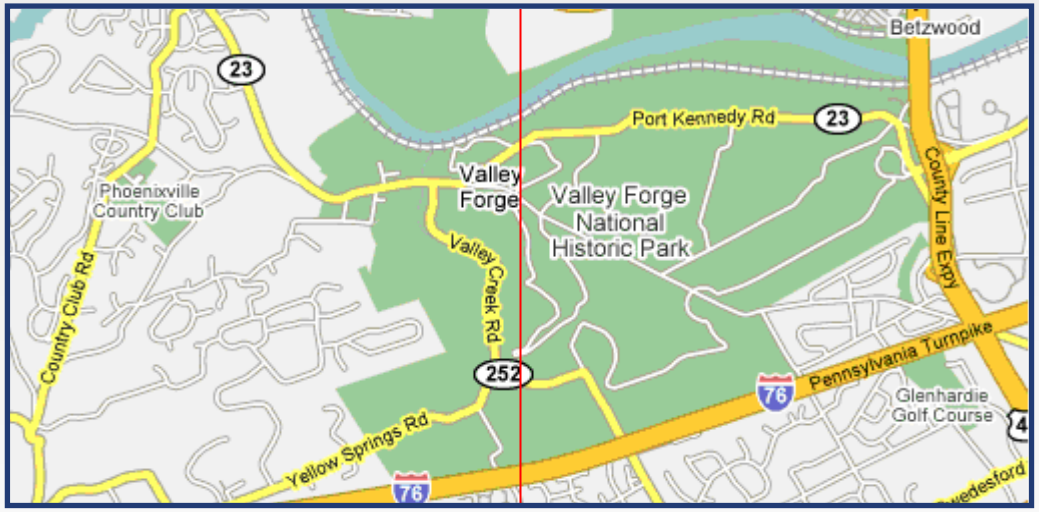
three: a synoptic view of multi-scale mapping operators

generalization – removing detail in a meaningful manner



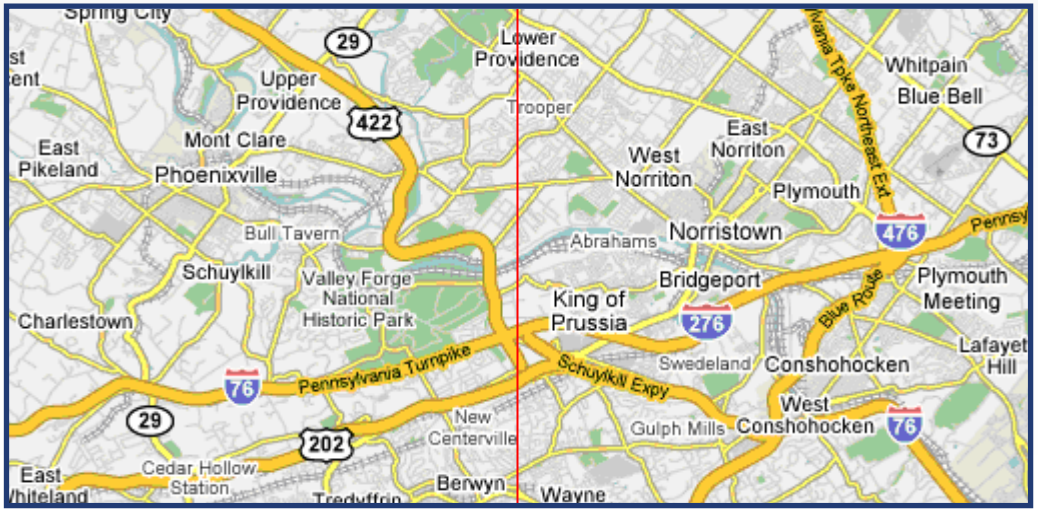
Grünreich's (1985) discrimination of object, model (or conceptual), and cartographic generalization (reprinted in Sarjakowski 2007)

multi-scale mapping – producing multiple representations of the same phenomena to maintain *legibility* at all identified map scales

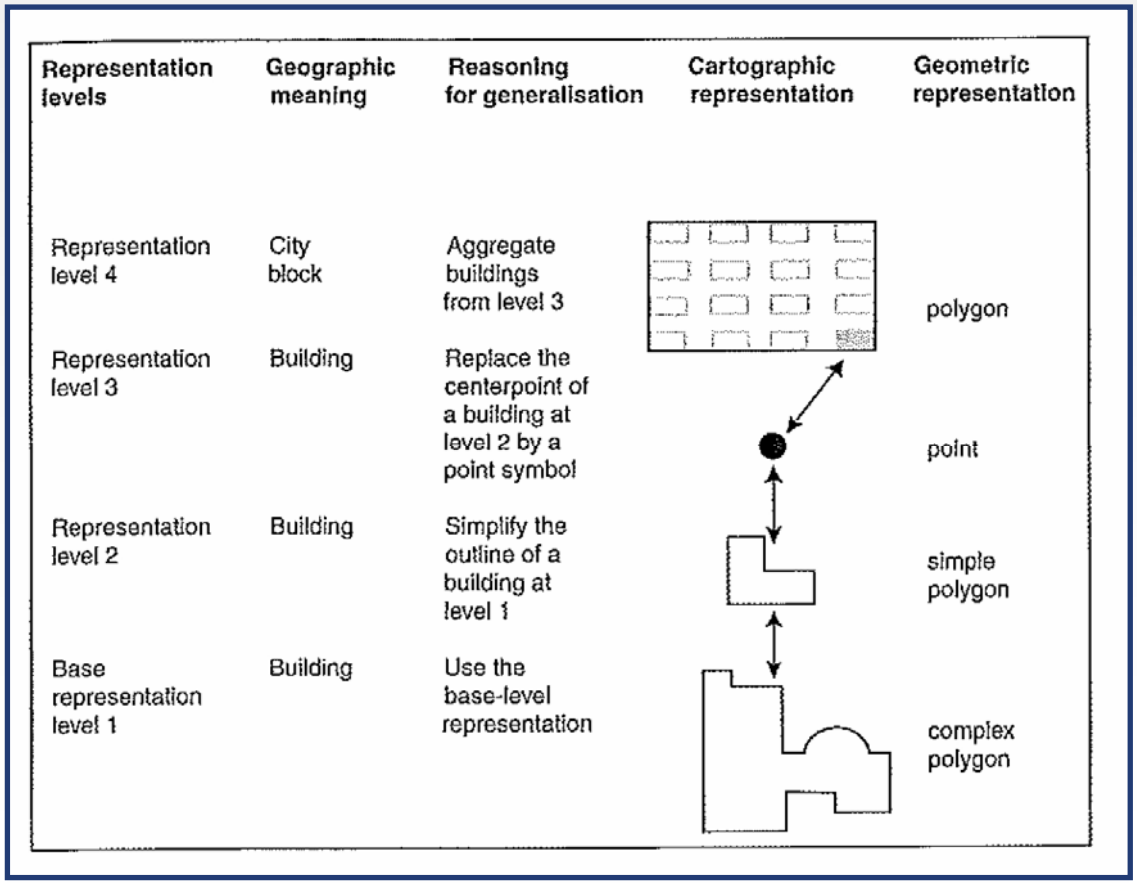


GoogleMaps scale #6
(~1:70,000)

GoogleMaps scale #8
(~1:280,000)

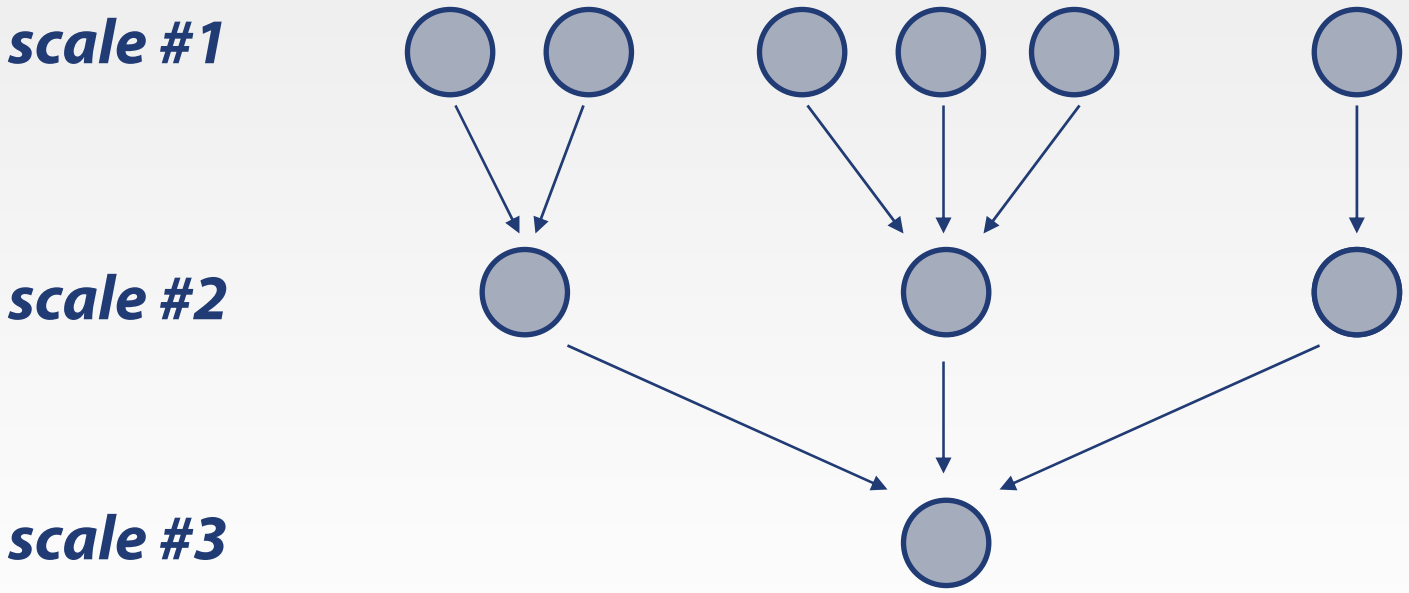


multiple representation databases (MRDBs) - representation of features on an object level, rather than scale-level, using several 'representation stamps' at fixed scales and then designing rules for deriving intermediate symbology from these fixed stamps



Kilpeläinen's (1997) proposal of MRDB

why? flexible database maintenance
and removal of data redundancy

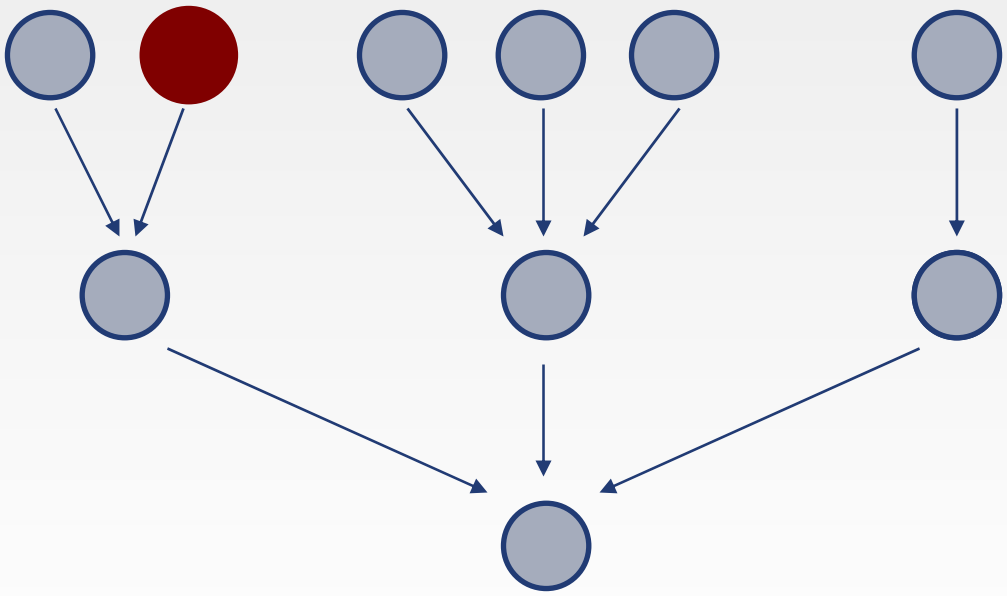


why? flexible database maintenance and removal of data redundancy

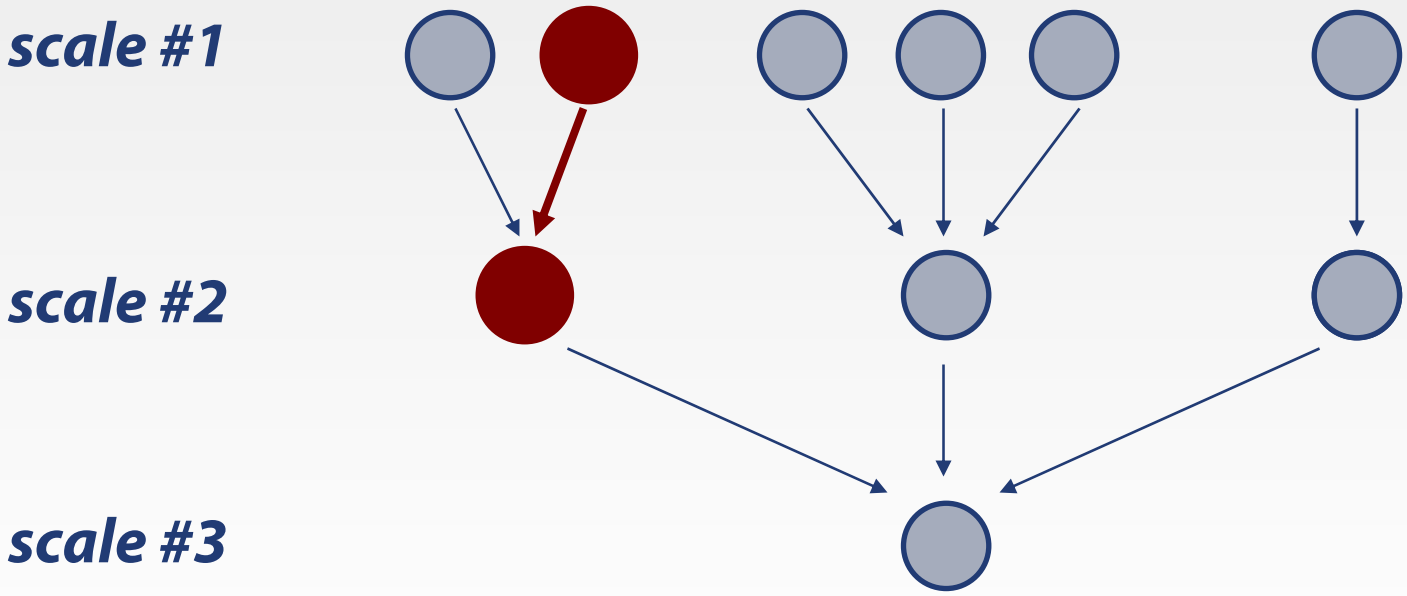
scale #1

scale #2

scale #3



why? flexible database maintenance
and removal of data redundancy



why? flexible database maintenance
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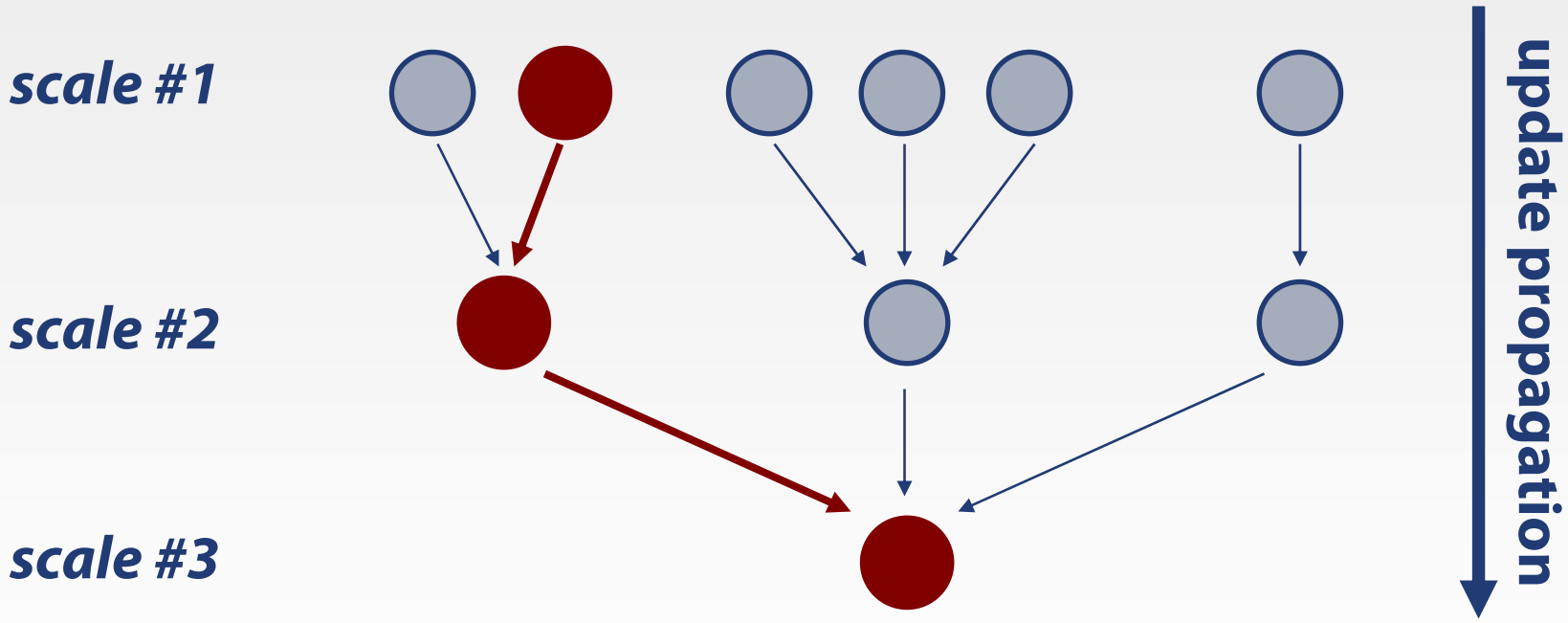
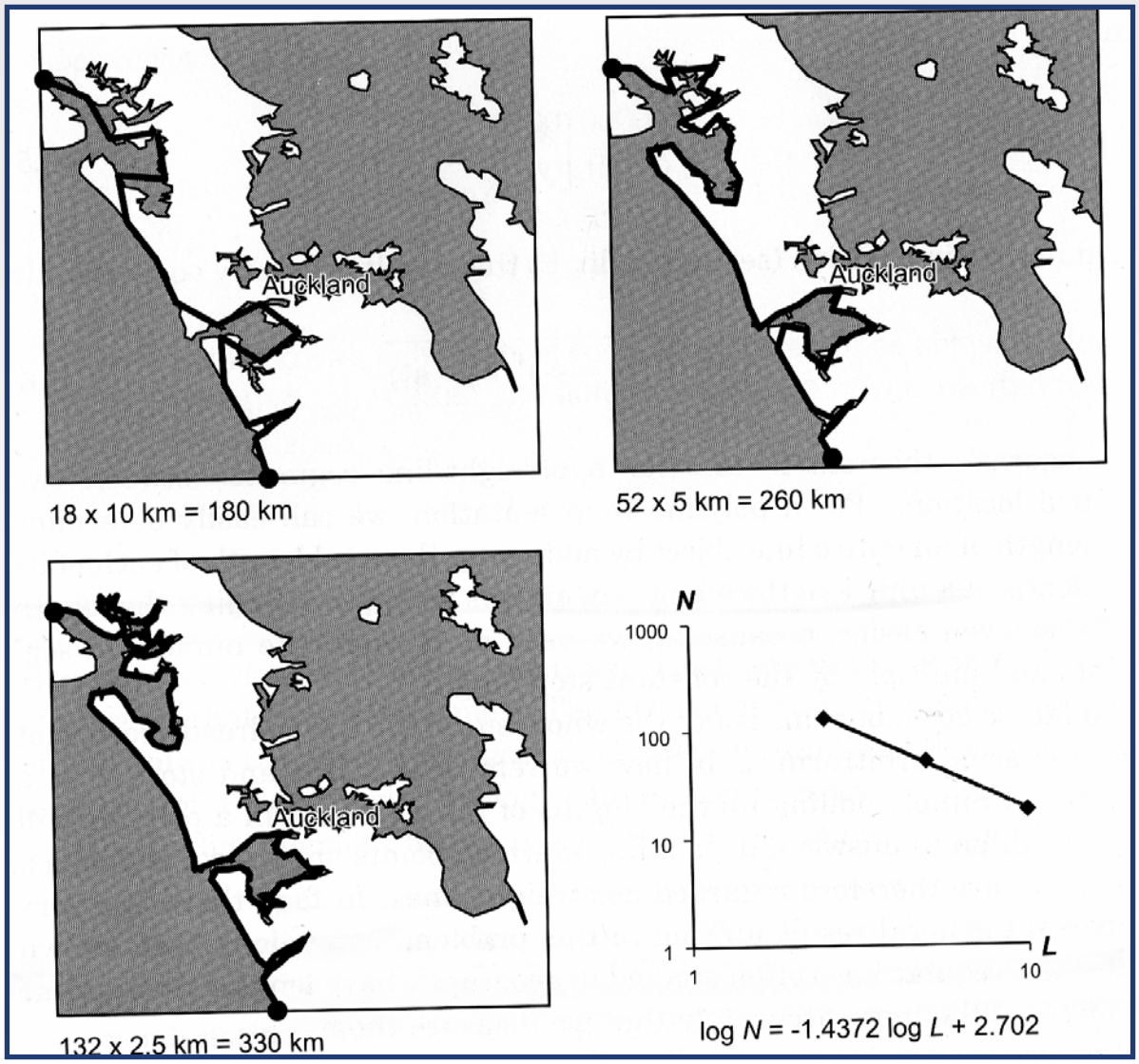


why? variable display resolutions and increased speed of information access

why? multi-scale spatial analysis



O'Sullivan and Erwin (2003)

why? not just multi-scale

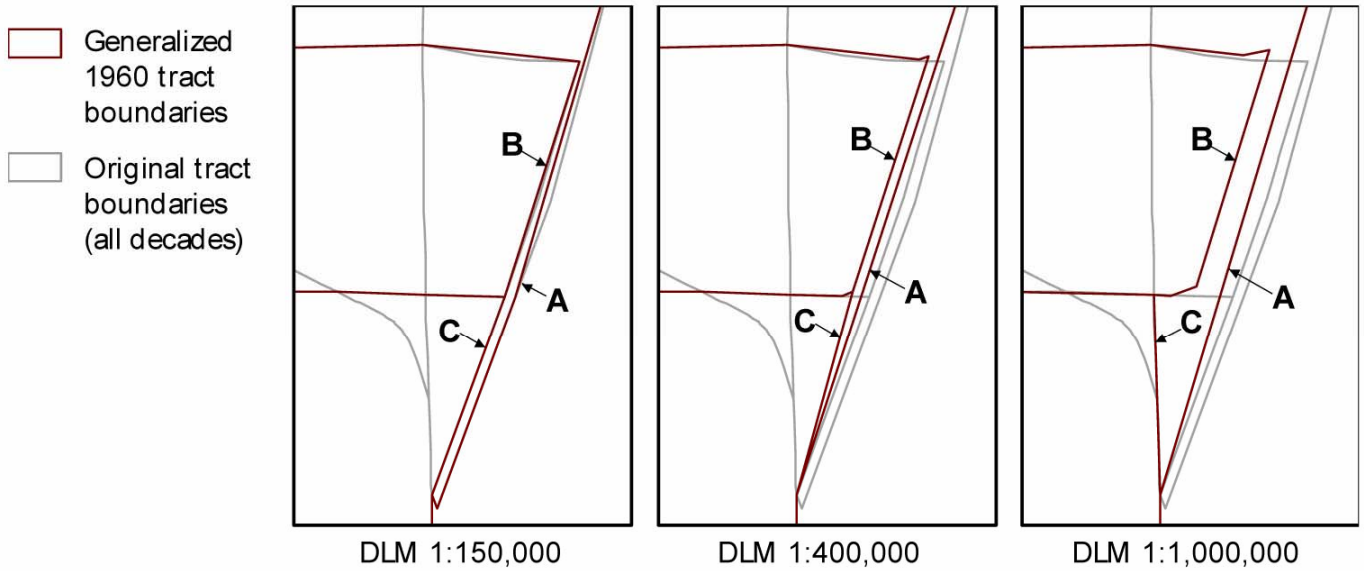
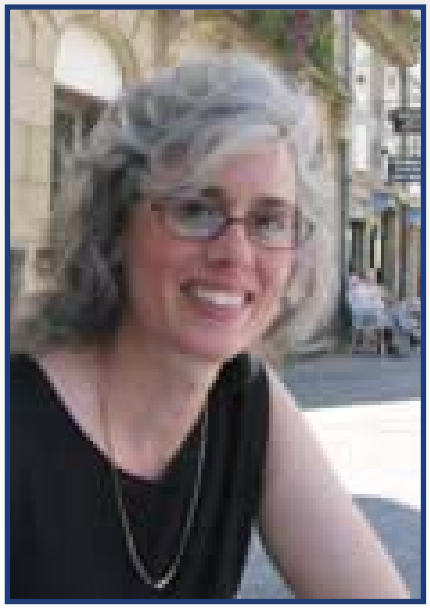


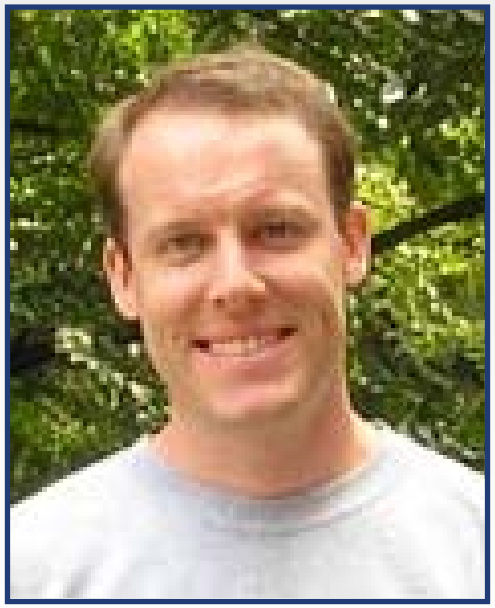
Figure 4: Preservation of topological consistency between decades during the removal of redundant points in model generalization. This area corresponds to the boxed area in Figure 2.

National Historical Geographic Information System: spatiotemporal MRDB of census units - Gallanda et al. (2005)

the **ScaleMaster.org** project



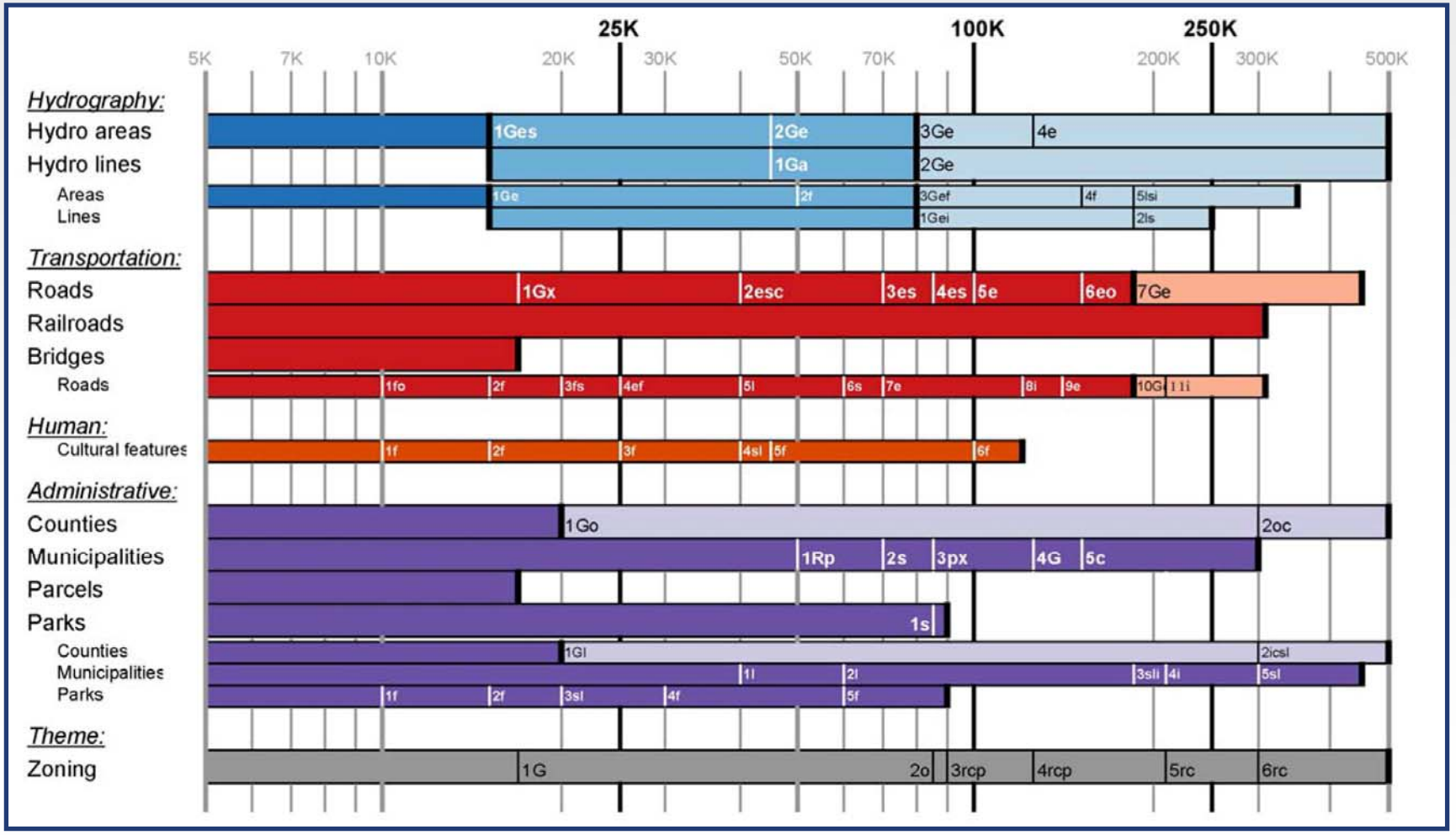
Cindy Brewer



Michael Stryker

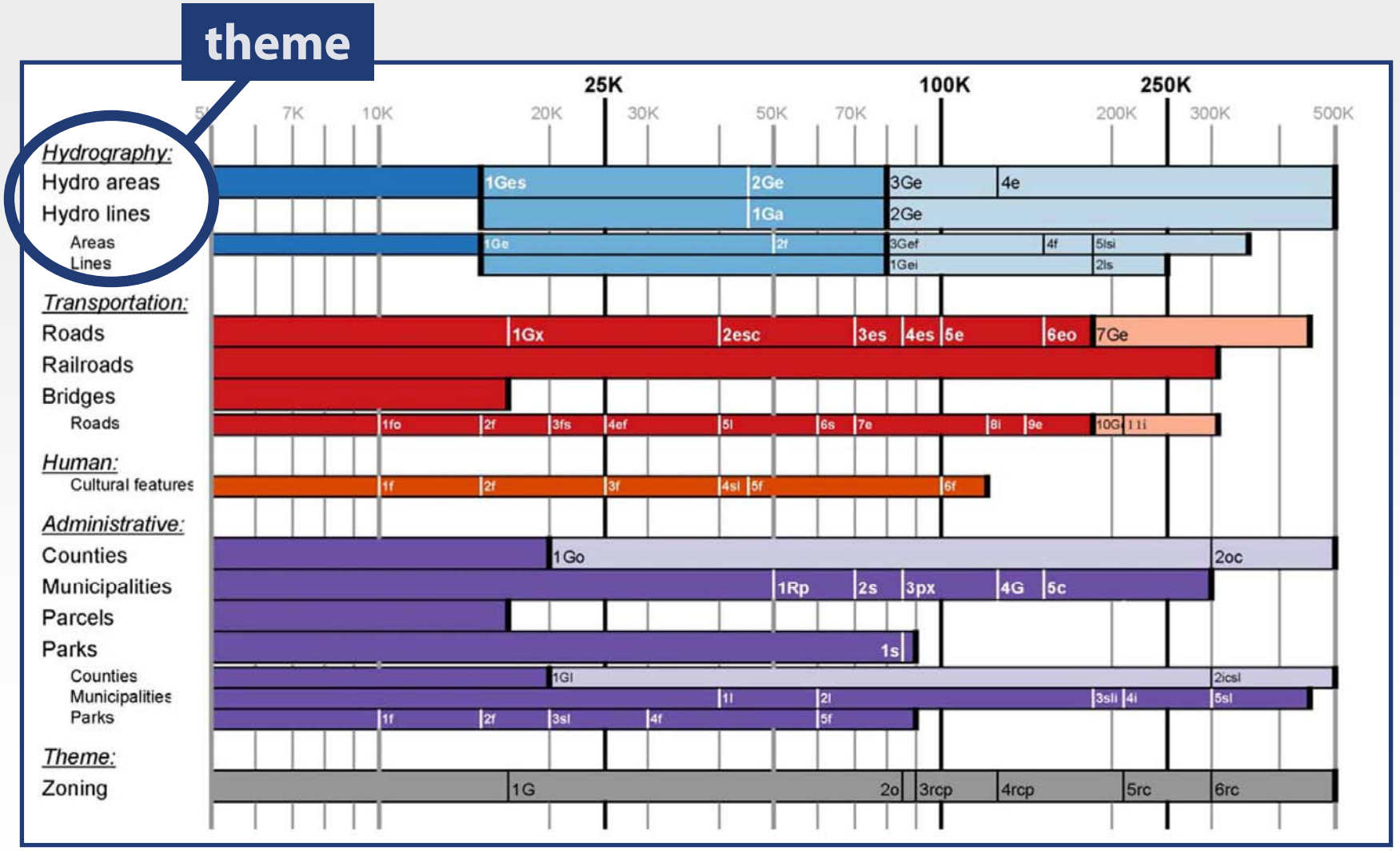
Robert Roth

ScaleMaster diagram: a schematic for organizing scale-dependent design specifications for a multi-scale mapping project



the ScaleMaster diagram as proposed by Brewer et al. (2007)

anatomy of a ScaleMaster diagram



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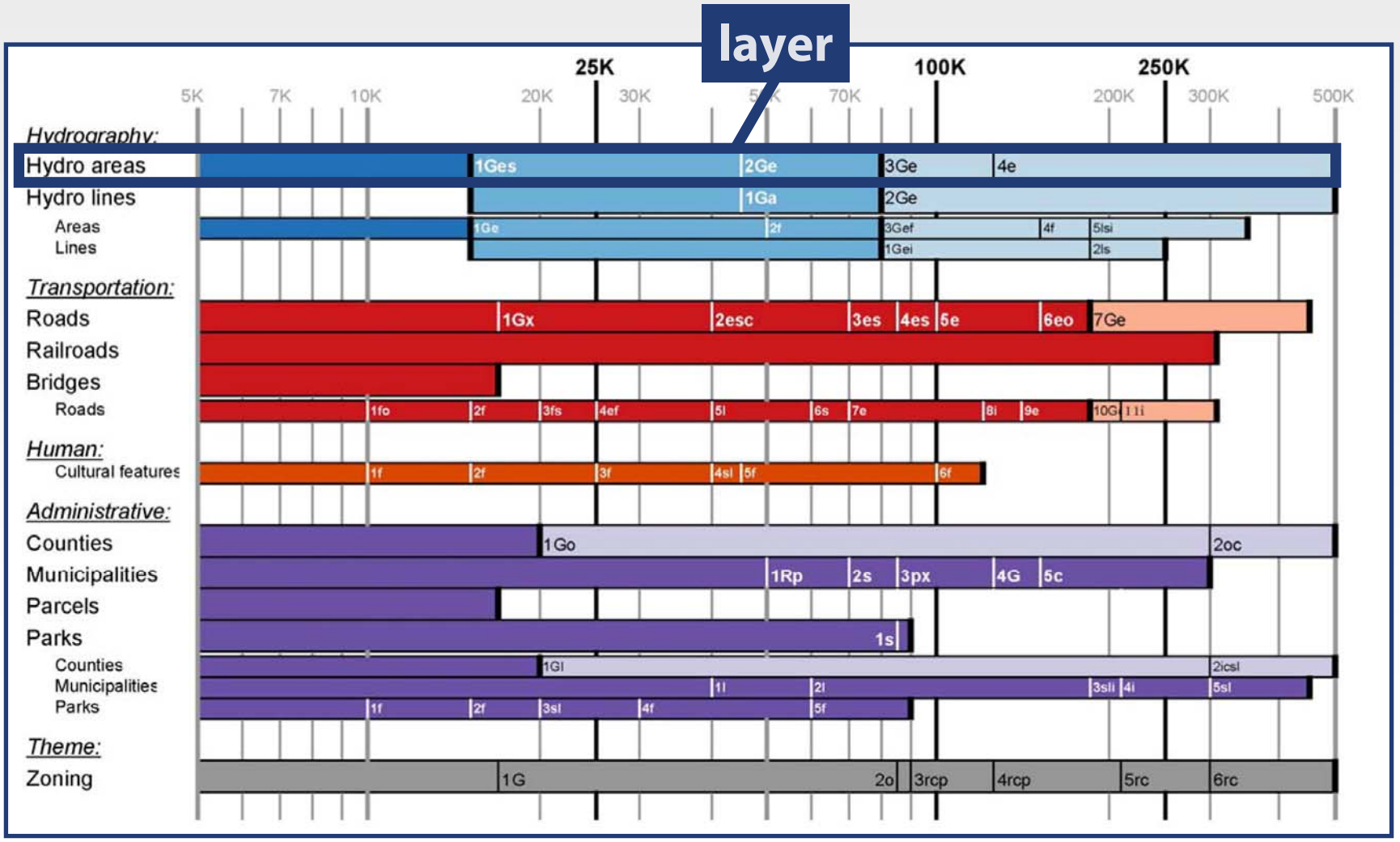
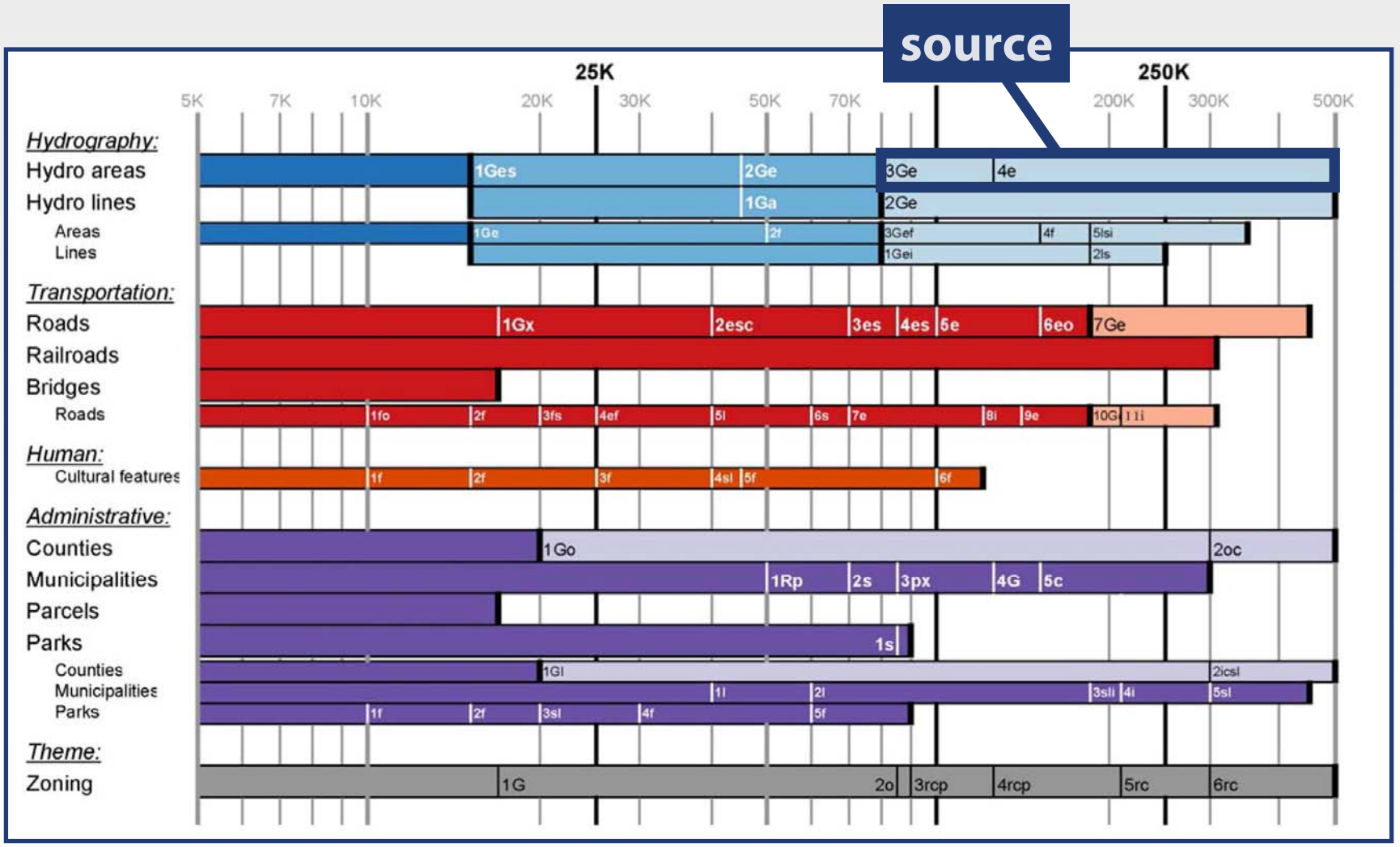


the ScaleMaster diagram as proposed by Brewer et al. (2007)

anatomy of a ScaleMaster diagram



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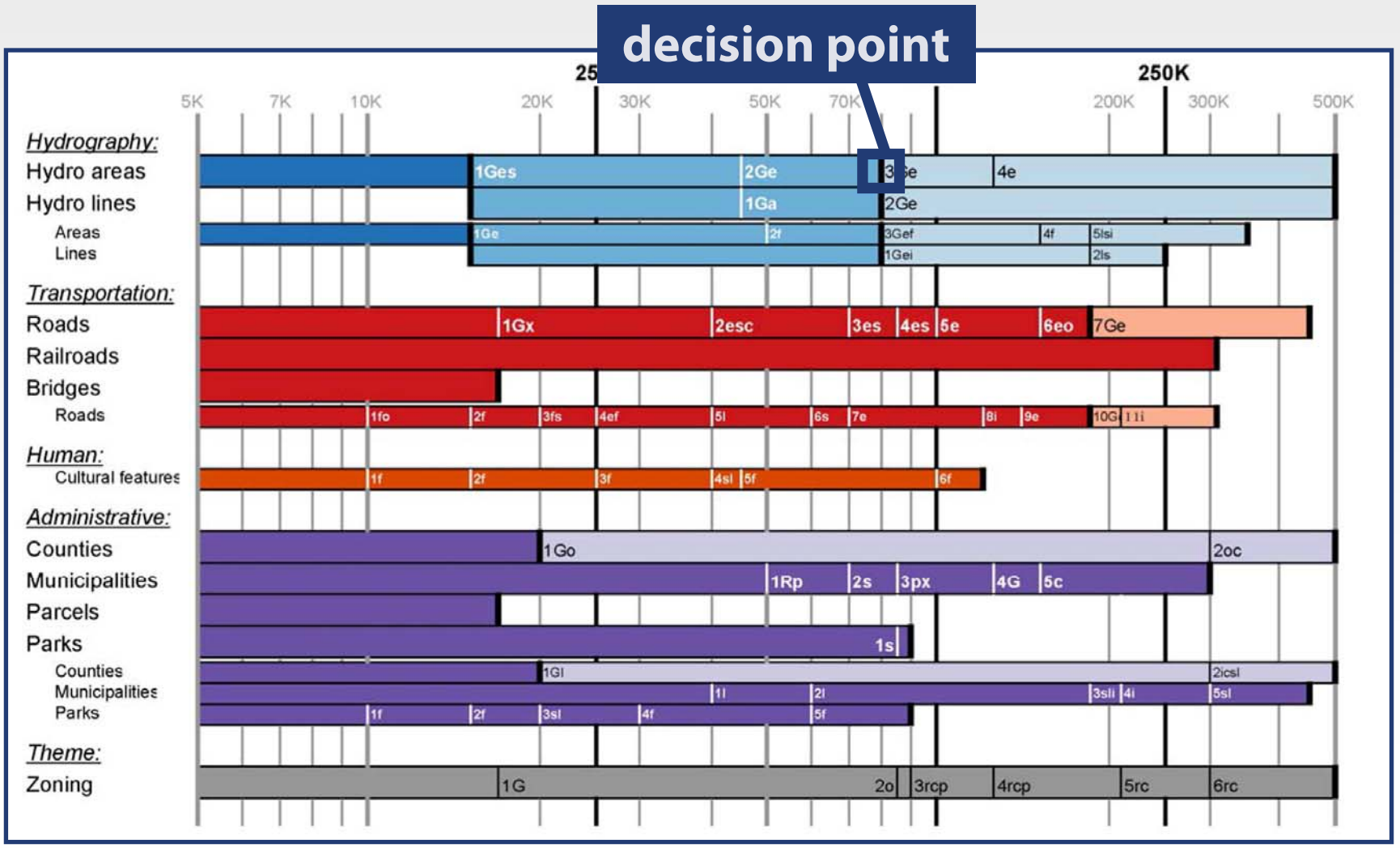
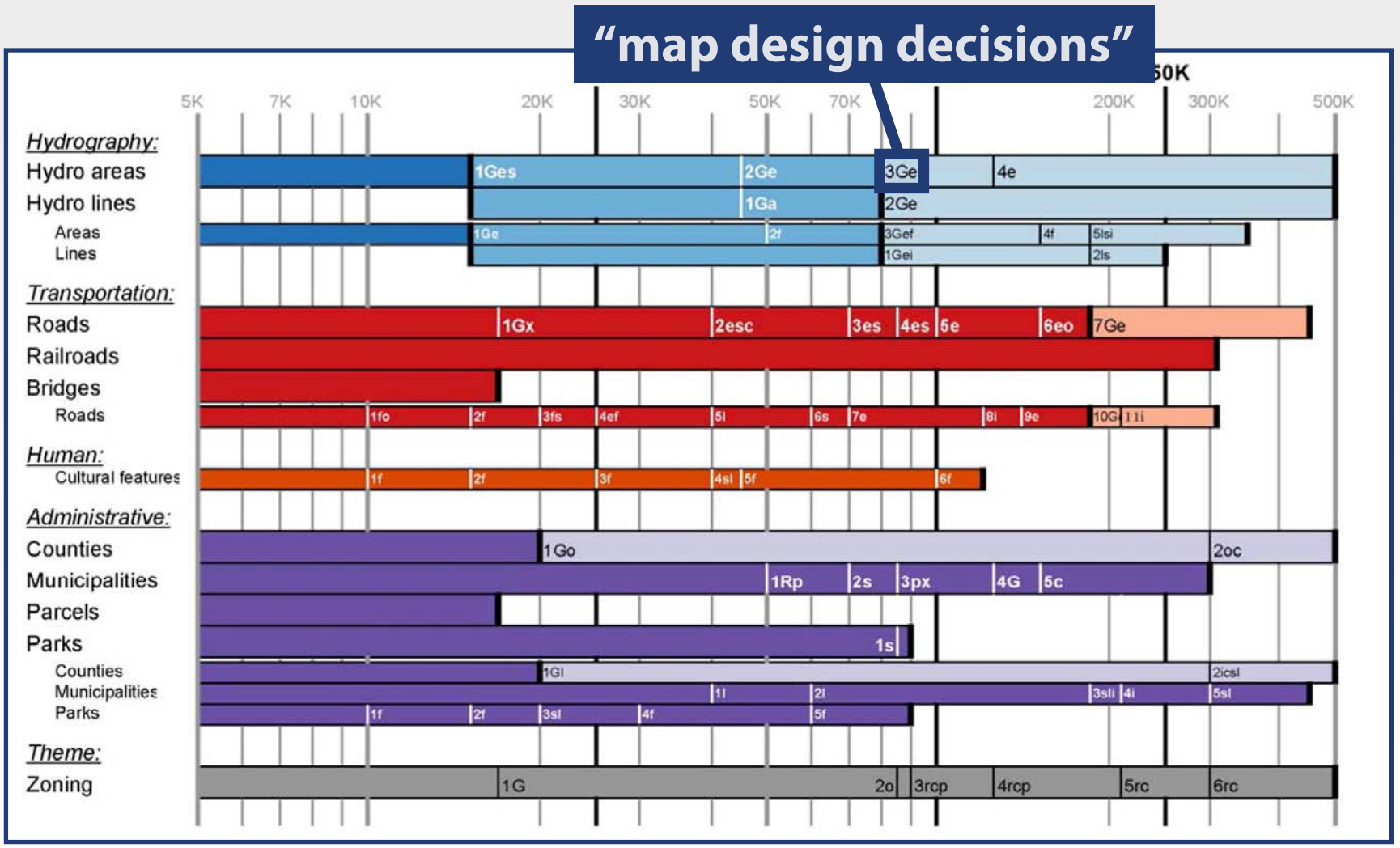
anatomy of a ScaleMaster diagram



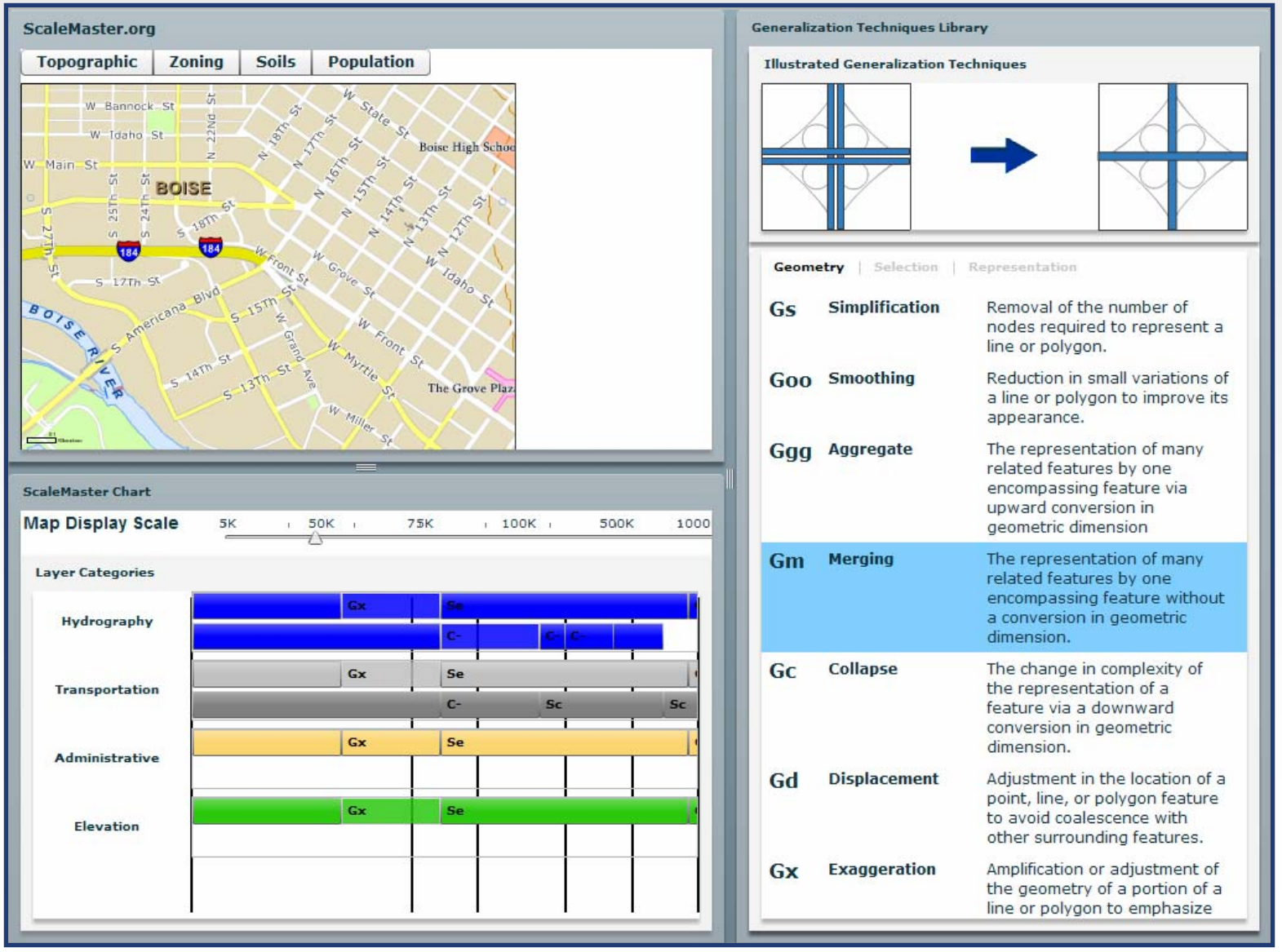
the ScaleMaster diagram as proposed by Brewer et al. (2007)

anatomy of a ScaleMaster diagram



the ScaleMaster diagram as proposed by Brewer et al. (2007)

the **ScaleMaster.org** project



synopsis **NOT** *typology*

multi-scale **NOT** *generalization*

vector **NOT** *raster*

two questions:

one: what is the most elemental, **micro-level** that can be consistently summarized and is understandable by a cartographer as a “map design decision”?

two: is there a broad, **macro-level** criterion that can group these micro-level units in a manner that assists in their interpretation and implementation?

one: micro-level

operator

a generic description of a single way to maintain legibility when transitioning to a smaller map scale

algorithm

a particular set of instructions for implementing a multi-scale mapping operator

one: micro-level

operator

a generic description of a single way to maintain legibility when transitioning to a smaller map scale

algorithm

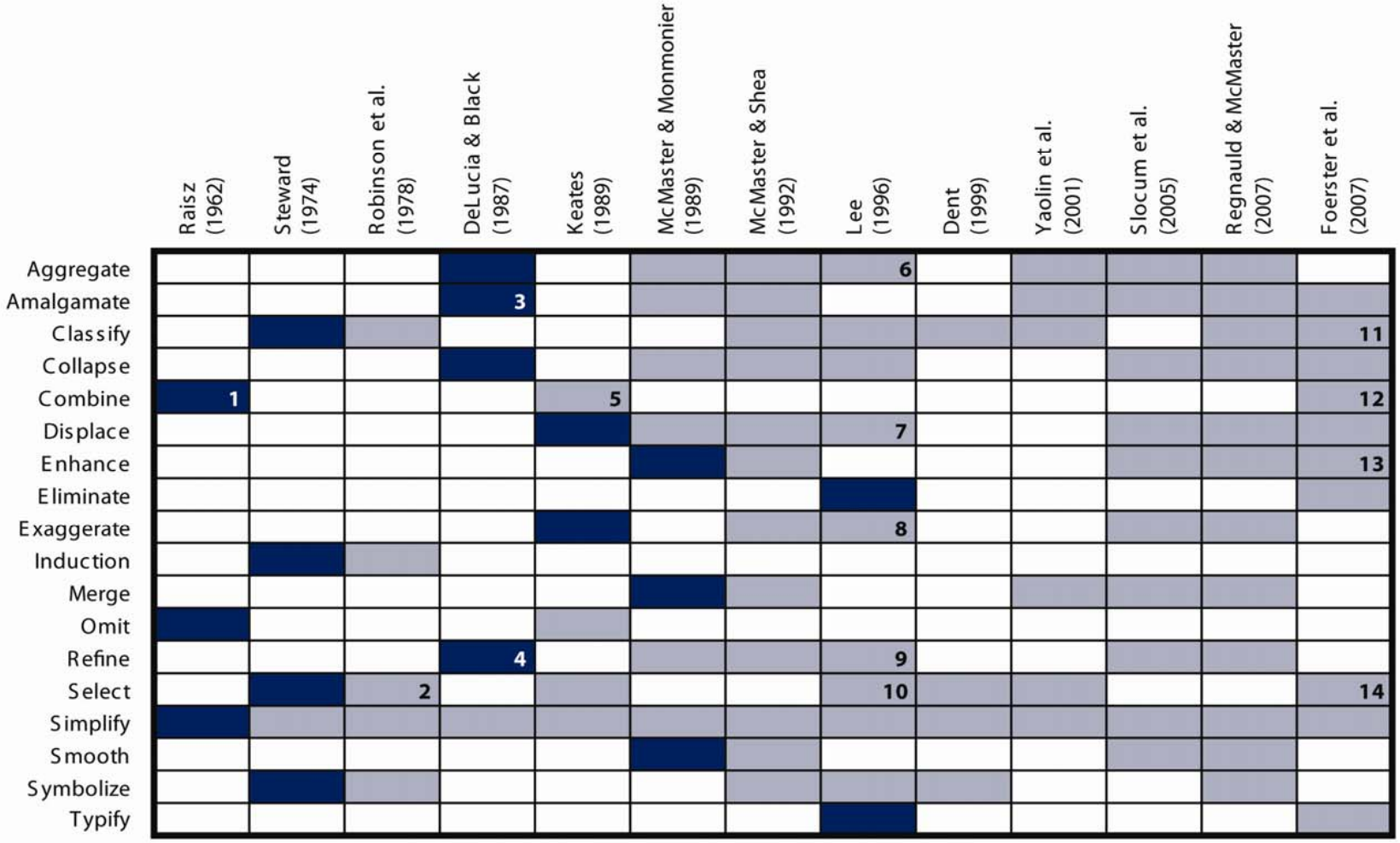
a particular set of instructions for implementing a multi-scale mapping operator

→ many algorithms to implement the same operator

→ many names for the same algorithm (software-dependent)

→ quickly becomes out of date as new algorithms are developed

a synoptic view of multi-scale mapping operators



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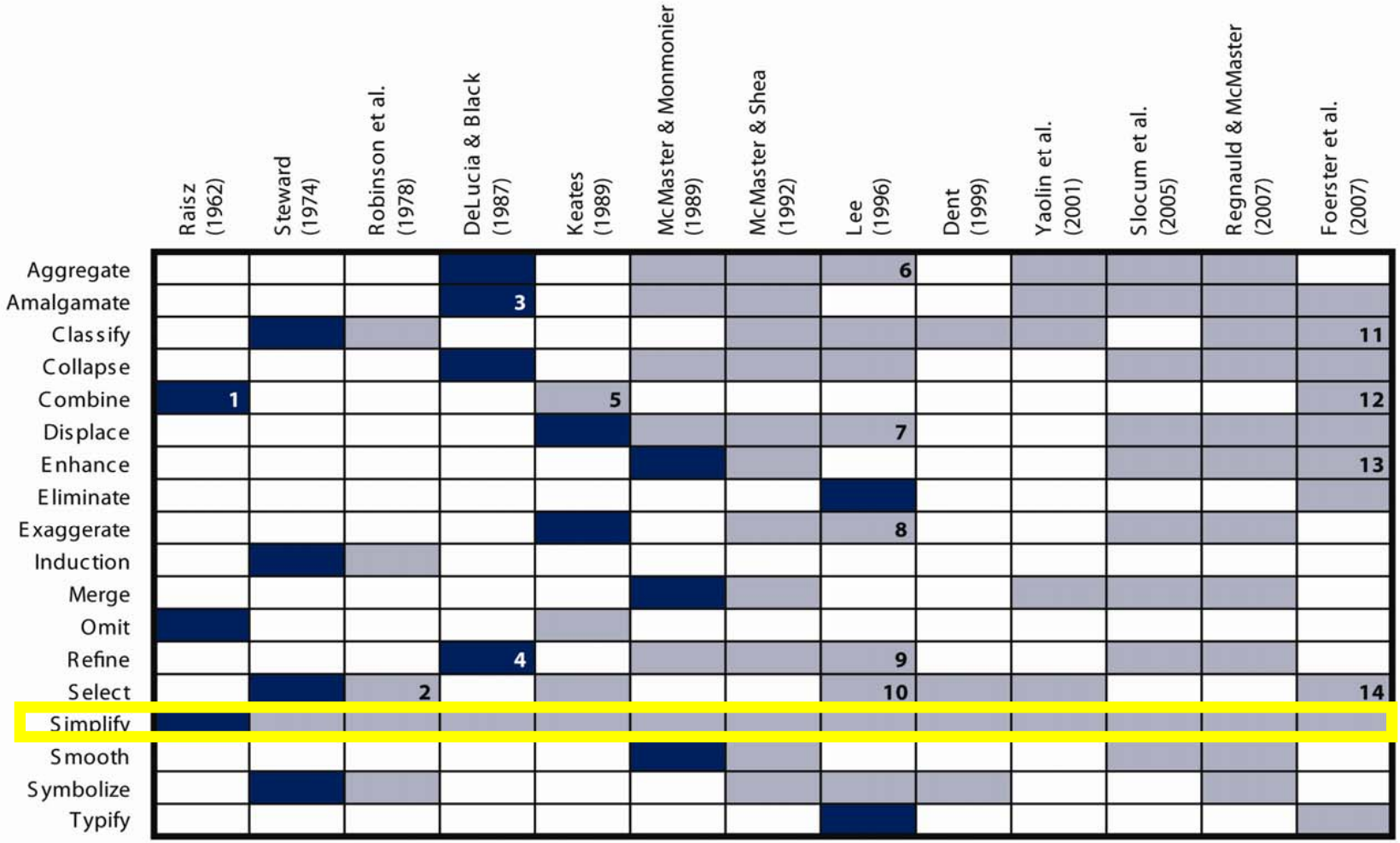

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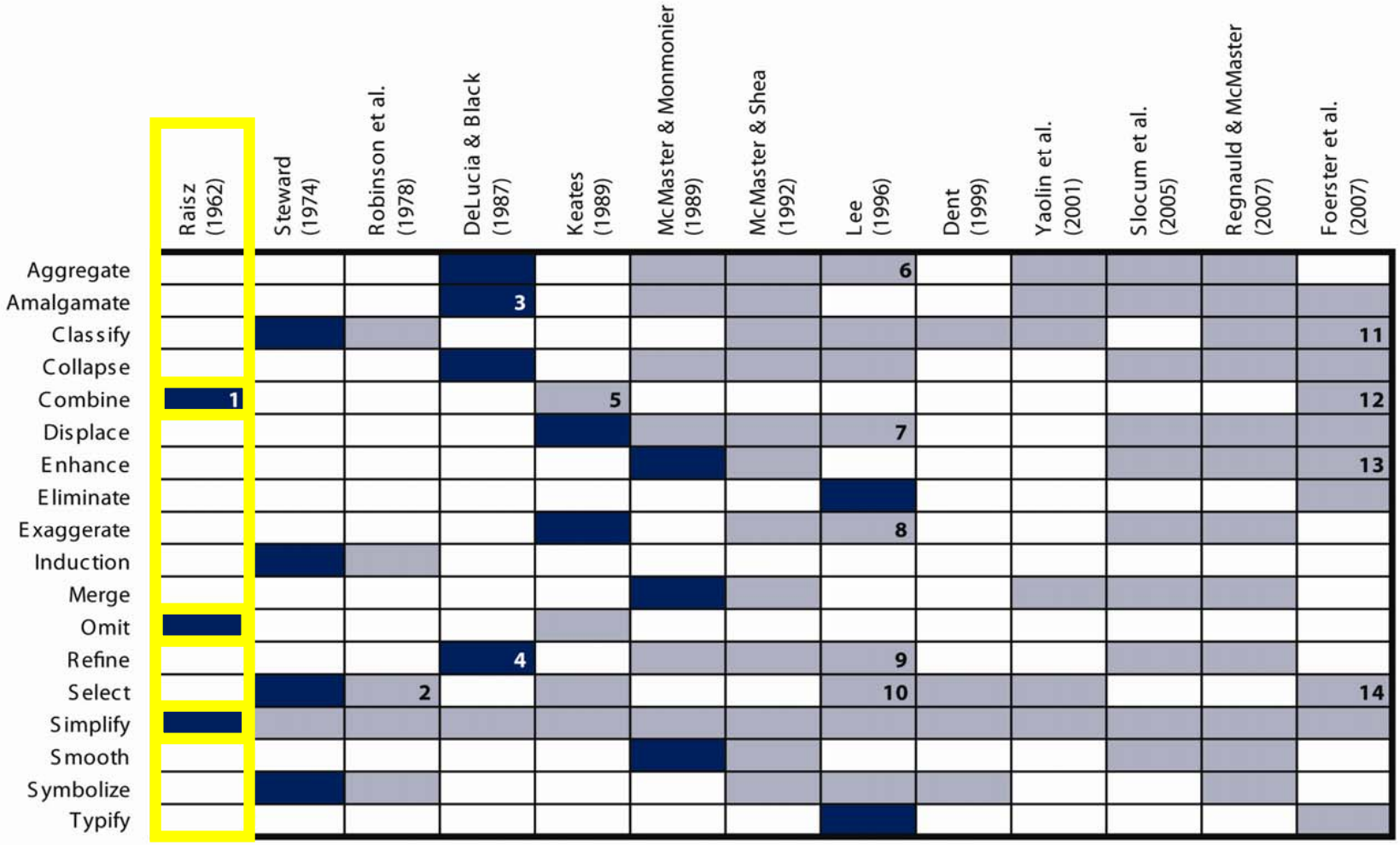
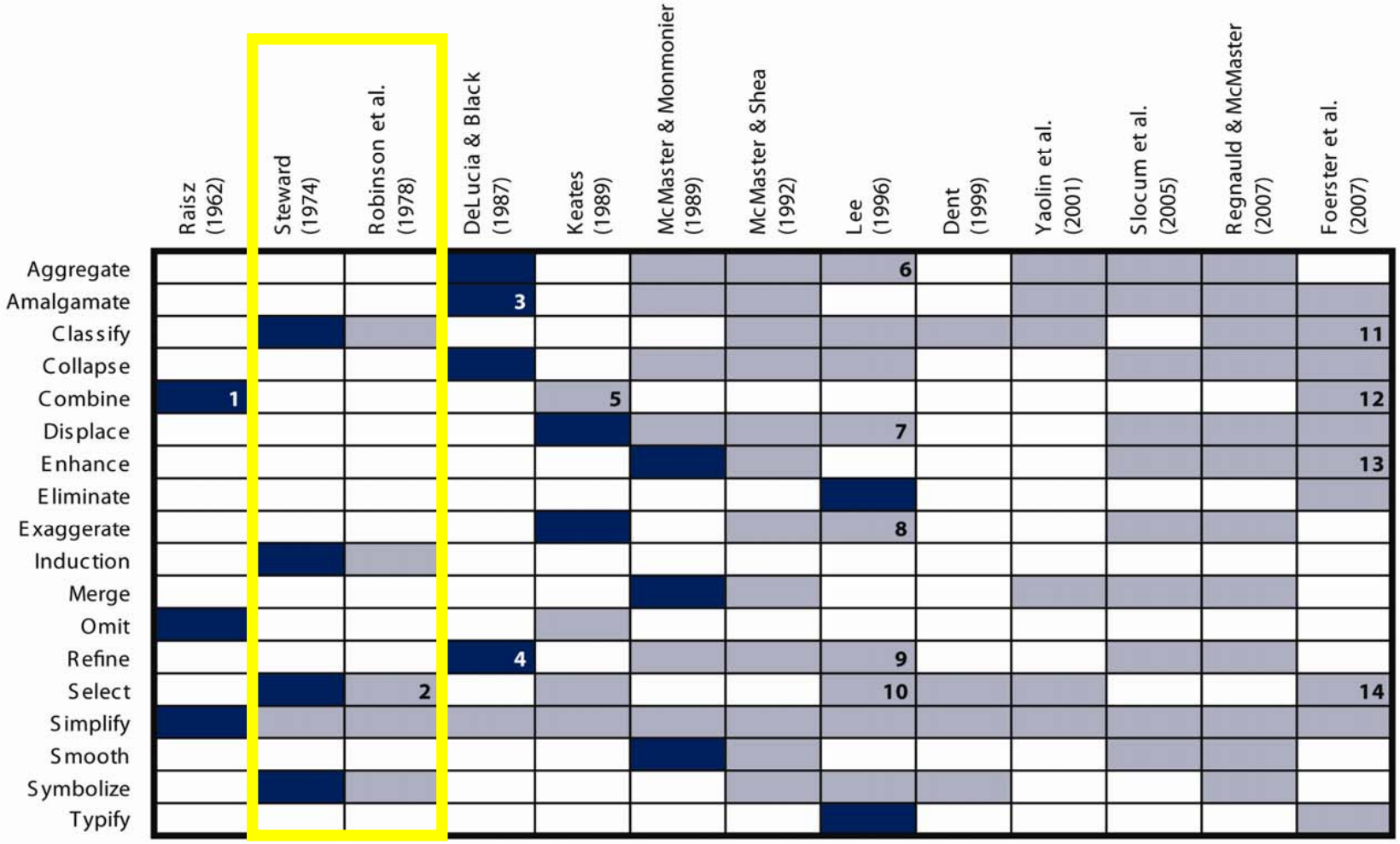


a synoptic view of multi-scale mapping operators



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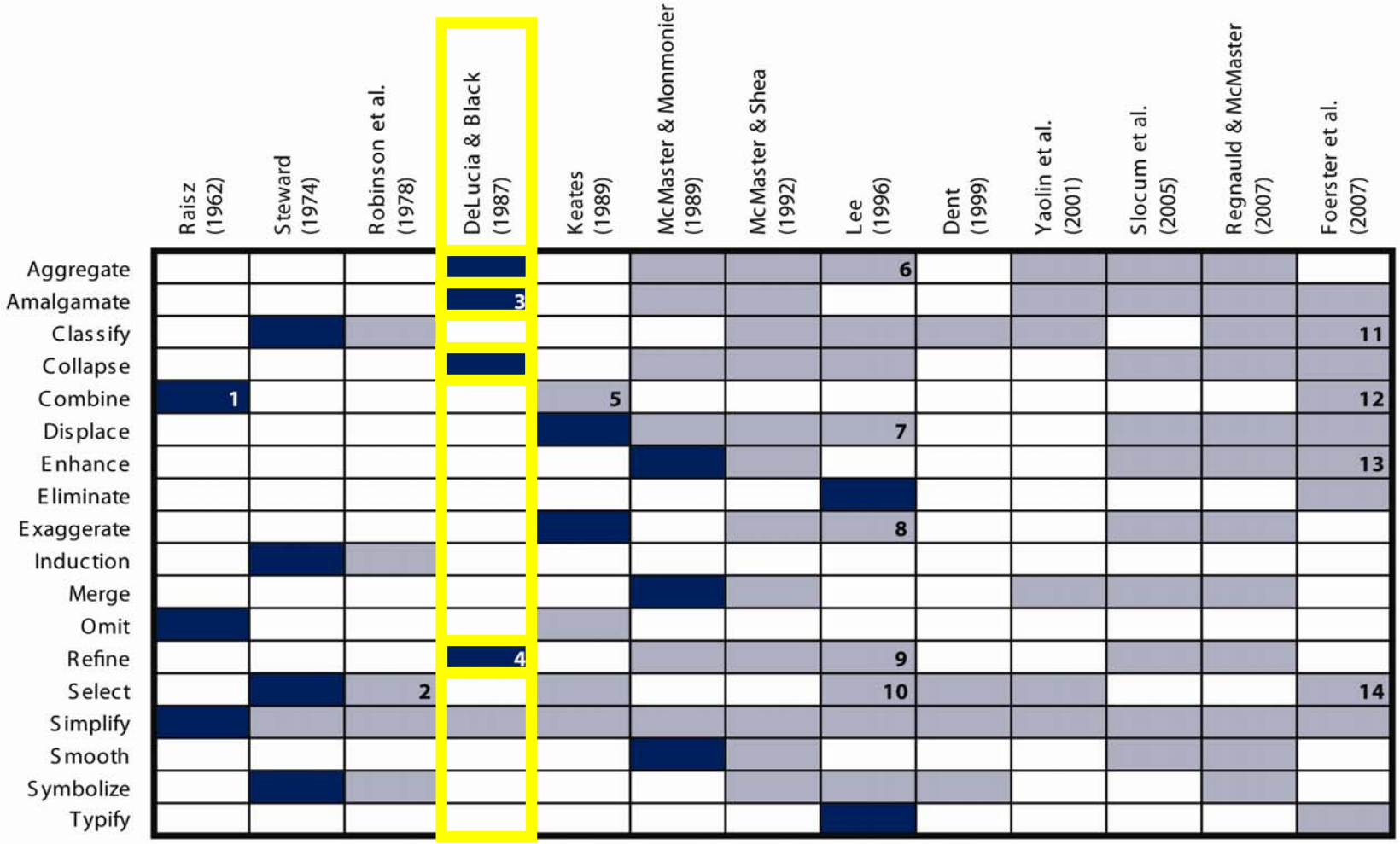

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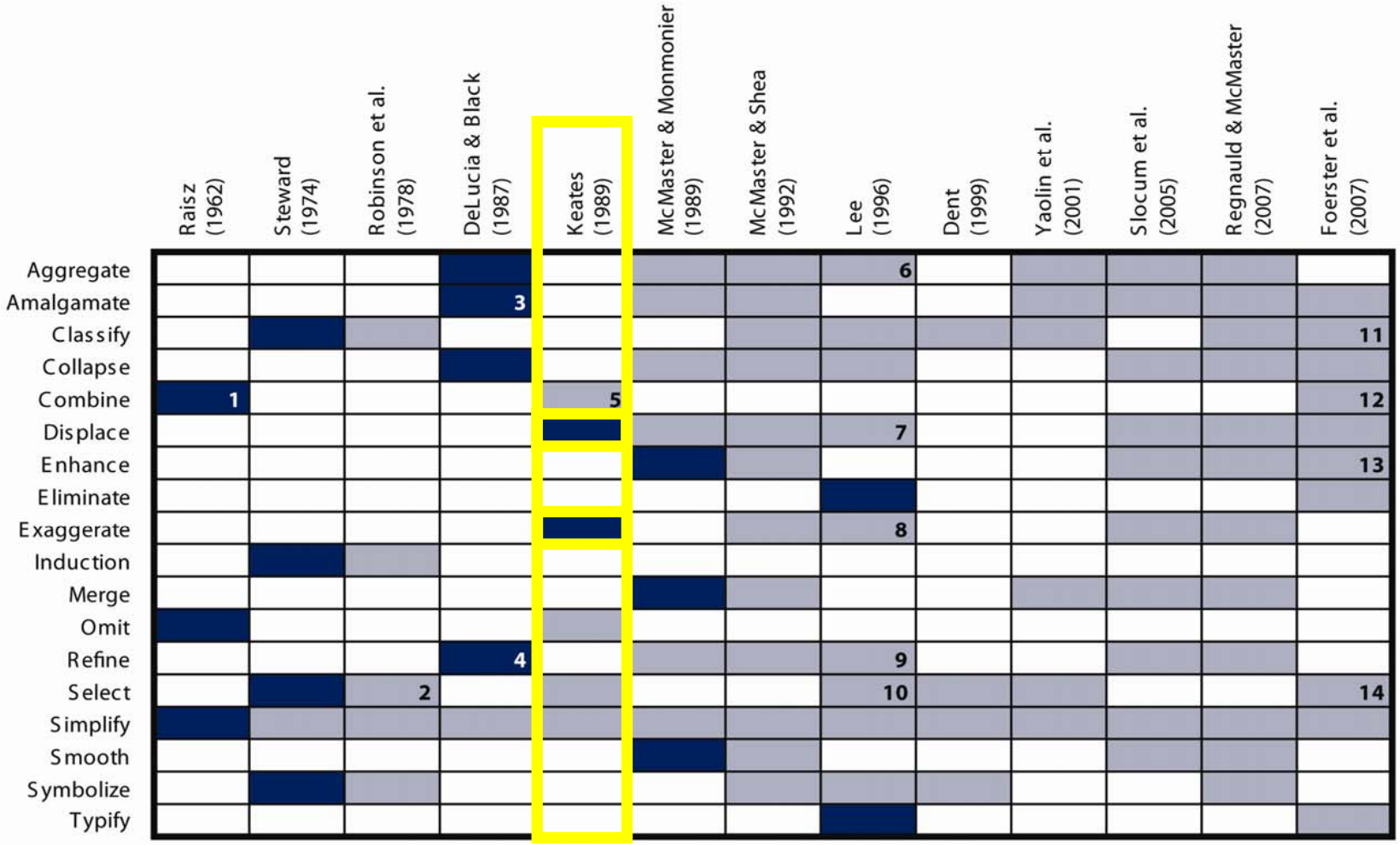

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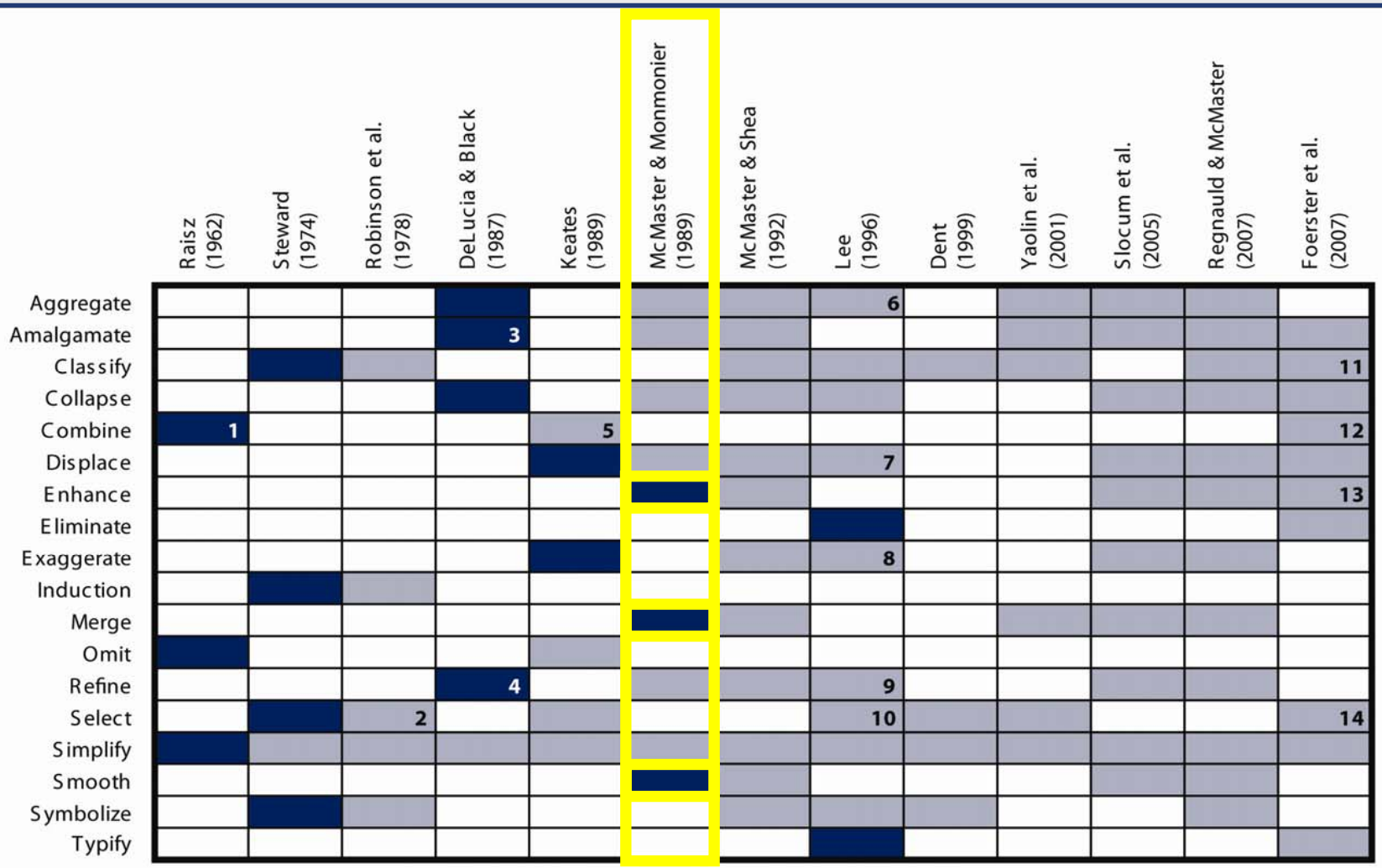

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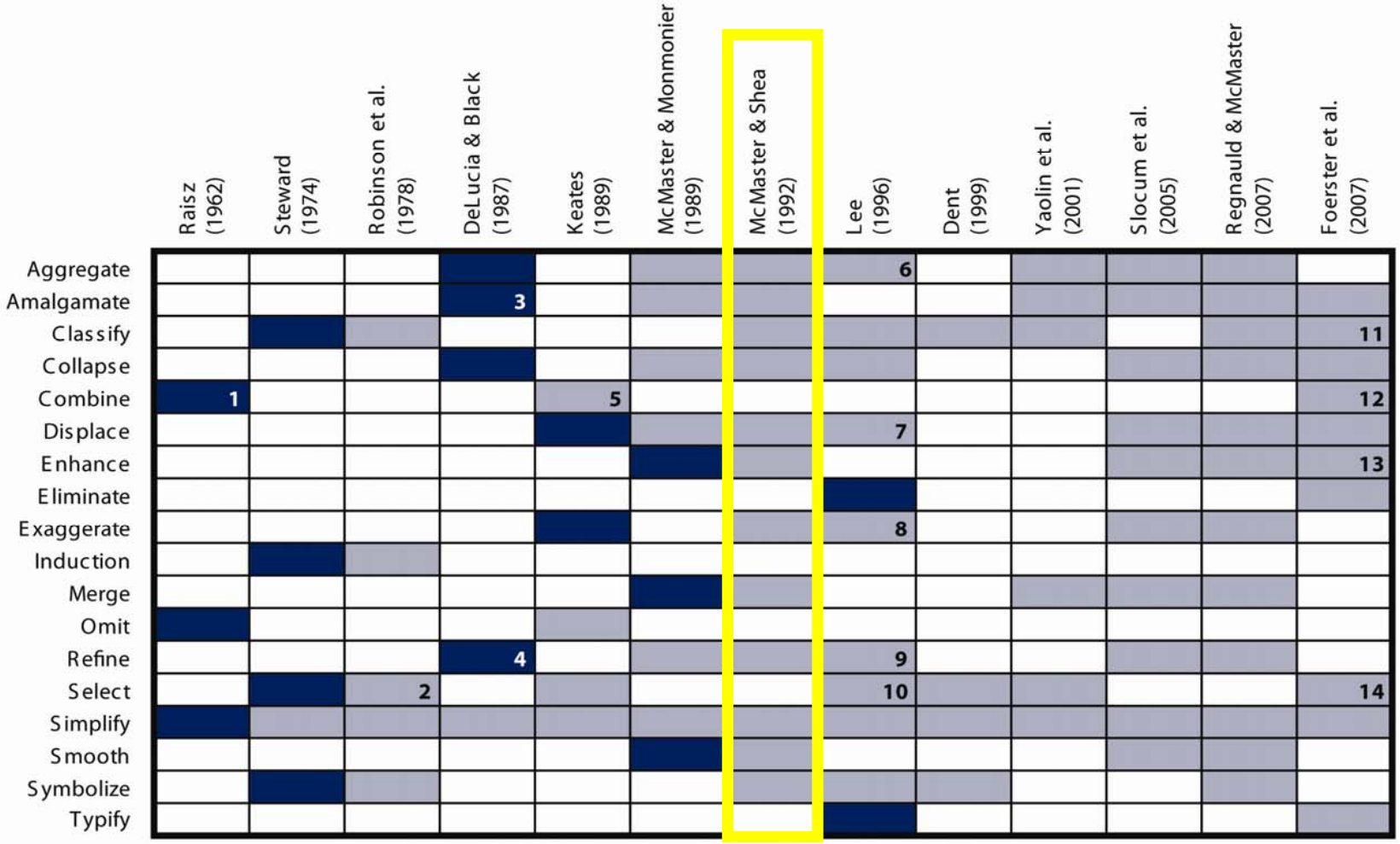

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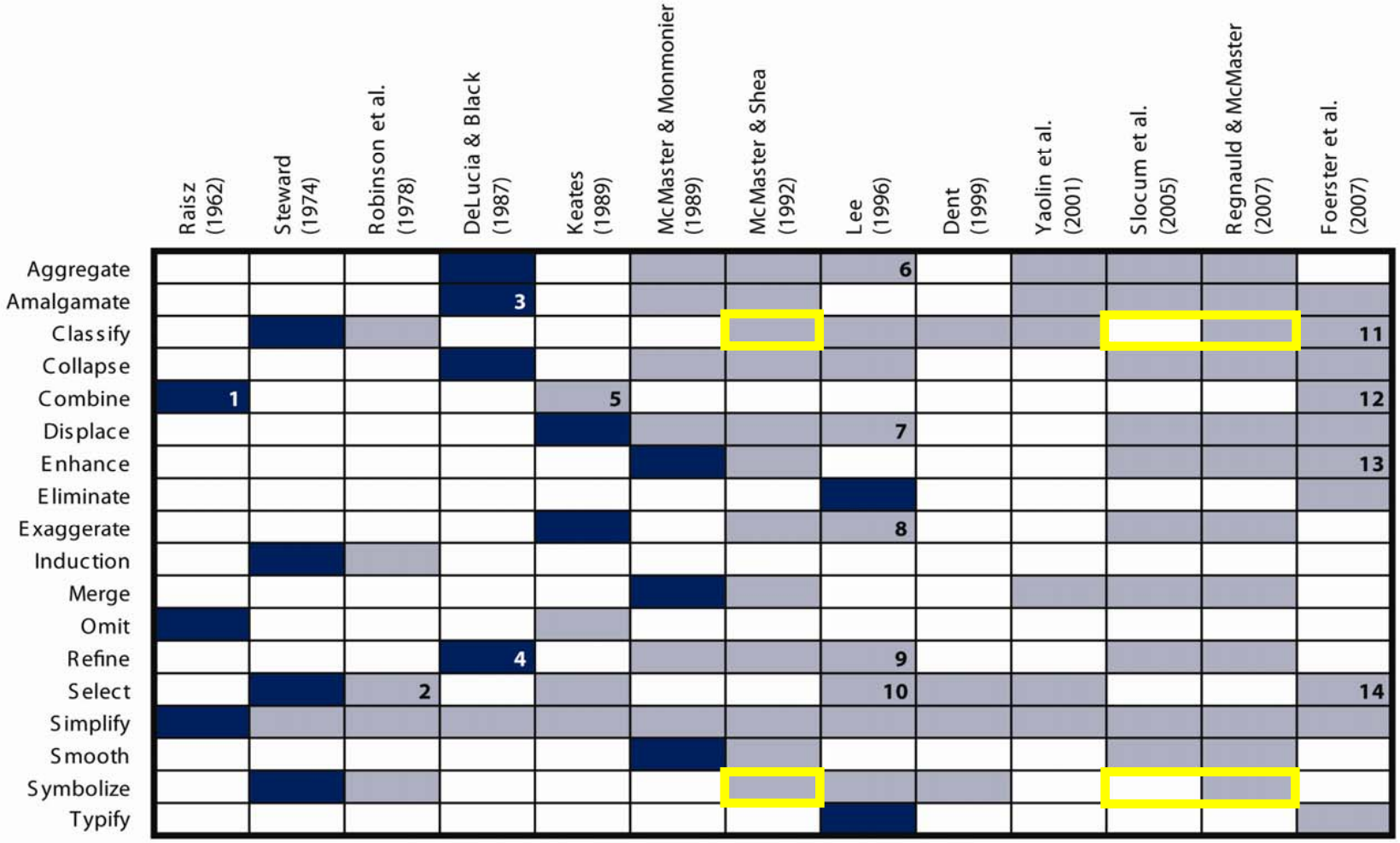

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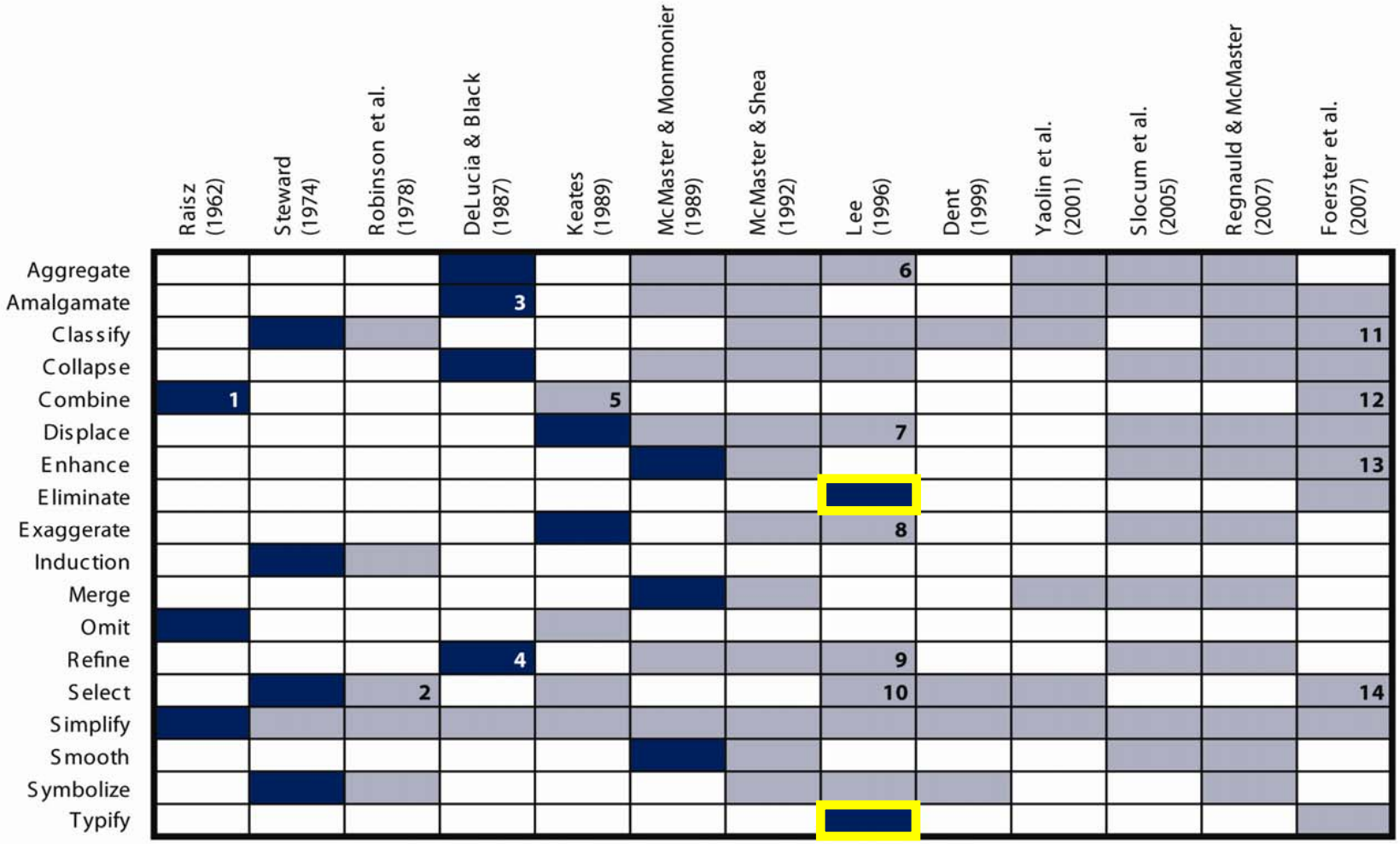

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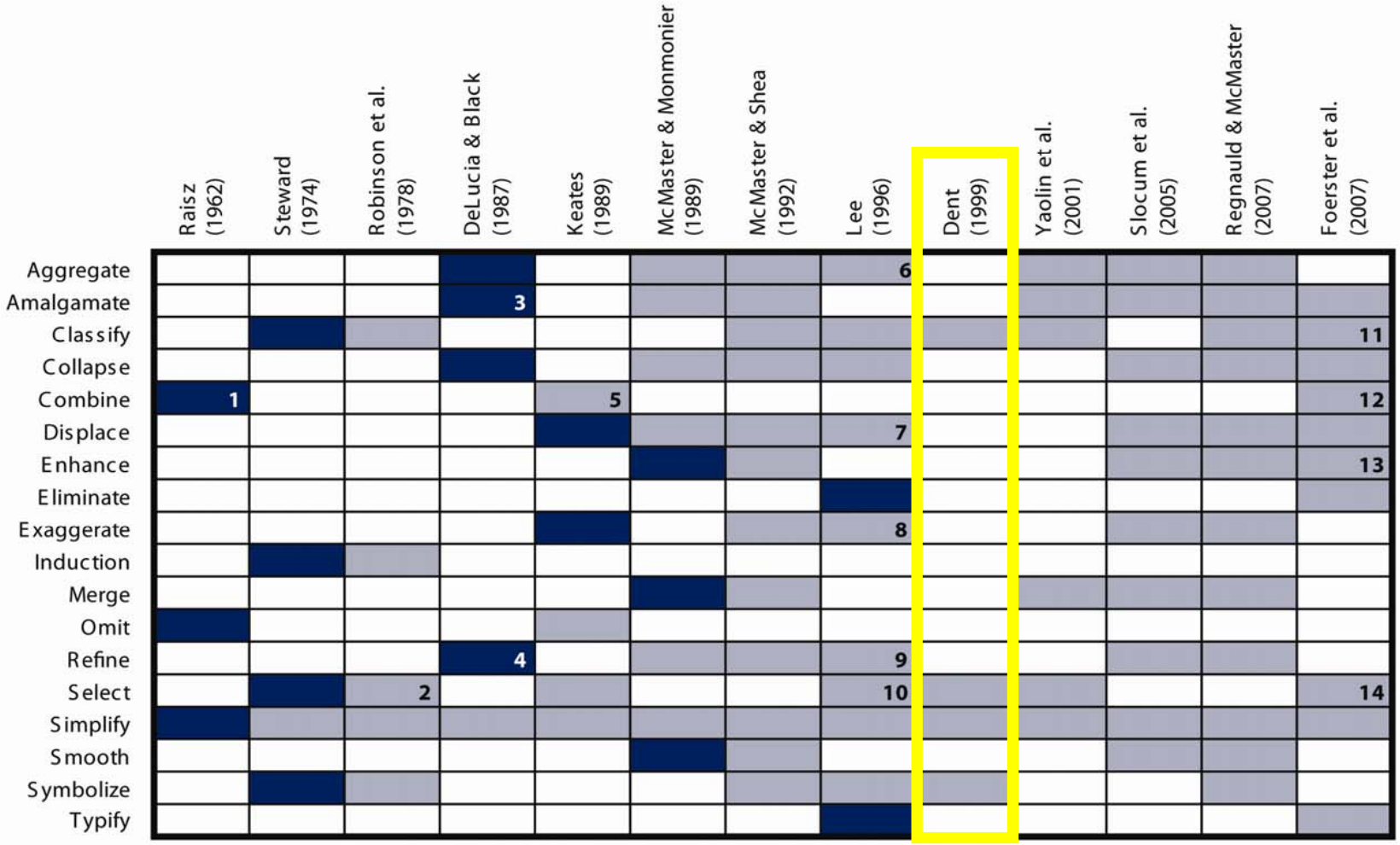

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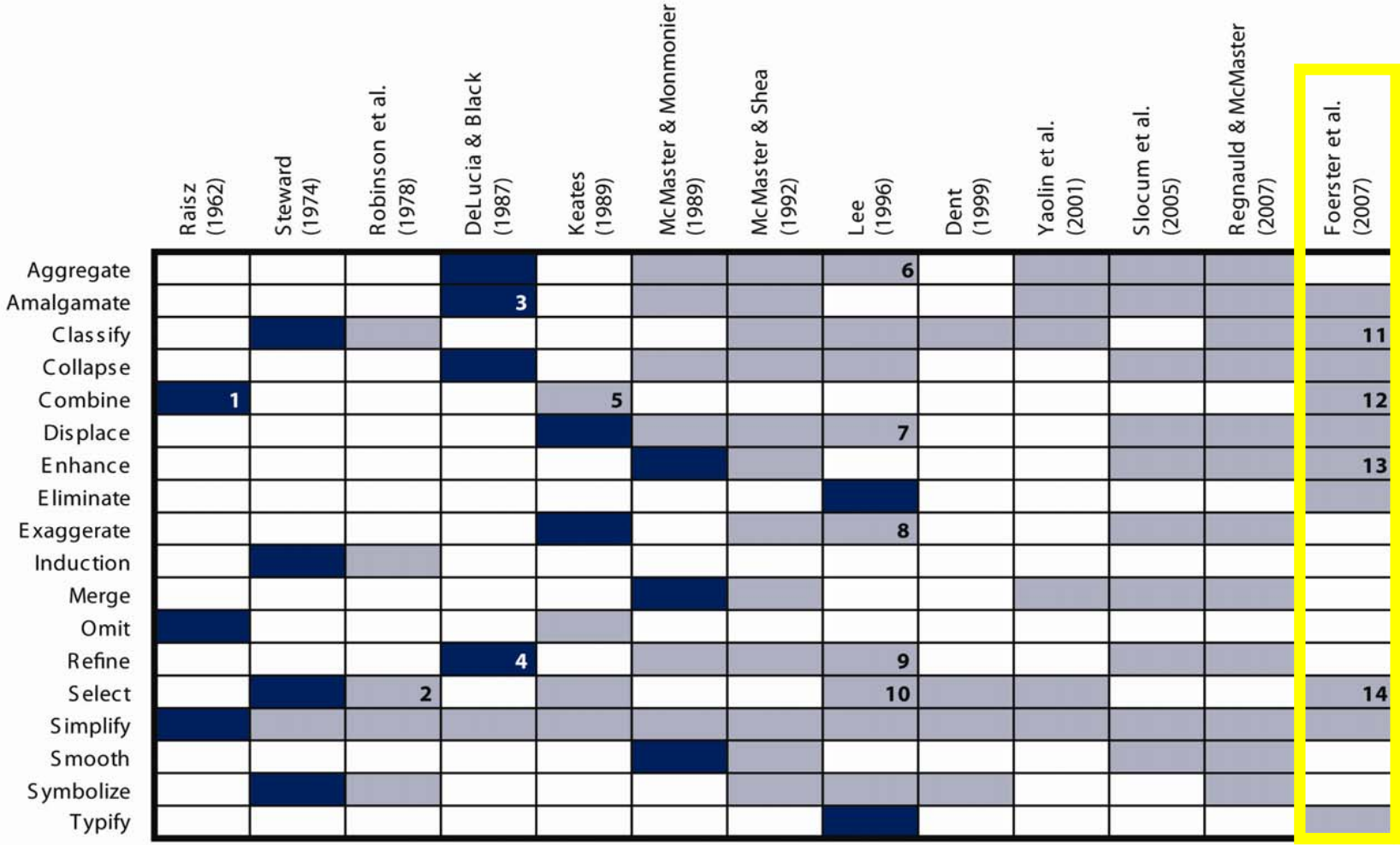

two: macro-level

pre-processing versus generalization
(Robinson et al. 1978)

dimension
(McMaster and Monmonier 1989; Li 2007)

model versus cartographic generalization
(Foerster et al. 2007)

attribute versus spatial transformation
(McMaster and Shea 1992)

two: macro-level

pre-processing versus generalization
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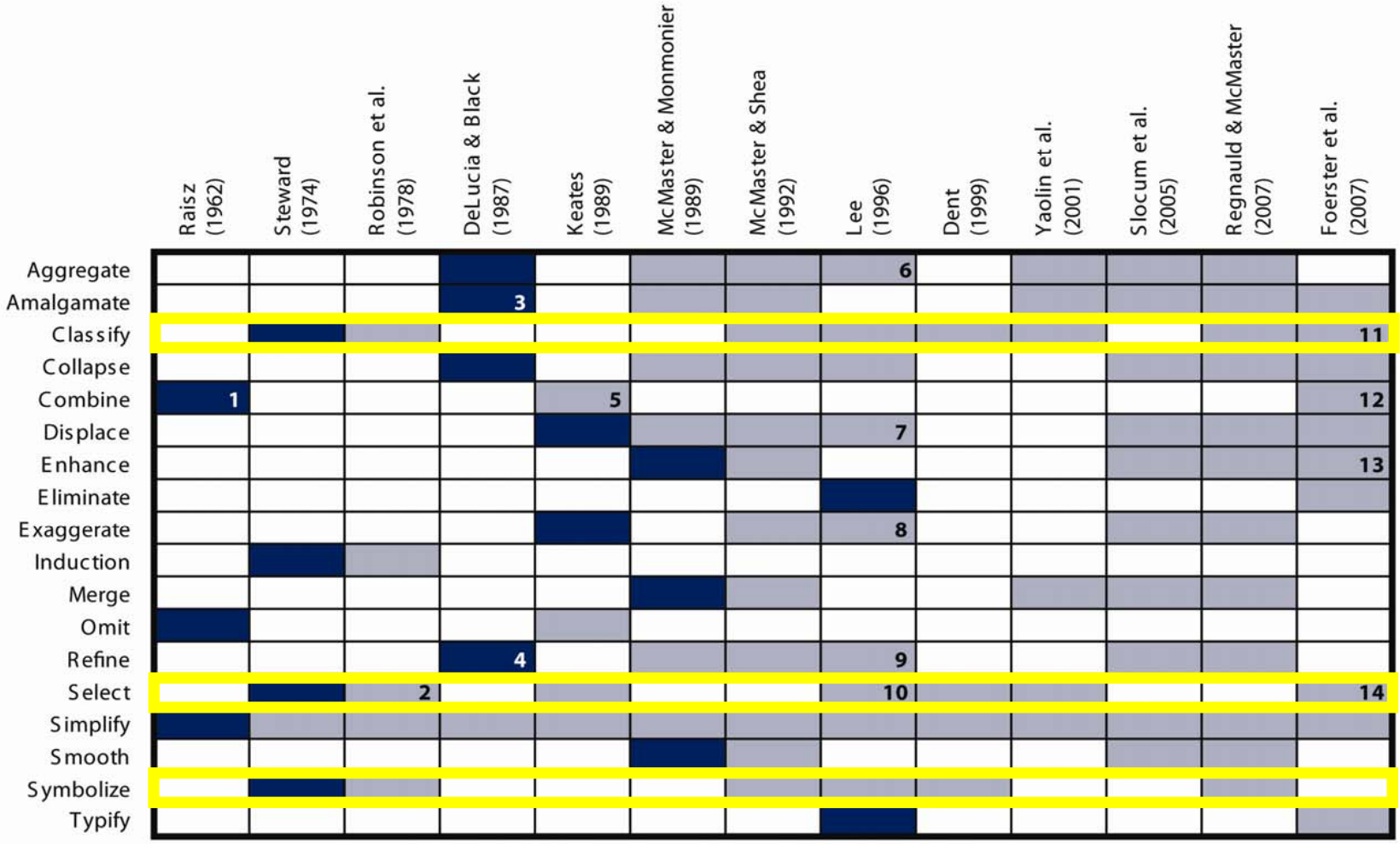
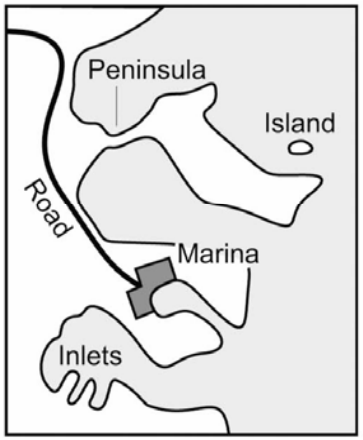


geometry-only versus **cartographer-oriented** views

a.
Original compilation scale



Small map with features reduced to 20 percent of original size (final presentation size):

b1.
No modifications to display or geometry:
- symbol widths retained (1 pt coast line and 2 pt road line),
- feature details and locations retained

c1.
Modify display only:
- thinner road and coast lines,
- remove outline of marina area

d1.
Modify geometry:
- displace road,
- enlarge island and peninsula neck,
- eliminate small islands,
- collapse marina area to point symbol

e1.
Modify both display and geometry:
- thinner road (less width change than c1) and coast,
- displace road (less displacement than d1) and small inlets,
enlarge island and peninsula neck (less enlargement than d1),
- simplify marina area (retain general shape) and remove area outline

Screen images of small maps enlarged to 200 percent:

b2.

c2.

d2.

e2.

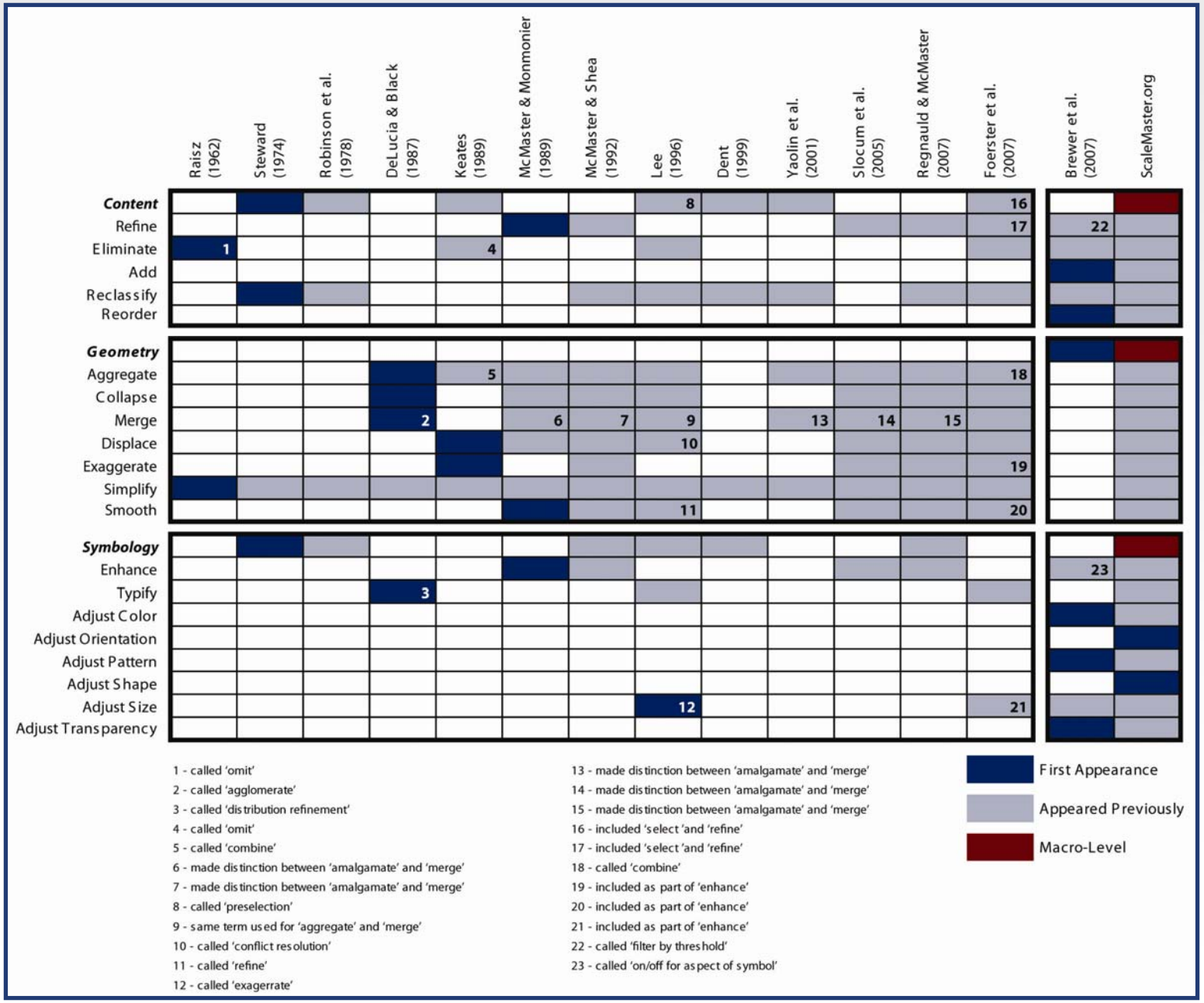
geometry versus symbology for multi-scale mapping (Brewer and Buttenfield 2007)

Table 1. Types of map design decisions for scale change
The letters listed below code each decision in the ScaleMaster diagrams (Figures 2 to 5)

code	*description*
s –	size change
c –	color change
p –	pattern change (e.g., dash, crosshatch)
t –	transparency change
l –	modify label appearance (e.g., bold, italic, character spacing, leading)
i –	improve label positions in relation to nearby features or labels (e.g., overrun, remove duplicates, feature weighting)
o –	on/off for aspect of symbol or label (e.g. remove outlines for areas with feature type still present)
r –	reclassify features by attribute (e.g. fewer categories)
f –	filter by threshold on feature attribute (e.g., filter on size to remove small parks)
e –	eliminate layer or eliminate by feature type (e.g., eliminate intermittent streams)
a –	add layer or add by feature type (e.g., add labels for physiographic features classed as large; similar level of generalization--not a geometry change)
x –	change layer order in TOC (e.g., roads moved from beneath transparent area to above)
R –	use Representations tools (e.g., set endings of dashes with full pattern)
G –	geometry change (e.g., new data set or new layer with generalized features)

Brewer et al.'s (2007) list of map design decisions for scale change - note that most decisions reflect a change in *content* or *symbology*

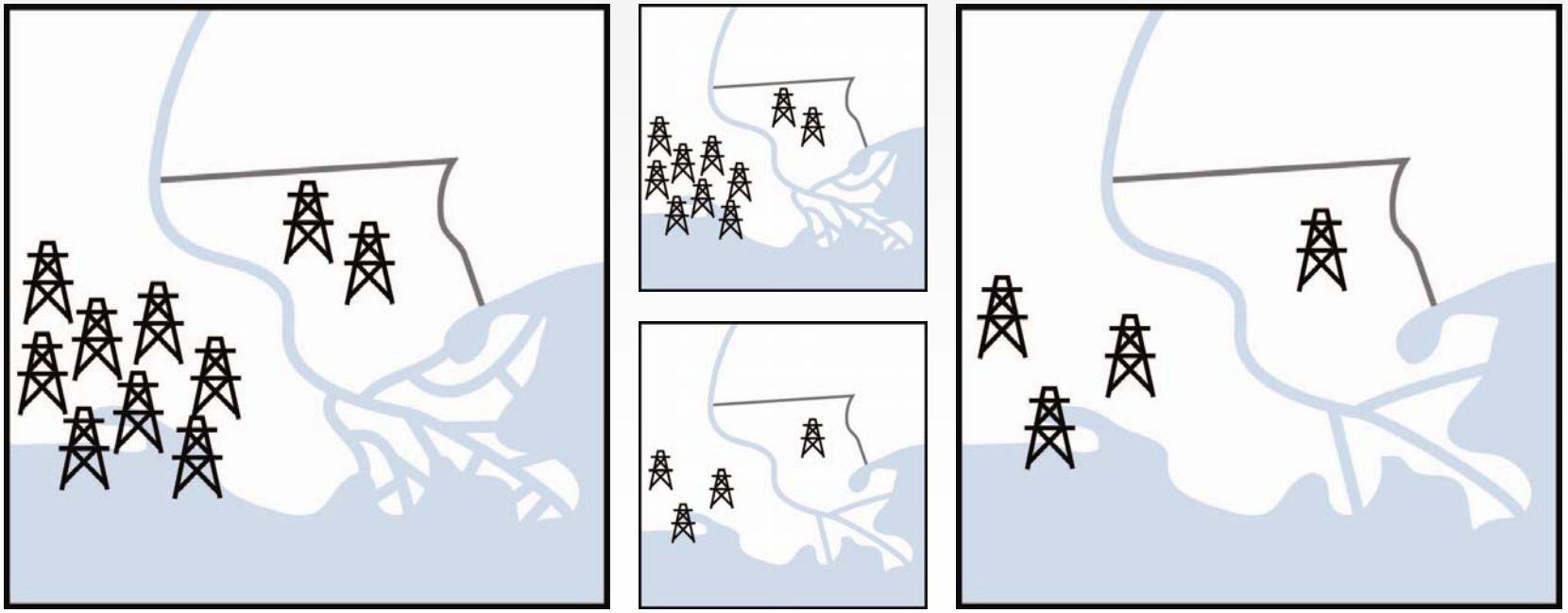
a synoptic view of multi-scale mapping operators



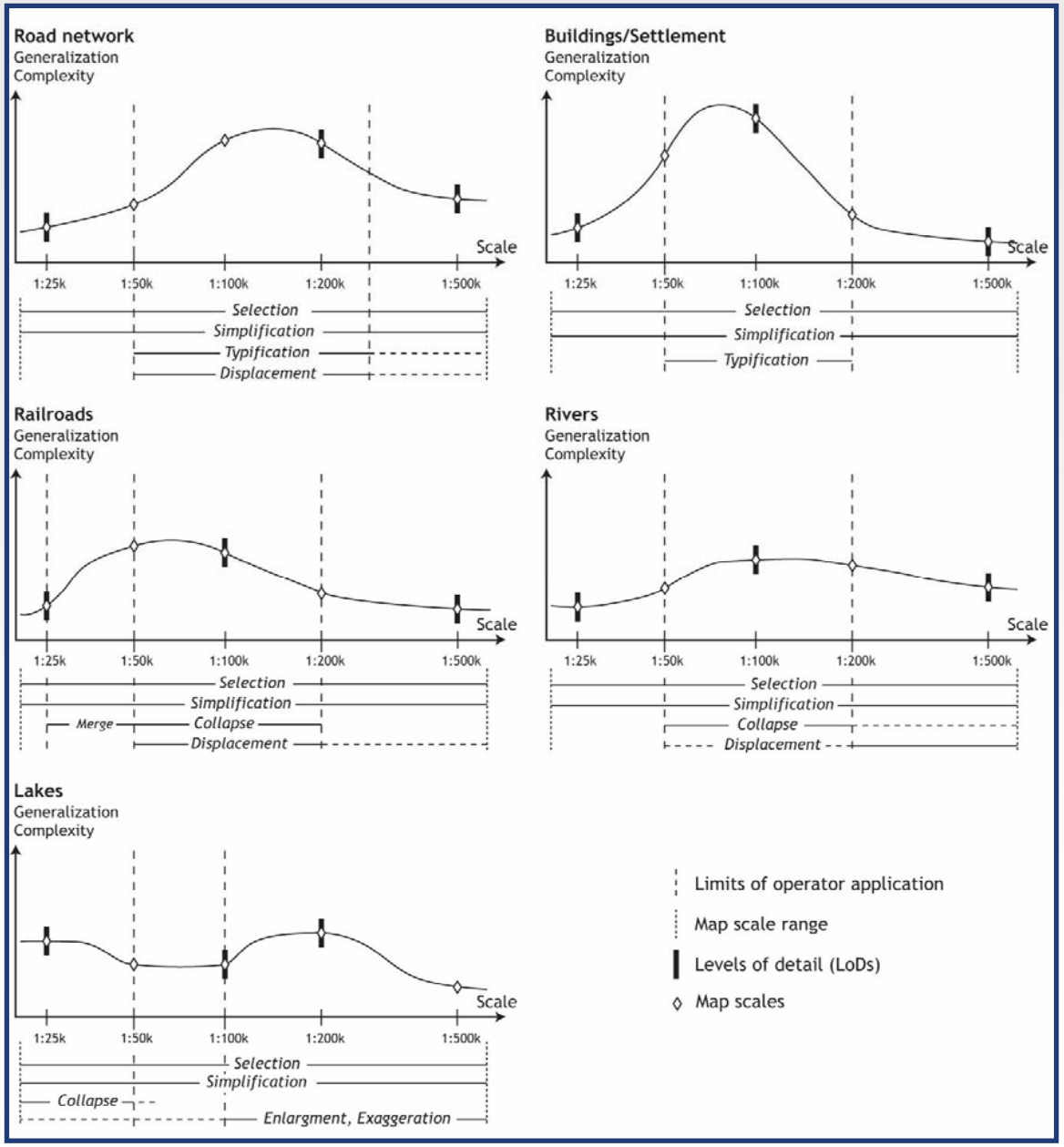
typify

Sy

reduction in complicatedness of many related features by replacing them with a smaller, representative arrangement of the same symbols



future directions



scope of generalization operators from Cecconi et al. (2002)

questions?

thanks for your time!

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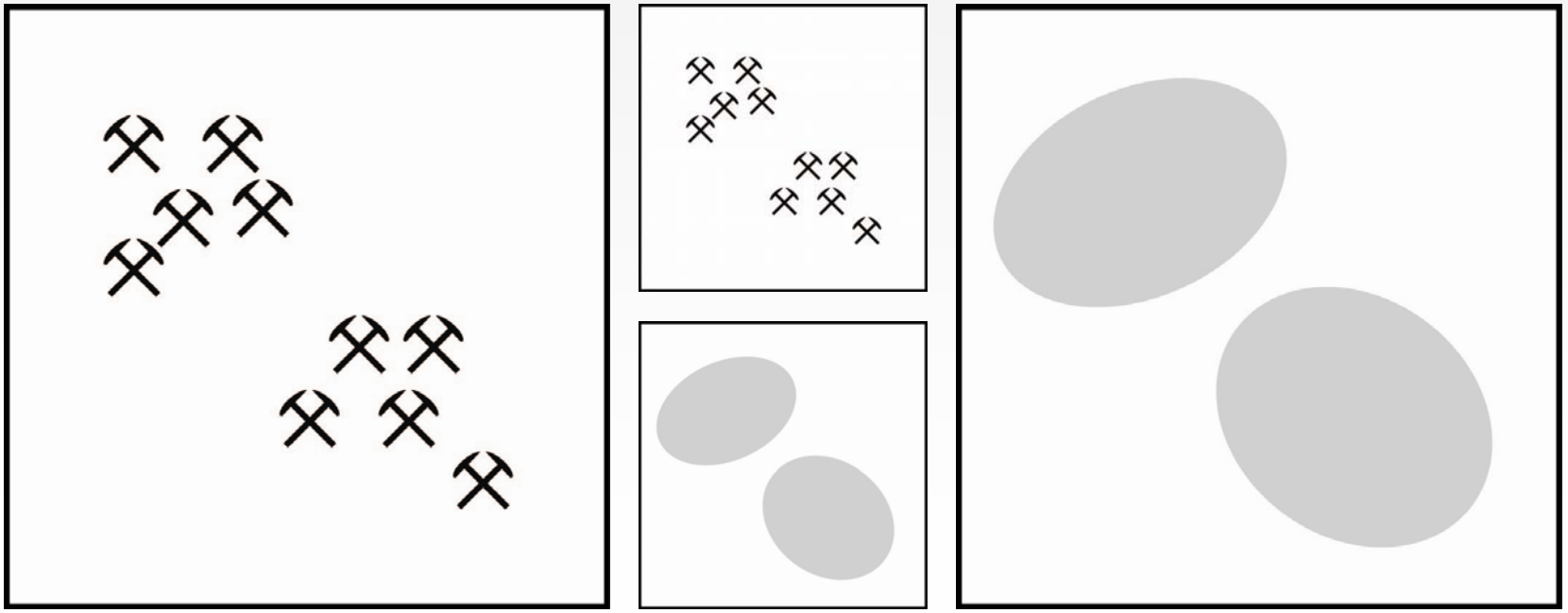
aggregate

Ga

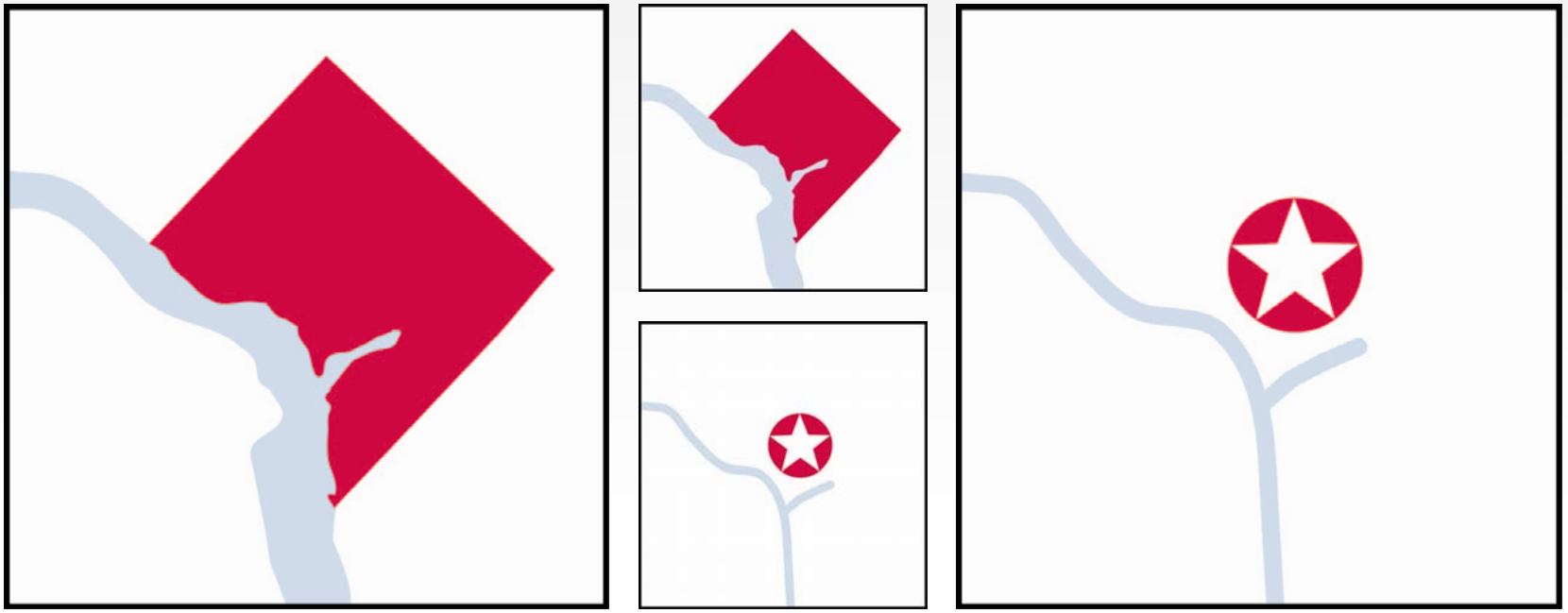
reduction in complicatedness of many related features by replacing them with a representative feature of increased dimensionality



collapse

Gc

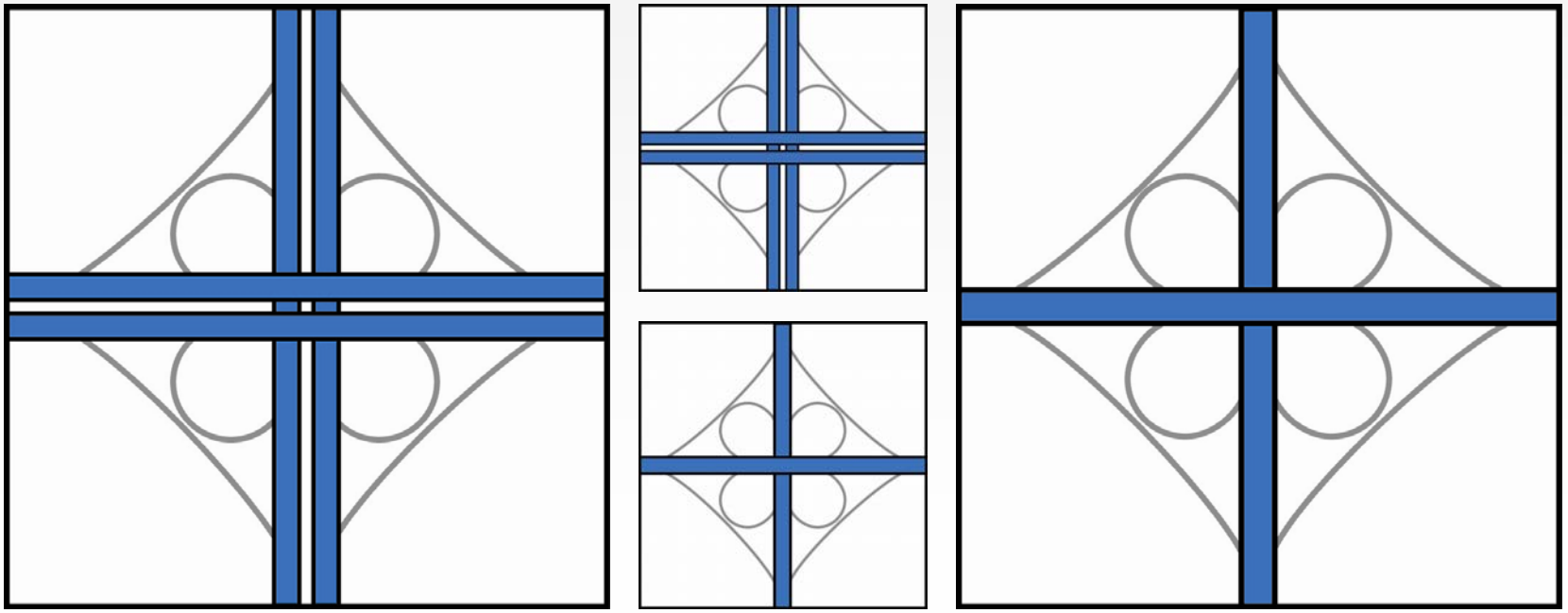
reduction in complicatedness of a feature or features by replacing it/them with a representative symbol of lower dimensionality



merge

Gm

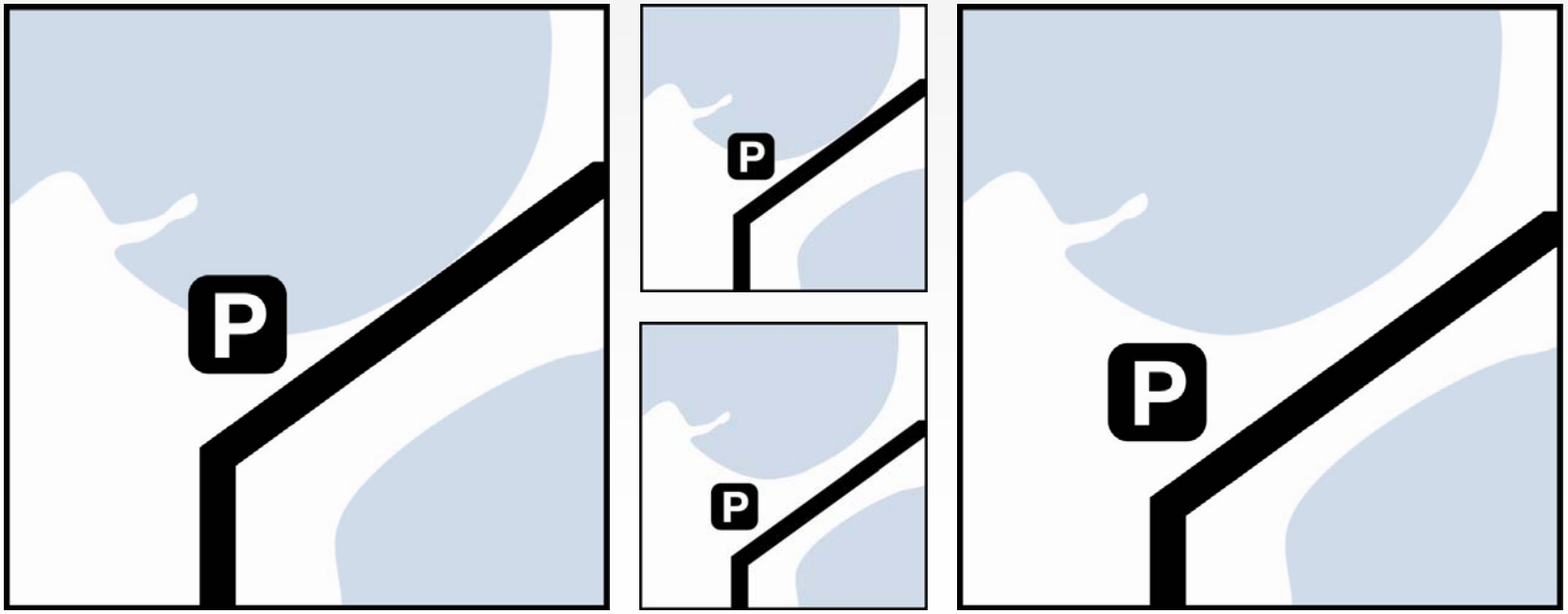
reduction in complicatedness of many related features by replacing them with a representative symbol of equal dimensionality



displace

Gd

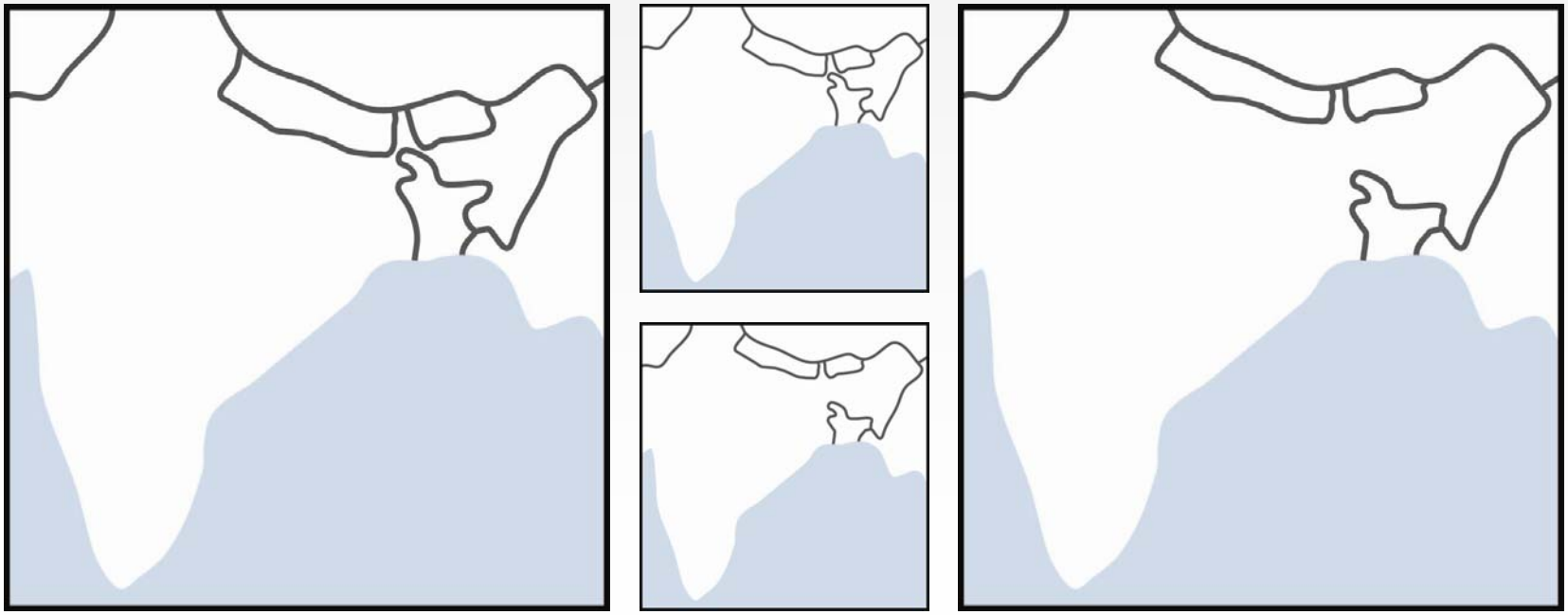
adjustment in the location of a point, line, or polygon feature to avoid coalescence with other surrounding features



exaggerate

Gx

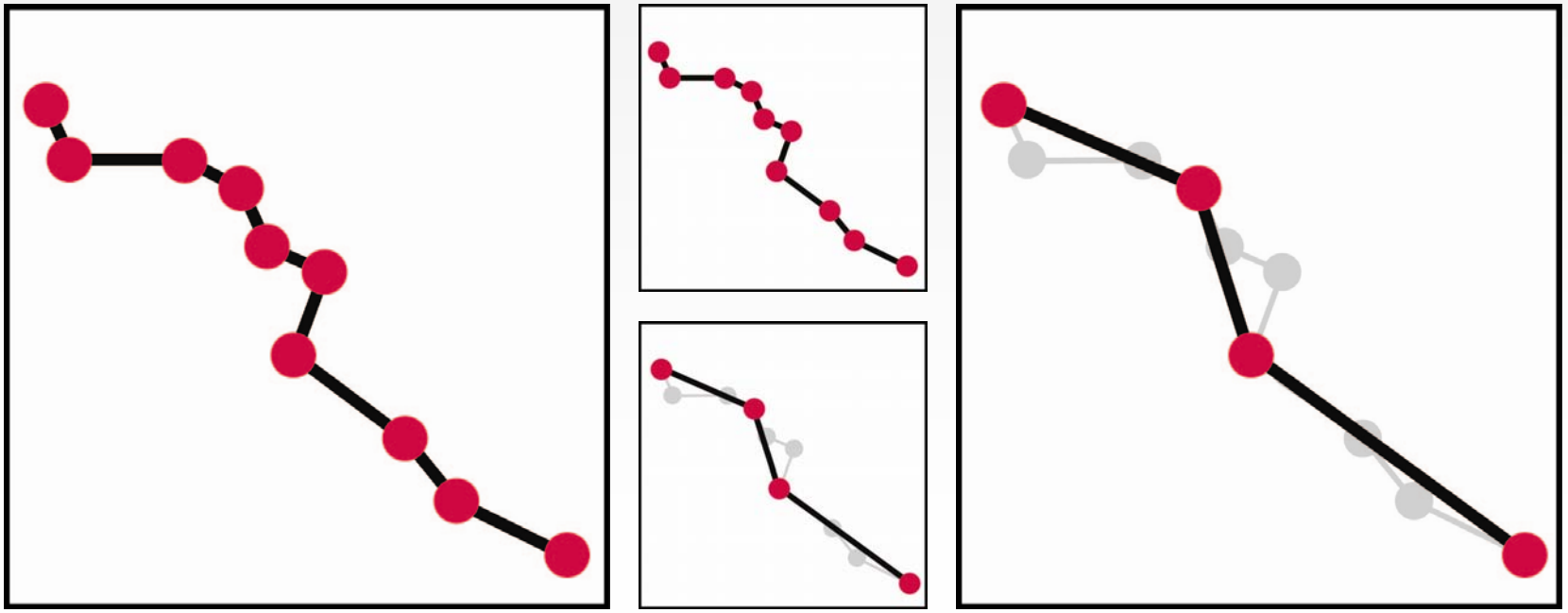
amplification or adjustment of portion of a feature to emphasize or maintain a characteristic aspect of it



simplify

Gs

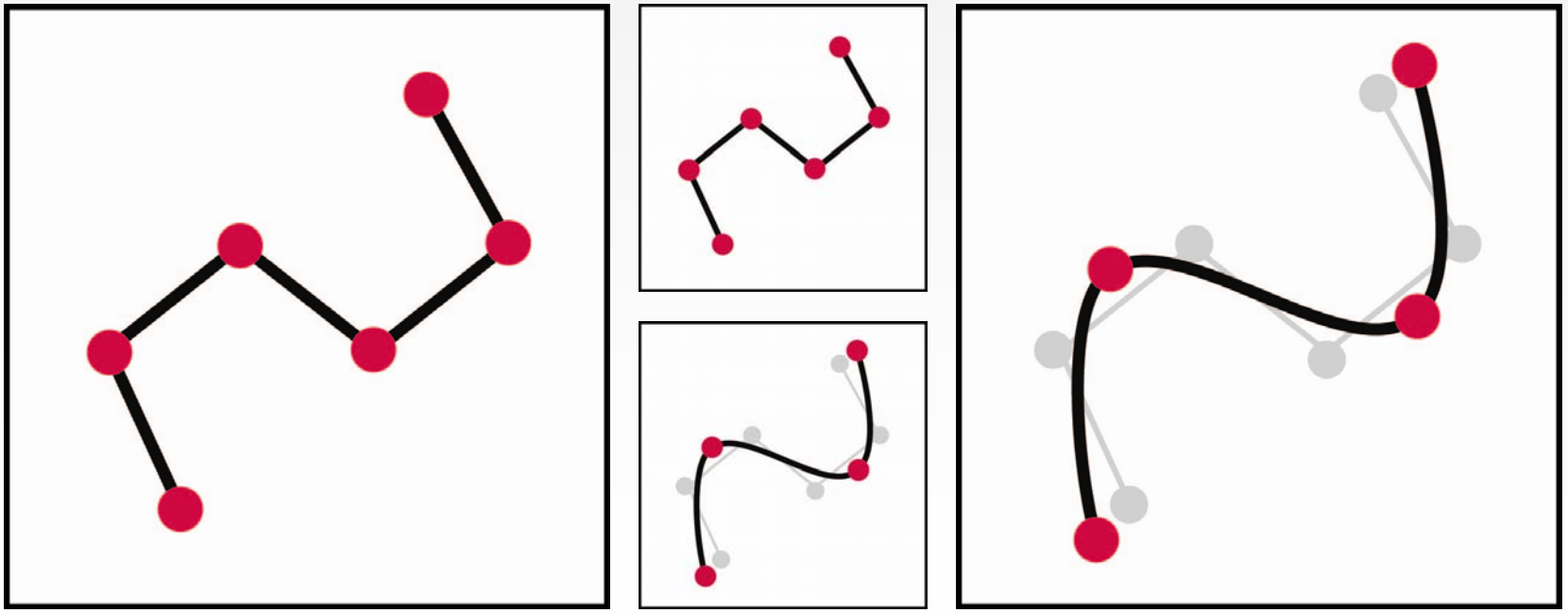
reduction of the number of points constituting a feature



smooth

Go

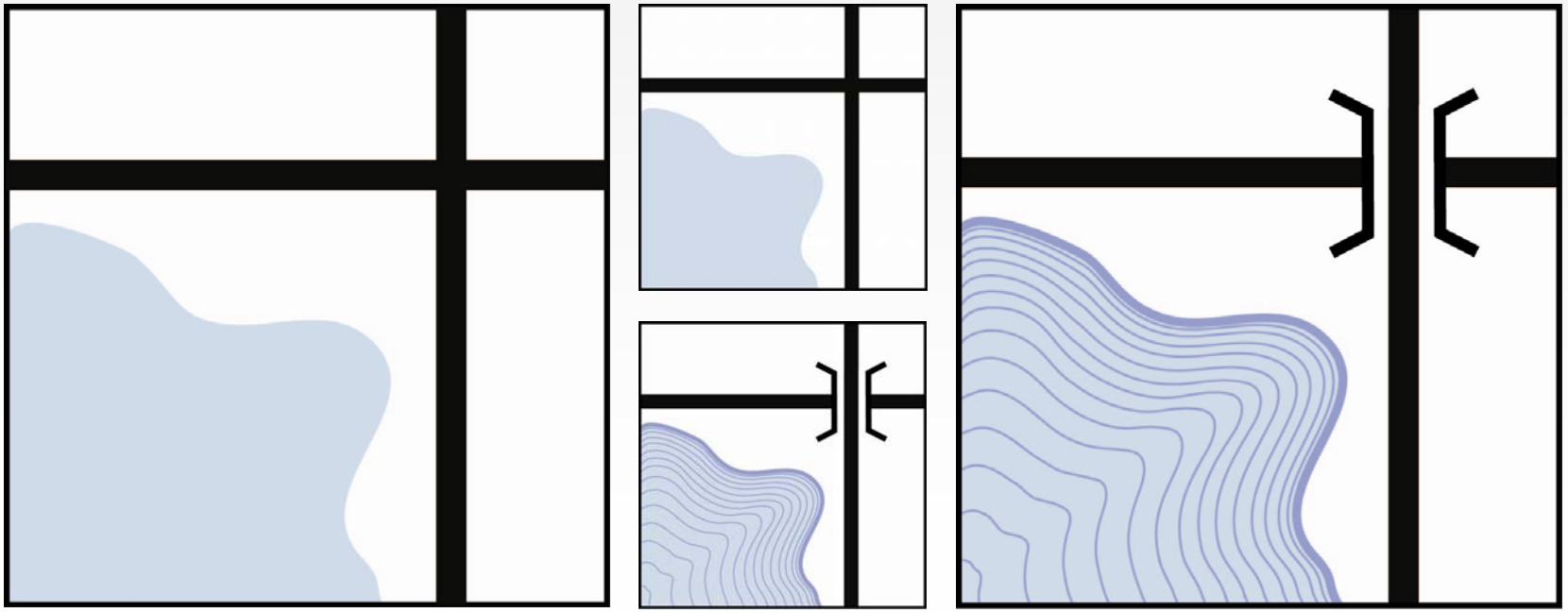
removal of small variations of a line or polygon to improve its appearance



enhance

Se

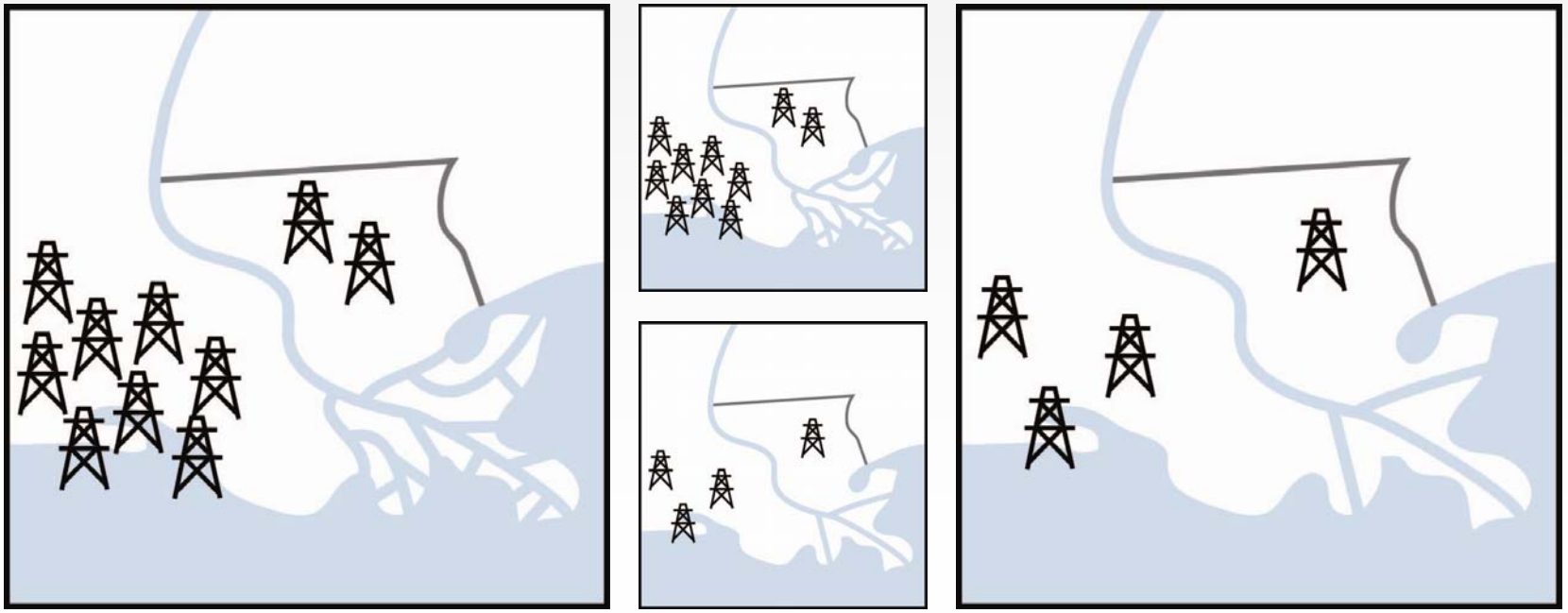
inclusion of graphic embellishments around or within a symbol to maintain or emphasize important characteristics of its relations to other features



typify

Sy

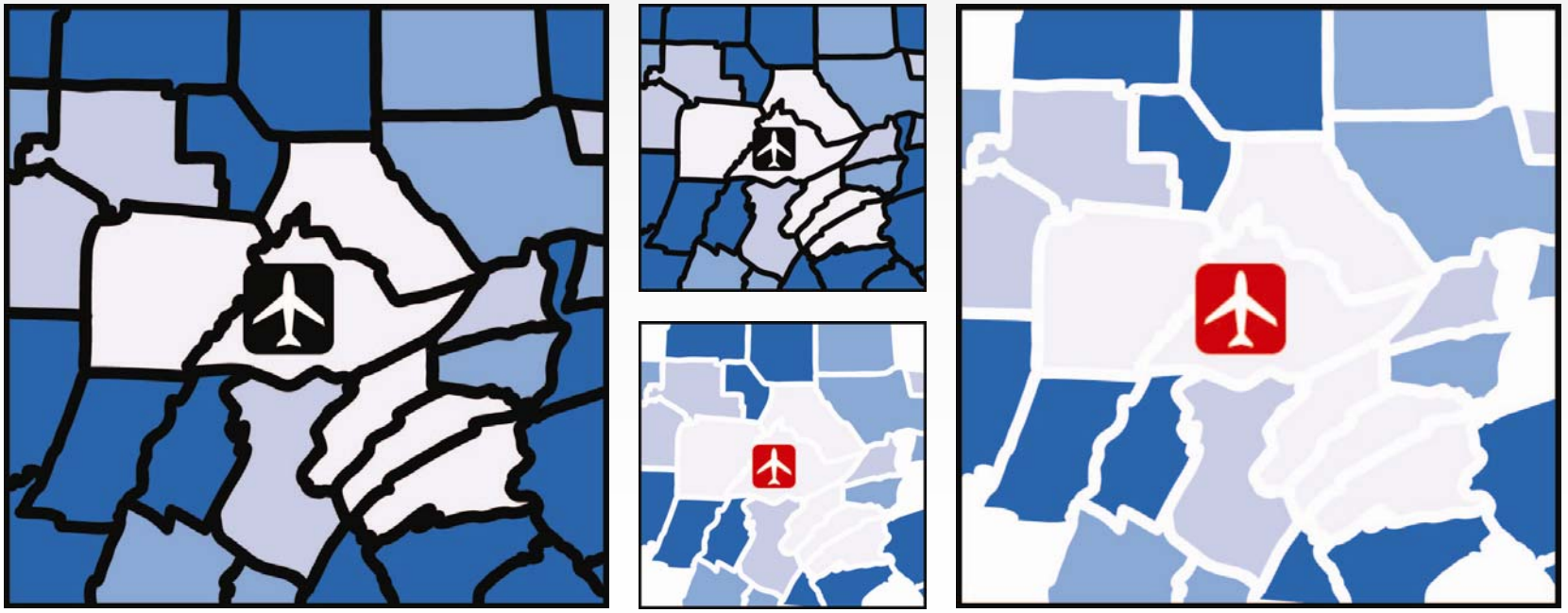
reduction in complicatedness of many related features by replacing them with a smaller, representative arrangement of the same symbols



color

Sc

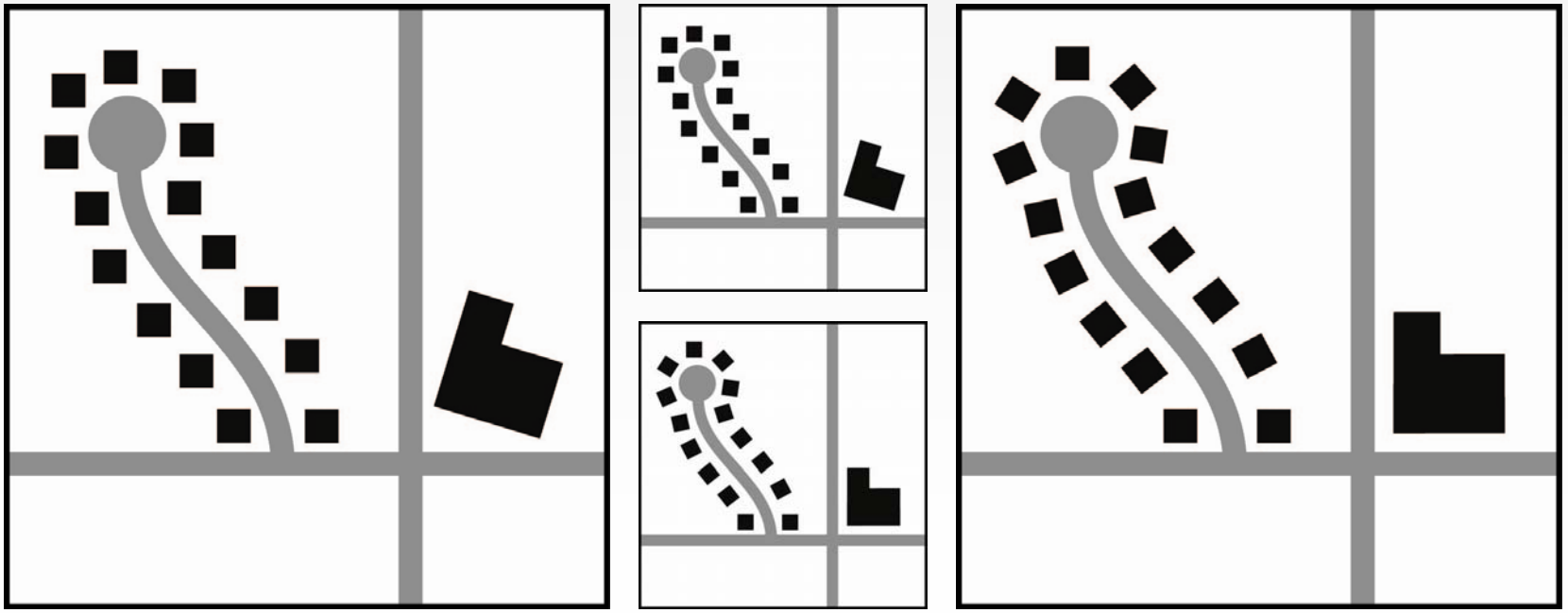
Adjustment of symbol color to ensure legibility of the feature or surrounding features.



orientation

So

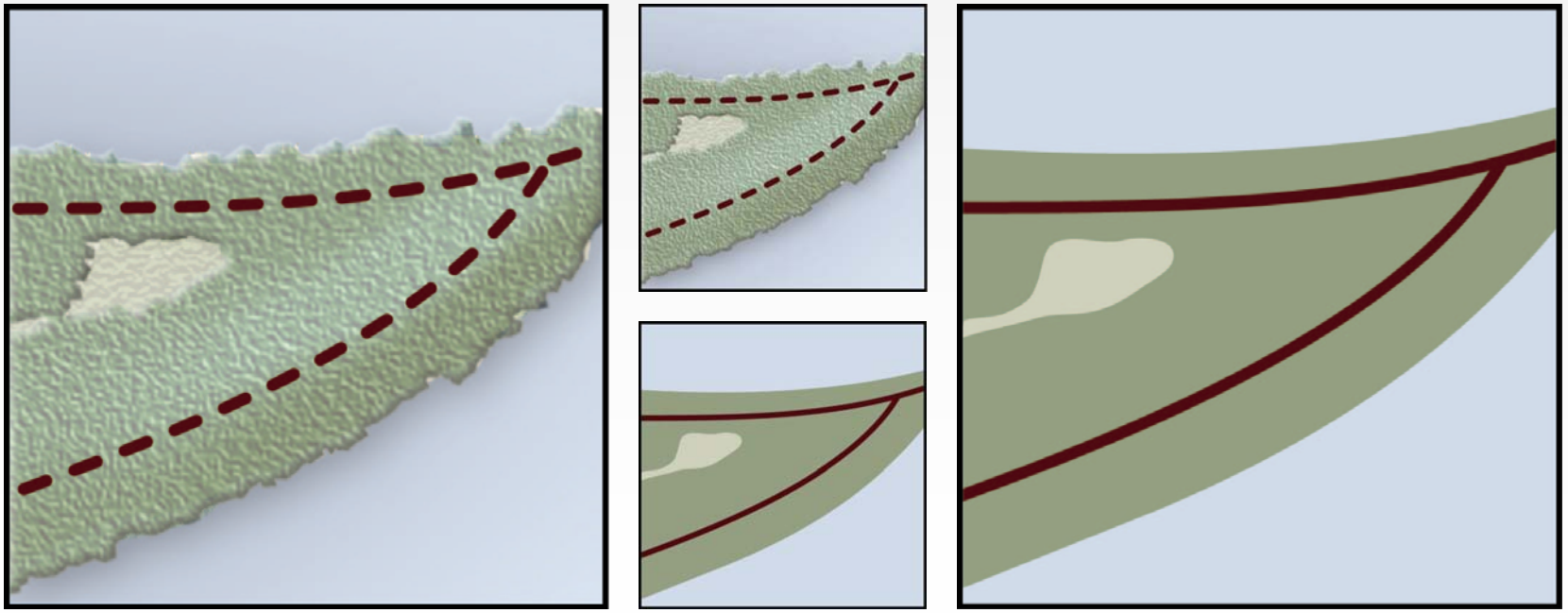
adjustment of the rotation of a symbol to maintain or emphasize important characteristics of its relations to other features



pattern

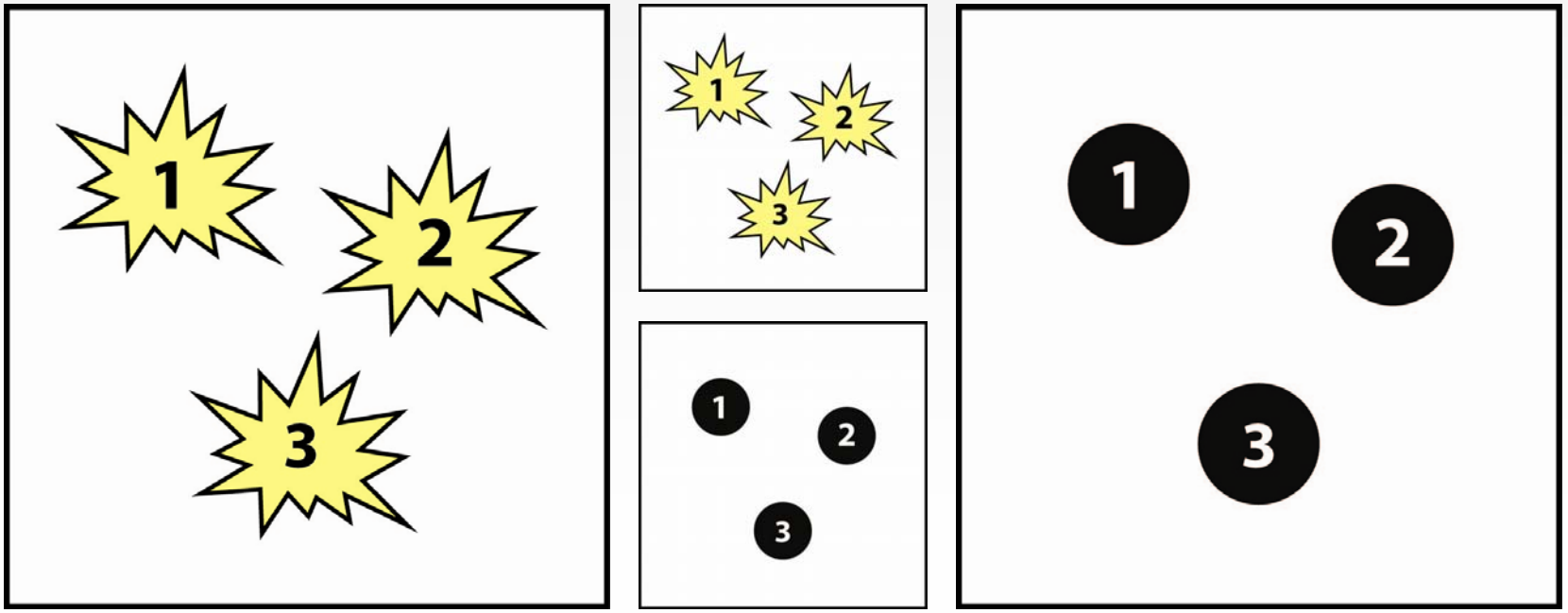
Sp

substitution of an elaborate texture for one that is less complex without changing the underlying geometry



shape Ss

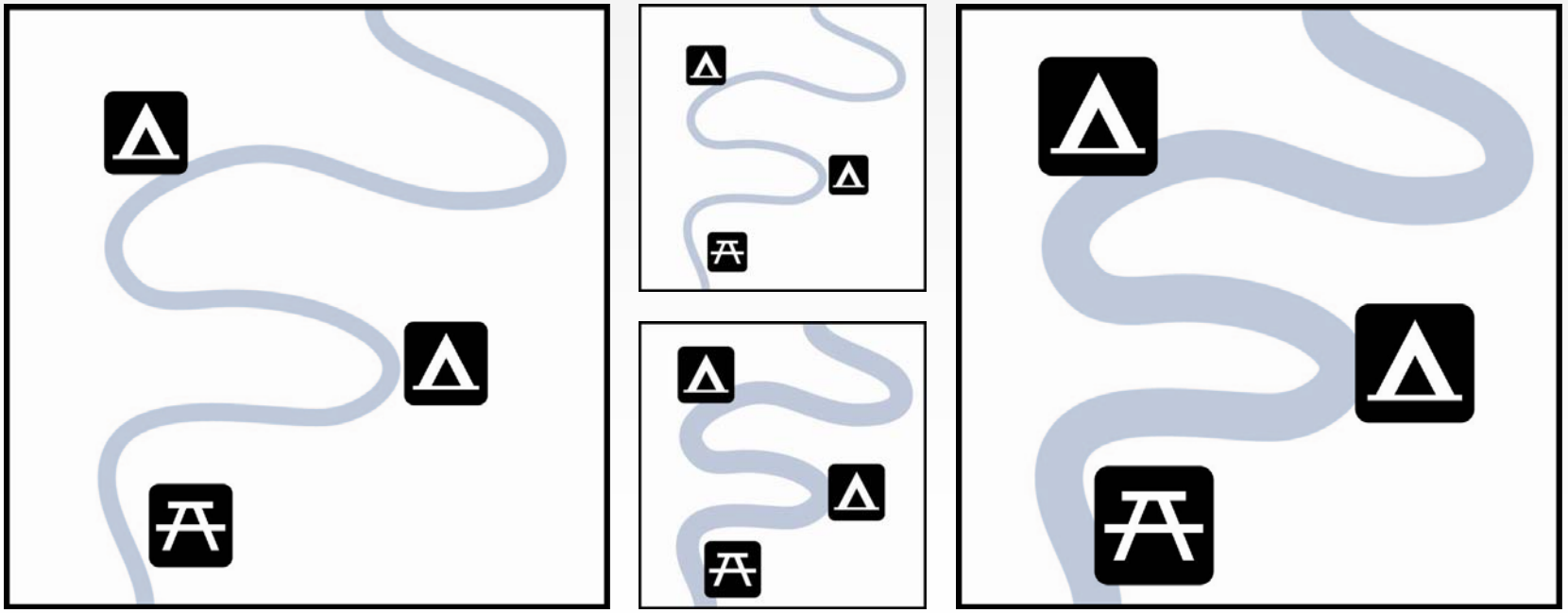
substitution of a complicated symbol shape with one that is less intricate without changing dimensionality



size

Sz

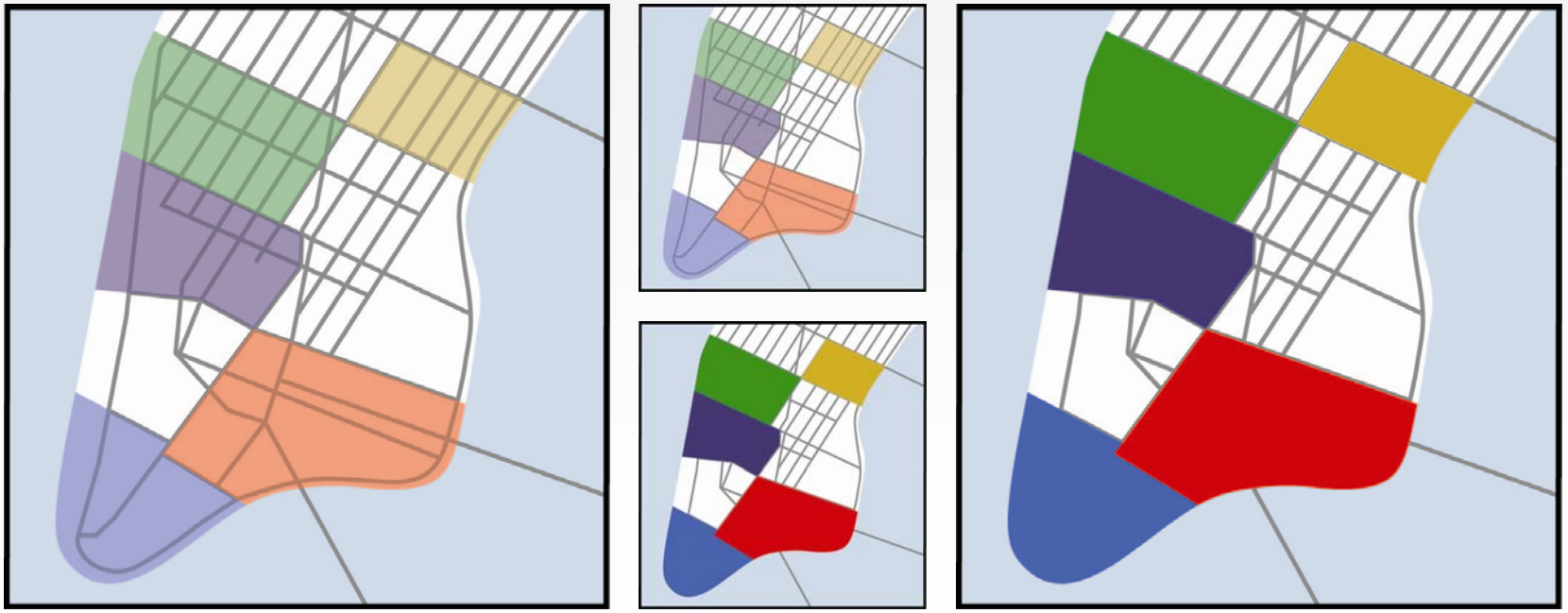
uniform enlargement of a symbol without changing dimensionality



transparency

St

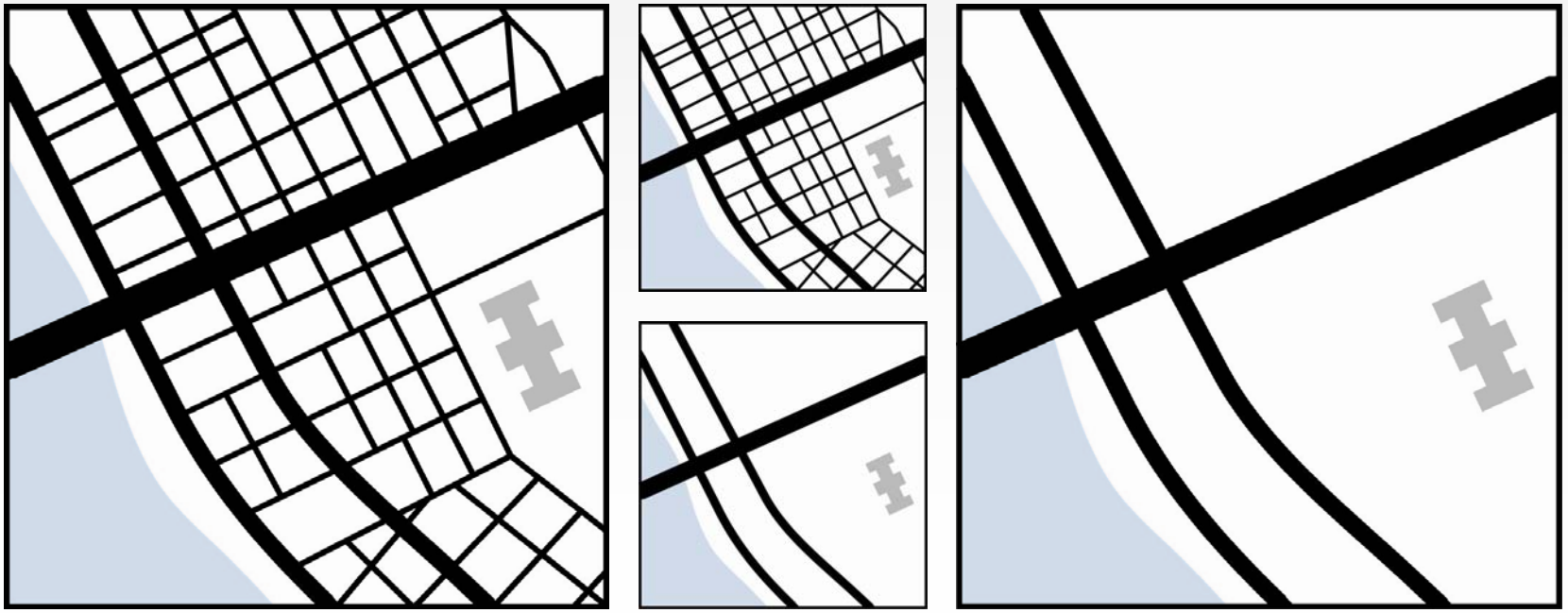
adjustment of the opacity of a symbol to improve clarity of the symbol or underlying features



refinement

Cr

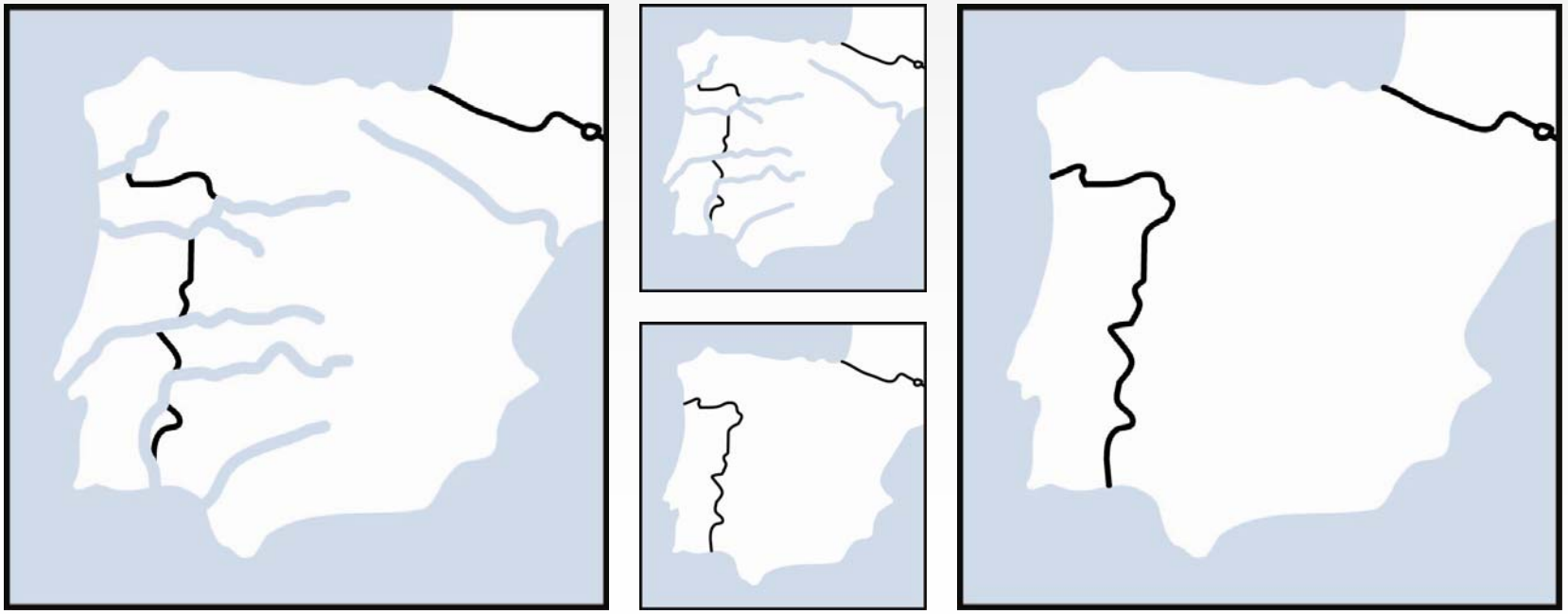
filtering of a set of features to remove a subset of features at a threshold value



eliminate

C-

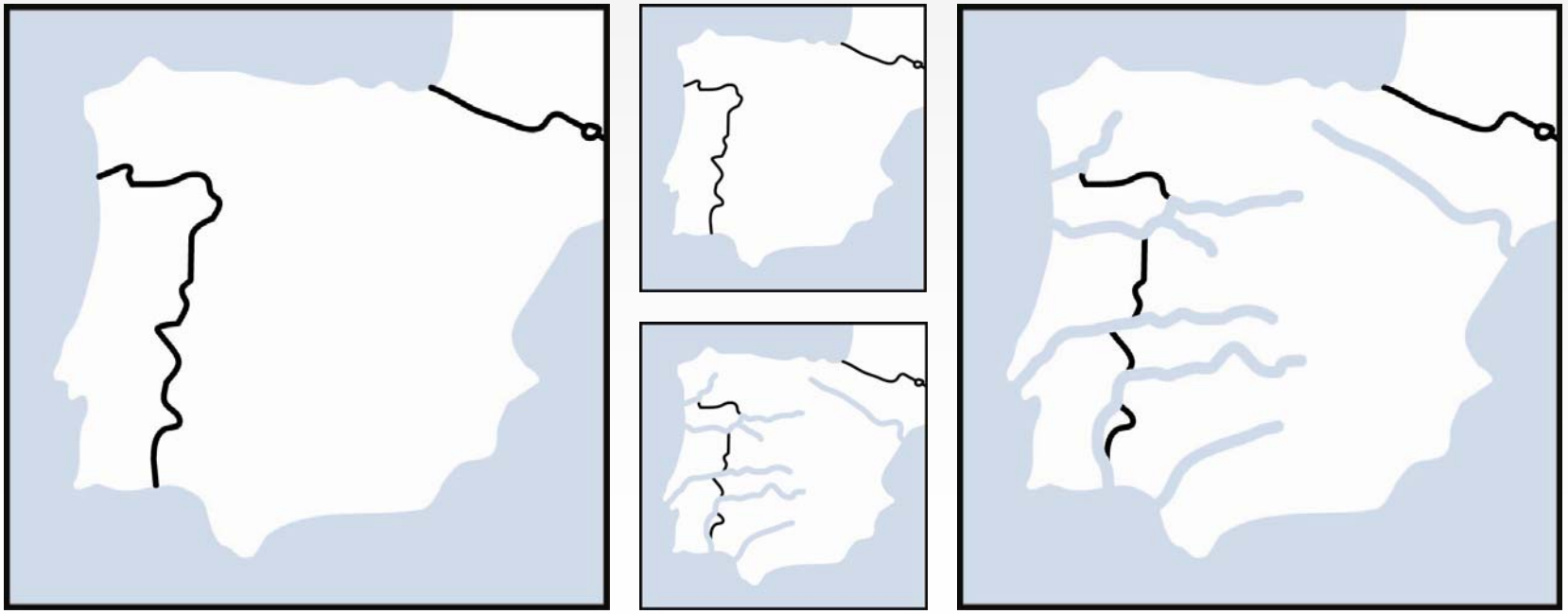
removal of a layer in its entirety



add

C+

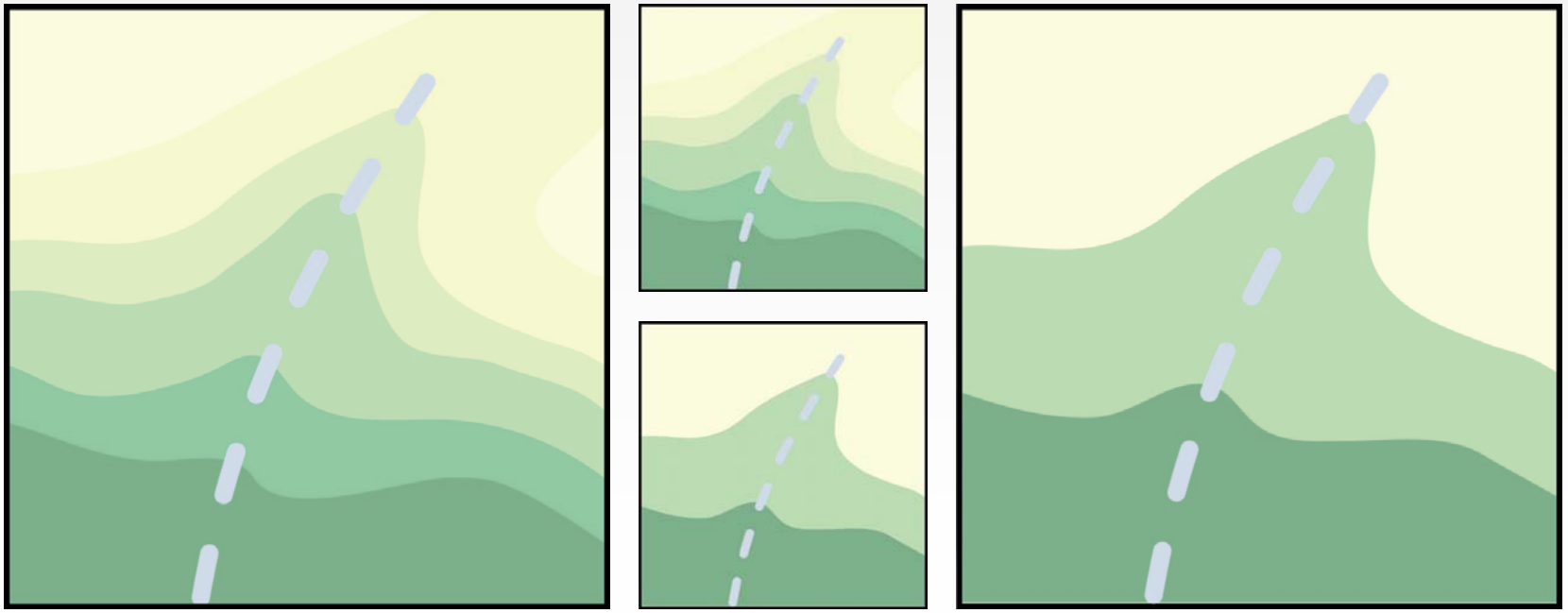
insertion of a layer in its entirety



reclassify

Cc

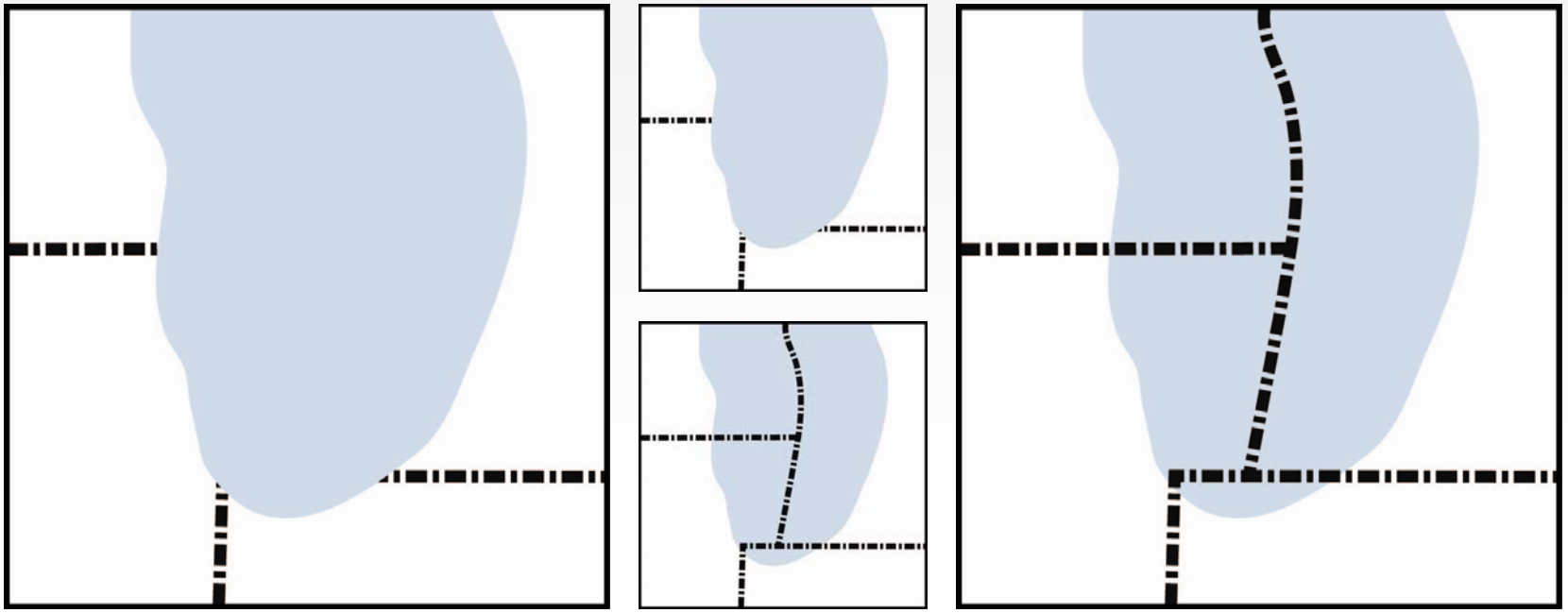
revision to the organization of selected features



reorder

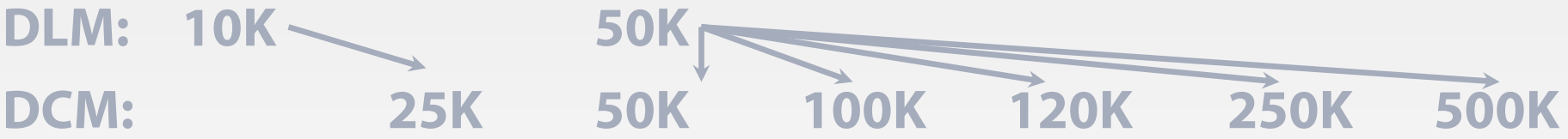
Co

adjustment of the stacking position of a layer relative to other layers

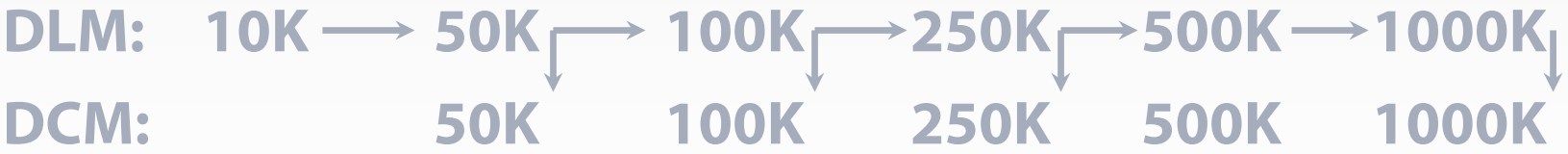


star versus **ladder** MRDB

France NMA: (star)



Sweden NMA: (ladder)



Stoter (2005)