A Design for a Legible Map Mash-up

Charlie Frye
Chief Cartographer
ESRI – Redlands

For "The Future of Maps and the Internet", a meeting of the ICA Commission on Maps and the Internet, Friday, November 13, 2009 at 7:30 PM - Sunday, November 15, 2009 at 2:00 PM (GMT-0400), Hotel Militar Coraceros, Viña Del Mar, Chile

Abstract:

Professionally produced map mashups should be as well designed as any professional graphical content available on the Internet. Today many map mashups produced by authoritative organizations or by credentialed professionals are not well designed or even legible. The simple map mash-up of points on a street or image base map usually produces a legible outcome, but map mash-ups adding complex line data, polygon data, or analytical surfaces typically produce indecipherable stacks of graphical content. By strategically designing base map layers to be separate-able to support map mashups, the layering of information in these mash-ups can be sequenced to support legibility. Polygons representing thematic content could be sandwiched between shaded relief on the bottom and then a layer of reference information representing boundaries, names, hydrography, etc. on top. This slightly more sophisticated approach has a much higher potential to result in a new professional quality map, instead of a stack of indecipherable graphical content.

Introduction:

Expectations for online information quality are changing as Web 2.0 applications become more widely used and as broadband access increases. Information consumers increasingly expect professional quality content delivered as actionable information, i.e., what you want when you need it. Several companies such as Google and Microsoft have proven, with no doubt, that content-rich map designs are better than the stick-figure map designs—nobody wants to use something ugly when an aesthetically pleasing alternative exists. This is an effective argument that more content is better than less content, but map mashups with richer content such as complex line, polygon, and analytical surface datasets have failed to deliver legible aesthetic results—the basic formula for a map mashup drawing user contributed content on top of a base map is flawed.

The communities of people who create map mashups have taken advantage, and continue to take advantage of the relative ease of assigning information to a point in space, and then placing that point on a map. Other simple scenarios exist as well, such as the point to point routing example in Figure 1. On the whole, the result is a mixed bag. A positive aspect is a vast amount of data is becoming spatially enabled, and new data is being designed to be more useful.

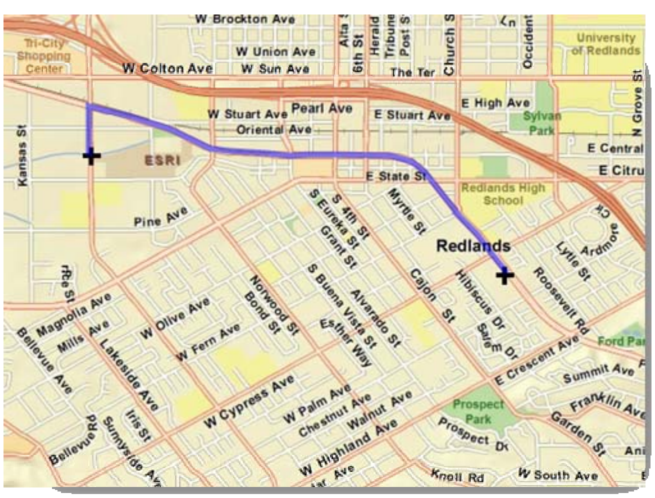

Figure 1. Example of point to point route mashed up on a ESRI's online street base map. This example is legible, i.e., both point locations are clearly drawn, and the route is clearly indicated—this kind of simple content works very well in a map mash up.

But, not all information can neatly or easily be represented with a digital pushpin. For instance much of the pre-existing spatial information produced by millions of GIS professionals takes the form of lines, polygons, raster surfaces, and collections of integrated points, lines, and polygons. These data, especially polygons and raster surfaces, do not make for either aesthetic or effective mashups. Figures 2 to 5 illustrate some of the problems that arise with legibility, aesthetic appeal, and most especially professional credibility. These maps were all produced by geospatial professionals. Granted the intent of those professionals was to illustrate the use of technology, but the outcome is more than a little embarrassing to a profession that purports to use maps as a significant means for communication.

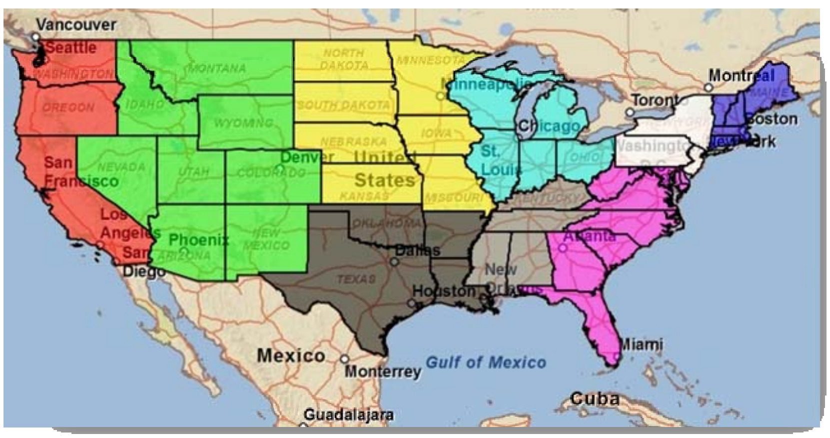

Figure 2. This example shows vernacular U.S. regions (defined in an attribute on ESRI's U.S. states dataset that is available on ESRI's Data and Maps sample data). The base map is ESRI's online street map service. The black state outlines visually collide with city names (New York and Dallas) and it is very difficult to read some state names, e.g., Maine.

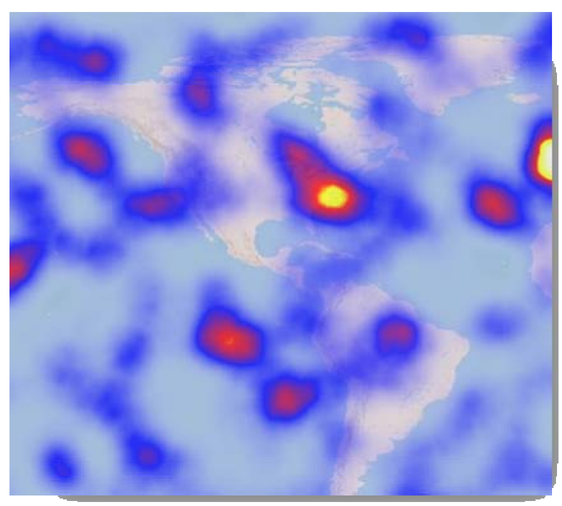

Figure 3. This example shows what is commonly called a "heat map". The geography is so obscured that the continents are barely discernable. The color choices for the heat map force the user to focus on the bright yellow areas. Those bright yellow areas create an affective design that conveys a sense of chemical burning. The meaning of the data and the intent of the map are unknown.

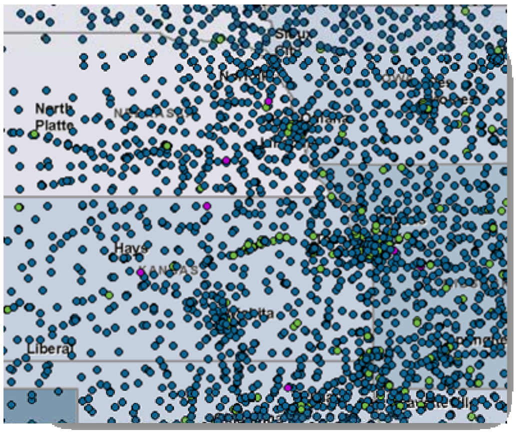

Figure 4. This example shows the initial view of a map mashup showing sites that have received funding from one of three different sources—at this scale too many points are shown and there is no way to know the funding level of any site. In most cases the place names on the base map cannot be read. Such a mash up dramatically increases the likelihood of a reader either getting the wrong message for not looking closely enough, or becoming frustrated for having to work harder to find the message.

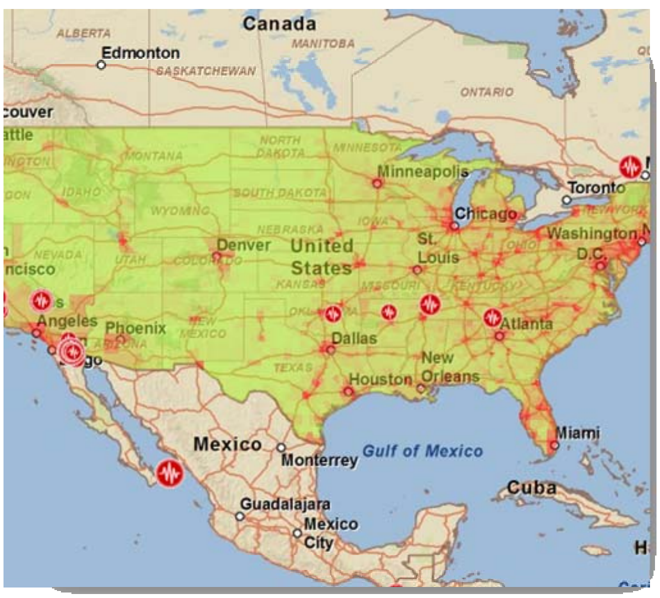

Figure 5. This example mashup shows a a raster dataset depicting population density on ESRI's online street map. Additionally there is a point dataset showing earthquakes. The color choices are problematic because red is used in all three layers: for roads on the street map, for densely populated areas, and for the points. Combining map services in such a fashion leads to a high potential for map readers to become confused.

Figures 2 to 5 clearly illustrate that not everybody can make a good mashup. When conflict between the technical ease of creating a mashup and the lack of proper cartographic education or intent on the part of the mashup author exists, the results are often underwhelming.

The reason why is the basic formula for a mashup: a base map web service is drawn beneath and a user's spatially enabled content drawn on top. This works well when the user's data are in the form of points or simple lines as Figure 1 shows, and in fact that is the sequence of information layering that a cartographer would typically use to make such a map. However, when polygons or raster datasets represent the user's data, a graphical the basic formula no longer works well. The polygons or rasters cover up the base map, making it difficult to read, or if the polygons or rasters are drawn with a degree of translucence, the base map's legibility varies, making it quite difficult to use equally well in all locations shown on the map. This is not an optimal solution no matter how beautiful or rich the base map—in fact the richer the level of content in the base map, the worse the legibility issue becomes.

Does legibility matter for map quality and in particular for map mashups? Ladniak and Kalamucki (2005) include legibility as one of their criteria for evaluating the contents of a map, and they are referring to the cartographic presentation of spatial data. Robinson et.al., (1995) define legibility of graphic symbols as their ability to be "easy to read and understand". Legibility of map mashup is important, particularly so because the users for map mashups expect content quickly and for it to be immediately useful.

Because it is possible to layer information in more sophisticated ways using Open GIS Consortium (OGC) technology, its proponents are often willing to offer their model for Web Mapping Services (WMS) or Web Feature Services (WFS) as the best way forward. Superficially, the OGC proponents have a good argument which is that content can be layered within either the WMS or WFS services making for a legible result. There are two practical problems with such an approach. First is performance; WMS services cannot be pre-cached, so the data is drawn every time a client makes a request for a map from a WMS service. This makes scaling WMS or WFS services for widespread use a very expensive proposition. The combination of computing power and data design expertise needed to make the WMS content draw sufficiently fast with high cartographic rendering quality is not a program most organizations can afford. Further, the expertise needed to facilitate high quality in such programs is not plentiful, meaning only a few organizations could benefit.

The pace of innovation in data rendering or symbolization techniques has naturally outpaced computing power, and will likely always do so. The graphics rendering algorithms that many software companies develop are well marketed and usually very highly demanded by clients who want to differentiate their own artwork, advertisements, and maps from their competitors. These clients pay a premium in computing time for the newest graphics rendering techniques, which are often relatively slow, but worth the wait because of the marketability of the newness of the effect.

This is not to say an open solution for a map mashup that is also aesthetically pleasing, well designed, and reasonably responsive is not possible. It is only that the currently available graphical options for doing so are much less likely to be implemented for reasons low practicality. It can also be argued, based on the body of evidence, that aesthetics in terms of map design have not been a priority for the open community. For instance, Thomas Brinkoff (2007) argues quite well how to improve the fitness of OGC-compliant web services for Web 2.0, but is entirely technology-centric, i.e., and neglects the map. An attractive compelling map is also needed, and not just as a base map, but as the final product of a mashup. Whether that map is open, does not matter to the map's consumers. A graphically-rich, aesthetic, performant open solution is not yet possible or feasible, and so a solution for a legible mashup using polygon or raster data is still needed.

People using or reading map mashups need to get information in a clear, productive and efficient way—what they see matters. This is especially true when the map mashup is serving a professional audience. That is an obvious reason to make a better looking mashup. Alexander Pucher (2005) correctly states, 'The User is the Client…" but then perhaps misstates the next part, "… Don't make him think." Perhaps he meant, don't make him work. The point of any map is to communicate, and that implies the formation of thought.

Figures 6 to 8 illustrate a sequence of more thoughtfully professionally produced map mashups in which cartographic design was applied while using the basic map mashup formula. Successful map mashups depend first on the choice of an appropriate base map. A street map or an image map are not always suitable base maps

Figure 6. This is an example of an online topographically styled base map that was recently published by ESRI. Such a base map is suitable as the basis for a mashup for information that requires topographic characteristics or land cover characteristics to be properly contextualized.

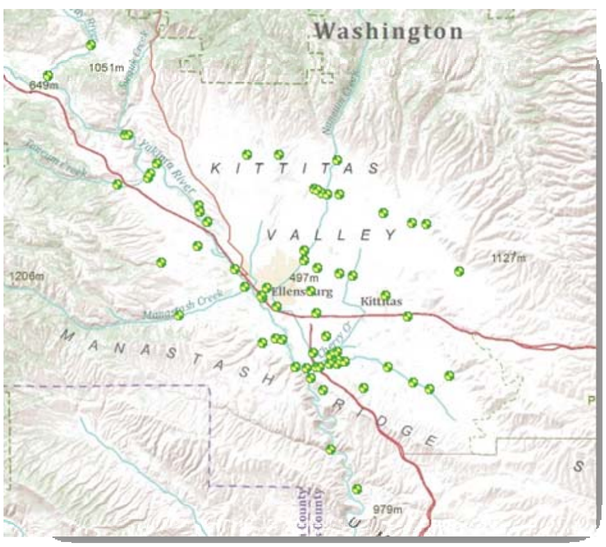

Figure 7. This example of a mashup of point data shows the locations of the U.S. Environmental Protection Agency's STORET water quality, biological, and physical data monitoring stations. As a mashup, this works reasonably well because most of the base map is still legible. In the area where a cluster of stations are located, a user would most likely zoom in to view that location with less visual clutter.

Figure 8. In this case a map service with watershed boundary lines is mashed up on the base map. In this case it works quite well, though line data often conflict with text in base maps.

Figure 9 then illustrates an attempt to mash up well designed polygon content with this same base map that worked well for figures 6 to 8. The result is not adequate as several kinds of information in the base map lose legibility.

Figure 9. In this case demographic information is mashed up on the base map in the form of U.S. Census Bureau census tracts. Depending on the color of the polygon, base map content is either obscured, e.g., river names or vegetation. Further, the figure-ground and visual hierarchy of the map that resulted in this mashup is compromised, forcing the reader to take more time to absorb or understand what is being presented. This may not be the ideal base map, but what base map would work?

It is worth exploring the question that Dodge and Perkins (2008) bring up, which is whether anyone does actually care about the quality of maps. Figures 2 to 5 illustrate that not all map makers are concerned or know to be concerned about the message of their maps. Dodge and Perkins assert that the geographic community seems ambivalent about producing professional quality maps. They identify an additional problem they aptly categorize as "ambivalent cartographic practice", which organizations that need a map opt for the easiest least expensive solution, and use a pushpin–style mashup made with one of the ubiquitous online maps as the base map. Such solutions are obviously inexpensive, easy, and are, at a minimum, adequate. Dodge and Perkins, however, do not describe at what point an organization recognizes the need for a better map. Frye (2009) argues that organizations often learn this too late, because they do not recognize the need for cartographic expertise in mapmaking endeavors. It does seem that the cartographic labor force and its value are not broadly perceived or well marketed.

Minimally adequate map mashups are not sufficient for mission critical, policy oriented, or sensitive topics. In other words a cheap, easy mashup is not appropriate to use for maps depicting important topics. The risk of miscommunication is too great. Map mashups for important topics must be well designed and executed, like any other map or communication product that has the role of educating or persuading an important audience. For instance the mashups in Figures 2 to 5 and 9 do not convey that the authors felt the information shown was important; the mashup looks unprofessional and the educated, non-geospatial public has little difficulty recognizing that fact.

Methodology

The best looking, most legible map mashups are points and simple lines mashed up on a well-designed base map. This is successful because it follows a well-known formula for cartography, in that point markers are typically drawn on top of other content. It therefore stands to reason that a map mashup with polygon data should also follow a proven cartographic formula. There is a basic formula to how a cartographer makes a polygon-filled map such as a choropleth map. That formula is expressed in how the information on the map is graphically layered: terrain, i.e., land is on the bottom, then oceans (if needed) to define the edge of land, then the polygons that are the basis of the choropleth map, and finally reference information, like boundaries and place names. This formula can be adapted to web maps and mashups of raster or polygon data. Instead of a minimum of two map services (base map and overlay), there are three services:

1. Land or terrain
2. Raster or Polygons
3. Reference content

To make a legible map mashup it is necessary to draw the raster or polygon data between the terrain and reference content of the base map. This allows the reference content to remain legible for map readers. Figure 10 shows how Figure 9 should ideally appear, with the reference information clearly legible.

Figure 10. In this case the demographic information is " sandwiched" between the terrain base and the reference information. This allows the reference information to remain legible. An easy way to understand this style of mashup is to think of it as a "map sandwich", where the base map is divided and represents the 'bread' and then any raster or polygon layer; even combinations of these can be the 'meat' of the sandwich.

Figure 11. Here are the three map services that were mashed up, and the sequence that was used to create the mashup in Figure 10. The polygons in the demographic service were drawn with 50% translucency. The color that appears as white in the reference layer on the top is actually transparent (the image is stored as a 32-bit PNG bitmap file).

Discussion

The three map services shown in Figure 11, sandwiched together, represent a formula that can be used to create a wide variety of relatively simple map mashups. This formula for a map mashup can be thought of as a "map sandwich". In fact this is the basic formula that most maps depicting raster or polygon data follow, at least at a fundamental level. The result of this formula for a map mashup is a legible map, not just a stack of map-like content.

The map sandwich method for creating a map mashup offers a great deal of time savings for organizations that produce polygon, raster, and collections of integrated data. Without terrain and reference services to sandwich their content, these organizations are in the difficult position of having to construct their own base maps to integrate their content. Furthermore, they would have to create a complete map service for each layer of content they produced that includes the base map content, recompiled each time. Until now, these organizations either did not publish their information as maps because they typically did not have the expertise to do so, or they only published the data, or they used inadequate map mashups. As the expectations driven by the presence of more and more Web 2.0 map based applications are set higher, none of these alternatives will be acceptable for much longer.

Figures 12 and 13 illustrate these same "bread" layers in the map sandwich being used with different raster and polygon map services. These 'meat' services can be compiled many times faster, with far less expertise and infrastructure than it takes to compile the same information with a base map.

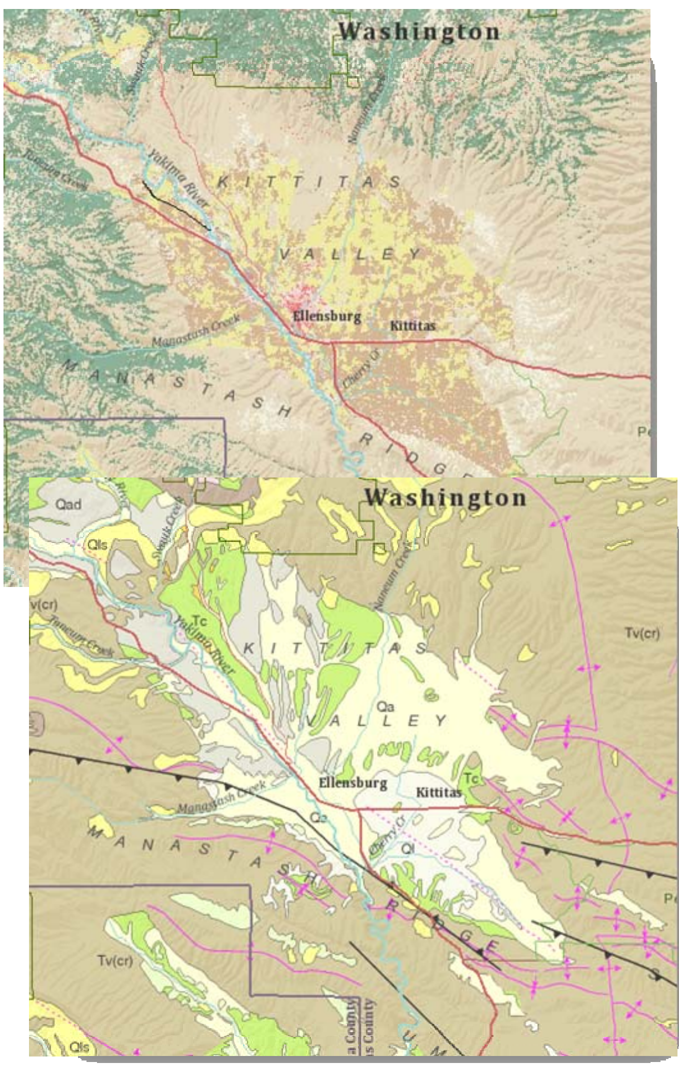

Figure 12. This example shows a raster image service of the UGSG National Land Cover Dataset (NLCD) instead of the demographic that was shown in Figure 10. Some care must be taken with the selection of the colors used to represent the various land cover classes, so as not to conflict with the reference information. However, the reference information in this service has also been designed to leave a wide swath of the color gamut available for producers of services for map mashups.

Figure 13. in this example geologic information from the Washington State Department of Natural Resources is shown in a prototype map service created by ESRI. In this case the geologic data represent an integrated collection of polygon, line, and point data (the points are only visible at larger scales). This is also an example where geologic points or lines could be drawn on top of reference information to increase legibility.

The base map in figures 6 to 13 is not just for the scale that is shown, but for scales ranging from about 1:18,000 in the U.S. to 1:147,000,000 world-wide. There are fifteen different maps compiled in a sequence of scales that result in the ability to zoom from a small scale map of the world to a relatively large scale map depicting a neighborhood. This collection of maps is available as one map service that is multi-scale.

Compiling base maps and designing them to be multi-scale, capable of separation into terrain and reference map services, and managing to leave large portions of the color gamut available to the community of content authors to create map mashups with these base maps are not trivial endeavors. Not many organizations have sufficient expertise in cartography, GIS, and web services information infrastructure to be successful. Those that do will become the producers of base maps. Currently there is only one base map, created by ESRI, that supports this new map sandwich mash up model. Here are the URLs for these services:

World Topographic Base Map

http://server.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer

World Terrain

http://server.arcgisonline.com/ArcGIS/rest/services/World_Terrain_Base/MapServer

World Reference

http://server.arcgisonline.com/ArcGIS/rest/services/Reference/World_Reference_Overlay/MapServer

These map services are designed to have a topographic style. Most online map users are already familiar with the street map, imagery, hybrid, and terrain styles from the various base map providers. These styles work well for many broad consumer market mashup scenarios. However, they are often not adequate for the professional geospatial and scientific communities. Additional base maps are needed to support their thematic content and also to support very large scale local content.

In many instances, professional and scientific organizations cannot afford to risk having their names or organization's names associated with underwhelming Web content. This is particularly true for organizations that produce authoritative content or compile content. These organizations are increasingly required to not just publish their content, but do so in a way that makes their content immediately useful for purposes of the mandate that drove them to produce the content in the first place.

Legible map mashups are far more likely to communicate properly and efficiently; however, there remains still, even in the cartographic community, a lack of either a shared understanding of, or the will to set a high standard for cartographic quality. Black and Cartwright were quite generous in 2005 with what they termed "high quality vector rendering" in referring to what was essentially "stick figure" map design. Today, in 2009, there is no reason to lower expectations for cartographic quality just because a map is viewed on a computer screen or PDA; though there are some basic map design issues that need to be addressed. Black and Cartwright (2005) in their assessment were referring to the design of web maps coming from GIS, not mashups.

The question that Dodge and Martin (2008) ask about whether good, and particularly good looking, maps are really needed has an obvious answer, which is yes. Common sense is the main reason—better maps mean better communication. The website http://www.gov2taskforce.ideascale.com is flush with ideas from people who want maps from their government, and not just maps but good maps on important topics. Complications relate to the subjects of who will build the maps and who will pay to not only build them, but maintain them. As is often the case in government, multiple agencies have to share responsibilities, and data collection and information publication are often a separate activities. In order to deliver the maps being requested, significant investments in infrastructure and expertise are required, and there is a dearth of such expertise because multi-scale cartography for the Web is not yet well understood or taught broadly in the academy or in practice.

The only sure way to convince people that they need a better, legible map, is to show them one and explain (if necessary) what is better.

Conclusions

In his book, *Tipping Point*, Malcolm Gladwell (2002) writes that many key information epidemics, like the knowledge to buy a certain brand of shoes or eat at a certain restaurant, begins with a messenger who is compelling or charismatic. But he also writes, "The content of the message matters too." That content must be memorable, and memorable enough to spur someone to action.

The same is true for map mashups—too many map mashups are not memorable, and they never had a chance because of lack of legibility and cartographic integrity. Map mashups are inherently positioned to spark "information epidemics" as Gladwell calls them; however, relatively very few mashup-spawned information epidemics have happened.

Black and Cartwright (2005) rightfully question whether cartography has changed in any significant way given the advent of the Internet. Their questioning focused, in particular, on the community of professionals who call themselves cartographers and Black and Cartwright (2005) reproached the cartography industry for being "conservative" with "avant-garde tools". The majority of this community of conservative cartographers is still not involved with the Web in any significant way; they are not making map mashups or online base maps—their cartographic expertise is needed. People are the vessels of cartographic expertise—it's not an abstract entity searching for a home. The only way for cartography can make its way onto the Web is if the cartographers bring their expertise to the Web in the form of high quality base maps and map mashups.

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