cartographic techniques

Cartographic Design on Maine's Appalachian Trail

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The Appalachian Trail (AT) is among the crown jewels of hiking trails worldwide. An opportunity to design the maps of the AT in Maine was more than just another job—as Maine residents and avid outdoorsmen we felt a personal responsibility, and honor, to take on this task. We embarked on a digital odyssey of sorts, manipulating terrain models and referencing existing paper sources, all the while designing with a strong humanistic element. These maps will be used to plan, attempt, and complete adventures in what some consider to be the most stunning trail landscape in New England. The project, similar to the trail, offered some unexpected challenges. This paper chronicles our journey along the design and production paths of Maine's Appalachian Trail.

Key Words: Appalachian Trail, map, design, terrain model, cartography

We had the opportunity in 2003 to redesign the seven-map series of the Appalachian Trail in Maine for the Maine Appalachian Trail Club (MATC). MATC was updating their 175-page guidebook, strip maps and hiker's overview maps. They contracted designers for each of these three tasks. Our role was to design and produce the color maps and elevation profiles, which comprise one side of the folded map, replicating the coverage of the existing series. We compiled available digital data and utilized paper map references using GIS and desktop publishing software. The finished maps were provided as Macromedia FreeHand files and printed on HopSyn by JS McCarthy printers in Augusta, Maine, spring of 2004.

Description of Project

These are strip maps, averaging 13 x 30 inches, folded to 6.5 x 3.75 inches, at a scale of 1:62,500; one inch to the mile. The seven map series begins at Katahdin, the northern terminus of the Appalachian Trail (AT), and continue to the Maine-New Hampshire border. The precedent of so much detailed, existing trail information made coordination between the three representations (guidebook, abstract maps, trail maps) important, yet the different media made this difficult. The color trail maps show the AT in its truest representation as a solitary trail winding across the landscape. A terrain model and contour lines aid the hiker to understand the task at hand, or foot, as it may be. The black and white maps on the backside of the map are more abstract and designed to be read with sidebar text. The guidebook is yet another resource, without maps, representing the AT through the written word. Distance is the common thread between these works, and by referencing all three mediums the hiker is given the best chance of fully comprehending the AT, both spatially and historically, as they move through the landscape. Our task was to update only the color trail maps at 1:62,500.

Because of such precedent, MATC needed to replicate the size, scale and coverage of the existing maps produced in 1996. We were unable to contact the original cartographers for insight to the 1996 project—as such our assessment may not be completely accurate. The existing cartography had some legibility issues. Based on the date of 1996 we believe the map represents a hybrid workflow; the shaded relief was created using GIS technology, yet the text layers appear to be based on USGS film separates. All USGS text is one color (blue) and oriented in the default USGS north-up position. However, the AT maps are not all north up; many use a unique orientation based on the trail corridors relationship to the map sheet. This puts the text at angles contrary to the reader's orientation, combined with the use of blue italic text much of this information is difficult to comprehend. The terrain models are based on the Japanese cartographer Kitiro Tanaka's method of hillshading with illuminated contours. This interpretation uses yellow contour lines to imply sun angle on lit slopes, and gray contour lines for shaded areas. One visual deterrent to the Tanaka method is an appearance of terracing; the slope does not look continuous, rather a series of ledges and intermediate plateaus come to mind. The Tanaka method can be helpful in certain instances to visualize the landscape, but from a hikers perspective we felt the terracing was misrepresenting the Maine highlands (Figure 1).

Our approach was to utilize USGS and Maine Office of GIS (MeGIS) digital data, with National Park Service (NPS) digital data of the AT centerline and campsite/lean-to locations. Some of this data was in beta form, meaning it had not been verified, and was used cautiously with much cross-referencing. The terrain models were created using the USGS National Elevation Dataset (NED). Our first task was figuring out

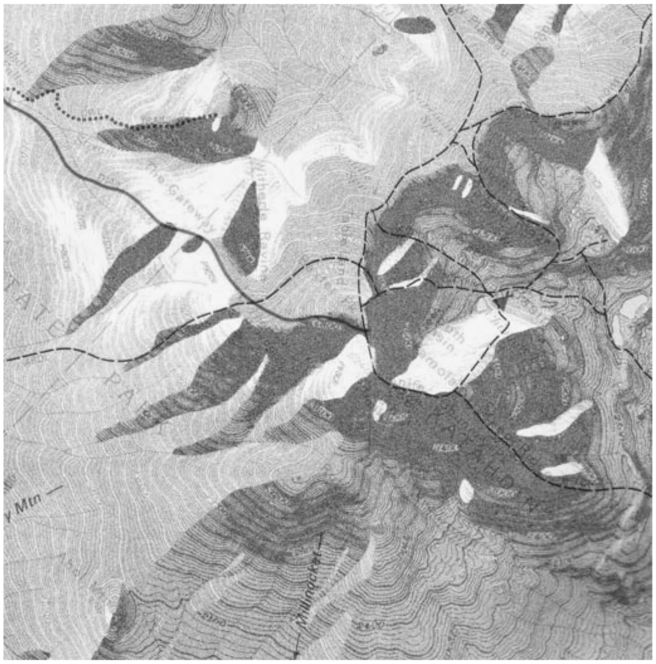

Figure 1. 1996 Edition focused on Katahdin, utilizing Tanaka method of illuminated contours (see page 82 for color version).

Figure 2. 2004 Edition focused on Katahdin, utilizing subtle hillshading and contours (see page 82 for color version).

the map extent (the four corner coordinates from the existing maps) and the rotation from north. This was a bit vague because the existing maps did not have a lat/long or UTM grid for reference. We compared the AT maps to other map resources to determine the corner points. This allowed us to crop the raw data within clipping paths associated with the coordinate extents, for both vector and raster (NED) resources. Each map is oriented differently based on the linear aspect of the trail: there is no consistent North-up flavor. We calculated the angle of rotation based on the existing north arrow and text elements that remained on a north-up baseline axis.

Digital Elevation Models

The terrain models were hillshaded individually based on their unique orientation to imply a sun angle from the northeast, a proven cartographic standard for maximum legibility and user cognition. Two raster images were produced and composited for the final relief; one a grayscale DEM (Figure 3) with hillshading, the other an elevation model utilizing a green to yellow to white color ramp (Figure 4).

Using Adobe Photoshop, these two layers were composited and edited (Figure 5). The opacity of the color model was adjusted to provide a subtle tinting that would not compete with the visual hierarchy of the vector and text data. The grayscale model was toned down using Photoshop's histogram controls to edit the color balance away from pure black, and adjusted further using the brightness tools for integration with the color ramps. Multiple artifacts associated with the model need to be removed manually, most notably a corduroy artifact common among DEMs of Maine (Figure 6). The selective polygon tool and low threshold Gaussian blur worked reasonably well, although the offending pixelation could not be completely removed.

Vector Layers

One criticism of the original maps was poor contour line legibility (Figure 1). The combination of Tanaka hillshading and a 20-foot interval produced visually congested areas of steep slope. We generated contour lines at 50-foot intervals to increase legibility, and felt this was a useful measurement for hikers given the slope and height of terrain. We emphasized the 1000-foot contour breaks with a thicker line, similar to the traditional USGS style, but added custom placement of elevation text (Figure 2). Traditional USGS cartography places the elevation text at random across the map. In this case, we felt the hiker would be most interested where the elevation intervals cross the trail, and we placed the text accordingly. Borrowing from the British Ordinance Survey style of textual elevation terraces, we attempted to place the interval text in an ordered fashion along areas of continuous slope. Much of the contour line vector coverage was plagued with right angle artifacts resulting from the poor source data inherent in the DEMs (Figure 7). These were

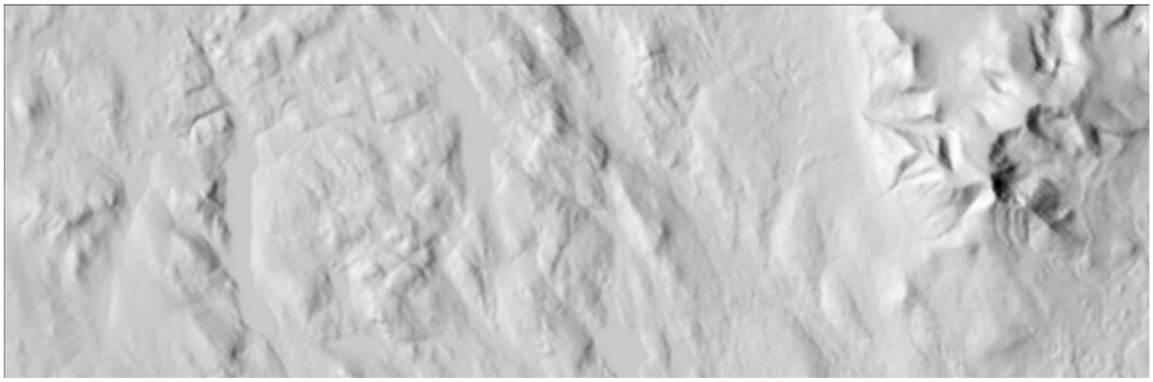

Figure 3. Grayscale DEM

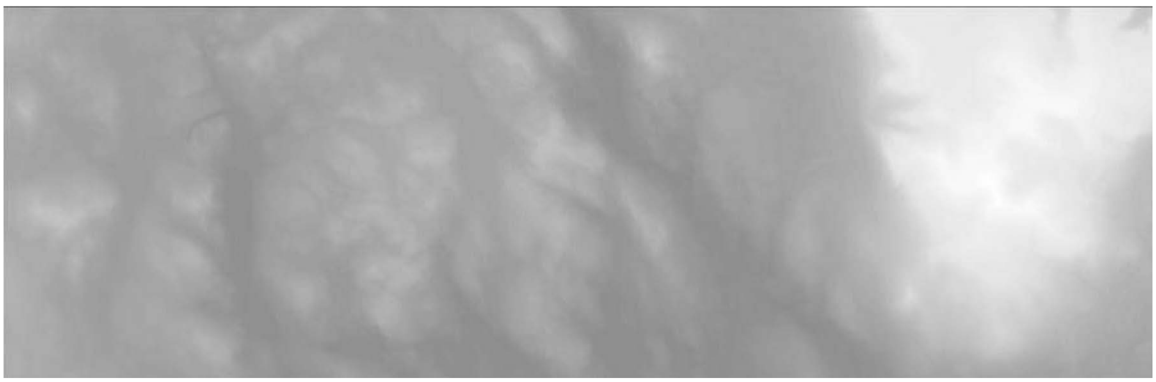

Figure 4. Color Elevation (see page 83 for color version)

Figure 5. Composite image (see page 84 for color version)

removed manually in Freehand. The combination of using Photoshop to blur the effect on the raster model and manual node elimination in Freehand created an aesthetically pleasing result, although the task was tedious.

The majority of the vector data came from the State of Maine GIS depository (MeGIS), a web-based resource. Some data layers were missing or incomplete, and those we compiled manually from other sources. The AT centerline was cloned with a 100% yellow line set at a slightly thicker weight, which serves to highlight it as the primary piece of information on the map. This style was replicated from the previous cartographer's work. The road and trail data became a deletion puzzle requiring a tremendous amount of manual sorting. We estimate deleting 80% of the road and trail data provided by the USGS. The AT corridor traverses commercially owned paper company land which is actively being logged. Industry cuts a vast network of dirt roads to support logging operations, and these private roads dominate the landscape as a cartographic element. MATC does not show the majority of these roads unless they cross the AT. From a hikers perspective the existence of these roads is irrelevant, they are rarely visible or accessible from the trail corridor. This presented a cartographic conundrum; as mapmakers

Figure 6. Corduroy artifacts inherent in DEM data before editing in Photoshop.

Figure 7. Jagged contour lines resulting from corduroy effect on DEM data.

we felt compelled to illustrate the known landscape, even though these roads may be inaccurate. MATC did not want to show this dense network of potentially irrelevant line work. Both arguments have validity, and we respected the client's wishes and deleted the roads.

A second piece of cartographic information was available from the National Park Service but MATC chose not to include. This is the polygon coverage of the federal lands that comprise the AT corridor. This is an interesting illustration of the AT due to the depth and breadth of the overall corridor. Instead of simply illustrating the trail itself, the actual corridor polygons serve to show the narrow areas as well as inclusion of individual lake shorelines and other property that has been preserved through federal acquisition. Without this piece of data, the reader has no reference of private or public lands unless a state park or similar public land area is traversed.

This geographer wonders what effect the true representation of roads and protected lands would have on public perception of the AT. The North Woods of Maine is steeped in myth as one of the last wilderness regions in the lower 48; in fact one section is called the Hundred Mile Wilderness. A glance at any highway atlas reinforces that myth: the lack of roads appears evident. But all that represents is a lack of paved, state maintained roads, when most of rural Maine is privately owned by pulp and paper conglomerates. A dense maze of dirt roads provides access to virtually every nook and cranny on both sides of the AT. The accuracy of these roads is vague at best because once logging operations pass through a region, the undergrowth may reclaim the roads, and public domain data may not reflect the current landscape. Although the hiker may not need this information while hiking, the environmentalist is easily fooled, perhaps envisioning a true wilderness area. By deleting the roads, the AT corridor appears insulated and protected, when in reality the logging operations cut within inches of the narrow buffer zone flanking the trail. Illustrating the harsh proximity of these roads may serve to increase the grassroots protection of public lands in Maine, and not hinder the aura of the AT.

Text Layers

We created an average of 17 text layers, each utilizing a separate style to maximize legibility. Our assumption was that features directly on the trail are of most importance to hikers; less important were places not accessible, and often not visible, from the trail corridor. This sort of visual hierarchy was not part of the previous map design, and reflects one of the most creative and utilitarian aspects of digital map design. We curved the text as much as possible to coordinate with physical features to add an organic aesthetic to the design. Following the previous cartographer's design, the use of red text keys elements specifically relevant to hikers; campsites, lean-tos and visible peak names with directional arrows comprise the majority of these layers. The red text is problematic on the green background so a text halo was created to lift the element off the page. A halo is created by cloning the text element, converting it to outlines, increasing the stroke, changing the color and placing on a separate layer. Some illustration software offers other ways to do this but they can be unreliable at press. The method described here is consistent on multiple output devices. A critical navigational aid in this part of Maine is township names, which were inconsistent on the previous edition. We included the political line and text in a legible, but not distracting, design across the series.

Early conversations with MATC suggested the addition of a lat/long/UTM grid for GPS users. Upon closer discussion MATC decided against providing this information citing concerns it would encourage short cuts along the trail. Although we do not have empirical data to support that concern, we did agree the AT is a well marked path that one does not need compass or GPS skills to navigate, hence no real need for a coordinate system on the map. A criticism of this decision still lies in the isolated cases of Search and Rescue (SAR), where a hiker may provide GPS coordinates from handheld unit (or transparently provided as cell phone 911-technology) and the searchers would not be able to rely on MATC maps for extraction.

Elevation Profiles

The elevation profiles were a separate task and one that we did not create from digital data as intended. We spent quite a bit of time analyzing data, writing and rewriting new programming scripts to adjust for error, but with limited success. Our computer-generated models produced slightly different profiles than the previously published models. We found multiple contradictions but could not determine which was truth. In places the profile does not reflect the exact elevation, but the line on the map may also be slightly off as it crests a rise or traverses a saddle. The GIS calculated a profile that averaged three miles less than the existing model (over a 25 mile section). Because the MATC publishes a detailed guide that is correlated to the existing profiles, we ended up scanning and tracing the current profiles and adjusting typography to improve legibility, but the overall slope and line is unchanged from the previous models. MATC gathered the info over several years using a rolling survey wheel on the trail; given the legacy and volume of scrutiny the trail receives we decided to simply trace the existing profiles for publication. However, we believe the truth lies somewhere between the two mediums.

The measured distance collected by a rolling wheel is effectively a line through the landscape at a scale of 1:1. While this information is an excellent resource for hikers, it would be impossible to show that much detail on the map and impractical to keep that much detail in a GIS. After overlaying the GIS version of the trail on a USGS elevation model, a very detailed profile of the trail was generated, but with one major drawback: the calculated distance along the trail was shorter than the actual trail distance.

Since the digital elevation data is a generalized representation of the terrain, the calculated distances are going to differ from the actual distances along the trail. As a result, the new profile based on the computer model was of no use despite the higher detail in the elevation profile. The differences in distances were irregular, so a simple scaling of the trail, graphically, could not produce a profile that matched the original. This problem of the measured ground distance not matching the GIS distance will always remain—even with a more detail trail location that could be created using a pack survey grade GPS unit. Millions of GPS points would be required to attempt to match the measured distance captured by a survey wheel, and even if such a data set were created, it would be impractical to keep such information electronically at this time.

One solution may be to include points along the trail with known distances and spread out the variance between the two known points. This would effectively hide the difference between the measured distance and the calculated distance. The differential would be minimized if it were spread out across the entire trail, so that a hiker would not notice it visually on the profile length and it would provide more elevation detail than the generalized profiles currently plotted by hand.

The existing MATC elevation profiles utilized an artistic abstraction that suggests lake and stream locations as well as side trails and road crossings. These are represented as shapes and forms floating in space above the profile, or obliquely distorted alongside. Our attempts to utilize the detailed lake polygons in a digital design world (using perspective and other warping tools) still provided a questionable aesthetic. They were more detailed, but not necessarily more useful. We were unable to significantly improve upon the abstractions, and simply replicated the generalized style created by the previous cartographer (Figure 8), adding our design modifications primarily through text and subtle aesthetics.

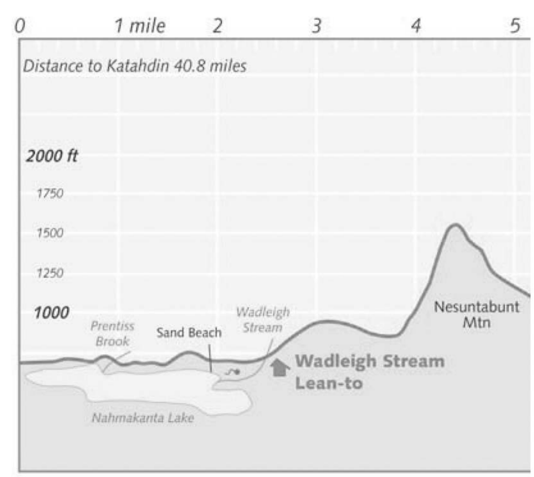

Figure 8. (see page 83 for color version).

Aesthetic Design

As the project progressed we were able to improve upon the overall look and feel of the maps. Designing a continuous series of maps has inherent difficulties. Design decisions made on one map may not be applicable to another; especially with the diversity of terrain the AT traverses in Maine. The northern terminus of the AT at Kathadin (5267 feet) drops to 600 feet within ten miles. No other map in this series illustrates that much vertical rise. Some traverse low wetlands, while others follow ridgelines. We wanted a consistency across the series, but wrestled with the design along the way. Creating an effective and pleasing look and feel of the colorized terrain model and contour lines involved much trial and error. Overall we believe we created a highly effective series of maps beneficial to the hiker, first and foremost, but also helpful to anyone interested in visualizing the AT corridor in Maine. The relief models are subtle; yet represent the undulations of the landscape, with contour lines for added reference. The AT is the most dominant piece of information, followed by the designated lean-tos and campsites. A hiker plans his or her day by the distance and topography between campsites. It was this mindset that governed our design decisions. As I worked on the map, I found myself vicariously hiking the trail; often resting as I came to specific attributes like a lean-to. The design should be equally effective for studying the maps around a kitchen table or huddling along the trail in a stiff wind and rain, perhaps aided by a flashlight. This is the mark of a truly effective design, one that bridges the artistic vision with pure utilitarian use; a map equally at home framed on the wall or crumpled up in the back pocket of an exhausted hiker.

Postscript: The 2005 ACSM/CaGIS 32nd Annual Map Design Competition recognized this series of maps with an Honorable Mention in the Recreational Map category.

See http://www.acsm.net/cagis/04mapwinners.html

cartographic collections

Illinois Historical Aerial Photography Digital Archive Keeps Growing

By Arlyn Booth, Map Coordinator and Tom Huber, Map Librarian
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The Illinois Historical Aerial Photography Digital Archive, representing the earliest Illinois statewide aerial photography acquired during 1938-1941 (Figure 1), has grown with the addition of twenty more counties. Forty-five counties comprising a total of 15,921 aerial photographs are now accessible through the Illinois Geospatial Data Clearinghouse located at http://www.isgs.uiuc.edu/nsdihome/webdocs/ilhap/. (Figure 2)

The aerial photographs for the latest 20 counties added to the web site, most of which are situated adjacent to the Illinois River, were funded by an Institute for Museum and Library Services (IMLS) grant to the Illinois State Library (ISL) and the Illinois State Geological Survey (ISGS). The ArcIMS interactive map service web pages (Figyre 3) have been significantly updated with new layers aiding search strategy, including the USGS 7.5-minute topographic map index, USGS Digital Raster Graphic (DRG) files, and the 1998-2001 USGS Digital Orthophoto Quarter Quadrangle (DOQQ) imagery. Record-level metadata is available

Figure 1. A July 27, 1939 LaSalle County photo.