



# Cartographic Perspectives

*Journal of the  
North American Cartographic  
Information Society*

SPECIAL MOUNTAIN CARTOGRAPHY ISSUE

Number 67, Winter 2010



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# Cartographic Perspectives

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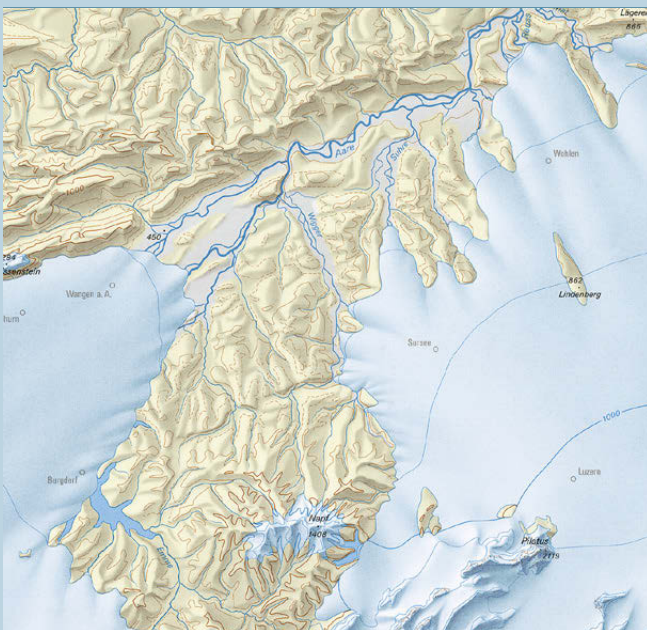
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Close-up of "Switzerland during the Last Glacial Maximum (LGM), 1:500,000"

## ABOUT THE COVER

The map of "Switzerland during the Last Glacial Maximum (LGM), 1:500,000" shows the maximum extent of glaciation in Switzerland at the height of the last Ice Age about 24,000 years ago. The Swiss Commission for Quaternary Research SKQ and Prof. Christian Schlüchter of the Institute for Geological Sciences at the University of Bern gathered the data and coordinated the scientific work. The Federal Office of Topography swisstopo is responsible for the cartographic work. The map published in 2009 presents the latest results of research on the Ice Age in Switzerland.

A digital version of the map is available for free from [www.swisstopo.admin.ch](http://www.swisstopo.admin.ch) > Products > Maps > Geological maps > Geological maps 1:500,000

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## LETTER FROM THE GUEST EDITORS

This special mountain cartography issue of *Cartographic Perspectives* features papers by members of the Commission on Mountain Cartography, a special interest group of the International Cartographic Association (ICA). The commission focuses on a range of issues related to the mapping of mountains—peaks, cliffs, scree, glaciers, and various other types of rough terrain. Mapping such extreme places presents challenges. For example, standard mapping techniques often do not apply, and collecting good geospatial data of high mountains is an ongoing challenge despite technology advances. There also is a cultural aspect to mountain mapping. Many mountain dwellers live under the threat of gravity-induced natural hazards, from avalanches to mudslides to damn bursts, which maps can help them better understand and deal with. But mountains have also long been a source of inspiration for those who visit and map them alike, prompting cartographic innovation. The well-known maps of Heinrich Berann, Richard Edes Harrison, Eduard Imhof, Hal Shelton, and Bradford Washburn highlight just some of the contributions by those engaged in mountain cartography to the profession as a whole. Most papers that follow are a sampling of those presented at the 2008 Mountain Cartography workshop at Lenk, Switzerland.

Since its founding in 1999, the Commission on Mountain Cartography has held biannual workshops at various mountain venues. To date these have included the Austrian Alps (2000), Mount Hood in the USA (2002), the Spanish Pyrenees (2004), the Julian Alps of Slovenia (2006), the Swiss Alps (2008), and the Carpathian Mountains of Romania (2010). The workshops have attracted an increasing number of presenters, reaching almost 60 participants at the last two workshops in 2008 and 2010. In addition to the formal program, the relaxed atmosphere of the workshops is conducive for catching up with old friends and making new ones. A workshop tradition is to devote the last day to outdoor activities for a range of interests and abilities, from ski touring to curling, or hiking, depending on the season. The workshops typically occur over three days in either late February or early September.

The workshop participants represent diverse backgrounds and interests, but share a common passion for mountain mapping. The presentations take many forms. These include longer academic papers, Pecha Kucha-style short presentations, software demonstrations, panel discussions, and posters. The presentation topics generally fall

into four thematic groups. In the first group are techniques, software, and ideas about 2D or 3D relief mapping, which are topics of recurring interest. This includes the related pursuits of contouring, relief shading, rock drawing, and vegetation mapping. The second group covers the monitoring of mountain environments and thematic mapping. The survey and visualization of glacier movements, and the mapping of avalanches and other mountain hazards are common topics in this category. The third group focuses on information systems and digital maps of mountain areas used by tourists and outdoor recreation enthusiasts. And, the fourth group concentrates on historical mountain mapping, looking at the activities of cartographers and expeditions from the past and their rich contributions to our profession. However, many of the workshop presentations are on alternative and innovative topics that do not fit into these neat groups.

This special issue contains three papers from North American and two papers from European authors. The first paper by Alex Tait (International Mapping, USA) examines maps of alpine ski resorts in North America. He compares the graphical styles of trail maps of more than 400 resorts, and traces the history of past and present artists, such as James Niehues, Hal Shelton and Bill Brown. The paper by Tibor Tóth (Tóth Graphix, USA) looks back on his forty-year career as a relief artist, much of it spent at the National Geographic Society. He discusses the manual development of relief art created by pencil, airbrush, and acrylic painting, and ends with digital relief shading. Tom Patterson (US National Park Service) discusses the making of a National Park Service map of Glacier Bay. He describes the various steps leading to a brochure map of this wilderness park visited mostly by cruise ship passengers. The paper examines various mountain-mapping challenges, including shaded relief, land cover, glaciers, fjord bathymetry, braided rivers, and place names. David Schobesberger and his coauthors (University of Vienna, Austria) describe the design of a map of mountainous Himachal Pradesh, India. The aim of this map is to support an interdisciplinary research network focusing on the cultural history of the western Himalayas. Schobesberger's paper describes data compilation from a variety of mostly suboptimal sources, starting with maps originally surveyed by the colonial British and ending with satellite imagery. The main author of the last paper is Anna Leonowicz (University of Zurich, Switzerland). Her paper discusses Terrain Sculptor, a new freeware application that prepares generalized terrain models for relief shading.

For additional mountain cartography readings and to learn more about the ICA Commission on Mountain Cartography, visit <http://mountaincartography.org/>. The website offers the proceedings of past workshops, the commission's terms of reference, a list of commission members, and information about the next scheduled workshop. We would welcome your participation.

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100 resorts. Niehues follows in the footsteps of two other Coloradans, Hal Shelton and then Bill Brown, and this Colorado School has been key in the development of a classic painted panoramic style of North American ski maps. Additional research is recommended to provide further details of the history of the maps and their creators as well as to analyze the artists' terrain manipulations and to look at the growing use of electronic trail maps.

## KEY WORDS

Ski maps, 3D-maps, panoramas, North America, map design, Hal Shelton, James Niehues

## MAPPING SKI MOUNTAINS IN NORTH AMERICA

Trails maps for ski areas are iconic images of the nature of the sport of skiing and its relation to the terrain on which ski resorts are built. Canada and the United States have well over 400 ski areas that are large enough to merit a trail map. The development of the maps has paralleled the development of the sport of lift-served skiing. As skiing in North America has grown and more money has flowed to building bigger resorts and marketing the resorts to skiers, more attention has been paid to marketing materials (Fry, 2006). The combination of bigger areas to map and an increase in money in the sport led to a shift from simple wayfinding maps to more elaborate mountain portrayals.

This study looks at the total number of ski maps in use during the 2007-2008 winter ski season and categorizes them by angle of view, method of creation, size, and artist, if known. An evaluation of these factors is provided in the context of how they affect the style of the ski map. In addition, an examination of the artists involved in the maps' creation yields information about the history of mapping ski resorts.

### *SURVEY OF SKI MAPS IN CURRENT USE*

A mountain ski map as defined for this paper is a map of the trails and ski facilities of a lift-served ski area. Maps are included for any ski area that has a vertical drop (top to bottom elevation change) of at least 200 feet (60 meters). In addition, due to the limit on time and expenses for gathering materials, the study includes only ski areas and resorts with established websites, indicating that they are both currently operating and that they are marketing to the public to entice skiers.

The resulting survey of ski maps does not include very small areas—because of the vertical minimum—and it does not include some of the smaller private and non-commercial ski areas that do not have websites or advertise in the manner of a commercial ski resort. Many of these areas have trail maps but are outside the main ski area focus of the industry and of this paper. Most resorts have additional maps in their marketing materials and on their websites that display Nordic or cross-country skiing trails, base lodge areas, resort towns, and lodging. These maps are not included in this study.

THE DEVELOPMENT OF THE MAPS HAS PARALLELED THE DEVELOPMENT OF THE SPORT OF LIFT-SERVED SKIING.

PAINTED PANORAMIC VIEWS HAVE A STRONG TRADITION IN SKI MAPPING IN NORTH AMERICA AND MUCH OF THIS DOMINANCE IN THE CURRENT SURVEY CAN BE ATTRIBUTED TO JUST A FEW ARTISTS.

The survey was conducted during January 2008 by searching the Internet for ski resorts and then for ski maps used by each resort during the 2007–2008 ski season. Compiled lists of resorts data were accessed at [www.skitown.com](http://www.skitown.com) and [www.skireport.com](http://www.skireport.com). Each ski map was obtained directly from the individual ski resort website. A visit to the individual websites confirmed that each resort was currently operating and allowed viewing of the trail maps provided by the resort. In cases of a resort with multiple trail maps, for example different maps for print and on-line use, the map designated for print and on-slope use was used. An electronic file was available for 428 out of 429 resorts researched (the only exception was Apple Mountain in Michigan, not included as part of the survey).

For each trail map the following information was catalogued: view type, creation method, artist, existence and type of interactive web map, and size of resort (vertical drop, number of lifts, number of slopes). In addition, subjective style notes were made to assist in categorizing maps and assigning authorship. View type describes the general nature of the view of the mountain, i.e. the location and orientation of the cartographer’s (or photographer’s) point of view in relation to the terrain. Creation method describes the technique used to construct the final image.

In order to isolate some of the more important trends in the creation of ski maps, a distinction was made between major resorts and minor resorts. The major resorts are the top 100 ski areas as defined by a size index calculated by multiplying the vertical drop (top to bottom elevation difference) by the number of lifts and then by the number of trails. The use of vertical drop in the index aided in putting the larger mountains (in terms of terrain covered) toward the top of the list. Many of the smaller mountains did not make it into the top 100 resorts.

The initial results of the survey are summarized in Table 1. Some immediate trends emerge, such as the preponderance of ski maps using the panoramic view. Indeed for the major resorts it is the only type of view used. Also, the painted technique—originally using traditional art tools and now often using computer painting applications—is the dominant method used to create the trail maps. Painted panoramic views have a strong tradition in ski mapping in North America and much of this dominance in the current survey can be attributed to just a few artists.

	All Ski Resorts	%	Top 100 Ski Resorts
<b>View type</b>			
panoramic	368	86%	100
profile	36	8%	0
planimetric	24	6%	0
<b>Total</b>	423	100%*	100
<b>Creation method</b>			
painted	307	72%	89
illustrated	85	20%	7
annotated photo	24	6%	1
computer rendered	12	3%	3
<b>Total</b>	428	100%*	100

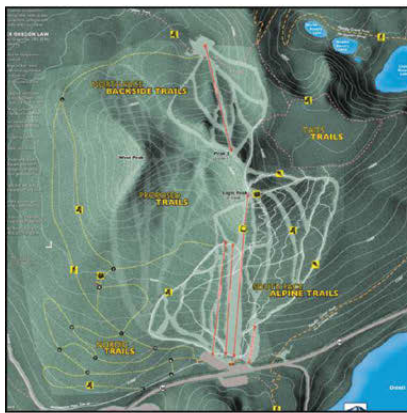
\*All percentages have been rounded

Table 1. Survey of North American mountain ski maps, counts, and percentages by view type and creation method.



## TYPES OF VIEWS

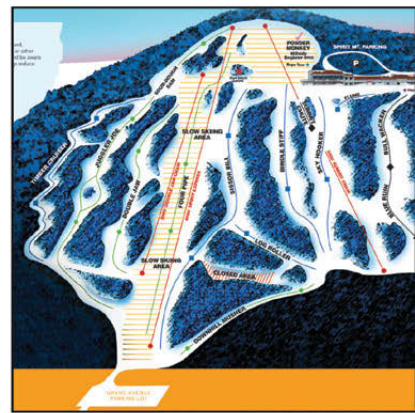
Three general types of views exist in the set of maps evaluated in the survey (see Figure 1). Planimetric views are images viewed from directly above all portions of the skiing area. Panoramic views are oblique perspective views of any angle—there are a great variety of angles used, from very low to very high. Panoramic views are often not topographically accurate. Artists distort the terrain to better show certain features and to emphasize certain areas for detail or accent (Patterson, 2000). Profile views are generally very simple elevational views of the mountain from a very low oblique angle or ground level that have little or no three-dimensional character and look into the mountain with little or no perspective. Assignment of some low oblique views to either panorama or profile groups was a difficult task. Those exhibiting little or no attempt at shading or perspective were labeled as profile. An important difference between panoramas and profiles is that a panorama usually shows the landscape context of the resort mountain and the profile only a single slope.



*Planimetric view*



*Panorama*



*Profile*

*Figure 1. General types of views utilized in mountain ski maps (left to right: Willamette Pass, Oregon; Crested Butte, Colorado; Spirit Mountain, Minnesota).*

Panoramic views comprise 86% of all ski trail maps and 100% of maps for the top 100 resorts. There are several probable reasons for this. Patterson (2000) notes in discussing the work of Heinrich Berann, one of the earliest panoramic mountain ski map painters, that with a panorama, “[s]omething truly magical happens. Readers feel drawn into the panorama as if they were flying high above the land.” The panoramic ski map may be particularly evocative of the mountain terrain for skiers and potential skiers for whom the feel of the image may replicate the feel of flying down the mountain on skis.

Profile maps constitute about 8% of the total ski maps in this survey. While in some ways a subset of panoramic maps, they generally lack the key features of panoramas such as depiction of a true depth of field. Resorts with smaller mountains often use profile maps perhaps because they can make small mountains look larger than they would in a panoramic view. Profile maps have other advantages for smaller resorts: they are easier and less expensive to produce and they are easily made more schematic to match simple trail layouts.

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THE DEMANDS OF  
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AT ODDS WITH AN  
ACCURATE PORTRAYAL  
OF THE MOUNTAIN  
(PHILLIPS, 2007;  
POWERS, 2008).

Planimetric views are relatively rare in the survey of current ski trail maps, only 6% of the total. In a brief examination of cross-country (Nordic) ski trail maps associated with ski resorts, the planimetric map is much more prevalent. Given the high accuracy of trail and feature placement it may at first seem surprising that planimetric maps are not used more. They can be better wayfinding instruments for experienced map users. Wayfinding, however, is only one reason for creating the map and can be minor compared to the need for the map to market the ski area and entice new skiers to visit.

The apparent preference for panoramas, and to a lesser extent profiles, may be attributable to the desire for resorts to look impressive to potential visitors. The need to attract visitors exerts a strong influence on all publications for a ski resort including trail maps. The demands of the marketing department can be at odds with an accurate portrayal of the mountain (Phillips, 2007; Powers, 2008). Ski areas often ask for the mountain to “look bigger” and for the artist to distort the mountain for this purpose. At other times requests are made for the trails to appear more clearly delineated and map-like. These two requests coming at the same time can pose a serious challenge that in some cases is resolved by local distortion of the mountain terrain and camera view.

#### METHODS OF CREATION AND GRAPHIC STYLES

Ski trail map artists use three basic production methods: painting, illustration, and computer rendering. Artists creating maps in the painted and illustrated styles use both traditional fine arts tools and computer paint and illustration applications. The author made an initial distinction between computer tools and traditional tools but because the resulting maps are very similar, this distinction was dropped.

The painted style is used in 72% of all ski trail maps and 89% of maps for the top 100 ski areas. For an example of a map created with traditional painting techniques, see the image of Mammoth Mountain ski resort painted by Hal Shelton (Figure 2). For an example painted on the computer see Mount Bachelor by Peter Powers of Terragraphics (Figure 3). Painted maps are primarily characterized by the use of brushwork. They provide the artist with great flexibility in terrain depiction and full control of all aspects of the image but they also require the greatest artistic skill. Despite the fine work by artists such as Hal Shelton and James Niehues, examples abound of unconvincing painted maps.

Illustrated maps are more prevalent in use for smaller ski areas (20% of all areas) than for larger areas (7% of top 100 areas). They are characterized by hard lines and sharp edges. While all maps use illustrated elements for some lines and for text, the group of illustrated maps uses vector-based art for the terrain itself. The illustrated maps of Gary Milliken (VistaMaps) are in use at several major ski areas and are the largest and most extensive of the vector art images encountered in the survey (see Figure 4 showing Vail, Colorado ski resort which replaced a painted map by James Niehaus). These maps usually rely on vector software programs—though some are illustrated with traditional tools—and have a mechanical, less natural feel than the other techniques.



Figure 2. Hal Shelton painted view of Mammoth Mountain ski resort in California using traditional painting techniques.

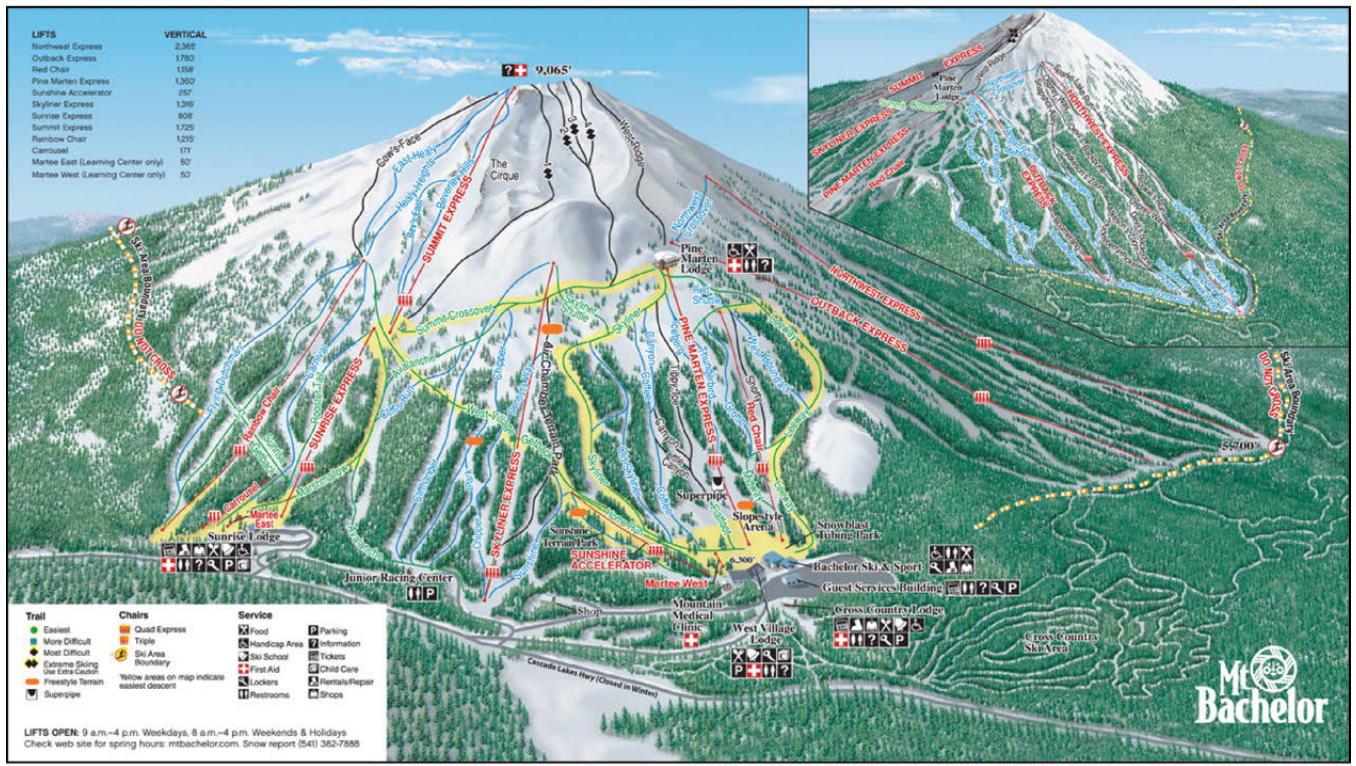


Figure 3. Peter Power's painted view of Mt. Bachelor ski resort in Oregon using computer painting techniques.



Figure 4. Gary Milliken's illustrated view of Vail ski resort in Colorado (image is from 2006-2007 season but mountain illustration is the same as for 2007-2008 season).

A SURPRISINGLY SMALL NUMBER OF RESORTS USE COMPUTER RENDERED IMAGES FOR THEIR TRAIL MAPS, ONLY 3% OF ALL RESORTS AND 3% OF TOP 100 RESORTS.

A surprisingly small number of resorts use computer rendered images for their trail maps, only 3% of all resorts and 3% of top 100 resorts. Computer rendered trail maps are virtual landscapes created in three-dimensional modeling applications. The author has created two such views for major California ski areas. See the example below (Figure 5) for Northstar-at-Tahoe. This view uses procedural textures and modeled trees to mimic the patterns of slope and forest on the mountain. Breckenridge is another resort that recently converted from a painted trail map by James Niehues to a computer rendered map (Niehues, 2008). The Breckenridge map (see Figure 6) employs a standard satellite photograph draped over a digital elevation model. It includes computer modeled and rendered three-dimensional buildings for the town of Breckenridge.

Six percent of all resorts use an annotated aerial photograph—taken from an oblique angle—in place of artwork for their trail map, although only one resort of the top 100 does. Annotated air photos are relatively simple to create and can be effective for some compact ski mountains. They suffer from the fixed nature of a photographic image, there is little or no ability to control generalization, selection or emphasis of terrain features as an artist can in a painted, illustrated, or computer rendered trail map. For a nice example of an annotated air photo trail map, see Figure 7, showing Whitewater resort, British Columbia.

## INDIVIDUAL ARTISTS AND SKI TRAIL MAPS

The array of ski maps in use today reflects the history of artists involved in the business. Maps by Hal Shelton, Bill Brown, and Don Moss, are still in use though some were created 30 to 40 years ago. Hal Shelton was the first prominent ski



Figure 5. The author's computer rendered view of Northstar-at-Tahoe, California.

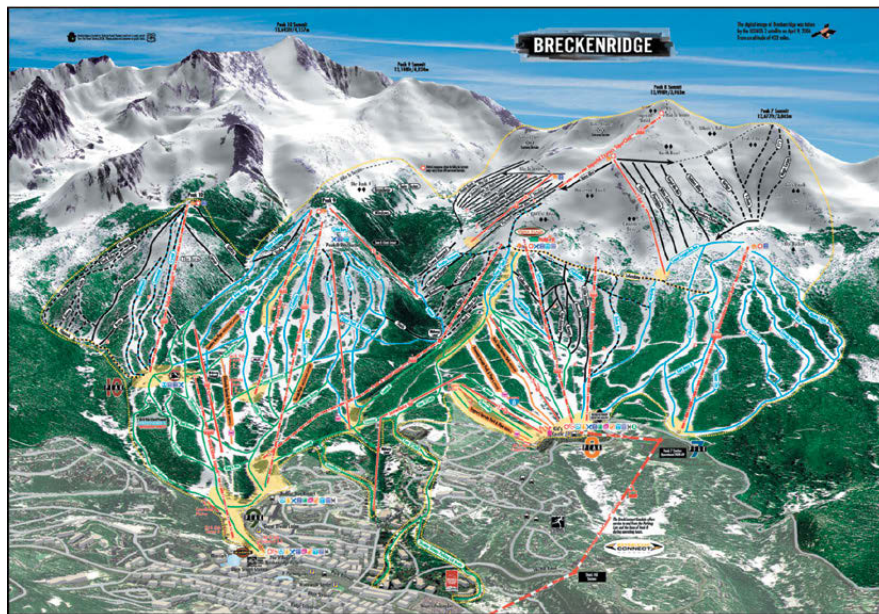


Figure 6. Computer rendered view of Breckenridge resort, Colorado (author unknown).



Figure 7. Annotated air photo trail map for Whistler, British Columbia (author unknown).

trail map artist and he came to the work from both landscape painting and cartographic backgrounds. Shelton had a distinguished career as an innovative map designer with the U.S. Geological Survey and with the Jeppeson Map Company (Patterson and Kelso, 2004). Painting ski maps was a bridge for him between his work as a cartographer and his later work as a fine artist painting landscapes (Masia, 2005).

Shelton was most active in the 1960s and 1970s. Later in the 1970s and into the 1980s the bulk of ski trail mapping work passed to Bill Brown and then in the 1980s to James Niehues, forming a progression of Colorado based artists (Phillips, 2007). Niehues (2008) describes this passing of the baton and notes that the business of ski trail mapping is a niche market that has been dominated by a single artist at most times. During this era of painted panoramas there were other important artists working in North America, they include Don Moss working out of the northeastern United States in the 1960s and 1970s (Masia, 2005) and Murray Hay working out of Alberta, Canada.

In the last decade, a greater number of artists have been making ski trail maps. Recent entrants into the business have included Peter Powers of Terragraphics, Gary Milliken of VistaMap, and this author. These artists have produced maps with a variety of computer-based techniques: vector-graphics illustration, digital painting, and three-dimensional modeling and rendering.

For January 2008, the count of ski trail maps by credited artists with at least two views is as follows. James Niehues tops the list with 112 total maps and 57 out of the top 100. Peter Powers' company Terragraphics counts 25 total, Gary Milliken 8, Don Moss 4, Murray Hay 3, Bill Brown 2, K.M. Mastin 2, Hal Shelton 2, and the author 2. Note that only about one-third of maps had clear attributions, additional research will be needed to identify more artists and obtain a more accurate count.

## HAL SHELTON

Hal Shelton's painted view of Mammoth Mountain ski area in the Sierra Nevada Mountains of California is truly a masterpiece (Figure 2). Its natural coloring, panoramic view, trees textures, and depth of field combine to produce a pleasing and easy to read trail map for skiers. A second painting of the mountain in summer appears to also have been painted by Shelton and uses a different view (higher oblique) but is no less effective. (Note that by the 2008–2009 season the Shelton maps for Mammoth had been replaced with newly painted maps by James Niehues.) Shelton was the first major ski trail map artist in North America and he set the bar very high for all those who have followed.

Of particular note in the Mammoth Mountain view is the effective depth of field achieved. Shelton used a slightly blurred effect for the background ranges, a light haze intensifying toward the horizon and careful placement of the mountain in relation to the background and sky. Though the summit does not break into the sky, it is the focus of the view and gives the impression of a big mountain, a desire that is always high on the list for any ski resort's map.

## BILL BROWN

Bill Brown's views of Ski Santa Fe, New Mexico and Arizona Snowbowl (see Figure 8) show a continuation of the classic painted panoramic trail map style initiated in North America by Hal Shelton. The individually painted trees, the use of haze to bring depth of field and the overall naturalistic look are key elements to this style. Brown's positioning of the subject mountain against the sky, without multiple background ranges, brings an intimacy to the view and also makes the mountain taller in the mind's eye.

HAL SHELTON WAS THE FIRST PROMINENT SKI TRAIL MAP ARTIST AND HE CAME TO THE WORK FROM BOTH LANDSCAPE PAINTING AND CARTOGRAPHIC BACKGROUNDS.

BROWN'S VIEWS OF SKI SANTA FE, NEW MEXICO AND ARIZONA SNOWBOWL SHOW A CONTINUATION OF THE CLASSIC PAINTED PANORAMIC TRAIL MAP STYLE INITIATED IN NORTH AMERICA BY HAL SHELTON.

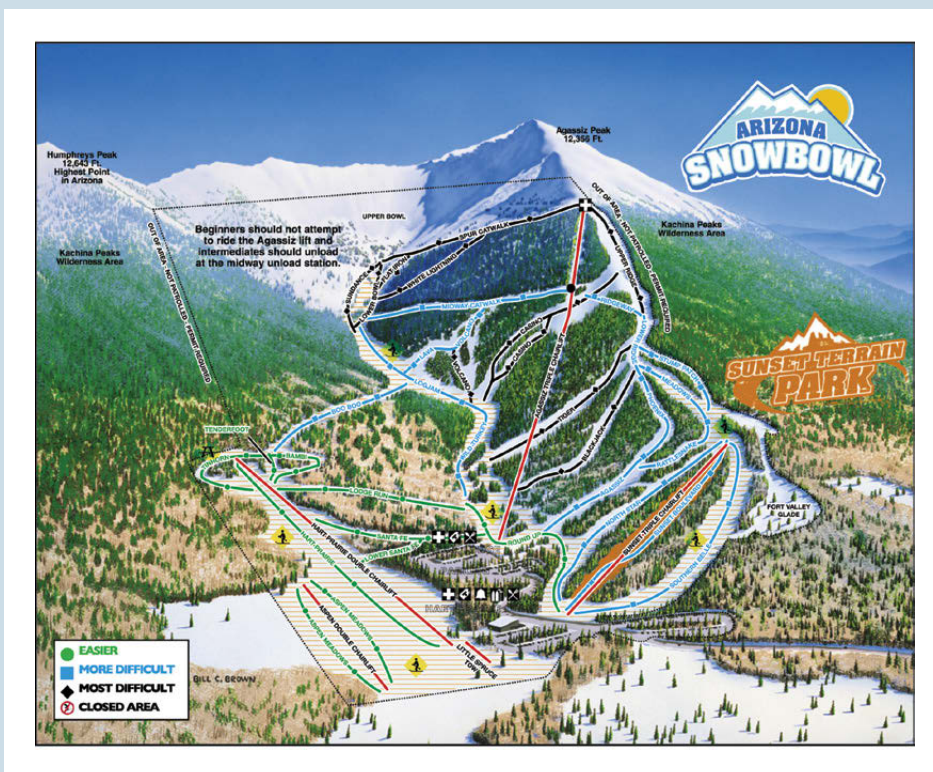


Figure 8. Bill Brown painted views of Ski Santa Fe, New Mexico and Arizona Snowbowl.

## JAMES NIEHUES

PERHAPS THE MOST DISTINCTIVE ELEMENT OF NIEHUES' WORK IS THE RENDERING OF TREES. HIS PAINSTAKING PAINTING OF EACH TREE, ITS FORM, ITS HIGHLIGHT, AND ITS SHADOW GIVE HIS WORK A FORESTED TEXTURE UNLIKE MOST OTHERS.

The distinctive signature of James Niehues appears on more ski trail maps in North America in the period of this study than any other. He has painted mountain ski maps around the world, over 120 by his count. Niehues sits firmly in the classic school of painted panoramas, he credits Hal Shelton and Bill Brown as his mentors but also the panoramic views from Europe, such as those created by Heinrich Berann (Niehues, 2008). See Niehues' view of Whistler Blackcomb (Figure 9) for an example of his trail maps

Perhaps the most distinctive element of Niehues' work is the rendering of trees. His painstaking painting of each tree, its form, its highlight, and its shadow give his work a forested texture unlike most others. The difference between evergreen and deciduous trees in areas such as Vermont (see his panoramic map of Jay Peak for example) is a tribute to the care he takes in preparing each map view. Other distinguishing characteristics are his buildings and cars parked at ski area bases.

Niehues does not use computer elevation models for visualizing terrain. He uses topographic maps and reference air photos, often taking the photos himself. He then prepares rough sketches for approval and completes the work with traditional brushes and paints (Phillips, 2007). Because of the variety in Niehues work it is hard to describe a single technique for positioning and distortion of terrain and camera for his panoramas. His view of Whistler Blackcomb uses the classic technique of a progressive projection (as described by Jenny, 2004) that renders the foreground with a steeper angle than the background.

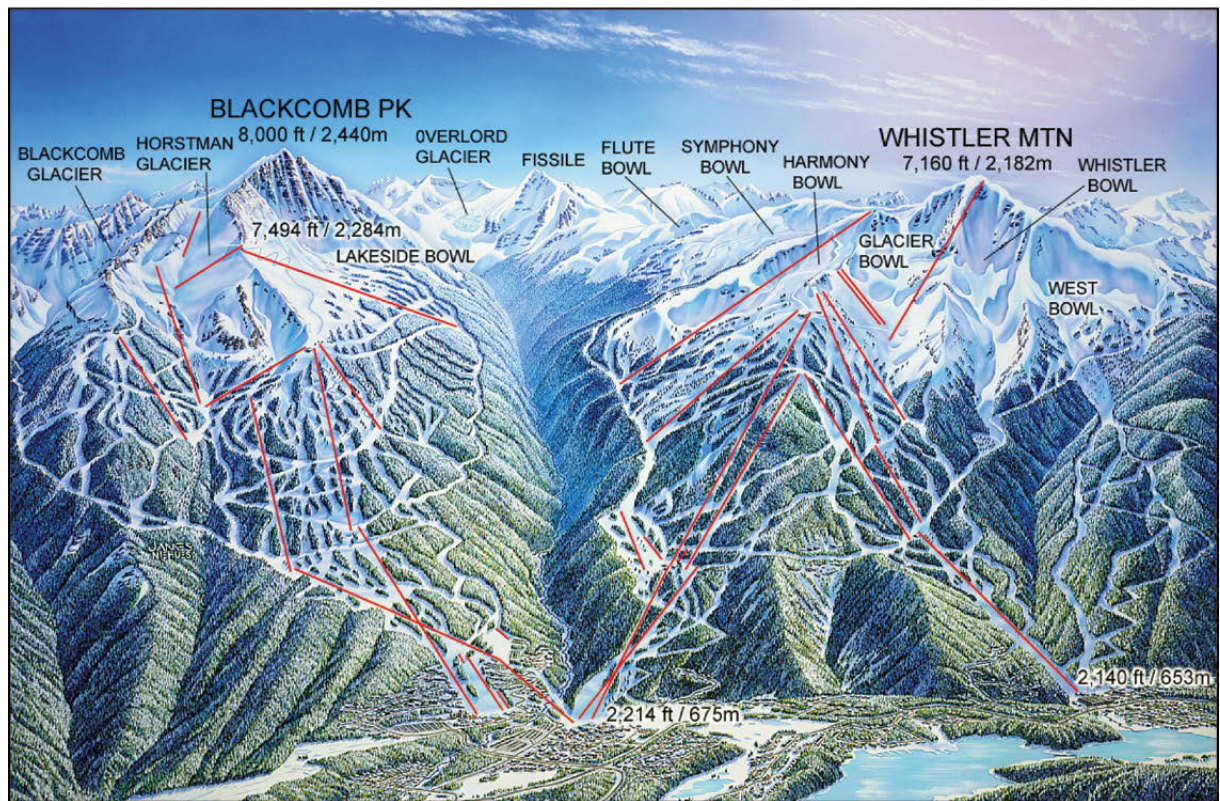


Figure 9. James Niehues painted view of Whistler Blackcomb in British Columbia.



## CONCLUSIONS AND FUTURE RESEARCH

This survey of mountain ski trail maps shows that the painted panorama style is preeminent. A series of three Colorado-based traditional artists—Shelton, Brown, and Niehues—have been key in the development of this classic style of North American ski maps. Digital techniques introduced by a new set of artists have brought changes around the edges of the Colorado style.

Much work remains to provide a complete picture of the history of ski maps in North America and the influences upon their style. A more extensive survey could evaluate North American ski trail maps at several dates from the early years of ski resorts in the 1930s through the decades to the present. It could also look at the succession of maps at individual resorts with long histories such as Vail, Colorado and Stowe, Vermont. Another aspect of the history of these maps is their relationship to the growing needs of resorts for advertising. When did the marketing need outweigh the wayfinding purpose of the map? Finally, one could examine the influence of the U.S. Forest Service on ski resort tourism. Approximately one half of the nations skiing is done on National Forest land and the Forest Service developed its own marketing materials and maps (Fry, 2006).

An analysis of panoramic view construction in the ski trail maps would be fertile ground for more research. Artists have altered vertical exaggeration, perspective, and many other aspects of the panoramic views. How exactly have they modified the physical mountain terrain? What objectives are driving these alterations? Is it possible to reconstruct the view from digital elevation data to see what the mountain should look like in the panorama versus what the artist's eye has created? (See Patterson 2000 for an example of reconstructing a panoramic view using digital elevation data.)

One final area for exploration is interactive maps. In this survey of ski trails maps, a note was made during the visit to each resort website of the existence of an interactive web map. In January 2008, for all ski area websites, 76 out of 428 (or 18%) had an interactive map, for the top 100 resorts, 52 websites had them. How fast have these on-line maps been adopted? How useful are they to skiers? Are they used on-slope with mobile phones? This may be the future of ski mapping for the next generation of skiers.

*A SERIES OF THREE COLORADO-BASED TRADITIONAL ARTISTS—SHELTON, BROWN, AND NIEHUES—HAVE BEEN KEY IN THE DEVELOPMENT OF THIS CLASSIC STYLE OF NORTH AMERICAN SKI MAPS.*

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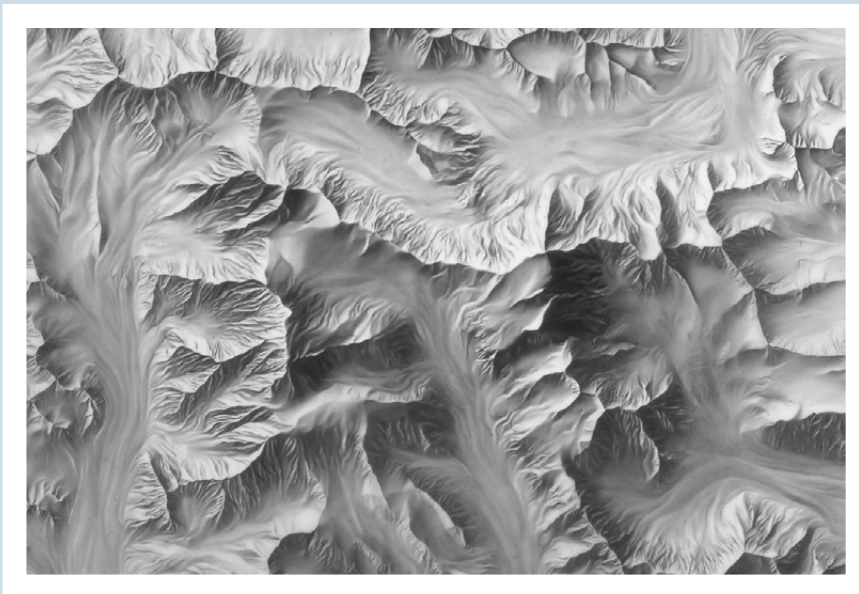
1. Skireport, <http://www.skireport.com/>
2. Skitown, <http://www.skitown.com/>
3. Whitewater Ski Resort, <http://www.skiwhitewater.com>





stick dipped into graphite powder to create rather crude relief images. After completion of the program, for the next ten years I worked as a cartographic draftsman at Freytag-Berndt & Artaria (Vienna, Austria), American Geographical Society (New York), and the National Geographic Society (Washington, D.C.), where I had the opportunity to produce several pencil relief originals. However, it was not until the National Geographic Society undertook a map of Mt. Kennedy, Canada, that my budding career as a relief artist gained momentum. This map, a joint research project involving the National Geographic Society, Boston Museum of Science, Michigan State University, and the University of New Brunswick, was to feature a new design: relief art in the Swiss topographic style. Because National Geographic Society had no in-house expertise in this area, they engaged the services of a retired Swiss cartographer, Paul Ulmer, to instruct a number of us in the relief presentation style made famous by Professor Eduard Imhof, Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule), Zurich. At the end of the training program, Ulmer selected me to draw the relief for the map of Mt. Kennedy published in August 1968 (Figure 1a).

*IT WAS NOT UNTIL THE NATIONAL GEOGRAPHIC SOCIETY UNDERTOOK A MAP OF MT. KENNEDY, CANADA, THAT MY BUDDING CAREER AS A RELIEF ARTIST GAINED MOMENTUM.*



*Figure 1a: The massif of Mount Hubbard, Mount Alverstone, and Mount Kennedy. 1968, 1:31,680. Washington: National Geographic Society.*

The Mt. Kennedy shaded relief was a major departure from past practices at the National Geographic Society. Abandoning the prevailing practice of drawing relief at 150 percent of size, I drew the relief for the first time at 100 percent, the final reproduction size. Instead of paper, the base was fine-grained Cronaflex drafting film that was dimensionally stable. On this surface I created a wide range of light gray to solid black tones using 4H (hard) to 6B (soft) Koh-i-Noor graphite leads, the same brand preferred by artists.

The relief shading principle of aerial perspective is the most important lesson that I learned from Ulmer and from reading Imhof's *Kartographische Geländedarstellung* (1965) (English translation: Imhof (1982)), which has application for both monochromatic and full color relief images. The basis for the principle is the real-life effect of atmospheric haze. When we view a landscape

*WITH THE AERIAL PERSPECTIVE EFFECT PROPERLY APPLIED, MOUNTAINS APPEARING ON A FLAT PAGE GIVE THE ILLUSION OF PRONOUNCED THREE-DIMENSIONALITY.*

WHEN COMPARED TO THE PENCIL SHADING TECHNIQUE, THE AIRBRUSH'S GREATEST BENEFIT IS THAT IT CUTS BACK ON THE PRODUCTION TIME BY AS MUCH AS ONE HALF.

obliquely, features that are far away, or near the horizon, appear soft and flat, while the features closest to us are visible in all of their details. Translating this principle to a map viewed from directly above, looking straight down, the illusion of depth enables us to see the highest peaks, the terrain that is closest to us—with more detail and contrast than the more distant lowlands that are subdued by comparison. With the aerial perspective effect properly applied, mountains appearing on a flat page give the illusion of pronounced three-dimensionality.

The graphical quality and accuracy of shaded relief created by pencil depends largely on the artist's skills: drawing ability, interpreting contours, and portraying the resulting mental image as a three-dimensional terrain on the page. In regard to production time, pencil drawing and painting with acrylics (which will be discussed below) are the most time-consuming methods of illustrating terrain, as well as the most difficult to learn.

#### AIRBRUSH RELIEF

My next major project for National Geographic was The Map of the Earth's Moon. The initial prototype that I drew with pencil had a rigid, chiseled look that did not quite look like the moon—creating this piece obviously would require a new way of working. I enrolled in a one-week course at the Lowell Observatory in Flagstaff, Arizona, to learn how to use a Paasche Type AB airbrush. This sophisticated device allowed me to create a shaded relief of the moon with realistic impact craters and broad lunar seas (Figure 1b). For an information source, I depended on 1966-67 U.S. Lunar Orbiter photographs that covered 99.5 percent of the Moon's surface.

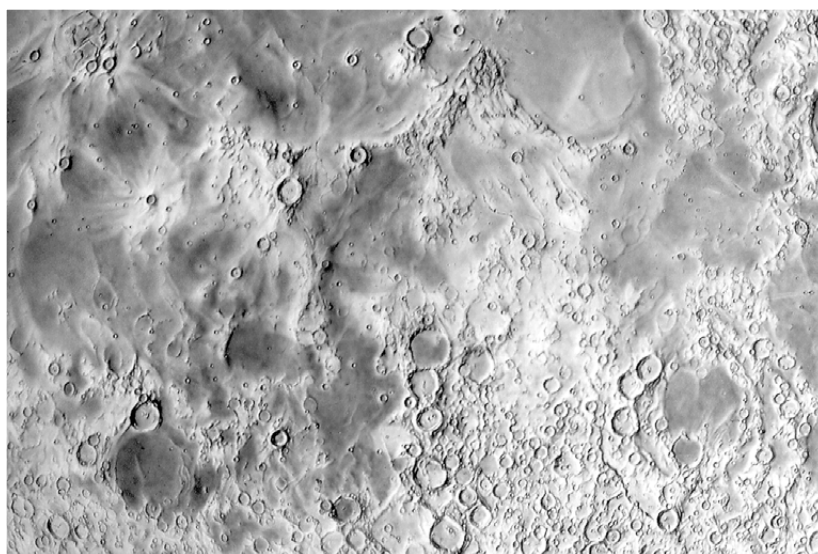


Figure 1b: The Earth's Moon. 1969, 1:11,620,000. Washington: National Geographic Society.

Producing high quality relief with a Paasche AB airbrush has demanding requirements: 1) regulating compressed air via a pressure gauge to provide a clean, dry and steady flow; 2) sharpening airbrush needles to a finer point than that provided by the factory; 3) creating a free-flowing mixture of black Pelikan T

ink, distilled water, and a drop of ammonia to further break down the ink particles to prevent clogging; and 4) using a hand-held, adjustable-speed electric eraser to eliminate any slight oversprays and to sharpen highlights.

When compared to the pencil shading technique, the airbrush's greatest benefit is that it cuts back on the production time by as much as one half. Unlike the reflective art produced by graphite pencil, which requires special care in camera reproduction, airbrush art has a matte surface conducive to photography.

### FULL COLOR RELIEF

After producing additional black-and-white airbrush relief art, the next challenge was to create relief in full color. Rather than develop a color technique from scratch, the National Geographic, Cartographic Division arranged for me to meet with Hal Shelton, the American master of relief painting, at his studio in Golden, Colorado.

To simply say that the two-day visit was useful would be a gross understatement. The technique that he shared with me was priceless. Immediately upon my return to Washington I started work on a series of continental physical maps (Figure 2a) for the National Geographic Atlas of the World, art that saw repeated reprints as recently as the 2005 edition. There was only one disappointment with my visit—I was unable to see any of Shelton's relief originals because they were stored in a vault at a distant location.



Figure 2a: Physical Map of Africa, National Geographic Atlas of the World. 1992, 1:16,950,000. Washington: National Geographic Society.

The colored National Geographic Atlas plates depict potential natural vegetation zones, the land cover that existed before/without any human influence such as farming, built-up areas, etc. I compiled this information

from a wide variety of sources, the most useful being A.W. Küchler's Potential Natural Vegetation map series. For terrain features, I depended on the landform maps made by fellow Hungarian, Erwin Raisz; jet navigation charts at 1:2,000,000-scale; and the 1954 edition of Atlas Mira, maps which provide very good small-scale contour information.

From these sources I generalized potential natural vegetation into eight categories: tundra, evergreen forest, mixed forest, deciduous forest, grass, shrub, desert, and ice. Following Shelton's palette as a general guide, I mixed Cadmium Red Medium, Phthalo Blue, Cadmium Yellow Medium, and Titanium White Liquitex acrylic paints to create a unique palette. National Geographic Society physical maps carried this color scheme for many years afterwards (for details, see Patterson 2004).

Following Shelton's practice, I initially painted the color relief originals on so-called "deep-etched" offset press plates. On these plates, the base map compilation consisting of lines appeared as shallow incisions cut into the metal. When painting, the lines were visible as guides if a light source were set at a shallow angle coming from the top left. During photographic reproduction, these lines disappeared under full frontal illumination.

After two or three maps produced in this time-consuming manner, I abandoned metal plates in favor of double-weight Bainbridge 80 Illustration Board. Compilation lines appeared on this super-white surface as blue lines, applied as a light-sensitive emulsion and exposed through photographic negatives to an extremely bright light source.

Visitors to the Cartographic Division frequently asked me, "How do you paint color relief?" Giving a satisfactory answer was always difficult because my process was as much about technique as it was "visualizing and feeling" the terrain. When pressed, I would give a simplified step-by-step answer. "First, lightly airbrush flat vegetation tints over the blue-line base. Then comes the detail work: after carefully studying the terrain characteristics, and imagining that I am viewing the area from high up in space, I start sketching in the relief, modeling features with darker tones and light highlight colors. Always referring to contour lines and other information sources, I continue building the relief image until I am satisfied with the result. Finally, sometimes after hundreds of hours of effort, to prepare the art for final reproduction, I eliminate the still visible blue lines in the compilation base by applying liquid bleach spray."

Another milestone in my relief career came in the early 1970s when Austrian artist, Heinrich Berann, visited National Geographic Society. His beautiful, brilliantly colored panoramas were and still are unmatched by anyone's work, and his ocean floor paintings brought to life a yet unexplored part of our world. That meeting, and subsequent extensive studying of his work, eventually enabled me to start the production of the Society's new set of ocean floor maps (Figure 2b).

Painting the ocean floor employs basically the same technique as that used for terrestrial areas, but with the obvious difference of a limited blue palette. As a source for bathymetric detail, I used the General Bathymetric Chart of the Oceans (GEBCO), ocean bottom charts produced by Marie

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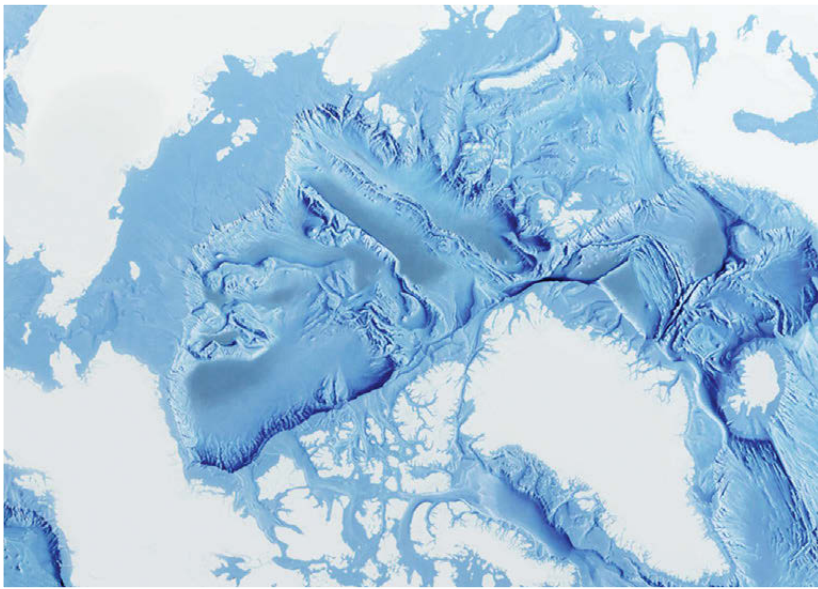


Figure 2b: Arctic Ocean Floor (Ocean relief only), *National Geographic Atlas of the World*. 1992, 1:10,100,000. Washington: National Geographic Society.

Tharp and Bruce Heezen (Lawrence 1999), and earlier Berann maps interpreting the original Tharp and Heezen data.

The Heart of the Grand Canyon was the largest (36 x 36 inches) and most time consuming (1,075 hours) relief that I painted during my twenty-two years at the National Geographic Society. I like to think of this work as my “relief thesis” because it effectively incorporated all that I had learned about relief shading up to that point (Figure 3). I produced it with a combination of airbrushing and acrylic painting with size “0” brushes. The base map with contour lines that guided me resulted from a 1972 aerial photography and field survey, so I am confident that the relief is the most accurate and detailed relief painting of Grand Canyon even to this day.

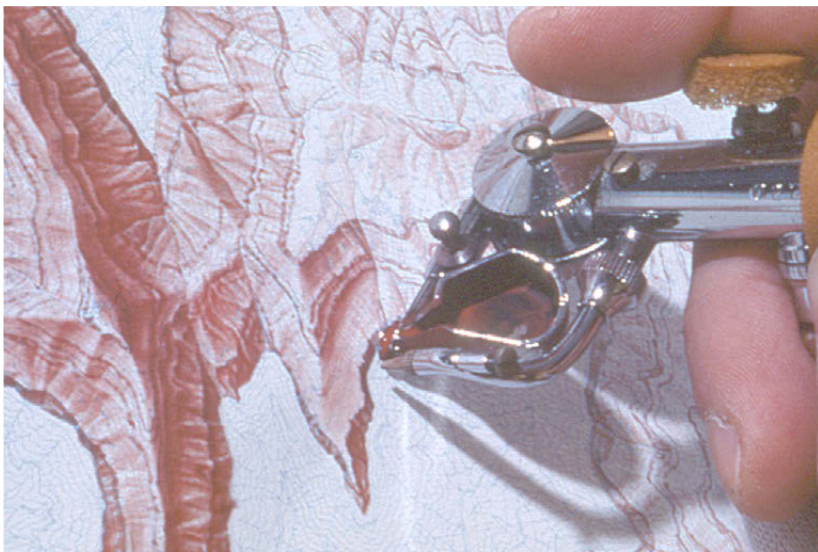


Figure 3: The Heart of the Grand Canyon. 1978, 1:24,000. Washington: National Geographic Society.

## DIGITAL RELIEF

In 1986 I left the employ of National Geographic to become a freelance relief artist (Tóth Graphix 2009). However, my working relationship with the Society continued unabated with each new relief art commission that I received from them. This change in career coincided with a groundbreaking new way of producing relief art.

My entry into the digital era started in 1993 when, during a visit to National Geographic, I observed someone using a digital airbrush technique on an Apple Macintosh computer to produce grayscale relief. I was eager to find out more about this new technique, with which I had no prior experience. Through the courtesy of the Cartographic Division, I became familiar with computer basics, the use of the Wacom tablet and Adobe Photoshop airbrush tool, and the amazing “undo” command. I purchased my first Macintosh computer and immediately “retired” my manual airbrush, brushes, and paints. Since going to an all-digital workflow, I no longer struggle with a splattering Paasche AB airbrush and dentist drill-like sounds. Now I listen to music.

On another visit to National Geographic I learned that digital elevation models (DEMs) and Bryce software could produce computer-generated relief images. So, the learning curve started all over again, this time with help from Tom Patterson at the U.S. National Park Service (Patterson 2009). Patterson, an early adopter of Bryce for creating relief art, has freely shared his techniques.

Presently my favorite application for rendering planimetric and oblique relief is Natural Scene Designer Pro 5.0 by Natural Graphics. With this fast and simple-to-use software, I start by producing a base relief image with resolution-bumped DEMs (Patterson 2001). As good as these images may appear at first glance, closer inspection reveals data-related deficiencies requiring retouching or, in extreme cases, more extensive over-painting. For these tasks I am grateful for all those years of conventional relief experience. For example, to create the oblique relief image of Hispaniola (Figure 4a), I spent more than half of my production time on re-painting the relief with

MY ENTRY INTO THE DIGITAL ERA STARTED IN 1993 ... I OBSERVED SOMEONE USING A DIGITAL AIRBRUSH TECHNIQUE ... TO PRODUCE GRAYSCALE RELIEF.

I [LATER] LEARNED THAT DIGITAL ELEVATION MODELS (DEMs) AND BRYCE SOFTWARE COULD PRODUCE COMPUTER-GENERATED RELIEF IMAGES.



Figure 4a: Central portion of West Indies. *National Geographic Magazine*. March 2003. Supplement map. Washington: National Geographic Society.

the Adobe Photoshop airbrush tool. To create smaller-scale relief art, the low resolution (30 pixels per degree) and poor data quality of the ETOPO2 (or even CleanTOPO2 (Patterson, n.d.)) source data necessitates manual retouching. This is especially true for the ocean floor that generally receives disproportionately more of my attention than the land (Figure 4b).



Figure 4b. Oblique Caribbean Sea digital relief created with Natural Scene Designer Pro and repainted with Adobe Photoshop airbrush tool; unpublished.

## CONCLUSION

For me, relief portrayal on maps is not only a job but also an enjoyable and challenging artistic activity (Tóth 1986, 2005, 2006). The more projects I work on, the more I realize that there is no definite work routine to this wonderful madness of digital relief production. Each project presents a different set of challenges and will require its own unique solutions. Be it an illustration depicting the sunrise over the Mediterranean (Figure 5), an oblique view map of the Alps for the National Geographic Magazine (Figure 6), or a physical map of Europe produced for Columbus Verlag, Germany (Figure 7), this “Accidental cARTographer” relishes new challenges.

Through the years, every project that I have worked on has become a growth opportunity, and my development in relief shading has mirrored National Geographic Society’s notable progress in the field. I consider myself fortunate to have met and learned from two of the world’s greatest artist-cartographers, Hal Shelton and Heinrich Berann. Both men come from a fine art background and merged their wonderful talents and visions with their love of cartography.

Shelton, who clearly recognized the importance of art to relief depiction on maps, and noting my lack of formal art training, advised to pursue training in this area. On the strength of his advice I took the Famous Artists correspondence course, hoping to gain exposure and experience in landscape painting. Instead, the course led me to the love of portraiture and to the realization that every time I create a relief, I am not only making a map but also am painting a portrait of our Earth’s old, wrinkled, beautiful face.

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CARTOGRAPHY.*

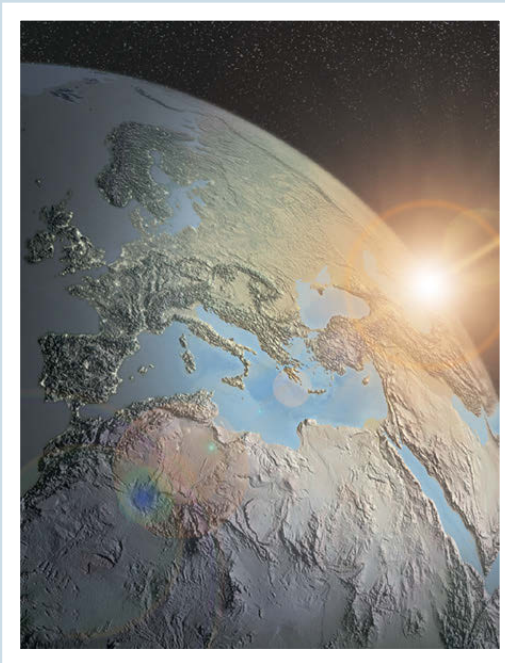


Figure 5. *Mediterranean Sunrise* produced with *Natural Scene Designer Pro. Digital; unpublished.*



Figure 6: *Meltdown in the Alps*. 2006. *National Geographic Magazine*. Feb. 2006, 102–103. Washington: National Geographic Society.

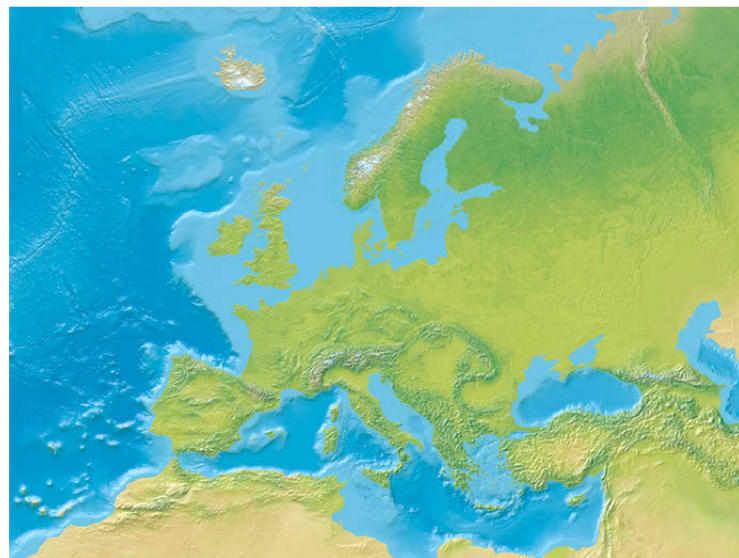


Figure 7: *Europa*. 2007, 1:6,500,000. Krauchenwies, Germany: Columbus Oestergaard.

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Since 1794 when British explorer George Vancouver visited the area, glaciers have retreated 100 kilometers up Glacier Bay and now exist tenuously only in the harsh uppermost fjords. Luxuriant temperate rainforest has colonized the lower reaches of the bay. Four hundred years ago Hoonah Tlingit Indians inhabited lower Glacier Bay before advancing ice associated with the Little Ice Age forced them out—they still regard Glacier Bay as their ancestral home. Land in deglaciated areas is rising at a rate of 2.5 centimeters a year, reconfiguring coastlines; braided drainages are in constant flux; and glacial silt is filling estuaries. A landslide triggered a tsunami in 1958 that scoured trees from a mountain 525 meters above sea level, the highest wave ever recorded. The paper discusses the challenge of mapping on a modest-sized sheet of paper this dynamic information for a park 13,520 sq. km. in area, about the size of Connecticut.

The new brochure and map will serve a most uncommon national park audience. Ninety-five percent of visitors to Glacier Bay arrive on cruise ships, never set foot ashore, and are older than the general population of park visitors in the U.S. All passengers arriving in Glacier Bay receive the National Park Service (NPS) brochure, which is an essential reference as they listen to park rangers deliver a day-long running narrative over the public address system of the ship. Because the weather at Glacier Bay is usually inclement, and the cost of an Alaskan cruise is always high, the brochure and ranger narrative help to assuage otherwise disappointed passengers when visibility is poor.

To show the park in a more engaging and accessible way to visitors, the new brochure contains a combination of maps, text, photographs, and illustrations. One side of the brochure, devoted entirely to reference and thematic maps, is titled “Compact Atlas of Glacier Bay.” This approach to NPS map and brochure design yields a unified product that, we believe, more effectively portrays the striking geography of the park.

THE NEW BROCHURE AND MAP WILL SERVE A MOST UNCOMMON NATIONAL PARK AUDIENCE. NINETY-FIVE PERCENT OF VISITORS TO GLACIER BAY ARRIVE ON CRUISE SHIPS, NEVER SET FOOT ASHORE, AND ARE OLDER THAN THE GENERAL POPULATION...

## MAP PLANNING

The mapping of Glacier Bay was a collaborative effort between a writer, graphic designer, and cartographer with the NPS Publications Program based at Harpers Ferry Center (HFC), West Virginia, the Glacier Bay park staff, and the local community. The creation of a new map and brochure of Glacier Bay required that the Harpers Ferry Center team become familiar with the park, know the concerns of the park staff, and understand the intended audience. The team traveled 5,300 kilometers to Glacier Bay for a week to begin planning the new brochure. To help reach this goal the park arranged for the Harpers Ferry team to experience the park the same way that visitors do—on board a cruise ship.

## THE VISITOR EXPERIENCE

In what must be a unique morning commute, park rangers leave the headquarters complex in a small boat that intercepts cruise ships as they enter Glacier Bay. As both vessels travel side-by-side at eight knots, the rangers climb a rope ladder entering the ship through a cargo hatch in its side. They do this every day during the summer tourist season, meeting up to two cruise ships allowed in the bay simultaneously. The rangers stay on board for the day as the ships travel 100 kilometers to the scenic fjords and tidewater glaciers at the head of the bay. At the end of the day, as the cruise ship heads out of the bay the rangers climb back down the ladder to the waiting launch and go home.

THE HARPERS FERRY CENTER TEAM SPENT THE DAY ON A HOLLAND AMERICA SHIP WITH THE RANGERS, OBSERVING HOW THEY WORKED AND HOW PASSENGERS USED THE BROCHURE.

The Harpers Ferry Center team spent the day on a Holland America ship with the rangers, observing how they worked and how passengers used the brochure. On board the ship early that morning as the passengers slowly awoke, the rangers busily prepared for work by setting up a table with interpretive displays, including the park map. Throughout the day the rangers staffed this table as a temporary visitor center, wandered the decks talking to passengers, and provided comments about the park to the entire ship over the public address system. All passengers received the park brochure, which stewards leave outside their cabin doors during the night before arriving at Glacier Bay. The rangers frequently asked passengers to look at the map as the ship passed points of interest.

The HFC team's observations that day revealed several issues that influenced the design of the new map. The rangers referred to several features in the bay that day not labeled on the map. Where possible, the new map includes these places. Out on deck passengers struggled to open and read the map as it flapped in the wind. The new brochure design places the map at the end of the brochure where it folds out for easier access, minimizing exposure to the wind. Finally, because many of the passengers were elderly and used the map in the glaring outdoor conditions, the new map uses much larger type and more vivid colors.

## DISCUSSIONS WITH PARK STAFF

For the rest of the week the Harpers Ferry Center team met with all available staff—some three dozen people in all—from maintenance to resource management to the superintendent, to hear their thoughts for improving the brochure. Looking at HFC-produced brochures for other parks was one source of ideas. A park ranger suggested that the brochure include a map of the entire park at a small scale plus a large-scale inset of only the bay, a solution that everyone liked and is used on the final layout. A consensus emerged that one word, change, best described the essence of Glacier Bay and that the new park brochure should reflect this. The landscape that park visitors see today has undergone dramatic changes during the past two centuries, is still undergoing rapid transition, and is likely to change again in the future (Figure 1). The challenge for the map is to introduce visitors to temporal landscape changes on a static sheet of paper.

THE CHALLENGE FOR THE MAP IS TO INTRODUCE VISITORS TO TEMPORAL LANDSCAPE CHANGES ON A STATIC SHEET OF PAPER.



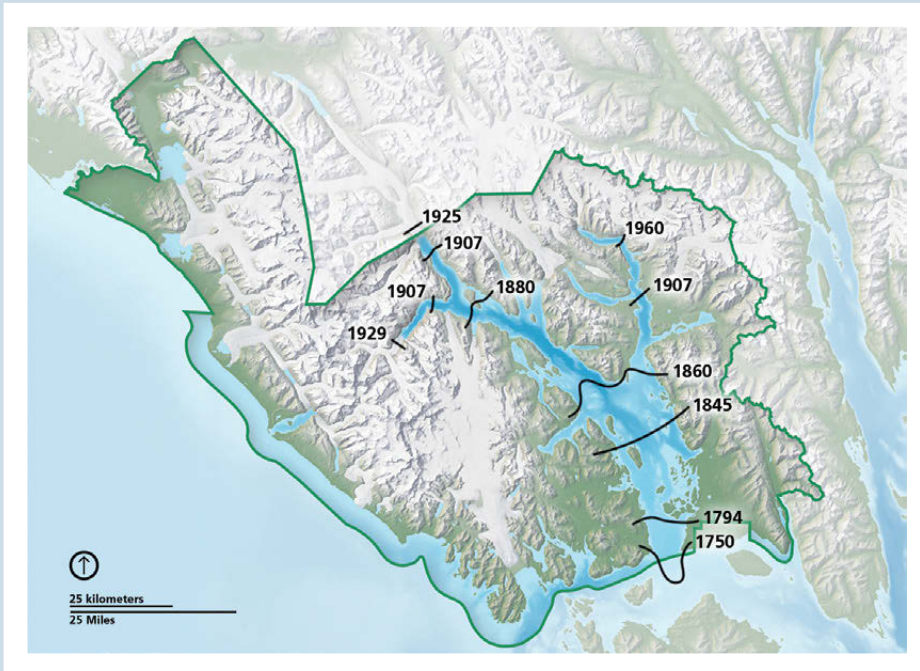


Figure 1. Most changes seen today at Glacier Bay relate to the retreating glaciers. Black lines on the map above show glacier extents for various years.

## MAPPING CHALLENGES

The section that follows details some of the challenges encountered when mapping Glacier Bay. Most challenges involved incomplete or poor quality data, and mapping an ever-changing natural environment. The first mapping task tackled—creating a shaded relief—involved all of these challenges.

### SHADED RELIEF

Shaded relief on the new Glacier Bay map derives from digital elevation models obtained from two sources. The first data source, National Elevation Dataset (NED), obtained from the USGS National Map Seamless Server, covered all of Glacier Bay National Park at 48-meter resolution. Based on digitized topographic maps of older vintage, this data nevertheless produced shaded relief with a clean appearance and would have sufficed for mapping the park except for the coarse generalized data found in adjacent areas in Canada. The origin of the provisional data found in Canada, occupying 20 percent of the land area shown on the Glacier Bay map, is unknown. Its use would require significant manual retouching. Because data quality was poor and to keep mapping costs down, Harpers Ferry Center sought other public domain data sources.

The second source of elevation data was Space Shuttle Radar Topography (SRTM) at 72-meter resolution, a product of NASA. These data collected

*MOST CHALLENGES INVOLVED INCOMPLETE OR POOR QUALITY DATA, AND MAPPING AN EVER-CHANGING NATURAL ENVIRONMENT.*

during eleven days in February 2000 by the Shuttle Radar Topography Mission (SRTM), are more recent and detailed than NED, despite having a lower resolution. The northernmost extent of SRTM coverage is 60 degrees north, which happens to match the northernmost edge of the Glacier Bay map. The huge downside with SRTM is its many data voids, irregular gaps in the coverage where elevation values do not exist. Data voids mar shaded relief generated from SRTM data and, where many voids exist, render the shaded relief useless. The voids are most prevalent in areas with high, steep mountains, landforms that typify much of Glacier Bay National Park.

Although the flaws found in NED and SRTM data prevented their individual use, merging shaded relief generated from each of the datasets minimized the flaws and yielded an acceptable product. Merging occurred in Adobe Photoshop at 300 dpi at the final map size (76 x 91 centimeters). The shaded relief generated from SRTM served as the primary shaded relief. In areas where there were data voids, a layer mask allowed the shaded relief generated from NED, placed on a layer below it, to show through. The layer mask contained the SRTM data voids represented in black (the masking color) on a white background. Expanding the black areas on the mask by 2 pixels and applying Gaussian blur provided a smooth transition between the merged shaded relief images. On the final merged shaded relief, Canada and the U.S. appeared with comparable detail and quality (Figure 2).

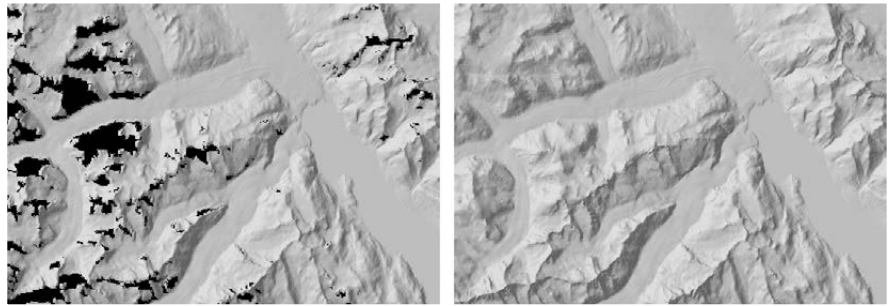


Figure 2. (left) SRTM shaded relief with data voids shown in black. (right) Merged SRTM and NED shaded relief.

## LANDCOVER

The use of landcover data on NPS maps to show vegetation types and environmental zones with natural colors has become increasingly common. On the Glacier Bay map landcover data had the potential for highlighting the differences between the forested lower bay and the upper bay, where bare rock and glacial ice predominates. The problem was that suitable landcover data did not exist.

An alternative source for this information had to be found. Depicting landcover in a generalized fashion provided a workable cartographic solution. The new map of Glacier Bay contains only four major landcover categories: water (blue); vegetation (green); barren land (gray); and, multi-year ice and

snow (white). In this simplified classification, elevation was the primary factor in determining the distribution of landcover categories. Tree limit in this part of Alaska generally occurs 760 meters above sea level, above which a band of alpine vegetation quickly gives way to expansive areas of bare rock and glacial ice. On the new map, green-tinted NED elevation data represents forested land below 760 meters in elevation. Because lower elevations where the climate is temperate have more biomass than higher elevations near tree line, the dark (lowland) to light (highland) transition in NED places the densest greens in lowlands and the lightest greens near the tree line. Above the tree line the NED data transitions to light gray (Figure 3).



*Figure 3. The final landcover's four basic categories are ice, barren land, forested land, and water.*

Portraying landcover at Glacier Bay based solely on elevation tells only part of the story, however. The rapid retreat of glaciers has left upper portions of the bay at sea level largely bare and awaiting the slow arrival of low vegetation and then forest cover from the lower bay, which has existed ice-free for two centuries. Photoshop and a graduated layer mask provided a way to create the transition from forest to bare rock at sea level on the map. Landscape photographs taken by the Harpers Ferry Center team from the cruise ship served as a reference for determining how much green or gray to show in any given area.

This stylized depiction gives visitors an impression of the landcover at Glacier Bay that does not interfere with the shaded relief. Furthermore, green forest cover created from NED in the lowlands serves as a rudimentary hypsometric tint enhancing the overall presentation of the terrain.

## GLACIERS

*DESPITE THIS PARK'S BEING FAMOUS FOR ITS GLACIERS AND SET ASIDE AS A PROTECTED AREA FOR SCIENTIFIC STUDY, DETAILED MAPS OF GLACIER BAY'S PRESENT-DAY GLACIERS WERE NONEXISTENT.*

Despite this park's being famous for its glaciers and set aside as a protected area for scientific study, detailed maps of Glacier Bay's present-day glaciers were nonexistent. Showing recent and accurate glacier information on the new visitor map was a high priority and required that Harpers Ferry Center map the glaciers from scratch. A Landsat image provided by the park GIS specialist, taken in early fall 2000, served as the primary base for interpreting glacial coverage. Since this image was not as recent as the Harpers Ferry Center team would have liked, the team used other imagery sources, including Google Earth, to update the positions of major tidewater glaciers.

Mapping glacial extents in Photoshop took considerable time and involved manual painting with the Brush tool and automated selection techniques. Differentiating between glacial ice and seasonal snow was one problem encountered. Using the Magic Wand selection tool in Photoshop (by clicking on white areas) resulted in the selection of glaciers and also many small temporary snow patches. Filtering these selections in Photoshop eliminated the smallest patches. However, the map does not differentiate large snowfields from glaciers.

Another apparent problem was the deep shadows found on northwest slopes near the summits of the highest peaks, obscuring the glaciers and making accurate mapping from the satellite images impossible. In the end, this



*Figure 4. Glaciers as they appear on the final map. Johns Hopkins Glacier flows northeast into an inlet of the same name near the middle of the image.*

proved to be no problem because the map gradually blends glacier shapes with a gray-white background tone at higher elevations, depicting these areas as uniformly icy. This technique solved a related issue, discussed next.

On the final map, the light-dark glacier coverage conflicted with shaded relief, also consisting of light and dark tones. This problem became most noticeable at high elevations where light colored glaciers occupied shadowed southeast slopes on the shaded relief. In effect, they cancelled each other out and obscured the shaded relief. Clearly the glaciers in these areas required modification. The solution again involved NED elevation data and Photoshop. Inverting the NED data so that high areas appeared dark and placing it into a layer mask diminished the contrast of the glaciers against the shaded relief for areas above 2,500 meters in elevation. Above this elevation, where snow accumulates year-round, the shaded relief appears as a cold blue-gray and is much easier to read. Below 2,500 meters in elevation, the zone of ablation where seasonal melting takes place, the glaciers become increasingly distinct from the adjacent shaded relief and landcover. At the very lowest elevations the glacier snouts reveal moraine striations, shown faintly, textural information obtained from the Landsat image (Figure 4).

### BATHYMETRY

At Glacier Bay, the largest protected marine environment in Alaska, the undersea world is the focus of research activity and is increasingly important to park interpretation. Using the latest bathymetry data, the new map also gives visitors a glimpse of what Glacier Bay is like beneath its silt-laden water.

The most spectacular bathymetry available is multibeam data collected by the USGS at 5-meter resolution. However, this data only covers a limited area in the lower and middle portions of the bay, excluding all near-shore areas. More

ABOVE THIS ELEVATION, WHERE SNOW ACCUMULATES YEAR-ROUND, THE SHADED RELIEF APPEARS AS A COLD BLUE-GRAY AND IS MUCH EASIER TO READ.

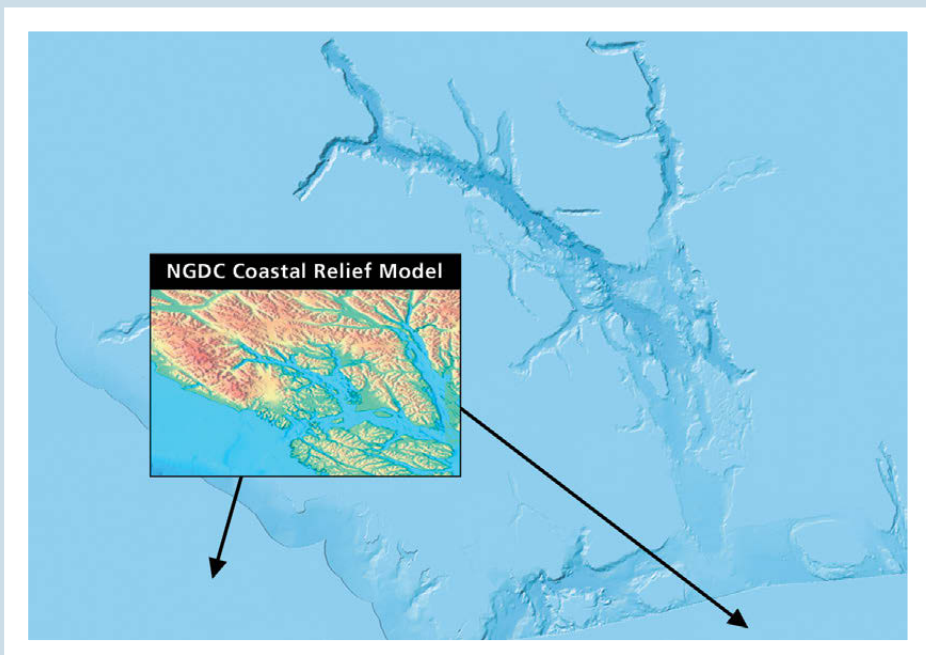


Figure 5. NOAA Coastal Relief Model fills in peripheral areas not covered by Inforain bathymetry (the blue background image), which ends at the park boundary.

USING THE LATEST BATHYMETRY DATA, THE NEW MAP ALSO GIVES VISITORS A GLIMPSE OF WHAT GLACIER BAY IS LIKE BENEATH ITS SILT-LADEN WATER.

appropriate for our purposes is a bathymetric dataset at 25-meter resolution produced by Inforain from digitized NOAA nautical charts. The Inforain data is reasonably clean and detailed, but it does not extend beyond the park boundary, leaving blank those adjacent marine areas that comprise much of the map. To fill in these blanks Harpers Ferry Center obtained pre-release Coastal Relief Model data at 90-meter resolution from the NOAA National Geophysical Data Center. Merging of the Inforain and NOAA datasets took place in Photoshop using a mask with a soft edge for seamless blending. The lower resolution NOAA data appear in the Pacific Ocean, Icy Strait, and Lynn Canal on the periphery of the map (Figure 5).

The depiction of bathymetry on the final map differs from the original design vision, which was to combine oblique hill shading with depth tints. The idea was to show the terrestrial and undersea topography as extensions of one another. When applied, however, this technique did not work because the shading confused where the land ended and sea began. This was especially the case in the narrow upper fjords that are the primary destination for visitors. Taking the shading out of the water and showing instead only blue depth tints solved the problem of figure-ground ambiguity between land and water. There is a second benefit to showing only the depth tints. As the bay becomes progressively deeper from its lower to upper reaches, the intensifying blue tints on the map point cruise ship passengers to where they will go.

#### HYDROGRAPHY

Although relatively few rivers appear on the map of Glacier Bay, and despite the fact that they are minimally relevant to cruise ship passengers, mapping them was nevertheless challenging and time-consuming. The Alsek River, a braided river that fills a flat floodplain up to five-kilometers wide, bounds the northwestern boundary of the park. Other large braided rivers flow north and east of the park. By showing these untidy and continually changing rivers, the map reveals a major characteristic of glacial landscapes.

As usual, a good dataset existed for areas in the park while information beyond its boundary was sparse and out of date. Where vector map coverage existed, discarding roughly two-thirds of the channels comprising the braided rivers improved their legibility. In areas where vector coverage was non-existent, the interpretation from the Landsat image and tracing from old topographic maps provided the vector drainages. The task was necessary and tedious and is finished for now—until the rivers again change course.

Coastlines at Glacier Bay also fluctuate greatly. Determining precise coastal boundaries along shallow coasts is made more difficult by three factors: the slow but steady rising of the land caused by glacial rebound; silt carried by glacial rivers that is converting shallow estuaries into mud flats extending for kilometers; and 5-meter tides that rearrange things twice daily (Figure 6). Even with satellite imagery, determining where mud flats end and silt-laden water begins is difficult. On the new map the coastline derives from an extremely detailed vector shoreline generated as part of a recent coastal inventory project. For this project people walked the entire 1,223-kilometer coastline of Glacier Bay.

BY SHOWING THESE UNTIDY AND CONTINUALLY CHANGING RIVERS, THE MAP REVEALS A MAJOR CHARACTERISTIC OF GLACIAL LANDSCAPES.

On the final map the thin blue lines representing drainages and coastlines were rasterized and printed lightly, to blend better with the relief art below. Diminishing their prominence lessened the complexity of the map and improved readability.

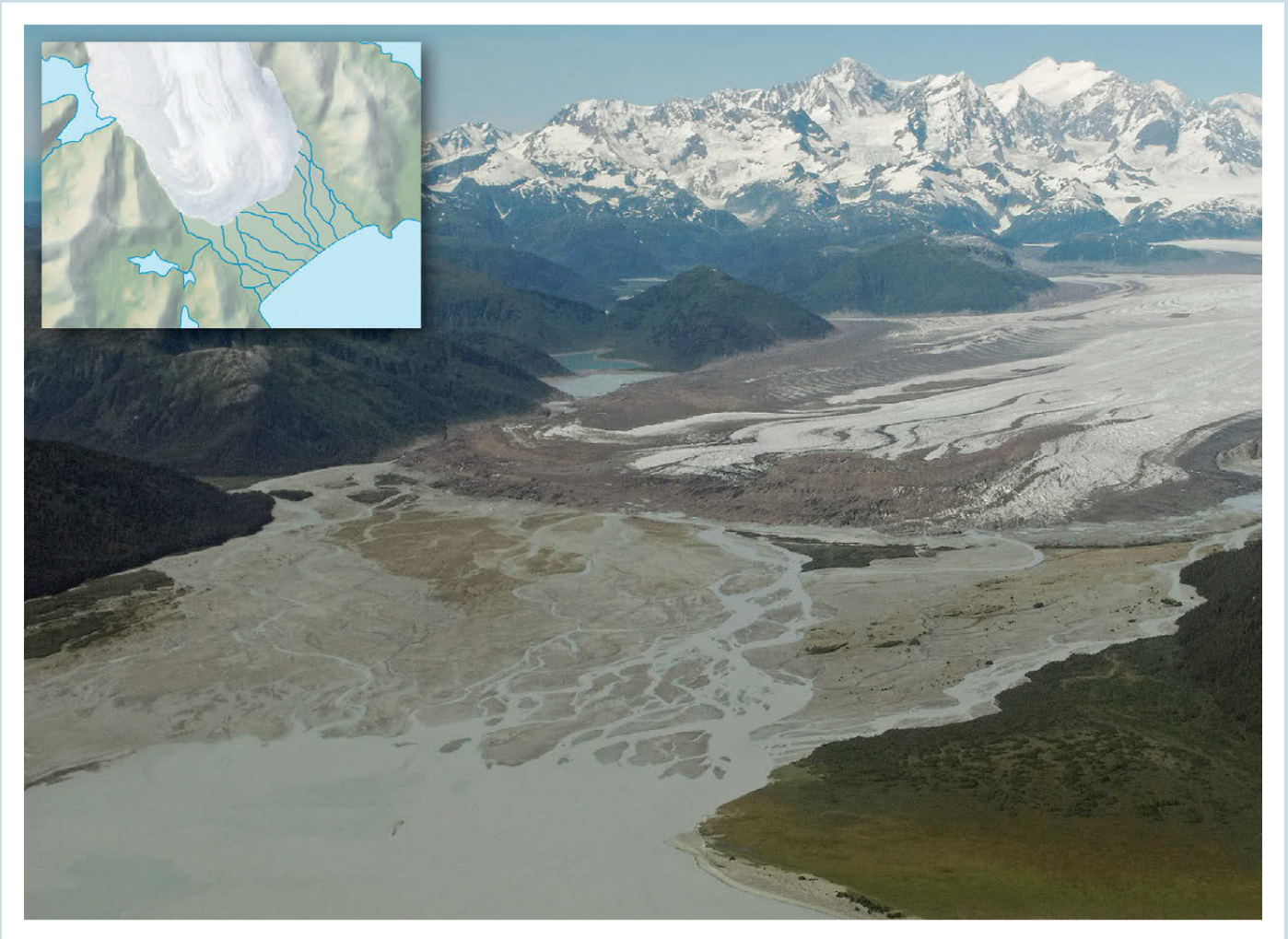


Figure 6. A braided stream flowing from Brady Glacier to Taylor Bay, which is rapidly filling with silt. The inset shows the generalized map depiction. Photograph: NPS/Bill Eichenlaub

## PLACE NAMES

Not all place names that park rangers frequently mention to visitors appear on the new map of Glacier Bay. For example, descriptive names for general regions of the park, like “upper bay” and “lower bay,” are not included. These omissions are not by individual choice but by government mandate. All maps made by federal agencies, including the NPS, must bear only the official spellings approved by the U.S. Board on Geographic Names (BGN). U.S. government mapmakers also are not permitted to place new names on maps until they are approved by BGN, normally a six-week process if the name is uncontested.

At Glacier Bay, however, this option does not exist. Most of Glacier Bay is a congressionally designated wilderness area, where a moratorium prohibits the coining of new place names. The idea behind the moratorium is to keep wild land untrammelled by humans as much as possible, even in the abstract realm of language and maps. Future visitors to Glacier Bay will only experience the “upper bay” as the wild place it is, not as a label on the map.

## THE FINAL MAPS

THE IDEA BEHIND THE MORATORIUM IS TO KEEP WILD LAND UNTRAMMELED BY HUMANS AS MUCH AS POSSIBLE, EVEN IN THE ABSTRACT REALM OF LANGUAGE AND MAPS.

From the components described above, Harpers Ferry Center created a master base map and two derivative maps of Glacier Bay for visitor use. One of the maps was for the brochure discussed in this article (Figure 7), and the other was a large wall map for display in the park visitor center and on cruise ships. Care was taken when preparing the master base map to ensure sufficient resolution in the raster shaded relief and vector detail for dual use at differing scales.

The design of both maps kept in mind the goal of attracting readers. The terrain art uses natural colors that resemble those seen in the park. Visitors travel great distances at great expense to see the park presumably because they anticipate finding it attractive—the map attempts to capitalize on this predisposition. Assuming that most readers intuitively associate green with vegetation, gray with bare land, blue with water, and white with ice, no legend explaining the landcover was used.

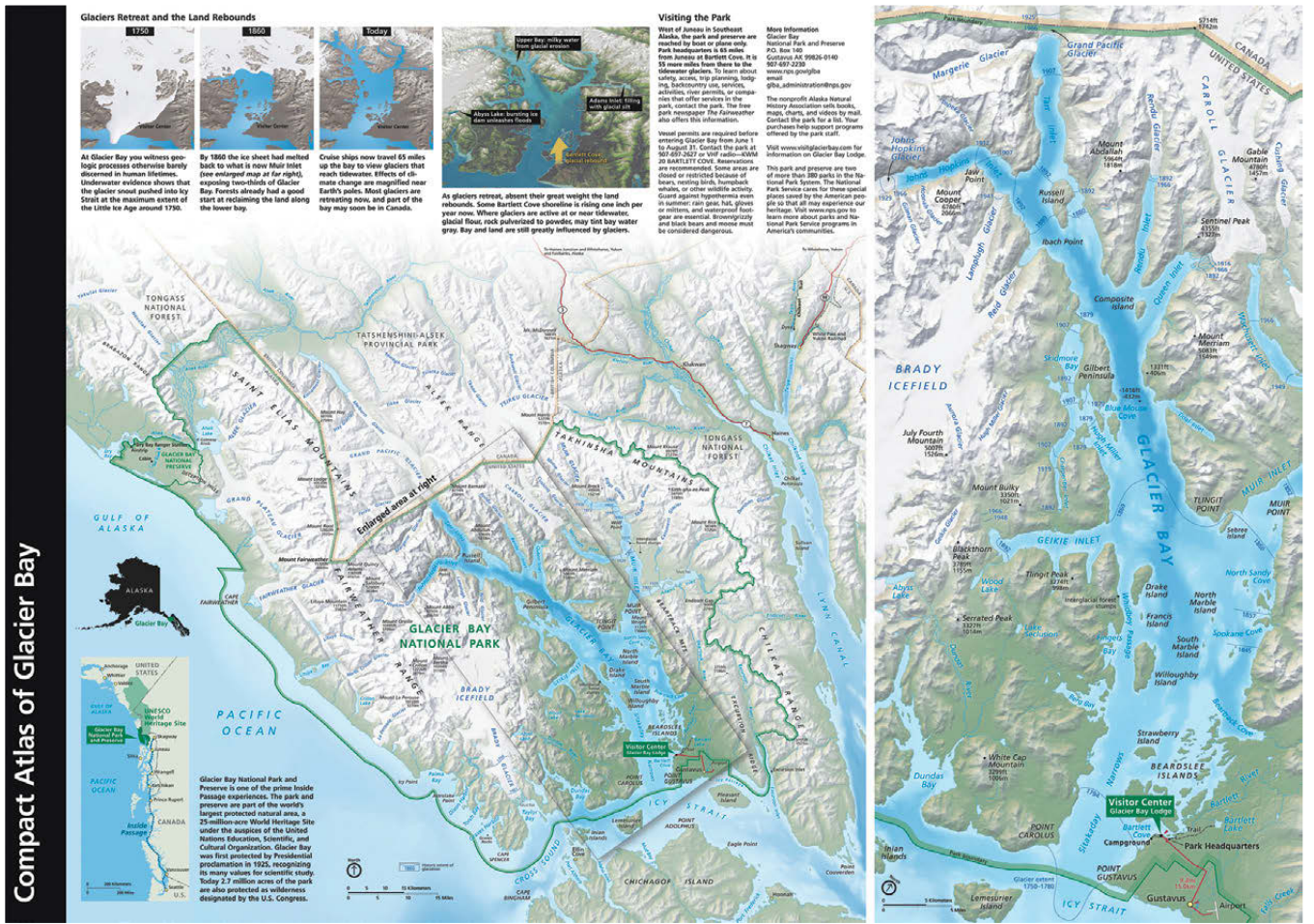


Figure 7. The final brochure map.



Information density balances the need to keep the map as uncluttered as possible while offering readers ample information about the park and enticing them to future exploration. A subtle softening of the shaded relief behind text labels enhances legibility. Other graphical embellishments—transparency, fades, vignettes, and drop shadows—that people find intrinsically attractive enhance the visual hierarchy and guide the reader’s eyes from one area of interest to the next. Like the physical landscape that it represents, the map contains spatial connections. Most visitors see Glacier Bay from the insulated confines of a cruise ship for only a few hours. The goal of the map and brochure is to broaden and deepen this experience.

## CONCLUSION

The new Glacier Bay map, published in 2009, is functioning as intended according to feedback from park rangers and the observations of the author, who visited Glacier Bay again in 2010. Despite a strong wind and bright sunlight, cruise ship passengers were able to use the map outside while watching tidewater glaciers calving. The Glacier Bay map has influenced the design of other NPS maps. Brochures for other spectacular Alaskan parks managed by the NPS, published decades ago, are overdue for major revision—and the Glacier Bay map treatment. For example, a remake of the Denali National Park map currently underway uses the Glacier Bay map as a model for depicting the mountains, glaciers, and subarctic vegetation of that park. Because the Glacier Bay map is in the public domain, companies can use it to create spin-off products, from iPhone apps to posters. One of these products has found its way back to the Park Service. In 2010, Summit Terragraphics, Inc., repurposed the Glacier Bay map as a raised plastic relief map. The rangers take this portable map with them on their daily cruise ship visits.

*MOST VISITORS SEE  
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HOURS. THE GOAL  
OF THE MAP AND  
BROCHURE IS TO  
BROADEN AND  
DEEPEN THIS  
EXPERIENCE.*

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NPS GIS data: [http://www.nps.gov/gis/data\\_info/park\\_gisdata/ak.htm](http://www.nps.gov/gis/data_info/park_gisdata/ak.htm)

Alaska Geospatial Data Clearinghouse: <http://agdc.usgs.gov/>

Inforain bathymetry:

<http://www.inforain.org/alaska/glabaycd/CATALOG/htm/gistoc.htm>

NOAA National Geophysical Data Center bathymetry:

<http://www.ngdc.noaa.gov/mgg/coastal/coastal.html>

Summit Terragraphics, Inc.: <http://www.summitmaps.com>

USGS multibeam bathymetry:

<http://usmo4.discoverlife.org/mp/20q?go=http://geopubs.wr.usgs.gov/open-file/of02-391/>

US Board on Geographic Names: <http://geonames.usgs.gov/redirect.html>

National Map Seamless Server National Elevation Dataset (NED):

<http://seamless.usgs.gov/>

ASA Space Shuttle Radar Topography Mission (SRTM): <http://srtm.usgs.gov/>



# Design and Production of the Himachal Pradesh Topographic Overview Map, 1:500,000

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## ABSTRACT

This article describes the design of a map of the Indian state Himachal Pradesh at the scale of 1:500,000. The aim of this foldable map with topography is to support an interdisciplinary research network focusing on the cultural history of the western Himalayas starting in the eighth century. In this research network, cartography and geography fulfill a mediating role between the disciplines of art history, numismatics, Buddhist philosophy, and Tibetan and Sanskrit philology. The map's goal is to facilitate scientific work and interdisciplinary collaboration both in the office and out in the field. In addition to the printed version, the map is available for download to the general public through a Web-based cartographic information system. Topographic data was compiled from a variety of sources—starting with maps originally surveyed by the colonial British and ending with satellite imagery. Production involved ArcGIS and Natural Scene Designer for initial data preparation and Adobe Photoshop and Illustrator for final map compilation.

## INTRODUCTION

The cartography group at the Department of Geography and Regional Research, University of Vienna, is engaged in the Cultural History of the Western Himalaya Research Network, an interdisciplinary project investigating this mountainous area

from the eighth century onward. The spatiotemporal relationships between objects of cultural historic relevance (such as temples, mural paintings, philosophical texts, and inscriptions) represent an important research focus. In this research network cartography and geography play a bridging role between the disciplines of art history, numismatics, Buddhist philosophy, and Tibetan and Sanskrit philology. The cartographers' goal is to facilitate internal scientific collaboration and the presentation of research results to the general public. The cartography group also assists participating scholars with their research tasks in the office and on field trips. It is for this reason that we produced a foldable topographic overview map of the Indian state Himachal Pradesh—one of the project's key places of interest.

Himachal Pradesh is one of India's twenty-eight states, situated in the northwestern part of the country, bordering China's Tibet Autonomous Region. The state takes in a land area of approximately 55,000 square kilometers. Shimla, the state capital in the Himalayan foothills, became famous as a summer retreat for the British-Indian colonial government. Himachal Pradesh's literal meaning is "the region which lies in the slopes and foothills of snow" (Ahluwalia 1998), an apt description considering that about 80 percent of the state consists of either "Shivaliks" (the first range of foothills) or the main Himalayan mountain range. Due to the geographical proximity there exists a strong cultural influence from Tibet, especially in eastern parts of the state and in Dharamsala, seat of the exiled Tibetan government and the home of Tenzin Gyatsho, the fourteenth Dalai Lama.

This article describes the design and production processes for making a topographic map compiled from a variety of sources—ranging from maps originally surveyed by the British to satellite imagery—converted to a publicly available reference map at the scale of 1:500,000. Production involved data preparation in ArcGIS and Natural Scene Designer and final map compilation in Adobe Photoshop and Illustrator.

## AVAILABLE TOPOGRAPHIC MAPS AND GEOGRAPHICAL DATA SOURCES

The Survey of India, the national mapping organization of India, restricts the release of topographical maps of Himachal Pradesh, especially to foreign institutions. Because the state borders China, the Survey of India considers topographic maps of this area military secrets. For our project, the best available topographic maps were those compiled by the British in the early twentieth-century (Figure 1). The British maps are generally inaccurate, sometimes incomplete, and greatly outdated. The U.S. Army Map Service and the Russian military have produced 1:250,000-scale topographic maps of Himachal Pradesh. These maps mainly derive from the preexisting British maps and in most cases are poorer in quality than the originals.

HIMACHAL PRADESH'S LITERAL MEANING IS "THE REGION WHICH LIES IN THE SLOPES AND FOOTHILLS OF SNOW" (AHLUWALIA 1998)

FOR OUR PROJECT, THE BEST AVAILABLE TOPOGRAPHIC MAPS WERE THOSE COMPILED BY THE BRITISH IN THE EARLY TWENTIETH-CENTURY

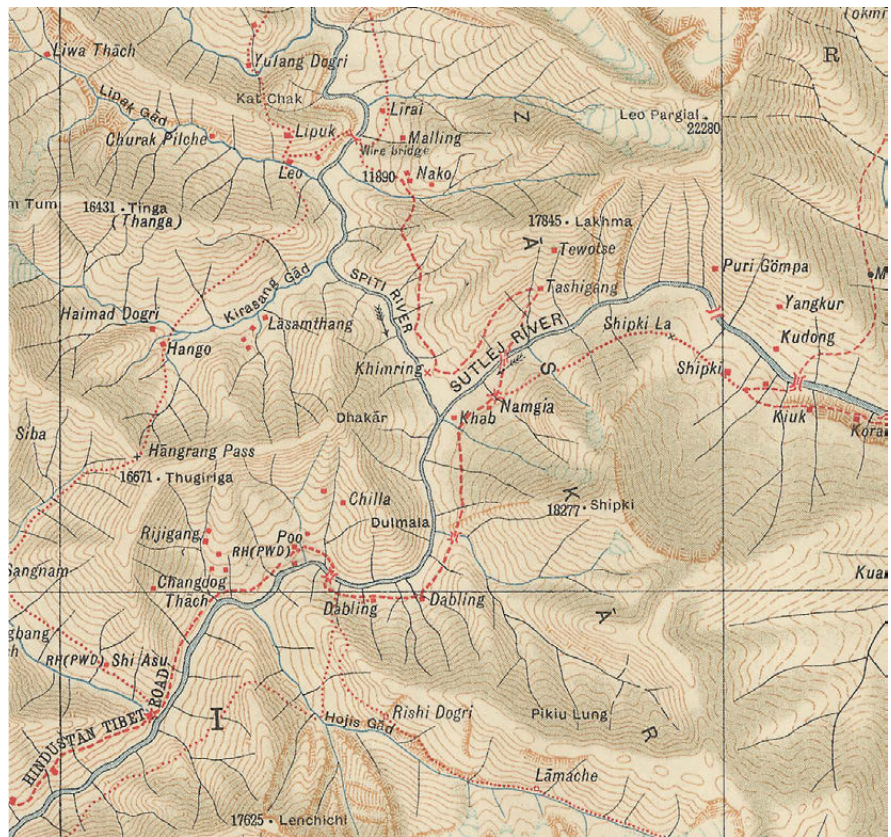


Figure 1. Topographic map of the Survey of India (1932), 1:253,440.

Although a wide variety of commercial maps of Himachal Pradesh exist at different scales, these products also suffer from poor quality. The information is often inaccurate, outdated, and/or inconsistent with other maps, and the graphical presentation is mostly crude. This lack of reliable and detailed topographic information led the project partners to ask the cartography group to produce a new topographic overview map.

Due to a tight budget, the idea guiding map production was to use only freely available geographic data and, if necessary, to digitize from existing maps. Main data sources were Shuttle Radar Topography Mission (SRTM), Vector Map 0 (VMAP0), the Digital Chart of the World (DCW), Global Administrative Database, GeoNames, Natural Earth II, vector data and Landsat satellite imagery from the U.S. Geological Survey (USGS). Printed maps for digitization and verification purposes were various Freytag and Berndt road maps (at scales between 1:2,750,000 and 1:4,000,000), The Book of the World (1:4,000,000; Bertelsmann 1995), the Himachal Pradesh Tourist Map (1:500,000; Eicher, 2007) published by Eicher Goodearth, Ltd., for the official state tourism bureau and the Leomann Trekking Maps series (1:200,000; Leomann 1998, 2005). Data from these sources were incorporated into a Web-based cartographic information system, parts of which were extracted for producing the printed topographic map.

THE INFORMATION [WAS] OFTEN INACCURATE, OUTDATED, AND/OR INCONSISTENT WITH OTHER MAPS, AND THE GRAPHICAL PRESENTATION IS MOSTLY CRUDE.

## SHADED RELIEF WITH NATURAL COLOR OVERLAY

The production of shaded relief with a natural color overlay was a multi-stage process. SRTM data (<http://www2.jpl.nasa.gov/srtm/>) with a geometrical resolution of 3 arc seconds (approximately 90m) was used as the underlying digital elevation model (DEM). Because the original SRTM data from NASA contained many voids (holes in the digital elevation model surface), especially in the high mountain areas, we used modified SRTM data from an alternative source. Viewfinderpanoramas.org offers DEM tiles with infilled voids based on the digitized contours of Russian military maps. However, even this modified elevation model was not free from artifacts. The infilled data did not blend smoothly with the original SRTM data. It was necessary to patch rough areas by manually touching up the DEM with a variety of Adobe Photoshop tools. Figure 2 illustrates shaded relief from original SRTM datasets (left) and from the enhanced blended tiles (right).

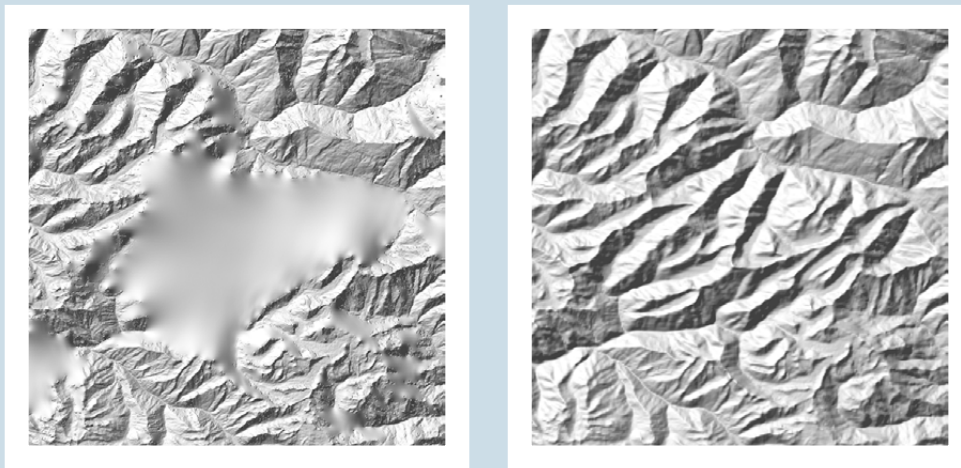


Figure 2. Inaccurate shaded relief from original SRTM data (left) and from enhanced blended tiles (right).

The revised DEM was downsampled to a resolution of 6 arc seconds (approximately 180m), and a soft blur filter was applied to decrease detail and noise in the resulting shaded relief. The shaded relief rendered with Natural Scene Designer resulted in two images: The first image was rendered as oblique hill-shading with standard north-west illumination; the second image depicted slope-shading by placing the illumination source directly overhead. Combining these two images in Photoshop produced a relief with familiar three-dimensional shading effects plus enhanced detail on the slopes. Because the shaded relief would combine with a colored environmental overlay on the final map, shadow tones were lightened and flat areas were kept white.

In the next step, we applied additional Photoshop enhancements to the shaded relief, employing the techniques described at [www.shadedrelief.com](http://www.shadedrelief.com). Using layer masks, we added a subtle yellow tint on illuminated slopes as well as a light blue tone on the shadow slopes. A height mask was used to increase saturation and lightness in higher areas as well as to decrease both in lowlands.

USING LAYER MASKS, WE ADDED A SUBTLE YELLOW TINT ON ILLUMINATED SLOPES AS WELL AS A LIGHT BLUE TONE ON THE SHADOW SLOPES.



Figure 3. Oblique relief shading combined with slope shading with yellow highlights and blue shadows.

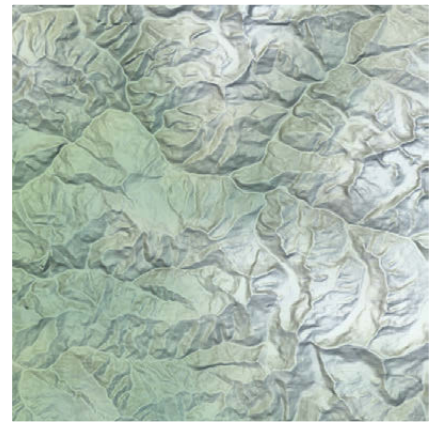


Figure 4: Shaded relief with environmental color overlay from Natural Earth data.

Figure 3 shows the combination of oblique relief shading and slope shading with yellow highlights and blue shadows. Nevertheless, room still exists for additional improvements to the shaded relief. For example, enhancing ridgelines on the underlying DEM could give these blunt features a chiseled appearance to better represent the alpine landscape.

One of the goals of the topographic overview map was to provide the map reader a general impression of the terrain and vegetation of Himachal Pradesh. This was accomplished with a natural color overlay created from landcover data. The Natural Earth raster dataset, derived from MODIS satellite imagery, was the first choice that we considered ([www.naturalearthdata.com](http://www.naturalearthdata.com)). Unfortunately, the spatial resolution of Natural Earth raster data is only 1.24 kilometers, six times coarser than the shaded relief. This resulted in a pixelated appearance when Natural Earth was upsampled to the higher resolution of the shaded relief. However, employing a blur filter in Photoshop helped remove pixel patterns—similar to the pan-sharpening processes applied to multi-resolution satellite imagery. Thus the natural color overlay was adapted for use with the higher resolution shaded relief (Figure 4).

## CONTOUR LINES, SPOT HEIGHTS AND GLACIERS

In an area where villages are found above 4,000 meters, and even higher passes serve as transportation corridors between far-flung cultural centers, elevation is an important factor. To give readers more information about elevation than what is available in the shaded relief, and to enable cartometric evaluation, contour lines derived from SRTM data were added to the map. Considerable manual editing was necessary to register the contour lines with the shaded relief and river network. The contour line interval is 500 meters. We created contour line labels with the Maplex extension in ArcGIS. Next, in Adobe Illustrator, where the final map assembly took place, the team deleted surplus contour labels and repositioned the remaining labels.



Additionally, a spot height dataset of prominent mountain peaks and passes was digitized from existing paper maps, mostly old topographical maps produced by the British and the U.S. Army Map Service.

In a high mountain area such as the western Himalaya, glaciers play an important role. They have shaped the landscape and are a source of the water supply. Glaciers have been—and still are—barriers to pilgrims and traders traveling the area. Many glaciers have spiritual significance for the local population. Unfortunately, no accurate vector datasets could be acquired for this area at the final map scale of 1:500,000. Therefore, the team had to interpret glacier extents from Landsat 7 satellite imagery at a resolution of 30 meters. Using summer images when ice and snow surfaces have a high albedo and distinctive spectral signature, we derived a spectral classification to identify the glaciers. However, moraines and glaciers covered by rocks or dirt were not detected by this classification. Solving this problem required manual edits and referring to existing maps, which resulted in a more or less complete and accurate glacier dataset. We then merged the glaciers with the shaded relief, depicted with a subtle transparent blue tint. This treatment of the glaciers provides enough contrast to differentiate them from the relief and draped natural color overlay.

*[GLACIERS] HAVE SHAPED THE LANDSCAPE AND ARE A SOURCE OF THE WATER SUPPLY. GLACIERS HAVE BEEN—AND STILL ARE—BARRIERS TO PILGRIMS AND TRADERS TRAVELING THE AREA.*

## ADDITIONAL MAP FEATURES

Administrative boundaries derive from the Digital Chart of the World (<http://www.maproom.psu.edu/dcw>) and the Global Administrative Database (<http://www.gadm.org>). We had to manually adjust the boundaries to register with the shaded relief and river network.

Roads and railroads derive primarily from the USGS global transportation datasets (scale 1:1,000,000), a secondary product of VMAP0, and partially from tourist road maps. Because parts of the road network obtained from the digital data were very crude, revisions to these from paper map sources were a necessity for mapping at 1:500,000-scale.

For rivers and lakes, the VMAP0 datasets served as the main source of information. However, the team had to manually adjust river courses to fit the shaded relief. The many smaller rivers, which create a dense network filling even the smallest valleys, were omitted to improve map legibility. Since VMAP0 does not contain names attributes for rivers and lakes, we acquired this information from topographic maps made by the British Survey of India and the U.S. Army Map Service.

The settlement layer originates with Digital Chart of the World and the GeoNames database (<http://www.geonames.org>). It contains numerous updates obtained from printed maps and other sources. The team recorded additional settlement locations, not found in the sources above, with GPS devices during a four-week field trip in summer 2007. The spelling of place names in this area is highly ambiguous due to the influence of different languages and cultures. Unfortunately, the most up-to-date maps by the Survey of India were not available to verify spellings. Therefore, the map editors had to rely on what other sources they could find, such as maps by

SUPPORT[ING] THE RESEARCH AND FIELD ACTIVITIES OF THE PROJECT PARTNERS, CULTURAL AND HISTORICAL SITES OF RELEVANCE TO THE PROJECT APPEAR AS A THEMATIC LAYER ON THE MAP.

the state tourist agency. Place names were additionally checked by project partners on their field visits to Himachal Pradesh. Despite this effort, many place name spellings on the map are still best regarded as provisional.

Because the topographic overview map supports the research and field activities of the project partners, cultural and historical sites of relevance to the project appear as a thematic layer on the map. These sites, selected in consultation with the scholars, include historic temples and monasteries. This layer and the other map layers, including a map frame, coordinate grid, and legend, were symbolized and assembled in Adobe Illustrator. Figure 5 shows a section of the final map that is available for download at the project Web page (<http://www.univie.ac.at/chis>). In 2009 we printed a small run of the map complete with a hardcover.



Figure 5: Section of the final map showing Beas Valley and Chandra Valley.

## CONCLUSION AND OUTLOOK

The first version of the foldable Himachal Pradesh Topographic Overview Map is now serving the needs of the project partners in the research network. The mapping of Himachal Pradesh is not yet finished, however. We will update information based on feedback received from those using the map in the field. Looking ahead, additional classes of information will be added, such as historical pilgrimage and trade routes, and modern trekking routes. Data acquisition for these layers is currently under way for the cartographic information system on the Cultural History of the Western Himalaya Web site (<http://www.univie.ac.at/chis>). A second map sheet at the same scale and with identical data layers is planned for the Ladakh/Leh region in the state of Jammu and Kashmir, which is north of and adjacent to Himachal Pradesh.

The need for continual updates to the Himachal Pradesh map and plans to produce sheets of other areas have led us to investigate ways to further automate the production process. Other projects conducted at the Department of Geography and Regional Research, University of Vienna, indicate the potential of high-quality vector map production with Mapyrus software (<http://mapyrus.sourceforge.net>). However, mapping the western Himalayas is very complex, and the quality demands are high. Ongoing research will reveal to what degree the production can be automated.

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# Terrain Sculptor: Generalizing Terrain Models for Relief Shading

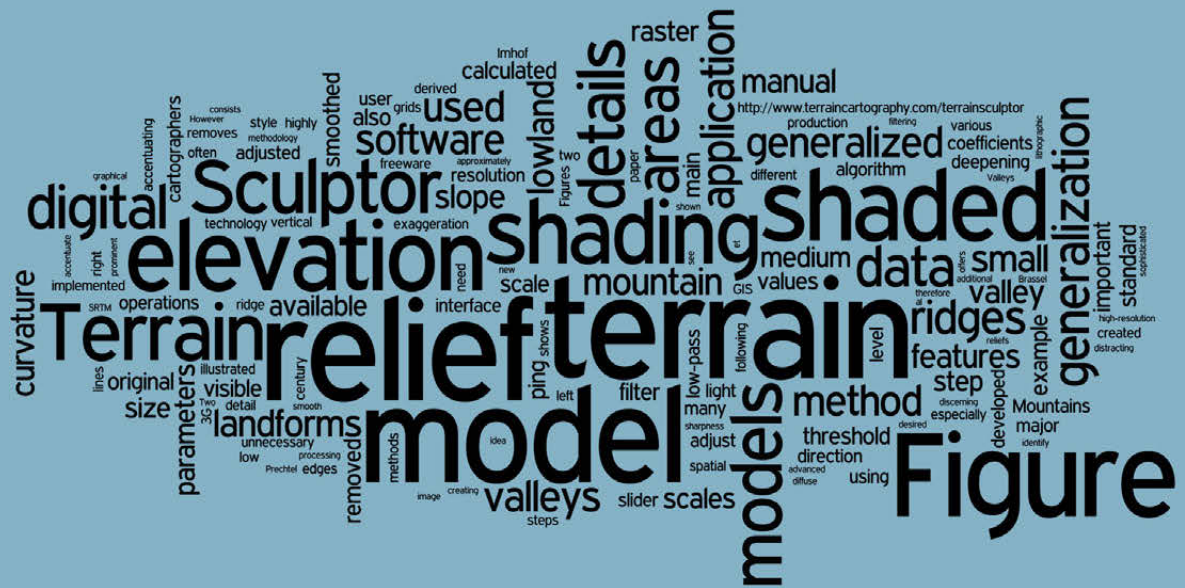
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## ABSTRACT

Shaded relief derived from high-resolution terrain models often contains distracting terrain details that need to be removed for medium- and small-scale mapping. When standard raster filter operations are applied to digital terrain data, important ridge tops and valley edges are blurred, altering the characteristic shape of these features in the resulting shaded relief. This paper introduces Terrain Sculptor, a software application that prepares generalized terrain models for relief shading. The application uses a generalization methodology based on a succession of raster operations. Curvature coefficients detect and accentuate important relief features. Terrain Sculptor offers a graphical user interface to adjust the algorithm to various scales and terrain resolutions. The freeware application is available at <http://www.terrainsculptor.com>.

## INTRODUCTION

Shaded relief can be calculated from digital elevation data with most GIS applications and with many raster mapping software packages. With high-resolution digital elevation data now available for almost the entire Earth, relief shading has become a de facto standard for visualizing terrain. However, relief shading is not a recent addition to mapping, as it was

developed long before digital computer technology. Manuscript maps have employed shaded relief for hundreds of years, for example, the maps painted of the Zurich area by Hans Conrad Gyger in the seventeenth century (Imhof 1982). At the end of the nineteenth century, the lithographic printing process was the first technology to allow for mass production of maps with smooth tonal variations (Ristow 1975). With the advent of lithographic printing, the high-contrast hachures representing terrain were replaced with varying, continuous tones. Of note were the experiments by Swiss cartographers with this new technology during the first half of the twentieth century to create highly sophisticated shaded relief maps (Jenny and Hurni 2006). Today, few cartographers possess the extensive training and understanding of relief interpretation needed to create manual shaded relief in this same manner.

Digital relief shading—also called analytical shading—has major advantages compared to manual shading: it does not depend on the individual style of a cartographer, and it is faster and cheaper to produce (provided a digital terrain model is available). However, digital relief shading is not without problems, especially at medium and small map scales where excess detail is commonplace. A small-scale shaded relief with many intricate terrain details can inhibit the perception of the main landforms (for example, main ridges and valleys). As Patterson (2001a) notes, the dense details obscure macro topography—it is impossible to see the forest for the trees. Nowadays, when highly detailed elevation data are abundant and freely available, conducting research to automate the removal of unwanted details from terrain is highly relevant. The software available to production cartographers does not adequately address this issue. Although simple methods exist to remove local irregularities from terrain (for example, low-pass filtering), they also apply smoothing to important ridges and valley edges, solving one problem but creating another. More sophisticated methods, specifically developed for simplifying terrain models for relief shading, are not implemented in commercial software, and therefore rarely used (Weibel 1992, Böhm 2000, Prechtel 2000, Patterson 2001b, c, Leonowicz et al. 2010).

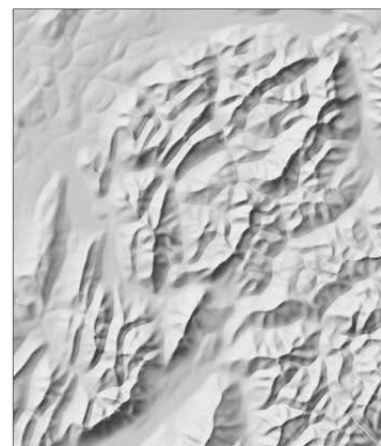
DIGITAL RELIEF SHADING IS NOT WITHOUT PROBLEMS, ESPECIALLY AT MEDIUM AND SMALL MAP SCALES WHERE EXCESS DETAIL IS COMMONPLACE. A SMALL-SCALE SHADED RELIEF WITH MANY INTRICATE TERRAIN DETAILS CAN INHIBIT THE PERCEPTION OF THE MAIN LANDFORMS



Manual

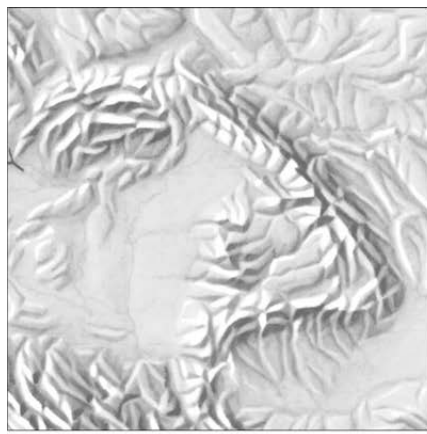


Digital

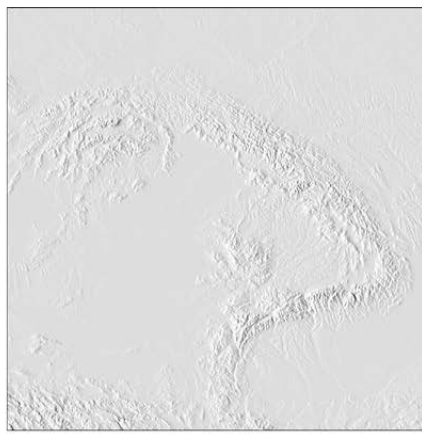


Digital  
Terrain filtered with Terrain Sculptor

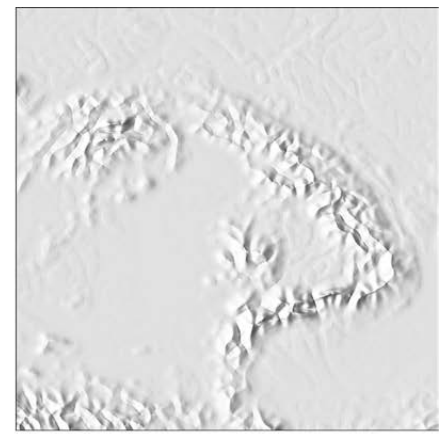
Figure 1: Shaded relief at 1:1,000,000. Left: Federal Office of Topography swisstopo (DV033492.2). Middle: from raw SRTM data. Right: from SRTM data generalized with Terrain Sculptor.



**Manual**



**Digital**



**Digital  
Terrain filtered with Terrain Sculptor**

Figure 2: Shaded relief at 1:15,000,000. Left: Swiss World Atlas 2008. Middle: from raw GTOPO30 data. Right: from GTOPO30 data generalized with Terrain Sculptor.

TERRAIN SCULPTOR DOES NOT OFFER A NEW SHADING METHOD, BUT INSTEAD GENERALIZES TERRAIN MODELS VIA A FILTERING METHODOLOGY.

Figures 1 and 2 compare manual and automated shaded relief of the same geographic areas. Digitally shaded relief is often not successful at portraying the main structures of a terrain at medium and small scales. For example, looking at the unfiltered shaded relief (Figures 1 and 2, middle), the many details and the static light direction result in an unstructured portrayal of the terrain. It appears as a disjointed collection of minor features, and major landforms are difficult to detect. By contrast, the major landforms are immediately visible in the manual shading because unnecessary details are removed and the light direction is locally adjusted to optimally illuminate landforms within the terrain trending in different directions.

This paper presents a method for the generalization of digital elevation models, specifically designed for calculating shaded relief. The method not only removes terrain details from digital elevation models, but also accentuates important relief features. The method was implemented in the freeware software application Terrain Sculptor. Terrain Sculptor does not offer a new shading method, but instead generalizes terrain models via a filtering methodology. All shaded relief images presented in this paper are computed with a standard shading algorithm simulating diffuse reflection. More advanced methods developed for manual (Imhof 1982) and digital shading are not included in the current version of this application. For example, the light direction is not locally adjusted (Yoeli 1967, Brassel 1974, Zhou and Dorrer 1995, Prechtel 2000) and areal perspective is not simulated (Brassel 1974, Jenny 2001). These techniques also aim at a more clear representation of the terrain by graphically accentuating important landforms, but do not alter the underlying terrain model.

## GENERALIZATION METHOD

Terrain Sculptor implements a generalization method developed and described by Leonowicz et al. (2010). The method consists of a succession of raster operations performed on digital elevation data. The general idea is to classify the terrain as mountainous and lowland areas and to separately generalize these morphologically different areas—in different ways—and afterwards re-combine them into one elevation model. This idea follows a principle formulated for manual relief shading by Imhof (1982), who recommends accentuating ridge lines in high mountain areas and river valleys on flat plains. The digital method uses the following operations, which are illustrated in Figure 3:

1. Digital elevation data (Figure 3A) are filtered with a low-pass mean filter to produce a smoothed elevation model (Figure 3B). This model serves as a base surface onto which relevant details are added, using the following processing steps.
2. Terrain features (ridges and valleys) are detected by curvature coefficients: maximum and plan curvature are used to identify ridge lines, and minimum curvature is used to identify valleys (see Wilson and Gallant 2000 for details on curvature computation). For detecting large terrain features and removing small details, elevation data are smoothed, using a mean filter, before calculating the coefficients.
3. Two additional elevation models are created by vertically exaggerating and deepening the smoothed elevation model (models not represented in Figure 3).

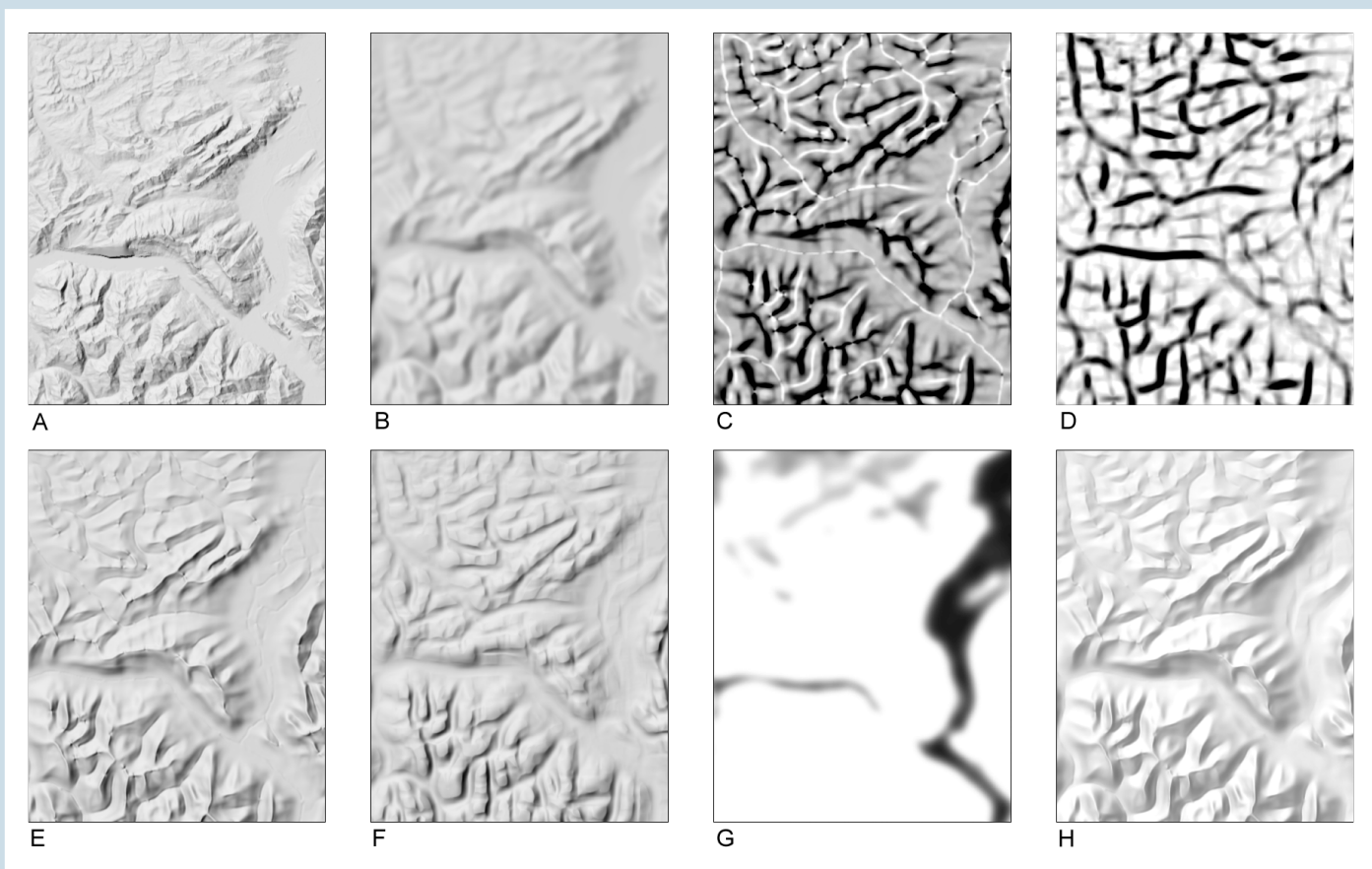


Figure 3: Intermediate steps of the generalization method. A. ungeneralized terrain model; B. smoothed terrain model; C. weights for exaggerating ridges; D. weights for deepening valleys; E. mountain model with exaggerated ridges; F. lowland model with deepened valleys; G. weights for combining models E and F; H. final shaded terrain model.

THE USER CAN INTERACTIVELY ADJUST SEVERAL PARAMETERS TO ACHIEVE THE DESIRED LEVEL OF GENERALIZATION, DEPENDING ON THE MAP SCALE AND THE SPATIAL RESOLUTION OF THE ORIGINAL ELEVATION MODEL.

4. Two grids with weighting factors are created from curvature coefficients (Figure 3C and D) and used to combine the exaggerated model and the deepened model of step 3 with the smoothed model generated in step 1. In areas with extreme curvature values, either the exaggerated model or the deepened model of step 3 is used, whereas the smoothed model of step 1 is used in areas with low curvature values. As a result of these combinations, two elevation models are created: a mountain model (Figure 3E) and a lowland model (Figure 3F).
5. Smoothed slope values (Figure 3G) are used to re-combine the mountain model with the lowland model. The mountain grid is used in the areas with high slope values (white in Figure 3G) and the lowland grid in areas with low slope values (black in Figure 3G).
6. A shaded relief image is calculated from the model generated in step 5 (Figure 3H).

#### IMPLEMENTATION: TERRAIN SCULPTOR

Terrain Sculptor is a cross-platform Java application implementing the generalization procedure described above. The application is intended as a production tool for creating generalized shaded reliefs at small and medium scales. It is freely available at <http://www.terraincartography.com/terrainsculptor/>. Terrain Sculptor reads digital elevation models as grids in ESRI ASCII format and saves generalized models to the same format. The generalized models can then be visualized with any shading algorithm in other GIS or mapping software. Terrain Sculptor can also calculate shaded relief using a standard diffuse shading algorithm and export it as a raster image file.

Terrain Sculptor processes elevation data according to the steps outlined in the previous section. Intermediate models produced after each processing step can optionally be visualized within the software (i.e., the lowland model, the mountain model, the slope mask used for the combination, as well as the original and the final generalized model). The user can interactively adjust several parameters to achieve the desired level of generalization, depending on the map scale and the spatial resolution of the original elevation model.

The user of Terrain Sculptor is not required to understand the details and the various steps of the generalization method. The graphical interface instead aggregates various detail parameters and displays them as slider controls that are straightforward to understand. The application offers two interface modes: the basic mode consists of only two sliders to adjust the level of detail and the scale-dependent shading style. The interface elements of the advanced mode are shown on the left side of Figure 4 marked with numbers 1–5. They adjust the following parameters (numbers as in Figure 4):

1. the size of the low-pass filter to smooth the original elevation model;
2. the size of ridges that are removed from the elevation model;
3. the vertical exaggeration of ridges;
4. the sharpness of ridges; and
5. the slope threshold discerning between lowland areas and mountain areas.



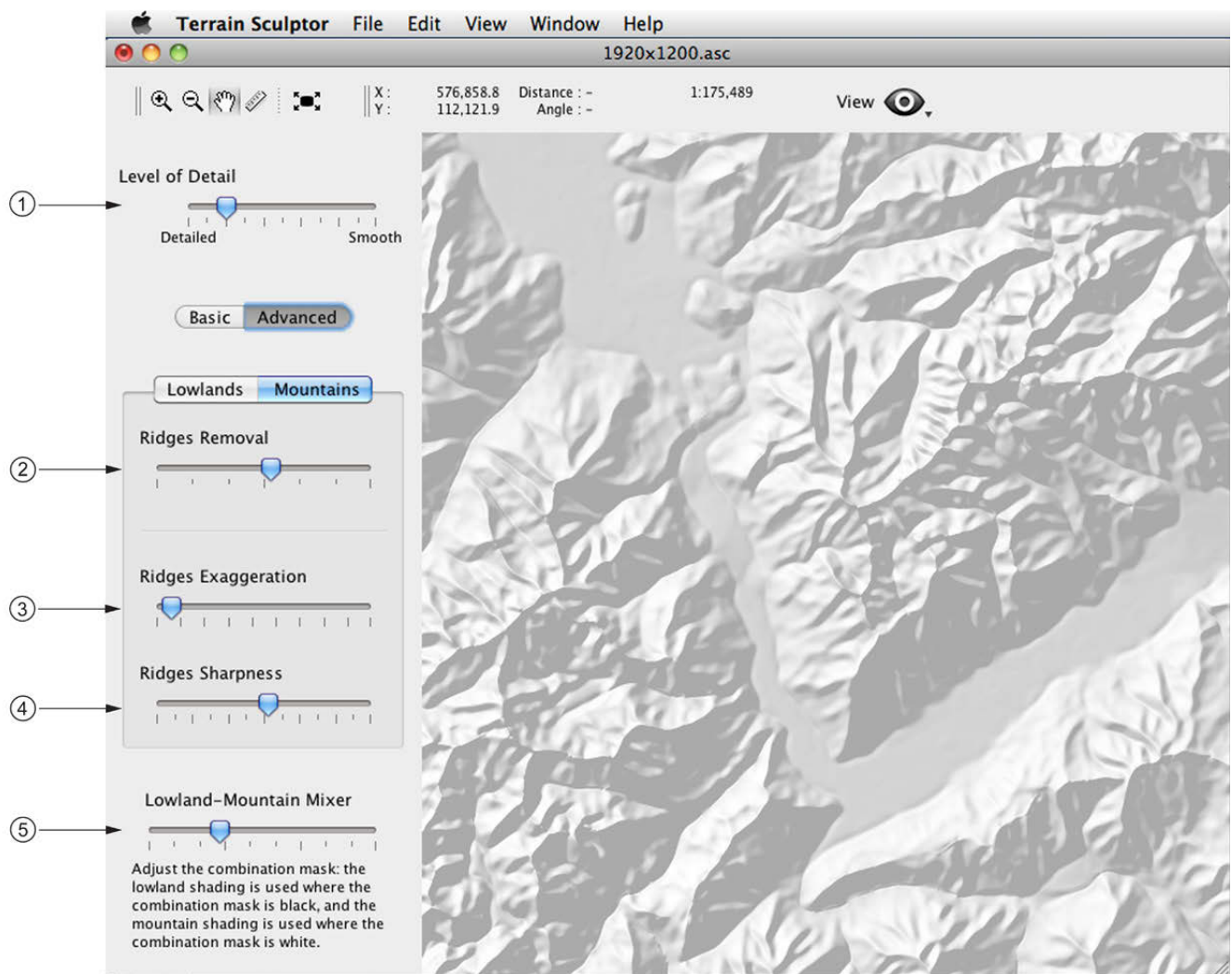


Figure 4: Graphical user interface of Terrain Sculptor in “Advanced” mode for adjusting generalization parameters.

Three additional parameters can be adjusted in the lowlands panel (not visible on Figure 4):

- the size of valleys that are removed from the elevation model;
- the amount of valley deepening; and
- the width of valley bottoms.

## RESULTS

Figures 5 to 8 show how parameters influence the resulting shaded relief. Figure 5 compares three levels of generalization achieved by moving the “Ridges Removal” slider, which increases the size of ridges removed from the elevation model. Valleys are generalized in the same way using the “Valleys Removal” slider (in the Lowlands panel, not visible in Figure 4). Ridge lines can be made more prominent by increasing their vertical exaggeration. This is illustrated in Figure 6 showing the Carpathian Mountains calculated from GTOPO30 data. To accentuate valley edges, the user increases the amount of valley deepening. This operation is illustrated in Figure 7, which depicts a section of the Jura Mountains in

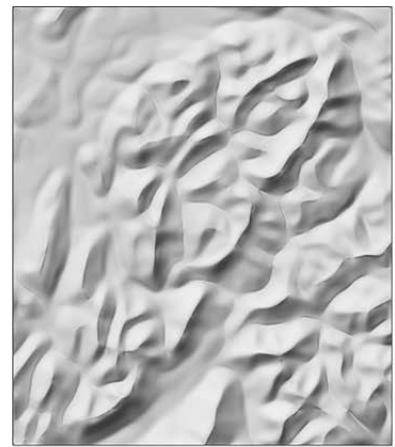
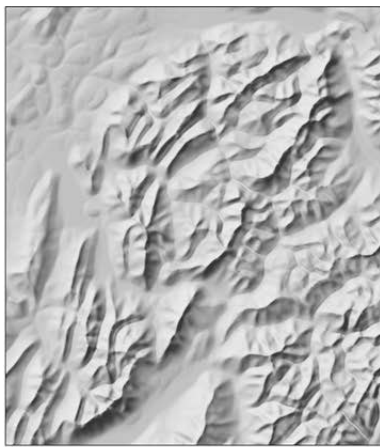


Figure 5: Increasing the size of ridges removed from the elevation model (1:1,000,000).

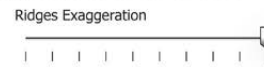
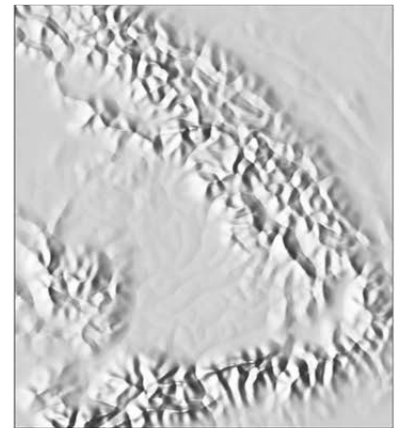
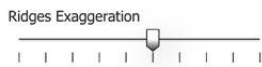
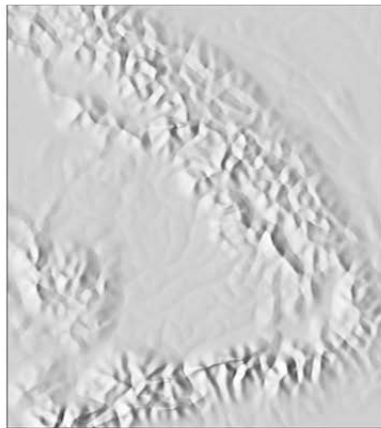
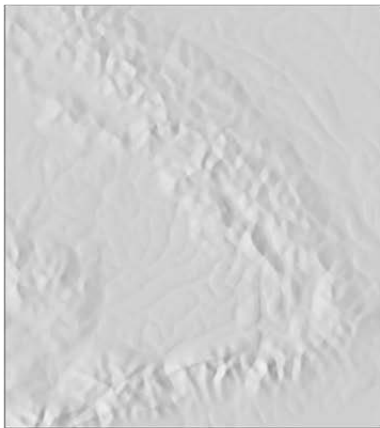


Figure 6: Increasing vertical exaggeration of ridge lines (1:7,500,000).



Figure 7: Increasing the depth of valleys (1:200,000).

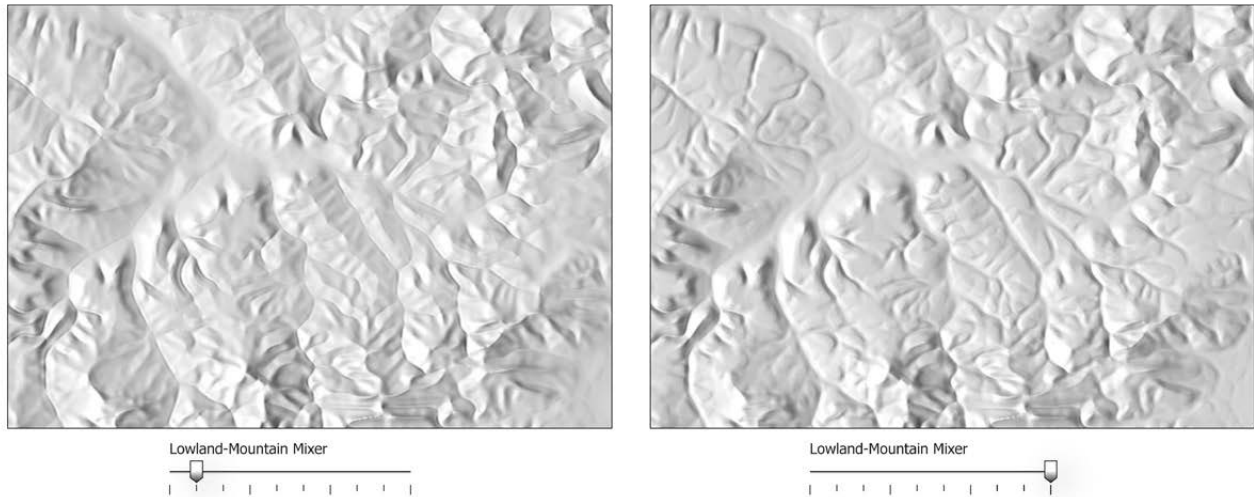


Figure 8: Increasing the slope threshold discerning between lowland and mountain areas (1:200,000).

northern Switzerland, calculated from a model at 25 meters resolution (DHM25 by Swisstopo) and generalized to the scale of 1:200,000. The character of the shaded landforms can be accentuated by adjusting the slope threshold that differentiates between lowland and mountain areas (slider “Lowland-Mountain mixer”). A lower threshold creates a shaded relief with a more mountainous aspect (Figure 8, left), while a higher threshold produces a gently undulated surface carved with valleys (Figure 8, right).

Figure 1 shows medium scale terrain shadings at 1:1,000,000. SRTM data with a spatial resolution of 3 arc seconds (approximately 100 meters) were generalized with Terrain Sculptor (Figure 1, right). A comparison with the shading derived from the original SRTM data (in the center of Figure 1) shows that Terrain Sculptor removes many of the unnecessary small terrain details, while the sharp structures of the main landforms are preserved. Ridges and valleys are clearly visible and unmarred by small terrain irregularities. The level of details achieved with Terrain Sculptor is similar to that of the manually-produced shaded relief at the same scale (Figure 1, left). Differences are mainly due to local adjustments of the light direction and the individual cartographer’s manual shading style. Identical results can, therefore, not be expected.

Figure 2 shows shaded reliefs at 1:15,000,000 of the Carpathian Mountains. They were calculated from GTOPO30 data with a spatial resolution of 30 arc seconds (approximately 1 km). The shaded relief derived from the terrain model generalized with Terrain Sculptor is shown on the right. Compared to the ungeneralized shaded relief, major landforms are more clearly visible, especially in low relief areas. Mountains are much more prominent and have a unified structure.

In summary, to increase the level of generalization, the minimum size of ridges and valleys as well as the size of the low-pass filter for smoothing the original elevation model need to be increased. Low-resolution grids at small scales generally need stronger vertical exaggeration of ridges and stronger valley deepening. In addition, the width of valleys and the sharpness of ridges should be increased, and the slope threshold for discerning between lowland and mountain areas can be lowered.

TERRAIN SCULPTOR REMOVES MANY OF THE UNNECESSARY SMALL TERRAIN DETAILS, WHILE THE SHARP STRUCTURES OF THE MAIN LANDFORMS ARE PRESERVED.

## CONCLUSION

Terrain Sculptor is a freeware software application that can be downloaded from <http://www.terraincartography.com/terrainsculptor/>. The implemented generalization method removes unnecessary and distracting terrain details from digital terrain models, while accentuating main landscape features. Several generalization and feature-enhancing parameters can be interactively adjusted according to the desired visualization scale. The application can preprocess terrain models before standard shading is applied in GIS and raster mapping software, which often does not provide appropriate terrain generalization algorithms. Terrain Sculptor will hopefully help geographers and cartographers generate improved shaded terrain visualizations, especially at small and medium scales.

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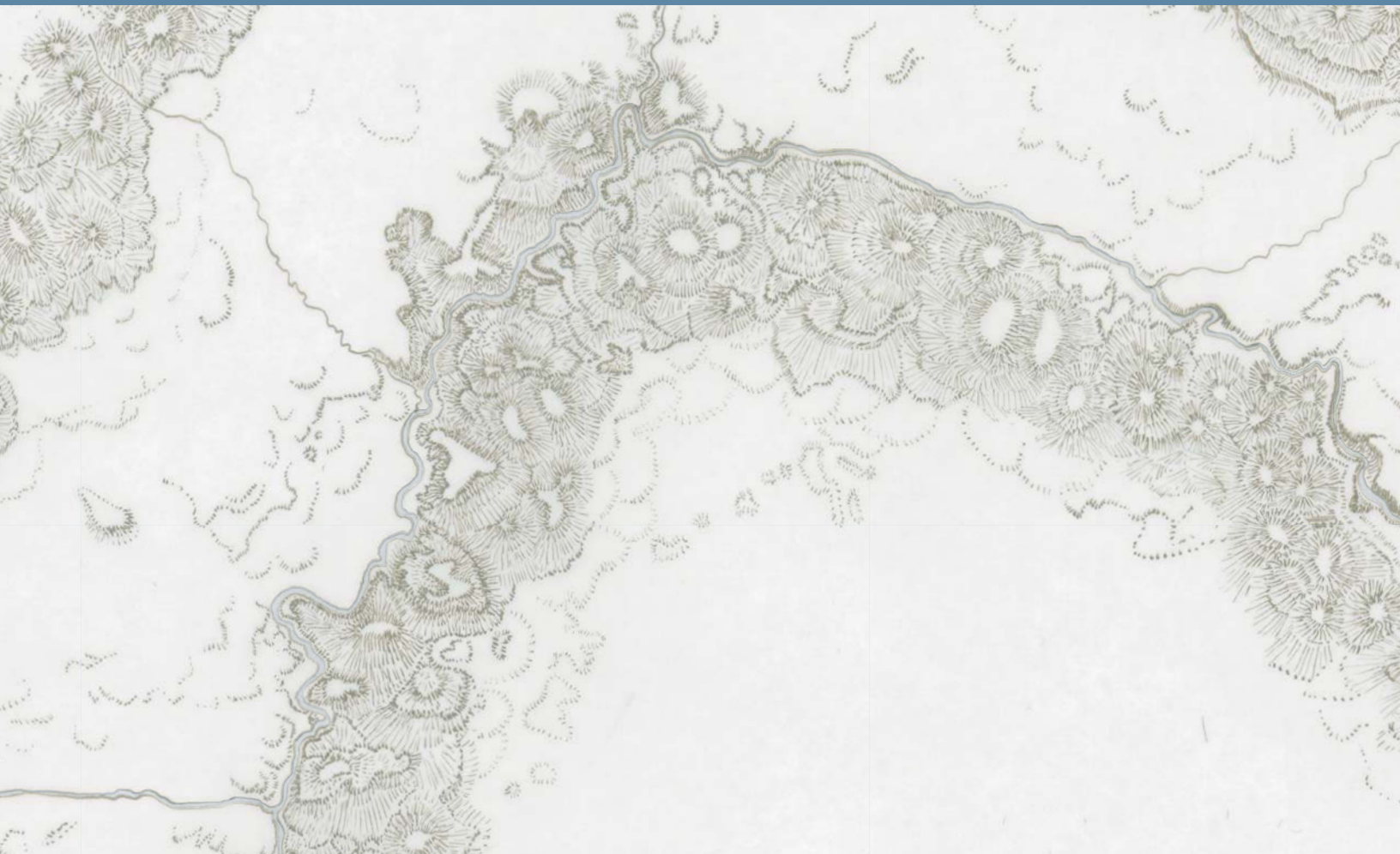
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### ABOUT THE IMAGE

This original map illustration (background) was one of many used to help depict the Gunnison-Beckwith survey for the Pacific Railroad (1853-1854) in the Atlas of Explorations for the Pacific Railroad (see image at left). This atlas integrates components from the original Pacific Railroad Reports with new spatial and temporal elements, producing an integrated narrative piece designed to be read as a novel. The design mimics the original incorporated format of the Railroad Reports through the linking of original report materials (text, narrative and illustration) by location within each new original map. Historic cartographic techniques are preserved through the combination of hand-drawn (detail of the hand-drawn relief technique above) and digital elements; using current data as a guide, relief was hand rendered following the tradition hachuring style of the 19th century cartographer and combined with modern digital symbols chosen to mimic the original historic style of those found in the reports. The example (above) displays a mountainous area north-west of present day Grand Junction, Colorado through which the expedition party passed on their way to California.

For more information: <http://www.bentleycartographic.com>





# Some Useful Digital Elevation Datasets

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## INTRODUCTION

For this special *Cartographic Perspectives* issue on mountain cartography, what better topic to cover than working with digital elevation data? I had originally planned to cover both data sources and provide how-to techniques for working with digital elevation data. I soon realized that even a brief review of data sources ran to many pages and that techniques for working with elevation data will need to wait until a future episode of the *Practical Cartographer's Corner*.

As most practicing cartographers know there is a wealth of digital elevation data available, much of it free (Gamache, 2004, provides a review of datasets and useful evaluations of their quality and usability). The United States government's policy of placing most datasets in the public domain—and distributing them effectively through the Geological Survey, NASA and other agencies—has not only provided terabytes of material but has encouraged the opening of datasets by other national governments. The governments of Canada and Mexico have opened much of their digital geo-data, including elevation data, to public access.

It is beyond the scope of a short summary such as this to enumerate all the elevation datasets available to map makers. I have omitted commercial geographic data and government data not distributed to the public. My summary of selected sources for digital elevation data includes freely available worldwide datasets and publicly released larger scale data from North America.

## WORLDWIDE, LOW-RESOLUTION

Several digital elevation datasets provide worldwide coverage. One of the earliest datasets, completed in 1996, came from the U.S Geological Survey and was named GTOPO30. It had a resolution of 30 arc-seconds and was derived from a variety of digital and topographic map sources from U.S. and other national mapping services (USGS, 2011a).

A quick note is helpful here about resolution specifications for digital elevation datasets. The two common units of measure are arc-seconds (or minutes) and meters. Though a single data set is often referred to in both units, they are not strictly convertible. Seconds or minutes of a degree refer to unprojected units of an arc of a sphere and meters refer to measured distance along a line or an arc.

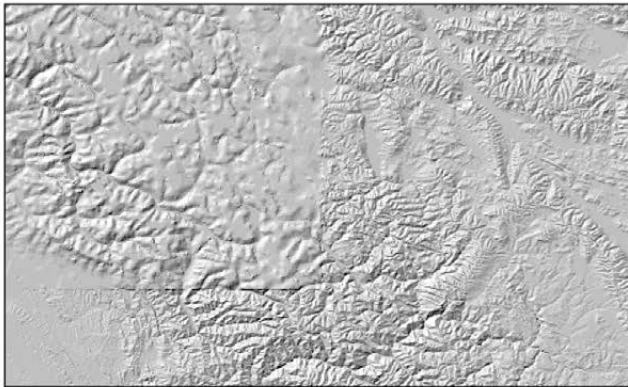
For the GTOPO30 dataset, 30 arc-second data is often referred to as one-kilometer data. One kilometer is only an average cell size. Because lines of longitude converge at the pole, the number of meters in one degree, minute, or



second of latitude is lower at the pole and higher at the Equator. Most global elevation datasets are stored in a latitude equals longitude grid (Geographic or Plate Carrée projection) and have a variable resolution in meters per pixel as you move from low to high latitudes. When examined for a local area or when projected to a UTM grid, these data vary far less and can be referred to in fixed meters per pixel.

GTOPO30 was the primary source for cartographers who needed international elevation data in the 1990s and early 2000s. The USGS created an improved version called SRTM30 that was corrected and updated by use of the SRTM (Shuttle Radar Topography Mission) data described below, but only for the SRTM coverage area of 56° South to 60° North (USGS, 2011b). Figure 1 shows a sample area that highlights the improvement provided by the SRTM data.

**GTOPO30**, 30 arc-second data, at 144 pixels/inch (30 arc-seconds per pixel, no resampling)



**SRTM30**, 30 arc-second data, at 144 pixels/inch (30 arc-seconds per pixel, no resampling)

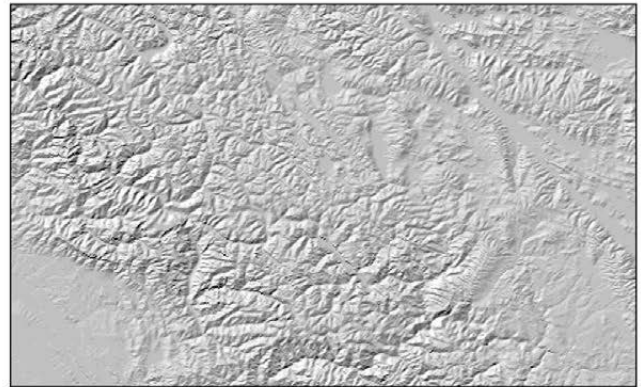


Figure 1. Sample shaded relief images of the western Himalaya along the India/China border, generated from GTOPO30 and SRTM30 data. Note the increased detail of the upper left section of the SRTM image.

Although a little harder to find now that higher resolution data is available, the 30 arc-second data is still a very useful low-resolution world digital elevation dataset. The USGS has direct links to the GTOPO30 (USGS, 2011c) and SRTM30 (USGS, 2011d) data.

## WORLDWIDE, HIGH-RESOLUTION

The Shuttle Radar Topography Mission, flown in 2000, resulted in a radical improvement for worldwide digital elevation data. When the data were processed and then released the following couple of years, the best publicly available world elevation data jumped from 30 arc-second resolution to 3 arc-second resolution, a tenfold improvement! For the United States, the U.S. Government also released SRTM 1 arc-second data. See the United States National Aeronautics and Space Administration, Jet Propulsion Laboratory (NASA-JPL) website for detailed information (NASA-JPL, 2011a).

The original SRTM data has been processed and improved by the United States National Geospatial-Intelligence Agency into version 2 and in 2009 a version

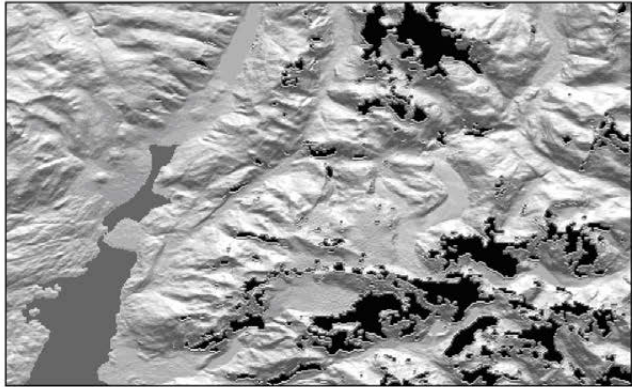
2.1. The outline of water bodies has been improved and single pixel errors (spikes and wells) have been eliminated. There are still voids—areas of missing data—due to shadows, phase-unwrapping anomalies, or other radar-specific causes. This is particularly noticeable in high mountain regions, a serious problem for mountain cartographers.

The USGS provides direct access to the SRTM 3 arc-second data for the world (USGS, 2011e) and SRTM 1 arc-second data for the United States (USGS, 2011f). The Global Land Cover Facility at the University of Maryland (2011) also provides access to the same SRTM 3 arc-second data and 1 arc-second data.

Because of the above-mentioned voids in the SRTM data, several groups have worked to improve the 3 arc-second data. They have used a variety of methods to fill the voids and provide a more usable version of the data. One very useful void-filled SRTM dataset was created by Dr. Andy Jarvis and Edward Guevara of the International Center for Tropical Agriculture (CIAT) and Dr. Hannes Isaak Reuter and Dr. Andy Nelson of the Joint Research Centre of the European Commission (2008). Version 4 of this database is available from the Consultative Group on International Agricultural Research, Consortium for Spatial Information (CGIAR-CSI, 2011) and from a mirrored site at King's College London (2011). See Figure 2 for an example of the improved provided by the void-filling process.

A unique source for worldwide digital elevation data is the *Viewfinder Panoramas* site constructed by Jonathan de Ferranti (2011). The site provides custom void-

**SRTM unfilled**, 3 arc-second data, at 144 pixels/inch  
(3 arc-seconds per pixel, no resampling)



**SRTM void-filled**, 3 arc-second data, at 144 pixels/inch  
(3 arc-seconds per pixel, no resampling)

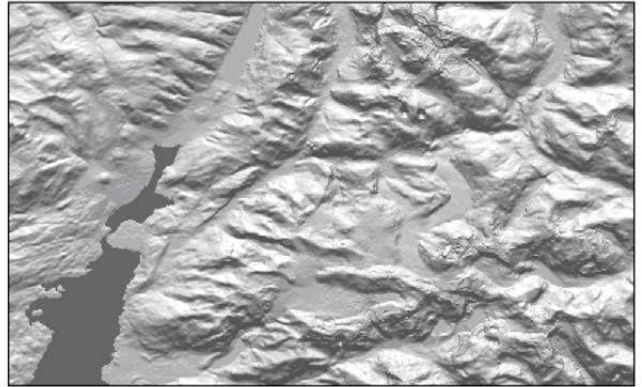
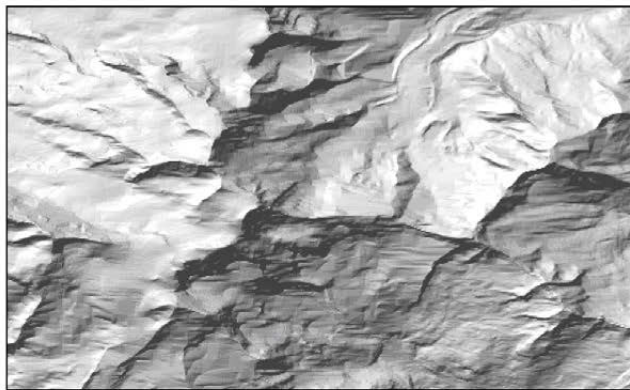


Figure 2. Sample shaded relief images generated from SRTM 3 arc-second data for a section of the Andes Mountains in Chile. The USGS version 2.1 with black areas showing voids is on the left and the CGIAR-CSI void-filled version is on the right.

filled SRTM 3 arc-second data and some higher-resolution data sets for selected mountain regions. It also provides 3 arc-second data (and larger scale) data for areas above 60° North and below 56° South, the poleward limits of the SRTM data. These datasets have been derived from large-scale cartographic contours and other sources and they have been specifically tailored for high-mountain areas.

The site has good coverage for European mountain areas including both 3 arc-second data and 1 arc-second datasets. Figure 3 compares data from the *Viewfinder Panoramas* site to data from the SRTM 3 data showing the higher quality for this area of the Alps.

**Viewfinder Panorama**, 1 arc-second data, at 144 pixels/inch (1 arc-second per pixel, no resampling)



**SRTM**, 3 arc-second data, at 144 pixels/inch (3 arc-seconds per pixel resampled to 1 arc-second per pixel)

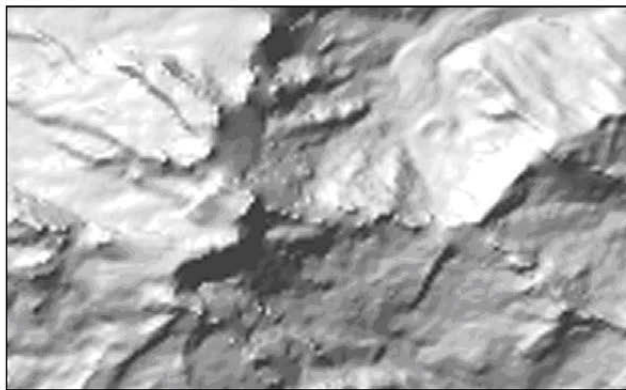


Figure 3. Sample shaded relief image of the Monte Rosa area in the Alps showing the quality of data in the Viewfinder Panoramas 1 arc-second data elevation data set. SRTM 3 arc-second data image is shown for comparison.

NASA-JPL and Japan's Ministry of Economy, Trade and Industry (METI) have recently developed a new global high-resolution digital elevation dataset based on data from the ASTER (advanced spaceborne thermal emission and reflection radiometer) satellite sensor. The ASTER digital elevation data can be downloaded for free, after registration, from both NASA-JPL (2011b) and METI (2011a) websites.

The elevation data are at nominal 1 arc-second (about 30 meters) resolution, even higher than the released SRTM data for non-U.S. areas. But, after testing the quality of three-dimensional terrain views and shaded relief renders from the 30 meter ASTER data, the resulting quality is, at best, equivalent to the 90 meter (3 arc-second) SRTM data, not three times more detailed (see Figure 4, and Gamache, 2004).

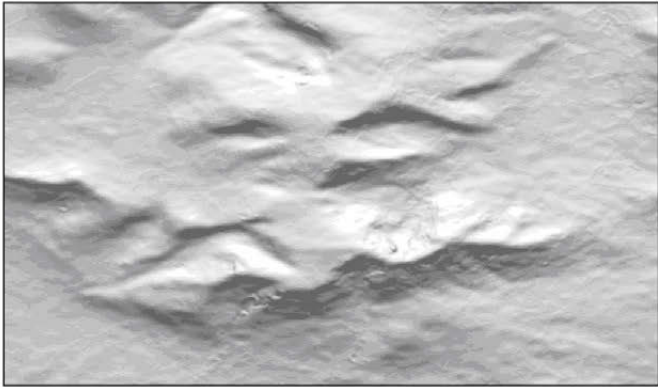
## UNITED STATES

The primary source for digital elevation data for the United States is the National Elevation Dataset (NED) maintained by the U.S. Geological Survey (USGS). The NED contains the best available raster elevation data for the conterminous United States, Alaska, Hawaii, and territorial islands. It is a seamless nation-wide coverage and has replaced the earlier set of DEM format files produced by USGS on an individual topographic quadrangle basis (USGS, 2011g).

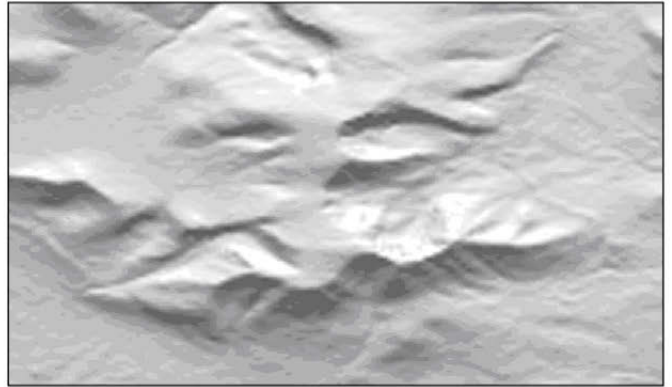
The NED is available in several resolutions. For the United States (other than Alaska), it contains complete 1 arc-second (about 30 meter cells) and 1/3 arc-second (about 10 meter) data and limited 1/9 arc-second (about 3 meter) data. For Alaska, the NED has mostly 2 arc-second data and limited 1 arc-second and 1/3 arc-second data. The USGS has compiled the NED from a variety of sources ranging from cartographic contours to LIDAR data sets and it is continually updating and improving the data. The improvement can be seen in Figure 5, showing a glaciated area on Mount Rainer where the 1/9 arc-second image shows the detail collected using LIDAR technology.

The NED can be downloaded from several sites at USGS. Data access at USGS has recently been consolidated into the viewing and downloading tool at their *National Map* site (USGS, 2011h). There is also a special purpose NED tool for downloading 1 arc-second and 1/3 arc-second data by defining latitude and longitude bounds or by state and county (USGS, 2011i). Using this tool is much quicker than going through the *National Map* viewer.

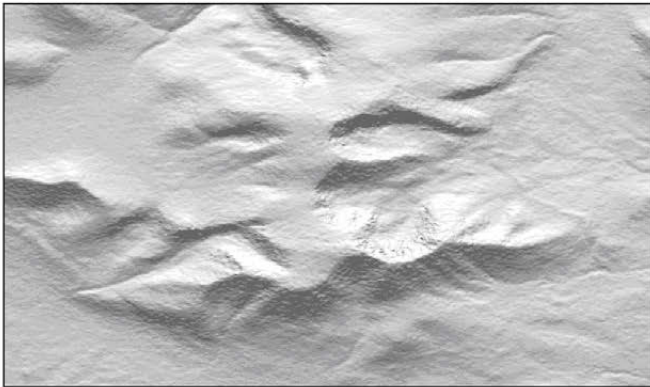
**ASTER**, 1 arc-second data, at 144 pixels/inch  
(1 arc-second per pixel, no resampling)



**SRTM**, 3 arc-second data, at 144 pixels/inch  
(3 arc-seconds per pixel resampled to 1 arc-second per pixel)



**SRTM**, 1 arc-second data, at 144 pixels/inch  
(1 arc-second per pixel, no resampling)



**NED**, 1 arc-second data, at 144 pixels/inch  
(1 arc-second per pixel, no resampling)

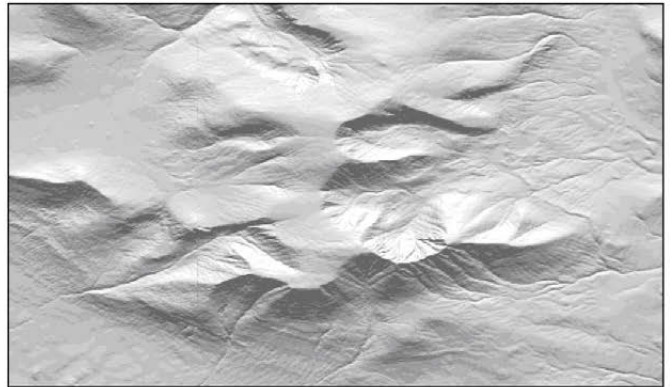
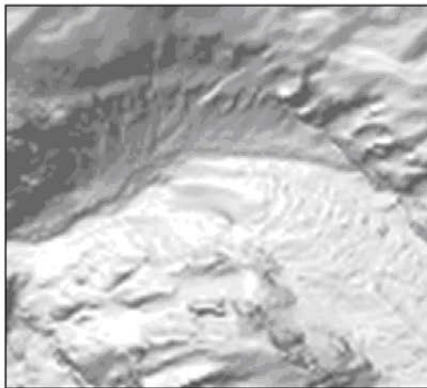


Figure 4. Sample shaded relief images of the Mount Katahdin area in central Maine comparing data sets: ASTER 1 arc-second, SRTM 3 arc-second, SRTM 1 arc-second and NED 1 arc-second. Note the definition of the drainages and the sharpness of the escarpments and cirques in the NED image.

**NED**, 1 arc-second data, at 144 pixels/inch  
(1 arc-second per pixel resampled to  
1/9 arc-second per pixel)



**NED**, 1/3 arc-second data, 144 pixels/inch  
(1/3 arc-second per pixel resampled to  
1/9 arc-second per pixel)



**NED**, 1/9 arc-second data, 144 pixels/inch  
(1/9 arc-second per pixel, no resampling)

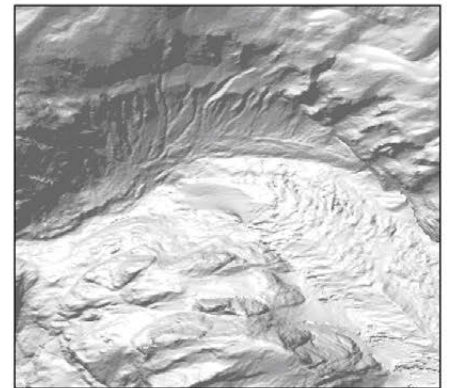


Figure 5. Sample shaded relief images of part of the USGS Mount Rainier West quadrangle generated from NED data at 1, 1/3, and 1/9 arc-second. Note the ability to discern the glacier at 1/3 arc-second image and the glacial crevasses on the 1/9 arc-second image.

## CANADA

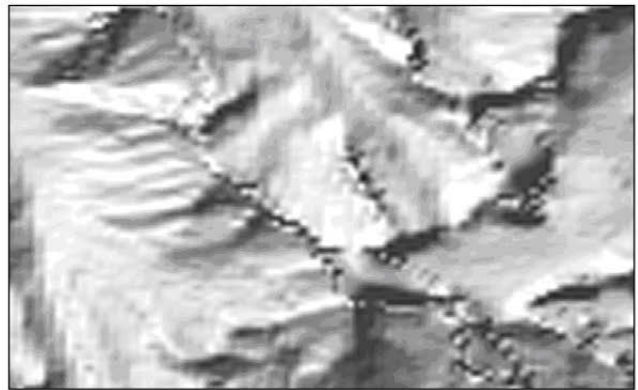
Digital elevation data collected by the Canadian national government comes from Natural Resources Canada (NRC, 2011) and is available at two resolutions: 3 arc-seconds (about 90 meter) and  $\frac{3}{4}$  arc-second (about 20 meter). These digital elevation datasets are based on the Canadian 1:250,000 and 1:50,000 topographic map series and can be accessed by the quadrangle numbers for those maps.

The data is based on best available sources and some areas have better quality data than others. The provinces contribute data and in Figure 6, you can see that the British Columbia data is superior to that for Alberta and the NRC data in Alberta is similar to the SRTM 3 arc-second data.

**NRC, 3/4 arc-second data, at 144 pixels/inch**  
(3/4 arc-second per pixel, no resampling)



**SRTM, 3 arc-second data, at 144 pixels/inch**  
(3 arc-seconds per pixel resampled to 3/4 arc-second per pixel)

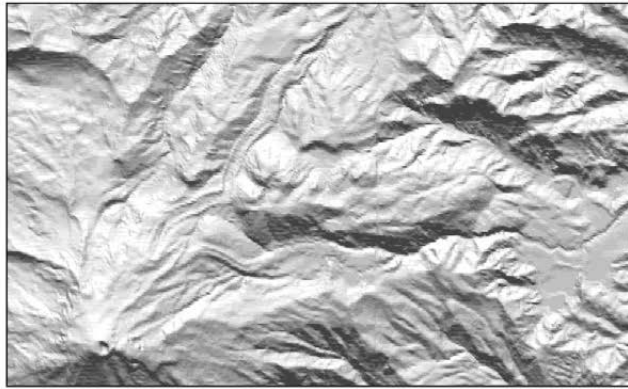


*Figure 6. Sample shaded relief image of the Mt. Joffre area on the border of British Columbia and Alberta showing the quality of data in the Natural Resources Canada 1:25000 digital elevation data set. While nominally a  $\frac{3}{4}$  arc-second resolution, the data is uneven and the provincial boundary shows high quality data in British Columbia (to the South) compared to lower quality data in Alberta (to the North). SRTM 3 arc-second data image is shown for comparison.*

## MEXICO

Digital elevation data for Mexico comes from the Instituto Nacional Estadística y Geografía (INEGI, 2011). If your Spanish is good you can complete the registration process and download data based on the Mexican 1:50,000 and 1:25,000 topographic maps. The data is available by quadrangle number or user specified area (up to 2 x 2 minutes). INEGI created the data at 30 meter intervals (about a 1 arc-second resolution) and it provides much greater detail than SRTM 3 arc-second data (Figure 7).

**INEGI**, 1 arc-second data, at 144 pixels/inch  
(1 arc-second per pixel, no resampling)



**SRTM**, 3 arc-second data, at 144 pixels/inch  
(3 arc-seconds per pixel resampled to 1 arc-second per pixel)

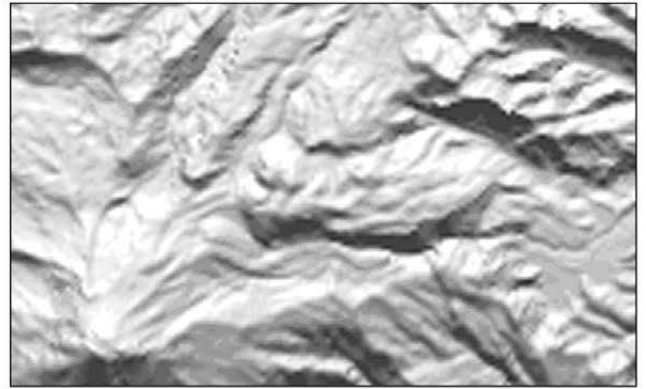


Figure 7. Sample shaded relief image of the Pico de Orizaba area in Mexico showing the quality of data in the INEGI 1 arc-second elevation data set. SRTM 3 arc-second data image is shown for comparison.

## BATHYMETRIC DATA

The U.S. National Oceanic and Atmospheric Administration (NOAA) is the best source for free world bathymetry datasets. They released their first world data set in 1988 (with some improvements in 1990). Named ETOPO5 it has bathymetric depths on a 5 minute grid. This was followed by a much higher resolution and higher quality dataset called ETOPO2. The data for ETOPO2 are at 2 minute grid intersections and build primarily on the pioneering work of Walter Smith and David Sandwell (1997). The original ETOPO2, released in 2001, was replaced in 2006 by ETOPO2v2 which incorporated improved data for the Great Lakes, U.S. coastal waters and the Caspian Sea.

In 2008, NOAA released their most detailed worldwide gridded bathymetry, the ETOPO1 dataset, at 1 arc minute resolution (Amante and Eakins, 2009). The ETOPO1 data has superseded the earlier ETOPO5 and ETOPO2 data. It, too, primarily relies on the Sandwell and Smith (2009) bathymetric data derived from sea-surface satellite altimetry measurements and ocean soundings with incorporation of additional detailed datasets.

The datasets are available from NOAA's National Geophysical Data center website: ETOPO5 (NOAA, 1990), ETOPO2 (NOAA, 2006) and ETOPO1 (NOAA, 2008). They include land elevation data in addition to the bathymetry and are very convenient to use when you need both. NOAA also provides Internet tools for accessing its higher-resolution bathymetric data for U.S. coastal and interior lake waters (NOAA, 2011). Figure 8 shows the increasing detail of the ETOPO2, ETOPO1 and Coastal Relief Model data (3 arc-seconds) available from NOAA.

The folks at Scripps Institution of Oceanography at the University of California San Diego have released their own combination land elevation-bathymetry worldwide dataset (SIO-UCSD, 2011). They have merged USGS SRTM30 data and improved 1 arc minute bathymetric data from Smith and Sandwell. This dataset is called SRTM30-Plus and is available at the Scripps website.

**ETOPO2**, 2 arc-minute data, 144 pixels/inch (120 arc-seconds per pixel resampled to 3 arc-seconds per pixel)

**ETOPO1**, 1 arc-minute data, 144 pixels/inch (60 arc-seconds per pixel resampled to 3 arc-seconds per pixel)

**NOAA**, 3 arc-second data, 144 pixels/inch (3 arc seconds per pixel, no resampling)

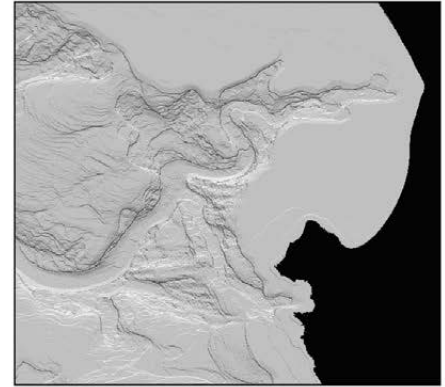
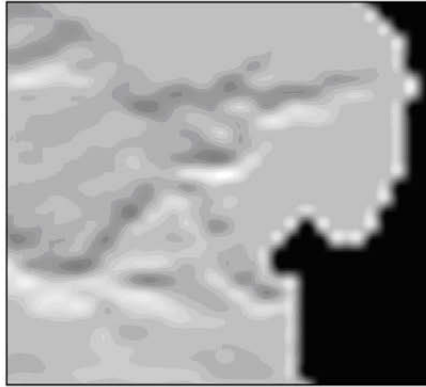
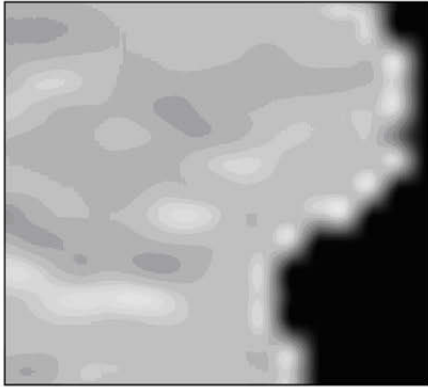


Figure 8. Sample shaded relief image of the Monterey Canyon area off the California coast showing the quality of data in the ETOPO2, ETOPO1 and Coastal Relief Model datasets from NOAA.

Tom Patterson of the U.S. National Park Service has developed a very useful, low-resolution bathymetric dataset called CLEANTOPO2 (Patterson, 2011). It is a version of the SRTM30-Plus dataset from Scripps (at 2 arc minute resolution) that he has improved for small-scale terrain modeling and relief shading. Patterson filled ship paths, voids and other anomalous features of the dataset to improve its usability for geographic visualizations.

## CONCLUSIONS AND FUTURE TRENDS

For many practicing cartographers, the two most important freely available digital elevation datasets are the USGS NED (1, 1/3 and 1/9 arc-second) for United States coverage and the SRTM (3 arc-second) data for much of the rest of the world. It is important to note the differences between NED and SRTM data, especially for U.S. areas that are available at 1 arc-second from both. Table 1 summarizes these differences and reflects the different methods of data collection and processing. The bare earth characteristic of the NED is usually more useful for 2-D and 3-D cartographic renderings.

	NED	SRTM
Source Data	Maps/Aerial Photos/LIDAR data	Radar data
Source Resolution	3m, 10m & 30m DEMs	30m
Source Dates	1925–present	February, 2000
Source Type	“Bare-Earth”	“First Return”
Vertical Accuracy	2.44m RMSE measured (root mean square error)	10m RMSE (root mean square error) was the mission specification

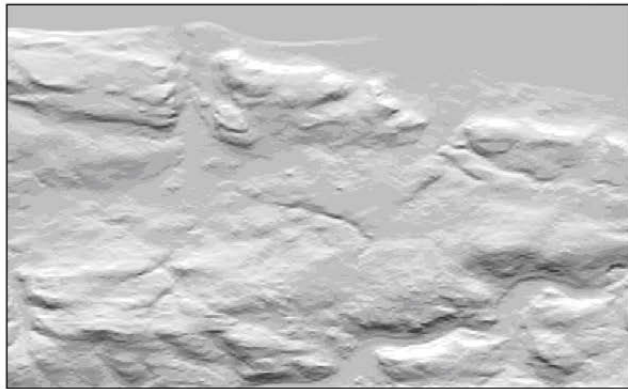
Table 1. Comparison of NED and SRTM data set characteristics.

Looking to the future, what will be happening with these two important sets of digital elevation data? Additional efforts are underway to better fill voids and otherwise improve the SRTM data, but a big question remains for this dataset. Will the U.S. Government release the SRTM 1 arc-second data for the world beyond the U.S. any time soon? At the USGS, digital elevation data just keeps getting better and better. They update the 1 arc-second and 1/3 arc-second datasets on a scheduled two-month cycle to integrate new and improved elevation source data. For the higher resolution 1/9 arc-second data, the USGS release new datasets on a monthly basis as they are created.

Compared with what was available in the recent past, practical cartographers have access to excellent digital elevation data. It is high resolution and high quality and works well for most small and medium scale uses. For highly detailed large-scale purposes, better public digital elevation data is still needed, especially outside the United States.

Recent developments in the United Kingdom show there is reason for optimism. The Ordnance Survey (2010) has released its *Panorama* product elevation data at 50 meter cell size (approximately 1 arc-second). The elevation data were generated from cartographic contours on the 1:50,000 *Land Ranger* map series. Note that the *Panorama* data were collected between 1970 and 1980 and have not been updated since then. The level of detail is markedly better than the comparable SRTM 3 arc-second data (Figure 9).

**Ordnance Survey**, 1 arc-second data, at 144 pixels/inch (1 arc-second per pixel, no resampling)



**SRTM**, 3 arc-second data, at 144 arc seconds/inch (3 arc-seconds per pixel resampled to 1 arc-second per pixel)

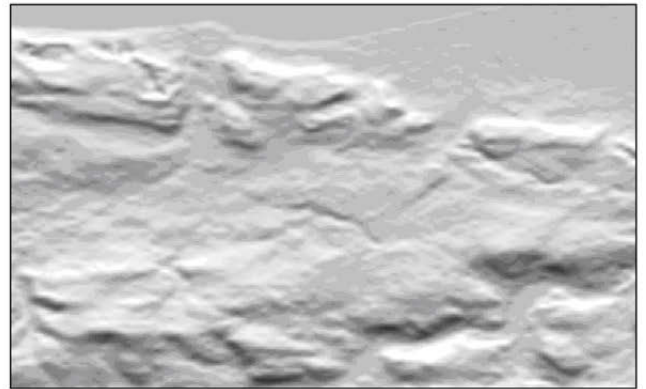


Figure 9. Sample shaded relief image of the North Wales coast showing the quality of data in the Ordnance Survey 50 meter (about 1 arc-second) elevation data set. SRTM 3 arc-second data image is shown for comparison.

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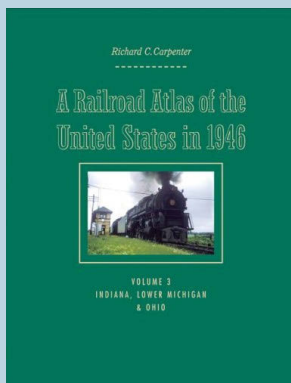
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## A RAILROAD ATLAS OF THE UNITED STATES IN 1946 – VOLUME 3: INDIANA, LOWER MICHIGAN, AND OHIO

by Richard C. Carpenter.

Creating the American Landscape Series. Baltimore, MD: The Johns Hopkins University Press, 2008. xxii, 329 pp, maps, appendix, indexes. Price \$65.00 (available new online for \$40.95). Hardcover. ISBN 0-8018-9002-0.

**Review by:** Russell S. Kirby, University of South Florida

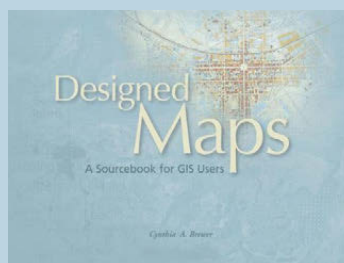
Richard Carpenter has set for himself a seemingly monumental task – to document, using large scale maps, all of the railroad lines in operation in the continental United States in the year 1946. This certainly compares in complexity and detail with the late Frederic G. Cassady's *Dictionary of American Regional English* project, which also contains thousands of maps and will soon culminate in a final volume. Unfortunately, Carpenter's project also shares many of the less fortunate features of that undertaking. Cassady began his project in the mid-1960s, with the first volume eventually appearing in 1985 and the final volume's publication projected for 2010, well over 40 years after the project was initiated. Carpenter has now published the third volume in his undertaking, with volume 1 ( the Mid-Atlantic States) appearing in 2003, volume 2 (New York and New England) in 2005, and volume 3 (the eastern half of the Old Northwest) in 2008. While this reviewer cannot divine Carpenter's grand plan, it would seem unlikely that this project can be completed in fewer than 8 or 10 additional volumes, which, given his pace, may require another 20 years of effort to bring to fruition.

*The Railroad Atlas* is definitely a labor of love. The basic mapping unit throughout is the 30-by-30 minute quadrangle, based on the USGS 1:250,000 map coverage of the continental US. With additional detail maps (for example, within the city of Chicago) and reference maps to orient the reader to selected quadrangles, this volume has approximately 250 maps, all apparently drawn in color by hand using the same scheme of map elements and features.

The details of Carpenter's approach are well explicated in Gordon Kennedy's review (*CP*, Number 55, pp. 67-69); for the most part both the superlatives and criticisms made in regard to *Volume 2* still stand. The bigger question for this reviewer is why a multi-volume hard-copy railroad atlas of the U.S. in 1946? Other mechanisms would provide considerably greater

flexibility and utility to readers, be they railroad enthusiasts, business historians, historical geographers, or others with interests in the subject. Two examples come readily to mind. The atlas could be published as a web-enabled application, allowing the reader to select the region of interest, and print the relevant maps, perhaps at the scale Carpenter has selected but perhaps at other scales as well. Or, the atlas could be a GIS-enabled tool, one that would allow the reader to customize the subject of interest, perhaps highlighting a particular railroad company in relation to its competitors in a catchment area. While it is true that 1946 approximates the apex of the American railroad network, a GIS-enabled tool might define, for each segment of railroad line, and each railroad feature, when it was constructed or modified, during what time period it was owned by each company, when it was decommissioned, and the current status of the right-of-way. The researcher or enthusiast could bring additional data into the application, to map traffic volumes, passenger service frequencies, unit trains, and other measures of the economic activity generated by each line. While it is theoretically possible for a reader to use the *Railroad Atlas* to support some of these activities, the print format and static approach severely limits its broader utility.

None of the foregoing should detract in any way from Carpenter's achievement. Volume 3, like the first two volumes, is informative, attractively produced, and contains a wealth of detail to interest those of us who are railroad scholars or rail enthusiasts. In an era when America is once again considering the potential of high-speed trains for inter-urban routes, the *Railroad Atlas* reminds us that the paradise we find may indeed be one we only recently lost.



## DESIGNED MAPS: A SOURCEBOOK FOR GIS USERS

by Cynthia A. Brewer

2008 ESRI Press, Redlands, CA. 167 pages  
Price \$40. Paperback.  
ISBN: 9781589481602

**Review by:** Ian Muehlenhaus, University of Wisconsin – River Falls

A book such as Cynthia Brewer's *Designed Maps* is long overdue. Aside from several annual bound collections, there have been relatively few widely distributed anthologies of superbly crafted maps to inspire cartographers. Though I was skeptical that a single, relatively slim anthology could do the topic justice—that

is, highlight the idiosyncrasies and innumerable design traits of well designed maps—I was happily surprised to see that *Designed Maps* offers a gallant first effort. It more than lives up to its unpretentious goal: “to invite you to see design elements [of well-made maps] and to prompt you to combine and customize them for your own mapping” (xi).

Most cartography and GIS instructors have had to collect a variety of “good maps” on their own to illustrate different design styles to their students. Building a personal collection of good maps is largely a time-consuming, ad hoc, and often redundant task. It can be difficult to find a variety of well designed maps created for different audiences. Moreover, it is often dubious as to whether students trust an instructor who carries in an armload of loose-leaf maps and says that they are all “pretty good.” *Designed Maps* offers practicing cartographers and instructors alike the opportunity to carry around a variety of good map designs in one bound copy.

The book organization is smart. The maps are divided into three types, each with two sub-categories. This nuanced division of maps proves much more useful than the typical binary division of maps into either reference or thematic types. The first two chapters deal with *reference maps*—with the sub-categories being *topographic* and *navigation*. Chapters Three and Four deal with different types of special purpose maps—*visitor* and *recreation* and *infrastructure*. The final two chapters dwell on *thematic cartography: categorical and quantitative*. (It should be noted that this book is concerned solely with static maps; there is no section on dynamic cartography.) By dividing the topics into sub-categories, a reader can more easily find maps that pertain to their current interest, rather than have to page through half a book on thematic maps, dog earring pertinent ones.

The design of the book is in itself highly laudable. The page layout promotes the maps over everything else in the book’s visual hierarchy. The descriptive text accompanying each map is literally marginalized (to the right or left of the map it describes). Brewer avoids the bane of many map appreciation books by systematically keeping her explanations concise and to the point. Each map has a one-to-two paragraph explanation of the design decisions made by the cartographer. For a book emphasizing the visual, *Designed Maps* is remarkably readable!

The maps found in the book offer a great variety of design techniques and visual elements. As might be expected, many of the maps used were created using ESRI software. Hopefully, this has more to do with ESRI’s dominance in the realm of GIS applications than with the fact that the book was published by ESRI Press. Brewer does note in the beginning that not all

of the maps were made with ArcGIS, but she fails to mention which other programs were used. (To be fair, it should be noted that many of the maps were created using Macromedia (now Adobe) FreeHand, Adobe Illustrator, Avenza Mapublisher, and other graphics and GIS programs.) The sample maps are all well produced, beyond a doubt. However, some of them seem better organized (data-crunched and visualized) than designed (aesthetically pleasing and cognitively usable).

For example, one map from the *Pacific Disaster Center* shows all Pacific tropical cyclone tracks between 1945 and 2006. Due to the hundreds, if not thousands, of tracks, most areas of the map are visually impenetrable, and look more like a piece at the MOMA than a map. Brewer notes that following individual tracks is impossible, but argues that map shows the general patterns of where cyclones most frequently occur. The problem I find with the map is that you cannot see the base map underneath the blob of cyclones. Thus, you have no idea where the cyclones are hitting. All the map tells us is that Indonesia and Malaysia rarely get hit by cyclones; everywhere else in the Indian and Pacific Oceans is swamped with them. There is no doubt that GIS can be useful for *exploring* and understanding natural hazard risks in all sorts of circumstances. However, this and several other maps, in my opinion, fall well short of *presenting* the data effectively—generally the chief purpose of static cartographic design.

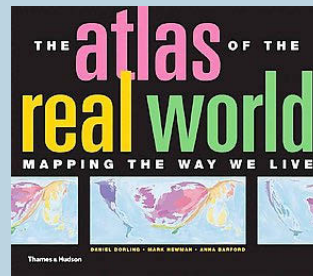
A second critique might be that many of the maps come from NACIS members. Now to be fair, this makes sense for several reasons: first, the idea for this book was purportedly sprouted at a NACIS meeting; and second, one would reckon that there are many gifted cartographers who belong to NACIS. Nonetheless, parts of the book may be a bit of a yawn for those who already interact with these cartographers and have collected a variety of their maps over time. On the other hand, it is always great to see members of our community heralded in a book such as this.

Lest the above comments dissuade you from reading this book, I can assure you that a vast majority of the maps included are incredible design specimens. Moreover, rather than merely function as an art book for cartographers, *Designed Maps* offers some practical cartography tips as well. At the beginning of each chapter, Brewer takes a map and redesigns it in a variety of ways to show different techniques for emphasizing different data in the visual hierarchy. These case study sections are truly useful—for novices and practiced cartographers alike. In fact, I believe the book would benefit by having more of them. Alas, Brewer notes that many of the cartographers whose works were showcased were rightfully loath to cough up their data files for her to redesign.

The beginning section of each chapter is also linked to an appendix called *ArcMap Tips*. For each of the maps redesigned by Brewer, references are made to specific tips that will explain how one can implement the same design using ArcGIS software. For users of ESRI products, particularly those that have been more involved in spatial analysis than data presentation, this section may prove invaluable. Even as an experienced user of ArcGIS, I learned a new trick or two from the *ArcMap Tips* section.

All in all, I was pleasantly surprised by this book. From the rather unassuming title, I had feared that *Designed Maps* may be a glorified coffee table piece. *I could not have been more wrong*. It is easily readable and full of inspiring maps and yet still very much of practical use. To some extent, the book may suffer from being too encompassing. A separate book for each of the three main map types Brewer lays out at the beginning would have done the topic more justice. However, this was pioneering work and Brewer needs to be commended for what she achieves—collecting a compendium of well-designed maps, securing permission to reproduce and bind them together, and analyzing how each map was created. In this light, it was likely prudent of Brewer to cover a variety of maps appealing to cartographers as a whole.

Cartophiles aside, determining the appropriate audience for this book presents a bit of a conundrum. *Is this book worth having GIS students buy it for a class?* Probably not. Novices are likely better off with a true cartographic design book. *Is Designed Maps* worth owning as a GIS instructor? Absolutely. It is full of design ideas that can be shared with students. In fact, I have already shown several maps to students to help them explore new design ideas. *Is Designed Maps* worth owning as a practicing cartographer? It depends. If you do not have a large collection of maps to inspire your creativity and if you use ArcGIS regularly, then it is indubitably a wise investment. If you have a large collection of well-designed maps to look at already, you are probably safe to skip this. Regardless, I believe it can only benefit our discipline if similarly themed books of this caliber and quality come out in the future.



**THE ATLAS OF  
THE REAL WORLD.  
MAPPING THE WAY  
WE LIVE**

by Daniel Dorling, Mark Newman, and Anna Barford

New York: Thames & Hudson, 2008. 400 pages, 366 maps, figures, graphs.  
Price US\$ 50.00, hardcover  
ISBN-10: 0500514259  
ISBN-13: 978-0500514252

**Review by:** Jörn Seemann Department of Geography & Anthropology, Louisiana State University

A few weeks before Christmas, *The Atlas of the Real World* was in the top three of Amazon book sales in the following categories: Maps, Atlas, and Human Geography. Only Jared Diamond's controversial *Guns, Germs and Steel* and Alan Weisman's *The World Without Us* received more online orders. On December 16, 2008, the bulky 5.2 pound book was even temporarily out of stock. What is the secret of this success, taking into account that books on geography are rarely blockbusters or bestsellers?

*The Atlas of the Real World* is a "joint venture" between the British geographers Danny Dorling and Anna Barford and the American physicist and specialist in complex systems Mark Newman. It contains "366 maps showing all sorts of geographical and social statistics, ranging from basic data on population, health, wealth and occupation to how many toys we import and who's eating their vegetables" (8). The maps, however, are not conventional thematic world maps, but area cartograms inspired by such previous attempts to produce value-area maps as Erwin Raisz's diagrammatic maps, Waldo Tobler's pioneering computer-aided cartograms, and the *State of the World Atlas* (Kidron and Segal 1981). In each map, the areas of the countries are resized according to the statistical value attributed to them. For example, a world map showing absolute numbers for each territory's population exaggerates the size of countries such as China and India that together make up for more than one third of all the human beings on our planet.

Dorling, Barford, and Newman divide their atlas into six different "Worlds" or sections that are dedicated to broader thematic categories. In the "Resourceful World," we can find cartograms on population, travel, transport, natural resources, and energy. The "Trading World" entails issues of globalization and internationalism, food and consumables, and the flows of natural resources and petrochemical products. Closely related to this are the cartograms that (re)present aspects of the "Economic World." These maps do not only touch on export/import statistics of manufactured goods and services, but also display indicators of wealth and poverty (including the (in)famous human development index), employment, and productivity. The "Social World" discusses housing,

education, communication, media, and health topics while death, disaster, war, and crime are contemplated in the “Perilous World.” The last section deals with environmental issues such as pollution, resource depletion, and the endangerment and extinction of the global fauna and flora.

Behind these overarching categories, we can find a considerable number of cartograms ranging from run-of-the-mill topics, such as absolute population and precipitation, to highly unconventional and cartographically neglected themes. Have you thought about cartograms showing condom use by men, the number of mopeds and motorcycles, the number of protest events against the 2003 Iraq War or of McDonald’s restaurants, faults with landline telephones, or people killed by earthquakes, volcanoes, floods and avalanches? What about prison populations (the United States has the highest rate of all: 0.75 percent of its population is incarcerated, p. 346), or animal and plant species at risk of extinction? The published atlas is only a small sample of possible thematic maps: the online database of the Worldmapper project ([www.worldmapper.org](http://www.worldmapper.org)) permits access to almost 600 different cartograms and is updated frequently.

Each map is accompanied by a brief text that provides the reader with additional information, a table with the ranking of the highest and lowest rates for each topic, complementary graphic representations (pie, line, or bar charts) with relative figures, and/or a catchy quotation from a newspaper article, report, or book that refers to the theme. For example, on the map sheet on the exportation of toys (map 129), we can read that toys are not only made *for* children but also *by* children: “At City Toy Ltd., . . ., Shenzhen, youngsters worked 16-hour days, seven days a week” (148). All the source citations for statistics, primarily “seven key data sources” (392) which includes data from the World Bank and the United Nations, are referenced at the end of the book.

The layout and the content of the pages render the atlas extremely user-friendly, especially for school children and the general public. Different tones of colors, carefully avoiding any color bias, are attributed to the twelve regions that the authors have defined. The cartograms do not contain overly saturated colors and no red at all. South American countries are represented in light blue colors, North America in dark blue and Western Europe in purple tones, African countries appear in green hues and Asia in yellows.

The authors of *The Atlas of the Real World* present an innovative technique to visualize geographically relevant world affairs. The elaboration of the cartograms is based on a linear diffusion method derived from elementary physics (Gastner and Newman 2004). According to these proceedings, it is possible to predict the motion of a fluid at any time by the use of differential equations. How does this work in cartography? The process of the map production can be compared to a bottle of ink

spilt into a swimming pool (it could also be a terrified octopus releasing ink from his ink sac): Initially, the ink does not mix immediately with the water. The highest concentration can be found at the point where it has been dropped into the pool. Due to currents and movements in the water, the ink diffuses over time until it is dispersed throughout the water body. In a density-equalizing process, the ink spreads from high density areas to areas with a lower concentration, and this diffusing movement can be modeled using the standard linear diffusion equation of elementary physics. Of course, in this case we are not dealing with liquids, but with world maps that are first cast on the rectangular grid of an equidistant cylindrical projection and then distorted according to the transformation algorithm (“fast Fourier transform, multiplied by a Gaussian kernel,” 12).

For the production of the cartograms, the definition of boundaries is essential. The authors defined a set of 204 resizable territories: 200 countries and, “for cosmetic reasons” (12), four non-contiguous areas with data considerably different from their motherland (Alaska, Falkland Islands, New Caledonia, and French Guiana). The complete set of territories corresponds to 99.95 percent of the world population (12).

The transformation technique does not permit non-values, so missing data in the statistics has to be estimated. In most cases, average values for neighboring countries in the same region were computed in order to give a “roughly correct” and “reasonable picture” (12). This leaves us with the same problem mapmakers faced hundreds of years ago: what to do with the blank spaces? On the one hand, the measures taken by the authors are necessary to produce the maps, but, on the other hand, fictitious data are not “real” values. It is doubtful, for example, if the cultural, political, and economic uniqueness of Brazil in South America could be expressed through average figures or “guesstimates” from the adjacent countries. All the cartograms are based on absolute values (such as total population, number of exported cars, etc.), but some of these values are computed figures that some readers may find far from orthodox. For example, the cartogram on International Justice (map 074) defines the values for the areas as total population multiplied by the number of years since the date at which a country signed the Geneva Conventions.

Flipping through the 366 maps, I can agree with the authors when they write that *The Atlas of the Real World* is a “thought-provoking way to learn about the world around us and understand our place within it” (8). The atlas is a good exercise for map reading. It can be opened on any page, although some readers might get tired quickly after looking at too many of these maps in one sitting. The authors are eager to stress the educational value of their product: “Open this book at almost any page and you will learn something you never knew about the world” (118).

Unlike conventional thematic maps, area cartograms emphasize values visually. This is one of the few moments in cartography when cartographers are allowed to *consciously* distort the size and shape of a territory. Country sizes are not “taken-for-granted” fixed structures, but amoeba-like territories. We do not have to worry about scale and coordinates. The transmission of the geographic message is more important than conventional notions of geographic accuracy. The central idea of the atlas is to “challenge views by distorting a familiar image prompting [readers] to ask why is something the wrong size” (Dorling, Barford, and Newman 2006, 757).

Although the authors attempt to maintain the shapes of the countries, some of the maps suffer severe deformations due to the centrifugal effects of the area-equalizing technique. For example, in map 129 (Exports of Toys), the area of China almost annihilates the rest of the world, and many of the health cartograms (HIV Prevalence, Cases of Malaria, Cholera, and Yellow Fever) emphasize a grotesquely distorted and swollen shape for the African continent. On the other hand, map 042 (total carrying capacity of cargo ships) is one of the rare moments to see Malta as big as the United States. In this map, we can easily understand why the authors compare their cartographic method to an “ink-in-the-pool” diffusion. The world seen like this seems to be a whirlpool or (more negatively) a maelstrom, with the landmasses and the oceans literally streaming around the principal centers of cargo shipping and “flags of convenience” such as Liberia, Bahamas, Malta, Cyprus, and Panama. However, the emphasis here on small countries can only be considered an exception to the rule. Since most of the maps are related to absolute population figures, small countries do not become more visible. Should size always dominate the message in the map? In the cartogram on international immigrants (map 016), Andorra is rendered imperceptible, while the country’s statistics show that in relative terms Andorra has the highest rate of immigrant population in the world (80 percent).

The problem with projections is that they are always centered on a reference point or line. Based, as they are, on a cylindrical projection type rectangular format, the cartograms in the atlas do not offer a solution to the problem of severe distortions at higher latitudes. Since Russia is rarely the center of the density-equalizing process, the Russian territory appears unrecognizably twisted and turned in most of the maps. Could transformation cartograms rooted in a polar projection provide better results?

Some of the maps, especially those with Third World topics such as health issues and food security, would be more explicit as regional representations. Although the authors are aware of the generalizing nature of world maps, they do not tackle this problem and “will leave this to another day” (12). It is also notable that most of the

maps describe present conditions and not processes and changes. There could be more combinations between the different maps, allowing “overlays” of temporal sequences or the comparison of key issues. The atlas would be even more interesting as an interactive CD application than as a coffee-table book.

Dorling, Barford, and Newman use their cartograms as weapons to unmask a “worrying picture of the world” (10) and to show that “worldwide inequality is on the increase, with the rich getting richer and the poor poorer” (10). Their aim is to make readers think about the social and economic injustice on our planet. Janos Szegö’s (1987) reflections about “human cartography” represent a red thread for the authors in their attempt to represent the human experience of space. Szegö writes that human cartography aims “to create maps *about* people *for* people” (Szegö 1987, 10, emphasis by author). In other words, “how can actual events and processes in the world of man (sic) be translated into maps and how can this translation be made comprehensible for the human brain?” (Szegö 1987, 10).

The initiative of *The Atlas of the Real World* should be saluted, with a caveat. Although the authors reach a broad audience (as we can prove by the sale numbers), they do not diminish the gap between mapmakers and society. On the one hand, the cartograms are a fantastic exercise for map reading, but, on the other hand, the understanding of the mapmaking process employed (for example, the “fourth-order Runge-Kutta integrator” 12) remains restricted to the insiders. Even if one rejects a Harleian or postmodern critique of the ideological and persuasive nature of maps and atlases, as Dorling has made clear in his other writings, it is important to establish a dialogue between cartography and people, and to reduce the distance between mapmakers and society. It sounds strange when the authors refer to the “real world” and how they map “the way *we* live,” “showing *us* where *we* are now, allowing *us* to navigate *our* way through the world” (11 emphasis added). The more the map reader understands the mapping process, the better he/she will be able to recognize the map as a powerful tool to express and communicate ideas. Of course, due to their scale and high level of abstraction, world maps will always have a limitation with regards to the messages they convey.

All in all, *The Atlas of the Real World* represents refreshing views and substantial food for thought, not only for cartographers and mapmakers, but also for anyone interested in visual culture. For me, there is yet another aspect: one that shows the enormous potential of the atlas. Maps are projections and distortions of reality, and we cannot deny the artistic value in their production. Behind the technical facade of the cartograms (Fourier transforms, algorithms, Runge-Kutta integrator, etc.) is looming an artistic creativity. In fact, Dorling, Barford, and Newman unconsciously revive a counter-tradition from the Renaissance defined as anamorphic



art: Cartograms are examples of the “subjectification” of the viewing process, similar to seventeenth-century anamorphoses such as the drawing of Saint Francis de Paul from Jean-François Nicéron’s *Perspective Curieuse* (see Figure 1) that was transmogrified by the use of a “cylindrical mirror” (Nicéron 1638). The viewer is first deceived by the strange appearance of the image and then introduced to the formal construction of it. This means that “the spectator must play part and re-form the picture himself [herself]” (Leeman 1975, 9). With these observations in mind, we will be able to come closer to the “real world.” Let’s jump into the pool!

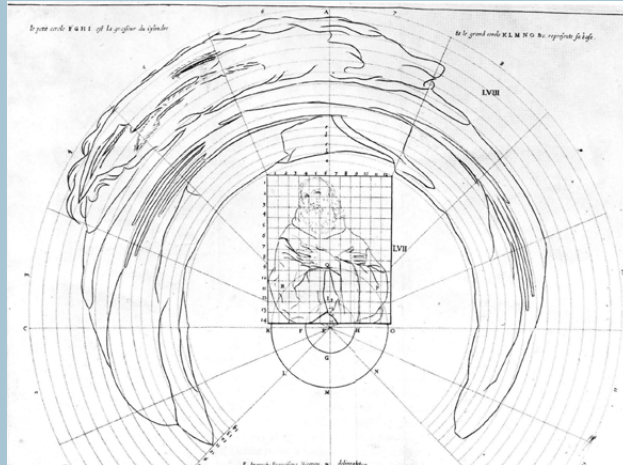


Figure 1.

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## AN ATLAS OF RADICAL CARTOGRAPHY

Lize Mogel and Alexis Bhagat, eds.

Journal of Aesthetics and Protest Press, Los Angeles, CA, 2007. 160 pp., 10 poster maps, 17 figures, endnotes, contributors’ biographies, publisher’s note. Price: \$30.00, Softbound.

ISBN 978-0-9791377-2-3

**Review by:** Daniel G. Cole, Smithsonian Institution

This atlas of ten loose folded poster maps and an accompanying text of ten essays provide the reader with plenty of food for thought. As the editors mention in the Introduction, “While all maps have an inherent politics that often lies hidden beneath an ‘objective’ surface, the contributions to *An Atlas of Radical Cartography* wear their politics on their sleeve” (6). Indeed, as the editors continue, “Our criteria for selecting these ten maps emphasized radical inquiry and activist engagement” (7). The ten texts and maps, typically with different authors and cartographers, respectively, are intended to be read together, although any good map reader may draw his or her own conclusions from the maps.

The first chapter, “Other Worlds, Other Maps: Mapping the Unintended City,” by Jai Sen, is matched with a

map titled *Chetla Lock Gate: Marginal Land Settlement in Calcutta* by the Unnayan in Kolkata organization. The author admits that this map was serendipitously sparked by a map on a peanut bag that showed a planned road project adjacent to an unrecognized settlement. Sen points out that “official” maps blank out unauthorized neighborhoods of unintended settlers, thus blatantly labeling such locations as “vacant land.” The Unnayan NGO wanted to help settlers better locate common services and spatial relationships through the use of maps. Unnayan also mapped marginal land settlements along drainage canals, major roads, and railroads. As a critique, Sen states that “What I think we failed to sufficiently do was to engage the people of the settlements either in mapping themselves or in studying the maps we were producing” (15-16). The sample map provided for the book is of the Chetla Lock Gate area of southwest Calcutta. It is a pen and ink drawing with very clean linework and typography. Humbly, Sen finishes by refusing to assert that their mapping efforts empowered all of the communities that were mapped.

The Institute for Applied Autonomy (IAA) wrote and illustrated Chapter 2, “Tactical Cartographies” and produced its accompanying map, *Routes of Least Surveillance: Manhattan, USA circa 2001*. The authors wanted to present an alternative view of the urban landscape as dominated by surveillance. They identify

a prior example (and perhaps derive inspiration) from Greenpeace, which used spatial data as a weapon: for example, GPS receivers with digital cameras that documented illegal logging in Brazil, Cameroon, and the USA. As noted, surveillance networks in the U.S. are decentralized: agencies have “virtually no public records of the number and distribution of surveillance cameras currently monitoring American cities” (32). The IAA decided to investigate the use of surveillance cameras based on data obtained through the New York Civil Liberties Union, and then posted the mapped results on their iSee Web site. The map itself consists of screened brown tones symbolizing city blocks and parks with white-line streets, red dots for surveillance cameras locales, and a gray toned circuitous path of least surveillance.

Chapter 3, “Mapping Ghosts: Visible Collective Talks to Trevor Paglen,” who together with John Emerson drafted the map *CIA Rendition Flights*, delves into the importance of exposing through a map the extralegal “invisibility” of prisons, prisoners, and their circuitous routes to confinement and torture. In addition, the fact is stressed that innocent people have been entangled in this geographic nightmare and no one has been held accountable. The map’s design consists of black countries on gray-toned oceans with white type and lines illustrating CIA aircraft routes, pick-up points and destinations on what looks like a stereographic projection centered on northern Africa.

Maribel Casas-Cortes and Sebastian Cobarrubias provide Chapter 4, “Drawing Escape Tunnels through Borders,” where they present a discussion around the map *Geography of the Furth Departure Center* and other maps by the German activist group Architektur. The authors contend that the European Union is creating a lethal “gated community” encircling Europe, but with permanent or even deliberate holes (51). This particular map “centers on a (distorted) map of western Germany but is labeled with” far-away places. “Deportation prisons are represented by boldly outlined circles” (55). A mess of flow lines show legal and illegal barriers and passageways. The map is confusing and it is hard to read the topography and symbology, although it probably mirrors the confusing system of immigrant detention in Germany. On it, “Itineraries of five migrants are mapped from their entry into Germany, their passage through different holding centers, and their arrival at the Furth deportation center after months, or years, of detention” (56).

Other maps are also discussed, and shown as tiny reproductions, including: 1) a proportional circle maps (originally in color but reproduced in black and white) indicating the number and causes of migrants’ deaths; 2) a dot map showing the locations of migrant camps which are not to be found on Europe’s “regular” maps (echoing the issues of Chapter 1); 3) a flow map to illustrate the movement of people between Morocco and Spain; and 4) extracted portions of Migmap, a typographic map,

route map, and cartogram showing the confusion of EU bureaucracies, NGOs, treaties, movements, borders, and migrant sites. “Seen together, these maps create a richer and denser picture of the border and possible points of attack or lines of flight into, underneath and against it” (65).

Alejandro de Acosta wrote Chapter 5, “Latino/a America,” giving the reader a philosophical discussion, including quotes from Nietzsche, about Pedro Lasch’s map of the same name. This map is purely an artistic rendering of North and South America, identifying all of the two continents as Latino-Latina territory, while ignoring national and ethnic boundaries. As such, de Acosta bluntly notes that “Lasch’s maps are, as maps, quite useless” (73).

Chapter 6, “Our Land is Changing – Soon Yours Will, Too,” by Sarah Lewsiton, is paired with Lize Mogel’s map, *From South to North*. Mogel created a cartographic conundrum by overlapping and connecting Canada’s Northwest Passage with San Francisco Bay and Panama. Each area is portrayed at a different scale and facing different directions. The land/water interface is depicted with black land and white water for northern Canada and Panama whereas San Francisco is shown as white land and black water with seven black scribbles symbolizing the Navy’s moth-balled fleet and old piers. The connectivity of “these landscapes—subjected to the same expediciencies of development, exploitation and design—begin to look very similar” (83). Overall, the Panama Canal, Northwest Passage, navy ships and piers, seem to indicate past and future (due to global warming) trade conduits and the power to enforce them.

The text of Chapter 7, “Drawing (on) Water in Los Angeles,” is a roundtable discussion between Jane Tsong (the map’s author) and six others. This “map,” *The Los Angeles water cycle: the way it is, not the way it should be and one day will be...*, is a whimsical set of drawings regarding the L.A. water cycle and, bluntly, how it affects the environment in different ways, including withdrawal from the Sierra Nevada Mountains, the Colorado River aqueduct, pavement, runoff, pollution, littering, and wastewater.

Heather Rogers wrote Chapter 8, “The Power of Garbage,” which is joined with Justyna Judycka and Damon Rich’s map, *New York City Garbage Machine*. They deal with a topic that most people don’t think about unless a garbage strike occurs. The map presents a screened light brown area of New York City as background with a flow chart superimposed illustrating the administration of the collection and disposal of residential and commercial waste. The flows include pictures and comments by individuals from local government and commercial refuse and recycling operators. In addition, pictures of NYC residents are placed on black waste cans making serious and sarcastic comments about garbage. Lastly, a small inset map of

the world is included to depict the global reach of a major waste company and its subsidiaries. The chapter discusses how the Mafia controlled refuse collection from after World War II until the 1990s, when the big garbage conglomerates took over. Reform of this type also wiped out small legitimate haulers, moved transfer stations into poorer areas, and then mostly shipped the waste to rural areas in Ohio, Pennsylvania, and Virginia.

Chapter 9, "The Struggles over Transition: Emancipating Energy" by Kolya Abramsky, is teamed with the map *The U.S. Oil Fix, 2006/2007* by Brooke Singer. A graduated flow map, depicting only those countries that supply oil to the U.S., is presented, along with 13 sidebars noting life expectancy, GDP per capita, percent of children underweight at age 5, adult literacy, percent of the population below the poverty line, and percent of the world's CO2 emissions. The text goes beyond the map's obvious message of production and consumption and notes how the future of energy through renewable resources is being controlled by the powers-that-be.

The last chapter, "A World Map" by Avery F. Gordon, is paired with Ashley Hunt's *A World Map: in which we see...* This map is not a map at all except in the theoretical sense; instead, it is a confusing array of points, centers, flows, reactions, and so on related to global capitalism. Gordon describes it as a "conceptual map of the process and forces of globalization" (139) and "As a whole, the map is unreadable. It makes me dizzy" (141). Unfortunately, this poster looks like it was designed by a committee where no one agreed on its design.

Overall, the atlas comes neatly packaged with the book and ten fold-out maps inside of a slip cover. Unfortunately, because the maps are all folded with the printing on the inside, one has to hunt for the appropriate map desired. The editors and publishers should have at least numbered the outside of the folds to enable easier text/map match-ups. And while I normally would not consider a collection of ten maps to constitute an "atlas," I will grant the editors the benefit of the doubt in terms of naming this collection as they see fit. As with many multi-authored works, a bit of unevenness is seen between these maps and chapters. Most of them stand out as good examples of cartography that readers will want to study and mull over later, while a few others are purely cartographic art or graphic design that may or may not inspire further investigation. Apparently, this book and map set are intended to inspire left-wing activists to further or related actions. Whether it succeeds in this goal by reaching its proposed audience will be interesting to see.



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### TITLE PAGE

The title serves as the author's invitation to a diverse audience. It should be chosen wisely. The title page should include the full name(s) of the author(s) and academic or other professional affiliation(s).

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An abstract of 250 words or less should summarize the purpose, methods, and major findings of the paper.

### KEYWORDS

Keywords should be listed at the end of the abstract.

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References should be cited parenthetically in the text in this order: author's last name, year of publication, and page number when a direct quote. Example: (Doe 2001) and (Doe 2001, 2). Use the Chicago Manual of Style published by the University of Chicago Press for the correct style for various sources.

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Doe, John. 2001. *Citing a book*. Duluth: Northstar Publications.

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Doe, John, and Jane Doe. 2001. Citing an article in a periodical. *Cartographic Perspectives* 30: 120-129.

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Doe, John, Jane Doe, and James Doe. 2001. Citing an article in an edited volume. *101 Ways to Cite an Article*, edited by Joseph Doe, 120-29. Duluth: Northstar Publications.

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Doe, John, "Homepage," May 1, 2006. <<http://www.citing a personal web site.edu>> (May 17, 2006).

Doe, John, and Jane Doe, *Citing a Professional Web Site*, May 1, 2006 <<http://www.citing a personal web site.edu>> (May 17, 2006).

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