

HILLSHADING WITH HALFTONES

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Letter from the Editor

Dear Members of NACIS,

Another issue of *Cartographic Perspectives* comes to fruition. Jim Anderson has requested another editorial column; so here I sit, on a bus with my son's soccer team and 20 other soccer parents. We are on our way to Elk River, MN (a 2 hour and 45 minute ride from Duluth) for yet another soccer game. It is partly cloudy, about 79 degrees, and no one thought to bring any beer or wine coolers...geesh. It's gonna be a long night. Anyway, too much information, right? Call it editor's privilege...<grin>.

Okay, back to *Cartographic Perspectives* (I'll try to stay on task...forgive me if I wander). First off, let me provide a bit of an update on the status of *CP*. It has been a long building process to get *CP* to the point where it is today. Like other "cartography" journals, *CP* has been behind schedule in publications. Over the past two years, the editorial board has been

(continued on page 3)

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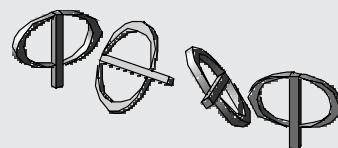
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about the cover



"The cover design was created by Lou Cross. Lou is a cartographer and graphic artist with the Florida Resources and Environmental Analysis Center at The Florida State University.

successful in building a “pool” of manuscripts that are at various stages of review and publication. This pool is critical for *CP* to get back on publication schedule. It also speaks well for the recent changes in *CP* that have resulted more submissions.

A few years ago, the Cartography Specialty Group of the Association of American Geographers talked at great length about changing it’s name. These discussions were fostered by the Board members, which, if I remember correctly, included Jeremy Crampton, Liz Nelson, Charlie Rader, Ann Goulette, Frank Boscoe, Anna Williams, Ute Dymon and myself. The reason for the discussion was that some members of the specialty group expressed to the board that the current name was not inclusive enough...that cartography was only part of what they did...and that visualization included cartography among other kinds of endeavors (e.g., animation, multimedia, 3D, virtual reality). The discussion fostered two position papers written by two of the specialty group members: Jeremy Crampton was pro, and Keith Clarke was con. The name of the specialty group was never changed, but the forces behind visualization remained.

Relax, I do not intent to resurrect that discussion here (is that a collective sigh of relief I heard?). What I wanted to talk about here are some discussions we’ve had in our department regarding courses, and the names of proposed courses. At present, we have a series of courses that include:

- Introduction to Maps and Cartographic Theory
- Map Design and Graphic Methods
- Advanced Cartography
- Introduction to GIScience
- Advanced GIScience
- Environmental Applications in GIScience
- Resource Management in

GIScience

Introduction to Remote Sensing and Image Interpretation

Sounds like standard fare, right? The discussions we have had include changing the very structure and content of our course offerings, as well as changing the names of the courses to (1) reflect some current trends in GIScience, and to (2) include the broader perspective that visualization brings to the design of spatial “things”. Here is the list of courses that have been proposed:

- Introduction to Maps and Mapping Technologies
- Map Design and GEO Visualization
- Multimedia and Animated Maps
- Earth Imagery
- Digital Imaging and Image Analysis
- Introduction to GIScience
- Advanced GIScience
- Resource Management and Policy in GIScience
- Participatory Mapping in GIScience
- Environmental Applications in GIScience

What’s different in this list of courses? Well, I am certain that many of you noticed that the word “Cartography” is nowhere in this list. At the same time, the word “map” or “mapping” is peppered throughout, as well as the term GIScience. Hmm...

This curriculum change is in the proposal stage at this time. Many discussions will take place over the next year, some related to the financial implications of this new curriculum, and some related to a huge change in how we think about our role as educators about many aspects of spatial information. It certainly has us thinking about “who we are”. The people in our department who are having these discussions include a

water resource biologist, a physical geographer, a cultural ecologist and myself. We all have different perspectives on GIScience and cartography...the proposed program is a collective view, one that has been reached by consensus.

So, what do you think? Is this a “not so good” thing? Are other programs looking at similar changes? In spite of the fact that our organizations embrace their names (the Cartography Specialty Group as a case in point), the impact of visualization can be seen in our program, and I suspect in others. Is this incorrect thinking?

I am tossing this out for discussion. I welcome any comments or views on this. In fact, I would propose that we have an opinion column about this in a future issue of *CP*. Anyone up for the task?

Warmest regards,

*Scott Freundschuh
Editor*

Earle Birney's "Mappemounde": Visualizing Poetry With Maps

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*"Our survey reveals not only
 the complexity of
 Mappemounde" but the degree
 to which Birney uses medieval
 world maps as visual metaphors
 for his life and the world he
 knew."*

This paper is about "Mappemounde," a beautiful but difficult poem composed in 1945 by the esteemed Canadian poet Earle Birney. While exploring the reasons for its composition, we examine the poem's debts to Old and Middle English poetry as well as to medieval world maps known as *mappaemundi*, especially those made in England prior to 1400. But Birney took only so much from these maps. In search of more elusive inspirations, both cartographic and otherwise, we uncover other sources: Anglo-Saxon poems never before associated with "Mappemounde," maps from the Age of Discovery and beyond, concealed details of Birney's personal life. Then we trace Birney's long-standing interest in geography and exploration to show how he used maps, especially *mappaemundi*, as visual metaphors for his intellectual, spiritual, and personal life.

Keywords: Poetry about Maps, Medieval World Maps/*Mappaemundi*, Medieval Poetry, Renaissance Maps, *Moby Dick*.

Earle Birney was one of Canada's most beloved writers and public figures, a man whose life spanned most of the twentieth century from 1904 to 1995. Among his finest poems is "Mappemounde," written in 1945 when Birney was forty-one. This paper introduces "Mappemounde," then explores the poem's inspirations and analogues—literary as well as cartographic. These range from Anglo-Saxon poetry and Herman Melville's *Moby Dick* to medieval *mappaemundi* and maps from the Age of Discovery. Our survey reveals not only the complexity of "Mappemounde" but the degree to which Birney uses medieval world maps as visual metaphors for his life and the world he knew.

Earle Birney's "Mappemounde"

No not this old whalehall can whelm us
 shiptamed gullgraced soft to our glidings
 Harrows that mere more which squares our map
 See in its north where scribe has marked *mermen*
 shore-sneakers who croon to the seafarer's girl
 next year's gleewords East and west *nadders*
 flamefanged bale-twisters their breath dries up tears
 chars in the breast-hoard the brave picture-faces
 Southward *Cetegrande* that sly beast who sucks in
 with whirlwind also the wanderer's pledges
 That sea is hight Time it hems all hearts' landtrace
 Men say the redeless reaching its bounds
 topple in maelstrom tread back never
 Adread in that mere we drift toward map's end

Line 1. "Whalehall": i.e., "the sea" (Birney 1972, 85)¹
 Line 3. "Mere": Old English, "the sea"
 Line 6. "Gleewords": Old English *gliwword*, "song" (Jakes 1979, 73)
 "Nadders": Old English *naedre*, "adder," "serpent," "dragon" (Birney 1972, 84)

- Line 7. "Bale": Old English *bealu*, "evil," "destructive"
- Line 8. "Breast-hoard": Old English *breosthord*, "thoughts"; i.e., "the memory of loved ones" (Birney 1972, 85)
- Line 9. "Cetegrande": Old French *cete grande*, "great whale"
- Line 11. "Hight": Old English *haten*, "called," "named"
- Line 12. "Redeless": Old English *raedleas*, "resourceless," "helpless"
- Line 14. "Adread": Old English *ofdraedd*, "frightened," "terrified"

In 1945, Earle Birney was on his way home. A major in the Canadian Army during World War II, Birney had contracted diphtheria while on duty in Europe. After treatment in an English military hospital, he was awaiting his return on the hospital ship *El Nil*, when he overheard Canadian soldiers and their English girlfriends pledge eternal love. Wondering how many promises would be broken by distance and time, Birney composed "Mappemounde" as he sailed west over the Atlantic. About a seafarer's ill-fated struggle to cross the ocean of medieval world maps, "Mappemounde" laments the ephemerality of love, fidelity, and life itself (Birney 1972, 86; Aichinger 1979, 76-78).

Birney would later credit World War II with making him a poet (Davey 1971, 20-21). He received his first prestigious Governor General's Award for poetry in 1942. The second came in 1945, the year he wrote "Mappemounde." Three years later, Birney placed the poem immediately after the one opening his third collection of poetry, *The Strait of Anian* (Birney 1948, 4). Since then, "Mappemounde" has been heavily anthologized. Acknowledging its importance, Birney included revised versions in his *Selected Poems 1940-1966* (Birney 1966, 90), *Ghost in the Wheels* (Birney 1977b, 34), and the *Collected Poems of Earle Birney*, from which our text derives.² (*The Collected Poems of Earle Birney* by Earle Birney, 2 vols., Toronto: McClelland and Stewart, 1975, 1:92. Courtesy of Wailan Low, executor of the estate of Earle Birney.)

The poem's charm, as well as its difficulty, has its origin in Old English (c.450-c.1100) and Middle English (c.1100-c.1500). An academic as well as a poet, Birney had received his doctorate in English from the University of Toronto in 1936 and taught there before serving overseas. After the war, he went on to teach medieval literature and creative writing at the University of British Columbia (1946-1965). There, he regularly offered courses on Old English and Geoffrey Chaucer, who was the subject of both his dissertation and a book of essays on irony (Birney 1985). Birney was so adept at medieval English "that he often quipped in phrases or lines from early literary works" (Cameron 1994, 380, and 352).

As the words appended to the poem attest, "Mappemounde" abounds in the Anglo-Saxon and Viking-borne Norse vocabulary of Old English. The noun *nadder* ("serpent") may be as obsolete as the adjectives *redeless* ("helpless") and *adread* ("fearful"). But the names of the cardinal directions, the adverbial suffix "-ward," and the strong, monosyllabic verbs "suck," "hem," "tread," and "drift" all betray the Germanic roots of Modern English. "Mappemounde" also mimics the Old English use of vivid metaphorical compounds, called *kennings*, to replace simple nouns: "gleeword" (*gliwword*, "entertaining-word") rather than "song," "breast-hoard" instead of "thoughts." For the Anglo-Saxon *scop* ("bard"), kennings displayed poetic talent and aided the oral transmission of verse. Birney imitated their bardic practice. By combining words derived from Old English, he created "whalehall" (*hwael + heall*) along with its wealth of associations no longer obvious in the more prosaic "sea."

Also reminiscent of Old English verse are the poem's alliteration and rhythmic pattern. Accents and italics help us visualize how the second line

"About a seafarer's ill-fated struggle to cross the ocean of medieval world maps, "Mappemounde" laments the ephemerality of love, fidelity, and life itself."

"As the words appended to the poem attest, "Mappemounde" abounds in the Anglo-Saxon and Viking-borne Norse vocabulary of Old English."

sounds when read aloud, particularly its four major stresses and repetitions of initial "s" and "g":

shíptamed gúllgraced sóft to our glídings...

"Mappemounde' imagines the sea voyage—with its isolation and terror, its loneliness and awe—as a poignant metaphor for life's journey."

In "Mappemounde," Birney's division of lines into two parts signals the poem's roots in Anglo-Saxon poetry. Such obvious *caesurae* (or pauses) are used by editors of Old English poetry to emphasize that every line is actually a combination of two short phrases, each with its own rhythm and two stressed syllables. The scop joined these phrases when he alliterated the sound beginning one or more of their stressed syllables: "shiptamed" and "soft," "gullgraced" and "glidings." By inserting central caesurae and eliminating the punctuation that distinguished his *Strait of Anian* version (where the line read "shiptamed, gullgraced, soft to our glidings"), Birney deliberately recast "Mappemounde" in a typography unfamiliar to the non-specialist and made the poem look as strange as it sounds. Yet its very "foreignness" is key to its heritage. Old English might as well be a foreign language, and Anglo-Saxon poetry not only was meant to be heard but was composed and transmitted orally (Birney 1972, 85; Alexander 1966; Bessinger 1974, 587-88).

Nor did Birney stop there. In theme and content "Mappemounde" recalls such classics of Old English literature as *Beowulf*, *The Wanderer*, and *The Seafarer*. Birney's *nadders* conjure up the fire-breathing, treasure-hoarding dragons in Germanic literature, like the one Beowulf slays in the oldest extant Anglo-Saxon poem (*Beowulf*, 2000-3187, in Jack 1994; see Raver 2000). Birney's "wanderer" and his ill-fated "pledges" evoke the speaker of *The Wanderer*, a man forced to sea after the deaths of lord and kin. Birney's "seafarer" and "whalehall" allude to *The Seafarer*, whose protagonist crisscrosses the *hwaelweg* ("whale-route"), far from his loved ones and *bitter in breosthord* (lines 55-63: see Alexander 1966, 90-105; Crossley-Holland 1982, 47-52). Like *The Wanderer* and *The Seafarer*, "Mappemounde" imagines the sea voyage—with its isolation and terror, its loneliness and awe—as a poignant metaphor for life's journey.

Birney's title, however, is not Anglo-Saxon. The medieval word *mappe-mounde* appears six centuries after the composition of *Beowulf* and three centuries after William the Conqueror installed a French-speaking aristocracy on English soil. In fact, when the word was first recorded near the end of the fourteenth century, the royal court still spoke Anglo-French.³ Birney picked this Middle English word, in part, because Chaucer—the focus of Birney's scholarly work—may have been the first to write it in English. Here are the opening lines of Chaucer's lyric poem, "To Rose-mounde":⁴

Madame, ye ben of al beautè shryne
As fer as cerced is the mappemounde;...

Mappemounde is one of eleven words that Chaucer rhymes with "Rosemounde," the name he gives to the poem's unidentified beloved in line 15. "To Rosemounde" is a light-hearted *ballade* about courtly love modeled on the French forms Chaucer preferred for his shorter poems (Davies 1963, 42-43; Reeves 1970, 157-58). Though the speaker declares undying love in the face of his beloved's thrice-remarked indifference ("thogh ye to me ne do no daliaunce": lines 8,16,24), he cannot help also comparing his passion to a fish swallowed in sauce ("...pyk walwed in galauntyne": line 17). Birney had catalogued some of that poem's whimsical qualities in his essay "The Beginnings of Chaucer's

Irony," which was published six years before he wrote "Mappemounde" (1939, in Birney 1985, 56-59). It may, therefore, have been his intent to contrast "Mappemounde" ironically with one of its inspirations: "To Rosemounde" couldn't differ more from Birney's melancholy, heavily stressed verses.

Birney clearly chose the word *mappemonde* for its cartographic implications. To use the words of the Chaucerian editor, Walter Skeat, Rosemounde is the shrine of all beauty "as far as the map of the world extends" (Skeat [1899] 1952, 549). Writing in the second half of the fourteenth century, Chaucer imagined the earth that was portrayed in contemporary world maps—an island "cerced" by the ocean/sea (cf. Tomasch 1992). Historians call such maps *mappaemundi*, "maps of the world," which is the plural form of the medieval Latin *mappa mundi* (du Cange 1954, 5:255). Approximately 1100 *mappaemundi* survive of those made in Europe between the fifth and the mid-fifteenth centuries. Some are little more than sketches of a "T-O" shaped world: they show the earth as an ocean-embraced circle of land ("O") divided by the cross-like intersection ("T") of the Mediterranean Sea with the Don (Tanais) and Nile rivers forming the boundaries of the three known continents: Asia, Africa, and Europe. Other *mappaemundi* are adorned with hundreds of names, pictures, and legends. Still others portray the earth divided into five (later seven) zones, with frigid polar regions, temperate zones, and a central uninhabitable belt at the equator known as the *perusta zona* ("the burnt up zone"). Most represent the world as a Christian allegory, featuring prominent figures from the Old and New Testaments alongside characters from classical mythology and ethnographies. Although gradually modified by trade and travel, *mappaemundi* continued to superimpose Christian theological views about space upon Greco-Roman conceptions of geography. Even during Chaucer's time, in the late Middle Ages, many world maps resembled those made in the thirteenth century and earlier (Harvey 1991, 37; Delano-Smith and Kain 1999, 15-22).

Birney's "Mappemounde," *Mappaemundi*, and Early English World Maps

Birney displays his familiarity with *mappaemundi* throughout "Mappemounde."⁵ His reference to "scribe" reminds us that the vast majority of *mappaemundi* illustrated the Bibles, psalters, and encyclopedic treatises produced in cathedral communities and monastic *scriptoria* ("writing-rooms"). Monks, trained as scribes, copied these texts by hand and drew the accompanying maps (Woodward 1987, 286 and 324; Campbell 1987, 428-29). Birney's emphasis upon the cardinal directions reflects their prominence on *mappaemundi*. Although zonal *mappaemundi* had varying orientations, most medieval world maps feature east at the top because the Bible locates the earthly paradise there (Genesis 2:8; Isidore of Seville, *Etymologies* 14.3.1-2). "East" represents man's early innocence and the promise of everlasting life in Heaven. "West," by contrast, symbolizes the world's decay and the eternal damnation of sinners in the depths of Hell (see below, and Baritz 1961). Birney's *nadders* suggest the dragons lurking in the west, below the world's frame on the diminutive Psalter map, made around 1300 (Figure 1, page 65). Though illustrating a book of Psalms, the Psalter map is distinctly apocalyptic. It displays Christ above, in the east, flanked by angels; below, in the west, two dragons represent Satan and his emissaries. In "Mappemounde" Birney multiples the dragons, locating them in the east and west, and calling them *nadders*, which means "devils" as well as "serpents" or "dragons."

"Writing in the second half of the fourteenth century, Chaucer imagined the earth that was portrayed in contemporary world maps—an island "cerced" by the ocean/sea."

"Birney displays his familiarity with mappaemundi throughout 'Mappemounde.'"

*"Birney was aware that the medieval term *mappa mundi* did not have to imply a graphic representation of the world; it could also mean a verbal description, one like 'Mappemounde' itself."*

*"Birney's poem begins by offering a uniquely ironic view of *mappaemundi*—particularly those created, like the Psalter map, in England prior to Chaucer's death in 1400."*

"The sketch map's whimsical illustrations, however, are better suited to Birney's later explanation of "Mappemounde" than to the bleak "Hardyean irony" of the poem he composed thirty years earlier."

Birney was aware that the medieval term *mappa mundi* did not have to imply a graphic representation of the world; it could also mean a *verbal* description, one like "Mappemounde" itself (Woodward 1987, 287-88; Delano-Smith and Kain 1999, 7). As we shall see, his poem does not describe any single map, nor does it conform to any single image of the world. Instead, it begins by offering a uniquely ironic view of *mappaemundi*—particularly those created, like the Psalter map, in England prior to Chaucer's death in 1400.⁶

We confront an inadequate representation of these *mappaemundi* in a sketch map by an unidentified artist, Figure 2 (page 66), which is the only illustration in Birney's critical study, *The Cow Jumped Over the Moon: The Reading and Writing of Poetry* (Birney 1972). Based on actual medieval maps, it was inspired by and illustrates Birney's five-page guide to "Mappemounde." At the top of the map, a serpent-entwined tree flanks an embarrassed Adam and Eve; the circle around them represents Eden, from which they are about to be expelled. The map reveals that their descendants spread out from the east, eventually crossing rivers and mountains to build cities as far as the edge of the circumfluent ocean. Beyond the habitable tripartite world of Asia (top), Europe (lower left), and Africa (lower right) lies the "unknown." Unexplored regions are often graphically expressed by monstrous human hybrids on *mappaemundi*, like those lining the southern border of the Psalter map. On the sketch-map, as in Birney's "Mappemounde," the strange creatures in the corners play a similar role.

The sketch map's whimsical illustrations, however, are better suited to Birney's later *explanation* of "Mappemounde" than to the bleak "Hardyean irony" of the poem he composed thirty years earlier (Birney 1972, 86). Let's ignore the fact that the *nadders* do not oppose each other across the map, and that the whale is the only creature in its proper place ("southward"). Let's overlook the fact that the poem contains no mermaid; and that Birney's 1972 explanation, which *does*, neglects to mention Ulysses' ball-of-wax trick when he encounters such "treacherous mermaids" on his return from antiquity's legendary world war (Birney 1972, 85; *Odyssey* 12.177-200). Even so, the creatures in the corners are disconcerting. They look no more terrifying than the figures of Triton, Neptune, Thetis, and Aeolus arrayed around a zonal map in a thirteenth-century copy of the *Etymologies* by Isidore of Seville, for example (Figure 3, page 67). The 1972 sketch-map seems to have combined such naive figures with Chaucer's light-hearted touch in order to teach well-meaning, if slightly obtuse readers how to approach "Mappemounde." In his attempt to counter charges of his poem's obscurity and to increase appreciation of poetry generally, Birney offers a delightful lecture—but strips "Mappemounde" of its dark complexity. The sketch map, for all its charm, trivializes the very material it should help us envision.

To make sense of Birney's poem, we need to go to the actual maps themselves. Let's imagine, then, that Birney *had* been offered the opportunity to illustrate "Mappemounde" with the *mappaemundi* that inspired his poem's setting. Which of them, besides the Psalter map, might he have chosen?

The Anglo-Saxon map immediately springs to mind (Figure 4, page 68). Dating to the tenth or eleventh century, it is one of the earliest world maps that survives, and the *only* example of a non-zonal map from the Old English period.⁷ Also known as the Cotton [Tiberius] map, it is as remarkable for its precocious depiction of the British Isles as it is unusual for the rectangular shapes of land and sea. The Anglo-Saxon map is one of the few *mappaemundi* that matches the wording of the version of "Mappe-

mounde" from *The Strait of Anian*: "Harrows that mere more *that* squares our map" (line 3: italics mine).⁸ This earlier version of the poem seems to mean "that sea—the one that squares our map—torments us more than the 'shiptamed' one we are now crossing." Yet the very rectangularity of its sea prevents the Anglo-Saxon map from having room for anything at the corners, an option on the nearly ubiquitous circular or oval world-maps. It is precisely that extra space that Birney wanted to emphasize when he revised the line to read "Harrows that mere more *which* squares our map" (italics mine). Instead of referring back to the poem's previous lines, the revised sentence looks ahead to his catalogue describing "those strange designs which scribes placed in the corners of that perilous sea" (Birney 1972, 84).

Italian mapmakers of the fourteenth and fifteenth centuries are especially noteworthy for this feature. Pietro Vesconte, the earliest chartmaker known to us by name, worked in Venice. On four of the early fourteenth-century atlases ascribed either to him or to Perrino Vesconte, portraits of saints illuminate the corners of the portolan charts.⁹ (The *portolano*, or early nautical chart, with its geographical accuracy and usefulness for both navigation and trade, its distinctive windroses and network of intersecting rhumb lines, is now treated separately from the *mappamundi*. In the thirteenth and fourteenth centuries, however, the term *mappa mundi* embraced both allegorical world maps and practical sea charts based on compass readings. [Woodward 1987, 287; Campbell 1987, 439]) There is also a fascinating anonymous 1390 Venetian atlas, which pictures the authors of the gospels in the corners of at least one of its portolan charts (Mollat and Roncière 1984, fig.10 and 204). Each evangelist appears as one of the six-winged, many-eyed creatures from the Book of Revelation. In the Bible, they stand beside God's throne proclaiming his eternal glory (Revelation 4:7, in [Bible] 1973):

the first living creature like a lion, the second living creature like an ox, the third living creature with the face of a man, and the fourth living creature like a flying eagle.

On the chart, each saint presides over one of the earth's four corners, and each holds a scroll bearing his name (Woodward 1987, 336).

The figures on this chart help us read the 1452 *mappamundi* of the Venetian cosmographer, Giovanni Leardo, who incorporated portolan rhumb lines into his world map (Campbell 1987, 379 n.71). Part of the left side of the Leardo map is missing and the figures in the corners are unnamed, but the vague images of the evangelists are recognizable. The Leardo map arranges its figures differently than the anonymous 1390 portolan: Mark, the lion, appears in the southeast (upper right); Luke, the ox, in the southwest (lower right); Matthew, looking like an angel, in the northwest (lower left); and John, the eagle, in the northeast (only his head is visible: upper left). Furthermore, the Leardo map emphasizes the interconnectedness of time and space, an intimacy as explicit on *mappaemundi* as in Birney's phrase "that sea is hight Time." Leardo's evangelists frame not only the circular world map but also a number of calendrical rings emanating from it. The central ring, for instance, specifies the dates of every Easter until 1547 (Wright 1928, 3-4; Woodward 1987, 338, cf. 355).

In addition to the Italian maps, Birney had an English source that predates them—the twelfth-century Sawley map, formerly known as the Henry of Mainz *mappamundi* (Figure 5, page 69). In contrast to the Anglo-Saxon map, which scholars consider heavily indebted to Roman

"There is also a fascinating anonymous 1390 Venetian atlas, which pictures the authors of the gospels in the corners of at least one of its portolan charts."

"The Leardo map emphasizes the interconnectedness of time and space, an intimacy as explicit on *mappaemundi* as in Birney's phrase 'that sea is hight Time.'"

"In addition to the Italian maps, Birney had an English source that predates them—the twelfth-century Sawley map, formerly known as the Henry of Mainz *mappamundi*."

"The angels should not lure us into thinking that the Sawley map is more sentimental than the Psalter map. They probably symbolize the apocalyptic events preceding the Last Judgment."

"The final book of Honorius' text details the medieval belief, popular since Augustine and Bede, that history has followed a westward course since the creation of man."

"Details in 'Mappemounde' reveal Birney's familiarity with the Hereford map."

and, possibly, Carolingian models (McGurk 1983, 86; Harvey 1991, 21-26; Delano-Smith and Kain 1999, 34), the Sawley map "is generally accepted as the earliest surviving *English* example of a *mappamundi*" (Delano-Smith and Kain 1999, 37, emphasis mine). Drawn most likely at Durham Cathedral Priory and then transferred to Sawley Abbey in Yorkshire sometime around 1200, this *mappamundi* appears as the frontispiece to a copy of the immensely popular eleventh-century encyclopedia, the *Imago Mundi*, by Honorius Augustodunensis (Harvey 1997, 33, 36-37; Delano-Smith and Kain 1999, 36). Like the Anglo-Saxon *mappamundi*, the Sawley map is oriented to the east, the words *Oriens* and "Paradise" being visible at the top. But this time the world is an oval with four angels gracing its corners.

The angels should not lure us into thinking that the Sawley map is more sentimental than the Psalter map. They probably symbolize the apocalyptic events preceding the Last Judgment: in Revelation, four angels appear at the four corners of the earth after the Lamb has broken the sixth seal, and together they hold back the four winds (7:1). On the Sawley map, the angel in the northeast (top left) points toward Gog and Magog, warning that the man-eating hordes of Cain's *gens imunda* ("impure race") will soon break free from their Caspian confines to ensure the world's demise (Revelation 20:7-9). More foreboding still are the angels at the bottom of the map: stationed at the western edge of the world, they represent the end of time and the imminent demise of the world as we know it. The final book of Honorius' text details the medieval belief, popular since Augustine and Bede, that history has followed a westward course since the creation of man. At the end of the sixth age will come the apocalypse, the six-day destruction of the world, followed by the Last Judgment on the seventh. On the Sawley map, the angel in the southeast corner carries a book. Whether this book represents Honorius' text, the Book of Revelation, or the Bible itself doesn't matter; each reminds us that the faithful alone will triumph over this terrifying eventuality.¹⁰

Closely associated with the Sawley map in content is the monumental Hereford map in Hereford Cathedral (Bevan and Phillott [1873] 1969, chpt.1, sect.14.3). Wonderfully preserved and detailed, the Hereford map is the only surviving example of what may be a typically English style of *mappaemundi* from the thirteenth century—the large world maps displayed on palace or abbey walls and used, perhaps, as altar-pieces or decorations (Harvey 1991, 25; Edson 1997, 141). Because of its size, the Hereford map is a veritable encyclopedia of legends, cities, and creatures, presenting the interconnectedness of time and space more graphically than any other *mappamundi* (Figure 6, page 70). Not only do we see mythical monsters and historical cities beside scenes showing Christ's crucifixion and the expulsion of Adam and Eve from Paradise; the map also demonstrates that civilization began in the east and has followed a "linear" course west through the center of the known world. The Garden of Eden represents the beginning of life and the knowledge that precipitated our fall; the Tower of Babel, the scattering of peoples throughout the earth; Jerusalem, the central pivot of human history; Delos, the Greek navel of the world, pictured beside a seductive mermaid; Rome, the imperial city turned capital of the Church; and the Pillars of Hercules (Strait of Gibraltar), the traditional western limit of man's knowledge of the world. The placement of these areas on a vertical line running through the center of the Hereford map highlights their temporal and geographic import for mankind (Moir 1970, 13; Westrem 2001, xxxii; cf. Edson 1997, 26, 34-35, 50, 140-144; and see Haft 2003).

Details in "Mappemounde" reveal Birney's familiarity with the Hereford map. Two *dracones* ("dragons") appear in Taphana (Ceylon/Sri

Lanka), the large triangular island in the mouth of the rubricated Red Sea and Persian Gulf on the map's southeast edge (top right). Of the wind gods depicted, eight are dragon-heads spewing fire across the ocean. Just below Jerusalem, at the center of the map, an enchanting mermaid admires herself as she rests on the oversized label *Mare Mediterranea [sic]*. Her position on the map, coupled with her lack of attire, suggest the temptations that beguile unwary pilgrims (Letts 1955, in Moir 1970, 36). In the frame at the top, Christ orders sinners after the Last Judgment into the gaping maw of a dragon-like monster (top right). An angel announces their fate on a scroll issuing from his trumpet: *Leuez—siez au fu de enfer estable* ("Rise—you are going to the fire prepared in hell"). While most of the inscriptions on the map are in Latin, the angel's words are in Anglo-French, the language spoken by the English court when the Hereford map was made (Harvey 1997, 54; Westrem 2001, 4). And gold letters spelling *M-O-R-S* ("Death") appear on posts that extend from the ocean into the map's frame.

The Limitations of *Mappaemundi* for Understanding Birney's Poem

In many ways, of course, the *mappaemundi* I have described differ markedly from the poem they helped inspire. Though "Mappemounde" begins optimistically with one sea tamed and the other merely "squar[ing] our map," this second sea quickly becomes the center of the map, the poem, and life itself. Most medieval maps, however, privilege land over water—to such an extent that the ocean appears as a narrow ribbon encircling the continents. Yet, despite its appearance on maps, the earth was believed to be spherical by most medieval scholars, including Honorius.¹¹ Consider the ball Christ holds in his left hand on the Psalter map (Figure 1, page 65). It has the "T-O" pattern still recognizable on the Psalter map itself.

Mappaemundi raise the question: what did the other side of the earth look like? Though celestial globes were used for educational purposes in the fourteenth century and earlier, no evidence remains of any terrestrial globe: for all we know, Martin Behaim's *Erdapfel* ("Earth-Apple") of 1492 is not only the oldest extant globe depicting the earth but perhaps one of the first made in Europe since classical antiquity (Stevenson [1921] 1974, 1:43-47; Dekker and van der Krogt 1993, 17-18).¹² Medieval scholars are often vague or conflicting on the subject. The great thirteenth-century scientist Roger Bacon, for instance, posited that land filled six-sevenths of the globe (Wright [1925] 1965, 187-188; Bacon [1267-68] 1962, 1:311). Most others believed that the known world took up only a quarter of the surface; the possibility of other landmasses existing in the temperate zones opposite or south of the known world did not necessarily prevent the ocean from covering half the globe or more (Kimble [1938] 1968, 147, 162-63; Taylor 1966, 53; Westrem 2001, xxxviii). This "oceanic" theory simply can't be conveyed on most *mappaemundi* (Haft 1995, 26-29; Edson 1997, 110). Nor did the portolan charts fill the void. Until the Age of Discovery, they typically depicted coastal sections of the Atlantic and relatively contained bodies of water like the Mediterranean or the Black Sea. Destinations of merchants and sailors, such waters are pictured as embraced by shorelines and filled with comforting names of harbors. Birney, by contrast, focuses on what *mappaemundi* and portolan charts omit altogether: the other half of the globe, with its vast ocean stretching ominously beyond sight of land.

"Mappemounde" proves far less optimistic than its mapped counterparts. Many *mappaemundi* illustrate life's dangers so that the faithful may

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"'Mappemounde' proves far less optimistic than its mapped counterparts."

"Journey's end is obliteration as 'we'—no longer viewers of the map (line 3) but helpless wanderers upon it (line 14)—envise 'toppl[ing] in maelstrom' over the edge of map and world."

"Like the devil, the whale is sly, tempting fish into his maw by the sweetness of his breath.

Then 'those grim jaws snap around their prey,' just as the devil 'slams shut hell's doors after the slaughter'."

avoid worldly temptations and save their souls. On the back of the Psalter map, for instance, Christ holds a T-O shaped world that represents or, at least, covers his body. Beside his head at the top of the map, four angels appeal with outstretched arms as he tramples the dragons of the west beneath his feet (Edson 1997, fig.7.1).¹³ St. John's vision of redemption and rebirth in the Book of Revelation finds its graphic counterpart on the Hereford map. There, in the upper frame, Mary's plea to Christ is fulfilled as the faithful rise from their graves on his right and line up for Paradise. Birney's "Mappemounde" offers no such escape from our faithless world.

Then there is Birney's representation of the ocean itself. If *mappaemundi* picture anything in that narrow band, it is the heads of wind gods blowing across the sea; some add islands, fish, even the occasional boat.¹⁴ Birney's sea is both lonelier and more threatening than the one plied by the speaker of *The Seafarer*; in "Mappemounde" the seafarer's only company is treacherous and destructive monsters. Confronted by references to divine mercy in *The Wanderer* and *The Seafarer*, scholars remain divided as to whether these brief prologues and epilogues are additions to a pagan poem that posited no afterlife (Crossley-Holland 1965, 107; Alexander 1966, 84-88). Birney's "Mappemounde," of course, includes no such postscript, and no Christian message at all. It remains as irreconcilably pessimistic as the lines preceding the contested final stanza of *The Wanderer* (Alexander 1966, 96):

Wealth is lent us, friends are lent us,
man is lent, kin is lent;
all this earth's frame shall stand empty.

Despite his emphasis on the cardinal directions, Birney favors none of them. Portolan charts share this lack of orientation so that they may be read from every direction (Campbell 1987, 378). But in "Mappemounde," there is no way to navigate the "dreadful ocean" (Birney 1972, 84). Journey's end is obliteration as "we"—no longer viewers of the map (line 3) but helpless wanderers upon it (line 14)—envise "toppl[ing] in maelstrom" over the edge of map and world. So Birney, medieval scholar and master of irony, plays his final cartographic trick: echoing the nineteenth-century view that the earth was considered flat in the Middle Ages (see Jones 1934, 296-307).

Other Inspirations: Cartographic and Otherwise

Maps, of course, were not Birney's only inspiration. In *Patience*, an anonymous poem written in the northwest Midlands around the time of Chaucer's "To Rosemounde," *a wylde walterande whal* ("a wild, rolling whale") swallows Jonah after he attempts to shirk his duty to God (Gollancz 1913, line 247; Kurath 1952-). There is also "The Whale," an Anglo-Saxon poem never before linked to "Mappemounde." "The Whale," an anonymous composition from the ninth century, was recorded over a century later in the Exeter Book, the same manuscript that contains the texts of *The Wanderer* and *The Seafarer*. Unlike these, however, "The Whale" is a short poem from a Bestiary (or *Physiologus*), a compendium of strange beasts that proved enormously popular in the Middle Ages. Only two other pieces survive from the Anglo-Saxon Bestiary, namely "The Panther" and the fragmentary "Partridge"; yet they contextualize "The Whale" as part of an ancient tale overlaid with Christian instruction. The panther represents Christ; the whale, the devil. Like the devil, the whale is sly, tempting fish into his maw by the sweetness of his breath (lines 49-62). Then "those grim

jaws snap around their prey," just as the devil "slams shut hell's doors after the slaughter" (61-62, 77-78, trans. Crossley-Holland 1982, 251-252, 257-259; see Krapp and Dobbie 1936, 171-74). More appalling is how the whale deceives weary sailors. Mistaking his back for an island, they secure their ships "to this pretence land" (14) and cook their dinner before sleeping. Only then does the whale, "master of evil" (24), make its treacherous move, dragging both sailors and ships to the "hall of death" (30), just as the devil plunges sinners into hell's "bottomless swell beneath the misty gloom" (46-47). A manuscript illumination from the Latin *Ashmole Bestiary* highlights the danger the whale poses to men and fish alike. On that image, created perhaps in England's North Midlands around 1210, three men in a fragile vessel seem unaware that a whale is devouring its meal below them, or that the whale is as large as the ocean.¹⁵

Similarly, the *Navigatio Sancti Brendanis Abbatis* ("Navigation of Saint Brendan the Abbot"), which was in circulation by the early tenth century, tells how the Irish monks accompanying Saint Brendan nearly succumbed to that same fate while sailing west four hundred years earlier. They survived, of course, celebrating several Easters on the whale's back and visiting the terrestrial Paradise before their return to Ireland (Short and Merrilees 1979). Saint Brendan's Islands became a cartographic "reality," first on the Hereford map and subsequently on charts and globes well into the eighteenth century (see Figure 9, below; Bevan and Phillott [1873] 1969, 106-108; Babcock 1922, 39-49; Westrem 2001, 388-389). Most often associated with the Canaries, the islands appear in the Atlantic as far south as the Cape Verde Islands and as far north as Newfoundland.

Early maps portray Saint Brendan's encounter with the whale. The Piri Re's Chart of 1513, for example, pictures two men in the North Atlantic making dinner on the back of a whale. From their ships nearby, three cowled monks look on anxiously (Mollat and Roncière 1984, fig.28; Soucek 1992, 269-272 and fig.14.7). That Birney had access to these later maps and sources is obvious from the title he gave to his collection, *The Strait of Anian* (see below). Whales seem to appear on maps in the fifteenth century and are commonplace in the sixteenth and seventeenth centuries, thanks to the whaling industry in the North Atlantic.¹⁶

Birney's specification of *Cetegrande* as "southward" is reflected by the sixteenth century in the world maps of Sebastian Münster, whose whale-like monsters grace his otherwise empty southern ocean (Cumming et al. 1972, 44; Portinaro and Knirsch 1987, plate xvi). In the years leading up to World War II, Birney would have known of the southern whaling stations (Ellis 1988, 43 and 69). Furthermore, he would certainly have remembered the direction that Herman Melville's ill-fated Pequod was sailing in its final weeks. After Ahab destroyed his quadrant, a typhoon disoriented ship and crew in the Japanese fishing-grounds (Melville [1851] 1972, 609-611). The Pequod then headed "south-eastward...by Ahab's level log and line...toward the Equator" (631). There, in the uncharted waters of the "Southsea fishery" (664) and somewhere near "the line" (631), the Pequod encountered the enormously crafty sperm whale, Moby Dick, whose death throes ultimately sucked the Pequod and its crew beneath the sea (Figure 7, page 71).¹⁷ And the southern constellation Cetus, usually imagined as a giant whale, has been pictured on star charts since antiquity. Melville himself refers to this celestial sea monster (378):

Nor when expandidly lifted by your subject, can you fail to trace out great whales in the starry heavens, and boats in pursuit of them;....
Beneath the effulgent Antarctic skies I have boarded Argo-Navis, and joined the chase against the starry Cetus far beyond the utmost stretch of Hydrus and the Flying Fish.

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"Birney's use of multiple sources when creating 'Mappemounde' means that we can't expect any single mappamundi to contain all the details in his poem."

"In the Age of Discovery, maps abound with mermen, the most fascinating of which is the crooning merman on a 1570 map by the Dutch cartographer Abraham Ortelius."

"In May of 1943, Birney had sailed in a troopship to England over an Atlantic infested by German U-boats, those mechanical analogues of Cetegrande."

Because sailors have long used the stars to find their way across featureless seas, the location of the constellation Cetus in the night sky may have given Birney another reason for portraying *Cetegrande* "southward."¹⁸

Birney's use of multiple sources when creating "Mappemounde" means that we can't expect any single *mappamundi* to contain all the details in his poem. The Triton figure in the Isidore manuscript, for instance, doesn't look like the merman he is traditionally described as being (Pliny, *Natural History* 9.4; Pausanias 8.1.7; Benwell and Waugh 1965, 36-39). Medieval writers and painters nevertheless continued to catalogue the merman's unusual appearance and habits. That fish-tailed men frequented the British Isles was the report of the English historian Gervase of Tilbury (Benwell and Waugh 1965, 76). Author of the *Otia Imperialia* (1211), Gervase may have been responsible for the creation of the Ebstorf map, the monumental thirteenth-century *mappamundi* destroyed in the bombing of Hanover during World War II. In the Age of Discovery, maps abound with mermen, the most fascinating of which is the crooning merman on a 1570 map of Scandinavia from the groundbreaking *Theatrum Orbis Terrarum* by the Dutch cartographer Abraham Ortelius. In the northern latitudes so appropriate for Birney's mermen, Ortelius pictures a ship sailing west from the British Isles towards North America. Just below, as if waiting for the sailors to lose sight of land, a lute-playing merman slowly makes his way toward the fair maidens they've left behind (Figure 8, page 72).

Love and Loss

Finally, there is a deeply personal side to "Mappemounde," one that Birney concealed behind the ironist's filters of temporal distance, indirectness, and universality (see Nesbitt 1974, 53-54, 132, 156; Cameron 1994, 163 and n.9). A year before Birney died at the age of ninety-one, Elspeth Cameron published *Earle Birney: A Life* (1994). The biography is a brilliant piece of research, painstakingly culled from hundreds of letters, drafts, and personal papers housed in the University of Toronto's Thomas Fisher Rare Book Library. From that extensive collection Cameron assembled a rich portrait of the man who had composed "Mappemounde" nearly half a century earlier.

Birney, it turns out, had reason to dread the monsters he italicized in "Mappemounde." In May of 1943, he had sailed in a troopship to England over an Atlantic infested by German U-boats, those mechanical analogues of *Cetegrande* (see Churchill 1951, 12). True, the war in Europe had ended by the time Birney stepped onboard the *El Nil* in July of 1945. But if "this old whalehall" was now "shiptamed," the sea Birney calls "Time" stretched perilously out before him. At the end of his journey lay his wife, their baby son, and the stability his family represented; for prior to marrying Esther Bull in 1940, Birney had suffered the failures of two engagements and of his brief first marriage (Davey 1971, 8-12). But his return came at a huge cost. Behind, in England, he left the woman who arguably was the love of his life, Margaret Crosland (Cameron 1994, 230 and 567).

Birney had met the twenty-five-year-old student on his fortieth birthday while on duty in England (Cameron 1994, 220-242). They shared a year together, in which their passion for poetry, medieval French, and Anglo-Saxon literature infused the letters and sonnets they exchanged, ultimately inspiring "Mappemounde." Birney had used the word to describe his desire for Margaret: "We've lept into a land as wide as you...and cry

to chart our *mappemounde* of love" (228 and n.23). Margaret, in turn, called Birney her "flammenwerfer love" ("German flame-thrower"), alluding to their intimacy and to his time at a flame-throwing unit in Sussex (229 and n.27). And Birney's *Cetegrande* echoes Margaret's interest in medieval French (220 and 225) even as it recalls her lines: "In the great ocean of our love, whales/ are the utterance to swing your being's tide" (242).

To the brevity of life, a theme already evident on many *mappaemundi*, Birney has added the dissolution of faithfulness and love.

Epilogue: After "Mappemounde"

Time, the great bugbear in "Mappemounde," was also to be a healer in Birney's life. He and Margaret remained friends until she hurt him irreparably years later by selling the letters and poems he had once written to her. His marriage to Esther withstood his ambivalence and love-affairs until 1977, three decades after his return from the war. By that time, Birney had discovered in Wailan Low the ideal companion for the final quarter century of his long life (Cameron 1994, 518-570; "...o many and many/ and happiest years": Birney 1975, 2:180).

In the meantime, "Mappemounde" was published in *The Strait of Anian*, a collection whose name derives from the strait much sought after from the sixteenth to the eighteenth centuries (Nunn 1929; James Ford Bell 1956; Keating 1970, esp. 51-67; Gough 1988).¹⁹ Now identified with the Bering Strait, the Strait of Anian provided the western access to the Northwest Passage, a northern water route thought to link the riches of Asia with the ports of Europe while bypassing the enormous and largely unexplored landmass in between. Birney refers to this strait twice in his 1948 collection. The first time is in his epigraph, a quote from Thomas Blundeville's description of the circumnavigation of the globe by Sir Francis Drake from 1577 to 1580. It relates how the explorer hoped to return to England by sailing north through the "narrow sea Anian," then eastward and home; but his mariners, stung by the cold, refused to go in that direction. Drake had reason for optimism: the strait had been mapped in 1562 by Giacomo Gastaldi. And a year before Blundeville's account was published, the Dutch cartographer Cornelis de Jode came out with a detailed and seemingly authoritative map entitled *Quivirae Regnum cum aliis versus Boream* (Figure 9, page 73). This map complements Birney's own vision in its recognition of the importance of North America, especially Canada. De Jode portrayed the region on this map and on the two-page *Americae Pars Borealis*, both of which he created in 1593 for the second edition of his atlas *Speculum Orbis Terrae*. Figure 9 shows the western part of North America and presents the Strait of Anian (*El Streto de Anian*) and the Northwest Passage as a direct and unhindered water route north of the continent. Between Alaska (*Anian Regio*) and California (*Quivirae Regnum*) ships sail in waters frequented by a sea unicorn and another strange creature reminiscent of Birney's "Mappemounde" (see Nebenzahl 1990, 152-155).

Birney's second reference to the Strait of Anian appears in "Pacific Door," the poem that bookends "Atlantic Door" to frame the first half of the collection, "One Society" (1-37). Within this section are Birney's poems about Canada, titled and organized "geographically" from east to west coast and emphasizing the stunning variety of the country's physical landscape—its plains, forests, mountains, cities, and waterways. But what has been called Birney's "Pan-Canadian vision" must be viewed in the context of "Atlantic Door" and "Pacific Door" (Livesay 1948, in Nesbitt 1974, 60). For these poems emphasize the vastness of the oceans separat-

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“Although de Jode’s depictions of the Strait of Anian and Northwest Passage are highly optimistic, Birney’s poems focus on the failure of early explorers to navigate such treacherously icy waters.”

“An inveterate wanderer, Birney retained his interest in exploration, geography, and maps throughout his long career.”

“Not until the late 1960s, however, did Birney return to maps as the subject of his verse.”

ing Canada from Europe and Asia, and warn of the “bleak and forever capacious tombs” at the ocean depths (Birney 1948, 3 and 37). Although de Jode’s depictions of the Strait of Anian and Northwest Passage are highly optimistic, Birney’s poems focus on the failure of early explorers to navigate such treacherously icy waters. For Birney, the Strait of Anian became a metaphor for Canada’s isolation from the rest of the world. In “Pacific Door,” Birney summarizes eighteenth-century attempts to cross from the Strait of Anian into the Northwest Passage (Birney 1948, 37; cf. *Oxford Atlas* 1997, 140-141):

Here Spaniards and Vancouver’s boatmen scrawled
the problem that is ours and yours,
that there is no clear Strait of Anian
to lead us easy back to Europe,
that men are isled in ocean or in ice
and only joined by long endeavour to be joined.

With his usual irony, Birney calls the second half of *The Strait of Anian “One World”* (41-84) and fills it with war poems. The world war was one way of shattering Canada’s physical and cultural isolation.

An inveterate wanderer, Birney retained his interest in exploration, geography, and maps throughout his long career. “Pacific Door” would be followed by “Trial of a City” (Birney 1952 [1957], published later as *The Damnation of Vancouver*, Birney 1977a), “Vitus Bering” (1953), “Captain Cook” (1958-59), “Giovanni Caboto/John Cabot” (1965), and “Conrad Kain” (1974). His fascination with geography is evident in the way he arranged the poems for his collection about the city of Vancouver, *Trial of a City* (Birney 1952, esp. 47-57); in the titles and subjects of poems like “North of Superior” (1946), “Alaska Passage” (1960), “Perth, Australia, I Love You” (1968); and in later collections like *Ice Cod Bell or Stone* (Birney 1962) or *Near False Creek Mouth* (Birney 1964), both of which describe his international ports of call from the 1950s on. *Near False Creek Mouth* is not only filled with place-name titles (“Guadelupe,” “Machu Picchu,” “Epidaurus”) but includes four playful sketch maps illustrating the places Birney wrote about during his many travels. The only place these maps share is “False Creek Mouth,” another name for Vancouver, emphasizing that city’s—and its poet’s—connection with the rest of the world.

Not until the late 1960s, however, did Birney return to maps as the subject of his verse (Birney 1971; 1975, 2:159). Always the experimenter, Birney chose an entirely different format from the linear, sonnet-like appearance of “Mappemounde.” This time he turned to visual poetry and created poems *shaped* like maps. His 1967 poem “up her can nada” ironically observed his nation’s centenary. A sketch-map of Upper Canada, Ontario’s official name from 1791-1841, Birney’s poem is a masterpiece of concrete poetry caricaturing Ontario’s pretensions as well as historical maps of the province. And shortly after he won the Canada Council Medal in 1968 “for distinguished achievement over an extended period” (Aichinger 1979, 44), Birney composed “Hare Krishna.” Read aloud, it sounds like the mantra chanted by the sect’s members to purify their souls. In its appearance, however, the poem resembles Hindu and Jain cosmographical diagrams (see Schwartzberg 1992, figs. 16.6, 16.29; and plates 25 and 28). So unique is Birney’s “Hare Krishna” that it may be the *only* visual poem based on traditional east Indian maps to have been composed in the twentieth-century by a North-American poet. But discussions of Birney’s other map-poems will have to wait for another day (see Haft 2000, 74-75).

1. Birney did not include etymological notes with "Mappemounde." Unless otherwise noted, medieval English translations and etymologies derive from Jember 1974, Borden 1982, and the second edition of the *Oxford English Dictionary* (OED 1989); Latin phrases, from Lewis and Short [1879] 1975, and Niermeyer and van de Kieft 1976. (Note that the Old French word for "great whale" spawned the medieval English *Cethegrande*.)

2. Regarding these revisions, the following do not affect the poem's meaning: the replacement of "NO" by "No" (line 1) or of "the dear face-charm" by "the brave picture-faces" (line 8); the fact that "in" ends line 9 instead of beginning line 10. More significant are two changes discussed below: Birney's replacement of "that" by "which" (line 3) and his typographic alterations. The typography Birney adopted in *Selected Poems 1940-1966* and later collections remains controversial (Birney 1966, ix; Nesbitt 1974, 10, 142-43, 153-54, 159-60, 212-13).

3. The French word *mappemonde* derives from the medieval Latin *mappa mundi*. The forms *mappemond* and *mappemonde* also appear in Middle English (OED 1989). For French spellings prior to 1500, see Tobler and Lommatzsch 1963, 5:1102-1103, s.v. *mapemonde* (with alternatives *mappamonde* and *mappemonde*) as well as "*mapemont*" (with *mapemund*). Birney helped his Canadian readers translate his title "Mappemounde" by reminding them of their high-school French (Birney 1972, 84).

4. The quote comes from an edition familiar to Birney: Skeat [1894-1900] 1926-54, 1:389. Skeat, who first published the poem and gave it a title, notes that the late fifteenth-century manuscript containing the untitled poem actually uses the spelling *mapamonde*. The current edition spells the word *mapamounde* (Benson 1987, 649). Chaucer's contemporary, John Gower, also uses the word in his *Confessio Amantis*: "And sette proprely the bounde/ Afstre the forme of Mappemounde" (3.102: OED 1989).

5. At the time when Birney was composing "Mappemounde," the great compendium of medieval maps was Miller (6 vols., 1895-98). Also important were works by A.E. Nordenskiöld (1890s), Charles Raymond Beazley, especially *The Dawn of Modern Geography* (3 vols., 1897-1906), J.K. Wright, and Richard Uhden (1930s); see Woodward 1987, 513-558, for fuller bibliography.

6. Harvey suggests that the Psalter Map was drawn in London (1996, 29). According to Delano-Smith and Kain (1999, 38), "about two dozen English *mappaemundi* are known (excluding 19 copies of the Higden map) of which fewer than half are extant." (The Higden map illustrated the *Polychronicon* of Ranulf Higden, a fourteenth-century monk from Chester; see Harvey 1997, 35.)

7. The manuscript in which the Anglo-Saxon map appears features a zonal map as well (McGurk 1983, 65-66); both seem to have been drawn by the same person to suit the manuscript's "overall plan" (Edson 1997, 3, and 77-78, 95, 106-107). Delano-Smith and Kain suggest that the "apparent dearth [of English *mappaemundi*] from the seventh to the twelfth centuries may be due to rarity or to loss" (1999, 8).

8. The Albi *mappamundi* of the eighth century and the Ashburnham Beatus map of the tenth have rectangular frames (McGurk 1983, 79 and 85; Woodward 1987, 348, fig.18.56; Williams 1998, 3:27-28). On the shapes of *mappaemundi* and their symbolism, see Woodward 1987, 318 n.149.

NOTES

9. See Campbell 1987, 398 and n.226, for the atlases; and 406-407, for Perrino's identity. See Mollat and Roncière (1984, fig.6 and 200), for a portolan chart from Pietro Vesconte's Lyons atlas (c. 1321) depicting the coasts of England, Ireland and France and framed by St. Nicholas, the Virgin Mary, and an angel.
10. For the myth of the six ages, see Honorius Augustodunensis, *Imago Mundi*, Book 3; and, more generally, Wright [1925] 1965, 233-35; Edson 1997, 98-99 and *passim*. Interpretation of the Sawley Map is provided by LeCoq 1989, 22; 1990, 155-201, esp. 160-62; Edson 1997, 111-17.
11. See Honorius' *Imago Mundi* 1.1.5; and 1.6, for his discussion of zones. That medieval scholars did not consider the earth flat and wheel-shaped, see Woodward 1987, 318-21, 342; and Russell 1991, esp.13-26.
12. See Mollat and Roncière 1984, plate 20. Behaim's globe depicts the ocean between Europe and Japan as an inland sea occupying only 130 degrees of longitude, filled with texts about the various climates, and freckled with islands, ships, hippocamps, a triton, and mermaid.
13. By the ninth century, the "T" on the "T-O" maps was identified with the cross: Edson 1997, 5. The earth represented Christ's body on the enormous Ebstorf map (3.5 m or 11' 8" in diameter), destroyed in 1943 during the bombing of Hanover, Germany: Christ's head, hands, and feet indicate the cardinal directions as they emerge from the world-map into the circumfluent ocean (Woodward 1987, 307-309 and fig.18.19; Harvey 1991, 28; 1997, 31). For similar images of the earth as Christ's body, see Hahn-Woernle 1988, 40 and 50-51.
14. Besides the Psalter, Hereford, and related Ebstorf maps, the Duchy of Cornwall map (c.1150-c.1220) and at least one Ranulf Higden map from the late-fourteenth century are among the English *mappaemundi* depicting wind gods and islands in the ocean: see Woodward 1987, plate 14 and fig.18.67, respectively. (Birney duplicated this Higden map [British Library, Royal MS. 14 C.IX., ff.1v-2] and a modern rendering of Eratosthenes' world view of about 200 B.C. to show the illustrator of the 1972 sketch map [Figure 2, above] how different our own views of the earth are compared with those held in antiquity and the Middle Ages. See note 6 and Birney's "xerox 'notations'" [sic] in Box 114, p.122, of the Birney Collection at the Thomas Fisher Rare Book Library at the University of Toronto.) Fish appear on the Ebstorf map; fish and (sometimes) boats fill the ocean on Beatus maps like the St. Sever *mappamundi* (Wright [1925] 1965, 69; Edson 155, fig.8.4; and, on Beatus maps generally, Williams 1994-98). The early fifteenth-century Borgia World Map, similar to world maps made two centuries earlier, shows sailing ships in its ocean (see Harvey 1991, 68); see also the Andrea Bianco world map of 1436 (Bianco 1869). By the sixteenth century, monsters and ships filled the empty spaces on maps (Edson 1997, 16).
15. Manuscript illumination of the Whale, from the section "De Balena" (Bodleian Library, Oxford: MS Ashmole 1511, fol. 86r). See Morgan 1982, 1:64-65, and *Vollständige Faksimile-Ausgabe* 1982.
16. See the 1413 Mecia de Viladestes chart in Campbell 1987, 393 and 446, fig.19.22; and in Mollat and Roncière 1984, 205-206 and fig.12. Several sixteenth-century "whale" maps are reproduced in Portinaro and Knirsch 1987, esp. plates VII, XVI, XXVII, XL, XLI, XLIV, L, LV, LVII, LXVII.
17. Birney's phrases "the sly beast who sucks in/ with whirlwind" and "the redeless [who] topple in maelstrom" may recall Melville's use of "whirlpool" (660), "boiling maelstrom" (669), and "vortex" (685, 687) to describe the Pequod's sinking by Moby Dick.
18. One of the most beautiful star charts ever made is the "Sterre Kaert of

Hemels Pleyn" by Remmet Teunisse Backer, bound in Johannes van Keulen's *Boeck zee-kaardt* of 1709. On this map of the heavens, *Argo Navis* sails off while *Cetus Balena* straddles the celestial equator near the central line drawn through the vernal equinox (Stott 1991, 9 and 88-89). The position of *Cetus'* head on this Dutch chart bears an uncanny correspondence to the Pequod's terrestrial coordinates during its encounter with Moby Dick. For maps of Melville's novel locate the disaster near the intersection of the equator and the international date-line, that fateful place where past and present collide. (See the map in Herman Melville [1851] 1972, 1014-15, which places the disaster between Kingsmill Island ["On the line—East"] and Fanning Island ["On the line—West"].)

19. The name "Ania" is medieval and comes from Marco Polo's accounts, see *Travels* [1908] 1921, 331 n.1, where "Ania" is identified as Tung-ki(a)ng in eastern Manchuria, north of Japan.

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I dedicate this piece, with love, to another Canadian writer and poet, Jordan Zinovich, who lives his poetry and guides me with his maps.

Hillshading With Oriented Halftones

Hillshading renders a surface with a three-dimensional appearance using shades of gray. Although shades appear as continuous tones, they must undergo a halftoning process for use with most computer output devices. This process generally uses one pattern of black and white pixels for each shade of gray, while attempting to make patterns associated with black and white pixels as difficult to detect as possible.

The method described in this paper adds aspect information to hillshaded maps with oriented halftones. Twelve orientations of clustered-dot ordered dithers represent 30° intervals of aspect. Additionally, dithering matches sixteen shades of gray associated with analytical hillshading, with each interval representing 16 of 256 shades of gray. This process allows pattern and gray tone representations of the surface simultaneously.

Hillshading is a cartographic technique that has been used to represent continuous surfaces with shades of gray for hundreds of years (Imhof, 1982; Horn, 1981; Horn, 1982; Robinson *et al.* 1995). The tonal variations on the resulting map give the impression of a three-dimensional surface (Clarke, 1995; Horn, 1981; Horn, 1982). This effect is based on chiaroscuro, the interplay of light and shading commonly used by Renaissance artists (Burrough and McDonnell, 1998; Horn, 1981; Horn, 1982). To achieve this effect, the cartographer selects a direction of illumination and makes surface elements most directly illuminated bright and those more obliquely illuminated increasingly dark. Such hillshading uses the Lambertian assumption of an ideal diffuse reflector approximated by a matte surface. A brightness value is calculated for each surface element based on the cosine of the angle θ between the selected illumination vector and the normal vector for each surface element.

Historically, cartographers working with hillshading focused on the methods of producing this effect, but also needed to concern themselves with the technologies for reproducing the maps. The hachure method devised by Lehmann (1799) used fine lines drawn in the direction of steepest topographic gradient. It was widely used because copper engraving, a popular reproduction technique for maps at the time, could not reproduce continuous shades of gray, but worked well for black lines on white paper to approximate grayscales. Only after the patent of the halftone screen in 1865 and the crossline screen in 1869, did lithographs that allowed the continuous variations of shades of gray become a commercial success (Horn, 1981; Horn, 1982).

Computer cartographers working with hillshading also necessarily concerned themselves with reproduction methods. Before plotters could output continuous shades of gray, researchers automated two methods devised by Tanaka (1932 and 1950) that used contour lines to approximate the hillshading effect. Peucker *et al.* (1972) were the first to automate these methods. An alternative algorithm for Tanaka's orthographic relief method was later suggested by Yoeli (1976). Brassel *et al.* (1974) devised a

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INTRODUCTION

"Historically, cartographers working with hillshading focused on the methods of producing this effect, but also needed to concern themselves with the technologies for reproducing the maps."

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“Printed maps with hillshading are not continuous tones of gray, but are composed of black halftones on white paper that give this illusion.”

method for creating the hillshading effect with a special character set on a line printer. Finally computer cartographers were able to reproduce hillshading maps with continuous shades of gray with new gray tone plotters (Peucker *et al.*, 1974).

With the ease of computer-based hillshading methods and the availability of continuous tone plotters, hillshaded maps have been produced and reproduced widely. From a cartographic perspective, current hillshading methods are the solution to surface rendering with the Lambertian assumption. From a computer graphics perspective, however, part of the reproduction method could be exploited to add information to the map. Printed maps with hillshading are not continuous tones of gray, but are composed of black halftones on white paper that give this illusion. The method developed and discussed here assigns different orientations to halftone patterns based on the aspect of the surface, matches shades of gray based on the hillshading values, and combines pattern and shading in a single hillshaded map.

PREVIOUS CARTOGRAPHIC RESEARCH

Variations in tone have been used to create the hillshading effect greater than or the same resolution as the data being mapped. Hillshading greater than the resolution of the data frequently used black point symbols on a white background, while hillshading at the resolution of the data frequently used continuous shades of gray.

Eckert (1921) used dots of various sizes to create a hillshaded map of the Lake Lucerne region of Switzerland (see **Figure 1**). With his use of

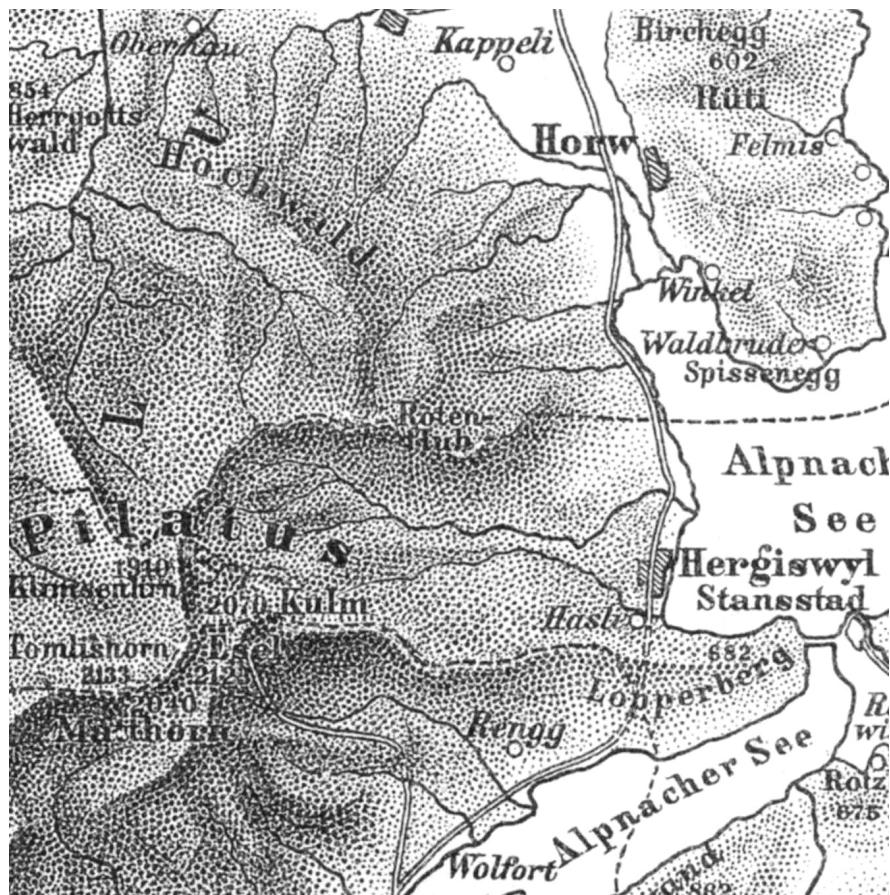


Figure 1. A portion of Max Eckert's dot map of the Lake Lucerne region of Switzerland. (From Eckert (1921) with permission from Walter de Gruyter publishers, Berlin)

large and small dots, the landscape has the appearance of an enlargement of a halftone image printed by press. These macroscopic dots proved difficult to draw, overloaded the map, and never found popular use (Imhof, 1982).

Vertical hachures were used widely in the first half of the 19th century. Lehmann (1799) quantified a method by which large-scale hachures could be drawn in the direction of slope, with the thickness of the hachure being proportional to the steepness of the slope. The hachure method with an oblique illumination effect reached its cartographic and artistic apex with the Swiss "Dufour" maps (see **Figure 2**). The first editions of these 25 hachure maps were published at 1:100,000 by the Swiss Federal Office of Topography between 1845 and 1865 (See <http://www.swisstopo.ch/en/maps/ak/tk.htm> for more detail).

The process was computer-automated by Yoeli (1985) (see **Figure 3**). Both manual and computer hachure methods were based on a contour framework. Although relating hachures to the resolution of the data is difficult, it would be fair to say that the hachures were less detailed than the contours from which they were created. Kennelly and Kimerling (2000) automated a method for creating small-scale hachure maps based on regularly spaced points instead of a contour framework (see **Figure 4**). These hachures are well above the resolution of the data, with Digital Elevation Model (DEM) grid cells first aggregated into 3x3 grid cells, then each new grid cell represented by a single hachure.

Horizontal hachures can also create tonal variations associated with hillshading (Imhof, 1982). Instead of lines in the direction of maximum slope, horizontal hachures are lines in the direction of no change in elevation (see **Figure 5**). These horizontal form lines are similar to contours,

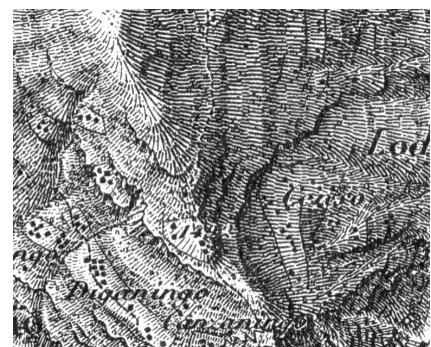


Figure 2. A portion of a large-scale topographic map using hachures to represent topography. (From Sheet 19 [1858], Switzerland, 1:100,000, the "Dufour map.")



Figure 3. A computer-automated large-scale topographic map south of Haifa, Israel using hachures to represent topography (From Yoeli (1985) with permission from the Cartographic Journal).



Figure 4. A computer-automated small-scale topographic map of Mt. Adams, Washington using hachures to represent topography (From Kennelly and Kimerling (2000) with permission from Cartographic Perspectives).

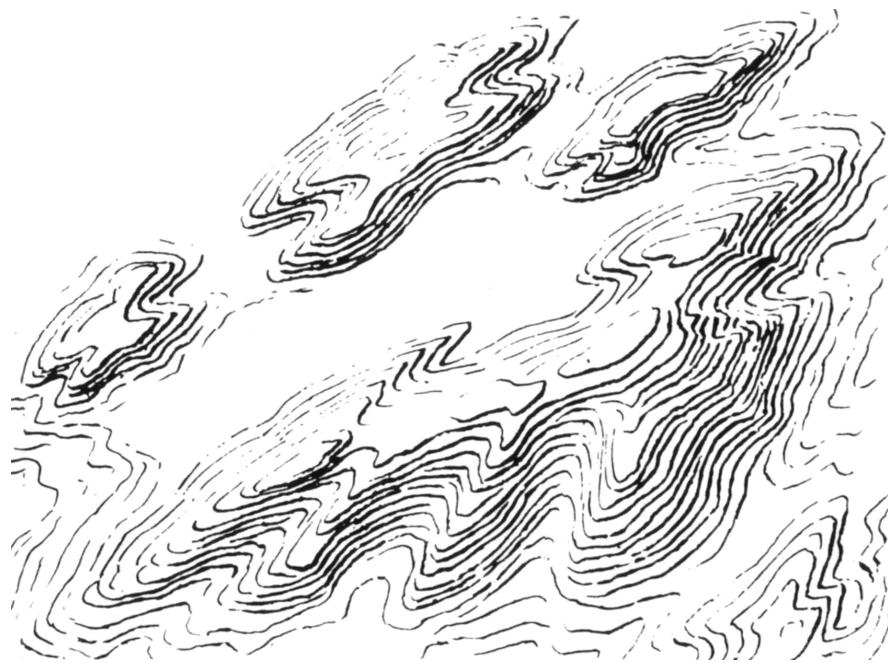


Figure 5. An example of horizontal hachures (From Imhof (1982) with permission from Walter de Gruyter publishers, Berlin).

but more compactly and evenly arranged, not assigned an exact elevation value, and vary in thickness based on hillshading values. Horizontal hachures were often used in the 19th century, but are not commonly used today.

Hillshading with tonal variations at the resolution of the data includes both manual and computer automated methods. Manual hillshading, like hachuring, often was based on a contour framework, with shades of gray interpreted at and between contour lines (Imhof, 1982; Yoeli, 1959). This method created striking portrayals of topography when used by skilled cartographers (Imhof, 1982).

Computer-based hillshading often operates on a DEM, with the angle and resulting shade of gray calculated for each grid cell. Although a straightforward process (Peucker *et al.*, 1974), the earliest development of the method was nearly thwarted due to technological constraints. Yoeli (1965) used an early computer technology to calculate hillshading values for a 25x25 topography grid, but had no way of outputting his results without a gray tone plotter. Undaunted, he screened a gray wedge of ten classes, cut the screen into 2 cm. squares, and created a mosaic based on the computed hillshading value of each grid cell. Next, Yoeli (1966) related the light intensity calculated for hillshading with the density of black dots a white background. Finally, Yoeli (1967) was able to use a computer-controlled electronic typewriter to print and overprint desired characters into each cell of a hillshaded grid (see Figure 6). In this manner, he could match 20 shades of gray from dot densities to the brightness values associated with hillshading.

Inherent differences stand out between methods greater than or the same resolution as the data. Hachuring results in strong patterns associated with the form of the topography. Hachuring, however, results in a map that only approximates values calculated for hillshading with the Lambertian assumption. Hillshading results in smooth variations in shades of gray. Patterns (e.g. hachures, contours) have been overprinted on hillshading, but cartographers have never attempted to use hillshading itself to

"Patterns (e.g. hachures, contours) have been overprinted on hillshading, but cartographers have never attempted to use hillshading itself to create patterns."

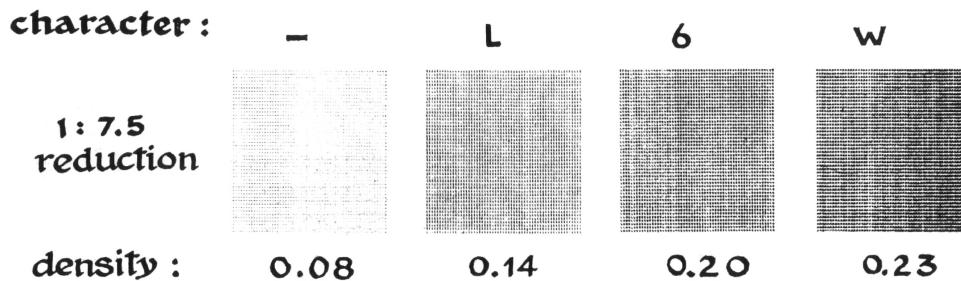


Figure 6. Examples of various densities of gray represented by repetitive printing of a single character within a grid cell (From Yoeli (1967) with permission from the Cartographic Journal).

create patterns. This project describes how this can be implemented with digital halftones.

In the field of computer graphics, shading or rendering includes illumination models for diffuse reflectors that are identical to cartographic hillshading techniques using the Lambertian assumption (Shirley, 2002; Hearn and Baker, 1994; Zhou, 1992; Foley *et al.*, 1990; Rogers, 1985). Cartographers and computer graphic professionals, however, often render different sorts of data. Cartographers render detailed elevation data, which reveals small scale geometry and large scale detail of the landscape. Computer graphic professionals often use geometric shapes approximated with polygonal surfaces (Shirley, 2002; Hearn and Baker, 1994; Foley *et al.*, 1990). Resulting edges at surface boundaries are smoothed using a number of interpolated shading methods, such as Gouraud shading. (Hearn and Baker, 1994; Foley *et al.*, 1990; Rogers, 1985). Cartographers also have used Gouraud shading to smooth edges of topographic models (Weibel and Heller, 1991).

Surface details often are added to computer-rendered graphics, as "smooth, uniform surfaces [appear] in marked contrast to most of the surfaces we see and feel." (Foley *et al.*, 1990, 741). Two general methods are used to map texture onto a smooth surface, one a mathematical mapping function and the other a perturbation function (Rogers, 1985). Two dimensional texture mapping uses a coordinate transformation to map a pattern or image onto a surface (Shirley, 2002; Foley *et al.*, 1990). The resulting graphic continues to appear geometrically smooth and may not follow patterns associated with principles of shading.

Bump mapping overcomes this problem by adding irregularities to the surface before shading. Foley *et al.* (1990) explain; "A bump map is an array of displacements, each of which can be used to displacing a point on a surface a little above or below that point's actual position" (744). In practice, bump mapping perturbs the surface normal vector before shading is calculated using mathematical functions, including ones that are random or periodic (Hearn and Baker, 1994). In this manner, correctly shaded texture can be added to a surface.

Patterns can be added to smooth surfaces with texture and bump mapping, but no new information is added from the original surfaces. Patterns based on data can be displayed on rough topographic surfaces, adding new information from the original surface. One method for adding texture is through the use of derivatives of the DEM, such as fractals (e.g. Clarke, 1988). McCullagh (1998) points out one issue with using a regional statistical value on individual cells; "The roughness introduced into the landscape may be statistically correct and visually effective but will not be locationally accurate" (102).

COMPUTER GRAPHICS AND HALFTONES

"Surface details often are added to computer-rendered graphics, as 'smooth, uniform surfaces [appear] in marked contrast to most of the surfaces we see and feel.'"

"Patterns can be added to smooth surfaces with texture and bump mapping, but no new information is added from the original surfaces."

"Halftoning may use ordered or random dithers, with ordered dithers allowing control over the dithering pattern."

The method used in this project addresses this concern, by basing texture on local derivatives of the DEM, which vary at each grid cell. The local variable is the aspect direction, the same variable used in hachure maps. The detailed texture is created with digital halftones.

Ulichney (1987) states "Digital halftoning, also referred to as spatial dithering, is the method of rendering the illusion of continuous-tone pictures on displays that are capable of producing only binary picture elements." (xiii). Halftoning may be necessary for video displays that are implemented with frame buffers that limit gray scale capability, and are almost always necessary for raster images with computer hard copy devices (Ulichney, 1987).

Halftoning may use ordered or random dithers, with ordered dithers allowing control over the dithering pattern. Ordered dithers can be clustered or dispersed. Clustered dithers are used in this project, as "a clustered-dot halftoning mimics the photoengraving process used in printing, where tiny pixels collectively comprise dots of various sizes" (Ulichney,

Classical Halftones

%Gray

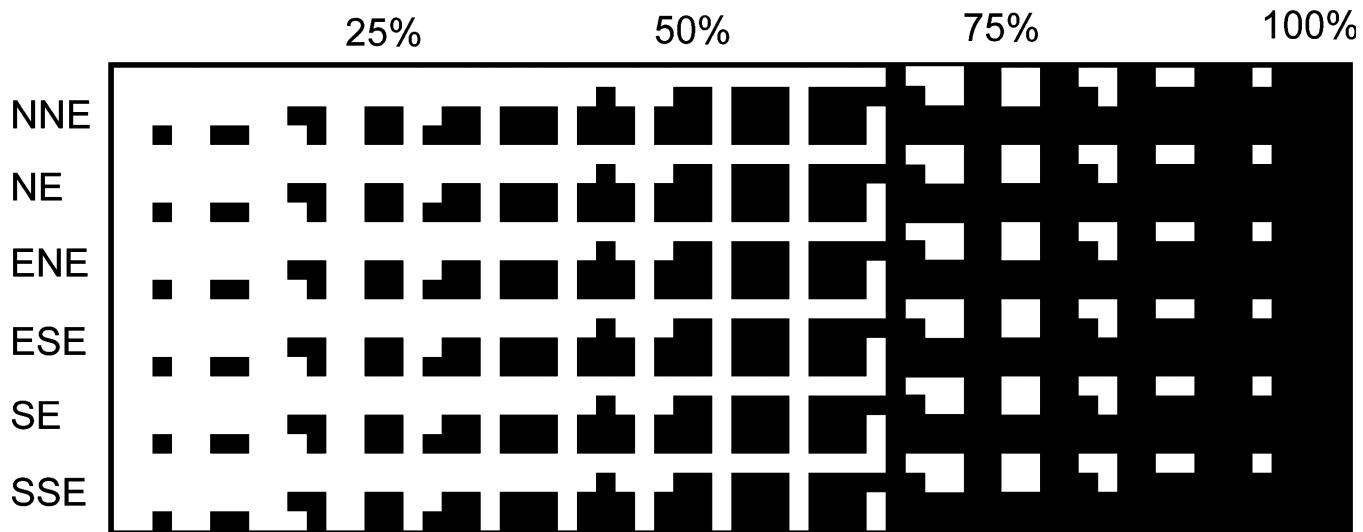


Figure 7. A classical clustered-dot ordered dither representing 16 shades of gray. (Modified from Ulichney (1987); Figure 5.5 on page 88).

"Sometimes a pattern is desirable."

1987, 3). This type of halftoning is referred to as the "classical", graphic arts, or printer's screen (see Figure 7).

This classical monochrome screen is often oriented at a 45° angle from the edge of the video screen or paper. This orientation is generally considered to result in the least visual disturbance or a minimum in perceptual sensitivity (Robinson *et al.*, 1995; Ulichney, 1987). Sometimes a pattern is desirable. Computer graphic professionals use clustered-dot line screens to create a halftone special effect (Ulichney, 1987). The linear dithering resulting in one pattern across the entire image, but adds no additional information to the display.

Computer graphic professionals have manipulated the orientation of individual halftones in various ways. Sloan and Wang (1992) oriented halftones based on the information contained in grayscale images. They



Figure 8. An image with halftones oriented in the direction of gradient of gray values (From Sloan and Wang (1992) with permission from SPIE).

choose locally different ordered dithers based on measures of local variations in values of gray (see **Figure 8**). Their rationale is that this method provides “an extra channel that we can use to convey information about the image” (149).

A more difficult problem is orienting halftones base on three dimensional (3D) geometries in virtual scenes. Sloan and Wang’s (1992) research begins with a grayscale image, devoid of information on the 3D geometry captured in the image. Saito and Takahashi (1990) began with a 3D computer graphics model and stored orientation information in a series of geometric buffers (g-buffers). Information on many different geometric components of a virtual scene is often stored in this manner. This method was modified by Haeberli (1990) to orient the pattern of brushstrokes for virtual 3D scenes. Veryovka and Buchanan (1999) used g-buffers to orient halftones on an image of a 3D model based on its geometry. Haeberli (1990) and Veryovka and Buchanan (1999) used complex raytracing algorithms to define the geometry of the objects in the virtual scene.

The method outlined in this paper includes geometric information derived from a 2.5 dimensional surface, one in which each grid cell has a unique z-value. A hillshaded image can contain multiple grid cells of one shade of gray that represent any or all aspect directions. An example is a map of a conical hill under vertical illumination. The entire hill would be shaded with the same tone of gray. With a constant gray value, no pattern would be added to this hillshaded image with Sloan and Wang’s (1992) method. The only geometric information needed to orient halftones to create patterns similar to hachure maps is the aspect of each grid cell. The methodology for creating such maps is described below.

This project computes hillshading from DEMs and reclassifies the resulting 256 shades of gray into 16 equal interval classes. Aspect is calculated from the same DEMs and the resulting 360 degrees of aspect values

“Haeberli and Veryovka and Buchanan used complex raytracing algorithms to define the geometry of the objects in the virtual scene.”

“The only geometric information needed to orient halftones to create patterns similar to hachure maps is the aspect of each grid cell.”

"The vertical and horizontal hachure textures cut across shades of gray."

"Areas of moderate gray tone (i.e. moderate number of black halftones) show pattern most clearly."

are reclassified into 12 equal interval classes. The grids are converted into one point coverage containing hillshading and aspect information. Each point then is displayed with a 4x4 bitmap based on its aspect and hillshading classes.

Bitmaps are constructed for each of the 192 combined classes. The number of black pixels (1-16) matches the classes of gray associated with hillshading. The patterns of the pixels are based on the aspect direction. North-south and east-west aspect patterns are not used, as the resulting linear patterns are too distracting. Identical patterns are used for aspect directions of northeast and southwest, etc. Thus only 96 unique bitmap patterns are constructed.

Ordered clustering of individual halftones can approximate vertical or horizontal hachuring using the same bitmaps. The arrangements for various orientations to create a vertical hachuring effect are shown in **Figure 9** and those for a horizontal hachuring effect are shown in **Figure 10**. Both figures show only the 96 unique halftones used to pattern the eastern aspect directions; the western aspect directions would be a reflection of these across a vertical plane.

These halftone patterns are applied first to a gridded hemisphere composed of 170x170 grid cells and shaded from the northwest. A hemisphere is used because of its smooth variations in aspect and hillshading, as well as its easily recognized form. Any discontinuities in halftone shades or patterns should be obvious on the hemisphere. The hemisphere is dithered with the classical halftone pattern in **Figure 11**, the vertical halftone pattern in **Figure 12**, and the horizontal halftone pattern in **Figure 13** (compare with **Figures 7, 9 and 10** respectively). Although the 12 classes of aspect can be discerned, distracting apparent changes in shades of gray between various aspect classes are minimal.

The vertical and horizontal hachure textures cut across shades of gray. This result is expected, as halftone orientation is based on aspect direction and gray tone is based on hillshading. If Sloan and Wang's (1992) method are applied to this image of a hemisphere, halftone patterns would follow changes in gray and be coincident with the concentric areas defined by hillshading.

These same halftone patterns are then applied to a DEM of a portion of the Sweet Grass Hills of north-central Montana illuminated from the northwest. This area was chosen because the landform shows frequent variations in aspect direction associated with peaks, ridges, and valleys. Also, the area is covered by a good quality DEM. The portion of this DEM is composed of 170x170 grid cells, each 30x30 meters. **Figure 14** shows the original hillshading of the DEM with all 256 shades of gray. **Figure 15** shows the shades of gray reclassified into the 16 classes used in the dithering processes. Although only 16 shades of gray are displayed, each is dithered at a much finer resolution by the printing process than the dithered images in subsequent figures.

The DEM is dithered with the classical halftone pattern in **Figure 16**, the vertical halftone pattern in **Figure 17**, and the horizontal halftone pattern in **Figure 18** (again, compare with **Figures 7, 9 and 10** respectively). Although the dithered appearance is inescapable, all three figures match the 16 shades of gray in **Figure 15**.

If areas of similar aspect in **Figure 17** are large enough, the method effectively applies a vertical halftone pattern. Areas of moderate gray tone (i.e. moderate number of black halftones) show pattern most clearly. Regional and local peaks, as well as stream intersections, appear as divergent or convergent patterns. Some stream valleys and ridgelines appear as a

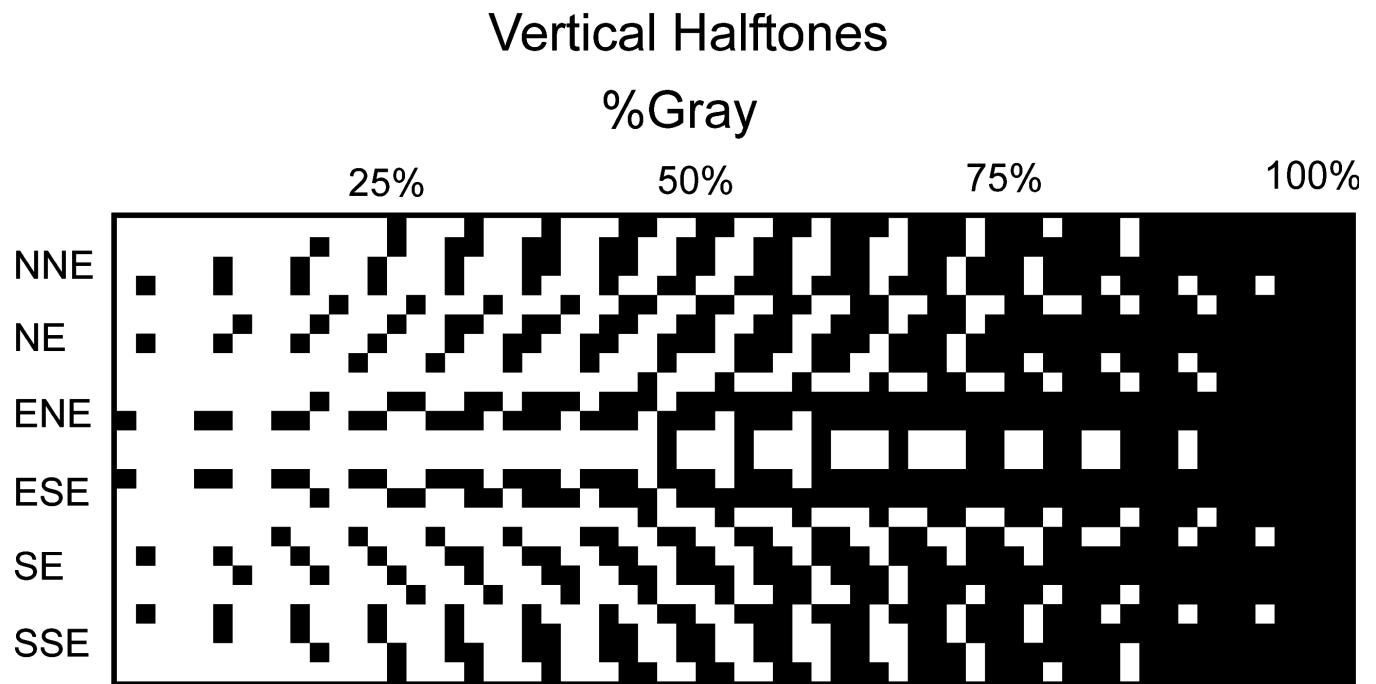


Figure 9. A dithering pattern for halftones oriented in the direction of aspect.

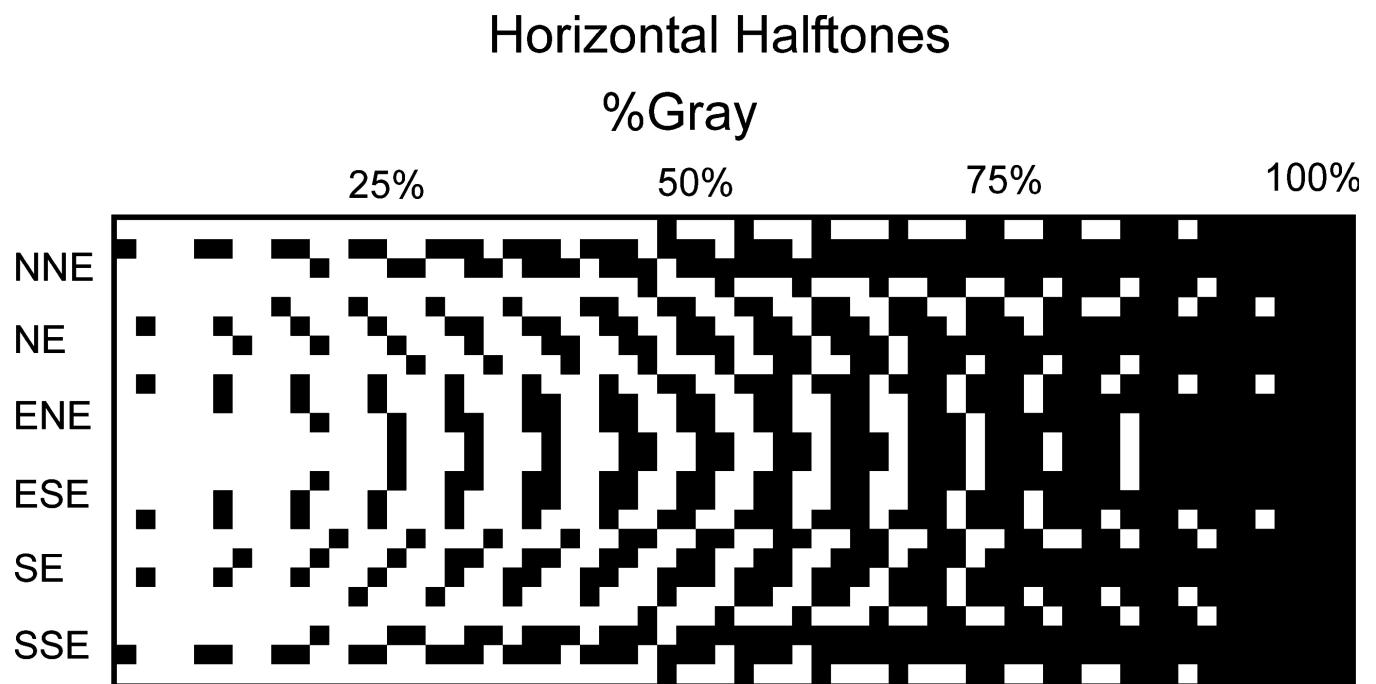


Figure 10. A dithering pattern for halftones oriented perpendicular to the direction of aspect.

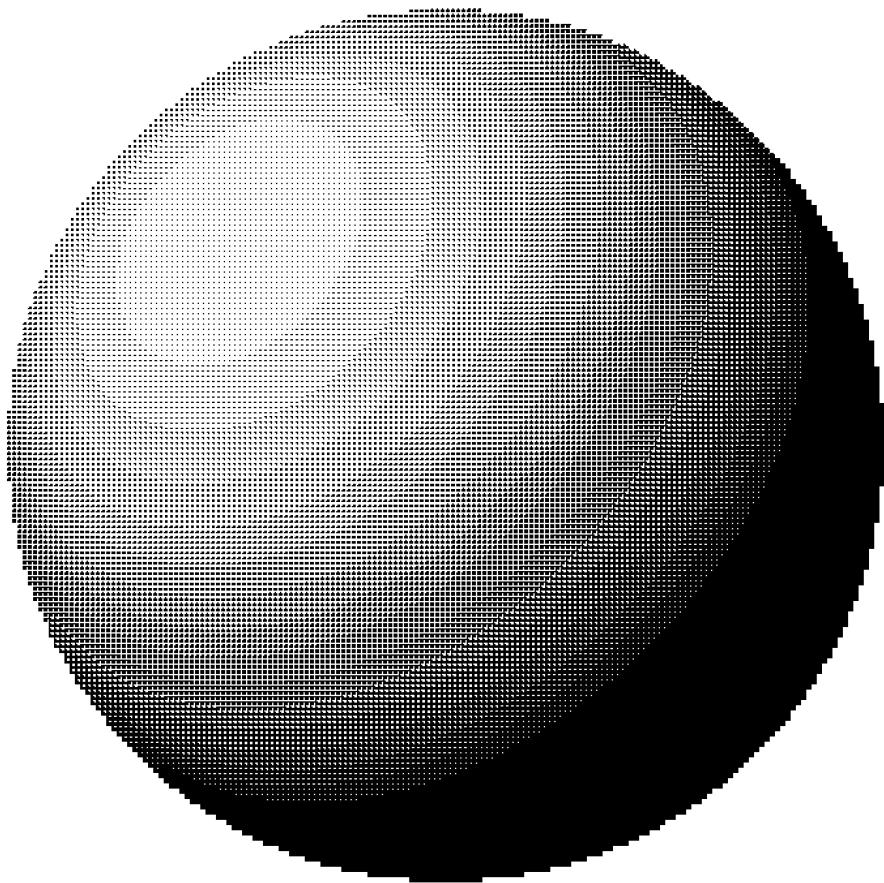


Figure 11. A hillshaded hemisphere dithered with the classical halftone pattern from Figure 7.

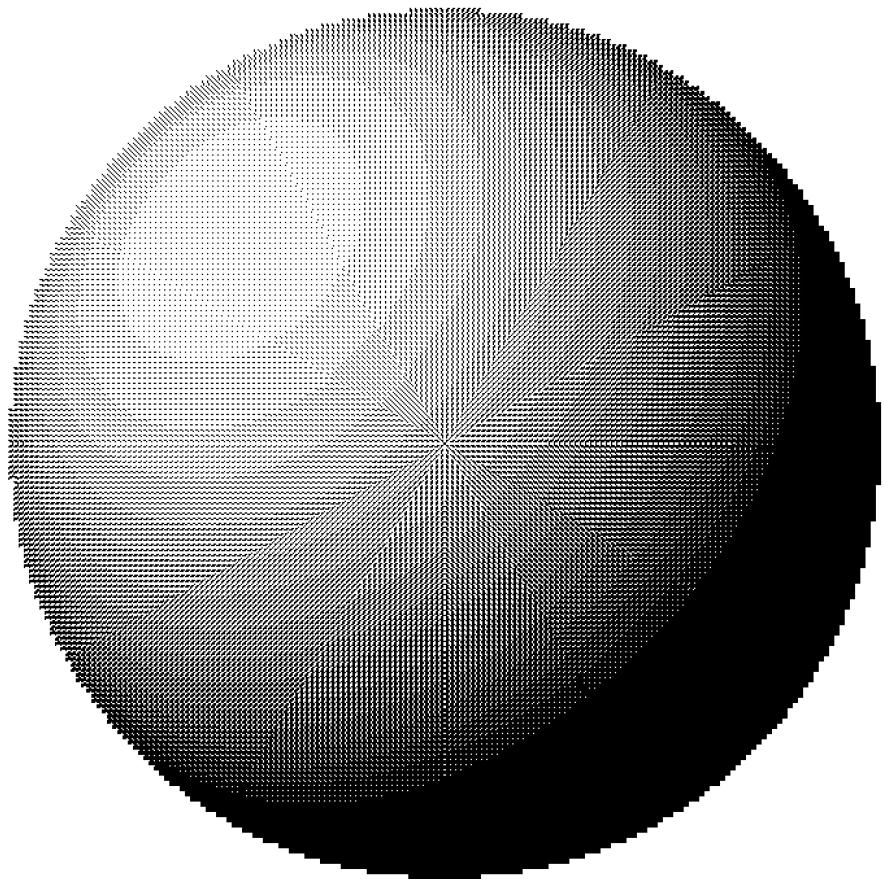
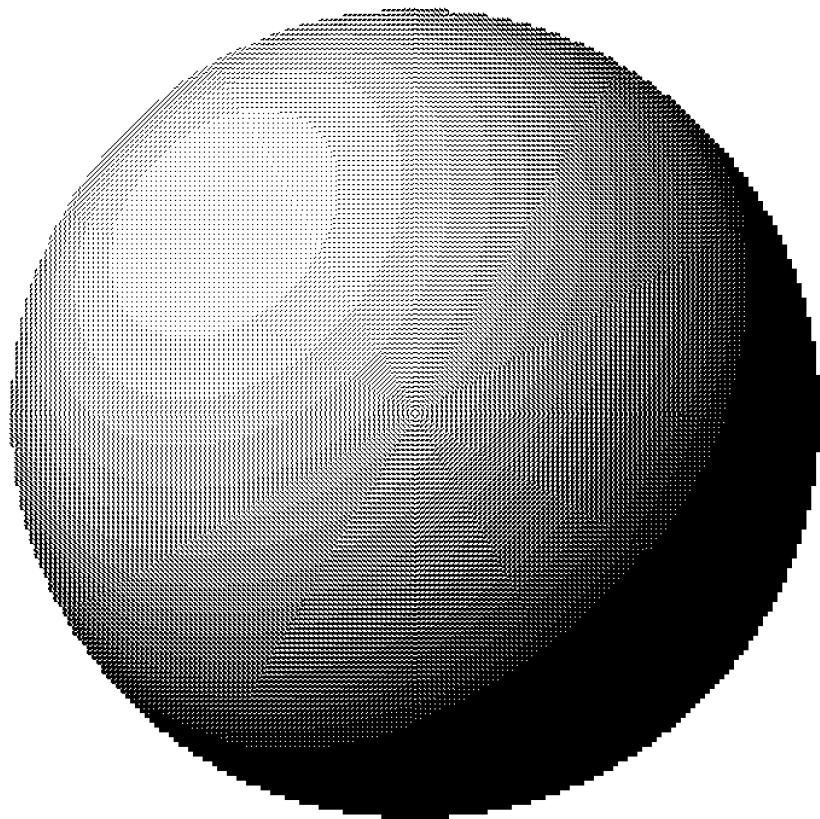


Figure 12. A hillshaded hemisphere dithered with the halftone pattern from Figure 9 oriented in the aspect direction.

Figure 13. A hillshaded hemisphere dithered with the halftone pattern from Figure 10 oriented perpendicular to the aspect direction.



single line, with divergent halftone patterns on either side. Valleys tend to form V's pointing downstream, as is the case with traditional hachures.

Figure 18 shows patterns associated with horizontal hachures. Areas of similar aspect with moderate hillshading values again show the most obvious patterns. Regional and local peaks appear as nearly closed forms. Valleys are delineated by a series of V's that point in the upstream direction, as is the case with horizontal hachures and contours.

Strongly and weakly illuminated landforms are not well delineated by this method. For example, strongly illuminated valleys are light gray and are composed of few black halftones. These few black squares are unable to create the patterns described above. In a similar manner, nearly black area with a few white squares would not be effective at creating pattern.

Limiting the classes of aspect to 12 has a noticeable effect on the resulting maps (see **Figures 17 and 18**). Overall, patterns tend to be angular rather than smooth. An obvious artifact results from aspect patterns of northeast, southwest, southeast, and northwest occurring exclusively over a large enough area. Examples of this artifact can be seen in the southeast and east-central portion of these maps. Such artifacts can be smoothed using various computer graphic techniques, the most common of which is error diffusion (Strothotte and Schlechtweg, 2000; Ulichney, 1987). Error diffusion would improve the look of such images, but also introduces additional noise into the display.

One way to improve the appearance of these maps would be to increase the resolution of the bitmaps that represent each point. If bitmaps were 16x16 pixels, 60 directions of aspect could be used (again avoiding

"Error diffusion would improve the look of such images, but also introduces additional noise into the display."

DISCUSSION

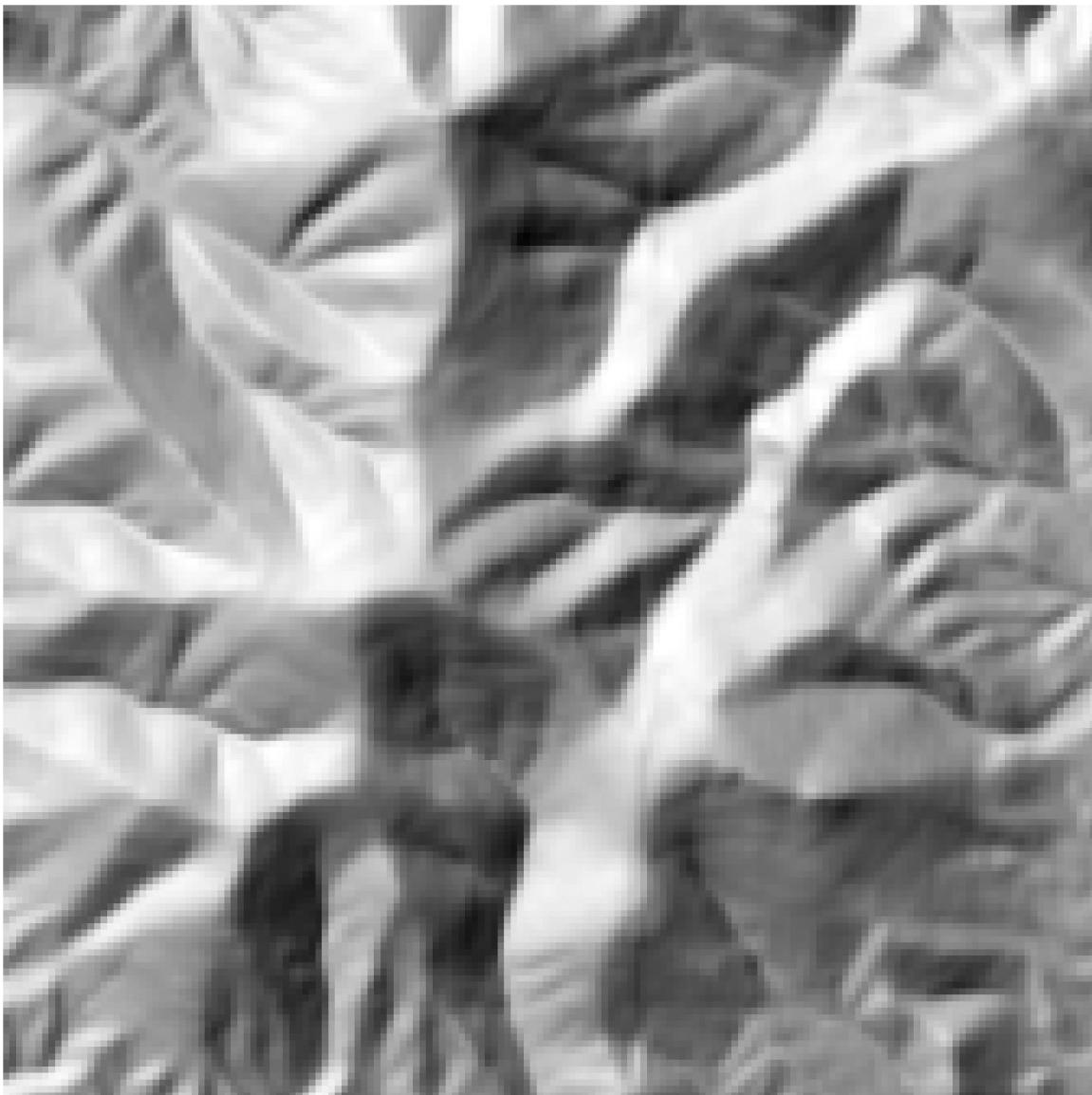


Figure 14. A hillshaded map of the Sweet Grass Hills of north-central Montana using 256 shades of gray.

"An alternative approach would be to design and use a series of vector-based point symbols, with each point symbol precisely representing grayness."

north, south, east and west orientations). This would decrease the interval of each aspect class to 6° (from the interval of 30° in **Figures 17 and 18**). This method also would allow unique representation of 256 shades of gray, but require 3,840 unique bitmaps.

An alternative approach would be to design and use a series of vector-based point symbols, with each point symbol precisely representing grayness. Such point symbols can be designed as characters in a true type font and converted into point symbols. Vector-based point symbols would be high resolution, unlike the pixellated bitmaps used in this project. Additionally, only 16 point symbols would be required to match shades of gray used in this paper, because all vector-based point symbols could be rotated by 1 degree increments of aspect. The effect would be similar to **Figure 4**, but grayness would more closely match exact hillshading values.

The issue with such an approach is that point symbols rotated around an axis at the center of a square grid cell can overlap neighboring point symbols. This overlap would decrease the overall darkness of the shad-



Figure 15. A hillshaded map of the Sweet Grass Hills of north-central Montana using 16 shades of gray.

ing over various parts of the map. A simple example showing one point symbol in two rows of square grid cells representing two aspect directions is illustrated in **Figure 19**. The relative brightness is increased by more than 20% in the lower row due to overlap of the black point symbol upon rotation.

The resolution of **Figures 17 and 18** is approximately 160 dots per inch (dpi) for individual black and white pixels. If each clustered dither is considered a dot, the resolution is approximately 40 dpi. The desired resolution is somewhat higher than 40 dpi, and was chosen to allow map users to resolve the shapes associated with the clustered pixels so that (s)he can identify the pattern.

Cartographers have not studied the ability of map users to identify patterns of dithering in hillshaded maps. Cartographers, however, have looked at the ability of map users to perceive pattern in gray area symbols composed of black dots on a white background. Although they were looking at a different issue, their results on the scale at which pattern can and cannot be perceived may serve as a starting point for the scale of display-

"Cartographers have not studied the ability of map users to identify patterns of dithering in hillshaded maps."

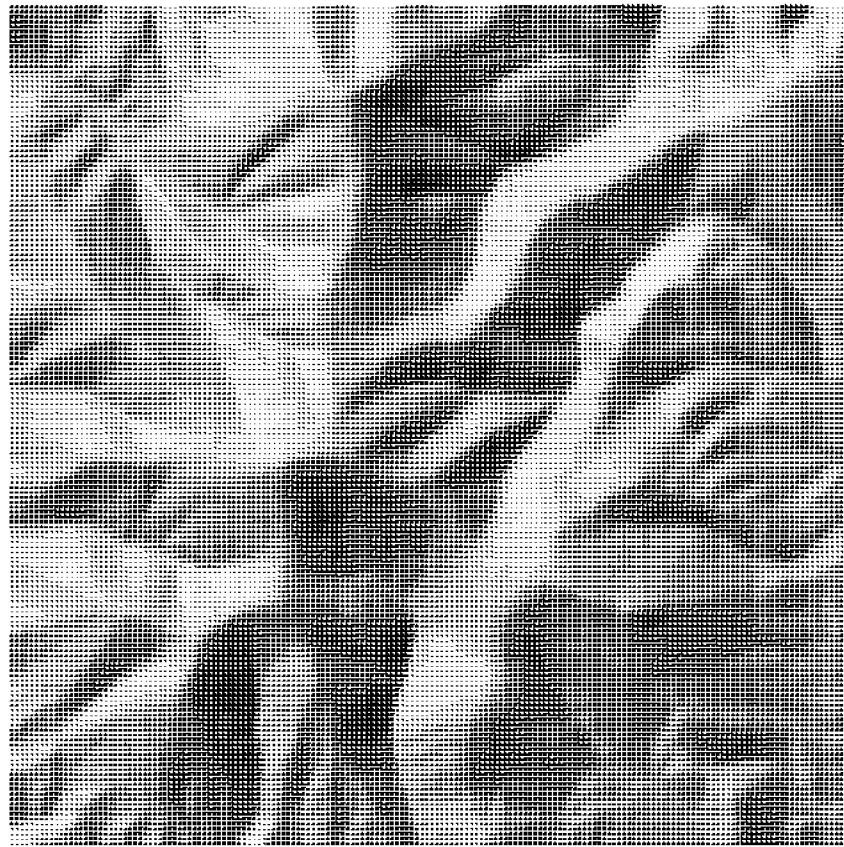


Figure 16. The same hillshaded map in Figure 15 dithered with the classical halftone pattern from Figure 7.

"MacEachren . . . distinguishes between the issues of discrimination, the ability to recognize a difference, and detection, the problem of discriminating between some signal and the background on which that signal appears."

ing oriented halftones with this method.

Castner and Robinson (1969) studied the map user's ability to discriminate a pattern in gray area symbols created from black dots on a white background. They determined that below 40 lines per inch (lpi = dpi) most map users perceived the patterns of dots and not the grayscales, above 75 lpi they perceived gray tones and not patterns, and between these resolutions they perceived both.

MacEachren (1995) also discusses gray area tones comprised of dot patterns. He distinguishes between the issues of discrimination, the ability to recognize a difference, and detection, the problem of discriminating between some signal and the background on which that signal appears (p. 124). He identifies ambiguous patterns at resolution between 40 and 85 dpi, where fills can be seen as either shades of gray or textures (p. 125).

Figures 17 and 18 are meant to have such ambiguous patterns. The goal of this method is to create hillshaded maps in which the map user can see both shades of gray and patterns in the halftones that create the shading. An additional issue with ambiguous patterns with important implications to this method may be that such patterns can be seen as gray or textured, but not both at once (MacEachren, 1995, 125).

CONCLUSIONS

This paper explains a method for hillshading that uses different patterns for 12 classes of aspect, each comprised of 16 shades of gray. The clustered-dot ordered dithers form patterns similar to those in vertical and horizontal hachure maps. Dithering with this method allows patterns



Figure 17. The same hillshaded map in Figure 15 dithered with the halftone patterns from Figure 9 oriented in the aspect direction.

at the resolution of the input data, while matching classes of gray determined by hillshading.

Creating accurate hillshaded maps with continuous shades of gray has twice been a goal of cartographers, first with hand-rendered and then with computer-generated maps. The computer reproduction technique of halftoning adds a new control to shading. Halftones, the elemental building block of computer hardcopy displays, can be used to create a pattern, while maintaining the grayscales determined from hillshading.

The author welcomes users to experiment with this method and the resulting images. Copies of the bitmaps used for **Figures 7, 9 and 10** and the ESRI ArcView legend files (.avl extension) used to create **Figures 16, 17, and 18** can be downloaded from http://www.mbm.mtech.edu/gis_hillshading.htm. This website also includes GIS based methods for automating the methods of hachure mapping and those developed by Tanaka (1932 and 1950) that are discussed in this paper. For other recent applications of hillshading methods, see the NACIS Shaded Relief Homepage maintained by Tom Patterson at <http://www.nacis.org/cp/cp28/resources.html>.

The author would like to thank Dr. Robert Ulichney, Dr. Kenneth Sloan, and Vincent Cotter for early comments and suggestions on this halftoning method, and Dr. Jon Kimerling for his perusal of the initial manuscript. Thanks also to *Cartographic Perspectives* editor Dr. Scott Freundsuh and

ONLINE RESOURCES

ACKNOWLEDGEMENTS



Figure 18. The same hillshaded map in Figure 15 dithered with the halftone patterns from Figure 10 oriented perpendicular to the aspect direction.

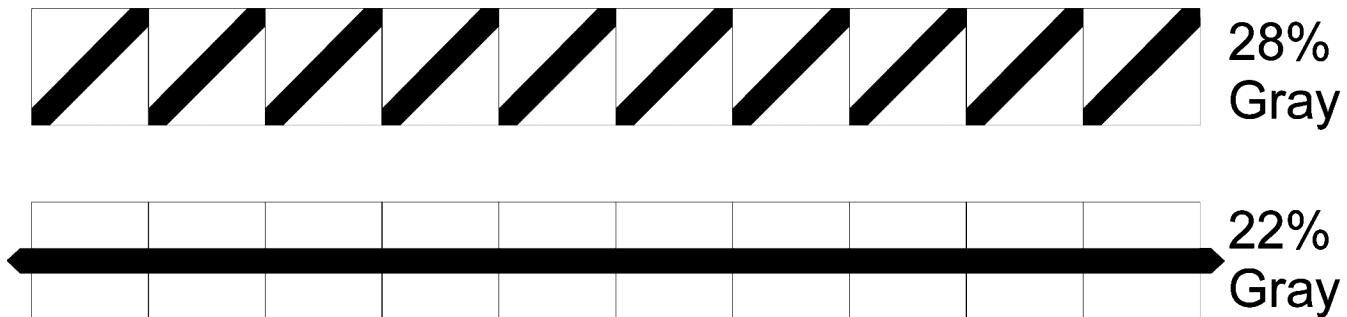


Figure 19. Two rows of vector-based point symbols centered in square grid cells. Symbols in the second row have been rotated 45° clockwise around the center of the grid cells. Overlap of the black point symbols in the second row results in a decrease in overall darkness between rows from 28% gray to 22% gray, a relative change of more than 20%.

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Getting Real: Reflecting on the New Look of National Park Service Maps

To make more inviting and understandable maps for general audiences, the U.S. National Park Service has been experimenting with cartographically realistic map design. Using rasterized geodata and unconventional image processing techniques, cartographic realism draws inspiration from traditional cartographic art, modern graphic design, observations of nature, and aerial photograph maps. The aim is to combine the best characteristics of imagery and maps into a more intuitive hybrid product. Discussed techniques include aquafication, texture substitution, illuminated relief, and outside land muting.

Keywords: Cartographic realism, park landscapes, shaded relief, illuminated relief, cartographic art, Walensee, aerial photograph maps, Aitutaki, raster map design.

Note on illustrations: The online version of this paper (www.nacis.org/cp.html) contains color illustrations. Map samples of the described techniques are located in the color section at the back of this issue.

This paper examines the techniques being developed by the U.S. National Park Service (NPS) Harpers Ferry Center for designing plan (2D) maps with a faux realistic look. The NPS produces tourist maps for 388 parks in a system spanning a large swath of the Earth's surface from the Caribbean to Alaska to the South Pacific, and which is visited by nearly 300 million people each year. Many park visitors are inexperienced map readers and non-English speakers. In our ongoing effort to make NPS maps accessible to everyone, the design of NPS maps has become less abstract and increasingly realistic, particularly in the depiction of mountainous terrain and natural landscapes (Figure 1). Many of the techniques discussed herein are borrowed from or inspired by 3D mapping (Patterson, 1999). However, the scope of my paper deals exclusively with plan mapping—a format that has received scant attention in the digital era in regard to abstract vs. realistic depiction compared to the 3D world. It is also the format in which the majority of NPS maps will continue to be made.

Cartographic Realism

As one would expect, the term "realism" occurs frequently throughout this paper. It is important to define the meaning of this term in the cartographic context before continuing. *Webster's New World Dictionary* defines realism, in the artistic sense, as:

The picturing in art and literature of people and things as it is thought they really are, without idealizing.

Applying this definition to maps is problematic because all maps (and even many remotely sensed images) are idealized representations of the Earth and are inherently abstract. On the other hand, most of us would agree that some maps appear more realistic and are more intuitively comprehensible than others. For example, a shaded relief map with terrain represented by softly modulated light and shadows appears more realistic than a contour map with a multitude of isolines connecting points of equal

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INTRODUCTION

"In our ongoing effort to make NPS maps accessible to everyone, the design of NPS maps has become less abstract and increasingly realistic, particularly in the depiction of mountainous terrain and natural landscapes."

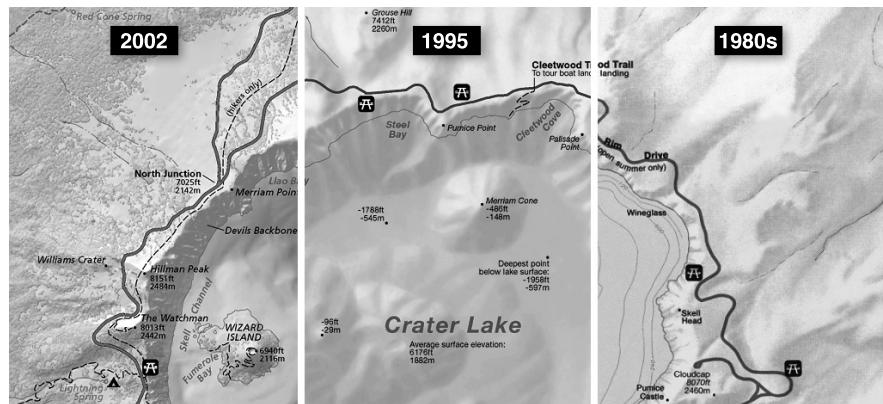


Figure 1. Crater Lake, Oregon. (right to left) NPS maps have become more accurate, detailed, and cartographically realistic in appearance over the past two decades, while at the same time retaining their familiar clean design. The 1980s map uses isobaths to show depths in Crater Lake, the only elevation isolines ever to be published on an NPS map. The 1995 map uses hand-drawn bathymetry. The 2002 map, produced entirely from digital sources, combines a forest cover texture with shaded relief.

"Faux realism has become ubiquitous in almost every graphical medium today from tele-vision to print publishing to multimedia."

"... realistic maps have the potential to communicate more efficiently to a greater number of users. Think of this as the cartographic implementation of universal design."

elevation value. The ersatz realism one sees on a map—which I will call “cartographic realism”—is not reality, but is instead a graphical representation. The snow on the ground outside my window as I write this is real. The white coloration representing snowy mountain peaks on the topographic map of the Alps on my wall is cartographic realism. This being a paper about map design, use of the term “realism” throughout the following discussion is solely intended in the context of “cartographic realism.”

The move to more cartographically realistic map design by the NPS has been gradual and unplanned. Using graphical software applications that allow sophisticated designs to be routinely produced, which were previously only imagined, the NPS has found itself inextricably drawn toward using greater realism. Cartography is not alone in this trend. Faux realism has become ubiquitous in almost every graphical medium today from tele-vision to print publishing to multimedia. For example, the graphical user interface (GUI) of Mac OS X, the virtual environment in which I am now immersed, uses soft drop shadows, transparency, pulsing 3D buttons, and a soothing “aqua” desktop to hide its complex Unix underpinnings from the casual computer user. The enhanced realism of NPS maps has a similar aim—sparing the park visitor from the off-putting technical aspects of conventional cartography with a map user interface (MUI) that is more user-friendly and that simultaneously delivers relevant and accurate information.

When depicting maps with cartographic realism, we are constrained by the finite limits of graphical methods—only so much is possible on a 2D surface—and our pre-conceived ideas of how the Earth appears from above. Geographic, graphic, and perceptual reality are often at odds with one another and must be reconciled by the cartographer in order to design a map with realistic characteristics.

With increased cartographic realism, map use becomes more a matter of looking rather than reading. Compared to conventional maps, realistic maps are, undeniably, dumbed down—users have to grapple with fewer abstractions, and intelligence is commonly defined as the ability to think abstractly. However, by avoiding the use of abstract symbolization, realistic maps have the potential to communicate more efficiently to a greater number of users. Think of this as the cartographic implementation of universal design. Users can comprehend realistically portrayed map

information relatively effortlessly without explanation (such as text and legends), so they can spend more of their limited time extracting essential information and examining spatial relationships.

Maps designed in a cartographically realistic manner also have the potential to be more attractive, even beautiful, compared to their conventional counterparts. This is not a frivolous concern when trying to connect with audiences. In this media-driven age of short attention spans, it is important that we design maps that attract and hold a reader's attention. People purchase expensive cars based solely on color, vote for telegenic political candidates, and invest substantial sums in corporations that publish slick annual reports. Are map users any less susceptible to the allure of attractive packaging?

Finally, making realistic NPS maps is a personal interest. Today, for the first time cartographers have the tools and data available to push the limits of map design with relative ease. Using new technology and data to design better maps for park visitors is, for me, irresistible.

Cartographically realistic map design is not by any means new to cartography. Among the most spectacular and enduring efforts in cartographic realism are those made by 20th century artist/cartographers.

Artist/cartographers

In the 1950s Hal Shelton, an employee of the USGS and an accomplished fine artist, painted small-scale plan maps of the US to be used by air travelers for general orientation. Shelton's maps were unique in that they portrayed land cover—forest, agricultural land, and built-up areas—in combination with shaded relief to mimic what passengers would actually see on the ground from an aircraft. On Shelton's maps land cover was portrayed more prominently than the terrain. Many of Shelton's original pieces, still under copyright protection, are housed at the US Library of Congress where they may be viewed by appointment only.

Meanwhile, on the other side of the Atlantic, Eduard Imhof's painted map of Walensee, Switzerland is perhaps the most famous example of early cartographic realism ever produced (Figure 2). Imhof's piece is noteworthy for its artistic use of strong colors to model topography, which is combined with less dominant land cover. Deep reds are used at higher elevations to give mountain peaks visual loft, blue-gray haze suppresses the lowlands, and cast shadows thrown by steep mountains extend onto the aqua green surface of Walensee. Holding true to the Swiss cartographic preference, cliffs receive considerable textural detail while agricultural fields and forests are depicted with flat color. Drainages and light colored roads are slightly incised into the landscape, as a viewer would expect them to be when viewed from above.

The Walensee map was painted experimentally to showcase the unrestrained application of art in the cartographic context. The resulting masterpiece is on permanent display at the Swiss Alpine Museum in Berne. However, despite the accolades, Imhof was opposed to the idea that his Walensee map would serve as a model for general cartographic design.

According to Imhof

"What is achieved by such painting experiments? When successful, beautiful impressions, natural plan-view landscape pictures result—the pictures that please the hearts of many viewers. But the end result

"People purchase expensive cars based solely on color, vote for telegenic political candidates, and invest substantial sums in corporations that publish slick annual reports. Are map users any less susceptible to the allure of attractive packaging?"

LOOKING BACK

"The Walensee map was painted experimentally to showcase the unrestrained application of art in the cartographic context."

“One can only speculate about what Imhof might have said differently had he lived long enough to experience the widespread adaptation of DEMs, Photoshop, the Internet, and other digital tools.”

is not a map. Paintings such as these are unable to provide, anywhere and in any respect, the topographic, conceptual and metric information which one expects from a map” (Imhof, 1982).

Although Imhof’s words are unequivocally discouraging, it is important to remember the context in which they were written. Recognizing that few other people possessed the artistic ability and geographic expertise to paint maps such as Walensee, that the technology of the day was inadequate for the mass reproduction of painted maps, and that cartographic employers were not demanding such products, his admonitions were, it seems, intended to keep impressionable students from wasting their time. The Walensee map is a tempting but forbidden fruit. One can only speculate about what Imhof might have said differently had he lived long enough to experience the widespread adaptation of DEMs, Photoshop, the Internet, and other digital tools.

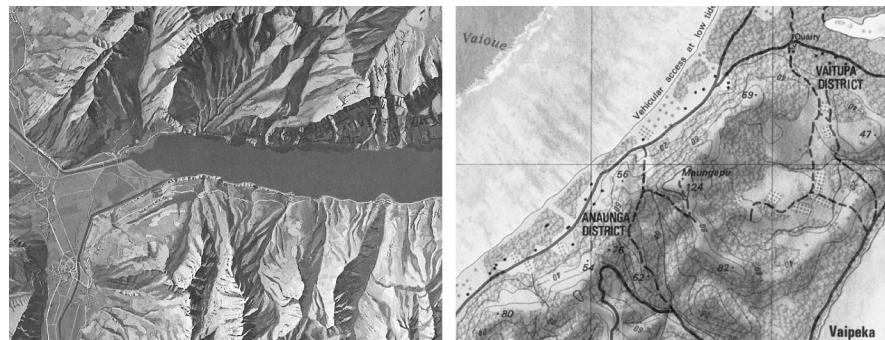


Figure 2. Traditional approaches to cartographic realism:

(left) A much reduced portion of Eduard Imhof’s map of Walensee, Switzerland, painted in 1938. The original measures 200 x 480 cm. Source: Virtual Library Eduard Imhof, Map Collection, Swiss Federal Institute of Technology (ETH). www.maps.ethz.ch/imhof_engl.html

(right) Aitutaki, Cook Islands. A colorized aerial photograph depicts the coral reef. Source: New Zealand Department of Survey and Land Information. Crown copyright reserved. www.linz.govt.nz/services/topo-hydro/pages/topo/topographicmaps/topo-downloads.html

Aerial photograph maps

“Aerial photographs contain inherent flaws, particularly in mountainous areas, that translate poorly to the graphical format of maps.”

While Shelton and Imhof were exploring map realism via art, others were pursuing a more technical approach using aerial photographs (and, later, satellite images). A snapshot of the Earth from above, aerial photographs are the ultimate in geo-realism providing cartographers with a means to deliver pure and uncensored geographic information to the reader (Keller, 2000). And aerial photograph maps are easy to make. Just place some type and lines on rectified aerial photography, such as a USGS Digital Orthophoto Quadrangle (DOQ), and the map is finished, and you can go to lunch. Despite these advantages, outside of the engineering, surveying, and scientific fields, aerial photograph maps have not caught on for general cartographic use. Aerial photographs contain inherent flaws, particularly in mountainous areas, that translate poorly to the graphical format of maps. Flaws include:

- Relief inversion - Most aerial photographs and satellite images are taken in mid morning when the atmosphere is clear and when sun-light originates from the lower right or southeast (in the northern

hemisphere). Shaded relief illuminated from this direction is highly susceptible to relief inversion, an optical illusion in which mountains and valleys appear to be inverted. Although it is possible to adjust embedded shadowing in aerial photographs to counter relief inversion in relatively flat areas (Rudnicki, 2000), the technique is not applicable in high mountains.

- Cast shadows - Shadows cast by high, steep terrain often obscure important information on adjacent slopes and flat areas. They also cause drainages to appear misregistered with terrain and can disfigure an image with unsightly dark blotches. Cast shadows are impossible to remove when their density approaches 100 percent.
- Information overload - Aerial photographs show raw, unfiltered data in all its confusing glory. Untrained readers may find the minute detail to be fascinating, but few actually understand what they are seeing.
- Inappropriate information - Do we really need to see parking lots, power lines, construction sites, and Christo art?
- Invisible information - Small buildings, trails and streams often cannot be seen through dense forest canopies. Clouds, which tend to persist over mountainous regions, and their shadows obscure the ground below.
- No visual hierarchy - From above, a park visitor center and a nearby sewage treatment facility might appear equally significant.
- Temporal sensitivity - For better or worse, aerial photographs show us a single moment in time. By the time the map is made, an image taken of a farm field could have been replaced with suburban homes, a glacier could have melted, or a winter-bare deciduous forest may be in leaf.

Notwithstanding these shortcomings, aerial photographs have been used to produce realistic maps. Most innovative, perhaps, are the South Pacific island maps, including Aitutaki, Cook Islands, produced by the New Zealand Department of Survey and Land Information during the 1970s. On the Aitutaki map, terrestrial areas are shown in a competent and conventional cartographic manner. However, the depiction of water is unique (Figure 2). Using a colorized aerial photograph to show areas below sea level only, coral reefs, shoals, and surf breaks are shown with detail and clarity that can not be achieved with conventional cartographic methods. Relief inversion and cast shadows are not a problem because coral reefs are essentially flat and covered by a layer of shallow water that diffuses otherwise troublesome southeast illumination.

By selectively integrating conventional cartography and aerial photography, the Aitutaki map points to the approach used by the NPS for realistic mapping.

The NPS uses a multi-disciplinary approach for bringing cartographic realism to its maps. The artistic inspiration of Shelton and Imhof can be found in our products, as can bits and pieces of aerial photographs and satellite images, DEMs, and vector geodata, all of which are combined selectively and with subtlety in Adobe Photoshop and other graphical software applications (Figure 3). Realistically designed NPS maps are

"The artistic inspiration of Shelton and Imhof can be found in our products, as can bits and pieces of aerial photographs and satellite images, DEMs, and vector geodata . . ."

NPS APPROACH

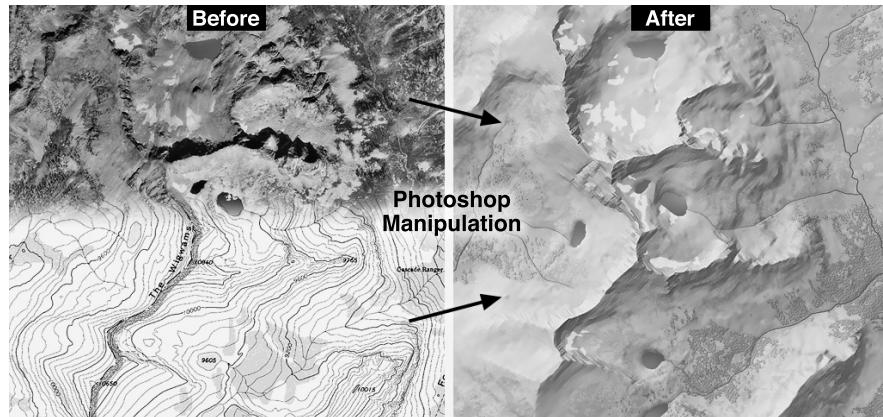


Figure 3. The Wigwams, Grand Teton National Park, Wyoming. Combining and manipulating a USGS DOQ (left top) and DLG and DEM data (left bottom) in Adobe Photoshop results in a more realistic map (right).

"The making of cartographically realistic NPS maps is an opportunistic enterprise used only when special conditions are met."

"They are also much loved and over used by map makers. Strong in form and visually distracting, lines are extremely rare in the natural world. Take them off your map wherever possible."

not photorealistic. Instead, they are a stylized view of the Earth as seen through a powerful graphical lens, which attempts to show landscapes not as they actually are but how readers might expect or desire them to look.

The making of cartographically realistic NPS maps is an opportunistic enterprise used only when special conditions are met. The availability of high quality data is the most critical requirement. A missing piece of key information can prevent the transformation to realism from happening. Time and money are also important considerations, because realistic maps are elaborate productions that take considerably longer to complete than their conventional counterparts. Finally, one must identify an NPS map situation that would benefit significantly from cartographically realistic design treatment—not every NPS map is a suitable candidate, particularly those in urban areas or maps that emphasize property ownership. But, when excellent data is at hand, schedules are open, and a suitable project identified, realistic map design is an option to consider.

On those NPS maps that receive cartographically realistic design treatment, some classes of map information are more suitable for realistic depiction than others. In general, physical landscape features are highly suited, cultural features less so, and explanatory elements not at all (Figure 4).

To design realistic maps, the NPS attempts to consolidate all physical features—shaded relief, land cover, drainages, etc. as a single graphical entity. By grouping physical features together on one level, the base, the visual hierarchy of the entire map is simplified, which allows cultural and explanatory information to be seen more legibly above. Although physical features occupy the same visual level, they can be made to appear distinct from one another by employing graphical special effects.

Four rules for cartographically realistic map design:

- 1) Remove lines – As shown by their use in prehistoric cave art and children's drawings, lines are the most rudimentary form of graphical expression. They are also much loved and over used by map makers. Strong in form and visually distracting, lines are extremely rare in the natural world. Take them off your map wherever possible.
- 2) Rasterize – Vectors and realism are incompatible. Rasterizing vector lines and fills in Photoshop makes them less artificial and more

	Map Element	Realism index
Explanatory	Labels Point & recreational symbols Arrows & call-out boxes	Low (abstract)
Cultural	Political boundaries Trails Roads Built-up areas	
Physical	Drainages & water bodies Agricultural areas Lava/sand/rock/coral reef Glaciers Forest Topography (shaded relief)	High (organic)

Figure 4. On NPS maps, physical features are more apt to be portrayed with cartographic realism than cultural and explanatory map elements.

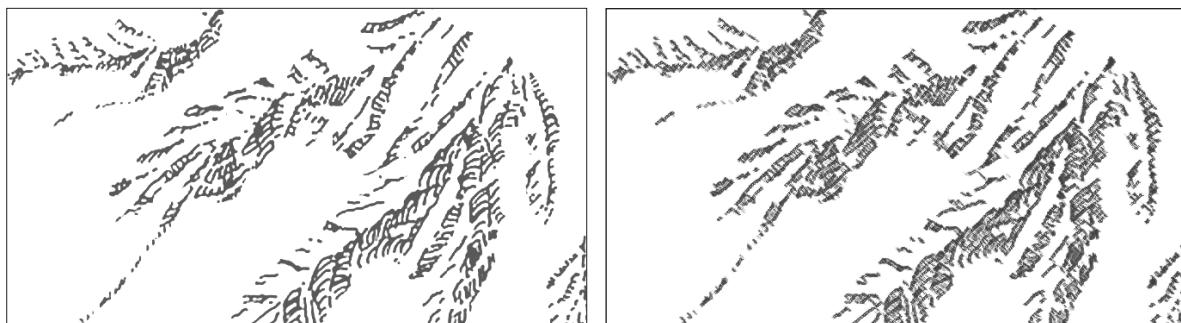


Figure 5. Mt. Rainier National Park, Washington. (left) Hand-drawn rock hachures. (right) The hachures are rasterized and lightly filtered in Photoshop to appear more rock like.

organic. Rasterizing also sets the stage for later exotic filter manipulations that can be applied only to pixels (Figure 5).

- 3) Modulate tones – Just as lines are rare in nature, so too are perfectly flat area tones. Seemingly flat surfaces such as water bodies, ice fields, and deserts contain subtle tonal variations that need to be emphasized.
- 4) Texturize – Graphical noise and embossed textures give selected area tones, such as cliffs and forests and even rasterized lines, a tactile appearance that more closely mimics nature (Figure 6).

Applying the rules mentioned above to the design of cartographically realistic maps requires utmost restraint. Not only is the philosophy for designing realistic maps somewhat different from that of conventional cartography, so too are the production techniques used to apply these designs. Although merging physical landscape features can yield spectacularly realistic results, the potential for a disaster is also high—the

“Modulate tones - Just as lines are rare in nature, so too are perfectly flat area tones. Seemingly flat surfaces such as water bodies, ice fields, and deserts contain subtle tonal variations that need to be emphasized.”

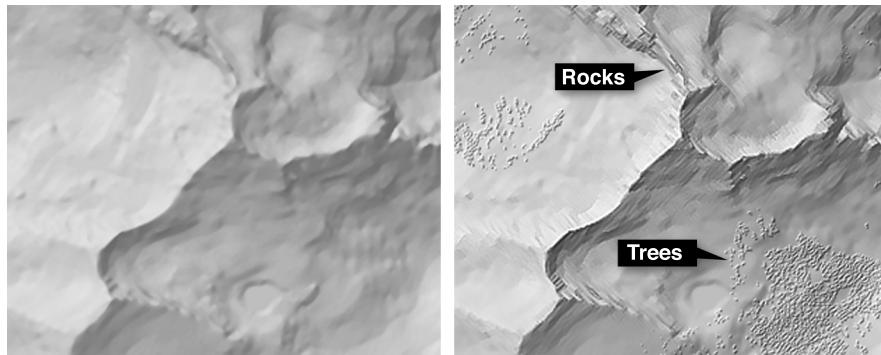


Figure 6. Grand Teton National Park, Wyoming. (left) Conventional shaded relief. (right) Land cover textures embossed onto the shaded relief surface.

"The cartographer must be mindful that the unrestrained pursuit of cartographic realism can yield unsatisfactory results, and that even realistically designed maps sometimes need to resort to conventional solutions out of graphical necessity."

cartographer must put more physical information than ever before on a rasterized base map using unfamiliar techniques. A light touch is required. For example, applying an embossed forest texture on a map any heavier than a mere hint creates distracting noise that obliterates shaded relief and other raster information below (Figure 6). To help see whether the merged physical elements on a realistic map are in graphical balance, try viewing the map on screen at large and small scales. A map that may look perfectly legible at any given spot at 100 percent scale may not work as well when viewed in its entirety at thumbnail size, and vice versa. The objective is to create a map that appears realistic and legible at both macro and micro scales.

The design of cartographically realistic maps depends heavily on a reader's observations and perceptions of natural phenomena, particularly when choosing color. Even USGS topographic maps, which are quintessentially conventional, use earth brown for printing contour lines, light green for forests, and blue for water. Determining the degree of literalness in which to portray natural phenomena on a map is an imprecise art. A flexible design approach is essential for success. The cartographer must be mindful that the unrestrained pursuit of cartographic realism can yield unsatisfactory results, and that even realistically designed maps sometimes need to resort to conventional solutions out of graphical necessity. For example, to an observer deep in the Grand Canyon, the silt-laden Colorado River is the same color as the terra cotta landscape through which it flows. Showing the Colorado River and Grand Canyon topography in their natural colors on a map would camouflage the river from readers. In a pragmatic nod to cartographic convention, the compromise would be to depict the river as an impure shade of blue.

TECHNIQUES

This section briefly describes specific techniques used by the NPS for making more cartographically realistic maps.

Aquafication

"The depiction of hydrography on conventional maps is usually a perfunctory exercise."

The depiction of hydrography on conventional maps is usually a perfunctory exercise. Drainages and shorelines are drawn as vectors shown as uniformly thin blue (or cyan) lines, and water bodies are filled with a flat tint of the same color. Hydrography produced in such a workmanlike manner appears mechanical and is discordant with other physical elements on the map.

By contrast, on maps designed with cartographic realism hydrography is given a softer, more natural appearance. The idea is for the hydrogra-

phy to become a harmonious part of the landscape (Figure 7). The key to achieving aquafication is to remember that lines are seldom found in nature—therefore, all casings are removed from oceans, lakes, and double-line rivers. Drainages are made to appear more natural by tapering widths based on their relative size and direction of flow—a tedious technique that is a throwback to our pen and ink cartographic forebears. However, it is relatively easy to taper drainages in a program like Adobe Illustrator by using custom brushes. A library of custom brushes can be built to represent various thin-to-thick tapering progressions, which are easily applied to stream vectors (Nelson, 2001).

In the aquafication process, all hydrographic features, including water bodies and tapered drainages, should be assigned the same color (avoid using pure cyan) and rasterized as a single layer in Photoshop. Once in Photoshop, subtle adjustments can be applied to give the hydrography a more realistic appearance. By adjusting the opacity, blending mode, and color of the layer, hydrography can be given just the right amount of prominence compared to other physical landscape elements. As a final touch, sun glints (a form of modulation) can be added to water bodies and rivers by applying light tone with the airbrush tool and a big soft brush.

"Drainages are made to appear more natural by tapering widths based on their relative size and direction of flow—a tedious technique that is a throwback to our pen and ink cartographic forebears."

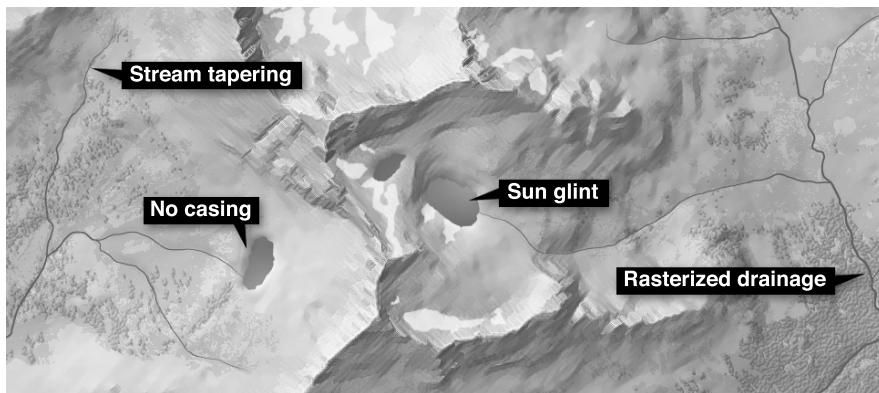


Figure 7. Grand Teton National Park. Hydrography harmoniously integrated into the cartographic landscape.

As a general rule, water bodies are blank space on maps. They are a convenient dumping ground for legends, text notes, and photographs that pertain to terrestrial areas, usually the prime focus of the map. The secondary status of water bodies on maps, and their constantly changing appearance in nature, also provides cartographers with a blank canvas for applying realistic special effects not applicable to terrestrial areas where conflicts with primary information are a concern. Special effects on water surfaces are more than artistic embellishments. They can improve map communication. For example, a sun glint strategically placed near a shoreline park visitor center can be used to subconsciously draw the reader's attention to that area. Other special effects can imply environmental phenomena. By showing a wave pattern only on the choppier windward shore, the leeward and windward shores of a tropical island can be differentiated (Figure 8).

More precise mapping is possible with artistic embellishments on water. For example, a partially submerged reef can be mapped, albeit indirectly, by showing its effect on water—breaking surf—by transferring an image of the surf from a registered aerial photograph. The NPS has used a similar technique to map rapids on the Potomac River at Great Falls Park, Virginia.

"Special effects on water surfaces are more than artistic embellishments. They can improve map communication."

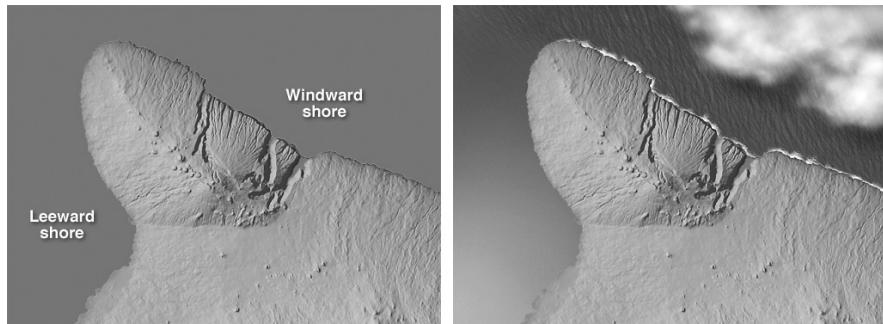


Figure 8. Kohala, Hawaii: (left) The Pacific Ocean depicted as flat blue. (right) Waves, breaking surf, and a leeward sun glint suggest prevailing northeast trade winds without having to use labels. Clouds are optional.

Finally, a discussion of aquafication would not be complete without mentioning the portrayal of ocean floors and lake bottoms with shaded relief and continuous tone depth tints (Figures 1 and 12). Popularized by the ocean floor maps published by National Geographic, this style of bathymetric depiction is being used increasingly on NPS maps to show connectivity between underwater and terrestrial environments.

Texture substitution

"Maps created with texture substitution appear more like a picture of a detailed physical model than an aerial photograph."

"The selection of appropriate generic textures to substitute is a critical consideration for preventing a map from turning into a grossly inaccurate caricature."

The textures found on aerial photographs contain a wealth of rich visual cues for differentiating land cover. Forest canopies often appear hummocky, rocky areas can be rough and fractured, and agricultural fields appear as a patchwork of mottled tones. However, except for some water features, transferring these textures directly to a map is not feasible because of the inherent flaws in aerial photographs discussed earlier.

A technique known as texture substitution can be used to partially circumvent this problem. Here's how it works. Using an aerial photograph or satellite image (registered to a base map), land cover is carefully delineated as Photoshop selections with pixel-level precision. These selections are then transferred to the base map, where they are filled with generic land cover textures cloned from the aerial photograph, or even from other photographs (Figure 9). The result is a reconstituted final product that selectively brings the best traits of aerial photographs—their often eye-catching beauty, realism, rich textures, and tiny details that readers find so fascinating—to the familiar and readable format of a map. Maps created with texture substitution appear more like a picture of a detailed physical model than an aerial photograph. On aerial photographs textures begin coalescing at scales smaller than 1:50,000 (Imhof, 1982). This problem can be solved by substituting large-scale textures onto a small-scale map. The results of this procedure look surprisingly plausible and natural.

The selection of appropriate generic textures to substitute is a critical consideration for preventing a map from turning into a grossly inaccurate caricature. Substituted textures must accurately characterize the land cover being depicted, with just enough variability to look authentic. However—and this is extremely important—the variability must also be small and inconsequential in nature so it doesn't mislead readers with false information. Substituted textures should be completely avoided on very large-scale maps, because at these scales the generalized textures would be a blatantly incorrect replacement for actual detail.

Substituted textures look most natural when used inside complex land

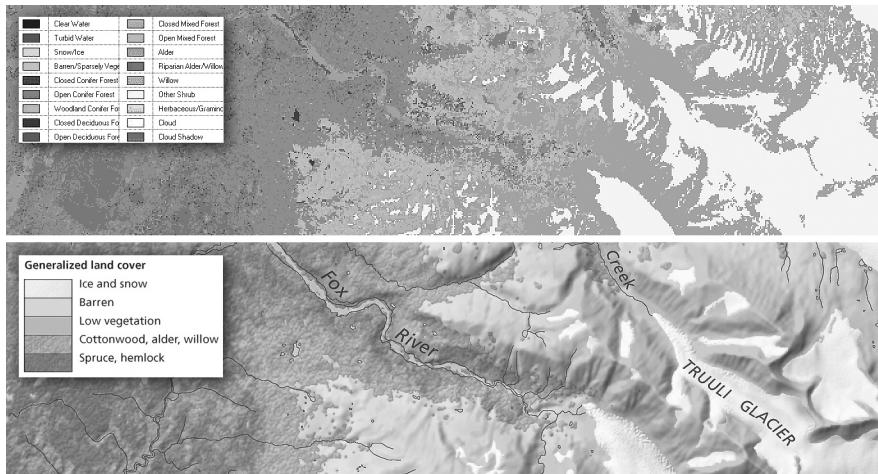


Figure 9. Texture substitution: Kenai Fjords National Park, Alaska. (top) Detailed land cover generated in ERDAS from SPOT and Landsat satellite images. (bottom) The same land cover reduced from 18 to 5 categories on the park visitor map. The substituted forest texture was cloned from an aerial photograph taken near San Francisco, California.

cover selections as opposed to generalized selections (Figure 9). Alternating textured/nontextured areas produces a tessellation that compliments the texture pattern as a whole. With some classes of land cover, such as forests, a slight amount of 3D embossment (known as bump mapping in 3D applications) applied to forest polygons themselves suggests a forest edge rising above adjacent non-forested areas (Nighbert, 2000). The orientation of the tiny highlights and shadows on an embossed 3D texture must synchronize with the illumination and shadows on the shaded relief—usually from an assumed light source in the upper left. In general, textures should be used sparingly on a map. Keep in mind that not every type of land cover warrants or is suitable for texturized portrayal. On NPS maps land cover textures are mostly used to depict forests, glaciers, lava flows, and rocky peaks. Other classes of land cover are left untextured to give the reader's eyes a place to rest.

When aerial photograph textures are not suitable for texture substitution, manual touchups and synthetic texturing (both done in Photoshop) are the options of last resort. If these techniques must be used they should be printed lightly and applied to polymorphous features, such as sand dunes or glaciers, where cartographic accuracy is elusive under the best of circumstances (Figure 10).

"The orientation of the tiny highlights and shadows on an embossed 3D texture must synchronize with the illumination and shadows on the shaded relief . . ."

Illuminated relief

The illuminated relief technique enhances shaded relief combined with land cover textures. Normally, combining shaded relief and land cover textures on a map involves graphical compromise. Together these elements are not as effective as when they stand alone, especially shaded relief, which has a wispier appearance compared to land cover textures.

When illuminated relief is used, supplemental illumination and shadowing enhance topographic modeling by also lightening and darkening land cover textures. The technique uses adjustment layers and alpha channels to manipulate the hue, saturation, and brightness of selected areas on a shaded relief map. By using multiple adjustment layers that build upon one another, complimentary illumination and shadow colors can be made gradually more intense at higher elevations to suggest alpenglow (Figure 11). Conversely, substituting gray-blue for dark gray in

"Normally, combining shaded relief and land cover textures on a map involves graphical compromise."

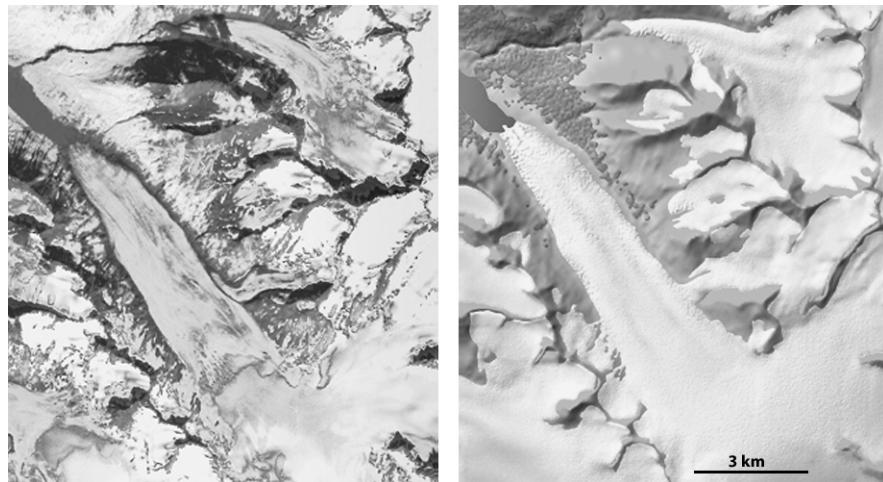


Figure 10. (left) A Landsat image of Dinglestadt Glacier, Kenai Fjords National Park, Alaska in late summer. Glaciers in nature can be untidy. (right) A manually enhanced depiction of the same area without medial and lateral moraines and blotchy patches of dirt, snow, and ice. The glacier snout has been given a domed appearance and a texture to suggest disintegrating ice. Smooth virgin ice and snow is shown at higher elevations.

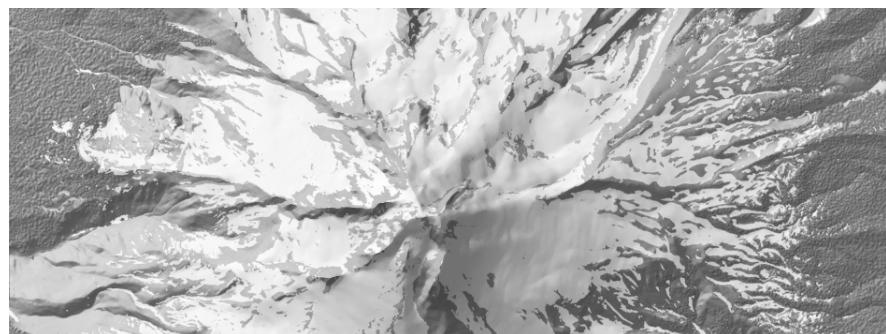


Figure 11. Illuminated relief: Mt. Hood, Oregon. Warm illumination and cool shadow tones strengthen the sense of three dimensionality in the topography despite the presence of prominent snow and forest textures.

upper elevation shadows diminishes the visual weight of the entire map (a good thing when additional information needs to be added) without degrading the topographic form (Patterson, 2001). Transparent pastel colors are preferred. When choosing a palette to depict illuminated relief (as well as other map elements), the NPS seeks fault-tolerant colors that can withstand the vagaries of offset printing, conversion between CMYK and RGB color modes, and screen viewing on multiple computer platforms.

Outside land muting

"When choosing a palette to depict illuminated relief (as well as other map elements), the NPS seeks fault-tolerant colors that can withstand the vagaries of offset printing, conversion between CMYK and RGB color modes, and screen viewing on multiple computer platforms."

Just as the natural and cultural worlds co-exist, so too must park and non-park lands on realistically designed NPS maps. Differentiating these areas by using figure-ground contrast is a simple matter of applying lightening or desaturation to non-park lands with an adjustment layer in Photoshop (Figure 12). Using a transparent green boundary ribbon accentuates the boundary.

More problematic, many National Parks are surrounded by, or contain within their boundaries, an intricate quilt of public and private lands and

administrative zones, such as wilderness areas, that need to be mapped. Depicting additional property ownership on a realistic map is a challenge, which sometimes cannot be resolved satisfactorily. The flat colors usually used to represent property holdings conflict with shaded relief and land cover textures shown below. However, providing that the quantity and complexity of property ownership is not overwhelming, using a combination of color-coordinated lines, transparent boundary ribbons, and labels is the least damaging method for depicting property and realistic landscapes together.

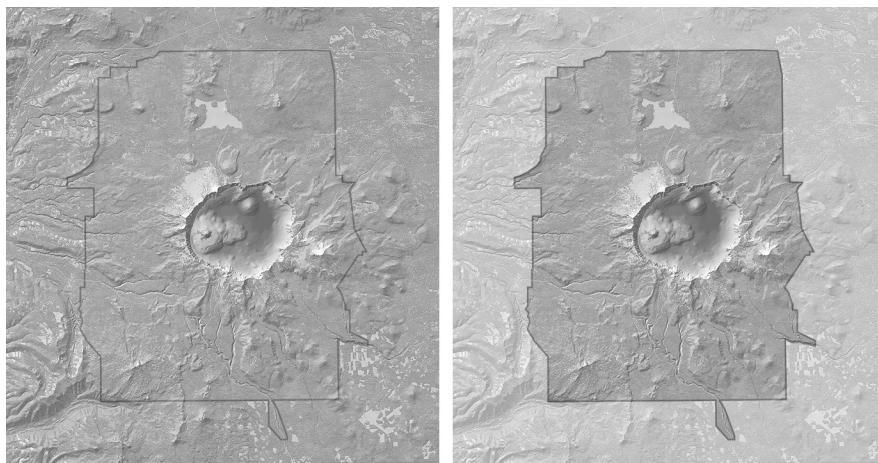


Figure 12. Crater Lake National Park, Oregon. (left) Land inside and outside the park boundary portrayed the same. (right) Lightening the outside land in Photoshop enhances park/non-park figure-ground and hides clear-cut logging (the light gray patches)—if only nature could be healed as easily.

Writing this paper has provided an opportunity to reflect on the design trends that are changing the look of NPS maps. Until recently, the design of NPS maps has been constrained by half-century-old design values and production technology. Digital technology has brought unprecedented opportunities to refine the design of NPS maps, moving away from abstraction to a more cartographically realistic appearance. Whether this design transformation will significantly improve a map user's park experience remains to be seen, although the anecdotal evidence is encouraging. At the few parks where maps designed with cartographic realism are available, map use appears to be dramatically up—people are probably drawn to the more attractive packaging. If map users also come away with a better understanding and appreciation of the parks, the realistic map design effort will be judged a success.

CONCLUSION

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reviews

Atlas of Oregon, Second Edition

By Loy, William G. (editor); Allen, Stuart; Buckley, Aileen R.; Meacham, James E. (authors) University of Oregon Press, 2001 301 pages More than 700 maps, hundreds of charts and diagrams Hardbound, ISBN: 0-87114-101-9, \$100.00

Reviewed by Joseph Stoll
Syracuse University

When a review copy of the *Atlas of Oregon, Second Edition* arrived, it was received with anticipation since many positive comments regarding it had been heard. Paging through the atlas proved those expectations to be warranted since it is a visual feast. It was quickly realized that for greatest enjoyment, the atlas should be perused slowly—one topic or two topics at a sitting. It is well designed for this approach. The atlas will continue to reside on an easy-to-reach bookshelf for frequent examination of the myriad masterful maps, diagrams, and textual entries found in its approximately 300 pages.

The *Atlas of Oregon, Second Edition*'s appearance is tastefully plain and gives an early indication of the atlas's quality. The opening pages, including an especially spacious and readable table of contents, are generally unadorned. The only graphics on these pages are two differently sized versions of the state seal. The atlas is pleasantly compact given the amount of material it contains. The reader need not be a body-builder or a contortionist to place the atlas on his or her lap and comfortably page through it, even over a lengthy period of time. The materials of the atlas seem adequately durable. The

paper is of sufficient weight and seems to be of good quality. It holds colors well and its texture is suitable for reproduction of the delicate details found in some graphics and in fine lines of text characters. As the reader turns a page, contents of the next or previous pages are faintly visible through the paper, but not to the point of distraction.

The pages are nicely laid out. They maintain a good balance of graphic and textual elements. The elements keep the pages interesting and interrelate well so the content does not seem gratuitous. The page designers have made good use of color and white-space. The pages are able to "breathe" even though a large number of them contain a high density of graphics and text.

The atlas is colorful without becoming garish. In nearly all cases the colors are appropriately and tastefully chosen. This is no small feat given the atlas's large number of maps and graphics with multiple colors.

From the standpoint of graphic legibility, the atlas fares quite well. The black type is distinct against the details of background graphics. There are occasional examples of colored type not reading clearly against a colored or detailed background. One such example can be found on the "Landforms: Shaded Relief" map. This map contains colored county lines and type that will likely be problematic for many readers of the atlas to distinguish against the relief background. There is also a significant amount of small-sized type that might require readers with eyesight disadvantages to use magnification.

It is interesting to compare the *Atlas of Oregon, Second Edition* with the *Atlas of Oregon, First Edition*. At first glance one sees the significant difference in the physical sizes of the two books. The *Second Edition* is considerably

more compact. The page orientation of the two editions has also changed. The *Second Edition* has a vertical orientation whereas the *First Edition* was oriented horizontally.

The authors note that the *Atlas of Oregon, Second Edition* differs from the *First Edition* by containing more maps and less text. As one compares the two editions of the atlas, the *Second Edition* quickly confirms the authors' statement regarding the number of maps. It is less evident if the *Second Edition* contains less text since it is more efficiently placed and different fonts are used.

In a direct comparison of maps from the two atlases, the difference that will no doubt have the strongest impression upon any reader is the striking graphic quality of the maps in the *Second Edition*. They are technically executed to be of the top-notch caliber one would expect from the persons involved in its design and production. Since some of the producers of the *Second Edition* were also involved in the production of the *First Edition*, it becomes a glowing testament to their development as cartographic designers along with their abilities to select and direct capable cartographic technicians to produce an atlas of this exceptional quality.

The *Atlas of Oregon, Second Edition* is comprised of three main sections. The first section (approximately two-thirds of the atlas) contains thematic maps and associated text and diagrams. This section has three divisions: *Human Geography*, *The Economy*, and *Physical Geography*. The second section contains 81 pages of *Reference Maps*. These include population center maps, historic growth maps and more generalized reference maps. The third section of the atlas is a *Reference* section which includes USGS map index pages, a gazetteer, an essay on place names, sources and index.

In reading the *Atlas of Oregon, Second Edition*, it is helpful that each set of facing pages is a self-contained topic. This enables the reader to read the text and study the related graphics without the distraction of turning pages ahead or back. The only activities requiring the reader to turn pages are when he or she moves to a new topic or compares between maps/topics. The upper left corner of each left page contains a header that shows the topic exactly as it appears in the *Table of Contents*. The reader is also assisted by an *Index* of key words at the end of the atlas. The combination of *Table of Contents*, headers, and the *Index* provide straightforward and adequate navigation assistance to readers.

Cross-referencing or map-comparison is an important use of any atlas. Readers examine multiple maps by comparing data in one location with the same or similar data in other locations. They might also compare maps at different scales in order to gain understanding of locations. Readers are as likely to perform map-comparison as they are to confine examination to a single map. When readers of the *Atlas of Oregon, Second Edition* wish to perform cross-referencing or map-comparison, they must be prepared for a considerable amount of page-turning. This is due to the number of maps in the atlas and the varying scales of maps the reader might wish to compare. This is not an unusual problem regarding atlases nor is it unusually problematic in this atlas. Since the reader does not find reference maps until the final third of the atlas, a large number of pages must be turned if reference maps are consulted for additional locational information while thematic maps are being studied in the front part of the book. Map-comparison of this nature could be improved with inclusion of a state-wide general reference map near the front of

the book.

The thematic portion of the atlas contains material covering an interdisciplinary range of subjects. Historians will find material related to early maps of Oregon, Native American history, early exploration and settlement, immigration, social and political development, population growth, and place name origins. Human geographers and social scientists will find material related to immigration, population growth, race and ethnicity, and several additional topics related to the social development of Oregon. Economic geographers and economists will find material related to a variety of sectors and occupational components of Oregon's economy. Physical geographers and scientists will find material related to Oregon's landforms, geologic history, soils, water, vegetation, wildlife, and climate. The topics covered in the thematic portion of the atlas are treated with striking maps and diagrams that invite careful examination. The interrelationship between text and graphics is evident. Each successfully supplements the other.

The *Introduction* to the atlas states that very little information from the 2000 census was available in time to be included and that the date of "most recent" information varies from subject to subject. Examples of this variation readily appear. Readers will find "most recent" year labels on graphics ranging from 1990 to 2000, with most seeming to fall in the late 1990s and 2000. There is an instance in the review copy of the atlas where proportional symbols are labeled with year 2000 population totals by county and appear inconsistent with bar graphs on the same page that also show year 2000 population data for each county. This was the most puzzling instance encountered involving variation of "most recent" information.

Readers who are serious about

researching Oregon will appreciate the reference materials in the final section of the atlas. Of special value to researchers is the *Sources* section containing bibliographic information for each topic found in the atlas.

The *Atlas of Oregon, Second Edition* authors note the atlas is an attempt to illustrate and explain, by use of maps, the "essential nature of Oregon." It is also intended to be a reference that presents information in map form that previously existed only in tables, lists, and text. Finally the atlas is intended to be a tribute from the authors to the State of Oregon.

In this reviewer's opinion, the authors have accomplished their goals. The contents of the atlas portray the nature of Oregon in its historical, social, cultural, economic and physical complexity. The sheer number of colorful, well-designed maps and diagrams indicate that a considerable amount of non-graphic information has undergone a graphic conversion. The result is an attention-grabbing and fascinating tool for the study of Oregon. This seems a very fitting tribute to the beautiful state of Oregon. Apart from the addition of a state reference map in an early chapter and some graphic reworking of lines and text against the visual details of relief maps, there is little else one could wish to change about the atlas. Examination of the *Atlas of Oregon, Second Edition* finds it to be a superb atlas that is most highly recommended. It will likely become (and may already be) the standard against which forthcoming state atlases will be measured.

Atlas of Oregon CD-ROM

James E. Meacham, Erik B. Steiner,
Editors
2-CD set, PC and Mac Compatible,
\$49.95

Reviewed by Joseph Stoll
Syracuse University

Some time after receiving the *Atlas of Oregon, Second Edition*, this reviewer also received a copy of the *Atlas of Oregon CD-ROM* (two compact disk set). While a considerable amount had been previously heard regarding the printed version of the atlas, less had been heard about the CD-atlas so it was approached with fewer preconceptions.

The CD-atlas authors address the purpose of its creation in the introductory material on the first disk. They note that the CD-atlas was created to use the thousands of maps developed during the Oregon Atlas book project and to "develop new and compelling ways to present the same information using multimedia design tools". They also note that the CD-atlas is *not* intended to compete with or be a replacement for the printed atlas, but it is rather intended to be a "complementary reference and learning tool".

The CD-atlas operated without difficulty on both a Macintosh G4 computer (OS 9.2) and an older Dell Optiplex computer (Windows NT). The Macintosh required the installation of the CarbonLib extension that is included on the first atlas disk. Once the extension was installed, the CD version worked well. It initially seemed the CD response time was slower than most readers would prefer. This impression changed when the CD-atlas was used in a new Dell Optiplex computer (Windows XP) that also contained a current and considerably speedier CD reader. The CD-atlas response times were noticeably quicker on this computer making

the CD-atlas considerably more enjoyable to use.

In its appearance, the *Atlas of Oregon CD-ROM* is visually harmonious with the printed version of the atlas. Choice of colors, fonts, and design elements is attractive. While the CD design contains more visual elements than the cover design of the book, it is tastefully packaged. The contents of the first disk are analogous to the contents in the thematic portion of the printed atlas. The second disk contains reference maps and aerial photos.

Once the CD-atlas is initiated, a title page appears. Along with the title, this page displays a colored globe centered on Oregon, and four "clickable" options. The "Introduction" option leads to a single-page display that gives a general description of the CD-atlas and goals behind its creation. The "About the Atlas" option leads to another page of options where one can learn about the CD-atlas authors and designers, read acknowledgements, publication and copyright information, etc. The remaining options allow the CD-atlas reader to "Begin" or "Quit".

When the CD-atlas reader selects the "Begin" option, a display appears that is equivalent to the *Table of Contents* in the printed version of the atlas. A general description of the CD-atlas, disk 1 display is as follows.

Three main sections of information: *Human Geography*, *Economy*, and *Physical Geography* are indicated by large buttons at the bottom left half of the screen. When the cursor pauses on these buttons, a fly-up menu of topics within that section appears. Once a topic is selected, it changes color to assist the user in remembering which topics have or have not been selected. It should be noted that while the topics are often the same as those in the book version of the atlas, they are not always identical. Because of this, readers wishing to examine

the treatment of the same topic in both versions of the atlas might occasionally experience minor confusion.

Four buttons appear at the bottom right side of the screen. These buttons are assigned the functions of printing the screen on a page of paper, showing a state map of Oregon, providing user help, and returning the user to the opening screen of the CD-atlas.

The button assigned to show the state map of Oregon is particularly noteworthy. This option displays a full-screen state map with main layers to show *Counties, County Seats, Rivers and Lakes, and Relief*. Each of these four layers also contains a sub-layer that shows labels of the layer's features. The layers can be toggled on or off so it is possible to make separate maps containing any combination of these layer features. It is especially useful that this state map of Oregon can be accessed quickly, at any time, and it is printable. The CD-atlas reader can easily print useful and attractive base maps of Oregon either with or without labels. Readers should heed the advice in the "Quick Tips" section of the User's Guide informing that best printing results when "landscape" is selected in the printer settings.

Each map contains its own interactive settings. These settings aid in navigation and in many cases allow the reader to interact with the map data, see additional graphics, or read additional information. The level and type of interactivity varies from one page to the next. In addition to their value in navigation, viewing, and interaction, these actions become educational. The act of panning around the state to see what is being shown at a particular location or zooming in for closer examination allows the reader to repeatedly interact with the counties, locations, and physical features of the state. Readers

of the CD-atlas (especially the "non-Oregon" readers) will likely master knowledge of place and feature locations in the state more efficiently than will readers of the printed atlas. This seems even more certain since the reader of the CD-atlas is only a button-click away from the extremely convenient state map of Oregon that has already been mentioned. While the printed atlas suffers from lack of such a handy reference map, especially among the thematic maps, the CD-atlas provides this in a superb fashion.

The importance of being able to cross-reference or compare maps was briefly discussed in the review of the printed atlas. Since this is so fundamental in a reader's use of an atlas, it deserves a second mention. In a conventional atlas, cross-referencing or map-comparison often becomes an onerous exercise of page number memorization, page marking, or repeatedly returning to the *Table of Contents*. The CD-atlas however, provides tools to considerably increase the ease and efficiency with which cross-referencing or map-comparison is performed. The CD-atlas furnishes easy-to-find buttons for clicking and quickly moving from one map to another. One can simply use the "clickable" *Table of Contents* however the designers have added an extra tool very useful for moving between maps. There is a button at the top of the screen labeled "Compare". This button allows the reader to instantly switch between two different maps with a single click. Cross-referencing or comparison by use of maps has never been quicker or easier.

The maps contained in the CD-atlas maintain the high graphic quality of the maps found in the printed version. Of course the finest lines and most subtle color differences found on the printed page suffer somewhat when viewed on a computer monitor

and can differ markedly when viewed on different monitors. However given the limitations of RGB monitor viewing, the maps remain graphically pleasing and seemed impressively similar to the printed versions. Quality control appears to have been carefully conducted. While comparing several maps between the CD-atlas and the printed atlas, only one map in the CD-atlas was found to be missing a type label that was included on the same map in the printed atlas.

The contents of the second disk in the CD-atlas set include aerial photos from selected locations in Oregon. These locations are: Alsea Bay, Astoria, Belknap Crater, Crater Lake, Hells Canyon, Hood River, Mount Hood, Portland, Smith Rock, Umatilla, and Warner Valley. No rationale was visible to explain the inclusion of photography from these specific locations. One could perhaps assume this photography covers specific physical or environmental features in Oregon. Since they are from different regions in the state, perhaps the purpose of the photos is simply to demonstrate Oregon's ecological diversity. This section is not included in the printed atlas. Similarly, the printed atlas contains a reference section not found in the CD-atlas.

It has long been this reviewer's preference to read text and view graphics on a printed page rather than on a monitor screen. Initially, using the two versions of the *Atlas of Oregon* did not alter this preference though it was soon evident that the *Atlas of Oregon* CD-ROM possesses distinct advantages when compared to its printed counterpart. One of its advantages lies simply in the fact that such a well-produced atlas exists on CD-sized media. The convenience of having the *Atlas of Oregon* on two compact disks provides a tremendous payoff in terms of the density of good quality information

provided per amount of storage "real estate" required.

The more the CD-atlas was used, however, the more its interactive qualities became valued. This aspect makes using the atlas both enjoyable and educational. In the opinion of this reviewer, this is the most important way in which the CD-atlas complements the printed version of the *Atlas of Oregon*. It allows the reader to manipulate images, view the data at varying scales, easily compare between maps and even print base maps for one's own use. These capabilities are what carry the atlas beyond merely being a reference tool to truly serving in the capacity of an educational tool.

Given the quality of the CD-atlas, not many suggestions for improvement come to mind, however there are two minor items. Flexibility in the use of this atlas would be increased with the inclusion of a "minimize" option to allow users to more conveniently use other software while keeping the CD-atlas active. Using the *Alt-Tab* or *Command-Tab* keys (*Alt-Tab* for Windows, *Command-Tab* for Macintosh) enables readers to alternate between different programs, however a minimize button located on the CD-atlas screen would be helpful. A second suggestion would be to place the "Next Section" button in exactly the same position throughout the atlas. This would allow the reader the option of quickly paging through the different sections of the atlas with his or her eyes remaining on the contents of the pages rather than having to shift to the top of the monitor to relocate a button because its location has shifted. Since the "Previous Section" button does appear to retain its position, the reader would have the option of going to the end of the material contained on each disk and quickly page toward the beginning. Again, these are certainly minor matters.

In comparison to print atlases,

production of atlases in electronically readable formats is still young. *Atlas of Oregon CD-ROM* succeeds in assisting the maturation of this process. It admirably achieves the goal of its designers that it becomes a complementary reference and learning tool to accompany the outstanding printed version of the *Atlas of Oregon*. The *Atlas of Oregon CD-ROM* is also most highly recommended.

**The Map that Changed the World:
William Smith and the Birth of
Modern Geology**

Simon Winchester. New York, NY: HarperCollins Publishers Inc. 10 East 53rd Street, New York, NY 10022, 2001. 325 pp, maps, diagrams, illustrations, suggested reading list, index. Hardcover. USA \$26.00 Canada \$39.50 (ISBN: 0-06-019361-1).

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Simon Winchester has a knack for digging up beautiful stories from the lost pages of history books. My introduction to Winchester came in the same delightfully surprising manner in which he spins his tales. I literally stumbled across Winchester's work one night in a dimly lit Nepali tea-house, tripping over a well-worn traveler's copy of his remarkable description of the creation of the *Oxford English Dictionary*. As I carried that chronicle throughout my travels, Winchester's eye for historical detail and penchant for anecdote caused me to wonder, "Why had never heard this story before?" Really, a mental institutionalite wrote

the definitions quoted at keynote speeches and in term papers across the world? That book, *The Professor and the Madman*, succeeds in bringing vivid life to the creation of one of the most important, and commonly taken-for-granted, books of our time.

Winchester's most recent opus, *The Map that Changed the World*, succeeds in much the same way. Here, Winchester replaces the dictionary for something far more familiar to me, a geologic map. I must admit my bias here; I was excited to read this book from the moment it landed (again by chance) in my hands. If Winchester's writing had me excited about something as mundane as the dictionary, how could I *not* like this new tale about the creation of the world's first true geologic map? Bias aside, I loved this book. Even if you are not versed in the intricacies of geology, Winchester is able to describe the detail and significance of this map, entitled (in appropriately English fashion) "Delineation of the Strata of England and Wales with part of Scotland exhibiting the Collieries and Mines, the Marshes and Fen Lands Originally Overflowed by the Sea, and the Varieties of Soil According to the Variations in the Substrata, Illustrated with the Most Descriptive Names." Instead of repeating this loquacious title again, I will borrow a page from Winchester's account and subsequently refer to it as "the map". The map is one that defined the field of geology, marked a paradigm shift in scientific inquiry, revolutionized the coal industry which drove the industrial revolution in early 19th century England, and is the theoretical basis for the billions of dollars spent on modern petroleum exploration. While this wonderful cartographic element of the story is not to be understated, the true complexity and brilliance of the map is found through Winchester's riveting account of

its cartographer, William Smith (1769-1839). The artistic mastery and scientific endeavor contained within the map was entirely the product of this singular man. Winchester's tale follows William Smith from the depths of a debtors prison, back to his childhood fossil digging days in Oxfordshire, across his young apprenticeship as a canal digger, and arrives at his peaceful retirement by the sea in Scarborough. His story is very readable throughout and supported by wonderful anecdotal tangents, that enliven the life, work, and historical context of William Smith in way that can only serve to honor one of history's great scientists and cartographers.

In Winchester's tale, we first meet this great scientist and cartographer as he emerges from a debtor's prison, penniless, hopeless, and thoroughly crushed by the conservative society of early 19th century England. In a time that should have been the pinnacle of Smith's career, he finds himself stripped of his due glory as the "father of modern geology," robbed of his priceless fossil collection, and thoroughly disconnected from the map he spent his lifetime creating. This paradoxical injustice was a product of the certitudes of religious dogma and class structure that defined Smith's world. Through this injustice, Winchester gives the reader a glimpse of what is to come in the book. More importantly, he uses this paradox to speak volumes about the historical context of Smith's life and work. Thus, in the first chapter, Winchester shows the reader the importance of Smith's work; it was to eventually crumble the foundations of English society. It was not Smith's original intention to begin this Copernican revolution, he was just a curious and innovative blacksmith's son from Oxfordshire. Smith was only revolutionary in that he innately possessed what is now known as a scientific method.

As Winchester continues, we find that this natural-born "revolutionary" talent first sprouted when Smith was a young lad in Oxfordshire. Upon the death of his father when he was eight, Smith was brought up on his uncle's farm. He began to notice peculiar stones around the farm, stones that looked like remnants of living creatures. While there were others that had made the same observation, the idea of fossils was heresy to late 18th century England. Nevertheless, he was acutely aware that others silently held the belief that fossils were actually remnants of animals that existed long before the genesis of the world set by the biblical scholar James Ussher. As Winchester points out, scientists of the late 17th and 18th centuries were beginning to erode the certitude of biblical knowledge. This slowly changing atmosphere of scientific inquiry allowed the young Smith to accept and examine the fossils he found in his boyhood home. Smith's study of fossils and their geographical distribution had begun and became the foundation for his great map.

While Smith is now credited as the father of modern geology, Winchester's account characterizes Smith as a geographer through and through. The young Smith landed his first job, a surveyor, through his recognized talents for observation and geometry. Smith was schooled in the ways of surveying and cartography, and quickly became respected in the field. In a seemingly pre-destined coincidence, his first major job was a commission to survey a path for the Somerset coal canal. Smith's love of fossils had found a practical application, and his new home of Rugborne Farm, Somerset is now christened "the birthplace of geology." It was his geographical training and talent that led Smith to the discoveries that marked the birth of geology

on Rugborne Farm. Winchester notes his "uncanny ability to perceive the spatial geometry of the world beneath his feet" (p. 89). While deciding which coalfields to put on the canal, Smith became aware of a possible order to the spatial arrangement of the coal strata. He noticed that the strata above and below the coal layers were remarkably similar across the different mines in the area and began to sketch three-dimensional maps of what he saw and learned from the miners. Smith's major breakthrough was connecting his knowledge of fossils to the stratigraphy he saw beneath his feet. He found that fossils were a way to make sense of the strata, and most importantly, be able to unmistakably map their distribution. Geology was born, and the map had its key theoretical foundation.

Smith's brilliance can be appreciated from many different disciplines and trades. He was one of the most influential canal builders of his time, a civil engineering whiz. He made a substantial side income draining and irrigating farmers' fields across England, garnering a reputation as a man who could seemingly make water move uphill. Moreover, he was quickly becoming a cartographer of note. Smith's ventures into cartographic design arose from a necessity to display three-dimensional geologic strata variations across the land surface. His use, choice, and manipulation of color led to the cartographic principles of geologic maps that are still visible today. Smith defined a color for each strata, and many of the color schemes have carried over into modern geologic maps. Smith's cartography was as creative and brilliant as the geology for which he is more readily known. His original geologic map not only made use of hand-applied color, but he applied the color in a way to be darker where the strata outcrop occurred, then

fade in color towards the next outcrop.

While Smith excelled in many disciplines, all his work was directed at the creation of the map. The canal building, irrigation projects, and cartography were all directed at collecting and manipulating stratigraphic data to produce the map. Smith's desire to produce the map was unquenchable. He was fully aware of the profoundly important nature of his research, and spent his life's work in pursuit of the map. His extensive travels, professional connections, and cartography began to bring Smith a sizeable income. His post as the head canal digger for the Somerset canal was one that not only brought him income, but also respect. He bought a small estate outside Bath, found a wife, and began to share his ideas with newfound friends that made up the upper crust of Bath intellectual society. Just as his work was challenging socially accepted norms, Smith's life was defying his born societal class. His travels now also frequently took him to London, where he acquired another mortgage on a flat. Smith seemed well on his way to the recognition he deserved, and had every indication that his soon to be completed map would be a thriving success.

However, the same society that seemingly accepted Smith as one of their own, was the one to disown him, plagiarize him, and relegate him to the debtor's prison where Winchester began his story. The proximate causes for Smith's demise are many and give this great man an all too human character. He lost his job with the canal company after a tiff with his boss, his wife became ill, and he had two mortgages to pay. However, it is strikingly obvious to the reader, and to Smith himself, that after publishing the map, he should never want for money again. English society

knew the worth of the map all too well, and that is precisely why they robbed him of it. Smith had begun socializing with the elite of London, with a group that called themselves the Geological Society of London, but he did not recognize their motives for dealing with him. At its founding the Geological Society held the belief that "the theory of geology is in the possession of one class of men and the practice in another" (p.228). To the Society, Smith's field-worn hands clearly gave him the mark of the practicing class. A man of the practicing class could not be trusted to produce a map of such importance, and the Society would not accept Smith's brilliant map. Rather, they began producing their own map, which when produced was strikingly similar to Smith's. Smith knew he had been plagiarized, but by this time he was penniless, and imprisoned. It is no wonder that when let out of the debtor's prison by the few sales of the map he did have, he left London in disgust.

Unlike many historical figures, Smith was lucky enough to stick around long enough to see his work appreciated. Young scientists inspired by Smith had ousted the elite of the Geological Society and called Smith out of retirement to accept the accolades due to him. He was awarded the Wollaston Medal (the Nobel Prize equivalent for geology), given a royal pension, and granted an honorary doctoral degree. Smith's work had shaken the foundations of British society and amid the rubble, Smith and his work stood tall. The map was now the foundation of a science and a new paradigm that would inspire Darwin and others.

My account of the story fails to include the anecdotes and historical narrative that Winchester provides. His writing brings life to this great story of a visionary man and the timelessness of one map. As he tells us in a footnote,

his story is directed toward the reader who needs no knowledge of Smith, geology, or cartography. Other, more exhaustive works are available, and Winchester even provides a suggested reading list for those inspired to learn more about William Smith and the birth of modern geology. Winchester succeeds admirably in writing this book towards his general audience, it is a delight to read, and completely readable in the course of a trans-continental journey to a conference. While the reader is sure to take away scores of facts and bits of knowledge, the book reads like a favorite novel. I admire Winchester as a writer, his work succeeds in being academic, yet his presentation is cherished by a general audience. Moreover, *The Map that Changed the World* is a singular work from Winchester's library. Winchester himself was trained as a geologist at Oxford and claims William Smith as his hero. This personal connection shines through in the book, adding another level of enjoyment above all his books. In one interlude of the book, we follow Winchester as he retraces his hero's footsteps and discoveries of the geographic distribution of Jurassic rocks. The interlude is a microcosm of what makes this book special, it reads like a delightful travelogue, following our native guide past his youthful stomping grounds. Yet somehow, in the course of splashing through waves on the English channel, or chipping a stone off a cliff in blustery Lincolnshire the reader learns the foundations and complexities of geology.

While I highly recommend this book to anyone, geologists, geographers, cartographers, and scientists in general will find it a delightful and relaxing read. As an added bonus for cartophiles like myself, the hardcover version which I reviewed contains a full color 23"x27" replica of Smith's

great map folded up into the dust jacket. Even without Winchester's lovely narrative, the map is a cartographic wonder and historical treasure. The hand applied colors, shading, annotation, and calligraphy of the cartographer himself make this map a treasure to be held as a piece of art. However, cartography is an art and a science. The greatest praise for Winchester's book is that it succeeds admirably in describing the science, and the scientist that produced such a singular and historically important cartographic work.



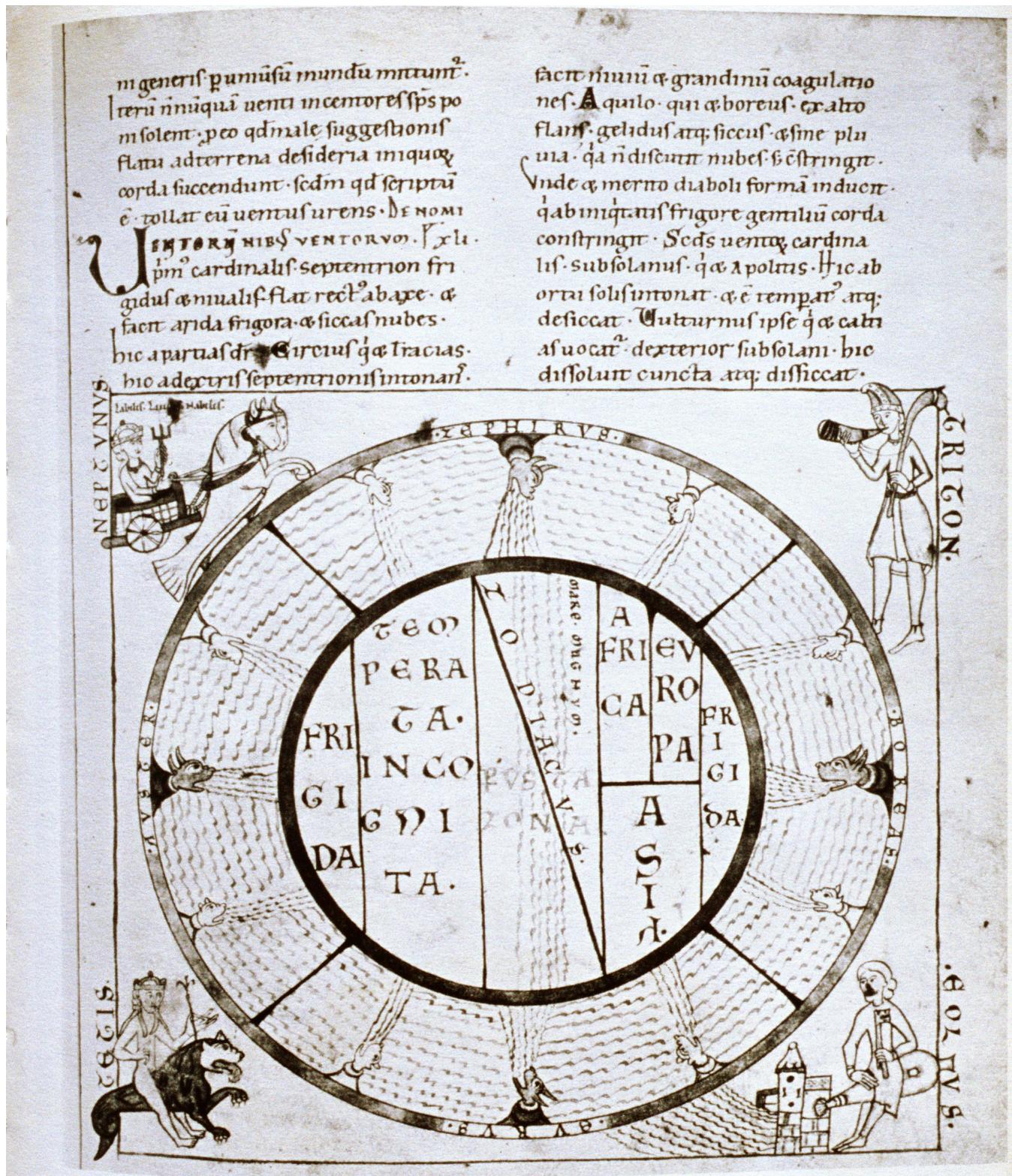
Earle Birney's "Mappemounde" Figure 1

Psalter Map, circa 1300 (BL Add.28681 f 9). Size of the original: rectangular frame, 14.5 x 10 cm (5 3/4" x 4"); diameter of circular world, 9.5 cm (3 3/4"). By permission of The British Library.



Earle Birney's "Mappemounde" Figure 2

*Sketch of a generic medieval world map or mappamundi. Size of the original: diameter of circular world, 10 cm (4"). Untitled and uncredited in Earle Birney's *The Cow Jumped Over the Moon: the writing and reading of poetry*, Toronto: Holt, Rinehart and Winston of Canada, 1972, 84. By permission of Harcourt Canada.*



Earle Birney's "Mappemounde" Figure 3

Zonal map, thirteenth-century. Size of the original: square frame, 18.5 x 18.5 cm (7 1/4" x 7 1/4"); diameter of circular world, 17 cm (6 3/4") The map, which illustrates a manuscript of the Etymologies by Isidore of Seville, shows the earth divided into five zones: frigid zones in the north (right) and south (left); two temperate zones—the southern one being unknown, the northern one containing the three known continents; and a central perusta zona, separating the habitable zones with its heat and ocean. At the map's corners are four classical deities associated with the sea: Triton, Neptune, Thetis, and Aeolus. By permission of Leiden University Library, ms. Periz. F.2, fol. 145r.



Earle Birney's "Mappemounde" Figure 4

The Anglo-Saxon, or Cotton [Tiberius] Map, tenth or eleventh century (BL Cott.Tib.B.V f 56v). Size of the original: 21 x 17 cm (8 1/2" x 7"). By permission of The British Library.



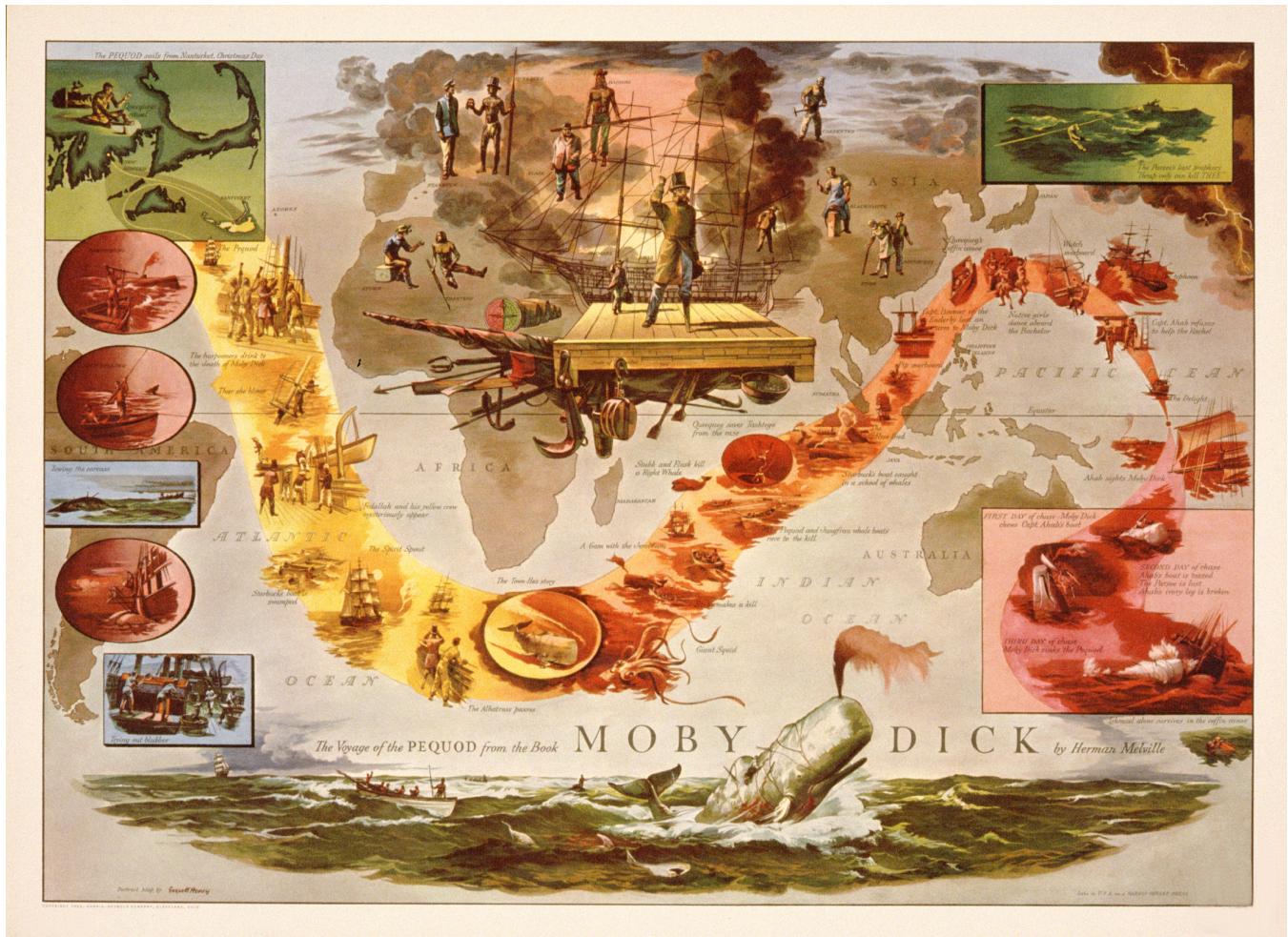
Earle Birney's "Mappemounde" Figure 5

The Sawley Map, twelfth century (CCC MS 66, p.2). Size of the original: 29.5 x 20.5 cm (11 1/2" x 8 1/2"), with the modern binding 31.5 x 2.2 (12 3/4" x 7/8"). By permission of the Master and Fellows of Corpus Christi College Cambridge.



Earle Birney's "Mappemounde" Figure 6

The Hereford Map, circa 1300, in a nineteenth-century facsimile. Size of the original map: approximately 1.59 x 1.29-1.34 m (5'2" x 4'4"). ©Peter Whitfield. By permission of Peter Whitfield.



Earle Birney's "Mappemounde" Figure 7

The Voyage of the Pequod from the Book Moby Dick by Herman Melville, Everett Henry, illustrator, Cleveland: Harris-Seybold, 1956. Original size: 43 x 61 cm (17" x 24"). Everett Henry emphasizes the apocalyptic destruction of the Pequod in his illustration of Ahab's prophetic Parsee lashed to Moby Dick (at the bottom), on his inset diagram of the three-day chase (right), and by his depiction of storm clouds where North America—and home—should have been. By permission of the Harris Corporation and The Library of Congress, Geography and Map Division.



Earle Birney's "Mappemounde" Figure 8

Abraham Ortelius' Septentrionalium Regionum Descriptum ("Map of the Northern Regions"), from his Theatrum Orbis Terrarum, 1570, plate 45 (Antwerp: Aegid. Coppernium Diesth.; reprinted, New York: American Elsevier, 1964). By permission of The Map Division of The New York Public Library—Astor, Lenox and Tilden Foundations.



Earle Birney's "Mappemounde" *Figure 9*

*Cornelis de Jode, Quivirae Regnum cum aliis versus Boream ("Realm of Quivira and Other Northern Territories"), the western extension of his America Pars Borealis... ("Map of North America"), Antwerp, 1593. Hand-colored copperplate engraving (Ayer *135 J9 1953, Part 1, folio XII). Size of the original: 34.5 x 23 cm (13 1/2" x 9"). By permission of the Edward E. Ayer Collection, The Newberry Library, Chicago.*



Getting Real Addendum A

Excerpt from the NPS map of Kenai Fjords National Park, Alaska at actual size. Illumination applied to northwest slopes on the shaded relief depicts the relief more lightly and legibly when combined with background landcover textures.



Getting Real *Addendum B*

Excerpt from the NPS map of Crater Lake National Park, Oregon at actual size. The map employs the texture substitution technique to portray forests. The tree canopy texture derives from a cloned aerial photograph taken in California. It fills a forest boundary delineated precisely—small copses of trees are visible on the map—from a USGS Digital Orthophoto Quadrangle of Crater Lake. Graphical embossment gives forest edges a slightly three dimensional appearance.