Caribmap: A Mobile-friendly Web Resource for Caribbean Maps that Facilitates Quantitative Historical Analysis

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Caribmap presents high-resolution images of Caribbean maps printed since the early sixteenth century, including modern topographic maps. It incorporates mobile Web programming that automatically formats the site for the device being used. Image zooming is accomplished with a recursive subdivision approach (quadtree tiling), allowing large map images to be viewed quickly on a desktop or small device. Starting with Jamaica, a series of narrated, multimedia essays was launched on Caribmap that combines Google Earth video tours, history, and biology. Digital map collections can facilitate and catalyze new areas of research by allowing users to explore cartographic history quantitatively. Historical time lines can be estimated for many aspects of maps including toponyms, land shapes, and graphic components. A toponym time line is presented as an example.

KEYWORDS   *Caribbean, Antilles, West Indies, database, images, quantitative historical cartography, time line, mobile Web*

INTRODUCTION

The Caribbean has been one of the most intensely mapped regions of the world throughout history (Nebenzahl 1990; Burden 1996). It was the focal point for discovery and exploration of the New World, and later the gateway for commerce from the Old World. Most of the earliest printed maps (Burden 1996; Shirley 2001), including the 1507 Waldseemüller wall map of the world, which exists as a single impression in the Library of Congress (Hessler and

Van Duzer 2012), show the Caribbean islands. Also, the volatile political history of the region, which featured islands controlled by multiple European countries, often at war, contributed to the unusually high mapping activity. The actual number of different Caribbean maps produced over the centuries is unknown, but it is probably more than 10,000. Cueto (1999) lists 715 maps of—or containing—Cuba, made between 1500 and 1600. This suggests that all maps in which Cuba appears must number in the thousands. Other compendia of maps of specific islands can be found in issues of the Map Collector's Circle (Campbell 1965; Kapp, 1968; Mallet 1964; Tooley 1966, 1969, 1970, 1972), and elsewhere (Bodington 2005; Buisseret 1996; Demorizi 1979; González 1973; Higman 1988; Hopkins 1989, 1992a, 1992b, 1992c; Ling 1887).

Caribmap is a Web resource (http://www.caribmap.org) of map images of Caribbean islands. It was created by the author in 1999 and now contains more than 1,500 high-resolution images. The geographic scope is the Caribbean Sea and its islands, including those bordering the Middle and South American mainland, such as the Bay Islands of Honduras, ABC Islands (Aruba, Bonaire, and Curaçao), Trinidad, and Tobago. Some islands technically in the Atlantic Ocean, such as the Bahamas and Turks and Caicos, are included because they are culturally, economically, and historically linked to the Caribbean islands. Thus, the region covered by Caribmap includes the West Indies and other Caribbean islands (Figure 1).

Caribmap provides users, including researchers and the general public, with the ability to locate and read toponyms (place names) and other details on maps that are often not discernible in reduced versions of map images
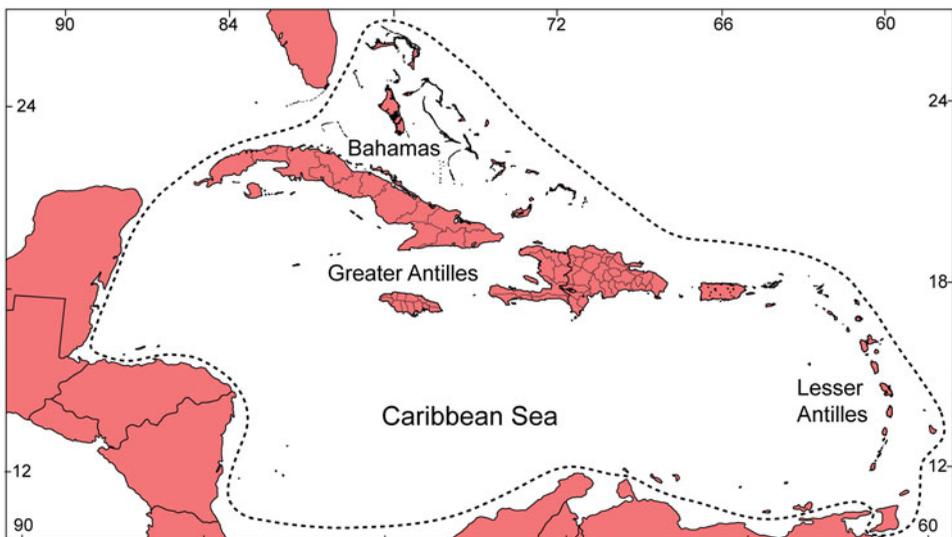
FIGURE 1 Geographic region covered by Caribmap.

encountered in print and online publications. Most map image files average about 100 megapixels. Initially the site was focused on historical maps in the collection of the author, but donations of images from other map collections has greatly expanded Caribmap, which now includes modern topographic maps. The site has been visited more than 100,000 times in recent years, and usage rate continues to increase. This article provides some details on the structure, function, and potential use of this Web resource.

STRUCTURE

Caribmap is a relational database using SQL (programming language for databases), with a front end written in PHP and HTML (programming languages for Web development). Image zooming is accomplished with the free software Seadragon and DeepZoom (Microsoft). In the quadtree tiling approach used, images are recursively subdivided into groups of four smaller tiles and assembled, hierarchically, as needed when a region is selected in the zooming process. To the human eye, the zooming appears smooth and fluidlike. Most image-zooming software uses some version of tiling, but usually not as smoothly implemented.

Maps from the author's collection were scanned on large-format flatbed scanners, usually at the 600-dpi scanner setting. Because Web viewing of images is at 72 dpi, this results in sufficient magnification to read the smallest of toponyms. Most donated images were also scanned at high resolution by their respective institutions. The metadata associated with each image include map title, year published, map creator, language, medium (usually woodblock, copperplate, or lithograph), dimensions (height × width) in centimeters of the outermost border (usually the neat line), publication information (e.g., of the book or atlas in which the map was included), source of the map image, and the unique Caribmap identifier beginning with *CM*. These metadata were selected because they were readily available with most maps and map images obtained, and are data typically listed in printed map compendia e.g., Burden, 1996; Shirley 2001). Also, they meet or exceed the typical amount of metadata available in online digital collections. A future enhancement will be to include OCLC bibliographic identifiers.

FUNCTION

The home page of Caribmap (Figure 2) includes a geographic index and toolbar in the left column, a thumbnail slider in which maps are loaded after a region is selected, and a map viewer area where the map image is shown. At the top of the geographic index is a search window where any map term or combination of terms can be entered, including unique

FIGURE 2 Home page of Caribmap as it appears on a desktop monitor. In this case, Jamaica has been selected in the navigation toolbar at left, and a 1720 map by Moll is loaded in the viewer. The horizontal thumbnail slider, with maps of Jamaica, is shown above the viewer.

Caribmap identifiers. Boolean search terms can be used. The geographic index is arranged alphabetically by island or island group, and the total number of maps in each region or category is shown in parentheses. This is the number of map images that will be loaded in the thumbnail slider, sorted by year. In the case of topographic maps, an index is shown first in the thumbnail slider, and each map is sorted by map index number. For each geographic region selected, the first map shown in the thumbnail slider is a Google Earth satellite map, which will appear in the map viewer when selected and is zoomable. The video tour for the region, if available, is shown
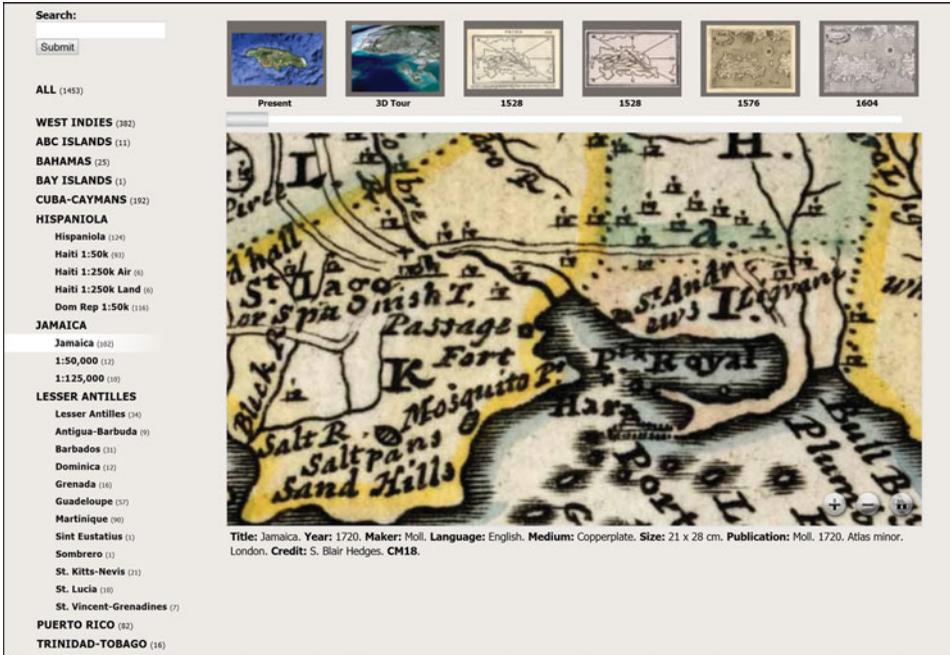
FIGURE 3 Map viewer of Caribmap showing same map of Jamaica as in previous figure, but after zooming in on a small area where the capitol, Kingston, exists today.

as the second thumbnail choice. Social networking share tags are available at the bottom of the left-hand toolbar.

The central viewing area displays the default or selected map. Three semitransparent buttons in the lower right corner of the image allow the user to zoom in and out (Figure 3), or reset the image size. However, zooming in is more easily accomplished by clicking on the image with the mouse pointer, in which case the zoomed image centers on the area clicked. Moving the image is done by holding down the mouse button and moving it. Map information (metadata) is displayed below the viewing area. When a video is loaded, it can be started by clicking the Play button (Figure 4). At that point, the standard YouTube controls appear at the bottom of the viewer, allowing the user to select greater resolution and control other functions. Clicking the YouTube symbol in lower right corner of the video frame will open a separate window with the YouTube video, if that is preferred by the user.

When Caribmap is viewed on a smartphone browser, mobile Web programming causes the site to format specifically for the device used. For example, on an iPhone (Figure 5), a dedicated app is not needed because the reformatted site is fully functional. One major change in the smartphone format is how the maps are selected. Instead of a geographic index, a drop-down tool is presented. Also, instead of the horizontal thumbnail slider,

FIGURE 4 Map viewer of Caribmap after the map tour of Jamaica has been selected, loaded in the viewer, and started. Caribmap videos are also accessible on YouTube.

which would not fit on a small device, the thumbnails are shown tiled below the main viewer. Controlling image zooming is accomplished by tapping once with the finger. Because smartphone screens have specific functions tied to lateral movement of a finger, it is not possible to move an image in the map viewer with the fingertip. Instead, the user must select the area of interest by tapping (zooming) on that map region. When a video tour is selected, a separate video control is activated, which adapts to vertical or horizontal orientation of the device (Figure 5).

As with most Web sites and databases, the content of Caribmap is protected by copyright. However, copyright protection of digital collections is often misunderstood. It is a violation of copyright agreement to copy an entire database, or significant portions of a database, even for personal use. The copyright of an object in an image is a different issue. Maps older than 1923 or those produced by the U.S. government are not under copyright, but this means that a person is free only to scan an original document, assuming he or she can locate that document, obtain permission to scan it, and use the resulting scanned image. It does not mean that a person automatically has the right to take someone else's scan of that document, on the Web (for example), without permission. Doing so would be a violation of the copyright protecting the Web site content, regardless of the age or copyright protection of the documents in the images. Unfortunately, because there is a market for reproductions of old maps and other art objects, image theft is
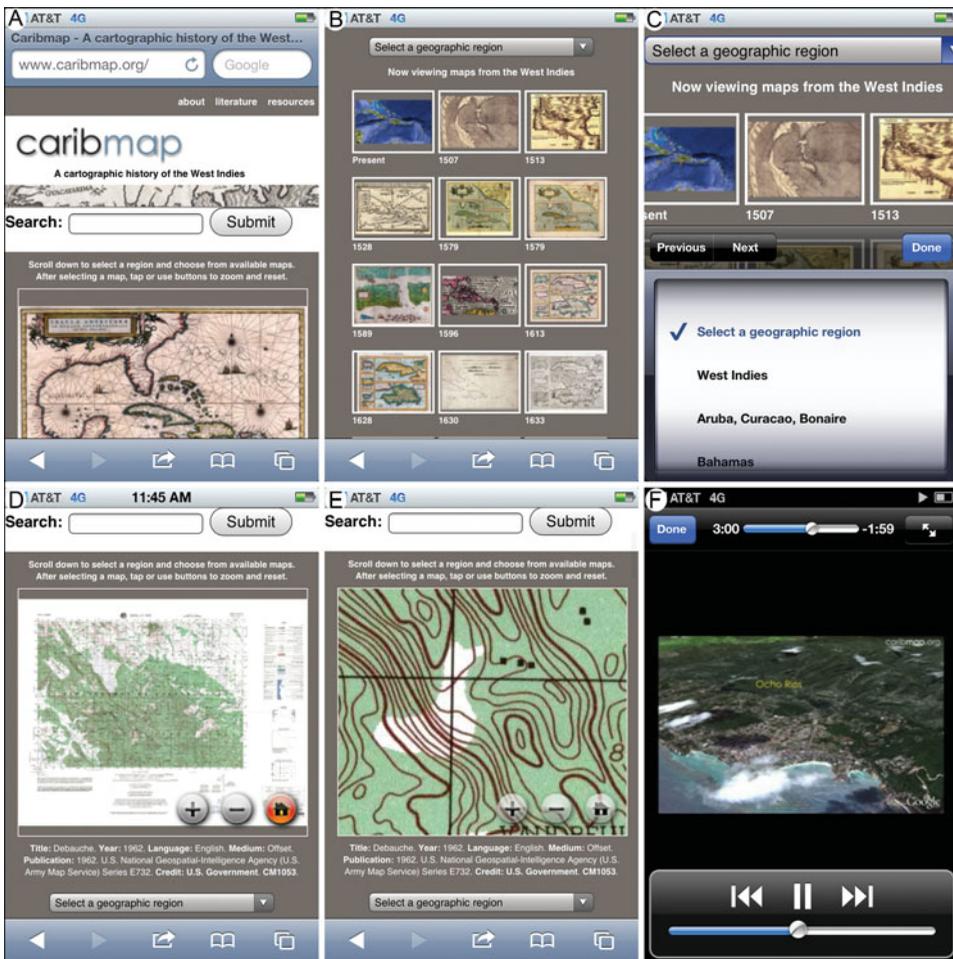
FIGURE 5 Six iPhone displays illustrating how mobile Web programming recognizes and automatically formats Caribmap on a smartphone device. (A) Top of scrollable home page, showing upper half of viewing window. (B) Lower down on the home page, thumbnails are presented as tiles rather than the horizontal slider of the desktop format. (C) Selection of geographic region by drop-down menu. (D) Modern topographic map loaded in viewer. (E) Same topographic map, but after zooming in on a small area. (F) Video map tour showing vertical view.

not uncommon. Nearly all owners of digital collections will give permission for research use of their images, if asked.

TIME LINES

Among the many potential research uses of an image collection is the creation and study of historical time lines that show change in a subject through time.

They allow a user to explore history quantitatively, with maps or other objects such as books and prints. In a time line, a feature of interest (e.g., toponym) is chosen and scored as present or absent, or assigned a quantitative value, in each of the objects scored (e.g., maps, books, or prints). The resulting scores are then binned into time intervals and summarized in a histogram of time. As with any histogram, there is a tradeoff between sample size and bin size. If a large sample size (e.g., map images) is available, it may be possible to use a small bin size such as a single year. However, with smaller samples, larger bins are needed, such as bins of five, ten, or more years. If a larger bin size is needed, it is also possible to use a sliding window (overlapping bins) whereby the value for a larger time interval is assigned to a single year at the center of that interval, which may help smooth random irregularity and better reveal an underlying pattern (if window size is too large it will oversmooth, i.e., flatten, the curve). In some cases, the total count (sum) of scores per time interval may be of interest, whereas in other cases one might be interested in frequency change. Statistical variance can be computed, and differences between time lines and inflexions within time lines can be tested for significance. Unless the collection used is complete (e.g., all known maps of a particular region), the results should be interpreted accordingly: for example, the earliest occurrence of a feature may be earlier than in the sample. In most cases, time lines will enhance literary scholarship, but in some cases new and unforeseen historical discoveries could be made.

A diversity of time lines can be created from maps. A time line of geographic shape, such as shape of a continent or island, can be created whereby historical maps of a geographic area can be compared with the current shape of the area and deviation from current shape quantified. With a high enough density of maps, mean deviation can be summarized for each year, or other short time interval, and plotted. As cartographic accuracy increases through time, the geographic time line of shape deviation will show decrease with time. Inflexion points, wherein the rate of cartographic improvement is greatest, should be attributable to major surveys and discoveries such as the charting of coastlines. At an even more basic level than shape, a time line can be constructed for the geographic location (coordinates) of a continent, island, ocean, toponym, or other geographic entity, by reference to its current location and deviation backward through time. One can also envision time lines produced for topography. In that case, deviation from the present could be determined for a combination of location (coordinates) and elevation. Visualizing time lines of geography and topography could be done in both time-lapse animation (e.g., shapes of continents and islands) or on a current map of the region, showing the time period (color shading) when different areas became resolved (e.g., within 5 percent of current information). Such a figure could be the best possible representation of the progress of cartography of a region, derived entirely and automatically from historical map data.

Besides time lines of cartographic accuracy, there are many other possibilities for constructing time lines from maps. For example, trends in the medium (e.g., woodcut, copperplate, and lithograph prints) used across the centuries could be quantified accurately, and should mirror, in general, what is already known of the history of printing (Hults 1996). However, with large samples of maps, the resulting time lines are likely to reveal new and unexpected patterns. For example, by focusing on maps from individual countries, it might be possible to show, statistically, which countries were first to make transitions in print media and which ones lagged. Time lines also can be created for different parts of maps, such as cartouches, compass roses, sea monsters, sailing ships, and rhumb lines. The time line would indicate not only when a particular map component was most popular, but also the frequency of maps with that component in any time period.

Toponyms are an abundant source of data for time lines. Any given region of the world could have dozens or hundreds of possible toponym time lines. This is especially true in the Caribbean, where different names have been applied to different islands over time. To illustrate the concept of a toponym time line, I show time lines for the two names that have been applied to the group of islands now called the Bahamas (Figure 6). Of the maps scored, 181 applied the original Taino-derived name "Lucayas" and 332 used "Bahamas." The two time lines show that Lucayas was the only name used in the sixteenth and seventeenth centuries, that Lucayas and Bahamas were used about equally frequently during the eighteenth century, and that the nineteenth century saw a gradual decline in usage of Lucayas until that word disappeared from maps by the beginning of the twentieth century. Because Caribmap does not contain every map of the Caribbean ever printed, maps that are missing may change some of that pattern, especially during time periods when sampling is sparse. Also, no effort was made to sample
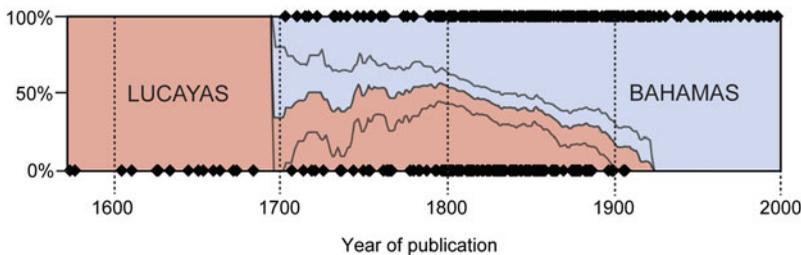
FIGURE 6 Toponym time lines for the Bahamas. The graph shows the relative frequencies of the two names, Lucayas (red) and Bahamas (blue) that have been applied to the islands currently called the Bahamas. Black diamonds are individual maps, with maps indicating "Bahamas" (n = 332 maps) on upper line and "Lucayas" (n = 181 maps) on lower line. For the frequency plot, a sliding window of 20 years was used, with sampling every year. The middle gray line separating the colors is the mean frequency; standard deviations above and below the mean are indicated by additional gray lines.

toponyms used in books—for example the name Lucayas dates from the time of Columbus. However, the overall pattern, especially the gradual transition from Lucayas to Bahamas during the nineteenth Century, is unlikely to change given the dense sampling of maps already available.

In summary, there are many possible uses of digital collections of maps and prints that have yet to be explored. Maps are especially amenable to time series analysis because the same geographic region was often mapped hundreds of times over the centuries, providing enough information for resolving detailed trends through time. Not all time lines will necessarily answer burning historical questions. However, I have touched on a few examples above, out of many possibilities, in which quantitative time line analysis should be a useful tool for historians.

CONCLUSIONS

Digital collections are growing rapidly and will eventually contain the majority of printed works. Some growing collections, such as Caribmap, already have reached a level of completeness that permits quantitative historical analysis. To facilitate those analyses, metadata associated with image files will need to be expanded in the future, beyond current international standards, to include as much information as possible about the objects (toponyms, etc.) in the image. Advances in image analysis, including optical character recognition in complex backgrounds, eventually will facilitate automated annotation of images. In turn, this would permit researchers and other users to routinely perform complex analyses on countless images, revealing new patterns and insights about history.

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