USING ANIMATED CARTOGRAPHY TO ILLUSTRATE GLOBAL CHANGE

Leonard J. Gaydos
William Acevedo
U.S. Geological Survey
Cindy Bell
Johnson Controls World Services
Ames Research Center, 242-4
Moffett Field, CA 94035 U.S.A.
FAX 1-415-604-4680

Abstract

Cartographers can use computer animation to bring to life global changes that affect society. An animation of urban growth in the San Francisco Bay area, U.S.A., serves as an example. Experience with this animation points out the importance of achieving consistency in mapping patterns from diverse historical sources, simplifying the themes to be portrayed, adopting a spatial and temporal extent that completely encompasses the pattern being shown, and employing a temporal scale that allows the viewer to track significant patterns while maintaining interest.

1 Introduction

Mapping and deciphering the effects of global change is a significant challenge. However, cartographers have the means to portray convincingly the extent and pace of global changes such as deforestation, urban growth, loss of wetlands, and cropland expansion. These land transformations can be visualized using animation techniques over suitable time periods. Computer animation can contribute to society's recognition of profound changes affecting the landscape. Recognition of these land transformations is the first step toward devising policies to mitigate the effects of adverse changes. As these issues are debated, cartographers can play an important role both in sounding the alarm and in monitoring compliance with resulting policy.

An animated map will be a success if the cartographer takes care to ensure that the interpretation of historic source material is consistent, only simple themes are shown, sufficient space and time are included, and a temporal scale is adopted that maintains viewer interest while enabling the viewer to track important patterns. This paper will recount one recent success and suggest some considerations for others to follow in using animated cartography to illustrate global change.

2 Background

The use of animation (literally, bringing to life) in cartography was first described by Thrower [1]. One of the earliest applications was by Tobler [2] who created a movie simulating urban growth for Detroit, Michigan, U.S.A. from decennial census data. Tobler's work and that of others [3] predated the ability of computers to do anything more than create individual frames that could be photographed and made into a movie. More recent advances have freed cartography from almost total reliance on paper media. The computer itself is being used as a cartographic medium. Animation takes advantage of this new computer-based medium, opening new horizons to cartography [4, 5]. The discipline is starting to embrace the new interactive and animated cartography summarized by Peterson [6]. Still, there are far more examples of interactivity, where the user alters map content, scale, symbolization or perspective through their interaction, than of animation, where maps move.

Although animated cartographic examples are rare, one type is pervasive, with an audience that may be greater than for any other map ever made. The success of the television weather map, made by animating and annotating a series of geostationary satellite images, illustrates the power of this new form of cartography. Maps that move can convey dynamic processes like weather patterns and the land transformations of global change better than the traditional paper maps ever could.

The pace and extent of urbanization in the San Francisco Bay area, U.S.A. was recently illustrated by animating a series of historic maps derived from diverse sources [7]. This demonstration, showing 140 years of urban growth in 30 seconds, had immediate visual impact and created intense media interest. The sequence was shown regionally on four television stations during several newscasts and was the subject of two major newspaper articles [8, 9, 10]. Key to its success in capturing the public's imagination was the use of animation. This experience suggests cartographers consider several points prior to preparing similar animations of global change.

3 Considerations

3.1 Source Materials

Most land transformations studied under global change take place over decadal time scales. During the lifetimes of many of us, immense changes have taken place. Perhaps because human beings have time frames more aligned to days, weeks, and years than to decades and centuries, it is hard for us to comprehend the true dimensions of transformations like tropical deforestation or urban growth.

Cartographers must adopt an appropriate time frame, dating back a hundred or more years to portray these changes. Luckily, historic maps have preserved some information on the past condition of the landscape. This information is not as complete as any of us would like, but space images, old aerial photographs, topographic maps, land use maps, even road maps, plats, and textual descriptions, can all be used as sources for building data bases of land transformations.

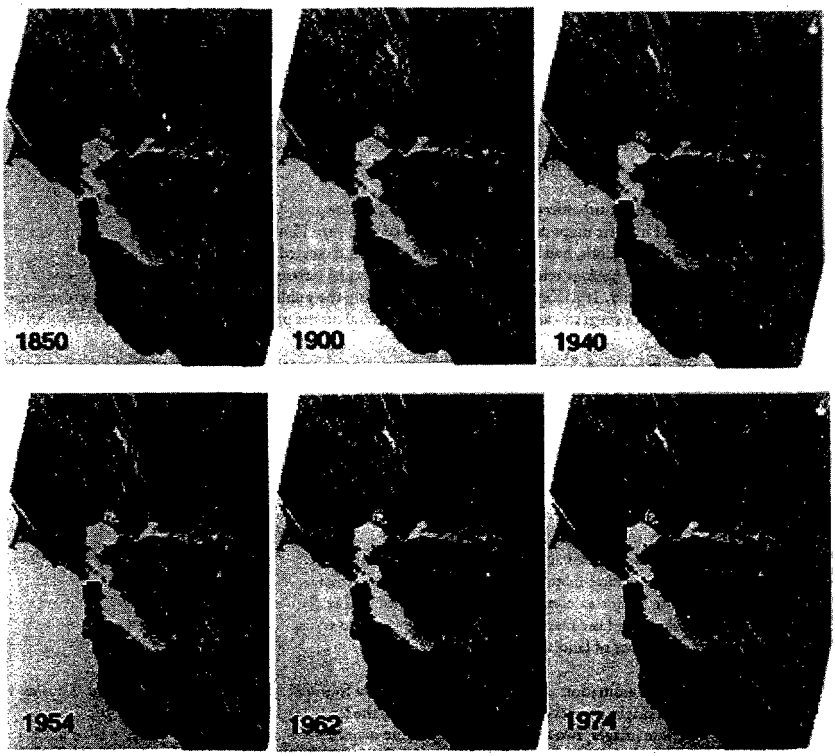
The San Francisco animation used cartographic products from every era of the U.S. Geological Survey's history, from the original series of topographic maps to the latest satellite images (Figure 1). Included were two sets of satellite images, two sets of regional land use maps, two interpretations of topographic maps, and various descriptions of original town sites during the California Gold Rush in the 1850s. To create the data base for the animation, procedures were devised to interpret urban land use consistently from these sources. The latest Landsat source was used as a reference for the patterns of urbanization to be mapped. Urban and built-up surfaces appear bluish to white in color when the data are displayed as a color-infrared image. Regions with this pattern were mapped as urban, and criteria were adopted for mapping similar urban areas using the other data types [11].

Having information from as many time periods as possible is important because more temporal data sets produce a smoother and more accurate depiction of the changes being portrayed.

3.2 Data Display

Traditional cartography using paper as a medium tends to overload information on the map. This is done for a good reason. Paper maps are time consuming and expensive to make. It makes good sense to err on the side of too much data rather than too little under these circumstances. The use of electronic media changes these rules. Maps can now be views of data bases rather than the data base itself. This ability to separate data storage from display is particularly important for animation.

In depicting information over time, great care must be taken to simplify the themes shown. The eye is attracted so much by the movement, that it can barely see anything else. Features must be very clear and



Urban Land Use Change San Francisco Bay area

Maps of urban land use were compiled from satellite images, regional land use maps, topographic maps, and descriptions of original town sites. These seven temporal base maps were used to create an animation depicting urbanization of the San Francisco Bay area from 1850-1990.

Figure 1

sharp. The San Francisco map is a good example of this. It is based on a simple, gray tone, shaded-relief map with blue water to show the context of the physical environment on which urbanization has taken place. This background image is a constant through the animation. Only a single theme, urban land use, is shown. This theme is colored red, to contrast readily with the background and ensure visibility during movement. The only legend provided is a constant title and a year clock that ticks off each year as the animation unfolds.

One must view the animation several times before some of the important information can be discerned, even if themes are simplified significantly. Even such a simple display conveys so much information when it incorporates the time dimension that it is hard to track important changes in just one viewing. During an initial viewing of the San Francisco map, an impression of rapid growth toward the end of the animation might be noted. Another time, growth early in the 20th century along the San Francisco Peninsula will be focused on. Another viewing will show the explosive growth of the Silicon Valley around San Jose. Yet another time one might notice rapid recent growth around Sacramento, and so on. The same phenomenon is seen in viewing the weather map. It is usually shown several times in a loop to enable this selective focusing to take place.

3.3 Spatial and Temporal Perspectives

Animation fosters the mapping of a dynamic process by placing the viewer at vantage points in time and space that are appropriate to the process being mapped. This is important in conveying information on global change. As Vice President of the United States Al Gore points out, "In order to recognize the pattern of destruction, we have to see it from a distance, both in time and space" [12]. Just as it is hard to see the forest for the trees, it is difficult to comprehend major land transformations from our normal spatial and temporal reference points where incremental changes may be noted, but broad patterns may be hidden.

The cartographer must select a perspective that includes enough space and time to encompass the transformation being depicted. Global changes, particularly land transformations, have regional components. For instance, an animation of tropical deforestation in South America might include the Amazon Basin over the last 50 years. Animating the urbanization in Mexico would include the region surrounding the Basin of Mexico over 500 years. Our map of urbanization in the San Francisco Bay area included much of Central California over 140 years.

The viewer should be encouraged to abandon the normal time reference of days, months, and years for the decades and centuries required to see in full force the land transformations that are taking place. In the San Francisco example, the effect is one of viewing central California from space and seeing, in less than a minute, the changing pace and extent of urbanization that took decades to occur.

Temporal scale deserves special attention. Just as it is important to include a suitable temporal extent, it is also important to scale animation time appropriately to real time. It may be useful to define temporal scale as the ratio of animation time to the actual time being depicted, just as spatial scale is defined as the ratio of a unit on the map to units on the ground. For the San Francisco example, the temporal scale is approximately 1:150,000,000, a half minute representing 140 years. Stretching the animation time out (increasing the temporal scale) without increasing the amount of base data would be the animated equivalent of enlarging a printed map. Decreasing the temporal scale would result in a faster showing that would make it harder to focus on significant change patterns. The San Francisco temporal scale was chosen by trial and error. It seemed long enough to enable important patterns to be tracked, while short enough to hold the viewers attention. As animation plays an increasing role in cartography, research on temporal scale will be warranted.

4. Conclusion

Animated cartography is a way of bringing important global change issues to life for society. Just as with traditional cartography, design considerations include source material, data display, and spatial and temporal perspectives. Animation forces some rethinking of these issues and adds temporal scale to the list. By following some guidelines for creating animated maps, the technology can play an important role in helping society recognize profound changes that are occurring in our world.

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