

feature article

Cartography Resources on the World Wide Web

This paper provides an overview of recent developments on the World Wide Web from a cartographer's perspective. The first section briefly describes how the Web came to be and discusses the conceptual models that control the Web's functionality. The second section of the paper is an overview of a variety of cartographic Web resources (ranging from federal to commercial to educational) that are available on the Web. These sites offer tremendous resources for use in the classroom, research, and even leisure activities. The paper concludes with examples of two Internet projects that make extensive use of cartographic materials: the *Geography Virtual Department* (out of the University of Texas–Austin) and the *Bosnian Virtual Fieldtrip* (out of George Mason University).

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It's probable that you have heard of the Internet, the World Wide Web (the "Web"), and perhaps even the "Information Superhighway." But it's also probable that a year or 18 months ago you had not. This rapid rise from the exclusive domain of a few scientists to the covers of weekly news magazines is unprecedented in the history of the Internet. The Web is one of the fastest growing parts of the Internet. Since its inception in 1989, it has swept through most of the industrialized world at a staggering pace. By spring 1995, according to estimates published in *Business Week*, the number of sites was doubling every 53 days, reaching 27,000 by February 1995. Other figures indicate a similar rise to prominence; Web traffic ranked second (in kilobytes) of all traffic going across the National Science Foundation's network by March 1995, rising from a rank of 80th in January 1993, and it may already be the busiest part of the Internet by the time you read these words. The Internet as a whole is said to have grown at 10 percent a month for the last three years, and there are no signs of slowing. No one knows for sure how many available Web documents there are, but a reasonable guess as of mid-1995 would be at least ten million.

This paper is not a "how-to" paper on the specifics of setting up and using the Web. Fortunately one of the truisms about the Web is that everything you need to know about using the Web, is on the Web. Plus, the Web changes too quickly for this type of discussion to appear in print. Given the dynamic nature of the Web, this paper focuses on demonstrating the realization and potential of the Web from several cartographic perspectives.

The World Wide Web dates from 1989, when the European nuclear research agency (CERN) started thinking about how it might communicate research findings among its widely dispersed (and multinational) staff. The method that eventually evolved was based on something called "hypertext." This allowed the European scientists to collaborate with each other and their colleagues in America over the Internet. The term "hypertext" was originally coined in the 1960s by Theodore (Ted) Nelson, a professor at Brown University, but the term probably dates back much

INTRODUCTION

THE WEB CONCEPT

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earlier.¹ The basic definition of "hypertext" is simply: non-sequential writing. However, this definition does not manage to convey the radicalness of the idea. Consider for a moment how you are reading this text. Each word follows one from another in an orderly progression from start to finish. As you hold the journal in your hands, you can tell at a glance how far you have read and how much more there is left. Now imagine that you could read this paper backwards, if not word by word, then perhaps paragraph by paragraph (hypertextualists call these "chunks" of text a "lexia"). Does it make any sense? Now imagine that you can read this paper by beginning anywhere—middle, near the end, the third paragraph—and then can go to any other paragraph or lexia. And if the work was long enough (with each lexia linked into others stored around the world), you could keep following the path for as long as you wanted (or until you got bored). This would be a completely "open," non-hierarchical hypertext.

The real World Wide Web is much less chaotic than this, partly because the true possibilities of hypertext have not yet been explored, but also partly because humans crave order of some kind (thus creating an interesting contradiction at the heart of the Web; it is based on a destabilizing system which has to be "stabilized" in order to be comprehensible). But it is still possible to take long meandering routes through those ten million documents on the Web, following links from place to place. By comparing this navigation of "dataspace" to navigation of physical space, it is easy to appreciate that there might be some of the same problems of getting lost and wayfinding.

Some hypermedia developers have explicitly considered the utility of a "spatial metaphor" (such as a map or city environment) to guide users around a large, complex, and non-linear database.² The use of a spatial metaphor for hypermedia access has also been considered by cartographers. In a recent paper, Tilton and Andrews (1993) argued that the spatial metaphor is a mixed blessing and may actually impede database searches: "[w]e are concerned that the spatial metaphor is not descriptive of the structure and access of information; it is prescriptive" (Tilton and Andrews 1993, 62). Their reasoning is that the spatial metaphor has been over-literalized in interfaces by using a concept of a topological or "true" (Euclidian) space and that navigation through complex multimedia databases has no such inherent Euclidian structure. This point is a valid one and it shows how a metaphor can break down when it is literalized (Rorty 1989). However, their argument downplays two things. First, there is a long tradition of work on non-Euclidian spaces by geographers and cartographers (e.g., time-spaces, multi-dimensional scaling, cognitive maps, and cartograms). Although it is a useful reminder that "space" in hypermedia is unlikely to be a Euclidian space, it is a (non-Euclidian)

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1. Most writers on hypertext date the explicit idea to Vannevar Bush and his 1945 classic article, "As we may think" (now available as a hypertext document on the Web), but it is intriguing to push the date even further backwards. Could we usefully think of the Koran—with its commentaries and commentaries upon commentaries—as early hypertext? Other people have suggested seventeenth-century "reading wheels," which were designed to reduce the effort of reading many books at once, as another precursor of the Web. A more familiar source is the academic article, with its footnotes, references to other texts (bibliographies), and citation indexes.

2. A simple illustration was discussed by the organizer of a workshop held as part of the European Conference on Hypermedia Technology (ECHT) in 1994. It can be viewed on the Web and its URL is http://www.gatech.edu/lcc/idx/Faculty/andreas_dieberger/Workshop.ECHT94.html.

space nonetheless.³ I would suggest that multi-dimensional scaling (MDS) may be a better metaphor for hypermedia because of its nonlinear and multi-dimensional maps and because, of course, it is spatial (e.g., one can analyze regions [or "nodes"] of the MDS space, as well as closeness and distance matters).

Second, Tilton and Andrews separate semantic networks (the organizing principle behind most hypermedia databases according to them) from spatial networks. This has the effect of disallowing navigation as a strategy for using hypermedia. In fact, I would argue that semantic networks have spatial elements (our mental processes are a bit like MDS in that there are regions of interlinked associations where "closer" associations are activated before more "distant" ones [see Lakoff 1987]). If we expand the notion of navigation to include temporal travel ("I want to go to that document from five minutes ago") as well as negotiation through non-Euclidian spaces, this would allow for the non-literal interpretation of navigation and space that Tilton and Andrews believe is lacking.

This focus in hypermedia research on giving users a sense of where they are probably comes from the human aversion to being lost (an aversion so strong it became a fundamental metaphor in non-spatial realms). Tilton and Andrews are right to criticize the over-literal use of this metaphor in hypermedia and its resulting focus on informing users about where they are.⁴ But we do not need to discard this or all metaphors; instead, we need to de-literalize the spatial one and think of new ones (such as MDS or user-specific dynamic maps).

Whatever the case, for now many "spatial" metaphors are present in navigating the Web. Web use is a matter of moving backwards or forwards from "page" to "page." The main indexing pages are called "homepages." Homepages are usually the central reference point for a site's Web resources and it is a good idea to begin there, for a well-designed homepage should provide access to the main supplemental pages at that site. The George Mason University Geography homepage is shown in Figure 1. The page is displayed in a "browser" called Netscape. Text and graphics are combined, and both can be used to provide reference points or links to other pages that are accessed by simply clicking on the highlighted link (e.g., "faculty" in Figure 1). In addition to text and graphics, sounds, animations, and binaries can often be provided through the use of so-called "helper" programs that are called-up by the browser to process the downloaded information.

Since the Web is highly distributed by design, some method of locating resources is necessary. This is provided by the Universal Resource Locator (URL). Each "resource" on the Web, whether it is a homepage,

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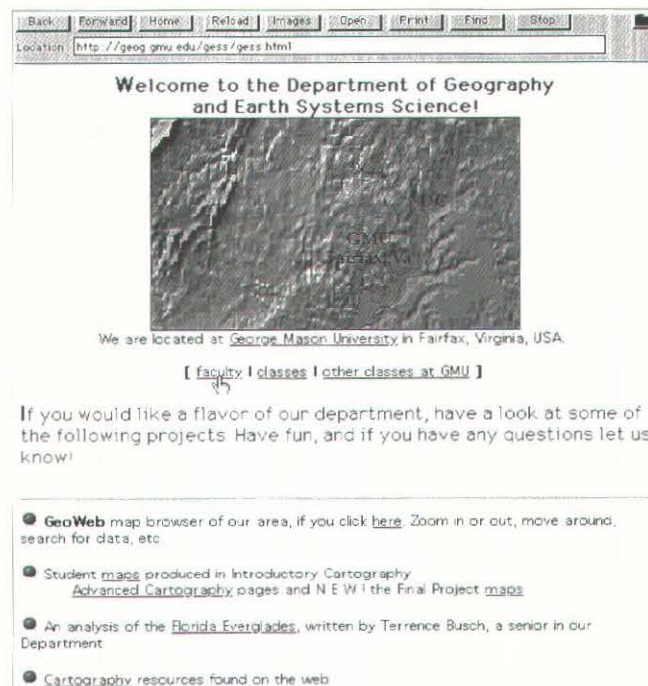


Figure 1. George Mason University's homepage on the Web.

3. By non-Euclidian space I am thinking of spaces where the concepts of "near" and "far" pertain, but that are also non-commutative (for example in cognitive maps [which have also suffered from over-literalization of the map concept] where A may be perceived as further than B, which is further than C, but C is not perceived as further than A [see Wood 1978]).

4. It might be better to let hypermedia users have a very rough rather than an exact sense of where they are (i.e., within a certain area, not at a certain point. Research with expert wayfinders suggests that this can decrease the processing load and increase solution times [Crampton 1992]).

map, sound, or binary program, requires a URL to be given to the browser before it can find the resource. You can type in the URL or simply follow a link from another page (the most usual method). Ritter (1994) provides information on configuring and using browsers as well as URLs. The reader should be aware that there have been several significant developments since Ritter's article appeared, including the ability to animate icons through a new strategy called "push-pull" from the Netscape Communications Corporation (NCC). NCC has also announced a deal with Macromedia to incorporate its animation software directly into the browser (*Macweek*, June 7, 1995). This means that animations will be played "live" as they are received rather than waiting for long downloads. This should speed up getting large multimedia resources from the Web. Although these developments are interesting, they have yet to be fully realized.

CARTOGRAPHY RESOURCES

The Web is changing rapidly due to its tremendous growth. For this reason, a Web-based online supplement (the Cartography Resource Page) has been developed to accompany this article in order to ensure the most up-to-date information. The Cartography Resources Page (Figure 2) contains the Web's most complete listing of cartographic resources available. It is part of a larger international effort to document available resources in what is called the "Virtual Library" (VL). The VL was organized by the MIT-based W3 Consortium (a group of Web experts and some of the original CERN researchers who developed the Web). The VL

takes advantage of the Web's inherent, distributed nature; each Library entry (cartography, geography, physics, anthropology, etc.) is maintained by a different author, thereby reducing the individual's load. All materials discussed in this paper (and much more) are available in this cartography supplement, and readers should check there often for updates.⁵ The VL provides an index to cartography resources on the Web rather than a repository of data itself. The index is organized thematically to cover the main providers of cartography resources on the Web: commercial, federal and educational sites, geography, and desktop publishing. There are also some related sites for GIS and remote sensing interests.

The Web has been notable for its broad reach beyond the confines of universities and research labs, and it has been widely embraced by the commercial sector. For cartography, this means opportunities for map companies to provide information about themselves and, of course, to advertise their products and services. In many cases this amounts to no more than a simple announcement—a kind of "look, we're here." In other cases, however, map companies offer a true

value—namely, added service through their pages. In the increasingly competitive world of the Web, the winners are likely to be those sites that offer an actual service that entices someone to return and thus generate sales. This implies committing resources to the Web site, keeping it up-to-date, and responding to inquiries in a timely manner.⁶

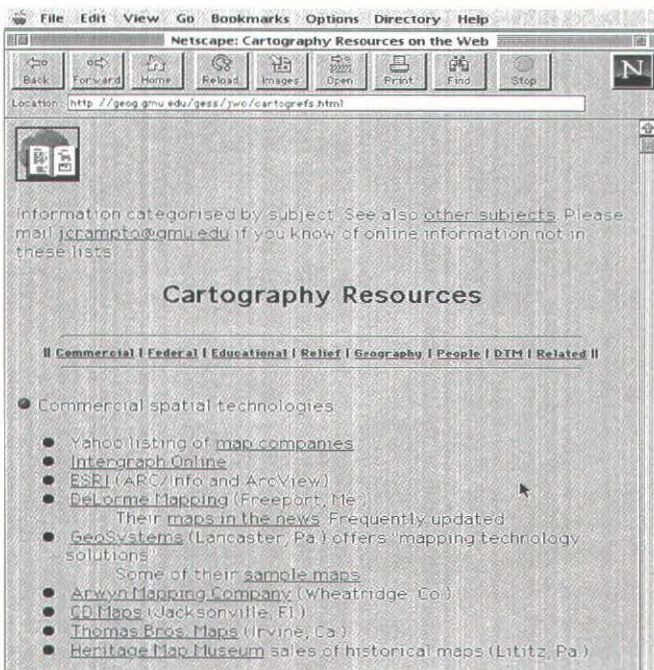


Figure 2. The Cartography Resource homepage on the Web.

5. The URL is <http://geog.gmu.edu/gess/jwcl/cartogrefs.html>.

6. The most visited site in the United Kingdom, for example, is the Electronic Telegraph, which offers a free full news service every weekday (foreign, domestic, and front page news, along with full sports reporting, the weather etc.). Like many free newspapers they earn their money from advertising. The URL is <http://www.telegraph.co.uk/>.

One map company that has taken this approach is DeLorme Mapping of Freeport, Maine. DeLorme, already an established provider of maps, CD-ROMs, and atlases, is also now using the Web to provide information about the company and demonstration versions of some of its software (e.g., Map'n'Go, a travel planning program), as well as featuring, "maps in the news" advertising job openings, and so on (see Figure 3). DeLorme has been on the Web since 1994, and visitors to its site can download demonstration copies of its software or view recent news items illustrated with DeLorme's own mapping software (examples include the site where Scott O'Grady was shot down in Bosnia and Hurricane Allison in Florida). This service connects DeLorme's products with actual events and demonstrates uses for its software in a way that is designed to encourage people to purchase it.

Another map company with a substantial World Wide Web site is GeoSystems, of Lancaster, Pennsylvania. GeoSystems provides mapping services, locational database development, and GIS to many commercial sectors. One of their recent ventures was the animated cartography for Grolier's Encyclopedia (David DiBiase, a consultant on the project, has provided a description of these maps and the process used to create them [DiBiase 1994]).

DeLorme and GeoSystems are well-stocked sites, but as yet, they do not take advantage of the Web's innovations (i.e., things which are only possible on the Web). They are perhaps at "stage 2" of the three stages of computer cartography described by Clarke (1995, 4-5). Stage 1 is a period of resistance to the technology; stage 2 is a "replication stage," where computers are used to emulate previous practices done manually (e.g., getting the computer to draw lines or label maps); only in stage 3 (a "full implementation" stage) is the computer used in new and innovative ways.

An example of stage 3 Web cartography is the TIGER Mapping Service (TMS), a joint effort between the Bureau of the Census and Brandon Plewe, a researcher at the University of Buffalo. The TMS was initiated in October 1994 to provide realtime (so-called "on the fly") maps of roads and boundaries in the USA generated from the TIGER database. The advantage of map generation is that it responds to the particular needs of the user. Although preset maps are useful (e.g., those from Cartesia, a New Jersey-based map clip art company), they might not include the details, centering, projection, and features required by the user. TMS maps can be obtained at the Website⁷, or more innovatively, they can be fed and displayed into other pages as "inline" images. The TMS will generate these maps (such as the one shown in Figure 4 [page 8] of the Mall in Washington, DC) in response to a set of variables which can be sent to it.⁸

The second goal of the TMS is to meet the requirements of the Freedom of Information Act by making the Census Bureau's spatial database

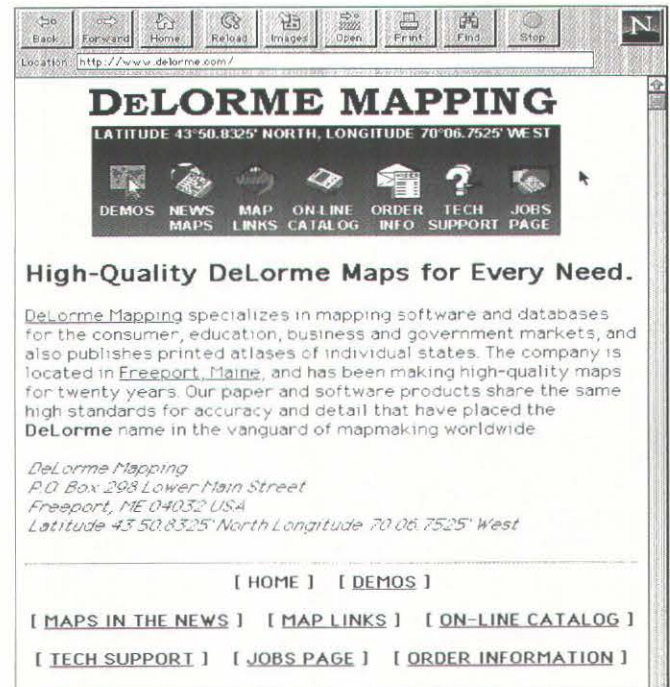


Figure 3. DeLorme Mapping's homepage on the Web.

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7. <http://tiger.census.gov/>.

8. An earlier implementation of an on-the-fly map server by the Xerox Parc company apparently provided some of the inspiration for the TMS project.

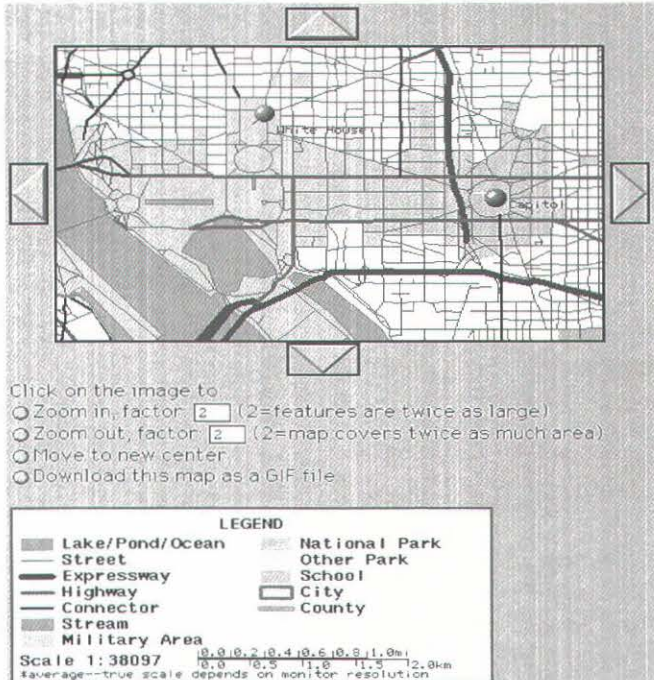


Figure 4. A map of the Mall in Washington D.C. generated by TMS from its Web site.

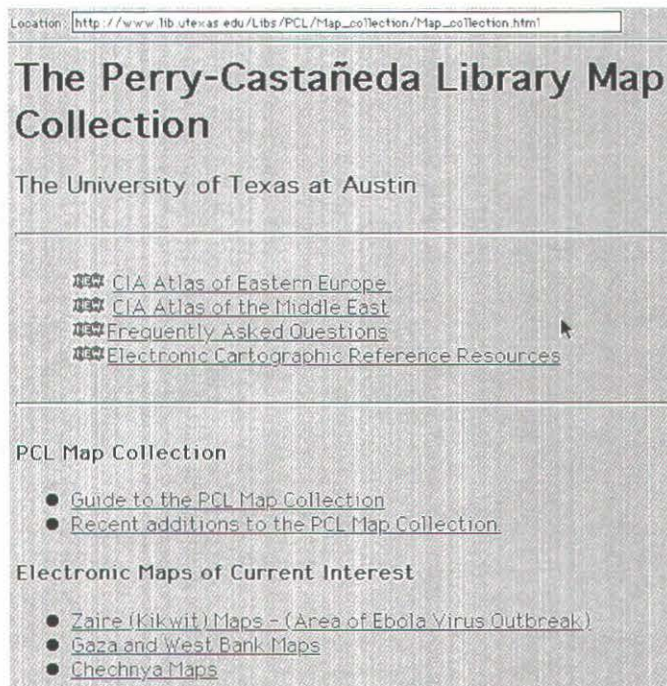


Figure 5. The Perry-Castañeda Map Collection's homepage on the Web.

public. As a federal agency, the Census Bureau provides its data to the public at cost recovery, which, to date, has meant delivery on CD-ROMs (over twenty of which are needed for the TIGER database alone). Future plans for the TMS are to create a thematic layer from the Census's statistical database (e.g., to create a user-defined map on-the-fly of Northern Virginia showing the percentage of the population earning more than \$50,000 household income).

In contrast to the user-generated maps offered by the TMS, other sites offer the delivery of pre-existing maps of regions, countries, or historical maps. For example, The Perry Castañeda Library Map Collection (PCL) at University of Texas-Austin holds over 230,000 maps, many of which have been made available via the Web.⁹ The PCL is very much of a barebones map site in that, despite the size of its collection, it follows the model of a traditional library-maps can be "checked out" (downloaded) or looked up in the table of contents (see Figure 5). Other than that, the site is a relatively unsophisticated stage 2 site, though still of course very useful. One problem with the Web delivery of maps is the potential copyright infringement, and therefore, a significant proportion of the PCL is copyright-free, federal maps, particularly CIA maps. The Web does have a copyright site that examines several general issues of copyright that apply to maps, such as the "fair use" provision of American law-when it is applicable, what it covers, etc.¹⁰

Other sites that are becoming major cartographic resources include federal agencies (such as the USGS) and weather sites that can deliver up-to-the-hour satellite images and movies (a well-known and particularly well-stocked one is at Michigan State¹¹). One can also access relief maps and animations made from USGS digital elevation models (DEMs), and even personal information about some cartographers. Obviously, given the wealth of material available, it is not possible to do more than mention many interesting sites in passing (all these can be accessed from the Virtual Library cartography page referenced above). The Geography Virtual Department Project, which is headed at the University of Texas at Austin, ties many of these resources together in a handy and useful manner.

9. The URL is http://www.lib.utexas.edu/Libs/PCL/Map_collection/Map_collection.html.

10. The URL is <http://www.benedict.com>.

11. The URL is <http://wxweb.msu.edu/weather>.

The goal of the Virtual Department Project is to build up a set of geography resources for curriculum delivery that potentially can become an entire undergraduate course in geography. It consists of the amalgamation of existing resources and newly written materials, both of which can take advantage of the distributed nature of the Internet and the hypermedia format of the World Wide Web.

The principal leader of this initiative is Kenneth Foote, a Professor of Geography at the University of Texas–Austin. He has already developed a two-semester graduate course, "The Geographer's Craft," which is "concerned with active-learning, problem-solving methods of instruction and hypermedia, using Internet-based course materials" (Foote 1994). These materials include lecture notes, syllabi, exercises, glossaries, and bibliographies.

According to the description at the Web site,¹² the scope of the Virtual Department is as follows:

*The project will concentrate first on linking and developing materials that will be useful to the widest range of geography departments, those aimed at: 1) undergraduate courses and laboratories in physical geography; 2) undergraduate courses in human geography; 3) courses addressing geographical techniques including cartography, GIS, and spatial analysis; 4) upper-division seminars on the history and philosophy of geography; and 5) materials designed for K-12 and pre-collegiate curricula.*¹³

This Project represents a very exciting opportunity for cartographers and geographers. It is a major undertaking (a three-year plan is in place)¹⁴ and has been endorsed by several geography associations, including the Association of American Geographers and the National Council for Geographic Education (see Figure 6). Already, some cartographic materials, such as notes on projections and cartographic communication, are available. It is easy to imagine how useful these are to, say, an adjunct professor or someone giving a cartography presentation. The resources are free, highly accessible, and self-contained. They take advantage of the Web's ability to link text, graphics, and animations (e.g., imagine a spinning globe unwrapping as the viewer zooms in through different projections, finally seeing an animated fly-through based on digital elevation models).¹⁵

12. The URL is <http://www.utexas.edu/depts/grg/virtdept/about.html>.

13. It is still unclear how to reference quotations from the Web, but this passage can be found on the Web page located in footnote 12. The intellectual value of Web materials is one issue to be addressed in the discipline's first online, fully refereed journal, *EarthWorks*. The URL is <http://www.utexas.edu/depts/grg/eworks/eworks.html>.

14. The plan calls for thirty new credit hours per year to be in place starting in 1996, with a goal of ninety credit hours—enough for an undergraduate major in geography.

15. A courselist of materials from the participating universities can be obtained at the URL <http://www.utexas.edu/depts/grg/virtdept/courses/courselist.html>.

the Virtual Department Project . . . take[s] advantage of the distributed nature of the Internet and the hypermedia format of the World Wide Web.

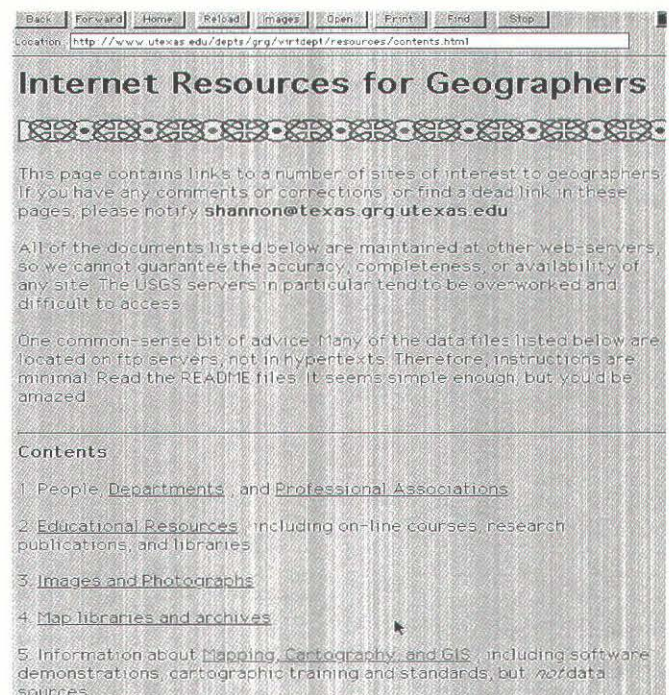


Figure 6. The Virtual Department's homepage on the Web.

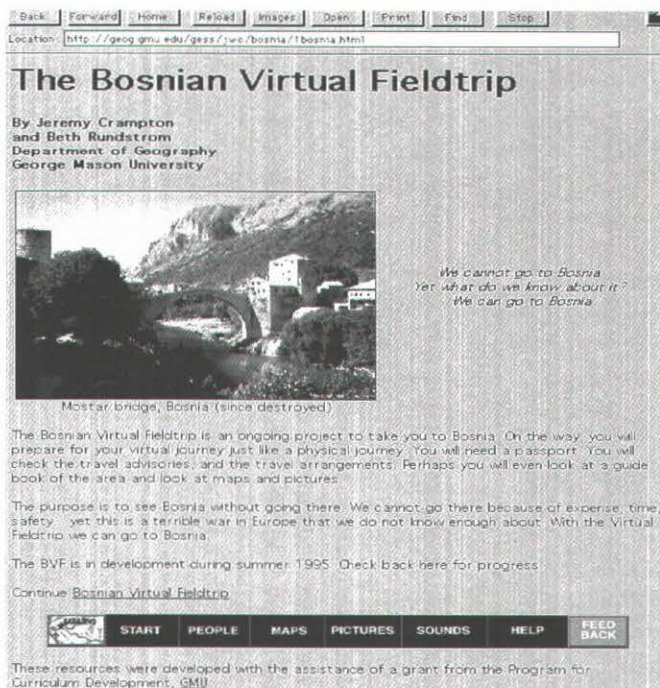


Figure 7. The Bosnian Virtual Fieldtrip's homepage on the Web.

Cartographers can use and contribute to the Geography Virtual Department in a variety of ways: by taking advantage of the workshops at professional conferences where preparation and use of the materials will be taught (e.g., setting up a homepage), and by contributing materials in their own fields.

Another project underway that is designed to be part of the Virtual Department is George Mason University's "Bosnian Virtual Fieldtrip" (BVF) (Figure 7).¹⁶ The BVF proceeds from the very strong tradition in geography of taking fieldtrips to encounter unknown landscapes first hand. Unfortunately, with rising enrollment and costs, it has become less feasible to run fieldtrips for undergraduates. In the case of Bosnia, there are the additional problems of safety, access, and time. Yet, Bosnia is now perhaps one of the most important regions on the planet. Over the last three years, war has come to Europe for the first time in two generations with little sign of resolution. From a geographic and indeed cartographic perspective, this conflict involves some of the most fundamental issues we are likely to teach in an undergraduate program, including but not limited to ethnicity, the territorial imperative,

irredentism, refugees, political geography, physical terrain, and cartographic partition. The BVF offers a "virtual" (Web-based) encounter in lieu of a physical one. It is aimed at beginning undergraduates enrolled in an introductory human geography course, and since it is on the Web, it is also accessible to the interested layperson.

The BVF uses a mixture of resources (text, maps, photographs, sounds, and timelines) to gradually introduce the virtual fieldtripper to the region. In Part I, for example, the fieldtripper studies the effect of scale on the amount of detail shown in Bosnia, the physical terrain, and the historical background of the region. Although there is a designed sequence to the BVF, fieldtrippers can access, via hypertext links, the main resources from any page they happen to be on. These resources include a picture gallery, sound archives, help files, and a map library. In Part II, the fieldtrippers get a closer look at some of the ethnic groups and their leaders, and they can pick from a list of places (e.g., Sarajevo, Mostar, Bihac) to study in more detail. Many of these pages are local, but some also take students out to other sites, whether it be the Bosnian Embassy or the homepage for Croatia.

COMMENTS

In summary, the rapid popularization of the World Wide Web over the past few years brings incredible opportunities for cartographers. Not only are innumerable cartographic materials available from a variety of federal, commercial, and educational sources (such as the USGS, the Census Bureau, map companies and libraries), but cartographers are moving to the forefront of material provision. The next few years will no doubt be a very productive time cartographically. If you have not already ventured out onto the Web, it is now time.

16. The URL is <http://geog.gmu.edu/gess/jwc/bosnia/bosnia.html>.

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