GloVis as a Resource for Teaching Geographic Content and Concepts

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ABSTRACT
Teachers of geography and related topics across a range of educational levels benefit from convenient access to graphic materials that illustrate key geographic information and concepts. GloVis (Global Visualization Viewer) is an online tool designed by the U.S. Geological Survey to facilitate archival searches for Landsat and related imagery. GloVis preview images provide a resource for teachers who wish to illustrate geographic concepts in the context of landscapes local to their institutions. This article introduces instructors to GloVis and offers classroom examples illustrating a variety of applications. Specific examples, including Virginia’s physiographic provinces, regional phenological changes, New Orleans observed before and after Katrina, surface-mined landscapes in eastern Kentucky, and suburban sprawl along Virginia’s I-95 corridor, illustrate the capabilities of this resource.

Key Words: teaching, GloVis, remote sensing, landscape, Landsat, geography

INTRODUCTION
Teachers of geography and related topics across a range of educational levels benefit from convenient access to graphic materials that illustrate key geographic information and concepts. In the geography classroom, access to graphic materials that simultaneously address topical learning objectives and are relevant to specific places and times is often problematic. For example, many teachers experience difficult access to images that illustrate specific concepts as they apply to local settings relevant for their classes. This article proposes that GloVis (Global Visualization Viewer), a web-based graphic search tool available through the U.S. Geological Survey (USGS) EROS Data Center (eros.usgs.gov), provides an effective tool to illustrate geographic concepts in the classroom. The purpose of this article is to introduce instructors to GloVis and to offer examples illustrating applications in a variety of classroom settings.

GloVis
GloVis (http://glovis.usgs.gov/) is designed as a search tool to support users of the USGS Landsat archive. It provides a variety of capabilities to facilitate searches of archives, which are described here to familiarize readers with its capabilities. Most readers who wish to use GloVis in support of their classroom activities will apply only a few of its capabilities for searching for and displaying their images. This discussion pertains to GloVis version 7.8, first available June 2007.

GloVis works with a variety of popular browsers. If users experience difficulties accessing GloVis, they should be sure pop-up blockers are disabled and that “Java Runtime Environment” is installed on their computers; help and documentation resources provide specific details. When GloVis is activated, the user first sees a primary window, and then, after a short time, a secondary window opens to permits users to access GloVis imagery. Users should keep the main GloVis window open, even though they will use the secondary window to access GloVis.

Although GloVis provides access to several forms of imagery, it opens by default to display the Landsat archive using Thematic Mapper (TM) imagery. Landsat TM and other sensors collect information in several regions of the electromagnetic spectrum—images displayed as color composites formed using three of the numerous bands, usually with the brightnesses in the green, red, and near infrared regions displayed in the blue, green, and red channels, respectively. Readers who are not familiar with these concepts should consult an introductory remote sensing text such as Campbell (2007), Jensen (2007), or Lillesand, Kiefer, and Chipman (2008), or online resources such as http://chesapeake.towson.edu/data/all_composite.asp. Thematic mapper imagery is indexed using the Worldwide Reference System (WRS), a grid system in which positions of Landsat scenes are specified by “Path/Row Designations”; the paths and rows form columns and rows.

The user opens a Web-enabled window (Fig. 1) that allows the user to select a location anywhere within the Landsat coverage area (encompassing the Earth’s land areas, excepting some polar regions) by entering latitude and longitude, or by positioning a cursor on a world map. The GloVis Viewer opens to show nine contiguous thumbnail images of Landsat TM scenes tiled to form an array centered on the location of interest (Fig. 1). The center image outlined by the yellow frame is the active image, subject to the operation of the program tools. Users can navigate by using the arrows in the box at the left to shift the active window up, down, left, right, or diagonally. Or, the user can enter latitude/longitude, or Landsat path/row designations, to shift the location as desired. On the left-hand panel, the “prev scene” and the “next scene” options

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allow the user to scroll through other scenes for that region that were acquired at different dates. At the left of the window, a dialogue window allows users to constrain selection of scenes to satisfy their requirements for season or maximum cloud cover. The “scene information” frame lists characteristics of the center scene, to show its cloud cover, scene quality, and date of acquisition.

The menu bar at the upper left of the GloVis screen allows users to access tools relevant to archival searches, and the display of results:

**Collection:** Permits GloVis users to select the sensor of choice, from a variety of imagery available from USGS archives.

**Resolution:** Allows the user to select either smaller scale (the “1000 meters” option) to display coarse detail, or larger scale (the “240 meters” option) to display fine detail. For most applications suggested here, users will prefer to select imagery at larger scale, finer detail.

**Map Layers:** Allows the user to select from a variety of geographic features, including roads, political boundaries, and principal cities, which can be selected to be projected over the images displayed in the GloVis viewer. These features assist viewer navigation by providing locational references.

**Tools:** Offers users a selection of tools; some are described in subsequent paragraphs, most are not of immediate significance for the applications suggested here.

**File:** Allows the user to manipulate scene lists and metadata.

**Help:** Provides explanations of the various tools and options available for the GloVis user.

The GloVis window opens by default to show Landsat TM scenes. The collection menu allows the user to select from a list of several sensors, including aerial photography. This capability allows users to show the same region as recorded by several sensors, at different levels of detail.
For example, users can easily show an area at large scale by selecting an aerial photograph from GloVis, and represent the same area in its regional context by displaying a Landsat image of the same region. The scene list panel at the lower left allows users to maintain a list of scenes of interest for convenient reference.

GloVis’ Help utility and the Quick Start Guide (http://glovis.usgs.gov/QuickStart.html), provide detailed information pertaining to use of GloVis and its full set of features. Advanced users can access features not discussed here, including the option to download source code, if they have an interest in applying all of the features offered. It is important to note that although GloVis is designed as a search tool to access the complete archive of full Landsat scenes, the applications proposed in this article address use of the preview images in the classroom. Because preview images are configured to fulfill a purpose that differs from that proposed here, they are not perfectly matched to instructional needs. Therefore teachers should take care to match their examples to their students’ ability to understand the patterns recorded by any given image. Applications that require more subtle interpretations work best for older students and those with more experience in examining maps and imagery. Students with less familiarity with use of maps and images will learn best from images that depict key features at larger scales and sharp contrast. More experienced students can usually comprehend learning points presented at smaller scale with subtler differences in tones and colors. In either instance, use of images of regions familiar to students accelerates comprehension of content portrayed on maps and images.

The following points highlight key considerations for teachers who desire to use GloVis imagery in their classrooms:

GloVis advantages for classroom use are that it:

- offers a worldwide archive of digital imagery, spanning several decades;
- is easily accessible at no cost to users;
- can be used without special training or specialized software;
- presents content suitable to support a wide variety curricula, at a range of grade levels; and
- offers imagery free of the copyright restrictions that apply to much of the imagery available using Google Earth and related sources.

Disadvantages are that:

- assignment of colors to bands is not always consistent across different images;
- users will often desire finer resolution than the preview images can present;
- preview images may be of uneven quality; the cloud cover percentages are not always correctly stated; and
- search capabilities may require that users search through many scenes and/or dates to identify imagery suitable for an intended application.

**Context and Related Resources**

Online resources, including GloVis, empower teachers to introduce concrete, authentic, geographic content, and to cultivate development of a geographic perspective and a geographic awareness. Most teachers, even if they are unaware of the specifics, probably understand that there is a wide variety of online tools that are available gratis, or at nominal cost. These resources offer a continuum of capabilities for visualization, analysis, and accessing of archived imagery. Such resources exist within a larger context of on-line resources, software systems, and educational resources available to educators. Although this article addresses only a very narrow topic at one end of this continuum, readers may wish to refer to discussions such as those of Nellis (1994), Gatrell (2001), Sui (2004), and Baker (2005), who address broader options for use of Internet and GIS (geographic information system)-related resources in the classroom.

This article introduces teachers to the pedagogical potential of GloVis, so it will not attempt to survey the full range of capabilities offered by these resources. However, it is important to recognize related resources relevant to the capabilities discussed in this article. Google Earth (http://earth.google.com/), perhaps the most widely known online resource for immediate access to aerial imagery, can offer teachers convenient access to imagery worldwide, with convenience and flexibility in navigation and display. (Google Earth provides advanced versions such as Google Earth Plus, and Google Earth Pro that provide enhanced capabilities for users.) Google Earth imagery forms a valuable resource that can be used in concert with the proposed applications of GloVis outlined here. However, in its present form, Google Earth does not offer the quality of broadscale views offered by GloVis, nor does it provide sequential perspectives, including varied seasons, over the three-decade history of the Landsat archive, that GloVis provides.

**GloVis in the Classroom**

The purpose of this article is to inform the reader of the capabilities and potential of GloVis preview images for use in the classroom, and to provide specific examples to stimulate and inspire teachers to develop applications that more closely parallel their specific needs. Its premise is that GloVis images can enrich existing teaching resources, not by replacing existing classroom materials, or forming independent stand-alone content, but rather by offering engaging visual illustrations to support teaching of content and concepts already identified as significant learning goals.

Examples illustrate how GloVis can contribute to teaching of state standards of learning. For example, Virginia’s 2001 Standards of Learning (http://www.pen.k12.virginia.us/standards/2001/2001standards.html).
va.us/VDOE/Instruction/History/hist_11.pdf) include goals specifically focused upon content conveyed by Landsat imagery:

- Apply geographic skills and reference sources to understand how relationships between humans and their environment have changed over time (VUS1).
- Analyze and interpret maps to explain relationships among landforms, water features, climatic characteristics, and historical events (VS1).

Other U.S. states have similar standards that, although stated differently, depend upon related topics and concepts.

GloVis imagery permits teachers to illustrate core geographic themes, such as those discussed in subsequent paragraphs:

- Regionalization: a common theme in grades 4–6 (Example 1)
- Urban growth: significance of urban systems, and urban sprawl (Example 2)
- Environmental change: a common theme in state standards of learning (SOLS) (Example 3)
- Human impact upon landscape: urban sprawl, strip mining (Examples 3, 4, and 6)
- Impact of natural disasters: floods, hurricanes, wildland fires (Examples 5 and 7)

The value of this resource lies in its ability to provide concrete visual evidence of concepts and events that otherwise typically must be presented as abstract ideas, without a local dimension. Aerial imagery, especially as historical sequences, can contribute valuable geographic and historical dimensions to these discussions. Such imagery can be especially effective when it can represent regions that are specific to a student’s locale or region, or events that are relevant to students at a personal level.

GloVis contributes to teachers’ capabilities to develop multifaceted discussions in which students encounter a variety of learning resources, including not only aerial imagery, but maps, photographs, data, and first-hand personal accounts. In selecting images from the archive, teachers should select those that best suit not only the concepts at hand, but also match, with respect to visual and academic complexity, the level and skills of their students. Those images that might require recognition of subtle features or previous experience are clearly best matched for presentation to students prepared with the background and experience to recognize the significance of the patterns portrayed by the images.

Accessing the GloVis archive requires resources that are available to most teachers. A teacher basically requires access to the Internet, a screen capture utility, such as Microsoft Paint, and presentation software, such as Microsoft PowerPoint. After selecting a specific region, the user can scroll through dates to select those with the best visual qualities to illustrate the concepts at hand, and then use screen capture, and paste the images into PowerPoint for classroom use. If digital projectors are not available, images can be prepared as overhead transparencies. In such a context, access to a color printer may form the biggest obstacle for teachers who do not have access to a digital projector.

One of the principal merits of the use of GloVis for teaching geographic content is its ability to provide the instructor with visual examples applicable to relevant states and regions. The following sections present seven examples of interest to teachers in several disciplines at several academic levels. (The Virginia examples presented here are intended as models for analogous content specific to other regions.) These examples illustrate also the availability of supporting information for many topics readily accessible through the World Wide Web.

Some Examples

Example 1: Virginia’s Physiographic Provinces
Virginia’s physiographic provinces are an important learning objective at several levels in Virginia’s educational programs. It is specifically included in earth sciences (E.S. 8a) portion of Virginia’s 2003 Standards of Learning (SOLs). Virginia’s physiographic provinces—Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau are shown in Figure 2 as they are typically represented in conventional instructional materials. Woodward (2005) describes each of Virginia’s physiographic provinces, providing source material appropriate for use of K–12 teachers.

Coastal Plain. Virginia’s easternmost physiographic province, the Coastal Plain, sometimes known as “tidewater,” borders the Chesapeake Bay and the Atlantic Ocean on the east. Its western edge, known as the fall zone, is a series of low scarps that form low waterfalls or

Figure 2. Schematic sketch illustrating Virginia’s physiographic provinces. (Credit: The Geology of Virginia, Department of Geology, College of William and Mary (http://www.wm.edu/geology/virginia/index.php).)
Figure 3. GloVis Landsat preview scene illustrating Coastal Plain and Piedmont landscapes. (Credit for inset: The Geology of Virginia, Department of Geology, College of William and Mary (http://www.wm.edu/geology/virginia/index.php.).)

rapids as streams leave the Piedmont. The shore of the Coastal Plain is formed from four peninsulas—Eastern Shore, Northern Neck, Middle Peninsula, and Peninsula, all visible in Figure 3. Estuaries separate the peninsulas—rivers are tidal to the fall zone. The topography of the Coastal Plain has low relief, and is characterized by salt marshes, wetlands, sandy soils, and a series of low escapements, like stair steps, increasing in elevation towards the west.

Piedmont Province. Virginia’s Piedmont is a broad, undulating, surface sloping to the east of the Blue Ridge, bordered on the east by the fall zone (Figs. 3 and 4). At its eastern edge, the Piedmont is perhaps 200 feet above sea level, rising to about 800 or 900 ft elevation at the base of the Blue Ridge. The Piedmont’s surface has a gently undulating character created by local stream erosion; it is covered by deep, highly weathered, soils. Near the Blue Ridge, resistant rocks ridges form isolated peaks that extend above the surrounding Piedmont terrain. Here also are Triassic basins, formed many millions of years ago, by rifts—splits, in the Piedmont’s surface rocks that were later filled with sediments eroded from nearby terrain, are now nearly level with nearby terrain, but their soils contrast with those of the surrounding Piedmont.

Blue Ridge Province. The Blue Ridge is an extensive upland extending roughly north-south, from Georgia through the Carolinas north into Virginia, formed of resistant metamorphic rocks of varied origins (Figs. 4 and 5). The east-facing slope, known as the Blue Ridge Front, is a steep escarpment forming a distinct boundary with the western edge of the Piedmont. The northern Blue Ridge is roughly linear in form, narrower and lower than the southern Blue Ridge. South of Roanoke, the mountains from a broader region, known as the Blue Ridge Upland. Mt. Rogers, the highest point in Virginia at 5,729 feet (1,746 m) and Whitetop, Virginia’s second highest elevation at 5,520 feet (1,683 m), are positioned just north of Virginia’s border with North Carolina. The Blue Ridge is recognizable on imagery as a continuous mostly forested ridge at the north. The broader zone at the south includes the Blue Ridge Uplands—a more complex pattern of forests and open land, principally in pasture.

Ridge and Valley Province. The Ridge and Valley province is an elongated valley extending roughly northeast-southwest positioned just to the west of the Blue Ridge (Figs. 4 and 5). The Ridge and Valley is formed from sedimentary rocks, severely folded and faulted to create parallel ridges and valleys. Typically ridges are formed from sandstone, some very resistant to erosion, and the valleys from limestone, easily eroded in Virginia’s humid climate. Often sideslopes are formed of slate, of intermediate resistance to erosion. The limestone valleys often form karst topography—the name for underground drainage characterized by sinkholes, caves, and related landforms. Limestone terrain presents special problems for construction of buildings and highways, but forms fertile soils, so much of the Ridge and Valley is devoted to agricultural land.

The Ridge and Valley has a distinctive appearance on the satellite imagery—linear valleys and ridges, recognizable especially for the open, cleared land, and forested ridgelines. The Ridge and Valley province is bordered by forested uplands both to the east and west.

Appalachian Plateau. The extreme southwestern portion of Virginia includes a small portion of the Appalachian Plateaus (Fig. 5), positioned to the west of the Ridge and Valley. The Appalachian Plateaus are formed from flat-lying strata that form plateaus, but ones highly dissected by stream erosion such that only narrow crests of summits remain to indicate the even surface. This terrain is characterized by steep slopes and narrow river valleys.
Figure 4. GloVis Landsat preview scene illustrating landscapes of Virginia’s Piedmont, Northern Blue Ridge, and Ridge and Valley. The central region of the image shows portions of the Shenandoah Valley and Massanutten Mountain. (Credit for inset: The Geology of Virginia, Department of Geology, College of William and Mary (http://www.wm.edu/geology/virginia/index.php).)

Example 2: Suburban Sprawl Along the I-95 Corridor
The historical length of the Landsat archive, and consistency of the image format, facilitates illustration of phenomena that change over time. The TM and Multispectral Scanner Subsystem (MSS) archives are long enough to observe human/environmental changes that have developed over several decades. Although Landsat’s broad-scale detail limits use to phenomena that occur over rather large areas, even at the coarse scale of the thumbnail images, GloVis provides visual evidence of the impact of both human and environmental processes as they operate over time. These images support the content covered by the lesson plans provided by Ruchelman (2005), Fontaine (2005), and especially Hodges (2005), designed for use at grades 4 to 6. Hodges discusses cities with varied growth rates, with examples based mainly upon data and thematic maps. Use of such sequential images can supplement these resources by providing concrete images that illustrate differences between growth patterns of different cities. It is in this context that the GloVis archive of several decades of sequential imagery offers teachers an especially valuable resource.

Transportation corridors connecting Virginia’s fall line cities have historical significance as foci for development of the urban infrastructure into continuous metropolitan systems, as described by Gottman (1961). Landsat images are effective in representing the location, extent, and evolution of urbanized regions. Figure 6 depicts the urbanized region between the Baltimore metropolitan region (at the top center of the image) and the Washington metropolitan region (in the center). Hydrographic features are prominent, especially the Chesapeake Bay, and the Potomac River and its estuary. Urbanized regions appear as the grayish tones, dense at their urbanized core, with thin, web-like threads extending outward along transportation corridors.

The 1995 image represents urbanized regions as nodes, with distinct dense regions at their core, and tentacles radiating outward along transportation routes. Physical infrastructure is focused on localized structures. The Baltimore and Washington foci are only loosely connected. By 2005 (the left-hand portion of Fig. 6) the pattern has lost its node-like structure. Here we see a more mature pattern, with a filling-in of gaps in the urbanized corridor—Baltimore and Washington are now connected by a solid connection of urban and suburbanized territory. Development has extended along new axes oriented roughly at right angles to the principal north-south transportation axis of the megalopolitan structure.

Example 3: Phenology
Phenology, the study of seasonal changes in natural phenomena, especially vegetation, is an especially valuable tool for understanding the distributions and behavior of biotic phenomena. Phenology records the principal events of the growing season—budding, leafing, and blooming in the spring, and senescence and the fall of deciduous leaves in autumn. Phenology has practical significance for understanding agricultural calendars, local climate patterns, and the seasonable behavior of wildlife and insects, among other phenomena. Related information is available at http://www.metla.fi/eu/icp/phenology/index.htm and archive.globe.gov/tctg/earth_chapwelcome.pdf?sectionId=243.

Because such images permit students to directly observe local phenology, they can contribute to discussions of local climate, agriculture, and other seasonal phenomena. The
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**Figure 5.** GloVis Landsat preview scene illustrating landscapes of Virginia’s Piedmont, southern Blue Ridge, Ridge and Valley and Appalachian Plateaus. This image represents the southern portions of Virginia’s Blue Ridge, specifically the Blue Ridge Uplands. (Much of the Appalachian Plateaus region visible in this scene lies within West Virginia.) (Credit for inset: The Geology of Virginia, Department of Geology, College of William and Mary (http://www.wm.edu/geology/virginia/index.php).)

GloVis TM archive permits instructors to demonstrate local phenological cycles. For example, in Figure 7, the left-hand image illustrates southwestern Virginia in early May, just as the vegetative cover has started to emerge from winter dormancy—in the right-hand portion of the image (where elevations are lower), leaves have already emerged, recognizable as the green tones. Further to the right of Figure 7’s left-hand image, the landscape is characterized by light gray (mainly open agricultural land) and light violet tones (forested land, still dormant from the winter season). Here, the interior position and higher elevation delay the green-up, so vegetation here is still largely dormant at the time of this image. Within a few weeks, the green tones will spread throughout the image, as leaves emerge at higher elevations. In the right-hand image of Figure 7, the seasonal changes have progressed throughout the region, so the vegetative cover is now uniformly green across the scene.

This pair of images demonstrates the ability of GloVis to identify Landsat scenes that show a landscape at different stages in the annual phenological cycle. Landsat scenes show large enough areas that they can portray phenological differences due to elevation, continentality, vegetation cover, land use, or crop patterns. Teachers can use GloVis to identify such images for their locality, providing relevant images to teach phenological concepts to their students. The inset in Figure 7 is a graph (available on GloVis for recent years), that displays seasonal variation of several classes of vegetation for the scene at hand. (These graphs show vegetation differences using a ratio named the normalized difference vegetation index (NDVI), widely used in the field of remote sensing to monitor vegetated areas (Campbell 2007)). These graphs are useful tools for teaching phenology of local landscapes.

**Example 4: Surface Mining, Eastern Kentucky**

The dramatic impact of surface mining upon the landscape is well-known. In Figure 8, the impact of surface mining is visible as the pink and violet tones that mark differences in the vegetative cover and phenological responses of the vegetative cover of the mined areas against the background of the surrounding forest cover. In 1986 the surface-mined areas (left) are visible as the violet regions where the forest cover has been disturbed, presenting a different vegetation cover to the sensor. By 2006 (right), several new areas have been added, visible as the pink patches. Teaching points for such images might include the nature and patterns of varied forms of mining, reclamation practices, and the significance of mining for local, regional, and national economic structures. Related information is available at: http://www.uky.edu/KGS/coal/coal_mining.htm and http://www.dmre.ky.gov/.

**Example 5: New Orleans, Pre- and Post-Katrina**

The GloVis resource provides regional overview that shows in a single image both the impact in New Orleans and along the Mississippi coastline (Fig. 9). This pair of images shows New Orleans, and a portion of the Gulf Coast, pre- (August 22, 2005) and post- (September 7, 2005) Katrina. The flooded districts are visible here as discrete patches recognizable by standing water impounded within areas flooded by the failure of levees. Further, even at the coarse detail of the preview images, disturbed regions are visible in the marshes south of New Orleans, Gulf Coast of Mississippi, and along the Pascagoula.
Figure 6. GloVis preview scenes illustrating growth in suburban sprawl along Virginia’s I-95 corridor, 1985–2006. Left: In 1985, the gray-blue tones, indicating dense urban development, form detached spots focused on urban centers. Right: twenty years later, the urbanized areas form a continuous strip centered on the I-95 transportation corridor.

Figure 7. GloVis preview images illustrating phenological changes. Left: April scene, illustrating uneven progression of spring green-up through the irregular topography and land use of southwestern Virginia. Right: July scene, acquired after completion of spring green-up throughout the region. Top center: GloVis NDVI diagram, illustrating seasonal progression of vegetative growth within several contrasting land-use classes.
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Figure 8. GloVis preview scenes illustrating changes in areas subjected to strip mining, eastern Kentucky, 1986–2006. The magenta regions signify disturbance of the forest cover, chiefly areas of surface mining. The arrows on the right-hand image (2006) identify new disturbed areas not present on the left-hand (1986) image.


Example 6: Bonnet Carré Spillway, Louisiana

The Bonnet Carré Spillway is a flood control structure constructed by the U.S. Army Corps of Engineers on the Mississippi upstream from New Orleans. Construction of the floodway was completed in 1931, as one of several projects constructed in the aftermath of the catastrophic 1927 floods of the lower Mississippi to reduce impact of high water during high flood stages. The Bonnet Carré Floodway is one of several structures intended to reduce the flood threat to New Orleans’ urbanized region, just a few miles downstream from the floodway.

The floodway consists of a concrete embankment with removable gates that in effect forms the eastern bank of the Mississippi north of New Orleans. When the gates are opened, a substantial portion of the river’s flow is diverted eastward through a floodway about 1.6 mi (2.8 km) wide and 5.5 miles (9.5 km) in length, to flow into Lake Pontchartrain, a tidal embayment located east of the lower Mississippi. Figure 10 shows a Landsat image of Lake Pontchartrain illustrating the open floodway with an earlier image for comparison depicted the closed floodway. This image, acquired April 10, 1997, shows the plume of sediment-laden waters discharged into Lake Pontchartrain when the floodway was opened during the March 17- April 18, 1997 interval to relieve pressure on New Orleans levees caused by the floodwaters resulting from heavy rains upstream in the midwestern United States. The image also shows open water in the floodway that can be compared with the same area on the companion image, acquired in January 1997 when the floodway was closed.

Although the opening of the floodway achieves its intended purpose by reducing the flood threat for New Orleans, it has a negative impact upon Lake Pontchartrain’s shellfish fishery, which suffers from the increased load of suspended sediment, and the

**Example 7: Yellowstone National Park Fires, 1988**

During the summer of 1988 severe drought throughout the Yellowstone region (Montana-Wyoming) created an environment favorable for severe wildland fires. By mid-July fires were burning at several sites within the Yellowstone region (Christensen et al. 1989). At the end of the fire season, there had been 248 fires in the region.
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**Figure 10.** GloVis preview scenes illustrating effects of opening of Bonnet Carré Floodway, 1997. Upper left: Floodway closed (normal position). Lower right: Floodway open, with open water visible in the floodway.

...including fifty within park boundaries, burning about 1.2 million acres in the vicinity of the park, affecting about 36 percent of the park’s territory, causing three million dollars property damage.

Figure 11 presents a pair of Landsat images showing effects of fires in this region. At the left, the landscape is seen just as the fire situation was recognized as serious. At the date of the image, July 22, 1988, several smoke plumes are visible; at this time 8,500 acres had burned. Despite efforts to fight these fires, they continued through the remainder of summer, ending only in mid-September when snows brought an end to the fires. The extent of the fire damage is evident in the second image, acquired in October 1988. Because of the high visibility of the fires during peak of the tourist season, the fire management policy in Yellowstone formed a topic of heated debate that included both local communities and official Washington D.C. Despite the controversies raised during the debate, in subsequent years Yellowstone ecosystems began to recover quickly and the park continued to attract visitors. Related information is available at biology.usgs.gov/luhna/chap8.html.

**SUMMARY**

GloVis, although designed as a tool for browsing the archive of Landsat and related remotely sensed imagery, can serve as an archive of satellite imagery for teachers to select imagery suitable for illustrating geographic content and concepts, especially as it might apply to regions relevant for their students. Although the preview images have coarse resolution, their detail is adequate for many classroom purposes. GloVis provides a useful source for imagery illustrating geographic events and concepts. Its ease of access assures its availability for teachers working in a wide variety of professional circumstances. The range of the archive spans several decades, so it provides a resource effective for illustrating long-term landscape changes. Further, the broad geographic scope of the archive...
allows teachers to select imagery illustrating regions local to their institutions. Its use is effective for illustrating phenomena that can be observed over large regions and display discrete changes.

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