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Capitalizing on Views: Assessing Visibility by Using 3D Visualization and GIS Technologies for Hotel Development in the City of Niagara Falls, New York

Li Yin and Jonathan Hastings

HOTELS are a tourist's largest expenditure apart from travel expenses and can have many beneficial effects on a local economy. The pricing of hotel rooms is a function of a bundle of amenities, such as hotel category and size, location, surrounding environment, etc. Scenic views from a hotel room can have considerable economic significance and value. The view quality can carry a premium over the basic price of the room. This premium may result in millions of dollars in revenue each year and tens of millions of dollars over a full investment cycle, which may contribute to the continuing development or rejuvenation of a tourist destination after it "matures."

Goldberg et al.

Lange and Schaeffer

Butler

A hotel may be developed in a variety of design alternatives, including low-rise bulky blocks and high-rises on small footprints. Choosing between these alternatives is complicated by the aesthetic issues that are regulated by a city's zoning code. Rutes et al. call these codes "a deciding factor" for hotel developers. While codes are important in protecting existing investments, they can also deter development if they are not sensible. If a high-rise hotel can provide clients with scenic views for which a premium can

Rutes et al. 1985

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be charged, stringent height restrictions may discourage hotel investment and suppress a city's economic development.

Using GIS and 3D visualization technologies, we conducted a case study in the tourist district of downtown Niagara Falls, New York to assess the visibility of Niagara Falls, the Horseshoe Falls in particular, and examine how a hotel could capitalize on views of the Falls and help revitalize the district. We also studied the potential negative effects of a high-rise hotel in the downtown district. The findings suggest that the city might benefit from reconsidering its sweeping building height restrictions that are applied to the entire tourist district.

GIS and 3D visualization technologies were the ideal tools for this study because of their ability to analyze spatial relationships and convert information into visual products. They allow the creation of geo-referenced, three-dimensional models for conducting studies that involve a combination of spatial and aesthetic considerations. GIS maps and a 3D model of the city and the Falls were created using both ArcScene and Sketchup to explore and analyze view potentials, compare view corridors, and examine shadow effects assuming that existing height regulations could be revised to allow high-rise hotels. The economic value of the view of the Falls was also examined. This study also demonstrates the value of GIS and 3D visualization technologies for designing and planning.

Background

The City of Niagara Falls, New York is about 25 miles north of Buffalo and is at the Great Falls of the Niagara River opposite Niagara Falls, Canada. Millions of visitors flock here yearly to gaze at one of the world's most spectacular natural wonders. Tourism is one of the city's oldest industries. In recent decades, its sister city on the Canadian side—Niagara Falls, Ontario—has surpassed it as a tourist destination by allowing for casinos and tower hotels. Niagara Falls, New York, however, is not attracting many hotel developers, despite its being adjacent to a world wonder and the first state park in the United States, a park designed by Frederick Law Olmsted, the landscape architect who designed New York's Central Park and many other well-known urban parks.

In the past, Niagara Falls, New York suffered from a lack of government investment in tourism. In recent years, governments

and agencies at all levels have made significant commitments to rebuilding the city's tourism industry. After a prolonged economic downturn, Niagara Falls has taken steps to revitalize its downtown area and to make it attractive to businesses, visitors, and residents. Hotel development could play a role in these efforts and deliver substantial tax revenues to the city, further helping to revitalize its downtown area. However, this development has not occurred, which may be a result of the stringent height controls and the perceived advantages of the Canadian views. Our discussion in this paper focuses on these two factors.

The Building Height Restrictions in the City of Niagara Falls, New York

Rutes et al. 2001

Major hotel operators generally prefer sites that allow for more than 500 rooms because of economies of scale. To achieve this threshold, a hotel developer will either build high or build out. Current building height restrictions in the tourist district of Niagara Falls limit hotel development to the low-rise bulky type. Chapter 1315 of the city's zoning code imposes a maximum height of 20 stories or 200 feet on buildings in the downtown tourist district. The height of a story can vary. Due to the large amount of wiring, ductwork, and other infrastructure built into each floor in recent years, a typical commercial story may be assumed to be about 13 feet. That makes the city's building height restriction roughly equivalent to 15 stories. The current regulations may scare away hotel developers because they are not allowed to build high enough to capitalize on views of the Falls and compete with hotels on the Canadian side of the Falls.

City of Niagara Falls, NY

The building height restrictions may be based on an assumption that tall buildings block view corridors and cast potentially harmful shadows on surrounding properties. This assumption may stem from the experience of development on the Canadian side. Over the past few decades, the Canadians have built tall and bulky hotels in their tourist district around the Falls. These buildings are packed tightly, effectively forming a tall wall along the Falls that blocks the view corridors towards the Falls from sites behind the barricade of hotels. This wall of high-rise hotels even disrupts local wind conditions, preventing the mist of the Falls from dispersing. By contrast, the building height restrictions of the City of Niagara Falls, New York has preserved several excellent view corridors although these view corridors come at the expense of economic development. Canadians have

realized the problems. They are, however, dealing with this issue in their future hotel developments in the immediate vicinity of the Falls by putting restrictions on bulk, not on height. Several new hotels on the Canadian side have been planned, including a 58-, a 59-, and a 61-story hotel, all with small footprints.

Views and Hotel Room Values

When Conrad Hilton was asked to name the three most important factors in a hotel's profitability, he replied "location, location and location." Hotel developers want their sites to be as close to an area's key attractions as possible. Scenic views from hotel rooms are as important as proximity for a hotel's profitability. The economic value of scenic views was found to be positively related to property values. A study of high-rise apartments found that residences with views of green space and water fetch significantly higher prices than residences without preferred views. Tse posited that homebuyers in Hong Kong strongly favored sea views and the housing values are higher on higher-level floors because views are better.

The Architects' Journal
Rutes et al. 2001
Huffadine
McDonough
Benson et al. 1998
Benson et al. 2000
Do and Sirmans
Rodriguez and Sirmans
Luttik
Yu et al.
Bishop et al.

The tourist district of Niagara Falls, New York makes for an excellent location for hotel development because it has easy access to the Falls and to major attractions. However, there is a perception that it is impossible to get good views of the Falls from the New York side. Ironically, there was a time when the popular perception was that New York had the superior view of the Falls. So, are views of the Falls really not possible in Niagara Falls, NY?

Ingram and Inman

The Study

The Tools

Geographical information systems (GIS) have been widely adopted by urban planners because of their immense capacity for the inventory, navigation, and analysis of both spatial and non-spatial data. Three-dimensional visualization tools provide additional information about spatial relationship among buildings, streets, and neighborhoods. Three-dimensional models speak in a "common visual language" that people can easily understand. The additional information they provide helps shape perceptions of an area and communicates the "real world" that people experience better than two-dimensional images or words. Three-dimensional models help planners more

Budic
Krizek and Johnson

Boyd and Chan

carefully consider the effects of changes in the urban fabric and communicate with the public (e.g., by presenting 3D-visualizations of a proposed development and comparing it to the existing condition of the site). This helps residents and other stakeholders better understand the impact of a new development on a neighborhood by showing the interplay between it and adjacent structures.

Al-Kodmany
Shiode

SketchUp is a simple and user-friendly, yet amazingly powerful tool for creating, viewing, modifying, and communicating 3D ideas quickly and easily. SketchUp was developed to be an alternative to more complicated design software like AutoCAD and 3D StudioMAX. It provides more people of all skill levels with access to computer-aided design and drawing. The second benefit of the program relates to the quality of the images and the visual clarity it produces. The renderings produced by SketchUp have greater aesthetic appeal than those produced by ArcScene, a 3D desktop application that comes with ArcGIS 9.1 3D Analyst extension. In our study, the shadows we produced look more realistic, and surfaces have a more appealingly defined quality. The third benefit of the program is that it can work with most other modeling, image editing, illustration applications, and GIS software that designers and planners use. Finally, it is quick and easy to make changes in Sketchup. For instance, changing a building's dimensions in ArcScene involves many more steps than in SketchUp.

Combining GIS and 3D visualization tools can be more powerful than using either alone. They allow planners to model environments, and then quickly modify those environments with different development scenarios. It is exponentially less expensive to make such changes in the virtual world of the 3D model than it would be in real life. GIS and 3D visualization technologies provide a tool to build and visualize terrain-based models that consist of GIS layers, imagery data, and other objects to help navigate, analyze, and understand complex and dynamic systems, as well as to make communication easy.

Koller et al.

Before GIS and 3D visualization tools became available, shadow analysis required complex calculations because shadows change minute by minute, day by day, and month by month. Making these calculations by hand must have involved predicting the exact position of the sun and the earth at a certain time; the exact position on the earth of the terrain on which a building sits; the height above sea level of the terrain on which the building sits; the size, shape, and height of the building; and the interference

of any other structures, terrain, or trees that come between the sun's rays and the building at a particular time. The services of an artist would also be required to illustrate the shadow so that people could understand the numbers from those calculations. Using geo-referenced data, Sketchup allows all of these tasks to be done by a computer in a matter of seconds.

Performing all of these calculations for major buildings before imposing height restrictions and setback requirements was not a trivial task for city planners. Modern GIS and 3D visualization tools now allow planners to not only conduct shadow analysis with precision and share the results with the public, but they also allow planners to analyze the impact of a specific proposed development on adjoining land uses as a problem-identification tool to forestall costly mistakes.

The Method

Our literature review suggested that scenic views are important to hotel development. To examine how a hotel could capitalize on views of Niagara Falls without hurting view corridors in the downtown tourist district of Niagara Falls, New York, this study examined the economic value of the views of the Falls and used GIS and 3D visualization tools to explore the view potentials. A survey was conducted to identify the value of a view of Niagara Falls to hotel operators. We then used viewshed analysis in ArcGIS to examine whether views of the Falls are possible from the sites in the study area. We followed the viewshed analysis by a view analysis in a 3D model. We used Sketchup and ArcGIS to build a three-dimensional model to see where views of the Falls are possible. The results of the viewshed and the 3D view analysis enabled us to choose a few sites to analyze further. The study also included a view-corridor analysis to see if high-rise development harms view corridors and a shadow analysis to see how a high-rise hotel built on a selected site would affect the sunlight available in the neighborhood.

Study Area

The study area was the tourist district of the City of Niagara Falls, New York. It sits along an international border with Canada's Niagara Falls, Ontario. (See Figure 1.) It is on the southwestern corner of the city and adjacent to Niagara Falls State Park. One of the world's most famous waterfalls, Niagara

FIGURE 1
Study Area

Source: Google Earth

Falls is to the southwest across the park. Niagara Falls is in fact made up of three waterfalls: the American Falls, the Bridal Falls, and the Horseshoe (or Canadian) Falls. Roughly half a square mile, the tourist district of Niagara Falls, New York is mostly commercial. The commercial offerings in this tourist district are not of the quality that one would expect to find next to an attraction of this magnitude and beauty. Tourists are often surprised when crossing the bridge from Canada's higher quality tourism offerings to this district, which is characterized by many vacant lots, acres of surface parking lots, and budget hotels. Very few buildings in the tourist district are more than five or six stories.

The site of the Days Inn at the corner of 1st and Niagara Streets was selected in our study for further analysis. One reason is that it is near the Niagara River, the park, downtown commercial operations, and the entranceway of the border crossing. It also sits at the junction of several major roads, and it is centrally located and visible from all directions. Another influential factor is that the city's Strategic Master Plan recommends it for more intensive hotel development, preferably as a four-star hotel.

City of Niagara Falls, NY 2004

Data Collection and Processing

A variety of GIS data was collected from the City of Niagara Falls and the New York State GIS Clearinghouse. This data included road, parcel, building footprint, and zoning district data, as well as aerial photographs. These data were then compiled into an ArcGIS personal geodatabase. Niagara Falls sits beside a deep gorge with an international border running down its center. We thus collected two Digital Elevation Model (DEM) files: one for the United States side and the other for the Canadian side to generate elevation maps. Ten-meter DEMs in Spatial Data Transfer Standard (SDTS) format were downloaded from the U.S. Geological Survey web site and converted into grids using ArcToolbox for the U.S. side. The Canadian-side DEM was Ontario provincial DEM interpolated using Natural Resources & Values Information System contour.

In addition to collecting read-to-use GIS data, we also identified building heights from field trips. The building footprint data that were obtained from the City of Niagara Falls did not contain height information. Thus, a quick windshield survey was conducted in the study area to count the stories of each structure and estimate the heights.

The Economic Value of Views of the Falls

To identify the value of a view of Niagara Falls to hotel operators, we surveyed the prices of hotel room in Niagara Falls, Ontario where many of the rooms have views of the Falls. This study took a total of 54 samples, or 27 pairs, for a summer weekend, a summer weekday, and a winter weekend using data from www.travelocity.com. The samples were of rooms with views and without views in hotels that had rooms facing the Falls and rooms facing the city. The study also compared hotel development in the two cities of Niagara Falls, New York and Niagara Falls, Ontario, using information collected from the U.S. Census Bureau and from the cities, themselves.

Views of the Falls

A major purpose of this study was to examine whether it would be possible for a hotel on the U.S. side to have views of the Falls if the city's regulatory environment were to allow for taller buildings. Since hotel developers generally evaluate more than one site, a viewshed analysis was used to explore the minimum heights required for a view of the Horseshoe Falls from all sites in the district. Then, a three-dimensional model of the city and the Falls was

created to demonstrate the view potential. For this study, we posited that a view of the Falls was available if one could see the Horseshoe Falls at least 20 feet down from the crest in the GIS viewshed model and see at least the top fifth of the Falls in the Sketchup model. The analysis was based upon conditions as they existed at the time of the study and would require re-analysis if new buildings were to be erected between these sites and the Falls.

This phase of the study involved working with data from digital elevation models (DEM) and data aerial photographs, as well as with building footprints and heights data. Viewshed is a term used to indicate the entire area an individual can see from a given point. It is characterized by visibility between locations. Viewsheds were generated by GIS based on topographic analysis. This study combined the DEM representing elevation of the terrain, as well as heights and volumes of the existing buildings to create an elevation surface providing information on any possible physical impediment of visual access to the Falls from any site of the study area. The analysis was performed on a grid with a resolution of 10 by 10 meters for the study area. The aim was to allow the visualization of what and how far a person might see from any site within the study area when standing at the center of each site or the centroid of each building's footprint. This process began by placing observers in the center of each existing site. There were 83 sites considered in the calculation. If the Horseshoe Falls was fully or partially visible from a site, the site was considered to have view potential of the Falls at that height. The height was then recorded for that site in feet. If not visible, the height of the site or the platform would be raised foot by foot, assuming that a multistory building would be built on the site until at least a partial view of the Falls was possible (at least 20 feet down from the crest). The result was a grid with a number for each site indicating the minimum height required for a view of the Horseshoe Falls from its center.

Next, the DEM was used to create the terrain in Sketchup. The city's building footprint data were then positioned onto the terrain, and building height extrusion values were applied to create the buildings. Because the base files were exported from ArcGIS, measurements and geographic positioning were fairly accurate, but not completely so. Some artistic judgment was required to correct the data irregularities. Once the model was built, vantage points were observed to determine where, and at what height, views of the Falls were possible.

The Sketchup model was used to estimate the minimum number of stories that are required for a view of the Horseshoe Falls from a variety of sites in the tourist district similar to viewshed analysis. The method used for calculating these heights was not as exact as the viewshed analysis. Subjective judgment was required for each site to determine what constituted a partial view of the Falls. However, the Sketchup model was able to capture the major patterns and helped to validate the results of the viewshed analysis. Sketchup was used to demonstrate the potential views of the Horseshoe Falls from the Days Inn Site for a number of stories including the 9^{th},15^{th}, 30^{th}, and 45^{th} floors. The ninth floor was used as a baseline because the existing Days Inn is nine stories.

View Corridors

Our study built three Sketchup models for three development scenarios on the Days Inn site to study the impact of different building masses on view corridors. One purpose of the 3D model was to test the validity of a presumption that high-rise hotels would block view corridors. The first scenario was the existing, nine-story Days Inn. The second was the type of redevelopment that is likely to occur under the existing height regulations, a low-rise bulky building. The third scenario was the placement on this site of a tall tower with a small footprint. The second and the third scenarios were both hypothetical and modeled to have a capacity of 500 rooms.

With a 3D model of the city and the Falls in Sketchup, the study compared different development scenarios to determine which best preserved view corridors. To compare the impact of these three scenarios on view corridors, a fixed position along Niagara Street facing Canada was selected. The views from the site across scenarios were compared to assess the impact of the building blocks on view corridors. Once comparable scenes were created in Sketchup, Adobe Photoshop and Adobe Illustrator were employed to highlight the view of Canada across the Niagara River. We drew a grid of squares and superimposed the view images. The view of the Canadian side was thus transformed into a vertical grid of square cells to count the openness of each scenario.

Shadow Analysis

Another issue analyzed was the shadow impact of high-rise hotel development on the Days Inn site. The 3D model was used to

analyze the shadows cast by the hypothetical 45-story hotel on the Days Inn site. The shadow analysis involved ensuring that the model was oriented in the right direction, setting Sketchup's shadow setting to Niagara Falls, New York, and moving the slider bar of the time setting. A physical visit was made late in the day, when the shadows are the longest, to confirm the results of the shadow analysis.

Results and Discussions

Economic Value of the Falls Views

Over the past decade, Niagara Falls, Ontario has seen a building boom of hotel development. In 1996, the city had 9,500 hotel rooms. By 2006, that number had increased to 13,785. Hotel development in Niagara Falls, New York, however, has been considerably less robust, likely even negative. The U.S. Census Bureau's economic census, which is conducted every five years, shows that in 1997, Niagara Falls, New York had 39 hotels and motels. By 2002, that number had decreased to 31 hotels and motels. Over this same period from 1997 to 2002, sales in Niagara Falls, New York's Accommodation and Food Services sector decreased from $105 million to $99 million.

City of Niagara Falls, Ontario

U.S. Census Bureau 1997

U.S. Census Bureau 2002

U.S. Census Bureau 1997, 2002

Tables 1, 2, and 3 show that the increase in revenue for rooms having views of the Falls from the Canadian side range from 8–39 percent, with a median difference of about 22 percent. A rough value of about $44 per room per night can be inferred to help estimate the value of a view of the Falls. Over a 20-year investment cycle, this view premium in a hypothetical 500-room hotel with 200 rooms having views of the Falls can translate into $45 million additional revenue without considering any gained interest in the 20-year period. Additional tax revenue from room taxes would also accrue to a city in desperate need of revitalization efforts.

A tourist destination usually goes through a process of exploration, involvement, development, consolidation, and stagnation as shown in Butler's resort life-cycle curve. The curve divides into two twigs after the stagnation stage to indicate that as a destination matures, reinvestment is needed to rejuvenate; otherwise, the destination declines. The experience of the two Niagara Falls confirms the validity of the resort life-cycle theory of Richard Butler. The Canadian side has received investment

Butler

TABLE 1
Hotel Room Values in Niagara Falls, Canada
Saturday, July 15, 2006

Hotel	*Quality Rating*	*With View*	*Without View*	*Price Difference*	*Falls-View Percentage*
Brock Plaza Hotel	◆◆◆	$247.40	$213.20	$34.20	14%
Doubletree Hotel Resort and Spa Fallsview	◆◆◆◆	$257.38	$187.26	$70.12	27%
Embassy Suites Niagara Falls Fallsview	◆◆◆◆	$400.42	$274.55	$125.87	31%
Hilton Niagara Falls Fallsview	◆◆◆◆	$477.99	$418.13	$59.86	13%
Marriott Niagara Falls Fallsview Hotel & Spa	◆◆◆◆	$316.33	$256.52	$59.81	19%
Michael's Inn by the Falls	◆◆◆	$198.00	$168.00	$30.00	15%
Radisson Hotel and Suites Fallsview		$204.27	$144.44	$59.83	29%
Ramada Plaza Fallsview		$299.00	$269.00	$30.00	10%
Renaissance Fallsview Hotel	◆◆◆◆	$307.61	$241.92	$65.69	21%
Sheraton Fallsview Hotel	◆◆◆◆	$298.42	$212.92	$85.50	29%
The Oakes Hotel Overlooking the Falls	◆◆	$306.68	$261.08	$45.60	15%

Source: www.travelocity.com

for decades for its tourism development. Moreover, hotels can demand premium rates for rooms with views as shown in Tables 1, 2, and 3. In the city of the Niagara Falls, New York, the view premium might spur investment or serve as a type of investment to help rejuvenate the city after stagnation. (See Figure 2, based on Butler's curve.)

Views of the Falls

Results of the analysis of views of the Falls are presented in Figures 3, 4, and 5. Figure 3 shows the minimum heights required for a view of the Horseshoe Falls from the centroids of existing sites or parcels in the tourist district: the darker the cell's color, the higher the building height required to view the Falls. As shown in Figure 3, the closer the sites are to the river, the lower

TABLE 2
Hotel Room Values in Niagara Falls, Canada
Wednesday, July 26, 2006

Hotel	*Quality Rating*	*With View*	*Without View*	*Price Difference*	*Falls-View Percentage*
Brock Plaza Hotel	◆◆◆	$204.07	$169.86	$34.21	17%
Doubletree Hotel Resort and Spa Fallsview	◆◆◆◆	$178.71	$144.51	$34.20	19%
Embassy Suites Niagara Falls Fallsview	◆◆◆◆	$226.60	$209.50	$17.10	8%
Hilton Niagara Falls Fallsview	◆◆◆◆	$268.50	$191.54	$76.96	29%
Renaissance Fallsview Hotel	◆◆◆◆	$256.52	$197.09	$59.43	23%
The Oakes Hotel Overlooking the Falls	◆◆	$226.88	$169.86	$57.02	25%

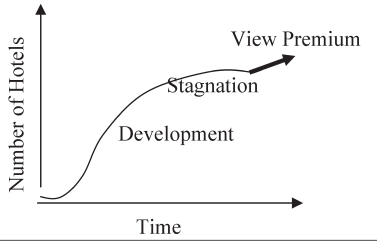
Source: www.travelocity.com

TABLE 3
Hotel Room Values in Niagara Falls, Canada
Saturday, December 16, 2006

Hotel	*Quality Rating*	*With View*	*Without View*	*Price Difference*	*Falls-View Percentage*
Brock Plaza Hotel	◆◆◆	$127.69	$110.58	$17.11	13%
Doubletree Hotel Resort and Spa Fallsview	◆◆◆◆	$137.67	$84.66	$53.01	39%
Embassy Suites Niagara Falls Fallsview	◆◆◆◆	$177.40	$114.04	$63.36	36%
Hilton Niagara Falls Fallsview	◆◆◆◆	$418.13	$299.28	$118.85	28%
Marriott Niagara Falls Fallsview Hotel & Spa	◆◆◆◆	$128.22	$111.12	$17.10	13%
Ramada Plaza Fallsview		$104.79	$84.66	$20.13	19%
Renaissance Fallsview Hotel	◆◆◆◆	$171.01	$136.81	$34.20	20%
Sheraton Fallsview Hotel	◆◆◆◆	$144.51	$110.31	$34.20	24%
Sheraton on the Falls	◆◆◆◆	$195.82	$144.51	$51.31	26%
The Oakes Hotel Overlooking the Falls	◆◆	$124.26	$76.11	$48.15	39%

Source: www.travelocity.com

FIGURE 2
View Premium as Reinvestment in the Tourism Destination Life-Cycle Curve for the City of Niagara Falls, NY



Source: Butler

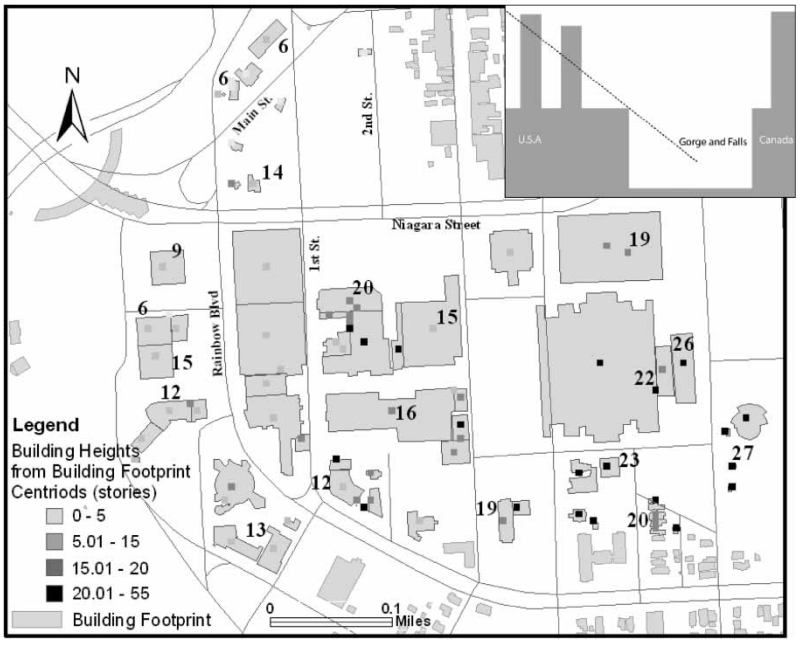
is the platform required for a view of the Falls. In order to get the view, most of the sites in the district need to reach higher than 195 feet, that is, 15 stories (assuming 13 feet for each story). Figure 3 also illustrates the concept of viewshed analysis.

Figure 4 shows the minimum number of stories required for a view of the Horseshoe Falls from a variety of sites in the tourist district using our 3D model. This finding confirms our result from the viewshed analysis and is significant because of the need for hotel development in the city. Attracting high-quality, large-size hotels would provide the much needed tax revenue to reverse the city's fortunes. There are sites close to the Niagara River that can afford views of the Falls from a reasonable height, which could potentially host high-quality hotel development.

Figure 5 contains four illustrations that represent an exploration of the potential views from one specific site, the Days Inn site. The images illustrate the views from the 9^{th}, 15^{th}, 30^{th}, and 45^{th} floors of a hypothetical high-rise hotel on the Days Inn site. Figure 5 shows that this site not only has potential views of the Falls but also has views of the state park. These views are partial views of the Falls, but they may be enough for a hotel operator to advertise Falls and park view rooms and capture a piece of the view premium.

The results of the analysis of views of the Falls that are shown in Figure 3, 4, and 5, help to belie the notion that views of the Falls are not possible from the U.S. side, a notion that may be deterring hotel development. An issue relating to the value of the view of the Falls that is, however, not considered in this study is the distance

FIGURE 3
Minimum Number of Stories to View Horseshoe Falls: Results from the Cell-Based GIS Viewshed Analysis



Benson et al. 1998

from a hotel to the Falls. Benson, et al. found that residential property views are distance-dependent. Possible hotel development sites on the U.S. side are further away from the Falls compared to most on the Canadian side. The Canadians certainly have the preferred views, exemplified by the ubiquitous use of the name "FallsView" in hotel advertisements. However, limited views of the Horseshoe Falls are possible on the U.S. side from a few sites in the tourist district. To be competitive, a hotel would likely have to be built tall enough to provide as many rooms as possible with views of the Falls.

View Corridors

Figure 6 shows the result of a view-corridor analysis of three scenarios on the Days Inn site. The first scenario shows that the existing 168-room Days Inn hotel blocks much of the views from Niagara Street towards Canada. In this scenario, only 524 cells are visible. As a small-scale hotel, the existing Days Inn does much to block

FIGURE 4
Minimum Number of Stories to View Horseshoe Falls: Results from the Sketchup 3D Model

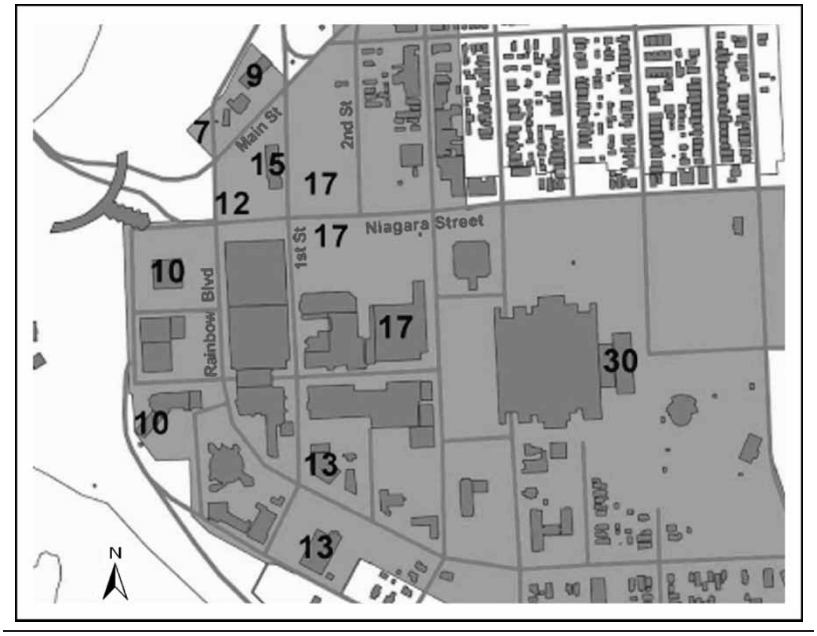


FIGURE 5
View Possibilities: Views from Different Floors

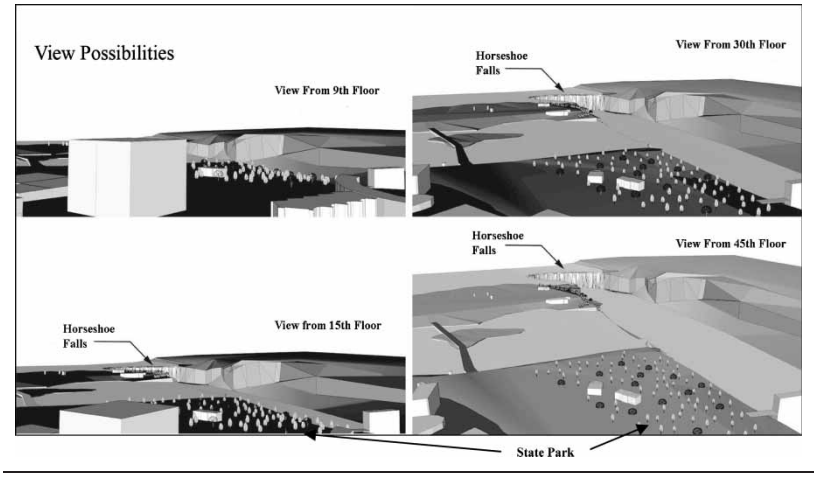
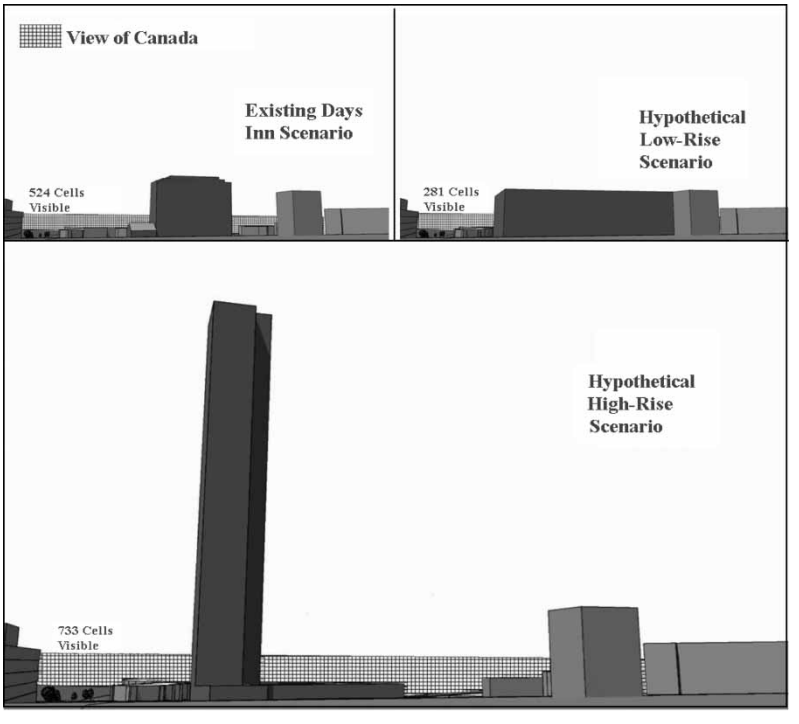


FIGURE 6
View Corridor Analysis: Existing, Hypothetical Low-Rise, and Hypothetical High-Rise



view corridors. The second scenario illustrates how a bulky, seven-story 500-room hotel on this site could block views across the river almost entirely. Only 281 cells are visible. This is the type of development that the city's building height restriction encourages. The third scenario demonstrates how a high-rise building on this site could open up views. In this scenario, 733 cells are visible. The high-rise scenario would provide approximately 2.6 times (733 cells divided by 281 cells) more visual openness than the low-rise scenario. The building modeled here has enough space for approximately 500 standard-sized hotel rooms. As shown by Figure 6, tall buildings on small footprints can, in some situations, do more to preserve view corridors than low-rise, bulky buildings.

The visual analysis demonstrates that the bulky seven-story, 500-room hotel blocks views nearly completely. Even the existing 168-room Days Inn hotel does substantial damage to view corridors. By comparison, the 500-room, high-rise hotel opens

up views across the site to Canada. Of the three development scenarios, the high-rise scenario, a tall building on a small footprint, would do the least damage to view corridors.

This finding is significant because the zoning code's building height restriction of the city may be based on a misconception that tall buildings harm view corridors. The visual analysis we conducted, however, is focused only on comparing effects of three different types of building mass on view corridors and is only based on a fixed position on the U.S. side. Further study needs to be done on the effect of high-rise towers on the U.S. side on the view from other locations including from the Canadian side and from the base of the Falls when there is a specific proposal for a high-rise hotel development. Similar models can also be built to compare the quality of the buildings to see whether they are in visually pleasing style when there is a specific proposal. The current zoning code's restrictions on height, but not bulk, may actually force developments, such as the low-rise hotel scenario, which do the most damage to view corridors. Our model also demonstrates the potential of orientating buildings on their lots to maximize important view corridors.

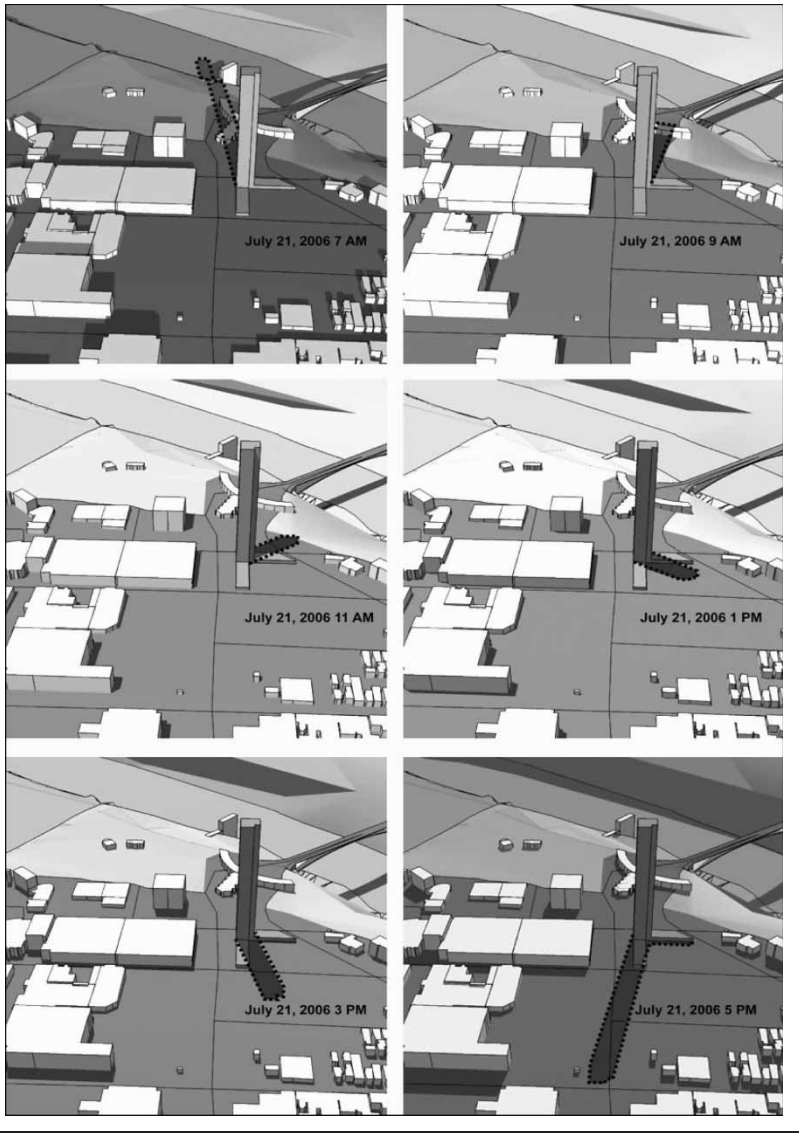
Shadow Analysis

Figure 7 shows the shadows cast by a hypothetical 45-story hotel built on the Days Inn Site on June 21, 2006. During most of a summer day, the shadows would fall within the site. The major times of concern would be during dawn and dusk. At dawn, the shadow would fall across the observation tower, and at dusk the shadow would fall across the aerospace museum and the casino. Unlike a bulky building, the shadow of this slender tower would not fall across any site for an extensive portion of the day. The shadows would change throughout the day and throughout the year on a daily basis.

Note that in this study we only looked at shadows in summer because Niagara Falls is a summer tourist destination. The tourist district largely shuts down during the winter. The shadow may stretch into some residential areas in winter, however. That is not captured in the model and should be studied further because it is a cause for concern. For this reason, specific proposals for a high-rise development should receive a comprehensive shadow analysis using a three-dimensional model to prevent problems.

It is not clear whether this information legitimizes the high-rise development of the site even though we can see that a slim building will not cast shadows on a site for as long as a bulky

FIGURE 7
Shadow Analysis: Shadow at Different Hours of July 21, 2006



building. What does seem clear is that proponents and opponents of high-rise development could use the data to make their arguments for or against the hotel development. The 3D model replaces uncertainty with more information and confidence. With the knowledge of shadows provided by the 3D model,

developers cannot hide problems and opponents cannot conjure imaginary fears. With solid information, stakeholders can make rational decisions and negotiate mutually acceptable solutions. The major concern is that not all stakeholders will necessarily have access to a 3D model in making their arguments, and those that do can selectively choose what information to share.

Conclusion

The tourist district of the City of Niagara Falls, New York has world-class assets. It is, however, not favored by many hotel investments that might bring benefits including tax revenue, jobs, and outside capital that would allow the city to rebuild its tourism industry. Using GIS and 3D visualization tools, this study found that views of the Falls are possible in the district, contradicting a common misconception that views are impossible on the U.S. side. These views may be enough for a hotel to capture the view premium and spur investment in the city to help revitalize the downtown district. However, the city's zoning code limits building heights to about 15 stories, which is barely high enough to offer views of the Falls for hotel operators to charge a premium rate. Views of the Falls are less a matter of the area's geography than the city's regulatory environment, which turns out to be an obstacle to hotel development. We also demonstrate that the high-rise structure required to achieve these views would not necessarily have negative aesthetic effects. The city's sweeping building height restriction, which is applied to the entire tourist district, should be reconsidered in light of these findings. The view premiums from a high-rise hotel may help to attract hotel development that the city needs to create much-needed jobs and generate tax revenue. Our findings would hopefully help to improve the attractiveness of the city for hotel development. We do not, however, envision a wall of high-rises similar to that on the Canadian side. Rather, we envision a few high-rises with adequate space in between to preserve important view corridors.

This study also demonstrates many of the benefits of 3D modeling and GIS technologies for planning. GIS and 3D visualization technologies are ideal tools for situations such as this one that involve complex spatial calculations. Used together, these programs offer planners tremendous capabilities for conducting studies that involve a combination of spatial, mathematical, and aesthetic considerations. Three-dimensional modeling and GIS

can help a planner create an economically favorable and flexible regulatory environment, while selectively blocking harmful developments. Three-dimensional modeling and GIS technologies enable users to employ complex calculations to make informed decisions about complex spatial issues, to compare different development scenarios, and to explore development sites from a variety of perspectives. Most of all, however, they provide information. With increased information and knowledge, decision makers can make better decisions on such issues as zoning codes and building height restrictions.

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