

An aerial photograph of a dense forest with a stream winding through it. The trees are mostly green, with some bare branches visible. The stream is a light blue-grey color, contrasting with the darker green of the forest. The overall scene is a natural, outdoor environment.

# A Land-Use-Planning Simulation Using Google Earth

by Alec M. Bodzin and Lori Cirucci

**G**oogle Earth (GE) is proving to be a valuable tool in the science classroom for understanding the environment and making responsible environmental decisions (Bodzin 2008). GE provides learners with a dynamic mapping experience using a simple interface with a limited range of functions. This interface makes geospatial analysis accessible and feasible for classroom use. The ability to use, analyze, and interpret remotely sensed satellite and aerial images is becoming more and more important in many scientific and industrial fields. To promote these skills in our eighth-grade science curriculum, we developed a four-week land-use-change curricular unit in which students use geospatial information technology tools including GE and other remotely sensed images to investigate modern-day land-use issues and land-use change over time. The land-use-change (LUC) unit is available online at [www.ei.lehigh.edu/nes/luc](http://www.ei.lehigh.edu/nes/luc). The unit's activities can be successfully implemented with pairs of students working together on computers. Activities can also be implemented in a one-computer classroom with the teacher projecting the screen image to the front of the classroom and distributing printed copies of certain GE screenshots for the analysis activities. If computers are not available, providing students with printed copies of GE screenshots will enable them to complete the learning activities.

As a culminating activity, we developed a role-playing simulation in which learners investigate the following question: Where should the new SuperMart Corporation build their new superstore in the greater metropolitan Lehigh Valley area to have minimal impact on the environment? In this six-day activity, students use Google Earth to analyze and evaluate features of different land areas for four proposed development sites (days 1 and 2). They develop a proposal to apply smart growth principles to their planning decisions (days 3 and 4) and communicate their plan with a presentation in a simulated planning-commission meeting (days 5 and 6). *Smart growth* is a term used to describe the desire and strategy to provide new growth and development in the most appropriate areas while protecting our natural resources. Although this activity was developed for a land-use-change unit, it can also be integrated into a middle school curricular unit that focuses on environmental issues related to human impacts on the environment.

## Background

Most urban areas experience commercial, industrial, and residential development associated with population growth and expansion, which may result in a loss of natural vegetation, agricultural lands, and open space (Alberti 2005).





# Search Maps

Such growth is often accompanied by a general decline in the extent and connectivity of wildlife and wetland habitat. Land-cover and land-use changes can be substantial but are difficult to grasp when they occur incrementally (Laymon 2003). Image displays in GE, when used with overlay features such as roads and 3-D buildings in urban areas, provide support for students to identify and interpret land-cover features (Bodzin and Cirucci, forthcoming).

The LUC unit is designed to assist students in understanding land-use-change concepts including urban heat-island effects and to promote the learning of essential skills used in aerial-photo interpretation. Urban heat islands occur when heat builds up in a city and creates a “hot spot” compared to nearby suburban and rural areas. To understand concepts involved in the formation of urban heat islands, students investigate how shopping malls change natural environments. They learn how communities can use certain heat-island reduction strategies to lower the impact of an urban heat-island effect. Students complete a case study of the greater Atlanta area to understand environmental issues that are typically associated with sprawl. Their investigations continue with a case study of the Lehigh Valley (LV) area in Pennsylvania to identify area land features. They then compare land-use types around five different shopping mall areas using Google Earth to examine the significance

of mall locations. Prior to the culminating activity, students analyze and interpret satellite data images and aerial photographs to examine landscape changes over time in different locations around the world. While the LUC activities are not a required prerequisite to complete the culminating Where Should We Build the New SuperMart? activity, they may be helpful for students to understand some of the environmental issues that are typically associated with developing a new, large commercial structure in a community.

The Where Should We Build the New SuperMart? activity is a full inquiry activity that includes all essential features of inquiry. It can be implemented in fewer days as a partial inquiry activity. For example, one can complete the GE analysis activity of the proposed sites in two days and not hold the simulated planning-commission meeting, thus eliminating the authentic communication feature of the activity in which learners consider alternative explanations to their planning decisions. The activity is a geographical case study that engages students with analyzing rural, suburban, and urban areas. The infrastructure considerations one makes in the simulation are reflective of authentic planning decisions in each type of demographic area. The ideas presented in this activity may be customized to reflect other geographical areas in the country. Google Earth’s website contains a tutorial that instructs you how to create, edit,

**FIGURE 1** Proposed SuperMart analysis form

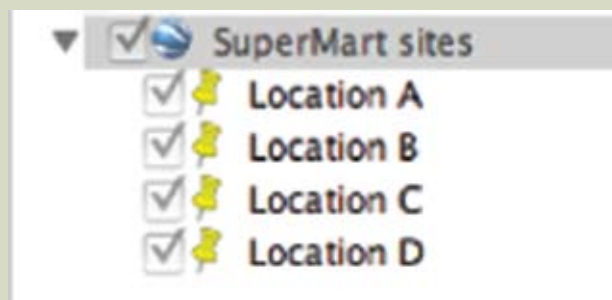
Examine the four proposed locations for developing a new SuperMart using the Google Earth file, SuperMartsites.kml. Respond to each item for all four locations in the chart below. After you have completed the chart, recommend the best location to develop a new SuperMart. (Answers are provided in italics.)

	Location A	Location B	Location C	Location D
Describe the current land use of the proposed site. (What does the land area look like?)	<i>Farmland. Agricultural area.</i>	<i>Primarily a cleared dirt area with some patches of trees.</i>	<i>Primarily a cleared dirt area.</i>	<i>Farmland. Agricultural area.</i>
What natural features are in the area?	<i>A wooded area is just south of the location. The residential area north of the site contains large grassy areas and small wooded areas.</i>	<i>A few tree stands.</i>	<i>A river is located 0.25 miles away from the site. There are a few trees near the site.</i>	<i>There are some wooded areas around the perimeter of the location. A river is located less than a mile from the site.</i>
What human-made features are in the area?	<i>Roads, fallow and cultivated fields, houses, and barns.</i>	<i>A highway (I-78), a major road (412), a nearby residential area, a town south of the highway, a city to the northeast (1 mile), and a large industrial area north of the site.</i>	<i>Many office complexes and industrial buildings are near the site. A highway interchange (I-22) with a major road is 1.5 miles away. A dense urban area surrounds the site.</i>	<i>Roads, fallow and cultivated fields, and houses in a residential area.</i>
Describe the nearby population areas. (Can people walk to the site? How far away are residential communities?)	<i>There are two very small residential areas near the site. One immediately north and one southwest. A small population center is located 2.4 miles southeast from the site.</i>	<i>Many people would be able to walk to the site from a nearby residential area, from the town south of the highway, and from the city to the northeast (1 mile).</i>	<i>A dense urban area surrounds the site. Many people would be able to walk to the site. The nearest residential area is 0.5 miles from the site.</i>	<i>A residential area is located 0.6 miles southwest of the site. A small population center is located 4.5 miles southwest from the site.</i>
Describe the existing infrastructure. (Are there existing roads and commercial or business areas near the location?)	<i>Route 309, a major road, is located next to the site. There are no commercial areas near the location. The site is located in a rural area.</i>	<i>A highway (I-78) interchange with a major road (412) is located 0.5 miles away from the site. There are stores located at the highway interchange.</i>	<i>There are many existing roads and industrial areas near the location.</i>	<i>Route 611, a major road, is located 0.4 miles from the site. There are no commercial areas near the location. The site is located in a rural area.</i>
Describe new infrastructure that will be needed for this site. (Will new roads need to be built? Do you think the site has easy access to water and electricity?)	<i>New roads will not be needed since the site is located next to Route 309. Water and electricity lines will likely need to be constructed.</i>	<i>A new road will need to be constructed to move people from 412 to the site. Water and electricity lines will likely need to be constructed.</i>	<i>Not much new infrastructure for water and electricity will be needed for this location. No new roads will need to be built.</i>	<i>New roads will be needed. Water and electricity lines will likely need to be constructed.</i>

**FIGURE 1** (continued)

	Location A	Location B	Location C	Location D
Describe the positive impacts of the site location. (What are the benefits and advantages of having a SuperMart at this location?)	<i>A SuperMart at this location will provide shopping access to many residents in an extended rural area. These people will not have to travel as far to do their shopping.</i>	<i>A SuperMart at this location will provide shopping access to many residents in an urban and sub-urban area. These people will not have to travel as far to do their shopping and many could walk. Easy highway access.</i>	<i>A SuperMart at this location will provide shopping access to many residents in a dense area. These people will not have to travel as far to do their shopping and many could walk. Nearby highway access.</i>	<i>A SuperMart at this location will provide shopping access to many residents in an extended rural area. These people will not have to travel as far to do their shopping.</i>
Describe the negative impacts of the site location. (What are the disadvantages of having a SuperMart at this location?)	<i>A SuperMart at this location will convert an agricultural area to a large impervious surface. The landscape will change, resulting in environmental consequences such as alteration of water runoff patterns, habitat destruction, and heat-island effects.</i>	<i>Some trees will need to be removed. The landscape will change, resulting in environmental consequences such as alteration of water runoff patterns, some habitat destruction, and some heat-island effects.</i>	<i>A few trees may need to be removed. The landscape will change, resulting in environmental consequences such as alteration of water runoff patterns, some habitat destruction, and some heat-island effects. Construction may impact the river ecosystem.</i>	<i>An agricultural area will be converted to a large impervious surface. The landscape will change resulting in environmental consequences such as alteration of water runoff patterns, habitat destruction, and heat-island effects.</i>

The best site that will have minimal impact on the environment is \_\_\_\_\_ (Location B or C)

**FIGURE 2** Drop-down list of SuperMart site locations

and position geographical placemarks of specific locations in your own area that students can analyze (<http://earth.google.com/userguide/v4/tutorials>).

### The simulation activity

The simulation activity is introduced by asking students what types of things developers must consider when

they plan to build a new, large department store in an area. We prompt students to think about infrastructure issues such as the availability of roads and sidewalks for transportation to get people to the store, and access to water and electrical lines to supply basic needs for the store to function. This activity introduction takes about seven minutes and we make sure that students understand the importance of needing basic infrastructure for new development.

Next, we tell students they will be conducting a role-playing simulation activity in which they will be employees of the Lehigh Valley Planning Commission (LVPC). We explain that the LVPC is an organization that helps guide sensible growth in the LV area and provides advice and recommendations to cities and towns that wish to further develop their existing lands. We tell students the LVPC has been asked by the SuperMart Corporation to help them decide where to locate and build the next SuperMart in the LV area so that the new store will have the least impact on the environment. Their task is to use Google Earth to examine four proposed



locations for the new store, make a recommendation, prepare a proposal statement, and develop and present a five-minute PowerPoint presentation that describes why their development plan is the best plan for the area. Since this is an authentic real-world task, students are highly motivated to begin work.

We distribute the Where Should We Build the New SuperMart? handout (see Activity Worksheet) to each student. This handout provides students with necessary content background about the role of the LVPC and about smart growth. After students read the handout, we hold a brief classroom discussion to ensure students understand the mission of the LVPC and the goals of smart growth, and to share ideas for developing land for new businesses in responsible ways.

Next, we distribute a blank copy of the Proposed SuperMart Analysis Form (Figure 1) to each student. Figure 1 depicts an example of a completed copy that illustrates correct responses. We then display the SuperMartsites.kml file (available online at [www.ei.lehigh.edu/learners/luc/SuperMartsites.kml](http://www.ei.lehigh.edu/learners/luc/SuperMartsites.kml)) in Google Earth and show students how to move from one site location to the next by extending the sites drop-down list and clicking on a specific location name (Figure 2). We then show students how to turn on the *roads* layer in Google Earth to view the existing transportation infrastructure. Next, we model how to use the *ruler tool* to measure the distances of residential areas to the proposed SuperMart locations. Most students complete the Proposed SuperMart Analysis Form in one and a half class periods. Student responses are shared and both positive and negative impacts of development at each location are discussed. To conclude this instructional segment, we ask students to analyze their responses and make their recommendation for the best site that will have the minimal impact on the environment.

Next, students write a proposal statement for the SuperMart Corporation. We tell students that their proposal statement should clearly describe how the proposed site selection promotes smart growth to slow down effects from sprawl. We instruct students to address the guiding questions (#4) on the Activity Worksheet. Each student receives a Proposal Statement Rubric (Figure 3) to use as a guideline for writing the proposal and is given one class period to complete this task.

We divide the class into teams of two students who have selected the same site recommendation. We tell students that their team will develop a five-minute PowerPoint presentation that clearly describes why their development plan is the best plan for the SuperMart Corporation to have minimal impact on the environment. We emphasize that they are trying to convince the

SuperMart Corporation to use their site selection. Their presentation needs to be as factual and persuasive as possible, and they should make claims clearly and support them with facts and evidence. Each student receives a Proposal Presentation Rubric (Figure 3). We have students read the rubric and tell them that their presentation needs to address each rubric criteria. In our classes with lower-level readers, we read to students each criterion on the Proposal Presentation Rubric, clarify any vocabulary terms they might have difficulty with, and provide explanations as needed. Finally, we instruct students to read through the guidelines for the proposal presentation (#5) on the Activity Worksheet. If computers are not available for students to create a PowerPoint presentation, we recommend that students create a poster presentation and be provided with printed screenshots of the site location. We found that two days was a sufficient amount of time for our student groups to assemble their presentation.

We provide students with a peer-assessment sheet to rate their partner's contribution to the presentation. This peer-assessment sheet promotes individual accountability and deters social loafing within groups. Peer-assessment sheets are also quite helpful in providing us with data for assigning an individual grade component for the presentation.

The final part of the activity is devoted to the student presentations in a simulated planning-commission meeting. To focus students on each group's presentation, we recommend having students adopt the role of community members and write down questions to ask the presenting group. At the conclusion of each presentation, randomly select two students to ask their questions to the presenting group. If desired, students' questions may be used as a participation assessment to provide accountability for paying attention during the group presentations.

## Student proposals and presentations

Overall, we were quite pleased with the quality of our student proposals and presentations. Many students considered both the positive and the negative trade-offs involved in their site selection. Students who recommended locations B and C as their proposed sites noted that these locations took advantage of existing transportation infrastructure since they were located near a highway and major roads. They also pointed out that water and electrical lines would likely be available since these sites were positioned near densely populated areas. Many students told us these areas appeared to be cleared of vegetation and would likely not affect

**FIGURE 3** Where Should We Build the New SuperMart? proposal statement rubric

Criterion	Exemplary (4)	Proficient (3)	Adequate (2)	Needs improvement (1)
Proposal discusses major transportation issues (such as existing roads) facing the SuperMart development plan.	Major transportation issues discussed are credible and completely accurate.	Major transportation issues discussed are credible and generally accurate.	Major transportation issues discussed are somewhat credible and accurate.	Major transportation issues discussed are inaccurate.
Proposal discusses how the new SuperMart will impact sensitive areas (such as nearby rivers, lakes, ponds, and streams) and natural features.	The proposal clearly discusses the impact on sensitive areas.	The proposal generally discusses the impact on sensitive areas.	The proposal is somewhat unclear as to the impact on sensitive areas.	It is unclear how the new SuperMart will impact sensitive areas.
Proposal discusses how the new SuperMart will preserve open space, farmland, natural beauty, and critical environmental areas.	The proposal clearly discusses the preservation of open space, farmland, natural beauty, and critical environmental areas.	The proposal generally discusses the preservation of open space, farmland, natural beauty, and critical environmental areas.	The proposal is somewhat unclear about how the new SuperMart will preserve open space, farmland, natural beauty, and critical environmental areas.	It is unclear how the new SuperMart will preserve open space, farmland, natural beauty, and critical environmental areas.
Proposal explains how the SuperMart will take advantage of existing structures, such as reusing abandoned industrial sites or existing roads.	The proposal clearly explains how the SuperMart will take advantage of existing structures.	The proposal generally explains how the new SuperMart will take advantage of existing structures.	The proposal somewhat explains how the new SuperMart will take advantage of existing structures.	The proposal does not explain how the new SuperMart will take advantage of existing structures.
Proposal discusses how the SuperMart will support existing communities and neighborhoods where roads, water, and electricity are already in place.	Discussion of how the SuperMart will support existing communities is thorough and complete.	Discussion of how the SuperMart will support existing communities is credible and substantial.	Discussion of how the SuperMart will support existing communities is partial or incomplete.	Discussion of how the SuperMart will support existing communities is very incomplete and includes misunderstandings.
Proposal discusses actions SuperMart could take to protect farmland, forests, and other natural areas.	Actions SuperMart could take are highly effective.	Actions SuperMart could take are generally effective.	Actions SuperMart could take are somewhat effective.	Actions SuperMart could take are ineffective.
Proposal includes recommendations of how SuperMart can develop this site to reduce the impact on the environment.	Recommendations are insightful and accurate.	Recommendations are generally accurate.	Recommendations are somewhat accurate.	Recommendations are inaccurate.

existing wildlife as much as the other site locations. They informed us that SuperMart would have to build a new access road to the new store locations. Consequently, students also noted that the new SuperMart would likely increase traffic to the area and produce pollution during the construction of the building and parking lot. Many students noted that locations A and D were located in rural areas and most likely did not have much existing infrastructure for water or electricity at those sites. During the presentations, students discussed an important social trade-off about these locations—while locating a store in these areas might provide easy access to small nearby population areas, most people would have to commute long distances to shop at these locations. Many groups noted that development in these areas would “destroy a whole lot of vegetation for the roads” and much money would be needed “to get water and electricity out there.”

Many proposals noted that the creation of a new SuperMart and its associated parking lot could disrupt the existing ecosystem, displace animals from their habitats, and contribute to urban heat-island effects. Students recommended many smart growth practices in their proposals to provide compromises for these negative consequences. These included planting trees in the parking lot and in areas adjacent to the store, using a lighter-colored concrete surface for the parking lot instead of asphalt, making the parking lot as small as possible, using a light-colored roof on the SuperMart to reduce the amount of heat absorbed by the building, and placing the store’s garden department on the roof to create a “green roof.”

We were surprised to discover during the activity that a few students had a naïve conception about developing in an agricultural area. These students noted that building a SuperMart on a large farmland area “would not disturb a natural area because there are no living things around it.” In discussions with these students, they told us they did not think dirt fields had existing life in them. They did not view a farmland area as having a distinct ecosystem. While this conception was a view held by only a few students, we recommend explicitly addressing this conception at the beginning of the activity if you teach students who live in an urban setting and may lack sufficient background knowledge about agricultural areas.

## Conclusion

Using appropriate pedagogical strategies, GE can be used effectively to highlight the impacts of human processes associated with developing rural, suburban, and urban areas. The ideas presented in this simulation activity can be adapted to any geographical area. If you wish to develop a related activity in your own geographi-

cal area, we recommend selecting four potential new SuperMart locations for students to analyze. Two locations should be better locations for developing a SuperMart than the other two locations. This reflects real-life planning decisions, since a particular geographic area will likely include multiple locations where existing infrastructure will be sufficient for a new site location. In rural areas, we recommend including locations that are located alongside roads and close to small communities. Such sites will likely have nearby existing electrical and water infrastructure. In urban areas, we suggest selecting locations that include abandoned industrial areas to emphasize ideas related to reusing existing structures. In addition, locations that people are able to walk to or have easy access to via public transportation should also be included. For suburban areas, site selections should include areas located nearby interstate exits or major roads that include existing malls, stores, and restaurants. Such locations emphasize suburban area consumer needs to attend to their shopping and related activities in one convenient area.

We have found GE to be an effective tool for developing in middle school learners certain spatial-thinking skills to investigate land-use features. Our land-use-planning simulation activity was an effective way for students to learn and understand how human activities influence environmental changes. In this activity, students learned about many trade-offs communities must consider when planning for new commercial development, thus placing science in personal and social perspectives. ■

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