EXPANDING THE USE OF VISUALIZATION TECHNOLOGY: 3D MODELING

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Abstract.—The Bureau of Land Management (BLM) uses three-dimensional (3D) models viewable in Google Earth in addition to traditional visual resource analysis tools to plan, visualize, and mitigate new landscape-altering projects. A rough model can be made in minutes, allowing for quick and inexpensive pre-planning. Even when sites are inaccessible due to winter snow, timing, cost, or other access issues, modeling gives an approximation of the look of the final project and identifies scenery concerns. Alternatives can be worked through "on the fly" during meetings with stakeholders or in the field (with an internet connection), and mitigations can be made before major time or expense has been poured into an alternative. When project proponents submit a final project design, sophisticated 3D models show the project more intuitively than any diagram or text could, since people naturally think and react to their world in 3D. As a Google Earth file, the model can be easily shared over email or Website to any stakeholders or members of the public who have this free program on their computer. Viewers can investigate how the project looks from whatever viewpoints interest them and not be limited to the handful of viewpoints chosen by the agency. Finally, models help create photographic visual simulations when working with unusual facilities or dirt work (i.e., soil grading) that cannot be simply copied and "Photoshopped in" from other projects.

INTRODUCTION

The Bureau of Land Management manages 248 million acres, approximately one-eighth of the landmass of the United States, and 700 million acres of subsurface minerals, for the benefit of current and future generations (Bureau of Land Management 2016). The Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701 et. seq.; 1. Section 102 (a) (8)) governs how the BLM lands are managed, and among its requirements is that "... the public lands be managed in a manner that will protect the quality of the ... scenic ... values." However, it also requires the BLM to support multiple resources that can affect scenery, including energy development, infrastructure rights-of-way, grazing, wildlife, archaeological and heritage conservation, and recreation. The National Environmental Policy Act of 1969 (43 U.S.C. 4321 et. seq.) requires the BLM to consider how a proposed project could affect the area's scenery, also called visual resources.

The BLM's visual resource management framework is similar to that of other land management agencies. First, existing visual qualities are inventoried and management goals are determined, then effects to visual resources from a particular project are predicted, and finally changes are made to the project, if necessary, to mitigate visual impacts to achieve management goals (Bureau of Land Management 1984). To predict impacts to visual resources, the BLM uses the Contrast Rating Process. First, locations of the most critical viewpoints are determined. Then, the basic features (i.e., landform/water, vegetation, and structures) and basic elements (i.e., form, line, color, and texture) of the existing scenery are documented, and the extent a project will alter and contrast each scenery element is rated. Contrast ratings are based on the professional judgment of the visual resource professional and their experience with similar types of projects. Occasionally, a two-dimensional (2D) visual simulation of the project on the landscape is created to help portray the relative scale and extent of the project (Bureau of Land Management 1986).

While contrast rating and visual simulations provide a methodical, repeatable framework to analyze visual impacts, they have some shortcomings. There can be subjectivity in determining contrast ratings and creating visual simulations, and the validity or reliability of the methods has been criticized (Feimer and Craik 1979, Smardon and Litton 1981). A project's novelty can increase the chances for inaccurate visual

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impact predictions, such as recent attempts to analyze new solar array designs (Sullivan and Abplanalp 2015, 2017). In addition, there are guidelines, but no standards, about how to select the viewpoints from which the project is judged. Finally, the public is often not effectively involved in the visual analysis process (Churchward et al. 2013).

In response to these criticisms, the BLM expanded the use of visualization technology by creating virtual 3D models of projects on a landscape. Three-dimensional computer modeling should be considered an additional tool that can increase prediction accuracy and aid in stakeholders' and the public's understanding of project impacts.

This paper describes simple and complex 3D modeling using Google Earth Pro, a free, widely available landscape imaging software. The paper then describes the benefits and disadvantages of 3D modeling compared to more traditional visual resource analysis tools.

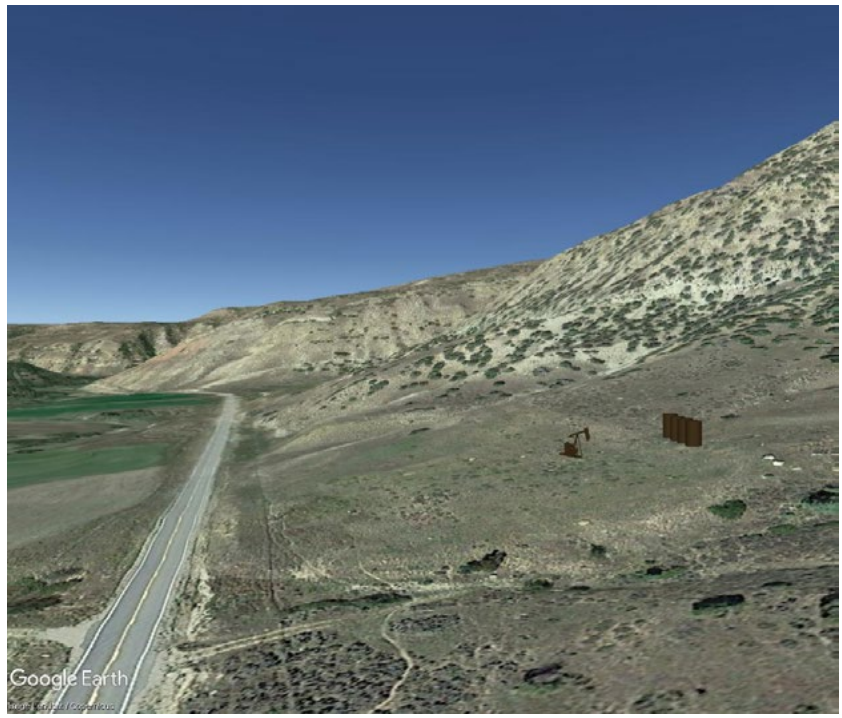

Figure 1.—Simple model of pumpjack and oil tanks. Google Earth.

RELATED WORK

The book Guidelines for Landscape and Visual Impact Assessment also discusses 3D modeling in conjunction with 2D visual simulations (Landscape Institute and Institute of Environmental Management & Assessment 2013). However, the utility of 3D models as a stand-alone tool is not examined and no specific software or examples are detailed. Technological innovations in computer capabilities make 3D modeling a rapidly evolving area of visual resource management.

MODELING EXAMPLES

At the simple level of 3D modeling, the user does not create a model from scratch. Instead, pre-made models of common project equipment such as power poles, recreation kiosks, or oil and gas tanks are inserted onto their project's position on the landscape. The simple level of modeling does not require the user to know how to make a model or use any modeling software. The most recent imagery in Google Earth is the baseline or existing environment, and a model (saved as a COLLADA file) of project equipment is created in the precise location using Google Earth Pro's "Add Model" command. This creates a rough model that can be inserted in a manner of minutes with very little computer expertise.

These simple models are useful for low-controversy projects, for early planning of larger-scale projects, and for users without familiarity of modeling software. The model can be viewed in Google Earth, and a 2D image can be saved to share in a report or analysis. Figure 1 illustrates an image from a model for an oil well pad made in this way. The basic equipment (pumpjack and tanks) is visible, giving viewers a rough impression of where the project will be visible from, and how it contrasts with its surroundings.

At the complex level of 3D modeling, the user creates a unique and detailed model from scratch using modeling software. All aspects of a project are created, including unique features such as the shape of dirtwork cuts and fills, or unique equipment such as a novel processing plant facility. Modeling software allows the models to be made to precise dimensions and accurate colors. In addition, any trees or human-made structures around the proposed project can be modeled to more clearly show how the project contrasts with its surroundings, and a model of the existing area can be built to use as a baseline for comparison. The models can be saved as Google

Earth files (.kml or .kmz) and shared online for viewing by anyone with Google Earth. Two-dimensional images of the models on the landscape can be saved and used in reports or analyses. Figure 2 shows the same oil well pad project from Fig. 1, but this time with precise dirtwork cuts and fills, all project equipment, and the trees already present in the surrounding area.

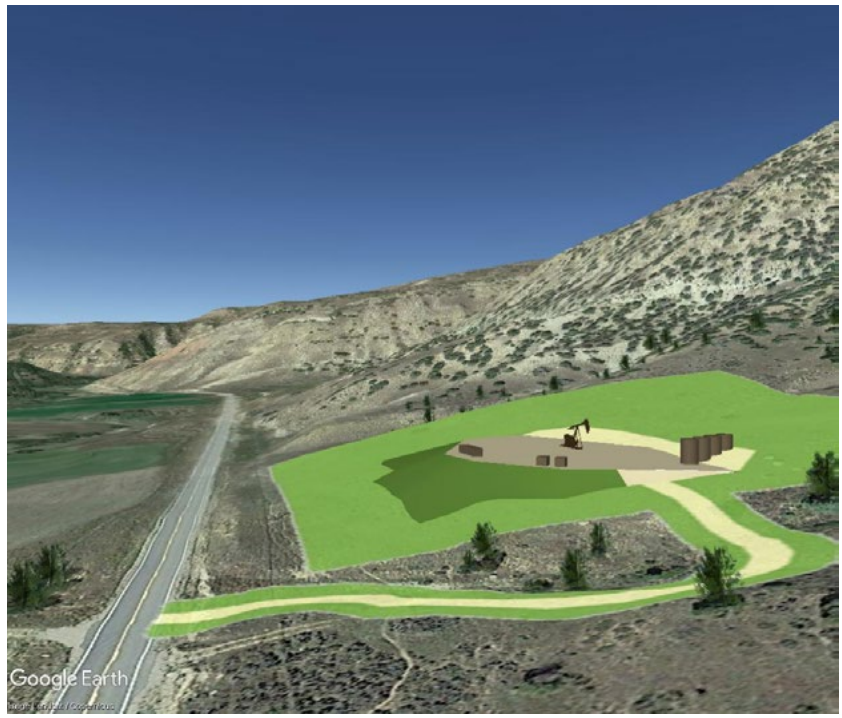

Figure 2.—Complex model of oil well pad. Google Earth.

BENEFITS

One benefit of 3D modeling is that it mimics how people naturally experience the world: in 3D. This is an improvement over both written descriptions and 2D images, which must be "translated" in the brain to create an impression of what the real-world project will look like. Also, 3D modeling allows the project to be viewable from changing perspectives, and users can create "walk throughs," "drive bys," and "fly bys" that mimic how they would likely interact with the project. The models are sharable online to anyone with Google Earth. This benefit increases the accessibility and understandability of the project and associated analysis for both the general public and experienced stakeholders.

These models are also unique in that they can be viewed from an infinite number of viewpoints. With traditional contrast ratings or visual simulations, a small handful of viewpoints are chosen and the project is analyzed from there. This is of limited usefulness to a stakeholder who is interested in how the project looks from a different viewpoint, such as from their front porch or favorite hunting spot. With a 3D model, once the model is in Google Earth, the user can "fly around" Google Earth and look at the model from anywhere.

Another benefit of 3D modeling is that no site visit is required in order to make it (although a site visit, in addition to other visual resource analysis techniques, is recommended for final analysis of higher-profile projects). A model can be made using just the construction diagrams or description of project attributes, and it can be input into a precise location on Google Earth from the comfort of your computer. This allows visual impact analysis to be completed when site visits are impossible, such as during the winter season or during road access disagreements. Many project alternatives and locations can be roughly modeled quickly, decreasing costs by identifying problems, preferred alternatives, and proper Key Observation Points before site visits and detailed design work is started.

Finally, these 3D models can complement 2D visual simulations. They can be used as checks on the placement and proper scale of equipment that is photo-montaged into landscape pictures, which is particularly useful for unique equipment or dirtwork. If no other image of equipment exists, the model can be rendered into a realistic image and input into a landscape picture. Using 2D and 3D tools in conjunction with each other can increase the accuracy of visual impact predictions.

DRAWBACKS

As with any new technology, low awareness of the tool and lack of familiarity using the tool decrease its use. Just to view a model on Google Earth, a person needs access to a computer, internet, and knowledge about use of Google Earth software. Creating a new model requires skill in a 3D modeling software. Google Earth Pro can also save a 2D image of a 3D model. However, if a user only has access to the 2D image, they lose some of the features and benefits of the 3D model.

Topography is another challenge. Google Earth creates ground contours from digital elevation model data collected by NASA's Shuttle Radar Topography Mission. This data has a vertical elevation precision of 30 meters (Wikipedia 2017). While a 30-meter difference is imperceptible for large hills and mountains in the distance, it can create noticeably wrong slopes on a specific project site. It is also difficult to show cuts or holes below the existing ground contours. In addition, the colors of the ground cover are not true-to-life and often are not available for all the seasons of the year.

The above drawbacks are technological in nature and may improve as technology improves. More fundamental drawbacks concern the misuse (intentional or otherwise) of simulations to sway decision making. As Sheppard (2001) emphasizes, visual simulations can strongly influence the public and decision makers, but there are no standards or simple checks to ensure that a model is accurate. Model inaccuracies include wrong size of equipment, unrealistically healthy or dead vegetation, or viewpoints that hide the project. These inaccuracies could over- or under-predict the impacts of a project but are hard for decision makers to detect until the project has been built. There are no widely agreed upon standards for model builders to ensure that they create trustworthy models.

Finally, while 3D modeling can show what a proposed project will look like, it does not determine whether the visual impacts are within management goals. The visual resource professional still needs to judge whether the resulting view is within some threshold level of acceptability, and identify mitigations if needed.

CONCLUSION

Three-dimensional computer modeling is an emerging technology that can increase visual impact prediction accuracy and improve stakeholders' and the public's understanding of project impacts.

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