

# **RA570 Advanced GIS: Wind Farm Viewshed Analysis Using Spatial Analyst and 3D Analyst**

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## **Abstract**

Proper wind farm development requires the right combination of several variables. Adequate wind speed and available land are two major components, as well as proximity to existing power infrastructure capable of transporting additional amounts of electricity. Another crucial component to a properly placed wind farm is local visibility and public perception. In an effort to maintain positive attitudes towards wind turbines as a source of renewable energy, proper planning in the early stages of development is imperative. Viewshed models designed using ArcGIS Spatial Analyst and 3D Analyst allow developers to analyze future visual impacts of wind farms and make calculated decisions. Line of Sight tools are also useful to make quick visibility analysis.

## **Introduction**

The analyzed viewshed model replicates a realistic scenario related to the development of wind farms. The visibility component was the only variable considered for purposes of simplicity. An actual suitability analysis project would incorporate several variables not addressed in this analysis.

## **Methods**

The study area is located in the bluffs of Winona County. This is an area with high amounts of elevation variability and offered a realistic Viewshed scenario. The DEM used was a raster layer of Winona County projected in NAD83 UTM Zone 15. This layer was added to the data frame twice. A Hillshade effect was applied to one layer. This layer was below the other identical raster layer. The top raster had a 40% transparency level to create depth and realism. Three shapefiles were created in ArcCatalog. The first, a point shapefile was for the individual wind turbines, which

included X, Y locations plus an elevation value. Wind turbine locations were selected on high elevations for maximum visibility. Elevation values for the individual wind turbines were obtained by zooming to the cell level of the raster layer and identifying the value. These elevation values were added in the attribute table of the wind turbines. After adding the wind turbine shapefile the base heights for the layer were obtained from the layers Z- field. This method placed the point features realistically on the surface. The second shapefile, another point shapefile, represented a cabin potentially in view of the proposed wind farm. The third shapefile was created as a polyline. The polyline was used to connect the cabin to each wind turbine. During an editing session, a line was snapped to the cabin and to one wind turbine. Every wind turbine was attached to the cabin via a separate line.

Three techniques were used to analyze visibility; the Viewshed Tool, and two different Line of Sight Tools.

The first technique utilized the Viewshed Tool, found in ArcMap. This tool can be accessed in both 3D Analyst and Spatial Analyst Extensions. An input raster and observation location are required fields to run the tool. The cabin was used as the observation point and the Winona DEM was the input raster. The cells contained in the output raster layer were divided into two categories, visible or not visible. The results were quantified by measuring cell count values. Both extensions were used and the results were identical. Figure 1 illustrates the Viewshed Tool along with the output raster. The orange color represents areas visible from the cabin while the light purple color represents areas not visible. It is clear from the figure that more area is *not* visible from the cabin than *is* visible.

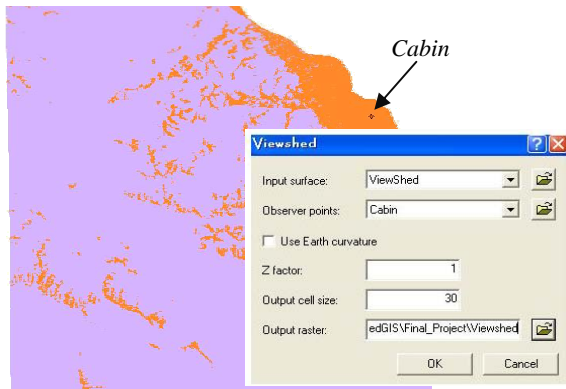


Figure 1. Viewshed Raster and Tool Dialog.

This analysis provides visual and quantitative data useful for determining those areas visible from any chosen observation point.

The second technique used was the Line of Sight Tool. Two tools share this tools name and perform similar analysis but are step up in different ways. The first tool uses 3D Analyst Extension and must be carried out in ArcMap. The tool draws a line connecting an observer and a target. Observer and Target offset Z-values were added to increase accuracy. For instance, a target offset was added to compensate for a

one hundred foot tall wind turbine. The line is bi-colored to represent areas along the line that are visible and those areas that are not visible. Figure 2 illustrates the results of the Line of Sight Tool.

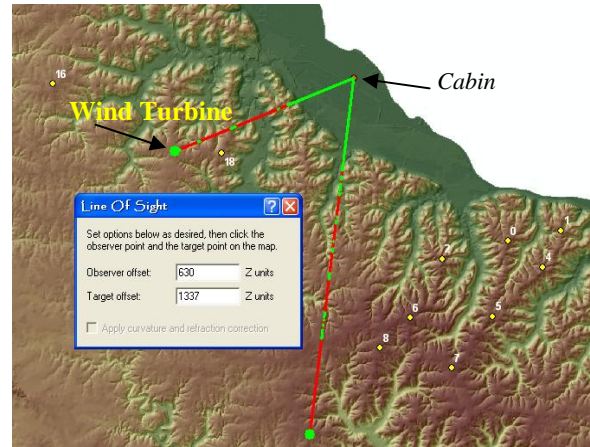


Figure 2. Line of Sight Tool in ArcMap.

The surfaces below the green line segments are visible from the cabin and the red line segments are not visible from the cabin. The illustration in Figure 2 indicates the two wind turbines would not be visible from the cabin. Every wind turbine was included in the Line of Sight analysis. While this tool can only be used in ArcMap, the lines can be copied and pasted into ArcScene where greater visual mobility is available.

A more accurate Line of Sight Tool is located in ArcToolbox under the 3D Analyst tools in the Functional Surface toolbox. This tool involved creating a new polyline shapefile. The shapefile was added to ArcMap and became the target in the editing session. Lines were drawn between the cabin and each wind turbine (Figure 3).

During this process features were snapped to, increasing the analysis accuracy. After drawing the lines the tool can be run. Unlike the previous tool, this tool can be run in either ArcMap or ArcScene. ArcScene was used to increase the visual effects of the tool results.

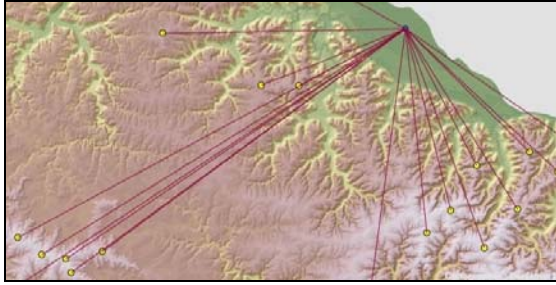


Figure 3. Polylines connecting the cabin to each wind turbine.

Figure 4 is a graphic from ArcScene with lines drawn from the cabin to the wind turbines after the tool ran. The solid red lines indicate that somewhere along the line there is an obstruction, thus preventing visibility between cabin and wind turbine.

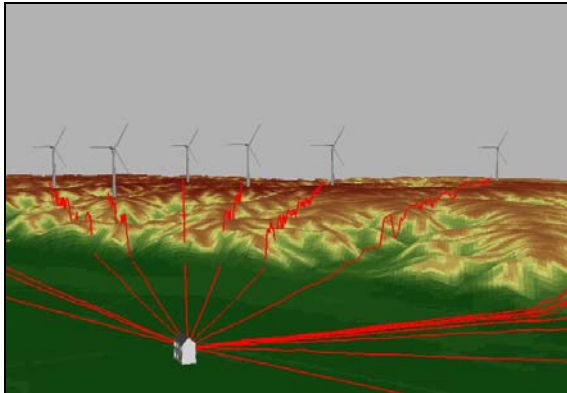


Figure 4. Sight lines connecting the cabin to each wind turbine.

## Discussion

This analysis was performed on a mostly imaginative model. The only data not created was the elevation layer. The position and sizes of the wind turbines and cabin were chosen to simplify the analysis and to create a visual model illustrating Spatial Analyst functionality. However, the applied analysis techniques would be the same in similar ‘real-life’ scenarios.

Exploring the functionality of ArcScene proved to be very rewarding. Three-dimensional models tell a story not easily conveyed through traditional two-dimensional maps. ArcScene offers tools for

displaying spatial relationships and telling a story in a way ArcMap cannot.

During the process of this analysis, a couple difficult problems arose. The biggest problem was defining surface location and elevation values for the cabin and wind turbines. Without accurate values, the visibility analysis would not make sense.

Another issue was displaying the features in correct size relative to each other. The elevation layer used actually represents a large area, over thirty miles across. If the model was spatially proportional, each wind turbine would be over a mile tall. However, displaying the features in sizes relative to their true sizes would render them as small spots on the map. This would have greatly reduced the desired visual impact.

## Results

Based on the results of applying three separate visibility analysis tools, the cabin in the model would not experience any visual impact from the proposed wind farm development. The results of the Viewshed Analysis indicate 6 wind turbines that are located on visible surfaces. However, surfaces labeled not visible are in close proximity and would allow for relocating the wind turbines. The two Line of Sight tools returned results indicating the target would not be visible to the observer. Assuming this was the one remaining variable needed before continuing development, the wind farm project would likely move forward. A more detailed analysis would include accurate measurements of all features in the viewshed. For instance, when analyzing visibility over large spatial areas the curvature of the Earth is an important factor to include. This analysis did not cover an area large enough to include Earth curvature as a variable. Figure 5 is the final map output from this analysis.

## Conclusion

When performing a visibility analysis, the functionality of 3D Analyst and Spatial Analyst Extensions proved to be very effective. The model created in this analysis

represents how developers concerned with visual impacts can approach spatial problems in an effort to maintain positive relationships with landowners.

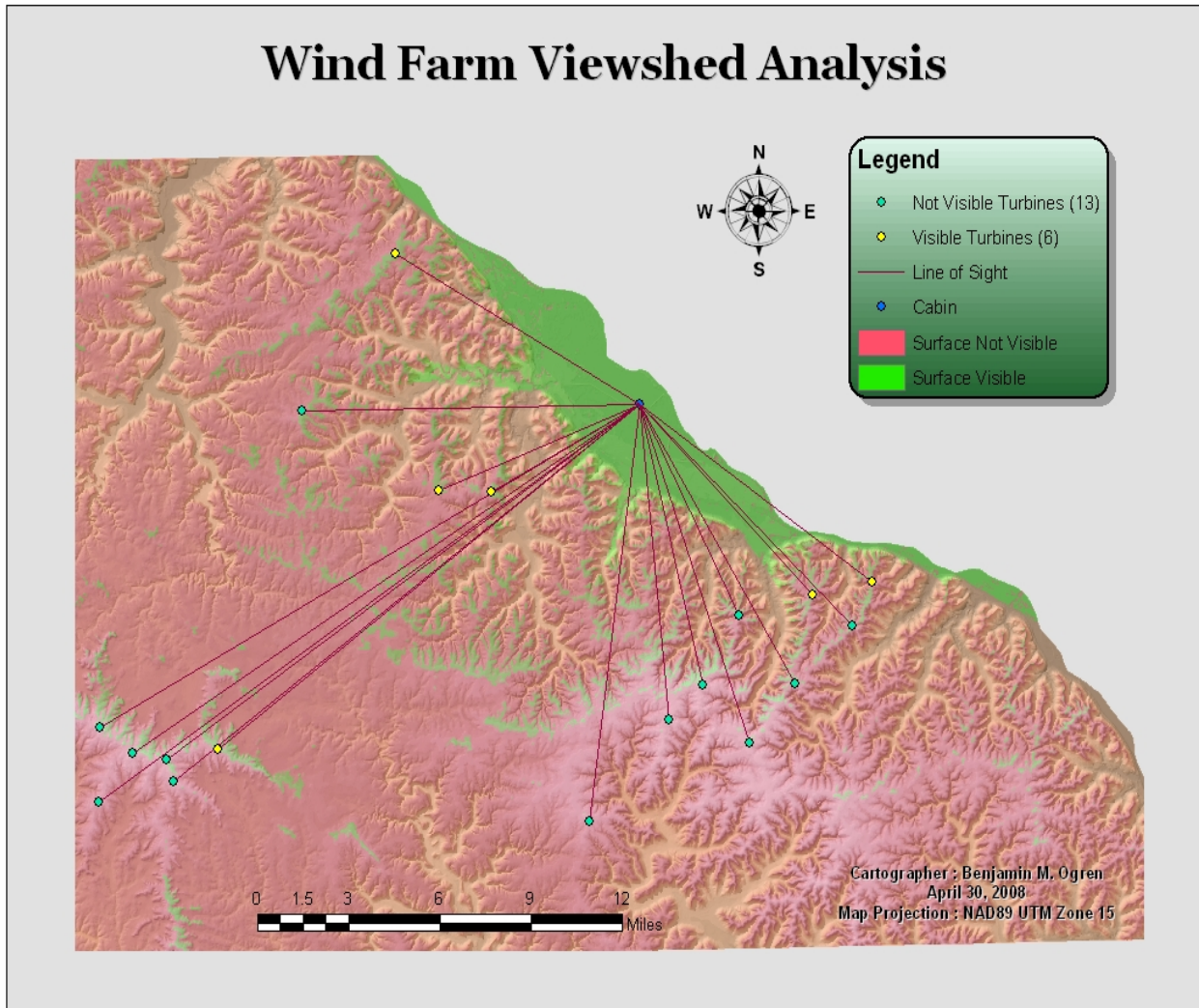


Figure 5. Final map showing viewshed from observation point (cabin) to each target (wind turbine).