Modeling Least Harm Zones For Natural Gas Hydraulic Fracturing Sites: Wattenberg Gas Field, Weld County, Colorado

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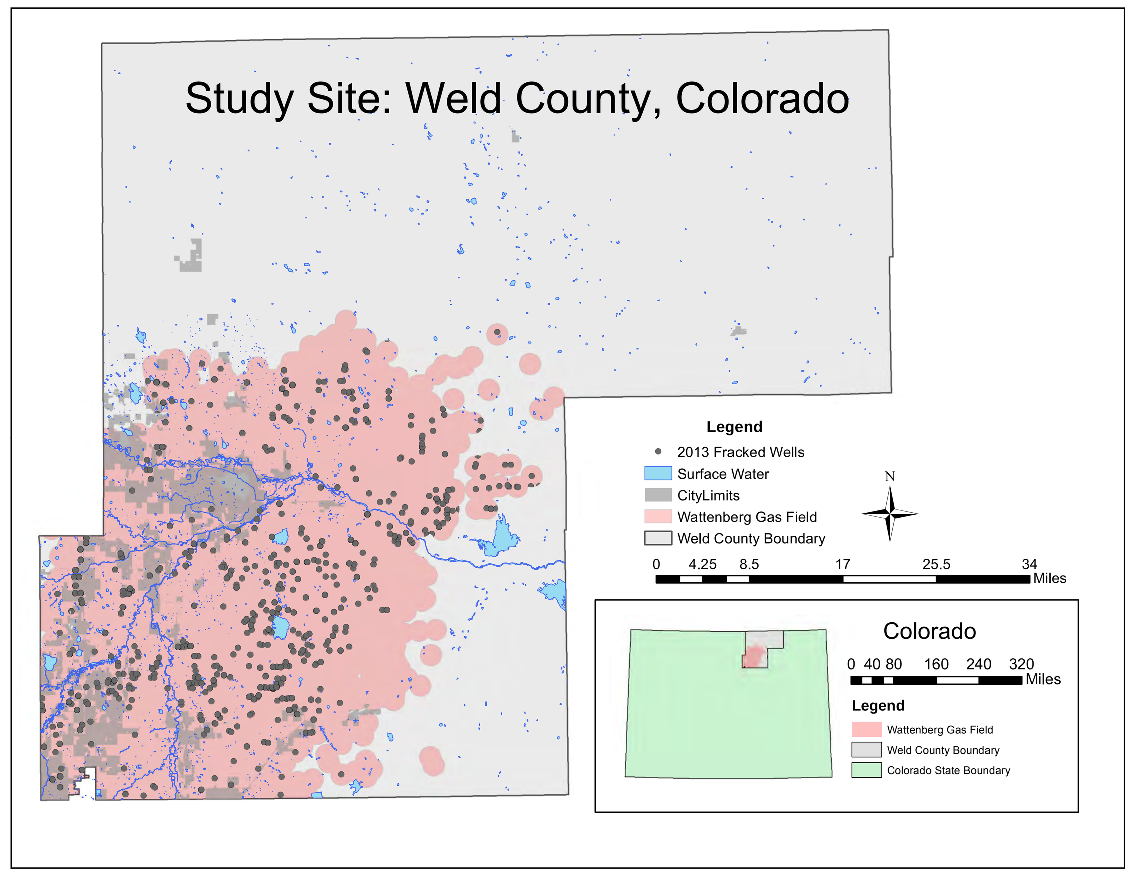
Introduction

Using a harm-reduction approach, we determined the best zones to drill new hydraulically fractured (fracking) gas well sites in the Wattenberg gas field of Weld County Colorado by maximizing gas production while keeping water supplies and residential areas at a maximum distance.

In 2013, the number of registered fracked wells in Weld County was over 1,600, making up 65 percent of all fracked wells in Colorado (Roth, 2013). Over 1,100 of those sites are located within the Wattenberg gas field, with hundreds more receiving permits to drill each year.



Though we found no data providing evidence of water contamination from the active well sites, there are growing concerns that water contamination is inevitable with time. In Pennsylvania water contamination was discovered within a 1 kilometer radius of well sites, caused by leaking steel lining near the surface of the wells (Jackson et al, 2013). To limit future water contamination we modeled the gas production of the Wattenberg field and maximized the distance of potentially high-producing well locations from surface water and city limits.

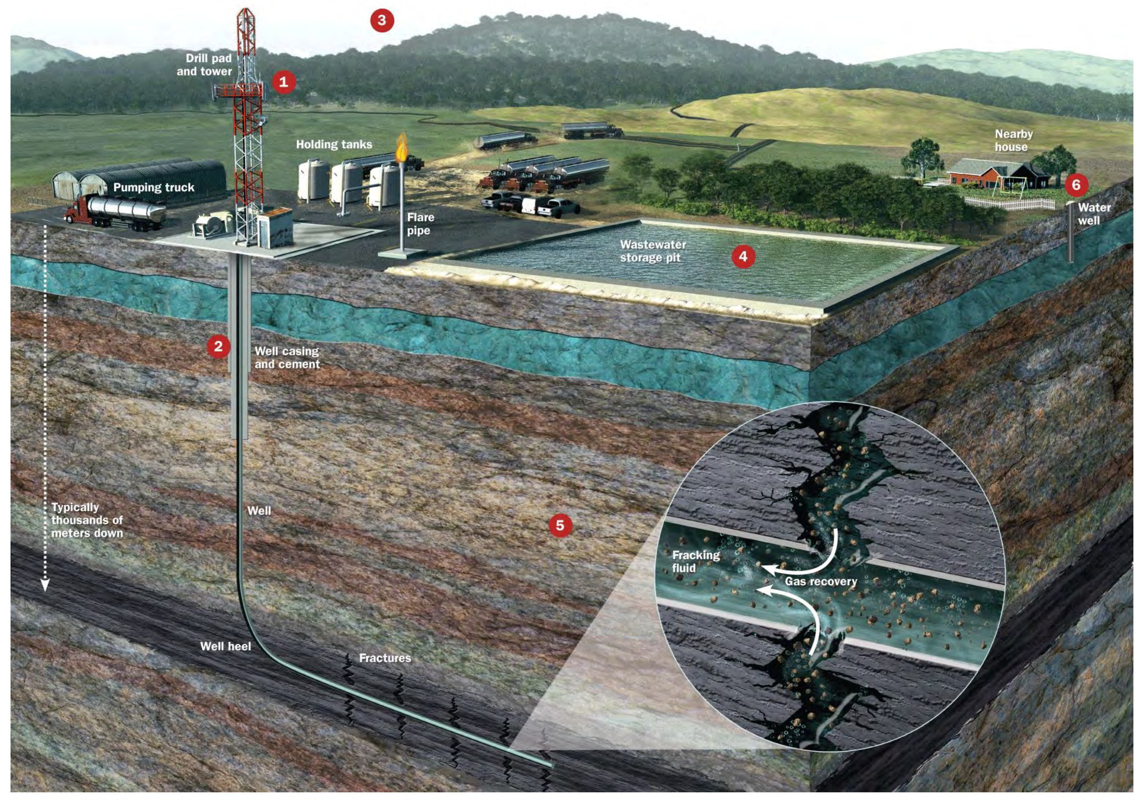


Figure 1: Hydraulic fracturing is a method used in the oil and gas industry where a well is drilled vertically 5000 to 10000 feet deep and then turned to run horizontal along a natural gas containing shale bed. The well is then injected with a fluid that creates fractures in the shale rock allowing the gas to migrate towards the well hole, from which it can be extracted to the surface (Crawford, 2013) .

References

Crawford, T. (2013, April 25). Hydraulic Fracturing: What is Hydraulic Fracturing? Retrieved March 1, 2015, from http://greenplug.nu/hydraulic-fracturing-what-is-hydraulic-fracturing/

Jackson, R., Vengosh, A., Darrah, T., Warner, N., Down, A., Poreda, R., Karr, J. (2013). Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. Proceedings of the National Academy of Sciences, 110(28), 11250-11255. Retrieved March 1, 2015, from www.pnas.org/cgi/doi/10.1073/pnas.1221635110

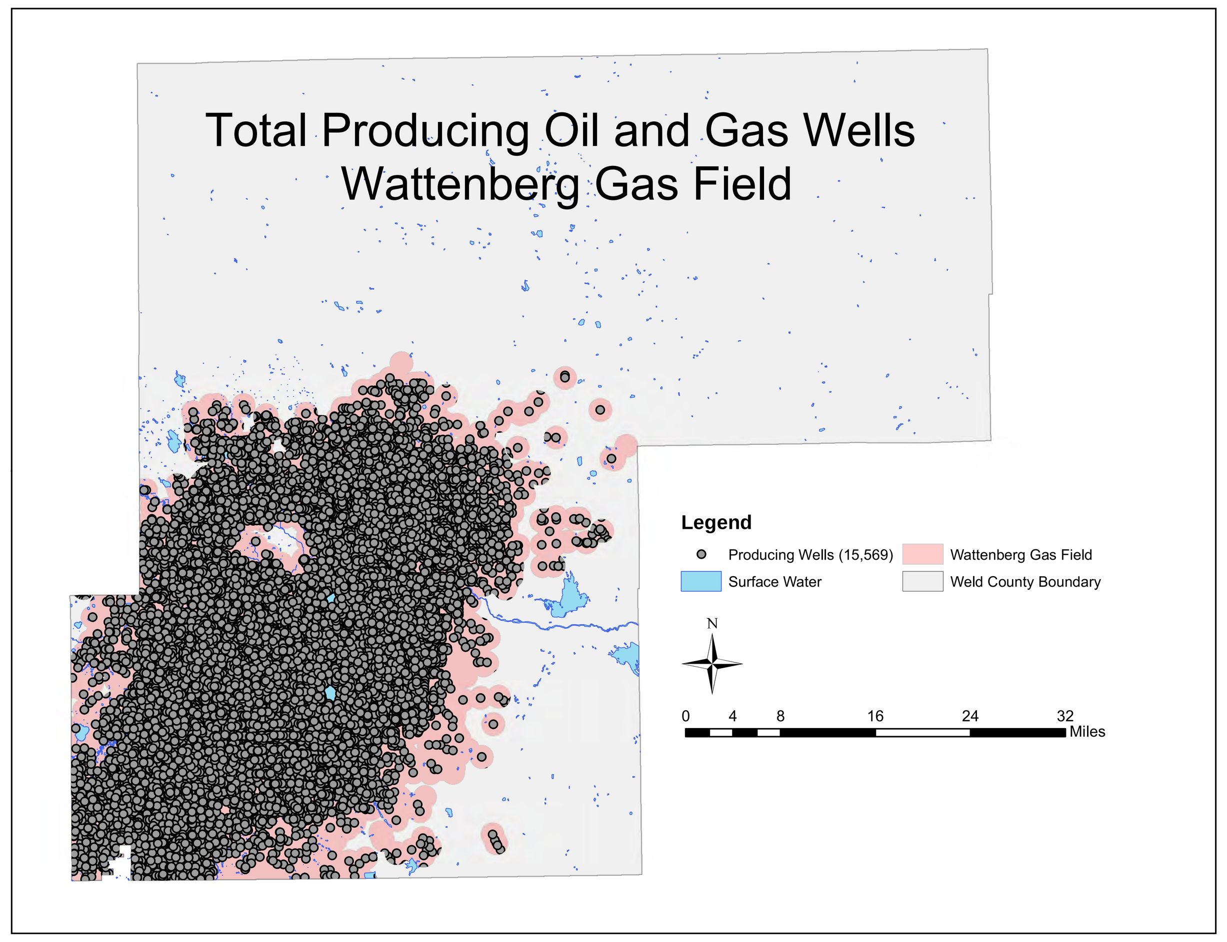
Roth, S. (2013, August 14). Fracking Becoming a Serious Stressor to Water Supplies. Retrieved March 1, 2015, from http://sierraclub.typepad.com/compass/2013/08/fracking-becoming-a-serious-stressor-to-water-supplies.html

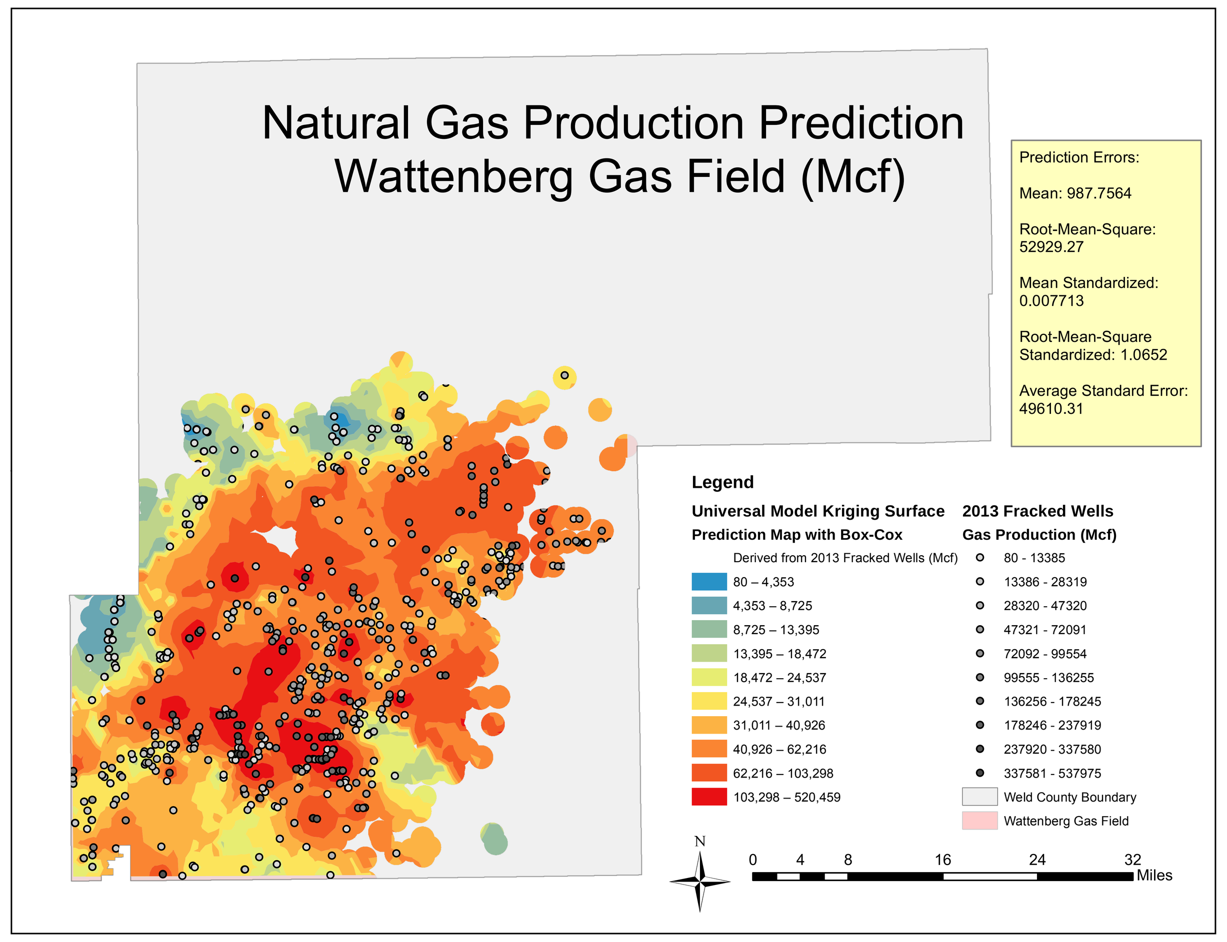
Methods

Before creating a gas production prediction model, we selected the Wattenberg Gas field within Weld County, Colorado as our study site due to its abundance of fracked wells and its proximity to settlements and surface water. In total, Weld County contains over 30,000 oil and gas wells. From these, well sites within the Wattenberg field where fracking was reported (997 wells) were selected, exported, and re-plotted. The Colorado Oil and Gas Conservation Commission website was used to link natural gas production values to each of the wells. After organizing this data in excel, we imported the table to ArcMap and joined the production values to the fracked well sites attribute table to create point values that represent natural gas production for each well.

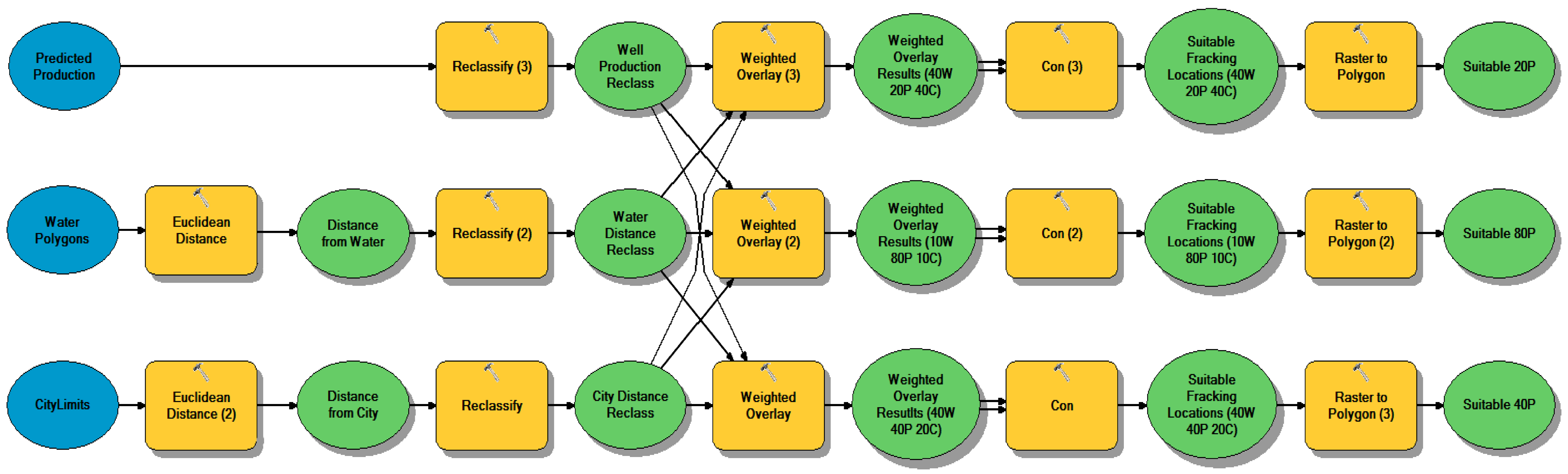
We reviewed the histogram and QQ plot for the gas production data and found that the data was not normally distributed. Using the trend analysis feature we found that the data exhibited a slight second order polynomial trend as well.

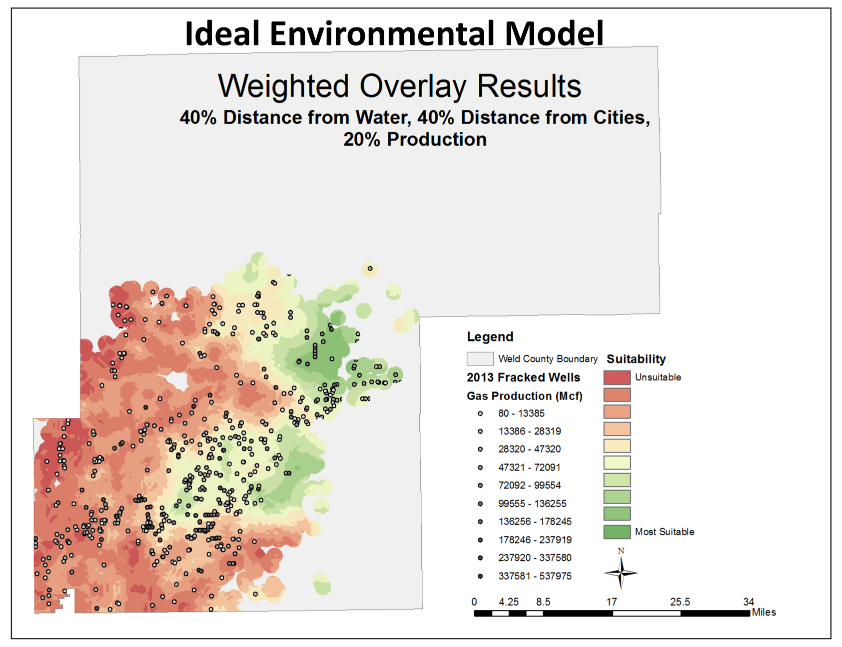
In order to create a predicted-production surface, we compared various kriging models. In particular, we looked at simple, probability, and universal kriging. We checked for anisotropy using the semivariogram cloud and by examining the results of different orientations of the "show search direction" feature. We debated if there was a directional trend but discovered that the universal model with false anisotropy fit best. After running the Geostatistical Wizard, we converted our results into a raster layer and added it into model builder.

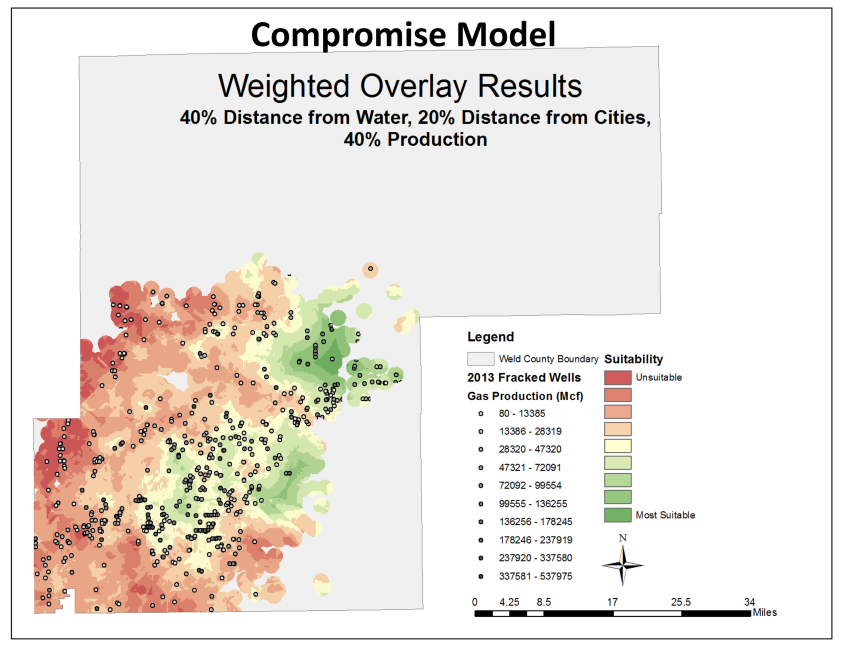


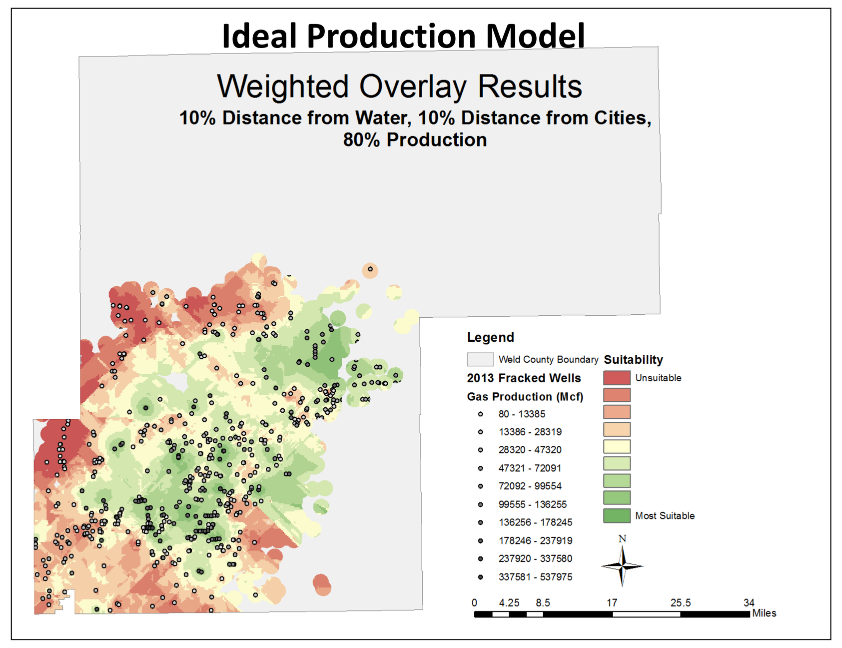


We then added a city limits layer and water polygon layer to the model builder. From here we created a model where we calculated Euclidean Distance from water and cities and classified them by 1,000 meter intervals. Then we reclassified the 1,000 meter intervals into single digit integers (1-10) and weighted each reclassified value using the Weighted Overlay tool. We created three results with various weighted values. Finally, we joined the Fracked Well Points to the Suitable Fracking Locations polygons to learn how many existing fracking sites lie outside our defined least harm zones.









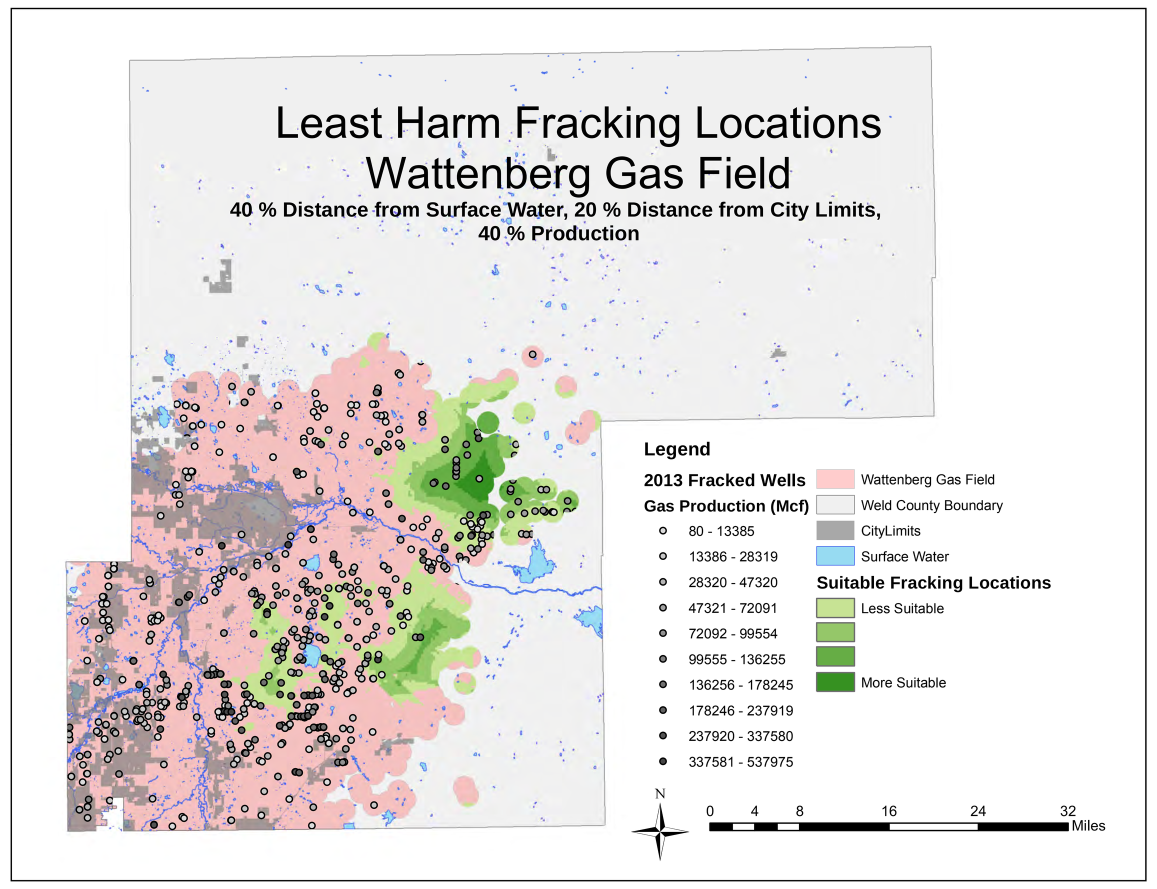
Poster created March 15th 2015

Results

Three separate models were created in this analysis to identify least harm sites for new fracking wells, by assigning different weights to each of the variables using the Weighted Overlay tool in ArcGIS. The first model is considered to be the "Ideal Environmental Model," with 40% of the weight attributed to distance from surface water features, 40%, attributed to distance from cities, and 20% attributed to the well production predicted using the Kriging method. The second model is considered the "Ideal Production Model" and of the models created likely mimics the real site selection process the closest. This model was given weights of 10% to distance from surface water, 10% to distance from cities, and 80% to predicted production. The final model that was generated focused on achieving a balance between the previous two models. The weights assigned to this model were 40% to distance from surface water, 20% to distance from cities, and 40% to predicted production.

For all three models, the Con tool was then used to implement a cutoff of acceptable scores for each location. We considered a score of six out of ten or better to be the least harm locations for new fracking wells.

An analysis comparing current registered fracking wells to the least harm locations shows that the majority of current sites did not take these factors into consideration when choosing a location. For the "Ideal Environmental Model," 88.1% (878) of the wells in the Wattenberg gas field fall outside of the least harm areas. Similarly, for the "Compromise Model," 86.5% (862) of the wells fall outside of the least harm areas. Most shockingly, for the "Ideal Production Model," 75.2% (750) of the wells fall outside of the identified least harm zones.



Discussion

The results of our analysis reveal that proximity to surface water and human populations are at best minimally considered when determining the location of new fracking sites. The "Ideal Production Model" reveals that the overwhelming majority of current well sites do not fall within these least harm zones. Additionally, there are many fracked wells within the Wattenberg gas field that fall within city limits and/or are within several hundred feet of surface water features. Many of these sites are not even in areas of high natural gas production.

We recommend that going forward, natural gas companies use something similar to our "Compromise Model" when considering the placement of new fracking wells. This model gives considerable weight to areas of high production, while minimizing potential risk to the future wellbeing of the environment and local populations. This would be a significant step for repairing the environmentally unfriendly image that fracking has created, while still allowing significant production of natural gas.

Data

Colorado Oil and Gas Conservation Commission: Gas field polygons (2011), well surface locations (2013); well production data (2013). http://cogcc.state.co.us/

ESRI: Colorado state-plane basemap (2014).

Weld County GIS and Mapping: County boundary (2014), city limits (2015), water polygons (2014), township (2014). http://www.co.weld.co.us/Departments/GIS/GISData.html