Potential impacts to hydrologic flows from exploration, production, and infrastructure development in the Eagle Ford Shale Play
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This study will examine possible hydrologic changes and trends developing as a result of the recent boom in the Eagle Ford Shale Play (EF).

I am still not quite sure how I will quantify hydrologic disruptions from oil and gas activities in the Eagle Ford Shale Play. I have been able to figure out a methodology for identifying the disturbance that is from oil and gas activities. However, I have only finished one county to completion. The process of image classification has proven to be very time consuming. I have completed image classification on all of the 25 counties in the EF. I have identified all disturbances for LaSalle County in order to be sure that I could figure out the methods to do this for the entire play. I thought of identifying the "hot spots" where first order streams are being affected mostly because it is thought that disruption to first order streams has the greatest ecological importance in semi-arid and arid climates.

I have decided to add landscape fragmentation analysis to this report also. I thought it will pair well with the hydrologic analysis.

Ratio or interval level data is required to perform spatial statistical analysis such as the Moran's I and Anselin's outlier and cluster analysis. I will use the percent of areal change in first order streams as the ratio level data for the spatial statistical analysis.

I have performed some small sample test runs on the spatial analysis to be sure I understood what the analyses mean and that I understood how to do them.

Below is my original proposal that has been brought up to date with changes and what has been done so far.

Goals and Questions:
The goal of this research will be to recognize and better understand how hydrology is changing in response to oil and gas (O&G) exploration and production (E&P) in the EF. This research will address the following questions:
1) How much hydrologic fragmentation is anticipated to occur in the EF?
2) How much E&P infrastructure is being built in each of the stream order classes?
3) Can trends be identified using spatial analysis techniques that identify and characterize spatial patterns and trends of hydrologic fragmentation?

An end result would be the first steps necessary to an infrastructure development guide that limits impacts to the Texas landscape. The intent of this research is to quantify patterns of change from recent Eagle Ford activity, so assessments can be made on long-term land management practices.
Expected results include:
1) Maps and associated data that would allow us to assess how E&P activities influence hydrologic processes;
2) An estimate of potential changes to hydrology at the play scale;

3) A better understanding of how hydrology is changing as a result of recent E&P in the Eagle Ford Shale Play.

Methods:

Areal Disturbance of hydrologic fragmentation

Datasets that include well location coordinates, spud date, operator name, geologic province name, and many other attributes associated with each well in the EF (whether used for production or injection) have been downloaded from the IHS website (Information Handling Services, Inc., 2013). This database contains well permits for the EF play acquired between March 30, 2001 and December 11, 2012. Using ArcGIS (version 10.2), wells were plotted and overlaid onto 2012 aerial imagery obtained from the National Agricultural Imagery Program (NAIP) (USDA NAIP, 2012). The area of disturbed land from the development of infrastructure, well pads, containment ponds, staging areas, etc., that were clearly from oil and gas activity, has been calculated by manually outlining disturbed area in ArcGIS at a 1:4000 scale. Any disturbance not obviously from oil and gas E&P or related infrastructure was not included in this step.

GIS data for oil and gas pipelines was obtained from the Texas Railroad Commission (RRC). Surface disturbance from pipelines currently under construction and those likely to be developed will be calculated. A 30 m buffer representing land disturbance will be assigned to the pipelines (a conservative estimation based on observations of NAIP imagery in ArcGIS). Unsupervised iso cluster image classification has been conducted on the 2012 NAIP in order to identify disturbance that has occurred because of pipelines. The classified images will be reclassified into two categories consisting of disturbed and undisturbed land. At this point, I have only finished LaSalle County to completion. However, the process for indentifying disturbance from pipelines has been established.

The National Hydrography Dataset (NHDPlusV2) will be downloaded from horizon-systems.com (Horizon Systems Corporation, 2013). A 200m buffer will be created around the 25 counties in the EF.

Using the raster calculator function in ArcGIS 10.2 the values in the NHD where disturbance from O&G has occurred will be reclassified with a value of zero. An overall estimate in the loss of available soil water holding capacity will be a result of this analysis. Additionally an overall assessment of disturbances in 1st, 2nd, 3rd, and 4th order streams will be a result of this analysis.

Landscape fragmentation of core forests

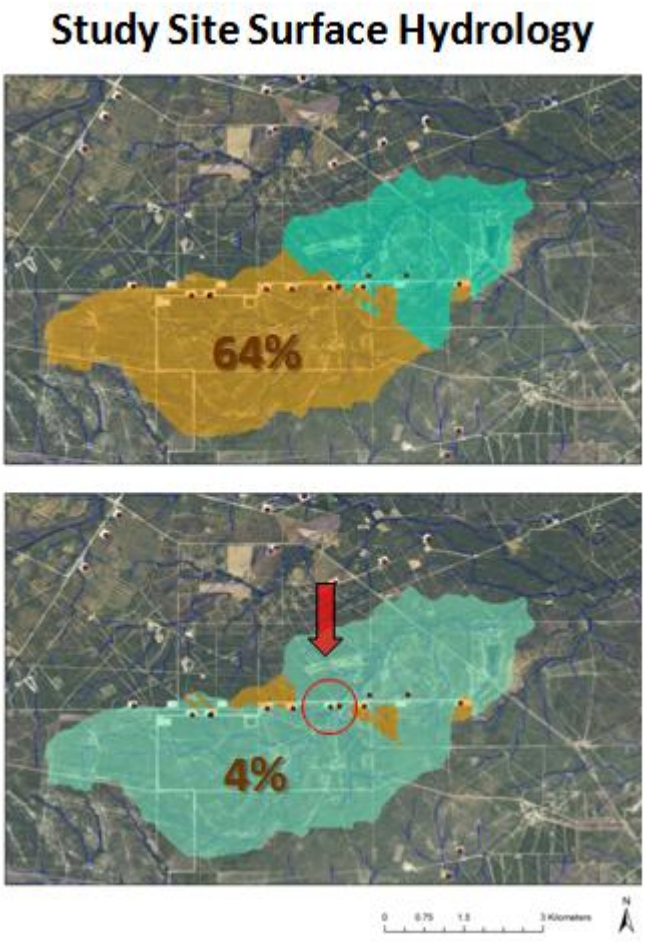
The Landscape Fragmentation Tool version 2 (LFT) was downloaded from the Center for Land Use Education and Research of the University of Connecticut. LFT has been used to identify the amount of core forest prior to activities in the EF. LFT has been used to show the change in core forest in LaSalle County. This process will be completed on the play scale. Landscape fragmentation will be included in the spatial statistical analysis.

Spatial Statistical Analysis of GIS Data

It is known that hydrologic fragmentation in the EF is not solely the result of O&G alone. Many other factors are contributing to hydrologic fragmentation. The examination of all fragmentation sources in the EF is beyond the scope of this study. Additionally, the methods to be used to identify the fragmentation from activity that appears to be exclusively from O&G will emphasize a conservative approach to identifying fragmentation from O&G activities. Disturbances will be outlined at a scale of

1:4000. Only those disturbances visible at this scale will be outlined. If a disturbance falls partially within this scaled window then the total disturbance will be outlined.
Exploratory analysis of the hydrologic fragmentation will then be carried out using principles of spatial statistical analysis to identify hot spots and trends in the change to the south Texas semi-arid landscape. This exploratory examination will be an attempt to develop a methodology for analyzing fragmentation caused by O&G activities. An ability to assess unexpected trends in an efficient and feasible way will be key to developing and employing remediation efforts.
To differentiate clusters of both high and low values of hydrologic and landscape fragmentation classes, spatial autocorrelation analysis using global and local Moran's I will be employed. The attribute used for this examination will be the percentage of areal change in first order watersheds core forests. Global and local Moran's I (Moran, 1948) along with Anselin's Local Moran's I using *Cluster and Outlier Analysis* (Anselin, 1995) will be employed. GI* statistics which differentiates between patterns of high and low densities will be employed to determine differences in patterns on a local scale compared to a play wide scale (Getis and Ord, 1992). All calculations will be carried out within toolsets provided by ArcGIS 10.1.

Here is an example demonstrating that if one well pad was removed or sited next to neighboring well pads that the potential for contamination greatly decreases. This was done by assigning pour points at the center of each well pad.



The red arrow points to a well pad that if sited differently or removed would reduce the potential for contamination by Hortonian flow over the drilling pad

References:

Anselin, L., 1995, Local indicators of spatial association—LISA: Geographical analysis, v. 27, p. 93–115.

Getis, A., and Ord, J.K., 1992, The analysis of spatial association by use of distance statistics: v. 24, p. 189–206.

Horizon Systems Corporation NHD Plus Version 2.

Information Handling Services, Inc, 2013, IHS.

Parent, J., and Hurd, J.D., 2007, Landscape Fragmentation Tool v2.0: Center for Land Use Education and Research, The University of Connecticut.

Railroad Commission of Texas, 2013, Railroad Commission of Texas.

US Department of Agriculture Aerial Photography Field Office, 2012, National Agriculture Imagery Program (NAIP).