APPALACHIAN LANDSCAPE CONSERVATION COOPERATIVE GRANT 2013 PROGRESS REPORT

Quarter: (circle one) (2013 1st) 2013 2nd 2013 3rd 2013 4th

Grant Number and Title: 2012-02; Assessing Future Impacts of Energy Extraction in the Appalachian LCC

Grant Receipt/Organization: The Nature Conservancy

Grant Project Leader: Joseph Kiesecker/Judy K. Dunscomb

Were planned goals/objectives achieved last quarter? YES

ALCC Need Addressed: Forecast Resource Extraction

Progress Achieved: (For each Goal/Objective, list Planned and Actual Accomplishments)

Shale gas model:

We have completed a shale gas model across the entirety of the Appalachian LLC (see Figure 1 below). To create a predictive model of gas potential across the Appalachian Landscape Conservation Cooperative we developed a presence-only "multi-model inferential" approach using the nonparametric random forests algorithm. To account for known problems of bias and overfit associated with presence-only models we generated a different balanced random sample, to act as the absence class, to specify each model in our multi-model ensemble. Once our ensemble of models converged on a test statistic that demonstrated stability of our resulting probability distribution the model was predicted to a raster surface. Based on development of a higher resolution model for the Marcellus shale formation (Figure 2 below), we came up with a suite of ten potential predictor variables, of which of six were identified via a model selection process. Unfortunately, three of these variables were based on deep-well monitoring data and one on a USGS report specific to the Marcellus shale formation and were not available at the extent of the LCC. We therefore specified the LCC model using the three remaining variables representing gravitational anomalies (bouguer, isogravmetric, magnetic, see Figure 3 below) and one additional variable representing topographic variability. We found, through testing effect size, that these variables were all significant predictors.

We found that the gas model fit was supported with a Kappa ($k=0.77$) and an AUC ($\alpha=0.94$) (Figure 4), and found that within the northern region of the study area the estimates correspond very well with the Marcellus gas model. However, model fit does not always represent accuracy of the spatial predictions. In specifying the model we found that the LCC shale plays are just starting to be developed, making data availability problematic – an issue we anticipated when we submitted our proposal to the LCC. Because of this it is not currently possible to develop a model specific to the Utica or other LCC potential shale plays. Instead, we chose to develop a model that represents general shale gas potential across the region by using all available data spanning both the Marcellus and Utica (Utica wells n=321, Marcellus wells n= 10,419) formations. While we expect this will illustrate potential hotspots of gas development across the study areas potential shale plays, we believe that the uncertainty associated with the spatial prediction in the southern portion of the study area is too high to support any scenario development or to be used to guide decision making. Outside the region where we have adequate training data the model estimates do represent an underlying probability of potential deep shale gas resources.

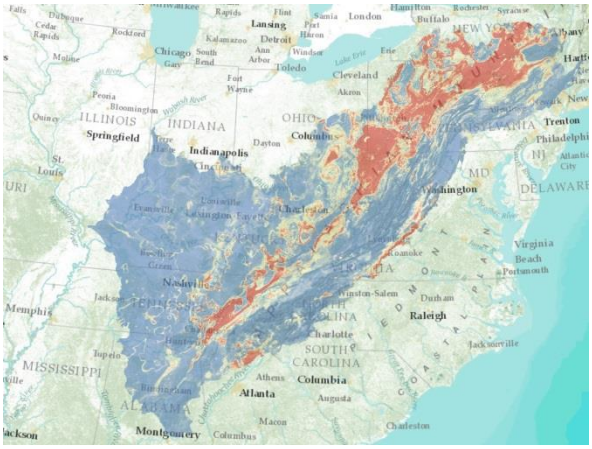


Figure 1. Probability prediction of deep shale gas potential across the Appalachian Landscape Conservation Cooperative.

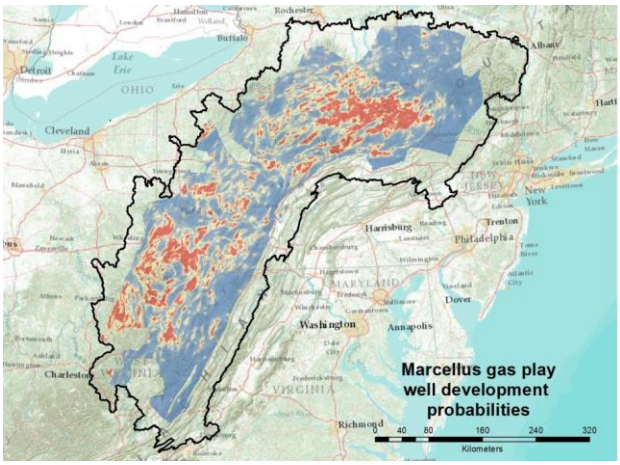


Figure 2. Probability prediction of deep shale gas potential across the Marcellus Shale Play.

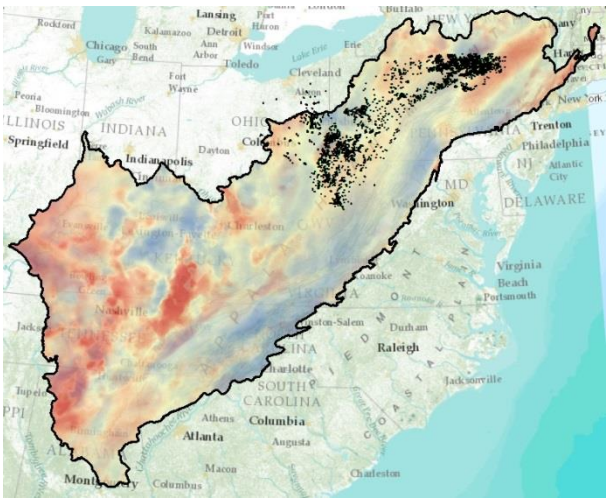


Figure 3. Study area with training data (black dots) overlaid on color RGB composite of gravitational anomaly covariate data.

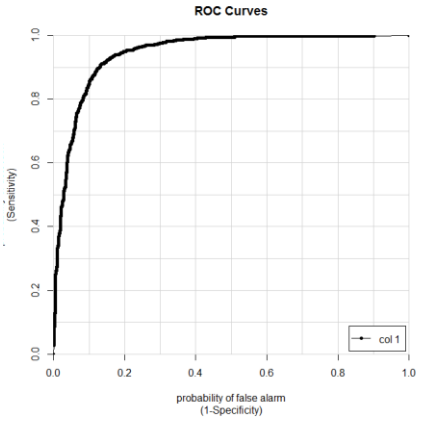


Figure 4. ROC/AUC plot of Appalachian Landscape Conservation Cooperative gas model fit (α=0.94)

Wind development model:
A wind model has been completed but new wind turbine data has just come available thru Ventyx so we are planning to revise the current model as this new turbine location data will likely improve model performance. This model will available in a few weeks. We have also completed wind development scenarios using predictions based on projections from the Eastern Wind Integration and Transmission Study (EWITS) that was commissioned by the Department of Energy through its National Renewable Energy Laboratory (NREL). We utilized scenario 3 that emphasizes development of wind resources close to load centers in the northeastern US. This scenario likely represents an estimate on the high end of potential wind development for this region (EWITS).

Coal model:
The coal modeling team (headed by Michael Strager at WVU) has run a preliminary surface mining spatial model using a 1KM grid cell size for the study area using the MAXENT Bayesian modeling program. We are continuing to rerun the model and integrate input layers that we develop. Currently the input layers in the model include surface mine permits as the training or observations, a coal geology layer representing the extent of the coal bearing area in Appalachia, population density, landcover, distance to power plants, distance to transportation ports, distance to intermodal transportation locations, distance or railroads, oil and gas development locations, abandoned mine land locations, and coal prep plant locations. The team has created landscape exclusions for future surface mining using data from the Conservation Biology Institute of protected areas database and the National Land Cover Data of developed classes and open water. In addition to the use of the MAXENT model, the team also plans to use the Random Forest statistical modeling technique to improve model fit and predictive power.

The coal team is developing a spatial econometric model to attempt to estimate the levels of production that would occur under each or three scenarios for coal extraction (increase, decrease, and continuation of current). They have assembled time series data by county from 1990 to 2011 which includes employment by industry from County Business Patterns datasets and the US Census Bureau (all industries, coal mining, oil and gas, includes number of employees, number of establishments, and total annual payroll). Coal mine production related data and sales from US Energy Information Administration (surface and underground mining, production, sales, number of mines and employment by type of mine) have also been assembled. The dependent variable - coal production - is being analyzed over the twenty year time period with the assembled variables previously listed. Since coal production reporting numbers include both surface and underground mining, it is necessary to scale the surface mine permit activity to total coal production. The surface mine permits can be found for each county being analyzed and linked to the correct year with their issuance date. The production rates and derived surface mine permit activity over the time period will lend insight into future surface mine

permits. The result of this effort will be a county level model which will complement the 1KM grid spacing of the landscape-based surface mining spatial model.

The Coal Modeling Team has also been developing disturbance mapping and summary statistics for TNC aquatic priority areas in the Central Appalachian Coalfields which can be overlain on coal buildout data to estimate impacts to aquatic resources from energy extraction activities. Three different land use/land cover datasets were tabulated for HUC12 watersheds identified in the TNC priority shapefile. For each of the three land cover datasets, area (in sq km) and percentage by land cover type was tabulated for each unique HUC12 polygon identified by TNC as a priority watershed. Results were provided in an Excel spreadsheet by HUC12 code. A data dictionary listing column headings and descriptions is also provided in the Excel file. The final data was provided in an Excel spreadsheet. The Excel file contains four worksheets; (1) All land cover classes for all three datasets, (2) data dictionary for above, (3) mining land cover class summary only, all three land cover datasets, and (4) a data dictionary for above. Each watershed was referenced by its unique HUC12 code.

Web Map Server: A template web map server has been prepared and once model results are finalized it can be populated.

Summary of Progress: (Provide a paragraph describing progress, work to come, and timelines)

To date a model has been developed that depicts the probability of wind energy development across the Appalachian Landscape Conservation Cooperative; this model is currently undergoing review and should be ready for release in early 2013. Wind development scenarios have also been completed. We have also completed a model that depicts the probability of shale gas development across the Appalachian Landscape Conservation Cooperative. Two models will be made available: a model at only a subset of the Appalachian LLC and a model across the entirety of the Appalachian LLC (see below). Shale gas development scenarios have been completed for the model for the subset of the LCC study area where adequate data exist to support those models. We think it will be unlikely to develop scenarios for the entire LCC within the project timeline since well drilling – and the data that result from it - beyond the Marcellus Shale has been very limited, however we are continuing to probe for any data sources we may have overlooked.

A draft coal model has been run, and data for input variables continues to be refined. The team is working on an econometric model that will allow assessment of probable rates of coal extraction activity based on 3 different demand scenarios. The team has also developed a layer showing current impacts to priority aquatic habitats that we will use to compare impacts among various scenarios.

Difficulties Encountered: As we indicated might be the case when we submitted our proposal, we have been unable to acquire detailed data for shale gas model across entire study area. Information that can be used to generate shale gas development scenarios is currently only available for the Marcellus Formation. Estimates as to the extent of shale gas development in formations outside the Marcellus (i.e. the Utica formation) are limited. To date we have been able to locate only ~300 shale gas well locations from the Utica Shale play. We have also gather information that to date ~40 wells have been drilled in the Chattooga, New Albany, Conasaugo, Floyd & Neal plays (potential shale plays found in the LCC study area) but have be unable to acquire specific locations for these wells. We doubt that incorporating this well data would result in appreciable improvement of the model. Regarding the coal model, our contacts with GEOMINE were unable to provide collated permit data for the study area, so we had to acquire it state by state.
Activities Anticipated Next Quarter: Conduct review with external advisory group; Revision of wind model; Populate and get feedback on web map server; complete econometric model, and refine the coal buildout model using both Maxent and Random Forests modeling techniques.

Expected End Date: December 31st 2013

Costs:

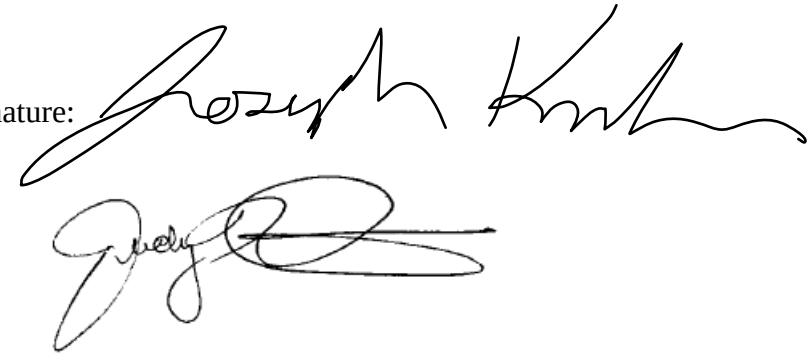
Funds Expended to Previous to this Report: $3,788.09

Amount of ALCC Funds Requested within this Report: $26,492.48

Total Approved Budgeted ALCC Funds: $219,680.18

Are you within the approved budget plan? YES

Are you within approved budget categories? YES

Signature: 

Date: 4/30/2013