A Geospatial Analysis of Mortality in Relation to Proximity of Coal Mining in West Virginia

---

Penn State Masters of GIS

Capstone Project Proposal

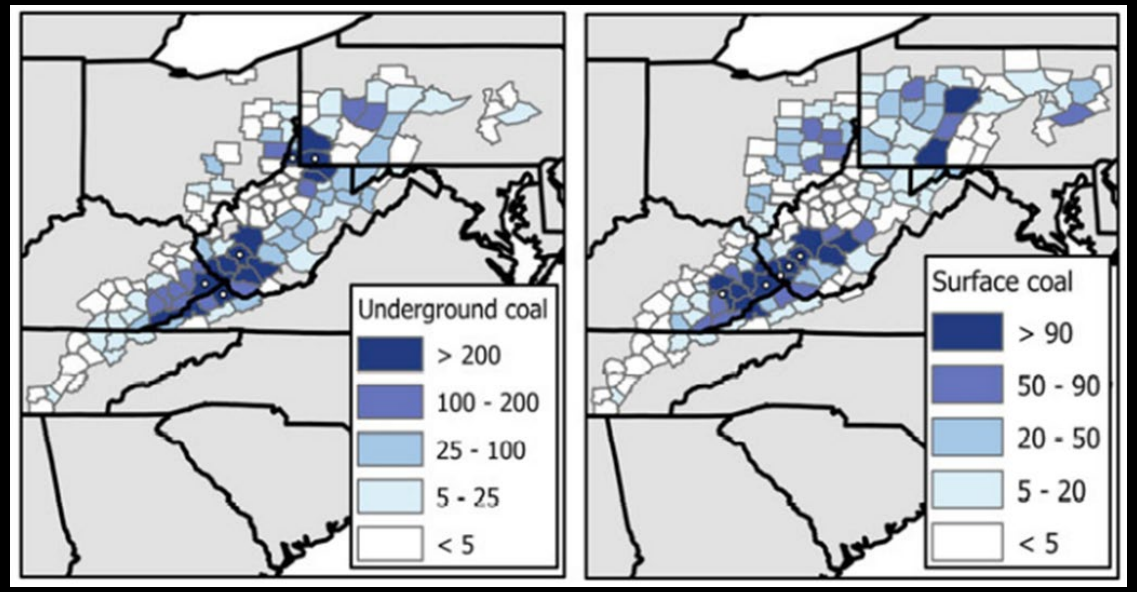
Presented By Clint Henry

Advised By Jennifer Baka

Project Overview

The aim of this project will be to investigate the impacts of coal extraction (mining) on the public health of communities surrounding impacted areas in the coal bearing regions of Appalachia, specifically in West Virginia.

It is proposed that a non-bias analysis of mortality in communities within the vicinity of surface coal mines to that of Appalachian communities outside the radius of these operations using a geospatial analysis might expose a definitive correlation between mortality and proximity to surface mining operations.



← Cumulative Coal Production (million tons), 1980-2018, by underground (left) and surface (right) mining methods, for Appalachian coalfield counties. The Top five coal-production counties for each mining method are designated with small white circles (Zipper, Adams, and Skousen 2021)

COAL AND APPALACHIA: A HISTORY

To understand the problem, it is important to understand to some extent the history of Appalachia and its relationship with coal and coal mining.

In the Eastern United States, Appalachia stretches from northern Alabama and Georgia, to Southern New York. It is both a mountains landform and a cultural region. The Central Appalachian Coalfield involves nearly all of West Virginia, as well as parts of Kentucky, Tennessee, Alabama, Virginia, Ohio and Pennsylvania.

Appalachia contains some of the largest reserves of natural resources in the United States including timber, coal and natural gas.

Central Appalachian Coalfields

(Zipper, Adams, and Skousen 2021)

Timeline

1750 to 1850	Large scale timber harvesting was one of the first significant industrial activities to affect the Appalachian coalfields starting in the mid-18th century, followed closely by coal mining.
1850 to 1950	Starting in the 1850s and lasting for well over a century, coal from Appalachia to a great extent fueled the American industrial revolution and the resulting prosperity in America.
1950 to 1970	The volatility of the industries and markets dependent on coal lead to a boom-and-bust cycle for the Appalachian coalfields, until the 1970s when dependent electrical markets reduce this volatility.
1970 to 2000	Appalachia coalfields capture metallurgical coal markets both domestically and abroad due to the abundance of anthracitic coal. This and the Clean Air Act past in the 1990' s stimulate continued coal mining in Appalachia.
2000 to Present	Coal mining persists despite the continued fluctuation of coal markets and the declining popularity of coal due to environmental concerns.

Deep Mining Vs Surface Mining

There are two primary methods used to conduct coal mining operations: Deep Mining, and Surface Mining.

Deep Mining

- → Takes place hundreds to thousands of feet underground.
- → Produces a relatively small surface footprint.
- → Labor intensive .
- → Coal reserves are left behind to support roof structure.

Surface Mining

- → Began after WWII with improved technology and mechanization.
- → Two types: Contour Mining & Mountain Top Removal (MTR).
- → Miners remove upper strata of dirt and rock (“Overburden”) to access multiple coal seams.
- → Excavate 100 to 300+ meters of Mountain Ridgeline.
- → Cheaper and uses less manpower, depending instead on explosives and large machinery.

SURFACE MINING & POLLUTION

Surface mining operations, both contour and mountaintop, have significant potential to affect air and water quality. Water quality can be affected both by runoff from these mines, and by the disposal of byproducts from the processing of coal. The exposure of rock and soil to oxygen and rain result in the release of minerals, metals and other chemicals previously confined in the rock strata.

The removal of forests and topsoil, the use of heavy explosives, and the heavy machinery used to excavate and haul rock and coal can create substantial amounts of particulate matter (PM) which is a portion of air pollution containing acids, organic chemicals, metals, soil and dust particles.

Today, coal mining sites are heavily regulated by state and federal organizations including the Department of Environmental Protection (DEP), the Mine Safety and Health Administration (MSHA), and the Environmental Protection Agency (EPA) which work to ensure that these hazards are mitigated.

WEST VIRGINIA & THE NATURAL RESOURCE CURSE

West Virginia is a textbook example of what some refer to as the Natural Resource Curse described by the observation that countries or colonies that have bountiful natural resources are “cursed” by poor economic performance.

The dominance and prioritization of industry and resource extraction over the rights of citizens due to the belief that these resources would bring wealth to the state has led to limited economic diversification and a single industry, resource-dependent economy

This economic dependence upon the extractive industries has not resulted in sustained economic growth and instead resulted in poor economic performance as described by the resource curse.

Health Disparities in West Virginia

Populations in West Virginia and Appalachia as a whole are known to suffer higher morbidity and mortality in relation to the rest of the nation. Cancer incidence in the Appalachian region is higher than that of the United States overall. The issue of cause is complicated by abnormally lower salaries, high rates of poverty, income inequality and resulting social stress, older populations (65+), lower percent of high school graduates, higher rates of obesity, and increased tobacco consumption.

All-Cause Mortality

- → Kentucky and West Virginia are two of the top five states with the highest age adjusted death rates.
- → Heart Disease, Cancer and Chronic Lower Respiratory Disease are the 1st, 2nd & 3rd leading causes of death respectively in West Virginia.

New Cancers and Cancer Deaths

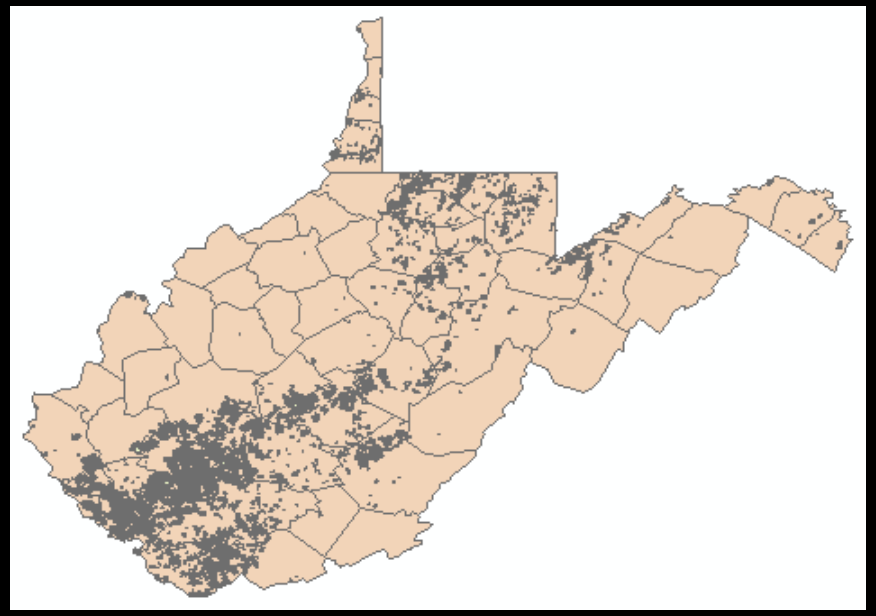
- → WV has the 4th highest rate of new cancers in the US.
- → Lung and Bronchus cancers are the leading cause of cancer death.
- → New cancers & cancer deaths in Appalachia have remained high or increased while falling for the rest of the US.

Respiratory & Cardiovascular Disease

- → WV currently ranks third highest in Chronic Lower Respiratory Disease Mortality among US states.
- → Appalachian states (WV, KY, TN) rank high in cardiovascular disease hospitalizations & deaths.

(CDC 2022)

Proposed Methodology



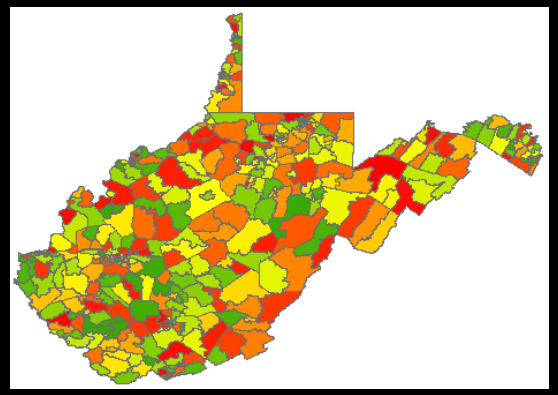
Mining Permits (WVDEP)

Goals and Objectives

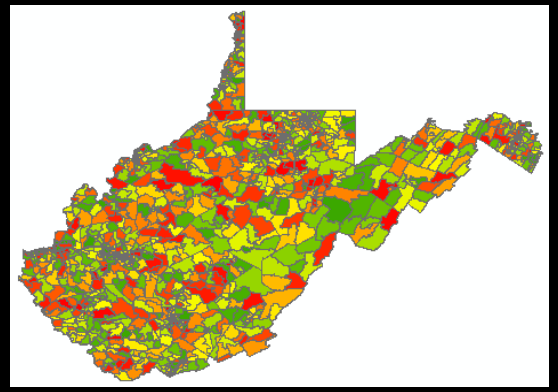
The goal of this analysis is to determine the factors contributing to high morbidity in West Virginia caused by All-Cause Mortality, All Cancers, Lung and Bronchus Cancer, Respiratory Disease, and Cardiovascular Disease. These dependent variables were chosen because of their abnormally high rate of occurrence in West Virginia, their causational relationship with PM, and because they were cited in a number of previous and related studies. Of the contributing factors (independent variables) it is hypothesized that surface mining will be a primary contributor to mortality, and that as proximity to surface mining increases, morbidity caused by the aforementioned dependent variables will similarly increase.

Data & Materials

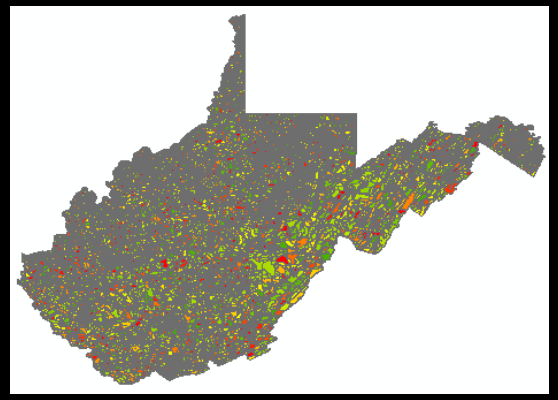
Health data for this investigation will be gathered primarily through the CDS'S WONDER site, a system for the analysis of public health. Information and geographic data on the location of active surface mining sites will be sourced from the WVDEP Open Data Hub. Additional datasets including population data, risk factors, and social and economic data, will be obtained from the WV GIS Technical Centers Data Clearinghouse (WVGISTC), The West Virginia Health Data Portal, the CDC's Interactive Atlas of Heart Disease and Stroke, the CDC/ATSCR Social Vulnerability Index and the United States Census Bureau Tiger/Line Geodatabases.



2010 Census, Population By Tract



2010 Census, Population By Block Group



2010 Census, Population By Block

Proposed Methodology (cont.)

Covariables

- → No Health Insurance: Percentage of people in each county without health Insurance.
- → Obesity: Percentage of people in each county considered obese adjusted for age.
- → Inactive: Percentage of people in each county physically inactive during leisure time adjusted for age.
- → Median Household Income: Median by county.
- → No Diploma: Percent of the county population without a diploma.
- → Poverty: Percent of county population living in poverty.
- → Unemployment: Unemployment Rate.
- → Tobacco Consumption

Analysis and Methods

- → Areal Interpolation and Dasymetric Mapping
- → Ordinary Least Squares (OLS) Regression
- → Exploratory Regression
- → Geographically Weighted Regression (GWR)

Conferences & Timeline for Completion

My goal for completion is Fall-2 semester of 2022.

<u>Potential Presentation Venues:</u>

THE 2022 INTERNATIONAL PITTSBURGH COAL CONFERENCE, 9/19/2022

AMERICAN COAL COUNCEL, COAL TRADING CONFERENCE, 12/2022

References

Anderson, Jonathan O., Josef G. Thundiyil, and Andrew Stolbach. 2012. “Clearing the Air: A Review of the Effects of Particulate Matter Air Pollution on Human Health.” *Journal of Medical Toxicology* 8 (2): 166–75. https://doi.org/10.1007/s13181-011-0203-1.

Aneja, Viney P., Aaron Isherwood, and Peter Morgan. 2012. “Characterization of Particulate Matter (PM10) Related to Surface Coal Mining Operations in Appalachia.” *Atmospheric Environment* 54 (July): 496–501. https://doi.org/10.1016/j.atmosenv.2012.02.063.

Borak, Jonathan, Catherine Salipante-Zaidel, Martin D. Slade, and Cheryl A. Fields. 2012. “Mortality Disparities in Appalachia: Reassessment of Major Risk Factors.” *Journal of Occupational and Environmental Medicine* 54 (2): 146–56. https://doi.org/10.1097/JOM.0b013e318246f395.

Burns, Shirley L. Stewart. 2007. “Bringing down the Mountains: The Impact of Mountaintop Removal Surface Coal Mining on Southern West Virginia Communities, 1970--2004,” January. https://www.academia.edu/72003483/Bringing_Down_the_Mountains_The_Impact_of_Mountaintop_Removal_Surface_Coal_Mining_on_Southern_West_Virginia_Communities_1970_2004.

CDC. 2022. “Stats of the States - Chronic Lower Respiratory Disease Mortality.” February 28, 2022. https://www.cdc.gov/nchs/pressroom/sosmap/lung_disease_mortality/lung_disease.htm.

Comber, Alexis, and Wen Zeng. 2019. “Spatial Interpolation Using Areal Features: A Review of Methods and Opportunities Using New Forms of Data with Coded Illustrations.” *Geography Compass* 13 (10): e12465. https://doi.org/10.1111/gec3.12465.

Hendryx, Michael. 2015. “The Public Health Impacts of Surface Coal Mining.” *The Extractive Industries and Society* 2 (4): 820–26. https://doi.org/10.1016/j.exis.2015.08.006.

———. 2018. “The Shocking Danger of Mountaintop Removal — and Why It Must End.” Michael Hendryx | Speaker | TED. May 2018. https://www.ted.com/speakers/michael_hendryx.

Hendryx, Michael, Keith J. Zullig, and Juhua Luo. 2020. “Impacts of Coal Use on Health.” *Annual Review of Public Health* 41 (1): 397–415. https://doi.org/10.1146/annurev-publhealth-040119-094104.

References (Continued)

Lindberg, T. Ty, Emily S. Bernhardt, Raven Bier, A. M. Helton, R. Brittany Merola, Avner Vengosh, and Richard T. Di Giulio. 2011. “Cumulative Impacts of Mountaintop Mining on an Appalachian Watershed.” PNAS. December 27, 2011. https://www.pnas.org/doi/abs/10.1073/pnas.1112381108.

Pope, C. Arden, Richard T. Burnett, George D. Thurston, Michael J. Thun, Eugenia E. Calle, Daniel Krewski, and John J. Godleski. 2004. “Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution.” *Circulation* 109 (1): 71–77. https://doi.org/10.1161/01.CIR.0000108927.80044.7F.

Pugh, James Howard Kent. 2017. “Moving Mountains : A Study Examining Long-Term Impacts of Mountaintop Removal Coal Mining on Mortality in the Appalachian Region Using Geographic Information Sciences Techniques.” University of Louisville. https://doi.org/10.18297/etd/2847.

US Census Bureau. n.d. “2019 American Community Survey Statistics for Income, Poverty and Health Insurance Available for States and Local Areas.” Census.Gov. Accessed May 1, 2022. https://www.census.gov/newsroom/press-releases/2020/acs-1year.html.

U.S. Department of Energy. 2021. “Annual Coal Report 2020,” 86.

Xu, Jiaquan. 2020. “Mortality Patterns Between Five States With Highest Death Rates and Five States With Lowest Death Rates: United States, 2017.” Products - Data Briefs - Number 345 - August 2019. January 29, 2020. https://www.cdc.gov/nchs/products/databriefs/db350.htm.

Zipper, Carl E., Mary Beth Adams, and Jeff Skousen. 2021. “The Appalachian Coalfield in Historical Context.” In *Appalachia’s Coal-Mined Landscapes*, edited by Carl E. Zipper and Jeff Skousen, 1–26. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-57780-3_1.

Zullig, K.J., and M. Hendryx. 2011. “Health-Related Quality of Life among Central Appalachian Residents in Mountaintop Mining Counties.” *American Journal of Public Health* 101 (5): 848–53. https://doi.org/10.2105/AJPH.2010.300073.

Thank you

Clint Henry| cfh3@psu.edu