Testimony provided by Michael Hendryx, PhD
To the Committee on Natural Resources, Legislative Hearing on H.R. 1644
May 14, 2015

Good day. I'd like to thank Chairman Lamborn and Ranking Member Lowenthal for the opportunity to speak with the subcommittee today. For the past nine years I have conducted research on the public health problems created by mountaintop removal coal mining in Appalachia. Evidence from research conducted by myself and others demonstrates that this form of mining causes serious air and water quality problems for surrounding communities, and that it contributes to poor health and premature death for people who live near these mining sites. The health problems include high rates of cancer, heart and lung disease, birth defects, and other diseases. I have come today to speak in support of stream buffer protection rules as a means of protecting public health. The proposed Stream Act in my view poses a danger to human health because it would delay enforcement of stream protection rules.

I have limited time to describe my research, but I will try to summarize briefly the scientific evidence for the harm caused by this form of mining. Mountaintop removal occurs in forested areas, on mountaintops and ridges directly above populated areas. Explosives are used to loosen rock and soil above the coal. Draglines are used to remove hundreds of feet of rock and soil, which is dumped into the nearest valleys. These valleys contain streams. Stream buffer rules are supposed to protect streams from mining overburden but the rules are not properly enforced. Eventually entire valleys are filled and streams permanently buried and destroyed. Water that emerges from the base of the fills is highly contaminated with sulfates, metals and other chemicals. Mountaintop removal occurs across an area of almost 50,000 square kilometers in four US states, and in proximity to a population of more than 1.2 million people.

Our research evidence shows that communities close to mountaintop removal activity have higher levels of air and water pollution compared to control communities farther away from mining. In one of our papers, we brought dust from mining and non-mining communities into the lab, and exposed human lung cell lines to the dust. Dust from non-mining control communities did not cause the lung cells to change, but dust from the mining communities caused cellular changes indicative of human lung cancer development and progression.

Research conducted by scientists at Duke University shows that streams in mountaintop mining areas suffer serious and long lasting damage caused by mining. Research conducted by our group has shown the presence of multiple contaminants such as phenols, ammonium, and polycyclic aromatic hydrocarbons (or PAHs) in ground water samples proximate to mountaintop removal mining. Some PAHs are known or suspected carcinogens. The EPA has established that conductivity levels present in streams in mountaintop removal areas should be no higher than 500 microsiemens per centimeter, and yet our stream samples in these areas found an average conductivity of 1234. Conductivity is a marker for sulfates, ion concentrations, metals and other chemicals present in water.

Our research has shown that people who live near mountaintop removal are at higher risk, compared to people living farther away, for a wide set of health problems. We see, for example, that rates of lung cancer are higher in the mountaintop removal communities. We have also found higher death rates from heart disease, lung disease, and kidney disease. The increased mortality in mountaintop removal areas translates to approximately 1460 excess deaths every year compared to death rates in other parts of Appalachia. In these estimates we have controlled statistically for other risks such as age, smoking, obesity, poverty, and other variables; our results are not due to higher rates of smoking, for example, or higher poverty

rates. We find that the most serious health problems are present where mountaintop removal is practiced relative to areas with other types of mining or no mining.

One of our most important papers examined birth defects. We did an analysis of almost 2 million birth records over an 8-year period. We found that mothers who lived in a mountaintop removal area during their pregnancy had significantly elevated risk of delivering a baby with a birth defect. Again, we controlled statistically for other risks such as mother's age, her smoking and drinking behavior, and others. One of the most common forms of birth defects is heart defects, and we found that mothers' risk of a baby with a heart defect was 181% higher compared to mothers who did not live in mining areas. It is clear from all of the evidence combined that mountaintop removal causes environmental harm to surrounding communities through air and water pollution, and that this harm results in serious health consequences for the people who live in these communities.

Our research has been published in many peer-reviewed academic journals. At present, we have published 30 studies in journals that document the environmental and public health problems in Appalachian mining communities. The written copy of my testimony includes a brief summary of these papers. These studies have been done with no funding from environmental or special interest groups. I have no financial conflict of interest. I have conducted these studies to arrive at the true situation to the best of my ability. The Stream Act in my view is an unnecessary delay and a threat to human health. Instead, I call for the complete enforcement of existing stream buffer rules, or stronger rules that the OSM may put forth, to prevent the dumping of mining waste into streams. Thank you for the opportunity to speak to you today.

Written Supplement to Oral Testimony

Summaries of research studies showing public health consequences of Appalachian coal mining. This document includes a short summary of each paper, followed by a list of the complete citations.
(As of May 2015)

1) Hospitalization Patterns Associated with Appalachian Coal Mining
In this study, researchers explored the relationship between quantity of coal mined in counties and hospitalizations for "coal exposure sensitive" ailments (those linked with coal mining in previous research) and "coal exposure insensitive" ailments (those that had not been shown to be associated with coal mining). After controlling for other risk-factors they found that hospitalization for Chronic Pulmonary Obstructive Disease (COPD) and high blood pressure, both coal exposure sensitive conditions, were linked with quantity of coal mined. The odds for a COPD hospitalization increased 1% for each 1462 tons of coal mined, and the odds for a high blood pressure hospitalization increased 1% for each 1873 tons of coal mined.

2) Relations between Health Indicators and Residential Proximity to Coal Mining in West Virginia
In this large survey study of West Virginia residents, researchers examined the relationship between amounts of coal mined in an area, levels of self-reported health, and rates of chronic disease conditions for residents. High levels of coal production were found to be associated with worse health status and with higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease, high blood pressure, lung disease, and kidney disease.

3) Mortality Rates in Appalachian Coal Mining Counties:
24 Years behind the Nation
Appalachia has higher rates of death than the rest of the country, and this study investigated whether this trend was linked with the high rates of coal mining in this region. It found that coal mining areas do indeed have higher mortality rates than both other Appalachian counties and the rest of the country. The association between coal mining and higher mortality rates remained even after controlling for other risk factors such as smoking, poverty, education, rural-urban setting, and race/ethnicity. Mortality rates present currently in mining counties lag 24 years behind the rates found in non-mining counties.

4) Lung Cancer Mortality is Elevated in Coal-Mining Areas of Appalachia
Researchers in this study examined nationwide data to test whether living in coal-mining areas of Appalachia contributed to the higher rates of lung cancer deaths observed in Appalachia relative to the rest of the nation. Results show that lung cancer death rates for the years 2000—2004 are indeed higher in areas of heavy Appalachian coal mining even after controlling for smoking, poverty, education, age, sex, race and other risk factors. Higher mortality may be partly the result of exposure to environmental pollution associated with the coal-mining industry.

5) Mortality from Heart, Respiratory, and Kidney Disease in Coal Mining Areas of Appalachia
This study compared the mortality rates from heart, respiratory, and kidney disease in four groups of counties: Appalachian counties with more than 4 million tons of coal mined from 2000 to 2004; Appalachian counties with mining at less than 4 million tons; non-Appalachian counties with coal mining; and other non-coal mining counties across the nation. For both males and females, mortality rates in Appalachian counties with the highest level of coal mining were significantly higher relative to non-mining areas for chronic heart, respiratory and kidney

disease, but were not higher for acute forms of illness.

6) Mortality in Appalachian Coal Mining Regions: the Value of Statistical Life Lost
Value of statistical life (VSL) is an estimate of the monetary value that society places on an abstract (or statistical) human life. VSL estimates are used to help decide how to allocate limited resources in order to maximize benefit to society, and are usually derived from studies on how much people are willing to pay to avoid risks to their life and health. This study found that, after other risk factors were controlled for, 2,347 to 2,889 yearly excess deaths are associated with living in an area in Appalachia with coal mining. Corresponding VSL estimates (which ranged from to $10.923 to $13.492 billion) exceeded the economic contributions of the coal mining industry. When the data was analyzed without controlling for other risk factors these numbers were much higher (8,840- 10,923 excess deaths, translating to VSL estimates of $41.283 to $51.010 billion.) The best point estimate for the mortality cost of Appalachian coal mining was $42 billion, while the benefits of coal mining for Appalachia totaled only $8 billion.

7) Higher Coronary Heart Disease and Heart Attack Morbidity in Appalachian Coal Mining Regions
This study tested whether self-reported cardiovascular disease rates were higher in Appalachian coal mining counties compared to other Appalachian counties and counties outside Appalachia with and without coal mining. Reported rates of cardiovascular disease, angina or coronary heart disease and heart attack were found to be significantly higher in Appalachian coal mining counties than in other counties. This trend was present among both men and women and held true even when other relevant risk factors, such as age and smoking rates, were controlled for. Cardiovascular diseases have been linked to both air and water contamination in ways consistent with toxicants found in coal and coal processing.

8) A Geographical Information System-Based Analysis of Cancer Mortality and Population Exposure to Coal Mining Activities in West Virginia, United States of America
This study used Geographical Information Systems (GIS) techniques to determine whether there is a link between how close people live to coal mining activities and cancer mortality rates. The results obtained from these techniques were contrasted with those from earlier similar studies examining the relationship between tons of coal mined per county and county cancer mortality rates. The GIS techniques yielded a stronger association between coal mining and cancer death rates, even after controlling for smoking and age, suggesting that where people live in proximity to mining, not just the county they live in, contributes to cancer mortality.

9) Mountaintop Mining Consequences
This article, published in *Science*, discusses and summarizes the growing scientific evidence for the negative impacts of mountaintop mining with valley fill (MTM/VF). In this practice, upper elevation forests are cleared and stripped of topsoil, and explosives are used to break up rocks to get at buried coal. Extra rock is pushed into neighboring valleys, where it buries existing streams. Analyses of current studies and new water-quality data from West Virginia streams reveal that MTM/VF causes serious damage to the environment that cannot be repaired. Published studies also suggest strongly that human health is being negatively affected by such activities.

10) Residence in Coal-Mining Areas and Low Birth-Weight Outcomes
This study investigated whether mothers living in coal-mining areas were at greater risk for giving birth to babies with low birth-weights. After adjusting for other factors that influence birth-weight, there was a 16% higher risk of a low birth weight infant in areas with high mining levels, and a 14% higher risk in areas with lower mining levels, as compared to areas with no mining.

11) A Comparative Analysis of Health-Related Quality of Life for Residents of U.S. Counties with and without Coal Mining
This study compared health-related quality of life (HRQOL) in mining and non-mining counties in and out of Appalachia. Residents of coal-mining counties reported significantly fewer healthy days for both physical and mental health and poorer self-rated health, as compared to U.S. non-mining counties, but disparities were greatest for people living in Appalachian coal mining areas.

12) Learning Outcomes among Students in Relation to West Virginia Coal Mining: an Environmental "Riskscape" Approach
To evaluate the impact of coal mining environment on the cognitive development of West Virginia children, this study examined pass rates on standardized school performance tests in counties in West Virginia with and without coal mining. Pass rates for children in schools in coal-mining counties versus non-coal mining counties were significantly lower in all subject areas. Lower pass rates were partly related to socioeconomic disadvantage, but remained significantly lower after controlling for county high school education rates, percent of low-income students, percent of highly qualified teachers, number of students tested, and county smoking rates.

13) Ecological Integrity Streams Related to Human Cancer Mortality Rates
Ecological integrity refers to a balanced community of organisms with healthy composition, diversity, and functional organization. This study explored the relationship between the ecological integrity of streams and human health. It found that lower ecological integrity corresponded with higher overall rates of human cancer death and higher mortality rates from digestive, respiratory, urinary, and breast cancer. Coal mining was also linked with higher cancer mortality and low levels of environmental integrity.

14) Full Cost Accounting for the Life Cycle of Coal
This paper examines and summarizes the enormous body of research and information on the harmful impact that the stages of the life-cycle of coal- extraction, transport, processing, and combustion- have on health and the environment. It also considers the costs of such damages, which are assumed by the U.S. public rather than coal companies and amount to a third to over one-half of a trillion dollars annually. Accounting for the damages conservatively doubles to triples the price of electricity from coal per kWh generated, making wind, solar, and other forms of non-fossil fuel power generation, along with investments in efficiency and electricity conservation methods, economically competitive.

15) Health-Related Quality of Life among Central Appalachian Residents in Mountaintop Mining Counties
Researchers in this study evaluated the health-related quality of life of residents in mountaintop mining counties of Appalachia relative to residents of counties with other types of mining and with no mining. People living in mountaintop mining counties reported significantly more days of activity limitation (e.g. work loss days), poor physical and mental health, and poor self-rated health compared to residents of the other two types of counties. Results were similar among males and females and among people of different ages. On average people in mountaintop mining areas experience four extra years of poor lifetime health compared to non-mining residents.

16) Poverty and Mortality Disparities in Central Appalachia:
Mountaintop Mining and Environmental Justice
This study investigated whether people in mountaintop coal mining areas in Appalachia

experience greater rates of death and poverty as compared to inhabitants of other mining areas or non-mining areas. The answer was yes: mountaintop mining areas had significantly higher mortality rates, total poverty rates, and child poverty rates every year (2000-2007) in comparison with other counties in the same states. For example, the child poverty rate in 2007 was about 35% in mountaintop mining areas compared to 21% in non-mining areas.

17) Chronic Cardiovascular Disease Mortality in Mountaintop Mining Areas of Central Appalachian States

This study looked at whether chronic cardiovascular disease (CVD) death rates are higher among people living in mountaintop mining (MTM) areas than among those in mining and non-mining areas, and whether there is a relationship between rates of MTM surface mining and CVD death levels. CVD mortality rates in MTM areas were found to be significantly higher than those of other areas, and the greater the amount of surface mining in an area, the higher the CVD death rates.

18) The Association between Mountaintop Mining and Birth Defects among Live Births in Central Appalachia, 1996–2003

In this study birth defect rates in mountaintop coal mining areas in central Appalachia were examined and compared to rates of birth defects in other coal mining areas and in non-mining areas of central Appalachia. After controlling for relevant risk factors there were 26% more birth defects in communities with mountaintop mining, as compared to non-mining communities. In earlier years (1996-1999) the increased risk was 13% higher, and grew more pronounced in recent years (2000-2003) to 42% higher. The mountaintop mining effect was most pronounced for defects of the cardiovascular and respiratory system, where the rate in more recent years was 181% higher than in non-mining areas.

19) Self-Reported Cancer Rates in Two Rural Areas of West Virginia with and without Mountaintop Coal Mining

Researchers in this study conducted door-to-door health interviews in one rural mountaintop mining area and in one rural non-mining area of West Virginia in order to compare cancer rates in the two communities. Self-reported cancer rates were two times higher in the mining versus the non-mining area after controlling for respondent age, sex, smoking, occupational history, and family cancer history, indicating that mountaintop mining is linked to increased community cancer risk.

20) Cancer Mortality Rates in Appalachian Mountaintop Mining Areas.

Researchers examined the association between cancer mortality rates in three types of counties in central Appalachia: those with mountaintop coal mining (MTM), those with other surface or underground mining, or those with no coal mining. County-level analyses examined the association between age-adjusted cancer mortality rates and MTM mining for two periods of time: 1999-2002 and 2003-2007. County-level covariates included smoking, health care access, adult obesity, poverty, and education. Mortality rates for leukemia and for lung, colon, and bladder cancer in MTM counties were significantly greater than those in non-mining areas in 2003-2007 (lung cancer mortality rates were also significantly greater than non-mining areas in 1999-2002). Kidney cancer mortality rates in MTM areas were marginally significantly greater ($p < .06$) than those in non-mining counties in 2003-2007. In conclusion, mortality rates from lung, colon, bladder, and kidney cancer and leukemia are significantly associated with MTM mining areas (vs. non-mining counties) in 2003-2007. Results may indicate either that exposures to water and air pollutants from MTM activity have accumulated, or that contamination in MTM counties may have worsened in more recent years in conjunction with increases in the extent of this activity.

21) Adult tooth loss for residents of US coal mining and Appalachian counties.
The authors compared rates of tooth loss between adult residents of Appalachian coal mining areas and other areas of the nation after control for covariate risks. Residents of Appalachian coal mining counties showed significantly elevated odds for any tooth loss, and for greater tooth loss measured by a 4-level tooth-loss severity scale. Greater risk of tooth loss among adult residents of Appalachian coal mining areas is present and is not explained by differences in reported receipt of dental care, fluoridation rates, supply of dentists or other behavioral or socioeconomic risks. Possible contributing factors include mining-specific disparities related to access, behavior or environmental exposures.

22) Public Drinking Water Violations in Mountaintop Coal Mining Areas of West Virginia, USA
Researchers analyzed the U.S. Environmental Protection Agency's Safe Drinking Water Information System to examine the number and type of public water treatment violations in West Virginia for the years 2001–2009. Violations were compared between three groups of water treatment facilities: those in counties with mountaintop coal mining (n = 161 facilities), coal mining other than mountaintop mining (n = 184 facilities), and with no coal mining (n = 137 facilities). Adjusting statistically for system size and water source, there were 73.0 violations per system in MTM areas, 16.7 violations per system in other mining areas, and 10.2 violations per system in non-mining areas. Excess violations in MTM counties were most often related to failure to conduct required sampling for organic compounds. Complete sampling and reporting of public drinking water quality in MTM areas is needed.

23) Air pollution particulate matter collected from an Appalachian mountaintop mining site induces microvascular dysfunction
Samples of ambient dust were collected from outside residential areas near mountaintop mining. The dust was analyzed for composition and used in a laboratory animal study. The dust consisted largely of sulfur (38% by weight) and silicon (24%). Rats received a dose of 300 µg of dust into their respiratory systems. The dust impaired normal microvascular function; such impairment is known to be a risk in the development of cardiovascular disease.

24) Personal and family health in rural areas of Kentucky with and without mountaintop coal mining
A community-based participatory research study was implemented to collect information from residents on health conditions and symptoms for themselves and other household members in a rural mountaintop mining area compared to a rural non-mining area of eastern Kentucky. A door-to-door health interview collected data from 952 adults. Adjusting for covariates, significantly poorer health conditions were observed in the mountaintop mining community on: self-rated health status, illness symptoms across multiple organ systems, lifetime and current asthma, COPD, and hypertension. Respondents in mountaintop mining communities were also significantly more likely to report that household members had experienced serious illness, or had died from cancer in the past five years.

25) Increased risk of depression for people living in coal mining areas of Central Appalachia, USA
Researchers examined the relationship between depression symptoms and living in areas where mountaintop removal coal mining is practiced. Data were analyzed from a survey of 8,591 adults residing in Central Appalachian areas both with and without coal mining. The survey included a validated measure of depression severity. Results showed that diagnosable levels of major depression were present in almost 17% of respondents in mountaintop removal mining areas, compared to 10% of residents in non-mining areas. After statistical control for

income, education and other risks, depression risk for residents in the mountaintop removal area remained significantly elevated. This study indicates that persons who experience environmental degradation from mountaintop removal coal mining are at elevated risk for depression.

26) Atmospheric particulate matter size distribution and concentration in West Virginia coal mining and non-mining areas

Coal mines and related mining activities result in the production of atmospheric particulate matter (PM) that is associated with human health effects. There is a gap in research regarding particle size concentration and distribution to determine respiratory dose around coal mining and non-mining areas. Mass- and number-based size distributions were determined were measured, and particle number concentrations and deposited lung dose were significantly greater around mining areas compared with non-mining areas, demonstrating elevated risks to humans. The greater dose was correlated with elevated disease rates in the West Virginia mining areas. This study provides evidence that environmental quality is impaired in mining communities in ways consistent with observed health problems.

27) An examination of the effects of mountaintop removal coal mining on respiratory symptoms and COPD using propensity scores

Previous research on public health consequences of mountaintop removal (MTR) coal mining has been limited by the observational nature of the data. The current study used propensity scores, a method designed to overcome this limitation, to draw more confident causal inferences about mining effects on respiratory health using non-experimental data. These data come from a health survey of 682 adults residing in two rural areas of Virginia, USA characterized by the presence or absence of MTR mining. Persons with a history of occupational exposure as coal miners were excluded. Nine covariates including age, sex, current and former smoking, overweight, obesity, high school education, college education, and exposure to coal as a home-heating source were selected to estimate propensity scores. Propensity scores were tested for balance and then used as weights to create quasi-experimental exposed and unexposed groups. Results indicated that persons in the mountaintop mining group had significantly ($p < 0.0001$) elevated prevalence of respiratory symptoms and chronic obstructive pulmonary disease. The results suggest that impaired respiratory health results from exposure to MTR environments and not from other risks.

28) Atmospheric particulate matter in proximity to mountaintop coal mines: sources and potential environmental and human health impacts.

This paper reports on the results of air samples collected from residential communities proximate to active mountaintop removal mining in West Virginia compared to non-mining control communities. Results showed that particulate matter collected from mining communities had high levels of silica, aluminum, and other rare earth metals that indicate that the dust is likely coming from overburden removal. Organic chemicals in the mining samples indicated the presence of low molecular weight polycyclic aromatic hydrocarbons (PAHs), consistent with non-combusted coal as the source. Some PAHs were also present from fossil fuel combustion sources, possibly related to diesel used in mining processes. Elevations in these forms of particulate matter in mining communities could be a contributing factor to observed health problems in these communities.

29) Appalachian mountaintop mining particulate matter induces neoplastic transformation of human bronchial epithelial cells and promotes tumor formation.

The purpose of this study was to investigate the carcinogenic potential of particulate matter (PM) collected from residential communities near mountaintop removal mining (MTR). Human lung cells were exposed in laboratory conditions to PM from MTR areas and to PM from non-mining control areas in West Virginia. Only the PM from the MTR area caused changes in lung cells indicative of tumor promotion. These changes included neoplastic transformation, cell proliferation, and enhanced cell migration. The main inorganic ingredients of the PM from MTR areas were silica and molybdenum. These results provide new evidence for the carcinogenic potential of PM from MTR areas and support implementation of exposure control for PM in MTR communities.

30) Association between residence near surface coal mining and blood inflammation.
This study collected air quality data and data on health status and blood inflammation in a sample of adults living near surface mining in West Virginia and Indiana. All participants were non-smokers and did not work as coal miners. Counts of particulate matter small enough to be inhaled were significantly higher in the mining communities versus non-mining controls. Health status indicators showed poorer health in the mining communities. This was the first study to collect biological indicators of health in mining populations, and showed that people living close to surface mining had significantly elevated C-reactive protein, which is a marker of blood inflammation that is an indicator of cardiovascular and other disease risk.

List of peer-reviewed studies showing public health problems in Appalachian coal mining areas in chronological order:

1. Hendryx M, Ahern M, Nurkiewicz T. Hospitalization patterns associated with Appalachian coal mining. *Journal of Toxicology and Environmental Health Part A,* 2007, 70, 2064-2070.
2. Hendryx M, Ahern M. Relations between health indicators and residential proximity to coal mining in West Virginia. *American Journal of Public Health*, 2008, 98, 669-671.
3. Hendryx M. Mortality rates in Appalachian coal mining counties: 24 years behind the nation. *Environmental Justice*, 2008, 1, 5-11.
4. Hendryx M, O'Donnell K, Horn K. Lung cancer mortality is elevated in coal mining areas of Appalachia. *Lung Cancer*, 2008, 62, 1-7.
5. Hendryx M. Mortality from heart, respiratory and kidney disease in coal mining areas of Appalachia. *International Archives of Occupational and Environmental Health*, 2009, 82, 243-249.
6. Hendryx M, Ahern M. Mortality in Appalachian coal mining regions: the value of statistical life lost. *Public Health Reports*, 2009, 124, 541-550.
7. Hendryx M, Zullig K. Higher coronary heart disease and heart attack morbidity in Appalachian coal mining regions. *Preventive Medicine*, 2009, 49, 355-359.
8. Hendryx M, Fedorko E, Anesetti-Rothermel A. A geographical information system-based analysis of cancer mortality and population exposure to coal mining activities in West Virginia, United States of America. *Geospatial Health*, 2010, 4, 243-256.
9. Palmer MA, Bernhardt ES, Schlesinger WH, Eshleman KN, Foufoula-Georgiou E, Hendryx MS, Lemly AD, Likens GE, Loucks OL, Power ME, White PS, Wilcock PR. Consequences of mountaintop mining. *Science*, 2010, 327, 148-149.

10. Zullig KJ, Hendryx M. A comparative analysis of health-related quality of life (HRQOL) for residents of US counties with and without coal mining. *Public Health Reports*, 2010, 125, 548-555.

11. Cain L, Hendryx M. Learning outcomes among students in relation to West Virginia coal mining: an environmental "riskscape" approach. *Environmental Justice*, 2010, 3, 71-77.

12. Hitt NP, Hendryx M. Ecological integrity of streams related to human cancer mortality rates. *EcoHealth*, 2010, 7, 91-104.

13. Ahern M, Mullett M, MacKay K, Hamilton C. Residence in coal-mining areas and low-birth-weight outcomes. *Maternal and Child Health Journal*, 2011, 15, 974-979.

14. Epstein PR, Buonocore JJ, Eckerle K, Hendryx M, Stout BM, Heinberg R, Clapp RW, May B, Reinhart NL, Ahern MM, Doshi SK, Glustrom L. Full cost accounting for the life cycle of coal. *Annals of the New York Academy of Sciences,* 2011, 1219, 73-98.

15. Zullig K, Hendryx M. Health-related quality of life among central Appalachian residents in mountaintop mining counties. *American Journal of Public Health*, 2011, 101, 848-853.

16. Hendryx M. Poverty and mortality disparities in central Appalachia: mountaintop mining and environmental justice. *Journal of Health Disparities Research and Practice*, 2011, 4(3), 50-59.

17. Ahern M, Hendryx M, Conley J, Fedorko E, Ducatman A, Zullig K. The association between mountaintop mining and birth defects among live births in Central Appalachia, 1996-2003. *Environmental Research*, 2011, 111, 838-846.

18. Esch L, Hendryx M. Chronic cardiovascular disease mortality in mountaintop mining areas of central Appalachian states. *Journal of Rural Health*, 2011, 27, 350-357.

19. Hendryx M, Wolfe L, Luo J, Webb, B. Self-reported cancer rates in two rural areas of West Virginia with and without mountaintop coal mining. *Journal of Community Health*, 2012, 37, 320-327.

20. Ahern M, Hendryx M. Cancer mortality rates in Appalachian mountaintop mining areas. *Journal of Occupational and Environmental Science*, 2012, 1(2), 63-70.

21. Hendryx M, Ducatman AM, Zullig KJ, Ahern MM, Crout R. Adult tooth loss for residents of US coal mining and Appalachian counties. *Community Dentistry and Oral Epidemiology*, 2012, 40, 488-497.

22. Hendryx M, Fulk F, McGinley A. Public drinking water violations in mountaintop coal mining areas of West Virginia, USA. *Water Quality, Exposure and Health*, 2012, 4, 169-175.

23. Knuckles TL, Stapleton PA, Minarchick VC, Esch L, McCawley M, Hendryx M, Nurkiewicz TR. Air pollution particulate matter collected from an Appalachian mountaintop mining site induces microvascular dysfunction. *Microcirculation*, 2013, 20, 158-169.

24. Hendryx M. Personal and family health in rural areas of Kentucky with and without mountaintop coal mining. *Journal of Rural Health*, 2013, 29, S79-S88.

25. Hendryx M, Innes-Wimsatt KA. Increased risk of depression for people living in coal mining areas of Central Appalachia, USA. *Ecopsychology*, 2013, 5(3), 179-187.

26. Kurth L, McCawley M, Hendryx M, Lusk S. Atmospheric particulate matter size distribution and concentration in West Virginia coal mining and non-mining areas. *Journal of Exposure Science and Environmental Epidemiology*, 2014, 24, 405-411.

27. Hendryx M, Luo J. An examination of the effects of mountaintop removal coal mining on respiratory symptoms and COPD using propensity scores. *International Journal of Environmental Health Research*, in press.

28. Kurth L, Kolker A, Engle M, Geboy N, Hendryx M, Orem W, McCawley M, Crosby L, Tatu C, Varonka M, DeVera C. Atmospheric particulate matter in proximity to mountaintop coal mines: sources and potential environmental and human health impacts. *Environmental Geochemistry and Health*, 2014, epub Dec. 24.

29. Luanpitpong S, Chen M, Knuckles T, Wen S, Luo J, Ellis E, Hendryx M, Rojanasakul Y. Appalachian mountaintop mining particulate matter induces neoplastic transformation of human bronchial epithelial cells and promotes tumor formation. *Environmental Science and Technology*, 2014, 48, 12912-12919.

30. Hendryx M, Entwhistle J. Association between residence near surface coal mining and blood inflammation. *The Extractive Industries and Society,* in press.