hearth.earth™ VIRGINIA TECH™

FOLLOW OUR HEART™

HABITAT & ECONOMIC ASSET RATING TOOL

A Decision-Making Tool for Surface Mining Landscapes in the Heart of Appalachia

REPORT PREPARED BY ROSS HAMMES

May 3, 2019

Table of Contents (CLICKABLE)

Table of Figures (CLICKABLE)

Executive Summary

Surface mining landscapes are broadly defined as mountainous regions with underlying coal deposits that have been blasted away from the surface, layer by layer, seam by seam, to the point where the resource has been almost entirely stripped away. This technique gained large-scale popularity in the 20th century as more technologically-advanced machinery began being developed. The process is different than the traditional underground mining technique that is commonly associated with mining through deep underground tunnels dug deep below the surface.

Surface mining was chosen as the preferred method because it was the more economically viable option for coal extraction as the technological advancements required fewer miners to be needed as "open-pit" access for the coal was then achievable to remove coal in larger quantities. Mountaintop removal with valley fills are the result of the blasting and digging that leads the removal of the vegetation, soil, minerals, and rocks that form this landscape to reach the underlying coal bed. This has left the Appalachian Mountains, one of the oldest mountain ranges on Earth, with barren landscapes and altered hydrologic flows that have led to drastic environmental, health, and economic problems that have became more widely accepted and understood. However, being more widely accepted does not necessarily mean the majority of people have accepted it, or perhaps many have simply ignored it because of society's need for electricity.

This research aims to review the issues associated with the mine's impact to the communities it once supported and reviews 240 surface mines across 20 counties in the Appalachian region within the states of Virginia and West Virginia. The purpose for review is to rate each former surface mine based on its proximity to certain features to which the land could be become assets to the communities they are a part of. This is done using geospatial analysis techniques which organies the data in a model and rates each site using various weights applied to the 40 data factors. The sites considered can be restored back to their natural state and original contour to become habitats to foster biodiversity or they can become economic assets by providing jobs to those in the community as a sustainable option for the labor force. These sites included solar parks, greenhouses, aquaponics facilities, breweries, and drug/alcohol recovery centers. The data used for each site along with the weights and a map of the sites selected can be found in their respective sections in the report. In addition, the web page https://hearth.earth/heart-app provides the user with the experience to interactively select each site and view the data used and the factors it was multiplied by. The H.E.A.R.T. App also allows the user to enter their own weights to implement different scenarios. The ability to do this aims to give the user the experience of input and engagement which is necessary in community planning and economic development. This report and interactive app are two tools that can be used to create the best strategies moving forward to give these communities an opportunity to receive better use out of these barren landscapes that cover their mountains. The research reviews the data which suggests high levels of poor health conditions and distress in the region and attempts to provide some potential solutions through the use of the data model and transparent, open-sourced access to the data being used. The ability to access the research and data through a detailed report and web page is a necessary tool in the modern age where every project can be one link away for anyone in the community or region to use.

The goal is to use geospatial analysis or geographic information sciences (GIS) to better understand the complexities of the various problems our Earth faces while also shedding light on the practical applications of GIS. Surface mining will be the topic of this project but there are many more cases ahead needing to be further analyzed and brought to the public's attention. This report highlights the issues that this region experiences due to the practice of surface mining and aims to connect the community to this landscape to promote positive use of the land that could be critical for the identity of this incredible place.

The results yielded some interesting findings that can be considered by the various stakeholders involved in making projects such as these to become further addressed and implemented into the region's master plan and the localities comprehensive plans. While a project such as this one can be particularly useful for private or public planners, policy makers, and other government officials, it can be viewed as most useful to the community members and local business owners who would receive the most benefit from the implementation of these strategies. This can be accomplished by receiving the grants which are available for projects such as these which seek to restore the land and provide jobs to the region. Not only is this project and report a resource to the region of Appalachia but it can also be considered for other similar projects regarding land use restoration or development for any site, whether this be an underused lot in an urban setting or an underused site in the Heart of Appalachia. My goal is for leadership to adequately understand the merit behind geospatial sciences in planning to make better informed decisions as to where we allocate our time, efforts, and resources. The research seeks to gather necessary attention by key personnel to begin creating new plans which will create new opportunities for a place that has traditionally had fewer resources available from the outside.

Introduction

Central Appalachian communities and habitats have suffered as the extraction of coal has become a less economically viable solution as other fossil fuel dependencies have grown to take its place. In many ways, Central Appalachia or what many call "the Heart of Appalachia," was this nations very own "canary in the coal mine" in terms of understanding the detrimental effects that fossil fuel extraction has on a region. This world has been growing rapidly, and the need for coal grew as it was the fuel our society needed. With this analogy, the Central Appalachian people are the "canary" and the negative impacts on their surrounding environment, their livelihoods, health, and the ability to earn an income became the "cage" that society placed around them and sent into this never-ending energy tunnel as an early warning of the potential dangers. As a result, the Heart is beating slower all-the-while the ability to mend this breaking Heart becomes more difficult. While it is true that coal mining has been an asset to this region and supported many of the region's families for generations, it is also true that this economic base is withering away. This provides the region with an opportunity to create new strategies that can better the region.

As strong and resilient as this Heart is and despite how much love it has to offer, it needs our help to be freed from the "cage" that society surrounded it with so it can breathe fresh air once more. We as people know of the effects and have seen the danger, but we must act before it is too late because we have an obligation to do so. We have an obligation because we all use electricity and are part of the reason why this region's economy and ecosystems are in need of help from us all. It can all be achieved through love.

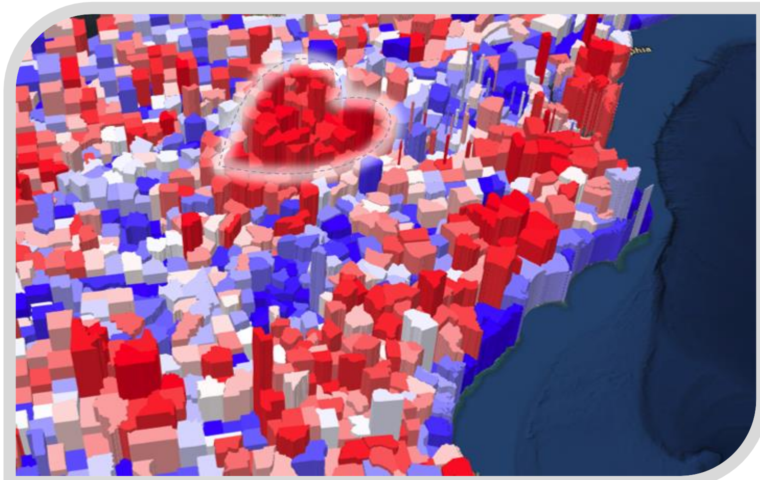
This project is the story of a breaking Heart from a destructive, toxic relationship. A relationship between communities in the region to the ground beneath their feet full of a highly combustible rock we know as coal. It is a story about how we as human beings and users of this land have a responsibility to leave this Earth better, not worse than it was before. I am not a relationship therapist, but I do have a background in and a passion for environmental sciences, community revitalization, and economic development that I will use to hopefully provide benefits to a region that holds a special place in my heart.

Over the course of this report, I will explain how the "Heart" is breaking and offer some suggestions as to how we may fix it by "following our H.E.A.R.T.," a geospatial modeling tool that rates these surface mining sites using various spatial factors to determine which can be viable economic assets or which would be better off being restored to their natural state to become an asset for biodiversity. This will also include a review on the current and historical policies covering this topic and how funds can be increased and directed to improve the economic or ecologic conditions surrounding this landscape. Unfortunately, this story is not a story in the common use of the word but rather a reality that a region of people face daily. A reality that leaves them in need of some love from the outside. Afterall, the best love is the kind that enlightens the soul, makes us strive for more, sparks a fire in our hearts, rekindles the flame around our communities' "hearth", and brings some peace to our Earth. Perhaps by spreading this love and combining our hearts together, we can make change happen by allowing our nation to slow down and love again to hopefully turn a "breaking Heart" into a healthy, self-sustaining one.

This is an image of one of the many "LOVE" signs scattered throughout this beautiful region. This image was taken in Buchannan County near a former surface mining site that is now being used for scenic areas for the vast outdoor recreation tourism that comes into the region.

Study Area: Heart of Appalachia

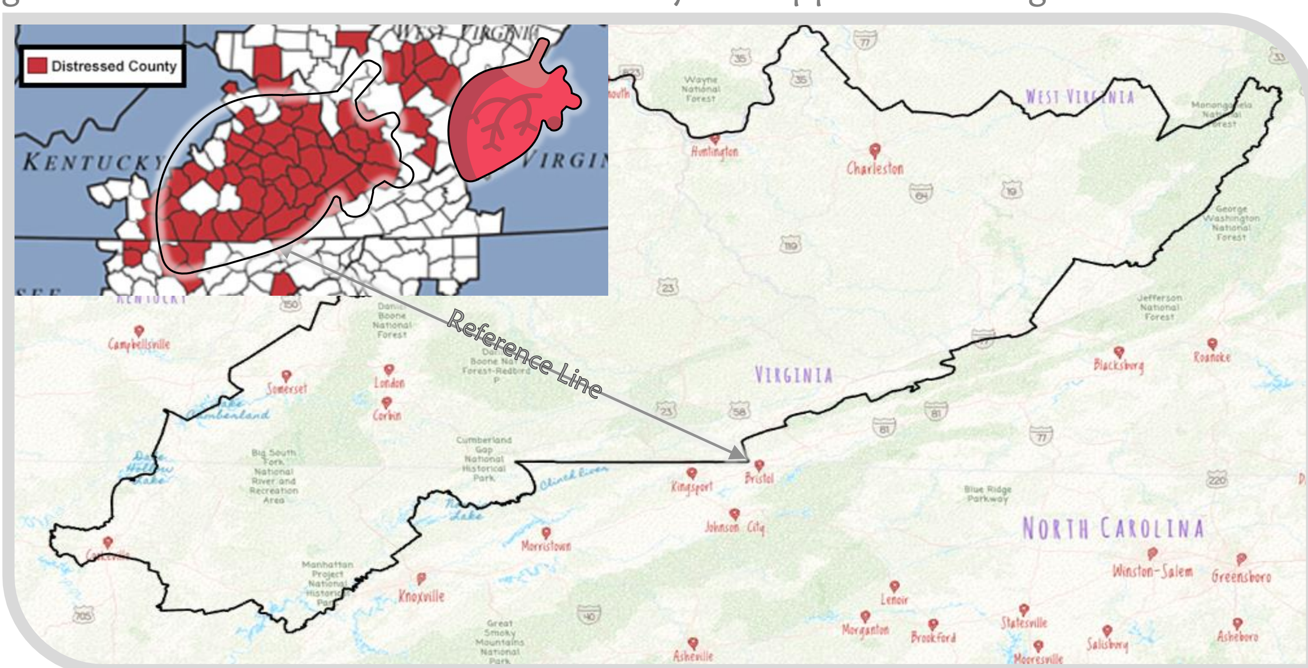
Figure 1: US Counties with "Poor Health"



This is a map showing the "Heart of Appalachia," the Central Appalachian Mountain Region that "stands out" with red representing poor health and the height representing poverty levels. It happened to make the shape of a heart with this visualization technique. It is colored based on rankings for counties in the US on over 20 health-related metrics including length/quality of life, disease, clinical care access, and quality.

The top 1,000 counties (of ~ 3,000) appear in blue, while the lower are red. Some of the specific socio-economic factors pertaining to health include disease, cancer rate, diet/exercise, substance/alcohol use, health insurance, education, employment, income, and the environmental quality (air/water). The extrusion value is based on poverty representing the height of each county polygon.

Figure 2: "Distressed Counties" Defined by the Appalachian Regional Commission



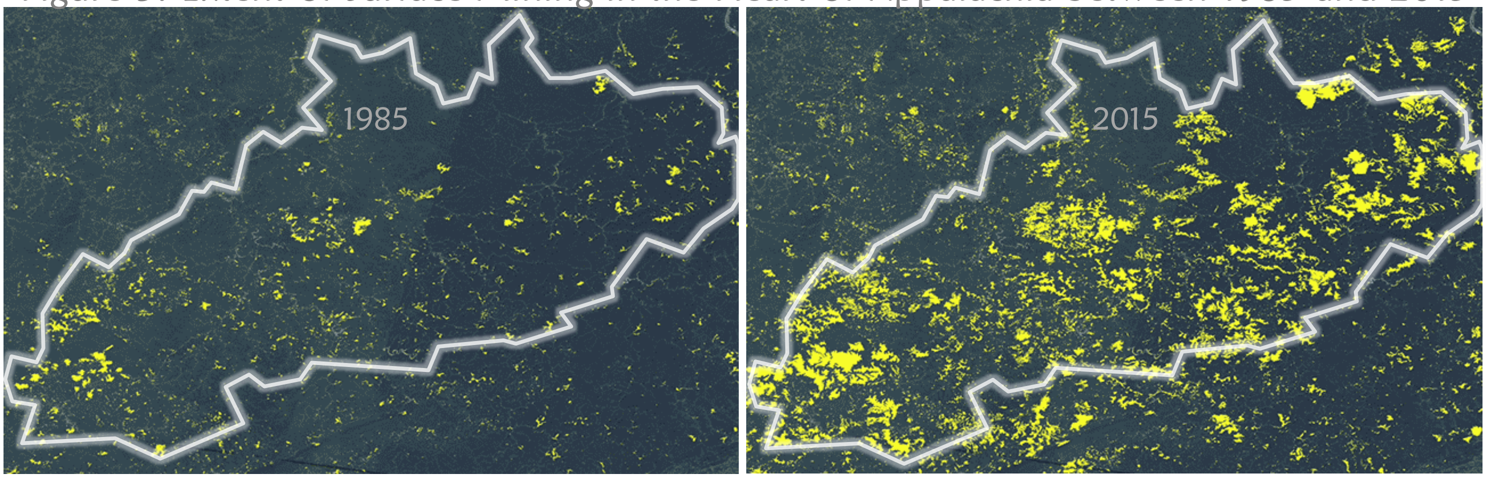
These maps also show the Appalachian Region but from a different angle, this time more closely resembling the shape of an actual human heart. Regardless of how you look at the "Heart" of Appalachia, it is not difficult to see what shapes this area, which is its "distressed" status as defined by the Appalachian Regional Commission as seen in the left corner of this map. The distressed status is based on a variety of data pertaining to poverty, income, and unemployment.

The larger map is of the 80,000 km² study area for a study recently published that comprehensively mapped the extent of surface mines in Central Appalachian Region by analyzing vegetation change (NDVI) from satellite imagery over the past three decades since land cover data became available in 1985. This study by SkyTruth and Duke University gives us the temporal resolution necessary to provide an accurate representation of surface mine locations like never before.

The study by SkyTruth/Duke found that 2,900 km^2 of land has been mined over the last 30 years. Adding this more-recent mining to surface mines prior to 1985, an estimated cumulative mining footprint of 6,000 km^2 exists in Central Appalachia. The side-by-side comparison below shows the extent of the surface mining increase encompassed by the 75-county area.

The EPA estimates that over 2,000 miles of headwaters have been buried and polluted. For comparison, based on the estimates from various studies like the one by the EPA and SkyTruth/Duke, the amount of rock and dirt removed from this area could fill the entire 16,800 m^3 of the Mississippi River, joining our country at the seam that physically divides us, if only this were the political case.

Figure 3: Extent of Surface Mining in the Heart of Appalachia between 1985 and 2015



Brief History

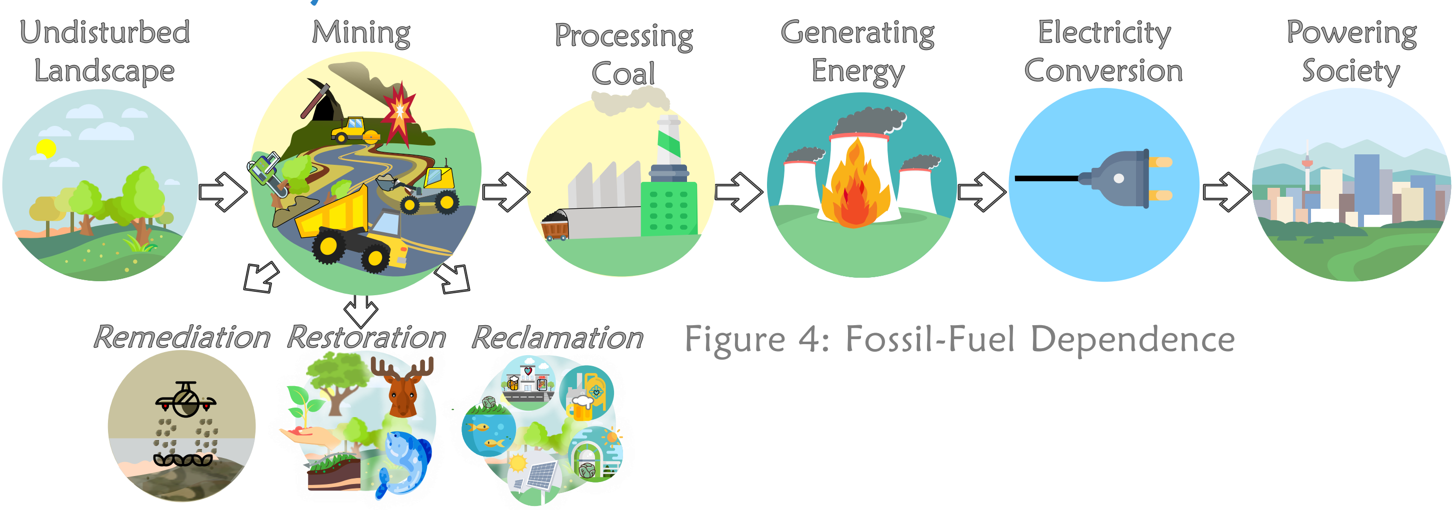


Figure 4: Fossil-Fuel Dependence

How did we get to the point where the mountains in Appalachia are flatter, the vegetation at these sites are cleared, the streams are altered, the ecosystems have been fragmented, and human health has heavily been impacted?

As the diagram above shows, the rights to the undisturbed land are bought by private energy companies and mined until the coal deposits are depleted and they move onto then next location to continue the process, leaving the land barren with minimal effort to restore it back to its origins or reclaim it for economic development purposes. This also leaves the surrounding environment, including the communities and their families within, with many problems which will be discussed in the following sections prior to discussing the recommendations from the geospatial model (H.E.A.R.T) to restore or reclaim the land to improve this region. To better understand why the coal is mined, it might help to read the diagram from right to left as the need to power our society drove the need for more fuel for energy, thus more coal mining. Coal production/consumption in the US steadily rose from the 19^{th} century into the 20^{th} century until the 1920's where it began to plateau until rising once more in the 1940's, staggering around 670 million tons per year. From the beginning of the 1960's, the demand for coal had nearly doubled, reaching its most recent "peak" at the beginning of the 2000's at around 1,170 million tons produced. Even though coal mining is on its way out, the damage has been done. Surface mining is no exception to this drastic increase.

With more than a quarter of the Earth's coal reserves being in the US and a quarter of the nation's reserves being in Appalachia, it is no wonder that coal has been such a huge part of the identity of this region. With about one-third of the US electricity consumed coming from coal, it is easy to understand how this problem originated when paired with being a the more financially viable extraction method.

The Problem

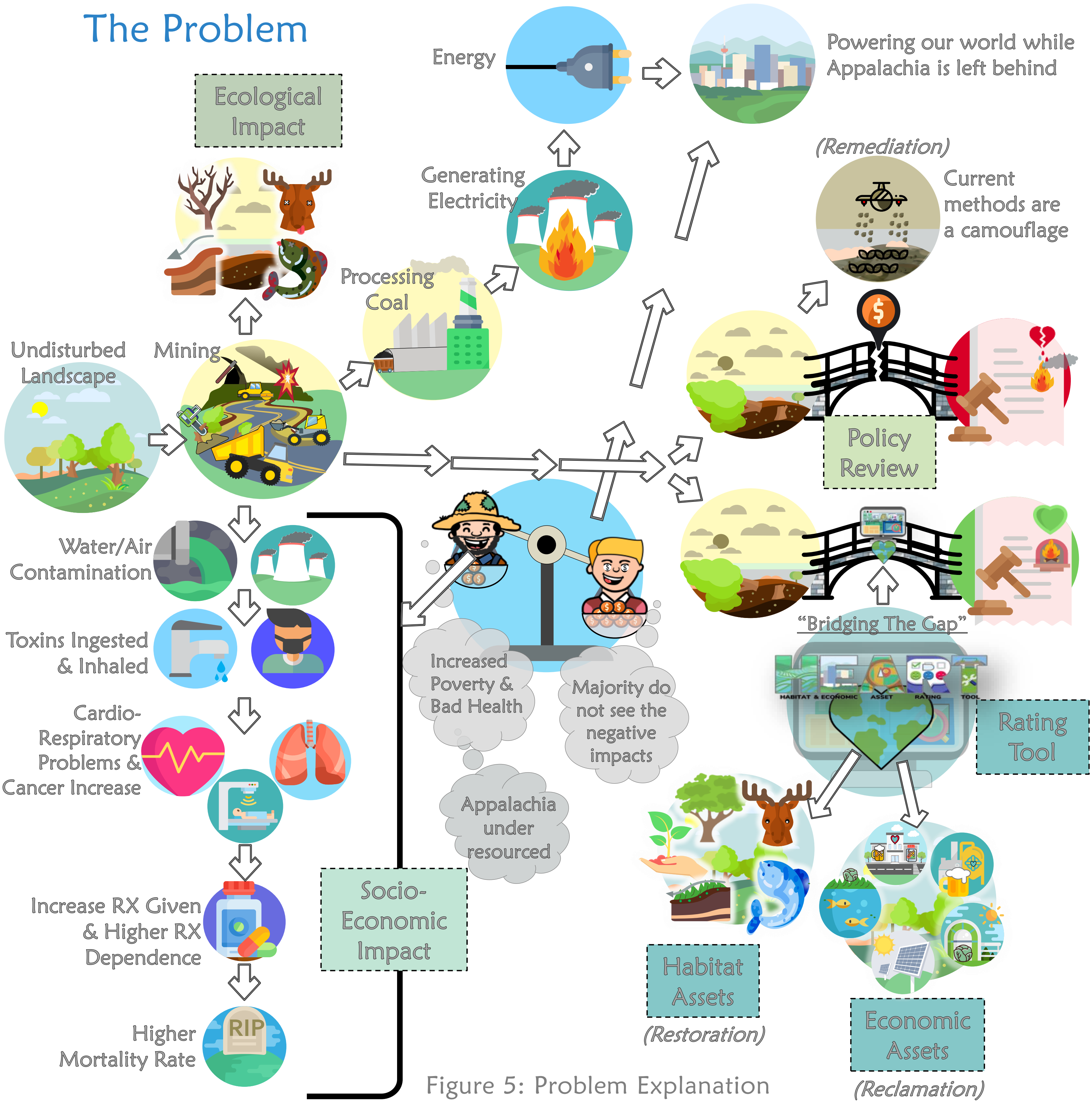


Figure 5: Problem Explanation

This is a diagram created to illustrate the full rationale behind this decision-making tool. The viewer can follow this illustration from the undisturbed landscape to the surface mining operation that includes removal of all vegetation and top soil and often often dumped in the valleys. Trees are often not used commercially but rather burned. From there, the blasting begins using millions of pounds of explosives and the digging begins so that the coal and other debris can be extracted.

From there the coal is processed and used for electricity to power the growing world. While the rest of the world benefits, many problems in Appalachia persist. The flow chart goes on to exemplify the current situation that typically involves the spraying of seed to create what looks like proper restoration but in reality, is just a mere camouflage. The other path suggests a refined method to achieve actual restoration or reclamation using spatial data to bridge the gap between society and policy.

A Solution

Change does not always happen at the top. By mapping and assessing former mining sites we move forward on new ways to utilize the resources the coal region has provided for so many years. The purpose of this project hits on two primary objectives: provide background on the problems associated with surface mining in the Heart of Appalachia and propose innovative ways to make better use of the mining sites through various funding streams than what is currently being done on this precious land. In doing this, the project will highlight which sites are better for economic development purposes and which are better for ecological restoration through an interactive decision-making tool that profiles each site based on specific parameters to determine which would be an asset for natural habitat, or which would be an economic asset.

The existing environmental and societal conditions encompassing a site directly link to how the site should be handled by the communities, municipalities, and economic development agencies involved. The H.E.A.R.T. App (Habitat & Economic Asset Rating Tool) is an interactive application that users can enter their own "weights of importance" to various factors used to assess these assets. This feature makes this project flexible to the various stakeholders involved while also providing recommendations with merit based on extensive research.

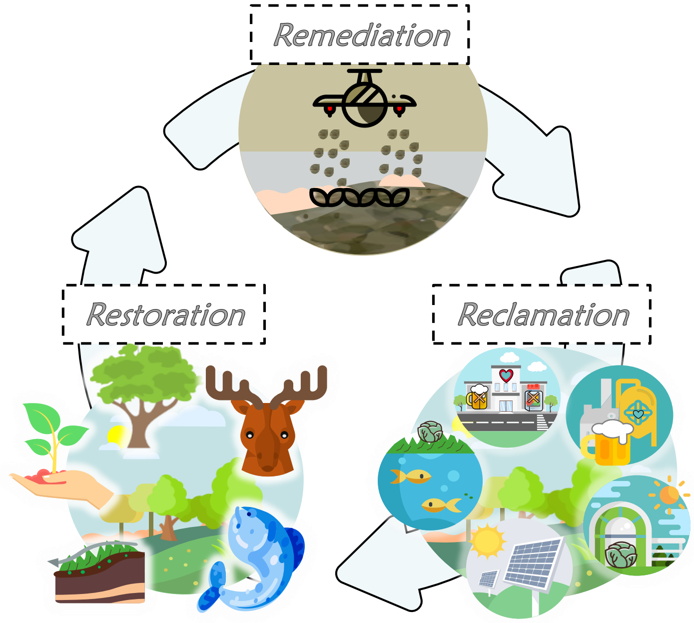
There is much room for improvement from the current minimal remediation methods from the energy companies. From the literature, a lot of "R-words" are tossed around and can sometimes be confusing. Rehabilitate and remediate are often used intermittently but relate to the same concept which many suggest is the bare minimum in terms of what else could be accomplished. These efforts can be improved to make better use of the land with the next best option being the use of these sites as economic assets, resulting in reclamation of the land that has already "graded/cleared" to allow for new development. The optimal solution would be to restore the land to its original, natural state. According to the EPA, it may take hundreds of years to re-establish habitat if the current efforts persist.

1 out of 10

The number of sites that have been used for economic purposes such as business parks, a prison, an airport, agricultural pastures, gas/oil wells, residential homes, or recreational (parks/golf/ATV) as of 2010

Source

Figure 6: Solution Explanation



For example, it might be best to restore the land to its natural state if it is not close to a populated area or the terrain is too difficult and expensive to grade for development or if it is surrounded forests and near other conservation land. On the other hand, it might be better to reclaim the land for economic development purposes. A site might be better for facilities pertaining to food and beverage processing (such as aquaponics, nurseries, breweries, etc.) if they provide the appropriate amount of access, sunlight, utility infrastructure, and other requirements appropriate for this development. Other development opportunities that will be explored include drug/alcohol rehabilitation facilities which would also consider proximity to populous places but instead, might favor sites further away to avoid the temptation to purchase or gain access to substances. In addition, this development type would also take views from the site into consideration because access to natural aesthetics has been proven to help in the drug & alcohol recovery process. The final economic development opportunity this study will explore will be solar parks, which would consider climatic conditions to maximize annual sunlight potential. How amazing would it be to see these locations once used to mine coal, as sites used to capture solar energy that can be tied to the electric grid and sold as credits to benefit the local economy? Especially when considering that this region is commonly associated with "dirty energy" and has historical relied on coal mining as its economic base, which according to the Bureau of Labor Statistics coal jobs continue to decline more every year along with the of coal.

It is up to us to push this forward to receive the appropriate amount of funding needed to boost and diversify this regional economy or protect and restore these precious landscapes. This economic and ecologic opportunity in this region needs more recognition from the general public (social capital) and increased funding to make these innovative projects a part of the national agenda.

Ecological Impact

The mountains in Appalachia are amongst the oldest in the world, containing some of the most biodiverse species on the entire North American continent. Unfortunately, the process of surface mining has led to many direct and indirect environmental consequences. A study completed by Appalachian Voices a decade ago found that 4,700 km² encompassing over 500 mountains have been cleared and flattened in Central Appalachia, which is now figured at 6,000 km² according to the 2017 SkyTruth study

7.5% of the total land in Central Appalachia has been cleared for surface mining operations

The consequences range from toxins and pollutants that stem directly from the mining process. The degradation of the soil persists due to the removal of vegetation and soil paired with the use of explosives that result in harmful metals being placed into the ecosystem. This occurs from acid rainfall, dust, and runoff that leaches into the hydrological system and poisons land & aquatic species. This all combines with the fact that these sites are not appealing to look at and litter the view of the landscape. Aside from biodiversity loss and impacts to air and water quality that occur directly from the mining process, other indirect consequences occur as a result of the industry.

These indirect consequences include increases in greenhouse gas emissions into the atmosphere as coal is one of the "dirtiest" forms of fossil-fuel burning. This is further worsened by the indirect consequences of losing "carbon stock" from diminished carbon sequestration ability that is the result of forest clearing. In addition to the implications this has on climate change, coal ash is another byproduct of the electricity generation that became the second largest waste stream in the US behind municipal garbage to landfills, pinning the coal industry as "most wasteful" ecologically speaking.

Figure 7: Negative Impacts to Habitat Health

The question we must first ask ourselves is whether we want to be a part of a generation with a hungering for coal, oil, and natural gas that requires the decimation of land that was previously undisturbed, or do we want to be a part of a generation that drives the shift toward a better, brighter future without the dependence of fossil fuels? Of course many would answer yes that the latter sounds more ethically appealing but "it is not that easy." By saying that, you would be right, it is an incredibly complex issue that requires an entire shift in the way we regulate and advocate for the investment of clean energy and do what is necessary to make it happen. Now more than ever must the problems be brought to wider public attention so that these opportunities are not overlooked. The current political climate in this nation is a whirlwind of regulatory roll backs and changes in law that do not allow the region to receive the necessary funds to implement more projects and awareness campaigns. However, these administrative changes do not change the minds of those that have more ambitious goals to continue down the path that started their career and those with greater ties to the community and region are working hard to make the necessary changes moving forward.. With the right approach and added pressures, perhaps we can "unearth" those that have been buried under the "fill" that has cluttered their minds when false promise of a future in fossil fuels. Perhaps we can restore those perceptions that only see this issue as an environmental one and realize that this has everything to do with improving the socioeconomic conditions in the Heart of Appalachia. May we see the reality of destruction and provide the region with the necessary funds to restore or reclaim.

This destruction can be seen below as examples of the altered landscape that occurs due to this process. These examples come from the USDA and just show three of the 500 or more mountains that have been destroyed to fuel the energy plants that power our society which has generated a growing need for more. Notice the lush greenery that covers the landscape in contrast to the barren, destroyed land that was left behind. These are the before and after photos of mining operations that occurred in West Virginia by three various parties between the years 2010 and 2014. Imagine these sites looking like their former glory as an asset to the local biodiversity and environmental quality. If not restoration, perhaps at the least, these sites can be used to bring jobs to businesses formed through best practices of sustainable development which often includes bringing more vegetation and greenery to the land to which the development is built on. These buildings usually focus on efficiency which includes technological improvements focused on reduced waste and increased energy savings which lowers its carbon footprint. These sites also often aim for biophilic design to connect people to the natural world by providing them with opportunities outside through walking paths and areas of refuge while also providing natural connections indoors by its layout and décor. The inclusion of diversity in design from the expansive pallet that nature provides us to the reduction of the carbon footprint by capitalizing on nature's unlimited supply of renewable energy sources may be the key to connect the built environment to the natural one. This efficiency can range from the basis of the operation such as solar parks to being businesses run predominantly on renewable energy.

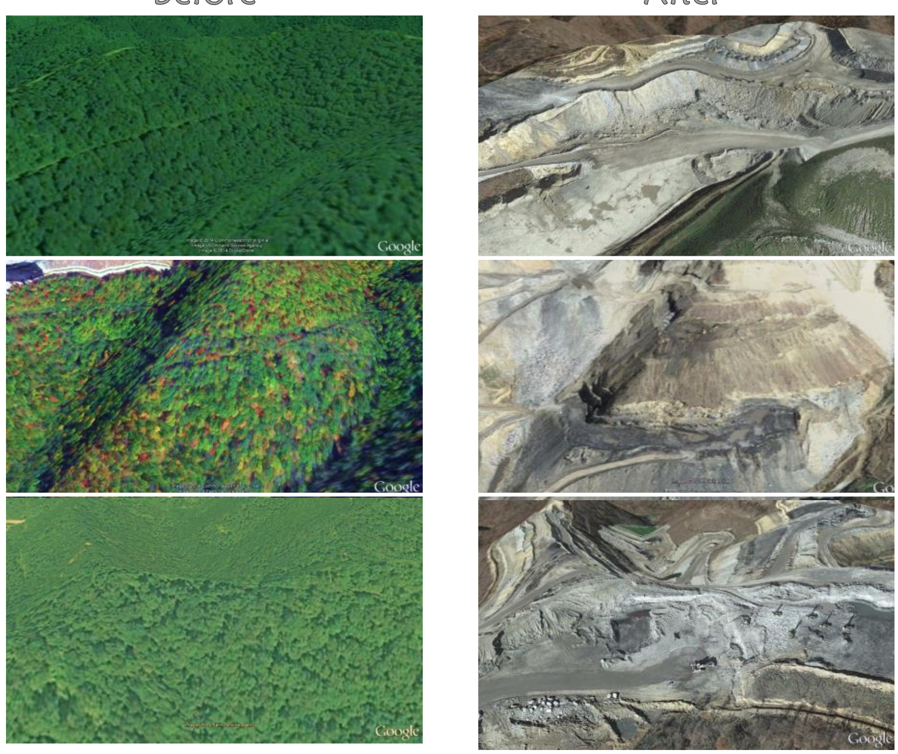
Figure 8: Historical Degradation

Before | After

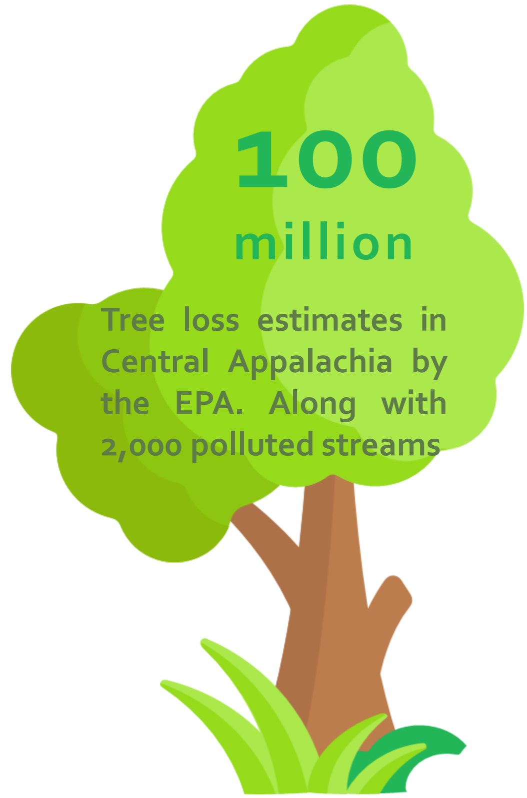
Toney Fork Surface Mine
Logan, WV
2011-2014
Cliffs-Logan Co. Coal LLC

Briar Mountain Surface Mine
Kanawha, WV
2010-2012
JMAC *(Leasing/Contractor)*

Pine Creek Surface Mine
Logan, WV
2010-2013
Coal-Mac Co.



The water and air we share with the natural world is vital to the longevity of human life and diversity of wildlife. The effects of surface mining has far reached into the history of biodiversity in the Heart of Appalachia as an integral part of the increasing threat that poor industry practices result in. This has led to an estimated 1.5 billion acres of forest lost which is suggested by the EPA to be tree counts in the upper millions to 100 million predominantly containing deciduous trees with intermittent evergreen spanning throughout. In terms of density, deciduous usually have fewer trees in any given area of land but typically grow much shorter to the ground than their leaf-shedding counterparts.

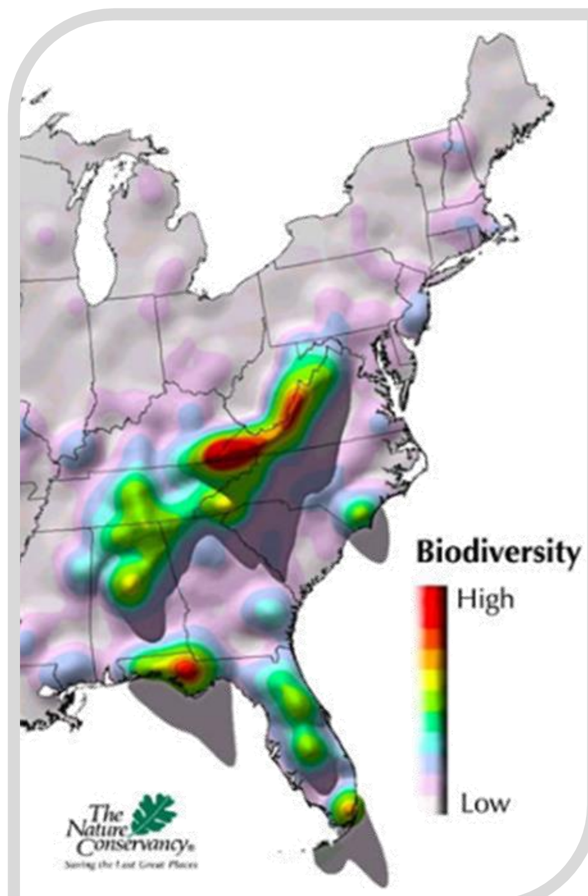


In addition, to vast forest land lost due to this operation, an increasing amount of stream is lost as well. The EPA estimates that over 2,000 streams have been impaired due to surface mining drainage often referred to as "yellow boy" or "slurry" which can be seen below. This drastically impairs the water quality for the aquatic life and neighboring terrestrial life such as land dwellers or birds that need this valuable habitat to survive. You can see the rich biodiversity that exists in Central Appalachia in the map to the bottom right provided by the Nature Conservancy. By comparing this region on multiple factors relating to biodiversity, one can see how this region stands out above all. A study by the Penn State & USGS proved that more than two-thirds of fish populations have been reduced from 1999 to 2011.

Figure 9: Hydrological Pollution

Acid Mine drainage referred to as "yellow boy" near a mine site in Virginia. Photo by USGS

Figure 10: Biodiversity Hotspot



Biodiversity in Eastern US.
Map by Nature Conservancy

In respect to air and water quality, our basic needs of life, more must be done to protect the keystone processes that provide the appropriate and necessary functionality to ensure life can be maintained as it was intended. This intention was not by chance but rather a definitive result of the resiliency of lifeforms, big or small, that began 3.5 billion years ago. The very lifeforms that decayed and became compacted under immense pressures that resulted in the fossil-fuels we now burn and emit in a way that nature did not expect. This has resulted in an uneven and unnatural processes that have even posed the question as to whether we have entered a new geological epoch that can be dated on a geological scale which could be recorded as actual proof billions of years from now that we humans existed much like the proof we discovered that the dinosaurs once did. This geologic shift is what we call the Anthropocene. Consider the fact below which puts this idea into a scale that humans may better understand. Imagine if you are around 46 years old and you found out just 4 hours ago that there could be an impeding health risk and then just one minute ago you found out that you have less a few seconds before threats begun to spiral out of control and even risk taking your life altogether. Then imagine you had the power to stop it from happening. Would you do what was necessary? Or would you continue doing what caused this ailment and threat to your life? Would you value this life, or would you allow yourself to make the problem worse and shorten whatever time you have left?

By scaling the Earth's 4.6 billion years of existence into 46 years. Humans have been around for 4 hours. The industrial process driving fossil-fuel consumption started 1 minute ago. In that one minute, over half of the Earth's forests have been cleared.

Let's say that this problem is an addiction to cigarettes, like the addiction humans have had with fossil-fuels. Now imagine you found out that you could switch over to a more sustainable and less toxic form of your addiction that would still supply you with the nicotine you crave without threatening your life. This is exactly what renewable energy is in this case in our modern society. This addiction has drastically effected our own "Heart health" from the vein-like rivers that are within to the air that enters our lungs and provides our bodies with the oxygen it needs. Now it takes the whole body and brain to work together to fight this horrible addiction. This includes grassroot efforts coming from the bottom to an in-depth understanding by our political figures and policy makers at the "top."

"If the life form cannot acclimate to life deep in a rubble pile, then it is eliminated. No effect on environmental values is more adverse than obliteration. Under a valley fill, the water quantity and quality of the stream is zero."

–Former Federal Judge Charles Haden II

Fortunately, the shift at the local scale is shifting and still believe that despite administrative changes within the government and rollbacks on regulations, that the world is not so doomed, and we will hopefully take the necessary actions. However, in order for this shift to happen, the courts must place accountability on themselves and on the mining/energy industries that took part in this bad habit, just like the cigarette industry should be responsible for its actions. Federal statutes like the Clean Water Act and Surface Mine Control & Reclamation Act (which are discussed in the policy section) have passed so that when these laws which pose threats to our natural environment is threatened, that legal action can be taken by citizens that are put in harms way. These entities are analogous to the support groups that one with an addiction may find that push you to quit your bad habit and protect what is vital for life. Some examples of these local enforcement entities include the Appalachian Citizen's Enforcement Project and Appalachian Water Watch which collect water quality samples and takes legal action against the mining organization when violations have occurred. Governmental regulatory agencies have failed to hold the coal industry accountable for its actions leading to water pollution. This lack of enforcement highlights the need for water quality inspections done locally, more frequently, and independently with the goal to better inform and establish real, lasting trust with citizens within and around these communities.

Socio-Economic Impact

Figure 11: Negative Impacts to Human Health

The prevalence of environmental injustice has riddled the Central Appalachian area for a century when the first coal miners strike occurred in Indiana due to the coal companies failing to recognize the coal miner's union established to ensure the protection of the miners, their families, and surrounding community. Failing to take responsibility for the ecological and socio-economic impacts that the mining process has, it is no surprise that many of the energy companies have turned their back to the proper maintaining and disposing of waste to avoid requirements placed on emissions and byproduct. In one case, the National Mining Association even blamed inbreeding as the reason behind the birth defects happening in communities around the mines. They have opted to illegally dump “fill” and waste into the valleys and air that leads to more toxins ingested and inhaled. The relocation of rock and soil into the valleys has resulted in persistent flooding leading to the loss of property. While the price of coal has always driven these companies to loosen up on adhering to the regulations posed on the mining operation, the cost has been detrimental to human lives.

This region has been a capitalists’ experiment over the past century since the beginning of the first world war when energy consumption began increasingly drastically, driving our ever-growing need for coal. This time period started tis region’s dependence on the coal industry. Many pop-up towns formed in sporadic parts of the region that followed the coal deposits and left communities sparse and their resources limited. Imagine trying to stay warm by the community’s fire from the other side of the campsite.

Negative health in the Heart of Appalachia clearly stands out when compared to surrounding counties. From shortened lives to higher presence of preventable illnesses like cardio-respiratory diseases to higher cancer rates; communities in this region suffer from extremely poor health with reasons being highly attributable to coal production and consumption.

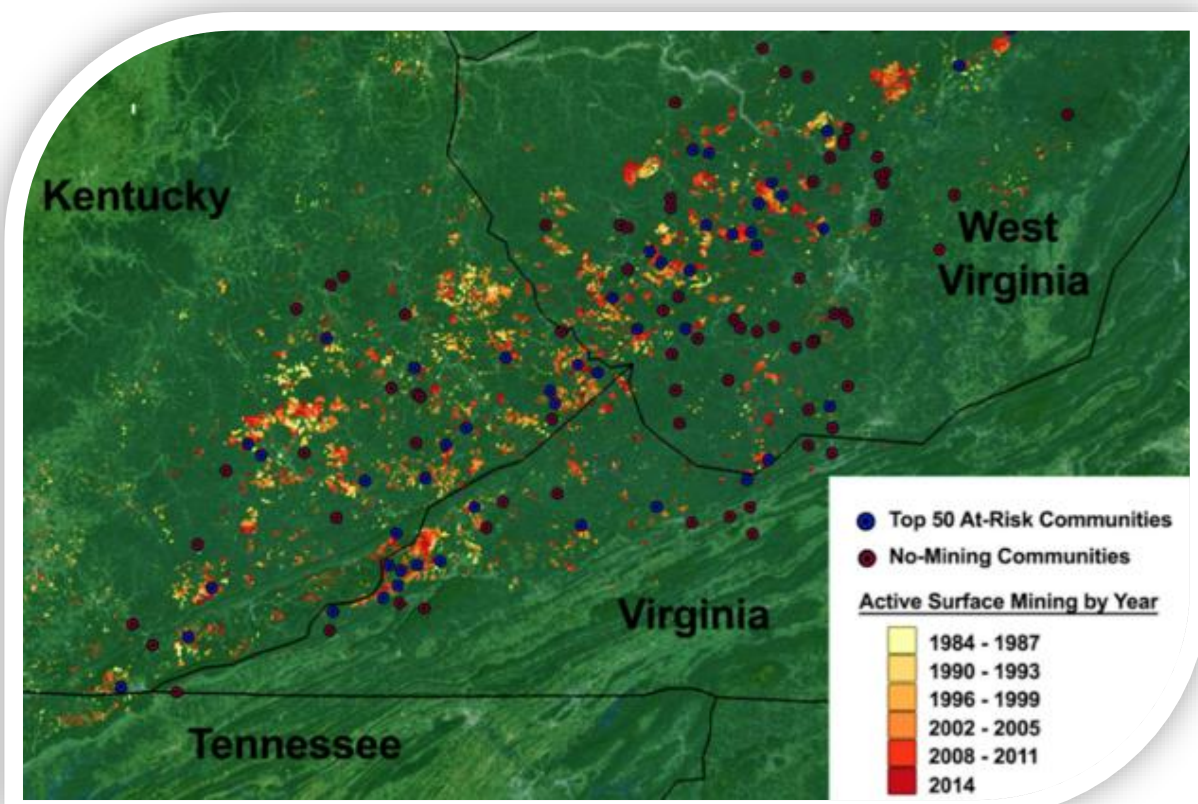
Population decline has been rampant in Appalachian for decades along with poverty and unemployment rates. This has a direct impact on health which will be addressed on the following page. The population decline has been the result of unsustainable growth that can be attributed to the decline of the coal industry. In other words, the state of Appalachia has directly reflected its relationship with the very industry that started it when this country was first becoming competitive in the ever-growing, globalized market.

Historically, this region has been a destination for manufacturing, mining, farming, and rail-related employment, in both the pre and post-war economy. Employment in all of these industries paid wages that could reasonably support families. However, as employment opportunities in the Heart decreased, younger populations and families began to look outside of the region for employment opportunities that better suited their needs. As a result, median age in Central Appalachia has risen over the past three decades and is projected to keep rising. Beginning in the 1990's and increasing around the 2007 recession, adults between 35-44 and their children, left the region in highest numbers indicating that families migrated out. Additionally, the number of households within the region decreased during this period resulting in an aging, declining population trying to adapt to the urbanized world growing around them while holding onto what makes them most unique which is their cultural identity and heritage.

The impeding threats associated with surface mining in this region that has continued placing communities at-risk has become a greater concern and increasingly studied topic. Appalachian Voices conducted a study three years ago on these communities by analyzing clusters of communities in Central Appalachia closest to surface mines in comparison to those within the same counties but further away from mining operations. They aimed to determine if the location of surface mines and socioeconomically "at-risk" communities were correlated. As shown in the map below, the blue dots representing the "at-risk" communities appear to surround the areas where surface mining has persisted over the last three decades, while the red dots representing communities without mining faced less population decline, unemployment, and health concerns.

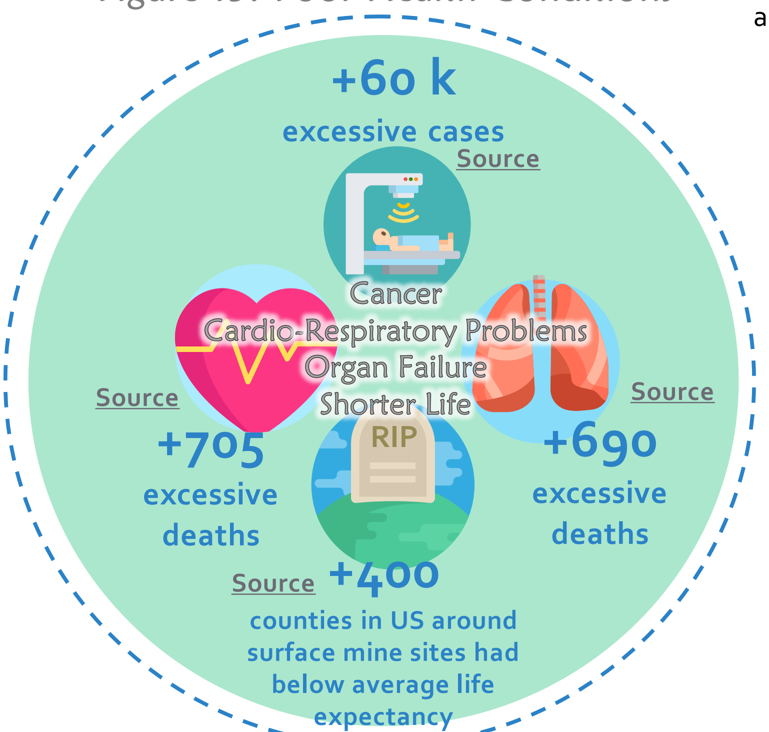
The key findings from this study are as follows: the "at-risk" communities in Central Appalachia are concentrated within Kentucky, West Virginia, and Virginia across 23 counties; communities where surface mine encroachment has increased, suffer higher rates of poverty and greater population decline at a rate more than twice as fast as nearby rural communities with no mining in the immediate vicinity; and communities that face the greatest current and future threat from mine encroachment are in areas where high-quality metallurgical coal is mine, particularly in the far southwestern part of West Virginia where around 15 of the worst 25 communities were located. This study can be found on Appalachian Voices website.

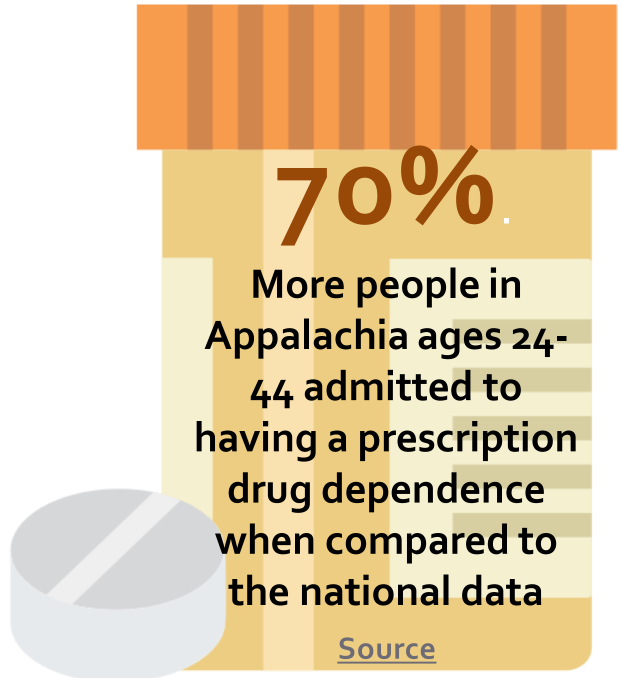
Figure 12: Most Impoverished 50 Communities with Declining Populations within the Central Appalachian Region



Dr. Michael Hendryx of WVU has dedicated his life studies to the health impacts occurring in Appalachia and has completed a few studies over the past ten years that that analyzed extensive health related data from various local, state, and federal sources for the counties within this region to show the increase in respiratory, cardiovascular, and other preventable diseases as well as higher cancer prevalence and lower life expectancy. Some studies have even shown that Central Appalachian mortality is more similar to those recorded in developing countries. He stated that "previous studies have been criticized for being only correlational studies of illness in mining communities. With this study we have solid evidence that mining dust collected from residential communities causes cancerous human lung cell changes." Some of the key findings from these studies showed that of the four states that have counties within this study area, West Virginia and Kentucky had the highest cancer deaths per capita, respiratory disease, and other preventable illnesses per capital when compared to other states in the nation, specifically in the counties containing surface mining operations during the study period as these operations increase exposure to toxic, lethal particles. Aside from these two states, the region in general showed a very high prevalence in all of these health-related ailments. This includes over 60,000 cancer cases directly linked to mountaintop removal mining due to the presence of the cancer-causing particles found in those patients. There were also more than 1,400 heart or lung related deaths during the study period and more than 400 counties in the US that had surface mining operations also had shorter lives. In addition, a study by the Appalachian Regional Commission suggested that approximately 70% more people in Appalachia had a prescription drug dependence than those of the same age cohort in the US.

Figure 13: Poor Health Conditions





Disasters effecting this region have also been a large part of the implications that this industry has had on people's lives resulting in more short-term impacts that have had long-lasting problems. This includes random acts such as a boulder from a mining falling on a home and killing a child to excessive flooding resulting in the loss of property. These disasters have been a part of the tragic story in how surface mining has led to worsening threat to human life that can occur on a moments notice which is already placed at extreme risk due to the leaching and increased exposure of the various toxic disease-causing particulates outlined on the left side of this page. From rocks flying due to mining operations like digging or blasting to the toxic sludge impoundments that contain more than ten dangerous heavy metals just waiting to fail and wipe communities out in its path, this problem should be taken just as seriously as any of the more long-term health impacts.

A 1,000 lb. boulder was pushed off a mountainside on a mining site in Appalachia, VA falling 650 feet below and crushing a 3-year who was probably attempting to fall sleep in his bedroom over the noise of frequent blasts and coal machines echoing across that somber Appalachian night. Jeremy Davidson would have just recently started driving and working as a productive member of this community, but never received that chance because a mining operation using heavy machinery was somehow allowed near or in harms-way of residential homes.

While the identity that makes the Heart of Appalachia will likely never be lost, it is important to do what is necessary to protect the beauty that resides within. A beauty that I realized when I worked for NASA Develop for a summer on various international projects and stayed at a friend's apartment in a new complex next to the UVA-Wise campus. I made friends with many people who grew up in this region their whole lives. Although I lived in the Appalachian-Blue Ridge Mountains my whole life (I am from Roanoke, Va), I had never experienced true Appalachia until that summer in 2015. From there I have repeatedly found myself wanting to help this region and its loving people that live lives of desirable simplicity within some of the most beautiful land this Earth has to offer. I believe that while I am an outsider looking in in some ways, I am also a part of this identity and how it moves forward. I hope that the way I see this region is a way that only ever helps each one of them, whether I have met them or not. I hope that through this project and the ones like it, which I have been eager to take part in, that I will be able to see through their eyes and allow theirs to see my heart. It is not necessarily easy to always see through someone's eyes, and some may think "who is this person to say that the Heart is breaking and needing help from the outside?"

As a planner, I can only go based off the data that points to extraordinary job losses, low median household income, poor health, and a lower quality of life. Despite the data, I know many of these people are fortunate for whatever they have. My role is to try and bring attention to the problem by providing some meaningful guiding principles and suggestions as to how that may be accomplished. My role is to promote fairness in how the mining industries take responsibility for their actions and neglect the communities by putting them at-risk. Lastly, my role is to suggest that was been done has already happened and that more could be done to promote new economic opportunities for the region. If sustainable development is not feasible, then perhaps restoring this land back to its natural state is the answer. A state that our great, great grandchildren do not ask why Central Appalachia was used as a bomb testing site. Which is a question I often ask myself and one that generations before us appeared to not have been as concerned with the outcomes from. As the diagram shows below there is a huge divide between the money and opportunities available where this fuel-source is burned compared to where it is processed and extracted. This case study is a shining example of environmental injustice and social inequality. It is time to even the scale.

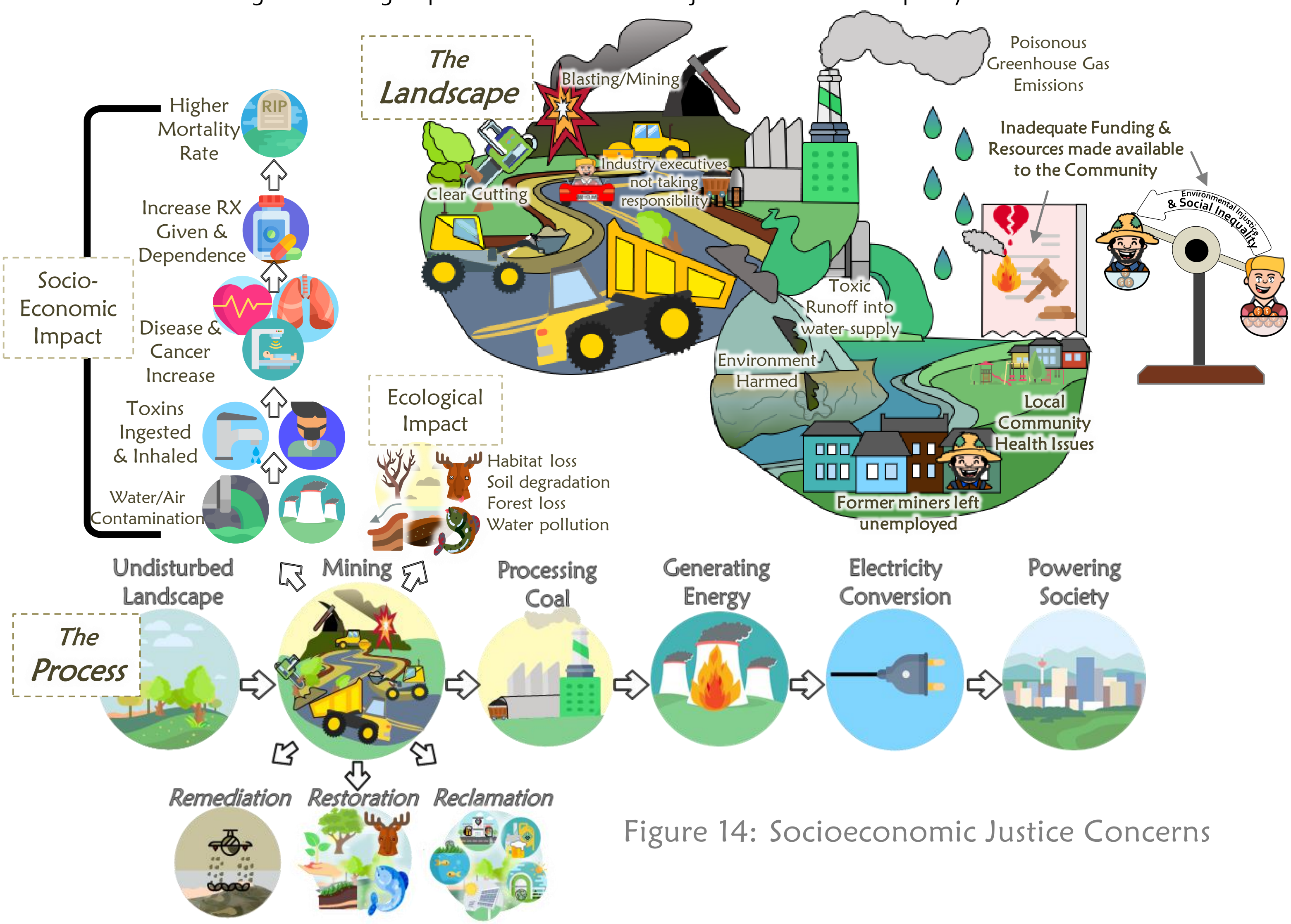


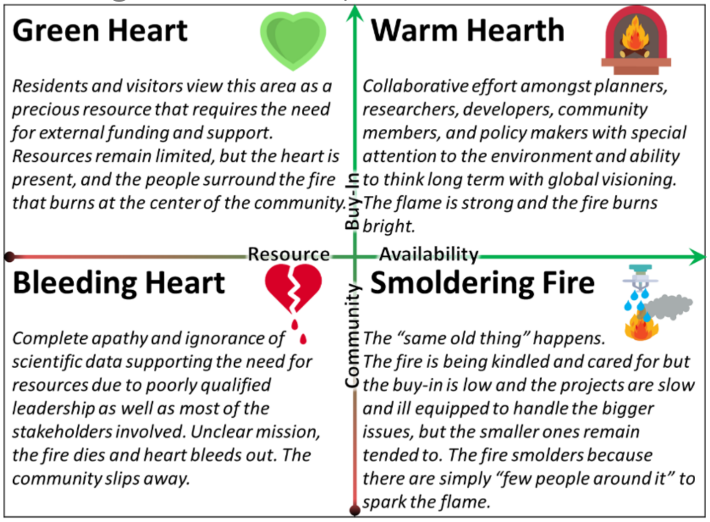
Figure 14: Socioeconomic Justice Concerns

Policy Review

The current political climate surrounding the process of surface mining and the overall acceptance, understanding, and willingness to take action to mitigate climate change is still a conundrum our world faces today. Environmental mandates have fluctuated over our history, often proven to be ineffective for mitigating the wounds that the fossil-fuel industry has inflicted. Despite laws that say the mining industry has the responsibility to restore the mountain to an appropriate contour, much of the top layer of mountain and vegetation that were stripped and cut away end up in the valley fill below. This pairs with higher erosivity while altering flow rates and accumulation of rainfall, which increases flooding and the amount of toxic chemicals found in the drinking water sources. Therein lies the problem regarding community health and ecological issues as highlighted. To better understand how this problem is so drastically effected by policy, it is important to understand how a planning scenario matrix works. It is a simple, measure of the drivers that can bridge the gap, connecting a problem to a solution and leading toward a path of positive change.

Figure 15: Required Resources & Engagement

Figure 16: Policy Scenario Matrix



This scenario shows the vertex between the amount of resources available to be dedicated to a problem like surface mining in comparison to the Y-axis expressing engagement from the community. These are the two primary factors in the implementation of successful, strategic planning geared toward effective policy adaptation. The top right is the best-case scenario and the bottom left is the worst. The Heart of Appalachia as a region could be best described as a "bleeding heart" as lower community engagement and under-funding generally persist. The "HEART Model" aims to influence decision makers to increase funding and bring greater awareness to the issue to turn this "bleeding, breaking Appalachian Heart" into a "Warm Hearth."

The idea of using the lands to build a new economy amidst the decline of the coal industry has been gaining more attention recently as the RECLAIM Act was passed by the U.S. House Committee on Natural Resources, a Congressional committee of the U.S. House of Representatives, to go to the floor for a vote. This bipartisan bill would direct $1 billion dollars from the Abandoned Mine Land fund over the next five years to restore abandoned lands to revitalize communities in the Heart of Appalachia, but unfortunately this bill languished in Congress as the Speaker of the House, Paul Ryan, prevented it from reaching a vote. For now, the Abandoned Mine Land Program currently only provides about 10% of that hopeful $1 billion with around $110 million annually to this region. It is no wonder that only approximately 10% of mines have been properly reclaimed for economic use or restored to natural state. One of the original sponsors of RECLAIM Act, House Rep. Morgan Griffith of the 9th VA district covering the coalfield region, stated the following:

> ***"Democrats and Republicans are coming together to identify a way that we can help make the environment better, help create jobs, and help people who are skilled but want to stay living in the mountains and pursue something different as we move forward."***
>
> **–Morgan Griffith, VA 9th District**

Despite the popularity and bipartisan acceptance of this bill in the coalfield region, the National Mining Association (NMA) lobbied against the legislation to avoid having to take responsibility for their actions by placing profit over people. The NMA even stated that our main objective should be to bring back coal jobs over improvements of these sites and expressed that regulations and fees should be loosened because they are too restricting. In addition, President Trump recommended that funding going to organizations representing coalfield communities such as the Appalachian Regional Commission (ARC) be drastically cut. However, despite Trump's wishes, the ARC saw a slight increase of $9 million earlier this year. Although the region is grateful for the investments it has received, the current funds available are merely a fraction of what they could be if the RECLAIM Act is passed. While President Trump and former EPA Administrator, Scott Pruitt, claimed that over 50,000 jobs were created in the coal sector since Donald Trump became president, that number is closer to 1,300 according to the Bureau of Labor Statistics and these jobs decline more every year. Coal jobs are not coming back as coal stocks have been declining for decades and now reach an all-time low. Even if coal stocks were not diminished, it is important to point out that with advanced, automatous machinery paired with the shift from underground mining to surface mining, that less than 10% of the workers are needed in this declining industry that has left many in this region without a job to support their families.

Our federal leadership is not adequately addressing these issues and while many great local efforts persist, the demagogy overshadows the masses. The network grows as former deputy administrator and avid coal lobbyist, Andrew Wheeler, is now the director of the EPA. This is the agency established to mitigate the very problems that industries like the coal sector create. Donald Trump promised to "drain the swamp," but considering the internal culture of deceitfulness of his administration, our Nation's capital is looking "swampier" than ever. Therefore, today we must act to help our region gain the attention it needs to pivot during this critical point in our history.

It is up to us to push this forward to receive the appropriate amount of attention needed to boost and diversify this region's economy or to protect and restore these precious landscapes. The current efforts do not go unnoticed as financial resource availability grows and community buy-in increases due to advocacy from various organizations such as *Reclaiming Appalachia* or *Appalachian Voices* or the various regional planning and economic development agencies encompassing the region. Appalachian Voices provides many great additional resources with updates on policy regarding this topic. They have also repeatedly testified to congress on behalf of the region to ensure the protection of the citizens and their environment is the main priority. Despite these great efforts, this economic and ecologic opportunity needs more recognition from the general public to make these innovative projects a part of the national agenda, not just as a regional or local goal. While funding certainly helps, it takes heart (interest), soul (determination), and mindfulness (data-based decision-making) from all levels to make change happen. Imagine what can be done with a billion more dollars over the next five years. However, mining executives have the opposite motives as they continue to suggest that the miners' well-being is their greatest priority, while the truth is that many are scrambling to cut compensation given to the former workers and their families as they lobby against the passing of laws such a RECLAIM Act that would improve the region.

Figure 17: Policy Concerns

In addition to automatous machinery and diminishing deep coal seam reserves, the rapid expansion of surface mining in the 1990's can be partially attributable to environmental legislation aimed to protect human health and the environment. This result is not typically the case, but it does prove how policy can lead to unintended consequences. This was the Clean Air Act amendments of 1990 that aimed to reduce acid rain by placing further restrictions on substances such as sulfur dioxide and nitrogen oxides, expanding the number of regulated substances from 7 to 189. This left power plants with the choice to either burn low sulfur coal or install "scrubbers" on their equipment to clean the exhaust and control emissions. This drove the demand for low sulfur coal which made the blasting/digging of the mountain more feasible. In addition, changes in 2002 to the Clean Water Act by the Bush Administration created loopholes which allowed for the dumping of waste into the valleys, ultimately allowing mine operators to designate lakes, rivers, streams, and wetlands as "waste treatment systems."

Now, decades later, the end of era is upon us and innovative ways to bring a new economy awaits with an abundance of land that can be more effectively used to better the communities that have been effected most by mining. According to the Energy Information Administration, coal provided about 34% of electricity in the U.S last year. Around 64% of coal comes from surface mining in total and approximately 4% of the coal used for electricity is mined in Central Appalachia from surface mines. 97% of coal is sent out of the region to be burned according to the EIA's 2017 data. Approximately 3% (or 8,000 MW) of all Central Appalachian coal burned for electricity is burned in power plants within the Central Appalachian Region. This includes four generators at plants in WV at 4,200 (MW capacity); ten generators at plants in TN at 2,650; two generators at a plant KY at 350; and one generator at a plant in VA at 670. If surface mining in Central Appalachia ended today, no one would notice, therefore the region should invest in renewable energy.

As of 2017, an estimated 1.5% or less of US electricity comes from surface mining in Central Appalachia. This means the damage is done and the coal industry is not coming back. Society does not need Appalachia anymore but Appalachia needs society.

34% of US electricity comes from coal

64% of coal comes from surface mining operations

97% of coal is burned at plants outside of defined the region

Due to the decline in coal over recent years, awareness and investment programs have been created to gain speed on the ever-slow process that has been the predominant story regarding this topic. However even with federal attention and initiatives like POWER+ during President Obama's tenure, which aimed to reinvest in communities effected by declining coal reserves and shift in extraction techniques, the topic remains a debate. POWER+ was a collective initiative of over 30 local governments and organization in Central Appalachia which called on Congress to pass the RECLAIM Act, Miners Protection Act (protected retired miner pensions), and the POWER Initiative (Partnerships for Opportunity and Workforce and Economic Revitalization). While POWER continues to provide investments to go toward new economic opportunities.

The process remains slow and the funds are limiting but the fight will continue to seek an increase in total investments for programs supporting renewable energy, tourism, health care, food/beverage systems, and other economic development initiatives combined with increased payback requirements emplaced on the mining companies responsible. This is the premise of the RECLAIM Act previously mentioned which stands for "Revitalizing the Economy of Coal Communities by Leveraging Local Activities and Investing More," however despite its overwhelming support, the bill remains collecting dust on a desk in Washington D.C. If passed, total investments into these communities would sky rocket. Stipulations of this bill include that 30% of funds can be used for acid mine drainage, 10% for planning and administration, and no more than 50% can be solely used for mine land restoration.

Programs like POWER and other pilots provide compensation to economic developers or environmental entities seeking to meet various land use goals pertaining to the various surface mine sites. The Abandoned Mine Land Trust Fund is the monetary "handshake" between the industry and the governing bodies established to ensure justice, protect public welfare, and provide for the common defense. However, some question if those convictions remain, especially regarding this conundrum. Unfortunately, that grip is being let go in a few short years as the AML's 30-year expiration date comes in 2021 after beginning in 1990. Health advocates, environmentalists, and economic developers are pushing hard for its reauthorization.

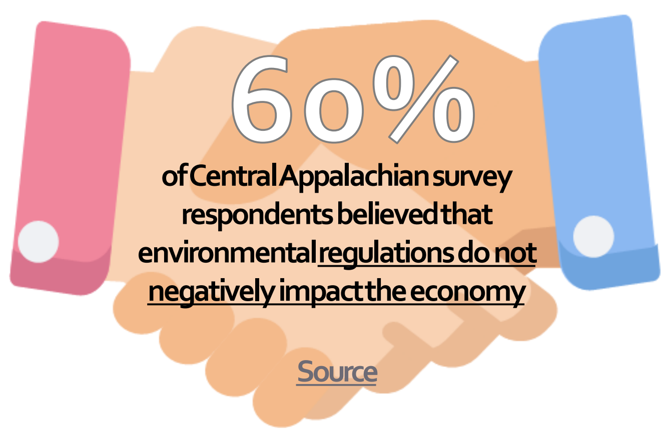
Think of the Office of Surface Mining Reclamation and Enforcement (OSMRE) at the federal level as the "hand," executing that handshake while agencies at the state level vary and can be viewed as the "fingers" using this analogy. Under federal law, these state agencies regulate the surface mine cleanup directly, giving them the power to create the tightest grip under the guidance of the "hand" or federal government. In West Virginia, this state entity is called the Department of Environmental Protection; in Virginia, this entity is the Division of Mining, Minerals, and Energy; in Kentucky it is the Department of Natural Resources; and in Tennessee it is also called OSMRE. In addition to these agencies, the EPA and Army Corps of Engineers also play a key part in the receival of funded projects. This is just a short example of the extensive stakeholder framework involved in this process. These entities collect a fee from the mining/energy companies based on production in tons to generate money to be redistributed for the various restoration or reclamation projects.

The reason behind these funding streams stem from the Surface Mining Control Reclamation Act (SMCRA) of 1977, a federal law that began four decades ago to control mining operations and allocate funds for land reclamation in order to obtain a mining permit. This is the "arm," without it, there would be no hand or handshake to get a grip on the problem (not that the "grip" has ever been as firm as it should be). Under SMCRA, exists the Forestry Reclamation Approach (FRA) which is overseen by the Appalachian Regional Reforestation Initiative (ARRI). The FRA provides guidelines that aim to re-establish healthy forests on former mines by adding a thick layer of topsoil and planting carefully selected tree species. This approach is simply a "suggested motion of the arm," if you will. Whether that motion is slow or fast is dependent upon the body which is comprised of all of US and powered by the Heart. A professor of Virginia Tech's Crop & Environmental Science Department is a consulting member of the ARRI Advisory Team. He led a research study suggesting that around 3,000 km² of mined land could be suitable for successful reforestation.

However, these are just guiding principles and are not required by law in the remediation process by the mining company resulting in inadequate restoration due to the costly methods required for successful reforestation. For these sites and the surrounding ecosystems to be protected to the fullest, these requirements must be binding by law, not just expected out of generosity. Many environmental regulatory bills have failed to provide long-term fixes regarding the mining operation. This includes bills proposed like the Clean Water Protection Act in 2009 which ultimately did not pass due to lobbying from the mining industry, despite the 170+ cosponsor of the bill and various organizations advocating for its passing. This bill would have redefined the definition for "fill material" and prevented waste from being dumped into our waterways after the 2002 Bush administration's change to the CWA.

This story of disappointment persists as the Stream Protection Rule was repealed last year (2017) under President Trump's administration and amended In February of 2019 to no longer place responsibility on the mine owners. This was a regulation intended to slow surface mining through stricter permits and it was finalized two years ago in 2016 by the Office of Surface Mining, Reclamation, and Enforcement but was denied two months later as one of the first "swings" that the president took at the environment and this region. This new legislation also prohibits any similar rule from being developed anytime in the near future.

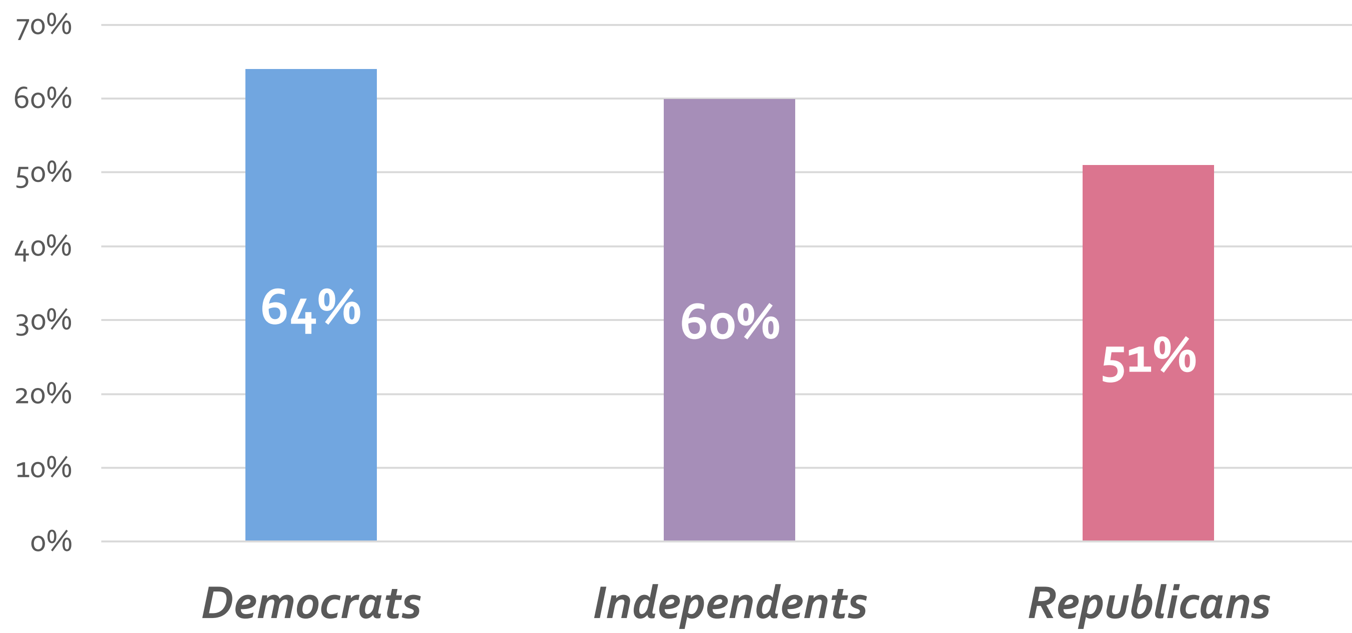
These "rules," despite their approval or denial, have inadequately lived up to their purpose of protecting the environment. For instance, the Stream Buffer Zone Rule of 1983 was supposed to prevent surface mining within 100-feet of a stream (about the length of a basketball court) but instead, mining operators were often granted exceptions to avoid adhering to the permit by arguing that the regulation would prevent thousands of jobs.



Ultimately, the dilemma exists due the low level of priority typically placed on ecological protection and health impacts in rural communities from the national and state level. This has typically been the case regarding many sustainability and equity related issues pertaining to the environment and society as profit from industry is often marginalized over the prosperity of the community. Therein lies the difference between economic growth and economic development. In terms of prosperity, the Heart of Appalachia is experiencing more hardship than success. Growth is not the same as development in that economic growth is necessary for economic development, but development is not contingent upon economic growth. Economic development is concerned with the long-term goals of a region's well-being which includes their livelihoods and anything effecting the environment that surrounds. The effects of sustainable economic development may lead to economic growth, but it is not the sole focus as much as prosperity or the ability to live a meaningful life is. Economic development alleviates people from lower standards of living into a more prosperous one which cannot be measured solely by a region's GDP, total number of jobs, or housing stock.

Economic development and adequate protection of natural resources is the basis of sustainability, particularly in regards to the reuse of land and issues associated to energy, for example our reliance on fossil-fuels. Effective change requires an upward movement of the entire social system. The "Heart" that powers the body needs appropriate actions to be taken to meet the necessary goals that reliable data can provide to make more informed policy and planning decisions moving forward. Resources made available to this issue will be a direct linkage to the implementation of successful policy making, socio-economic prosperity, and ecological protection moving forward as new information is gained and understood. The creation of new data and knowledge of the linkages between them does not solely lead to acceptance. It will be an uphill battle to reach the top and undo the damage done from loosened regulations on this industry. Not to mention the illegitimate claims from certain leadership that has created a false impression regarding the fate of coal employment . It also does not help that by 2020, the exit from the global climate change agreement, Paris Climate Accords, will be complete which will hinder our ability to deal with these effects from the federal level.

Figure 18: Percent of Voters by Party Opposing Surface Mining



The figure above is from a study implemented by Earthjustice, the Appalachian Mountain Advocates (formerly the Appalachian Center for the Economy and the Environment) and the Sierra Club in 2011. The study was conducted on over 1,300 registered voters in a survey created by Lake Research Partners and Bellwether Research & Consulting Group. The survey found that voters oppose surface coal mining by wide margins in the counties within or nearby the study area previously defined in this report. These states included Virginia, West Virginia, Kentucky, and Tennessee. This opposition to surface mining in the Heart of Appalachia and the decision makers who are involved exists across party lines. Opposition to the practice included 64% of Democrats, 60% of independents and 51% of Republicans. Source.

HEART Model

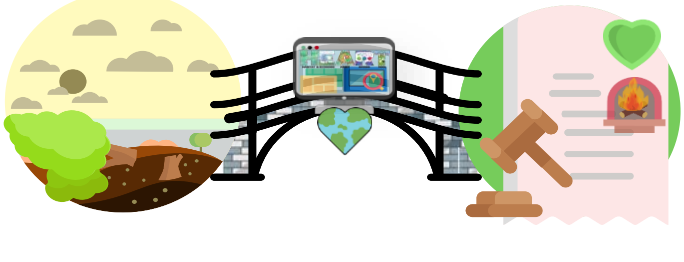
In the age of big data and increased computational capabilities, GIS has transformed the way in which new land development is planned and the ways which sites are more accurately evaluated in their assessment. In addition, data is becoming more available to the public at higher spatial and temporal resolution to implement into applications such as the H.E.A.R.T. model which can cut out the traditional trial-error approach and cut down the time it takes to choose a site by eliminating ones that do not fit the requirements by statistically rating the ones that are most suitable for either ecological restoration or economic development purposes. These ratings can then be sorted to narrow the focus down to a few rather than an overwhelming many.

There are thousands of square kilometers of surface mining sites varying in size and capacity in the Central Appalachian area but only sites in Virginia or West Virginia were considered in the analysis. After ground truthing the SkyTruth mining layer, there were approximately 800 km2 of surface mine area to evaluate in the H.E.A.R.T. model. The analysis considered assets based on various site requirements specifically outlined on the following pages. The geographic modeling tool used various layers and normalized them to calculate standard scores at normal, scaled distribution for ranking purposes generated from the various weighted factors incorporated in the model. Using GIS, data can be derived from spatial datasets in raster or vector formats at the site specific or county level.

Differing weights can be used to accommodate for the relevance the factor has on the asset being assessed. These weights can be changed to alter the output that shows sites more preferred for restoration or reclamation goals. On the project webpage, the user will be able to alter these weights or coefficients as desired to generate varying model outputs with varying preferences based on varying goals.

Geographic data is always linked to spatial relationships. For instance, the proximity tools analyzes how close or far multiple features are to one another. Proximity from the site to various factors is one of the most telling forms of assessment. For instance, cells located near one of the various factors chosen will have a lower value because it is closer (shorter distance) to the specific site parameter being analyzed, making them more or less favorable, depending on the goal. Proximity to roads, rails, utilities, water, attractions, higher education, industries, labor force, and certain factors related to the population as well as factors such as soil properties, surrounding land cover, land use goals, mine size, slope degree, slope orientation etc. are all some of the factors which may be considered when planning the future use of these former surface mines.

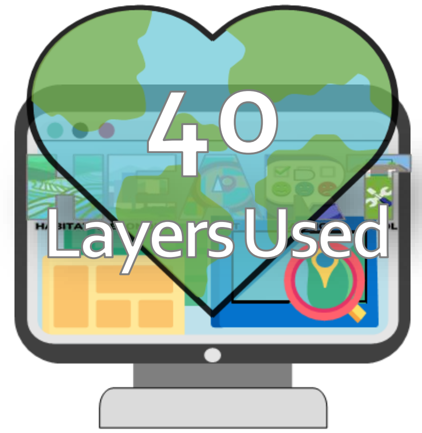
Figure 19: H.E.A.R.T. Model Bridging Gap



Rationale & Considerations

There are many opportunities that can make better use of these surface mines which are no longer active and provide merit for further discussion to channel more resources like policy changes and funding. The following are ways in which geospatial science analyzes data by overlaying multivalued datasets to better inform decisions when choosing habitat or economic assets:

- Sites closer to certain social groups such as younger populations, impoverished people, disabled people or to certain economic activities such as tourism resources or higher education institutions can help choose best sites.
- Sites are cleared of vegetation and graded to have <u>minimal</u> slopes. GIS data can select the flattest areas to lower costs and time associated with adding infrastructure.
- Sites that have relatively quick access to roads will be closer to primary roads and commuters in the labor force or methods of transportation such as railroads.
- Sites are typically far away from housing and other businesses, therefore development set-backs are not an issue (water resources, residential areas, other agriculture)
- Sites are typically in elevated areas which reduces the risks of flooding and direction of slope can be used so that it increases total sunlight received during the day on <u>southwestern</u> slopes.
- Sites are often located near water which is a key input for certain operations such as nurseries, greenhouses, aquaculture, breweries, or even restored habitat.
- Sites with scenic views <u>overlooking</u> the region in a remote location where drug and alcohol rates are high may be considered for drug and alcohol recovery centers.
- Sites close to surrounding forest or near existing land use goals such as conservation or protected land can be chosen to better refine the habitat restoration model.
- Site soil type <u>impacts</u> drainage, absorption, erodibility, albedo, crop potential, flood risk, etc. which can be used to meet development and agricultural preferences for the asset.
- Sites closer to powerlines or power plants may be highly considered for solar parks.

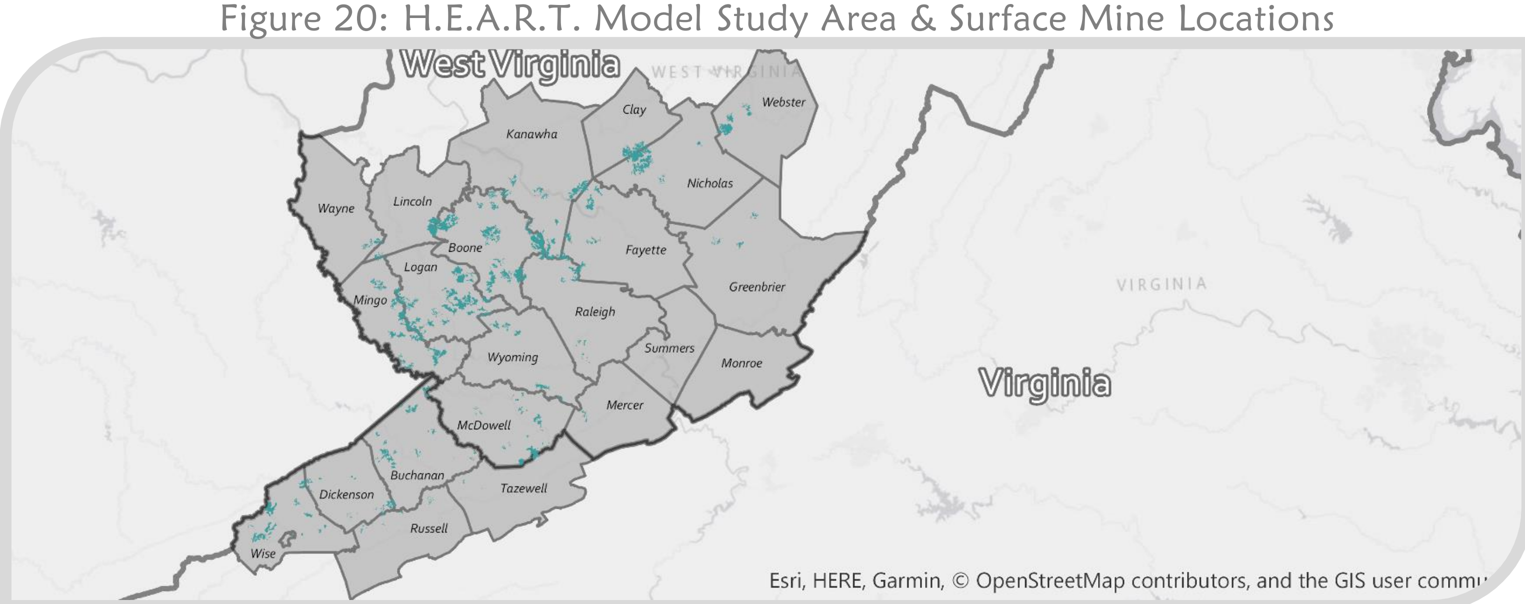


While GIS is a powerful tool for planning purposes and site evaluations, there are many data limitations that persist and should be considered when considering the output results. One limitation in doing a soil analysis of these sites is that the soil data is based on data surveyed for the site prior to the mining. This is also the case for elevation data, therefore an exact slope assessment is difficult. Both water and soil testing is needed at each surface mining site to determine the viability of developing the site for agricultural production. Another limitation for this model is the lack of site data pertaining to utility infrastructure available on or near the site. These are limitations that would need to be improved on in future studies when specifically looking at assets.

In addition to the data limitations, there are drawbacks that factor into the decision making of a developer such as things like land use regulations specific to a mine site which may not allow for agriculture facilities or industrial sites. Also, the expenses required to make roads and utilities accessible could be large and require additional digging and grading. Lastly, leftover contaminants and the degradation of the top soil may hinder certain sites for agriculture or ecological restoration and require more funding to make feasible.

H.E.A.R.T. Model Study Area

Figure 20: H.E.A.R.T. Model Study Area & Surface Mine Locations



Methods

The model was developed from the use of 40 data layers within the study area encompassing 20 counties in Virginia or West Virginia within the Heart of Appalachia. The model was created using the cell-to-cell overlay methods to create normalized weighted indices for comparison. This overlay example is depicted in the graphic below. The following is a detailed list of the steps used to perform this analysis:

- First, a list of relevant data was created with data source, year, and the tool needed to create or process it.

- Cumulative mining layer from SkyTruth study within the "Virginias" was reclassified and converted to polygons.

- Obsolete sites were eliminated after ground proofing. This step took some serious time to correct mistakes from the remotely sensed land classification model so that only actual surface mine sites were used. This left approximately 240 sites to merge the data with.

- Raster layers were collected and prepared for zonal overlay extraction, while vector county-level information was spatially joined to a county layer so each surface mine was given a value based on each data measure.

- Proximity layers such as proximity to roads, water, utilities, etc. were calculated using the Euclidean distance tool.

- Raster layers such as these Euclidean distance layers were joined to the proportional five kilometer mine site buffers using the zonal statistics tool which contained a matching unique identifier to the original surface mine layer. These buffers were created from each mine's center point to give a normalized representation of each.

- The mean and standard deviation were calculated to standardize the data to a normal statistical distribution scale.

- Only mine sites with the appropriate size and aspect (direction that slope generally faces) were considered.

- All mine layers were scaled between 1 and 240. In other words, if a site had the most preferred value, it received the highest score closer to 240 with less preferred values decreasing to 1 for continuous data. Discreet data that resulted in groups or classes of data values were assigned proportional values scaling from 240 to 1 as well. In other words, if the top sites for soil drainage had an equal value of 16, they were given an equal proportional index value of 220, and if the next class down was 8, then sites with a value of 8 were assigned 110 for example to given normal distribution.

- After mean data values were assigned to each surface mine site and scaled, weights were determined for each data layer based on the way in which the data layer impacts the site selection based on the asset type. In other words, a higher population positively influences the model as it suggests areas that are less rural, while a lower slope value means the surface is flatter which favors development or restoration of the site. If data lower data values were in favor of the model, those indices were reversed so that a lower value would result in a greater score to be factored into the model. In other words, data layers could be placed under three classes to be multiplied to the normalized data where a higher preference was assigned a weight of 1.6, a medium preference assigned a weight of 1.3, and low preference was not multiplied by a weight but still used in the sum of all.

-The model was run after collecting, joining, standardizing, and assigning weights so that each site could be ranked based on the sum of the final weighted factors related to each asset type (solar parks, drug/alcohol recovery centers, breweries, aquaculture facilities, greenhouses, and habitat).

-Sites that that were highly suitable for economic development assets were removed from consideration from the habitat restoration asset model. The model resulted in approximately 45 sites that ranked within the top 30 for each economic asset type, while approximately one-third or 15 of those sites made the ranks for all five site types and may be considered first for economic development purposes.

- Keeping to this method, the top 45 sites were considered for ecological restoration. My proposal is that these top 15 sites for economic development and top 15 sites for ecological restoration should be the first 5 year goal with completion of all projects by 2025. The next 15 sites could be the goal for 2030 and the remaining sites could be the goal for 2035 so that after a 15 year period the top 45 economic development asset sites and the top 45 ecological restoration sites may be complete or in progress. While this is an ambitious goal, it would mean that approximately one-third of the 240 mining sites in the Virginias in Appalachia would be an asset for the local communities over the next 20 years.

- The following pages provide information on the tools used, data sources, model results and a map of the nonduplicative sites chosen with an example of the assets.

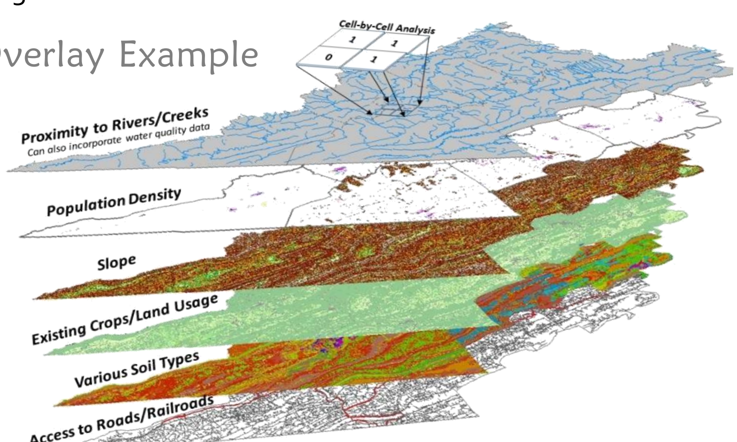


Figure 21: Data Overlay Example

Data Information

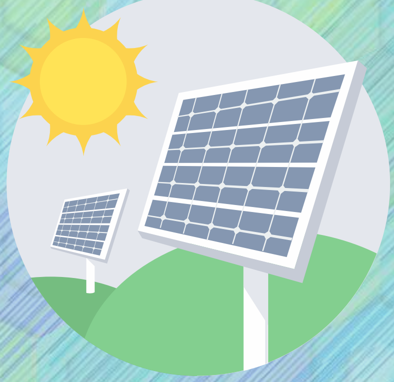
The 'aspect' layer comes from USGS and was originally collected in 2015. The data was extracted at the site scale and was processed using the zonal statistics tool. This data layer has a conditional influence, in other words, sites were only selected if they met aspect requirements. The 'size' layer comes from EIA and was originally collected in 2017. The data was extracted at the site scale and was processed using the area calculation tool. This data layer has a conditional influence, in other words, sites were only selected if they met size requirements. The 'slope' layer comes from USGS and was originally collected in 2015. The data was extracted at the site scale and was processed using the zonal statistics tool. This data layer has a negative influence, in other words, a lower value means flatter topography. The 'soil drainage class' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means better drained soils. The 'soil albedo' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means darker surface and greater organic matter. The 'soil erodibility and corrosivity' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means lower susceptibility to erosion. The 'proximity to amenities (entertainment, tourism, outdoor recreation)' layer comes from Database USA and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to colleges & educational institutions' layer comes from Database USA and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to power plant' layer comes from EIA and was originally collected in 2017. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to river/lakes' layer comes from USGS and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to rail' layer comes from TIGER/LINE and was originally collected in 2015. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to power lines' layer comes from HIFLD and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to protected area' layer comes from USGS and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to primary roads' layer comes from TIGER/LINE and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'proximity to streets' layer comes from TIGER/LINE and was collected in 2018. The data was extracted at the site scale and was processed using the Euclidean distance-5km buffer from mine centroid-zonal statistics tools. This data layer has a negative influence, in other words, a lower value means the surface mine is closer. The 'commuting times' layer comes from ACS and was collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a negative influence, in other words, a lower value means a shorter commute time. The 'food insecurity index' layer comes from USDA and was originally collected in 2015. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a negative influence, in other words, a lower value means more food insecurity. The 'historical and projected population decline from 2010-2030' layer comes from ACS and was collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a negative influence, in other words, a higher value means greater population growth. The 'mental health providers' layer comes from Database USA and was originally collected in 2017. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means a larger labor force. The 'agriculture and forestry workers' layer comes from BLS and was collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means a larger labor force.

Data Information Cont'd

The 'health and community care service workers' layer comes from BLS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means a larger labor force. The 'engineers, electricians, contractors, and installers' layer comes from BLS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means a larger labor force. The 'food and beverage manufacturing and processing workers' layer comes from BLS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means a larger labor force. The 'job postings' layer comes from VEC/EIS/WVBEP and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means greater frequency of job postings. The 'local poverty' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means greater poverty rate. The 'total population' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means greater population total. The 'generation X, Y, and Z' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means greater presence of 50 years old and under. The 'housing units' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means more places to live. The 'disabled population' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means more people with disabilities. The 'households with kids' layer comes from ACS and was originally collected in 2018. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means more families. The 'drug overdose rate' layer comes from CDC and was originally collected in 2016. The data was extracted at the county scale and was processed using the spatial join tool. This layer has a positive influence, in other words, a higher value means greater drug dependence.

The 'alcohol dependency and excessive drinking rate' layer comes from BRFSS/CHR and was originally collected in 2016. The data was extracted at the county scale and was processed using the spatial join tool. This data layer has a positive influence, in other words, a higher value means greater alcohol dependence. The 'surrounding forest canopy cover' layer comes from NLCD and was originally collected in 2011. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means greater surrounding forest density. The 'soil runoff' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means lower runoff potential. The 'soil flood hazard area' layer comes from FEMA and was originally collected in 2013. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means lower flood potential. The 'soil crop potential' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means greater crop production potential. The 'soil farmland class' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means greater crop production potential. The 'soil rainfall absorption' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means lower ability to retain moisture. The 'soil bedrock depth' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means larger depth to bedrock. The 'soil hydric class' layer comes from USGS and was originally collected in 2017. The data was extracted at the site scale and was processed using the 5km buffer from mine centroid-zonal statistics tools. This data layer has a positive influence, in other words, a higher value means lower ability to retain moisture.

Solar Parks



For every 1 job that coal provides, solar energy can provide 8 and the future of energy is not in coal, it is solar energy consumption. Last year solar energy employed twice as many people in America than coal did. Surface mining sites that have been cleared and graded to a flatter contour are prime locations to capture solar radiation. With Central Appalachia being traditionally dominated by coal extraction as an economic driver, new emerging and sustainable solutions should be considered to bring employment opportunities and an energy source back to the communities. There is not a better location than on a site above much of the surrounding topography and exposed to an average of six hours of peak sunlight during the day. This production can compare to a small coal power plant and be tied to the electrical grid. The last region to invest in coal energy will be the first to be deprived of its true power and capital.

There were 22 data factors considered for the model. Only sites that were at least 100,000 square kilometers and with a slope orientation facing south to west were given a high preference for the solar model. Southwestern facing slopes provide the maximum amount of sunlight during the day and this lot size is the average size for a solar farm. A lot this size could produce as much as 100 megawatts of electricity per day depending on the solar panel quality and amount of sunlight which depends on clouds and surrounding tree canopy conditions. The top sites included mine sites 28 and 64 of Kanawha County-WV as well as mines 186 of Tazewell County-Va, mine 185 of Buchanan-Va, and mine 219 of Russell County-Va. All sites ranked within the top 85 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, these sites can be seen on the following page with an example of how this sites appears.

Table 1: Weights by Data Layer

Data Layer	Weight
Proximity to Power Plant	1.6
Proximity to Power Lines	1.6
Projected Population Decline (2010-'30)	1.6
Labor force (engineers/electricians/contractors)	1.6
Gen X, Y, Z	1.6
Slope	1.3
Soil Albedo	1.3
Soil Erodibility/Corrosivity	1.3
Proximity to Amenities such as entertainment, tourism, outdoor rec.	1.3
Proximity to Higher Ed. Institutions	1.3
Proximity to Primary Roads	1.3
Proximity to Streets	1.3
Total Population	1.3
Housing Units	1.3
Families (households with kids)	1.3
Aspect	1.0
Size	1.0
Proximity to Rail	1.0
Commuting Times	1.0
Job Postings	1.0
Surrounding Forest Canopy Cover	1.0
Soil Flood Hazard Area	1.0

Solar Parks

Figure 22: Suitable Surface Mining Site Locations for Solar Parks

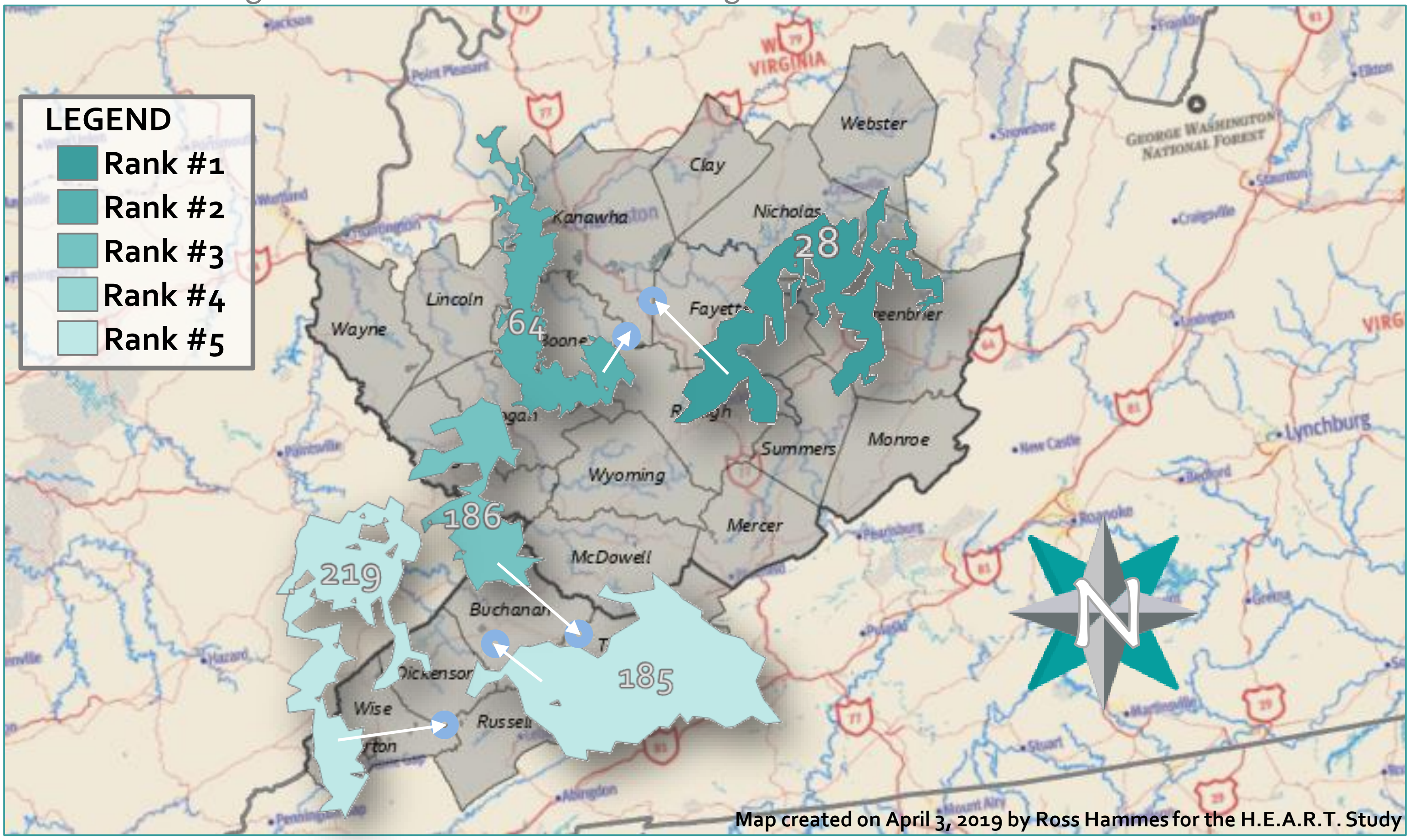


Figure 23: Example of Solar Park on Former Surface Mine

This is an imagined image of an industrial sized solar park on a former surface mining site where flattest sites receive sunlight for a majority of the day and have minimal shade. This site is imagined to be close to power lines and industrial power hubs such as former coal power plants.

Breweries

Breweries are a great escape to the solitude of the mountains and are great for all ages. Whether it's a small family, group of elderly friends, or two young hearts crossing paths on their first date, places such as these are jewels to the region and can be used as an economic driver to attract users of the 800+ miles of off-roading trails encompassing this study area from the Spearhead Trails in Virginia or Hatfield & McCoy trails in West Virginia. There is also an array of cultural heritage pertaining to bluegrass as expressed through the Crooked Road Music Heritage Trail. This type of venue would be an incredible start for anyone looking to share their passion and talents with the region. This type of economic asset can generate many full-time and part-time jobs for the regional labor force if it is also opened as a restaurant which is why locations near higher density populations were given preference.

There were 19 data factors considered for the model. Only sites that were at least 30,000 square kilometers were considered for the model as this lot size is the average size of the land needed for this economic development asset. The top sites included mine sites 27, 18, and 47 of Kanawha County-WV as well as mines 230 and 227 of Tazewell County-Va. All sites ranked within the top 85 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, these sites can be seen on the following page with an example of what this site may look like inside and out.

Table 2: Weights by Data Layer

Data Layer	Weight
Proximity to River/Lakes	1.6
Projected Population Decline (2010-'30)	1.6
Labor force (agriculture/forestry)	1.6
Gen X, Y, Z	1.6
Proximity to Higher Ed. Institutions	1.6
Proximity to Amenities such as entertainment, tourism, outdoor rec.	1.3
Slope	1.3
Proximity to Rail	1.3
Proximity to Power Lines	1.3
Proximity to Primary Roads	1.3
Proximity to Streets	1.3
Labor force (food/beverage)	1.3
Total Population	1.3
Housing Units	1.3
Families (households with kids)	1.3
Size	1.0
Commuting Times	1.0
Labor force (engineers/electricians/contractors)	1.0
Job Postings	1.0

Breweries

Figure 24: Suitable Surface Mining Site Locations for Breweries

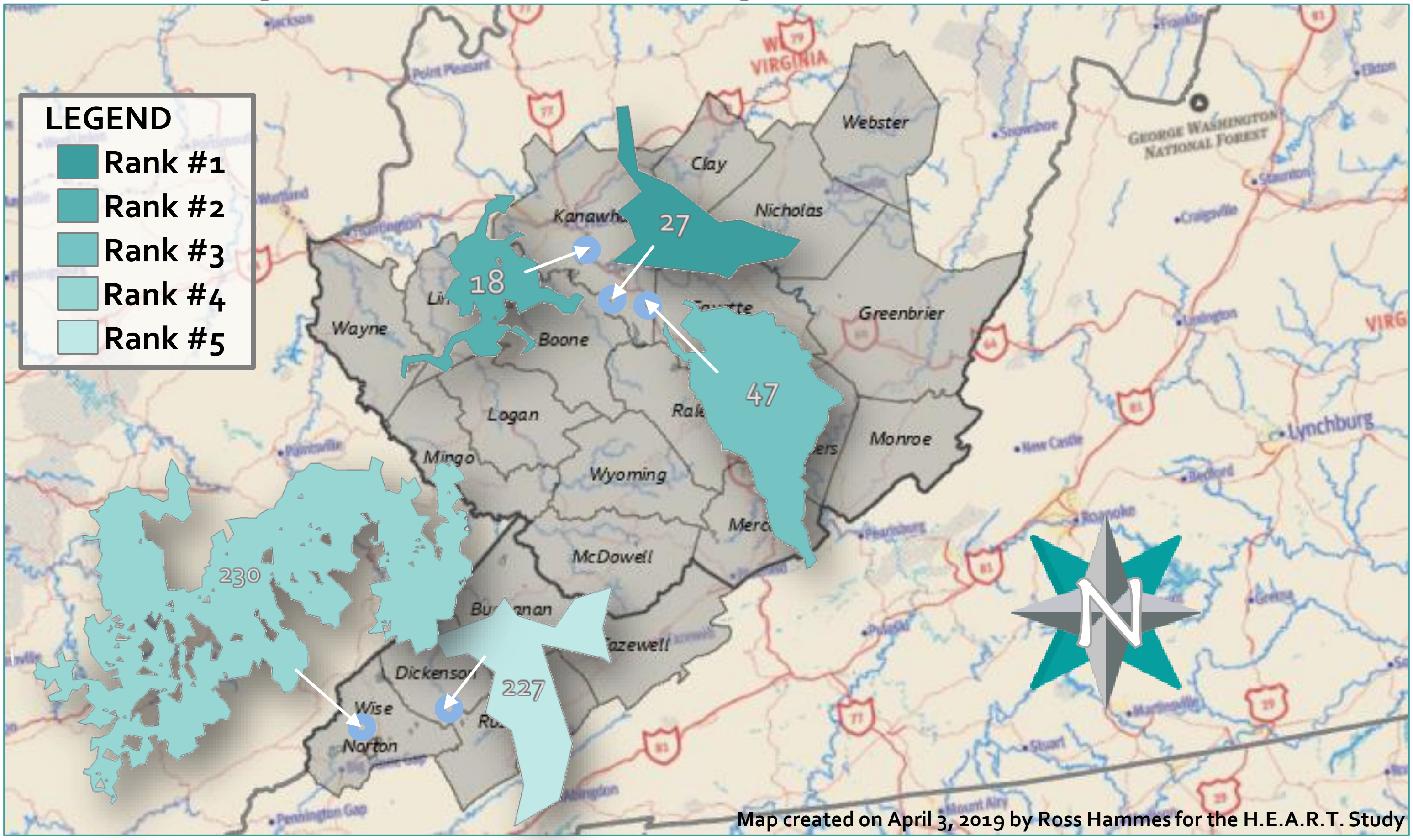
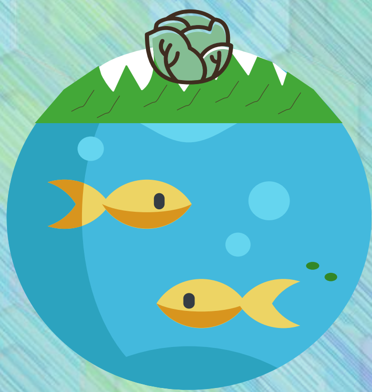


Figure 25: Example of Brewery on Former Surface Mine

Who wants a brew with a view? This is an imagined image of an industrial sized brewery on a former surface mining site where sites are closest to a primary road and water source for example. This also imagines remaining land as replanted and grown on other parts of the landscape.

Aquaponics



Aquaponics facilities are a hybrid between aquaculture and hydroponics. Aquaculture is a term used for industries growing water based proteins similar to a poultry operation but for fish instead. Hydroponics is a operation that utilizes tanks of water to nourish the roots of certain edible and medicinal plants by providing constant nutrients via the water supply rather than through sprinkler systems. Aquaponics are a combination of both systems to save costs and allow a natural system to run their course. This operation allows for the production of vegetables and leafy greens as well as water based protein. As the fish produce waste, the water is filled with nutrients for the plant's roots to absorb and filter the water, in the process saving money on maintaining the fish tanks and on nourishing the plants. Just feed the fish and watch it all grow! The more fish, the more nutrients can be drawn from the water for certain crops but this requires larger tanks and more space. This operation can vary drastically and often take place in facilities similar to indoor greenhouses that draw from outside tanks collecting rainwater and fed by local creeks. Catfish, perch, bass, and tilapia while plants are typically leafy greens such as lettuce, spinach, and kale. Peppers, tomatoes, broccoli, and beans require systems with more fish.

There were 32 data factors considered for the model. Only sites that were at least 20,000 square kilometers and with a slope orientation facing south to west were considered for the model. Southwestern facing slopes provide the maximum amount of sunlight during the day and this lot size is the average size for an aquaponics facility. The top sites included mine site 26 of Kanawha County-WV, mine 77 of Raleigh County-WV as well as mines 226, 237, and 238 of Wise-Va. All sites ranked within the top 85 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, these sites can be seen on the following page with an example of what this site may look like inside and out.

Table 3: Weights by Data Layer

Data Layer	Weight
Projected Population Decline (2010-'30)	1.6
Labor force (agriculture/forestry)	1.6
Gen X, Y, Z	1.6
Slope	1.3
Soil Drainage Class	1.3
Soil Albedo	1.3
Soil Erodibility/Corrosivity	1.3
Proximity to Amenities	1.3
Proximity to Higher Ed. Institutions	1.3
Proximity to River/Lakes	1.3
Proximity to Rail	1.3
Proximity to Power Lines	1.3
Proximity to Primary Roads	1.3
Proximity to Streets	1.3
Labor force (food/beverage)	1.3
Total Population	1.3
Housing Units	1.3
Families (households with kids)	1.3
Aspect	1.0
Commuting Times	1.0
Food Insecurity Index	1.0
Labor force (engineers, contractors)	1.0
Job Postings	1.0
Surrounding Forest Canopy Cover	1.0
Soil Runoff	1.0
Soil Flood Hazard Area	1.0
Soil Crop Potential	1.0
Soil Farmland Class	1.0
Soil Rainfall Absorption/Hydric Class	1.0
Soil Bedrock Depth	1.0

Aquaponics

Figure 26: Suitable Surface Mining Site Locations for Aquaponics Facilities

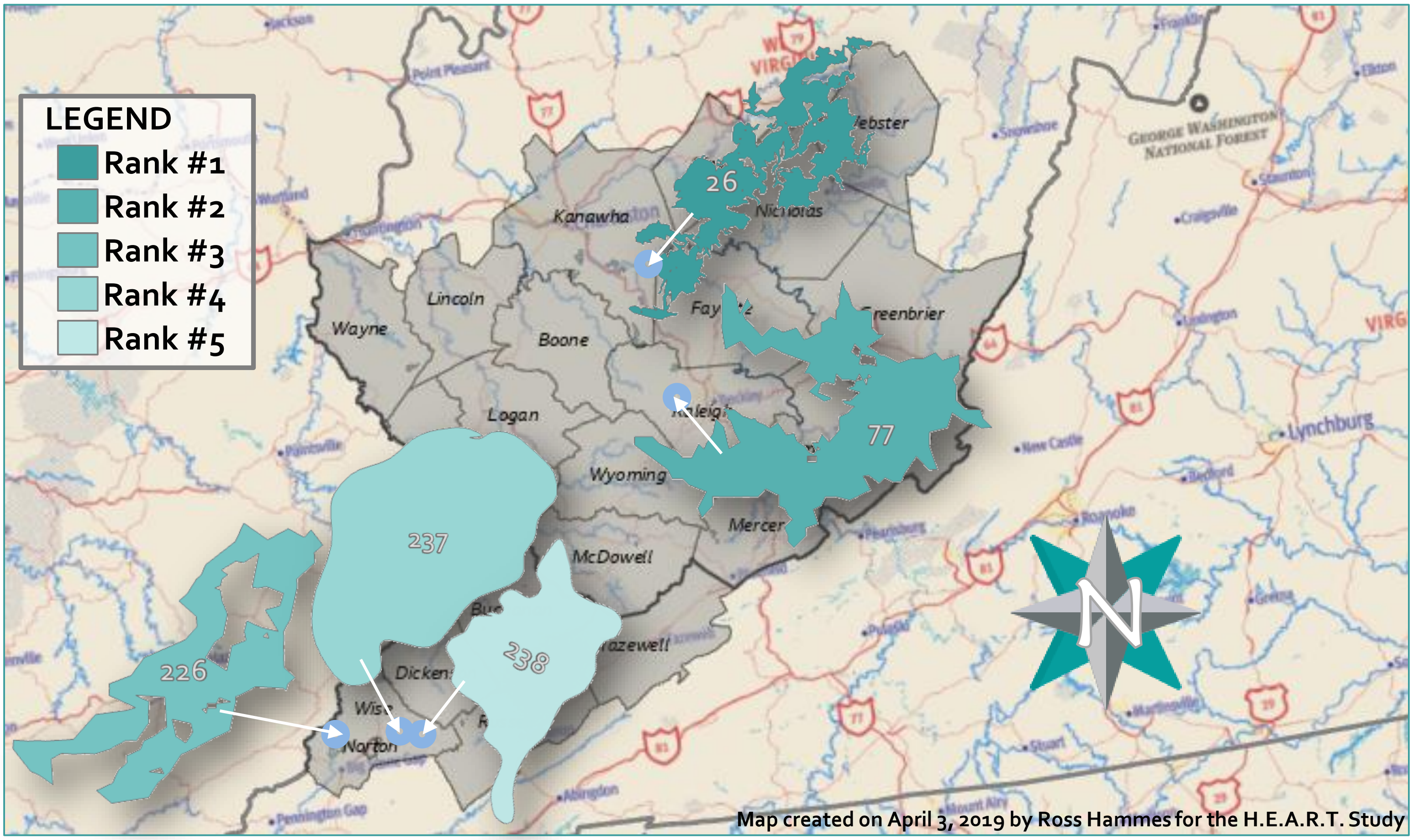


Figure 27: Example of Aquaponics Facility on Former Surface Mine

This is an imagined image of an industrial sized aquaponics facility on a former mining site where sites with maximum sunlight and closest to a primary road and water source were preferred. This also imagines remaining land as replanted and grown on other parts of the landscape.

Greenhouses & Nurseries

Greenhouses and nurseries are very similar with their only difference being climate control. A greenhouse allows for certain conditions to be replicated for optimal production of certain crops, while nurseries are typically exposed to the outdoor elements. In a temperate climate such as Central Appalachia, there are many suitable crops that could grow well in either circumstance as the weather is often fair with seasonal weather patterns. The surrounding land was considered in the analysis to prefer certain soil conditions that could favor crop growth. These properties were highly considered to save costs when adding soil to soil beds. One emerging opportunity is the potential to grow marijuana or the "cash crop" of today's market. Although this plant is not legal in Virginia, it is medically legal In West Virginia as of next year and may soon be in recreational according to a new bill that has been gaining headway over the last year. This is the reason why more sites in West Virginia were chosen over sites in Virginia for the first round of site selections. Much like the energy in which the skies provide, this plant can be a miracle remedy for many. Aside from this opportunity, there are hundreds of other plants such as vegetables that can be grown in greenhouses for nutritional consumption.

There were 34 data factors considered for the model. Only sites that were at least 20,000 square kilometers and with a slope orientation facing south to west were considered for the model. Southwestern facing slopes provide the maximum amount of sunlight during the day and this lot size is the average size for an aquaponics facility. The top sites included mine sites 24 and 30 of Kanawha County-WV, mine 139 of Mercer County-WV as well as mine 218 of Russell County-Va and mine 153 of Buchanan County-Va. All sites ranked within the top 85 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, sites can be seen on the next page with an example of what they may look like inside and out.

Table 4: Weights by Data Layer

Data Layer	Weight
Projected Population Decline (2010-'30)	1.6
Labor force (agriculture/forestry)	1.6
Gen X, Y, Z	1.6
Slope	1.3
Soil Drainage Class	1.3
Soil Albedo	1.3
Soil Erodibility/Corrosivity	1.3
Proximity to Amenities	1.3
Proximity to Higher Ed. Institutions	1.3
Proximity to River/Lakes	1.3
Proximity to Rail	1.3
Proximity to Power Lines	1.3
Proximity to Primary Roads	1.3
Proximity to Streets	1.3
Labor force (food/beverage)	1.3
Total Population	1.3
Housing Units	1.3
Families (households with kids)	1.3
Aspect	1.0
Commuting Times	1.0
Food Insecurity Index	1.0
Labor force (engineers, contractors)	1.0
Job Postings	1.0
Drug & Alcohol Dependency	1.0
Surrounding Forest Canopy Cover	1.0
Soil Runoff/Flood Hazard Area	1.0
Soil Crop Potential/Farmland Class	1.0
Soil Rainfall Absorption/Hydric Class	1.0
Soil Bedrock Depth	1.0

Greenhouses & Nurseries

Figure 28: Suitable Surface Mining Site Locations for Greenhouses or Nurseries

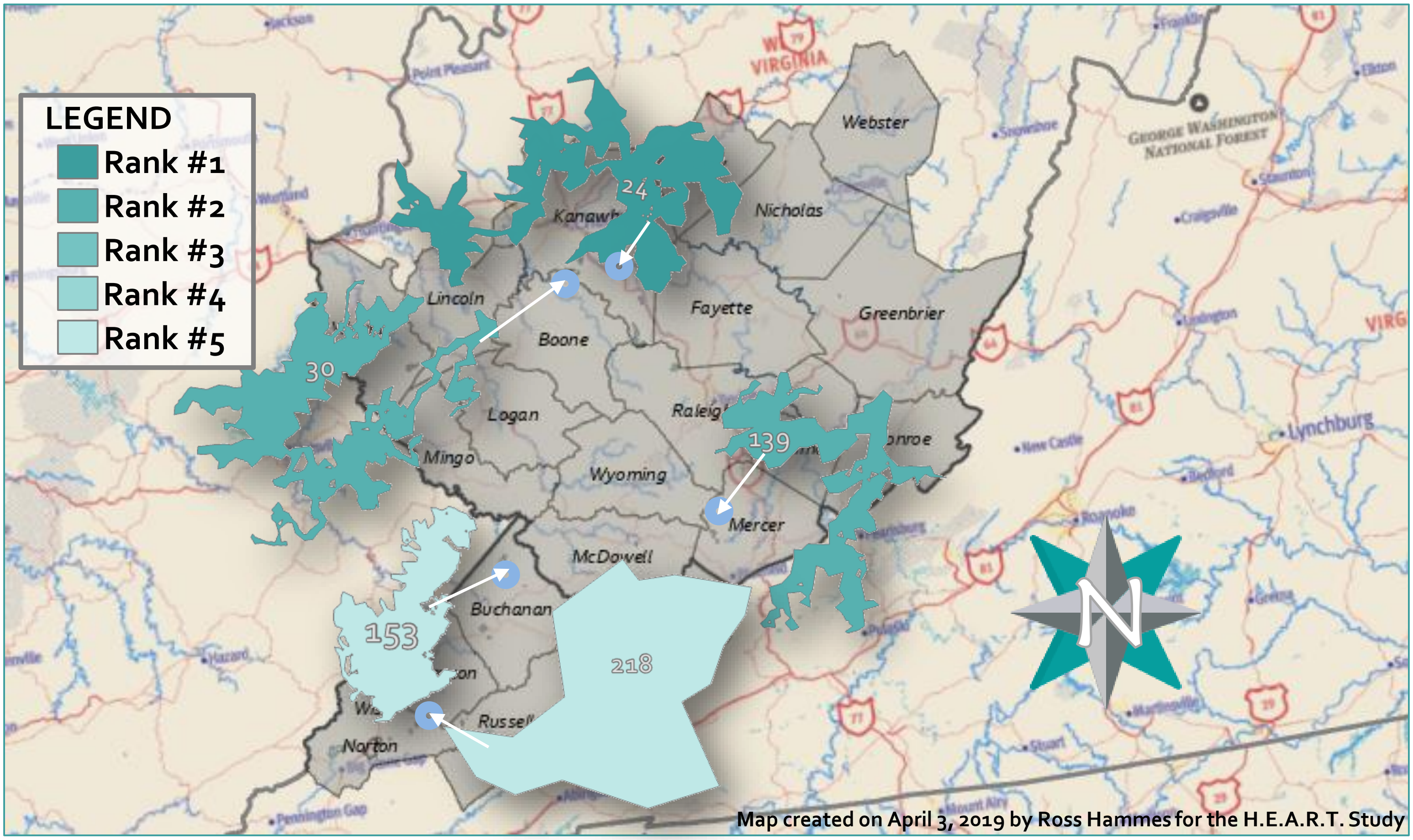


Figure 29: Example of Greenhouse on Former Surface Mine

This is an imagined image of an industrial sized greenhouse facility on a former mining site where sites with maximum sunlight and closest to a primary road and water source were preferred. This also imagines remaining land as replanted and grown on other parts of the landscape.

Recovery Centers

Drugs such as opioids and alcohol such as liquor can easily lead down a road toward addiction. The Heart of Appalachia has a marginally high drug and alcohol consumption rate per person when compared to other areas. This may likely be due to many of the factors outlined in the socio-economic impacts section as well as the higher number of distressed communities in the region which experience higher unemployment rates and income below the poverty level with lower educational attainment opportunities. It is easy to turn to substances when times become difficult to bear. Creating drug and alcohol recovery and rehabilitation centers on secluded former surface mine sites far away from opportunities to relapse can also provide beautiful scenic views to possibly find a deeper meaning of life. While this is an economic asset as it could bring jobs to areas with an already highly trained health related workforce and mental health providers, it is also a social asset in that provides opportunities to those from within or out of the region to recover and hopefully get back on the right path.

There were 21 data factors considered for the model. Only sites that were at least 40,000 square kilometers were considered for the model as this lot size is the average size of the land needed for this economic development asset. The top sites included mine sites 23 and 25 of Kanawha County-WV, and site 144 of Mercer County-WV, as well as mine 221 of Wise County-Va and mine 174 of Buchanan-Va. All sites ranked within the top 85 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, these sites can be seen on the following page with an example of what this site may look like inside and out.

Table 5: Weights by Data Layer

Data Layer	Weight
Projected Population Decline (2010-'30)	1.6
Labor force (mental health providers)	1.6
Labor force (health/community care services)	1.6
Local Poverty	1.6
Gen X, Y, Z	1.6
Drug Overdose Rate	1.6
Alcohol Dependency/Excessive Drinking	1.6
Slope	1.3
Proximity to Amenities such as entertainment, tourism, outdoor rec.	1.3
Proximity to Higher Ed. Institutions	1.3
Proximity to Power Lines	1.3
Proximity to Primary Roads	1.3
Proximity to Streets	1.3
Food Insecurity Index	1.3
Total Population	1.3
Disabled Population	1.3
Size	1.0
Commuting Times	1.0
Labor force (engineers/electricians/contractors)	1.0
Job Postings	1.0
Surrounding Forest Canopy Cover	1.0

Drug/Alcohol Recovery Centers

Figure 30: Suitable Surface Mining Site Locations for Health Recovery Centers

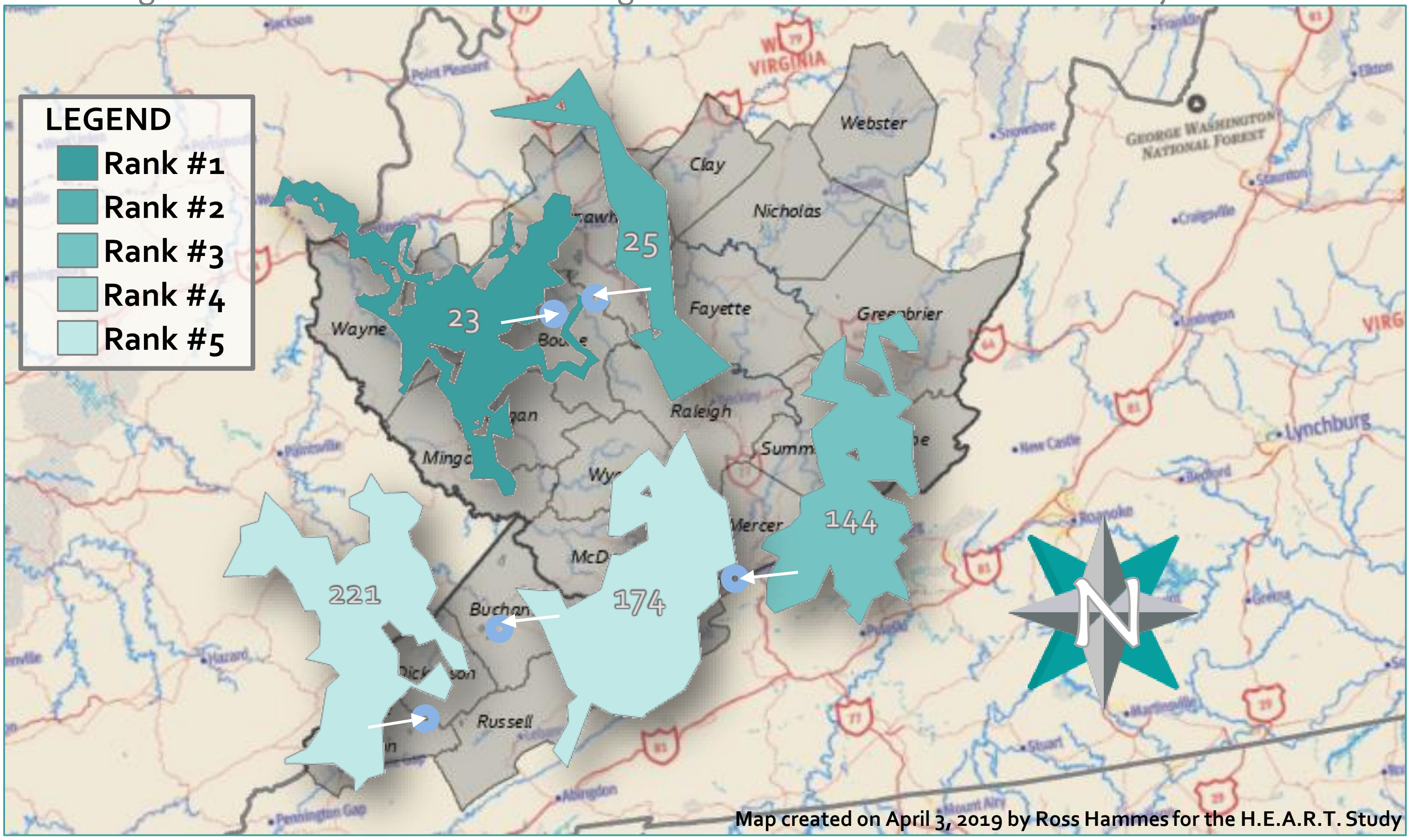


Figure 31: Example of Health Recovery Center on Former Surface Mine

This is an imagined image of a man seeking refuge in his time of recovery at the HEARTH Lodge in Wise County-Va off of the main highway. This includes vegetation on the landscape and a small pond with a bridge leading to a trail that surrounds the outdoor refuge area.

Ecological Restoration

The ecological region for the study region compassing all mines is described as dissected mixed forests with temperate climate within the Appalachian Plateau geological sub-region. This was chosen as an asset based on the information provided in the ecological impacts section.

While Kanawha-WV and Wise-Va dominated the sites chosen for economic development assets, Wise-Va also made up of a majority of the top sites for habitat restoration assets according to the model. In addition, sites in Nicholas County-WV made up one-fifth of all potential habitat restoration sites. There were 25 data factors considered for the model. Only sites that were at least 100,000 square kilometers and with a slope orientation facing west to north, north to east, or east to south were considered for the model. Slopes facing these directions provide less maximum daylight sunlight which is most preferred for soils needing to retain more moisture to foster the appropriate conditions for ecological restoration such as tree growth to reintroduce woody areas for surrounding habitat according to the "Forestry Reclamation Approach" guidelines. This also guided the choices of layers pertaining to soil properties, hydrology, and proximity to higher concentrations of vegetated land. In addition, only sites that did not rank within the top 30 for any economic asset were considered.

The top three sites for habitat restoration within the state of Virginia included mine sites 213 and 215 of Russell County-Va and mine site 220 of Wise County-Va. The top three sites for habitat restoration within the state of West Virginia included mine sites 9 and 17 of Nicolas County-WV and mine site 145 of McDowell-WV. All sites ranked within the top 90 percentile of the data model. The chart to the right shows the data layers and their associated factors used in the model. Lastly, these sites can be seen on the following page with an example of what this site may look like after it is restored and back to its natural state.

Table 6: Weights by Data Layer

Data Layer	Weight
Labor force (agriculture/forestry)	1.6
Surrounding Forest Canopy Cover	1.6
Soil Flood Hazard Area	1.6
Soil Crop Potential	1.6
Soil Farmland Class	1.6
Slope	1.3
Soil Drainage Class	1.3
Soil Albedo	1.3
Soil Erodibility/Corrosivity	1.3
Proximity to Amenities such as entertainment/tourism/outdoor rec.	1.3
Proximity to Higher Edu. Institutions	1.3
Proximity to Streets	1.3
Soil Runoff	1.3
Aspect	1.0
Size	1.0
Proximity to River/Lakes	1.0
Proximity to Protected Area	1.0
Proximity to Primary Roads	1.0
Commuting Times	1.0
Labor force (engineers/contractors)	1.0
Job Postings	1.0
Gen X, Y, Z	1.0
Soil Rainfall Absorption	1.0
Soil Bedrock Depth	1.0
Soil Hydric Class	1.0

Habitat Restoration

Figure 32: Suitable Surface Mining Site Locations for Habitat Restoration

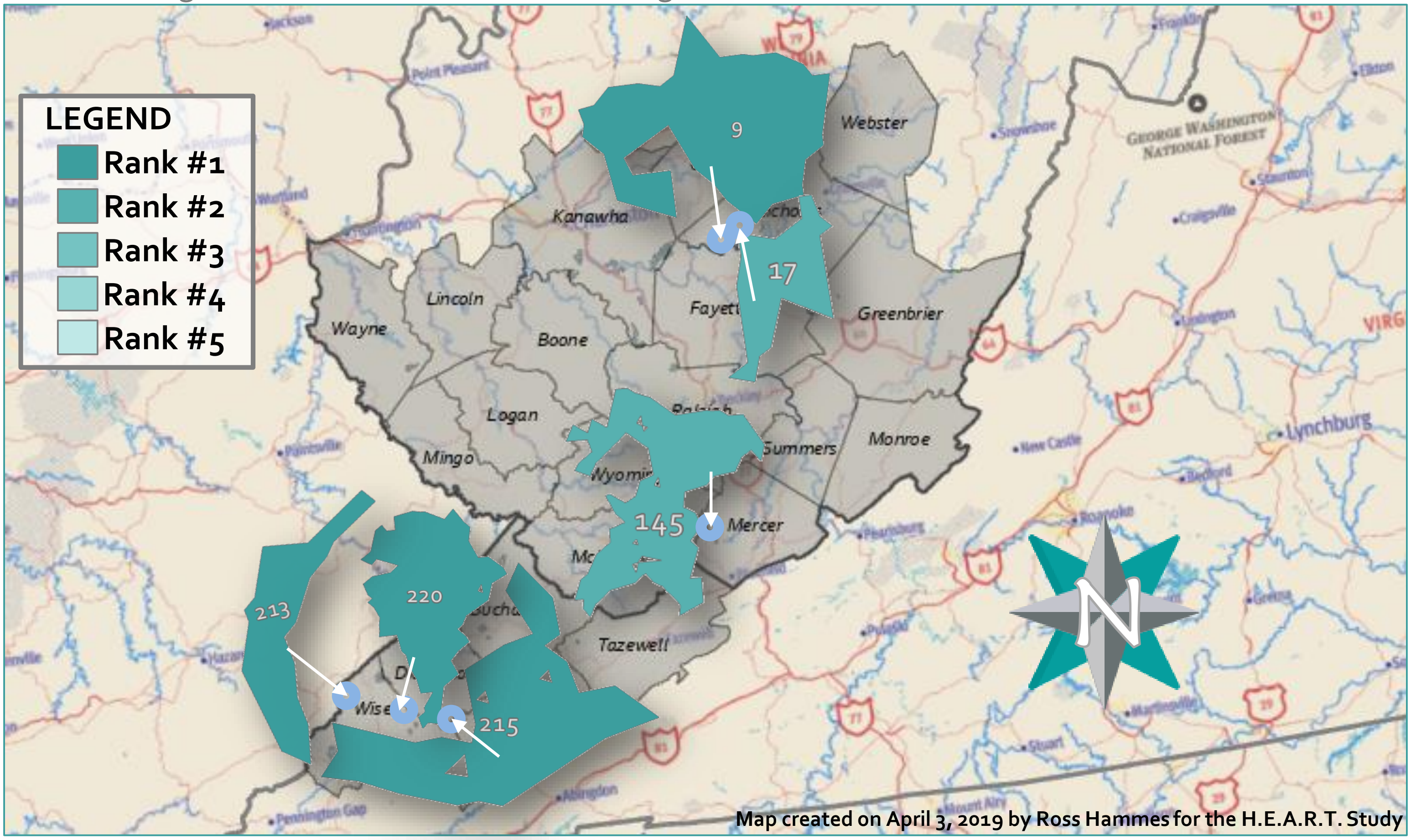
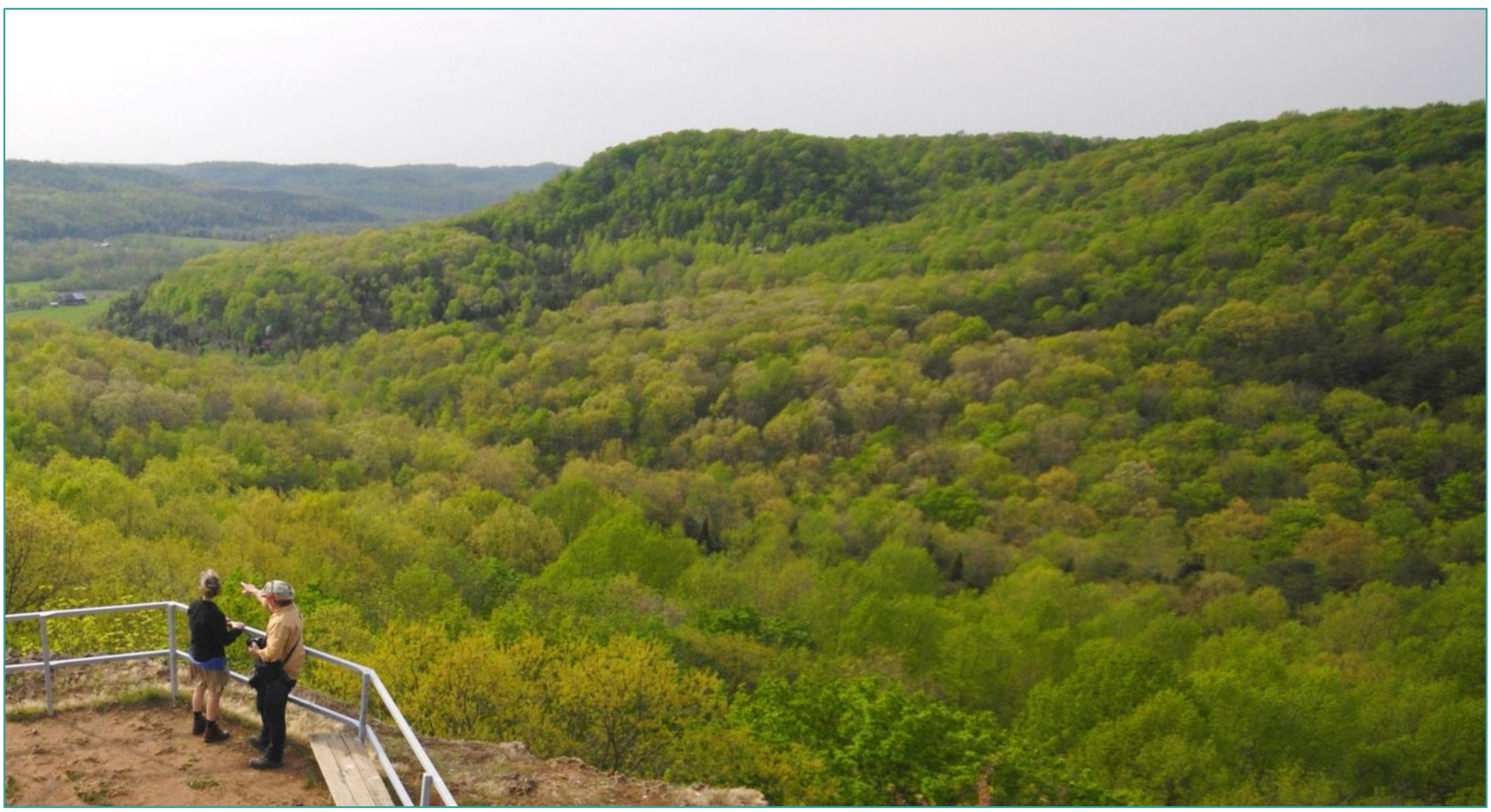


Figure 33: Example of Restored Habitat on Former Surface Mine



This is an imagined image of a professor and student visiting an overview at a restored surface mine site in the Heart of Appalachia. These sites can be sites used for outdoor recreation opportunities such as hiking, biking, or four-wheeling after they are restored.

Conclusion

Of all the sites chosen for economic or habitat asset purposes, half were located in Virginia and half were located in West Virginia to maximize the usefulness of this study across the two states. 25% of all were located in Wise County-Va and another 25% in Kanawha County-WV each. Other Virginia counties included Buchanan at 13% of total, Russell at 10%, and Tazewell County at 5% of total mines. Other West Virginia Counties included Nicolas at 8% and Wayne, McDowell, Raleigh, Greenbrier, and Mercer counties at 5% each. With more resources and potential funding this project could be extended to the remaining mine sites in the Heart of Appalachia located in the states of Kentucky and Tennessee. This would ultimately cover all Central Appalachian surface mines to provide to local governments and economic development agencies to consider the prioritized sites first. In addition, this model is flexible and can easily be altered with different weights. A virtual, interactive web map application will be provided on the HEART App web page so that users may change the weights while still using all of the extrapolated data contained within each surface mine polygon to see how the model outputs vary.

In conclusion, it is important to point out that this research is theoretical in that the sites chosen for analysis and layers chosen to asses each asset type, along with the implementation of various weights. The primary purpose of this study was to be used as a decision making or decision influencing tool by various stakeholders seeking to revitalize the Heart of Appalachia.

The goal of this report was to also encourage the idea of geospatial analysis when making large decisions covering large geographic regions. This report explained how the "Heart" is breaking and brought attention to some emerging opportunities by providing suggestions as to how we may help this community better foster economic opportunities or by improving the local ecosystems. By "following our H.E.A.R.T.," this geospatial modeling tool can identify sites based on various spatial factors to determine which can be viable economic assets or which would be better off being restored to their natural state to become an asset for biodiversity. The goal of this report was also to outline historical trends and policies covering regarding these mine sites and to better understand how funds can be increased and allocated to the appropriate stakeholders to improve the economic or ecologic conditions surrounding this landscape.

While there is never a "one size fits all approach," geospatial technologies do provide the ability to replicate the methods and implement the data into statistical models such as the H.E.A.R.T. Perhaps by utilizing a tool such as this model and by spreading our love joining our hearts together, we can make change happen by allowing our nation to slow down and love again to hopefully turn a "breaking Heart" into a healthy, self-sustaining one for our dear Appalachian neighbors. Lastly, I want to thank you for taking the time to learn from this project and please feel free to contact me directly for any questions regarding the data or methods at ross.hammes@vt.edu.

References

Appalachian Voices. "Communities at Risk from Mountaintop Removal." April 2015, http://appvoices.org/resources/reports

Appalachian Regional Commission. Source and Methodology: Distressed Designation and County Economic Status Classification System www.arc.gov/research/SourceandMethodologyCountyEconomicStatusFY2007FY2019.asp.

Anderson, Mark Gustav. "Viability and Spatial Assessment of Ecological Communities in the Northern Appalachian Ecoregion." University of New Hampshire Scholars' Repository, scholars.unh.edu/dissertation/2102/.

Andrei, et al. "Agrarian Economy and Rural Development - Realities and Perspectives for Romania, 2012." SSRN, 18 Dec. 2012.

Angel, Patrick. The Appalachian Regional Reforestation Initiative. 2012, www.epa.gov.

Avera, Bethany N., et al. "Development of Ecosystem Structure and Function on Reforested Surface-Mined Lands in the Central Appalachian Coal Basin of the United States." SpringerLink, Springer Netherlands, 2 Aug. 2015, link.springer.com/article/10.1007/s11056-015-9502-8.

Bernhardt, Emily S., and Margaret A. Palmer. "The Environmental Costs of Mountaintop Mining Valley Fill Operations for Aquatic Ecosystems of the Central Appalachians." Annals of the New York Academy of Sciences, John Wiley & Sons, Ltd (10.1111), 30 Mar. 2011, nyaspubs.onlinelibrary

Clark, Gregory, and David Jacks. "Coal and the Industrial Revolution, 1700–1869 | European Review of Economic History." Cambridge Core, Cambridge University Press, 26 Mar. 2007, cambridge.org/core/journals/european-review-of-economic-history/article/

"Coal Mining, Economic Development, and the Natural Resources Curse." Energy Economics, North-Holland, 29 Apr. 2015, www.sciencedirect.com/science/article/pii/S0140988315001279.

County Health Rankings and Roadmaps. County Health Rankings Key Findings Report. 2016-2019.

Diver, Steve. Aquaponics—Integration of Hydroponics with Aquaculture. 2006, backyardaquaponics.com.

"Environmental Aspects and Impacts Its Mitigation Measures of Corporate Coal Mining." Procedia Earth and Planetary Science, Elsevier, 30 June 2015, www.sciencedirect.com/science/article/pii/S1878522015000533.

"Estimating Solar Radiation on Slopes of Arbitrary Aspect." Agricultural and Forest Meteorology, Elsevier, 3 July 2001, www.sciencedirect.com/science/article/pii/S0168192301002453.

George, J., "The Coal Miners' Strike of 1897." The Quarterly Journal of Economics, www.jstor.org/stable/1882118.

Grenoble, Jessica. "Fading into the Horizon: The Disappearance of Appalachian Hollow Communities and Culture." Ethnographic P raxis in Industry Conference Proceedings, John Wiley & Sons, Ltd (10.1111), 3 Mar. 2013, anthrosource.onlinelibrary.wiley.com/ doi/abs/

Haaga, J. "The Aging of Appalachia." Appalachian Regional Commission. April 2004, http://citeseerx.ist.psu.edu/

Hendryx, M. "Self-reported cancer rates in two rural areas of West Virginia with and without mountaintop coal mining." West Virginia Department of Community Medicine-West Virginia University. April 2012, https://www.ncbi.nlm.nih.gov/pubmed/21786205

Hendryx, M. "Lung cancer mortality is elevated in coal-mining areas of Appalachia." West Virginia Department of Community Medicine - West Virginia University. October 2008, https://www.ncbi.nlm.nih.gov/pubmed/18353487

Hodkinson, Brendan P. "A First Assessment of Lichen Diversity for One of North America's 'Biodiversity Hotspots' in the South ern Appalachians of Virginia." Castanea, Southern Appalachian Botanical Society, bioone.org/journals/castanea/volume-75/issue-1/

Ibarra, José Manuel Nicolau, and Mariano Moreno de las Heras. "Opencast Mining Reclamation." SpringerLink, Springer, New York, NY, 1 Jan. 1970, link.springer.com/chapter/10.1007%2F0-387-29112-1_53.

"Journal of Irrigation and Drainage Engineering." Controlled versus Conventional Drainage Effects on Water Quality | Journal of Irrigation and Drainage Engineering, ascelibrary.org/doi/abs/10.1061/

Kammen, D. "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" DIANE Publishing. 2008.

Kratzer, Nate W. "Coal Mining and Population Loss in Appalachia." Journal of Appalachian Studies, vol. 21, no. 2, 2015, pp. 173–188. JSTOR, www.jstor.org/stable/10.5406/jappastud.21.2.0173.

Lineback, Neal G. "Low-Wage Industrialization and Town Size in Rural Appalachia." Southeastern Geographer, The University of North Carolina Press, 3 July 2013, muse.jhu.edu/article/430500/summary.

"Loopholes in the Clean Water Act." Earthworks, earthworks.org/issues/loopholes_in_the_clean_water_act/.

"Measuring Consensus for Collaborative Decision-Making: A GIS-Based Approach." Computers, Environment and Urban Systems, Pergamon, 15 Mar. 2010, www.sciencedirect.com/science/article/pii/S0198971510000177.

Meit, M., Heffernan, M., Tanenbaum, E., and Hoffman, T. "Appalachian Diseases of Despair." Appalachian Regional Commission. August 2017.

Misiolek, Walter S., and Thomas C. Noser. "Coal Surface Mine Land Reclamation Costs." Land Economics, vol. 58, no. 1, 1982, pp. 67–85. JSTOR, www.jstor.org/stable/3146077.

Orem, W.H., Tatu, Calin, Pavlovic, Nikola, Bunnell, Joseph, Kolker, Allan, Engle, Mark, and Stout, Ben, 2010, Health effects of energy resources: U.S. Geological Survey Fact Sheet 2009–3096, pubs.usgs.gov/fs/2009/3096/

Palmer, M. A., et al. "Mountaintop Mining Consequences." Science, American Association for the Advancement of Science, 8 Jan. 2010, science.sciencemag.org/content/327/5962/148.

Pericak, Andrew A., et al. "Mapping the Yearly Extent of Surface Coal Mining in Central Appalachia Using Landsat and Google Earth Engine." PLOS ONE, Public Library of Science, 2018, journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0197758.

Popovich, Nadja. "Today's Energy Jobs Are in Solar, Not Coal." The New York Times, The New York Times, 25 Apr. 2017, www.nytimes.com/interactive/2017/04/25/climate/

Rochow, James. "The Far Side of Paradox: State Regulation on the Environmental Effects of Coal Mining." HeinOnline, 1979, heinonline.org/HOL

References Cont'd

Sandeep C Kulkarni, et al. "Falling behind: Life Expectancy in US Counties from 2000 to 2007 in an International Context." Population Health Metrics, BioMed Central, 15 June 2011, pophealthmetrics.biomedcentral.com/articles/10.1186/1478-7954-9-16.

Schoenberg, Nancy. "Appalachian Residents' Experiences With and Management of Multiple Morbidity." SAGE Journals, 2011, journals.sagepub.com/doi/abs/10.1177/1049732310395779.

Smith, Evan. "Implementing Environmental Justice in Appalachia: The Social and Cultural Context of Mountaintop Removal Mining as Seen through the Lenses of Law and Documentaries." HeinOnline, 2012, heinonline.org/

Sonter, Laura. "Processes of Land Use Change in Mining Regions." Journal of Cleaner Production, Elsevier, 12 Apr. 2014, www.sciencedirect.com/science/article/pii/S0959652614003175.

"Stories of Spiritual Awakening: The Nature of Spirituality in Recovery." Journal of Substance Abuse Treatment, Pergamon, 21 Nov. 1998, www.sciencedirect.com/science/article/pii/S0740547297002110.

Sweet, Thomas. "Acid Coal Mine Drainage: Past Pollution and Current Regulation." HeinOnline, 1979, heinonline.org/HOL/

"The Earth's Open Wounds: Abandoned and Orphaned Mines." National Institute of Environmental Health Sciences, U.S. Department of Health and Human Services, 2003, ehp.niehs.nih.gov/doi/abs/10.1289/ehp.111-a154.

Tidwell, James. "Aquaculture Production Systems." Wiley Online Library, 2012, onlinelibrary.wiley.com/doi/pdf/10.1002/9781118250105

Topal, Erkan. "When Will Fossil Fuel Reserves Be Diminished?" www.sciencedirect.com/science/article/pii/S0301421508004126.

"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." EIA Projects That U.S. Coal Demand Will Remain Flat for Several Decades - Today in Energy - U.S. Energy Information Administration (EIA), www.eia.gov/todayinenergy/detail.php?id=35572.

Wickham, et al. "Overlooked Terrestrial Impacts of Mountaintop Mining." OUP Academic, Oxford University Press, 1 May 2013, academic.oup.com/bioscience/article/63/5/335/229211.

Wieder, R. Kelman. "A Survey of Constructed Wetlands for Acid Coal Mine Drainage Treatment in the Eastern United States." SpringerLink, Springer Netherlands, link.springer.com/article/10.1007/BF03160750.

Young, April M., and Jennifer R. Havens. "Transition from First Illicit Drug Use to First Injection Drug Use among Rural Appalachian Drug Users: a Cross-Sectional Comparison and Retrospective Survival Analysis." Addiction, John Wiley & Sons, Ltd (10.1111), 26 Oct. 2011, onlinelibrary.wiley.com/doi/abs/

Thank You!