DOE | Tailoring the use of coal waste and carbon-neutral biomass in modular gasification technology in distressed communities in the Appalachian region

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July 2021

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1.0 Introduction

1.0 INTRODUCTION

On January 27, 2021, President Biden made a commitment to communities which for nearly 200 years had provided the nation with coal. *"We're never going to forget the men and women who dug the coal and built the nation. We're going to do right by them and make sure they have opportunities to keep building the nation in their own communities and getting paid well for it."* In response, an **Interagency Working Group** was formed and in April 2021 the 12 collaborating members delivered an initial report to President Biden. The report outlined the framework for developing a plan to empower workers through revitalizing energy communities. The report identified:

- "A set of communities across the country hard-hit by coal mine and coal power plant closures, which should be prioritized for focused federal investment.

- Existing federal program with potentially available funding totaling nearly $38 billion which could be used to provide immediate investments in Energy Communities.

- Immediate steps the Interagency Working Group should take within the next year to support Energy Communities."[1]

In this Report, the Department of Energy (DOE) identified technological innovation as an area of focus. The **Office of Fossil Energy at the DOE National Energy Technology Laboratory (NETL)** conducts research and development to utilize coal/oil wastes as well as carbon-neutral biomass. One potential method for helping economically depressed communities in the Appalachian region, while reducing environmental burden is to utilize existing waste coal and biomass feedstock to develop pellets for use in modular, gasification systems for the coproduction of renewable methane and hydrogen. Production of gaseous fuels from coal or carbonaceous-fuel sources includes not only hydrogen (H_2), but synthetic natural gas (SNG). SNG is equivalent to natural gas, which is mostly methane, and can be substituted for it in all the same natural gas applications.[2] Production of hydrogen and synthetic natural gas are necessary for advancing the green economy. Although alternative methods of hydrogen production are being pursued, alternative approaches such as the electrolysis of water reduces potable water, thereby creating other global problems. This makes methods such as conversion of waste coal and biomass to H_2 and SNG a contender.

1.1 GREEN ENERGY'S IMPACT ON COAL COMMUNITIES

According to the Environmental and Energy Study Institute (EESI), renewable energy is steadily declining in cost while the coal production costs are increasing in Central Appalachia, thus making the industry even less profitable.[3] The rise of the clean economy has led to the chronic job loss and other hardships for many coal communities.[4]

Environmental regulations, like the Clean Air Act, have played a role in coal's decline.[5] In 2019, renewable energy consumption in the U.S. "surpassed coal for the first time in over 130 years."[6] Furthermore, "2019 saw the second-highest number of coal-fired power plant closures, behind 2015, and coal mining employment in the United States declined by 39 percent between 2009 and 2016. These trends were exacerbated by the COVID-19 pandemic."[7] Employment rates for coal communities hinge on the price of coal. As shown in Figure 1, the cost of coal increases the number of coal workers decreases.

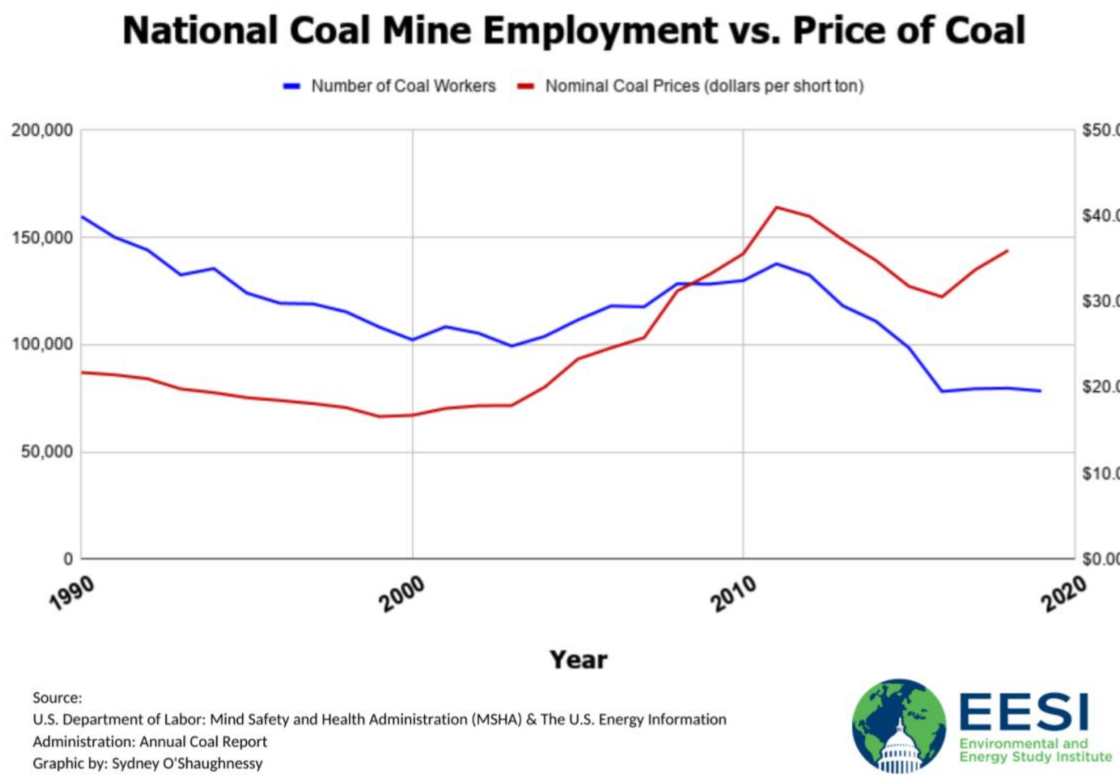

Figure 1: National Coal Mine Employment vs. Price of Coal

If communities do not have other industries in place to provide employment for those individuals, as the number of coal mines close the community is subjected to economic distress.

1.2 OBJECTIVES

The objective of this report is to determine the extent to which information on the quantity and quality of **gob ("garbage of bituminous coal")** in the Appalachian region is available, and which sites had adjacent biomass that has been and/or is about to be cultivated. The ultimate goal is to determine if it is possible to identify optimal sites that contain high quality gob and biomass, where gasification systems could potentially be developed, tested and used. The scope of the research was limited to abandoned surface and mountain-top removal mines in the eight states of the Appalachian coal region: **Alabama; eastern Kentucky; Maryland; Ohio; Pennsylvania; Tennessee; Virginia; and West Virginia**. According to the enhanced Abandoned Mine Lands Inventory System (e-AMLIS) there are 48,529 abandoned coal mines.[8]

A variety of terms are used, often interchangeably, when discussing waste coal. However, there are minor differences associated with each term. There are also regional differences in the use of the terms: gob; boney; and culm.

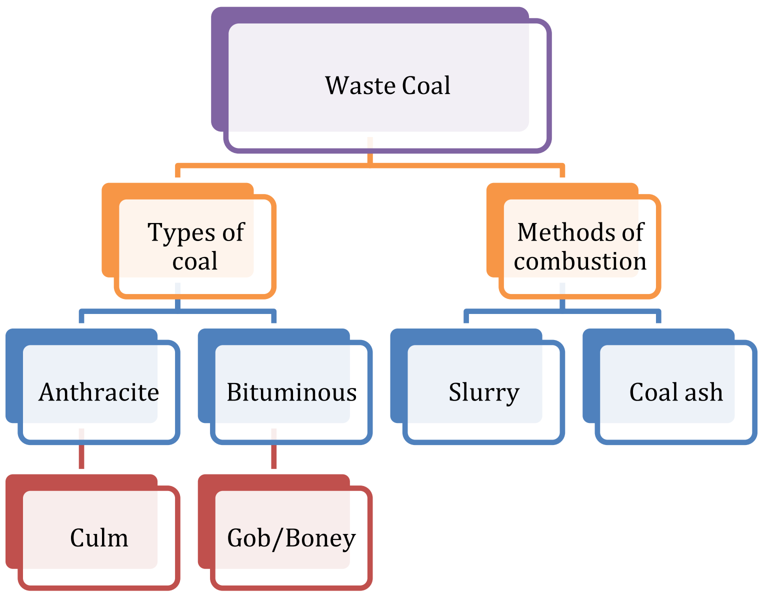

Figure 2: Terms associated with waste coal

This report begins with a brief, up-close look at three communities within counties listed as priority communities in the report produced by the Interagency Working Group: (1) Boone County in West Virginia; (2) Buchanan County in Virginia; and (3) Greene County in Pennsylvania. These communities exhibited environmental, ecological, and/or economic distress as a direct result of the mining industry.

1.3 BOONE COUNTY, WEST VIRGINIA

Boone County, West Virginia was identified as a Priority Community in the 2021 Interagency Working Group report. As of the 2010 census, Boone County had a population of 24,629. Cities in Boone County include Madison (county seat), Danville, Whitesville, Racine, Comfort, Sylvester, Van, Greenview and Twilight. The 2020 Census revealed a 12.9% reduction in the population (21,457) in the past 10 years.[9]

The coal industry has deep roots in Boone County. *"Boone County is where coal was first discovered in 1742, and has been the economic lifeblood of the country for a century."*[10] The coal mining industry is still Boone County's greatest economic resource; in 2003, the county produced more than 29,674,000 tons of coal.[11] **Hobet 21 coal mine**, operating from 1974 to 2015, was one of the **largest mountain-top removal mining operations** in Appalachia, located in West Virginia on the border of Lincoln and Boone Counties.[12,13,14] It is owned by two entities: **West Virginia Economic Development Authority (WVEDA)** and **ERP Environmental Fund, Inc.**[15,16] WVEDA owns approximately 2,400 acres of the site with the balance being owned by ERP. In 2002, the mine produced 5 million pounds of coal in that single year. It is so big that it can be spotted from space.[17]

Since 2015, however, the revenue and employment rates in Boone County have steadily declined (Figure 3). The local government had its funding cut in half over the last five years due to coal mine closures.[18] The State itself was bankrupt in 2017.[19] As the country focuses on clean energy, Boone County can potentially be left behind since its economy still depends on coal. However, during a visit to West Virginia, Energy Secretary Jennifer Granholm said, *"her primary goal on that trip was to reassure citizens of the coal mining-dependent state that Biden's clean energy plans won't destroy their economy."*[20]

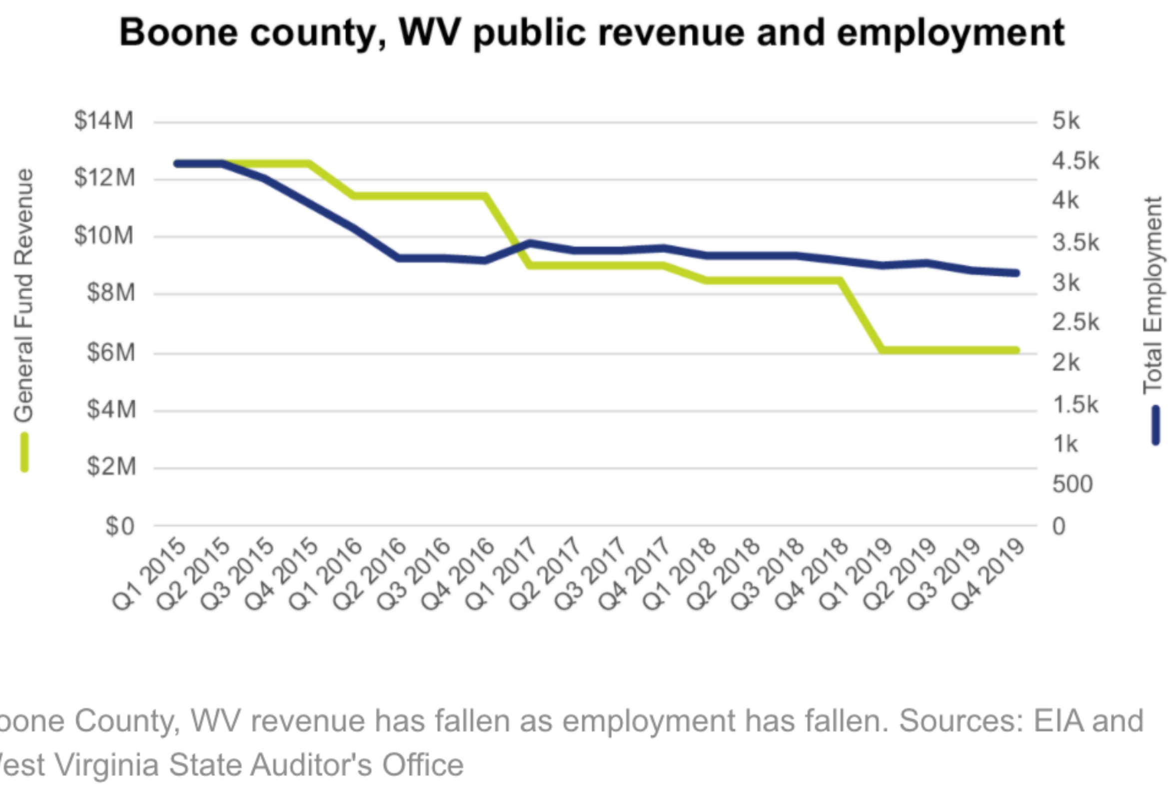

Figure 3: Boone County, WV Public Revenue and Employment Q1 2015 - Q4 2019

Madison, West Virginia is the county seat of Boone County with a population of 3,076 as of 2010.[21] Madison has been receiving grants from the government for a variety of projects. The Boone County Community Development Corporation was awarded an Abandoned Mine Lands grant of $3.37 Million to add infrastructure for an ATV trail and resort, which is anticipated to bring money to the area.[22] There is also renewed interest in developing an access road at the former mine site to further enhance economic development. In 2020, Governor Jim Justice vowed to "make development of the Hobet mine property a top priority by intensifying efforts to attract companies to the site" in addition to the West Virginia National Guard resuming their activities at Hobet.[23] Recently, the EPA selected a site in Madison for a Brownfields Clean-up Grant in the amount of $181,794 to battle contamination from petroleum-based products.[24]

Environmental Impact

The Mud River sub-watershed "happens to drain the 9,900-acre Hobet 21 coal mine."[25] Mud River is a 72-mile-long tributary flowing northwest through West Virginia, which empties into the Guyandotte River.[26,27] It is part of the Lower Guyandotte River Watershed and the Mud River sub-watershed.[28] Mud River flows through the abandoned Hobet 21 coal mine. The area suffers from environmental and ecological distress as a direct result of the former mine. The toxicity of the river directly impacts the lives of some residents of Boone County whose drinking water is supplied by Mud River.[29]

> *I am proud to be a Coal Miner's daughter.* ***Coal put the food on my table. It also put the poison in my water.***

The acid mine drainage from Hobet 21 has led to severe stream pollution. The mining operations buried streams under hundreds of feet of rubble which in turn increased the amount of trace elements like selenium in water runoff.[30] In 2015, local citizens and clean water groups filed suit against **Patriot Coal Corporation** for the pollution caused by mining at Hobet 21.[31] The mining operations were so damaging that it has essentially resulted in the entire Mud River watershed being biologically impaired, "*meaning that the pollution is killing off aquatic life, to the point where these streams are no longer healthy ecosystems."*[32] A 2004 study found the mussel population was "a mere 'shell' of its former self" and although "stricter enforcement of mining regulations in the last 30 years … have contributed to an improvement … [the river] may never recover to its pre-mining condition."[33] Today, "the Mud River ecosystem is on the brink of a major toxic event."[34]

1.4 BUCHANAN COUNTY, VIRGINIA

Buchanan County, Virginia is also listed as a Priority Community in the 2021 Interagency Working Group report. The 2019 county population was 21,788 and is home to numerous small cities including Big Rock, Davenport, Grundy, Hurley, Keen Mountain, Maxie, Oakwood, Pilgrim's Knob, Raven, Rowe, Shortt Gap, Vansant, Whitewood and Wolford. **Grundy, the County seat, was dubbed "the sickest town in America" by a 2015 article**.[35] While the county has invested money into development, the area is still "a one-industry community, and that's coal," a mountaintop mine once operated by Paramount Coal Company.[36] With the decline of coal, Buchanan County residents' income has "fallen to about two-thirds of the national average," the population has declined by 10.5% since 2010 (a rate faster than any other county in the state),[37] and over a quarter of the residents live in poverty.[38] It has no high-end shops like in Arlington County, 400 miles away; instead, it recently got a Wal-Mart in 2011 that employs 230 people.[39] Unfortunately for residents in Grundy, coal mining is all they have. In addition to the economic distress, the residents of Grundy suffer from many health problems – believed to be linked to working in the coal industry – and though it's a U.S. town, it has the health statistics of Bangladesh.[40]

> *"Coal is still the most prominent business, employing one in six workers in the county and accounting for one-third of its total wages. But it can no longer support such living standards. The income of Buchanan County's residents has fallen to about two-thirds of the national average. And about 40 percent of that comes from federal transfers like Social Security.*
>
> *The county population has declined to under 22,000, of whom almost 3,500 people receive disability benefits. Over a quarter live in poverty. And it is getting old. The only age group that has grown in the last two decades is the population over 55. Ms. Brown's high school, which housed about 1,000 students when she was there, these days educates just a bit over 400. The county's elementary and middle school population has shrunk by a fifth over the last 10 years, to under 2,000 students.[41]"*

1.5 GREENE COUNTY, PENNSYLVANIA

Like other counties in Appalachia, coal mining was foundational to the growth of Green County, PA. This county is said to have produced more coal than any other county in Pennsylvania.[42] In 2016, more than half the state's coal production came from Greene County.[43] When the coal industry began to decline, fracking replaced it as a source of revenue.[44] "The fact that longwall mining and hydraulic fracturing – co-exist in Greene County is a rarity in the U.S. Greene County is also home to many abandoned mines from more than a century of coal extraction."[45] In 2019, the county had 1,257 natural gas wells.[46]

Greene County is the home to 36,000 residents[47] with the county seat at Waynesburg. Other cities in the county include Greensboro, Wind Ridge, Rogersville, Fairdale, Carmichaels, Clarksville, Crucible, Mather, Rices Landing, Mount Morris, Nemacolin, Morrisville, Brave, Jefferson, Bobtown, New Freeport and Mapletown. It is "one of 31 counties statewide receiving 'impact fee' payouts through a state program … based on factors such as the number of well in an area and population."[48] Despite the payouts, the county is struggling to balance its budget and is slowly going broke.

The county's economy is tied closely with the coal industry, which in turn impacts other aspects of the residents' lives. With the close of two big Greene County mines plus the falling production at a third, the county's five school districts have felt the sting – 27% of the tax base ($414 million in value) is tied to coal.[49] "Some school districts receive over half of their funding from a tax on the value of coal mined, which has declined almost 13% county-wide from 2010 to 2019."[50] By 2019, the county's population shrank by about 2,500 residents as the number of active mining sites dropped from nine to four.[51] The overall population growth since 2010 is -8.37%.[52] The decline of the coal industry has impacted other businesses such as a family-run hardware store established in the early 1950s, which now has only 4 clerks and emptying shelves.[53] The Monongalia County Mine in Greene County, owned by Murray Energy, was the fifth largest coal mine in Pennsylvania; in 2019, it filed for bankruptcy and is now permanently closing with 180 layoffs beginning in August 2021.[54]

> **We always knew coal revenue would come to an end.** *The problem was we weren't counting on it coming this quickly.*

2.0 Locating Sites with Waste Coal (Gob, Boney, Culm)

2.0 LOCATING SITES WITH WASTE COAL (GOB, BONEY, CULM)

Recognizing that many towns in Appalachia are losing their source of income due to the decrease in the use of coal and natural gas, this project set out to determine how readily one could find information about the quality and quantity of gob associated with surface and mountaintop removal mining in the Appalachian region. Gob is one of the ingredients in the proposed modular, gasification system for the coproduction of renewable methane and hydrogen. Once this resource was found, the next step was to explore the availability of biomass in proximity. The proposed process could be conceptualized as combining reclamation and economic development.

2.1 METHOD

To gather the most comprehensive information, a wide selection of stakeholders were contacted by either email or phone. This included Associations, Energy Justice Groups, Federal Representatives from the U.S. Department of the Interior (DOI) and the Environmental Protection Agency, (EPA), the Department of Energy (DOE), State Officials, Power Generation/Cogeneration Companies, and Universities. Table 1 summarizes the outreach and response rate of each group.

Table 1: Outreach Conducted and Response Rate

Affiliation	Sent	Received	Response Rate
Associations	4	3	**75%**
Energy Justice Groups	2	1	**50%**
Federal (DOI & EPA)	14	11	**79%**
State Officials	21	14	**67%**
Power Generation / Cogeneration Companies	32	7	**22%**
Universities	7	2	**29%**
Totals	**80**	**38**	**48%**

2.2 FEDERAL ORGANIZATIONS

Three federal organizations were contacted due to their specific relevance to the topic including the **U.S. Environmental Protection Agency (EPA); the U.S. Energy Information Administration (EIA); and the U.S. Department of Interior's Office of Surface Mining Reclamation and Enforcement (OSMRE).** The representatives were asked about abandoned mine locations and the volume of waste associated with those mines. Of those contacted, eight individuals replied (five from the EPA; one from EIA; and two from OSMRE).

None of the federal organizations possessed the requested data (volume and quality of gob/culm). The communications with the individuals associated with the EPA clarified that this agency doesn't keep an inventory of abandoned mine sites. Instead, this is maintained by individuals at the Office of Surface Mining Reclamation and Enforcement (OSMRE) which has the responsibility to regulate surface coal mining under the **Surface Mining Control and Reclamation Act (P.L. 95-87)**.[55] OSMRE was created in 1977 with the purpose to *"protect society and the environment from the adverse effects of surface coal mining operations*."[56] While headquartered in Washington D.C., the OSMRE has three regional offices (one in Appalachia), which include area and field offices, and their role includes balancing the protection of the environment with the need for coal production. As part of the effort to catalogue data related to abandoned mine lands, the OSMRE maintains the Electronic Abandoned Mine Land Inventory System (e-AMLIS, sometimes simplified to AMLIS), which is a computer system that details reclamation problems—both completed and pending.[57]

> e-AMLIS – the Abandoned Mine Land Inventory **System** is a computer **system** used to store, manage, and report on the Office of Surface Mining Reclamation and Enforcement's Inventory of Abandoned Mine Land Problems

However, in contacting OSMRE, it was determined that this organization also does not keep the necessary information. While the information as to abandoned mine lands is known, the specific information needed for this study— i.e., detailed data related to waste coal—could not be found in this resource. Representatives that we spoke to indicated that "*The e-AMLIS repository only includes Abandoned Mine Lands (AMLs)… Gob piles, while they are a lower priority problem type in e-AMLIS, they do not have any volumetric values in the system. Those are probably better identified through individual state AML divisions/agencies. Unfortunately, e-AMLIS does not contain finer, more detailed information like volumes.*" Most, if not all, of the Title IV (AML) programs are administered by the respective primacy states so, unfortunately, OSM[RE] is unable to be of much assistance.

2.3 STATE ORGANIZATIONS

Representatives for each state's Abandoned Mine Land Reclamation Office were therefore contacted by phone and email to determine how they collected information on the quantity and quality of gob, boney or culm. Through this process, it was determined that each state collects a different degree of detailed information. For example, Alabama only provides the names of five sites, while Ohio provides a topographical overlay with the rough shape of the gob on the map. In Pennsylvania, they estimate that they only know of half of the abandoned mines in the state; and that only half of what they know is reported to DOI because of lack of funding.

Alabama

In contacting the Alabama's Office of Abandoned Mine Land Reclamation, information was provided that five major gob sites exist in the state. Viewing the files on Google Earth revealed that the information only identifies the location of the five sites—but does not include any information about the waste coal itself. *"In order to quantify the volume of material we would have to do on-site borings to determine depth.Typically, that type of analysis would not be conducted until the site is selected for reclamation and we begin engineering design."* The aerial view of thefive known gob piles in Alabama are depicted in Figure 4.

The e-AMLIS system cannot be viewed as a comprehensive source because it does not accurately reflect what the state representatives know to be true. For example, conducting a search on e-AMLIS, yields three sites where gob is listed as a priority (Figure 4); however, it was previously determined that Alabama has five known sites.

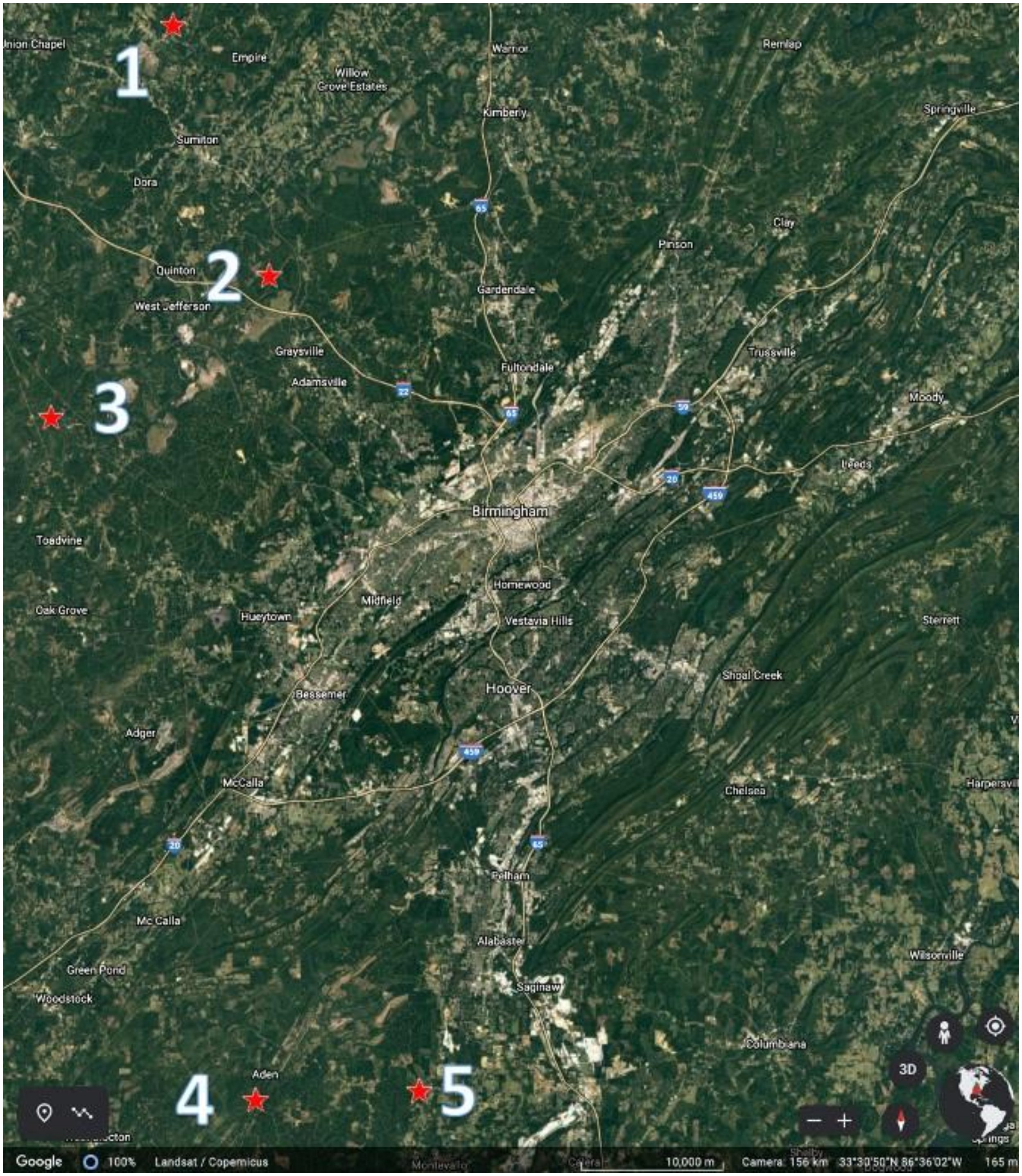

Figure 4: Location of known Gob Piles in Alabama according to Google Earth

May 12, 2021 3:42:53PM

OFFICE OF SURFACE MINING RECLAMATION & ENFORCEMENT

Abandoned Mine Land Inventory System (E-AMLIS)

Problem Type Cost Detail

Priority ALL PRIORITIES	**Type of Mining** SURFACE	**State/Tribes** ALL STATE & TRIBES
Problem Types ALL PROBLEM TYPES		**Programs Area** ALL PROGRAMS AREA
Additional Criteria STATE_KEY EQUALS TO ALABAMA , PROB_TY_CD EQUALS TO GOBS(GO)		

State / Priority / Problem Type	Unfunded Cost	Funded Cost	Completed Cost	Total Cost
Alabama				
Priority 1				
Gobs (Acres)				
AL000345	0.00	0.00	0.00	0.00
AL000769	0.00	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**	**0.00**
Priority 2				
Gobs (Acres)				
AL000136	1.00	0.00	0.00	1.00
Total	**1.00**	**0.00**	**0.00**	**1.00**
Priority 3				
Gobs (Acres)				
AL000008	0.00	0.00	5,000.00	5,000.00
AL000018	0.00	0.00	0.00	0.00
AL000071	0.00	0.00	75,000.00	75,000.00
AL000077	6,500.00	0.00	0.00	6,500.00
AL000148	140,000.00	0.00	0.00	140,000.00
AL000148	0.00	0.00	1.00	1.00
AL000148	0.00	0.00	0.00	0.00
AL000368	1.00	0.00	0.00	1.00
AL000411	0.00	0.00	280,000.00	280,000.00
AL000415	0.00	0.00	833,339.00	833,339.00
AL000415	0.00	0.00	267,642.00	267,642.00
AL000453	0.00	0.00	1.00	1.00
AL000486	70,000.00	0.00	1.00	70,001.00
AL000500	1.00	0.00	0.00	1.00
AL000509	0.00	0.00	1.00	1.00
AL000580	0.00	0.00	1.00	1.00
AL000608	4,500.00	0.00	0.00	4,500.00
AL000612	0.00	0.00	10,241.00	10,241.00
AL000613	21,000.00	0.00	0.00	21,000.00
Total	**242,002.00**	**0.00**	**1,471,227.00**	**1,713,229.00**
Grand Total	**242,003.00**	**0.00**	**1,471,227.00**	**1,713,230.00**

Figure 5: e-AMLIS Query for Alabama shows only three priority sites

Kentucky

"Many years ago, our agency had some PAD maps showing where gob/refuse piles were, but this is really not something that KY – [Abandoned Mine Lands] ever references or seeks out to supplement our work. Furthermore, the accuracy of these records is an unknown. Truth be told, it would take a tremendous amount of field work to accurately document and inventory this data."

PAD maps stand for Protected Areas Database of the United States, which is the nation's official inventory of public open space and private protected areas. It is administered by the U.S. Geological Survey Gap Analysis Project.

Maryland

The Maryland contact disclosed the inventory of waste coal in Maryland is low. Since the coal industry is dead, most of the waste coal has either been reclaimedor reprocessed through their organization's abandoned mine land initiative. He said there is not much marketable value in the small amount of waste coal, which he told other companies who have contacted him in the past. KMZ files of the largest gob piles was provided. The KMZ file provided the names of the mines, which werecatalogued. See Figure 6 for an example of the information provided by the Maryland KMZ data.

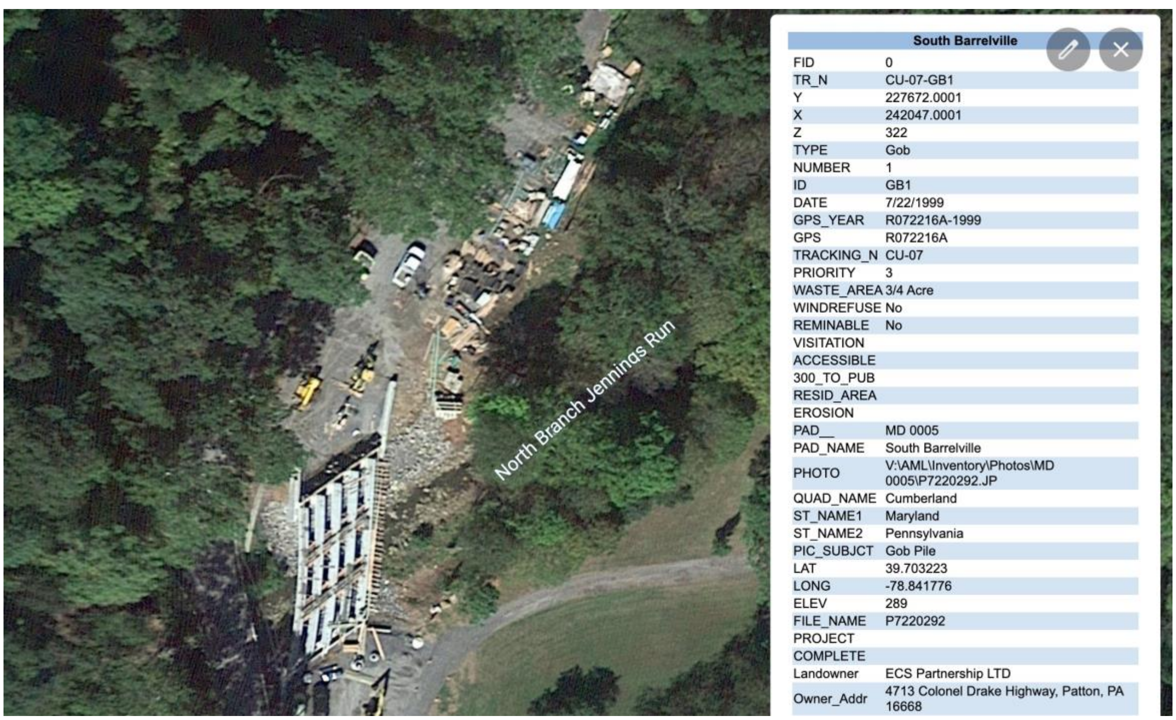

Figure 6: Example entry from Maryland's KMZ data as Shown in Google

Ohio

For the surface mines in Ohio there are no records, just that mining took place at some point in time. Representatives indicated that "*The gob piles may or may not be there and a field survey is strongly suggested to verify. This data was obtained from USGS topographic maps as well as an aerial survey (helo flights) in the early 80's.*" KMZ files and excel files that directly correlate to the KMZ data (Table 2) were provided. An example of how the information is presented when accessing the information provided using Google Earth is illustrated in Figure 7.

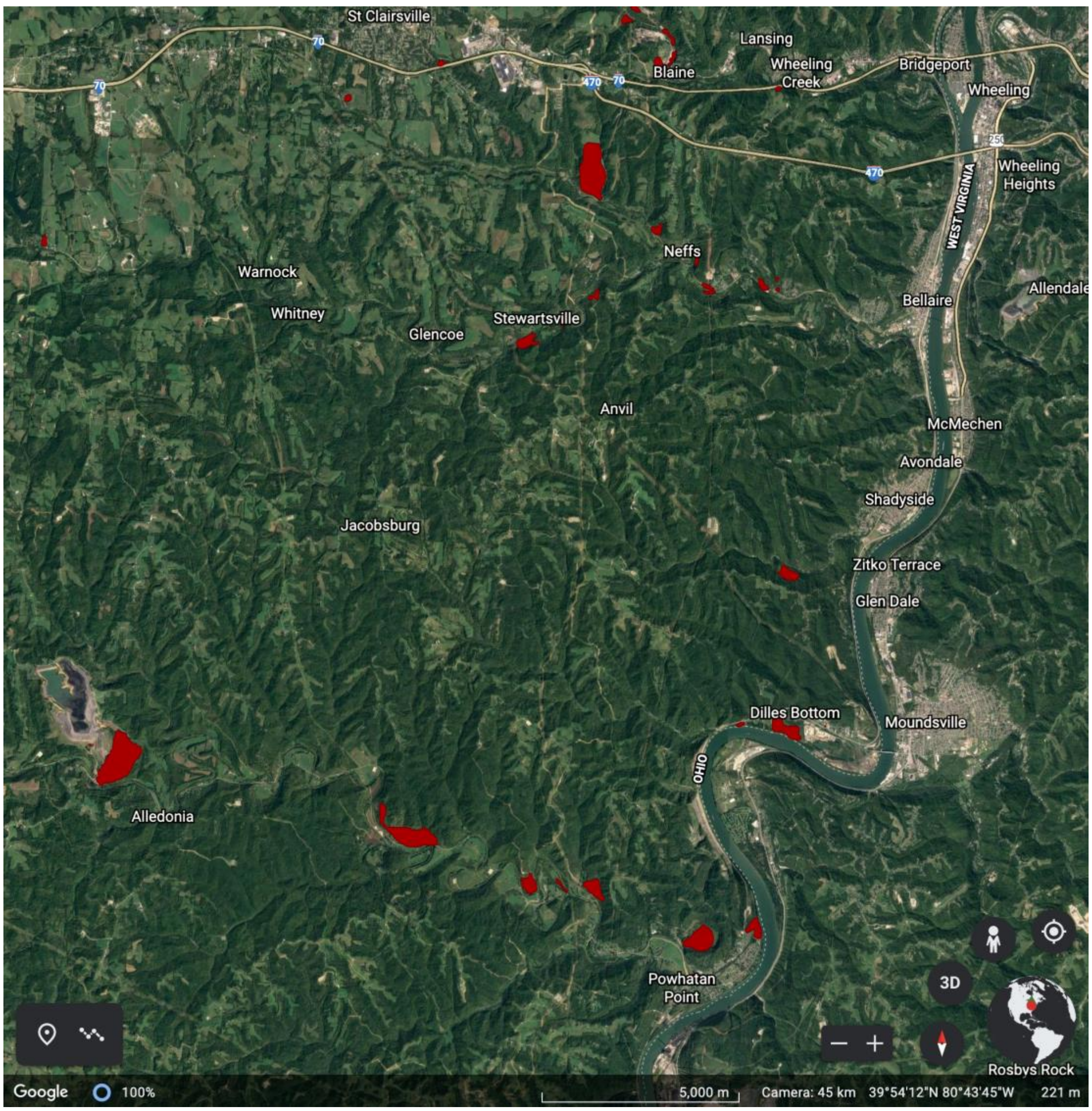

Figure 7: Selection of Gob Piles in Ohio

OBJECTID	discontinu	publicat	photoRevis	photoRev	SOURCE	Site	COUNTY_1	Comment	Date_Visit	Visited	AMLIS	Staf	Shape_area	Shape_len
1	0	0	0	0	OEPA	30001605.00000000	Guernsey	tiny pile	2/28/11	Y	N	TC	7814.17027683000	313.76071973400
2	0	0	0	0	OEPA	34000205.00000000	Harrison			N			7814.17312538000	313.76077692800
3	0	1961	0	0	OEPA & AMLIS	64000305.00000000	Perry	d permit	2/14/11	Y	N	BJ	435334.94080300000	3511.98431310000
4	0	1961	0	0	OEPA & AMLIS	60002505.00000000	Muskingum	vegetated, missplaced 1 valley south	2/9/11	Y	N	BJ	359172.64240000000	3133.67749931000
5	0	1961	0	0	OEPA & AMLIS	60002405.00000000	Muskingum	tracks on pile	2/9/11	Y	Y	BJ	131949.98773000000	1446.73206730000
6	0	1961	0	0	OEPA & AMLIS	60002805.00000000	Muskingum	East Fultonham AML Project -reclaimed gob pile	3/21/11	Y	N	BJ	109852.19836800000	1193.49420736000
7	0	1960	1972	1976	OEPA & AMLIS	7005805.00000000	Belmont			N			3389440.85702000000	7316.82267053000
8	0	1960	1972	1976	OEPA & AMLIS	7005705.00000000	Belmont			N			1259887.56532000000	5520.29077915000
9	0	1960	1972	1976	OEPA & AMLIS	7005505.00000000	Belmont			N			234333.52589400000	3095.82969488000
10	0	1960	1972	1976	OEPA & AMLIS	7005405.00000000	Belmont			N			1648113.06202000000	5640.99862770000
11	0	1960	1972	1976	OEPA & AMLIS	7005605.00000000	Belmont			N			1364212.86001000000	5064.59260693000
12	0	1961	1972	1975	OEPA & AMLIS	60003005.00000000	Muskingum			N			474111.74361300000	3987.90341656000
13	0	1961	1972	1975	OEPA & AMLIS	60002905.00000000	Muskingum			N			227884.60700000000	2748.51807453000
14	0	1960	1972	0	OEPA & AMLIS	7001205.00000000	Belmont			N			5617573.22099000000	14999.94032960000
15	0	1960	1972	0	OEPA & AMLIS	7001805.00000000	Belmont			N			8926657.81221000000	13367.03366920000
16	0	1960	1972	1976	OEPA & AMLIS	7005305.00000000	Belmont			N			172201.84091300000	1727.93981773000
17	0	1960	1972	1976	OEPA & AMLIS	7005205.00000000	Belmont			N			2354620.28343000000	7538.23405648000
18	0	1961	0	0	OEPA & AMLIS	30001305.00000000	Guernsey	previously visited	3/8/11	Y	N	TC	30864.87451440000	698.00143065900
19	0	1961	0	0	OEPA & AMLIS	30001305.00000000	Guernsey	previously visited	3/8/11	Y	N	TC	25119.95584340000	612.45324174400
20	0	1960	1972	1978	AMLIS	7000002.00000000	Belmont			N			206153.49624700000	2238.03506446000
21	0	1960	1972	1978	AMLIS	7000003.00000000	Belmont			N			71493.40954600000	977.23201617600
22	0	1962	1972	1978	AMLIS	30000001.00000000	Guernsey			N			169781.39783100000	1566.74317843000
23	0	1961	0	0	AMLIS	7000004.00000000	Belmont	possibly eroding into stream, hal project?	2/4/11	Y	Y	MM	285772.60350500000	2202.34418275000
24	0	1960	1972	1978	AMLIS	7000005.00000000	Belmont		2/4/11	Y	N	MM	248132.95291500000	1834.85426410000
25	0	1960	1972	1978	AMLIS	7000006.00000000	Belmont			N			212555.89068800000	1707.04675727000
26	0	1960	1972	1978	AMLIS	7000007.00000000	Belmont			N			900962.56558200000	3837.68492009000
27	0	1960	1972	1978	AMLIS	7000008.00000000	Belmont			N			390308.57862700000	3723.76753026000
28	0	1960	1972	1978	AMLIS	7000009.00000000	Belmont			N			227838.30580800000	2026.43700047000
29	0	1960	1972	1978	AMLIS	7000010.00000000	Belmont			N			107240.66077200000	1267.16580197000
30	0	1960	1972	1978	AMLIS	7000011.00000000	Belmont	reclaimed	2/25/11	Y	N	MM	144996.77170800000	1425.30257409000
31	0	1960	1972	1978	AMLIS	7000012.00000000	Belmont			N			41214.24265960000	775.23343457100
32	1	1960	1972	1978	AMLIS	7000013.00000000	Belmont			N			1379252.03201000000	6561.20308249000
33	0	1962	0	0	AMLIS	30000002.00000000	Guernsey			N			97159.02697390000	1416.59884490000
34	1	1960	1972	1978	AMLIS	7000014.00000000	Belmont	ds	2/22/11	Y	Y	MM	596316.75456000000	3022.40150370000
35	0	1961	0	0	AMLIS	7000015.00000000	Belmont	mined through d permit	1/31/11	Y	N	MM	53489.55971710000	868.65125813000
36	0	1962	0	0	AMLIS	16000000.00000000	Coshocton	COMMENT_20150513_093005.jpg	5/13/15	Y	Y	MB	160887.06753900000	1571.97892362000
37	1	1968	0	0	AMLIS	41000000.00000000	Jefferson			N			435104.48437200000	3385.46056851000
38	0	1960	0	0	AMLIS	34000000.00000000	Harrison			N			1635634.43182000000	5421.26143126000
39	0	1960	0	0	AMLIS	34000001.00000000	Harrison			N			118154.67743600000	1276.44322917000
40	0	1960	0	0	AMLIS	34000002.00000000	Harrison			N			165764.16487600000	1579.56905722000

Table 2: e-AMLIS Data Related to Gob Piles for Ohio

Pennsylvania

According to the Appalachian Region Independent Power Producers Association (ARIPPA), there are 770 gob piles scattered throughout Pennsylvania covering approximately 8,300 acres of abandoned mine lands.[6] The representatives in Pennsylvania were extremely responsive and helpful. Access to a website showing the location of some of the abandoned mines in Pennsylvania was provided. Many of these maps were over 70 years old (for examples see Figures 8 and 9), the location of waste coal was rarely expressed on the site map, the status of the mine (reclaimed/or abandoned) was not always known.

The Appalachian Region Independent Power Producers Association (ARIPPA)was organized in 1989 as a non-profit trade association located inPennsylvania and West Virginia. ARIPPA is "comprised of independent electric power producers, environmental remediators, and service providers that use coal refuse as a primary fuel to generate electricity."[7] Since this association utilizes coal refuse for the energy industry, it was anticipated that information relevant to gob quantities would be readily available.

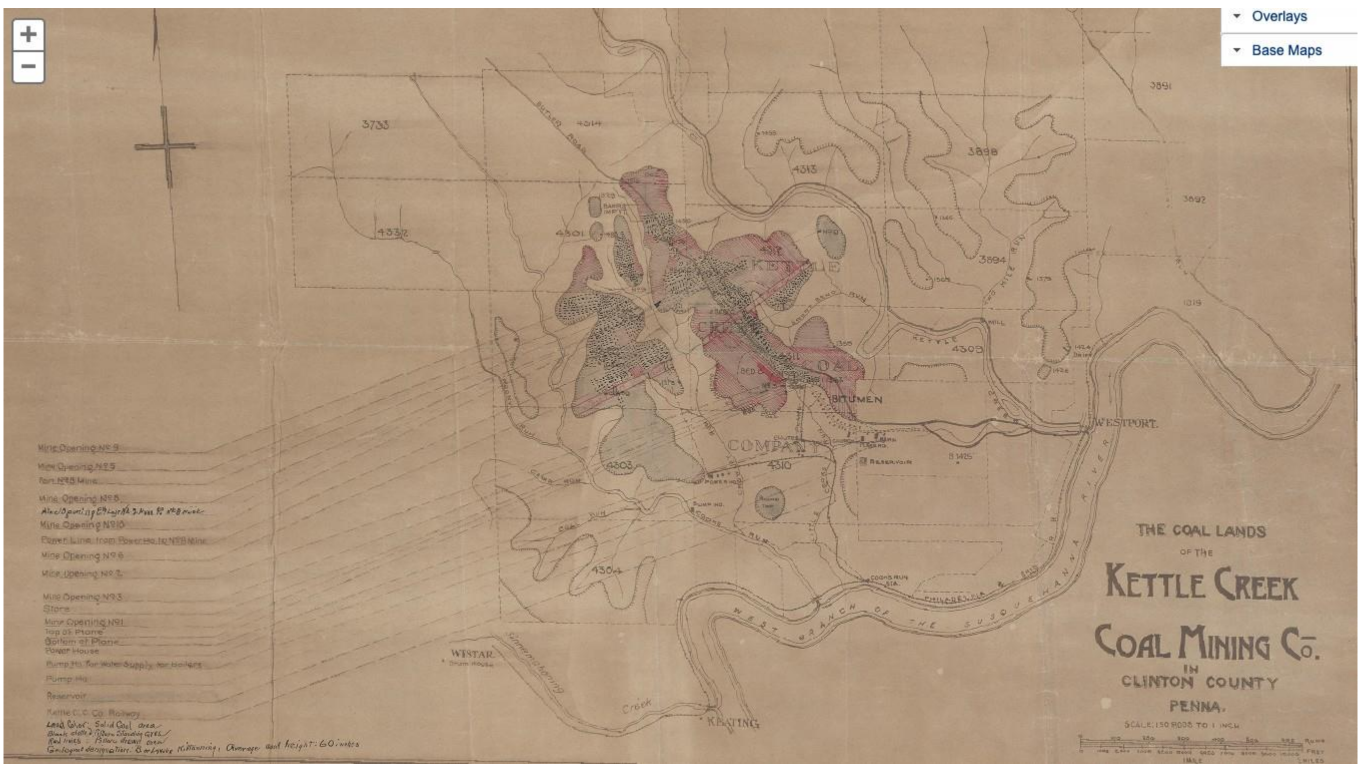

Figure 8: Map of Kettle Creek Coal Mine

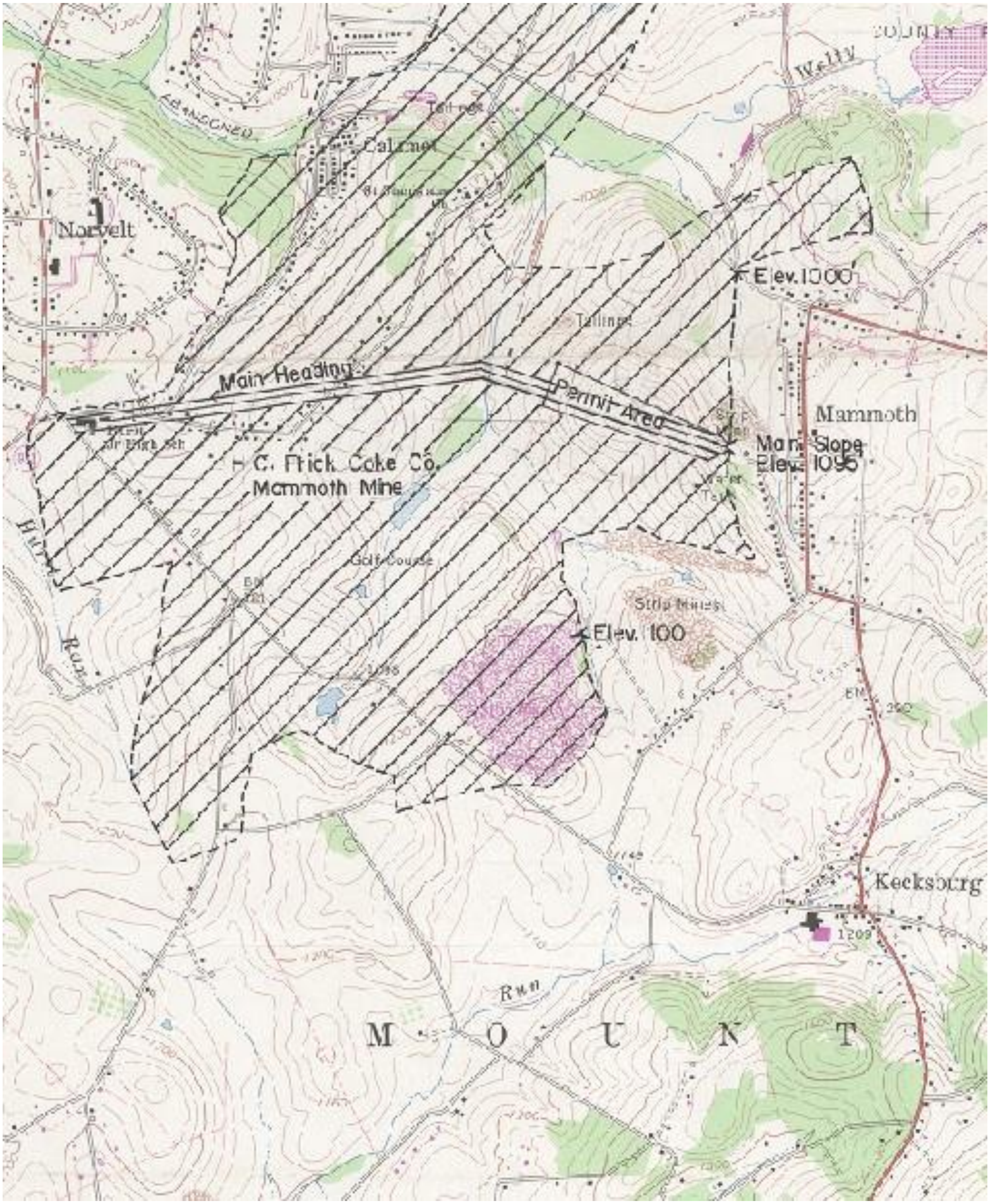

Figure 9: Map of Mammoth Mine

e-AMLIS reports included an estimated reclamation cost. However, we were advised this was subjective to the individual who performed the site visit at the time and accounted for many factors whereas disposing of waste coal was only a small part.

When looking at the maps provided for Pennsylvania and comparing them to current photos from Google Earth, it was found that many of these abandoned mines have been transformed into a Golf Course, a Wild Game Reserve, or other types of development (See Figures 10 and 11 below for current aerial views of Kettle Creek Mines and Mammoth Mine). In fact, more than 200 million tons of coal refuse have been removed from various locations around Pennsylvania, "resulting in about 7,000 acres of land being reclaimed and hundreds of miles of streams being cleaned and restored."[8] However, the e-AMLIS data doesn't necessarily reveal these changes.

Figure 10: Location of Kettle Creek Mine According to Google Earth

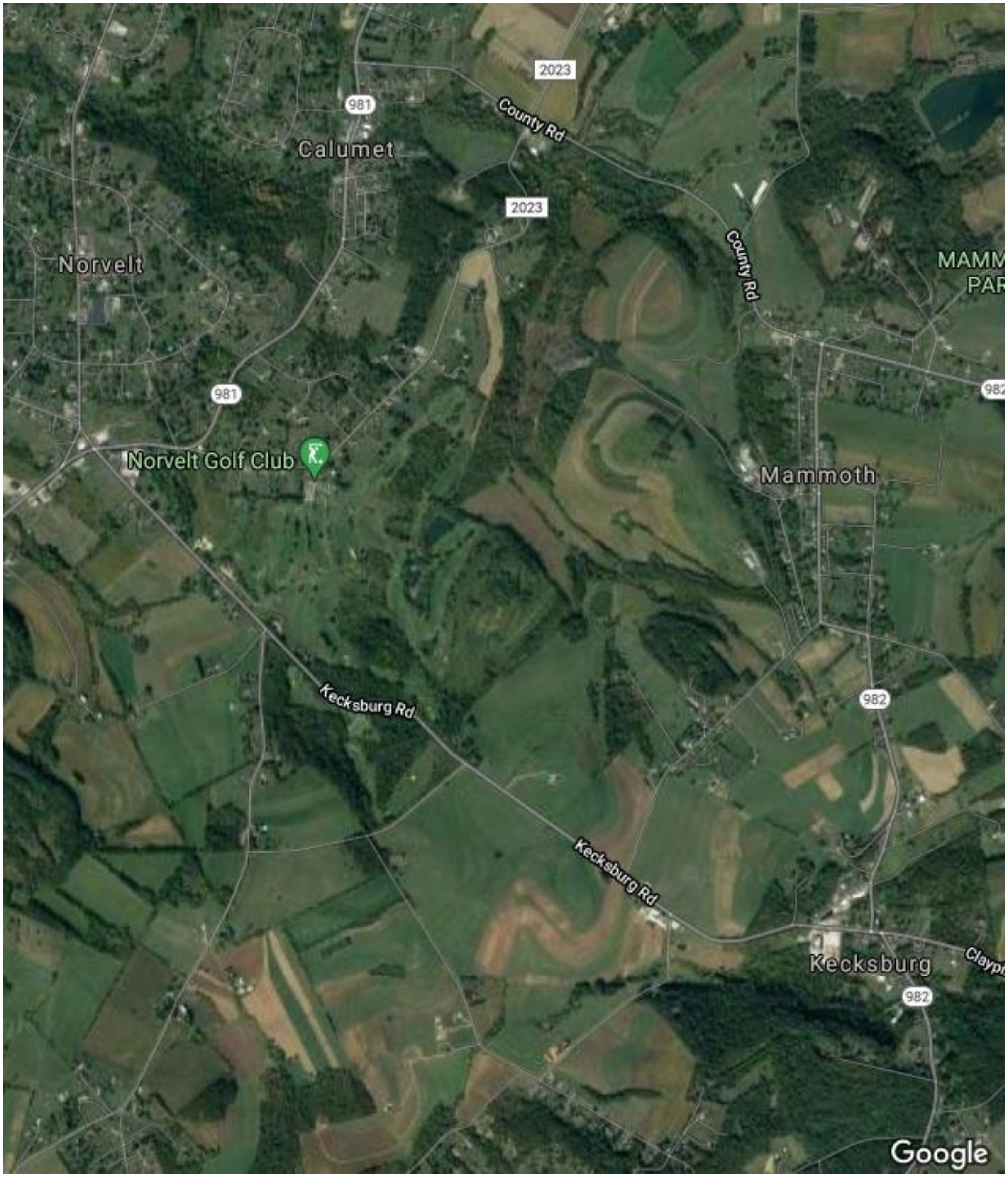

Figure 11: Location of Mammoth Mine According to Google Earth

The information in e-AMLIS is only updated when a reclamation project had taken place that involved some sort of federal funding. If the site has since been reclaimed by the private sector (such as with assistance from a Cogeneration Company) this data wouldn't necessarily make it back into e-AMLIS as there is no reporting requirement to do so.

Cogeneration plants, or Cogens, process waste coal piles in Pennsylvania. If a landowner is interested in reclamation assistance, they contact the State to see if there is federal/state funding that assists with reclamation. If the site is not at a high enough priority level to justify assistance, the State might recommend that they reach out to a local Cogen to see if they would be interested in buying the refuse.

Cogen companies have scouts/leasing agents that they employ to check the status of piles brought to their attention by landowners. They will visit the site and perform a core sample checking for BTUs, sulfur content, ash content, moisture, and depth. As a practice the piles have to be of at least 4,000 BTUs to start the reclamation discussion. Sulfur content is also a large factor as lime needs to be added to waste coal with a sulfur content above 1% before processing. This increases the cost of doing so.

If, after a site visit the waste coal is determined to be of high enough value to justify reclamation, they will either lease the property or buy the property with the coal on it. The waste coal may sit there for years before it is processed so cogen companies may have a steady stream of inventory for their burners.

When expressing the idea that DOE was interested in finding the location of waste coal piles with adjacent land suitable for growing biomass, knowing the volume and BTUs, who owns the surface and subsurface rights, contacts indicated that there are many roadblocks to obtaining this information. You need boots on the ground, performing core samples and meeting with landowners, in order to find suitable locations. It was suggested that there are a few considerations to take into account:

- Who owns the surface versus subsurface rights?
- Has the mine been reclaimed since it was last listed in e-AMLIS
- Cogen companies may have a monopoly on leasing agents/site assessors

It was suggested that cogen companies would be reluctant to share information withthe Department of Energy as to the location of waste coal piles because they might view this initiative as competition.

Tennessee

Trevor Martin, AML Program Manager, Division of Water Resources in Tennessee, did express that they can provide locations of gob piles but that the quantity and quality is not always known. He also expressed that the piles were pretty small.

Virginia

Contacts in Virginia did not provide any information during the study.

West Virginia

Similar information was obtained from West Virginia's Abandoned Mine Lands & Reclamation Program's representative. However, a vital piece of additional information revealed that *"thickness and ownership are not identified in the information we maintain because it's nothing we worry about until the site is recommended for reclamation*." While some of the maps and information include the area of the waste coal sites, this can be somewhat misleading when trying to identify volume. Refuse a half inch thick covering an acre is identified as an acre of refuse. An adjacent pile might also cover an acre but be 10' thick."

2.4 SUMMARY OF FINDINGS OUTLINING POSSIBLE OBSTACLES & IMPLICATIONS FOR RESEARCH

Each representative stressed the data might be outdated and not comprehensive. While it was important to this study to determine the volume and quantity of waste coal, it became apparent that those details were not a priority for those responsible for cataloguing information related to waste coal. Consequently, this introduced a significant problem to the research. Since the federal organizations claimed the state organizations were the stewards of these data, but it turned out that the state organizations, in fact, do not capture this data, the question became who collects it? Furthermore, it was explained that if an abandoned mine was reclaimed without federal funding by the private sector, it was not reported back to their office to be updated in e-AMLIS. Therefore, there is no way of knowing whether an abandoned mine listed on e-AMLIS in Pennsylvania (and it can be assumed the same goes for subsequent states) is untouched or has since been reclaimed without a site visit.

Figure 12 summarizes the themes of the answers received during the outreach phase of the research conducted with industry professionals. The majority of individuals contacted redirected the query to another individual or organization. Overall, it seems the information needed is not readily available, nor does one organization have access to it. Conversations with the state representatives echoed the same sentiment that a site visit would be necessary in order to confirm the volume of gob present. Essentially,the only way to know the quality and quantity of gob at a specific abandoned mine location would be to perform a site visit and take core samples. This would be time- consuming and labor-intensive. While identifying the locations of the mines proved a bitmore readily available, the data related to waste coal in the way the study required wasnot available from any of the organizations/agencies contacted.

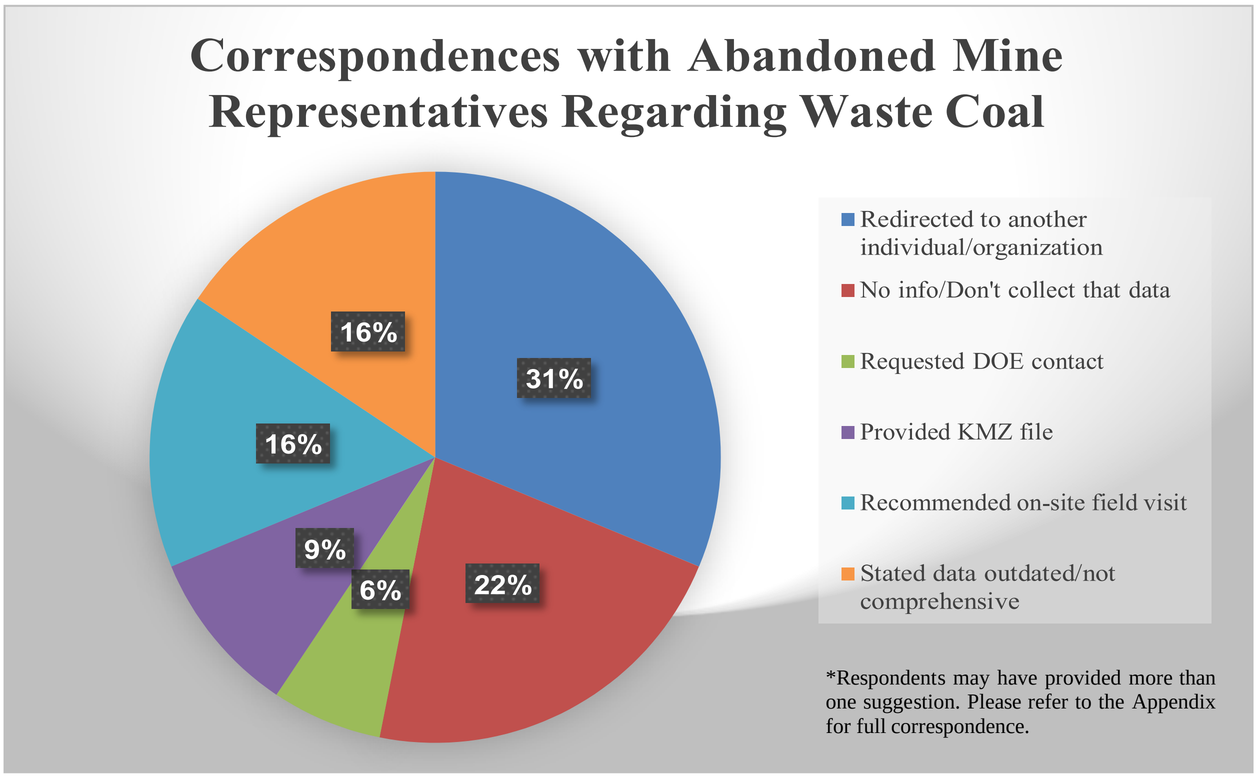

Figure 12: Correspondences with POCs Regarding Waste Coal at Abandoned Mines

In reviewing the interviews and suggestion provided by industry professionals, it was determined that the most promising avenue to identifying information related to gob/culm piles was to speak with representatives affiliated with cogeneration plants. These cogen companies have been actively seeking waste coal piles by utilizing mine scouts (in-house leasing agents) to perform site visits and take core samples, which the various state and federal representatives mentioned would be necessary to determine the actual quality and quantity of waste coal present at these abandoned mines.

Furthermore, most, if not all, of the mine scouts are employed by the cogens. Given that cogens use waste coal for their businesses, we had been advised by others that a newly interested party may be viewed as competition and thus they would have no incentive to share their resources—scouts and methods for acquisition—with a third party. Moreover, a logistical obstacle concerns ownership: if a pile has not been spoken for by a cogen company, the landowner where the pile is located may not own the subsurface rights, and since the material previously came from the ground, there might be complications regarding who owns the pile.

3.0 Power Generation & Cogeneration Companies

3.0 POWER GENERATION & COGENERATION COMPANIES

Cogeneration companies were suggested as the most invested parties in regard to waste coal and identified as the player who would have the data of interest (quality and quantity of gob/culm). Following the information obtained during interviews pertaining to abandoned mines, representatives at power generation and cogen companies were interviewed with regard to locations of waste coal and their respective volumes. As summarized in the previous section, representatives from cogen companies were identified as the most personally invested parties as to the use of gob at abandoned mine locations. Twelve power generation/cogen companies were identified in Pennsylvania and West Virginia.

Phone interviews were conducted with six managers of those facilities to gather information related to locations of gob piles and the quantities. The summaries of these exchanges can be read at length in the appendix. Over the course of these interviews, it was discovered an overlap exists with abandoned mines and active mines where power generation and cogen companies are concerned.

3.1 POTENTIAL SITES AND WILLINGNESS TO PARTICIPATE

Conversation with representatives of power generation and cogen companies proved extremely productive. They reiterated that the coal industry had taken a big hit in the past few decades. Many operations are going out of business and have been purchased by larger players. According to the interviews, many of these power Generation/cogen facilities own or have access to millions of tons of waste coal that is just sitting, waiting for the price of energy to go up so as to justify the cost of processing.

The representatives associated with power generation and cogen companies had knowledge of potential sites where a study could take place and/or had access to waste coal. In some instances, they provided detailed information related to waste ponds, special landfills, or expressed interest in more information from the DOE.

All six representatives mentioned BTU quality as a factor which would weigh into any biomass-related projects associated with waste coal. Figure 13 illustrates the themes of these exchanges.

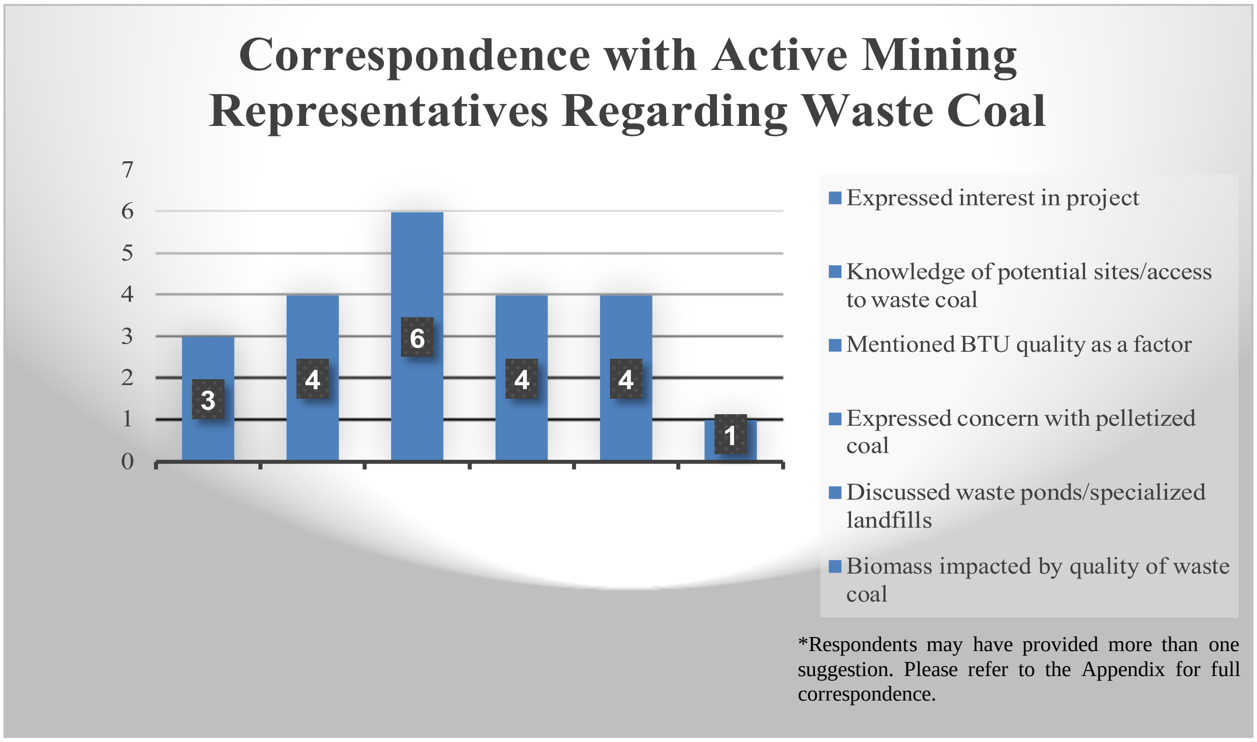

Figure 13: Correspondence with cogen representatives regarding waste coal

Since these individuals have access to waste coal piles, their information can be regarded as comprehensive. For example, some of the people interviewed from the cogen firms had been in the mining industry for over 30 years and had access to million tons of culm. One individual noted that he possessed a lot of knowledge related to pelletized fuel and is interested in the progression of the DOE's project. The General Manager for another cogen plant expressed not only an interest in the study but offered to provide a test site for such an operation. He possesses 15 million tons of waste coal with approximately half of it in waste ponds being "fines" in nature, which typically have a higher BTU content. A representative of the Bureau of District Mining Operations independently confirmed that "fine[s] would be better than coarse when mixing with biomass." In order to process waste coal to be pelletized with biomass the coal would have to be pulverized first. Utilizing fines from waste ponds represents a form of coal that has already been "pulverized." Using waste coal in this form saves money due to the lack of processing needed. It has also been expressed that fines, on average, have a higher BTU content than other forms of waste coal.

3.2 SUMMARY AND IMPLICATIONS

The objective of this phase of the study was to determine the quality and quantity of gob, boney, culm that could be reclaimed and used as part of an initiative to assist distressed communities in the Appalachian region. What was found was that the data that has been collected by the Department of Interior's **Office of Surface Mining Reclamation and Enforcement (OSMRE)** is woefully out of date and inconsistent with ground truth. In order to determine the actual quality and quantity of these coal waste products in this region one has two choices: (1) invest billions of dollars to update the OSMRE information or (2) work with cogen companies in the region that have already invested funds to determine significant locations of waste coal and have expressed an interest in being involved. Further discussions with cogen companies working in those areas that have been identified by the Interagency Working Group report as priority areas is highly recommended.

4.0 Biomass Crops Suited for Appalachian Region

4.0 BIOMASS CROPS SUITED FOR APPALACHIAN MINE REGION

This section of the report is intended to provide a perspective on biomass crops suited to be grown in the Appalachian Region of North America, and more specifically, on surface mined sites in Appalachia. In addition, information on Appalachian surface mined sites where such biomass has been cultivated and/or is about to be cultivated is also discussed.

Figure 14 shows the Appalachian region of the U.S. On the right, the pink shaded areas are surface mined sites, where the literature indicates there is vast potential for growing energy crops.

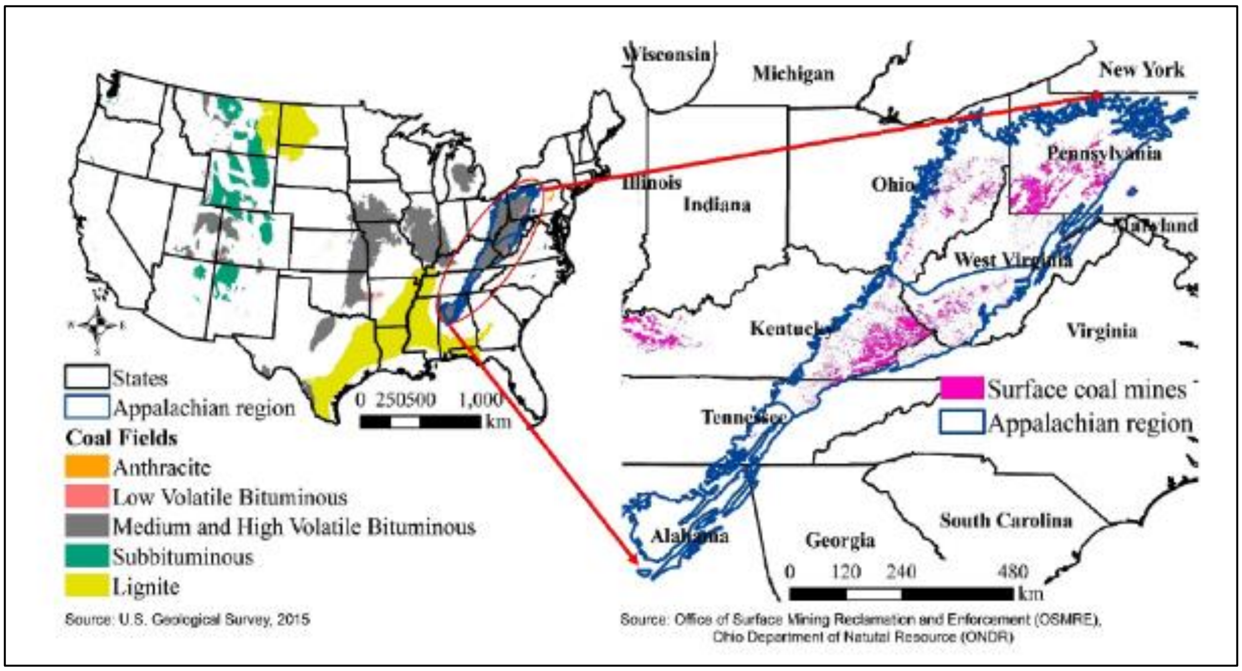

Figure 14: Distribution of coal mined lands across the U.S. and Appalachia[58]

Options for Repurposing Surface Mine Sites

Past coal mining in Appalachia produced large expanses of surface-mined lands that, to meet standards set by the SMCRA, have been reclaimed with cool-season perennial grasses and legumes. If biofuel crops were grown instead of the cool-season grasses, there may be potential economic benefit to the area by selling the biomass for bioenergy, depending on market demand.

More than 10,000 km2 of Appalachia have been surface mined for coal and in recent decades researchers have been exploring various ways that these degraded mine sites can be converted to productive use. Uses being implemented or explored include:

- Seeding with various grasses to develop pastureland for livestock while supporting wildlife habitat
- Replanting with native grasses and/or trees for carbon sequestration, or reforestation for lumber production
- Planting native crops to control invasive plants and control erosion and acid runoff
- Developing sites into renewable energy operations – such as solar installations or growing biomass as feedstock for the production of bioenergy
- If geotechnically stable, mined lands could support housing projects, industrial sites, and other large-scale building structures[59]

The Biomass Cultivation Option

Biomass crops grown on mine sites are being explored as feedstock for biofuel, as well as feedstock for other bioproducts such as bio-adhesives, biochemicals, resins for 3D printing, bicarbonate nanomaterials, and carbon products such as activated carbon and biochar.[60]

Since biomass can be the feedstock of various products in addition to biofuels, it has been suggested that having a flexible end product approach may be wise - where biomass production can be intended for several different end products, in response to markets or seasonal needs, such as growing a switchgrass biofuel production stand, that in drought years when cool-season grass hay is unavailable, can be used for livestock forage instead. Also advised is a strategy that meets some of the other priorities as well. For instance, to enhance wildlife habitat in a biofuel production stand, strategies can include delayed winter harvest (to retain winter cover for wildlife) and rotating harvest, so that some fields or portions of fields are harvested only once per 2 - 3 years.[61]

The literature indicates that there are several herbaceous biomass crop options that will grow in reclaimed mining site conditions, including: **Switchgrass**; **Miscanthus**; **Giant cane (Arundo)** – and several short rotation woody crop options – such as **Poplar** and **Willow**, as well as a few other native trees. Growth success can vary not only by plant type, but also by the sub-variety chosen, the individual mine site conditions, the soil inputs used, and the cultivation method (seed vs. seedlings, etc.).

4.1 SWITCHGRASS (PANICUM VIRGATUM)

Switchgrass Benefits

Native switchgrass is a hardy, tall-growing, deep-rooted warm season perennial grass known to thrive despite poor soil quality, drought, or flooding. Its deep roots can break through rocky soil layers, improving long-term soil structure. It can be converted into heating fuel pellets or ethanol. Switchgrass is a carbon-neutral crop that can produce high yields — 7 or 8 tons of dry matter per acre when harvested. One ton can produce about 80 gallons of ethanol.[62]

As a warm season grass, switchgrass typically takes longer to establish than its cool-season counterparts, but once established, it tends to live much longer with less maintenance. It is known to tolerate soils with pH levels from 5.0 to 8.0, and with textures from sandy to clayey and high yields can be achieved with minimal fertilizers or other agricultural inputs. As a perennial species, switchgrass can be harvested annually for approximately twenty years. In addition to being a feedstock for biofuel production, it can be used as livestock forage and wildlife cover. Its carbon sequestration can be traded as carbon credits to offset industrial carbon emissions. With many cultivars, growers can make site-specific seed selections that allow for tolerance of periodic flooding. When varieties are selected and established properly, yields of 3 to 6 tons per acre can be expected annually on marginal lands. Yields of switchgrass typically reach their full potential in three years. Traditional hay mowing and baling equipment is ideal for switchgrass harvest.[63]

Switchgrass Economics

Per 2012 data, total costs for planting, annual maintenance, and harvesting switchgrass average about $1,000 per acre over the first five years. Depending on the yield, breakeven prices can vary from $40 to $80 per ton at the farm gate.[64]

Varieties

There are at least 700 switchgrass varieties.[65] Three varieties - Carthage, Cave-in- Rock, and Shawnee – were compared in a 2008-2009 experiment at West Virginia mine sites. Biomass yields were highest for the Cave-in-Rock variety.[66] However, seed dormancy has been noted as a serious concern with the Cave-in-Rock variety. [67]

Alamo, a lowland variety of switchgrass developed in Texas, grows well throughout most of the South and mid-South, exhibits little problem with seed dormancy, and, while best adapted to alluvial soils, also does well on upland sites. But Alamo may suffer damage from extreme cold in the central Appalachians. [68]

John Lovell, Jane Grimwood, and Jeremy Schmutz, researchers at Alabama's HudsonAlpha Institute of Biotechnology, have been working with Tom Juenger at the University of Texas Austin on experiments transposing traits from one variety of switchgrass to another using gene editing, in an effort to create switchgrass that can grow anywhere. The Juenger Laboratory has collected switchgrass from across America and planted research gardens. The team mapped the genomes of more than 700 different switchgrass plants.[69]

End Use Applications

Growing Switchgrass has been found to meet many environmental and wildlife needs, and market pull for switchgrass is coming from multiple industries.

> Researchers found that switchgrass, if used in streamside buffers or as a cash crop, stores harmful carbon at a level similar to trees and better than land planted with other native grasses. If switchgrass takes off as a biofuel, it could be processed in refineries where carbon could be captured and stored, making it even more viable as a significant fuel source. They also found that switchgrass, even grown as a monoculture, has much more biodiversity than corn and supports more insects, birds and pollinators, partly because it isn't cut and replanted every year. Soil health practices were augmented by switchgrass, and crop pests were fewer.
>
> While silt socks and poultry bedding are the two most salient success stories, switchgrass advocates see these possible markets developing: cat litter; bale building blocks for homes; fuel pellets; cover for wild game; feed for cattle; abandoned mine reclamation; medium for growing mushrooms; ornamentals; plantings under solar panels; and burning methane in anaerobic digesters to produce electricity on a farm scale.[70]

Competing Site Options

In addition to mine sites, other types of waste land are being planted with switchgrass to meet these potential market demands, including vast areas of underperforming farmland.

> In fact, using satellite imagery, Penn State researchers estimated that there are more than 500,000 acres of farmland in Pennsylvania that are currently idle or in traditional crops that are not growing well because they are in wet or flood-prone areas. When one adds in existing buffers that could be expanded for switchgrass, or set-aside programs like CREP, the total rises to 800,000 acres. That's a potential for 6 million tons of harvestable switchgrass worth perhaps $590 million annually … in southeastern Virginia, where the Piedmont Geriatric Hospital is entirely heated and cooled by the burning of switchgrass ... to support the hospital's boiler, 13 farmers in seven Virginia counties are growing switchgrass on 3,300 acres of marginal soil or government land set-aside programs. Surplus switchgrass is sold for silt socks, cattle feed and other byproducts. "Our business is the conservation industry," said Fred Circle, CEO of Ohio-based FDC Enterprises, which built and runs the project. "The idea is to be able to do something on a local basis, help farms with underperforming land and solve erosion and invasive species problems. "If we can turn that land into switchgrass, all these things go away. And we are improving wildlife habitat. [71]

4.2 GIANT MISCANTHUS (MISCANTHUS X GIGANTEUS)

Miscanthus Benefits

Miscanthus is a warm season non-native grass (native to Asia) that grows up to 13 ft tall. It is very cold tolerant, and, while it can tolerate drought, it performs best under wetter – even flood - conditions. It has been cultivated successfully for energy production in Europe for decades. It is sterile and non-invasive. Early studies in the U.S. show great promise for its success here, as it has yielded more than twice the biomass of corn and switchgrass per acre. Miscanthus is productive much longer than corn, since it produces green leaves 6 weeks earlier and maintains leaves about 6 weeks after corn leaves die. Miscanthus is a perennial crop, not an annual like corn, so it does not need to be seeded every year and can be harvested annually for 20 years with negligible inputs following its 2–3-year establishment period. Miscanthus can be converted to ethanol, and it can be pelletized or pressed into biomass logs for combustion as a heat source. It is also used for animal bedding, as an absorbent, and for bio-based materials such as fiberboard. It also provides income potential through carbon credits, which can be awarded to offset industrial carbon emissions in exchange for a crop's carbon sequestration. Miscanthus can be harvested using traditional hay equipment, and the bales can be left in the field for a very long time without the crop breaking down.[72]

Miscanthus Economics

Per 2012 data, assuming rhizomes are 10–25 cents each, about 6,000 rhizomes per acre comes to $600 at minimum for plant material. Other planting expenses are similar to that of other row crops at about $400 per acre. Harvest costs range from $300 to $500 per ace depending on the type of machinery used. Depending on the yields, breakeven prices range from $40 to $80 per ton at the farm gate.[73]

4.3 GIANT CANE (ARUNDO DONAX)

Giant cane (Arundo donax L.) is a non-native perennial grass that grows up to 25 feet tall, with hollow stems. It is native to Asia and is viewed as an invasive plant in the U.S. It can form dense stands on disturbed sites, sand dunes, wetlands, and riparian habitats. Giant cane needs to be established by vegetative propagation (rhizomes) due to a lack of viable seed production. It is capable of growing on a wide range of soils and can provide very high biomass yields with low environmental impact and low inputs from fertilizer, tillage, and pesticides. Heating value is similar to other biomass crops.[74]

West Virginia **University research results from three mine site planting projects found that Arundo did not perform as well on reclaimed land, compared to switchgrass and miscanthus**.[75]

Reclamation of Mined Land with Switchgrass, Miscanthus, and Arundo: Conclusions

After the 3rd year on reclaimed land
Switchgrass: 3.0 to 5.0 Mt ha-1
Miscanthus: 5.0 to 20 Mt ha-1
Arundo: < 1.0 Mt ha-1
West Virginia University Research results[76]

4.4 WILLOW (GENUS SALIX)

Numerous willow varieties are bred for biomass production. SUNY- ESF and the New York State Agricultural Experiment Station in Geneva, NY (Cornell) have developed and are continually developing new varieties that have improved biomass production, more upright form, and are resistant to insect and disease pests. Currently, SUNY-ESF/Cornell shrub willow varieties are licensed for sale by Double A Willow, in Fredonia, NY, through their web site.[77]

Willow grows best in loamy soils with a rooting zone of 45 cm or greater with pH between 5.5 and 7.0. While agricultural soils represent an ideal situation for willow cultivation, mine soils are commonly coarse textured with high rock fragment, resulting in challenging conditions for manual planting of willow cuttings and hindering root establishment. Further problems with mine soils include pH extremes (below 4.0 and above 8.0), poor fertility, and poor water holding capacity. [78]

In a West Virginia mine site planting study where three willow clones – SX61 (Salix sachalinensis), Fish Creek (S. purpurea), and Preble (S. viminalis x S. miyabeana) – were cultivated in coarse, rocky mine soil, the Preble clone showed advantages over Fish Creek and SX61. Fertilizer treatments showed effectiveness for increasing growth of the Preble and SX61 clones.[79]

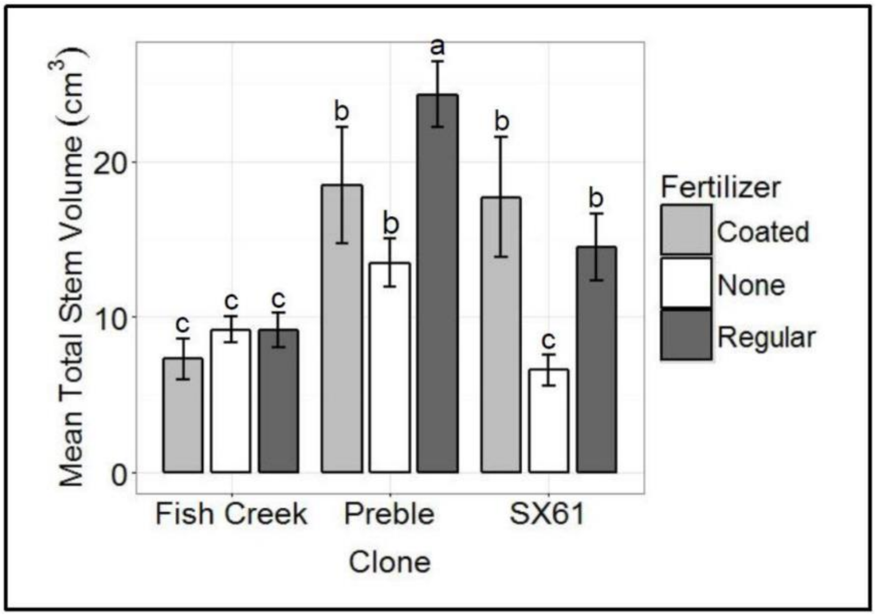

Figure 15: West Virginia Mine Site Planting Study of Three Willow Clones [80]

About Double A Willow

Double A Vineyards, through its subsidiary Double A Willow, has taken the lead in the large-scale commercialization of shrub willow and other commercial uses. The company was chosen in 2004 by SUNY ESF as the only licensed commercial nursery to grow and distribute their patented high yielding and fast-growing shrub willow varieties. Double A Willow has developed a large nursery capable of providing willow cuttings to growers across North America, to be used primarily to ultimately provide fuel supplies for wood and coal power plants and combined heat and power projects. It is hoped that, as technology improves, willow can be used as a source fuel for large scale biofuel projects.[81]

4.5 POPLAR (POPULUS SPP.)

Poplar (i.e., cottonwood, hybrid poplar) is one of the fastest-growing temperate trees in the world and is a very promising feedstock for the production of biofuels and other bio-based commodities. Plantations established on marginal lands such as mining sites can provide bio-energy feedstock while providing soil remediation and stabilization benefits.[82]

There are ongoing efforts to address factors that are negatively affecting poplar's efficient conversion to biofuel. According to Oak Ridge National Lab, one of the major factors negatively affecting poplar's efficient conversion to biofuel is the inherent recalcitrance to enzymatic saccharification due to cell wall components such as lignin. To this effect, there have been research efforts to modify gene expression to reduce biomass recalcitrance by changing cell wall properties and the resulting effects on subsequent pretreatment efficacy and saccharification. Recent studies have shown promising improvement in the biological conversion of transgenic poplar to biofuels.[83]

A February 2021 report, Opportunities and barriers for biofuel and bioenergy production from poplar, expands on the barriers and the various strategies to improve bio-energy production from poplar.

A 2009-2010 hybrid poplar clonal trial was conducted to determine if poplars and their hybrids – widely considered to be the premier woody perennial candidate for bioenergy feedstock production on non-mined land sites – would thrive in mined land sites. The three clones evaluated were Populus x generosa (P. deltoides x P.trichocarpa); Populus x Canadensis (P. deltoides x P. nigra); and Populus deltoides x Populus maximowiczii. First-year survival was excellent, at >90%. Height growth of surviving trees was highly variable, ranging from <1 foot to >7 feet, with average height growth of all clones >3 feet. Populus deltoides x Populus maximowiczii taxon had the largest number of clones with average height growth > 4 feet. Visual evaluation revealed a minor incidence of poplar leaf rust (fungus Melampsora) but >80% of planted clones were visually rated as having “no” or “light” rust. Second-year growth (at the time of publication) appeared as excellent.[84]

Results of research conducted under the leadership of James Burger of Virginia Tech demonstrates that **hybrid poplar far out yields commonly used reclamation species such as native hardwoods and eastern white pines on reclaimed mine**. With additional involvement by Virginia Tech foresters A. Brunner and J. Munsell, the research has been expanded to evaluate and compare 97 genotypic varieties of hybrid poplar for production, agronomic, and wood-quality characteristics when grown on reclaimed mine areas; and to compare the biomass production capabilities of hybrid poplar to other fast-growing species that yield denser biomass materials.[85]

5.0 Biomass Cultivation Sites

5.0 BIOMASS CULTIVATION SITES

Much of the mine site biomass cultivation work is being conducted by two USDA NIFA-funded consortiums, MASBio (Mid-Atlantic Sustainable Biomass Consortium) **at West Virginia University**, and NEWBio (Northeast Woody/Warm-season Bioenergy Consortium) **at Penn State University**. Research conducted by these consortiums covers multi-state regions within and beyond Appalachia.

While the Appalachian Region Office of Surface Mining Reclamation and Enforcement (AR OSMRE) regulates coal mining reclamation activities and OSMRE initiatives in the appalachian region have addressed acid drainage, reforestation, dam safety, and restoration of fish habitat, AR OSMRE does not report any OSMRE initiatives for the cultivation of biomass.[86]

5.1 WEST VIRGINIA SITES

West Virginia has very little uncommitted agricultural land, but has up to 150,000 acres of reclaimed or soon-to-be reclaimed surface mine sites that are potentially available for conversion to production of bioenergy crops.[87] In the past decade, organizations such as the Northeast Woody/Warm-season Biomass Consortium (NEWBio) and the Mid-Atlantic Sustainable Biomass Consortium (MASBio), have focused on the production of biomass for biofuel in areas that don't compete with food crops, such as abandoned and reclaimed coal mines.

As of September 2019, approximately 200 acres of reclaimed mine land and other land has been planted with biomass crops in the state of West Virginia.[88]

West Virginia University, a partner in both these consortiums, has been a major participant in projects to grow biomass as biofuel feedstock on reclaimed mine land, with six projects in West Virginia and one in Ohio.[89]

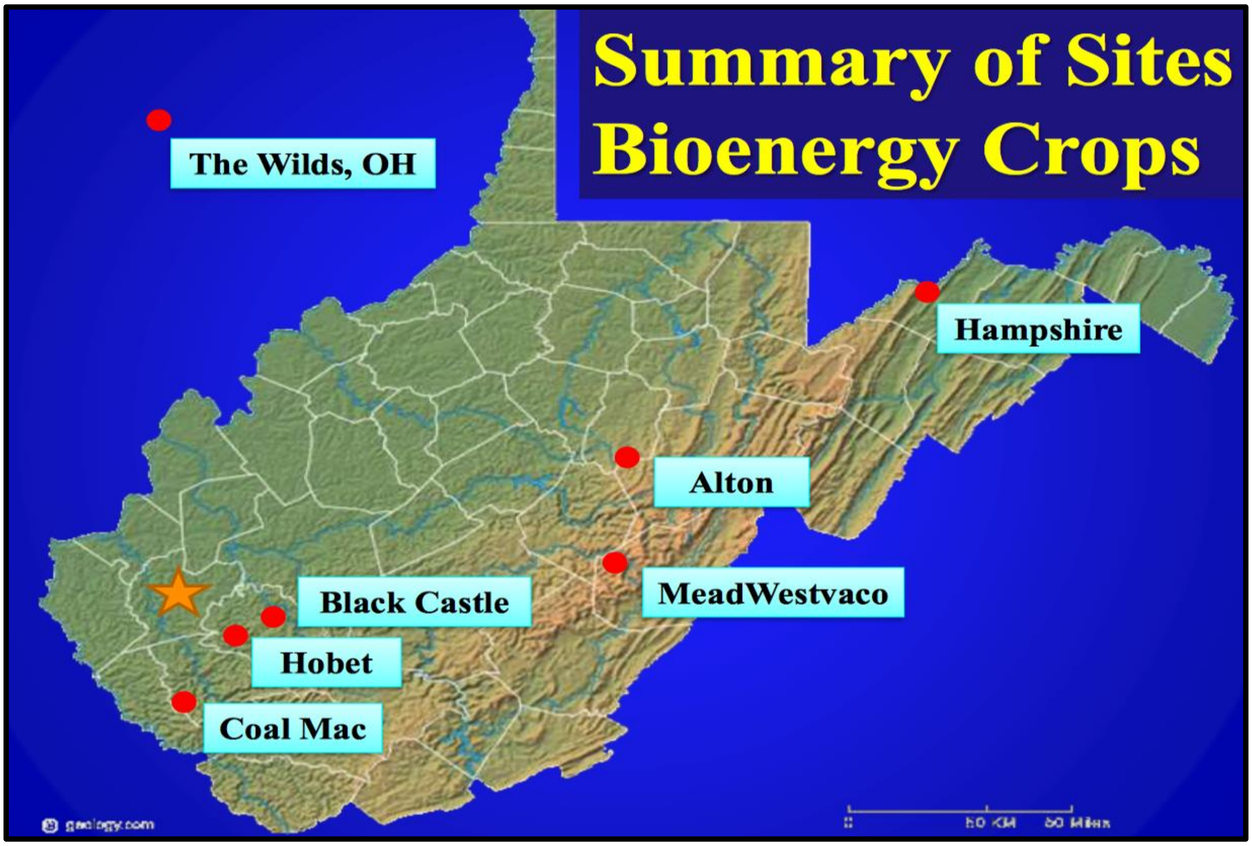

Figure 16: West Virginia University Mine Site Research Sites[90]

5.1.1 Hobet, Coal-Mac, Hampshire Hill Mine Sites

In a 2008-2010 WVU research project these mine sites in West Virginia were selected for switchgrass demonstration plots. The intention of this study was to identify the best varieties of switchgrass for mined lands in northern Appalachia, their planting and management requirements, yields, biofuel feedstock potential, capacity for carbon capture and sequestration and other revenue streams.

Soil and Planting Details

> The Hobet 21 mine was reclaimed with mostly topsoil substitute mixed with some original topsoil; soil pH was 7.2 and total C was 1.5%. The Coal-Mac mine was reclaimed with mostly original topsoil mixed with some topsoil substitute; soil pH was 6.1 and total C was 1.5%. The Hampshire Hill mine was reclaimed almost entirely with original topsoil amended with municipal biosolids; soil pH was 7.2 and total C was 7%.
>
> Three varieties of switchgrass (Carthage, Cave-in- Rock and Shawnee) were randomly assigned and planted into 0.4 ha plots, which were replicated three times

for a total of nine plots at each site. Planting was conducted in May of 2008. At the end of the 2009 growing season, biomass yields were highest for the Cave-in-Rock variety in plots that were well established. The Hampshire Hill plots that received high amounts of municipal biosolids outperformed other plots with no organic amendments.[91]

Variety	Hobet 21	Coal Mac	Hampshire Hill
Cave-In-Rock	Very Poor to Poor	Poor to Moderate	Very Good
Shawnee	Very Poor to Poor	Poor to Moderate	Very Good
Carthage	Very Poor to Poor	Poor to Moderate	Very Good

Average vigor for 2009 between mine sites and variety.

Figure 17: West Virginia University Mine Site Switchgrass Year One Results[92]

5.1.2 Black Castle & Coal Mac Mine Sites

In a WVU switchgrass study to determine optimum levels of mulch and fertilizer, the Black Castle and Coal Mac mines were seeded with Cave-in-Rock switchgrass on the newly reclaimed land in 2011.

The first site, Coal Mac (37.7 N 82.0 W), is located on a large mountaintop surface mine in Mingo, Logan, and Boone counties operated by Coal-Mac, part of Arch Coal, Inc. The site of switchgrass planting was leveled and reclaimed in 2011 with 60 to 90 cm of topsoil and weathered sandstone mixture that was placed over gray sandstone overburden. [93] The Coal-Mac mine was reclaimed with mostly original topsoil mixed with some topsoil substitute; soil pH was 6.1 and total C was 1.5%.[94]

The second site, Black Castle (38.1 N 81.7 W), is located in Boone County on a large mountaintop surface mine operated by Black Castle Mining Company and owned by Alpha Natural Resources. Reclamation was done in 2011 by leveling unweathered overburden and covering it with a 20 to 30 cm layer of topsoil mixed with crushed weathered rock. Research determined that fertilizing with 67 kg N ha-1 may be best for switchgrass grown on reclaimed surface mines if high biomass production is the goal.

The two sites, Black Castle and Coal Mac, were comparable in the average amount of switchgrass they yielded over three years.[95]

Property	Hampshire	Hobet	Black Castle	Coal Mac
pH	7.3 a[a]	7.7 b	5.8 x[c]	6.1 x
EC (µS cm^{-1})	648 a	140 b	460 x	96 y
% Fines (%)	78 a	57 b	37 x	42 x
% Sand	42 b	63 a	51 x	60 x
% Silt	47 a	27 b	25 x	28 x
% Clay	11 a	10 a	13 x	12 x

Figure 18: Selected soil chemical and physical properties at Hampshire and Hobet averaged over 2010–2013, and at Black Castle and Coal Mac averaged over 2011–2013[96]

At some point the Coal Mac site was also planted with Arundo and an average of 10,000 kg ha-1 of Arundo was produced after the third growing season.[97]

5.1.3 Alton Site

Beginning in 2010, three biofuel feedstocks have been cultivated at the Alton site in West Virginia, a previously surface mined area of 160 ha located in Upshur County, WV (38°49’N 80°11’W). To determine their potential for biomass production, varieties of switchgrass (Kanlow, BoMaster), varieties of miscanthus (Private, Public), and giant cane (Arundo donax L.) biomass plots were established.[98]

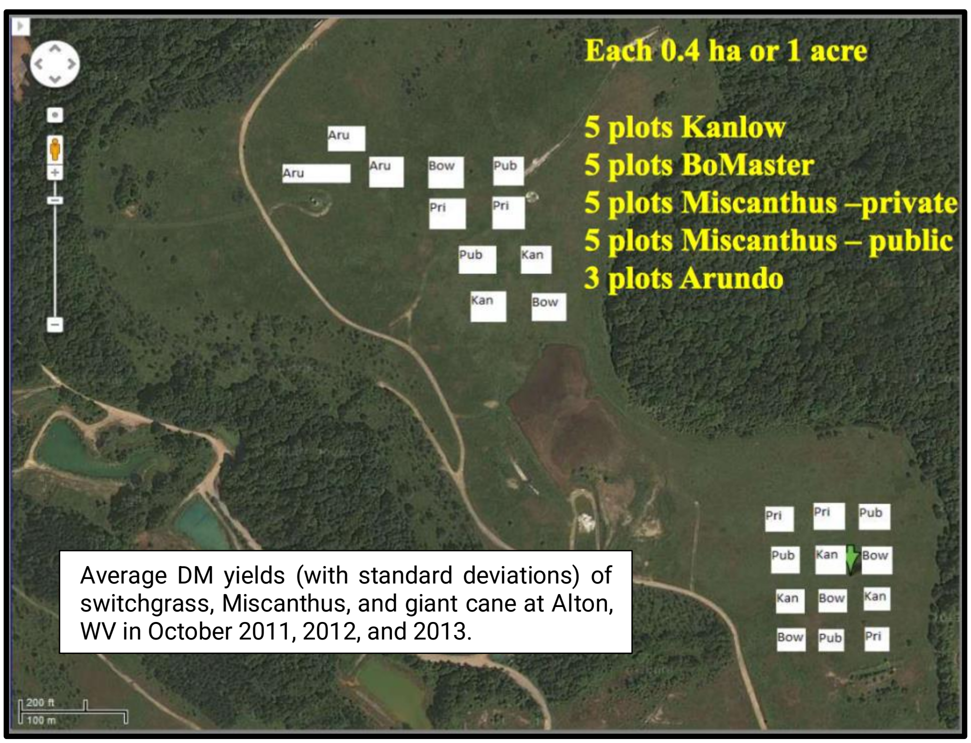

Figure 19: Alton Site Plantings[99]

Plant Species	2011	2012	2013
	----------------------------	kg ha^{-1}	----------------------------
Switchgrass			
Kanlow	4,040 (2,643)	4,887 (1,138)	4,963 (3,541)
BoMaster	2,752 (1,381)	3,981 (3,136)	5,415 (9,829)
Miscanthus			
Public	2,248 (2,006)	4,905 (3,002)	7,029 (6,613)
Private	6,553 (5,847)	15,467 (10,447)	11,058 (6,811)
Giant Cane			
Arundo	NA	515 (180)	797 (1,204)

Figure 20: Alton Site Year 1-3 Results[100]

Fourth Year Results

After the fourth growing season, the dry matter (DM) yield averaged 5,200 kg ha-1 for switchgrass (Kanlow and Bomaster varieties) and 9,000 kg ha-1 for two varieties of Miscanthus. Giant cane had less than 1,000 kg ha-1.[101]

Miscanthus yields after the 5th year averaged 13.7 Mg ha-1 for Private and 14.4 Mg ha-1 for Public. Switchgrass yields after five years averaged 7.9 Mg ha-1 for Kanlow and 7.3 Mg ha-1 for BoMaster, which is approaching the yields of switchgrass on agricultural soils in the region. With these recorded biomass yields, switchgrass and Miscanthus are able to provide alternative, more sustainable energy sources, whilst providing a more profitable post-mining land opportunity for surface mined landowners.[102]

After 6 years of growth at Alton, biomass yields were 6-8 and 7-13 Mg DM ha-1 among genotypes of switchgrass and miscanthus, respectively.[103]

5.1.4 MeadWestvaco Site

In 2013, Cave-In-Rock switchgrass was planted on 8 ha at the MeadWestvaco (MWV) site. After the first growing season, switchgrass production was 752 kg ha-1 at MWV. Miscanthus was also planted and biomass production after one year was 200 kg ha-1. These biomass averages at MWV were lower than averages produced at Alton after the first growing season.[104]

5.1.5 C-1 Surface Mine Site

At the C-1 surface mine, located near Mount Storm, Grant County, WV (39.133639,-79.281323), three willow clones were planted for a WVU study – SX61 (Salix sachalinensis), Fish Creek (S. purpurea), and Preble (S. viminalis x S. miyabeana). The objective was to determine willow planting strategies to overcome common mine soil challenges, such as high rock fragment content that causes planting difficulties and reduced water- and nutrient-availability.[105]

The three shrub willow clones were planted using six planting/fertilizer treatments. The planting treatments compared a horizontal planting method to traditional vertical planting of cuttings. Fertilizer treatments compared no fertilization to controlled release and traditional fertilizer at a rate of 140 kg N ha-1.[106]

After two growing seasons, Preble outperformed the others in both survival and production, but the influence of fertilizer treatments was inconsistent and varied by clone. Survival and growth for horizontally planted cuttings was 46% relative to vertically planted cuttings at 83%. Results of this study will be used to direct future establishment practices for willow on reclaimed mine soils in West Virginia. [107]

5.2 OHIO SITES

5.2.1 The Wilds

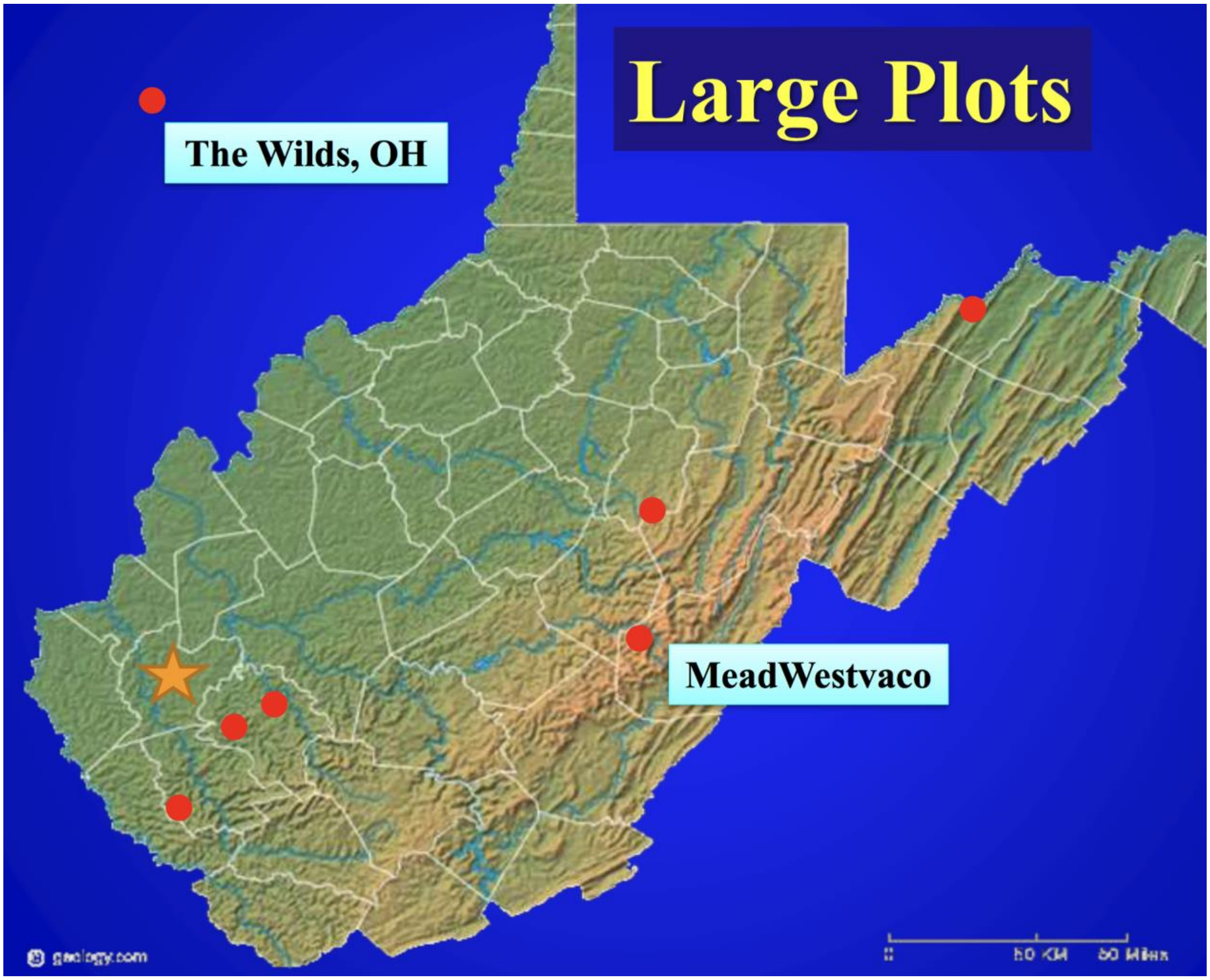

Figure 21: West Virginia University[108]

The Wilds (New Cumberland, OH – about 70 miles southeast of Columbus) – known by the general population for its 1,200-acre safari park exhibiting rare and endangered animals – also includes land dedicated to native conservation, including a prairie plant project. Its restoration ecologists have grown a variety of native plants on 700 acres. The property was surfaced mined for coal for decades, until it was idled in 1991.[109]

In 2013, Cave-In-Rock switchgrass was planted at The Wilds site. After the first growing season, switchgrass production was 1,045 kg ha-1. Miscanthus was also planted, and biomass production after one year was 600 kg ha-1.[110] These biomass averages at The

Wilds were lower than averages produced at Alton after the first growing season.[111] After the second growing season, switchgrass production was 5 Mt ha-1.[112]

Point of Contact
Rebecca Swab, Director of Restoration Ecology The Wilds, 14000 International Rd, Cumberland, OH 43732 740-638-5030 Email: information@thewilds.org

5.2.2 Steubenville, Ohio Site

Double A Willow and Anthony Mining, near Steubenville Ohio, are examining the possibility of working with large coal plants in Ohio on conversion or co-firing projects. There are 2000 acres of tillable reclaimed coal strip mine land available in Steubenville, Ohio for this demonstration project.[113]

Point of Contact
Dennis and Sue Rak, Owners Double A Willow, 10277 Christy Road, Fredonia, NY 14063 716-672-8493

5.3 PENNSYLVANIA SITES

As of 2017, Pennsylvania still had hundreds of thousands of acres of land that had not been reclaimed after strip mining.[114]

5.3.1 Pennsylvania Environmental Council Demo Project 4 Sites

From 2007 to 2011, the **Pennsylvania Environmental Council, in partnership with the Penn State University's Department of Crop & Soil Sciences**, successfully demonstrated the enhanced reclamation of 70 acres of **four separate former surface mine sites in western Pennsylvania** using poultry manure combined with wastepaper mill sludge to improve soil conditions and cultivate switchgrass and native grassland biofuel crops. This effort included a 30-acre demonstration project at 3 recently active surface mine sites in Clearfield County and a 40-acre demonstration project at a former surface mine site in in Elk County. Key personnel involved include Brian Hill, Scott Van de Mark, and Jack Ubinger of PEC; Richard Stehouwer and Marvin Hall, od Penn State U., and others.[115]

- **Lower Emigh Mine Site**
  On this 12-acre Clearfield County demonstration site, various plots were amended with different treatments of manure/pulp mill sludge mix, compost and lime/fertilizer mix and seeded with monocultures and polyculture stands of switchgrass, big bluestem, Atlantic coastal panic grass. Some of the strip plots were also seeded with the legumes showy tick trefoil and birdsfoot trefoil. [116]

- **J Mine Site**
  On this 8-acre Clearfield County demonstration site, the soil was amended with manure plus paper mill sludge and half was seeded with a monoculture of switchgrass, with the remaining acreage seeded with a mix of switchgrass, Atlantic coastal panic grass and big bluestem. [117]

- **Maxton Mine Site**
  On this 10-acre Clearfield County demonstration site, located adjacent to the Lower Emigh mine site near Morrisdale, similarly amended land was seeded with monocultures and polyculture stands of switchgrass, big bluestem, and Atlantic coastal panic grass. [118]

- **Sweet Soil Site**
  On this 40-acre Elk County demonstration site, located approximately 3 miles north of the town of Brockway in northern Jefferson County, 30 acres of Sweet Soil site land, along with 10 acres of land leased from the adjacent BrockWay Sportsmen's Club, were similarly amended, and seeded with a 50% switchgrass and 50% Atlantic coastal panic grass mix to establish a biomass crop. The seed mix was applied at a rate of 9 pounds of combined seed per acre. The 50/50 mix of switchgrass and Atlantic coastal panic grass resulted in comparatively greater biomass productivity of that mix in test plots at the Lower Emigh demonstration project.[119]

5.3.2 Philipsburg Site

In a project to determine which switchgrass would survive and thrive on strip-mined ground in PA, Penn State forage agronomist Dr. Marvin Hall, with colleagues Rick Stehouwer, an environmental soil scientist, and John Carlson, a molecular geneticist, oversaw the planting of 4,000 seedlings of some 150 switchgrass varieties in 2013. To support cultivation, agricultural manure and paper-mill sludge were used to rebuild soil quality and sustainability. This Clearfield County property had first been deep mined in the late 60's, then strip mined in the mid-2000s.[120]

In 2017, Hall identified those varieties that fared well and 1,500 seedlings of the 30 top-performing ecotypes were planted – with an ultimate goal to narrow selection to the five top performers for the land conditions and climate, then make seed from these selections available to the public for planting. Funding for the project was provided by the NEWBio consortium, funded by the USDA's National Institute of Food and Agriculture.[121]

5.4 CURRENT MASBIO BIOMASS TRIALS (NY, PA, WV, OH)

MASBio is conducting 30 biomass trials in New York, Pennsylvania, West Virginia, and Ohio. Surface mined lands within the MASBio research area, (approximately 0.5 million hectares) are located predominantly in southwestern and northern West Virginia, as well as the middle region of Pennsylvania.[122]

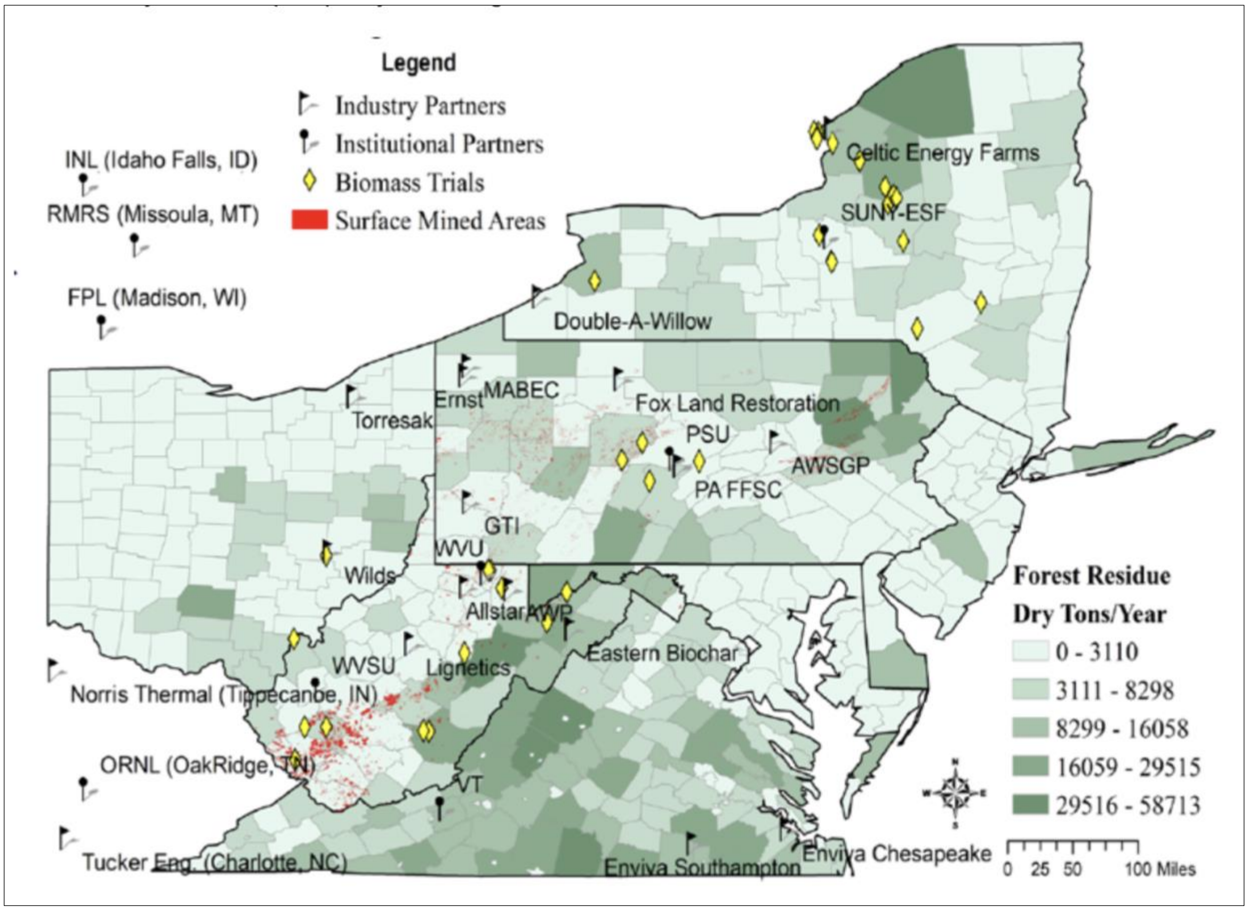

Figure 22: Current MASBio Trial Areas[123]

MASBio Biomass Trials in Appalachia include four trials In Pennsylvania, to be conducted in Centre, Cambria, Blair, and Mifflin counties, and 11 trials In West Virginia, to be conducted in Monongalia, Preston, Tucker, Mineral, Randolph, Greenbrier, Mingo, Logan, Raleigh, and Mason counties. In Ohio, there is 1 trial in Morgan County.[124] *Specific mine sites are not named*. [Learn more](#).

MASBio Contacts
Molly Ramsey, MASBio Project Manager Division of Forestry and Natural Resources West Virginia University (304) 293-0061 molly.ramsey1@mail.wvu.edu **Dr. Jingxin Wang, MASBio Project Director** Director of Renewable Materials and Bioenergy Research Center Associate Director for Research Professor of Wood Science& Technology Division of Forestry and Natural Resources, West Virginia University (304) 293-7601 jxwang@wvu.edu

5.5 FUTURE PA, OH, & WV SITES

Dr. Evan Blumer, Principal, OsoMono, LTD, was involved in The Wilds project in Ohio. Now he is involved with the Coal First project: **Advanced PFBC Power Plant Project** (CONSOL Pennsylvania Coal Company — DOE Funding: $147,000[125]). For this project, biomass will serve as a secondary fuel, providing about 10% of the fuel feedstock. A **variety of grassy and woody biomass crops will be cultivated over** an area of land that includes between 22,000 and 25,000 acres, across **parts of SW PA, Eastern OH, and possibly Northern WV** (CONSOL has significant landholdings in PA, WV, and OH). A power plant is planned on or near CONSOL's Pennsylvania Mining Complex. The plant will utilize a coal slurry and biomass combination. **Switchgrass, miscanthus, willows, and some other experimental crops will be cultivated.** The project may also integrate some timber and hemp industry waste.[126]

In a March 10, 2021 meeting, Dr. Blumer and Jacquie Fidler, VP of Environmental & Sustainability at Consol Energy, Inc, provided details about this project. A video recording of that meeting is available here.

Per Dr. Blumer, the biomass produced will be contained within a 50-mile (or less) radius as illustrated by the blue circle in the image on the left below.

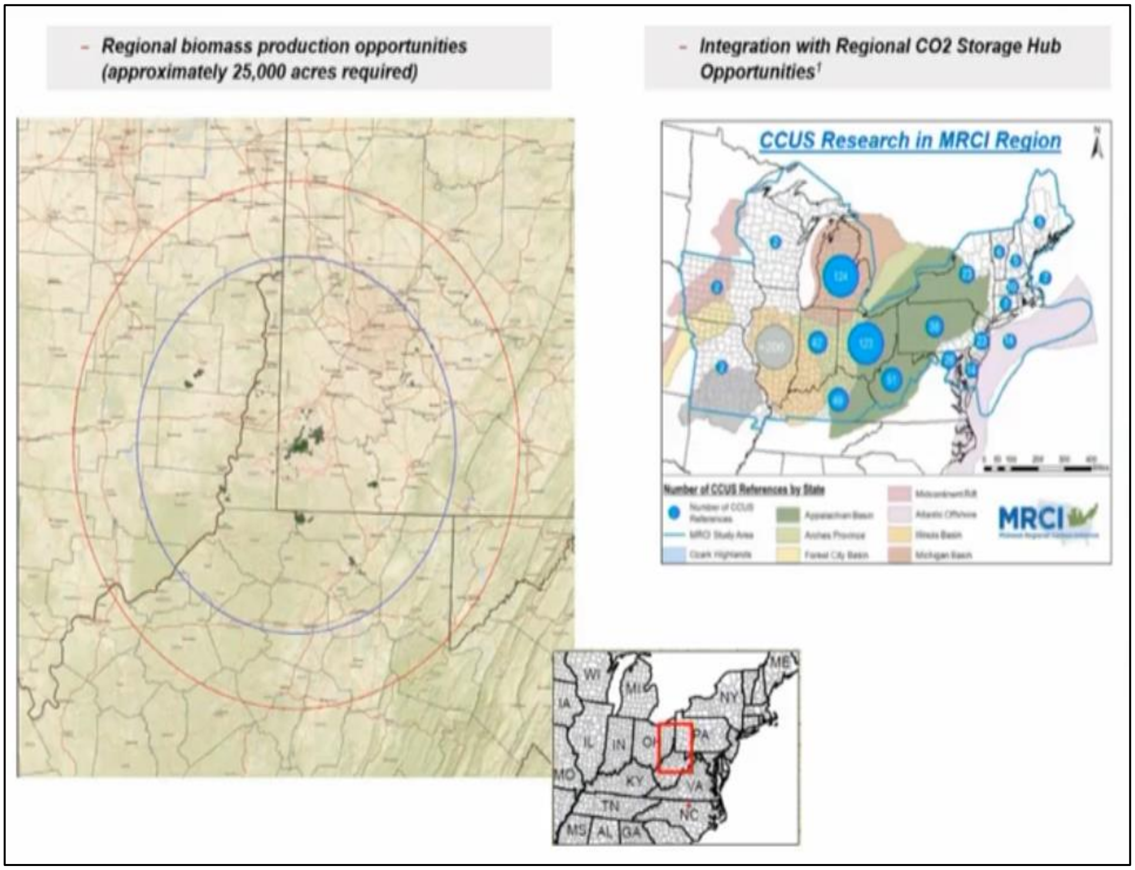

Figure 23: CONSOL Pennsylvania Coal Company[127]

Point of Contact
Dr. Evan Blumer, Principal OsoMono, LTD eblumer@osomonoltd.com osomonoevan@gmail.com LinkedIn: https://www.linkedin.com/in/evansblumer/

5.6 VIRGINIA SITES

Per the U.S. Energy Information Administration, while hydroelectric power is the renewable resource with the greatest generating capacity in Virginia; biomass fuels a larger share of the state's electricity generation annually. In 2019, biomass fueled more than 4% of the state's total net generation. Municipal solid waste and landfill gas are common forms of biomass used for electricity generation in Virginia, but the largest share of generating capacity is at facilities that use wood and wood waste. Virginia also has seven wood pellet manufacturing and Virginia also has a liquid biofuels industry, with three biodiesel plants one fuel ethanol plant.[128]

5.6.1 Powell River Project Site

Carl E. Zipper of Virginia Tech has been involved in mine land biomass projects in Virginia, funded by the Powell River Project, a public-private research and outreach partnership between Virginia Tech, other educational institutions and environmental organizations, and natural resource industries, serving the southwest Virginia coalfield region.

The unique mined land resources located at the Powell River Project site in Wise County allow researchers to conduct field studies and long-term experiments right on site, as well as at other mine sites throughout the region.[129]

Carl Zipper was involved with a project conducted from **2009-2010 to compare poplar clones' production results on reclaimed mine land at the Powell River Project Research and Education Center site in and two sites in the Southside region of Virginia**. [130]

A 2011 report describes **biomass planting projects at three sites in Wise County, Virginia where plots were planted with hybrid poplar cuttings** (Populus trichocarpa L. (Torr. and Gray ex Hook.) x Populus deltoides (Bartr. Ex Marsh.) hybrid 52-225), **American sycamore** (Platanus occidentalis), **and black locust** (Robinia pseudoacacia), each at two planting densities.[131]

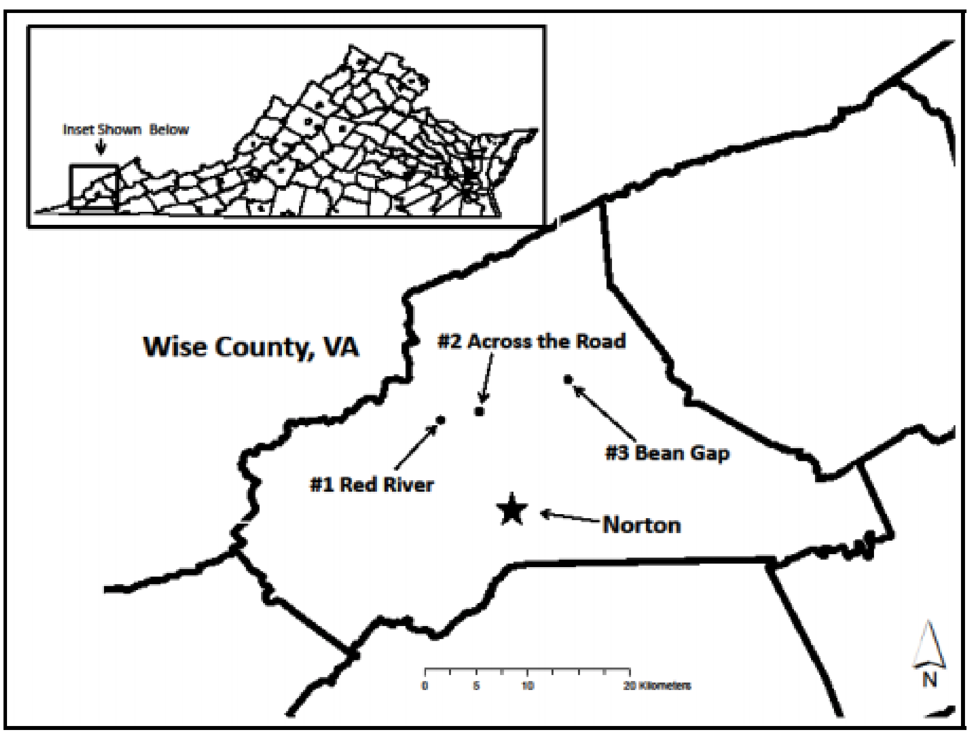

Figure 24: Biomass study locations on ripped mine sites in Wise County, VA[132]

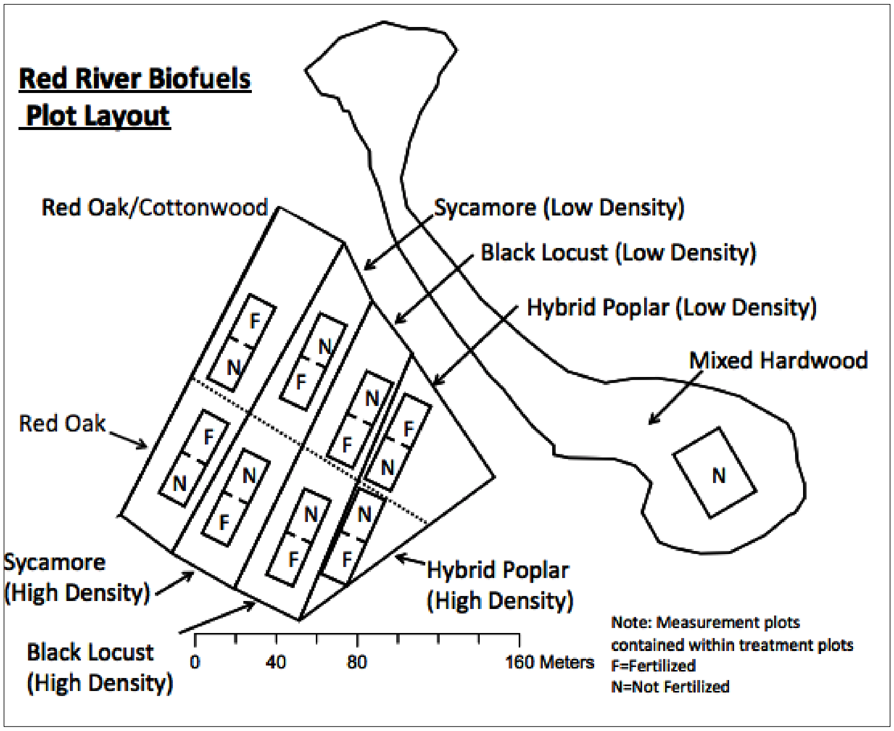

Figure 25: **Red River** biofuels treatment and measurement plot layout including black locust trial. For the black locust trial: **I**=improved. U= un-improved. F=fertilized. NF= no fertilization.[133]

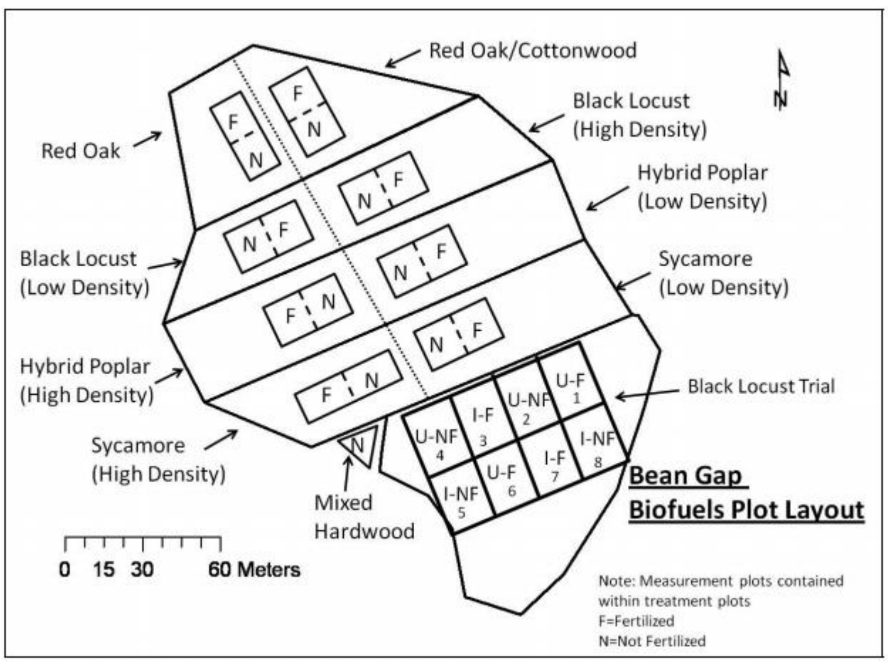

Figure 26: **Bean Gap** biofuels treatment and measurement plot layout including black locust trial. For the black locust trial: **I**=improved. U= un-improved. F=fertilized. NF= no fertilization.[134]

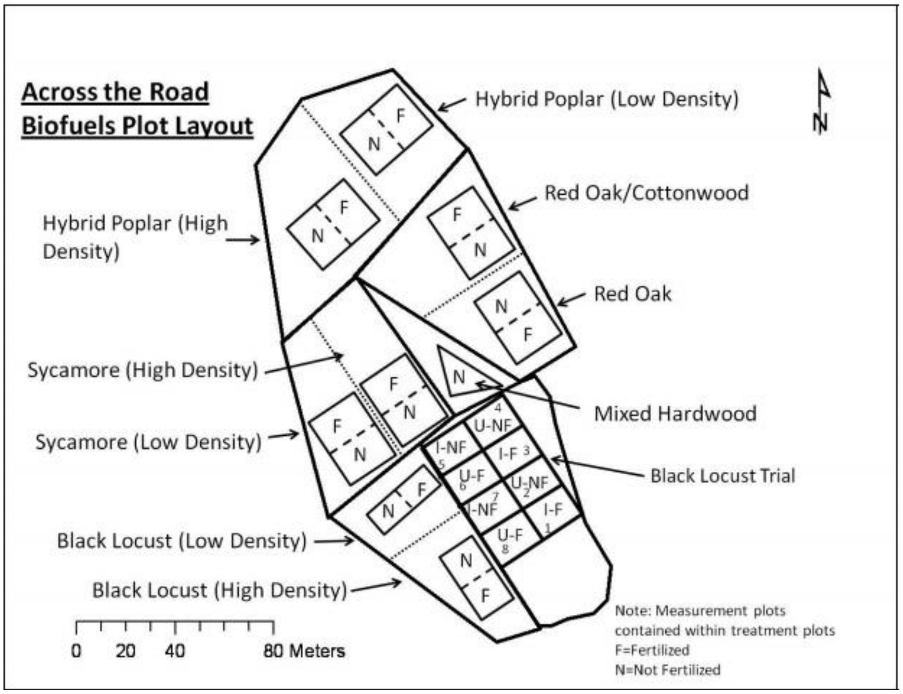

Figure 27: Across the Road biofuels treatment & measurement plot layout including black locust trial. For the black locust trial: I=improved. U= un-improved. F=fertilized. NF= no fertilization.[135]

Point of Contact
Carl Zipper, Crop and Soil Environmental Sciences Virginia Tech czip@vt.edu For further information on Powell River Project programs, contact W. Lee Daniels, Director of the Powell River Project, School of Plant and Environmental Sciences, Virginia Tech. Blacksburg, Virginia 24061-0404. Lee can be reached by email at wdaniels@vt.edu, or by phone at (540) 231-7175, or through his website at landrehab.org. For further information about the Powell River Project Research and Education Center, contact Phil Meeks at the Wise County Extension Office. Phil can be reached by email at pmeeks@vt.edu or by phone at (276) 328-6194.

Point of Contact
John Warren, Director and Principal Contact Virginia Department of Mines, Minerals and Energy Washington Building 1100 Bank Street, 8th Floor Richmond, VA 23219 (804) 692-3206 john.warren@dmme.virginia.gov

5.7 KENTUCKY SITES

While **research revealed no bioenergy feedstock crop projects in Kentucky**, apparently warm season grasses such as switchgrass were frequently used for reclamation. A 2012 report mentions that **switchgrass and other warm season grasses were cultivated on the western Kentucky coal-mining sties for ecological maintenance more than 20 years ago. The GPS coordinates for two unnamed si**tes were provided in this 2012 report from University of Kentucky researchers.

> The western Kentucky coal fields are located within the native distribution region for switchgrass along with other warm season grass species. **Around 300,000 ha of abandoned coal mines exist in Kentucky**, and these represent a target for reclamation and enhancing ecosystem services. **Warm season grasses such as switchgrass have frequently been used for reclamation**. Herein, <u>we identified two sites</u> (referred to as site 1 and site 2) and selected switchgrass plants that displayed vigorous growth habit. Specifically, 20 switchgrass plants were collected separately in July 2010 from **two reclaimed strip-mining sites in western Kentucky** (USA), where they were established as a monoculture during reclamation (approximately 20 years ago). Selection **<u>site 1</u>** was located between the GPS coordinates of W:087 25' 04,13'' to 087 25' 07, 31'' longitude and N:037, 15' 46, 21'' to 037, 15' 50, 60'' latitude; **<u>site 2</u>** was located between the GPS coordinates of W:087 32' 18, 09'' to 087 32' 19, 14'' longitude, N:037, 12' 55, 44'' to 037, 12' 55, 81'' latitude.[136]

Dr. Seth Debolt, a professor of plant science at the University of Kentucky, was the corresponding author for this 2012 report.

Possible source for information on surface mined land biomass projects in Kentucky
Seth Debolt, Professor 309 Plant Science Building, Lexington, KY 40546-0312 (859) 257-8654 seth.debolt@uky.edu Seth DeBolt's Plant Biology Lab **Rick Honaker, Ph.D., Professor of Mining Engineering** 859-257-1108 rick.honaker@uky.edu Honaker Web Site Rick Honaker has led research teams looking into extracting Rare Earth Elements from coal fly ash, refuse rock, and acid mine drainage at coal mine sites in Kentucky and elsewhere.

5.8 ALABAMA

While some research has been conducted at two loblolly plantations located in Coastal Plain Alabama to explore the economic feasibility of short rotation loblolly plantations as a feedstock for biofuel production,[137] and pine plantations have also been researched for biomass production,[138] **nothing was found for biomass plantations located on surface mined lands in Alabama.**

Aside from the switchgrass genome research being done at Alabama's HudsonAlpha Institute of Biotechnology[139] no information was found for surfaced mined sites that have been cultivated with short rotation biomass crops, although switchgrass is said to grow all over marginal lands in Alabama and the South.

The Alabama Forestry Commission, the one organization focused on biomass for energy production in Alabama, is focused on woody biomass, which it defines as "a renewable product typically left in the forest during harvests or produced as manufacturing waste products … typically called fuelwood."[140]

According to the U.S. Energy Information Administration, Alabama is the fifth-largest producer of electricity from biomass in the nation, and the state ranks third in timber acreage among the Lower 48 states.[141] With more than two-thirds of Alabama covered by forests, Alabama appears to be focusing on timber sources for biofuel feedstock. As of 2019, Alabama had at least four biomass plants that produce about 600,000 tons annually, mostly using hard and softwood.[142] A 2009 report, *Woody Biomass Energy Opportunities in Alabama*, does not mention switchgrass, miscanthus, cane/Arundo, poplar, or willow. Rather the focus was on available biomass material from fuelwood – unused logging residues and cull (low-grade) timber.[143]

Possible source for information on surface mined land biomass projects in Alabama
Alabama OSMRE Contact **Richard O'Dell, Director, Birmingham Field Office** 135 Gemini Circle, Suite 215 Homewood, AL 35209 Phone (205) 290-7282 Email rodell@osmre.gov **Alabama AML Contact** **Dustin W. Morin, State Mine Land Reclamation Supervisor** 4351 Crescent Road Irondale, AL 35210 Office Phone: 205-945-8671 Direct Line: 205-582-5182 Email: Dustin.Morin@labor.alabama.gov

5.9 MARYLAND

Research revealed no surface mined land bioenergy feedstock crop projects in Maryland.

A 2010 study that included data on woody biomass availability in Maryland makes no mention of mine sites, and states that "Energy crops appear to be an immediately adoptable solution to address biomass feedstock demands, but in field sustainability research on these systems in Maryland is nascent."[144] The only mention of mining sites in this report is in its definition of Plantation Lands.

> Plantations – Tree crops planted on lands that have been converted from an alternate land use. Plantation lands are usually former agricultural lands (degraded and productive), abandoned mining sites or naturally vegetated areas that have been cleared specifically for establishment. Planted species may be of one or many, native or exotic, natural, selectively enhanced or genetically modified.[145]

According to the U.S. Energy Information Administration, Maryland increased its Renewable Portfolio Standard (RPS) in 2019 to require that 50% of the state's electricity sales be generated from renewable sources by 2030. In 2019, about 11% of the state's total electricity generation came from renewables.[146]

As of March 10, 2021, reporting, while Maryland's RPS includes biomass as an eligible Tier 1 renewable energy source (along with solar, wind, and other), targets have been set for solar and wind but not biomass. *Tier 2 renewables being large hydroelectric*.[147]

Possible source for information on surface mined land biomass projects in Maryland
Brian A. Kittler Pinchot Institute for Conservation 202-797-6580 bkittler@pinchot.org Mr. Kittler co-authored the 2010 Pinchot report "The Potential for Sustainable Wood-Based Bioenergy in Maryland" and was the project manager for that study.

5.10 TENNESSEE

No biomass cultivation projects were found in Tennessee.

In calendar year 2017, Tennessee ranked twenty-second in coal production among the 25 coal producing states. Like other states, coal mining in Tennessee has been on the decline, so one would assume the availability of previously surface mined lands is increasing. During FY 2018, five mines produced coal in Tennessee. Coal was produced at two surface mines comprised of 1,810.9 acres and three underground mines comprised of 172.5 acres.

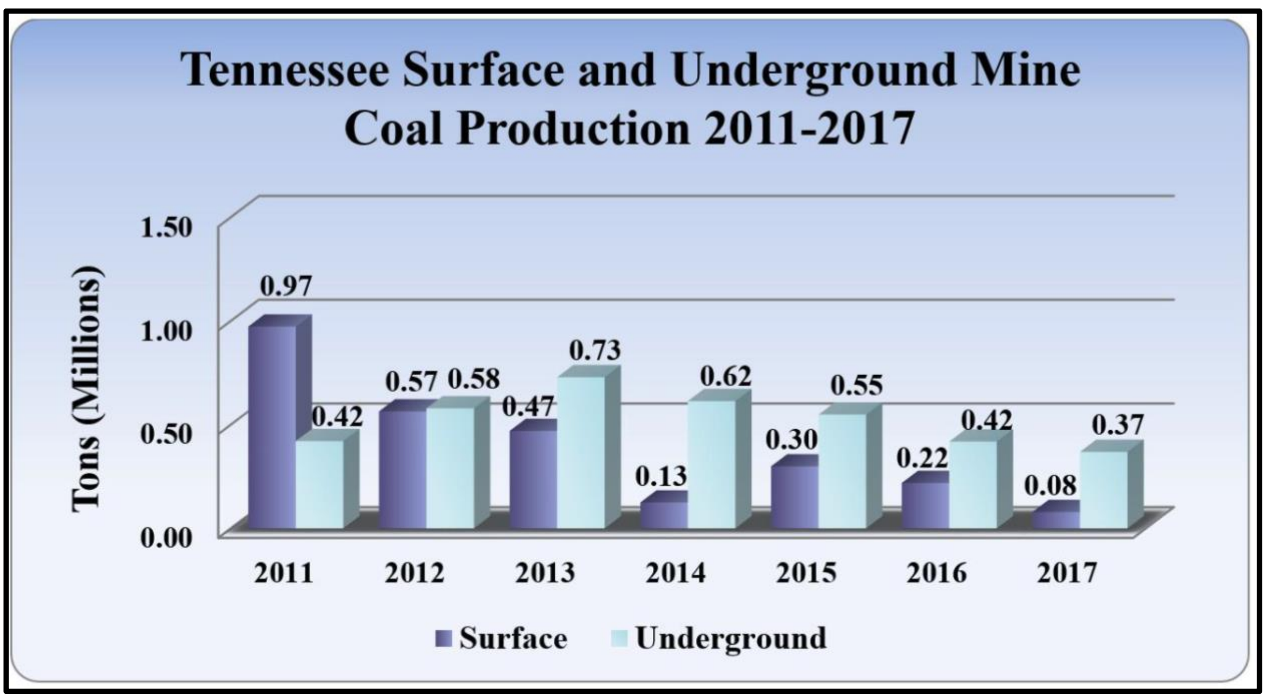

Figure 28: Source: OSMRE[148]

In Tennessee, the Federal OSMRE is the primary regulator under the SMCRA, as there is no state regulatory program. OSMRE's Knoxville Field Office is in charge of oversight of the Tennessee Abandoned Mine Land (AML) Program implemented by the State of Tennessee's Department of Environment and Conservation (TDEC).[149]

TDEC reports that even though money is appropriated each year from the bond fund for forfeiture reclamation projects, only the highest priority surface mined sites are reclaimed because the fund is limited. While TDEC reports that, since 1981, the Tennessee Land Reclamation Section has reclaimed over 4,200 acres of abandoned surface mine lands, they do not provide any details regarding plantings.[150]

> The Land Reclamation Section is responsible for reclaiming those mine sites that have been designated as "abandoned", meaning those sites which have been mined prior to surface mining laws, those sites with no reclamation bond, or those sites where there is no continuing obligation to the mine operator(s). Both appropriated state dollars and federal grant dollars from the U.S. Department of Interior's Office of Surface Mining (www.osmre.gov) are used to reclaim the sites. With an annual operating budget of approximately 3 million dollars, the Land Reclamation Section administers around 10 reclamation contracts each year.
>
> Land Reclamation staff are responsible for identifying potential reclamation project sites, designing reclamation plans and specifications for those sites, awarding reclamation contracts, and inspecting the reclamation work as it progresses.[151]

Per the U.S. Energy Information Administration, about one-eighth of Tennessee’s electricity net generation is supplied by renewable resources, mostly hydropower. Biomass from wood, wood waste, and landfill gas contributes the second-largest share of renewable generation, seven utility-scale biomass facilities provided about 8% of the state’s renewable net generation and slightly more than 1% of total generation in 2019. Wood waste is also used as feedstock for the state’s three wood pellet manufacturing plants. Tennessee is also a biofuels producer. It is the largest ethanol-producing state in the Southeast and the 14th-largest in the nation. The state has three ethanol plants—two use corn as feedstock and a third, smaller plant recycles waste. In addition, Tennessee has two biodiesel plants.[152]

While biomass to biofuel research is conducted at the University of Tennessee Institute of Agriculture, no research was found specific to locating biomass projects on surface mined lands in Tennessee.[153]

Possible Contact for information on mine land biomass projects in Tennessee
Burton C. English, Institute Professor, Agricultural and Resource Economics **University of Tennessee Institute of Agriculture** 308 Morgan Hall 2621 Morgan Circle Drive Knoxville, TN 37996-4518 865-974-3716 benglish@tennessee.edu See Bio Professor Burton English is a Tennessee expert on the economics of producing herbaceous and short rotation woody feedstocks for bio-energy at the UT Institute of Agriculture.

Additional Points of Contact in Tennessee

Tennessee	
Abandoned Mine Lands (Title IV)	Regulatory (Title V)
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Source: OSMRE[154]

6.0 SUMMARY & RECOMMENDATIONS

As part of the Interagency Working Group, the Office of Fossil Energy at the DOE National Energy Technology Laboratory (NETL) identified technological Innovation as an area of focus. The purpose of this report was to determine if waste coal in the form of gob, boney, or culm had been characterized and was in abundance and proximity to biomass near distressed communities within the Appalachian region. The study determined that there was a large discrepancy between "ground truth" and the records available from the Office of Surface Mining Reclamation and Enforcement (OSMRE). In order to quantify the volume and quality of waste coal from surface mining in this region, one would have to conduct extensive on-site borings. This is an expensive endeavor for which funding has not been available. The best source of information regarding viable waste coal was cogeneration companies with holdings in the Appalachian region. A number of the cogeneration companies that were interviewed had already characterized and purchased rights to large holdings of waste coal. Many expressed an interest in collaborating with the Department of Energy.

The second part of the study explored the conversion of surface-mined land in Appalachia to productive use through biomass cultivation. A variety of biomass crops suited for the Appalachian Mining Region were reviewed and then specific cultivation sites near mines in the Appalachian region were highlighted.

Although the study did not surface specific communities where waste coal and biomass were in abundance and in close proximity to a town, the report did surface the issues associated with the characterization of gob, culm and boney in the Appalachian region. An additional benefit was finding that cogeneration companies in this region had the desired information, as they had paid for the characterization of the waste coal to which they obtained access. Of particular note is their interest in collaborating with the Department of Energy. The survey of biomass crops that grow well in this region and which could be raised on reclaimed land serves as a good starting point for researchers in the Appalachian region dedicated to helping communities that once depended upon coal for their livelihood.

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