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2017

Energy Development on Pennsylvania's Public Lands



A Comprehensive Review

Saint Francis University, Institute for Energy

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ENERGY DEVELOPMENT ON PENNSYLVANIA PUBLIC LAND

Executive Summary

How are Pennsylvania Public Lands being used for energy development?

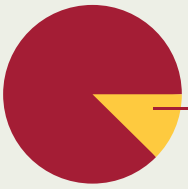
The energy industries have a significant influence on Pennsylvania's landscapes. The Commonwealth is a principal supplier of coal, natural gas, and electricity to the Northeast and Mid-Atlantic regions. In addition to the fossil and electricity industries, Pennsylvania is committed to supplying 18 percent of the electricity within the Keystone State from alternative energy by 2021.

With a robust energy sector and access to so many natural resources, it may not be surprising to know that Pennsylvania public lands are also being utilized for energy resource extraction. Portions of Pennsylvania state game lands, state forests, and state parks have been leased for energy development. Additionally, complicated Pennsylvania property laws allow many of these public lands to be developed because the state lacks ownership to the subsurface mineral rights.

The objective of this report is to provide both Pennsylvania citizens and policymakers with accessible information about how Pennsylvania owned lands (specifically, state parks, state forests, and state game lands) are being used and managed for energy resource development. The research examines how oil, gas, coal, and renewable energy have been developed on state owned lands and discusses the potential health and environmental risks associated with such development. Additionally, the research provides technical and policy background information about each of the energy resources. To further aid in public accessibility of this information, interactive PA public land use maps are available at www.FracTracker.org.

Department of Conservation and Natural Resources (DCNR):
Manages 121 state parks and 2.2 million acres of state forest land
Mission: "To conserve and sustain Pennsylvania's natural resources for present and future generations' use and enjoyment."

The Pennsylvania Game Commission (PGC):
Manages 1.5 million acres of state game lands
Mission: "To manage Pennsylvania's wild birds, wild mammals, and their habitats for current and future generations."



These public lands represent 13% of the land area in PA.

Commerical Energy Development
on Pennsylvania Public Lands

- ✓ OIL
- ✓ GAS
- ✓ GAS STORAGE
- ✓ COAL MINING
- ✗ WIND
- ✗ SOLAR
- ✓ BIOMASS (TIMBER)

"The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. ***Pennsylvania's public natural resources are the common property of all the people, including generations yet to come.*** *As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."*

THE PENNSYLVANIA CONSTITUTION, ENVIRONMENTAL RIGHTS AMENDMENT, ARTICLE 1 SECTION 27

THE HEINZ ENDOWMENTS
HOWARD HEINZ ENDOWMENT • VIRA I HEINZ ENDOWMENT

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Oil and Gas Development
ON PENNSYLVANIA PUBLIC LAND

Marcellus Shale, one of the largest natural gas fields in the world, underlies about **60%** of the Commonwealth

Titusville, Pennsylvania
site of the first ever commercial oil well

The Sproul State Forest has the most acreage leased where DCNR owns the mineral rights. Susquehannock State Forest has the most where they do not own the subsurface rights. SGL #87 has the most active gas wells of any SGL.

Currently, there are no active gas drilling rigs on any state forests or parks, however three rigs are expected to drill on DCNR land in mid-2018.

As of August 2017, there were five state game lands where operators were actively drilling and/or hydraulic fracturing: State Game Lands number 25, 12, 36, 223, and 117.

FEE SIMPLE describes a landowner's possession of both mineral and surface property rights. In Pennsylvania these rights are often severed. The owner of the mineral rights has legal privilege to recover the natural resources and the owner of the surface rights has right to protection from unreasonable damage.



Active Conventional and Unconventional Wells

The DCNR has **2,141** active wells.

The PGC has **2,970** active wells.*

Active status: Defines a well that has been permitted but not necessarily drilled or producing.

Health Impacts
Unique to PA Public Lands

- Ease of public access to dangerous active and abandoned oil and gas infrastructure
- Recreators/Hunters potential exposure to VOCs, diesel emissions, and other toxins in the air and water from active oil and gas infrastructure

Environmental Impacts
Unique to PA Public Lands

- Habitat fragmentation on lands dedicated for conservation
- Potential water contamination that is both difficult to monitor and detect, due to vast size of public land and limited dwelling
- 3,400 miles of streams travel through the core gas state forest lands, which includes many of the best known fishing and boating waters in PA
- Potential water contamination related to abandoned oil and gas wells on state lands

Data from February 2017 DEP Spud Report.

By the numbers…

Currently, 265,158 acres of DCNR managed property (2.2 million acres) are under lease for gas production in state parks and forests.

In addition to oil/gas production, DCNR has about 68,000 acres under gas storage lease.

About 89,000 acres of the PGC managed property (1.5 million acres) is leased for oil and gas activity, roughly 6%.

POLICY TIMELINE

1915 PGC acquires first land with existing oil and gas infrastructure

1947 First lease of state forest land

1950s PGC begins leasing land for mineral development

1955 Oil and Gas Lease Fund (OGLF) set up: All mineral royalties to go into fund set aside for "conservation purposes"

1984 - early 2000s Nearly 1,000,000 of PA's 2.2 million acres of parks/forests were under lease for oil and gas activities

2008 DCNR leases 74,000 acres for Marcellus drilling, totaling $163 million in royalties

2009/2010 PA Legislature and Governor Ed Rendell authorize transfer of OGLF revenues ($383 million) into general fund. Drilling funds no longer used solely for conservation

2010 Pennsylvania Governor Ed Rendell issues a state moratorium on the additional leasing of DCNR land

2014 Pennsylvania Governor Tom Corbett reverses moratorium, allowing for future leasing of DCNR land for oil and gas exploration

2015 Pennsylvania Governor Tom Wolf reinstates the moratorium — banning new leases of DCNR land

2016 "Natural Resources and Rights of Way" leases contribute 30% of the PGC budget, more than any other revenue stream for the agency

2016 Pennsylvania experiences first fracking attributed earthquake

2017 Pennsylvania Supreme Court rules that oil and gas lease royalties must be utilized for conservation and not PA general fund spending

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Coal Mining
ON PENNSYLVANIA PUBLIC LAND

About Coal Mining in Pennsylvania

- Coal has actively been mined in Pennsylvania since the 1700s.
- Coal is a mineral governed by the same "fee simple" land ownership laws as oil and gas.
- More than 3,000 miles of streams have been contaminated from Abandoned Mine Drainage (AMD).
- Coal mining in Pennsylvania went unregulated for nearly 200 years.

DCNR's current mining leases are for land reclamation purposes — DCNR has not signed a virgin coal mining lease since the 1990s

There are no mining operations on state forest lands where DCNR owns the coal and stone rights.

There are mining operations on state forest lands where DCNR **does not** own the coal or stone rights.

The Game Commission has no policy limiting the leasing for virgin coal mining

ACT 18 The Conservation of Natural Resources Act, also known as Act 18, grants DCNR legal authority to "make and execute contracts or leases in the name of the Commonwealth for the mining or removal of any valuable minerals that may be found in State forests."

TITLE 34 The Game Commission has legal authority to mine for coal under Title 34. Specifically, "the commission may dispose of, by lease, sale or otherwise, timber, buildings, other appurtenances, minerals, oil and gas, or rights therein, including natural gas storage, or any other product, on or under lands to which it has title."

Both DCNR and PGC have current reclamation projects on the properties they manage.

There are approximately 29 SGLs and 7 state parks with identified abandoned coal mines. DCNR estimates there are 182 abandoned mines on State Forests.

182 abandoned mines on state forests

72 state game lands that have had surface mining operations

5 game lands with known subsidence related to underground mining activities

Health Impacts
Unique to PA Public Lands

- Risks associated with improperly filtering and ingesting AMD water
- Easy public access/limited surveillance of abandoned mines and dangerous pits
- Potential exposure to toxic gases from coal mine fires on recreational lands

Environmental Impacts
Unique to PA Public Lands

- Destruction of rivers and riparian habitat from AMD associated with coal mining on lands purposed for conservation
- Habitat modification on lands purposed for habitat conservation
- Land, stream, and lake subsidence caused by underground mining, affecting neighboring ecosystems and recreational opportunities - as seen in Ryerson Station State Park
- Creation of new bat habitats in abandoned mines

TIMELINE

- **1761** Fort Pitt Mine, near Pittsburgh, is constructed
- **1918** Peak of Pennsylvania coal production
- **1945** PA passes the "Surface Mining Conservation and Reclamation Act" — the first mining specific regulation in Pennsylvania
- **1968** PA Legislature passes "Operation Scarlift" to finance the reclamation of abandoned mined lands
- **1977** First Federal coal regulations are passed — "The Surface Mining Control and Reclamation Act of 1977"
- **Early 1980s** DCNR starts leasing land for coal mining activities
- **2005** Ryerson Station dam is breached after being damaged considerably by longwall coal mining operations, resulting in the complete disappearance of Duke Lake

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Renewable Energy
ON PENNSYLVANIA PUBLIC LAND

The Alternative Energy Portfolio Standard (AEPS) mandates 18% of electricity sold in PA be from alternative energies by 2021.

There are 25 utility scale wind farms and 23 utility scale solar farms, none of which are located on DCNR or PGC property.

An estimated 35% of Pennsylvania's developable wind acreage is on public lands.

Biomass is organic material such as wood, manure, and agricultural crops. Forest currently covers approximately 60% of the state.

Approximately **178,054** acres (720.6 km2) of State Game Lands have a wind resource that could support utility scale wind energy.

An estimated **179,776** acres (727.5 km2) of State Parks and State Forests have a wind resource that could support utility scale wind energy.

DCNR does not have legal authority to lease state forests or parks for wind development. Unlike, oil, gas and coal, wind is not considered a mineral and clear rules about the rights to development on state land do not exist. Consequently, the agency has denied all requests for wind farm development.

The PGC has legal authority to allow wind development but has denied **19 out of 19** proposals for utility scale wind farms on state game land.

Approximately 7,240 MW of installed wind energy capacity is currently considered undevelopable in Pennsylvania because it's located on state owned land.

Environmental Impacts
Unique to PA Public Lands

- Habitat Fragmentation caused by turbine land clearing and supporting infrastructure on land assumed for conservation
- Negative impact to birds and bats-special concern for Indiana Bat (federally listed endangered species) mortality
- One out of the eight total Indiana Bat fatalities on wind farms occurred in Pennsylvania
- Wind energy on Pennsylvania public lands could offset an estimated 14,480,000 tons of carbon dioxide into the atmosphere

Health Impacts
Unique to PA Public Lands

- Increased risk of injury for hunters and recreators in close proximity to turbines due to potential ice throw and rotor failure (blade throw)
- Ease of public access to high voltage equipment and infrastructure

Biomass

The harvesting of timber occurs on both DCNR and PGC lands and provides funding for these departments. The DCNR individually records the end use of non-timber forest products, including fuel wood. In 2015, 8,055 cords of fuel wood were harvested providing $167,607 in revenue. PGC does not track the end use of timber products.

Environmental and Health Impacts:

- Exposure to air pollution from prescribed burns
- Erosion from improper timbering practices

TIMELINE

1681 William Penn's list of concessions for those settling in the state include a rule keeping "one acre of trees for every five acres cleared"

1740 Benjamin Franklin experiments with different windmill models in Philadelphia, PA

1936 Rural Electrification Act leads to the dismantling of residential electric producing windmills

1998 PGC receives first solicitation by wind developers to lease state game lands for wind energy

2000 First utility scale wind farm is constructed, Somerset County

2004 Pennsylvania passes the Alternative Energy Portfolio Standard Act — requiring 18% of electricity sold in PA be from alternate energies by 2021

2005 DCNR receives first solicitation by wind developers on state forests and state parks

2006 DCNR establishes the Pennsylvania Wind and Wildlife Collaborative, a working group tasked with development BMPs for wind energy development

2007 PGC drafts Wind Energy Voluntary Cooperative Agreement

2008 First utility scale solar farm is constructed, Bucks County

2013 Senator Wozniak proposes Senate Bill 684 that would explicitly allow wind energy development on state lands

2017 PA DEP begins study to find ways to increase in-state solar electricity generation

Other Renewables? Small scale wind, solar, hydro, geothermal and biomass projects exist on PA public lands for onsite consumption, however nothing on a commercial/utility scale.

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INTRODUCTION

The objective of this report is to provide both Pennsylvania citizens and policymakers with accessible information about how Pennsylvania-owned lands are being used and managed for energy resource development.

Pennsylvania's public lands have critical purposes. From providing recreational opportunities to contributing economic benefits, thoughtful use and management of these lands is essential. The bulk of Pennsylvania's public lands are managed by two state agencies: the Department of Conservation and Natural Resources (DCNR), who manage the state's forest and park system, and the Pennsylvania Game Commission (PGC), who manage the state's game lands. Adventurers can enjoy hiking, biking, kayaking, fishing, and a host of other activities at any of the state's state forests or 121 state parks. Sportsmen and women have hunting and trapping opportunities on over 1.5 million acres of state game lands. Pennsylvania public lands also support important ecosystems for rare and endangered species, such as timber rattlesnakes, Allegheny woodrats, and Indiana bats. But the property usage on Pennsylvania public lands has not been limited to recreation or conservation — public lands are also part of the robust energy development industries in Pennsylvania.

The Commonwealth has historically been, and continues to be, home to an abundant array of energy resources. Coal mines have been active in the state since the late 1700s[1] and the petroleum industries have been drilling oil and gas producing wells since the mid-1800s. Renewable energy, too, has a long history of use in the Commonwealth. Pennsylvania farmers have been harvesting wind energy for electricity production and pumping techniques for over 100 years as well as combusting wood to create heat for centuries. Oil, gas, coal, timber and windy ridgetops are plentiful in Pennsylvania.

Expectedly, these natural resources are found both on publicly and privately held land. Natural gas, more specifically, the Marcellus Shale formation, underlies approximately 1.5 million of the state's 2.2 million-acre state forest system.[2] It is estimated that 700,000 acres of state game lands have Marcellus Shale beneath them as well.[3] Thousands of acres of state forests and game lands have been mined for coal since the 1930s.[4] Timbering also generates revenues for both agencies as well. Some of Pennsylvania's best wind resources can be found on the mountain ridges in the Commonwealth's state forests and game lands too, however, no utility scale wind farms have been built on state land.

This report discusses how Pennsylvania state-owned land has been utilized and developed by oil, gas, coal and renewable energy industries. It discusses the environmental and health impacts associated with development of each of the different industries. The report outlines state policy, energy development procedures, and overall

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[1] William E. Edmunds, *Coal in Pennsylvania, Educational Series 7*, 2nd ed. (Harrisburg: Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Geological Survey, Fourth Series, 2002), 1, http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_014594.pdf.

[2] Pennsylvania Department of Conservation and Natural Resources, *Natural Gas Development and State Forests, Shale Gas Leasing Statistical Summary*, (Harrisburg, PA: Bureau of Forestry, May 2017,) http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20029363.pdf.

[3] M. DiMatteo, Chief, Environmental Planning & Habitat Protection Division, Bureau of Wildlife Habitat Management, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

[4] C. Martson, Assistant Counsel, Pennsylvania Game Commission, personal correspondence, November 20, 2017

management of energy resources on public land. Mapping information of where development is (or is not) occurring is also included in this research. Static and interactive maps have been created to visually demonstrate areas of energy development on state-owned land. The interactive maps can be accessed at www.fractracker.org.

This document provides essential information for Pennsylvania residents and offers considerations for future energy development on Pennsylvania public lands.

About Pennsylvania's Public Lands

Roughly 13 percent of Pennsylvania's land acreage is represented by public lands, managed by two separate agencies, the Pennsylvania Game Commission and the Department of Conservation and Natural Resources.[5] The state owns additional property, including buildings, waterways, roads and bridges; however, for the purpose of this report, assessment of energy use will focus only on state parks, state forests, and state game lands. Federal lands located in Pennsylvania are also not included in this analysis.



Photo by: Allison Rohrs

About the Pennsylvania Game Commission

The mission of the Pennsylvania Game Commission is to "manage Pennsylvania's wild birds, wild mammals and their habitats for current and future generations."[6]

According to the Pennsylvania Game Commission, the agency "owns and manages roughly 1.5 million acres of state game lands throughout the Commonwealth."[7] The agency was created in 1895, when, then Pennsylvania Governor Daniel Hastings, signed a law creating the Pennsylvania Board of Game Commissioners.[8] The "Act approved June 25, 1895 P.L. 273" authorized the appointment of six Pennsylvania citizens to act as game commissioners and defined their qualifications, compensation, meeting locations, and duties. The Act also empowered the Commission to appoint ten "Game Protectors" to enforce game law and defined the Protector's compensation, duties and powers. In 1937, Section 1401 of the act of June 3, 1937 (P.L.1225, No.316), known as the "The Game Law" was enacted. The Game Law was later amended in 1986 as Title 34, the Game and Wildlife Code.[9]

Today, the Game Commission is still an independent administrative commission; however, it is now overseen by eight commissioners (appointed by the governor and approved by the Pennsylvania Senate) instead of the original six.[10] Title 34, the law that governs the PGC, "requires that each [commissioner] be a citizen of the Commonwealth, and

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[5] "Pennsylvania: Farm Numbers, Land In Farms, Average Size and Land Area, 2009," *USDA National Agricultural Statistics Service-PA Office*, 2010, https://www.nass.usda.gov/Statistics_by_State/Pennsylvania/Publications/Annual_Statistical_Bulletin/2009_2010/farm_number%20and%20land%20in.pdf. Calculation based upon 28,682,630 total acres of land in Pennsylvania.

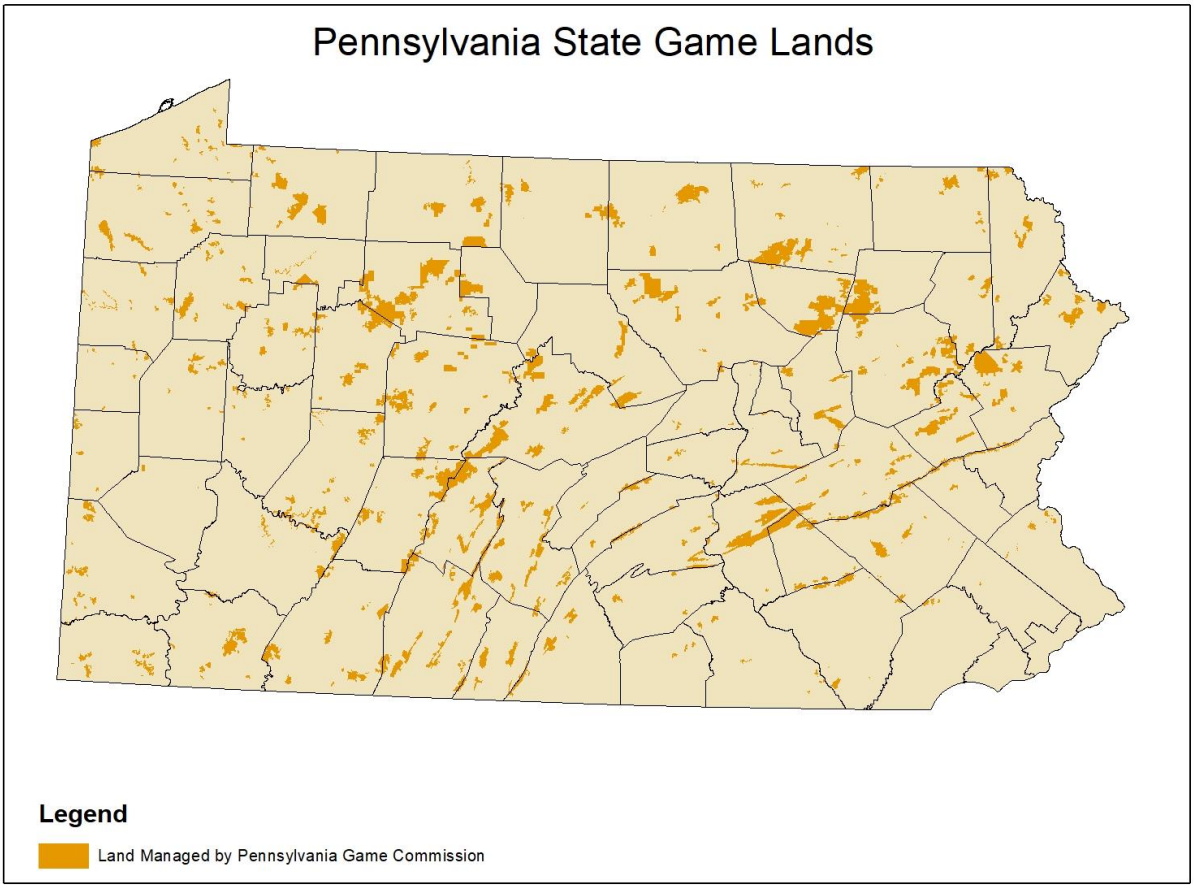
[6] Pennsylvania Game Commission, *Strategic Plan 2015-2020*. Harrisburg, PA: June 1, 2015, http://www.pgc.pa.gov/InformationResources/AboutUs/Documents/PGC%20Strategic%20Plan%202015-2020.pdf.

[7] "Pennsylvania State Game Lands," *Pennsylvania Game Commission*, http://www.pgc.pa.gov/HUNTTRAP/STATEGAMELANDS/Pages/default.aspx, accessed October 5, 2017.

[8] Herman P. Miller and Harry W. Baker, *Smull's Legislative Handbook and Manual of the State of Pennsylvania*, (Harrisburg PA: Harrisburg Publishing Company, 1909).

[9] HB 2079, (Sess.of 1986-93) (Penn), http://www.palrb.us/pamphletlaws/19001999/1986/0/act/0093.pdf.

[10] *Game*, Title 34, Chapter 3, Pennsylvania Game Commission, Subchapter A, Organization, Officers, and Employees.



well informed about wildlife conservation and restoration."[11] Commissioners are selected from various geographical regions across the state and do not receive any compensation.[12] Game Commissioners can serve terms of four years and allowed reappointment for a maximum of two additional terms.[13]

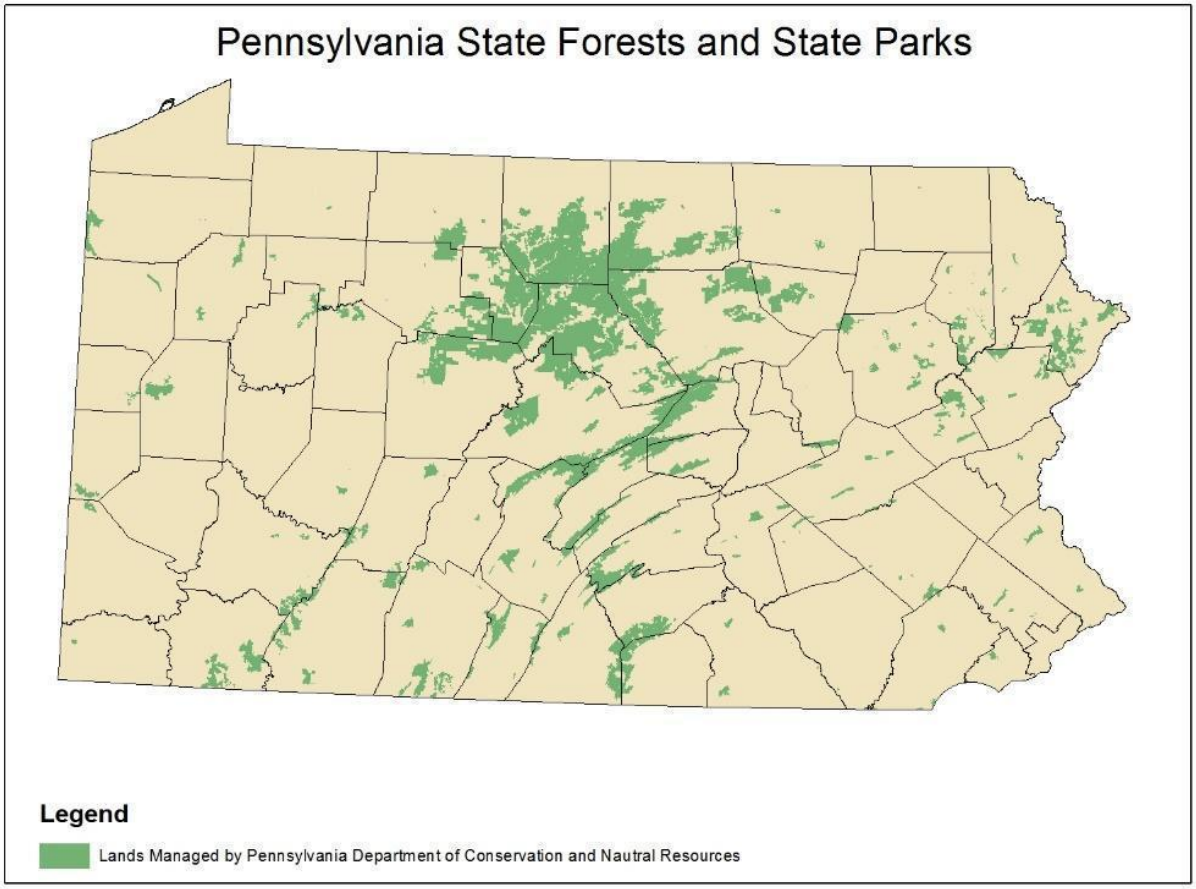
Although the PGC is a Commonwealth entity, the Commission does not receive any funds from the Pennsylvania general fund. According to the PGC website, the agency is "funded primarily by hunting and furtaker license sales; State Game Lands timber, mineral and oil/gas revenues; and a federal excise tax on sporting arms and ammunition; the Commission is almost entirely supported by hunters and trappers, or assets that have been procured with license

[11] "Pennsylvania Board of Game Commissioners," *Pennsylvania Game Commission*, http://www.pgc.pa.gov/InformationResources/AboutUs/Commissioners/Pages/default.aspx, accessed October 6, 2017.
[12] Ibid.
[13] Ibid.

dollars."[14] The PGC also receives some state and federal funding through various conservation related grant programs.[15]

About the Department of Conservation and Natural Resources

Pennsylvania's Department of Conservation and Natural Resources (DCNR) manages the state forest system, which is comprised of 2.2 million acres of publicly owned forests and parks.[16]



[14] "About the Pennsylvania Game Commission," *Pennsylvania Game Commission*, http://www.pgc.pa.gov/InformationResources/AboutUs/Pages/WhatWeDo.aspx, accessed October 12, 2017.
[15] Pennsylvania Game Commission and Pennsylvania Fish & Boat Commission, *Pennsylvania Wildlife Action Plan: 2015-2025*. ed. Catherine Haffner and Diana Day. (Harrisburg, PA: 2015), http://www.pgc.pa.gov/WILDLIFE/WILDLIFEACTIONPLAN/Pages/default.aspx, accessed October 6, 2017.
[16] "State Forests," *Pennsylvania Department of Conservation and Natural Resources*, http://dcnr.state.pa.us/forestry/stateforestmanagement/index.htm, accessed October 5, 2017.

The Pennsylvania Department of Conservation and Natural Resources' mission is "to conserve and sustain Pennsylvania's natural resources for present and future generations' use and enjoyment."[17]

Pennsylvania's first state park dates back to 1893 when then Governor Robert E. Pattison, designated Valley Forge a public park.[18] In 1895, the Division of Forestry was formed under the Department of Agriculture but later became its own Department of Forestry in 1901.[19] In 1923, the Department of Forestry was renamed the Department of Forests and Waters which consolidated the functions of the Department of Forestry, the Water Supply Commission, and the Bureau of Topographic and Geologic Survey.[20] In 1929, Governor John Fisher formed the Bureau of State Parks under the Administrative Code of 1929, Act of April 9, 1929.[21] In 1970, the Act was amended to create the Department of Environmental Resources and took on the responsibility for the management of forests, parks and environmental protection programs. DCNR, as it is today, was created in 1995 by the Conservation of Natural Resources Act, also known as Act 18. "The purpose of the act, as stated in § 1340.101, was to create a new department to serve as a cabinet-level advocate for our state parks, forests, rivers, trails, greenways, and community recreation and heritage conservation programs and to provide more focused management of the commonwealth's recreation, natural, and river environments," according to the *2016 State Forest Resource Management Plan*.[22]

DCNR's legal authority is governed by Act 18. Specifically, Section 302 of Act 18, governs how the agency is authorized to use state forests and state parks for mineral development and timbering.

DCNR is funded through the Pennsylvania state general fund, the Oil and Gas Lease Fund (OGLF), the Growing Greener Bond Fund, federal grants, and other special funds.[23]

Public Land Ownership

Land ownership in the state of Pennsylvania is complicated. Often, property ownership is divided between surface and subsurface rights. In the case of Pennsylvania public lands, the agencies own some of their land as "fee simple," which means they own both the surface and subsurface (mineral) rights. In many situations, however, the Commonwealth only owns the surface rights to its public lands. In these events, and under Pennsylvania law, the

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[17] "About DCNR," *Pennsylvania Department of Conservation and Natural Resources,* http://www.dcnr.pa.gov/about/Pages/default.aspx, accessed September 13, 2017.
[18] "History of Pennsylvania State Parks," *Pennsylvania Department of Conservation and Natural Resources*, http://www.dcnr.state.pa.us/stateparks/thingstoknow/history/thefirstpark/index.htm, accessed October 5, 2017.
[19] Ruth E. Hodge, *Guide to African American Resources at the Pennsylvania State Archives*, (Commonwealth of Pennsylvania, Pennsylvania Historical and Museum Commission. Harrisburg, 2000), records of the Department of Forest and Waters, as described at http://www.phmc.state.pa.us/bah/aaGuide/AA-RG-06.html.
[20] Ibid.
[21] PA-DCNR, "History of Pennsylvania State Parks;" The Administrative Code of 1929," http://www.legis.state.pa.us/WU01/LI/LI/US/PDF/1929/0/0175..PDF.
[22] Pennsylvania Department of Conservation and Natural Resources, *2016 State Forest Resource Management Plan*. (Harrisburg, PA: Bureau of Forestry, February 2016), http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20032045.pdf, 21.
[23] Joe Markosek, *2016/2017 Budget Briefing, Oil and Gas Lease Fund*, (Harrisburg: PA: House Appropriations Committee, May 16, 2016), http://www.pahouse.com/Files/Documents/Appropriations/series/2899/OGLF_BB_FINAL_051616.pdf.

state agencies are required, legally, to allow mineral extraction on the property, even if extraction involves altering, or temporarily occupying parts of public real estate surface.

Fifteen percent of DCNR managed state parks are fee simple, with 85 percent of the land having severed surface and mineral rights.[24] State forests are 85 percent fee simple and 15 percent severed ownership.[25] The Pennsylvania Game Commission estimates that about 50 percent of state game land is fee simple, although an exact figure is not available.[26]

[24] Teddy Borawski, Program Manager, Department of Conservation & Natural Resources, Bureau of Forestry – Subsurface Programs, Certified Petroleum Geologist #5440, personal correspondence, July 18, 2017.
[25] Ibid.
[26] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

Methods

About the Pennsylvania "Right to Know Act"

Many facts within this report were obtained through Pennsylvania's "Right to Know Law." The Right to Know Law (RTKL) governs use of the public's access to Pennsylvania government records. Both the Pennsylvania Game Commission and the Pennsylvania Department of Conservation and Natural Resources were contacted by filing a formal right to know request.

The formal request to DCNR asked for records pertaining to:

- Leases for coal mining/extraction on DCNR property
- Oil and gas leases, including pipeline construction
- Applications from wind energy developers for wind projects on state forest or state park land
- Oil and Gas Fund records, deposits, withdrawals, and balance since 1955

The request was granted to the extent that copies of the specifically identified and requested records listed above were available for a fee of $4,225. The fee was associated with duplication of the documents. Payment of this fee was not within the budget for this project. The Institute for Energy worked with the agency to file a follow up "informal request" for information and traveled to Harrisburg to review many of these documents to reduce costs. Documents reviewed in the DCNR Harrisburg office on April 26, 2017 included:

- Various coal mining leases, including both virgin and reclamation mining
- DCNR subsurface cooperative agreements
- Various oil and gas leases where DCNR owned both surface and mineral rights (fee simple property)
- Documents related to wind development on DCNR land

Follow-up and e-mail correspondence with DCNR's Bureau of Forestry Subsurface Programs Manager were also performed.

Two separate right to know requests were submitted to the Pennsylvania Game Commission. Cumulatively, these requests included records pertaining to:

- Oil and gas leases on PGC land
- Coal mining leases on PGC land
- Formal requests from wind developers to develop on PGC land
- Site selection criteria guidelines for oil and gas on state game lands
- Game Commission reviews of proposed oil and gas development
- Environmental impact analysis of oil and gas projects that were leased
- Environmental analysis and conservation plans associated with State Game Land 42
- Most up to date list of wind developers who have entered into the Wind Energy Voluntary Cooperative Agreement.

The Game Commission also granted these right to know requests and requested a fee of $18.00, which included hard copies of some of the documents and CD media storage for the remaining documents. The Game Commission replied

with 16 different responses to wind energy developers seeking development on state game lands along with reasoning for project denial; oil and gas leases/cooperative agreements signed by the Commission with detailed terms of the agreement; coal mining agreements; and the most recent wind energy cooperative agreement. The PGC Agency of Open Records Officer and the Chief of the Environmental Planning & Habitat Protection Division of the Bureau of Wildlife Habitat Management were accessible for multiple follow-up questions and calls throughout the duration of the research.

More information was requested from the Game Commission than from DCNR due to the fact that DCNR had more information already publicly available in documents and reports, and on their website.

The formal Right to Know requests were focused on oil, gas, coal and wind energy development. Informal requests seeking information about solar, hydropower, biomass and geothermal energy projects were also addressed to the individual agencies. Information about these resources were obtained through e-mail and personal communication.

Hundreds of documents and media sources were researched and reviewed for the development of this report. Many useful and informative documents were already publicly available on DCNR's and the PGC's websites. Key documents include: DCNR's *Shale-Gas Monitoring Report*, DCNR's *2016 State Forest Resource Management Plan*, the Pennsylvania Game Commission's *Strategic Plan 2015-2020*, EPA's *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States* report, *StateImpact Pennsylvania* reports and the Nature Conservancy's *Pennsylvania Energy Impacts Assessment* report. All of these documents were free and, at the time of publication of this document, available to the public via the internet.

DCNR's 2014 *Shale-Gas Monitoring Report* was an instrumental resource for developing this report. It includes important state geologic information, historical energy development information, and present shale development data. The report discusses gas related development policies and procedures and details the agency's shale gas monitoring techniques.

"The State Forest Resource Management Plan (SFRMP) is the primary instrument that the Bureau of Forestry uses to plan, coordinate, and communicate its management of the state forest system," the DCNR states.[27] This comprehensive document is 234 pages and addresses, in detail, key mineral development policy and procedures on DCNR owned land. It also addresses public comments to the agency regarding energy development on state forest and park lands.

The Pennsylvania Game Commission *Strategic Plan 2015-2020* discusses the role energy development plays on state game lands. Information about policy and procedures for developing energy resources on Game Commission land, however, is not included in this report. This document, like the State Forest Resource Management Plan, also addresses public input and comment.

Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States is a 2016 report completed by the United States Environmental Protection Agency. The report is

[27] PA-DCNR, *2016 State Forest Resource Management Plan*, http://dcnr.state.pa.us/forestry/stateforestmanagement/sfrmp/2016sfrmp/index.htm, 2.

a culmination of the most recent research, data, and analysis of hydraulic fracturing impacts on water resources and quality.

Other organizations have been following and researching energy development on state owned lands as well. *StateImpact Pennsylvania*, a collaboration of Pennsylvania public broadcasting, covers the economic and environmental impacts of Pennsylvania's energy sector. Many articles from *StateImpact* were reviewed and content from them has been used in this report.

The *Pennsylvania Energy Impacts Assessment* was published in 2010 by the Nature Conservancy, Western Pennsylvania Conservancy and Pennsylvania Audubon. The report analyzes how development of Marcellus Shale natural gas, wind, wood biomass, and associated electric and gas transmission lines would likely impact high priority conservation areas across Pennsylvania. The Nature Conservancy's research does not address other potential impacts, including air quality or environmental quality, nor is it specific to development on public lands. The document provides key information regarding potential wildlife and habitat effects of energy development specific to Pennsylvania.

OIL AND GAS

BACKGROUND

Pennsylvania's unique geology has distinguished the state as a leading fossil fuel producer and supplier. Oil and gas are sourced from the deposition of organic materials that have been subject to intense pressure and temperature over hundreds of millions of years.

In a conventional petroleum system, oil and gas travels from the source rock until it encounters a trap, or reservoir, and in some instances, it may travel all the way to the surface. In parts of Pennsylvania, oil literally seeps through ground to the surface.[28]

Some source rocks, however, do not allow such free flow of petroleum but instead contain oil and gas in tiny, tightly trapped pores. These type of source rocks, known as shale formations, underlie the majority of the state. The low permeability of the shale characterizes the formation as an unconventional resource. Both conventional and unconventional oil and gas formations have been drilled in Pennsylvania.

The state of Pennsylvania has played a historically important role in the development of the oil industry, as Edwin Drake drilled the first ever commercial oil well, in Titusville, in 1859.[29] Pennsylvania became a critical producer of petroleum, producing half of the world's total oil supply until 1901, when oil was discovered in East Texas.[30] Again, in 2004, Pennsylvania experienced another petroleum industrial boom when new horizontal drilling and multi-stage hydraulic fracturing technologies allowed producers access to natural gas from unconventional shale, more specifically from the Marcellus Shale.

The Marcellus Shale formation underlies approximately 60 percent of the entire Commonwealth, including thousands of acres of publicly owned lands.[31] Accessing natural gas from the Marcellus Shale requires different drilling techniques than accessing traditional oil and gas reservoirs, due to the tight, low permeability of the rock formation mentioned above. Conventional oil and gas wells are drilled vertically into known oil/gas reservoirs where the pressure from the well is all that is typically needed to bring the oil/gas to the surface. Unconventional drilling methods, such as those used to extract gas from the Marcellus Shale, involve a combination of horizontal drilling and multi-stage hydraulic fracturing techniques, also known as "fracing" or "fracking." Unconventional drilling processes are most commonly associated with chemical use and fracking; however, conventional drilling technologies often utilize chemical additives and fracking techniques as well. For simplicity, in this report, the term *unconventional drilling* will describe the drilling processes used to extract gas from the Marcellus Shale utilizing multistage hydraulic

[28] S. Resse, *Oil Seeps, Venango County*, (Middletown, PA: Pennsylvania Geological Survey, Department of Conservation and Natural Resources, 2012), http://www.gis.dcnr.state.pa.us/topo/ogf/OGF_OilSeeps.pdf.
[29] "The Story of Oil in Pennsylvania," *Paleontological Research Institute*, https://www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania.html, accessed October 6, 2017.
[30] "The Story of Oil in Pennsylvania (continued)," *Paleontological Research Institute*, https://www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania2.html, accessed October 6, 2017.
[31] "Pennsylvania State Profile and Energy Estimates," *U.S. Energy Information Administration*, updated July 20, 2017, https://www.eia.gov/state/analysis.php?sid=PA.

fracturing and horizontal drilling technologies. The term *conventional drilling* will describe vertical wells drilled into conventional oil and gas reservoirs.

Oil and gas drilling in Pennsylvania is regulated under numerous state laws, such as the Pennsylvania Oil and Gas Act, the Coal and Gas Resource Coordination Act, and the Oil and Gas Conservation Law. The Pennsylvania Department of Environmental Protection (DEP) oversees compliance with the provisions of these acts and laws. Within DEP, "the Office of Oil and Gas Management is responsible for the statewide oil and gas regulatory programs to facilitate the safe exploration, development, and recovery of Pennsylvania's oil and gas reservoirs in a manner that will protect the commonwealth's natural resources and the environment."[32] DEP regulates the drilling processes; however, it plays no role in the negotiations of leases. Leases between drilling companies and state agencies are negotiated similarly to those of private landowners.

Environmental Impacts

As with development of all energy resources, the exploration and production of oil and natural gas has potential to cause negative effects on the environment. In fact, between 2009 and 2016, the PA Department of Environmental Protection collected 31.2 million dollars from the oil and gas industry as a result of environmental violations.[33] Some of the major potential environmental issues

Conventional and Unconventional? Reservoirs vs. Drilling Technologies



The words "conventional" and "unconventional" mean different things to scientists and politicians in Pennsylvania. To geologists, these terms describe the type of rock formation being drilled, with conventional describing typical, permeable source reservoirs and unconventional describing tighter, less permeable shale formations.

In 2008, when lawmakers were designing new regulations specific to the booming Marcellus shale development, they used "unconventional" to define a rock formation that required hydraulic fracturing, (or other gas stimulation techniques) in order to economically recover the resource. (http://www.legis.state.pa.us/WU01/LI/LI/CT/PDF/58/58.PDF)

Because of this, the term "unconventional" is often synonymous with fracking, even though fracking techniques are sometimes used to access oil and gas from both conventional and unconventional reservoirs.

Image: Natural gas drilling rig, credit: Allison Rohrs

[32] "Oil and Gas Programs," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/Pages/default.aspx, accessed October 6, 2017.
[33] "2016 Oil and Gas Annual Report," *Pennsylvania Department of Environmental Protection,* May 17, 2017, http://www.depgis.state.pa.us/oilgasannualreport/index.html.

associated with oil and gas development include habitat fragmentation, water contamination and air pollution. Each of these environmental issues are discussed in the following paragraphs.

Habitat Fragmentation

The construction of new roads, well pads, compressor stations, pipelines, and other oil and gas related infrastructure has effects on the landscapes, ecosystems, and wildlife habitat they replace. The Wilderness Society describes habitat fragmentation as "alter[ing] the distribution of wildlife species across the landscape and affects many of their life functions such as feeding, courtship, breeding, and migration."[34]

Prior to issuance of a drilling permit from DEP, oil and gas companies need to demonstrate how the project will likely impact such areas of concern as well as their companies' plans to avoid, mitigate, and/or monitor such impacts. The drilling companies work closely with DEP, DCNR, PGC and the PA Fish and Boat Commission to determine any impacts to wildlife and habitat, regardless of whether the project is developed on public or private lands.

The Pennsylvania Natural Heritage Program houses the Pennsylvania Conservation Explorer, an online "tool that provides conservation information on biological diversity, protected lands, streams and other natural resources for planning purposes. This also allows users to screen an energy development project area for potential impacts to threatened, endangered, and special concern species."[35]

Using Pennsylvania Natural Heritage Program records, the Nature Conservancy's *Pennsylvania Energy Impacts Assessment* found that 132 species of concern (out of 329 species tracked by the program in these areas) were located in areas likely to experience Marcellus Shale gas development. The green salamander (*Aniedes aeneus*), whose entire Pennsylvania population exists within areas favorable to shale development, is cited as an example of a species that could be affected by drilling operations. The report also describes snow trillium (*Trillium nivale*) as having nearly three-fourths of its habitat in lands identified as favorable for drilling. The authors state that, "a well-managed screening system to identify the presence of these species and their preferred habitats will be critical to their survival as energy development expands across the state."[36]

There are few studies that conclude how oil and gas development affect ecosystems specific to Pennsylvania, however there has been research completed in other western states with similar drilling activity. Researchers from Western Ecosystems Technology Incorporated "used data from 187 mule deer across a 17-year period to determine whether deer habituated to energy development in the Upper Green River Basin of Western Wyoming."[37] The study revealed that "mule deer did not acclimate to gas development and the population declined by 36 percent despite

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[34] Mark Wilbert, Janice Thomson, and Nada Wolff Culver, *Analysis of Habitat Fragmentation from Oil and Gas Development and its Impact on Wildlife: A Framework for Public Land Management Planning,* (The Wilderness Society Ecology and Economics Research Department, May 2008), https://www.fws.gov/southwest/ES/Documents/Oil-Gas-Fragmentation-Wilbert%20et%20al%202008.pdf.

[35] "Heritage News," *Pennsylvania Natural Heritage Program*, http://www.naturalheritage.state.pa.us/News.aspx, accessed October 6, 2017.

[36] Nels Johnson, *Pennsylvania Energy Impacts Assessment*.

[37] Hall Sawyer et al., "Mule Deer and Energy Development-Long-term Trends of Habituation and Abundance," *Global Change Biology* (2017), 4521–4529. DOI: 10.1111/gcb.13711

aggressive mitigation efforts and a 45 percent decrease in deer harvest."[38] The avoidance of oil and gas infrastructure is a long-term behavior that reduces the amount of winter ranges available for deer and therefore impacts the population for decades, according to the report.[39]

Mule deer populations were also analyzed in Northwest Colorado, an area that provides critical winter habitat for one of the largest migratory mule deer herds on the continent. Northwest Colorado is also home to the Piceance natural gas basin, an area that has seen a boom in natural gas production in recent years. The Piceance Basin produced only 126 billion cubic feet of natural gas in 2000, but by 2012, was producing 859 billion cubic feet.[40] Starting in 2008, scientists placed GPS collars on 53 female mule deer in the Piceance Basin to track their movements and behaviors.[41] The study determined "that gas development areas in the Piceance comprised between 25 and 50 percent of mule deer's critical winter range. At active drilling sites, the deer stayed an average of a half-mile away, and were especially skittish at night, likely trying to avoid the bright lights and jarring noise of around-the-clock industry at the same time they're trying to do their nightly foraging."[42]

Introduction of non-native species to an ecosystem is also a consequence of land clearing for natural gas development. Non-native plant species, also called "invasives," can be introduced when soil and other building materials from distant locations are used in the process of construction. Disturbed soil presents prime locations for these invasive plants to take root and are evident on newly constructed well pads, pipeline rights-of-way and newly constructed access roads. A study conducted in Pennsylvania state forests found that 14 of 18 well pads evaluated contained non-native plants, with Japanese stiltgrass being the most prevalent.[43]

Habitat Fragmentation on Public Land

The effect of habitat modification and fragmentation on public lands is different from the effect on private lands. Traditionally off limits for other industrial development, Pennsylvania public lands are set aside to "manage Pennsylvania's wild birds, wild mammals, and their habitats for current and future generations"[44] (PGC mission) and to "conserve and sustain Pennsylvania's natural resources for present and future generations' use and enjoyment"[45] (DCNR mission). Energy resource development on habitats reserved for these purposes has led many taxpayers, hunters, furtakers, and outdoor enthusiasts, to express concern that the use of these state lands are contradictory to their missions. Both the PGC and DCNR accept public comments from such stakeholders through different processes and both agencies have received comment specifically about habitat fragmentation on public lands.

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[38] Ibid.
[39] Ibid.
[40] Joshua Zaffos, "New Research on How Drilling Affects Deer in Northwest Colorado," *High Country News*, August 18, 2015, http://www.hcn.org/articles/study-quantifies-drilling-impacts-on-mule-deer, accessed July 28, 2017.
[41] Ibid.
[42] Ibid.
[43] Pennsylvania Department of Conservation and Natural Resources, *Shale-Gas Monitoring Report*, (Harrisburg, PA: April 2014), http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20029147.pdf, 70-101.
[44] PA-PGC, *Strategic Plan 2015-2020*.
[45] "About Us," PA-DCNR.

DCNR encourages public commentary on nearly every aspect of their operations. In 2016, the public was invited to comment on DCNR's *State Forest Resource Management Plan*. Many people expressed concern over the effects of habitat fragmentation, mainly due to gas development, but also related to other forms of development.[46] DCNR response to this issue was:

> The bureau recognizes that fragmentation is one of the greatest threats presented by gas development, right-of-way construction, and other forms of development. The draft and final SFRMP contain goals to minimize permanent conversion from forest to non-forest and to minimize forest fragmentation. This can be done in a number of ways, such as avoiding conversion and fragmentation or co-locating unavoidable fragmentation next to existing fragmenting features. The SFRMP also calls for improvement of edge habitat and mitigation of edge effects, and the bureau is presently working on a new set of best management practices to do just that. Options include new shrub or tree plantings in temporary work-spaces of pipelines, and feathering the edges along fragmenting features.[47]

The Game Commission has also addressed public concern regarding habitat fragmentation caused by the oil and gas industry. In a 2012 interview by the *Towanda Daily Review* reported on by *StateImpact*, a Game Commission spokesperson responded to the public's concern regarding habitat fragmentation issues associated with oil and gas development:

> 'We've found that state game lands can actually benefit two different ways from natural gas development,' Press Secretary Jerry Feaser said. 'We've discovered that well pad and pipeline construction can actually benefit wildlife in the long run. The initial excavation, construction and drilling processes are temporary habitat displacements. When the development enters the production stage, we've actually witnessed and photographed habitat improvements because well pads in production are meadow-like areas and pipelines provide a linear food supply.
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> 'The other benefit is for the game commission, itself, in the form of increased revenue,' Feaser said. 'Through lease payment and eventual royalty revenue, we'll be able to provide more funding to the game lands, hire more personnel and acquire more lands.'[48]

Some hunters also support the leasing of game lands for energy development. HuntingPA.com is an online resource for Pennsylvania sportsmen and women to share their opinions. In a February 2017 online forum, hunters discussed, "Gas Drilling and coal removal from State Game Lands: Are you in favor of this undergoing, and if so will the outdoorsmen see the profits of this?" Five sportsmen/women replied that yes, they were supportive of the Game Commission leasing the land for gas drilling and coal removal, citing positive benefits such as increased revenues for

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[46] Pennsylvania Department of Conservation and Natural Resources, *2016 State Forest Resource Management Plan: Response to Public Comments*, http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20032040.pdf, accessed August 23, 2017.

[47] Ibid.

[48] Scott Detrow, "More State Land to be Leased for Drilling," *StateImpact Pennsylvania*, May 17, 2012, https://stateimpact.npr.org/pennsylvania/2012/05/17/more-state-land-to-be-leased-for-drilling/.

the agency, easier access to deeper forest, and clearings for deer they would not otherwise have.[49] In this forum, no hunters disputed their opinions or observances.

Both agencies defend their decisions to lease land for drilling on the basis that budget contributions from the oil and gas industries, in many cases, outweigh the potential negative effects of development and are significant portions of both agencies' budgets. Additionally, both agencies have been leasing their land for oil and gas development for over 50 years, without much opposition, until the recent deluge of drilling from the Marcellus Shale. Operational costs to run each agency have skyrocketed as well. According to the PGC's *2015-2020 Strategic Plan*, it cost the Commission approximately $40 million to pay its 731 full-time employees in 1997. In 2016, PGC projected it would spend over $80 million to employ 714 full-time personnel, less employees at more than double the cost.[50] DCNR has faced, and still faces, similar budget woes. The department has seen its funding cut by 24 percent over the past 10 years, factoring in inflation.[51] Both agencies argue that through prudent habitat management practices, oil and gas development provides an opportunity to sustain their organizations and fulfill their missions. Both DCNR and the PGC have different oil and gas management approaches.

In 2014, DCNR released its first *Shale-Gas Monitoring Report*. The report showed that forests were being converted and fragmented, but less than originally expected. DCNR cited this as "the result of management decisions to place this activity within or adjacent to existing infrastructure or existing disturbances, where it is more noticeable to the public but requires less forest disturbance."[52] The agency actively monitored all well and infrastructure construction through GIS and GPS spatial analysis, which aided in quantifying and identifying modifications and issues to the habitat. As of DCNR's 2014 report, "approximately 1,486 acres of forest have been converted to facilitate gas development in the core gas districts...including roads, infrastructure, well pads, and pipelines."[53] A follow up report is expected to be released in 2018.

The Game Commission states that they "are dedicated to managing habitats and maintaining the quality of the game lands for Pennsylvania hunters and trappers."[54] PGC has a fleet of land managers and habitat maintenance crews that are regularly on active oil and gas development sites. These PGC staff ensure the oil and gas exploration companies are adhering to their lease agreements, are performing remediation on schedule and other tasks that safeguard critical habitats. Deer habitat are of great concern to the Game Commission, as deer hunting is a primary use for state game lands. Research analyzing the effects of oil and gas infrastructure on white-tailed deer populations has been limited. Scientists have studied mule deer (as discussed above), considered a "surrogate species" to whitetails,

[49] "Gas Drilling and Coal Removal from State Game Lands." *HuntingPA.com*, http://www.huntingpa.com/forums/20-general-hunting-forum/174769-gas-drilling-coal-removal-state-game-lands.html, accessed October 13, 2017.
[50] PA-PGC, *Strategic Plan 2015-2020*.
[51] Matt Stepp, "The State Budget Negotiations are Poison Pill for PA's Environment," *PennFuture Blog*, May 22, 2017, https://www.pennfuture.org/Blog-Item-The-State-Budget-Negotiations-are-Poison-Pill-for-PAs-Environment, accessed August 23, 2017.
[52] PA-DCNR, *Shale-Gas Monitoring Report*.
[53] Ibid.
[54] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, November 21, 2017.

but not found in Pennsylvania, and their interactions with the industry in some states.[55] The Pennsylvania Game Commission has an extensive white tail deer management plan; however, it has not published any research or documents pertaining specifically to oil and gas development and deer populations in Pennsylvania, citing insufficient resources to do so.

Although there are potentially negative impacts on ecosystems and wildlife from oil and gas development, such impacts are typically mitigated through careful environmental planning. Such planning is required prior to the issuance of a drilling permit from DEP. Large amounts of biological surveys that were not available prior to drilling, are now accessible. Similarly, large wetland surveys for size, location, and function are available solely because of oil and gas development.[56]

Water Quality

In addition to habitat fragmentation concerns, oil and gas development poses potential impacts to water resources and water quality. Because the process of oil and gas exploration involves drilling through the water table as well as storing and transporting contaminated water, there are known water pollution risks. According to the United States Environmental Protection Agency (EPA), the five typical stages of the oil and gas exploration processes where there is a potential for water contamination include:

1.) Acquiring water

2.) Chemical mixing

3.) Well drilling and injection

4.) Produced water handling

5.) Water disposal and reuse[57]

These stages and water contamination issues vary with drilling technology. All stages pose potential water quality issues in unconventional natural gas drilling that utilize hydraulic fracturing techniques. Conventional wells, do not have the same impacts, even though many wells drilled in Pennsylvania since the 1940s have been hydraulically stimulated in one way or another.[58] Details of these five potential water contamination processes and associated drilling techniques are discussed below.

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[55] Steve Dyke et al., *Potential Impacts of Oil and Gas Development on Select North Dakota Natural Resources: A Report to the Director*, (Bismarck, ND: North Dakota Game and Fish Department, 2011), https://gf.nd.gov/sites/default/files/publications/directors-report-oil-gas-may-2011.pdf.

[56] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, November 30, 2017.

[57] U.S. Environmental Protection Agency, *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States: Executive Summary*, (Office of Research and Development, Washington, DC, 2016), https://www.epa.gov/sites/production/files/2016-12/documents/hfdwa_executive_summary.pdf. (EPA-600-R-16-236ES)

[58] Teddy Borawski, Department of Conservation & Natural Resources, personal correspondence, November 3, 2017.

Water Acquisition: Conventional oil and gas production requires water for well "control, cooling, and cuttings removal."[59] Unconventional drilling processes also use water for the same purposes as conventional drilling, however, they use significantly more water per well for the hydraulic fracturing process.[60]

Water required for hydraulic fracturing is originally acquired from either surface or groundwater (or sometimes both).[61] In some scenarios, the water acquired for fracking also supplies drinking water reserves.[62] The possible environmental and health impacts of water acquisition for oil and gas production are associated with changing the quality or quantity of current drinking water or supplies that may be used for drinking water in the future. The impacts can also be more severe in areas that rely on "declining groundwater resources," areas that experience "seasonal or long-term drought[s]," and areas with low "groundwater recharge rates."[63]

Expected water impacts of acquisition of frack water on water supply in Pennsylvania, however, seem to be lower than expected. According to EPA's 2016 *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States* report: "In the Susquehanna River Basin, multiple studies and state reports have identified the potential for hydraulic fracturing water withdrawals in the Marcellus Shale to impact surface water resources. Evidence suggests, however, that current water management strategies, including pass-by flows and reuse of hydraulic fracturing wastewater, help protect streams from depletion by hydraulic fracturing water withdrawals."[64]

In Pennsylvania, oil and gas companies also reuse large amounts of frack water, lowering the overall need for surface and groundwater resources. EPA states, "In the Marcellus Shale region of the Susquehanna River Basin, approximately 14% of injected fluid was reused hydraulic fracturing wastewater, while approximately 90% of produced water was managed through reuse in other hydraulic fracturing operations."[65] Implications of frack water reuse are discussed later in this research.

Chemical Mixing: The second stage in the oil and gas production procedure that has potential impact on water quality is the chemical mixing process. Both conventional and unconventional wells use chemical additives to enhance resource recovery. Hydraulic fracturing techniques are typically used to access gas from tighter, less permeable unconventional shale formations; however, fracking is also used in some conventional well drilling applications as

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[59] "Water Use and Quality in the Oil and Gas Industry," *ExxonMobil,* http://corporate.exxonmobil.com/en/current-issues/water/water-and-energy/water-use-in-oil-and-gas-industry, accessed October 5, 2017.
[60] Duke Today Staff, "How Much Water Does U.S. Fracking Really Use?," *Duke Today*, September 15, 2015, https://today.duke.edu/2015/09/frackfoot. Although more water is typically used in the unconventional drilling process per well, a 2015 study by researchers at Duke University found "that fracked oil wells generate about half of a barrel of wastewater for each barrel of oil, while conventional oil wells on land generate more than three barrels of wastewater for each barrel of oil."
[61] US-EPA, *Hydraulic Fracturing for Oil and Gas.*
[62] Ibid.
[63] Ibid.
[64] Ibid.
[65] Ibid.

well.[66] The amount of water and chemicals used for hydraulic fracturing in conventional drilling is significantly less than that used for unconventional drilling, with unconventional fracking requiring nearly 10 times as much.[67] Water is the most common hydraulic fracturing base fluid.[68] Proppant (sand is the most common) and chemical additives are combined with a base fluid (water) to create the final hydraulic fracking fluid. EPA estimates that chemical additives account for "typically 2% or less of the total volume of the injected fluid."[69]

The types of chemical additives vary significantly, with 1,084 unique additives being recorded as used in fracking fluids between the years of 2005 and 2013.[70] Despite the low percentage of chemicals in the fracking fluid, the large volumes of fluids used for the fracking process corresponds to thousands of gallons of chemical additives both stored on drilling sites and injected into the ground.

Chemical mixing errors and chemical spill threats do indeed exist. According to EPA's report, "an EPA analysis of spill reports from nine state agencies, nine oil and gas wells operators, and nine fracking services concluded there were 151 spills of hydraulic fracking fluids or additives between January 2006 and April 2012. Thirty-four percent caused by equipment failure, 25 percent from human error, and more than 30 percent from fluid storage tanks."[71]

The potential impacts of spills depend on the characteristics of the chemicals and the spill. The size of the spill, the proximity to water resources, and the permeability of the soil and rock surrounding the drilling site affects the risk for contamination. According to the EPA report, "Spills of hydraulic fracturing fluids and additives during the chemical mixing stage of the hydraulic fracturing water cycle have reached surface water resources in some cases and have the potential to reach groundwater resources."[72] Unlike flowing surface water, groundwater has the potential for greater impacts due to the increased difficulty to naturally and physically remove chemicals from the resource.[73]

EPA recommends, "site-specific studies on the factors that affect the severity and the frequency of impacts on water are needed along with groundwater monitoring after spill events to better understand the environmental health effects from chemical mixing in fracking fluids."[74]

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[66] Trisha A. Smrecak and the PRI Marcellus Shale Team, *Marcellus Shale: The Science Beneath the Surface, Marcellus Shale*, Paleontological Research Institution. (Ithaca, NY, January 2012), Issue 6, http://www.museumoftheearth.org/files/marcellus/Marcellus_issue6.pdf.
[67] Ibid.
[68] US-EPA, *Hydraulic Fracturing for Oil and Gas.*
[69] Ibid.
[70] Ibid.
[71] Ibid.
[72] Ibid.
[73] Ibid.
[74] Ibid.

Well Drilling and Injection: Shale formations and oil reservoirs are typically found hundreds to thousands of feet below the surface. The water table is typically only a few hundred feet below the surface. To access natural gas and oil, a well is drilled through this freshwater aquifer. Human error or mechanical failure during drilling and injection could result in aquifer contamination. Such failures are typically related to poorly constructed steel well casings and faulty or cracked cement casings. Because both conventional and unconventional drilling procedures require drilling through the fresh water aquifer and, if a well bore's steel casing cracks or the cement casing degrades, an opportunity for contaminants to flow into the water table arises.



Well Casing Example
Photo by: Allison Rohrs

Both drilling techniques inject water and chemical mixtures into the well. Conventional wells use chemical additives for reducing friction or increasing well stability. Conventional wells also use hydraulic fracturing techniques to minimize drilling complication and to increase gas flows in vertical wells.[75] In unconventional well drilling, hydraulic fracking fluid (chemical properties described above) is injected into the oil and gas production well to fracture tighter shale formations. As mentioned previously, compared to conventional drilling techniques at this stage of the gas production, unconventional drilling that utilize hydraulic fracturing techniques require substantially more injected fluid and therefore significantly more chemicals.

In unconventional wells used to recover gas from the Marcellus Shale in Pennsylvania, fracking fluids travel within the wells and through "fracture networks." Several layers of casings and cement are usually installed to protect the groundwater and inhibit the flow of fracking fluid outside of the well. EPA notes that this is especially important "where the well intersects oil-, gas-, and/or water-bearing rock formations."[76] The fracture networks created during the hydraulic fracturing process create opportunities for frack water to potentially interact with groundwater. The EPA explains:

> because fluids travel through the newly-created fractures, the location of these fractures relative to underground drinking water resources is an important factor affecting the frequency and severity of potential impacts on drinking water resources. Data on the relative location of induced fractures to underground drinking water resources are generally not available, because fracture networks are infrequently mapped and because there can be uncertainty in the depth of the bottom of the underground drinking water resource at a specific location.[77]

More research and data is needed to fully understand how fracturing networks created by hydraulic fracturing techniques can possibly reach and contaminate water supplies.

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[75] Trisha A. Smrecak and the PRI Marcellus Shale Team, *Marcellus Shale.*
[76] US-EPA, *Hydraulic Fracturing for Oil and Gas.*
[77] Ibid.

Injected water can reach the groundwater supply through naturally occurring faults, improperly cased wells, and active or abandoned wells in close proximity.[78] Naturally occurring fissures or faults in the earth can create unexpected and unknown paths for injected water to travel through. Improperly cased wells or cracks in the well's casing also presents opportunity for injected fluid to reach the groundwater supply. Many abandoned oil and gas wells in Pennsylvania also pose a significant threat to migrant injected frack fluids. The EPA report states,

> Abandoned wells near a well undergoing hydraulic fracturing can provide a pathway for vertical fluid movement to drinking water resources if those wells were not properly plugged or if the plugs and cement have degraded over time. For example, an abandoned well in Pennsylvania produced a 30--foot (9-meter) geyser of brine and gas for more than a week after hydraulic fracturing of a nearby gas well. The potential for fluid movement along abandoned wells may be a significant issue in areas with historic oil and gas exploration and production.[79]

With figures estimating 350,000 to 750,000 abandoned oil and gas wells in Pennsylvania, significant threats to water supply from oil and gas injection fluids exist.[80]

Produced Water Handling: Once the hydraulic fracturing stage is complete, the pressure in the well is released. This causes the injection fluid (fracking fluid), along with the oil and gas, to return to the surface. This "flowback" water, combined with oil and gas, called "produced water," returns to the surface to be separated. EPA reports that produced frack water samples have included the following contaminants:

- Salts, including those composed from chloride, bromide, sulfate, sodium, magnesium, and calcium
- Metals, including barium, manganese, iron, and strontium
- Naturally-occurring organic compounds, including benzene, toluene, ethylbenzene, xylenes (BTEX), and oil and grease
- Radioactive materials, including radium
- Hydraulic fracturing chemicals and their chemical transformation products.[81]

Handling of this produced water creates opportunities for spill and water contamination. According to the EPA, an estimated 4 million gallons of water is used to frack an individual well in the Marcellus Shale, which equates to hundreds of thousands to millions of gallons of produced water.[82] This produced water flows from the well through a network of onsite piping, water holding tanks and/or surface pits.[83] The water is then moved by trucks and/or pipelines offsite to be disposed of or stored onsite to be used again.[84]

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[78] Ibid.
[79] Ibid.
[80] Marie Cusick, "Pennsylvania Has More Abandoned Wells Than Expected, Says New Study," *StateImpact Pennsylvania*, November 14, 2016, https://stateimpact.npr.org/pennsylvania/2016/11/14/pennsylvania-has-more-abandoned-wells-than-expected-says-new-study/, accessed October 6, 2017.
[81] US-EPA, *Hydraulic Fracturing for Oil and Gas*.
[82] Ibid.
[83] Ibid.
[84] Ibid.

Spills of the produced water can and do occur. Human error and equipment leaks and failures are the leading causes of water contamination on oil and gas production sites, according to the EPA.[85] "The [PA] DEP says spills are the second most common problem their inspectors confront, after erosion and sediment control issues," according to a 2016 *StateImpact Pennsylvania* article.[86]

Water Disposal and Reuse: The final process in the oil and gas exploration cycle is the disposal and reuse of hydraulic fracturing wastewater, which is only applicable in wells that utilize hydraulic fracturing techniques. Wastewater is typically handled in one of three different ways, according to EPA:

- injection into Class II wells
- reuse in other hydraulic fracturing operations
- various aboveground disposal practices[87]

Hydraulic fracturing wastewater is often injected back into the ground through injection wells. Injection wells are used across a variety of industries for enhancing oil production, storing carbon dioxide, and disposing of other waste products.[88] EPA classifies the injection well type based on the purpose, with Class II injections wells representing the oil and gas industry.[89] Class II wells are usually federally regulated by the Underground Injection Control (UIC) program under the Safe Drinking Water Act.[90]

As previously mentioned, many oil and gas companies also choose to reuse the frack water. Specifically, in Pennsylvania, "DEP promotes recycling as a first option when it is technically and economically feasible. However, some liquid waste must ultimately be disposed of and deep underground injection has been identified as one of the safest ways to manages such waste."[91] According to EPA, "approximately 90% of hydraulic fracturing wastewater from Marcellus Shale gas wells in Pennsylvania was reused in other hydraulic fracturing operations in 2013."[92]

Additionally, aboveground disposal methods, such as wastewater treatment facilities, evaporation pits, and irrigation are other wastewater management strategies used by the oil and gas industries. Wastewater treatment plants treat the water to remove harmful chemicals and then release the water back into other surface water and inject the chemical byproducts beneath the earth or send them to acceptable landfills.[93] "Evaporation ponds allow liquid waste

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[85] Ibid.
[86] Susan Phillips, "Lack of Data on Fracking Spills Leaves Researches in the Dark on Water Contamination," *StateImpact Pennsylvania*, January 22, 2016, https://stateimpact.npr.org/pennsylvania/2016/01/22/lack-of-data-on-fracking-spills-leaves-researchers-in-the-dark-on-water-contamination/, accessed October 9, 2017.
[87] US-EPA, *Hydraulic Fracturing for Oil and Gas*.
[88] "General Information about Injection Wells," *U.S. Environmental Protection Agency*, https://www.epa.gov/uic/general-information-about-injection-wells, accessed October 8, 2017.
[89] Ibid.
[90] US-EPA, *Hydraulic Fracturing for Oil and Gas*.
[91] Pennsylvania Department of Environmental Protection, *Injection Wells for Enhanced Recovery and Disposal*, (Harrisburg, PA: November 2016), http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-115614/8000-FS-DEP2250.pdf. Accessed September 28, 2017.
[92] US-EPA, *Hydraulic Fracturing for Oil and Gas*.
[93] Ibid.

to naturally evaporate. Percolation pits allow wastewater to move into the ground, although this practice has been discontinued in most states."[94]

Errors in wastewater treatment management has devastating potential environmental and health (discussed later) impacts. Water quality has been affected by improper wastewater management. Specifically, in the Marcellus Shale region, wastewater treatment facilities were found to have released inadequately treated wastewater into the Allegheny and Monongahela River Basins.[95] According to EPA, "The scientific literature and recent data from the Pennsylvania Department of Environmental Protection suggest that other produced water constituents (e.g., barium, strontium, and radium) may have been introduced to surface waters through the release of inadequately treated hydraulic fracturing wastewater. In particular, radium has been detected in stream sediments at or near wastewater treatment facilities that discharged inadequately treated hydraulic fracturing wastewater."[96]

As of October 2017, Pennsylvania DEP had reported 294 instances where it was determined that a private water supply was impacted by oil and gas development.[97] Under Pennsylvania's Oil and Gas Act, water contamination can be attributed to oil and gas activity when a well operator is responsible for pollution of a water supply if:

(i) The water supply is within 1,000 feet of an oil or gas well; *and*
(ii) The pollution occurred within six months after completion of drilling or alteration of the oil or gas well;

Or

In the case of an unconventional well:
(i) The water supply is within 2,500 feet of the unconventional vertical well bore; *and*
(ii) The pollution occurred within 12 months of the later of completion, drilling, stimulation or alteration of the unconventional well.[98]

Under the same law, "a well operator who affects a public or private water supply by pollution or diminution shall restore or replace the affected supply with an alternate source of water adequate in quantity or quality for the purposes served by the supply."[99]

Water Quality on Public Lands

Potential water quality impacts from oil and gas production, specific to public lands, can be attributed to abandoned natural gas wells on public lands and the remoteness of the public lands being utilized.

[94] Ibid.
[95] Ibid.
[96] Ibid.
[97] Pennsylvania Department of Environmental Protection, *Regional Determination Letters*. October 2, 2017, http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf, accessed October 9, 2017.
[98] Pennsylvania General Assembly, Pennsylvania's Oil and Gas Act, Act 223, Title 58 Oil and Gas, Chapter 32 Development, Subpart B General Requirements, § 3218: Protection of Water Supplies.
[99] Ibid.

Some of the best data and evidence available regarding environmental impacts from oil and gas industries specifically addresses known concerns with operations in close proximity to abandoned oil and gas wells. Pennsylvania public lands have an abundance of abandoned oil and gas wells. Oil Creek State Park alone has over 1,500 abandoned unplugged wells.[100] DCNR does not have specific data on the total number of abandoned wells in state parks and forests, however, the subsurface programs manager estimates orphan "wells number in the thousands."[101] Scientific evidence, discussed above, identifies abandoned gas wells as potential pathways for injected fluid to reach the groundwater, creating serious potential environmental impacts to water sources.

The remoteness of drilling operations on public lands creates other environmental impact issues as well. Pennsylvania's Oil and Gas Law becomes meaningful when discussing potential implications of oil and gas development on water quality on public lands. Public lands are not typically used for residential purposes and consequently there is limited access to water wells to gather aquifer contamination data. Additionally, because state lands are not a place of permanent dwelling, there are not consistent opportunities to report any signs of pollution, such as smelling an odor or seeing discolored water. The size of the public land's water supply that should be monitored also presents a major issue. If under Pennsylvania law, there is a 1,000 foot (conventional) and 2,500 foot (unconventional) radius that defines polluter responsibility, monitoring that square footage around each well should be a priority in order to hold the drilling operators accountable and pursue any necessary remediation funds. Approximately 500 conventional wells are producing today, and 483 wells, mostly unconventional, have been drilled on DCNR land since 2008.[102] For DCNR alone, this equates to over a quarter million acres of uninhabited area where pollution may have occurred, unnoticed because of the remoteness and lack of already drilled water wells to collect water samples. In addition to remote land, PA DEP reports that approximately 3,400 miles of streams travel through the core gas state forest lands, which includes "many of the best-known fishing and boating waters in Pennsylvania," also difficult to monitor.[103] Details about each of the agencies' monitoring techniques are discussed in following sections.

Air Quality

Oil and gas exploration and production activities are linked to air pollution resulting from the release of volatile organic compounds, hazardous air pollutants, and greenhouse gases. These pollutants are emitted into the atmosphere during every stage of their lifecycles, which includes well site preparation and road construction, well drilling, hydraulic fracturing, and well completion, production, processing and storage, transmission, well abandonment and site rehabilitation.

In Pennsylvania, DEP monitors air emissions from the oil and gas industry, however, DEP does not require "emissions data and source reports from well development activities for traditional gas/coal bed methane wells."[104] The focus of air emissions regulation is primarily on the unconventional oil and gas industry. Industry is required to self-report

[100]Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence October 10, 2017.
[101] Ibid.
[102] Teddy Borawski, Department of Conservation & Natural Resources, personal correspondence, July 18, 2017.
[103] PA-DCNR, *Shale Gas Monitoring Report*, 103.
[104] "Emission Inventory," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/business/air/baq/businesstopics/emission/Pages/default.aspx, accessed October 9, 2017.

emissions to DEP. The most recent data set of PA unconventional gas showed, "emissions of methane and Volatile Organic Compounds (VOCs) from unconventional well sites and mid-stream reporting facilities increased from 2014 emission levels while several other pollutants including nitrogen oxides (NO_x), sulfur dioxide (SO_x) and particulate matter ($PM_{2.5}$) all saw decreases from 2014 emission levels."[105] Note, these figures represent not only well drilling and drill site operations, but midstream activities like gas processing, transportation, and storage, as well. In 2015, 10,287 well sites and 534 midstream facilities reported emissions data to DEP. Emissions tracked by DEP include:

- CO
- NOx
- PM-10
- PM-2.5
- SOx
- VOC
- Benzene
- Ethyl Benzyne
- Formaldehyde
- n-Hexane
- Toluene
- Xylenes
- 2,2,4 Trimethylpentane
- Carbon Dioxide
- Methane
- Nitrous Oxide

The majority of these pollutants are monitored because they have potential adverse health effects and are discussed further in the next section of this analysis. The greenhouse gasses, carbon dioxide, methane, and nitrous oxide are monitored due to their potential atmospheric warming effects. The state of Pennsylvania has additional emissions control requirements for methane specifically. Some studies estimate that within its first 20 years in the atmosphere, methane has 86 times the climate-altering potential of carbon dioxide.[106]

Air Emissions On Public Lands

The environmental effects of air pollution from oil and gas activity on public lands is unique. Data associated with the acute effects of the aforementioned pollutants directly on wildlife, however, is sparse. The concern of the effects of excess greenhouse gases, such as carbon dioxide and methane, on wildlife arise on both a local and global scale. Recent studies link the climate-altering effects of greenhouse gases to threatening wildlife. According to a 2013

[105] DEP Newsroom, "2015 Air Emissions Inventory for Unconventional Natural Gas Operations Released," *Pennsylvania Department of Environmental Protection*, August 31, 2017, http://www.ahs.dep.pa.gov/NewsRoomPublic/articleviewer.aspx?id=21283&typeid=1.

[106] Phil McKenna, "The EPA's Natural Gas Problem," *NOVA NEXT by WBGH for PBS Online*, February 24, 2015, http://www.pbs.org/wgbh/nova/next/earth/methane-regulations/, accessed June 29, 2017.

National Wildlife Federation report, "nowhere will the Appalachian habitats and wildlife be left untouched by climate change."[107] The report addresses habitats similar to those found on Pennsylvania public lands, stating,

> Species dependent on mountaintops and their predominantly coniferous habitats will be particularly at risk, due to limited opportunity to move upward in elevation...Brook trout that inhabit cold Appalachian streams are also at risk. As air and water temperatures rise, areas of suitable water temperatures are projected to recede from the lower elevations into the higher elevations, resulting in more isolated and smaller populations.[108]

The long-term effects of excess methane and carbon dioxide in the atmosphere have a potential negative effect of the habitats located on public lands.

HEALTH IMPACTS

The health concerns related to oil and gas development are similarly related to water and air contaminants discussed in the environmental impacts section above. Health impacts include water contamination, destruction of air quality, potential risks associated with active and abandoned oil and gas infrastructure, and earthquakes.

Water Contamination

There is substantial concern about chemically laced water used for unconventional natural gas production reaching the groundwater supply. "Chronic oral toxicity values" have been studied and identified by researchers for some, but not the majority, of the chemicals used in hydraulic fracturing fluids and flowback water.[109] According to EPA, "of the 1,606 chemicals identified by the EPA, 173 had chronic oral toxicity values from federal, state, and international sources."[110] Roughly 87% of the critical toxicity values for the chemicals used in hydraulic fracturing processes are unavailable. More specifically, "given the large number of chemicals identified in the hydraulic fracturing water cycle, this missing information represents a significant data gap that makes it difficult to fully understand the severity of potential impacts on drinking water resources."[111] Of the chemicals with known toxicity values, "Potential human health hazards... include cancer, immune system changes, changes in body weight, changes in blood chemistry, cardiotoxicity, neurotoxicity, liver and kidney toxicity, and reproductive and developmental toxicity," according to the EPA.[112]

Oil and gas activities can affect water supplies by introducing compounds that were not there previously or by raising them above standards set for reasons of health, safety, taste or appearance. The most widespread contaminant in Pennsylvania's groundwater related to oil and gas drilling is methane. When ingested, methane gas is not toxic and does not cause adverse health effects. Health issues arise when elevated concentrations of methane escape from the

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[107] Amanda Staudt et al., *Wildlife in a Warming World*. National Wildlife Federation, (Merrifield, VA: 2013), 32, https://www.nwf.org/~/media/PDFs/Global-Warming/Reports/NWF_Wildlife-Warming-World_Report_web.ashx.
[108] Ibid.
[109] US-EPA, *Hydraulic Fracturing for Oil and Gas*.
[110] Ibid.
[111] Ibid.
[112] Ibid.

water into poorly ventilated or confined areas, like basements, creating serious explosive potential.[113] Methane can seep into homes through cracks in the foundation and other openings.[114]

Contamination to surface water from fracking fluid and flowback water is also a concern. Such spills can and do occur, contaminating drinking water supplies with chemicals known to have a broad range of adverse health effects, discussed above.

Water Contamination on Pennsylvania Public Lands

Similar issues addressed in the environmental impacts/water pollution section of this research exist with regard to human health impacts in Pennsylvania public lands. Size and remoteness of the public land make it difficult to accurately monitor effects to groundwater. With no permanent dwellings, however, the impact to water supplies is also less likely to be an issue, as no one is using it as a primary drinking source and no dwellings are at risk for methane related explosion. There is also potential for public land users to ingest contaminated water if improperly filtered for drinking water purposes.

Air Emissions

As mentioned previously, the emissions monitored by PA DEP have serious health implications. Carbon monoxide, NOx, PM-10, PM-2.5, and volatile organic chemicals all have a range of respiratory impacts. According to the Center for Diseases Control and Prevention, "Breathing Carbon Monoxide (CO) can cause headache, dizziness, vomiting, and nausea. If CO levels are high enough, you may become unconscious or die. Exposure to moderate and high levels of CO over long periods of time has also been linked with increased risk of heart disease. People who survive severe CO poisoning may suffer long-term health problems."[115] Nitrogen oxides are "poisonous, highly reactive gasses."[116] Particulate matter is pollution made up of tiny, microscopic particles that can have negative effects on the heart and lungs when inhaled.[117] Volatile Organic Compounds "are organic compounds that easily become vapors or gases" and are notably released during many different stages of oil and gas exploration and production.[118] The toxicity of VOCs depends on the specific pollutant and the level and length of exposure.[119]

Other toxic pollutants released during oil and gas operations and monitored by DEP include benzene, toluene, ethylbenzene, and xylene (BTEX). Health effects associated with these toxins include "irritation of the eyes, nose, mouth and throat, aggravated asthma, blood disorders, harm to a developing fetus, immune system-related diseases,

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[113] Bryan Swistock, "Methane Gas and Its Removal from Water Wells," *Penn State Extension*, August 14, 2017, https://extension.psu.edu/methane-gas-and-its-removal-from-water-wells.
[114] "Methane," *Wisconsin Department of Health Services*, March 13, 2017, https://www.dhs.wisconsin.gov/chemical/methane.htm, accessed October 9, 2017.
[115] "Carbon Monoxide Poisoning." Centers for Disease Control and Prevention, October 26, 2016, ephtracking.cdc.gov/showCoRisk.action.
[116] United States Environmental Protection Agency, "Nitrogen Oxides (NOx) Control Regulations," September 1, 2017, https://www3.epa.gov/region1/airquality/nox.html.
[117] "Health and Environmental Effects of Particulate Matter (PM)," *U.S. Environmental Protection Agency*, July 1, 2016, https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm.
[118] ToxTown, "Volatile Organic Compounds (VOCs)," *U.S. National Library of Medicine*, https://toxtown.nlm.nih.gov/text_version/chemicals.php?id=31, accessed July 17, 2017.
[119] Ibid.

and cancer."[120] A study commissioned by the West Virginia Department of Environmental Protection found that even at 625 feet from oil and gas activity, sites were still experiencing benzene levels exceeding "what the [Center for Disease Control and Prevention] calls 'the minimum risk level for no health effects.'"[121]

In another western study, many hydrocarbon pollutants such as trimethylbenzenes, aliphatic hydrocarbons, and xylenes were found in Colorado's Garfield County, which have been linked to adverse respiratory and neurological effects. Concentrations of these toxins increased with proximity to the wells and were also found to be nine times higher during well completion than during well production.[122]

Methane commonly occurs within Earth's atmosphere in trace amounts.[123] This gas is not toxic, however, "Methane in its gas form is an asphyxiant, which in high concentrations may displace the oxygen supply need[ed] for breathing, especially in confined spaces. Decreased oxygen can cause suffocation and loss of consciousness. It can also cause headache, dizziness, weakness, nausea, vomiting, and loss of coordination," according to the U.S. National Library of Medicine.[124] Humans may be exposed to higher concentrations of this gas near oil, natural gas and coal related facilities, among others.[125] Methane can be detected in the body through health screenings, but no methods exist to measure methane exposure levels or the resulting health effects.[126]

Diesel emissions are another air pollutant associated with hydraulic fracturing. These emissions come "from the combustion engines of heavy trucks and machinery used during well site preparation," drilling, hydraulic fracturing, on-site combustions, production, and compressor stations. Fine soot particles found in diesel exhaust is a specific concern. [127] Once inhaled, these particles can cause asthma, lung cancer and heart disease.[128]

Health Concerns on Public Lands

The "fresh" air people seek during their visits to state parks, forests and game lands could be polluted by natural gas leaks, particulate matter, VOCs and more. Those that use these public lands could be increasing their risk of health effects associated with these pollutants simply due to their close proximity to fracking processes.[129]

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[120] Tanja Srebotnjak and Miriam Rotkin-Ellman, *Fracking Fumes*, (Natural Resources Defense Council, December 2014), https://www.nrdc.org/sites/default/files/fracking-air-pollution-IB.pdf.

[121] West Virginia Department of Environmental Protection, *Air, Noise, and Light Monitoring Results, for Assessing Environmental Impacts of Horizontal Gas Well Drilling*, (Charleston, WV: West Virginia University School of Health, May 3, 2013), http://www.dep.wv.gov/oil-and-gas/Horizontal-Permits/legislativestudies/Documents/WVU%20Final%20Air%20Noise%20Light%20Report.pdf.

[122] Ibid.

[123] "Atmospheric Methane," *NASA Earth Observatory*, February 22, 2015, https://earthobservatory.nasa.gov/IOTD/view.php?id=5270.

[124] ToxTown, "Methane."

[125]ToxTown, "Methane," U.S. National Library of Medicine, https://toxtown.nlm.nih.gov/text_version/chemicals.php?id=92, accessed October 13, 2017.

[126] "Methane," *Wisconsin Department of Health Services.*

[127] Tanja Srebotnjak and Miriam Rotkin-Ellman, *Fracking Fumes*.

[128] Reid Frazier, "On Health Effects, Blame the Trucks, Not the Fracking?" *The Allegheny Front*, June 16, 2017, https://www.alleghenyfront.org/on-health-effects-blame-the-trucks-not-the-fracking/.

[129] PA-DCNR, *Shale-Gas Monitoring Report*, April 2014.

On DCNR lands, public access to state forest and park lands are usually through roads that are zoned for public access. According to a DCNR representative,

> Each oil and gas lease has setbacks for multiple industrial facilities like drill sites, water impoundment, compressor stations and pipeline corridors. Roads, trails, streams, camp-sites, wild areas, natural areas and specific features are to be respected by a 300-foot setback. This is designed to provide a buffer if necessary, but cannot keep the public off the actual drill pad, etc. The public has a right to access every square foot of state forest lands if they so wish. During drilling and other activity, DCNR limits access for safety reasons. This is usually done by the individual drilling company with their personnel according to DCNR's limitations. When drilling ceases the public is again allowed full unrestricted access. This includes active production pad sites and pipeline corridors. Compressor stations and metering sites are usually fenced off for safety in perpetuity, which consists of the site of the building and machinery. DCNR works to ensure that only a very small amount of forest that remains restricted by the fenced area is not a problem for the public.[130]

The Pennsylvania Game Commission often works with the drilling companies to determine individual setback requirements for the drill rigs on their property.[131]

With studies like those performed in West Virginia demonstrating pollutants reaching as far as 625 feet from the well site, potential exposure exists for those using Pennsylvania public lands.

Active and Abandoned Oil and Gas Infrastructure

Active drilling and hydraulic fracturing sites have many different hazards due to increased traffic in and out of the site and equipment handling explosive natural gas.

[130] Teddy Borawski, Department of Conservation & Natural Resources, personal correspondence, July 18, 2017.
[131] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

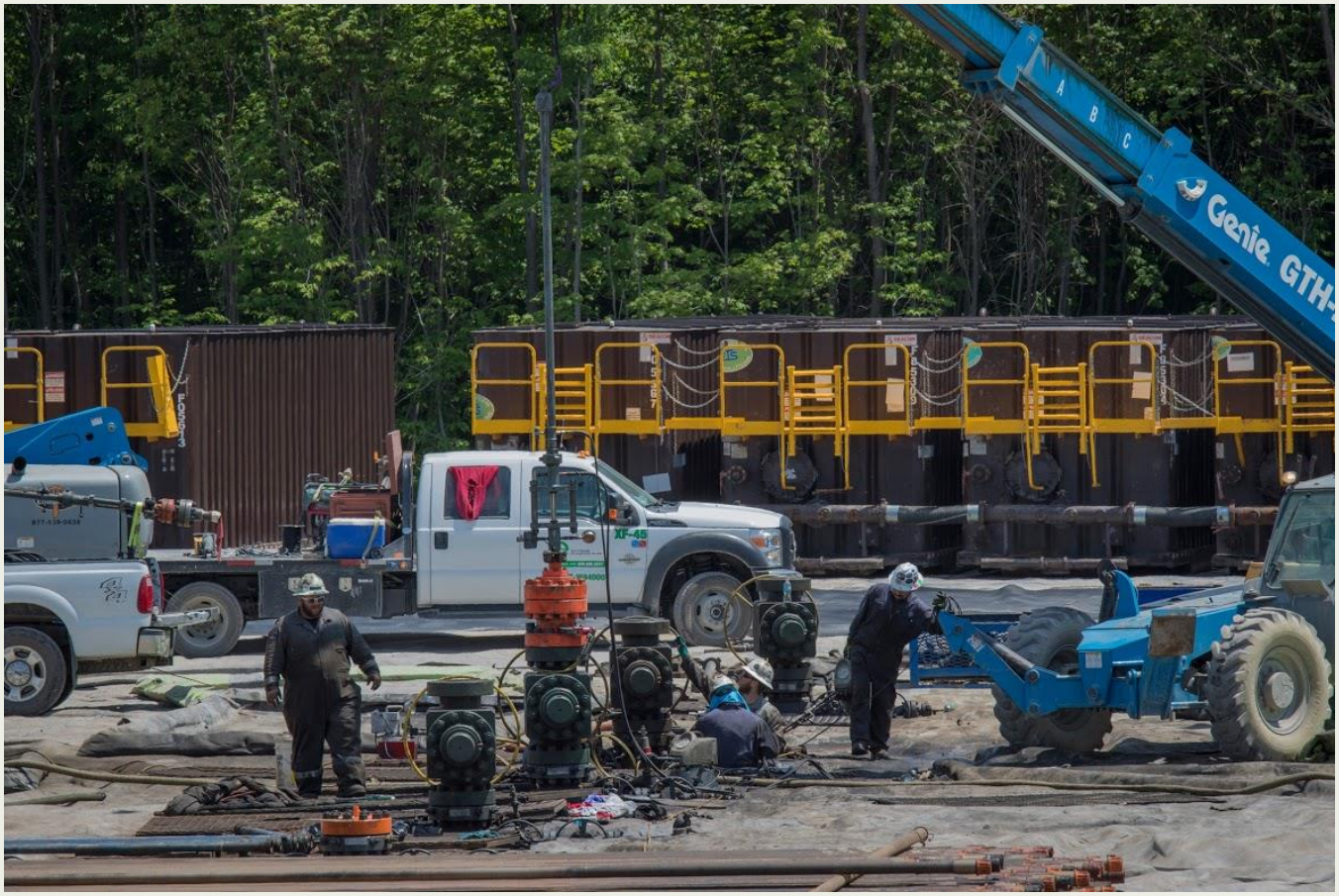


Photo by: Brook Lenker

Traffic increases significantly around wells and hydraulic fracturing operations. Producing oil and gas can require up to 4,000-6,000 vehicle trips to the site.[132] This increased traffic corresponds with increased vehicle accidents. In fact, one study determined that vehicle accidents were responsible for over a third of deaths involving oil and gas workers.[133] Increased diesel emissions from new heavy truck traffic can also degrade the air quality, contributing to health impacts mentioned above. A recent study found that "daily NOx emissions may increase by over 30% and hourly noise levels can double (+ 3.4 dBA)" on hydraulic fracturing operations.[134]

Although onsite fires and explosions are rare, they have occurred. Pennsylvania has experienced oil and gas production infrastructure failures that have resulted in pipeline explosions, gas storage explosions and compressor station blasts.[135] Abandoned wells present additional threats. The first oil well drilled in Pennsylvania was in 1859;

[132] Reid Frazier, "On Health Effects, Blame the Trucks, Not the Fracking?"
[133] Lisa Gardner, "Is Fracking Dangerous?" *Inside Energy*, September 18, 2017, http://insideenergy.org/2017/09/18/ie-questions-is-fracking-dangerous/.
[134] Paul S. Goodman et al., "Investigating the Traffic-Related Environmental Impacts of Hydraulic-Fracturing (Fracking) Operations," *Environmental International* 89-90, (April-May 2016): 249-260.
[135] Matt Kelso, "Oil and Gas Explosions Are Fairly Common," *FracTracker Alliance*, July 18, 2012, https://www.fractracker.org/2012/07/oil-and-gas-explosions-are-fairly-common/.

however, DEP did not start permitting wells until 1956.[136] "An unplugged abandoned well can be a hazard to the health and safety of people and cause pollution to the environment," according to the DEP. and "air, water and soil contamination can be attributed to leaking wells."[137]

Active or Abandoned Oil and Gas Infrastructure on PA Public Lands

Active fracking and drilling sites are busy and dangerous places. Hazards exist to untrained visitors. Most drilling companies mitigate this issue with fencing around the area, security, and other measures to keep unwanted visitors out. Although site hazards can be mitigated by fencing and securing the location, this becomes an issue when the property is owned by the public. Denied access to these public lands during oil and gas production has been observed in state parks and state forests. *StateImpact Pennsylvania* has reported incidents where the public has been denied access or followed by security while using public lands that are also being developed for oil and gas production.[138] The Game Commission addresses site hazards with fencing and signage. Their standard surface use agreement states: "Producer shall construct a fence around all potentially dangerous surface structures or equipment to prevent public access. The Commission shall have the discretion to order such fencing where protection of the public is deemed necessary. All equipment which is unguarded and unfenced shall be posted with hazard warning signs."



SGL 45, Photo by: Lane White

Increased vehicle traffic on public lands poses an increased likeliness for vehicle accidents. DCNR notes this in their most recent *Shale-Gas Monitoring Report*, stating, "The need for road access for shale-gas development has resulted in heavier traffic on state forest roads. Upgraded roads may be safer and easier to drive but may have lost some of their 'wild character' value."[139]

Although increased vehicle traffic is a negative impact, new roads can sometimes be viewed as a positive impact. New roadways can provide access to use for timber extraction activity, at no additional costs to the Commonwealth.[140]

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[136] Pennsylvania Department of Environmental Protection, *Abandoned and Orphan Oil and Gas Wells and the Well Plugging Program*, (Harrisburg: PA, Bureau of Oil and Gas Planning and Program Management, November 2014), http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-116427/8000-FS-DEP1670.pdf.
[137] Ibid.
[138] Marie Cusick, "On Public Land, A Gas Company Takes Private Control," *StateImpact Pennsylvania*, August 11, 2014, https://stateimpact.npr.org/pennsylvania/2014/08/11/on-public-land-a-gas-company-takes-private-control/.
[139] PA-DCNR, *Shale-Gas Monitoring Report*, April 2014.
[140] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, November 30, 2017.

As mentioned earlier, public lands are home to thousands of abandoned gas wells. These wells are one of the most significant environmental hazards on public lands because of their potential to turn into pathways for frack fluid or injected wastewater to reach the groundwater and drinking supply, as discussed in an earlier section.

Earthquakes

Pennsylvania experienced its first fracking-attributed earthquake in 2016.[141] The earthquake took place in Lawrence County, Pennsylvania, where the Hilcorp Energy Company was utilizing a "zipper" hydraulic fracturing technique in which two wells in close proximity were simultaneously fracked.[142] Just across the state line, in Mahoning County, Ohio, scientists linked 77 earthquakes to hydraulic fracturing in the region.[143]

Earthquakes have also been observed in Oklahoma, a state with very little natural seismic activity, and linked not only to the fracking process, but also to the use of wastewater injection wells. As of March 2017, Pennsylvania only had six active underground injection wells approved for oil and gas production wastewater.[144]

Earthquakes alone can change the soil, ground, and landscape of an area. The newly faulted earth also creates new pathways for injected wastewater or frack fluid to flow. These "geologic cracks or faults and past drilling activities can provide a pathway between shallow fracking sites and an aquifer, allowing fracking chemicals, oil, and methane to reach drinking water supplies."[145] There is little available data, however, linking specific oil and gas induced seismic incidents and groundwater contamination.

Earthquakes on Public Lands

Earthquakes caused by fracking or wastewater injection wells are a concern not unique to public lands. There are no Class II injection wells on state parks, state forests, or state game lands. Both DCNR and the Game Commission have been approached by developers, but nothing materialized. Additionally, the Game Commission requires seismic studies prior to drilling in their standard surface use agreements to minimize the risk of potential earthquakes. Seismic studies are not required for a DCNR lease agreement, however DCNR is not currently issuing surface use agreements, due to the current moratorium on new leases. However, if one is undertaken, DCNR does require a copy of the processed data be submitted to the department to be added to their seismic database.[146] Many drillers now voluntarily perform seismic studies prior to drilling operations. In fact, the acquisition of such detailed seismic data over large regions of state forestlands is viewed as a positive impact for DCNR.[147]

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[141] Reid Frazier, "Pennsylvania Confirms First Fracking-Related Earthquakes," *StateImpact Pennsylvania*, February 18, 2017, https://stateimpact.npr.org/pennsylvania/2017/02/18/pennsylvania-confirms-first-fracking-related-earthquakes/.
[142] Ibid.
[143] Robert Skoumal, Michael Brudzinski and Brian Currie, "Earthquakes Induced by Hydraulic Fracturing in Poland Township, Ohio," *Bulletin of the Seismological Society of America*, January 6, 2015, http://bssa.geoscienceworld.org/content/105/1/189.
[144] Marie Cusick, "Pennsylvania OKs New Injection Wells for Oil and Gas Wastewater," *StateImpact Pennsylvania*, March 27, 2017, https://stateimpact.npr.org/pennsylvania/2017/03/27/pennsylvania-oks-new-injection-wells-for-oil-and-gas-wastewater/.
[145] Jeff Johnson, "Shallow Fracking Wells May threaten Aquifers," *Scientific American*, August 6, 2015, https://www.scientificamerican.com/article/shallow-fracking-wells-may-threaten-aquifers/.
[146] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence November 27, 2017.
[147] Ibid, November 27, 2017.

PENNSYLVANIA STATE OIL AND GAS POLICY

Oil and gas policy in Pennsylvania is incredibly extensive. Below is a summary of Pennsylvania oil and gas legislation and regulations most relevant to oil and gas development on public lands.

Pennsylvania Oil and Gas Act

The Pennsylvania Oil and Gas Act was one of the state's first pieces of legislation to regulate the extraction of natural gas. The initial Oil and Gas Act was enacted in 1984 to provide regulatory control for operations of natural gas drillers in Pennsylvania. The original law underwent major reform in February of 2012 and became Chapter 32 (58 Pa.C.S Section 3201-3274). The February 2012 recodification also added regulations, through Act 13, regarding shale natural gas drilling operations that use hydraulic fracturing.[148]

Act 13

Act 13 (2012 Act 13 Oil and Gas, 58 PA.C.S. P.L. 87, No. 13 Cl. 58) was passed by the Pennsylvania Legislature in 2012 to specifically address the Commonwealth's booming new shale gas market. The Act sought to address some of the issues thwarting shale development, streamline the natural gas development process in the state, and add additional environmental protections specific to unconventional well exploration and operations. Major initial provisions included in Act 13 were: stripping local municipalities' zoning rights and mandating all municipalities allow for oil and gas exploration; imposing an impact fee on each well drilled that stays both locally and funds other statewide programs; giving power to the Pennsylvania Utility Commission (PUC) to review local municipality zoning laws and the ability to potentially withhold impact fees; requiring gas companies to disclose chemicals used in the hydraulic fracturing process; granting oil and gas storage companies the right to use eminent domain to seize property for natural gas storage; requiring DEP to disclose public water pollution related to oil and gas activity to those affected, but exempting DEP from reporting to private well owners; increasing fees against drillers who violate the law; setting new bond requirements for wells; and increasing the water pollution liability zone from 1,000 feet to 2,500 feet.[149]

Townships and citizens challenged many of Act 13's new provisions, particularly the removal of local zoning rights. Prior to the enactment of Act 13, local municipalities in Pennsylvania had control over local zoning ordinances. This made developing oil and gas (and other industries) challenging for the industry because local authorities had significant power over what businesses can and cannot operate. Act 13 stripped municipalities of this local zoning power and required that all municipalities follow statewide guidelines that allowed oil and gas operations. Only a few months after Act 13 was passed, townships and environmentalists challenged this provision of the Act and the

[148] Tad J. Macfarlan, R. Timothy Weston, and Craig P Wilson, "New Pennsylvania Oil and Gas Law Targets Unconventional Gas Operations for Heightened Regulatory Oversight," (Harrisburg, PA: K&L Gates Legal Insights, February 14, 2012), http://m.klgates.com/files/Publication/6a187fc5-6cb7-46cc-bd2f-7eaff2ac7d4a/Presentation/PublicationAttachment/0a3884fe-2abf-4079-9578-4d648f4cd02d/Alert_Regulatory%20Oversight_Weston_021312%20(2).pdf.

[149] "The Oil and Gas Law of the Land, Act 13," *StateImpact Pennsylvania*, https://stateimpact.npr.org/pennsylvania/tag/act-13/, accessed October 20, 2017.

Pennsylvania Supreme Court ruled they were indeed unconstitutional, ultimately restoring power back to the local municipalities.[150]

Although zoning power was restored back to the local level, it took several more years for the Supreme Court to withdraw the law that granted the PUC authority to review local ordinances and potentially withhold impact fees. This ruling came in 2016 when the Supreme Court ruled that using eminent domain for gas storage and withholding pollution information about private water wells was also unconstitutional.[151]

The law has changed considerably since first passed in 2012, but many pieces remain intact. The impact fee still requires oil and gas operators of unconventional gas wells to pay an impact fee for wells.[152] In 2016, over 173 million dollars were disbursed from the impact fee.[153] Additionally, the Unconventional Gas Well Fund and the Marcellus Legacy Fund were created by Act 13.[154] The purpose of these funds was to focus on remediating acid mine drainage, managing and plugging gas wells, creating and improving greenways, and fixing bridges.[155] Importantly, this fee can be revised depending upon the number of wells and for adjustments to a regional Consumer Price Index.[156] However, the impact fee remains controversial because the citizens most affected by the oil and gas development are displeased with having to share the impact fee with residents not immediately affected by oil and gas development. For example, from 2010 to 2012, Bradford County, PA experienced more unconventional wells drilled than anywhere else in the Commonwealth.[157] Locals of Bradford County encountered increased traffic, polluted water wells, an acid spill, and a gas well blowout; for all these issues, the PUC reimbursed Bradford County $8.4 million in impact fees in 2012 (for 2011, the first year fee was applied).[158] In contrast, Philadelphia County, which had no drilling, received approximately $1.3 million.[159]

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[150] Ibid.

[151] Susan Phillips, "PA Supreme Court Rules with Environmentalists Over Remaining Issues in Act 13," *StateImpact Pennsylvania*, September 28, 2016, https://stateimpact.npr.org/pennsylvania/2016/09/28/pa-supreme-court-rules-with-environmentalists-over-remaining-issues-in-act-13/.

[152] "Act 13 (Impact Fee),"Pennsylvania Public Utility Commission, http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_13_impact_fee_.aspx, July 2017.

[153] "Act 13 (Impact Fee),"Pennsylvania Public Utility Commission, https://www.act13-reporting.puc.pa.gov/Modules/PublicReporting/Overview.aspx.

[154] Pennsylvania Public Utility Commission, *Unconventional Gas Well Impact Fee: Annual Report of Fund Revenue and Disbursements*, (Harrisburg, PA: Sept. 30, 2016), http://www.puc.state.pa.us/NaturalGas/pdf/MarcellusShale/Gas_Well_PUC_Rpt_093016.pdf.

[155] Ibid.

[156] Ibid.

[157] "Oil and Gas Reports: Interactive Reports - Wells Drilled by County" *PA Department of Environmental Protection*, http://www.dep.pa.gov/DataandTools/Reports/Oil%20and%20Gas%20reports/Pages/default.aspx, accessed October 20, 2017. Calculations by the Institute.

[158] "Pennsylvania's Busiest Drilling County: Bradford," *StateImpact Pennsylvania*, https://stateimpact.npr.org/pennsylvania/tag/bradford-county/, accessed October 16, 2017.; PUC, Unconventional Gas Well Impact Fee: Annual Report.

[159] Pennsylvania Public Utility Commission, *Act 13 County/Local Government Impact Fee Disbursement* (Harrisburg: PA, 2012). http://www.puc.pa.gov/NaturalGas/pdf/MarcellusShale/Act13-County_Muncipality_Payments2011.pdf, accessed October 20, 2017. It should be noted that Philadelphia is located outside of the Marcellus Shale region. In addition,

The Pennsylvania Oil and Gas Conservation Law

The Pennsylvania Oil and Gas Conservation law (58 P. S. § § 401—419) (OGC Law) was passed by the Pennsylvania General Assembly in 1961. The OGC Law was passed with the stated legislative intent to:

> foster, encourage, and promote the development, production, and utilization of the natural oil and gas resources in this Commonwealth…in such manner as will encourage discovery, exploration, and development without waste; and to provide for the drilling, equipping, locating, spacing and operating of oil and gas wells so as to protect correlative rights and prevent waste of oil or gas or loss in the ultimate recovery thereof…and to protect fully the rights of royalty owners[160]

The OGC Law seeks to maximize extraction of oil and gas resources by guiding the minimization of waste through encouragement of efficient development. Additionally, the OGC Law was intended to protect the rights of property owners and limit development of wells, which penetrate deeper than 3,800 feet into the strata known as the Onongada Horizon.[161] The OGC Law, at the time it was enacted, sought to be comprehensive in nature, covering all drilling practices available to well operators at the time.[162] However, the OGC Law is not applicable to natural gas development of the Marcellus Shale because when the OGC Law was written, oil and gas extraction from shale formations was considered unproductive or not economically viable.[163]

Chapter 78 and 78a

The DEP's Office of Oil and Gas Management (OOGM) maintains Pennsylvania's oil and gas management program which provides guidance through various regulations, policies, and procedures.[164] The DEP is authorized as the agency to generate rules and regulations for oil and gas activities through the Oil and Gas Act.[165] The DEP is responsible for permits and inspection at all oil and gas well sites, pipelines, and compressor stations.[166] In 2016, 158 conventional well drilling permits and 1,321 unconventional well drilling permits were issued by DEP in Pennsylvania.[167]

Philadelphia is located within the Delaware River Basin Commission, which has had limited hydraulic fracturing while the Commission researches potential water quality impacts.

[160] Oil and Gas Conservation Law, 58 Pa.C.S. §§ 401-419 (1961).

[161] Jim Cawley, *Governor's Marcellus Shale Advisory Commission Report*, (Harrisburg, PA: Office of the Governor, July 22, 2011), http://files.dep.state.pa.us/PublicParticipation/MarcellusShaleAdvisoryCommission/MarcellusShaleAdvisoryPortalFiles/MSAC_Final_Report.pdf.

[162] Ibid.

[163] J.A. Harper, "Devonian Shale Gas: A Bonanza in the Backyard?" *Pennsylvania Geology* 11, no. 1 (1980): 2-7.

[164] Department of Environmental Protection, *Administrative Policy and Procedure Manual*. Office of Oil and Gas Management, May 31, 1992, Doc. Num. 550-2000-001. [Effective as of July 2017].

[165] Ibid.

[166] "2016 Oil and Gas Annual Report," Department of Environmental Protection, Office of Oil and Gas Management. (2016). Harrisburg, PA, http://www.depgis.state.pa.us/oilgasannualreport/index.html.

[167] Ibid.

Chapter 78 and Chapter 78a were developed to regulate oil and gas drilling practices by setting up rules that well operators must follow. Chapter 78 focuses on conventional wells while 78a regulates unconventional wells. The law however remains unsettled because, in 2016, in order to maintain regulations of unconventional wells, Governor Tom Wolf signed a bill that eliminated some regulations of conventional wells found in Chapter 78.[168] The DEP is currently undergoing rulemaking specific to conventional wells. Chapter 78a remains the law for unconventional wells, although it is also being challenged by industry groups.[169] The most significant piece of Chapter 78a, as it affects energy development on public land, is the element that DEP has been granted, by Pennsylvania courts, the authority to consider public resources, like state parks and forests, in well permit applications.[170]

[168] Susan Phillips, "Gov. Wolf Signs Bill that Rejects Conventional Drilling Regulations," *StateImpact Pennsylvania*, June 23, 2016, https://stateimpact.npr.org/pennsylvania/2016/06/23/gov-wolf-signs-new-oil-and-gas-drilling-rules/.
[169] "Chapter 78: controversial new drilling rules," *StateImpact Pennsylvania*, https://stateimpact.npr.org/pennsylvania/tag/chapter-78/page/2/.
[170] Marie Cusick, "After Bitter Fight, New Marcellus Shale Regulations Set to Take Effect," *StateImpact Pennsylvania*, October 6, 2016, https://stateimpact.npr.org/pennsylvania/2016/10/06/after-bitter-fight-new-marcellus-shale-regulations-set-to-take-effect/.

OIL AND GAS DEVELOPMENT ON DCNR LAND



DCNR Oil and Gas Policy

As of 2014, an estimated 15 percent of all gas produced in Pennsylvania came from state forest land.[171] The state forest and park system has played a critical role in oil and gas development in the Commonwealth ever since the state issued its first oil and gas lease on state forest land in 1947. Eight years later, in 1955, the state passed Act 256 and established the "Oil and Gas Lease Fund." Act 256 requires that rents and royalties from oil and gas leases on Commonwealth land be placed into a special fund to be used for conservation, recreation, dams, and flood control.[172] It also authorized the Secretary of Forests and Waters (DCNR as of 1995) to determine the need for and location of such projects and to acquire the necessary land.[173] The decisions made by Pennsylvania leaders to allow, or deny, energy development on state lands has been a topic of interest. For years, Pennsylvania state forests and parks were leased and profits generated from those lease agreements (and subsequent energy development) were placed into the Oil and Gas Lease Fund (OGLF).

The agency leased the most acreage in the 1980s as developers sought natural gas reservoirs from the shallow, Upper Devonian Gas play. From 1984 to the early 2000s, nearly one million acres of the agency's 2.2 million acres were under lease.[174]

The energy industry changed dramatically in 2008 when access to natural gas from the Marcellus Shale became both economically and technologically feasible through multi-stage hydraulic fracturing and horizontal well drilling technology. Leasing of DCNR owned land proved to be incredibly lucrative and critical to DCNR's operation. In fact, in 2008, the agency leased approximately 74,000 acres for a record payment of $168 million.[175] In 2010, leases brought in another $120 million in bonus payments. Marcellus bonus payments generated more revenue than all of the OGLF payments since inception (1947) combined.[176]

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[171] PA-DCNR, Shale-Gas Monitoring Report.
[172] Establishing the Oil and Gas Lease Fund Act of Dec. 15, 1955, P.L. 865, No. 256, http://www.legis.state.pa.us/WU01/LI/LI/US/PDF/1955/0/0256..PDF.
[173] Ibid.
[174] PA-DCNR, *2016 State Forest Resource Management Plan.*
[175] Ibid.
[176] PA-DCNR, *2016 State Forest Resource Management Plan*.

Things changed in 2010, when then Pennsylvania Governor Ed Rendell issued a state moratorium on the additional leasing of state forest land. The executive order clearly stated, "no lands owned and managed by DCNR shall be leased for oil and gas development."[177] Wells, however, continued to be permitted and drilled on state owned land that had previously been leased. In fact, in 2011 alone, DEP permitted 315 new wells, the most in the state's history.[178]

Governor Rendell and the Pennsylvania legislature also passed a bill that allowed funds from oil and gas operations to be used toward budget deficits unrelated to DCNR's mission or work. Beginning in 2009, the Pennsylvania General Assembly transferred money from the Oil and Gas Lease Fund to help balance state budgets, including proceeds from three Marcellus Shale lease sales between 2008 and 2010 that raised $413 million for the state.[179]

In February 2012, Pennsylvania legislators passed Act 13, as discussed previously, significantly revising the state's oil and natural gas law. Act 13 placed an "impact fee" on gas extracted in Pennsylvania. The fee is determined by the market prices of natural gas and changes with the market. The Act also significantly affected the Oil and Gas Fund by "authoriz[ing] the annual transfer of millions of dollars from the [OGLF] to Environmental Stewardship Fund and Hazardous Sites Cleanup Fund," according to *StateImpact*.[180]

In 2014, Governor Tom Corbett reversed the moratorium with an executive order that permitted state forests to be developed for oil and gas, so long as there were no additional long-term surface disturbances. The executive order allowed for horizontal drilling from neighboring private property onto state owned lands, but limited well pads, roads, and pipelines on newly leased state owned land.[181]

In 2015, Governor Tom Wolf, reinstated the moratorium banning new leases on state forest and state park land.[182] The moratorium however only banned new leases, not new drilling activities. Much like the 2010 moratorium, it had no effect on the production from wells that were already generating oil or gas, or the permitting of new wells on previously leased state land.

In 2017, the Pennsylvania Supreme Court ruled that oil and gas lease royalties must be utilized for conservation purposes only, and not for general fund spending. The Supreme Court ruled that money received from drilling in

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[177] Executive Order, 2010-05 Commonwealth of Pennsylvania Governor's Office, October 26, 2010.
[178] PA-DCNR, *Natural Gas Development and State Forests Shale Gas Leasing Statistical Summary*.
[179] Don Hopy and Laura Legere, "Pa. Supreme Court Rules State Forest Gas Royalty Transfers Unconstitutional," *Pittsburgh Post-Gazette*, June 20, 2017, http://powersource.post-gazette.com/powersource/policy-powersource/2017/06/20/Pa-Supreme-Court-rules-state-forest-gas-royalty-transfers-unconstitutional-budget-General-Assembly-oil/stories/201706200117.
[180] "The Oil and Gas Law of the Land: Act 13," *StateImpact Pennsylvania.*
[181] PA-DCNR, "Gov. Corbett Issues Executive Order Protecting State Forests, Parks from Gas Leasing That Involves Surface Disturbance," May 28, 2014, http://www.apps.dcnr.state.pa.us/news/resource/res2014/14-0528-execorder.aspx.
[182] Executive Order, 2015-03 - Leasing of State Forest and State Park Land for Oil and Gas Development, https://www.governor.pa.gov/executive_orders/executive-order-2015-03-leasing-of-state-forest-and-state-park-land-for-oil-and-gas-development/.

state forests must again be appropriated to the state Department of Conservation and Natural Resources through the Oil and Gas Lease Fund, as it had been for more than 50 years prior to the Marcellus Shale boom.[183]

Development Procedures and Processes

DCNR recognizes that "oil and gas development is a highly industrialized activity which starkly contrasts with the expectations and experiences of state forest users."[184] The DCNR's "Bureau of Forestry Gas Management Team facilitates the management of gas exploration, development, production and transportation across state forest land."[185] "The Bureau uses the general approach of avoidance, minimization, mitigation, and monitoring to manage any undesirable effects of natural gas development for state forest users."[186] Some land is avoided completely; the agency prohibits surface development on 60 designated state forest natural areas and 18 state forest wild areas as well as all state parks where they own the subsurface rights.[187] If avoidance is not feasible, impacts are minimized through setback requirements from important features, such as wetlands, campsites, trails, streams and other measures. Mitigation of any impacts incurred refers to the reclamation and restoration of the land back to its original functioning ecosystem prior to energy development activities. Lastly, the Bureau of Forestry monitors oil and gas activities through a designated monitoring program. The monitoring team is tasked with collecting, analyzing, and reporting oil and gas related data through the production of the *Shale-Gas Monitoring Report.*

It is important to note that DCNR performs monitoring in addition to the monitoring performed by the state Department of Environmental Protection (DEP).[188] Bureau of Forestry has a dedicated Gas Monitoring Program staffed by 15 specialists to monitor water, plants, animals and human responses to gas activity in the forest. This has been in place since 2010. Bureau staff members conduct weekly inspections during active construction, unless problems or weather conditions dictate otherwise. When feasible, the Bureau attempts to conduct and coordinate field inspection activities with DEP District Oil & Gas Operations. It is from these inspections that violations and potential issues are identified and addressed.[189] According to the most recent *Shale Gas Monitoring Report*, "From July 1, 2009, when incidents specific to oil and gas began to be tracked, through December 31, 2012, 264 incidents in 50 different categories were reported through the Bureau of Forestry Incident Reporting System across all state forest districts directly related to gas development activity."[190]

DCNR has also partnered with the Susquehanna River Basin Commission and installed remote and continuous monitoring sensors in state forests located in the shale gas development areas.[191] These monitoring systems are unique because they provide real time data that can be used to detect water pollution and can assist in more timely

[183] Don Hopy and Laura Legere, "Pa. Supreme Court Rules State Forest Gas Royalty Transfers Unconstitutional."
[184] Pennsylvania Department of Conservation and Natural Resources, *Guidelines for Administering Oil and Gas Activity on State Forest Land, Fourth Ed*. Bureau of Forestry, 2016, http://dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20032134.pdf.
[185] PA-DCNR, *Guidelines for Administering Oil and Gas Activity on State Forest Land.*
[186] Ibid.
[187] Ibid.
[188] PA-DCNR, *Shale-Gas Monitoring Report*.
[189] Ibid.
[190] Ibid.
[191] PA-DCNR, *Shale-Gas Monitoring Report*, Part 2 Monitoring Values Water.

responses to contamination. The monitoring system has been designed specifically to "help verify whether or not natural gas well activity is causing negative impacts on local water quality conditions."[192]

Management

DCNR has recognized the potential for adverse impacts on their lands. They have established a set of best management practices for managing oil and gas activity on state forest lands through the specific development of the "Guidelines for Administering Oil and Gas Activity on State Forest Lands," document. In addition to the guidelines document, DCNR also published the *Shale-Gas Monitoring Report*, in April 2014. The document outlines the agency's strategies, efforts, and data regarding shale gas development on their land. An updated report is expected out in 2018. Additionally, the DCNR website offers a wide variety of oil and gas related information such as maps, data, educational materials, and records accessible to the public. The following section is a summary of key development procedures, management strategies, and monitoring efforts obtained from that report.

Wells in State Parks and State Forests

Prior to the Marcellus Shale boom in 2008, DCNR conducted 74 oil and gas lease sales that accounted for approximately 2,000 wells on state forest and park land.[193] DCNR has approved 1,026 shale gas wells on state lands since 2008, however, only 483 wells of those have been drilled, completed and are currently producing.[194] In addition to oil/gas production, DCNR has about 68,000 acres currently under gas storage lease, which does not allow drilling for any zone other than the storage horizon.[195]

As of December 2017, there was not a single drilling rig on state forest, however, DCNR expected to have three new drill rigs on state forest lands in mid-2018.[196]

The Institute for Energy worked with FracTracker Alliance to analyze DEP gas well data and develop both interactive and static maps of active well locations on state forests and parks. PA DEP spud report data was used to examine the total amount of wells in the entire state. The earliest available data (noted as 1/1/1800 in DEP records) through December 6, 2017 was included. All counties, regions, municipalities, and operators were included as well as both conventional and unconventional wells in the initial query. We excluded all sites that did not have corresponding latitude/longitude coordinates. This data was imported into ArcGIS as a layer and then clipped to the DCNR property data layer. From this, results were filtered by well status to quantify active conventional wells and active unconventional wells. It was determined that DCNR has 1,515 active conventional wells and 626 active unconventional wells, totaling 2,141 total active wells on state forests and parks. The definition of an "active" well, given by PA DEP, is a when a "permit has been issued and [the] well may or may not have been drilled or producing,

[192] Susquehanna River Basin Commission, *Remote Water Quality Monitoring Network: Information Sheet*, January 2014, 1-4, http://mdw.srbc.net/remotewaterquality/assets/downloads/pdf/RWQMN_InfoSheet013014.pdf.
[193] PA-DCNR, *Shale-Gas Monitoring Report*, Part 2 Monitoring Values Water.
[194] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, August 2017.
[195] Ibid.
[196] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, August 2017.

but has not been plugged."[197] Regulatory inactive wells were not included on this map. Regulatory inactive wells are defined as:

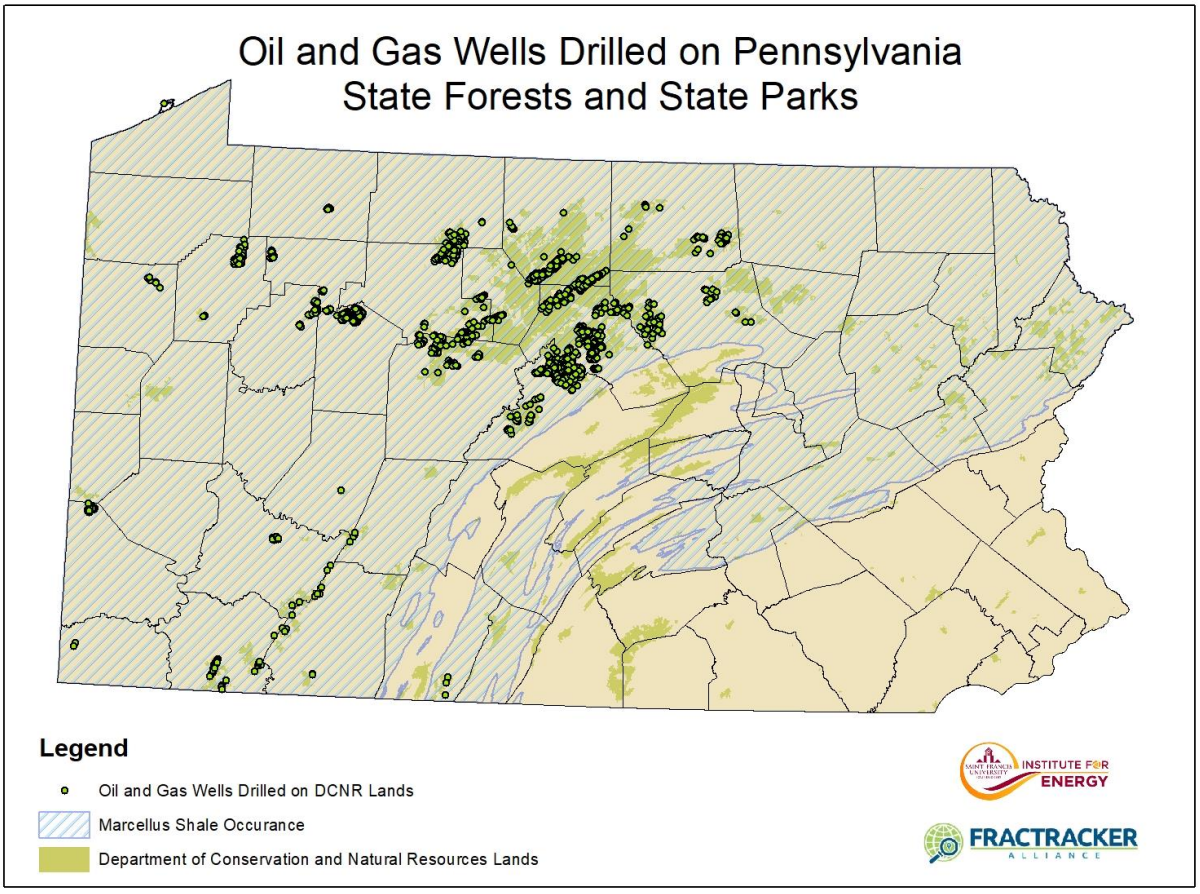
(A) Significant reserves remain in place and the operator plans to produce the well.

(B) The well will be used as a disposal well.

(C) The well will be used as a storage well.

(D) The well will be used as an observation well.

(E) The well will be used as a secondary or tertiary recovery injection well or that the well will be used for other purposes specified by the applicant.[198]



[197] Pennsylvania Department of Environmental Protection, Oil and Gas Reports Data Dictionary, Version 1.1, (Office of Oil and Gas Management Division of Compliance and Data Administration, March 22, 2017), http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/HelpDocs/SSRS_Report_Data_Dictionary/DEP_Oil_and_GAS_Reports_Data_Dictionary.pdf.

[198] § 78.102. Criteria for approval of inactive status.

According to the December 2017 DEP data used to make the map above, the Sproul State Forest has the most active gas wells of any DCNR managed property.

According to DCNR, the Sproul State Forest has the most acreage leased for both gas development and gas storage where DCNR owns the mineral rights. The Susquehannock State Forest has the most acreage leased where DCNR does not own the subsurface rights.[199]

It is important to note that many of the natural gas wells drilled on state land are attributed to the mineral ownership of that land. In some instances, the state owns only surface rights and not the mineral rights to their property. In fact, the state only owns roughly 15 percent of the mineral rights under state parks, and roughly 85 percent of the mineral rights in state forests.[200]

[199] PA-DCNR, *Shale Gas Monitoring Report*, 15.
[200] PA-DCNR, *2016 State Forest Resource Management Plan*.

Oil and Gas Development on State Game Lands

PGC Policy

Like DCNR, the Game Commission has determined that, in some instances, development of oil and gas on state game lands aligns with their purpose and mission. They are also subject to severed mineral ownership rights and often lack the legal authority to discourage oil and gas development on state game lands. The Pennsylvania Game Commission is an independent agency and is not included under Act 256, therefore they do not receive funds from the Oil and Gas Lease Fund like DCNR does. Revenues generated from oil and gas activities stay within the agency. The PGC leasing practice began in the 1930s.[201]



SGL 45, Photo by: Lane White

Development Procedures and Processes

Oil and gas developers wishing to develop on state game lands start the process by contacting the Game Commission's Bureau of Land Management, Division of Environmental Planning & Habitat Management. Prior to initiation of any formal bidding process, the Game Commission assesses the project using a "Natural Resource Recovery Questionnaire" (NRRQ). The questionnaire is a PGC internal document intended to identify potential impacts to the state game land from the proposed resource recovery. The NRRQ is sent to the regional office staff and to all the division chiefs in Harrisburg for input and comment on the proposed project. If the NRRQ shows little to no impact to the PGC mission, the project can proceed to a surface or non-surface use agreement (lease).

When an energy development company is going to operate on state game lands, the Commission and the company will work together to avoid, minimize, and/or mitigate for impacts. An NRRQ may not be required to be completed in instances where there will be no surface use of the game lands.[202]

Management

In the PGC's standard oil and gas agreement, the agency typically requires pre and post drilling water supply sampling and holds the drilling companies accountable for any pollution incurred. [203] The Commission also requires environmental impacts analysis and seismic studies as part of their Surface Use and Non-Surface Use Agreements. PGC staff also perform periodic environmental testing related to oil and gas development. All of the PGC's gas records are available to the public through the Right to Know Law and through the agency's office of open records; however, no specific reports or easily accessible data is available for public review on the agency's website. There are no internal or external reports or research regarding the environmental impacts (if any) from drilling operations on state game lands. Any environmental violations incurred on state game lands are handled by the Pennsylvania

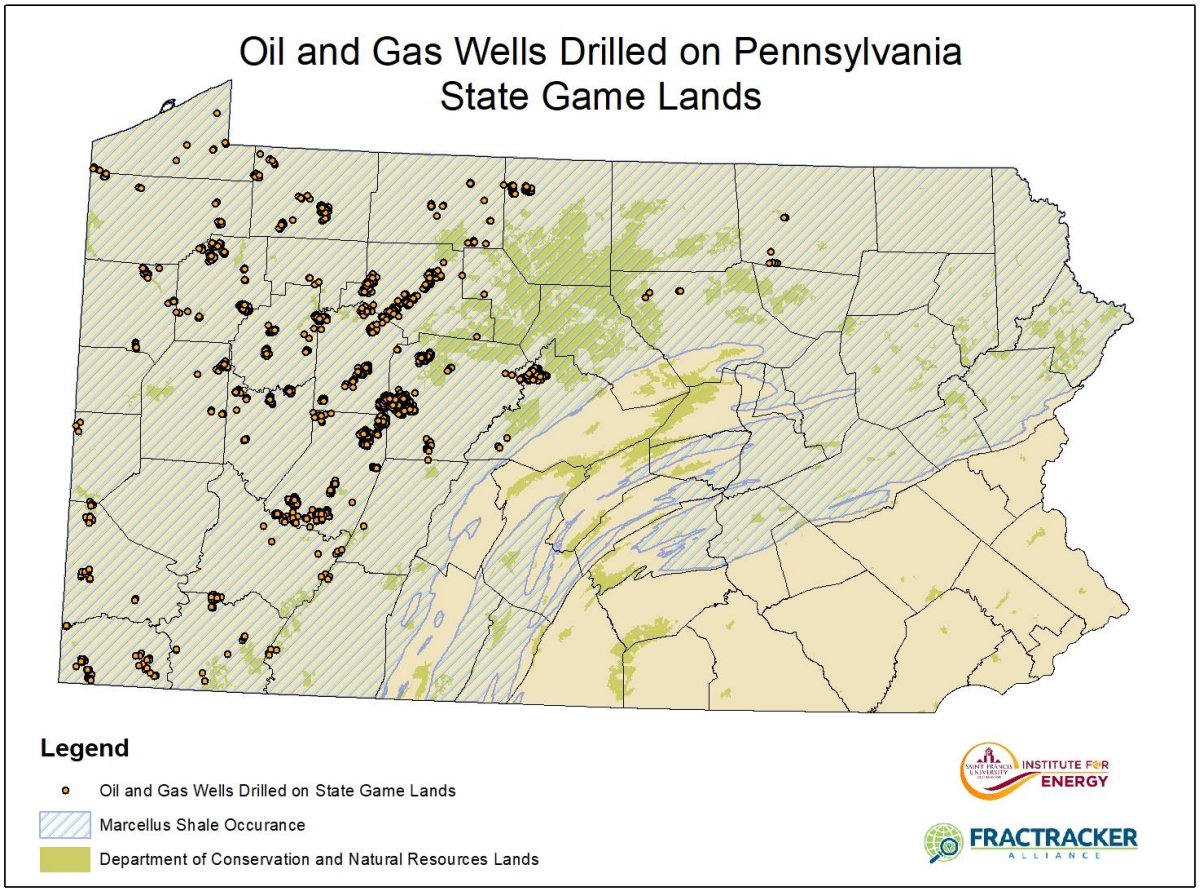
[201] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, November 20, 2017
[202]Michael DiMatteo, Pennsylvania Game Commission, e-mail correspondence, March 3, 2017.
[203] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

Department of Environmental Protection (DEP) and those details are also available for public review through the Right to Know Law. [204]

Wells on State Game Lands

Approximately 89,000 of the 1.5 million acres of state game lands are under oil and gas leases.[205] As of December 2017, DEP records indicated that there were 2,788 active conventional wells and 182 active unconventional wells on state game lands.

The map below was also created using DEP well spud data from December 2017 using the same process described above for quantifying active wells on DCNR managed lands.



[204] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, November 16, 2017.

[205] Tory N. Parrish, "Pennsylvania Game Commission Reaps Revenue from Shale Gas Under Game Lands," *TribLive*, November 29, 2015, http://triblive.com/business/headlines/9504996-74/game-commission-gas.

As of August 2017, there were five state game lands with active drilling and/or hydraulic fracturing: State Game Lands number 25, 12, 36, 223, and 117.[206]

Oil and gas development on state game lands can be attributed to various different circumstances. In some cases, the Game Commission acquired land with existing oil and gas infrastructure. In other instances, the Game Commission does not own the mineral rights and therefore has little say in oil and gas development. In some occurrences, gas is being extracted from the state game land via a horizontal well from an adjacent private landowner. In this case, there are minimal surface disturbances on the PGC property and the developer and the PGC enter into a subsurface cooperative agreement and not a full lease of the land. Lastly, there are situations where the Game Commission determines that the compensation for drilling positively outweighs the surface disturbances caused by oil and gas development.

[206] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, August 21, 2017.



COAL MINING

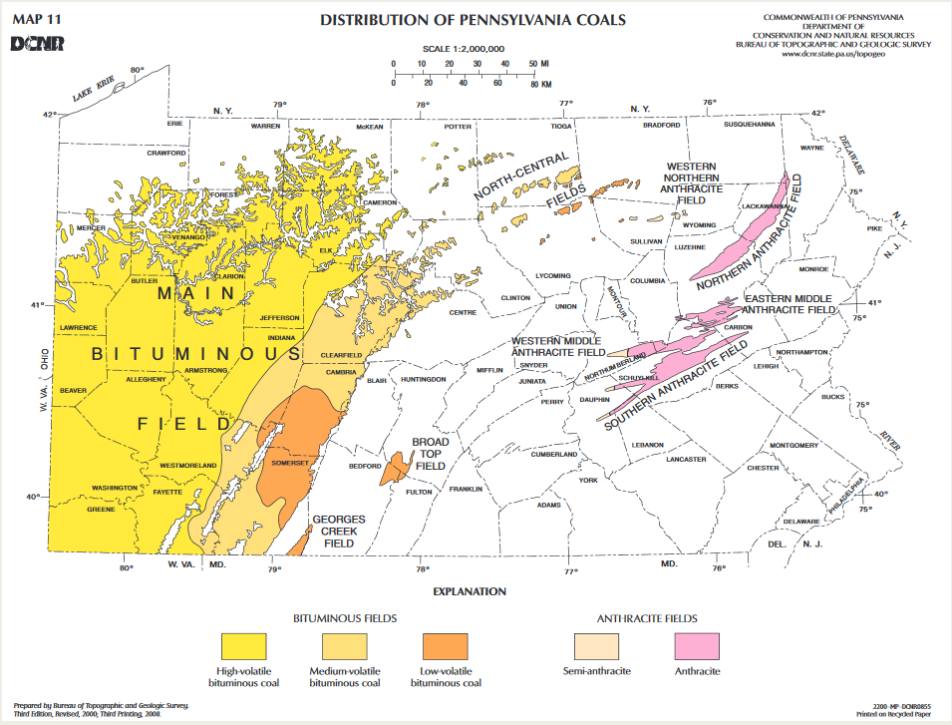
BACKGROUND

In addition to Pennsylvania's abundant oil and gas resources, the state also has plentiful coal assets. Mining operations are deeply rooted in Pennsylvania's energy history- with the Fort Pitt mine (near what is now downtown Pittsburgh) constructed in 1761.[207]

The coal industry has played a significant role in the industrialization of the nation, fueling trains and ships, producing electricity, heating homes, and manufacturing steel commodities. Like oil and gas, the industry has seen periods of boom and bust. The Pennsylvania coal industry was at its peak in 1918 during the First World War, producing an astounding 277,000,000 tons of coal.[208] The industry slowed dramatically after the war and during the Great Depression of the 1930s.[209] Although it picked up again during World War II, it declined steadily when the war ended. By the 1960s, production was still low and stagnant as Pennsylvania coal was forced to compete with other fossil resources such as oil, gas, and with other coal supplies in Appalachia as well as in western states. Coal mining in Pennsylvania continued to decline in the early nineties when a combination of low demand, depleted resources, and unfavorable regulations negatively affected the industry.[210] As electricity demand slowly grew in the late nineties and early two thousands, so too did coal production. [211] Today, Pennsylvania is the fifth-largest coal-producing state in the nation, producing approximately 45,387,322 metric tons of coal as of 2015.[212]

[207] Edmunds, *Coal in Pennsylvania*.
[208] Ibid.
[209] ibid.
[210] Ibid.
[211] Ibid.
[212] "Rankings: Coal Production, 2015," *U.S. Energy Information Administration*, https://www.eia.gov/state/rankings/?sid=US#/series/48, accessed October 11, 2017. Value calculated by converting short tons to metric tons.

The value and quality of coal is determined by its carbon content. Like the oil and gas rich rocks in Pennsylvania, coal too is formed from decaying organic material yielding an energy rich hydrocarbon material. The highest quality of coal is called anthracite and it is mined in the eastern part of the state. Bituminous coal, a lower quality and lower carbon content coal, is abundant in western Pennsylvania. As of 2016, Pennsylvania was the only state producing anthracite coal.[213]



Pennsylvania Coal Resources, DCNR

Coal is extracted from the earth by methods of either underground or surface mining. In Pennsylvania, the majority of coal is extracted through underground mining techniques.[214] The extraction methods are typically determined by size and depth of the individual coal seam being mined. There are two underground mining methods most commonly used in Pennsylvania today: Room-and-Pillar and Longwall. Both of these underground mining techniques utilize heavy equipment and machinery to access and remove coal from deep beneath the surface.[215] The difference between the two is simply in the mining techniques and how the supporting ground is left in place. Removal of underground materials to the surface leaves a void in the ground, which can cause subsidence. Subsidence is defined as the "gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials" and discussed in further detail in the Environmental Impacts section of this research.[216] Surface mining techniques used in Pennsylvania today include strip mining and highwall mining. Strip mining is a method used "to extract the coal using open cut (also referred to as open cast or open pit) mining methods."[217] Highwall mining is when "an outcrop of coal is removed by traditional excavators, or by using auger mining (drilling directly into the coal) to remove the coal seam, leaving the surrounding rock layers intact."[218]

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[213] "Pennsylvania: State Profile and Energy Estimates - Profile Overview," *U.S. Energy Information Administration*, https://www.eia.gov/state/?sid=PA, accessed October 11, 2017.
[214] Pennsylvania Department of Environmental Protection, "Coal Mining History in Pennsylvania, PA Mining History," http://www.dep.pa.gov/Business/Land/Mining/Pages/PA-Mining-History.aspx, accessed December 7, 2017.
[215] Colorado School of Mines, Energy and Minerals Field Institute, *Coal Mining Methods*, (Golden, CO: 2011) http://emfi.mines.edu/emfi2011/Coal%20Mining%20Methods%20-%20EMFI%20Summary.pdf, accessed October 11, 2017.
[216] USGS, "Land Subsidence," https://water.usgs.gov/ogw/subsidence.html.
[217] Colorado School of Mines, *Coal Mining Methods*.
[218] Pennsylvania Department of Environmental Protection, "Surface Mining," http://www.dep.pa.gov/Business/Land/Mining/Pages/Surface-Coal-Mining.aspx, November 29, 2017.

Coal is also sometimes mined through mountaintop removal, another "form of surface mining that involves scraping off the topmost portion of a mountain to expose the underlying coal."[219]

In the early years of coal extraction, unwanted waste products from coal mining and coal that was deemed unmarketable, accumulated in piles near active coal mines. This "waste coal," (also referred to as culm, boney piles, and gob) are common in Pennsylvania coal country and have significant impacts on the land and environment where they are located. Today, many of these waste coal piles are being reclaimed by power generation companies that have the technology to effectively burn the coal to generate electricity.[220] Electricity production from such materials is even considered a 'Tier II' alternative energy source and assists in helping Pennsylvania reach its alternative energy generation mandate.[221] Details of the Alternative Energy Portfolio Standards are discussed in further detail in the "Wind Energy Policy" section of this report.

Environmental Impacts

The state of Pennsylvania has recognized serious environmental impacts from coal mining. Such major environmental issues include land subsidence, habitat fragmentation, water pollution, and underground coal mine fires. With over 200 years of mining history in Pennsylvania, improvements to the environment through land reclamation and waste coal utilization can be viewed as positive environmental impacts. Additionally, abandoned mines now provide important habitats for some critical species of bats. These environmental impacts and how they might be unique to public lands are discussed below.

Subsidence

One of the most significant environmental hazards associated with underground mining is the issue of subsidence. Subsidence, as mentioned previously, is the gradual caving in or sinking of the ground surface commonly caused by underground mining. Such sinking can significantly impact the landscape and ecosystems it displaces. Some specific impacts of subsidence on ecosystems include: a general slumping of the land, changes in groundwater flow, the drying up of springs, and the sudden appearance of springs or wetlands elsewhere.[222] Such changes in water quality and quantity have a resulting effect on plant growth, stream quality, and riparian species and their habitats.[223] The effects of subsidence on ecosystems and water quality are discussed in further detail in the following two sections.

As a result of the detrimental effects of underground coal mining on the environment in Pennsylvania, many regulations are now in place to ensure environmental quality. Subsidence is addressed specifically under the Bituminous Mine Subsidence and Land Conservation Act. This act requires PA DEP to collect and report on water quality and land movement from every underground bituminous mining permit issued in the state. It also requires all

[219] Ibid.
[220] "Coal Refuse Piles," *Abandoned Mine Reclamation Clearinghouse,* http://www.amrclearinghouse.org/Sub/landreclamation/coal-refuse-piles.htm, accessed October 11, 2017.
[221] "About AEPS," PA-PUC.
[222] Jan W.Briede and David A.Dixon, *The Potential Effects of Longwall Mining and Associated Activities on the Ecology of Southwestern Pennsylvania*, (Cincinnati, OH: Dames & Moore), https://act54.files.wordpress.com/2011/09/1-of-2.pdf.
[223] Ibid.

new mining operations to demonstrate minimal subsidence impacts prior to issuing a permit and holds mine operators responsible for any damage to property or water quality associated with mining operations.[224]

Subsidence on Public Lands



Sign for Duke Lake, Ryerson Station State Park, December 2017, Photo by: Michael Sell

Subsidence caused by underground mining on public lands is of great concern, primarily because it has been an observed and documented issue on PA public lands. An example of subsidence occurring as a result of coal mining activity on public land can be witnessed at Ryerson Station State Park, in Greene County, Pennsylvania. Ryerson Station Dam was constructed in 1960. Construction of the dam created a 62-acre body of water (Duke Lake) intended for recreational use.[225] The Ryerson Station Dam was breached in 2005 after being damaged considerably by underground longwall coal mining operations, resulting in the complete disappearance of Duke Lake.[226] The disappearance of the lake significantly changed the landscape, ecosystems, and recreation opportunities it provided.

[224] Pennsylvania Department of Environmental Protection, *A Guide to Water Supply Replacement and Subsidence Damage Repair*, (Coal Center, PA: California District Mining Office, October 2016), http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-115234/5600-BK-DEP4054.pdf.
[225] Pennsylvania Department of Environmental Protection, *Ryerson Station State Park Ryerson Station Dam Damage, Claim Number SA1736, Interim Report*, California District Office, February 16, 2010, http://files.dep.state.pa.us/Mining/District%20Mining/DistrictMinePortalFiles/California/Ryerson_Station_Dam_Damage_Claim_Report_revised_2-12.pdf.
[226] Ibid.



Remains of Duke Lake Dam, Ryerson Station State Park, Photo by: Michael Sell

Habitat Fragmentation

The development of any energy type displaces habitats and ecosystems. Surface and underground coal mining can drastically change the landscape of the mined and surrounding areas. Introduction of "mining waste dumps, high shaft towers, large scale surface scarring from surface mining or land subsidence from underground mining," all significantly contribute to impacts on the landscape.[227]

Surface mining operations involve the removal of trees and vegetation to support mining activities. Often vegetation is removed through blasting and excavation and placed into valleys, further disrupting the ecosystem. Sometimes the removed soil and vegetation end up in streams and changes the chemistry of riparian habitats. Access roads are also constructed and traffic increases, similarly to oil and gas development. Specifically, the U.S. Fish and Wildlife Service notes the following impacts on habitats specific to coal mining operations:

> Some forest dwelling migratory birds (e.g., Cerulean warblers), migratory tree bats and other animals may be disturbed or even killed during forest clearing activities. Wildlife may also be displaced from the area due to habitat fragmentation and human activities. Aquatic species and animals that live near streams may be harmed or killed when material is placed in streams. Changes in water quality and quantity may result in changes in the number and types of species living in and around the stream. Invertebrates and salamanders are especially sensitive to changes in water flow and chemistry. Current research indicates that it is very difficult to fully restore a stream after completing mining activities. The inability to completely restore streams after placing fill material can result in permanent loss of stream function and value.[228]

In Pennsylvania, PA DEP's most recent report on underground bituminous coal mining and subsidence, notes that, "96 miles of stream were undermined [in Pennsylvania]. Of these stream miles, 39 miles belong to streams that

[227] Zhengfu Bian, "Environmental Issues from Coal Mining and Their Solutions," *Mining Science and Technology* 20, (2010): 218.

[228] "Coal Mining," *U.S. Fish and Wildlife Service, Ecological Services,* November, 15 2017, https://www.fws.gov/ecological-services/energy-development/coal.html.

experienced mining-induced flow loss or pooling."[229] Most negative effects resulting from flow loss or pooling were realized on mayfly taxa, although the study states there was limited biology data indicating "that both mining-induced-flow loss and pooling constitute adverse effects to the macroinvertebrate community."[230] The study also cites habitat impacts such as "declines in water quality, including increases in conductivity and pH, also accompany mining-induced flow loss impacts."

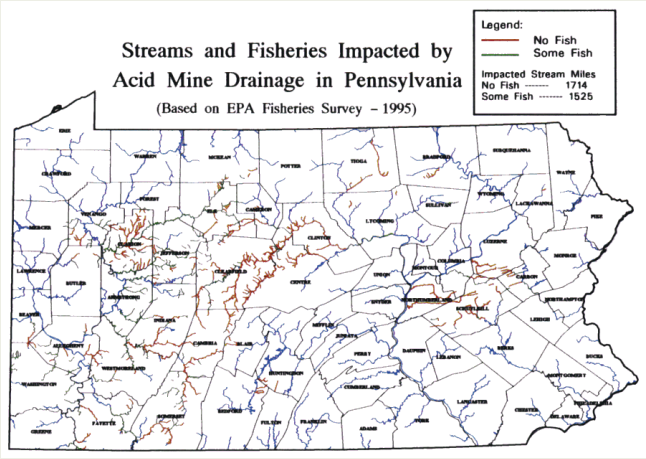
DEP's most recent report also addresses wetland habitats influenced by underground bituminous coal mining. According to the report, "wetlands acreage actually showed a slight net increase following undermining at three longwall mines. However, the increases result from a substantial loss of original wetland acreage and creation of new wetland acreage. The original and new wetland acreage often differ functionally and thus the newly emerging and created wetlands do not entirely replace lost wetland functions."[231]

Habitat Fragmentation on Public Lands

Coal mining does still exist on both DCNR and state game lands. State forests and parks, however, have not been leased for virgin coal mining operations in over 20 years. Active mining only exists on DCNR property where the state does not own the mineral rights. The Game Commission does, still enter into, surface and non-surface use agreements for coal extraction. State game lands are also mined in circumstances where the PGC does not own the mineral rights. Like oil and gas development on public lands, the issue of habitat fragmentation arises primarily in the purpose of these lands. Generally restricted, Pennsylvania public lands are intended to "manage Pennsylvania's wild birds, wild mammals, and their habitats for current and future generations"[232] (PGC mission) and to "conserve and sustain Pennsylvania's natural resources for present and future generations' use and enjoyment"[233] (DCNR mission).

Water Pollution

Mining activities have potential adverse effects on both surface and groundwater quality. Acid mine drainage (AMD) is the result of a chemical reaction between water and the sulfur contained within coal. AMD degrades stream and water quality and has been an ongoing issue ever since the origin of mining operations in Pennsylvania. Acid mine drainage (AMD), also referred to as abandoned mine drainage or acid rock drainage,



Coal-Mine-Drainage Projects in Pennsylvania, Pennsylvania Water Science Center, USGS 2010

[229] Stephen J. Tonsor et al., *The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008 to 2013: Bituminous Mine Subsidence and Land Conservation Act, Act 54 Amendments, 4th Five-Year Report,* (Pittsburgh, PA: University of Pittsburgh for the Pennsylvania Department of Environmental Protection, 2013), http://files.dep.state.pa.us/Mining/BureauOfMiningPrograms/BMPPortalFiles/Act%2054/0.4_Executive%20Summary_FINAL.pdf.

[230] Ibid.

[231] Ibid.

[232] PA-PGC, *Strategic Plan 2015-2020*.

[233] "About Us," PA-DCNR.

occurs when an abandoned or unsealed mine fills with water and dissolves trace metals, most commonly iron (Fe), aluminum (Al), and manganese (Mn), from the mine wall lining. This causes an increase in total acidity of the water and the pH to drop well below 7.[234] The concentrations of these dissolved trace metals can vary from small amounts (less than 10 parts per million) to extremely high levels (exceeding 1 part per thousand). AMD is perhaps the biggest water quality issue in Pennsylvania, as it has impacted more than 3,000 miles of freshwater streams and rivers.[235]

AMD can result from a variety of industrial and mining activities but is most commonly linked to coal mining. Much of the bituminous coal field in western Pennsylvania, which stretches from McKean County all the way to Greene County and into West Virginia, is within pyrite rock.[236] When pyrite, an iron-sulfide mineral, encounters water, it dissolves into sulfuric acid and dissolved iron. Most of the coal mines that produce acid mine drainage were abandoned and unsealed once the coal reservoir ran out in order to cut closing costs.

Coal mine operators are currently required to seal their mines after completing operation, even if the property is to be left abandoned, under the Code of Federal Regulations Title 30 Part 75 (30CFR75).[237] However, mining operations who fail to seal their mines, or mines that closed before the Federal Mine Safety and Health Act of 1977 (30CFR75) was passed, have resulted in abandoned mines that remain physically open and allowed to fill with precipitation and runoff water. The majority of the AMD discharges come from mines that have been abandoned by their mining company, many of which have gone out of business. With the rise and rapid fall of the coal industry, a significant number of mining operations were left abandoned, making it nearly impossible for these mines to be regulated. With no responsible party for the land, many mines have been acquired and reclaimed by the Commonwealth of Pennsylvania.

AMD has several environmental consequences immediately in the area of the discharge and further downstream in larger receiving bodies, with the biggest impact being on fish populations. Freshwater fish are highly dependent on water chemistry, especially the pH. The large amounts of acidity in AMD causes significant decrease in pH. Fish are typically resilient when it comes to pH change, but once the pH begins to dip below 5, their productivity begins to decrease. Constant acid stress on fish can cause “an alteration of gill membranes and/or coagulation of gill mucus” and “in cases of severe acid stress these changes [in pH] may actually represent the primary cause of death of the exposed animals.”[238] AMD also has an indirect impact on fish through the food chain. High iron concentrations can discolor the water and increase turbidity making it difficult for photosynthetic organisms to grow and subsequently result in their death.[239] This leaves minimal food sources from which fish can choose. The precipitation and deposition of the metals in the AMD can coat the bottom of the stream, also making it difficult for fish to find food

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[234] G. Nelson Eby, *Principles of Environmental Geochemistry* (Pacific Grove, CA.: Thomson-Brooks/Cole, 2004).
[235] Pennsylvania Water Science Center, "Coal-Mine-Drainage Projects in Pennsylvania."
[236] Amos Peaslee Brown and Frederick Ehrenfeld, *Minerals of Pennsylvania*, (Harrisburg, PA, W.M. Stanley Ray, 1913), 120; Pennsylvania Water Science Center, "Coal-Mine-Drainage Projects in Pennsylvania," *United States Geological Survey*, October 26, 2010, https://pa.water.usgs.gov/projects/energy/amd/, accessed October 11, 2017.
[237] Code of Federal Regulations, § 75.1711 Sealing of Mines.
[238] Paul O. Fromm, "A Review of Some Physiological and Toxicological Responses of Freshwater Fish to Acid Stress," *Environmental Biology of Fishes* 5, no. 1, (January 1980): 79-93.
[239] S.R. Jennings, D.R. Neuman, and P.S. Blicker, *Acid Mine Drainage and Effects on Fish Health and Ecology: A Review*. (Bozeman, MT: Reclamation Research Group Publication), 2008.

and causing them to ingest these metals.[240] These factors together can cause total loss of organisms in impacted reaches of streams.

Because of the realized detrimental impact from AMD, both surface and underground coal mines In Pennsylvania (and across the United States) are now heavily regulated to ensure minimal impact from acid mine drainage and proper reclamation of coal mines when they are completed. There have been three significant advancements in the coal mining industry that now help prevent acid mine drainage: overburden analysis, alkaline addition, and special handling of acidic mining materials. Pennsylvania surface mining laws require thorough analysis of the overburden (rocks or soil) to be removed to access the coal. This analysis allows the mine operator to characterize the chemical nature of the specific mine site and determine strategies for potentially alkalizing it should it show high acidity. If the analysis does indicate that the overburden is net acidic, the mine operator is required to add alkaline material to the backfill post-mining, at volumes that adequately offset the pre-mining acidity of the overburden. This process is known as alkaline addition, and has been highly successful in preventing AMD pollution. Lastly, if the overburden analysis demonstrates acidic material, mine operators will segregate the acidic material and place it in clay-sealed pods in the upper portion of the backfill post-mining, thus reducing the potential that this acidic material encounters water.[241] According to a 1999 DEP study, "only 1 percent of the [coal mining] permits issued in the past 10 years resulted in post-mining water quality problems severe enough to warrant holding reclamation bonds. This contrasts markedly with our performance during the prior 10 years -- 1977 through 1986, which resulted in a much higher incidence of post-mining AMD."[242]

In addition to AMD impacts, stormwater management is also an issue. When areas are surface mined, they are stripped of surface vegetation. This vegetation is essential to stormwater management because increased and accelerated sediment loads also have significant effects on stream quality. Coal mining studies confirm, "when rain washes the loosened topsoil into streams, sediments pollute waterways. This can hurt fish and smother plant life downstream and cause disfiguration of river channels and streams which leads to flooding."[243]

Other effects to water quality resulting from underground bituminous coal mining include pollution of wells, springs, and ponds. In a recent DEP report, DEP recorded 855 reported impacted water supplies, of which 57% the mine operator was found to be liable.[244]

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[240] Ibid.

[241] Rock Martin, Professional Geologist, Chief, Permits and Technical Services, Department of Environmental Protection, Cambria District Office

[242] Pennsylvania Department of Environmental Protection, *Evaluation of Mining Permits Resulting In Acid Mine Drainage 1987-1996: A Post Mortem Study*, (Harrisburg, PA: Office of Mineral Resources Management, Bureau of District Mining Operations, 1999), http://files.dep.state.pa.us/Mining/District%20Mining/DistrictMinePortalFiles/Acid_Mine_Drainage.pdf.

[243] Siva Prasad Dontala, T. Byragi Reddy and Ramesh Vadde, "Environmental Aspects and Impacts its Mitigation Measures of Corporate Coal Mining," *Procedia Earth and Planetary Science* 11, (2015): 3.

[244] Stephen J. Tonsor et al., *The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008 to 2013.*

Water Pollution on Public Lands

Again, to reiterate, the intended purpose of Pennsylvania's public lands are to "manage Pennsylvania's wild birds, wild mammals, and their habitats for current and future generations" (PGC mission) and to "conserve and sustain Pennsylvania's natural resources for present and future generations' use and enjoyment" (DCNR mission). Destruction of rivers and riparian habitat from AMD associated with energy development may appear contradictory to these missions. The risks from AMD, however, arise primarily from abandoned mine infrastructure and not new mining operations. New mining activities in the state adhere to stricter environmental regulations and are only

Case Study: Example AMD Restoration on State Game Land



In addition to reclamation projects, the Game Commission has also partnered with organizations to conduct research on AMD streams located on their property. Saint Francis University Environmental Engineering and the Clearfield Creek Watershed Association have conducted an extensive study of the Swank Open Limestone Channel located on State Game Lands 108 in Dysart, PA. The AMD pouring from three openings of the abandoned Swank 13 up-dip coal mine is unique in that it contains high concentrations of aluminum (15 mg/L average) and virtually no iron (0.5 mg/L average).[1] Typically, an open limestone passive treatment system is installed to treat AMD high in iron, not aluminum. Between 2011 and 2015, the AMD in the limestone channel was studied for improvement in water quality (pH) and water chemistry (metal concentrations) in order to summarize its ability to treat the AMD.[1] After this intense monitoring period, it was shown that the current limestone channel was only able to remove aluminum and increase pH during periods of low flow rate and high residence times (the time it takes water to travel the length of the channel).[1] Using these findings, preliminary equations were developed that relate the removal rate of aluminum acidity and residence times for the purpose of designing future channels treating similar AMD. This study is just one example of an AMD discharge effects on public lands – there are many additional discharges of varying water qualities across the state.

Source: Charles D. Spellman Jr., William H.J. Strosnider, Edward P. Zovinka, Kevin Tomkowski, Sergio Carvajal-Sanchez, Joel Bandstra, and Arthur Rose, "Open Limestone Channel Performance for Al-Rich Acid Mine Drainage" (research poster, Proc. of 33rd Annual Meeting of The American Society of Mining & Reclamation, Spokane, WA, 2016). Image: SFU students treating AMD stream, credit: Rachel Wagner

permitted when they can demonstrate mitigation and minimal risk of AMD discharge. It is also important to note that in many circumstances, DCNR and PGC have acquired damaged, unwanted, polluted land and performed extensive reclamation and restoration of habitats and ecosystems on those lands. These reclamation projects are discussed in detail later in this report.

Underground Fires

In addition to water quality threats, underground coal fires have been observed throughout Pennsylvania since the earliest years of mining.[245] These fires can be started simply by exposing the coal to oxygen, human interference (other mining operations), or lightning strikes. Coal fires are also responsible for, "atmospheric pollution, acid rain, perilous land subsidence, [and] the destruction of floral and faunal habitats."[246]

Recent figures estimate approximately 36 mine fires are currently blazing in the Commonwealth.[247] The underground fires can contribute to subsidence of land due to disappearing coal and loss of remaining mining structures supporting the land. One of the most infamous coal mine fires started in Centralia, Pennsylvania, nearly 55 years ago and still burns today.[248] The fire burns 300 feet below the surface and "scientists estimate it will continue to burn for another 250 years."[249]

Underground Fires on Public Lands

In the early 2000s, a small underground coal fire was extinguished beneath Boyce Park, an Allegheny County park.[250] Although Boyce Park is not a state park, it is an example of potential impacts that could occur on state land that overlie past mining operations. DCNR is not aware of any underground fires currently or previously burning in state forests or parks.[251]

Reclamation and Positive Environmental Impacts

With over 200 years of coal mining operations in the state and realized negative impacts on the environment, efforts are in place to remedy the destruction in the form of land reclamation. Pennsylvania DEP defines abandoned mine reclamation as, "the process of cleaning up environmental pollutants and safety hazards associated with a site and

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[245] Brian Bowling, "Abandoned Mine Lands Rife with Hazards," *TribLIve*, December 6, 2014, http://triblive.com/state/pennsylvania/7194295-74/mine-problems-priority.
[246] Glenn B. Stracher and Tammy P. Taylor, "Coal Fires Burning Out of Control Around the World: Thermodynamic Recipe for Environmental Catastrophe," (International Journal of Coal Geology, July 12, 2004), http://www.sciencedirect.com/science/article/pii/S0166516204000102.
[247] Jake Flannick, "State Works to Extinguish Longtime Underground Mine Fire in Plum," *Pittsburgh Post-Gazette*, *PowerSource,* April 7, 2017, http://powersource.post-gazette.com/local/east/2017/04/07/Plum-underground-mine-fire-being-extinguished/stories/201703310144.
[248] "The Underground Coal Fire that Been Burning for 53 Years," *Appalachian Magazine*, December 15, 2015, http://appalachianmagazine.com/2015/12/15/the-underground-coal-fire-thats-been-burning-for-53-years/.
[249] Ibid.
[250] Jake Flannick, "State Works to Extinguish Longtime Underground Mine Fire in Plum."
[251] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, November 30, 2017.

returning the land to a productive condition."[252] Through the 1977 Surface Mining and Control Act, abandoned mines were inventoried and classified based on effects to human health and environmental quality. "Priority 1" and "Priority 2" are those "posing a threat to the health and safety of people."[253] In addition to abandoned mines, abandoned, or waste, coal piles also pose environmental threats, especially in Pennsylvania. As stated earlier, in the early years of mining in Pennsylvania, coal that was deemed "unusable" by industry was simply discarded into piles. Today these piles look more like mountains, with exposed culm littering the landscapes of Pennsylvania and creating significant environmental impacts. When coal is removed from the ground and left unwanted, it becomes exposed to air. These piles of waste coal oxidize and contribute to water pollution and increased acidity in local water resources. According to a 2001 report published by the Western Pennsylvania Coalition for Abandoned Mine Reclamation, "Some environmental impacts of the piles are well documented. Nearby streams and lakes are usually impacted by erosion and sedimentation. Both acid and alkaline pollution drain into nearby waterways. Erosion from the piles is massive. Sedimentation fills creeks and ponds the adverse chemical content and lack of nutrients prevents re-vegetation."[254]

In the 1980s, new technology made use of this waste coal in power generation plants. Today, waste coal companies are reclaiming abandoned bony piles for the use of such electricity generation.

There have also been some unexpected positive impacts of the mining industry, such as the creation of new habitats for bat species in abandoned mines. In fact, a report conducted by Bat Conservation International states, "Abandoned underground mines provide important roosting habitat for more than half of the 45 bat species in the United States."[255]

Reclamation on Public Lands

Abandoned mines and waste coal piles located on public lands pose unique environmental quality threats as well as benefits. Although there are realized environmental impacts from waste coal piles, both DCNR and PGC are working with companies to allow the removal of waste coal in return for reclaimed land and improvements to the public land, like new recreational trails. The unexpected creation of new habitat for bats and woodrats from underground abandoned coal mines have also been realized on state game lands.[256] On "State Game Lands 036, reclaimed strip mine provides extensive habitat for a diversity of early successional and grassland dependent bird species. Henslow's, grasshopper, vesper and savannah sparrows along with bobolinks and prairie warblers have all been documented at

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[252] "PA's Mining Legacy and AML," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Business/Land/Mining/AbandonedMineReclamation/AMLProgramInformation/Pages/PA's-Mining-Legacy-and-AML.aspx, accessed October 20, 2017.

[253] "Abandoned Mine Land Hazards and Problem Types," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Business/Land/Mining/AbandonedMineReclamation/AMLProgramInformation/Pages/AMLHazards.aspx, accessed October 20, 2017.

[254] *Project Gob Pile, Final Project Report*, Western Pennsylvania Coalition for Abandoned Mine Reclamation, November 30, 2001, http://www.amrclearinghouse.org/Sub/landreclamation/ProjectGobPile/ProjectGobPileFinalReport.pdf.

[255] Natural Resources Conservation Service and Bat Conservation International, *Bats and Mines, (*Madison, MS and Austin, TX), https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_015580.pdf, accessed October 1, 2017.

[256] Michael DiMatteo, Pennsylvania Game Commission, e-mail correspondence, March 3, 2017.

the site. American woodcock and ruffed grouse utilize the aspen dominated edge habitat surrounding the reclamation site."[257] Another example can be found on SGL 31 where "portions of this SGL were extensively mined for coal. As a result of this mining and the reclamation process, some of the historically forested areas have been replaced with cool season grasslands that are interspersed with shrub and pine plantings. Many areas, however, remained un-reclaimed and have reforested over the exposed spoil. This has created a unique landscape and habitat that is attractive to many species of wildlife and provides good hunting and trapping opportunities for Pennsylvania sportsmen."[258]

Health Impacts

Like oil and gas development, health impacts related to coal mining are closely linked to environmental impacts. Destruction of both surface and groundwater quality not only poses a threat to environmental health, but also to the health of humans. Streams, aquifers and drinking water supplies can all be affected by coal mining activities. Lastly, abandoned mines are known hazards and have potential to cause adverse health issues as well.

Water Pollution

Many AMD discharges eventually empty into large fresh bodies of water, such as the West Branch of the Susquehanna River, which serves as a drinking water source downstream. Even though most AMD impacted streams are of noticeably poor quality (typically having an orange color), some sites look perfectly healthy, such as the stream shown here. According to the EPA, "Heavy metals can be leached from rocks that come in contact with the acid, a process that may be substantially enhanced by bacterial action. The resulting fluids may be highly toxic and, when mixed with groundwater, surface water and soil, may have harmful effects on humans, animals and plants."[259]



AMD affected stream on SGL, photo by: Charles Spellman

Improperly filtering and drinking these impaired waters can lead to ingesting an unhealthy amount of iron and aluminum. Although iron is an important element in the human diet (The World Health Organization, or WHO, states that the minimum iron requirement is anywhere from 10 to 50 mg/day), it can cause drastic side effects such as respiratory complications, comas, cardiac arrest and even cause some mutations when ingested at high rates.

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[257] Pennsylvania Game Commission, *Sportsmen's Recreation Map: State Game Lands No. 036, Bradford County*, (Harrisburg, PA: February 18, 2014), http://www.pgc.pa.gov/HuntTrap/StateGameLands/Documents/SGL%20Maps/SGL__036.pdf.
[258] Pennsylvania Game Commission, *Sportsmen's Recreation Map: State Game Lands No. 031, Jefferson County*, (Harrisburg, PA: January 2014), http://gohuntpa.org/SGL/SGL__031.pdf.
[259] U.S. EPA, "Abandoned Mine Drainage," October 24, 2016, https://www.epa.gov/nps/abandoned-mine-drainage.

Iron could even be fatal when the ingestion exceeds 200 mg/kg body weight.[260] Aluminum is considered acutely toxic by the WHO and ingestion can cause symptoms such as nausea, vomiting, mouth ulcers, skin rashes and arthritic pain. The WHO also states that aluminum ingestion can lead to some neurological problems such as dementia and potentially Alzheimer's.[261]

In addition to AMD polluted streams, abandoned coal mining equipment often contains polychlorinated biphenyls (PCBs), a man-made, toxic chemical, that can leach into water supplies. The EPA has identified abandoned coal mines as sources of PCBs stating, "Underground mines are emphasized here because abandoned PCB-containing equipment is likely to cause water pollution that can affect the environment and the health of downstream fish, and wildlife, and human populations."[262] PCBs are a significant pollutant in Pennsylvania waterways and have serious adverse health effects. According to the DEP, as quoted in a *StateImpact* article, "'while fish can be part of a healthy, balanced diet, some fish caught in Pennsylvania may contain chemicals of concern, such as mercury and Polychlorinated Biphenyls, or PCBs. These contaminants are found in some waterways because of their use in industry before many environmental regulations existed.'"[263] Health effects related to PCB, as seen in animal studies, "elicit a broad range of toxic responses including: acute lethality, body weight loss, carcinogenesis, dermal toxicity, fatty liver, genotoxicity, hepatomegaly, immunosuppressive effects, neurotoxicity, porphyria, reproductive and developmental toxicity, thymic atrophy, and thyroid hormone-level alterations."[264]

Water Pollution on Public Lands

Since a significant amount of AMD discharge sites are located within Pennsylvania State Game Lands and State Forests, many people who participate in recreational activities, such as hunters and hikers, may rely on water sources located on the property for drinking and have the potential to ingest unhealthy quantities of iron laced water. Also, like the health effects observed in the aquatic food chains from consuming fish high in iron, mercury, PCBs and other pollutants, there are potential adverse effects for humans consuming such fish as well. Advisories issued by DEP to avoid consumption of fish contaminated by mercury and PCB exist in rivers and streams across the state.

Abandoned Mining Infrastructure

In addition to health impacts related to AMD, access to dangerous abandoned mines is a public health hazard. According to the DEP, "abandoned coal mines present a variety of dangers including steep cliffs, abandoned buildings and equipment, water-filled pits, and unstable piles of waste coal and dirt."[265] "Some people try to swim or dive into

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[260] World Health Organization, *Iron in Drinking-water: WHO Guidelines for Drinking-water Quality*, Geneva, 2003, http://www.who.int/water_sanitation_health/dwq/chemicals/iron.pdf.
[261] World Health Organization, *Aluminum in Drinking-water: WHO Guidelines for Drinking-water Quality*, Geneva, 2010, http://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/aluminium.pdf.
[262] Dan W. Bench, *PCBs, Mining, and Water Pollution*, (Denver, Colorado: U.S. Environmental Protection Agency, May 2013), https://www.epa.gov/sites/production/files/documents/papert16polson03.pdf.
[263] Susan Phillips, "Where Not to Eat the Fish," *StateImpact Pennsylvania*, February 23, 2012, https://stateimpact.npr.org/pennsylvania/2012/02/23/where-not-to-eat-the-fish/.
[264] Agency for Toxic Substances & Disease Registry, "Polychlorinated Biphenyls (PCBs) Toxicity: What Are Adverse Health Effects of PCB Exposure?," May 14, 2014, https://www.atsdr.cdc.gov/csem/csem.asp?csem=30&po=10.
[265] "Why Are Abandoned Mines So Dangerous?," *PA Department of Environmental Protection*, http://www.dep.pa.gov/Citizens/JustForKids/Mines/Pages/AbandonedDangers.aspx, accessed October 20, 2017.

water-filled mine pits, or think that an old mine portal is an invitation to go spelunking," reported *TribLive*, as part of an interview with Brian Bradley, an environmental program manager with the DEP.[266] Alarmingly, "dozens of people are killed while exploring, swimming or playing in mines and more people die in abandoned mines in Pennsylvania than in any other state."[267]

Abandoned Mines on Public Lands

Other health risks associated with the coal mining industry that are unique to public lands are the dangers associated with abandoned mines. People hunting or recreating on public lands have easier access to abandoned mines because they are on public property. Public lands are usually located in remote locations with minimal surveillance. Hunters, trappers and other recreators are at a higher risk to injury simply because they can easily gain access to the abandoned mines via the public land.

PENNSYLVANIA STATE COAL POLICY

Pennsylvania coal mining practices went unregulated for nearly 150 years. It was not until 1913 when mining effects really started to become realized in rivers adjacent to mining practices. Today, the coal mining industry is a highly regulated industry on both a federal and state level. Below is a brief summary of key Pennsylvania and federal coal mining laws. The discussion is limited to policy related to health and environment and excludes mine safety laws.

In 1937, after almost two hundred years of active coal mining in Pennsylvania, the state passed the Clean Streams Act, a law aimed to protect Pennsylvania's waterways. The act "was amended in 1945 to include acid mine drainage specifically and revised again in 1965 to define acid mine drainage as an industrial waste, requiring all mines to treat their drainage to specified standards."[268] This act has been amended numerous times since inception and is one of the most influential laws regulating coal mining in Pennsylvania.

The Clean Stream Act is specifically purposed:

- To preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation;
- empowering and directing the creation of indebtedness or the issuing of non-debt revenue bonds by political subdivisions to provide works to abate pollution;
- providing protection of water supply and water quality;
- providing for the jurisdiction of courts in the enforcement thereof;
- providing additional remedies for abating pollution of waters;
- imposing certain penalties;
- repealing certain acts;
- regulating discharges of sewage and industrial wastes;

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[266] Brian Bowling, "Abandoned Mine Lands Rife with Hazards."
[267] "What Is Stay Out, Stay Alive?" *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Citizens/JustForKids/Mines/Pages/StayOutLive.aspx, accessed October 11, 2017.
[268] Lehigh Environmental Initiative, "Laws and Regulations Concerning Coal Mining," *Lehigh University*, 2001, http://www.ei.lehigh.edu/envirosci/enviroissue/amd/links/laws1.html.

- regulating the operation of mines and regulating the impact of mining upon water quality, supply and quantity;
- Placing responsibilities upon landowners and land occupiers and to maintain primary jurisdiction over surface coal mining in Pennsylvania.[269]

As environmental effects became realized in Pennsylvania, so too did regulation. In 1945, Pennsylvania passed the Surface Mining Conservation and Reclamation Act. This law was dedicated to "providing for the conservation and improvement of land affected in connection with surface mining and regulating such mining."[270] Additionally, the Act "provided for the establishment of an Emergency Bond Fund for anthracite deep mine operators" and corresponding penalties for polluters.[271] Since 1945, the Act has been amended multiple times and "formed the basis of current environmental regulations covering surface coal mining operations" we still see today.[272]

In 1966, Pennsylvania passed the Bituminous Mine Subsidence and Land Conservation Act of 1966 (BMSLCA) which addressed issues such as permitting and protection of structures from subsidence caused by coal mining.[273] This law was also amended several times and now includes measures that include more permitting, monitoring, and reporting by underground bituminous mine operators. It also further protects water supplies by holding the mine operator accountable for contaminated or diminished water supply.[274]

Two years later, in 1968, The Coal Refuse Disposal Control Act was passed to "help control pollution specifically from coal refuse piles."[275] The law specifically states the following intentions of the Act:

- Providing for the protection of the safety, health and welfare of the people, property and public roads and highways of the Commonwealth from conditions on coal refuse disposal areas, or parts thereof, which fail to comply with the established rules, regulations or quality standards adopted to avoid air or water pollution or to protect water supplies, and from the danger of slipping, sliding or burning of coal refuse disposal areas, or parts thereof, sometimes caused by the storage of coal refuse;
- prescribing for and regulating the operation of coal refuse disposal areas, and parts thereof; prescribing the powers of the Department of Environmental Resources with respect thereto;
- providing for the power to enjoin the operation of coal refuse disposal areas, or parts thereof, which contain certain conditions;
- providing for civil and criminal penalties; authorizing the acquisition by condemnation of certain land areas in certain cases;

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[269] The Clean Streams Law, P.L 1987, Act 394 of 1937, as amended (35 P.S.§§ 691.1 et seq.) https://pennstatelaw.psu.edu/_file/aglaw/Marcellus_Shale/Clean_Streams_Law_Update.pdf.
[270] "Surface Mining Conservation and Reclamation Act," Cl. 52 Act of May. 31, 1945, P.L. 1198, No. 418 AN ACT http://www.legis.state.pa.us/WU01/LI/LI/US/PDF/1945/0/0418..PDF.
[271] Ibid.
[272] Lehigh Environmental Initiative, "Laws and Regulations Concerning Coal Mining."
[273] Stephen J. Tonsor et al., *The Effects of Subsidence Resulting from Underground Bituminous Coal Mining, 2008 to 2013.*
[274] Ibid.
[275] Lehigh Environmental Initiative, "Laws and Regulations Concerning Coal Mining."

- establishing a permit system, authorizing the adoption of rules and regulations, establishing minimum standards;
- requiring bonds and for the maintenance of primary jurisdiction over surface coal mining in Pennsylvania; providing incentives for coal refuse disposal activities on previously affected areas; and
- providing for coal refuse disposal research.[276]

In that same year (1968), Pennsylvania passed the Land and Water Reclamation Act, which included issuing a $500 million bond aimed at restoring mine land that had been abandoned, "and to purchase land for conservation and recreation purposes."[277] Known as "'Project 500,' 'Operation Scarlift,' or 'The Bond Issue Program,'" this part of the act was managed by the Department of Mines and Mineral Industries and later by the Department Environmental Resources, which is now the Department of Environmental Protection.[278]

It was not until 1977, two hundred years since existence of the first commercial mining operation in Pennsylvania, that the federal government began regulating the coal industry. The Surface Mining Control and Reclamation Act of 1977 was enacted with the purpose to:

- establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations
- assure that the rights of surface landowners and other persons with a legal interest in the land or appurtenances thereto are fully protected from such operations;
- assure that surface mining operations are not conducted where reclamation as required by this Act is not feasible;
- assure that surface coal mining operations are so conducted as to protect the environment;
- assure that adequate procedures are undertaken to reclaim surface areas as contemporaneously as possible with the surface coal mining operations;
- assure that the coal supply essential to the Nation's energy requirements, and to its economic and social well-being is provided and strike a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy;
- assist the States in developing and implementing a program to achieve the purposes of this Act;
- promote the reclamation of mined areas left without adequate reclamation prior to August 3, 1977, and which continue, in their unreclaimed condition, to substantially degrade the quality of the environment, prevent or damage the beneficial use of land or water resources, or endanger the health or safety of the public;

[276] Coal Refuse Disposal Control Act, Cl. 15, Act of Sep. 24, 1968, P.L. 1040 No. 318 http://www.legis.state.pa.us/WU01/LI/LI/US/PDF/1968/0/0318..PDF
[277] Lehigh Environmental Initiative, "Laws and Regulations Concerning Coal Mining."
[278] "Operation Scarlift and Mine Reclamation in Pennsylvania," Pennsylvania Department of Environmental Protection, http://www.dep.pa.gov/BUSINESS/LAND/MINING/ABANDONEDMINERECLAMATION/OPERATIONSCARLIFT/Pages/default.aspx, accessed October 12, 2017.

- assure that appropriate procedures are provided for the public participation in the development, revision, and enforcement of regulations, standards, reclamation plans, or programs established by the Secretary or any State under this Act;
- provide a means for development of the data and analyses necessary to establish effective and reasonable regulation of surface mining operations for other minerals;
- encourage the full utilization of coal resources through the development and application of underground extraction technologies;
- stimulate, sponsor, provide for and/or supplement present programs for the conduct of research investigations, experiments, and demonstrations, in the exploration, extraction, processing, development, and production of minerals and the training of mineral engineers and scientists in the field of mining, minerals resources, and technology, and the establishment of an appropriate research and training center in various States; and
- wherever necessary, exercise the full reach of Federal constitutional powers to insure the protection of the public interest through effective control of surface coal mining operations.[279]

The passage of the federal law spurred further amendments in many of the previous state coal related laws in order to comply. Pennsylvania is now one of 24 states that has primacy, or primary regulatory responsibility, when it comes to coal mining. This means that the state "meets the requirements of the [Surface Mining Control and Reclamation] Act and that it is no less effective than the federal regulations in achieving the requirements of the act."[280] It also means that the state has shown it has the "administrative, financial, and legal capabilities to carry out the provisions of the act."[281]

In addition to state and federal regulations aimed specifically toward coal mining, the coal mining industry is also affected by the following Federal Regulations, as stated by the American Coal Foundation:

- National Historic Preservation Act (1966), which governs the preservation of historic properties throughout the United States;
- National Environmental Policy Act (1969), which established a process for the federal government to address environmental issues caused by federal actions, including the issuance of a federal mining permit;
- Endangered Species Act (1973), which governs the protection of endangered species;
- Resource Conservation and Recovery Act (1976), which governs the control of solid wastes;
- Clean Water Act (1977), which regulates the discharge of pollutants into water sources;
- Clear Air Act (1990), which regulates the discharge of pollutants into the air.[282]

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[279] Public Law 95-87, Surface Mining Control and Reclamation Act of 1977, https://www.osmre.gov/lrg/docs/SMCRA.pdf.
[280] Office of Surface Mining and Reclamation Enforcement, "Oversight, What Is Oversight," *U.S. Department of Interior*, Nov. 15 2010, https://www.osmre.gov/programs/oversight.shtm, accessed October 11, 2017.
[281] Ibid.
[282] "Coal Mining in America," *American Coal Foundation*, 2014, http://teachcoal.org/coal-mining-in-america, accessed October 11, 2017.

In Pennsylvania, the Department of Environmental Protection is tasked with providing permits for coal mining that comply with all the aforementioned regulations. DEP's Office of Active and Abandoned Mining Operations operates four bureaus that focus on specific aspects of the industry to monitor the mining of materials and limit impacts.[283]

Both the Pennsylvania Game Commission and the Department of Conservation and Natural Resources manage mining operations on their property. The following sections summarize the policy, development procedures, and management of coal on these public lands.

COAL DEVELOPMENT ON DCNR LAND

DCNR Coal Policy

Like oil and gas, coal mining is encompassed as part of the Conservation of Natural Resources Act, also known as Act 18. The legal authorization for the establishment, use, and control of state forest land is contained in the Conservation and Natural Resources Act, Section 302. The law explicitly states:

"The department is hereby empowered to make and execute contracts or leases in the name of the Commonwealth for the mining or removal of any valuable minerals that may be found in State forests."[284]

Development and Procedures

DCNR has the legal authority to lease state land for mining. Coal mines, both active and abandoned, exist throughout Pennsylvania's state forest system today. At present time, the agency currently restricts new mining operations to areas that:

- "have previously been disturbed by other mining practices and improperly reclaimed"[285]

or

- "where new mining proposals would allow for significant reclamation on nearby mine lands"

DCNR has not signed any virgin coal mining agreements in over 20 years. In the early 1990s, the bureau crafted an internal policy stating that it would no longer consider new proposals for surface mining for coal or stone, and it would only consider mining projects where reclamation of past mining impacts was to be addressed.[286]

The agency is also actively working with coal companies to remove waste coal from state forest land. For example, in 2017, a deal was reached between DCNR and D. Molesevitch & Sons Co. Inc. through a surface use agreement that allows the company to remove the waste coal in return for materials and construction upgrades within Weiser State Forest. The company owns a modern waste coal processing plant and will remove the waste coal from the state forest. Similar projects are underway in other state forests.[287] The noteworthy reclamation projects where DCNR has

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[283] "Mining Active and Abandoned Mine Operations," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Business/Land/Mining/Pages/default.aspx, accessed October 11, 2017.
[284] "Act 18," Pennsylvania Department of Conservation and Natural Resources, www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20033063.pdf, accessed October 11, 2017.
[285] PA-DCNR, *2016 State Forest Resource Management Plan.*
[286] Ibid.
[287] Teddy Borawski, Department of Conservation & Natural Resources, personal conversation, April 26, 2017.

allowed re-mining on existing mine sites to take place to gain the modern reclamation and/or additional off-site reclamation include:

- Two Mile Run In Sproul State Forest
- Bark Camp in Moshannon State Forest
- Middle Branch in Moshannon State Forest
- Fran Mine site in Sproul State Forest[288]

Management

The Bureau of Forestry's Minerals Division is responsible for issuing new mining agreements, oversight of mining operations, and the monitoring of coal and hard mineral resources. Any new mining project is conditioned to ensure that any new or previously impacted land within the project area is properly reclaimed to present-day standards.[289] Developers of new mining projects work with the Division to execute the department's standard surface use agreement (SUA) for coal refuse removal projects. The construction company wishing to mine enters into the SUA and pledges a surety bond on the project.[290]

Coal Mines on DCNR Lands

DCNR started leasing land for coal mines in the early 1980s, but only has solid leasing records starting in 1989.[291] DCNR's current mining leases are for land reclamation purposes, DCNR has not signed a virgin coal mining lease since the 1990s.[292] There are no mining operations on state forest lands where DCNR owns the coal and stone rights.[293] There are mining operations on state forest lands where DCNR does not own the coal or stone rights.[294] From 1989 to 2006, DCNR made $3,727,607 from coal royalties, hard minerals, and land exchange values.[295]

[288] Ibid.
[289] Ibid.
[290] Teddy Borawski, Department of Conservation & Natural Resources, personal conversation, April 26, 2017.
[291] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, August 2017.
[292] Ibid.
[293] Ibid.
[294] Ibid.
[295] Ibid.

COAL EXTRACTION ON STATE GAME LANDS

Policy

Presently, the Game Commission is governed by statute Title 34. Title 34 gives the Game Commission legal authority to lease their surface and subsurface rights for coal mining activities and is the primary law that governs the overall activities within the Pennsylvania Game Commission. Such legal authority for energy development on state game lands is addressed in *subchapter § 724: "Disposition of timber, minerals and other products*, and explicitly states that "the commission may dispose of, by lease, sale or otherwise, timber, buildings, other appurtenances, minerals, oil and gas, or rights therein, including natural gas storage, or any other product, on or under lands to which it has title."[296]

Management

Management of coal assets on state game lands is very similar to the Game Commission's management of oil and gas assets. The Game Commission performs periodic environmental testing; however, nothing is documented as a formal report or easily accessible. Mining leases, royalties, and other information is available through the Right to Know request process. There are no internal or external reports or research regarding the environmental impacts (if any) or health impact from mining operations on state game lands. The Pennsylvania Department of Environmental Protection (DEP) handles any environmental violations incurred on state game lands, as it would any private land owner.[297] Violations on game commission land are available to the public again through the right to know process as well.

Development and Procedures

Coal mining developers wishing to mine on state game lands start the process the same way as oil and gas developers, by contacting the Game Commission's Bureau of Land Management, Division of Environmental Planning & Habitat Management. Prior to initiation of any formal bidding process, the Game Commission assesses the project using their internal "Natural Resource Recovery Questionnaire." The questionnaire is intended to identify potential impacts to the state game land from the proposed resource recovery. The NRRQ is an internal Game Commission process used by the Oil Gas and Mineral (OGM) section in its leasing decision process. The NRRQ is sent to the Regional office staff and to all the Division Chiefs in Harrisburg for input and comment on the proposed project. If the NRRQ shows little to no impact to the PGC mission, the project can proceed to a lease agreement. The coal developer then works closely with the PGC to develop a suitable application for a mining permit from DEP that meets both DEP requirements and Game Commission priorities such as habitat conservation and specific land use.[298]

Coal, however, is different from oil and gas to the extent that strip mining, for example, is generally surface intensive, and removes considerable usable acreage for the purpose of hunting/trapping from the public. Such proposals are scrutinized accordingly by the Commission before they are approved.[299] Lease priorities are given to development applications that show detailed reclamation plans, water quality restoration, and land exchange values. In some reclamation cases, the PGC will deny proposals for reclamation (waste coal mining) because the old mining

[296] Title 34.
[297] Michael DiMatteo, Pennsylvania Game Commission, e-mail correspondence, March 3, 2017.
[298] Michael DiMatteo, Pennsylvania Game Commission, e-mail correspondence, March 3, 2017.
[299] Ibid.

infrastructure is playing an important role in wildlife habitat management. For example, there have been instances where the Game Commission has witnessed abandoned high wall mines that have created vital habitat for critical wildlife such as threatened bats and woodrats.[300]

Coal Mines on State Game Lands

The Game Commission, like DCNR, does not possess the mineral rights to all of the property they own, therefore development of some SGL tracts is not their decision nor authority. Additionally, there are also many instances where the Game Commission has received state game lands through donation or private land swapping that may have had previously existing coal mining operations. The Game Commission, however, still does allow virgin coal mining. Coal related royalties contribute to the Pennsylvania Game Commission's budget; in 2015 and accounted for $665,035 of their total revenue.

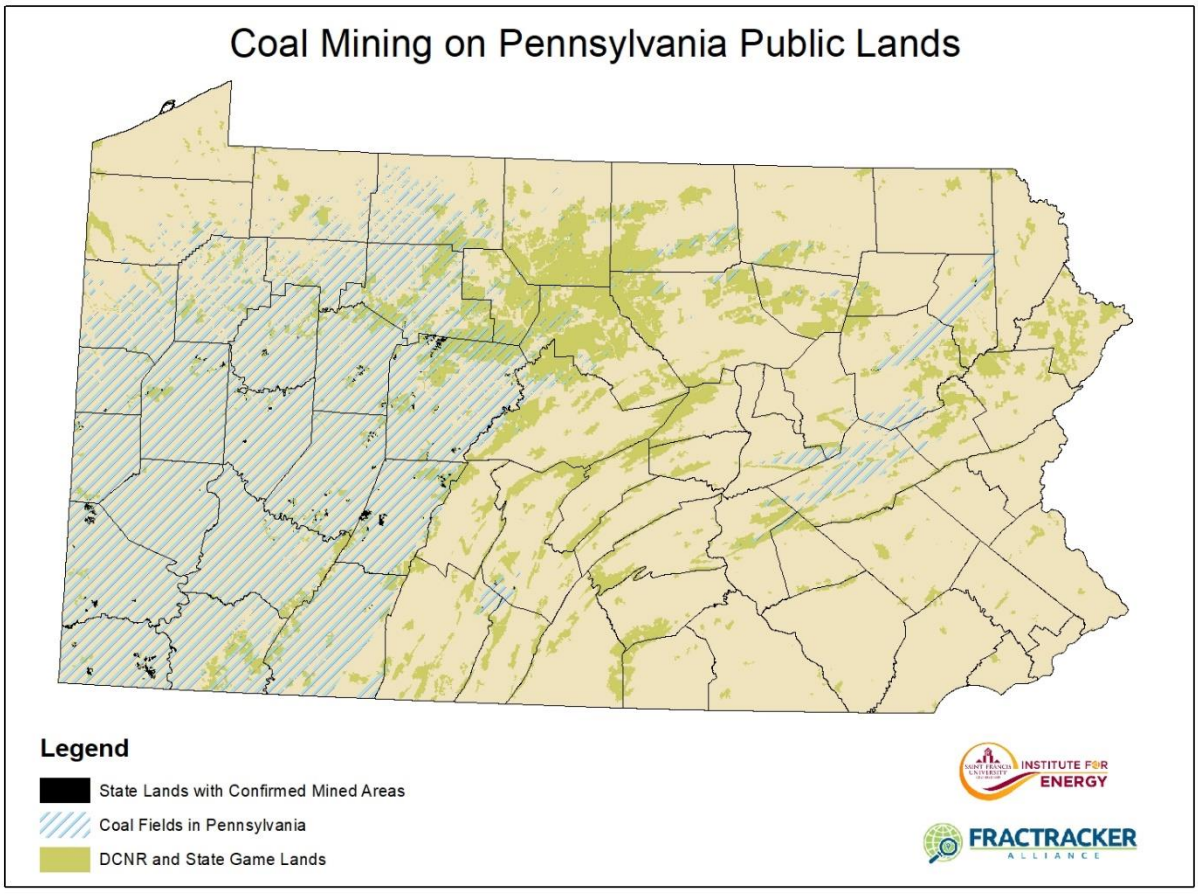
As recently as June 2016, the Game Commission approved a surface mining agreement on State Game Lands 153. The Commission did not own the mineral (coal) rights to this parcel of land, only the surface rights. The agreement involved both royalty payments and land swapping in which the Commission deemed "the payments to be made and the work to be performed are equal or greater to the surface damage royalty value of the coal and in the best interests of the Commonwealth and wildlife."[301]

Like DCNR, the Game Commission is also performing reclamation projects on damaged lands they acquired.

[300] Ibid.

[301] Commonwealth of Pennsylvania, Pennsylvania Game Commission, *Bituminous Coal Mining Surface Agreement* 153A-16.

CONFIRMED UNDERGROUND COAL MINES ON PA PUBLIC LANDS



The Institute for Energy worked with FracTracker Alliance to analyze and attempt to quantify mined areas on Pennsylvania public lands. Data to do this, however, is incomplete. The PA DEP is in the process of digitizing 84,000 hand drawn maps of mined out areas in Pennsylvania; a project anticipated to take 15 years. So far, they have completed digitizing only 30,000 maps. The map created shows where there is *confirmed* coal mining on state owned lands, but is not a complete picture of mined out state lands. The available digitized coal mine data (April 2017) from PA DEP was obtained through the Pennsylvania Spatial Data Access (PASDA) website.[302] This analysis was completed by going to "data frame properties" in ArcGIS, and selecting NAD 1983 Great Lake Basin Albers, an equal area projection appropriate for this area. New columns were then added to the public lands and digitized mined area files to calculate acres with the 'calculate geometry' tool. Note that the digitized mine acreage represents the original layer (i.e., it likely has multiple layers of mines for some coordinates that are being counted). The public lands data

[302] Pennsylvania Spatial Data Access, "Digitized Mine Areas 2017," (PA Department of Environmental Protection) http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=257.

layer was then clipped to the mined areas. A new column was added to the attribute table and then new clipped areas were calculated with 'calculate geometry.' Since these areas represent the surface land, there are not multiple mine layers being calculated for any one coordinate. Our analysis estimates that 10,178 acres of DCNR land and 39,803 acres of game lands have been confirmed as mined out. Note, this data only represents underground mine acreage.

In addition to quantifying the mined-out regions of Pennsylvania's public lands, we also examined abandoned mine land on state land. Using the "Abandoned Mine Land Inventory Polygons" dataset from the PA DEP and available through the PASDA website, the Institute concluded that 75 state game lands (plus 4 areas managed by the PGC), 8 state parks and 10 state forests contain abandoned mine land. The analysis was conducted using the geoprocessing clip tool in ArcGIS Desktop to clip the mined land to a state parks/forests layer and a state game lands layer.[303]

Additionally, DCNR estimates that there are 182 abandoned mines on state forest lands, but does not keep records for state parks.[304] The Game Commission estimates that there are 72 state game lands that have had surface mining operations and five game lands with known subsidence related to underground mining activities.[305]

[303] The following Pennsylvania-owned lands were determined to contain abandoned mines: State Game Lands: 12, 31, 33, 34, 36, 39, 42, 44, 51, 54, 60, 61, 62, 63, 67, 72, 74, 75, 77, 79, 87, 91, 93, 95, 98, 100, 105, 108, 111, 117, 120, 121, 137, 148, 153, 158, 174, 184, 195, 198, 207, 211, 223, 227, 228, 229, 238, 244, 245, 247, 248, 257, 259, 260, 261, 262, 264, 266, 268, 273, 276, 284, 285, 287, 296, 300, 303, 304, 307, 311, 320, 321, 326, 330, 332, 2411, 2418, 2419, 2427 (total: 79 if count the four 2000 level); State Parks: Archbald Pothole, Bucktail, Laurel Ridge, McConnells Mill, Moraine, Ohiopyle, Prince Gallitzin, Swatara; State Forests: Clear Creek, Elk, Forbes, Gallitzin, Loyalsock, Moshannon, Pinchot, Sproul, Tioga, Weiser.
[304] Teddy Borawski, Department of Conservation & Natural Resources, e-mail correspondence, October 12, 2017.
[305] Michael DiMatteo, Pennsylvania Game Commission, personal correspondence, November 20, 2017.



WIND ENERGY

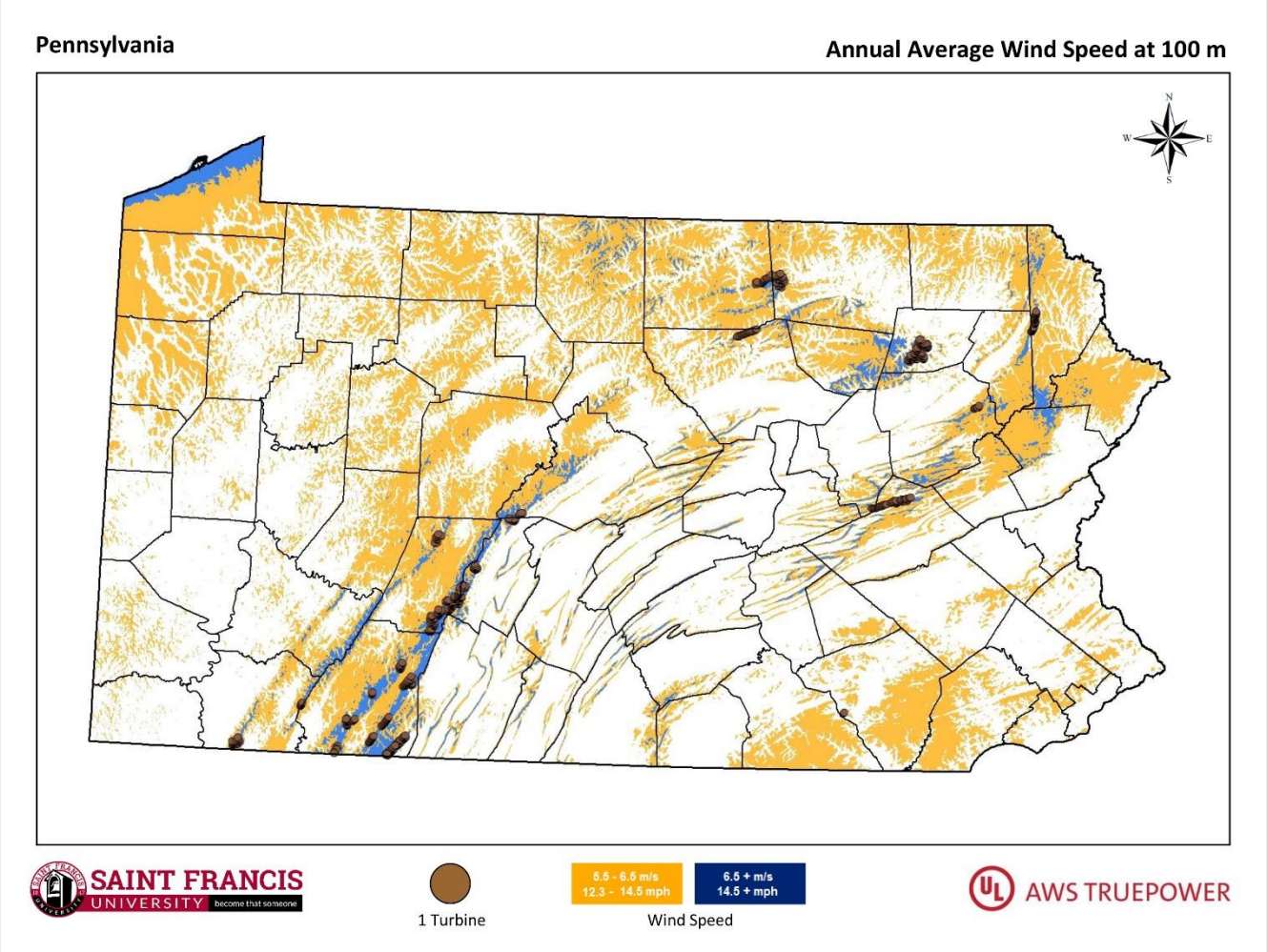
BACKGROUND

Wind power is one of the oldest forms of energy conversion and the wind industry has deep roots in Pennsylvania. As early as 1740, Benjamin Franklin was experimenting with windmill models in Philadelphia.[306] The Commonwealth was home to nearly a dozen different windmill manufacturers from the mid-1800s up through the 1920s. Most of these manufacturers were located in Philadelphia or other towns of the southeastern region.[307] Windmills were commonly used on rural Pennsylvania farms to pump water, grind grain, and produce electricity. Many of these historic windmills, however, were dismantled as part of the Rural Electrification Act of 1936, which provided electricity to rural areas that had previously been without it. [308] Nearly 70 years later, electricity production from wind energy took a whole new shape, in the form of multi mega-watt utility scale wind turbines. The first utility scale wind farm in Pennsylvania was constructed in 2000 at the Green Mountain Wind Energy Center in Somerset County. Somerset County is currently home to the most wind farms (8) and the most wind turbines (198) in Pennsylvania. As of 2017, the Commonwealth had 25 utility scale wind farms, all located in the southwest-central or northeastern areas of the state on privately owned land. The smallest wind farm, consisting of two turbines, is an exception, and is located in Lancaster County. The Mehoopany Wind Farm in Wyoming County is Pennsylvania's largest wind farm, with 88 wind turbines. Constructed in 2016, the Ringer Hill Wind Farm in Somerset County is the state's newest wind farm.[309]

Ridge tops and higher elevations in Pennsylvania host some of the best wind resources in the state. The map below illustrates where the best wind resources are located; areas shaded in blue represent developable utility scale wind locations where the annual average wind speed at 100 meters is 6.5 m/s or greater. The brown dots represent areas that have already been developed for utility scale wind.

[306] T. Lindsay Baker, *A Field Guide to American Windmills* (Norman, Oklahoma: University of Oklahoma Press, 1985), p. 13.
[307] Baker, 341, 342, 359, 364, 365, 368, 371, 375.
[308] Mary Ellen Hankinson, James Horetsky, Jerry Sharp and John Stonerook, interviews with author, 2009.
[309] Data compiled by the Institute, 2017.

Different government, industry, and academic sources have estimated the potential installed wind capacity in the Commonwealth. These estimates, however, do not consider significant policy issues that affect development unique to Pennsylvania. Such issues include the ability to develop wind projects on public lands. To date, no wind farms have been developed on any state owned land. Developers have sought state land for utility scale wind projects, however all have been denied.[310]



Environmental Impacts

Wind energy technology is constantly evolving to create wind turbines capable of harnessing the maximum amount of power from the wind. Like other forms of energy development, land clearing causes changes in the local habitat and ecosystem. Wind turbines can also have a negative effect on bird and bat survival. In addition to potential environmental impacts, wind energy also has environmental benefits, such as emission free electricity production. These risks and benefits are discussed below.

Habitat Fragmentation

Just as with any industry, wind development involves extensive project planning and requires clearing of land for maintenance roads, electrical lines, turbine transport, and the turbine placement itself. As seen with other energy

[310] Information obtained through the PA Right to Know Process - review of all wind farm proposals to DCNR and PGC.

resource development, habitat fragmentation is a byproduct of such land clearing. Habitat fragmentation is the "process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants" and is cited by the PGC and DCNR as a potential threat from developing wind turbines on state owned land.[311] Specific species of concern likely affected by habitat fragmentation from wind energy development are bats, songbirds, and the threatened Allegheny woodrat.[312] Another impact of fragmentation is the introduction of invasive plant species.[313]

As most lucrative wind farms in Pennsylvania are located on remote ridgelines, it is almost always necessary to clear land for new access roads. The design of these roads are dependent on the landscape, grade, and many other aspects of the terrain specific to the location. Access roads for wind turbines are generally larger than most roadways to accommodate the massive blades and tower sections, but can be reduced in size after the turbines are installed, only to be used for maintenance vehicles thereafter. Electrical lines that will connect the turbines to the grid are typically sited along or in close proximity to the newly constructed roads, as to not disturb the earth on two different occasions. Often times the wind farm has its own substation, which collects electrical energy from the individual turbines and directs electricity to the grid. This substation can sometimes be placed on the same cleared parcel of land as one of the turbines, but may require its own separate pad. In order to maximize efficiency, the turbines must be properly sited and spaced apart to minimize neighboring turbine interference. Spacing between the towers can be anywhere between 3 to 10 rotor diameters, which is a compromise between cost and a wake effect created by other nearby turbines.[314] The 2010 *Pennsylvania Energy Impacts Assessment*, conducted by the Pennsylvania Audubon, Western Pennsylvania Conservancy and Nature Conservancy, found that typical land use requirements of Pennsylvania utility scale wind turbines were 1.4 acres per turbine and 0.5 acres for associated infrastructure.[315]

Habitat Fragmentation on Public lands

Similar habitat fragmentation issues that exist with oil, gas, and coal also exist with wind development. Erection of the wind turbines combined with supporting infrastructure, such as roads and electrical collection lines, creates opportunity for adverse effects on wildlife habitat. Habitat conservation is an important function of both the Pennsylvania Game Commission and Department of Conservation and Natural Resources, as many programs exist that help conserve and preserve land that could be subject to deterioration or development.

Through the Right to Know Law, information about the Game Commission's concern regarding habitat fragmentation was collected. The PGC has specifically noted the following in response to wind turbine proposals on state game lands:

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[311] "Ecological Consequences of Habitat Fragmentation." *Encyclopedia of Life Sciences*, November 2010, http://www.els.net/WileyCDA/ElsArticle/refId-a0021904.html, accessed June 23, 2017.
[312] Summary of PCG NRRQs for 16 wind energy development proposals.
[313] Nels Johnson, *Pennsylvania Energy Impacts Assessment*.
[314] "Draft PPS 18: Renewable Energy Annex 1 Wind Energy: Spacing of Turbines," *United Kingdom Department for Infrastructure*, March 19, 2015, https://www.planningni.gov.uk/index/policy/planning_statements_and_supplementary_planning_guidance/pps18/pps18_annex1/pps18_annex1_wind/pps18_annex1_technology/pps18_annex1_spacing.htm, accessed May 25, 2017.
[315] Nels Johnson, *Pennsylvania Energy Impacts Assessment.*

- "Adverse impacts of critical and unique wildlife habitats such as deep hemlock valleys and rocky outcrops on mountaintops and valley sides, as well as vernal pools and spring seeps, which provide unique and critical seasonal microhabitats."
- "Fragmentation of existing contiguous forest and concomitant degradation of forest interior/core forest habitat for long- and short- distance neotropical migratory songbirds, upland game birds and resident songbirds."
- "The current management plan for (this specific) state game land does not include forest fragmentation, in fact it states that forest should not be removed but managed to increase the habitat of certain songbirds, bats, and woodrats."[316]

Habitat fragmentation also negatively affects hunting grounds. The Game Commission has cited: "Creation of a large non-huntable interior due to the creation of safety zones around the towers," and the "elimination of acreage available for wildlife management/conservation, hunting/trapping, and other recreational activities" as reasons for denying wind farms.[317]

Wildlife Mortality

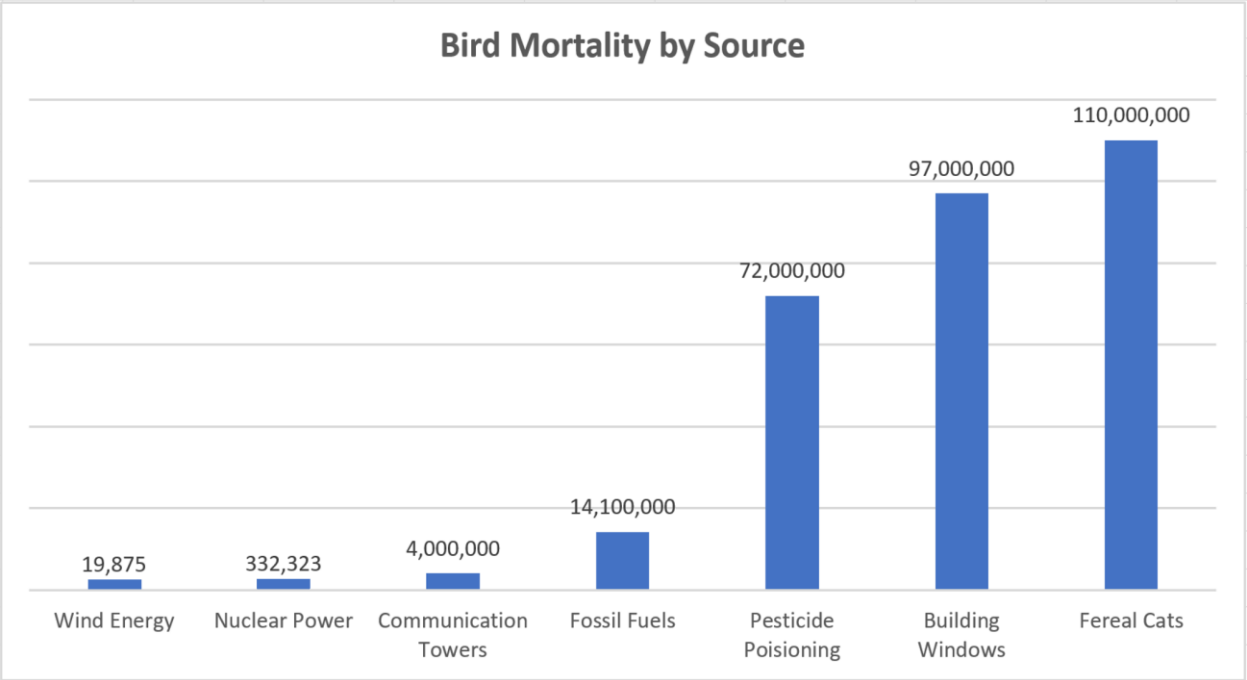
As the wind industry rapidly expands, so does the size of the wind turbines. With assemblies often reaching 100 meters in height observed in Pennsylvania, avian and bat impacts are inevitable. Due to many wind farms' typically forested locations, there will almost always be interference with local bird and bat populations. In this report, the physical effect on flying species is separated into categories of birds and bats due to the very different effects, trends, and research between the two generalized species. Wind energy also has potential effects on other non-flying species, such as deer, although limited research on this is currently available.

Birds

Wind turbines affect birds similarly to other large, man-made structures. These structures, such as tall buildings, power/transmission lines, and radio towers have been shown to block flight paths, reflect blinding sunlight, and often deter certain types of birds that are more comfortable hunting in undeveloped locations. The foremost problem is that birds will often unintentionally fly into the blades or base of large wind turbines and die as a result. However, this phenomenon is seen on other man-made structures as well. A 2009 study conducted by Benjamin Savacool concluded that feral cats, building windows, and pesticide poisoning resulted in 269 million bird deaths annually while wind energy was responsible for less than 20,000.[318] When compared to other energy producing industries in the same survey, it was found that nuclear and fossil fuel energy production killed 323,323 and 14.1 million birds respectively.[319] A more recent, 2013, study found that "between 140,000 and 328,000 (mean 234,000) birds are

[316] Letter from PGC to Mr. Kevin Lindquist, Senior Manager of Development, RES America Developments, October 21, 2011, denying wind farm development on SGL 42.
[317] Ibid.
[318] Benjamin K. Sovacool, "The Avian Benefits of Wind Energy: A 2009 Update," *Renewable Energy* 49, (January 2013) 19-24, http://www.greenwichwindpark.com/sites/default/files/uploads/Avian_benefits_of_wind_energy.pdf.
[319] Ibid.

killed annually by collisions with monopole turbines in the contiguous U.S."[320] Birds killed range in size from small warblers to large eagles and vultures and include federally listed endangered species.[321] Many of these documented



Bird Mortality by Source, Sovacool

bird deaths, are associated with songbirds.[322] Songbirds typically have higher and denser populations and fall victim to turbine collision more often than the rarer birds of prey.

According to a 2015 report, "for some [bird] species, Pennsylvania is fundamental to their global survival; more than 19% of the global population of scarlet tanagers and 9% of the global population of wood thrush breed within Pennsylvania's forests."[323] Pennsylvania is also home to many significant birds of prey, such as the red-tailed hawk, osprey, peregrine falcon, and bald/golden eagle.[324]

Pennsylvania's wind energy is not especially known for having a significant impact on its domestic birds of prey. In fact, there has not been any documented avian endangered species take (kill) related to utility scale wind turbines in Pennsylvania. In 2014, the Allegheny Mountains of Pennsylvania were the location of a study on the risk of wind turbines on Golden Eagles. Specifically, the study found that "in the Allegheny Mountains, the majority of wind

[320] Scott R. Loss, Tom Will, and Peter P. Marra, "Estimates of Bird Collision Mortality at Wind Facilitates in the Contiguous United States, Biological Conservation," *Biological Conservation* 168 (2013), 201-209, https://www.fws.gov/migratorybirds/pdf/management/lossetal2013windfacilities.pdf, accessed October 11, 2017.
[321] Avian Radar Project, "Impacts of Wind on Wildlife," *U.S. Fish and Wildlife Service*, May 21, 2015, https://www.fws.gov/radar/windpower/, accessed October 11, 2017.
[322] Sovacool, "The Avian Benefits of Wind Energy."
[323] Leslie S. Abrahams, Michael Griffin, and Scott Matthews, "Assessment of Policies to Reduce Core Forest Fragmentation from Marcellus Shale Development in Pennsylvania." *Ecological Indicators* 52 (May 2015): 153-160, http://www.sciencedirect.com/science/article/pii/S1470160X14005664?via%3Dihub.
[324] Ibid.

turbines (56%) were situated in poor eagle habitat; thus, risk to eagles is lower there than in the Ridge and Valley, where only 1% of turbines are in poor eagle habitat. Risk within individual facilities was extremely variable..."[325] Studies conducted up to 2012 found an estimated four birds per wind turbine were killed in Pennsylvania per year.[326]

Bats

Bat fatality is a negative and documented environmental impact of the wind industry. Bat mortality, occurring at wind farms, is typically caused by either a blunt force collision with the wind turbine structure (tower or blades) or barotrauma. Barotrauma happens when a sudden pressure difference (caused by the rotating blades) creates a significant pressure drop between the bat's body and its surroundings, triggering the lungs of a bat to hemorrhage. Although a 2008 study suggested barotrauma was the likely killer of bats at wind farms, traumatic injury caused by the collision of the bat and wind turbine has more recently been attributed to bat mortality at wind facilities.[327] A 2012 study found that "73% (190 of 262) of [Wind Farm] bats had lesions consistent with traumatic injury… and a small fraction (6%, 5 of 81) of [Wind Farm] bats with lesions possibly consistent with barotrauma etiology."[328]

Another report, conducted by the National Renewable Energy Laboratory eliminated barotrauma as a likely culprit of bat mortality at wind farms. The research used fluid dynamic simulations on a generic 1.5-megawatt (MW) turbine to estimate pressure differentials surrounding the blades as they rotate.[329] It was found that the wake created by the turbine blades only created a pressure difference of 1.4 kilopascals, about 2 percent of normal atmospheric pressure.[330] Researchers then used mice (because their mass and size was comparable to that of bats) to determine fatal pressure differentials.[331] Simulations showed that a pressure drop of roughly 30 kPa was needed to cause mortality in the mice, nearly 20 times that created by a wind turbine blade.[332] Recent studies, such as these, have largely excluded barotrauma as a major cause of death. Most biologists now have confidence that bat mortality on wind farms is likely due to physical collision with the blades or tower.

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[325] Tricia A. Miller et al., "Assessing Risk to Birds from Industrial Wind Energy Development via Paired Resource Selection Models," *Conservation Biology* 28, no. 3 (June 2014): Pages 745–755, http://onlinelibrary.wiley.com.francis.idm.oclc.org/doi/10.1111/cobi.12227/abstract;jsessionid=3ACE0F9CDE8950FF844DCC57D192B2D7.f03t01.

[326] John Taucher, Tracey Librandi Mumma, and William Capouillez, *Wind Energy Voluntary Cooperation Agreement: Third Summary Report*, (Pennsylvania Game Commission, December 27, 2012), http://www.pgc.pa.gov/InformationResources/AgencyBusinessCenter/WindEnergy/Documents/PGC%203rd%20Wind%20Energy%20Summary%20Report%202012.pdf.

[327] K. E. Rollins et al., "A Forensic Investigation into the Etiology of Bat Mortality at a Wind Farm: Barotrauma or Traumatic Injury?," *Veterinary Pathology* 49, no.2 (2012): 362-271, http://journals.sagepub.com/doi/10.1177/0300985812436745, accessed October 11, 2017.

[328] Ibid.

[329] "NREL Study Finds Barotrauma Not Guilty," *National Renewable Energy Laboratory*, March 22, 2013. https://www.nrel.gov/news/program/2013/2149.html.

[330] Ibid.

[331] Ibid.

[332] Ibid.

Since discovering the negative effects of wind power on bat life, the wind industry has worked closely with the U.S. Fish and Wildlife Service and other conservation groups to mitigate the effects of wind energy on bat populations. One proven way of lessening the impact is by increasing the cut in speeds of the wind turbines. Bats generally like low-wind speed conditions to hunt and are most active during these times. By increasing the wind speed at which the turbines can operate, a larger window can be created for the bats to safely navigate. One study found that by doing this, bat mortality rates were reduced by 73 percent.[333] Further turbine manipulation can be implemented during other important bat migration and roosting periods.

To date, there have been eight documented Indiana bat fatalities associated with wind facility operations in the United States, with one documented in

White-Nose Syndrome



Bats are an especially important topic in Pennsylvania, as the local populations have suffered greatly from a disease known as white-nose syndrome (WNS).[1] WNS first appeared in 2006 in New York State and has spread throughout the country ever since. The syndrome is caused by a white fungus that develops on the nose and wing membranes of bats. The fungus survives in cold temperatures so it only affects the population during the hibernating months of October to April. The fungus then causes irritation, which periodically wakes up the hibernating bats and causes them to burn precious fat and energy reserves that would otherwise help get them through the winter. The restless bats will then prematurely leave the area of hibernation and subsequently die in the cold weather. Other bats who are infected but do not leave the cave are thought to forego enough energy and reserves that they lose the ability to reproduce the following year. The syndrome predominantly affects those bats who hibernate, which is over half of the 47 bats species in the United States. Amongst the species affected by white-nose syndrome are the Indiana Bat and the Gray Bat, both of which are federally listed endangered species. The Gray Bat is not found in Pennsylvania, however, the Indiana Bat is. With the devastating implications of the white-nose syndrome, protecting bat habitats and populations are a top priority for both local and federal conservation groups.

Sources: Lori Pruitt and Jennifer Okajima, "Indiana Bat Fatalities at Wind Energy Facilities." and U.S. Fish and Wildlife Service, White-Nose Syndrome: the Devastating Disease of Hibernating Bats in North America, July 2015, https://www.fws.gov/mountain-prairie/pressrel/2015/WNS%20Fact%20Sheet%20Updated%2007012015.pdf, accessed October 11, 2017.

Image: A researcher analyzes a bat during a bat count. Credit: Allison Rohrs

[333] Edward B.Arnett et al., *Effectiveness of Changing Wind Turbine Cut-in Speed to Reduce Bat Fatalities at Wind Facilities, (*Austin, TX: Bat Conservation International, 2009), http://www.batsandwind.org/pdf/Curtailment_2008_Final_Report.pdf, accessed October 11, 2017.

Pennsylvania.[334] Studies conducted through 2012 found an estimated about 25 bats (range of 5 to 59) per wind turbine were killed in Pennsylvania per year.[335]

Other Wildlife

There has been limited research conducted on the impact of land-based wind energy facilities on larger wildlife, such as deer, bear and other non-avian species. No studies have been performed specifically on Pennsylvania wind farms; however, studies on pronghorn in Wyoming and Rocky Mountain elk in Oklahoma found no noticeable impact on the animals.[336]

Wildlife Mortality on Public Lands

Bird and bat fatalities would be likely impacts on state owned land. Referring back to the PGC's mission, "managing Pennsylvania's wild birds," protecting these species is a clear and top priority for the agency. The extensive and documented research demonstrating wind power's negative effects to bird and bat species has been an observed reason for denial of wind projects on state game lands.

The Institute for Energy analyzed the Game Commission's denials of proposed wind projects. All denials cited concerns about the presence of threatened and endangered bats and bat hibernacula. Pennsylvania's bats have been under an enormous amount of stress since the outbreak of white-nose syndrome. White-nose syndrome and endangered species hibernacula is not unique to state game lands and has been documented across the state, including on and near operational wind farms.[337] The Game Commission also cites the following species as being impacted by wind energy as reasons for denial on state game lands:

- Allegheny woodrats (threatened and unique species in Pennsylvania)
- Raptor flyways and bird habitat for migratory songbirds
- Timber rattlesnakes (candidate species of concern in Pennsylvania

In 2007, the Game Commission crafted protocols for monitoring bird and bat populations at wind farms as part of its wind energy cooperative agreement.[338] This agreement, and corresponding protocols, were not specific to development on state land and were intended for public land development.

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[334] Lori Pruitt and Jennifer Okajima, "Indiana Bat Fatalities at Wind Energy Facilities," *U.S. Fish and Wildlife Service*, December 2014, https://www.fws.gov/midwest/wind/wildlifeimpacts/inbafatalities.html, accessed October 11, 2017.
[335] John Taucher, Tracey Librandi Mumma, and William Capouillez, *Wind Energy Voluntary Cooperation Agreement*.
[336] "Wind Turbine Interactions with Wildlife and Their Habitats: A Summary of Research Results and Priority Questions," *American Wind Wildlife Institute*, June 2017, https://awwi.org/resources/summary-of-wind-wildlife-interactions-2/ accessed August 10, 2017.
[337] "Indiana Bat," *Pennsylvania Game Commission*, February 10, 2010, http://www.pgc.pa.gov/Wildlife/EndangeredandThreatened/Pages/IndianaBat.aspx, accessed October 11, 2017.
[338]Pennsylvania Game Commission, Wind Energy Voluntary Cooperative Agreement, February 23, 2007, http://www.pgc.pa.gov/InformationResources/AgencyBusinessCenter/WindEnergy/Documents/Original%20Cooperative%20Agreement%20and%20Exhibits%20-%202007.pdf.

In response to requests from wind developers seeking to develop state parks and forests, DCNR in 2007, drafted a "Wildlife Monitoring Protocols for Potential Industrial Wind Turbine Sites on DCNR Lands" document. The protocols adopted the PGC protocols but further included more detailed migration surveys for raptors and migratory songbirds.

Environmental Benefits

The focus of this research has been on energy resource *extraction* on Pennsylvania public lands. Once traditional energy resources are extracted (drilled, mined) they also need to be processed, transported, and utilized, likely for electricity generation or as a transportation fuel. Wind farms, however, harness and *produce* useful electricity all in one location, without need for additional built infrastructure, other than connection to the grid. Life cycle analyses are typically used as a way to compare different energy resources impacts (like pollution and global warming impacts) through their entire lifecycle, including manufacturing of the components, transportation, construction, decommissioning, etc. Most estimates of wind turbine life-cycle global warming emissions are between 0.02 and 0.04 pounds of carbon dioxide equivalent per kilowatt-hour. To put this into context, estimates of life-cycle global warming emissions for natural gas generated electricity are between 0.6 and 2 pounds of carbon dioxide equivalent per kilowatt-hour and estimates for coal-generated electricity are 1.4 and 3.6 pounds of carbon dioxide equivalent per kilowatt-hour.[339]

The National Renewable Energy Laboratory estimates that one Megawatt of installed wind power offsets "2,000 tons of carbon dioxide each year."[340] Through research conducted by the Institute for Energy, we found that Pennsylvania public lands could support 7,240 MW of wind energy (based solely on wind resource, discussed below). Subsequently, wind energy on Pennsylvania public lands could offset an estimated 14,480,000 tons of carbon dioxide into the atmosphere annually, if the entire resource was developed.



Photo by: Allison Rohrs

Health Impacts

As with all energy industries, there are certain health risks and potential hazards that exist and the wind industry is no exception to this. This section will examine topics such as ice throw and blade throw as potential health impacts of wind energy development on Pennsylvania public lands.

Ice Throw

Ice buildup occurs on wind turbine components, towers, and blades at low temperatures and relatively high levels of humidity. This formation of ice on the blades or the tower itself can

[339] Ottmar Edenhofer et al., *IPCC, 2011: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*, (Cambridge, UK and New York, US, Working Group III of the Intergovernmental Panel on Climate Change, 2012), Chapter 7 and 9, http://www.ipcc-wg3.de/srren-report/, access September 5, 2017.

[340] U.S. Department of Energy, *Energy Efficiency and Renewable Energy, Wind Powering America, Clean Energy for the 21st Century*, (National Renewable Energy Laboratory, September 2004), https://www.nrel.gov/docs/fy04osti/35873.pdf.

pose a risk to individuals around the site. The immediate vicinity around the turbine poses the greatest risk of injury due to falling fragments and sheets of ice, however there is also the possibility that when the blades are in motion that the ice can be launched several hundred meters from the blades depending on the conditions.[341] Wind turbine blades are subjected to this ice buildup regardless if they are in motion or not.[342] The best way to combat this issue is site planning and monitoring of the turbines. Turbines are often restricted to be a minimum distance away from public roads and dwellings.[343] Many city ordinances and industry standards use 1.5 × (hub height + rotor diameter) as the safe distance from other structures or roads.[344] Additionally, many modern turbines are equipped with sensors that can determine ice buildup on the blades and shut down the turbine to prevent the risk of third party (the public) injuries.[345]

Ice Throw on Public Lands

There are over a dozen different hunting seasons, including archery and rifle season that occur in the winter months (November to March).[346] These hunting seasons happen during the prime conditions that ice throw occurs, which can put hunters at risk. Posted signs and warnings could deter hunters from hunting in "dangerous" ice throw areas. Any limitation on hunting access, however, could possibly be viewed negatively by hunters and may violate the Game Commission's vision and mission.

Blade Throw

Another potential health risk associated with wind turbines is rotor failures that could result in blade throw. Although this is a very rare occurrence, it would result in damage to the surrounding environment and a potential risk to individuals in the surrounding area as well. Just like any mechanical device with moving parts, there is always a potential risk for the device to have a failure. In some cases, the whole blade or fragments of the blade can be dislodged and thrown great distances. Some blade fragments have been documented as traveling over 1,300 meters.[347] To mitigate risk of injury from this phenomenon, various research attempts and methodologies have been used to predict the possibility of blade throw and predict the affected areas in such an event. The key to avoiding bodily harm and damage to other structures relies heavily on the placement of the turbines.

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[341] "Evaluating Risks Caused by Ice Throw from Wind Turbines," *Lloyd's Register*, November 2015, http://www.lr.org/en/news-and-insight/articles/evaluating-risk-caused-by-ice-throw-from-wind-turbines.aspx, accessed June 28, 2017.

[342] David Wahl and Philippe Giguere, "Ice Shedding and Ice Throw, Risk Mitigation," *General Electric Company*, 2006, http://www.cbuilding.org/sites/cbi.drupalconnect.com/files/ger4262.pdf, accessed June 28,2017.

[343] "Evaluating Risks Caused by Ice Throw from Wind Turbines," *Lloyd's Register*.

[344] David Wahl and Philippe Giguere, "Ice Shedding and Ice Throw, Risk Mitigation."

[345] "Evaluating Risks Caused by Ice Throw from Wind Turbines," *Lloyd's Register*.

[346] "2017-2018 Hunting and Seasons and Bag Limits", *Pennsylvania Game Commission*, http://www.pgc.pa.gov/HuntTrap/Law/Pages/SeasonsandBagLimits.asp, accessed June 28, 2017.

[347] Giuseppe Carbone and Luciano Afferrante, "A Novel Probabilistic Approach to Assess the Blade Throw Hazard of Wind Turbines," January 2012, https://www.researchgate.net/publication/233417126_A_novel_probabilistic_approach_to_assess_the_blade_throw_hazard_of_wind_turbines, accessed June 28, 2017.

Blade Throw on Public Lands

There remains a constant risk of possible mechanical failure to occur which can cause severe injuries to hunters and others using public lands.

Decreased Pollutants

In addition to potential negative health impacts, wind power has some positive impacts to human health. Wind power does not "emit particulate matter, nitrogen oxides, and sulfur dioxide" pollutants that are linked with "causing human health problems and economic damages."[348] Wind turbines also do not "produce atmospheric emissions that cause acid rain [and] smog," according to the Department of Energy's Energy Efficiency & Renewable Energy Wind Energy Technologies Office.[349]

Decreased Pollutants on Public Lands

In a 2007 working document, DCNR recognized the positive effects of wind power, stating: "DCNR supports the development of properly-sited wind energy as an important alternative energy source to address global climate change, air pollution, and other environmental impacts associated with fossil fuel-fired electricity generation. Wind power produces no emissions detrimental to human and environmental health, and does not require continued input of fuels with their associated environmental, economic and social costs."[350] The document was intended to give guidance for land purchased using DCNR grants for wind power projects.

[348] "Advantages and Challenges of Wind Energy," *United States Department of Energy, Office of Renewable Energy and Energy Efficiency*, https://energy.gov/eere/wind/advantages-and-challenges-wind-energy, accessed October 20, 2017.
[349] Ibid.
[350] DCNR, "General Guidelines for Grantee Land Use Conversion Requests for Wind Energy Development." Obtained through the PA RTK request, Harrisburg Office.

Pennsylvania Wind Policy

The Alternative Energy Portfolio Standards (AEPS) Act mandates renewable energy generation in the state of Pennsylvania. The AEPS Act of 2004 is an implementation order that requires a heightened use of alternative energy in the state of Pennsylvania. It was put in place to further develop the energy industry as well as provide a more even distribution of power generation amongst suppliers. By 2021, it is required that 18 percent of all electricity produced by distribution and generation companies be derived from alternative sources.[351]

The AEPS breaks down alternative energy sources into two categories, Tier I and Tier II. According to the Pennsylvania Public Utility Commission, "Tier I sources include new and existing facilities that produce electricity from solar photovoltaics, solar thermal, wind, low-impact hydro, geothermal, biomass, biologically derived methane gas, coal-mine methane and fuel cell resources."[352] Embedded in this tier is a required .5 percent from solar photovoltaics, a .027 percent overall mandate. "Tier II sources include new and existing waste coal, distributed generation (DG), demand-side management, large-scale hydro, municipal solid waste, wood pulping and manufacturing byproducts, and integrated gasification combined cycle (IGCC) coal facilities."[353] The AEPS then further breaks down the 18 percent into certain amounts from each tier. Eight percent must be supplied by Tier I while 10 percent must come from Tier II.

Electric distribution and generation companies comply with the AEPS by procuring Alternative Energy Credits (AECs) from the aforementioned alternative energy resource facilities. Each AEC issued represents a megawatt hour (equal to 1,000 kilowatt-hours) of generation from a qualified alternative energy system.[354]

Pennsylvania is well on track to meet the expected 18 percent renewable standard by 2021. In 2015, utility wind power accounted for 42.5% of the retired Tier I resources.[355]

Wind power development has significantly slowed in Pennsylvania. Because not all AECs are required to originate in Pennsylvania, interest surrounds how many of these credits are coming from the state that implemented the Act in the first place. For the 2015 reporting year, which is the most recent version available by the PUC to the public, "74.1 percent of solar AECs, 35.8 percent of Tier I, and 62.3 percent of Tier II AECs retired by electric distribution companies (EDCs) and electric generation suppliers (EGSs) originated from generation facilities located within Pennsylvania."[356]

Wind Energy on DCNR Land

Small wind turbines were installed at six different state parks in 2007, including Prince Gallitzin and Yellow Creek, although technical challenges and high maintenance costs have led to at least several of the turbines being

[351] PA-PUC, "About AEPS."
[352] Ibid.
[353] Ibid.
[354] Ibid.
[355] Ibid
[356] Gladys M Brown et al., *2015 Annual Report Alternative Energy Portfolio Standards Act of 2004*, Harrisburg, PA: Pennsylvania Public Utility Commission and Department of Environmental Protection, 2016, http://www.puc.state.pa.us/Electric/pdf/AEPS/AEPS_Ann_Rpt_2015.pdf.

removed.[357] To date, however, there are no utility scale wind turbines on Pennsylvania state parks or forests. Utility wind energy developers have sought to develop on DCNR without success.



Yellow Creek State Park, Photo by: Michael Sell

In 2005, wind developer, PPM Energy, approached DCNR about developing a wind project on state land. In a formal letter from PPM to DCNR, PPM outlined some of the issues of developing on state owned land. PPM questioned DCNR's legal ability to grant a lease and also sought an exclusive lease option from the agency.[358]

DCNR then initiated an investigation into their legal authority to lease land for wind development. In a memorandum from the agency's Chief Counsel, Albert H. Masland, to then DCNR secretary, Michael DiBerardinis, Counsel addressed all policy issues associated with wind development on state lands. Such issues included:

- lack of a specific statute under Act 18 that explicitly provides authority to develop wind farms;
- broadness of an old forestry statute for "development of water power, etc" where it is unclear if wind power could be classified as 'etc'; and
- concern that revenue generated from the wind farms on DCNR land would not got back to DCNR.

Below are the details of the memorandum.

Leaseholds on State Forest Lands under Act 18:

> "Assuming there is no desire to locate farms on our State Parks (other than one or two turbines for park consumption) the focus herein will be on forest lands, for which our general mission is to manage them "to assure their long-term health, sustainability, and economic use." 71 P.S. § 1340.101(b)(1).
>
> It appears that the concept of leasing our lands for any type of alternative energy was not contemplated when Act 18 was passed. Admittedly, the goal then was to make as few changes as possible to previous

[357] Pennsylvania Sustainable Energy Board, *2009-2010 Annual Report*, 2010: 24, http://www.puc.state.pa.us/Electric/pdf/PASustainable_Energy_board_2009-10AR.pdf, accessed May 12, 2017. Note: The turbine at Presque Isle was decommissioned, according to Paul Wagner, "Presque Isle Wind Turbine to be Decommissioned and Lifeguards Moving to New Building," *Erie News Now*, last modified April 28, 2016, http://www.erienewsnow.com/story/31497587/presque-isle-wind-turbine-to-be-decommissioned-and-lifeguards-moving-to-new-building. Prince Gallitzin State Park's turbine was removed in early July 2017, personal correspondence with park staff during visit to the park, July 12, 2017.

[358] RTK request document, From Aaron Barnes, Senior Business Developer for PPM Energy, to DCNR Secretary Michael DiBerardinis, January 10, 2005.

statutes affecting our Bureaus to avoid raising legislative concerns. There are, however, numerous sections that authorize specific leases for specific subjects. For example:

- Section 1340.302(b)(3) provides a general right to grant rights of way through State forests if such a grant will not "so adversely affect the land as to interfere with its usual an orderly administration."
- Section 1340.302(b)(8) provides the authority to grant to public utility companies the privilege to construct, maintain, and operate their lines over, along and upon highways of roads that lie with or border a State forest.
- Section 1340.302(b)(9) provides that the privilege to construct antennas, towers, stations, cables and other devices and apparatus, helpful, necessary, or required for broadcasting, telecasting, transmission, relaying or reception of television may be granted. (Note, leasing land for cell towers is not clearly authorized either)

With such specificity, it will be difficult to argue that in the absence of an express prohibition on leasing state forests for windmills, the Department may proceed to do so. The legislature could have given blanket authority to grant leases and rights of way at their discretion. The absence of such authority suggests that the above examples were singled out as instances where DCNR could allow such activities to take place on its lands, while at the same time, accomplishing their overall mission. This is quite different from the placement of windmills on forest land. Although we may have stretched the statute to allow for cell towers, which, like television antennas, sit on one acre or less, the acreage required for wind turbines is significantly greater. Giver the substantial amounts of land DCNR would have to lease for a single farm, an analogy to the antenna provisions would break down quickly. In short, Act 18 does not provide the authority needed to proceed.

Separate Authority for Energy Production

Under an old forestry statute (32 P.S. § 136), which is still effective, the Department is authorized to lease land for "the development of water power, etc." Seldom does one see "et cetera" placed in a statute- its presence, coupled with several "and/ors" provide an argument to go beyond mere water power, which is the main focus of the statute. In particular, the last clause of the first sentence would permit leases "for use as sites for power houses and or transmission lines for the generation and transmission of electric energy." It could be argued that the turbines and their ancillary facilities constitute a "power house" for the generation of electricity. Admittedly, this does not constitute a clear grant of authority, but it does afford some room for argument if we decide to proceed without amending Act 18.

Revenue Generation

Unfortunately, if we proceed without a legislative grant of specific authority, we will not retain any revenue from wind farm leases, even under the old Department of Forestry statute. Therefore, whatever incentive we have for revenue generation will be lost without legislative action. It is suggested that regardless of any action taken in the near term, a long-term solution to this problem of revenue is to pursue an amendment to the recently signed action on renewable energy standards, Act 213 of 2004. As the Commonwealth requires

> utilities to ratchet up their use of alternative energy sources, the concomitant pressure on DCNR land will also increase.
>
> Finally, because the turbines have a 20-year life expectancy, the Department should ensure that there is appropriate bonding/insurance (as with any other leases) to cover the cost of removing the structures, which would consume any revenue received during the term of a lease.[359]

DCNR realized they needed to gather expert advice on wind energy in order to make sound decisions about potentially allowing development on their property. Meeting minutes from a February 16, 2005 Ecosystem Management Advisory Committee meeting (obtained through the Right to Know Act) demonstrate that wind development was a top priority for the agency: "Wind power has risen to the forefront and the Department has been inundated with requests. DCNR desires to establish criteria to guide the process of developing wind energy; and siting has been identified as the primary concern."[360]

More than a year later, in May 2006, DCNR formed the "Pennsylvania Wind and Wildlife Collaborative" group, an effort to bring in different stakeholders to determine best practices for developing wind projects on public lands. The group's first meeting was held on May 24, 2006, and included representatives from DCNR, the Nature Conservancy, the PA Game Commission, the PA Fish and Boat Commission, PennFuture, Audubon PA, Hawk Mountain, PA DEP, PA Biological Survey, AES, Community Energy, US Wind Force, Avatar Environmental, FPL Energy, Gamesa, PPM Atlantic Renewable, Clipper, UPC Wind Management, American Wind Energy Association, and EverPower Renewables. This list represents stakeholders such as environmental groups, wind industry advocacy groups, wind turbine manufacturers, wind farm developers, and others.[361]

The Collaborative developed a mission to:

> engage federal and state environmental agencies, nongovernmental conservation organizations, and the wind industry in a collaborative, consensus-based process to collect, share, review and use the best available science, data, and professional expertise to address how to best assist in the development of wind energy in Pennsylvania in an environmentally responsible manner.[362]

The goal of the Collaborative was "to develop a set of Pennsylvania specific principles, policies, best management practices, guidelines, and tools that can be used to assess risk to habitat and wildlife from wind power development and to mitigate for the impact of that development."[363]

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[359] RTK Requested Document: DCNR memorandum from Albert H. Masland, Chief Counsel to Michael DiBerardinis, January 4, 2005.
[360] Ecosystem Management Advisory Committee, Meeting Minutes-February 16 2005, Ramada Inn, State College, PA.
[361] DCNR Memorandum, TO: The Pennsylvania Wind Farms and Wildlife Collaborative, RE: Minutes of May 24, 2006 meeting, obtained at Harrisburg DCNR office.
[362] DCNR Memorandum, TO: The Pennsylvania Wind Farms and Wildlife Collaborative, RE: Minutes of June 28, 2006 meeting, obtained at Harrisburg DCNR office.
[363] Ibid.

The Collaborative group met recurrently through 2007. In June 2007, DCNR drafted a potential Wind Tract Lease Agreement for State Forest Lands. The lease was patterned after the current hard minerals, gas storage, and oil and gas leasing programs managed by the Bureau of Forestry (DCNR Department). The lease, however, was unworkable until the PA Legislature approved DCNR to lease the land for wind energy purposes.

Without proper legislation, pursuance of wind projects on state land came to a halt. Six years later, in 2013, Pennsylvania Senator John Wozniak introduced Senate Bill 684, legislation that would allow for development of alternative energy projects on state forest and game lands. More specifically:

> amending the act of May 28, 1923 (P.L.458, No.250), entitled 'An act authorizing the Department of Forestry, with the approval of the Governor and Attorney General, to lease for periods of not more than fifty years, on terms, conditions, and stipulations expressed in each lease, any portions of the State forests for dams, reservoirs, canals, pipe lines and other water conduits, power houses and transmission lines, for the development of water power, for steam raising and condensation, and for the generation and transmission of electric energy,' providing for wind, solar and other renewable energy projects. [364]

The Act would have allowed DCNR to lease state owned land for up to 50 years to different energy developers for the use of developing renewable energy projects and the transmission of electricity. The Act was passed by the committee but died in appropriations. No further legislation has been proposed to allow for the development of wind projects on state lands since 2013.[365]

[364] The General Assembly of Pennsylvania, Senate Bill no. 684, Session of 2013, http://www.legis.state.pa.us/cfdocs/legis/PN/Public/btCheck.cfm?txtType=HTM&sessYr=2013&sessInd=0&billBody=S&billTyp=B&billNbr=0684&pn=0674.

[365] "Bill Information History: Senate Bill 684; Regular Session," Pennsylvania General Assembly, 2013-2014, http://www.legis.state.pa.us/cfdocs/billInfo/bill_history.cfm?syear=2013&sind=0&body=S&type=B&bn=684, accessed October 11, 2017.

WIND ENERGY ON STATE GAME LANDS



SGL 93 with adjacent wind farm on private land in view, Photo by: Allison Rohrs

In 2005, the Game Commission developed guidelines for developing wind farms on their property. The guidelines outlined the steps wind developers should take in order to seek use of PGC property for wind energy. These guidelines were obtained through the PA Right to Know Law and are not available on their website. Below is a summary of the Game Commission's guidelines for wind development on state game lands.

1.) Developer should inquire to the Commission's Bureau of Land Management Division of Environmental Planning and Habitat Protection in Harrisburg.
2.) Request that the Commission perform an initial preliminary review of the requested property through their "Wind Energy Site Selection Questionnaire." If the proposed project could not generally comply with the Commission's duty to "protect, propagate, manage and preserve the game and wildlife of the Commonwealth", the Commission shall not support or otherwise encourage the Applicant to pursue the potential site area for a wind energy development project on the game land. It should be noted here that 16 different wind energy developers, from 2006-2011, submitted a wind energy questionnaire to develop on SGL- all 16 were denied at this point in the Game Commission's assessment. The following guidelines have never been implemented on a project, but are still important to note about the overall development process.
3.) Perform a more detailed site analysis - including a
    a. "Detailed site comparison of all potential project locations as pertaining to recently measured pertinent analytical wind/weather data.
    b. Detailed site comparisons of all potential project locations as related to surface impacts from the proposed project locations site configuration, and related infrastructure needs, accompanied by maps/diagrams
    c. Comprehensive environmental and wildlife impact analysis...and minimization efforts

d. A detailed site comparison of all potential project locations as relates to potential public benefits that would be derived from the project to include any known impacts to Federal, State, or public lands and/or natural resources and how those noted impacts would comply with any known regulations or policy governing the use of those lands for wind energy projects
e. all additional comparative analysis information as per the written request of the PGC."[366]

4.) If the site makes it through the rigorous assessments above, the Game Commission will begin negotiations of a land exchange. "The land to be exchanged to the PGC shall be deemed to be greater in aerial extent, wildlife habitat value, and recreational use potential than that of the Game Lands parcel proposed for exchange. It also requires that the land stay open to the public for hunting and other PGC use and that the PGC keep ownership of the timber, oil/gas, and mineral rights."[367]
5.) Development of a comprehensive 2 year pre-construction and 2 year post-construction monitoring proposal
6.) Annual payments per wind turbine on PGC property and additional payments based on turbine output over the lifetime of the project.[368]

Upon final review of these items, and at the sole discretion of the PGC, the agency would determine if a wind energy project would be deemed acceptable to pursue a more formal negotiation for the project's development.

According to Game Commission spokesperson, the Game Commission has received 19 formal requests from developers to develop on game lands. Only 16 of the 19 requests were available through the Right to Know request process. The Institute for Energy reviewed these 16 formal requests from wind developers to develop wind farms on SGLs. All projects were denied citing various environmental issues, most of which were addressed in the earlier section of this research.

In 2007, the Game Commission worked closely with DCNR in their endeavor to develop wind project standards for state forest and park lands. Then PGC Director of the Bureau of Wildlife Habitat Management, Bill Capouillez, was quoted as stating his biologists were strongly opposed to wind development on game lands, and although the Commission never publicly stated they would not allow development, in an e-mail correspondence between DCNR's Director of the Office of Conservation Science and then DCNR Director of Legislations and Strategic Initiatives, the PGC's lack of interest to develop wind farms was noted:

> "The Game Commission has determined that wind farms on Game Commission lands would pose a conflict with their mission and therefore will not permit their development. The protocols developed were not for Game Commission lands nor other public lands but for private lands. The public lands managed by the bureau of forestry are held in public trust to be managed for ecosystem health for now and future generations. Higher standards than those applied on private lands is fully expected and appropriate."[369]

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[366] RTK requested document, Pennsylvania Game Commission, Wind Energy Review Guidelines for State Game Lands, Submitted by William A Capouillez, Chief, Division of Environmental Planning & Habitat Protection, March 25, 2005.
[367] Ibid.
[368] Ibid.
[369] RTK requested document, DCNR, e-mail correspondence.

The protocol being discussed was the Wind Energy Voluntary Cooperative Agreement, drafted by the Pennsylvania Game Commission in 2007, and intended for wind energy development of private lands. The agreement was designed to establish "protocols that will pave the way for wind energy development to occur in a more amenable and disciplined manner that is expected to largely satisfy developers and address potential bat and bird impacts identified by the Game Commission's wildlife managers."[370] The agreement largely focuses on pre-construction monitoring of a site with respect to animal species such as raptors, bats, and other species of concern.

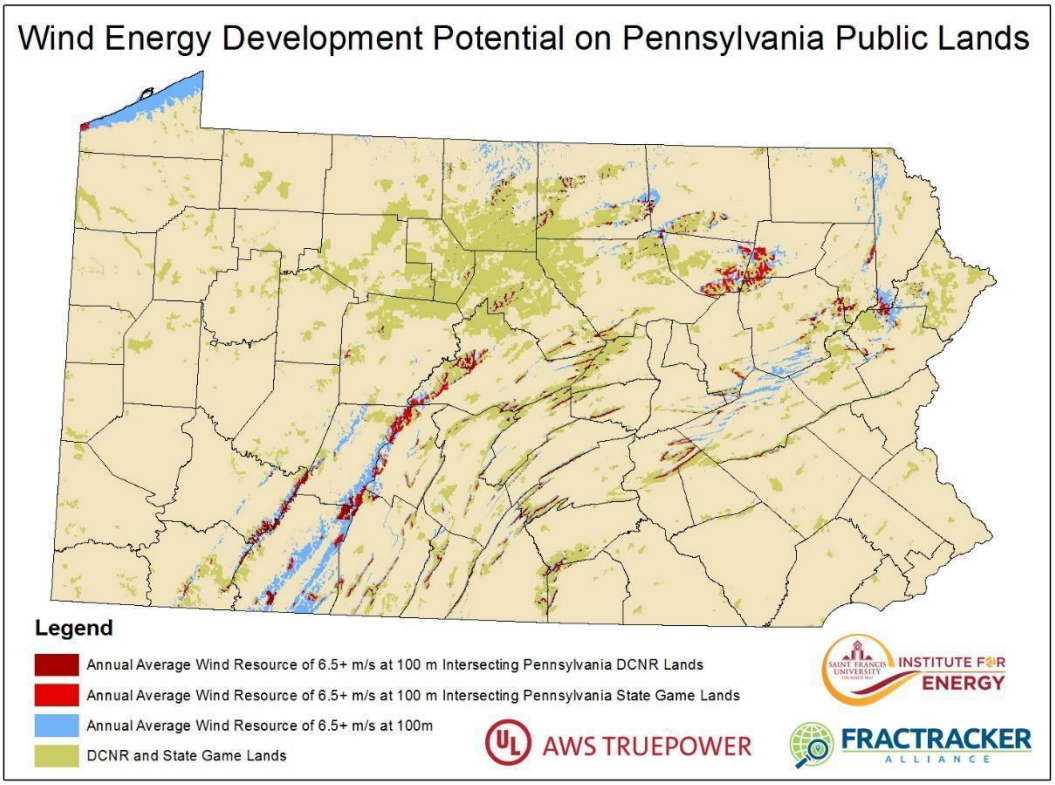
The agreement allows for very detailed monitoring and reports to be undertaken by both the PGC and the cooperators (wind developers). The annual wind energy summary report displays the usefulness of the program and documents a plethora of crucial information. Sections of the report include information on acoustic monitoring, threatened and endangered species mortality, and pre-construction raptor and bat monitoring results. These assessments help members of the agreement to better understand the footprint of wind development and also leads to new practices and innovations within the industry. With the combined effort of the PGC as well as collaborating wind developers, the Cooperative agreement aimed to develop a protocol for proposing and establishing wind farms. The Cooperative agreement was last amended in 2012 and had 33 wind industry cooperators.[371]

Potential Wind Power on Pennsylvania Public Lands

Public lands make up a considerable amount of remaining, developable wind area in Pennsylvania. Based upon SFU Institute for Energy calculations, an estimated 178,054 acres (720.6 km^2) of state game lands have a wind resource of 6.5 m/s or higher at 100 meters and are considered developable for utility scale wind from a resource availability position. An estimated 179,776 acres (727.5 km^2) of state parks and state forests have a wind resource of 6.5 m/s or higher at 100 meters. In fact, approximately 35 percent of the developable wind acreage in Pennsylvania is on public lands. The graphic below demonstrates, visually, the portion of Pennsylvania's developable wind resources that is currently off limits because it is co-located on state land:

[370] "Wind Energy Voluntary Cooperative Agreement." *Pennsylvania Game Commission*, http://www.pgc.pa.gov/InformationResources/AgencyBusinessCenter/WindEnergy/Pages/WindEnergyVoluntaryCooperativeAgreement.aspx, accessed July 21, 2017.

[371] Pennsylvania Game Commission Wind Energy Voluntary Cooperation Agreement Third Summary Report, December 2012, http://www.pgc.pa.gov/InformationResources/AgencyBusinessCenter/WindEnergy/Documents/PGC%203rd%20Wind%20Energy%20Summary%20Report%202012.pdf.



ABOUT THE MAP: Using ArcGIS and wind resource maps created by AWS Truepower, the total publicly owned land area that has a utility scale wind resource was estimated. The annual average wind resource of 6.5 m/s and higher wind resource layer was created by UL AWS Truepower for Saint Francis University. This layer was merged with the state game lands and DCNR land to demonstrate state owned lands that have a wind resource great enough to consider development of a utility scale wind project. This method was also used to estimate the total acreage of developable wind resource as well, which was calculated to be 1,035,830 acres (4,192 km^2) of developable wind resource in Pennsylvania. We define a wind resource "developable for utility scale" as an area that has an annual average wind speed of 6.5 m/s or greater at a 100 meter hub height. The resolution of each dot representing 6.5 m/s or greater wind speed is 200m x 200m. There were some locations where the entire 200m x 200m did not overlap the state owned lands. To decrease error and probability of overestimating the affected land, we created a 100m buffer and used the feature 'envelope to polygon' to make a square around the circle that corresponded to the original raster grid. Then we dissolved the layer and clipped them to match the public land layers. Also, please note that we are defining developable projects solely based on the wind resource and excluding other major development factors like utility interconnection access, environmental limitations, permitting regulations and other major issues that are important when siting a wind farm.



Wind turbine on private land (between tree trunks) as viewed from SGL 82, Photo by: Allison Rohrs

Many wind projects achieve capacity densities equal to or greater than 5 MW/ km^2.[372] Using this value, we can estimate that approximately 7,240 MW of installed wind energy capacity is currently considered undevelopable in Pennsylvania because it is located on state owned land. This is a significant amount considering that the state only has 1,369 MW of installed wind generation currently.[373] Allowing wind development on state owned land could provide significant new development opportunities.

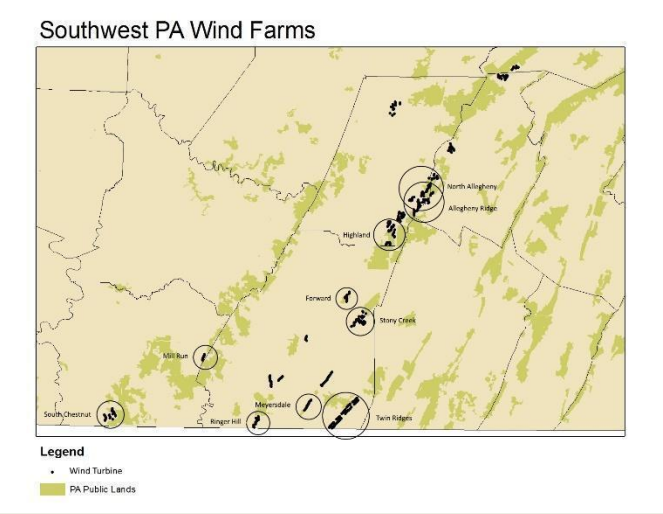
Consequently, wind farms have been built in very close proximity to state game lands, state parks, and state forests. The following are a few examples of wind farms built in close proximity to state owned land.

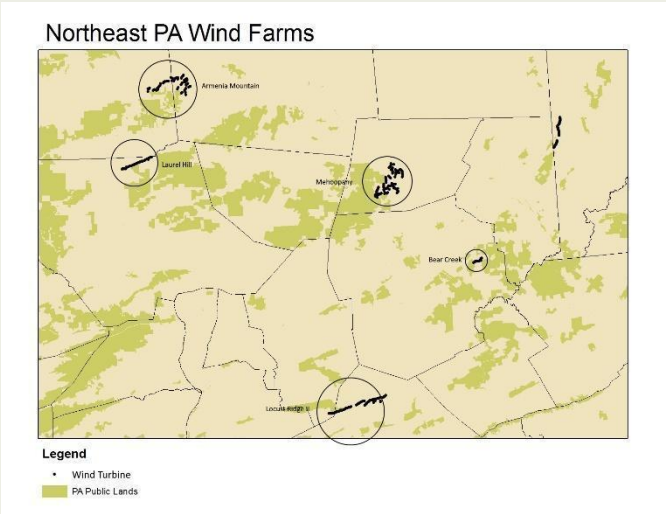
[372] Paul Denholm et al., "Land Use Requirement of Modern Wind Power Plants: NREL Technical Report," (Golden, CO: *National Renewable Energy Laboratory)*, August 2009, https://www.nrel.gov/docs/fy09osti/45834.pdf, accessed October 11, 2017.

[373] Office of Renewable Energy and Energy Efficiency, "Wind Energy in Pennsylvania," *U.S. Department of Energy*, https://windexchange.energy.gov/states/pa, accessed October 11, 2017.


Gallitzin State Forest
Highland
Wind Farm
State Game
Lands 26
State Game Lands 57
Mehoopany Wind Farm
State Game
Lands 138
Forbes State Forest
South Chestnut Wind Farm
State Game Lands 198
North Allegheny Wind Farm
Allegheny Ridge Wind Farm

Fifteen (out of 25) Pennsylvania wind farms have a wind turbine within 1000 feet of a state forest, park, or game land.





BIOMASS IN PENNSYLVANIA

BACKGROUND

Biomass is organic material, such as wood, manure, and agricultural crops. When burned, biomass provides energy that can be utilized for heating, transportation and/or electricity generation. As it can be replenished, biomass is considered a renewable energy resource. Although there is a diverse variety of biomass resources, forest wood is the most common type of biomass used for energy generation.[374]

Forests have played an important part of Pennsylvania for thousands of years. Native Americans relied upon wood for fuel and construction material. Prior to the European's arrival, it is estimated that forests covered more than 90 percent of the land. When Europeans arrived, they too utilized the wood, clearing the land for a variety of uses, including for fuel and agriculture. Unlike the natives, however, the Europeans were noted for cutting more wood than they could use.[375] In 1681, William Penn set forth a list of concessions for those settling in the state, including a condition "to leave one acre of trees for every five acres cleared, especially to preserve oak and mulberries, for silk and shipping," although this is noted for being widely ignored.[376] Carelessly set fires were a common occurrence in the Commonwealth for many years, particularly as fire laws, some of the first being established in the early 1700s, were not enforced. Education in the mid to late 1800s eventually begin to enlighten the state's citizens to the destructive nature upon which much of Pennsylvania's forests had fallen, but even in 1896, Dr. Joseph Trimble Rothrock reported that an area "equal to a strip of land one mile wide and 280 miles long" burned in Pennsylvania that year.[377]

A commission established by the Pennsylvania Legislature in 1893 to study the condition of the state's forests would result in the creation of the Division of Forestry in the Department of Agriculture in 1895. Consisting of Rothrock and W.F. Shunk, the commission prepared a report describing the economic importance of the wood industry and the impact that demand and taxation had on the timber harvest and the land. High taxation led many forest owners to cut their timber and abandon the land to avoid paying taxes. The commission calculated that only about a third of the state remained forested in the mid-1890s and encouraged better management of forestland. The report also emphasized the value that forests played in slowing water runoff, as flooding was a concern to many residents and water-related industries.[378]

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[374] Mary Booth, *Biomass Energy in Pennsylvania: Implications for Air Quality, Carbon Emissions, and Forests, (Partnership for Public Integrity, 2012), 11, http://www.heinz.org/UserFiles/Library/PFPI-Report-Biomass%20EnergyInPA_%2012-12-12.pdf, accessed May 25, 2017.*

[375] Lester DeCoster, *The Legacy of Penn's Woods: A History of the Pennsylvania Bureau of Forestry*, (Pennsylvania: Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, 1995), 5, http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20031932.pdf, accessed June 15, 2017.

[376] William Penn, "Concessions to the Province of Pennsylvania - July 11, 1681" *The Avalon Project*, http://avalon.law.yale.edu/17th_century/pa02.asp, accessed June 15, 2017.; Lester DeCoster, *The Legacy of Penn's Woods: A History of the Pennsylvania Bureau of Forestry*, 5-6.

[377] DeCoster, 28.

[378] DeCoster, 11-14.

As the first commissioner of the Division of Forestry, Rothrock begin to formulate the division into what would become the DCNR's Bureau of Forestry that exists today. He purchased 924,798 acres of land to be under state control and started an academy to train foresters. Over the years, tree planting, fire prevention, disease control, recreation, and education have been some of the responsibilities with which the bureau has been tasked.

The long-term vision set forth by Rothrock has helped to maintain and expand the amount of forestland in Pennsylvania, which now cover approximately 60 percent of the state.[379] "Over 1 billion dry tons of standing timber are in the forests," according to a 2016 report by the Pennsylvania State Wood Energy Team. The team estimates "2.4 million dry tons of wood are used annually for energy in Pennsylvania."[380] Forests located on publically owned local, state and federal lands accounted for about one fourth of Pennsylvania's total woodlands in 1995.[381]

The harvesting of timber occurs on both DCNR and PGC lands and provides funding for these departments. The DCNR individually records the end use of non-timber forest products, including fuelwood. In 2015, 8,055 cords of fuelwood were harvested, providing $167,607 in revenue.[382] A spokesperson for the Pennsylvania Game Commission Bureau of Wildlife Habitat Management reported that the Commission does not track the end use of the timber use harvested, making it difficult to determine how much, if any, of the resource may go towards energy production.[383]

Environmental Impacts

The removal of timber from forested land offers both environmental opportunities and challenges. When properly completed, wood harvesting can reduce pests, disease, and fire hazards. It can also differentiate wildlife habitat and allow for the growth of a higher quality forest.[384] At the same time, timber removal can lead to erosion, reduce food supply and habitat for animals, compact soil and cause other impacts that can be detrimental to forest health.[385] "A range of 15-30 percent of pre-harvest biomass – depending on soil type, forest composition and other factors – should always be left on site to buffer against nutrient depletion, erosion, loss of wildlife habitat and other factors," advises the DCNR in guidelines established for the harvesting of woody biomass for energy in Pennsylvania.[386] The report sets forth best management practices for the timber industry and provides general information for

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[379] Ed Dix and Seth Cassell, *Common Trees of Pennsylvania* (Pennsylvania: Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, 2014), I, http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20029752.pdf, accessed May 12, 2017.

[380] Daniel Ciolkosz and Mike Jacobson, *Pennsylvania Wood Energy Prospectus* (Pennsylvania: Penn State Extension, 2016), 14.

[381] Bureau of Forestry, *Penn's Woods: Sustaining Our Forests* (Pennsylvania: Pennsylvania Department of Conservation and Natural Resources, 1995), 6, http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20026631.pdf, accessed May 26, 2017.

[382] PA-DCNR, *2016 State Forest Resource Management Plan,* 100-101.

[383] M. DiMatteo, Chief, Environmental Planning & Habitat Protection Division, Bureau of Wildlife Habitat Management, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

[384] Ciolkosz and Jacobson, *Pennsylvania Wood Energy*, 15.

[385] Pennsylvania Department of Conservation and Natural Resources, *Guidance on Harvesting Woody Biomass for Energy in Pennsylvania* (2008), http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_20032092.pdf, accessed May 26, 2017.

[386] Ibid.

policymakers and the general public.[387] Pennsylvania's state forests are managed using Forest Stewardship Council standards, which focuses on utilizing sustainable practices.[388]

HEALTH IMPACTS

In addition to biomass harvesting having a direct impact on the forest system, the combustion of biomass material, for heating purposes or for prescribed burns for forest management, can result in various components to be released into the air, including particulate matter, nitrogen oxides, volatile organic compounds and carbon monoxide.[389] The level of pollution may vary based on the type of material burned, location, and weather, among a number of other factors.[390]

In 2009, state legislators passed the Prescribed Burning Practices Act, Act 17 of 2009, which sets forth guidelines for the use of prescribed fires by the Department of Conservation and Natural Resources and the Department of Environmental Protection. The acts states that prescribed burns "maintain specific resource values for which the areas were acquired," and "prepares sites for planting; removes undesirable competing vegetation; accelerates nutrient cycling; controls certain insect pests, pathogens and noxious weeds; and promotes oak regeneration. In these communities, prescribed burning improves and maintains the quality and quantity of wildlife habitats."[391] The act notes that the departments must "minimize the possibility that fire will escape from the desired area and minimize danger to the public and firefighting personnel from fire and smoke," taking care to "not be construed to otherwise limit the authority of the Department of Environmental Protection under the act of January 8, 1960 (1959 P.L.2119, No.787), known as the Air Pollution Control Act, and the regulations promulgated under this act."[392] The number of prescribed burns on state forest lands grew from 12 (covering 186 acres) in 2010 to 47 (covering 1,317 acres) in 2015.[393] Prescribed burns have also been conducted at state parks.[394] The PGC planned 16 controlled burns at 13 different game lands in 2017, totaling approximately 8,934 acres.[395]

Air pollution is noted for causing both short and long-term health effects, and can be particularly impactful to the elderly, children, sick and poorer members of society. "Air pollution increases the risk of respiratory and heart

[387] Pennsylvania Department of Conservation and Natural Resources, Guidance.
[388] "State Forest Management," Pennsylvania Department of Conservation and Natural Resources, "http://www.dcnr.pa.gov/Conservation/ForestsAndTrees/StateForestManagement/Pages/default.aspx," accessed October 23, 2017.
[389] Booth, *Biomass Energy, 18.*
[390] Booth, *Biomass Energy*, 18; Ciolkosz and Jacobson, *Pennsylvania Wood Energy*, 17.
[391] Act of July 14, 2009, P.L. 76, No.17, http://www.legis.state.pa.us/WU01/LI/LI/US/HTM/2009/0/0017..HTM.
[392] Ibid.
[393] PA-DCNR, *2016 State Forest Resource Management Plan*, 179.
[394] "DCNR Officials Planning Prescribed Burns in State Parks, Forestlands," *PA Department of Conservation and Natural Resources*, April 13, 2017, http://www.media.pa.gov/Pages/DCNR_details.aspx?newsid=360.
[395] Pennsylvania Game Commission, "Habitat Management," September 7, 2017, http://www.pgc.pa.gov/WILDLIFE/HABITATMANAGEMENT/Pages/default.aspx.

disease in the population," according to the World Health Organization.[396] It is estimated that each year more than 7 million people die from the effects of air pollution.[397]

Along with these health impacts, emissions from the combustion of biomass releases carbon dioxide, a greenhouse gas, into the air. In the atmosphere, this greenhouse gas traps heat. As carbon dioxide levels continue to rise, this can influence global temperature and changes in climate. Trees and other plants consume carbon dioxide and release carbon when combusted. Any excess carbon stored, or sequestered, in the plant, is beneficial in reducing the amount of carbon dioxide that can influence the greenhouse effect. When burned for energy, the stored carbon dioxide reenters the atmosphere. Some studies have shown that burning biomass releases more carbon dioxide than burning coal.[398] However, unlike with fossil fuels, new trees can be planted to consume the gases that have been released, negating the increase.[399]

Pennsylvania Biomass Policy

Biomass policy in the United States is primarily driven to increase energy independence and address environmental issues. Federal policy established in May 2017 sought to classify biomass as a carbon neutral energy solution.[400] Section 428 states that biomass will be looked at as carbon-neutral, "provided the use of forest biomass for energy production does not cause conversion of forests to non-forest use." It encourages private investment in the industry.[401]

At the state level, the Alternative Energy Portfolio Standard is noted as being a driver for biomass energy development.[402] Pennsylvania has included biomass as part of a plan to increase electricity generation by alternative energy sources to at least 18 percent by 2021.[403]

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[396] "Air Quality & Health: Questions and Answer," *World Health Organization*, http://www.who.int/phe/air_quality_q&a.pdf, accessed May 25, 2017.
[397] "World Health Assembly Closes, Passing Resolutions on Air Pollution and Epilepsy," *World Health Organization*, May 26, 2015, http://www.who.int/mediacentre/news/releases/2015/wha-26-may-2015/en/, accessed October 11, 2017.
[398] Ciolkosz and Jacobson, *Pennsylvania Wood Energy*, 29-30; Thomas Buchholz and John Gunn, "New Analysis Finds Burning Wood Pellets from U.S. Hardwood Forests Results in More Carbon Emissions than Burning Coal," *Southern Environmental Law Center*, https://www.southernenvironment.org/news-and-press/press-releases/new-analysis-finds-burning-wood-pellets accessed May 26, 2017.
[399] PA-DCNR, *Guidance on Harvesting Woody Biomass for Energy in Pennsylvania*.
[400] Anna Simet, "Omnibus Bill Policy Rider Deems Forest Bioenergy Carbon Neutral," *Biomass Magazine*, May 2, 2017, http://biomassmagazine.com/articles/14343/omnibus-bill-policy-rider-deems-forest-bioenergy-carbon-neutral.
[401] https://www.govinfo.gov/content/pkg/BILLS-115hr244eah/html/BILLS-115hr244eah.htm.
[402] PA-DCNR, *2016 State Forest Resource Management Plan,* 96-97.
[403] "About AEPS," *Pennsylvania Public Utility Commission*.

OTHER RENEWABLES

Hydroelectric

Water is constantly moving around the earth in a process known as the water cycle. This movement of water can be used to produce electricity. At a dam along a river or lake, this energy can be harnessed by pulling water downwards past a turbine, which spins a generator in the process.

While no utility-scale dams have been built specifically on Game Commission lands, several hydroelectric producing facilities are near state game lands.[404] In addition, the Commission has worked with other agencies to provide hunting access or other conservation activities around lakes, such as at the Conemaugh River Lake in Indiana County and the Muddy Run pumped-storage reservoir in Lancaster County.[405]

In 2017, Merchant Hydro Developers, LLC proposed developing pumped-storage hydroelectric facilities at 16 locations across the state, including several on or near state game lands.[406] One of the proposed projects would see the construction of a 100-acre upper reservoir and a lower reservoir of approximately 50 acres on State Game Lands 198, according to an application filed with the Federal Energy Regulatory Commission.[407]



McConnells Mill State Park, Photo by: Michael Sell

No hydropower facilities are located on state forest lands.[408] Seventy-two dams exist on state parks, according to the DCNR.[409] McConnells Mills State Park operates a gristmill from waterpower; no electricity is produced.[410] In 2016 the Pennsylvania Environmental Council received funding to analyze the potential to develop hydroelectric projects at Ohiopyle, McConnells Mill and Moraine State

[404] Review by Institute staff of large-scale hydroelectric plants and public land locations.
[405] "Conemaugh River Lake," *U.S. Army Corps of Engineers*, (Pittsburgh, PA: May 2009), http://www.lrp.usace.army.mil/Portals/72/docs/Recreation/Conemaugh1-aLGWEB.pdf, accessed September 11, 2017; "Muddy Run, Susquehanna River," Pennsylvania Society for Ornithology, http://www.pabirds.org/siteguide/PASitePage.php?SiteID=137, accessed September 11, 2017.

[406] "Tilting at Windmills? Old Coal Mines Could Play a Role in Renewable Energy," *Philadelphia Inquirer*, June 16, 2017, http://www.philly.com/philly/business/energy/tilting-at-windmills-old-coal-mines-could-play-a-role-in-renewable-energy-20170616.html.
[407] Application for Preliminary Permit Allegheny Pumped Storage Hydro Project Revised. FERC Project No. P-14820 by Merchant Hydro Developers LLC, Accessed through FERC Online eLibrary, https://www.ferc.gov/docs-filing/elibrary.asp, September 11, 2017.
[408] Teddy Borawski, Department of Conservation & Natural Resources, personal correspondence, September 19, 2017.
[409] "Penn's Parks for All: Planning for Pennsylvania's State Parks of Tomorrow," Pennsylvania Department of Conservation and Natural Resources, (Harrisburg, PA: 2017), https://pennstate.qualtrics.com/CP/File.php?F=F_9WZo6A7TsEOBZhb, accessed October 12, 2017.
[410] Park Operations & Maintenance Division Chief, Bureau of State Parks, e-mail correspondence, April 19, 2017.

Parks.[411] That same year, a micro-hydro system was installed at an acid mine drainage treatment site at Jennings Environmental Center in Butler County, providing electricity to a nearby building.[412]

Pennsylvania policy from 1923 allows for hydro development on DCNR lands:

> The Department of Forestry by the act of May 28, 1923 (P.L.458, No.250), entitled 'An act authorizing the Department of Forestry, with the approval of the Governor and Attorney General, to lease for periods of not more than fifty years, on terms, conditions, and stipulations expressed in each lease, any portions of the State forests for dams, reservoirs, canals, pipe lines and other water conduits, power houses and transmission lines, for the development of water power, for steam raising and condensation, and for the generation and transmission of electric energy.'[413]

The Alternative Energy Portfolio Standards (AEPS) Act mandates renewable energy generation in the state of Pennsylvania. According to the Pennsylvania Public Utility Commission, new and existing low-impact hydro projects are classified as Tier I sources, while large-scale hydro facilities are classified as Tier II sources.[414]

Permitting and licensing have been noted by the Pennsylvania Environmental Council as issues that have limited development of hydro resources in the state.[415] At the federal level, the Hydropower Regulatory Efficiency Act was enacted in 2013 to reduce costs and permitting requirements for smaller-scale projects.[416]

Solar

Solar energy comes to earth from the sun. This energy can be used passively (without moving parts) for space heating, such as in a greenhouse. It can also be used for water heating. Photovoltaics (PV) turn sunlight into electricity.

As of July 2017, there were 23 utility-scale (1 MW or greater) solar farms in Pennsylvania.[417] No large-scale private development of solar energy has occurred on Pennsylvania's state parks, forests or game lands. According to Pennsylvania Game Commission staff, no developers have inquired about installing solar projects on game land.[418]

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[411] Elizabeth Ingram, "Pennsylvania Studying Feasibility of Three Hydro Projects at State Parks," *Hydro World*, October 10, 2016, http://www.hydroworld.com/articles/2016/08/pennsylvania-studying-feasibility-of-three-hydro-projects-at-state-parks.html.

[412] Slippery Rock Watershed Coalition, *The Catalyst*, (Mars, PA, January 2017), http://www.srwc.org/download/Catalyst/2017/cat%2001-17.pdf, accessed May 12, 2017.

[413] Act 18, http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20033063.pdf.

[414] "About AEPS," *Pennsylvania Public Utility Commission*.

[415] Lindsay Baxter and Roger Adams, "Improving Permitting Efficiency in Pennsylvania," *International Water Power and Dam Construction*, (July 2014): 28-29. Accessed through http://pecpa.org/wp-content/uploads/Permitting-efficiency-in-PA.pdf.

[416] "FERC Conforms Its Regulations to Hydropower Regulatory Efficiency Act," September 24, 2016, http://www.hydroworld.com/articles/2014/09/ferc-conforms-its-regulations-to-hydropower-regulatory-efficiency-act.html, accessed October 12, 2017.

[417] "Electricity Data Browser: Number of Plants for Solar, Pennsylvania, All Sectors," *U.S. Energy Information Administration*, https://www.eia.gov/electricity/data/browser/#/topic/1?agg=2,0,1&fuel=004&geo=0001&sec=g&freq=M&start=200101&end=201707&ctype=map&ltype=pin&rtype=s&maptype=0&rse=0&pin=&datecode=201707, accessed October 24, 2017.

[418] M. DiMatteo, Chief, Environmental Planning & Habitat Protection Division, Bureau of Wildlife Habitat Management, Pennsylvania Game Commission, personal correspondence, August 18, 2017.

The Knouse Solar Project, operated by Knouse Food Cooperative Inc, and located in Peach Glen, PA, is located on property adjacent to the Michaux State Forest.[419] The Carlisle Area School District installed a 1 MW solar array in 2010. The 6.2 acre project is noted as being one of the largest owned by a public school system in the state.[420]



Prince Gallitzin State Park Park Office, with solar panels, Photo by: Michael Sell

DCNR installed small photovoltaic arrays at Codorus, French Creek, Lackawanna, and several other state parks in the mid-2000s for the generation of electricity from solar energy for park consumption.[421] In 2016, a 10 kW solar array was installed at Tom Ridge Environmental Center at Presque Isle State Park in Erie. "This installation marks the start of exciting and innovative things to come at our state parks," DCNR Secretary Cindy Adams Dunn was quoted as saying at the dedication of the array. The demonstration project can educate homeowners and businesses, Dunn said, while also allowing DCNR "to save money and reduce our carbon footprint."[422] Since that time, the DCNR planned photovoltaic installations at four other state parks, including a 103 kW system at Moraine State Park and a 1.74 kW array at Caledonia State Park. The projects were all scheduled for completion by early 2018.[423]

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[419]"Electricity Data Browser: Knouse Solar Project 1," *U.S. Energy Information Administration*, https://www.eia.gov/electricity/data/browser/#/plant/57412/?freq=M&pin=, accessed October 23, 2017.

[420] "Solar Power and Energy Conservation," Carlisle Area School District, http://www.carlisleschools.org/our_district/facilities_and_maintenance/solar_power___energy_conservation, accessed November 15, 2017.

[421] Jim Kalp, *DCNR Bureau of Facility Design & Construction News: Greening Parks & Forestry: Pause & Reflect*, (Harrisburg, PA: DCNR Bureau of Facility Design & Construction, February 2011), 7, http://www.panaturekids.com/cs/groups/codeasset/documents/codeasset/dcnr_20024687.pdf.

[422] "DCNR Secretary, Others Dedicate Solar Array at Tom Ridge Environmental Center, Presque Isle State Park" September 14, 2016 Press Release, http://www.docs.dcnr.pa.gov/cs/groups/public/documents/news/dcnr_20032068.pdf.

[423] Pennsylvania Department of Conservation and Natural Resources, "Sustainable Practices on DCNR Lands," http://www.dcnr.pa.gov/Conservation/SustainablePractices/Pages/default.aspx, accessed September 13, 2017.

The Pennsylvania Alternative Energy Portfolio Standards (AEPS) Act mandates renewable energy generation in the state of Pennsylvania. According to the Pennsylvania Public Utility Commission, solar photovoltaics and solar thermal systems are classified as Tier I resources. Embedded in this tier is a required .5 percent from solar photovoltaics, a .027 percent overall mandate.[424]

In 2016, the PA DEP received $550,000 in funding from the U.S. Department of Energy's SunShot program to find ways to increase the amount of solar electricity generated in Pennsylvania. The program, called Finding Pennsylvania's Solar Future, is currently formulating a plan to see what is achievable, with the initial intention of reaching 10% of the electricity that is produced in Pennsylvania coming from solar by 2030.[425]

Like with wind, there is a lack of a specific statute under Act 18 that explicitly provides authority to develop utility solar projects on DCNR lands.

Geothermal

Geothermal energy is heat in the ground. Underground, the temperature remains consistent year-round and can be utilized in different ways. In Pennsylvania, ground source heat pumps can utilize this resource for heating and cooling. A system of tubes transfers energy between ground and building, providing warmth in winter and cooling in summer.

Unlike in the western United States where electricity generation from geothermal is possible, Pennsylvania's utilization of this resource is limited to the heating and cooling of buildings. The visitor center at Middle Creek Wildlife Management Area, owned and operated by the Game Commission, received a new HVAC system that included a ground source heat pump system during renovations in 2014.[426] The DCNR's Ohiopyle State Park Office/Laurel Highlands Falls Area Visitor Center opened in 2014 and features a ground source heat pump system.[427]

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[424] "About AEPS," *Pennsylvania Public Utility Commission*.

[425] "Finding Pennsylvania's Solar Future," *Pennsylvania Department of Environmental Protection*, http://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/SolarFuture/Pages/Finding-Pennsylvania%E2%80%99s-Solar-Future.aspx, accessed October 20, 2017.

[426] "Middle Creek Wildlife Management Area," Pennsylvania Game Commission, http://www.pgc.pa.gov/InformationResources/AboutUs/ContactInformation/Southeast/MiddleCreekWildlifeManagementArea/Pages/default.aspx, accessed September 13, 2017.; "Resource" newsletter of the Department of Conservation and Natural Resources, February 19, 2014, http://www.apps.dcnr.state.pa.us/news/resource/res2014/14-0219-resource.aspx.

[427] "Ceremony Officially Opens Ohiopyle State Park Office/Laurel Highlands Falls Area Visitor Center," *Resource: Newsletter of the Department of Conservation and Natural Resources*, June 17, 2015, http://www.apps.dcnr.state.pa.us/news/resource/res2015/15-0617-ohiopylesp.aspx, accessed September 13, 2017.

Summary and Comparison of Energy Development on Pennsylvania Public Lands

Land Use Policy

The use of public lands for energy development has a long and complicated legacy. Realized and potential environmental and health impacts from energy development have led to conflicted choices and obligations by state agencies regarding land use.

Both DCNR and the Game Commission have approved oil, gas and coal mining on state lands, but denied wind development on those same lands. According to information provided by the Department of Conservation and Natural Resources, and cited in earlier sections of this report, the agency does not have the legal authority to lease state forests and parks for wind development because it is not explicitly stated in Act 18, the law that governs the agency. Oil, gas, coal, timbering, and hydropower are all explicitly approved for development on DCNR lands. DCNR has explored opportunities to change the legal language of their statute to allow wind development in the future, but no new laws have materialized.

The Game Commission, however, does have legal authority to lease the land for wind development, and has cited environmental concerns and surface use disturbance as primary reasons for not allowing development. The Commission is hypersensitive about surface disturbances of their property and has cited this as a major issue with potential wind development.

Specific examples of wind projects that were denied are found in State Game Lands 42. Three proposed wind projects by different companies were denied on this state game land. In 2006, CPV Wind LLC inquired with the Game Commission about developing on SGL 42, in 2008, PSEG Renewable Energy Generation inquired, and in 2011, RES America Development also inquired. The Commission denied all three requests citing similar reasons among all three. In the 2008 letter from PGC to PSEG Renewable Energy Generation, the following reasons for denying the wind project were cited:

1.) Critical and unique wildlife habitats comprised of deep hemlock valleys and rocky outcrops on mountaintops and valley sides. Vernal pools and spring seeps also present which provide unique and critique [sic] seasonal microhabitats.
2.) Fragmentation of existing contiguous forest and concomitant degradation of forest interior/core forest habitat for long- and short- distance neotropical migratory songbirds, upland game birds, and resident songbirds.
3.) Conflicts with a major access point to the game lands for hunting; access to Laurel Ridge Hiking trail that runs the entire length (north/south) of the game land ridge. The ridge road is also a designated route for biking and horseback riding as well as a popular snowmobile trail.
4.) Prevalent migratory flyway for raptors. Golden eagles are frequently observed by PGC staff over this game lands and Powdermill Nature Reserve has also documented golden eagles along this ridge. The forest complex supports a wide range of PA-Wildlife Action Plan listed species and the Breeding Bird Atlas confirms that broad winged hawks breed in this area.

5.) Located within Important Mammal Area #10- Chestnut Ridge/Laurel Ridge known to contain several bat species of concern (including the state listed threatened eastern small footed myotis and federally endangered Indiana bat) as well as the state listed threatened Allegheny woodrat. Active woodrat sites are present within 5 miles and several areas have been identified as potentially active within the project area; these locations are relatively well-connected for woodrat travel.
6.) Active rattlesnake denning and sunning areas present
7.) Elimination of acreage available for wildlife management/conservation, hunting, trapping and other recreational activities
8.) Several deer exclosures and forest spray blocks located within the project area where substantial monies and manpower have been expended to improve forest habitat
9.) Creation of non-huntable interior due to creation of safety zones around towers
10.) Alteration of the viewscape; ridge is a high point visible from many miles to the east and west
11.) Conflicts with currently existing [sic] approved private right of way agreement, gas well site location, and utility lines.

Oil and gas development exists on State Game Land 42. The Game Commission owns the surface and mineral rights to some, but not all, of State Game Land 42. State Game Land 42 Tract 42A-90 was originally leased to the "CNG Producing Company" on June 1, 1990. These 4,593 acres of SGL were leased for "drilling, operating for, producing, removing and disposing, of oil and gas and laying pipelines, etc" purposes, as stated in the lease agreement. The CNG Producing Company originally paid the Game Commission $241,178.43 to lease the land in 1990 and agreed to pay additional annual land rental fees and royalties based upon total oil and/or gas extracted. The lease was later amended in 1998 to further include 57.84 more acres of SGL 42. Rental and royalty payments were increased at that time as well. In review of the NRRQ for the development of oil and gas on this parcel of land, the Game Commission notes three "historical sites, scenic trails, public recreation areas, or any suspected or confirmed threatened and/or endangered species on or within close proximity to this Game Land," two that are similar to wind development: "Laurel Highlands Hiking trail: runs through parts of the areas L-79 & L-1552 (along ridge)" and "Timber rattlesnakes are found in these areas and dens are most likely located on this Game Lands." The internal review also notes that there are no ("none") potential negative impacts and states "Any and all impacts should be positive by following established standards."

To summarize, the PGC cited eleven different potential negative impacts caused by wind energy development, but when asked to describe potential negative impacts related to the natural gas project, the questionnaire lists "none."

State Game Lands 198 is an example of a coal mining project that is surrounded by wind energy. In this case, the Commission does not own the mineral rights to this mine and has legal obligation to allow mining activities on the game land. The map below depicts the North Allegheny Wind Farm constructed around the game lands. Twenty-three acres of the game land was originally leased in 1998 to Morningstar Mining Inc. for the "right of ingress, egress, and regress for the purpose of developing and removing all of the economically available coal of the Lower Kittanning and Lower Kittanning Rider coal seams from a deep mine." It should also be noted that Game Commission provided right of way access for the adjacent wind farm but denied development of turbines on the game land.



With respect to Pennsylvania public land use policy, traditional fossil fuels have successfully been developed on public lands where wind energy projects have not. Oil and gas extraction and coal mining exist in many situations where the state agencies have severed ownership of the mineral and surface rights. Authority to develop mineral resources has been legally well defined while renewable energy legislation does not exist.

Environmental Impacts on Public Lands

All energy sources have some impacts on the environments they replace. Habitat fragmentation was cited in oil, gas, coal, wind, and other renewable energy development. Oil, gas, and coal also pose threats to water quality. Air quality form active gas drilling sites is also of significant concern. Wind turbines have a clear and documented negative effect on avian and bat species. Below is a brief summary of both realized and potential environmental impacts identified on Pennsylvania public lands:

Oil and Gas Extraction

- Habitat fragmentation on lands dedicated to conservation
- The use of hydraulic fracturing fluids pose a significant threat to water supply because of their ability to reach the water supply through the many abandoned oil and gas wells on state owned lands
- Potential water contamination that is both difficult to monitor and detect due to lack of permanent dwellings and remoteness of on public lands
- 3,400 miles of streams travel through the core gas regions of Pennsylvania - including some of the best known fishing and boating waters in Pennsylvania
- Newly constructed access roads created by the oil and gas industry now provide additional roadways for timbering at no additional cost to the Commonwealth

- Access to more biological surveys, seismic data, and wetland data that can be used for conservation-information the agencies would otherwise not have

Coal Mining:

- Decreased stream quality from mining activities on land dedicated for conservation and recreation
- Land, stream and lake subsidence caused by underground coal mining that has negative effects on habitats on land dedicated for habitat conservation and recreation
- Abandoned mines create new habitats for endangered bat and threatened woodrat species

Wind Energy Development

- Potential habitat fragmentation caused by land clearing for turbines and supporting infrastructure on lands purposed for habitat conservation
- Potentially negative impact to birds and bats, especially the Indiana Bat, a federally listed endangered species
- Potential to offset carbon dioxide emissions and other pollutants

Biomass

- Erosion, reduce food supply and habitat for animals, and compacted soil during timbering, if not properly managed
- Reduction of pests, disease, and fire hazards

Energy from fossil fuels and renewable energy provide us with the modern luxuries and way of life we have come to rely on. Fossil fuels are used for heating, transportation, and to generate electricity. Wind power is only (directly) used for electricity generation. Comparing fossil fuels and renewables is a complicated task. The research in this paper focused primarily on traditional energy resource extraction from Pennsylvania public lands. It does not follow the resources downstream to examine transportation, processing, manufacturing or consumption, and all related impacts of such components of the energy industries. Consequently, positive impacts realized from using wind energy such as reduced greenhouse gas emissions and other air pollutants, are not a primary focus of this research.

In addition to environmental consequences from developing energy resources, potential impacts to human health exist also. Public access to active and abandoned energy infrastructure was observed as a health risk across all resources. Concerns about toxic contaminated surface and groundwater were observed in the fossil fuel extraction industries, but not the wind industry. The wind industry also has documented positive health effects from the offsetting of emissions known to cause health issues such as, particulate matter, nitrogen oxides, and sulfur dioxide. Below is a short summary of the identified health impacts of energy development on Pennsylvania public lands:

Oil and Gas Extraction

- Potential exposure to VOCs, diesel emissions, and other toxins in the air and in the water from active oil and gas activities on lands purposed for conservation and recreation.
- Increased vehicle traffic and traffic related pollutants and accidents on lands purposed for conservation and recreation
- Ease of public access to both active and abandoned oil and gas infrastructure

Coal Mining

- Risks associated with improperly filtering and ingesting contaminated fish and polluted water while using public lands
- Easy public access and limited surveillance of abandoned mines and dangerous pits

Wind Energy Development

- Potential risk of injury to public lands users in close proximity to turbines due to ice throw and blade/rotor failure
- Positive impacts include electrical power generated without emissions of particulate matter, nitrogen oxides, and sulfur dioxide

Biomass

- Exposure to air pollution from prescribed burns

Recommendations:

The purpose of this report was to create an informative and easily accessible document outlining how state owned lands are used, and have been used, for energy development. The report addresses the major known potential health and environmental risks associated with each type of development. The research demonstrates areas where the public land governing agencies were executing best management strategies but also identified areas for potential improvement, particularly since different energy sources are being developed that may have lesser environmental and health impacts. Below is a summary of recommendations and suggestions for future research and reporting.

Oil and Gas Development

1.) Promote (more) independent data collection on public lands, and publish all data results to public website

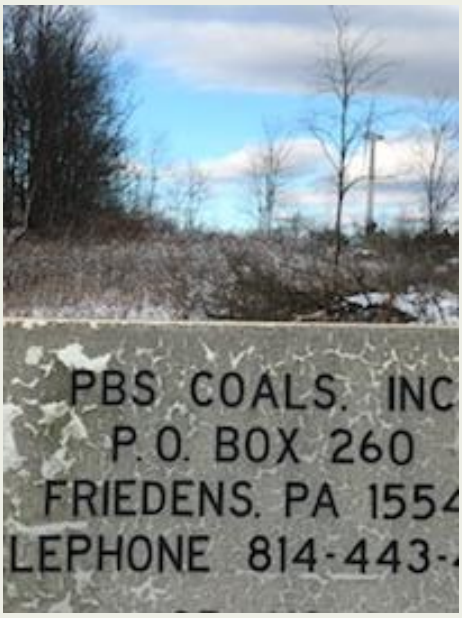
DCNR has made a significant attempt to make oil and gas development on their land transparent. Their website offers easily accessed educational documents and reports. The State Forest Resource Management Plan is a comprehensive document clearly outlining the DCNR's oil and gas management plan. The agency received nearly 4,800 public comments to the most recent 2016 draft of the SFRMP, demonstrating a commitment to keeping the public educated and informed. The 2014 *Shale-Gas Monitoring Report* provides an even more thorough management plan as well as monitoring efforts. Another *Shale-Gas Monitoring Report* is expected to be released in 2018. DCNR has also partnered with the Susquehanna River Basin Commission and installed remote and continuous monitoring sensors in state forests located in the shale gas development areas.

Although the *Shale Gas Monitoring Report* includes data collection efforts, actual data collection within the report is minimal. Although DCNR remotely monitors the streams and collects data about stream conditions, correlating stream changes with oil and gas activity would be difficult. Ultimately, the agency relies on DEP standard monitoring procedures. Allowing for more independent research with universities and/or non-partisan research groups would provide additional data and information regarding the effects of oil and gas development on state forest and park property.

The Game Commission indicates that the agency performs routine monitoring; however, none of the data is publicly reported. It is available to the public, but only through the right to know request process. To better understand the actual effects of oil and gas development on Game Commission land, including the effects on key PGC priorities such as wildlife habitat protection, hunting, and trapping, it is recommended that the Commission analyze and share the data they have collected. Additionally, it is recommended that the PGC also work with universities and/or non-partisan research groups in areas where little data and research analyses have been performed, such as oil and gas development effects on deer populations and other wildlife.

Coal Mining

1.) Collaborate coal reclamation projects with new renewable development



Stony Creek Wind Farm constructed on reclaimed mine land, Photo by: Eric Rohrs

As both agencies develop reclamation plans for legacy coal mines on their properties, they could consider partnerships with solar, wind, and hydro developers as part of their reclamation strategy. The EPA has researched these opportunities and concluded that renewables on abandoned mine lands are feasible opportunities. The EPA states:

> "Abandoned Mine Lands (AMLs) can serve as excellent locations for wind farms, as the requirements for a suitably-placed wind farm and the characteristics of AMLs are often similar to each other. First, wind farms require one critical element: a consistent and sufficient supply of wind. AMLs are often located in mountainous areas that receive consistent wind flows. Second, wind energy projects require access to large, open sites. The size of many AMLs means that large-scale wind turbines can be accommodated in one location. Third, many AMLs are located near existing infrastructure, including roads and power transmission lines. The availability of existing infrastructure can reduce project costs. As a result, while AMLs may be located in areas that are ill-suited for other commercial or industrial reuses, wind farms can be built and operated in these areas.[428]

This kind of development has already been proven in Pennsylvania. The 53 MW Stony Creek Wind Farm sits on top of an abandoned surface mine in Somerset County.[429]

2.) Improve coal mine location and tracking databases

Coal mining has negatively impacted Pennsylvania's state parks, forests, and game lands. DCNR no longer permits leases of virgin coal and now focuses strictly on reclamation projects. The PGC is still actively leasing rights for coal mining, but new mining is scrutinized. DEP is in the process of digitizing over 84,000 hand drawn coal mine maps,

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[428] U.S. Environmental Protection Agency, *A Breath of Fresh Air for America's Abandoned Mine Lands*, March 2012, https://semspub.epa.gov/work/HQ/176038.pdf.
[429] Mining Technology, "E.ON Opens Wind Farm on Old Mining Site," November 19, 2009, http://www.mining-technology.com/uncategorised/news70327-html/.

with only 30,000 completely digitized today. Additionally, Both DCNR and PGC have extremely limited coal mining data of their own. The lack of accurate site characterization data makes environmental and health impacts incredibly difficult to track. It is recommended that all three state agencies continue to work to digitize coal documents, lease information, and maps to create searchable data for future analysis.

Wind Farm Development

1.) Create a new wind energy advisory group for assessing wind development on public lands

There would be significant value in creating a new wind energy advisory group, led by the legislature, that includes stakeholders from industry, academia, government, and other agencies, to keep up with industry trends and to make informed decisions, using current and emerging best practices, about allowing development on wind farms for energy production on public lands.

Neither the PGC nor DCNR appear to recognize the evolution of the wind industry's emerging best practices relating to the latest technology, biological studies, and policy. Future wind farm development has not been pursued on DCNR land since 2013 when a house bill was proposed to create legal authority for DCNR to lease the land for wind projects. The bill was not passed. The *State Game Lands Wind Energy Review Guidelines for State Game Lands*, has not been updated since 2005, over twelve years out of date. Both agencies, at one point, had dedicated staff for wind energy development, and now do not. The Game Commission still cites barotrauma as a major bat mortality issues, but biologists now discount this theory. New research is now available demonstrating minimal risks to golden eagles, specifically in Pennsylvania.

The PGC has not released a wind energy report since 2011. Wind farms located in or around known endangered species already mitigate bat mortalities through Pennsylvania Game Commission and the U.S. Fish and Wildlife Service's best practices, such as reducing turbine cut-in speed and habitat conservation planning. Such planning and precautions could easily be applied to future wind farms developed on state game lands to reduce the impact to bat populations. Habitat restoration and best management practices could also be implemented to help avoid damage to woodrat and rattlesnake populations, similarly to how they are mitigated on privately held land. Overall, both agencies would benefit from a non-partisan redevelopment of a wind energy working group, that includes stakeholders from industry, academia, government, and other agencies, to keep up with industry trends and to make better-informed decisions about allowing development on public lands.

Biomass

1.) Create a new Biomass advisory group specific to public lands

Similar to a wind energy advisory group, it may be suitable to have an advisory group for biomass. While the DCNR does provide some end use data on fuelwood, additional tracking by the organization, along with data collection by the PGC, could provide a better understanding of the use of wood as a renewable energy source from PA's public lands.

FUTURE RESEARCH OPPORTUNITIES AND CONCLUSION

The economics, politics and technological advances within the energy industries are always changing. Although this research attempted to address all potential environmental and health impacts associated with different energy resource development on public lands, other issues may exist. As energy projects continue to be developed on public lands, future research in different areas were identified and recommended. Such future research includes:

- collecting data related to environmental violations by oil, gas, and coal development on state owned land;
- analyzing how energy development has affected state owned land, both environmentally and economically;
- obtaining more details and further investigation into the mined regions of DCNR and PGC land and obtaining detailed records of surface and subsurface ownership
- defining positive impacts of all energy producers to determine whether it would be appropriate to include wind and other renewable energy projects on public lands and whether wind energy projects on public lands would meet the requirements of the public trust
- how pipeline and electrical line development affect public lands

Energy development has historically, and continues to, play a critical role in the overall management of Pennsylvania's public lands. Development of oil, gas, coal, and biomass economically contributes to state park, forest and game land budgets. At the same time, development of these resources have both environmental and health risks unique to these special public spaces. Complicated state property laws and legal definitions continue to play a significant role in the decisions to develop (or not to) develop an energy resource on state lands. Other future opportunities for energy development include wind, solar, hydro, and geothermal resources. More work needs to be done to assess the value of including renewable resource options as part of the fabric of uses for public lands.

While this document intended to be a comprehensive review of energy development on Pennsylvania public lands, the energy industry, regulations, and politics are ever changing. We anticipate updating this document annually to include such timely information.

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About the Authors

The Saint Francis University Institute for Energy (IFE) serves as a reliable source of energy information for businesses, schools, policy makers, and communities in Pennsylvania. The Institute is committed to establishing high-quality, authentic, and accurate information to assist Pennsylvanians in making educated and sustainable energy choices.

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Cover Page Photos by: Allison Rohrs and Michael Sell