

Shale-Gas Monitoring Report

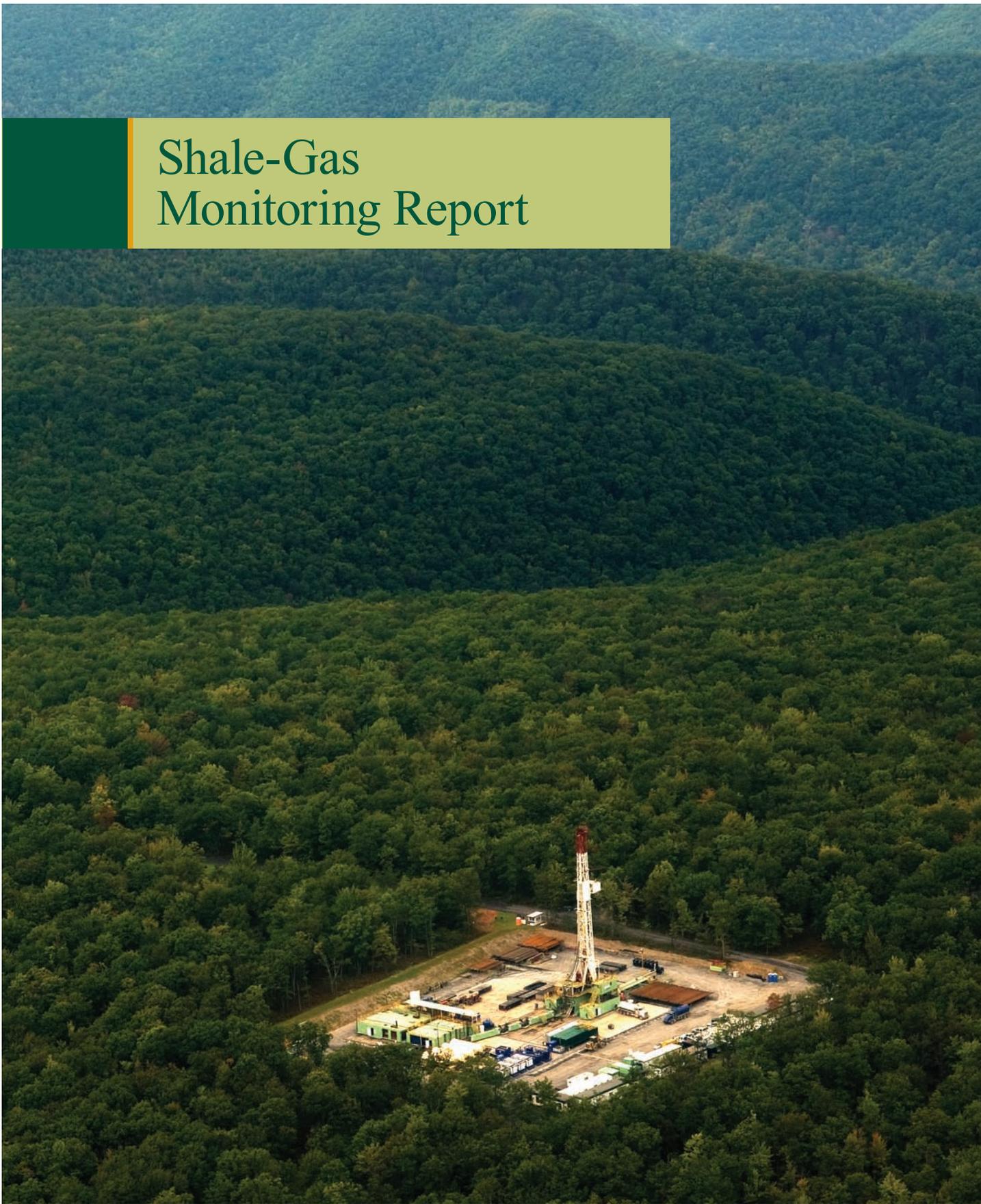


photo courtesy of Martha Rial

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[http://dcnrwebcenter.pa.gov:16200/DCNR/forestry/
NaturalGas/monitoringreport/index.htm](http://dcnrwebcenter.pa.gov:16200/DCNR/forestry/NaturalGas/monitoringreport/index.htm)



pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Preface



As scientists, we define “monitoring” as repeated measurements over time to determine trends or patterns. As managers and stewards of our forests on behalf of all Pennsylvanians, those trends and patterns inform our decisions as we balance the many uses and values of the state forest system.

This Shale-Gas Monitoring Report represents a first iteration of our measurements and is intended to represent a snapshot in time. Future reports are anticipated as more data are collected and analyzed and more trends are observed. Monitoring is a long-term effort and one that the department is committed to continue.

Most people want to be assured that shale-gas activity on state forest land is being “monitored” properly. They may have different perspectives on how monitoring is defined, but they want to know that staff members are on the ground observing and managing the activity that is occurring. I hope that the breadth and depth of this report allays those concerns and demonstrates that shale-gas production on the state forests is being carefully managed.

Monitoring helps us learn whether our management decisions are successful. We already have and continue to make adjustments based on our observations, and our management guidelines will continually be updated as more information is brought forth to inform our decision-making.

It is important to note that a broad set of values is being monitored. This is critical as limiting data collection to one or a few values may lead to misplaced conclusions. Only by viewing this activity in the broadest sense can one get a more complete picture of the various tradeoffs involved. Monitoring does not necessarily give you answers – it gives you data to inform or to be used for decision-making.

This report is not intended to impose a certain viewpoint on the reader. The intent of the report is to present information in as objective a manner as possible. Depending on one’s viewpoint, or perspective, the reader can place his or her values on the information presented in the report. For example, the addition of new roads on the state forest can be viewed as increasing access for forest visitors or viewed as diminishment of wild character, depending on one’s perspective.

Oftentimes, trends, or effects, are not evident for years or decades. Despite that, there are some findings that can be gleaned from this initial report.

First and foremost is that shale-gas production on state forest lands is neither benign nor catastrophic. There are clearly impacts and tradeoffs associated with this activity. The question is what tradeoffs are acceptable. The Bureau of Forestry considers these tradeoffs and attempts to balance the various uses and values of the forest.

Some examples:

- Water is the resource that most people cite when expressing their concerns about shale-gas production. This report describes our monitoring efforts, as well as other agencies' efforts, in some detail. Although incidents have occurred, the monitoring data show that water quality has not been affected due to this activity.
- Forest conversion and fragmentation also are often cited as concerns. The data do demonstrate that forests are being converted and fragmented, but less than originally expected. This is probably a result of the management decision 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.
- Invasive species are a concern as areas of disturbance tend to create conditions conducive to invasion by pests or unwanted species. The report clearly shows that invasive species need to be carefully managed and controlled.
- Recreational experiences and expectations vary by user. Some recreationists prefer solitude and a more wilderness-type experience, whereas others, such as motorized vehicle enthusiasts, are happy with a less primitive and more developed experience. The monitoring data show a trend from the more remote experience to a semi-primitive experience. This warrants close scrutiny in the future to ensure that a wide variety of recreational experiences are available on the state forests.

These observations are but a few that could be extracted from the report. Future iterations of the monitoring report will reveal more emerging and interesting trends. As well pads are reclaimed; impoundments are drained and converted back to forest; new well pads and pipelines are added; and new best management practices are implemented, there will be new findings and observations.

Shale-gas production on the state forest likely will continue to grow as the areas currently leased begin or continue to be developed. It is the management philosophy of the bureau to avoid this activity altogether in the most sensitive areas of the state forest. Where the activity is permitted to occur, we will strive to minimize the surface impact to the greatest reasonable extent and to mitigate for the impact whenever possible. And of course, we will continue to monitor this activity, use our observations to adjust management decisions, and report our findings periodically.

This monitoring report is the result of the hard work and effort of many dedicated staff members in the Department of Conservation and Natural Resources and specifically the Bureau of Forestry. I trust that you will find their work and this report informative.

We welcome your observations on this report and on our efforts to manage the state forests in a sustainable manner while balancing the many uses and values of these forests.



Daniel A. Devlin
*Deputy Secretary for Parks and Forestry
(Former Director, Bureau of Forestry)
Department of Conservation and Natural Resources*

Executive Summary

Introduction

The Department of Conservation and Natural Resources (DCNR) Bureau of Forestry is broadly responsible for conserving the forests of the commonwealth. One of the bureau's most significant roles is to act, in the public trust, as steward of the commonwealth's 2.2-million-acre state forest system.

Natural gas development is one of the management activities that historically has occurred on state forest land. The activity contributes significantly to Pennsylvania's economy and provides a source of domestic energy. Natural gas development, however, especially at the scale seen in the modern shale-gas era, affects a variety of forest resources and values, such as recreational opportunities, the forest's wild character, scenic beauty, and plant and wildlife habitat.

Overall, approximately 1.5 million acres of state forest are underlain by Marcellus shale. Of that acreage, 44 percent (673,000 acres) is available for gas development either through bureau-issued leases (386,000 acres) or severed lands development (287,000). Modern shale-gas leases restrict surface disturbance in sensitive areas and limit overall surface disturbance to approximately 2 percent of the acreage within the lease tract.

photo courtesy of Martha Rial





Given the host of potential impacts of shale-gas development to the state forest system and its associated uses and values, the bureau has established a Shale-Gas Monitoring Program to track, detect, and report on the impacts of the activity. The program aims to provide objective and credible information to the public and inform and improve shale-gas management efforts. The bureau's Shale-Gas Monitoring Program was initiated in late 2010, when the bureau was authorized to hire a dedicated monitoring team of 15 staff members. The program began full implementation in 2011, when the bureau completed staff hiring, met with advisory committees, and began developing monitoring protocols and building a variety of internal monitoring tools.

The bureau takes a three-tiered approach to its monitoring, recognizing that an effective, long-term monitoring program must be multifaceted. These tiers include: 1) an integrated and dedicated Shale-Gas Monitoring Team; 2) related forest resource monitoring and on-the-ground management activities; and 3) research and external partner collaboration. These tiers form the foundation for the bureau's shale-gas monitoring effort.

An essential function of the Shale-Gas Monitoring Program is to regularly compile and analyze its data and findings. This first report is also an opportunity to communicate basic information about the bureau's monitoring program and its plans for future monitoring efforts.

Monitoring Values

To help guide its monitoring program, the bureau devised a suite of "monitoring values." These values, developed with input from its advisory committees, help focus monitoring efforts on values that relate to the sustainability of the state forest system, the impacts of natural gas drilling on state forest to stakeholders and communities, and the bureau's mission. The values follow with key points and findings:

Infrastructure

Natural gas exploration and development can cause short-term or long-term conversion of existing natural habitats to gas infrastructure. The footprint of shale-gas infrastructure is a necessary part of shale-gas development; however, the bureau attempts to manage this infrastructure to reduce surface disturbance and minimize impacts to other state forest uses and values.

Key points and findings include:

- Approximately 1,486 acres of forest have been converted to facilitate gas development in the core gas districts (state forests subject to shale gas development), including roads, infrastructure and well pads and pipelines. During the same time period (2008 to 2012), the bureau acquired 33,500 acres to add to state forest system, including 8,900 acres in core gas forest districts.
- One hundred and sixty-one total miles of road have been improved or constructed for shale-gas development in the core gas districts. Of these, 131 miles of state forest roads that existed prior to the shale-gas development have been improved or upgraded for gas development activities, and 30 miles of new roads have been constructed for gas development activities.
- One hundred and ninety-one infrastructure pads have been constructed to facilitate shale-gas development in the core gas forest districts.
- One hundred and four miles of pipeline corridor have been constructed or widened in the core gas forest districts.

Flora (Plants)

The bureau oversees the protection of Pennsylvania state-listed native wild plants on state forest lands by reviewing proposed shale-gas development projects and advising bureau managers on the best means to avoid impacts to rare plant species and communities.

There are four main components of the plant monitoring program, including: evaluating vegetation communities immediately adjacent to shale-gas development; monitoring tracts subject to shale-gas development for non-native, invasive plant species; assessing rare plant populations and important wetland habitats; and conducting vegetation inventories in areas of potential future shale-gas extraction.

Key points and findings include:

- A majority of forest conversion for the construction of gas infrastructure on state forest lands occurs in the dry oak-heath community type.
- In undisturbed forest habitat surrounding pads, New York fern (*Thelypteris noveboracensis*) and hay-scented fern (*Dennstaedtia punctilobula*) had the highest average percent cover in the understory, with 31.2 percent and 31.0 percent cover, respectively.
- The most prevalent species in areas around the edges of pads re-vegetated with erosion and sedimentation control seed mixes were *Festuca* species, with 19.2 percent average percent cover, Orchardgrass (*Dactylis glomerata*, 16.0 percent), and red clover (*Trifolium pratense*, 14.2 percent).

Forest Health

The bureau promotes programs to improve and maintain the long-term health and biodiversity of forest ecosystems. The bureau evaluates biotic and abiotic factors affecting the health of trees and woodlands, utilizes integrated pest management techniques to mitigate the effects of destructive agents, and promotes forest health to the public.

Key points and findings include:

- The bureau participates with the USDA Forest Service in the Forest Health Monitoring Program, a national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis.
- The principal damage-causing agents from 2008 to 2012 in the core gas forest districts were gypsy moth, forest tent caterpillar, and frost.
- Impacts to the forest surrounding disturbance can only be discovered through long-term forest health monitoring.

Invasive Species

The development of shale-gas resources on state forest lands has the potential to increase the spread of nonnative invasive species. The bureau works cooperatively with the Pennsylvania Invasive Species Council, the Pennsylvania Department of Agriculture, the U.S. Department of Agriculture, and other state agencies and organizations to coordinate efforts regarding invasive species.

Key points and findings include:

- Eleven non-native invasive plant species were present at 14 of 18 representative pads across core gas forest districts. The invasive plant with the largest mean population size was Japanese stilt-grass (*Microstegium vimineum*).
- Increased susceptibility to pest attack, especially by nonnative invasive species, may occur wherever there is forest disturbance, especially for trees along newly created edges. However, impacts in the surrounding forests can be discovered only through long-term forest health monitoring.

Water

Numerous methods are employed by the bureau to sample and analyze water resources within the core gas forest districts, with an emphasis on water quality of surface waters. The present focus is surface water

quality because this forest system value is of critical concern to stakeholders, could be impacted by shale-gas development, and can be readily and cost-effectively assessed.

Key points and findings include:

- The majority of streams in the core gas forest districts (71 percent) are first-order, headwater streams.
- The majority of streams in the shale-gas region (87 percent) are classified as high quality or exceptional value by the DEP, and many streams are identified as having naturally reproducing trout populations by the Fish and Boat Commission.
- A widespread sampling of field chemistry, including over 300 locations, showed that pH results were primarily in the circum-neutral range, with 72 percent of results between 6.5 and 7.5 and a median pH of 7.01.
- A widespread sampling of field chemistry showed that 91 percent of specific conductance results were below 100 microsiemens(μ S)/cm, with a median of 41.3 μ S/cm.
- Initial water monitoring results have not identified any significant impacts due to shale-gas development. This is based on one round of field chemistry sampling throughout the shale-gas region and over a year of operation for 10 continuous monitoring devices in key watersheds. At this early stage, the data collected are primarily for establishing baseline conditions.
- Future monitoring efforts include longitudinal surveys of field chemistry, surface water grab sampling, installation of continuous monitoring devices, and an assessment of pipeline-stream crossings.

Soil

Shale-gas development often involves earth disturbance activities that require careful planning and oversight to minimize negative effects on soil quality. Soil resource management and monitoring is achieved in collaboration with DEP. Regulation of earth disturbing activities falls within DEP's jurisdiction. The bureau helps to monitor for problems relating to erosion and sediment control and reports issues to DEP.

Key points and findings include:

- To the extent possible, placement of shale-gas infrastructure has avoided wet soils and soils with high runoff potential.
- Of all pads, impoundments, and compressors constructed, over 85 percent were on well-drained to excessively well-drained soils, and over 80 percent were on soils with medium to very low surface runoff index.
- Of all pipelines constructed, over 70 percent occurred within well-drained to excessively well-drained soils and within soils with medium to very low surface runoff index.
- Of all roads newly constructed or improved due to shale-gas development, over 80 percent occurred within well-drained to excessively well-drained soils and within soils with medium to very low surface runoff index.
- Future research and monitoring will focus on the effects of well pad construction on soil physical and chemical properties, as well as the effects of best management practices on hydrology and sediment loads.

Air

Shale-gas development involves many stages that provide different avenues for the release of air pollutants. Although shale-gas development may emit various pollutants, the natural gas produced through shale-gas development also has the potential to create an overall positive effect on air quality.

The bureau is not conducting air quality monitoring. The bureau relies on DEP to assess potential effects of air emissions from the shale-gas industry and to require applicable air permits of shale-gas operations.

Key points and findings include:

- Since shale-gas development began in Pennsylvania in 2008, there has been a marked decrease in several major air pollutants, such as sulfur, nitrogen oxides, and carbon dioxide. This is due, in part, to the

increased use of natural gas for power generation, the shutdown of several major facilities, and the installation of air pollution control equipment.

- Short-term air sampling at several locations around the state has detected natural gas constituents and associated compounds in the vicinity of shale-gas operations. These compounds were not detected at concentrations that would likely cause health-related impacts, although some were detected at levels which would produce an odor.
- A one-year study is under way in southwest Pennsylvania to study the potential long-term and cumulative effect of air emissions from compressor stations and a major processing facility. A study is also under way to examine the concentrations of ground-level ozone in the vicinity of shale-gas operations.
- A short-term air quality study in Ramsey Village, in Lycoming County along the Pine Creek Rail Trail, did not detect air pollutants above rural background conditions.

Incidents

Incidents occurring on state forest lands related to shale gas development are recorded by both DEP and the bureau. DEP tracks incidents that are investigated involving violations of state environmental laws and regulations. Additionally, the bureau's Incident Reporting System records more general incidents in a variety of categories that occur on state forest land.

Key points and findings include:

- From 2008 through 2012, DEP investigated 324 incidents on state forest land, resulting in 308 notices of violations (NOVs).
- From July 1, 2009, through 2012, 264 incidents in 50 different categories were reported through the bureau Incident Reporting System across all state forest districts directly related to gas development activity.



Fauna (Wildlife)

State forest lands are an important source of food, cover, water, and space for wildlife, which are critical components of ecosystems. The bureau manages forested habitat, ensuring that natural biological communities can thrive. The bureau will base wildlife monitoring efforts on habitat and certain indicator species. The bureau will focus on habitats adjacent to gas development, along with restored gas infrastructure areas. Monitoring efforts will focus on well pads, roadsides, pipeline rights of way, wetlands adjacent to development, forest interior areas near gas infrastructure, and reclaimed or reforested areas.

Key points and findings include:

- Wildlife habitat will change due to shale-gas infrastructure, resulting in more edge and early successional habitat.
- The bureau is monitoring the positive and negative impacts of shale-gas development on wildlife communities to better understand their long-range implications and steps that can be instituted to avoid and mitigate negative impacts.
- The bureau is in the early stages of developing its wildlife monitoring protocols. The bureau will focus on monitoring changes in habitat conditions in relation to shale-gas development.

- Through its monitoring program, the bureau is funding multiple research projects to advance the understanding of the impacts of shale-gas development to wildlife species, such as interior forest birds and timber rattlesnakes.

Recreation

Gas development includes extensive infrastructure that requires careful siting to minimize impacts to recreational features. New infrastructure can affect wild character and viewsheds. Noise-generating activities may affect visitor experience. Roads, well pads, pipelines and other shale-gas infrastructure also can affect snowmobile and hiking trails. At the same time, opportunities to enhance recreational trails and experiences can be realized through new shale-gas infrastructure.

Key points and findings include:

- No national hiking trails in Pennsylvania have been impacted by shale-gas development. Three designated state forest hiking trails have been impacted.
- Statewide, since 2006, there has been a 5 percent increase (145 miles) in total snowmobile trail miles across the state forest system. This is the result of a 203-mile decrease in joint-use trails and a 348-mile increase in designated snowmobile trails.
- Snowmobile trail systems have been impacted in each of the core gas forest districts. New snowmobile trails have been created to replace impacted snowmobile trails.
- 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.
- The impact of shale-gas development on recreational experience and wild character as measured by the Recreation Opportunity Spectrum is a 9,341-acre increase in semi-developed and developed acreage; a 913-acre decrease in semi-primitive acreage; an 8,409-acre decrease in semi-primitive non-motorized acreage; and a 19-acre decrease in primitive acreage.



- Initial measurements at six out of the seven operating compressor stations measured on state forest lands were louder than the 55db(A) suggested by the updated *Guidelines for Administering Oil and Gas Activity on State Forest Lands*.
- Forty-six out of 116 comment card respondents in core gas forest districts indicated that Marcellus activity had changed their visitation experience. Forty-one out of 116 respondents indicated that Marcellus activity had changed their recreational use of the state forest.

Community Engagement

Natural gas development on state forest lands has potential economic and social effects on local communities. The bureau interacts with local communities through the implementation of its public participation policy, which includes public education and participation as an integral part of the management of state forest lands.

The components included in the community engagement section of this report are advisory committees, gas tours on state forest land, and focus groups.

Key points and findings include:

- Natural gas development on state forest lands has potential economic and social effects on local communities.
- The bureau uses advisory committees to promote stakeholder feedback and produce recommendations.

- Outreach offers valuable opportunities to demonstrate how natural gas activity is conducted and managed on public lands and has become a source of understanding public perceptions.
- Focus groups have been designed to identify and understand the social effects on communities resulting from natural gas development on state forest lands. One pilot focus group targeting community leaders in Pine Creek Valley was conducted in November of 2013. Two additional groups targeting government leaders in Tioga and Clinton counties were conducted in 2014.

Timber

One of the purposes for the creation of a state forest system was to provide a continuous supply of timber, lumber, wood and other forest products. According to the bureau's strategic plan, state forest lands should provide a sustained yield of high-quality timber consistent with the principles of ecosystem management. In relationship to shale-gas management, the bureau will monitor the impacts to silvicultural practices, timber sales, distribution and placement, logging access, and revenues.

Key points and findings include:

- Initial analysis shows that some timber management activities in core gas forest districts may be shifting away from areas leased for shale-gas development. Some of this change, however, may be due to gypsy moth salvage harvesting.
- The effect of shale-gas development on timber harvest placement and harvest allocation goals is inconsistent across core gas forest districts. More information and data are needed to discern reliable trends.
- Shale-gas development is indirectly decreasing timber harvest revenue due to Route 44 bonding costs resulting from heavy hauling associated with shale-gas development.

Energy

The modern energy mix within the United States today consists chiefly of five energy sources: oil or petroleum, natural gas, coal, various renewable energy sources,

and nuclear energy. The second-largest portion of U.S. energy usage is derived from natural gas or methane at approximately 25 percent of all consumption. Natural gas is a fuel of choice for heating and industrial processes and electrical production where available in large quantities at a competitive price. Natural gas can be expected to gain market share over time and may gain the majority of new national energy consumption that arises from normal annual energy need increases.

Key points and findings include:

- Approximately 15 percent of all shale gas produced in Pennsylvania comes from state forest lands. This gas is sold and distributed across the eastern and midwestern United States to service energy markets on a daily basis.
- Natural gas in the United States is an open-market traded commodity that has seen the price per product unit fall from a high of approximately \$10 per Mcf (1,000 cubic feet) in 2010 to the current (end of 2013) \$4.75 per Mcf as a direct result of Pennsylvania shale gas coming onto the market grid and forcing gas prices to moderate with respect to the gas supply.
- On state forest land, the number of wells per pad ranges from one to ten, with approximately four to eight wells being the average. A typical well drains approximately 100 acres, but that figure can be less or greater depending on a number of factors.
- The bureau anticipates that approximately 3,000 gas wells may be drilled on state forest lands to fully develop the current leased acreage on commonwealth gas leases, on which approximately 568 had been drilled by the end of 2013. A portion of these new wells will be drilled on existing well pads.
- State forest lease tracts targeting shale gas are estimated to be approximately one-fifth developed. This, however, is only a projection, as future energy development patterns are difficult to accurately predict and depend on market conditions and the performance of individual tracts.

Revenue

Since the first leases in 1947, the development of natural gas resources on state forest land has generated a steady and increasing revenue source for the commonwealth in the form of rents and royalties. The data presented have been tracked and tabulated by the bureau since 1947.

Key findings and points include:

- The pre-shale-gas period of oil and gas activity provided a total income to the commonwealth of approximately \$153,659,522. The shale-gas period (through 2012, for the purposes of this report) has provided \$582,250,644 in revenue. The combined total of all revenue from the oil and gas lease program from 1947 to the end of 2012 has been approximately \$735,910,166.
- The influx of shale-gas production revenue began in 2009 when most of the wells that had been first proposed in 2007, 2008, and early 2009 were drilled and connected to the pipeline system and gas was delivered to the market.
- Royalty income is just beginning to come to DCNR from the hundreds of new shale-gas wells on state forest land.
- Steady revenue growth from gas extraction is expected to continue for the next decade as the full development of the leases comes to a conclusion.

Forest Landscapes

Approaches to forest management must take into account not only the direct impacts of various activities, but also the cumulative, landscape-level impacts of these activities over time. Landscapes are contextual in nature, and thus there is no firm definition of what constitutes a “landscape” in a forested setting. This chapter, however, attempts to address certain forest values and impacts of shale-gas activities across the greater forested land base. This initial report focuses on the landscape-level impacts of shale-gas development to forest conversion, the value of “wild character,” forest fragmentation, and restoration.

Key points and findings include:

- Approximately 1,486 acres of the 2.2-million-acre state forest system have been converted to facilitate shale-gas development. During the same time period (2008 to 2012), the bureau acquired 33,500 acres to add to state forest system, including 8,900 acres in the core gas forest districts.
- One assessment of the current impact of gas infrastructure on wild character, using the Recreation Opportunity Spectrum as a measurement tool, is a 9,340-acre increase in semi-developed and developed acreage. Correspondingly, there was a 912-acre decrease in semi-primitive area, an 8,409-acre decrease in semi-primitive non-motorized area, and a 19-acre decrease in primitive area.
- In core gas forest districts, the bureau’s forest fragmentation analysis showed the largest increases in edge forest in Tiadaghton State Forest (1,813 acres) and Tioga State Forest (1,257 acres). Overall, core gas forest districts added 4,355 acres of edge forest.
- In the core gas forest districts, there was a loss of 9,242 acres of core forest greater than 200 hectares. Core forests are large parcels of interior forest not affected by roads, pipelines, well pads, and other infrastructure.
- Elk, Moshannon, and Tiadaghton state forests have had a combined total of 10 well pads that have been partially reclaimed by reducing the pad size and replanting the adjacent areas with vegetation. No gas infrastructure sites have received full ecological restoration.

Partner Monitoring

Susquehanna River Basin Commission

(Remote Water Quality Monitoring Network)

The Susquehanna River Basin Commission (SRBC) is a federal, interstate commission that guides the conservation, development, and administration of water resources of the Susquehanna River basin.

In response to increased levels of shale-gas development in the Susquehanna River basin, SRBC established its Remote Water Quality Monitoring Network (RWQMN) for real-time, continuous monitoring of field chemistry parameters. The RWQMN is intended to help SRBC and its stakeholders develop a baseline characterization of water quality in the shale-gas region and monitor for potential changes in water quality due to shale-gas development.

In November 2009, SRBC announced it was seeking partners with whom it could expand its RWQMN to rivers and streams remotely located in the northern tier of Pennsylvania. In 2010, the bureau provided \$280,000 from the Oil and Gas Lease Fund to SRBC to purchase monitoring equipment and for subsequent operation and maintenance costs. This funding source allowed for the establishment of 10 monitoring stations.

The bureau selected sites on state forest that were expected to experience shale-gas development and aid in the collection of baseline water quality data. It also selected areas where private shale gas development borders state forest and which DEP designated high quality or exceptional value streams.

Forest Certification

Pennsylvania state forests are certified (FSC® C017154) under Forest Stewardship Council™ standards. Timber harvested from Pennsylvania's state forests are FSC certified to ensure that the chain of custody from the forestland to the mill can be continued and that products are coming from forests managed in an environmentally responsible manner.

Third-party audits are conducted annually to ensure that state forests are managed in compliance with FSC® standards. Every five years, a comprehensive re-certification audit is conducted, followed by four annual surveillance audits. Results of these audits are included in reports to reflect the focus of the audit and to outline any areas for needed improvement.

In 2010, an audit with an intensified focus on shale-gas activities was conducted. In 2013, the bureau underwent a comprehensive five-year re-certification and was issued a new certificate with no major corrective action requests issued.

Since 2008, there have been four corrective action requests and six observations made related to the recent shale-gas activity and management. A summary of those findings by the auditors is listed in the report.

Research Partnerships

The bureau regularly seeks partnerships and cooperates with projects that advance the goals of its shale-gas monitoring program. These research projects are part of the bureau's overall monitoring approach, and help address specific questions and issues with a greater degree of scientific vigor and certainty. Research partnerships also help the bureau address management issues and questions with additional expertise and resources. The projects listed in this section will be completed in 2014 and 2015, and represent the bureau's initial round of research projects related to shale-gas development on state forest lands.

The following are research projects currently funded by the bureau's Shale-Gas Monitoring Program:

- Evaluating Storm Water and Erosion and Sedimentation Control Measures Associated with Shale-Gas Infrastructure in Forested Landscapes
- Quantifying Soil and Landform Change Across Shale-Gas Infrastructure in Northern Pennsylvania
- Quantifying the Cumulative Effects of Multiple Disturbance Regimes on Forested Ecosystems in Northern Pennsylvania
- Effects of Natural Gas Pipelines and Infrastructure on Forest Wildlife
- Assessing Potential Impacts of Marcellus and Utica Shale Energy Development on the Timber Rattlesnake (*Crotalus horridus*) in North Central Pennsylvania