

# The Landscape Corridor of PA Route 6

Its dynamic nature and Interventions of the Marcellus Shale gas industry

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MLA Capstone Project

## Contents

Abstract.....	4
Introduction .....	5
1 US Route 6 in Pennsylvania.....	6
1.1 Historic Route 6.....	6
1.1.1 About Route 6 .....	6
1.1.2 Pennsylvania’s industrial growth and transit infrastructure .....	9
1.2 Scenic byways.....	10
1.2.1 Importance of scenic byway program .....	10
1.2.2 Rt. 6 as a Pennsylvania Scenic Byway .....	10
1.3 Rt. 6: as a connecting corridor .....	11
1.3.1 Points of interest: Northern tier of Pennsylvania.....	12
1.3.2 Rt. 6: Connecting Communities .....	15
1.3.3 Rt. 6: A tourism experience .....	16
2 Marcellus Shale.....	17
2.1 Shale gas development in the Marcellus region and around the world.....	17
2.2 Impacts of Marcellus Shale .....	19
2.2.1 Impacts on forested land and habitats .....	20
2.2.2 Impacts on Water .....	22
2.2.3 Impacts on community .....	22
2.2.4 Impact on tourism.....	24
2.2.5 Impact on transit infrastructure .....	25
2.3 Pennsylvania Act 13 .....	28
2.3.1 About PA Act 13 .....	28
2.3.2 How does it work? .....	28
3 Spatial Analysis.....	30
3.1 Rt. 6: Land.....	30
3.1.1 Forested land cover .....	30
3.1.2 Impervious land .....	30
3.2 Rt. 6: Water resources.....	32
3.2.1 Forested wetlands and streams.....	32

3.2.2	Water based recreation .....	33
3.2.3	Water trails and impervious land .....	34
3.3	Rt. 6: Communities .....	36
3.4	Rt. 6: Tourism .....	37
3.5	Rt. 6: Transit infrastructure .....	38
4	Design and Planning Guidelines.....	39
4.1	Addressing specific issues .....	39
4.1.1	Forested land and habitats .....	39
4.1.2	Water .....	39
4.1.3	Community.....	39
4.1.4	Tourism and recreation.....	40
4.1.5	Designation as a scenic byway.....	41
4.2	A Design Implementation.....	42
5	Conclusion .....	47
6	References .....	47

## Abstract

This research investigates the functioning of US Route 6 in Pennsylvania as a landscape corridor and how that may be impacted by the recent shale gas developments in the Marcellus region. Route 6 is a transit corridor that holds immense historic and cultural significance to the residents of the commonwealth as well as visitors. The dependence of industries including the recent shale gas industry has caused the way it functions to change. Moreover, such a change has led to disturbances on the landscape in terms of natural resources like land, water, forests and habitats as well as cultural resources like local communities and tourism or recreational potentials. The methods of research includes a study of literature to establish the significance of Rt. 6 in PA and then conducts spatial analysis via map overlays in GIS to understand how the shale gas developments may impact the way this historic corridor functions. The findings will provide necessary clarity on the actual impacts due to Marcellus Shale and help devise guidelines for the industry's sustainable development in the future ensuring the environment stays protected.



Figure 1: Shale gas extraction pad near Susquehanna River

Source:

[http://www.pennlive.com/midstate/index.ssf/2011/08/marcellus\\_shale\\_drilling\\_to\\_bl.html](http://www.pennlive.com/midstate/index.ssf/2011/08/marcellus_shale_drilling_to_bl.html).

Photograph: Donald Gilliland. The Patriot-News. 2010

## Introduction

In landscape ecology, a corridor is defined as a linear area of a particular land cover type that is different in content and physical structure from its surroundings. Different types of corridors ranging from riparian or river corridors, to canals within an agricultural landscape, to interstate highway systems, serve multiple functions in various dynamic natural and socio-cultural ecosystems. US Route 6, also known as the Grand Army of the Republic Highway is a transit corridor stretching from Provincetown, Massachusetts in the east to Bishop, California in the west. Apart from serving as a crucial connection between historic towns and pristine landscapes of Pennsylvania, Rt. 6 is also an integral part of the commonwealth's unique cultural identity. However, the recent shale gas developments in the Marcellus Region have raised concerns regarding wellbeing of Pennsylvania's social, economic, natural and cultural processes, thereby posing a potential threat to its identity. Many frown upon the industry with apprehension of altering physical landscapes and socio-economic relationships. Since cultural and physical corridors connect parts of the landscape and enable dynamic interactions, concern has also been raised towards their effective functioning. This research looks at Rt. 6 as a transit and a cultural-landscape corridor which holds these elements together, and investigates how the shale gas industry activities currently or may potentially hamper its functioning as a dynamic entity. US Route 6 in Pennsylvania is a transit corridor that holds immense historic and cultural significance to the residents of the commonwealth as well as visitors. The dependence of energy industries including the recent shale gas industry has caused the way it functions to change. Moreover, such a change has led to disturbances on the tangible attributes of the landscape like land, water and habitats as well as cultural resources like local communities and tourism or recreational potentials. This research investigates the ways this highway has functioned as a dynamic entity in itself and as a corridor that connects different parts of the commonwealth including historic towns, ecologically significant zones as well as shale gas operation locations and seeks answer to the vital question of how the shale gas developments might have changed the way this corridor functions and has been an integral part of Pennsylvania's tourism and recreational experience. In doing so I look at the corridor of Rt. 6 and its surrounding areas. The research covers the northern tier of the Pennsylvania which includes the twelve counties, the corridor and surrounding natural and cultural resources which contribute to the corridor's significance.

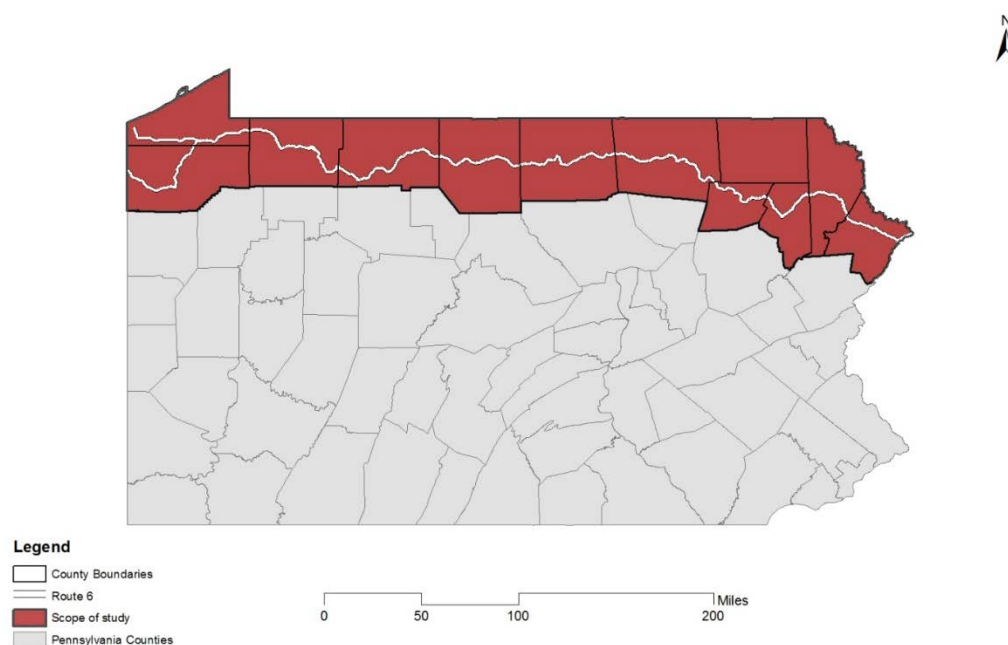


Figure 2: Scope of study

The following study is presented in four distinct sections. First, I have described Route 6 and its historic development in Pennsylvania, emphasizing how along with other transit infrastructure facilities it has been an integral part of the historic and industrial growth of the commonwealth. Second, I have introduced the Marcellus shale gas development briefly and then discussed its impacts on the landscape, both in terms of physical attributes like land and water as well as cultural attributes like communities and tourism and recreational potentials in the northern tier. Third, I have studied the US Route 6 along with other related attributes of the northern tier of Pennsylvania and elements related to shale gas industry through mapping using GIS. In this section the spatial proximity of potential threats to the resources in the study area has been focused. Finally in section 5, I will offer design and planning recommendations and suggest guidelines with a view to promote sustainable growth of the shale gas industry as well as conserve the landscape corridor of US Route 6.

## 1 US Route 6 in Pennsylvania

### 1.1 Historic Route 6

#### 1.1.1 About Route 6

US Route 6 is a federal highway running across the United States of America from Provincetown, Massachusetts in the east to Bishop, California in the west (See figure 3). It started as a small stretch between Provincetown and Brewster, New York, but in 1937 it was extended to a length of 3652 Miles thus making it the longest US highway then ([www.route6tour.com](http://www.route6tour.com) 2001). After 1960 highways in California were renumbered, which brought down its length to its current length of 3205 Miles ([www.us-highways.com](http://www.us-highways.com) 2000). In

the 1920s-1930s the highway was also known as the Roosevelt Highway, and was named later to The Grand Army of the Republic Highway in honor of the veterans of American Civil War.

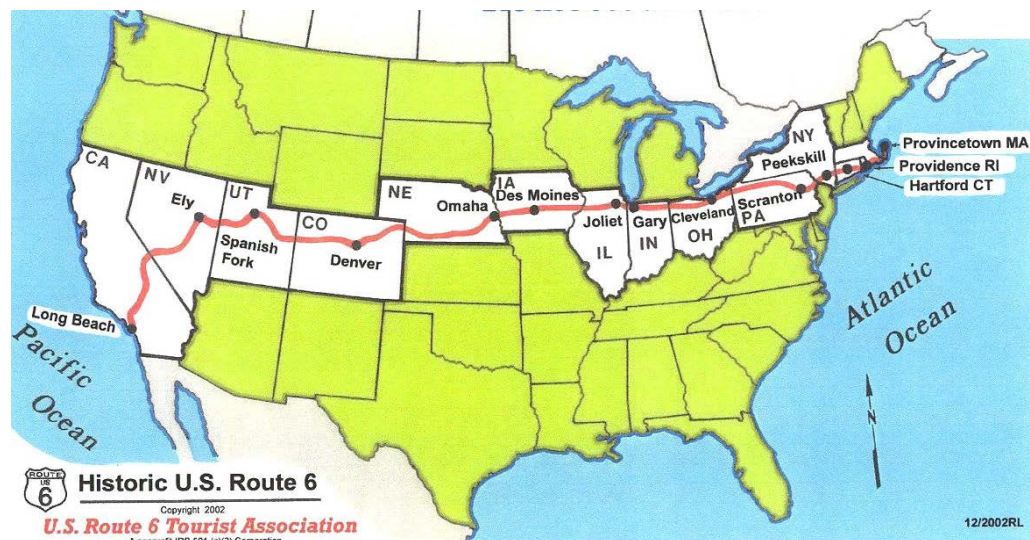
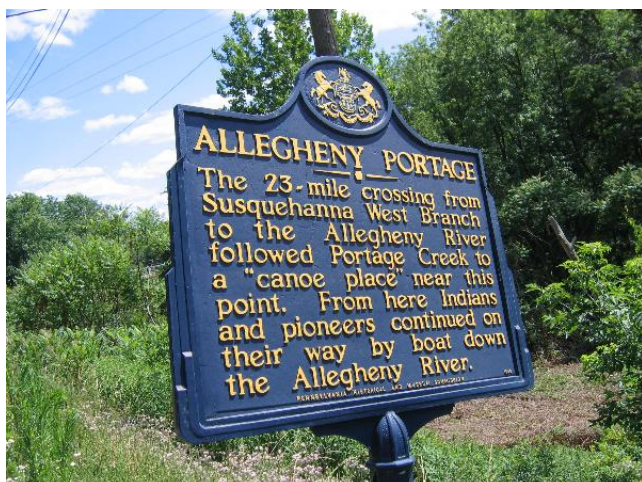


Figure 3: Extent of Route 6 in United States (Not to scale)

What we know as the Pennsylvania Route 6 now, was originally much of Pennsylvania Route 7, though in the beginning they were parts of the Native American trails (Hope and Seitz 2002, 11). The naming of the highway has changed since then from Roosevelt Highway, in honor of the US President Theodore Roosevelt to the Grand Army of the Republic Highway, and now one can possibly see both signs as a tribute to its historic significance. Route 6 in Pennsylvania has retained much of its historic character (Hope and Seitz 2002). An important reason behind this may be because the area around Route 6 is still sparsely settled and has not faced many developmental activities. The highway goes through or close to the county seats in each of these 11 counties except Erie. About 90 historical markers can be found along this scenic Route in Pennsylvania (See). Many of these markers speak of different political and historical events and eras. For example, a marker located at the junction between U.S. Rt. 6 and PA 155 at Port Allegheny (See figure 4) tells us about how the crossing to the Allegheny River used to be popular among native Indians for transportation via water.





The marker reads:

"The 23-mile crossing from Susquehanna West Branch to the Allegheny River followed Portage Creek to a "canoe place" near this point. From here Indians and pioneers continued on their way by boat down the Allegheny River."

Location: Junction U.S. 6 & PA 155, Port Allegheny, PA.

Figure 4: A historic marker on Route 6.

Source: [http://www.waymarking.com/waymarks/WM1WGB\\_Allegheny\\_Portage](http://www.waymarking.com/waymarks/WM1WGB_Allegheny_Portage)

Another marker highlights Smethport's evolution as the county seat of McKean County.



The marker reads:

"Smethport: County seat for McKean County since 1807, when land agent Francis King surveyed town lots. The first cabin was built in 1811 by Arnold Hunter; but permanent settlement was delayed until 1822. First courthouse built in 1827."

Location: US Rt 6 at Courthouse, Smethport, McKean County, PA.

Figure 5: A historic marker on Route 6.

Source: [http://www.waymarking.com/waymarks/WM34P3\\_Smethport](http://www.waymarking.com/waymarks/WM34P3_Smethport)

Some of the markers speak of war and war heroes. This monument marking the Battle of Lime Hill can be found near Wyalusing, PA. On its reverse it speaks of the Revolutionary War Service and heroic deeds of one of the soldiers, Joseph Elliott.

The front of the marker reads:

"Lime Hill Battlefield, April 14, 1782. Sergeant Thomas Baldwin's party in attempting to rescue Mrs. Rosewell Franklin and her four children, who had been captured by the Indians, met the enemy near this spot. After four hours of fighting, three of the children were rescued but Mrs. Franklin was killed. Sergeant Baldwin's breastworks were located seventy rods northwest of this marker. Marked by the Penna. Historical Commission and the Bradford County Historical Society, 1928."

Location: Location: Rt. 6, 3.7 miles north of Wyalusing, Bradford County, PA.



The rear of the marker reads:

9

"JOSEPH ELLIOTT. Second in command at the battle of Lime Hill, April 14, 1782. He killed the Indian who shot Mrs. Franklin and rescued three of her four children. He was in the engagement at Trenton, December 25, 1776, and was presented a sword by General George Washington for bravery. He broke from the Indians at Bloody Rock, Wyoming Massacre, and swam the Susquehanna River with a bullet in his shoulder and escaped to Wilkes-Barre. Erected by his descendants."

Location: Rt. 6, 3.7 miles north of Wyalusing, Bradford County, PA.



Figure 6: A historic marker on Route 6.

Source:

[http://www.waymarking.com/waymarks/WMBFWH\\_Battle\\_of\\_Lime\\_Hill\\_Joseph\\_Elliott\\_Monument](http://www.waymarking.com/waymarks/WMBFWH_Battle_of_Lime_Hill_Joseph_Elliott_Monument)

#### 1.1.2 Pennsylvania's industrial growth and transit infrastructure

Pennsylvania has always been a leader in industrial growth and has set trends in sectors like iron, coal, timber, oil and natural gas industry. The transportation sector has also been growing simultaneously to serve the related growing activities. The Pennsylvania railroads used to be extensively used in transportation of coal, iron and timber. In 1860s Pennsylvania increased the railroad mileage to 2,598 to support these industries. It was also then that the commonwealth led in production of Timber (Commission 2015). Later the commonwealth excelled in highway construction which reached its peak in the 1930s. Since then highways and transit infrastructure facilities have been closely related with industrial development.

Such connections may also be noticed in the energy industry including oil and natural gas owing to the increased needs for transportation of raw materials, movable infrastructure, heavy machinery and equipment, extracted products and waste materials (Commission 2015). The US Route 6 has also been witness to energy and other industrial development and the usage patterns have been changing since. The way a transit corridor is used often guides the development of surrounding land use patterns. This may lead to changes in the natural and built environment along the length of the US Route 6 in Pennsylvania which might impact the way it behaves as a social, cultural, ecological and recreational entity, apart from being the dynamic entity that connects these nodes of activities.

In 2014 Ronald Castille, the then Chief Justice of the Supreme Court of Pennsylvania had said:

*“Pennsylvania has a notable history of what appears, retrospectively, to have been a shortsighted exploitation of its bounteous environment, affecting its minerals, its water, its air, its flora and fauna and its people.”*

## 1.2 Scenic byways

When it comes to conservation of roadways owing to cultural and historic significance, scenic byway programs are of special significance. Scenic byways may range from interstate highways to dirt roads barely wide enough for vehicles to pass and there are various reasons why these programs are believed to be important.

### 1.2.1 Importance of scenic byway program

According to the 1991 National Scenic Byways Study, these are some of the reasons why designation of a roadway as a scenic byway may be potentially effective (USDOT, National Scenic Byways Study 1991):

- Making Americans more aware of the nation’s scenic, cultural and historic resources.
- Inducing new economic development in the form of job opportunities, stable industries and expanded tax bases.
- Protecting and enhancing the scenic, cultural and historic assets within scenic byway corridors.
- Reducing traffic congestion on some of the major travel Routes by attracting the tourism oriented traffic to less heavily used ones
- Encouraging tourism opportunities from international travelers.

### 1.2.2 Rt. 6 as a Pennsylvania Scenic Byway

US Route 6 is popularly used as a transit corridor for cross-country trips. The elements of attraction in such a trip may include many flamboyant, artsy, entertainment-rich towns but many of the places along this road may not be typical tourist destinations. Such unheard of places that were once locations on what used to be a primary travel route make the experience appealing to the road-trippers (Yolen-Cohen 2013). With the effort from Pennsylvania Route 6 Alliance of Galeton, PA, a resolution was passed in the Troy Borough Council supporting a

proposal to designate Pennsylvania Route 6 as a Pennsylvania Byway. The main reason behind this drive was to highlight its cultural, historic, recreational, archaeological, scenic and natural qualities. It aims at raising awareness about conserving the communities as well as the landscape along this corridor. Route 6 being designated as a Pennsylvania scenic byway speaks of its significance and importance to the local community. It may thus be noted as one of those approaches which direct upcoming developmental activities towards a sustainable treatment of the corridor.

Route 6 in Pennsylvania has been a topic of discourses regarding inclusion in the Federal Scenic Byways Program to emphasize its value as an asset on account of its scenic beauty, tourism potentials and cultural significance (Hrin 2014). Scenic byways are regarded as a distraction from the busy interstate highways and have often been termed as ‘the path less traveled’ (PA-Tourism n.d.). This sort of image of a scenic byway brings in expectations of an experience of peace and calm and discourages future development and growth of urban land use, as well as increased traffic volumes that might make the experience of a road trip stressful rather than pleasant! Mobility having been one of the prime concerns of development of highways, it is being tried to increase the speed limit of certain highways in PA to 70mph, as has been done in some parts of Texas (increased to 75mph) (Murphy 2014). The scenic byways, however, try something different. They focus more on the experience of driving through the flowing landscape and the limited traffic.

### 1.3 Rt. 6: as a connecting corridor

My research not only identifies the role of this highway as a connection between the various points of interest, but also looks at the corridor as an enriched recreational experience in itself. While recreational opportunities along the Rt. 6 flourish owing to the pristine natural beauty of the farmlands and the forests, the evidence of its significance to the residents of Pennsylvania can be found in the small historic towns that this corridor connects like beads in a string when one takes a tour of the natural and cultural heritage of the commonwealth.

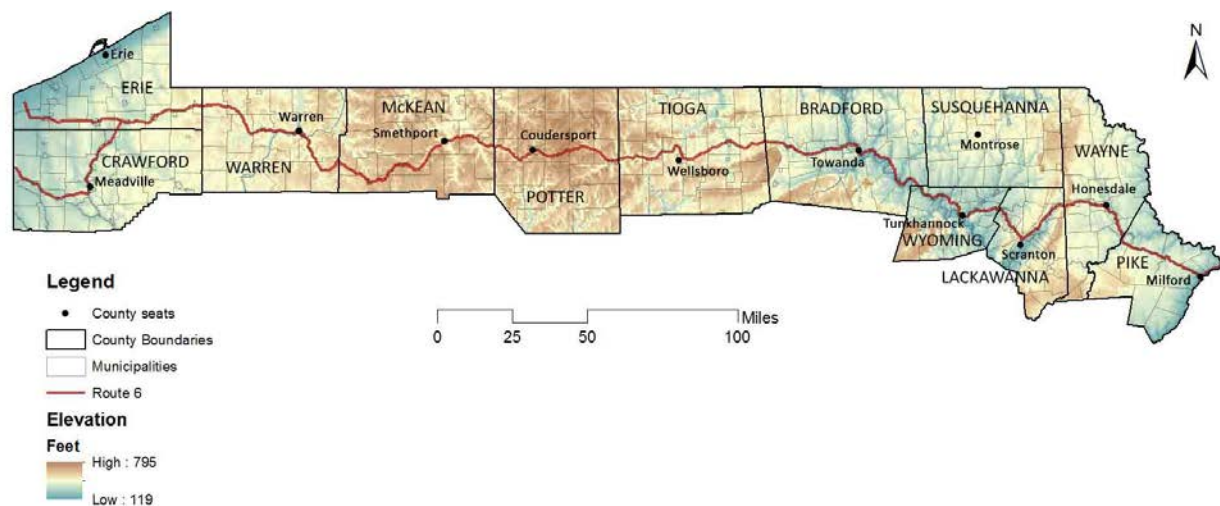


Figure 7: Counties and county seats in the northern tier of Pennsylvania



### 1.3.1 Points of interest: Northern tier of Pennsylvania

The northern tier of Pennsylvania is characterized by many historic towns, recreational trails and forested lands which provide ample opportunities for outdoor activities. These points of interest can be categorized as significant in two aspects: 1) historic, and 2) recreational or tourism oriented.

#### 1.3.1.1 Historic

The historic landmarks exhibit such closeness with the local community that the essence of pride about the commonwealth and the nation's heritage is exhibited clearly in these towns. Houses in Pike County, dating from 1865 have American Flags displayed in their porch.

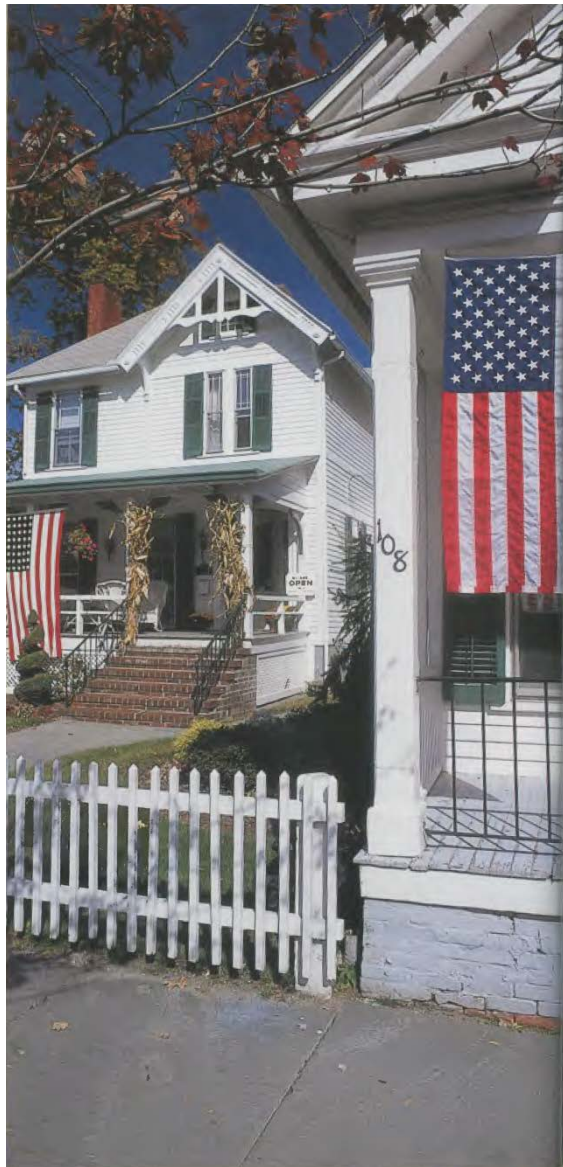


Figure 8: (left) American flags in houses in Pike County. (Hope and Seitz 2002)

Figure 9: (top) Artworks in the sidewalks of Tunkhannock. (Hope and Seitz 2002)

Many of the historic elements and cultural identities have thus remained unchanged for many years (Hope and Seitz 2002). Small details in how these towns have portrayed themselves and

maintained over time speak of how deep the unique cultural values are imbedded in them. Below is an image of a sidewalk from Tunkhannock. Tunkhannock, which is the county seat of Wyoming County, is also known as the gateway to the Endless Mountains Region (Refer to Figure 12). This sidewalk mural reminds visitors of the friendly reception that they receive in the Endless Mountains Region and in the entire northern tier of Pennsylvania.

It is characteristic of the people in this region to keep up their historic identity or renew it if faded. Wyalusing is a place located where the Susquehanna River merges with the Wyalusing Creek in Bradford County which holds a unique historic significance. The Iroquois Indians used the nearby Wyalusing Rocks as a signaling point for way finding. In 1765 a Moravian mission was launched to bring Christianity to the Delaware Indians. The streetscape of the town's Main Street features many restored 19<sup>th</sup> century buildings. Such renovations bring back the memory and show the willingness of the people to retain their historic nature.

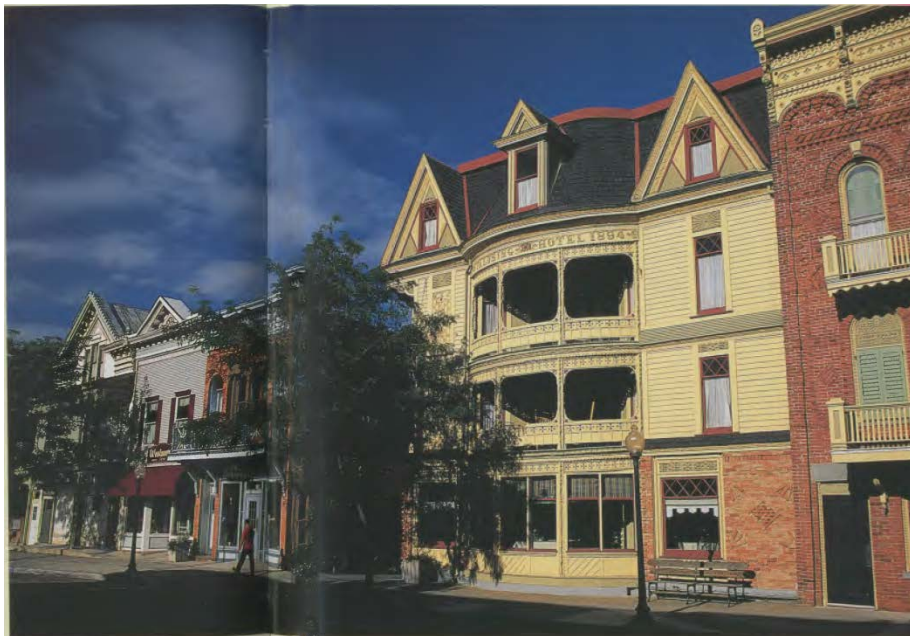


Figure 10: Restored 19<sup>th</sup> century buildings in the main street of Wyalusing. (Hope and Seitz 2002)

It is interesting to note that owing to their historic fabric, the small towns have never really faced large scale developmental activities or massive urbanization, until recently, when the development of the shale gas industry caused a huge influx of workers and their families (Brasier, et al. 2011). While a road trip to refresh our memory of the commonwealth's history used to be another reason for visiting towns like Wellsboro in Tioga County, it must be noted that the changing urban landscape might take away the values that drew travelers from places all around and in turn may hamper the industries like tourism and hence, the local economy.

#### 1.3.1.2 Tourism or recreational

The recreational opportunities on the other hand rely on natural resources that Pennsylvania is bountifully gifted with. Rolling mountains, vast farmlands, pristine rural landscapes, dense

forests and a rich network of streams provide opportunities for outdoor activities like hunting, hiking, bird watching and various water-based recreational sports. These activities are such closely embraced by people from Pennsylvania and surrounding areas, that it has been made a point to conserve zones that cater to such activities. Areas like the 'Pennsylvania Wilds', and the 'Endless Mountains Regions' have been designated specifically by PA-DCNR for the purpose of conservation of these natural and cultural heritage-based tourism opportunities.

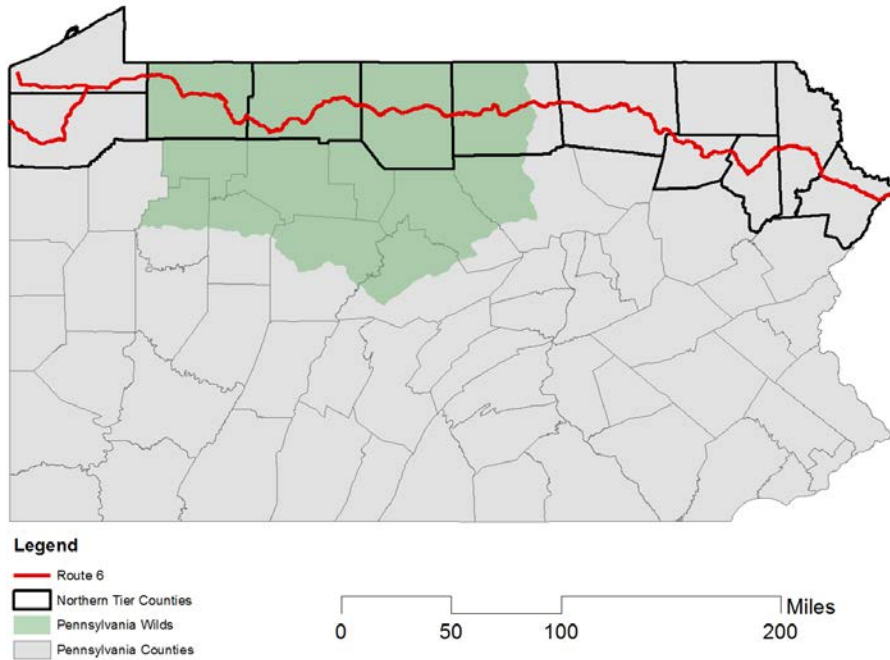


Figure 11: Pennsylvania Wilds

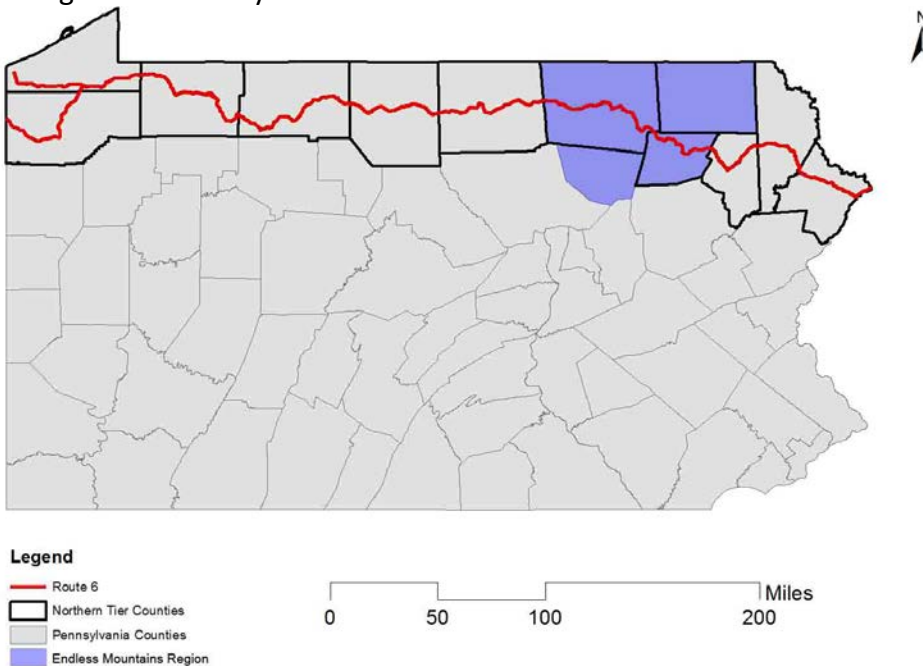


Figure 12: Endless Mountains region



Some of the most popular points of interest in Pennsylvania featuring tourism and recreational activities are the following:

1. Pennsylvania Grand Canyon: The Pine Creek Gorge, commonly known as the Pennsylvania Grand Canyon is flanked by approximately 165,000 acres of Tioga State Forest. The canyon begins south of Ansonia along US Route 6 and continues for about 47 miles. The gorge received a national acclaim when in 1968 the National Park Service designated a 12-mile section as a National Natural Landmark ([www.visittiogapa.com](http://www.visittiogapa.com) n.d.). This destination is popular among residents of Pennsylvania as well as visitors for various recreational activities like hiking, camping, canoeing, kayaking and others throughout the year. But the beautiful changing colors of the leaves during Fall add a special attraction to this beautiful natural area. The most popular route taken by travelers to visit the Pennsylvania Grand Canyon is via the US Route 6 through the historic town of Wellsboro in Tioga County which is also known as the gateway to the Pennsylvania Grand Canyon.
2. Upper Delaware Scenic and Recreational River is a 73.4 mile long stream enjoyed by thousands of people every year. The best way to enjoy the natural beauty is from the river via canoes, kayaks or rafts! This is a Class I stream and a popular fishing destination for brown and rainbow trout, small-mouth bass, walleye, white suckers, fallfish and American eels (Hope and Seitz 2002). Set amidst the rolling hills and riverfront villages, the clean waters of Delaware boast to offer the most tranquil experience to the visitors. The village of Hancock, New York, also known as the gateway to the scenic river is famous for its bluestone and timber industries.
3. Kinzua dam, Allegheny National Forest, Warren County: North of the Route 6 several small roads lead to the Allegheny National Forest and the Allegheny Reservoir created by the Kinzua dam. The Allegheny National Forest consists of 513,000 acres of forestland, 600 miles of trails, abundant wildlife, the Longhouse National Scenic Drive and 86.8 miles of North Country National Scenic Trail (Hope and Seitz 2002). The dam is essentially part of a flood control system operated by the U. S. Army Corps of Engineers for the Allegheny and Upper Ohio River Basins and provides a beautiful view for the visitors and plenty of opportunity for outdoor activities including fishing, hiking, kayaking, canoeing and fishing.
4. Susquehanna River, Susquehanna County. The Wyalusing Overlook. The Wyalusing Rocks are one of the most popular overlooks to watch the densely forested natural beauty of Pennsylvania as well as the Susquehanna River. This overlook also gives a nice view of the different measures of landscape conservation in the region such as contour strip-cropping, manure storage systems, barnyard runoff control, streamside buffers, bank stabilization, etc.

### 1.3.2 Rt. 6: Connecting Communities

The US Route 6 is popular for making cross-country trips in the US. However, its past use as a primary route for transport (not just tourism) is evident in how it connects various locations

that hold significance in political and historic grounds. In Pennsylvania a trip along the US Route 6 includes quite a few historic towns many of which serve as County seats (Hope and Seitz 2002). However, owing to the historic and cultural significance of these towns development has not been promoted in an unrestrained manner, unlike the common trend in urbanization. These small towns are unique and integral parts of the historic fabric of this region. Small communities, natural beauty and the slow pace of the calm and peaceful rural life have made these towns in Pennsylvania a popular choice for residence among seniors and retired people.

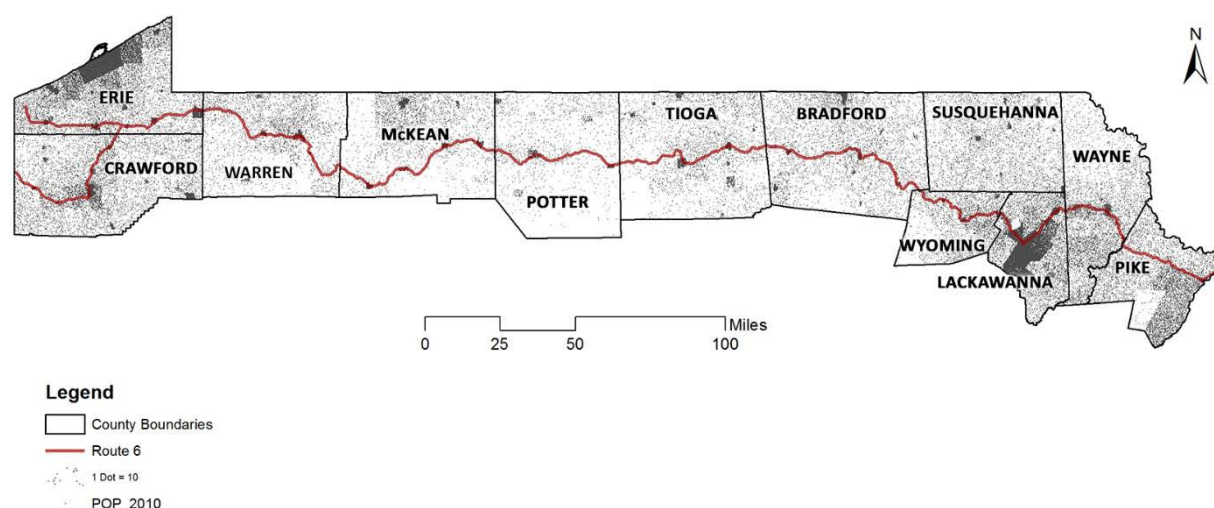


Figure 13: Population distribution map showing communities along Route 6.

The small towns along Route 6 are experiencing an influx of renters and home buyers owing to the shale gas industry development (Williamson and Kolb 2011). With growing demand, there is a shortage of housing opportunities that are available in these small communities. Hence, rent and home prices have increased tremendously. With the few rental units available, the prices have gone up to twice in Bradford, Lycoming and Sullivan County (Williamson and Kolb 2011). Towns like Wellsboro in Tioga County are well known not just for tourism purposes but also as retirement destinations. The increased price of housing and doubled rent thus makes it difficult for people with lower income or who don't work anymore to live here. Instead of being serene retirement destinations where pace of life is slow and the community has lived the same lifestyle for years, these towns are potentially becoming busy town centers with increased traffic volume, increased population and hub for a faster lifestyle that reflects the 'development' owing to nearby shale gas activities.

### 1.3.3 Rt. 6: A tourism experience

A trip to the US Route 6 is always characterized by an experience of peace and calm, as if it takes all the stress away. The highway complements the beauty of its surroundings and allows a relief in the mind of the traveler. A major factor in adding a sense of relief to the travelers is the worry free driving which is made possible because despite being a US Highway, much of Route 6 is two or three lanes with a speed limit of 55 m.p.h. Because of a low traffic volume the

driving experience will not require an intense concentration and sense of fear which is common in modern interstate highway driving (Hope and Seitz 2002).

Often it might seem to be a good idea to widen the traffic lanes in order to accommodate the higher traffic volume in response to increased tourism potentials. But that may instead have adverse effects on local communities, local businesses and natural environment, and hence related factors that attract the tourist population. There already have been discussions regarding whether Route 6 should be widened to support the increased traffic capacity near Cape Cod, Massachusetts. While potential environmental impacts have come up as a possible reason for discouraging such a measure, it has also been argued that a more significant concern is to retain the community character which might face major alterations with a widened highway, and increased scope for populating the region and inviting other developmental activities (Roberts 2002). Given the designation of US Rt. 6 as a scenic byway in Pennsylvania, which stresses on the cultural significance it holds to the commonwealth and the local community, such an argument proves to be valid and may be effective in conserving the historic and natural values as well as tourism potentials in the future.

Among different elements that contribute to the tourism potentials of US Route 6 in Pennsylvania apart from designated ecological conservation areas and historic landmarks are tiny details that enhance a perception of the sense of place in this region. The author of the book 'Pennsylvania's Scenic Route 6: A guide to historic sites, towns and natural lands', John G. Hope had maintained a notebook mentioning the things that struck him and it included things ranging from tangible elements like a small wooden church or a restaurant or bed and breakfast or a welcome sign in New Albany, to intangible ones like an experience of getting stuck in an unexpected traffic jam or the obvious patriotic vibe in the neighborhoods, or even enjoying the scenic views from a distance and the occasional glimpses of wildlife (Hope and Seitz 2002). Promotion of the Route 6 as in lights of tourism can be found in the official website of PA Route 6 Alliance which hosts an interactive map with a mile marker which when selected, shows the different tourism and recreational opportunities that one can avail when taking a trip along the historic corridor (Alliance 2015). The official website of the tourism department of Pennsylvania [www.visitpa.com](http://www.visitpa.com) also speaks about its historic values and hence the story of its designation as a Pennsylvania Scenic byway and proposal for a Federal scenic byway in the future (PA-Tourism n.d.).

## 2 Marcellus Shale

### 2.1 Shale gas development in the Marcellus region and around the world

Marcellus shale is a bed of shale rock with large deposits of natural gas trapped inside. The quantity of shale gas trapped in this region of north-eastern USA has been estimated to be among the largest in the world (See figure 14). Spread across a span of 34 million acres in New York, Ohio, Pennsylvania, West Virginia and Maryland, the Marcellus shale has been estimated to supply nearly 500 trillion cubic feet of natural gas (Engelder 2009) (See figure 15).

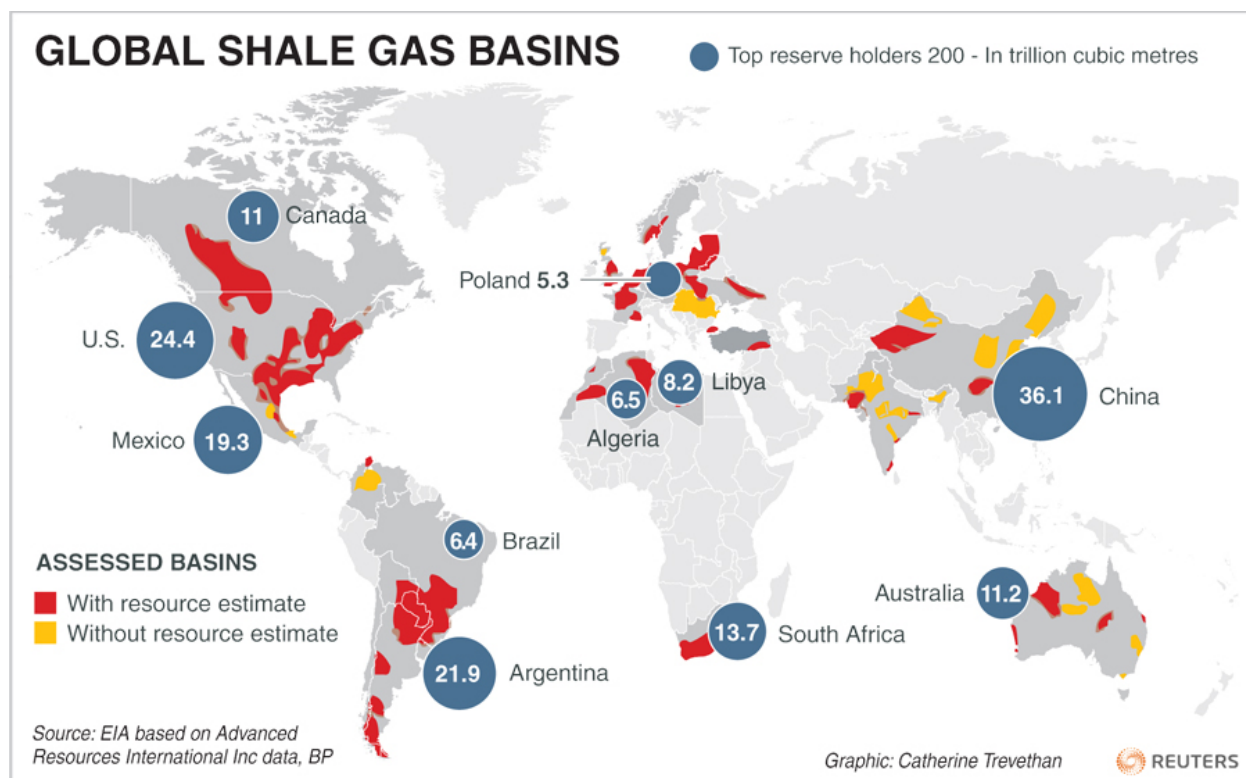


Figure 14: World-wide shale gas deposits (2012)



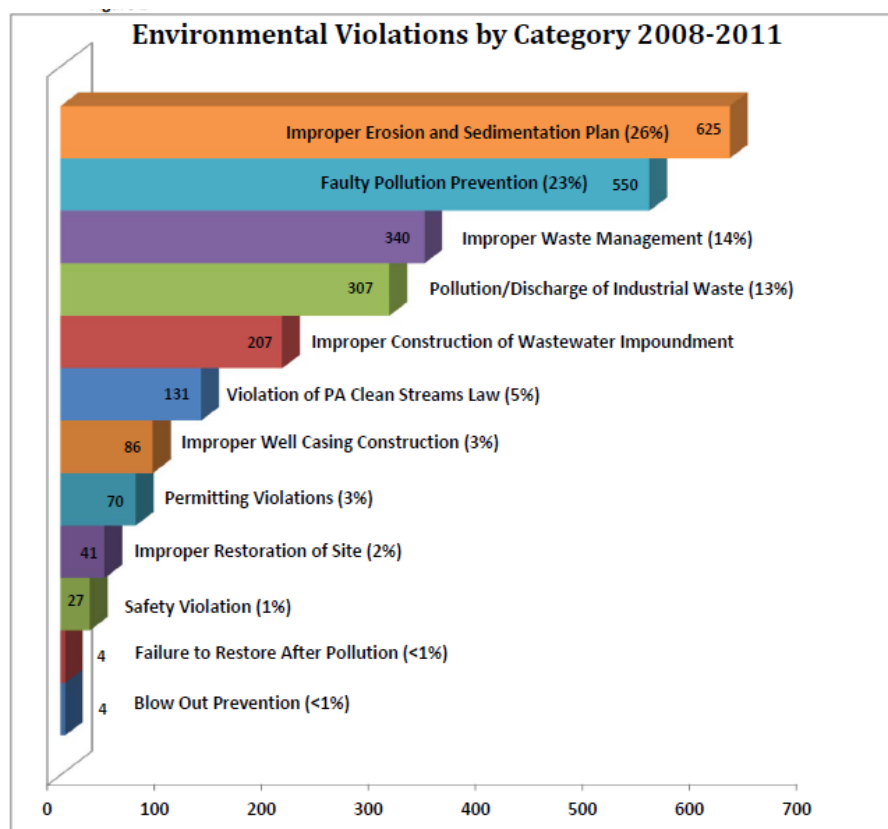
Figure 15: Extent of Marcellus Shale

The first Marcellus shale gas well was drilled in 2003 in Washington County in Pennsylvania. Since then more than thirty national and international oil and gas companies have established lease holds in the region (Brasier, et al. 2011). By 2035 shale gas resources will comprise of 46% of all natural gas production in the US ((USEIA) 2010).

Shale gas development have been subject to discourses all around the world based on potential negative impacts on the local economy, social and physical infrastructure, the natural environment and social dynamics within communities (Brasier, et al. 2011). It is interesting to note that New York State has restricted drilling and prohibited permitting of extraction of natural gas through hydraulic fracturing. However, such activities have still been regularly going on in Pennsylvania and West Virginia (Brasier, et al. 2011).

## 2.2 Impacts of Marcellus Shale

A thriving energy industry like Marcellus Shale must rely on sound infrastructure which requires clearing of forest and farmland for installing well pads, pipelines, building new roads as well as other operational and storage facilities for heavy machinery and concerned materials (including fresh water for hydraulic fracturing, and waste water that flows back with natural gas, for recycling). All of these activities bring significant changes to the landscape for an extended period of time, which in turn may negatively impact the natural environment, wildlife and natural habitats, local communities as well as existing infrastructure. These elements are components of a dynamic ecosystem in a number of domains including biotic, abiotic and cultural. The way these elements are connected to each other spatially and functionally via different landscape corridors (which may range from natural environments like wildlife corridors to infrastructural ones like transit corridors) impacts the dynamic nature of the entire



ecosystem. Any impact to these elements individually and the connection between them will hamper the corridor's functioning in terms of connectivity as well as the entire ecosystem as a dynamic entity. The following sections will thus identify the ways Marcellus Shale gas industry may potentially impact elements like land, water, community, and transit infrastructure and in turn, the corridor of US Route 6 that connects them.

Figure 16: Environmental Violations by shale gas companies in Pennsylvania.

Source: (Staaf 2012)



According to the Pennsylvania Department of Environmental Protection (PADEP), the '*Penn Environment Research and Policy Center*' identified a total of 3355 violations of environmental laws by sixty four different shale gas drilling companies between January 1, 2008 and December 31, 2011, among which 2392 violations posed a direct threat to our physical environment (Staaf 2012). The most occurring violations were due to: 1) Improper Erosion and Sedimentation Plan (26%), 2) Faulty Pollution Prevention (23%), 3) Improper Waste Management (14%) and 4) Pollution/Discharge of Industrial Waste (13%). These violations pose immense threats to the natural environments and the natural habitats that they house. While such negative impacts may lead to irreversible disturbances to the landscape structure, the consequences may lead to a change in how the landscape has been attracting people for its environmental heritage and tourism potentials.

### 2.2.1 Impacts on forested land and habitats

*Direct impact on land:* In Pennsylvania, approximately 45-62% of shale gas development occurs on agricultural land and about 38-54% in forest land much of which includes core forest areas (Drohan, et al. 2012) (See figure 17). That the shale gas industry has led to a major shift in source of income for many families previously occupied with agriculture can be attributed behind such pattern of farmland conversion. Considering this pattern in shift of land use, it has been predicted that the permits for shale gas operations as of June 2011 would convert at least 644-1072 ha of agricultural lands and 536-894 ha of forest land into shale gas operation facilities (Drohan, et al. 2012).

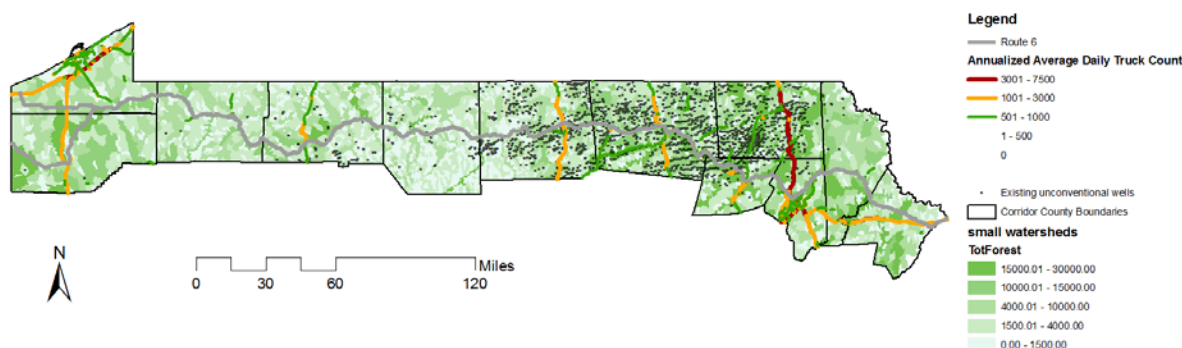


Figure 17: Spatial relation between truck traffic, shale well pads and forest cover

According to a study on change in land cover patterns due to shale gas developments (compared between existing and permitted well pads based on the USDA NAIP land cover data in 2010) conducted by P. J. Drohan and others, it is feared that construction of permitted well pads would result in an 81% increase over existing pads in forest cover and a 60% increase in agricultural cover (Drohan, et al. 2012). It is also estimated that core forests will continue to deplete due to shale gas development and lead to increase in fragmentation of forests and habitats.



*How significant?:* Any installation devised to extract natural gas from the underground shale deposits consists of a well pad, an access road, and storage areas for water, chemicals, sand and waste water, a compressor station and a collector pipeline. Such installations often require significant cut and fill of the land, sometimes on the steep slopes (Adams, et al. 2011). Given the amount of forested land that Pennsylvania has, one might wonder how much of a problem this might be. To put things into perspective, here is a statistic: in 2008, half of the installations in Pennsylvania were in forests and used, on average, 3.56 ha, thereby affecting approximately 15 ha of forested land per installation (N. Johnson 2010). Pennsylvania forests serve as habitats for a number of species. Forest fragmentation and loss threaten populations of several breeding birds of conservation concern in Pennsylvania and West Virginia, including wood brush, cerulean warbler and summer tanager (Brauning 1992) (Buckelew and Hall 1994) (M. A. Steele, et al. 2010). Concern has also been raised on the population of the area sensitive song birds of the region (N. Johnson 2010).

*Consequences on plant habitats:* Clearing and developing the land for installing extraction zones include a number of activities as mentioned above. These activities, especially building access roads and pipelines, and others which require clearing of forests and cut-and-fill actions create breeding ground for invasive species (Trombulak and Frissell 2000) (Forman and Alexander 1998). Roads act as corridors for the spread of non-native weeds and increased run off from the cleared land may affect the rare native plants in the adjoining habitats (Trombulak and Frissell 2000) (Thiele, Schuckert and Otte 2008) (D. A. Mortensen, et al. 2009) (Kiviat 2013).

Current trends of shale gas development raise concerns about our future and seek a sound understanding of the impacts thereby caused by the shale gas operations. This necessitates an assessment of possible risks to the natural environment before planning any future development.



Figure 18: Before and after Shale Gas Extraction

(Source: USGS Report: Landscape Consequences of Natural Gas Extraction in Greene and Tioga Counties, Pennsylvania. 2004-2010)

### 2.2.2 Impacts on Water

*Hydraulic fracturing:* As the name suggests, the process of extracting natural gas from the shale deposit, called hydraulic fracturing uses water (2-4 million gallons of water is used per fracking procedure) (Schmidt 2011). Technological development has enabled extraction of shale gas in a unique way where the pipes drill vertically and then are expanded horizontally to extract natural gas. Freshwater is mixed with sand and other chemicals which travel underground along with the water, hold the cracks in the shale deposit open as the natural trapped in the shale rocks escape through the pipe. As the extracted gas is collected above ground, a significant amount of the water (30-70%) previously used travels back as waste water which is known as the flow back water (Schmidt 2011). The flow back water is then treated on site, provided such facilities are available or it is stored and then transported to a facility where it may be treated.

*Direct impacts - altering the hydrology:* Other than drilling, the shale gas extraction process involves several construction-related activities like preparing the land, removal of soil, clearing of forests, building of roads and transmission lines, creating storage ponds for freshwater and waste water, all of which pose significant threat to the ground and surface water resources due to spills and leaks at drilling site, or erosion and contamination owing to improper storm water drainage (Rahm and Riha 2012). Hydrological alterations including withdrawal of surface waters, and increases in runoff caused by deforestation and impervious surfaces of the well pads and access roads may affect the hydrological patterns of streams and, floodplains, wetlands, springs as well as shallow ground water (Kiviat 2013). Drawing water from lakes and rivers for fracturing wells might reduce minimum in-stream flows in the summer which may in turn adversely affect stream fishes including brook trout and aquatic invertebrates (Orth and Maughan 1982).

*Indirect impacts:* Water sources can also be affected by means other than hydraulic fracturing, waste-water recycling, improper storage and transfer for flow back water. The rich aquatic habitats thrive under dense forest covers flanking the streams. With clearing of forests for installation of well pads and pipelines being a major concern for the natural environment, they also pose a potential threat to the fish habitats in the streams running through these dense forests. These streams provide ample fishing opportunities and hence form a crucial part of the commonwealth's tourism and recreation sector. These water resources amidst the forests constitute a pleasant landscape which is experienced popularly by means of activities like boating, kayaking, canoeing or even hiking or biking in the adjacent trails. Any threat to these water resources and the plentiful opportunities they provide is a potential threat to the tourism and recreational industry of the commonwealth.

### 2.2.3 Impacts on community

*Socio-economic:* Economic benefits are often the main reason for accepting energy development activities in the local communities by the people (Brasier, et al. 2011). While such benefits may reflect through employment opportunities and increased business, they are often the results in disruption of an already existing economic balance in a society. A large section of

the population in rural Pennsylvania used to engage in agricultural activities as a main source of livelihood before the onset of the shale gas activities. Since 2007 the increased income from royalties has been a boon for the farmers whose lands were leased for being used in shale gas drilling, thus giving rise to the 'new millionaires' of the region (Brasier, et al. 2011). Although the royalties depending on the amount of natural extracted have been varying and start diminishing as the reserve depletes, they have been significantly higher than the previous income levels for the families previously dependent on farming.

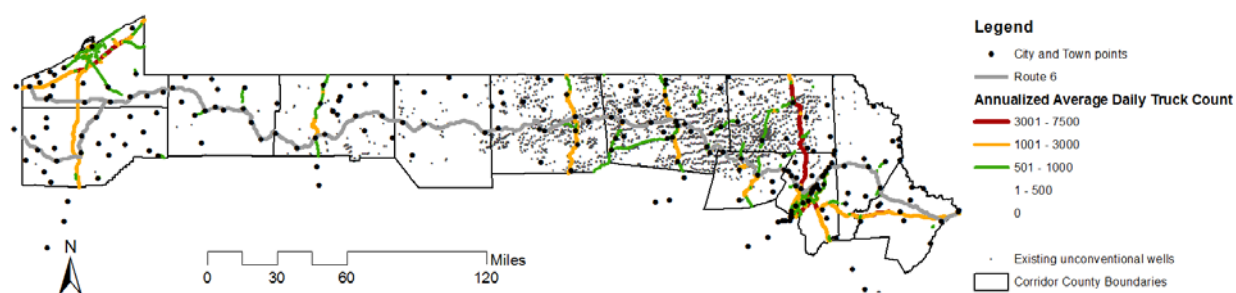


Figure 19: Spatial relation between truck traffic and town centers

*Housing:* Negative impacts of shale gas developments have also been felt in the housing scenarios. With the shale gas developments leading to an increase demand of housing facilities, rent and home prices are increasing (Brasier, et al. 2011). The heaviest impacts of housing shortage and increasing prices are being experienced by the ones whose housing situation was most at risk before the Marcellus shale gas industry growth, namely the non-working poor, seniors, the disabled and newly, even the working poor (Williamson and Kolb 2011). It is interesting to note that the influx of people in these areas is characterized by mostly out-of state workers, whose duration of residence in a particular town or locality will be dictated by the employment opportunities as available in relation with the shale gas industry (Jacquet 2011). This, however, may not be favorable to the residents who have chosen to spend the rest of their lives amidst this pristine landscape seeking peace and calm, over better financial opportunities in other parts of the country (Brasier, et al. 2011). The changing fabric might not be a welcome change for the people who have become an integral part of the landscape for so many years.

Many landlords are not evicting their current renters or keeping the rent same instead of going with the current trends and many are refusing housing to the workers in the gas company (Williamson and Kolb 2011). Although people are trying to resist any change in the housing situations, the shale gas industry is undoubtedly creating a potential difference as far as the socio-economic dynamics of the local communities are concerned. There have been worries if all the new development in these towns would turn them into mini-cities which might potentially result in an influx of drugs and alcohol in the communities (Brasier, et al. 2011).

*Cultural:* Excessive alterations to the landscape due to the shale gas development activities lead to changed perceptions among local residents and visitors about retaining the social relationships and identity of the communities. Such trends have been observed by Brasier et al. (2011) in their studies of Pennsylvania and New York cases where interviews were conducted with community leaders regarding potential and current impacts of shale gas development on the local community. The interviews considered several factors like economic benefits, changed relationships among community members, aesthetics and environmental quality, agriculture and roads and related physical infrastructure. The level of shale gas development activity and the stage of development interact with key community characteristics like population size, proximity to population centers, access to transportation networks, level of existing infrastructure and history of extraction of natural gas from the region (Brasier, et al. 2011). The ways people respond to alterations in these factors influence perception of the shale gas development in many different ways. However, the primary concerns about alternations in the community are mostly due to changing social relationships and physical beauty of the place they have called *home* for generations (Perry 2012)!

*Health:* Health issues associated with contaminated waste water, its storage and transportation have also been sources of concern for people residing in and areas surrounding the gas extraction sites. New York's Department of Environmental Conservation (NYDEC) has tested wastewater produced from fracking and reported the presence of radioactive materials (radium-226, 226Ra) as high as 267 times the safe disposal limit and thousands of times the limit safe for people to drink (Lustgarten 2009) (Kargbo, Wilhelm and Campbell 2010).

The route 6 being a transit corridor that connects these nodes which include historic towns, ecologically significant zones, farmlands and forested areas and various wildlife habitats, is facing a shift in terms of changed usage patterns and hence, its existence as an integral component of the regional cultural heritage.

#### 2.2.4 Impact on tourism

*Altered natural resources:* As discussed above in 'Section 3.2.1: Impacts on forested land and habitats', across Pennsylvania significant shale-gas development is occurring in the forested regions (Ritters, et al. 2002) (Wickham, et al. 2010) which pose threats to these natural resources owing to forest fragmentation (N. Johnson 2010) (Drohan, et al. 2012). Further development of shale gas activities in state forests may potentially change the ecological integrity and the wild character of the forest lands (PADCNr 2011a) (Drohan, et al. 2012). While the ecological integrity hampers the habitats, diminishing the wild character of the forests might be reflected in tourism and other recreational opportunities.

*Altered communities:* Other than impacting natural resources and transit infrastructure, there are several other issues such as potential noise, visual and air quality impacts associated with vehicle traffic, well pad construction and land-clearing activities, and use of heavy machinery and equipment, which concern local communities (Rahm and Riha 2012). Disruption of the natural environment and communities may lead to the northern tier of Pennsylvania lose its

unique identity which has been a primary factor that drew people from near and far to reside or visit this part of Pennsylvania.

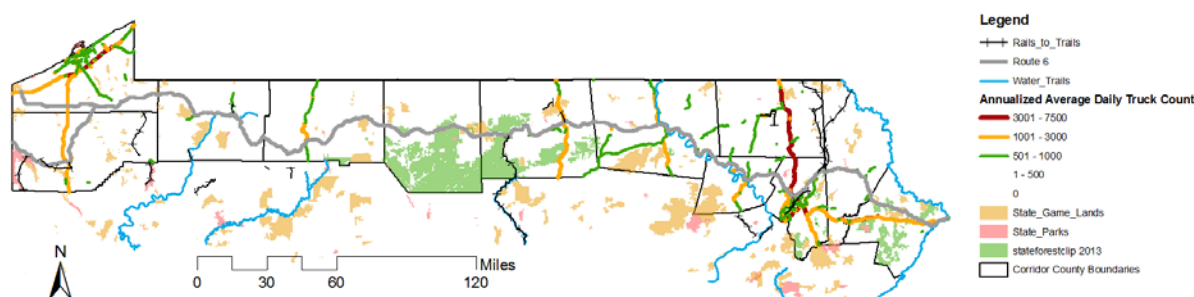


Figure 20: Truck traffic and recreational opportunities



Figure 21: Truck traffic and tourism based services

## 2.2.5 Impact on transit infrastructure

While shale-gas activities pose subsequent threat to the water quality and other natural resources of the region, the trucks carrying millions of gallons of water for extraction purposes and for treatment afterward have emerged as primary concerns for impact on transit infrastructure, especially rural roads. Trucks used to carry freshwater for fracking, waste water after fracking and for carrying drilling-related machinery, equipment and other associated machinery hold a special significance in the development and functioning of the shale gas industry.

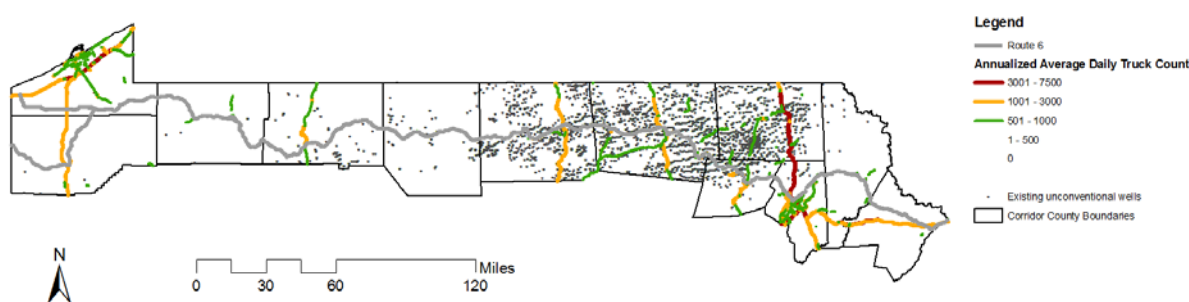


Figure 22: Spatial relation between truck traffic and shale gas well locations

According to Barry Scheetz and other, the increasing demands of trucking owing to the growing needs of the industry have exhibited the a variety of impacts on the rural roads of Pennsylvania and in turn the entire rural landscape in terms of impact on bridges, secondary and municipal roads, safety and cultural (Scheetz, et al. 2013). The impacts can be categorized as follows:

1. Direct
  - a. Traffic volume
  - b. Impact on bridges
  - c. Road safety owing to increased traffic volume and changed traffic pattern
2. Indirect:
  - a. Visual experience
  - b. Longer commute time
  - c. Fragmentation of the corridor
  - d. Cultural impacts on the local residents

*Direct impacts:* According to the existing requirement of roads for drilling, transmission and related purposes, it has been estimated that across Pennsylvania 367km of new road have been built to access the existing pads and 282km of additional roadways could be built to access the permitted well pads (Drohan, et al. 2012). While some of the gas companies made it a point to use the existing road infrastructure in rural Pennsylvania in order to reduce the amount of the disturbance on the landscape for building newer roads, most of the roads used were rural roads not designed to carry such heavy truck traffic load. This has led to damage of the rural roads in many forms of which rutting is the most commonly observed deterioration (Scheetz, et al. 2013). In the Susquehanna basin, more well pads are being developed closer together so as to minimize the construction of new roads, but to avail such sites well are being drilled farther from existing roadways, which will lead to more disturbance on the landscape (Drohan, et al. 2012).

*Indirect impacts:* Development of transit infrastructure in future to serve the shale gas industry may change Pennsylvania's landscapes remarkably (Drohan, et al. 2012). The landscape losing the forest cover due to shale gas activities takes a considerable time to recover and leaves a negative impact in terms of visual experience in the region. Following images obtained from Google street view along Route 6 in Mansfield, Tioga County show a clear difference in visual quality of the landscape while driving along route 6.



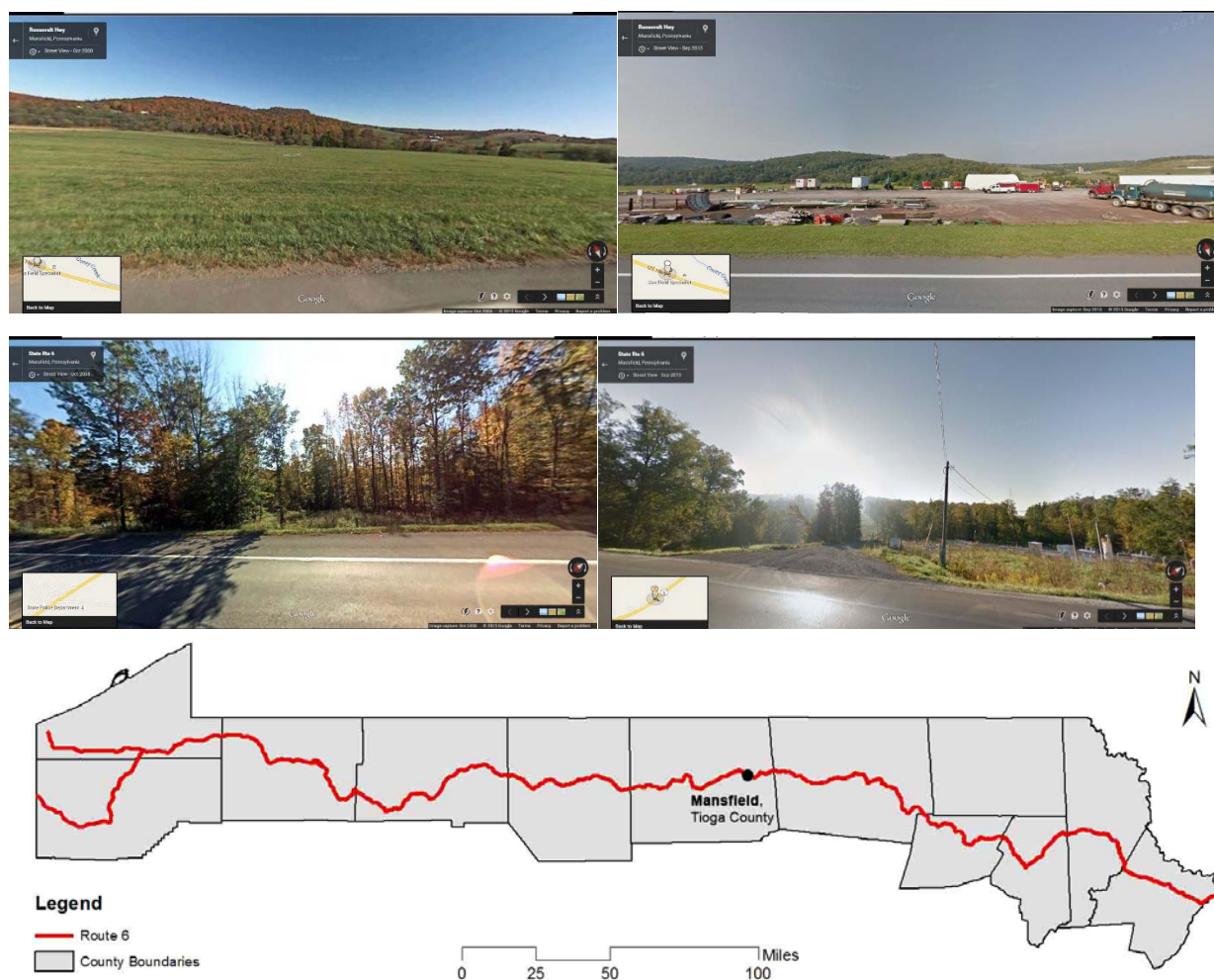


Figure 23: Changes in visual quality of the landscape on Route 6 due to shale gas development

With the increased traffic volume owing to the truck traffic commute time has increased between the small towns as well as between towns and other recreational points of interest. While heavy traffic between towns may impact the daily commuters, it can also cause a reduced interest in tourism and recreational activities among travelers. An interview with the youth of Bradford County, PA by Brasier et al. (2014) brought forward concerns about road safety and longer commutes times owing to the increased truck traffic volume (Brasier, et al. 2014).

Development of land for installation of well pads and pipelines as well as provisions for other necessary infrastructure may potentially impact the existing historic and pre-historic cultural resources. But a proper plan of action or even an initiative to conduct surveys towards identifying such potential impacts with necessary resources is lacking (Scheetz, et al. 2013). Apart from historic cultural resources, construction of roads may impact the landscape structures and relevant functions by contributing to the spread of invasive species (D. A. Mortensen, et al. 2009), negatively impacting wildlife species and their habitat (Cushman 2006)

(Lindenmayer and Fischer 2006), as well as cause significant change in the patterns of movement of water across landscapes (Forman and Alexander 1998).

## 2.3 Pennsylvania Act 13

### 2.3.1 About PA Act 13

Pennsylvania Act 13 is an act passed in 2012 that levies an impact fee on unconventional natural gas wells in account of the impact they might have on the landscape. Among others, the regulations have taken measures like increased setback requirements for unconventional well development, enhanced protection of water supplies and strong, uniform, consistent state-wide environmental standards. The environmental protection provisions set for by the law are effective as of April 16, 2012. The objectives of the PA Act 13 program are to:

1. Enact stronger environmental standards
2. Authorize local governments to adopt an impact fee
3. Take forward the state's ongoing efforts to move towards energy independence as unconventional gas development continues.

### 2.3.2 How does it work?

#### 2.3.2.1 Impact Fee

An impact fee is levied on every unconventional gas well in the Marcellus Shale formation in Pennsylvania. This fee is revised every year based on price of natural gas and consumer-price index [*CONSUMER PRICE INDEX: According to the Bureau of Labor Statistics, the Consumer Price Index or CPI is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. Source: (<http://www.bls.gov/cpi/>)*]. So far the impact fees collected have brought in \$854.5 million to Pennsylvania.

Following is a break-down of the yearly fees:

- 2011: \$204 million
- 2012: \$202 million
- 2013: \$225 million
- 2014: \$223.5 million

The five counties to receive the highest impact fee in 2014 are:

- Washington County - \$6.5 Million
- Bradford County - \$6.4 Million
- Susquehanna County - \$6.1 Million
- Lycoming County - \$4.8 Million
- Greene - \$4.5 Million

Sixty percent of the impact fee collection is used at the local level by the counties and the municipalities hosting wells. The rest goes to different state agencies involved in regulation of

drilling activities and to the Marcellus Legacy Fund. The fund gets distributed in the state for various environmental and infrastructural projects. The Pennsylvania Public Utility Commission (PUC) is responsible for collecting and distributing the fees.

### 2.3.2.2 Results

Enactment of this law has resulted in:

- *Added responsibility in drilling on the gas companies:* Driller's zone of presumed liability expanded from 1000 feet to 2500 feet. With these changes, if a water source within the revised buffer zone is contaminated, drilling in the nearby gas well will be assumed to be the cause.
- *Access to information:* Companies will be required to submit reports to the Department of Environmental Protection (DEP) with details on the chemicals used in the hydraulic fracturing process. This information will be published on FracFocus.org thus allowing access to the people regarding the concerned information.
- *Controlled growth:* The law sets new bond levels for drillers, based on the length of well bores and the number of wells each company operates.
- *Stricter rules:* Civil penalties against drillers who violate regulations would be increased to \$75000.
- *Government Intervention:* The Department of Environmental Protection (DEP) can now intervene into contracts with private well control teams, who would be given limited immunity from civil lawsuits.
- *Effective use of funds:* The bill authorizes the annual transfer of millions of dollars from the Oil and Gas Lease Fund to the Environmental Stewardship Fund and Hazardous Sites Cleanup Fund.
- *Zoning Rights:* The PA Act 13 of 2012 had a sub-section that restricted the local authorities from zoning and regulating natural gas drilling. In December 2013, Pennsylvania Supreme Court recognized this as unconstitutional and necessary revisions were made. According to Chief Justice Ronald Castille, the two subsections that allowed the state to preempt the local zoning rules and required municipalities to allow oil and gas development in all zoning areas violate the Environmental Rights Amendment of the state constitution. This amendment guarantees Pennsylvanians the right to, "clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment."

An example of how PA Act 13 ensures protection of the environment in terms of development of oil and natural gas industry can be seen in the prohibition of the preparation of any well site or drilling of any well within a floodplain if the site will include a pit or impoundment containing drilling cuttings, flow-back water, produced water, hazardous materials, chemicals or wastes located within the floodplain; or a tank containing hazardous materials, chemicals, condensate, wastes, flow-back or produced water within the floodway.

### 3 Spatial Analysis

#### 3.1 Rt. 6: Land

This section uses spatial analysis via mapping in GIS to understand the impact of shale gas development and allied activities on land resources in terms of two parameters: 1) forested land cover, and 2) impervious land.

##### 3.1.1 Forested land cover

The impact of shale gas development on forested land and habitats have been discussed in section 3.2.1. Figure 4.1 shows the area of forested lands categorized into small watersheds of the northern tier of Pennsylvania. The circle marks the watersheds with a high concentration of shale gas wells as well as areas with high forest cover. Such proximity increases the chances of forested lands being impacted by the shale gas industry.

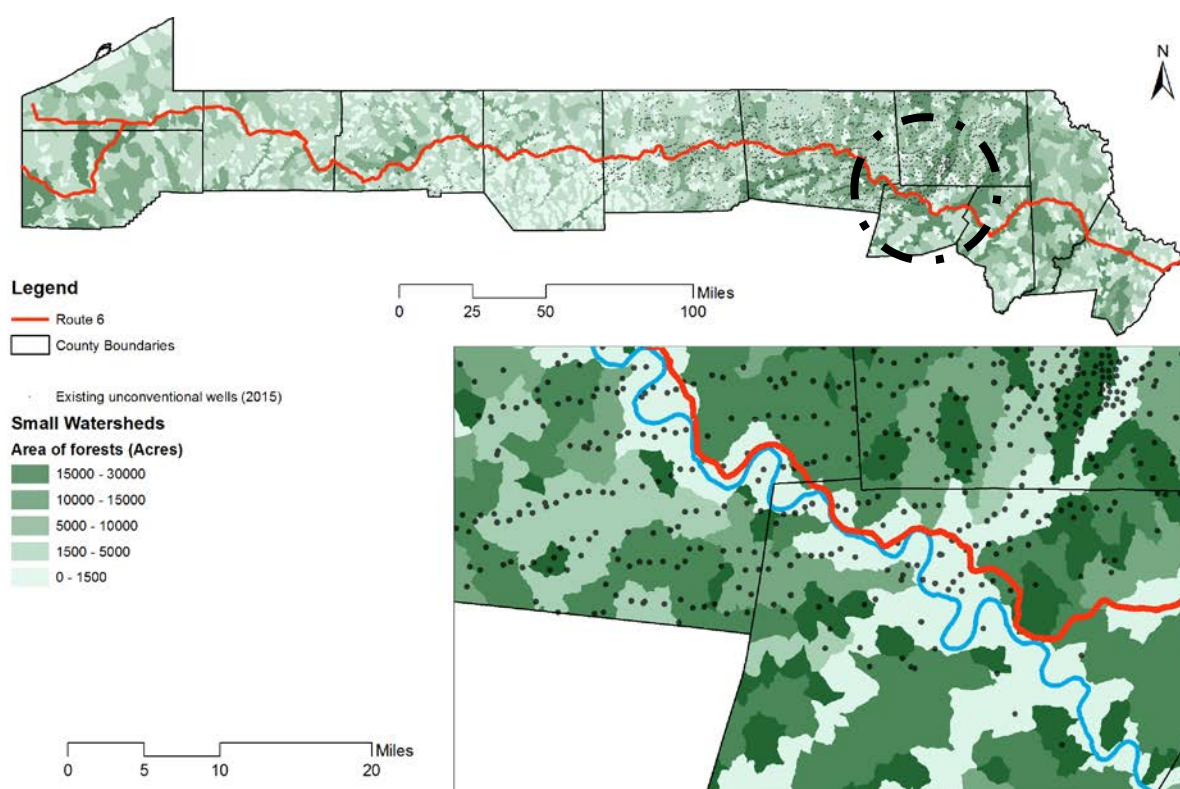
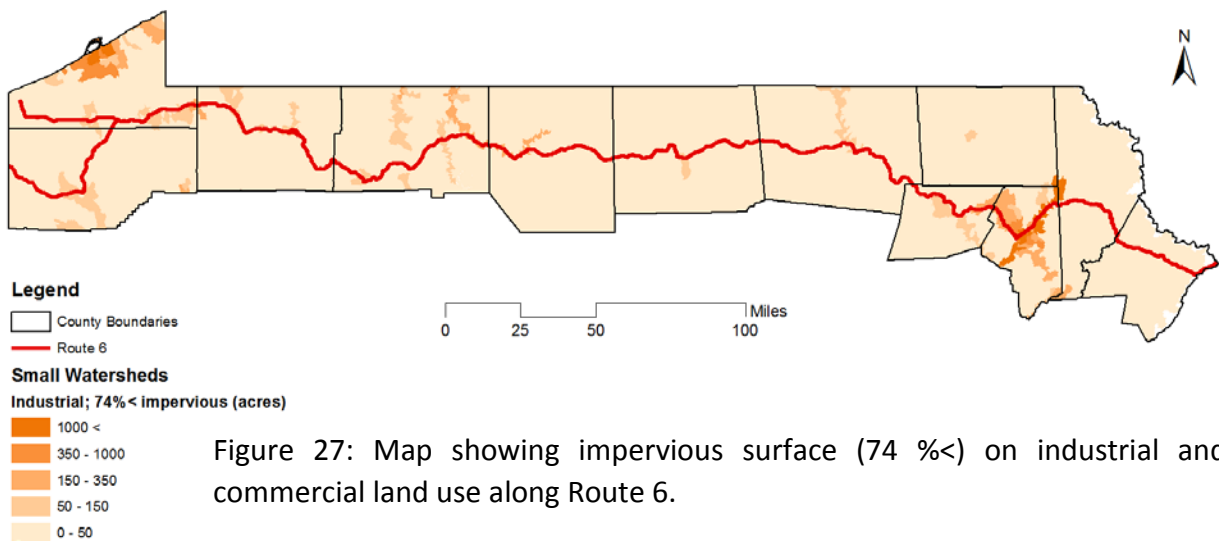
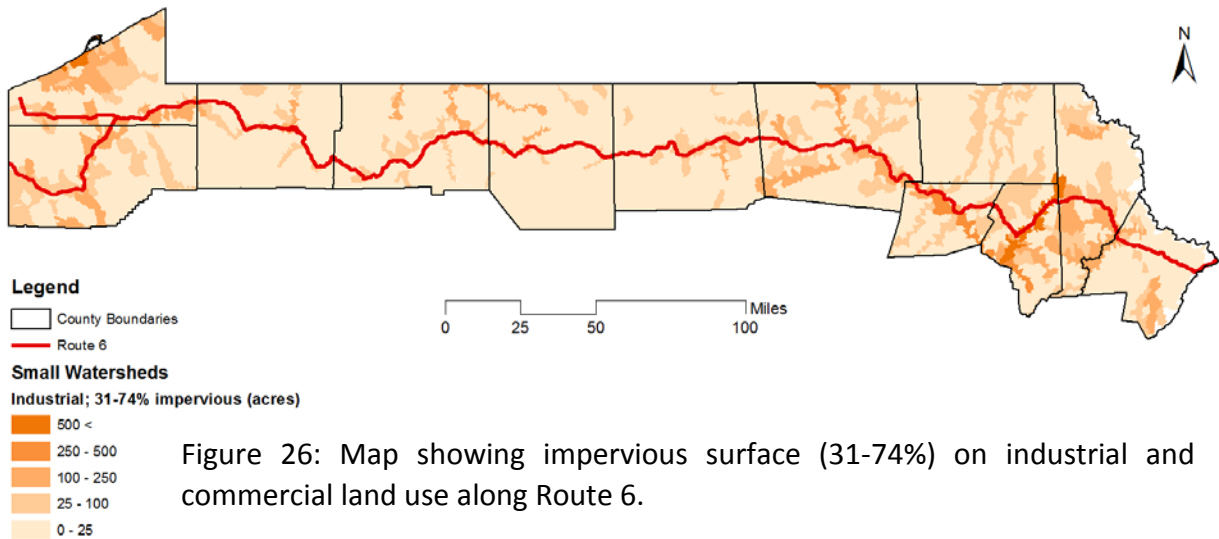
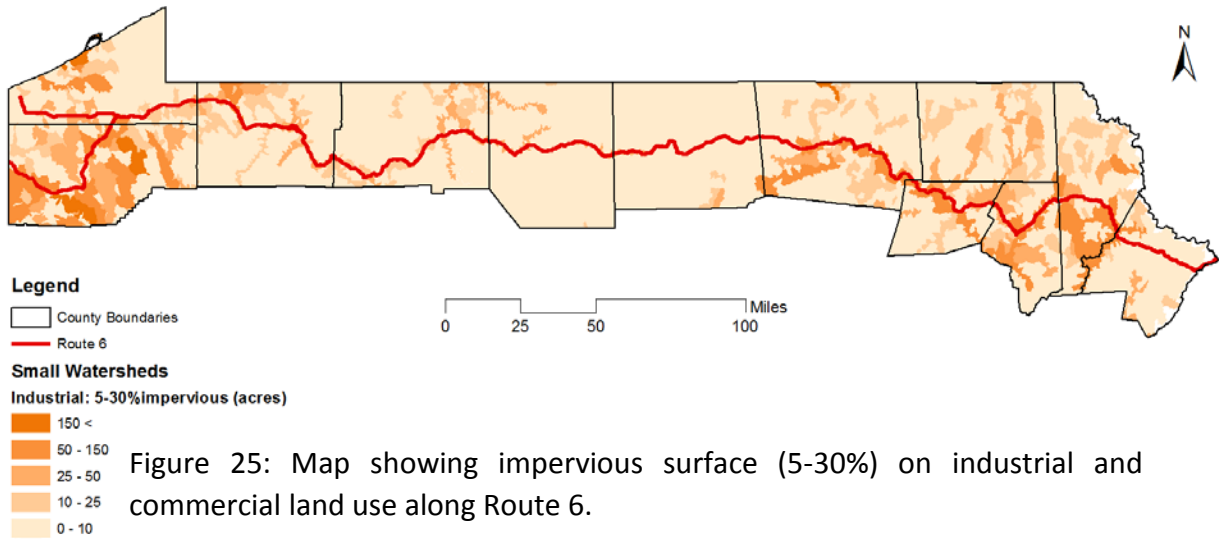


Figure 24: Map showing spatial proximity of shale well pads with area of forested land.

##### 3.1.2 Impervious land

Developments like the shale gas industry do more than just produce gas. They ignite future growth in sectors like housing and infrastructure. Such activities involve large scale construction, clearing of land including vegetation, and hence result in growing impervious surface which in turn increases run off and impacts ecological functions like ground water recharge. The following maps present the scenario about impervious surfaces categorized into small watersheds. The three maps show regions with industrial and/or commercial land use and impervious surface areas in three classes: 5-30%, 31-74% and more than 74%.





The above maps show a clear spatial relation in terms of proximity between areas with more impervious land and the US route 6. While some impervious surfaces run along the highway, many cut across it, following other roadways. Such spatial proximity can prove to be dangerous for the natural resources in these small watersheds in terms of ecological functions.

### 3.2 Rt. 6: Water resources

This section uses spatial analysis via mapping in GIS to understand the impact of shale gas development and allied activities on water resources in terms of three parameters: 1) forested wetlands and streams, 2) water based tourism and recreational opportunities and 3) impervious lands and water trails.

#### 3.2.1 Forested wetlands and streams

In Pennsylvania, 61% of land is covered with forest (about 6.8 million ha) (USFS 2015), which, apart from serving as a habitat for many species also provides protection for first-order streams (which in turn contribute to major river systems as the Susquehanna) (Rich, et al. 2004) (Brittingham and Goodrich 2010) (PADCNR 2011a) (PADCNR 2011b) (M. A. Steele, et al. 2010). The natural resources impacted due to shale gas development may include forests, wetlands and diverse plant and animal habitats. The following maps show how enriched the water resources are in the northern tier of Pennsylvania thereby representing the streams (categorized by length among small watersheds) and area of forested wetlands (classified by area in acres among small watersheds).

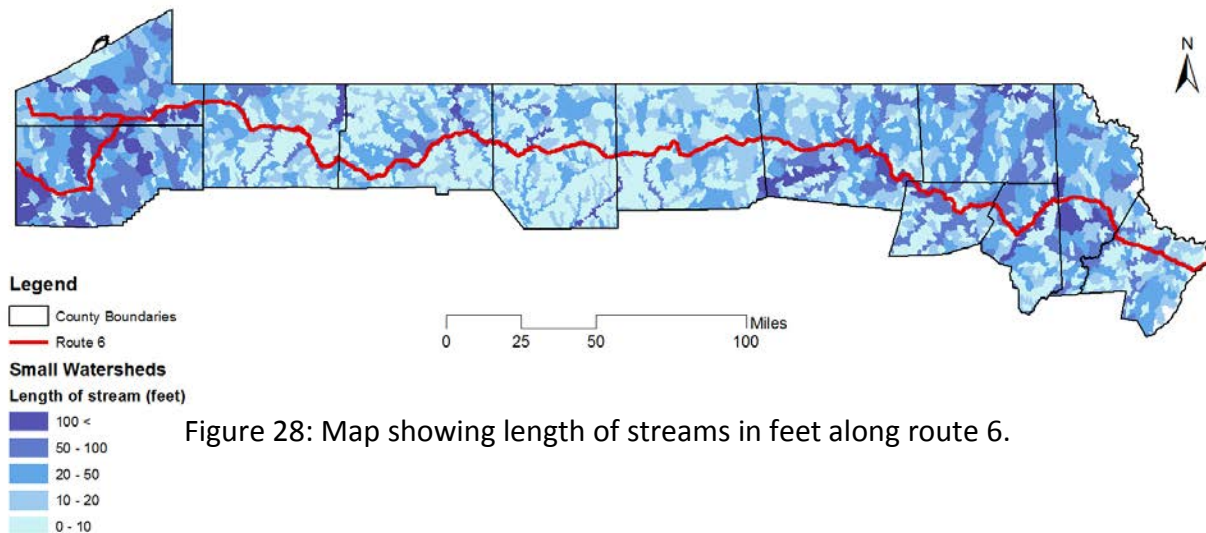


Figure 28: Map showing length of streams in feet along route 6.

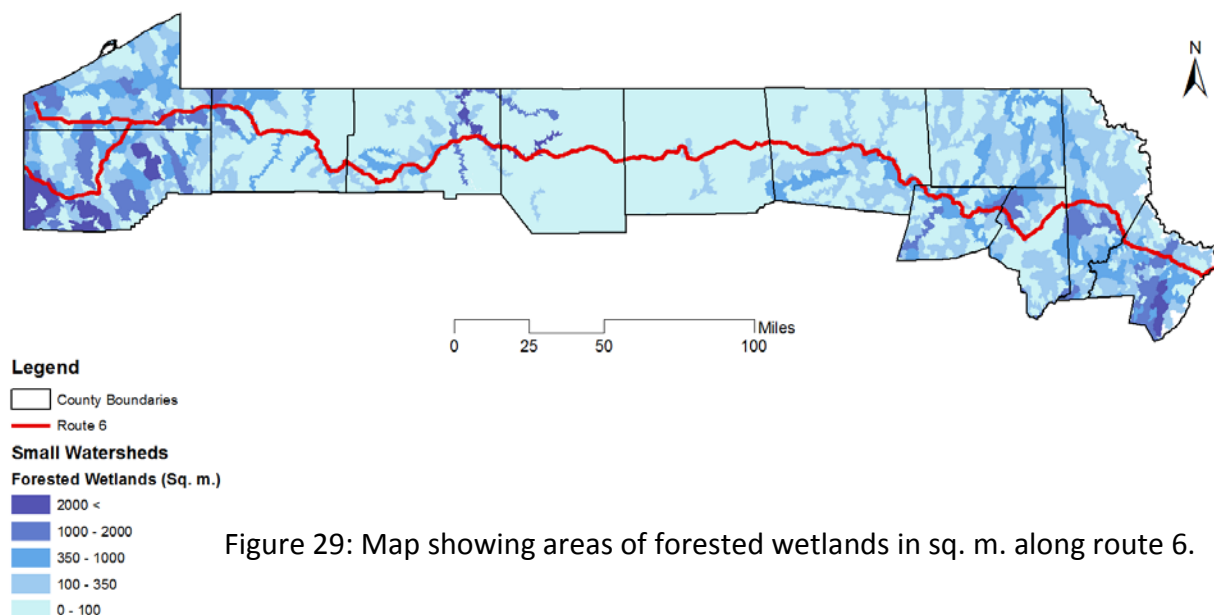


Figure 29: Map showing areas of forested wetlands in sq. m. along route 6.

### 3.2.2 Water based recreation

The network of streams, wetlands and water trails create opportunities for various water based tourism and recreational activities in Pennsylvania. Such activities may range from canoeing, kayaking, to fishing in the streams rich with trout population. The map below (Figure 4.2.2) shows the spatial proximity of water based tourism and recreational opportunities with route 6 and elements related to shale gas activities like well pads and truck traffic volume. Shale gas activities (including drilling in the well pads, waste water storage and treatment as well as truck traffic carrying waste water for treatment or disposal) in close proximity to water based recreational opportunities may pose threats to the natural resources and habitats. Such proximity raises concern over potential impacts due to shale gas activities as well as alteration in visitors' behavior in choosing Rt. 6 as an access route to water based recreational areas.

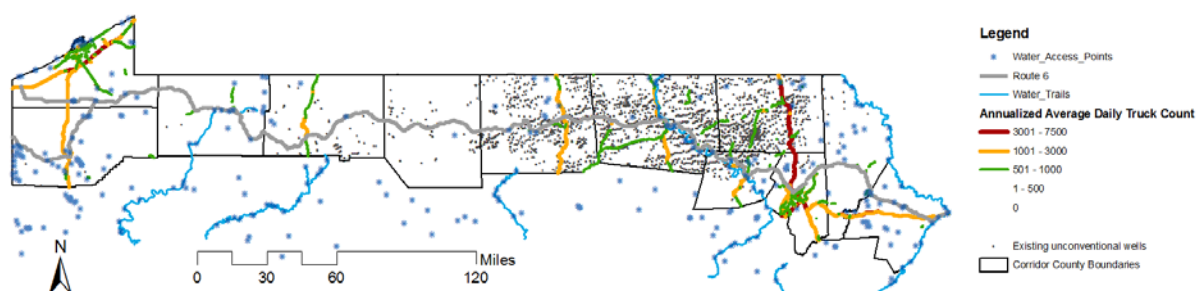


Figure 30: Map showing spatial proximity of shale well pads and regions of water based recreational opportunities along route 6.

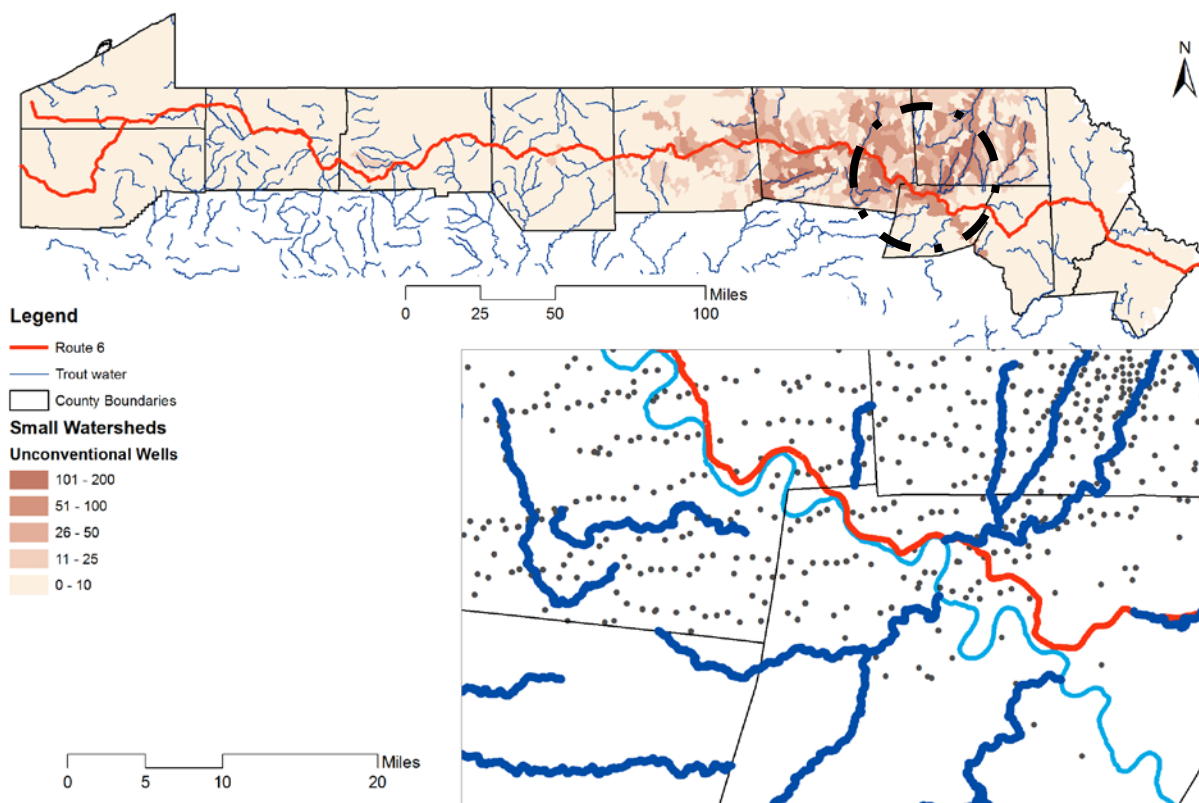


Figure 31: Map showing spatial proximity of shale well pads and trout streams along route 6.

### 3.2.3 Water trails and impervious land

Section 4.2.2 discusses the problems caused due to impervious surface and the impacts hold true for water based resources as well. Impervious surface allows increased run off to the streams, and given the increased shale gas activities on cleared land, chances of contamination of water resources through run off are higher. The water trails often are flanked by trails for running, biking, hiking and other outdoor activities. The flora and fauna in these areas encourage such initiatives. However, activities that add to the impermeable surfaces, like building roads and other construction activities encourage growth of non-native species, which may potentially impact the scenic and ecological quality and hence cease to be attractive destinations for travelers. The following map shows spatial proximity of the water trails with areas with industrial land use with 30-74% impermeable surface.

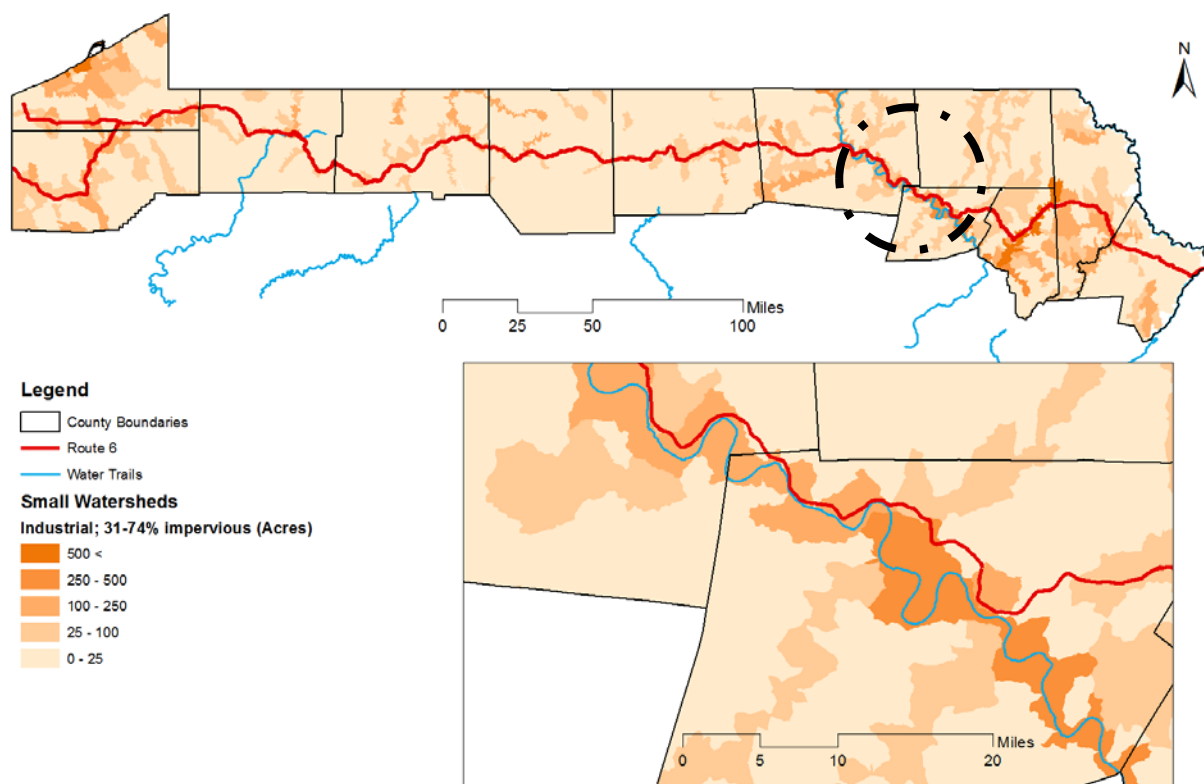


Figure 32: Map showing spatial proximity of impervious surface (31-74%) and water trails along route 6.

The highlighted area has been identified as one of the zones with increased risks to both the highway as well as the water trails adjacent to it owing to impervious surfaces. Another map of the highlighted area shown below (Figure 33) presents the violations in shale gas activities concerning health and environmental issues and water based tourism opportunities. This map, also showing the land use pattern of the region gives an idea of scenic qualities the highway and water trails might possess in terms of forested areas and pristine farmlands, which are characteristic of Pennsylvania, and hence, reinforces our concern.



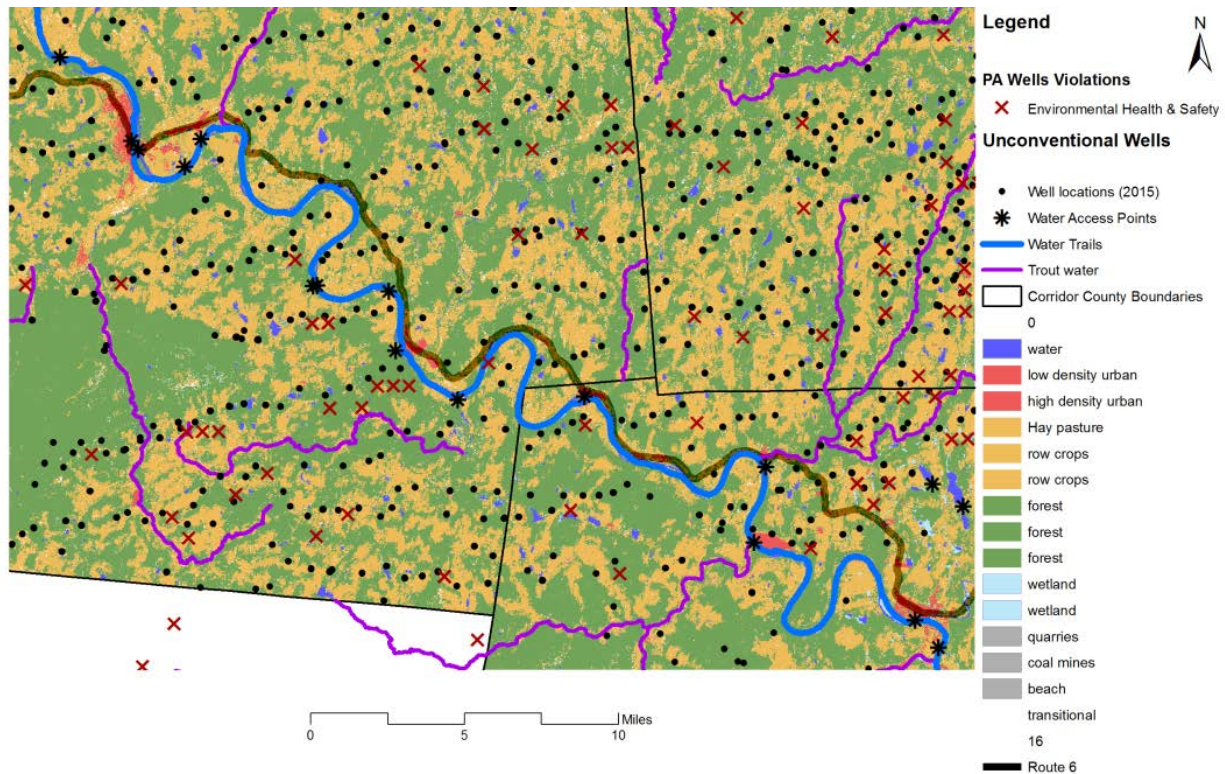


Figure 33: Map showing environmental violations due to shale gas wells and land use.

### 3.3 Rt. 6: Communities

The issues faced by the communities due to shale gas developments have been discussed in section 3.2.3. The following map shows the spatial proximity between the communities and the shale gas wells. The red dots represent the shale gas wells while the black ones represent the area's population by municipalities.

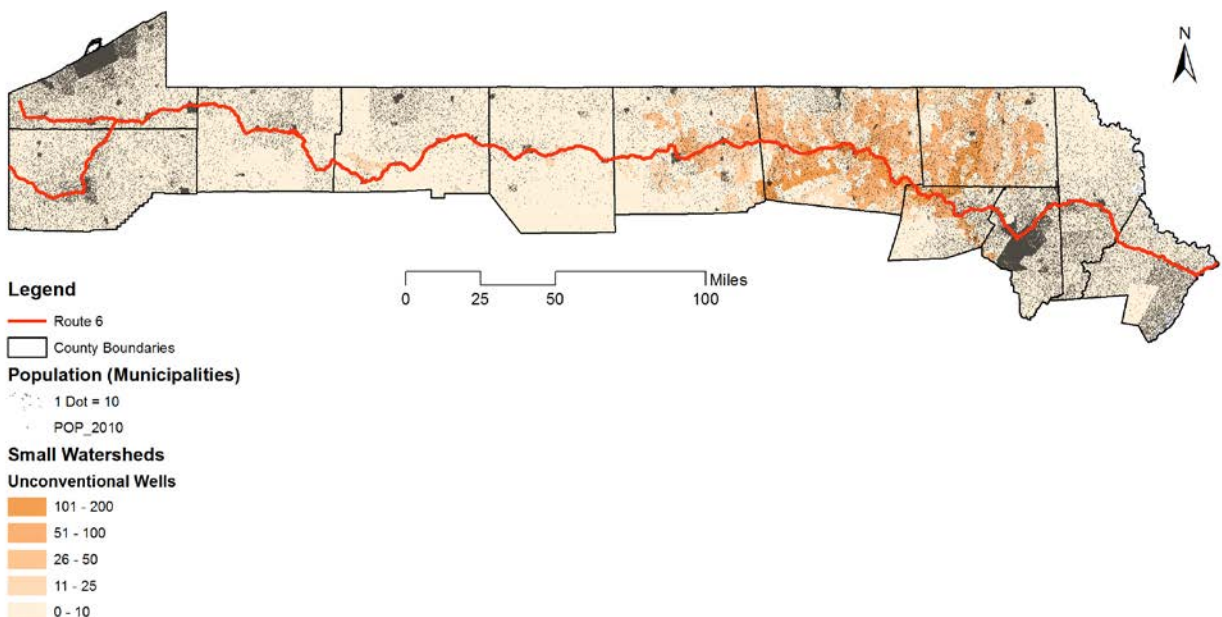


Figure 34: Map showing no. of shale gas wells and population in communities along route 6.



The following map shows the spatial reference between communities and the environmental violations caused due to shale gas activities in the region. These environmental violations support the concerns regarding health and safety of the communities in the northern tier of the commonwealth.

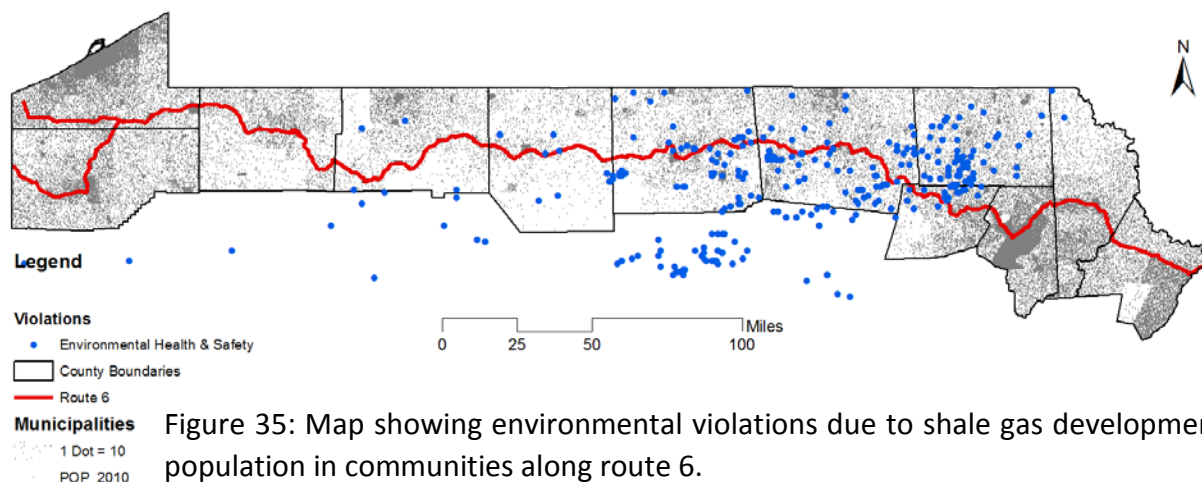


Figure 35: Map showing environmental violations due to shale gas development and population in communities along route 6.

### 3.4 Rt. 6: Tourism

The tourism industry in Pennsylvania thrives on its natural and cultural resources. Any threat to these assets poses a threat to tourism. The following map shows the tourism potentials in the northern tier of Pennsylvania and environmental violations that have been reported in the nearby locations. Some examples of dangerous proximity have been highlighted in figure 37.

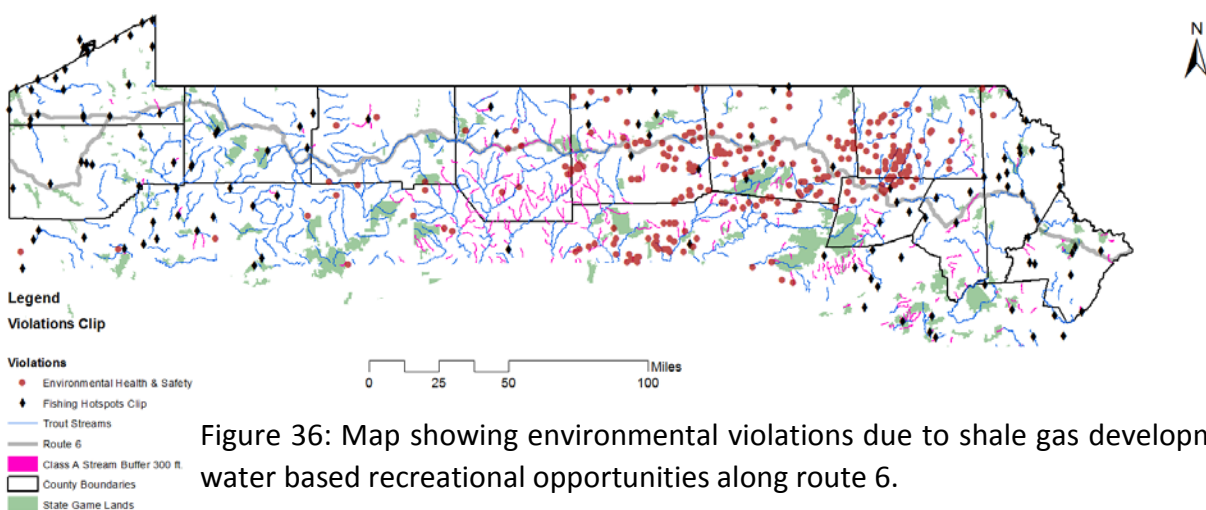


Figure 36: Map showing environmental violations due to shale gas development and water based recreational opportunities along route 6.

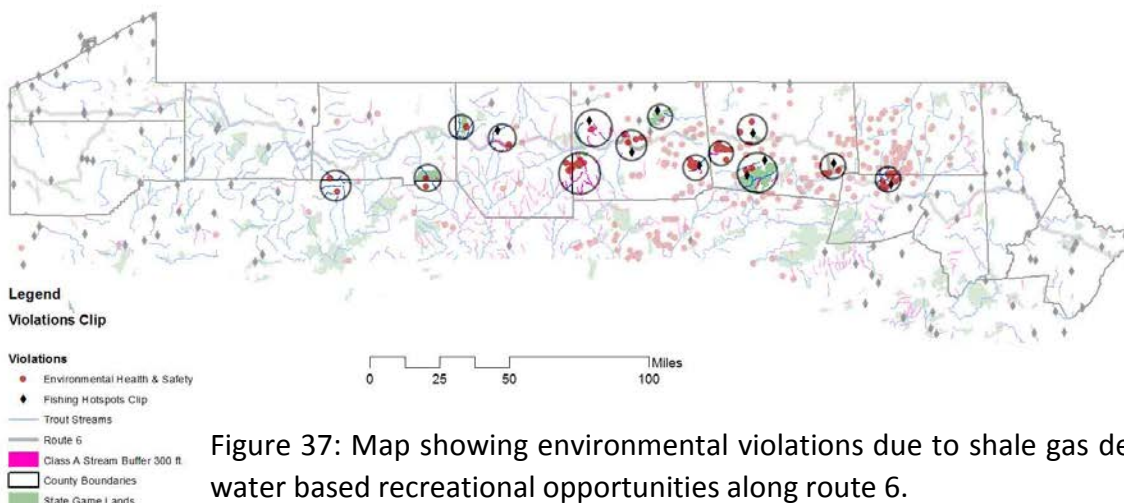


Figure 37: Map showing environmental violations due to shale gas development and water based recreational opportunities along route 6.

### 3.5 Rt. 6: Transit infrastructure

#### Spatial analysis:

- Although most of the route 6 highway doesn't fall under the category of roads supporting more than 1000 average annualized daily truck traffic volume, it does serve as a connection with other roads with high truck traffic volume.
- Such connections as can be seen are located in close spatial proximity with areas on Route 6 with high population density. This may be a problem for the communities in terms of health, noise pollution and road safety.
- Such high truck traffic may lead to a decreased interest among tourists and travelers in visiting these local communities, many of which are popular historic towns and other areas of recreational interest.

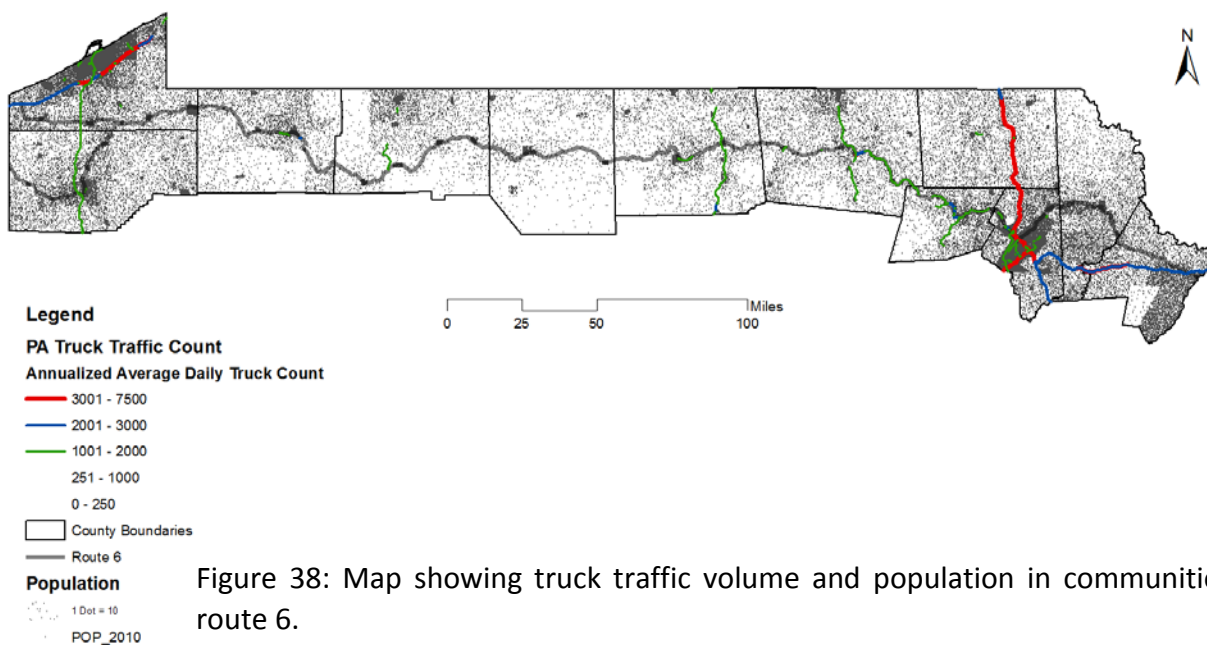


Figure 38: Map showing truck traffic volume and population in communities along route 6.

## 4 Design and Planning Guidelines

As landscape architects we are required to be thoughtful not just about the problems and their analyses but also about finding answers to the questions we have asked. After an assessment of the factors involved and the research analysis, design and planning guidelines can be formulated for future developments with emphasis on these elements:

1. Land
2. Water
3. Community
4. Experiential in terms of tourism and recreation
5. Conservation of a scenic byway.

### 4.1 Addressing specific issues

#### 4.1.1 Forested land and habitats

Prior to proposing design and planning interventions for transit corridors a thorough study and assessment of existing natural resources is conducted in the concerned location so as to identify potential risks. Concerned natural resources may include physiography/topography and geology, soils, surface and groundwater resources, floodplains, wetlands, terrestrial and aquatic habitat and species, and rare, threatened and endangered species. Such works have been mentioned with emphasis in the Natural Environmental Technical Report prepared by the Maryland Transit Administration in relation with the Red Line Corridor Transit Study (MTA 2008).

#### 4.1.2 Water

Direct and indirect impacts to the water resources due to shale gas activities can be avoided in many ways which include:

- Altering the landscape to restore functionality of the area and already altered hydrological functions,
- Reducing run off by decreasing impervious surface,
- Monitoring the changes in hydrology allowing early identification of environmental impacts on water resources.

#### 4.1.3 Community

Since scenic byways are designated upon application on behalf of the local communities, it is essential to involve them in the design and planning process before implementation is commenced. Whereas public participation may be feasible for a smaller study area, it may ask for bigger platforms like web based public participatory activities for larger regions (Cheng 2004). While government intervention is often sought after in situations like this to protect and safeguard the interests of the local communities and historic and cultural resources, it may get a bit tricky to control such activities given the property rights remain to private ownership to a large extent. Research shows that significant development due to the shale gas industry is happening in private land (about 90%; 1296 well pads in private land in comparison with 169

well pads in state land), which narrows down the scope of controlled growth of shale gas development by the state and federal bodies (Drohan, et al. 2012).

#### 4.1.4 Tourism and recreation

When it comes to conserving or restoring how a place has been experienced, the design and planning interventions can be thought of in terms of the time required. Apart from the complexity of the issue, the time required to restore a lost function or structure is directly related to how big the area of disturbance is. Based on the scale of the disturbed zone, design or planning guidelines can be categorized into macro and micro scale initiatives.

##### 4.1.4.1 Macro

1. In order to aim at reducing disturbances on the landscape drilling more wells per pad could seem like a feasible solution. While continued drilling may result in more local disturbances to the community in terms of noise pollution or degraded air quality or vibrations from traffic, it would result in using the already existing roads and other necessary infrastructure (Drohan, et al. 2012).
2. Sharing infrastructure not only among different oil and gas locations but among properties of different gas companies might contribute immensely in terms of reducing disturbances on the land minimizing impacts like depletion of forests, fragmentation of habitats, disintegration of ecological processes and pollution of wetlands and streams.
3. It is also necessary to identify regions which have found special mentions in literature or other media or are even important to the people of the place as fond memories. These places that are important to people as individual or collective memories (whether related to the built or the natural environment) (Castree, Kitchin and Rodgers 2013) should be prioritized in preservation and any design and planning procedures should be arranged around them.

##### 4.1.4.2 Micro:

1. Emphasis should also be given on how the elements of local scale form an integral part of the bigger picture. Among developmental activities commercial establishments such as shopping malls, highways, post-war US suburbs, and edge cities are typically described as placeless, although cultural geographers have argued that they can be sites of meaning-filled engagement and identity. (Castree, Kitchin, & Rodgers, 2013).
2. Elements of road design such as medians, lateral strips, temporary halting zones like dirt pull-overs, fences, etc. play important roles in terms of enjoying a road trip or just as part of the entire experience. Such initiatives may potentially minimize the experiential or visual impacts of shale gas development on the face of the landscape but also add to the bigger experience thus restoring balance in how the highway meets expectations of its visitors as a potential tourism and recreational structure.

Also, for implementing design and planning interventions to boost the corridor's potential for tourism and recreation, it is of utmost importance to retain the sense of place of the region.

The design guidelines should be flexible enough to retain the features of the past as well as make room for the future (Smirniotopoulos 2001).

#### 4.1.5 Designation as a scenic byway

##### 4.1.5.1 Criteria for designation as a scenic byway

It is interesting to note that, according to the 1991 US DOT National Scenic Byways Study, factors like what a road looks like, its design and alignment do not determine its designation as a scenic byway (USDOT, National Scenic Byways Study 1991). However, the 1997 Community Guide to Planning and Management of Scenic Byway speaks differently. According to it, the designation of a highway as a scenic byway has to be based upon the following six intrinsic qualities (USDOT, Community Guide to Planning and Managing a scenic byway 1997):

1. Scenic: Beauty, whether natural or human made. The quality is measured by how memorable, distinctive, uninterrupted and unified they are.
2. Natural: Minimal human disturbance of natural ecological features.
3. Historic: Landscapes, buildings, structures or other visual evidence of the past. It has to be something that can still be seen and not something that once used to be there.
4. Cultural: Visual evidence of the unique customs, traditions, folklores or rituals of existing communities.
5. Archaeological: Visual evidence of the unique customs, traditions, folklores or rituals of communities that no longer exist.
6. Recreational: The corridor itself has to add to the recreational values of its surroundings.

##### 4.1.5.2 Concerns for designation of scenic byways at the state level

Though the national scenic byway program aspires to protect and uphold the cultural heritage and historic significance of the country there are certain concerns regarding implementation of the program at the state level (USDOT 1991):

- Some states fear that a designation of a highway as a scenic byway may prevent improving them in the future
- Safety is an important factor taken into consideration by most States as a part of their designation criteria. Most States do not face any unique safety concerns as a result of the designation.
- Many states prefer to be flexible about developing programs that let them set their own designation criteria and meet their unique needs.
- Alaska and Hawaii feel that all their roads are scenic and see no need for a special designation
- A few states do not see any advantages and have expressed concerns about safety and the possible hazards about rerouting the traffic over narrow and poorly aligned roads.

##### 4.1.5.3 Recommendations for designation as a scenic byway

While designation as a scenic byway is seen in some communities as an opportunity, in others it is seen as a hindrance to future development. For communities sensitive about their scenic



byway, development is synonymous with unrestricted commercial growth but for others it may be portrayed as a lost business opportunity or degrading economic activities. Few aspects are kept in mind for making decisions about future developments along landscape corridors that have been designated as scenic byways (USDOT, Community Guide to Planning and Managing a scenic byway 1997):

1. Appreciation of existing values: It is important to understand and appreciate the existing values of the corridor which contributed towards the designation of a scenic byway in the first place.
2. Broader factors: It is essential to keep in mind the broader factors that are unique of a particular scenic byway including land ownership patterns, the number of local governments involved in the procedure, the predominant land use pattern along the scenic byway, anticipated amount of future growth, political climate, and community structure.
3. Government regulations: Government regulations and policies provide strong backing for resource protection and management. Involving planning departments in the process, identifying an enforceable zoning plan with acceptable land use distributions, enforcing design guidelines and signage provisions are some of the effective ways to do this.
4. Techniques and strategies: The techniques and strategies to be undertaken towards proposing developmental activities along the scenic byways should consider the uniqueness of that particular byway and focus more on the intrinsic values that have made the corridor special instead of relying on homogenous strategies of development all along the byway or implementing plans just because they have been successful somewhere else.

#### 4.2 A Design Implementation

Addressing a problem at the studied scale and proposing design and planning solutions accordingly is beyond the scope of this research. Hence, for the sake of this study, I have picked a location that shows the problems discussed and can be addressed in terms of physical design. Below is the base map of the region I have chosen as the site for this design:

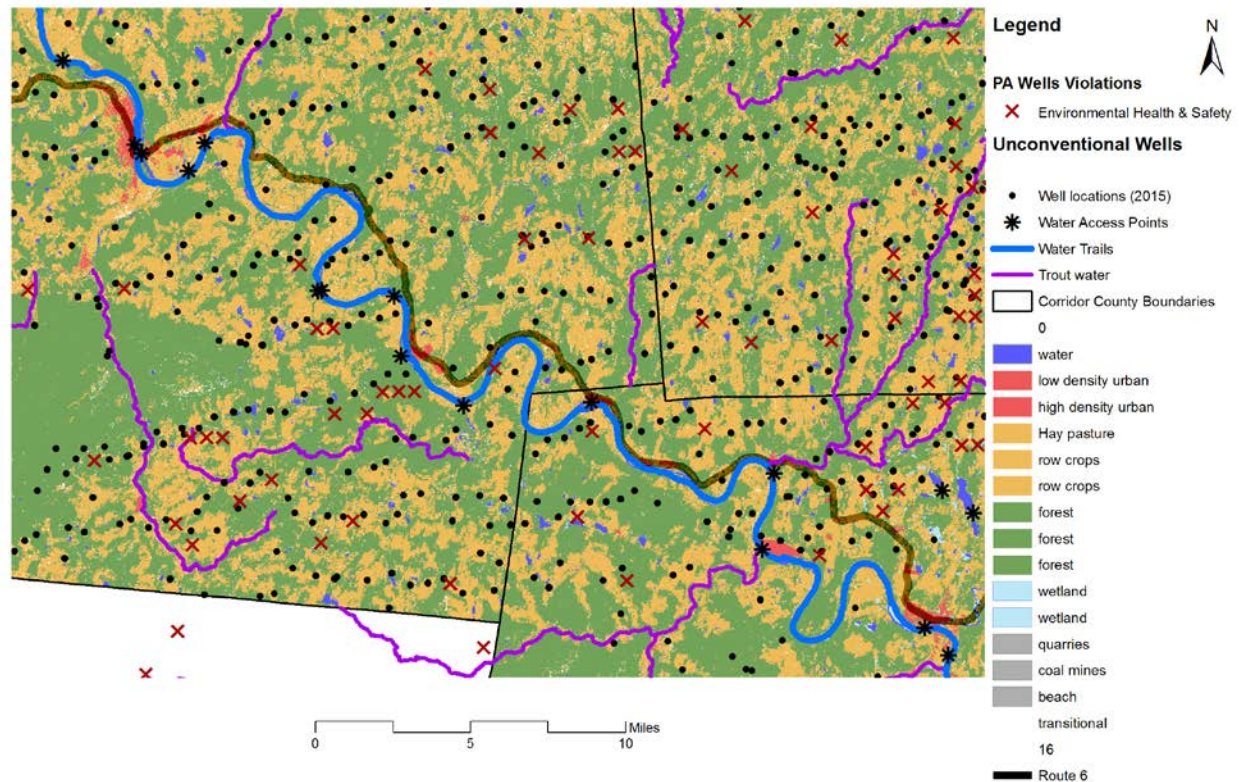


Figure 39: Map showing environmental violations due to shale gas development, land use and water based recreational opportunities.

This base map shows the region yet at a bigger scale but it is important to understand the context of the problem and the reasons behind this choice. This map represents the scenario by showing different layers like well pad locations as of 2015, violations due to wells in Pennsylvania that concern environment and health issues, water trails for tourism, streams rich with trout population, access points for water based tourism and recreation, a basic land use/land cover map and the position of Route 6 connecting all these elements along with a few cities like Wyalusing, Towanda and Tunkhannock.

However, for a detailed analysis and design proposal, the site has been narrowed down to the following location which contains the city of Wyalusing, a few well pads in the visible extents, a water trail running along the route 6 and a basic land use map for guidance in the process. Following the map is a section through the site which gives an idea of the terrain and has been used in understanding the nature of the site and hence in the design process thereafter.

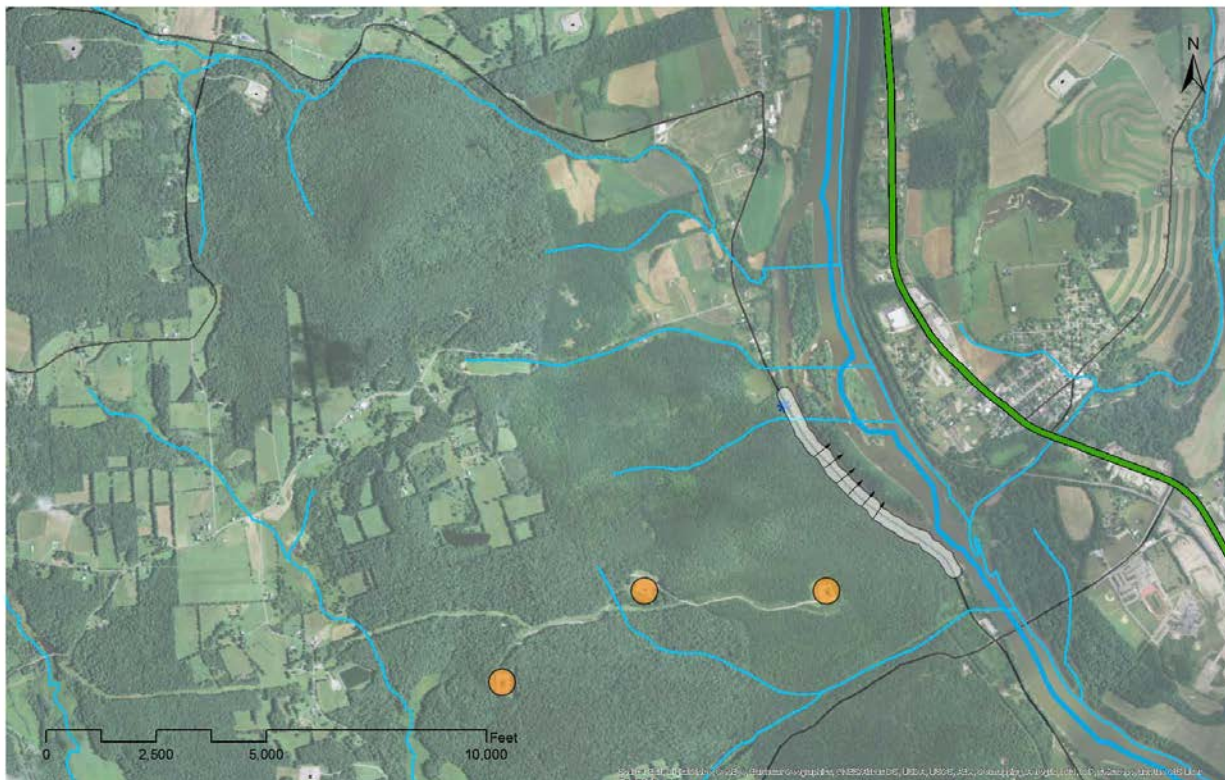


Figure 40: Map showing the area around Wyalusing in Bradford County with a potential threat of runoff into the river owing to the nearby shale gas well pads and environmental violations.

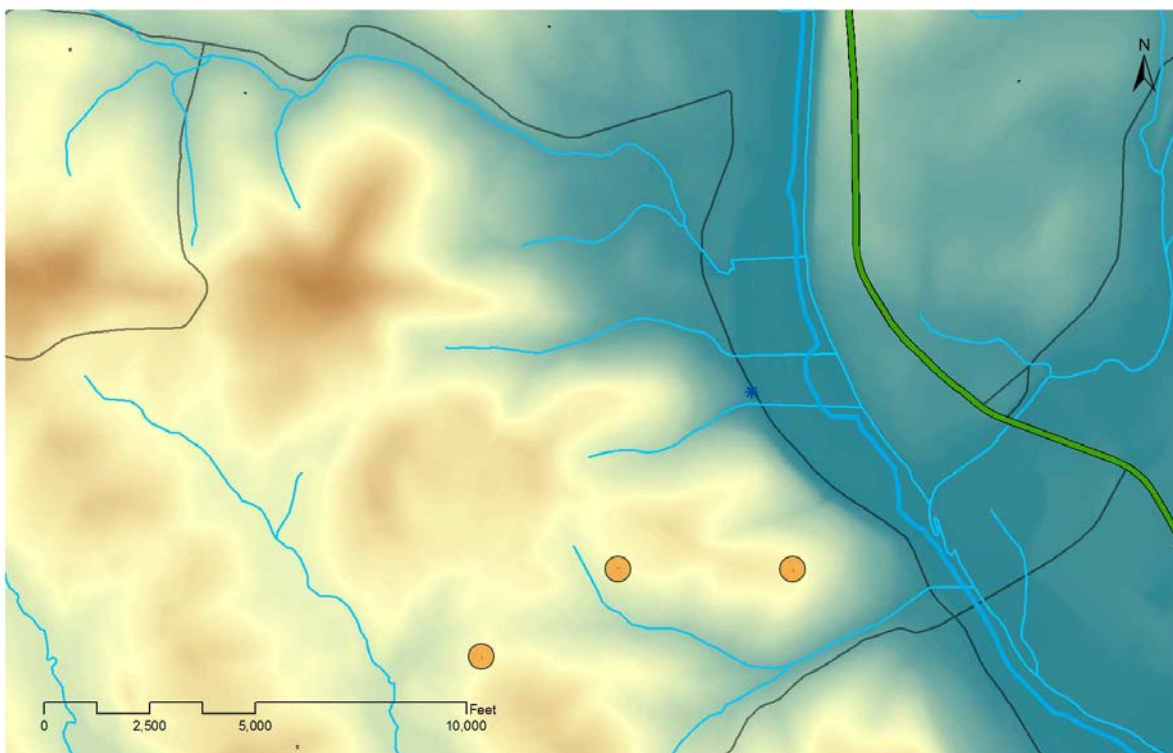


Figure 41: Map showing elevation in the area around Wyalusing in Bradford County with a potential threat of runoff into the river owing to the nearby shale gas well pads and environmental violations.



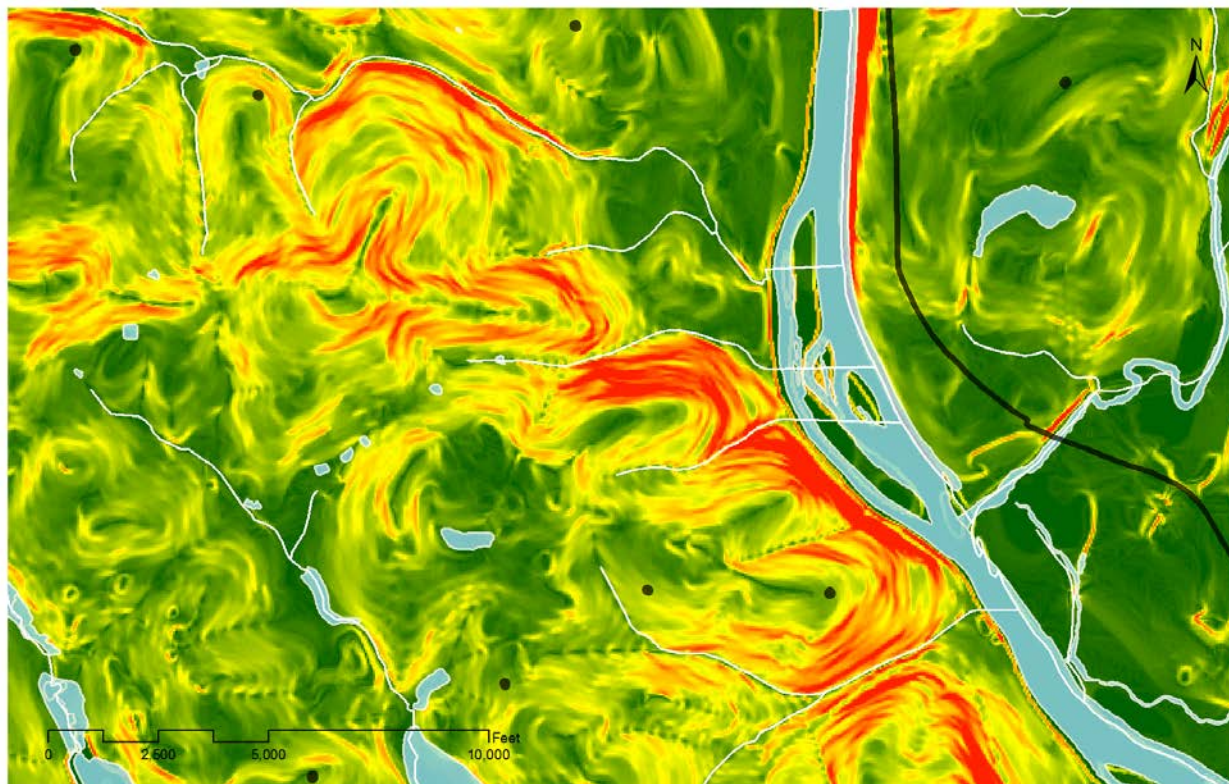


Figure 42: The steep slopes towards the roads and then to the stream increase the chances of runoff from adjacent grounds as well as from leaks and spills from transporting trucks. The maps show an area of potential threat owing to close proximity to shale well pads and zones of environmental violation.



Figure 43: Map showing the area around Wyalusing in Bradford County with a potential threat of runoff into the river owing to the nearby shale gas well pads and environmental violations.

The above image shows the section of potential threat owing to increased run off into streams from adjacent highways. The areas marked in orange show environmental violations that may hamper the natural environment.



Figure 44: Map showing the area around Wyalusing in Bradford County with a potential threat of runoff into the river owing to the nearby shale gas well pads and environmental violations. This capture from Google Street view shows the use of highways by heavy trucks as well as lack of proper plantation which may result in increased run off into the adjacent streams. As discussed above, such conditions may pose potential threats to stream ecosystem and aquatic habitats. Such threats in turn may hamper the tourism and recreational potentials of water trails and fishing hotspots access to which is now provided by Route 6.

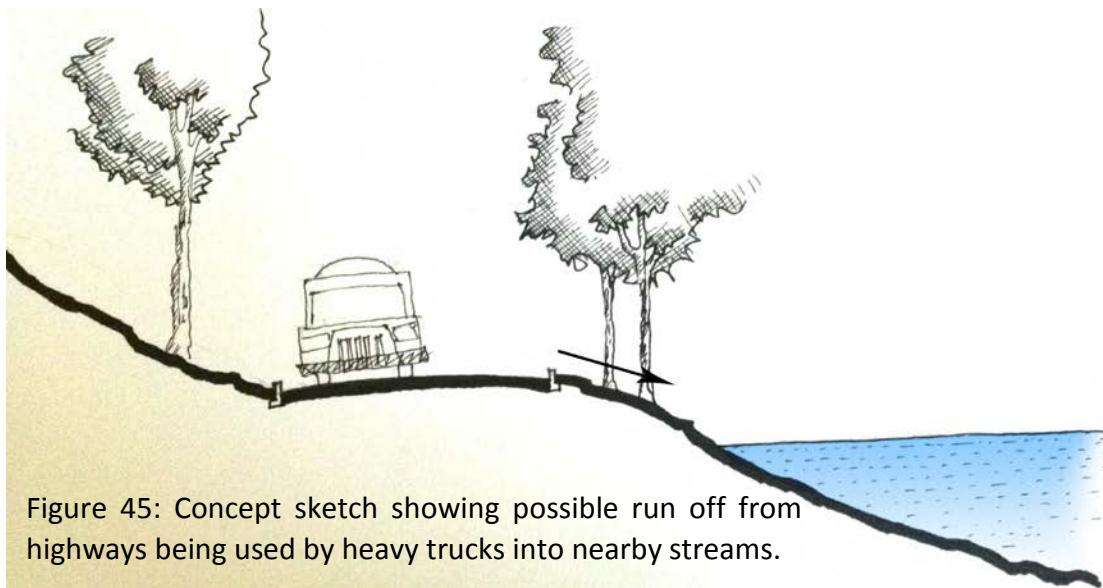


Figure 45: Concept sketch showing possible run off from highways being used by heavy trucks into nearby streams.



While lack of proper measures in terms of treatment of soil and plantation can result in increased run off from the roadways, planning the corridor edges accordingly can help solve this problem.

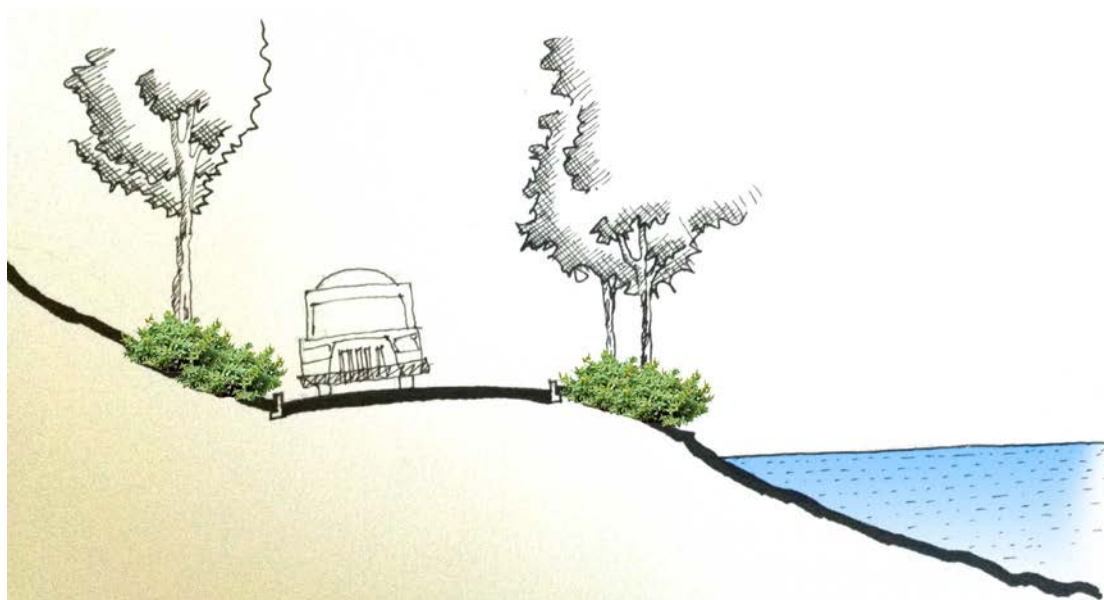


Figure 46: Concept sketch showing proposed vegetation to tackle run off from highways being used by heavy trucks into nearby streams.

## 5 Conclusion

Disturbances on the landscape caused by drilling-related activities occur mainly due to development of new roads or expansion of existing ones for improved accessibility to the well pads; construction of drill pads and associated storm water management systems; facilities for transmission of shale gas after extraction; development of compressor stations to transfer gas to transmission lines; construction of freshwater storage pond for facilitating hydraulic fracturing or fracking; storage and treatment facilities for flow-back water and development of land for storage and management of equipment and other necessary infrastructure (Drohan, et al. 2012). However, an answer for the sake of better management of the shale gas development and allied activities could be integrated work ventures between state and federal agencies, other public bodies, land owners and gas companies that promote landscape restoration principles and sustainable future practices (DellaSala, et al. 2003).

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