Capstone Project: Department of Landscape Architecture

Utilizing Crowdsourced Data for Visual Conservation Design in the Marcellus Shale Region of Pennsylvania

Case Study: Pennsylvania Wilds, Endless Mountains, and The Loyalsock Trail

Lacey K Goldberg
Spring 2014

Table of Contents

Chapter 1

1. Introduction
   1.1. Problem Statement

In Pennsylvania, the drilling and associated development of the Marcellus shale gas boom are having a significant impact upon not only the politics, the economy, and the environment, but also on the visual quality of some of the regions in which this activity is occurring. In north-central Pennsylvania, in the regions called the Pennsylvania Wilds and Endless Mountains, the landscape is known for its pristine woodlands, rolling mountain ranges, rugged trails, glistening streams, and bucolic farmland. These highly valued natural and cultural amenities are at risk of aesthetic degradation. Factors that contribute to the possible degradation of these amenities include, but are not limited to, the siting, forest clearing, and landform grading for well pads, construction of new roads or widening of existing infrastructure for well site access and maintenance, and linear clear-cutting and grading for the installation of pipelines and the long-term maintenance of pipelines right-of-ways.

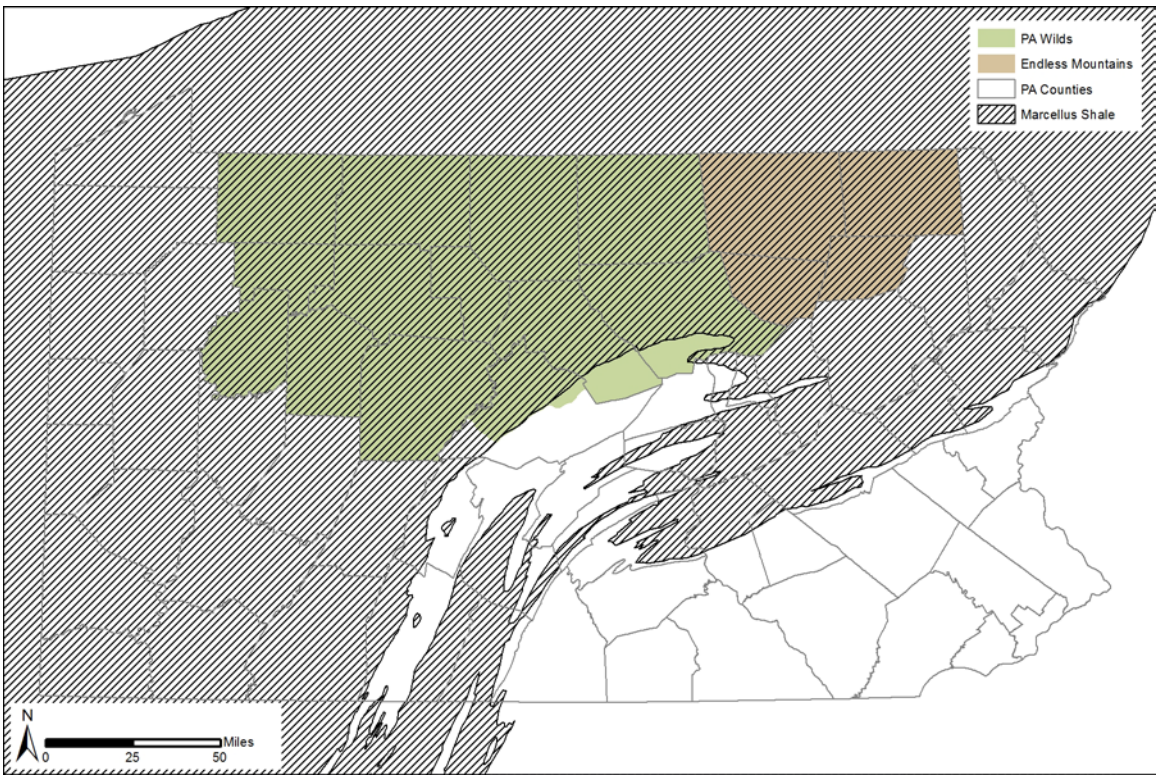


Figure 1 – Pennsylvania Wilds and Endless Mountains regions

   1.2. Purpose Statement

The purpose of this project is to compile a strategic conservation design document for visual resource protection that can be used for reference and/or be implemented by the municipalities within the

Marcellus shale region. The project will also demonstrate a case study of the process and hypothetical application of the design suggestions.

1.3. Project Scope

The project focuses on the Marcellus shale region of Pennsylvania: broadly those areas underlain by the natural gas-bearing geologic formation, regionally in the Pennsylvania Wilds and Endless Mountains regions, and specifically at the viewshed associated with the Loyalsock Trail in Lycoming and Sullivan counties of Pennsylvania.

It is very important to conserve the Loyalsock Trail, the Pennsylvania Wilds, and the Endless Mountains while they remain rural and natural in landscape character. If they are neglected and unchecked development is allowed to occur, they will lose the aesthetic appeal for which they are known and no longer be an asset to the region. While shale gas extraction has provided for a recent upturn in the local economy, royalties for individual wells begin to decline immediately as the pressure in the formation drops and the well produces less. (Bartlow, 2011; Geology.com, 2012). When the shale gas boom ends, the region will need to find other sources of economic revenue—for tourism, second-homes and outdoor recreation to contribute to the economy, the basic resource on which they depend, the scenic landscape, must be conserved.

Chapter 2

2. Background
   2.1. Marcellus Shale Gas Extraction in Pennsylvania

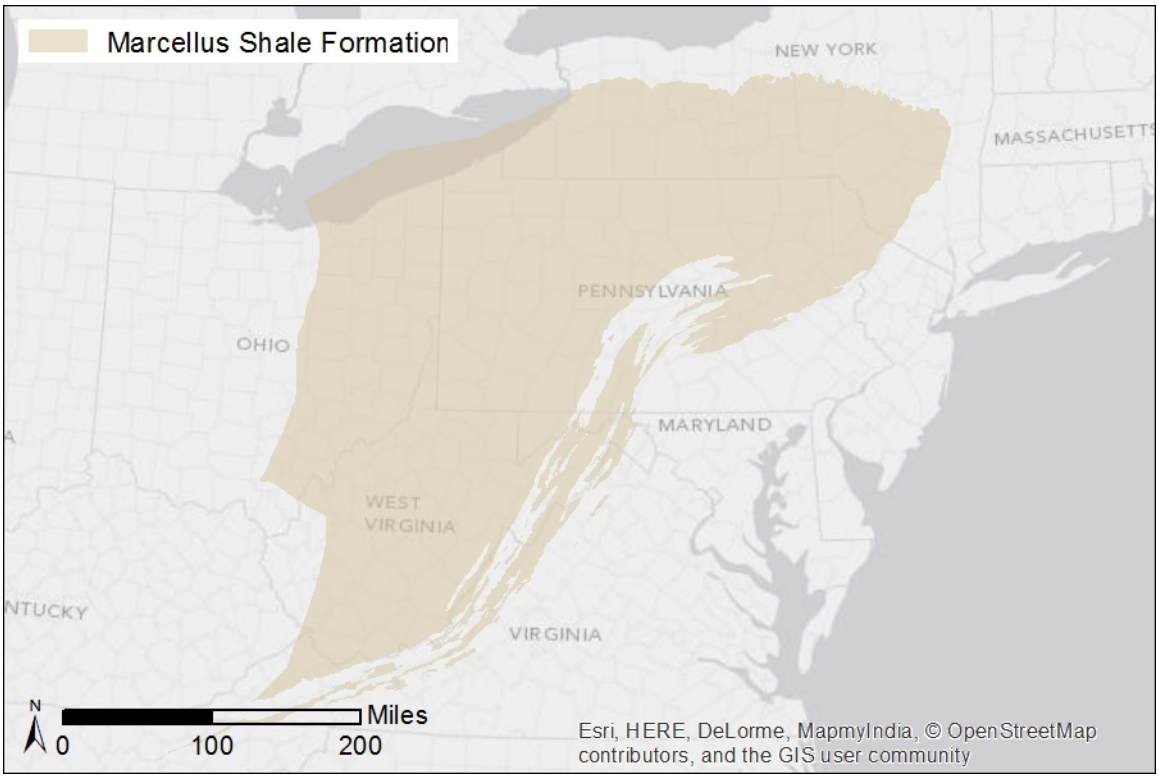


Figure 2 – The Marcellus shale formation

Though the discussion on Marcellus shale gas is a seemingly new topic, natural gas has been a part of Pennsylvania's history for more than 200 years. According to John A. Harper, a geologist with the Bureau of Topographic and Geologic Survey, gas was found as far back as the colonial times as settlers dug or drilled wells. (Harper 2008)

> *Citizens of Fredonia, N. Y., noticed gas bubbling up through the bed of Canadaway Creek, and someone had the foresight to sink a well to collect the gas and use it to light the town in 1821, 38 years before Drake drilled his famous oil well at Titusville, Pa. The Fredonia well was only 27 feet deep, but it produced enough gas to provide the light equivalent of "two good candles." In 1850, the well was deepened to 70 feet and produced enough gas to light 200 burners. In 1858, a second well was drilled to more than 200 feet, and the gas lasted another 30 to 35 years. As a result of the Fredonia wells, a flurry of drilling activity commenced along the Lake Erie shoreline, eventually reaching at least as far as Sandusky, Ohio*. (Harper 2008)

The underling geologic formation in this area was comprised mainly of black, organic-rich shales, fractured shales, and siltstones, above and interbedded with, the black shales. Wells at this time were shallow in comparison with those today, typically less than 1000 feet deep, and many

began producing as shallow as 25 to 30 feet. Many homes and businesses in Erie County had "backyard" wells that are still capable of providing gas today. (Harper 2008) The Lower Devonian Oriskany Sandstone formation of New York and Pennsylvania provided the oil and gas industry with commercial quantities of natural gas in the 1930's. Companies had to drill through the Marcellus formation to reach this layer and it was commonly noted that the Marcellus shale held large, short-lived "pockets" of gas that exhausted quickly and violently. While they knew the Marcellus held gas, they believed it was not enough to make a well. (Harper 2008)

In the 1970s Harper was part of the Pennsylvania Geological Survey Team tasked with mapping and correlating the formation thickness, net feet of organic-rich shales, and net feet of clean sandstone throughout the Middle and Upper Devonian sequence in north-central Pennsylvania, determining that the Devonian shales could be important gas reservoirs in north-western Pennsylvania where they were thick and close to the surface. (Harper 2008) At this time, the deeper shales, including the Marcellus formation, were deemed less desirable because of low gas prices and the lack of available technology to extract the gas. Engelder also mentions in a recent article in Midstream Business that research into new methods of increasing shale gas production had only just begun in the 1970's through the Carter administration's Eastern Gas Shales project; "If it weren't for federal research dollars in the 1970s, shale gas would certainly not have made as much progress as it has." (Nieto 2014) Harper states that only recently, due to the increase of natural gas prices, new innovations in extraction technology, and comparable development of black shales in other parts of the United States, has Marcellus shale gotten any notice. (Harper 2008)

Pennsylvania's Marcellus shale gas extraction began in 2003, when Range Resources–Appalachia, LLC (formerly Great Lakes Energy Partners, LLC) drilled a well in Washington County. The deep formations did not look promising, but the Marcellus shale had some potential. Range Resources drilled a number of experimental wells, and by implementing new drilling and hydraulic fracturing techniques borrowed and revised from those used on the Mississippian Barnett Shale gas play in Texas, began producing Marcellus gas in 2005. (Harper 2008)

2.1.1. Visual impacts upon the land

The focus of this study is on the visual impacts of the Marcellus shale gas industry. It does not look at the environmental or economic impacts, though these factors may be closely interrelated.

In the Pennsylvania Wilds and the Endless Mountains regions, residents and visitors expect the landscape to appear untouched by man, in pristine condition or only show minimal human impact such as elements representative of the agricultural cultural landscape or the forestry industrial history. Residents of the regions are proud of their cultural histories and visitors come to these regions to escape their overly developed cities and experience a simpler life by getting back to nature. Figures 3 – 10 show examples of the visual impacts occurring throughout the region.

Figure 3 – Pipeline construction Susquehanna County, PA (Source: http://stateimpact.npr.org/pennsylvania/2013/01/03/marcellus-shale-pipelines-heading-for-philly-suburbs/ Accessed: 6/12/2014))

Figure 4 – Hill top well pad and storage pond Waynesburg, PA (Source: http://articles.philly.com/2012-03-02/news/31117210_1_pipeline-route-natural-gas-ugi Accessed: 5/14/2014)

Figure 5 – One of Chesapeake Energy's Marcellus Shale wells sits high on a bluff over the Susquehanna River in Windham Township, Wyoming County, Pennsylvania, in September (Source: http://media.pennlive.com/midstate_impact/photo/pn-20100910165701-1jpg-60be8114ba067cc1.jpg Accessed: 6/12/2014)

The development associated with the Marcellus shale industry has laid a blanket of visual impacts across these landscapes. Large, highly visible swaths of forest are being clear cut and graded for well pads and pipeline right-of-ways, ridge tops are being flattened and routed out, scenic vistas and overlooks, trails, and waterways are being encroached upon, narrow country roads are being severely rutted or pulverized, or widened to accommodate large truck traffic, and the bucolic character of the farmlands is being destroyed by the influx of industrial noises, fumes, vehicles, and machinery.

Figure 6 – Oversized trucks on narrow country roads (Source: http://www.marcellus-shale.us/road_damage.htm Accessed: 6/12/2014)

Figure 7 – Rutting on gravel roads from trucks (Source: http://www.marcellus-shale.us/road_damage.htm Accessed: 6/12/2014)

Figure 8 – Loyalsock Trail (in red) at the Lycoming – Sullivan County Border, September 2010 (Source: Google Earth)

Figure 9 – Loyalsock Trail (in red) at the Lycoming – Sullivan County Border, May 2013 (Source: Google Earth)

2.2. The Pennsylvania Wilds and Endless Mountains Regions

2.2.1. The Pennsylvania Wilds Region

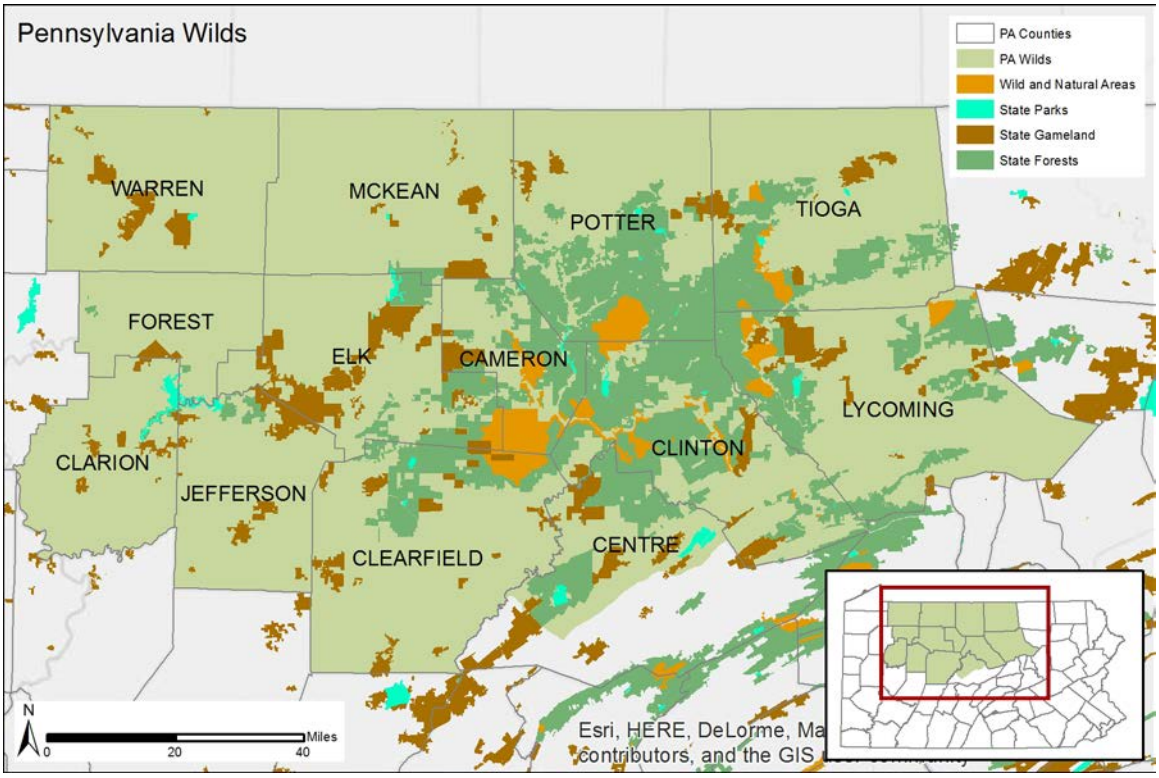


Figure 10 – Pennsylvania Wilds and public lands

The Pennsylvania Wilds is a considered a conservation landscape by the Pennsylvania Department of Conservation and Natural Resources (PA DCNR). The goals of this conservation landscape are to: ensure stewardship of the public lands and character of the region's communities, support and grow private businesses such as accommodations, services, and locally made products, promote the renewal of the region's communities and appropriate community planning, and invest in public infrastructure to enhance the visitor experience. (Pennsylvania Department of Conservation and Natural Resources n.d.) It resides in 12 and ½ counties, Warren, McKean, Potter, Tioga, Lycoming, Clinton, Clearfield, Forrest, Elk, Cameron, Clarion, Jefferson, and the northern half of Centre. It is comprised of more than 2 million acres of public land, comparable in size to Yellowstone, with 29 state parks, 50 state game lands, and hundreds of miles of land and water trails. (PA Wilds Resource Center n.d.) People are drawn to the region to experience nature and by the area's oil and lumber heritage and to experience authentic small towns. (Pennsylvania Department of Conservation and Natural Resources n.d.)

Sustainable tourism has recently, as of the earth 2000's, emerged as a way to create jobs, diversify local economies, improve quality of life and inspire stewardship of the region's natural and cultural assets. Common tourism activities include hunting, biking, hiking, camping, fishing, canoeing, and exploring America's heritage. (PA Wilds Resource Center n.d.) The PA Wilds is in close proximity to many major tourism markets and has more than 50 million people living within a day's drive. The region is easily accessible; the southern portion of the Wilds is accessible from Interstate 80, the busiest east-west

interstate in the United States and the north is accessible from Pennsylvania Route 6, rated one of America's most scenic drives by National Geographic magazine. The ease of access makes the region attractive for tourism and for economic opportunity for regional communities and business. (Pennsylvania Department of Conservation and Natural Resources n.d.)

2.2.2. Endless Mountains Region

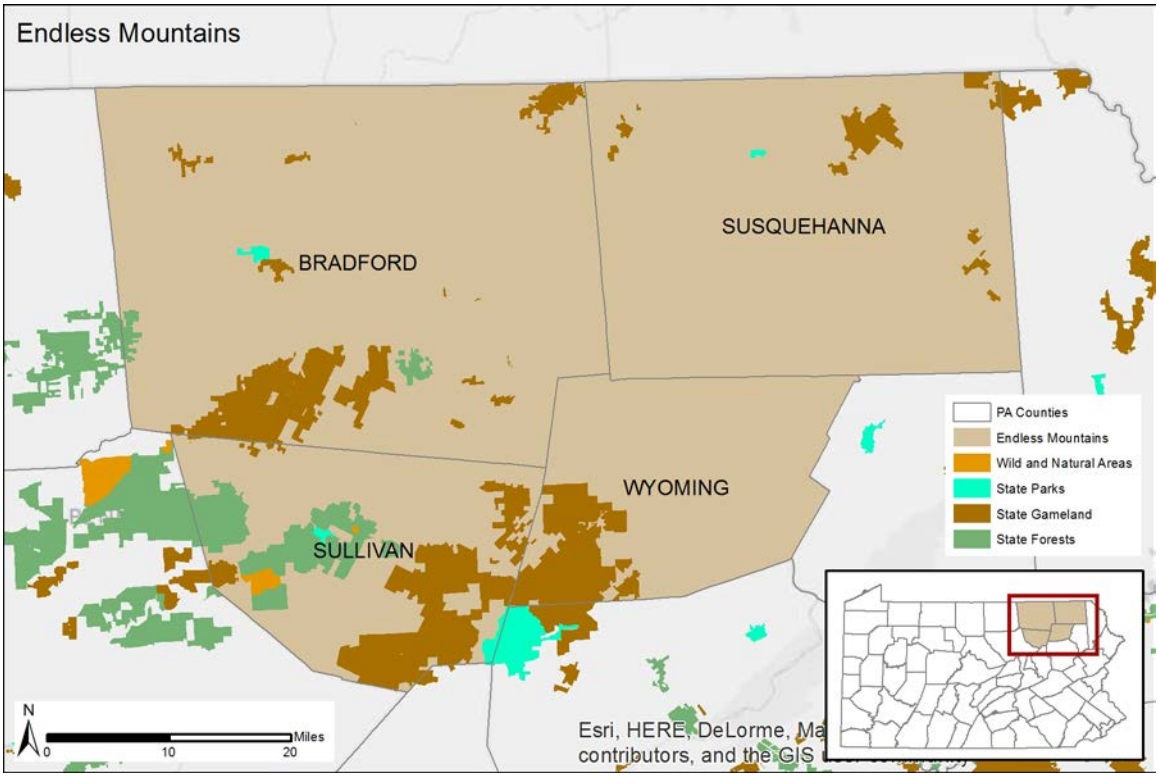


Figure 11 – Endless Mountains and public lands

The Endless mountain region is made up of four counties, Bradford, Susquehanna, Sullivan, and Wyoming in northeastern Pennsylvania. It is known for its agriculture and beautiful rural landscapes among rolling hills that have been shaped by centuries of farming and timbering. The Endless Mountains Heritage Region (EMHR) was created in 1998 as a non-profit agency whose industrial theme is agriculture and "living with the land". Its mission is "to maintain and enhance the unique rural character and culture of [the] Endless Mountains." (Endless Mountains Heritage Region 2009) The EMHR vision statement reads:

> *In the year 2020, the Endless Mountains region is a haven for the spirit. It is a place where we enjoy peace, quiet, and safety, and the thousand stars of the night sky. We live in harmony with our natural and cultural heritage, enjoying a beautiful countryside and healthy settlements that reflect our history. We are a rural community that works together to ensure that all who live, visit, and invest here appreciate our respect for the*

> *land as a source of prosperity and community tradition. In accommodating the needs of future generations, we seek to foster the entrepreneurial spirit, personal independence, and community values that are part of our heritage. We achieved this vision by purposeful hard work, encouraging and helping each other, and understanding, respecting, and communicating what we have set out to become.* (Endless Mountains Heritage Region 2009)

The EMHR assists with projects serving heritage tourism development, historic preservation and interpretation, greenway and trail development, cultural education and community development goals. EMHR serves as water trail manager for the Susquehanna River North Branch Water Trail, a National Recreation Trail, an official gateway agency of the Chesapeake Bay Gateways Network, and regional project partner of the Susquehanna Greenway Partnership. The agency is also involved in various greenway, land conservation, and trail initiatives in the region, as well as historic structures and scenic byways and vista enhancements. (Endless Mountains Heritage Region 2009)

One of the main goals of the EMHR is conservation of the regions heritage including its culture and landscapes. The EMHR website (http://www.endlessmountainsheritage.org) identifies the "emergence of exploration of Marcellus Shale natural gas throughout [the] region as present[ing] new challenges and opportunities for preservation and conservation" as scenic vistas are cleared for development. (Endless Mountains Heritage Region 2009) Environmental renewal has long been part of the region's history. Before the Great Depression, when the Endless Mountain's economy was beginning its decline, some natural resources were already exhausted in some areas. The Civilian Conservation Corps replanted deforested areas that had been purchased by the government. Today those lands are prized as valuable recreation areas. With reforestation the tourism industry took off in the late 19th century and expanded to include the region's many lakes. (Endless Mountains Heritage Region 2009)

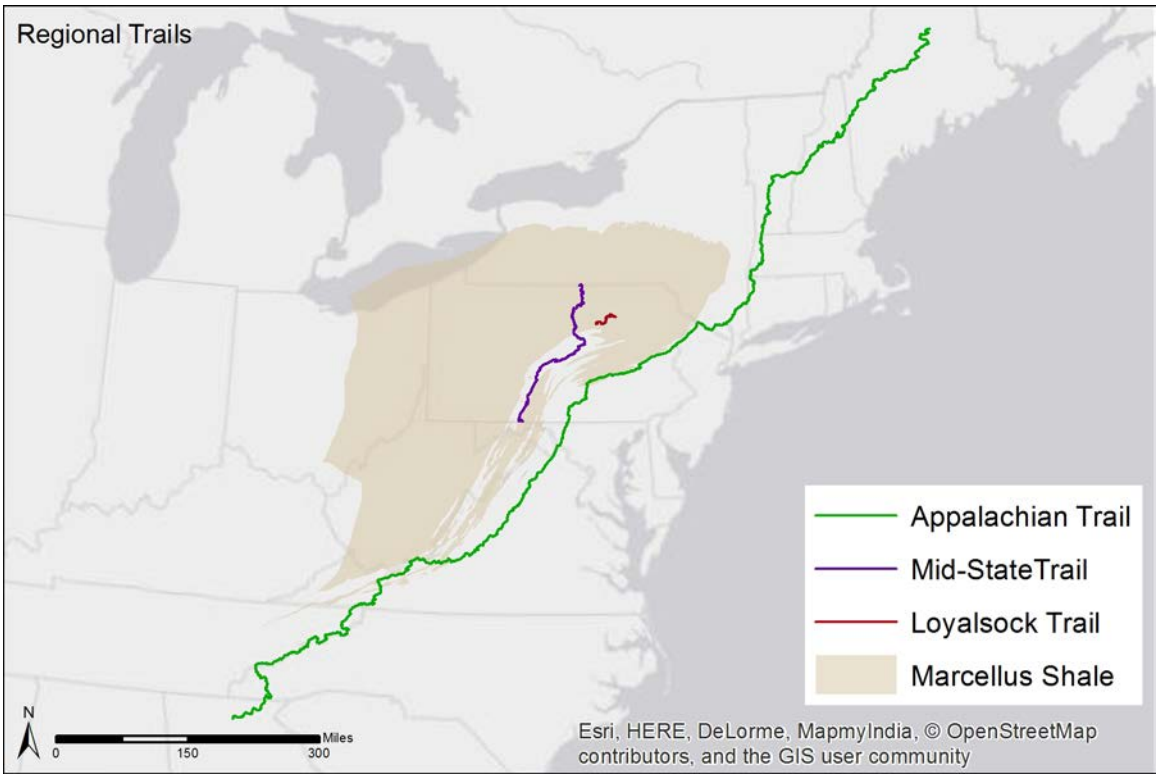
Today, the cultural heritage of the region's many peoples shows through its artistry and crafts. Art studios are scattered throughout the region and the Endless Mountains provides raw materials such as stone, wood, natural fibers, plants, for craftspeople. Crafts and skills associated with nineteenth century life, such as quilting, blacksmithing, and weaving have been passed from generation to generation. (Endless Mountains Heritage Region 2009)

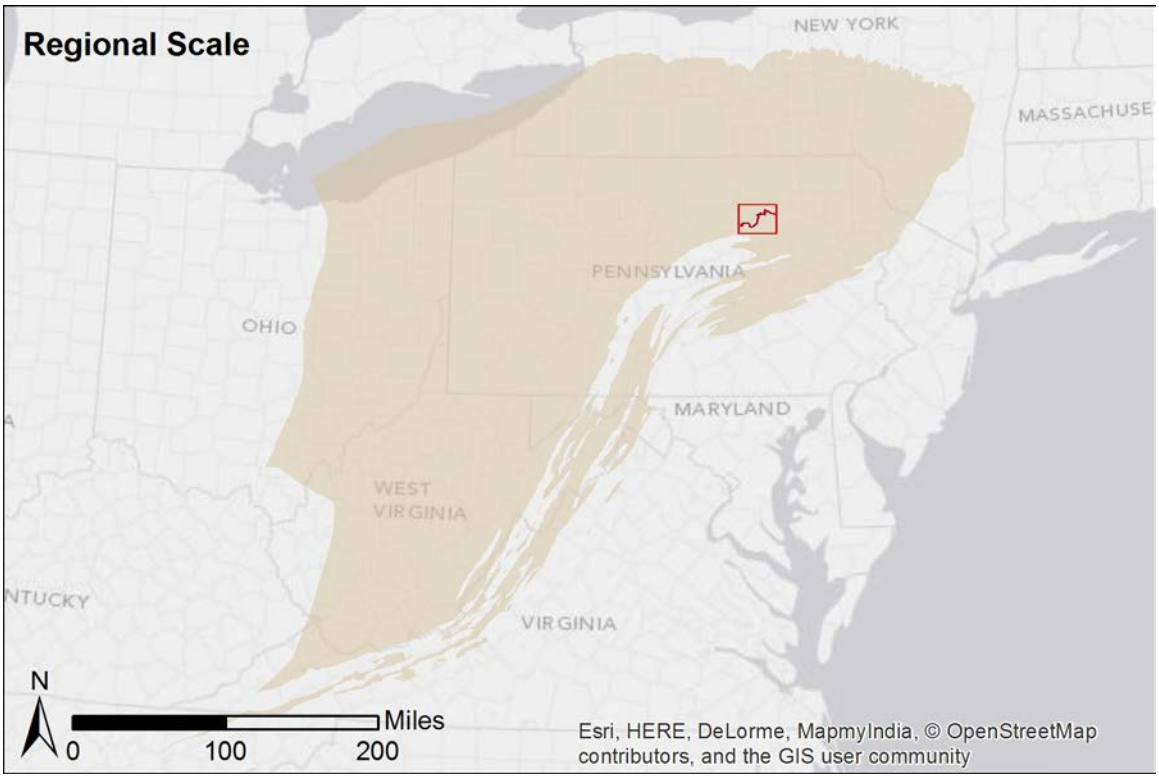
2.3. The Loyalsock Trail

The Loyalsock Trail (LT) is a 59.21-mile hiking trail laid out in 1951 by Explorer Scouts of Post No. 110 (Boy Scouts of America) from Williamsport, PA, led by Howard Ulman, Jr. (The Alpine Club of Williamsport - History 2011) The Alpine Club of Williamsport was organized in 1953 to maintain the original 30.4 miles of the trail. Both ends of the LT were extended to their present locations between 1960 and 1962; additional relocations were made in 1973, 1975, 1983, 1984, 1999 and 2011. (The Alpine Club of Williamsport - History 2011)

It is a footpath, meaning it only allows hiking on foot (or snowshoeing in the winter) and does not allow equestrian riding, bicycle traffic, or motorized vehicles. The intermittent ruggedness of the trail also precludes anything but foot traffic. (Rode 2014) The trail begins on PA Route 87, 9.0 miles north of the

Route 87-Montoursville exit of Interstate 180 (US Route 220), and ends at a parking lot on Meade Road, 0.2 miles from US Route 220. The entrance to Meade Road is 2.4 miles north of the intersection of Routes 220 and 154 near Laporte, PA. The extremes of elevation are 665' at its lowest, and 2140' at its highest. The LT follows mountain ridges and streams through the Loyalsock Creek watershed, the Loyalsock State Forest, and Worlds End State Park as it travels through the forests on footpaths, old logging roads and abandoned railroad grades. Logging of the old growth forests of the Loyalsock Creek watershed began in the early 1800s and was completed by the large railroad logging operations between 1902 and 1925. One segment of the LT, in the Highland Lake area, follows the Towanda Indian Trail, which dates from before the coming of European settlers. (The Alpine Club of Williamsport - History 2011)

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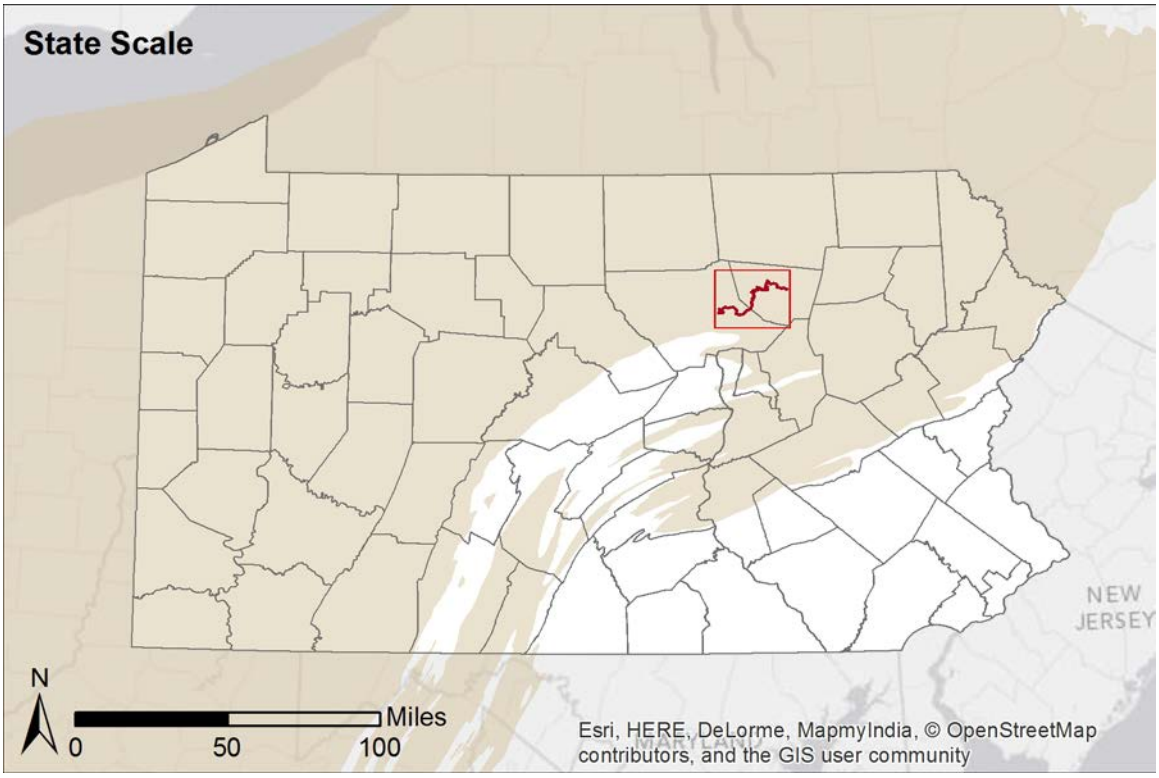
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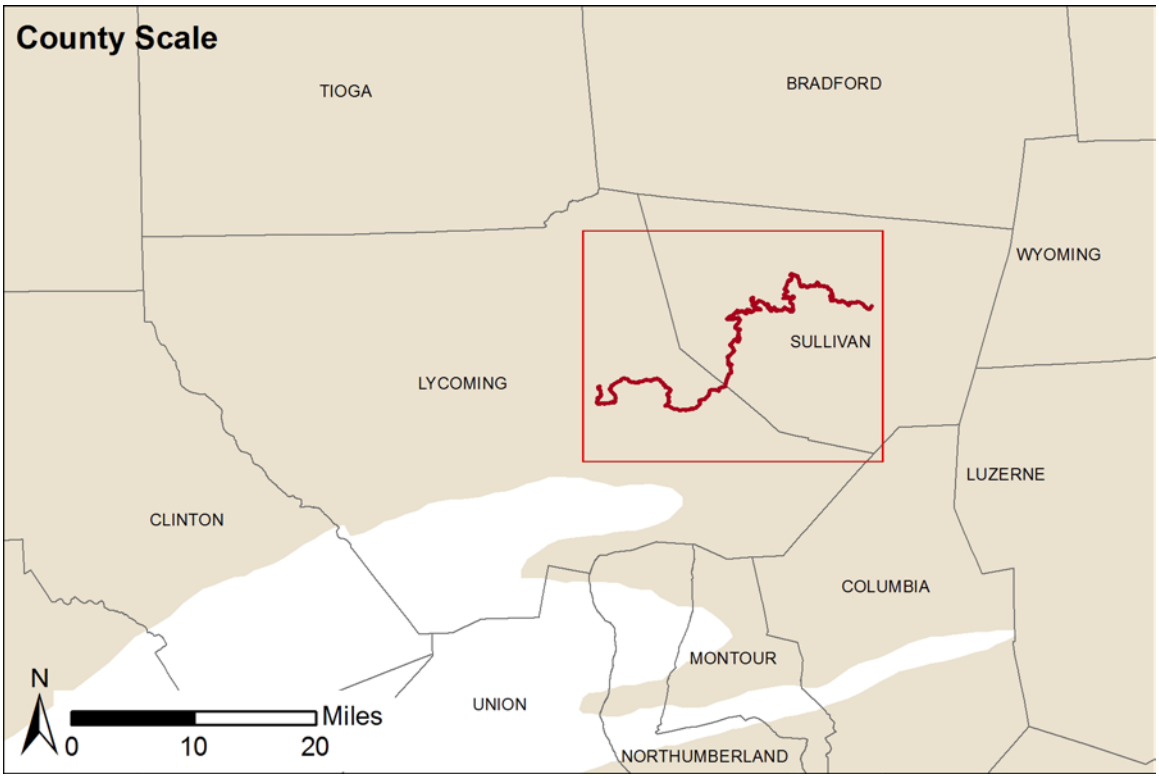
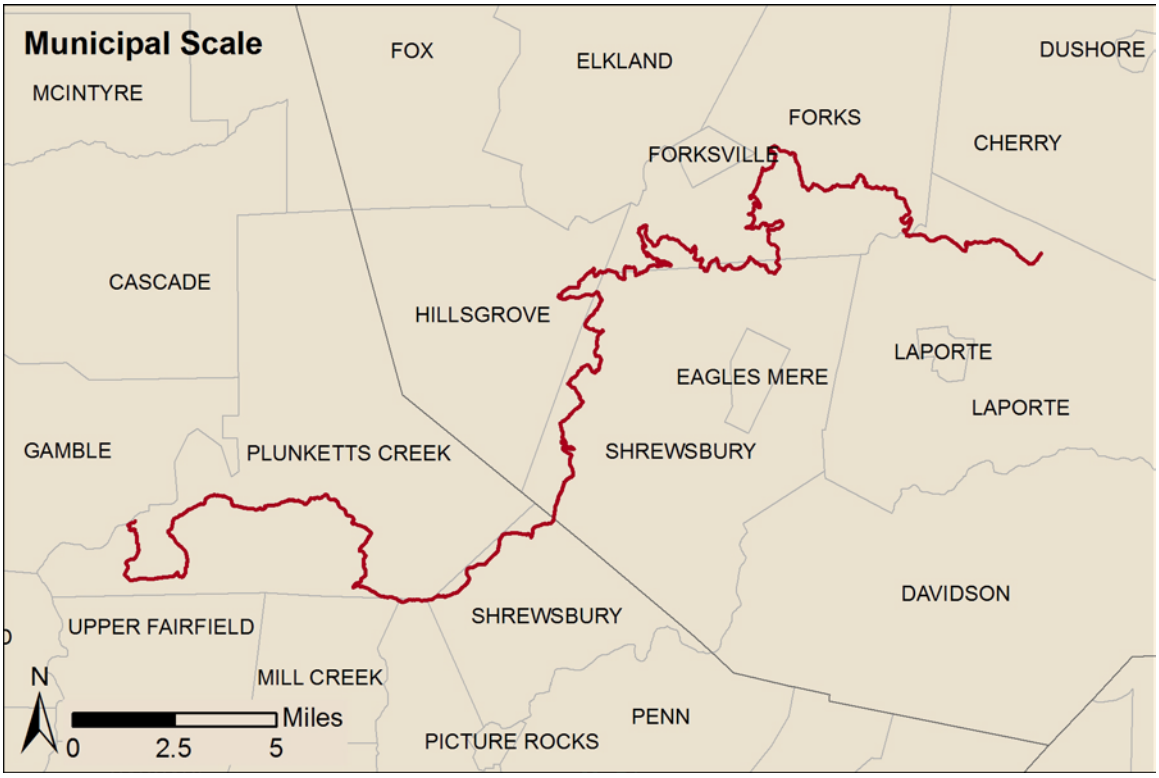




The Alpine Club of Williamsport identifies many points of interest along the trail: Allegheny Ridge, Helen's Window, Smith's Knob, Angel Falls, Kettle Creek Vista, Dutter Run Falls, Mary's View, High Knob,

Lee's and Rode Falls in Ketchum Run Gorge, Alpine Views, Mineral Spring, Loyalsock Canyon Vista, Worlds End State Park, High Rock Vista, Alpine Falls, Sones Pond, The Haystacks, and Dutchman Falls.

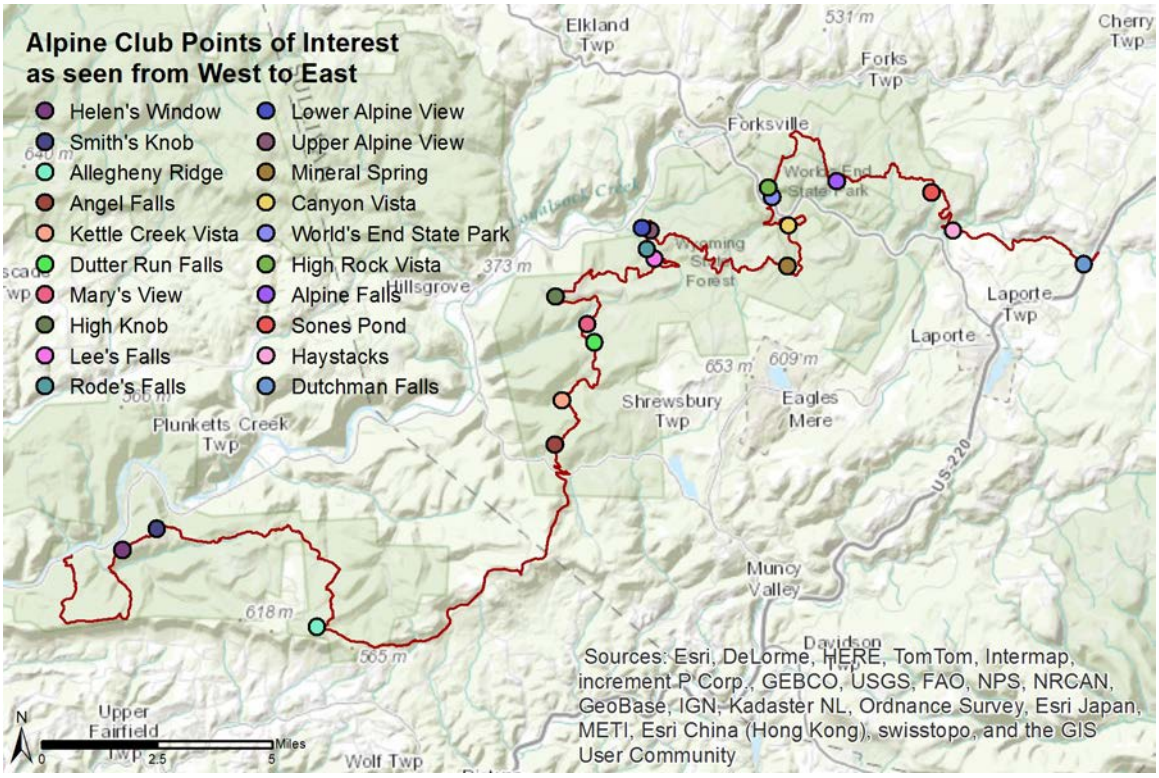


Figure 12 – Points of Interest along the Loyalsock Trail Identified by the Alpine Club of Williamsport

The Alpine Club of Williamsport is aware of the gas drilling occurring adjacent to, and in areas surrounding the trail. They have dedicated a page on the LT's website (http://www.lycoming.org/alpine/gasdrilling.html) to informing hikers about in current and possible future impacts of the drilling.

Figure 13 – Map of the Loyalsock State Forest. (Source: http://www.lycoming.org/alpine/gasdrilling.html) State Forest land that has been leased is shown in light blue.

Although drilling for natural gas will probably occur in the area shown in Figure 13, the Bureau of Forestry has designated a 100' buffer to minimize disturbance to the LT. (DCNR Bureau of Forestry n.d.) In the area of State Forest land shown in dark blue the gas is privately owned and the Bureau of Forestry has minimal control over gas extraction activities. The natural gas on much of the privately owned land along the LT has also been leased. (The Alpine Club of Williamsport - Gas Drilling 2011)

The Alpine Club notes the impacts upon hikers including: flagging, stakes, and equipment for seismic monitoring that may be places along the trail; the widening of adjacent roads for access of heavy equipment; well pad construction and associate deforestation; the actual drilling and fracturing process and the noise associated with those operations.

Figure 14 – flagging for seismic survey; widened road (LT mile 19.48 to mile 19.65); well pad on private land adjacent to the LT (trail on left, well pad on right) (Source: http://www.lycoming.org/alpine/gasdrilling.html Accessed: 5/13/2014)

The group identifies the construction of pipelines as the most impactful aspect of gas extraction. (The Alpine Club of Williamsport - Gas Drilling 2011)

Figure 15 – Construction of pipeline (Source: http://www.lycoming.org/alpine/gasdrilling.html Accessed: 5/13/2014)

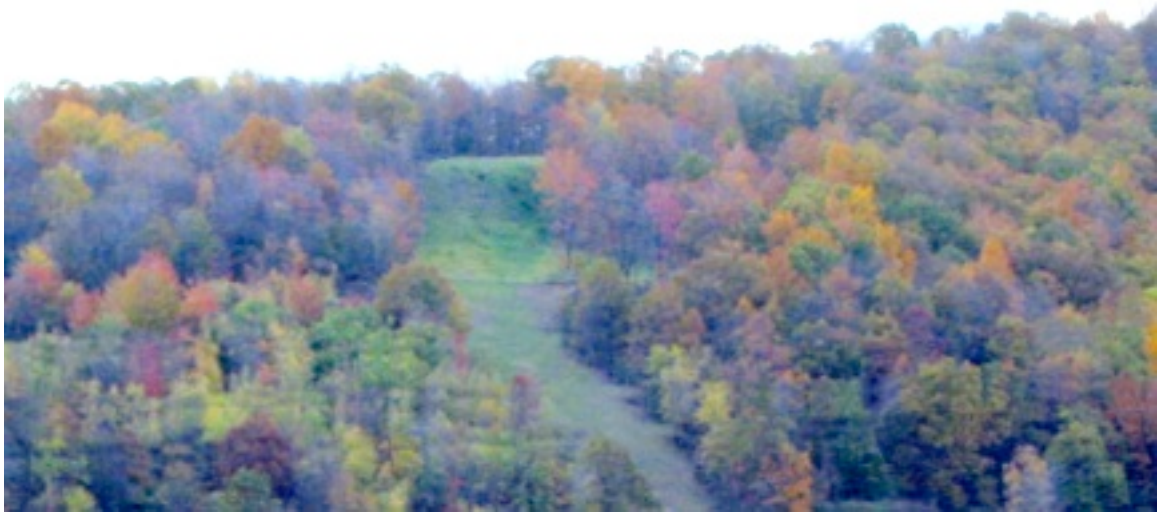


Figure 16 – Revegetated pipeline (Source: http://www.lycoming.org/alpine/gasdrilling.html Accessed: 5/13/2014)

Chapter 3

3. Relevant Literature
   3.1. Scenic Conservation

Studies examining the methods of protecting the landscape as public and visual amenity are numerous (e.g. Zube 1984, Daniel 2001, Dramstad et al. 2006, Fry and Sarlöv-Herlin 1997, Zube and Pitt 1981). The problem comes with finding the right level of coverage that can coexist with a mixture of public and privately owned land in central Pennsylvania. The following literature describes different methods used and various ordinances enacted for scenic conservation that begin to address the needs of the Marcellus Shale region, but none satisfy all requirements. My project intends to prototype a comprehensive plan to bridge the gaps left by these precedent examples and catering to the specific land use values of Pennsylvania landowners.

3.1.1. Indiana Department of Transportation

This document describes different methods, both regulatory and non-regulatory, for protecting scenic viewsheds, and provides frameworks for developing protection measures. Different steps and types described include conducting a resource inventory, comprehensive planning, corridor management planning, local land use regulations (zoning and subdivision regulations), capital improvements planning, and land donation or acquisition and conservation easements. It provides example ordinances and examples studies for communities or other groups to use for reference and lists of possible funding sourcing. (Indiana Department of Transportation n.d.)

3.1.2. Napa Valley Viewshed Protection Program

The Napa Valley Viewshed Protection Program is a collection of scenic ordinances and a manual of illustrations depicting the requirements and/or recommendations to the lay person. The document states that its purpose is to:

> *…protect the public health, safety, and community welfare and to otherwise protect the scenic quality of the county both for visitors to the county as well as for its residents by ensuring that future improvements are compatible with existing land forms, particularly county ridgelines and that views of the county's many unique geologic features and the existing landscape fabric of the county's hillside areas are protected and preserved. These regulations are consistent with the goals and policies of the Napa County general plan, particularly as specified in the land use, open space and conservation, circulation and the scenic highways elements. Furthermore, it is intended that these regulations accomplish the following:*
>
> *A. Provide hillside development standards to minimize the impact of man-made structures and grading on views of existing landforms, unique geologic features, existing landscape features and open space as seen from designated public roads within the county;*

B. Protect and preserve views of major and minor ridgelines from designated public roads;

C. Create a development review process that maximizes administrative, staff level approval of projects which meet administrative standards, while also providing a vehicle for review by the zoning administrator or planning commission of those projects that do not meet the administrative standards;

D. Minimize cut and fill, earthmoving, grading operations and other such man-made effects on the natural terrain to ensure that finished slopes are compatible with existing land character; and

E. Promote architecture and designs that are compatible with hillside terrain and minimize visual impacts. (County of Napa Planning, Building, and Environmental Services 2012)

The document stresses working with landform rather than against is by carefully situating structures, minimizing grading, grading to mimic naturally occurring landforms, minimizing cut and fill by contouring to existing terrain, and prohibiting construction on steep slopes over 15% (unless special measures are taken). Ridgelines are protected by prohibiting construction within 25 vertical feet of a ridgeline. The document also shows how to use vegetation to screen manmade disturbances or structures. Lastly, the document lists the public roads from which views may be conserved.

3.1.3.Bureau of Land Management – Visual Resource Inventory

The Bureau of Land Management of the United States uses Distance Zones as part of its process for determining scenic quality. It defines Distance Zones in this way:

IV. Distance Zones. Landscapes are subdivided into 3 distanced zones based on relative visibility from travel routes or observation points. The 3 zones are: foreground-middleground, background, and seldom seen. The foreground-middleground (fm) zone includes areas seen from highways, rivers, or other viewing locations which are less than 3 to 5 miles away. Seen areas beyond the foreground-middleground zone but usually less than 15 miles away are in the background (bg) zone. Areas not seen as foreground-middleground or background (i.e., hidden from view) are in the seldom-seen (ss) zone….

1. Foreground-Middleground Zone. This is the area that can be seen from each travel route for a distance of 3 to 5 miles where management activities might be viewed in detail. The outer boundary of this distance zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape. In some areas, atmospheric conditions can reduce visibility and shorten the distance normally covered by each zone. Also, where the foreground-middleground zone from one travel route overlaps the background from another route, use only the foreground-middleground designation.

2. Background Zone. This is the remaining area which can be seen from each travel route to approximately 15 miles. Do not include areas in the background which are so far distant that the only thing discernible is the form or outline. In order to be included within this distance zone, vegetation should be visible at least as patterns of light and dark.

3. Seldom-Seen Zone. These are areas that are not visible within the foreground-middleground and background zones and areas beyond the background zones. (Bureau of Land Management 1986)

For the purposes of this study and subsequent design proposals I will be focusing on the foreground-middleground areas set at a distance of five (5) miles.

3.1.4.ILARIS

The Intrinsic Landscape Aesthetic Resource Information System (ILARIS) model by the consulting firm Jones and Jones and illustrated in their Puget Sound project gives aesthetic qualities of the landscape a quantifiable value. (Jones, 2007) The intrinsic values they describe comprise cultural values as well as landscape values. These values include land forms (islands, beaches, trombols), water forms (cascades, waterfalls, watercourses), vegetation forms, wildlife forms (and viewpoints), and cultural forms (historic sites, landmarks). Defining the regions and sub-regions in the way allows for the prioritization of conservation efforts.

For my project, I am focusing on quantifying cultural preference of aesthetic qualities of the landscape and scenic views revealed through the examination of crowdsourced, geo-referenced photography generated by the general public visiting the Pennsylvania Wilds region. With this information I will define a recommended conservation plan. I follow the general pattern of the ILARIS model.

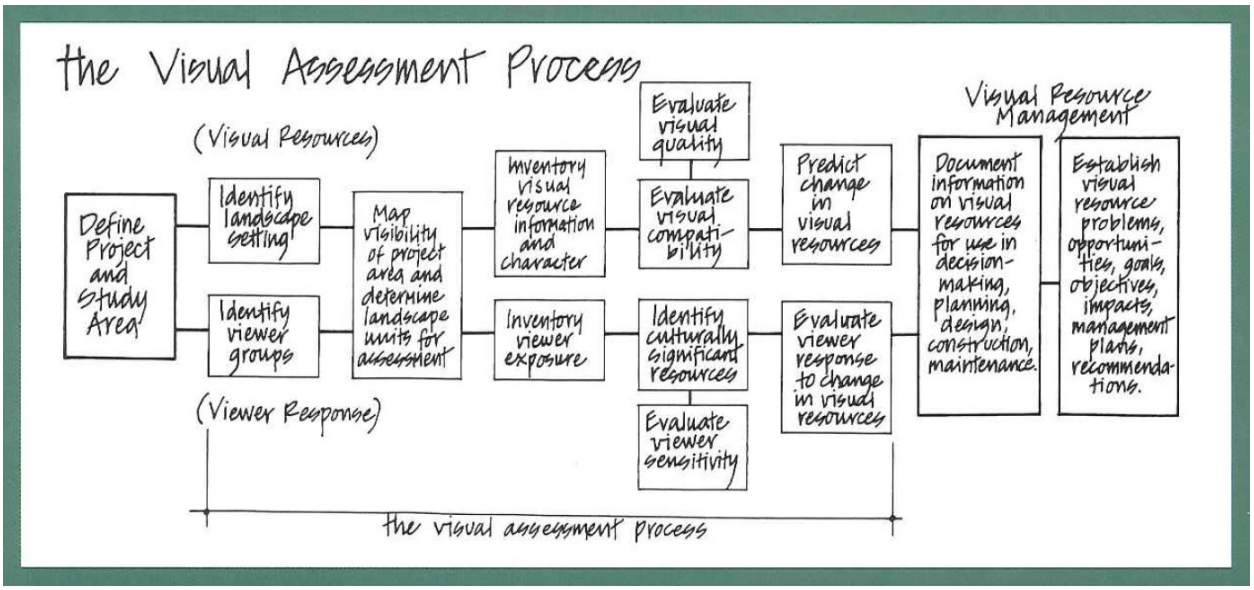


Figure 17 – Visual Assessment Process, Jones & Jones (Jones 2007)

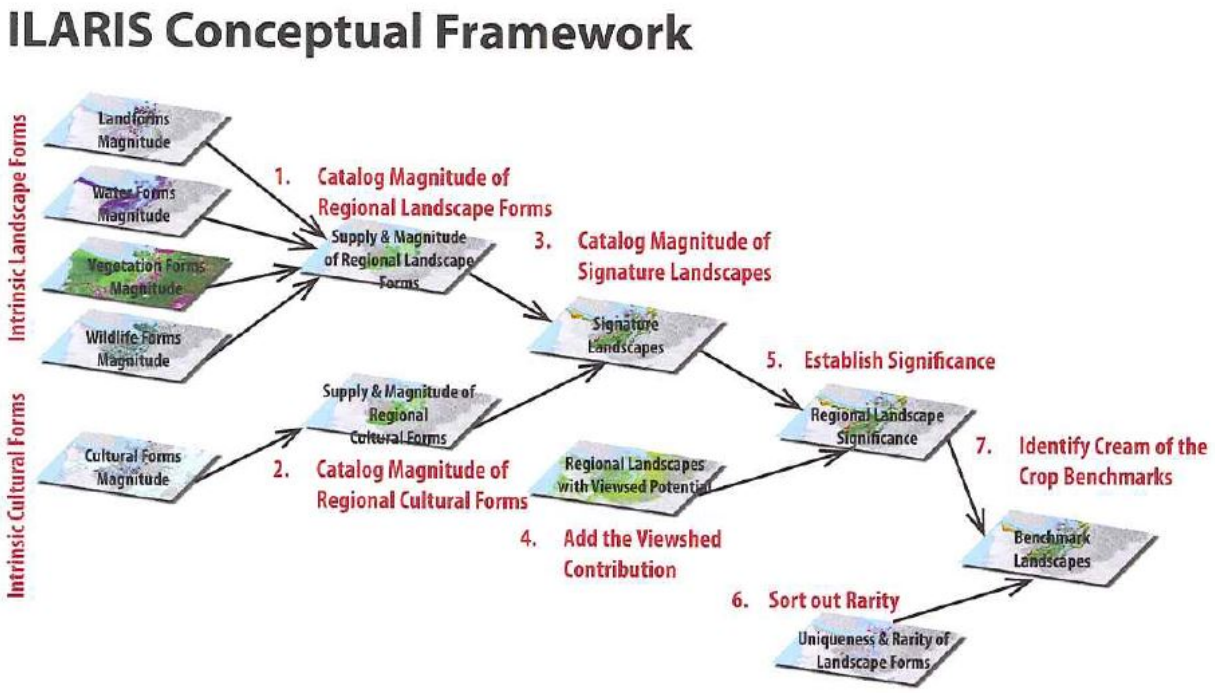


Figure 18 – ILARIS Conceptual Framework, Jones & Jones (Jones 2007)

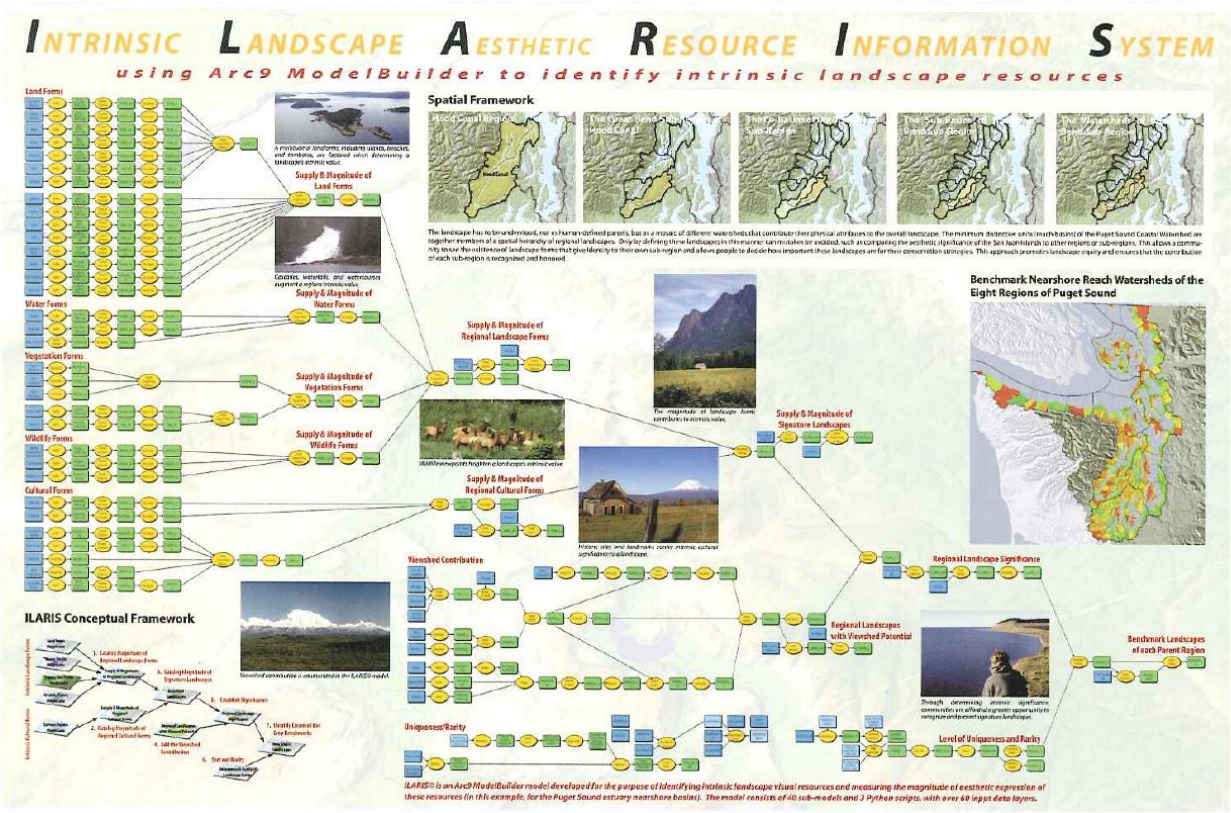


Figure 19 – Presentation board combines visual documentation with ArcGIS ModelBuilder output (Jones 2007)

3.1.5. Finger Lakes Trail Conference Comment on the [Draft] Supplemental Generic Environmental Impact Statement

The Finger Lakes Trail Conference Comment document looks at the effects of the Marcellus shale industry on the Finger Lakes Trail. The itemized effects of Marcellus shale gas extraction to the Finger Lakes Trail include dilution of [volunteer and financial] resources, loss of wilderness, los of trail quality, loss of trail continuity, loss of [hiker and volunteer] membership, decreased hiker safety (due to increased truck traffic, chemicals and emissions), stressed land owner relations, increased motorized use, and reduced likelihood of permanent protection. This document is a response to the Supplemental Generic Environmental Impact Statement and details where the document fell short in reference to protecting the trail and the surrounding landscape including that it needs to specifically identify the Finger Lakes Trail, recognize "statewide significance, include the trail in the permit process, provide for notification of Finger Lakes Trail Conference, provide assistance with landowner relations, and provide assistance with trail repair and reroutes. (Finger Lakes Trail Conference 2009)

This document provides insight to the effect the Marcellus shale gas industry can have on the Loyalsock Trail in the case study. It also shows what level of detail must be addressed to ensure the trail (or any other natural or cultural resource) is thoroughly protected.

3.2. Crowdsourced Data

Crowdsourced data is not a new form of data collection. In 1507, from information in a collection of books circulating Europe and a letter penned by Amerigo Vespucci, Martin Waldseemüller crafted the first known map of the new continent, *America.* (Goodchild 2007) The emphasis here is on the recent (within the last ten years, or so) flood of *volunteered* data. With much of the world so well connected via the internet and people so actively photographic, posting, contributing, blogging, and subsequently responding to others doing the same within the web-culture, the amount of data available for harvest is vast and deep. All one must do is seek it out and report those findings in an organized and ethical manner. The core research of this project uses crowdsourced photography and associated metadata to draw conclusions on scenic conservation and prioritization.

3.2.1. GIS in a Changing World

In his article on the quickly evolving state of GIS, Dangermond discusses the concept of crowdsourcing. Crowdsourcing, in this context sometimes called volunteered geographic information or user-generated content, is data that is generated and contributed by everyday citizens. In this case data comprises photographs as records of preferred scenes, of the time and location of those scenes, and of their content revealed in a picture shared on-line via any of the numerous social media image-sharing platforms. In a world that is so highly connected via the internet this newer source of information is extremely abundant. The problem, Dangermond states, is determining whether the information is authoritative and appropriates for its intended purpose. This may require the user to recheck the data or become part of the data collection themselves. (Dangermond 2010) Dangermond encourages the use of crowdsourced data as a way of augmenting purely authoritative data and suggests, as an example,

that it may help citizens provide feedback to their local government. With this in mind, ESRI is changing the way its software systems work to more easily integrate and modify crowdsourced data. (Dangermond 2010) With regard to general public values, crowd-sourced data may have more validity in representing general public values than the official sources more generally regarded as authoritative.

3.2.2. Citizens as Censors: The World of Volunteered Geography

Goodchild introduces the concept of volunteered geographic information, its possibilities and limitations, and defines associated jargon. He defines the concept of georeferencing as "the ability to specify location on the Earth's surface using a small number of well-defined and interoperable systems, of which latitude and longitude is by far the most universal." (Goodchild 2007) This can be done with several technologies including GPS enabled consumer products (hand-held units, cameras, or mobile phones) or by geocoding by attaching coordinates to a known street location in GIS software or on the Web. He states that Google Earth and Google Maps are common and simpler options to choose a point by a click of the mouse. (Goodchild 2007)

While Goodchild agrees that the citizen force is an amazing source of information he cautions that there is still a great deal of the world's population in developing nations or in undeveloped nations that are not represented. (Goodchild 2007)

3.3. National Recreation Trail Designation

Through the course of trying to devise ways to conserve the Loyalsock Trail, the process of National Recreation Trail designation presented itself as a viable option for affording the trail protection. Having the LT designated as a National Recreation Trail would give it more prestige, increase its visibility to the hiker community, and foster a greater sense of ownership and pride in the members of the communities through which the trail passes. Although the Alpine Club of Williamsport has no intention to pursue National Recreation Trail designation, the framework provided by the application process was very useful in structuring the means by which I would inventory existing resources and then proceed to means by which valued scenery and scenic vistas could be protected.

The Loyalsock Trail met all but one of the basic criteria for National Recreation Trail designation as set forth by the American Trails organization. Those it met were:

> *The trail must be open to public use and be designed, constructed, and maintained according to best management practices, in keeping with the use anticipated.*
>
> *The trail is in compliance with applicable land use plans and environmental laws.*
>
> *The trail will be open for public use for at least 10 consecutive years after designation.*

The criterion that it was uncertain whether it would meet was:

> *NRT designation must be supported by the landowner(s), public or private, whose property the trail crosses.*

3.3.1. Process for designation

Designation as a National Recreation Trail provides many benefits to a trail. Being part of the NRT system gives increased prestige and visibility, an online profile hosted through AmericanTrails.org, technical assistance from NRT Program partners, electronic newsletters, access to an e-mail news group for NRT managers only to receive updates on funding, resources, and technical assistance opportunities, access to networking and training opportunities, assistance with recognition and special events highlighting the trail, trail markers with the NRT logo for the trail, and letters of support for fundraising and trail protection efforts. (American Trails 2014) Designation also allows for funding from state agencies through the RecreationTrails Program. "The Recreational Trails Program, which provides funding for trails to each state through the Federal Highway Administration, provides this guidance on NRTs: 'In consultation with the Department of the Interior and the Department of Agriculture through the Federal Interagency Council on Trails, States are encouraged to give extra project evaluation credit to projects on National Scenic Trails, National Historic Trails (provided the project provides a recreational purpose), and trails designated as National Recreation Trails.'" (American Trails 2014)

The required information for NRT application can be found at: http://www.americantrails.org/nationalrecreationtrails/previewapp.html.

These excerpts from the AmericanTrails.org website explains the process for NRT Designation:

> *There are two procedures depending on whether the trail is on land administered by the US Department of Agriculture (typically National Forests), or on any other land.*
>
> > *If your trail is on federal land administered by (or associated with) the US Department of Agriculture:*
>
> - *The USDA Forest Service has authority for designating NRTs on land administered by the Department of Agriculture (National Forests, National Grasslands, and National Recreation Areas) and associated lands.*
> - *Contact the USFS National Recreation Trails Program Coordinator, Jonathan Stephens, USDA Forest Service, (202) 205-1701 - Fax (202) 205-1145 - Email: jstephens02@fs.fed.us*
>
> > *If your trail is on other federal land (outside the Department of Agriculture) or on state, local, or private land:*
>
> - *The Secretary of the Interior is the designating official for NRT's on all other federal lands and on state, local, and private lands, and has delegated responsibility to the National Park Service for the overall administration of the NRT program under that department's jurisdiction.*
> - *Online Application Process: Nominations for NRT designation for the Department of the Interior are done online through the NRT Database. Supporting materials,*

such as maps, brochures, photos, and letter of support must be in electronic format and are uploaded as part of the online submission process.

- *Note that trails on state, local government, or private land (anything other than Federal) should submit a letter of support from the appropriate State Trails Administrator/Coordinator.*
- *The Washington, DC contact is the Department of the Interior's NRT Coordinator at National Park Service: (202) 354-6910 or email: helen_scully@nps.gov*

Nominations for NRT designation for the Department of the Interior is done through the Online NRT Application Form. For examples of the kinds of trails that are eligible, see the trails designated as NRTs in the Annual Designations Index since 2001.

Timeline

November 1: Deadline for submittal of current year's online NRT applications to DOI NRT Coordinator in Washington, DC.

- *NRT Coordinator checks new applications*
- *Sends email confirming receipt of application*

December 15: DOI NRT Coordinator reviews each application for completeness and forwards to Regional NRT Contact or Federal agency NRT Manager.

- *Regional NRT contact or Federal agency NRT Manager reviews application*
- *Notifies State Trails Coordinator of nominated trails requesting letter of support (only if state, local government, or private trail)*
- *Makes follow-up contact with applicant to request additional information and/or site visit if necessary*

February 15: Regional NRT Contact or Federal agency NRT Manager sends additions or amendments to application(s) and a letter of concurrence/endorsement to the DOI NRT Coordinator.

March 15: DOI NRT Coordinator completes the review and processing of applications. The applications are forwarded for approval by the Secretary of the Interior.

June: New NRT designations announced

- *Secretary of the Interior sends news release officially announcing new NRT designations*
- *Local announcements and designation events*
- *Trail descriptions and graphics are added to the state by state NRT pages*
- *Newly designated trails are added to the on-line searchable database of NRTs*

(American Trails 2014)

Chapter 4

4. Methods
    4.1. Crowdsourced Data

The first form of crowdsourced data this project used was a digitized trail polyline file uploaded to TrimbleOutdoors.com by a person who hiked the Loyalsock trail while using a handheld GPS device. As Goodchild suggested (Goodchild 2007) I "fieldtruthed" the digitized trail by uploading the file onto Google Earth and comparing it to the trail guide compiled by the Alpine Club of Williamsport, and found it to be accurate.

4.1.1. Identifying Points of Interest

To identify points of interest for this project, I am using crowdsourced, georeferenced photos that are publicly available on Google Earth. With the digitized trail in place on Google Earth, and the "Photos" layer turned on (Figure 20), I was able to begin identifying points of interest as clusters of photos taken from, or within close proximity to, the trail.

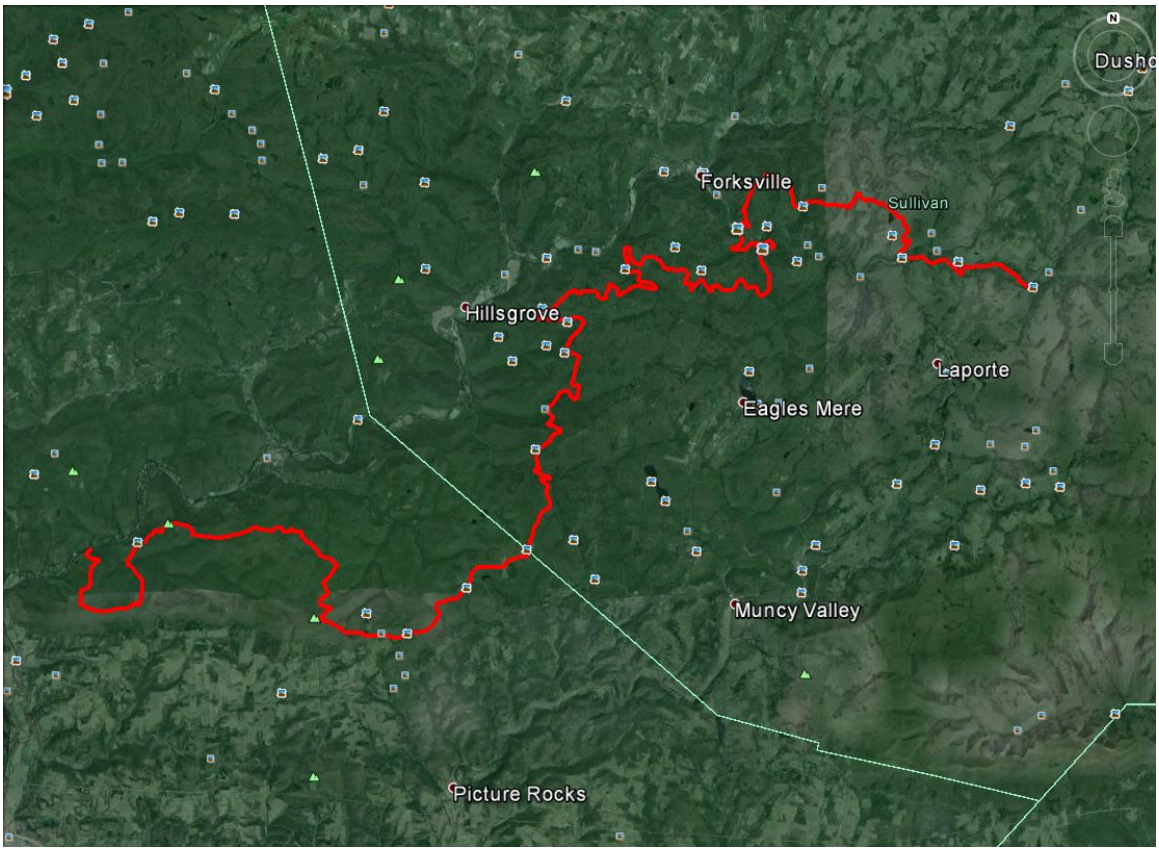


Figure 20 – Google Earth with Digitized Loyalsock Trail and Photos Layer turned on

4.1.1.1. Google Earth and image clusters

Depending on the scale at which a user is viewing a map in Google Earth, icons of individual or clusters of photos will appear when the Photo layer is turned on. The further the map is zoomed out the more likely there are to be clusters and the further the map is zoomed in the more likely there are to be individual photos. There are three sizes of photo icons in Google Earth. The single photo icon represents a single image taken at a location. The medium-sized cluster icon represents 2-29 photos taken at a location. The large cluster icon represents 30+ photos taken at a location. As you can see in Figure 21 all three icon sizes are represented. Hovering over the large icon with the cursor indicates that the most popular photo in this cluster is the Loyalsock Creek Vista and that this is a popular location for taking photos. It does not, however, immediately indicate that the Loyalsock Creek Vista is the most photographed thing in that location. It simply means in that location, within that cluster of photos, this photo is the most viewed on the internet. This particular icon is representing 43 photographs taken in this location at this scale and 18 of those photographs are of the Loyalsock Creek Vista, also known as the Canyon Vista at Worlds End State Park.

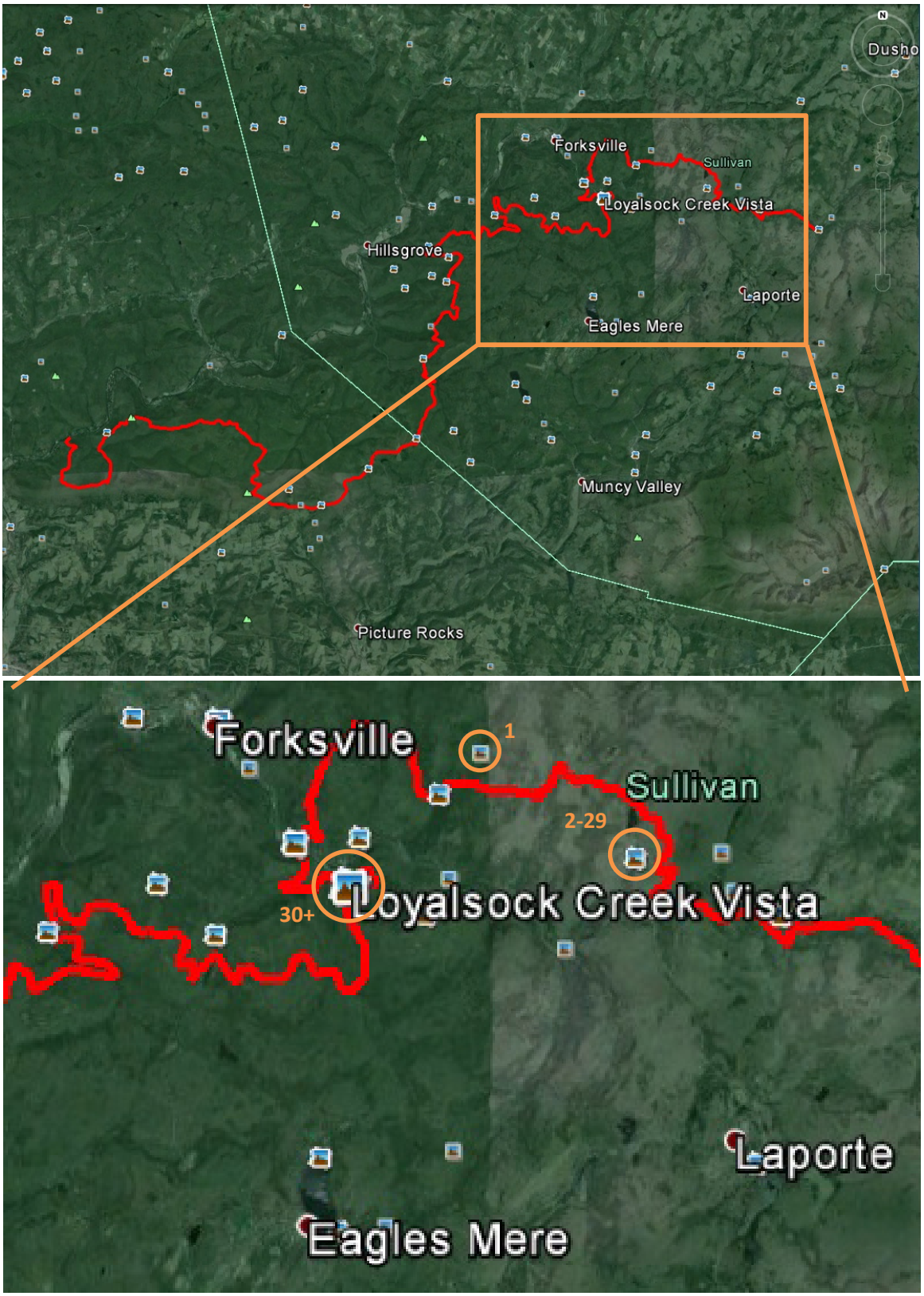


Figure 21 – Three different sizes of photo icons; Loyalsock Creek Vista is a large cluster icon indicating 30+ photos taken at that location (Accessed: 5/28/2014)

Zooming in to the Canyon Vista area (Figure 22), one can see that it is still a very popular location for photography. The icon is still large, and of you click on it, a window opens (Figure 23) showing that it represents 33 photos. All 18 photos of the Canyon Vista are still present in this cluster, meaning that more than half of the photos taken at this location are of the Canyon Vista.

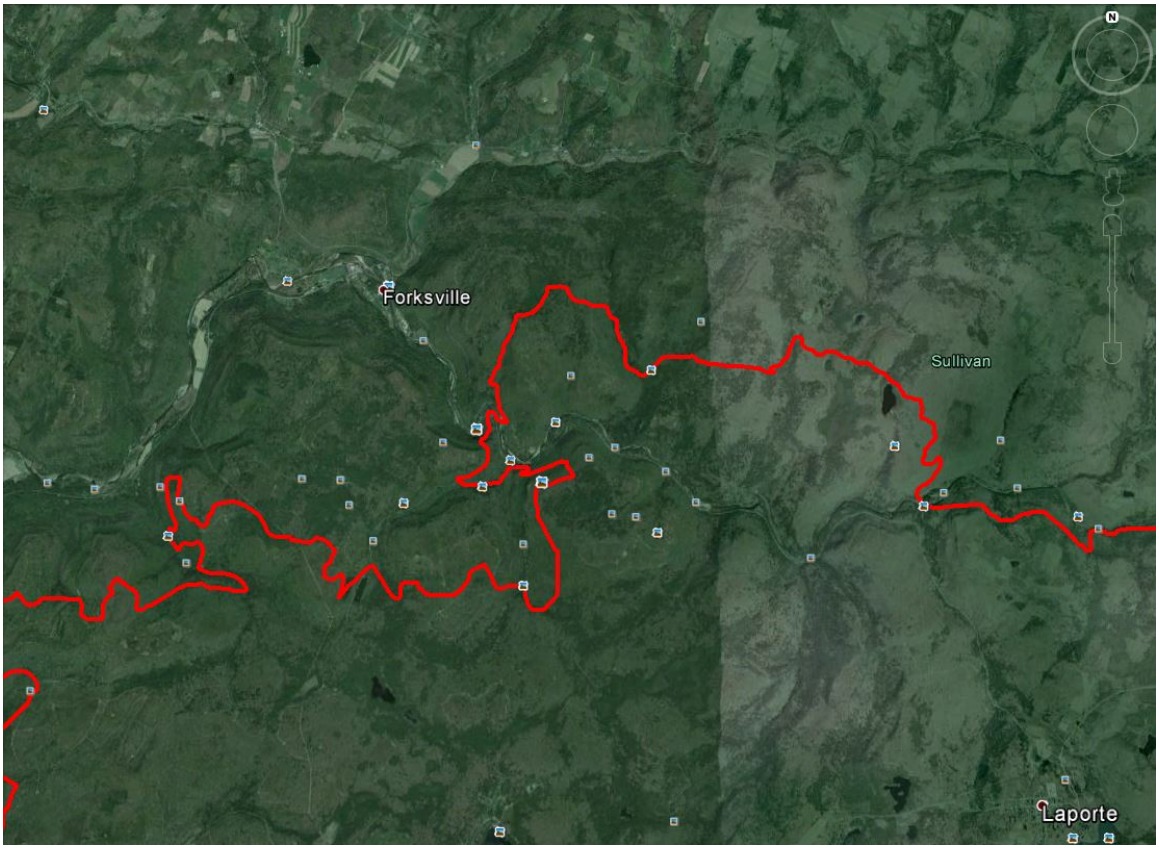


Figure 22 – Canyon Vista Area, large cluster icon representing 33 photos at this location (Accessed: 5/28/2014)

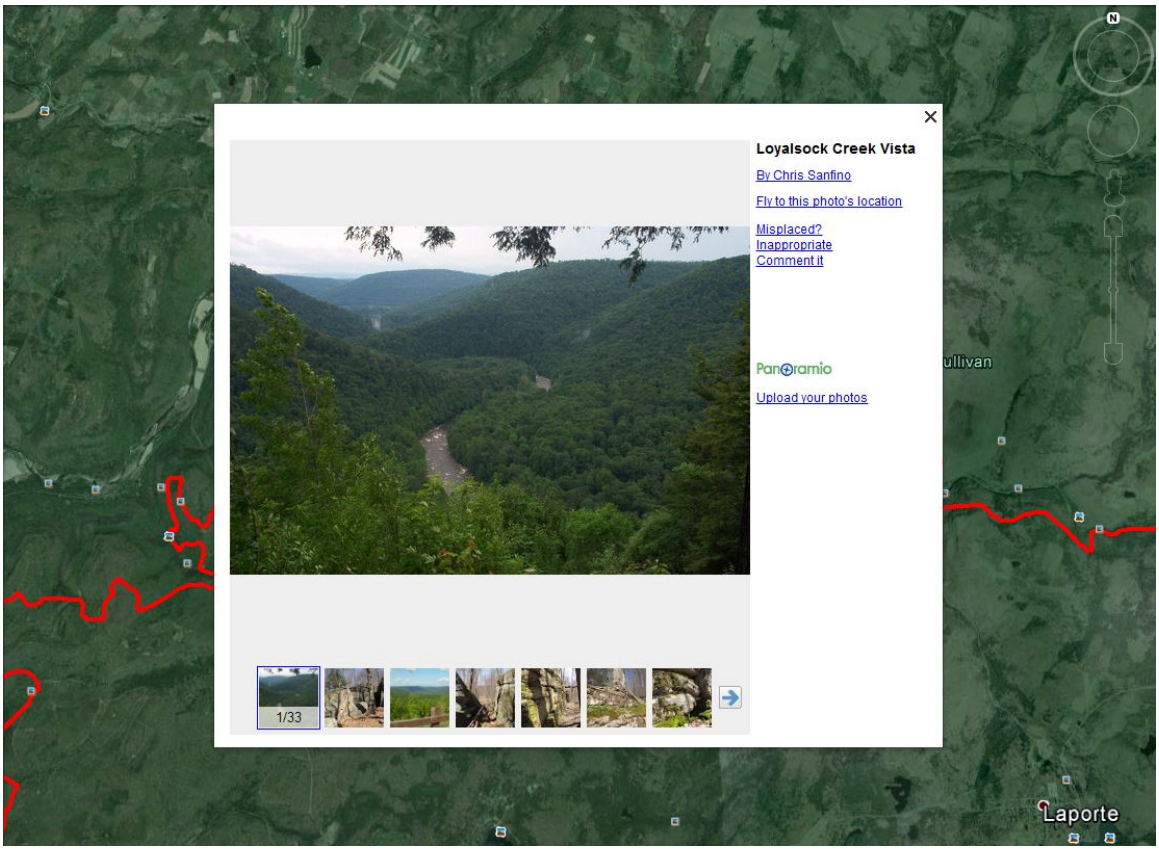


Figure 23 – Pop-up window showing all 33 photos represented in the cluster icon leading with the most viewed image (Accessed: 5/28/2014)

4.1.1.2. Panoramio, photo popularity, and photo metadata

As you can see in Figure 23, Google Earth uses Panoramio (www.panoramio.com) to host the images it displays on its maps. Switching to Panoramio the user sees the photos of a particular area in greater detail (Figure 24). Larger photo icons appear for more popular photos and smaller icons for less viewed images. Here the user is given sorting options (by popularity, recent, places, or indoor) and is also offered the option of viewing photos that are not shown in Google Earth. For this study, all available photos were viewed and they were sorted by popularity. Clicking on the image icon on the map or in the chart on the right takes the user to another section of Panoramio that hosts the metadata for that specific image (Figure 25). The metadata included show who posted the photo (as an online username), when it was posted, where it was taken (either automatically georeferenced by the photographic device or added manually by the author), and how many external views the image has had since it was posted. As of May 2014, the "Loyalsock Creek Vista" image, posted July 17th, 2007, by contributor Chris Sanfino, had 14,800+ views.

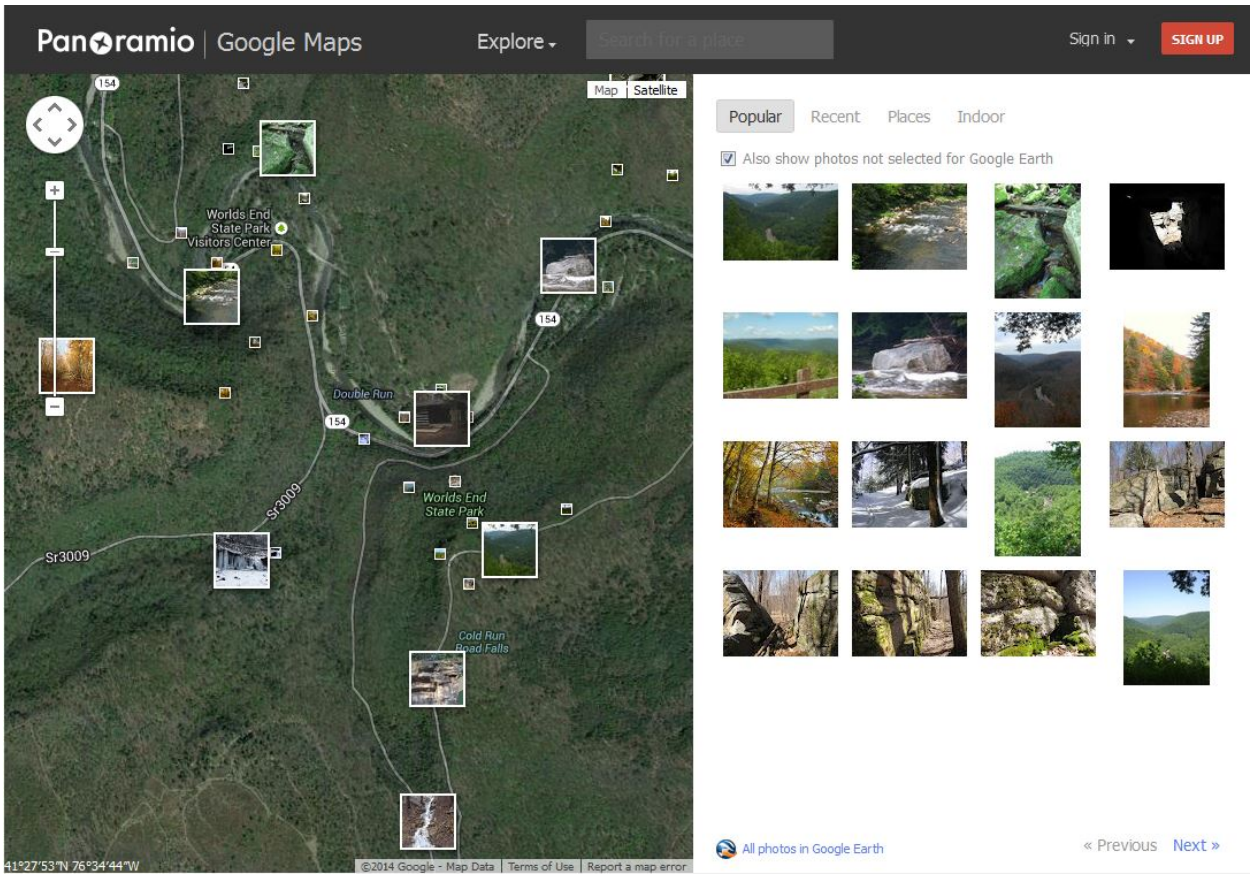


Figure 24 – Panoramio Interface - Worlds End State Park area; option chosen for all images, even those not selected for Google Earth, and all photos sorted by popularity (Accessed: 5/28/2014)

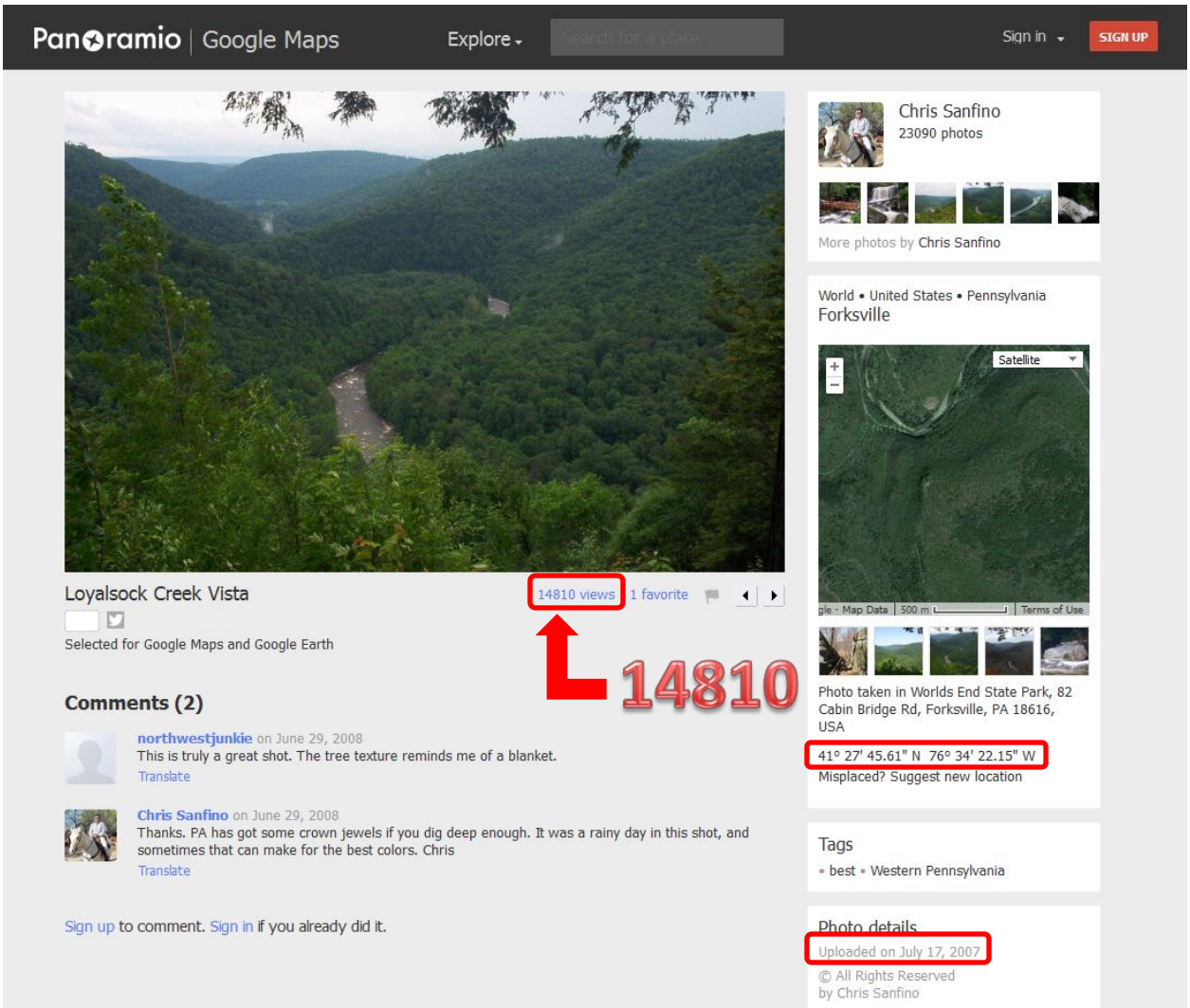


Figure 25 – "Loyalsock Creek Vista" photo in Panoramio and its associated metadata (Accessed: 5/28/2014)

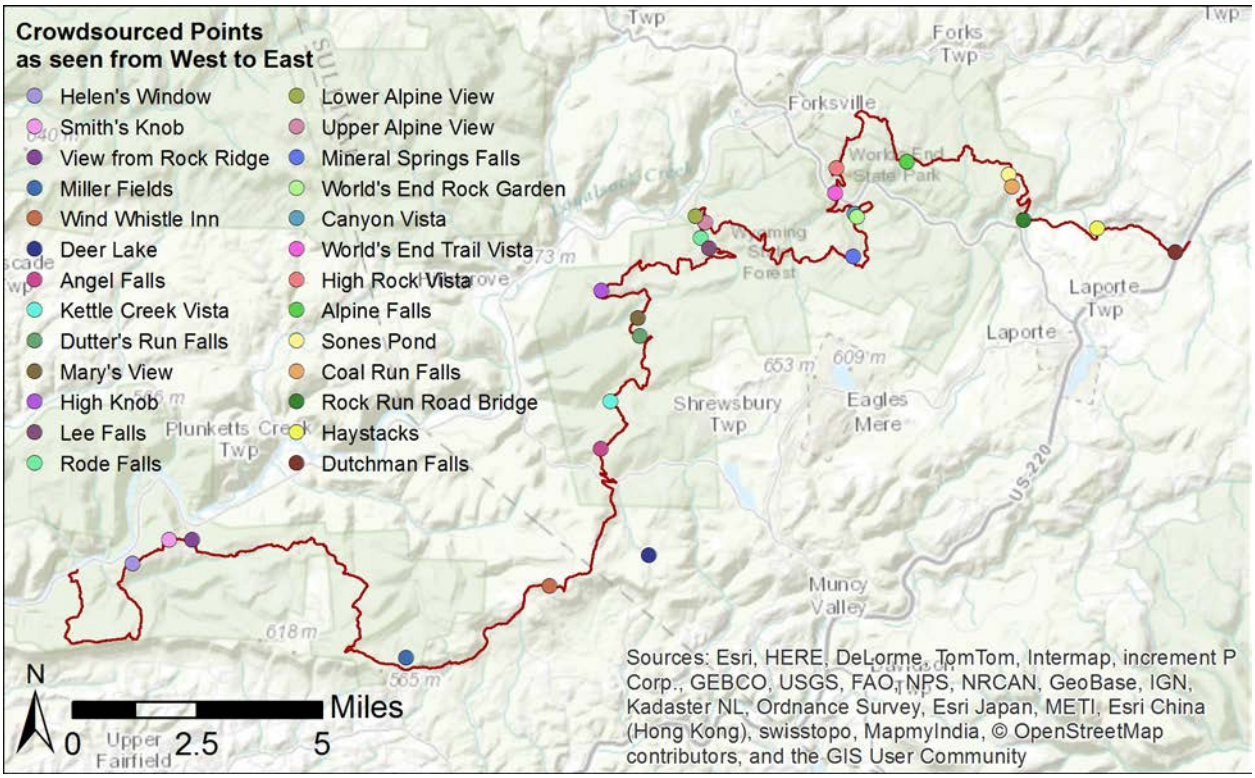


Figure 26 - Identified crowdsourced points of interest

4.1.2. Ranking Points of Interest

Points of interest were chosen by identifying locations on or near the trail that had more than one image associated with them. This shows that there is interest from hikers and sightseers in this location. From there, the most viewed photo (from World's End Trail Vista N=269 views up to Canyon Vista N=14,382 views; see Figure 27) was chosen from within that image cluster for comparison. This shows that not only are people who are visiting these locations finding them valuable but also that a large number of people online are also interested in viewing them.

4.1.2.1. Total Number of Views versus Averaged Views per Day

Choosing to rank the locations by the total number of views would be one method of determining the importance for conservation. However, the issue exists that some of these photos have been online far longer than others and will have had more time to be viewed. For this reason, I chose to normalize the data by determining the average views per day the photo was receiving since it had been posted. This was done by taking the total number of views and dividing by the number of days it had been online. While there is some variance among the most viewed locations and those with the most views per day, three of the top four are the same in both. To look at it another way, I assigned values of 1 through 26, one being the most popular and 26 being the least popular, for both methods and averaged those popularity ratings. The top five of the most viewed and averaged popularities are the same and the top three of the views per day and averaged popularities are the same. Regardless of the method, there is a

strong positive correlation among the most popular and among the least popular of the chosen locations.

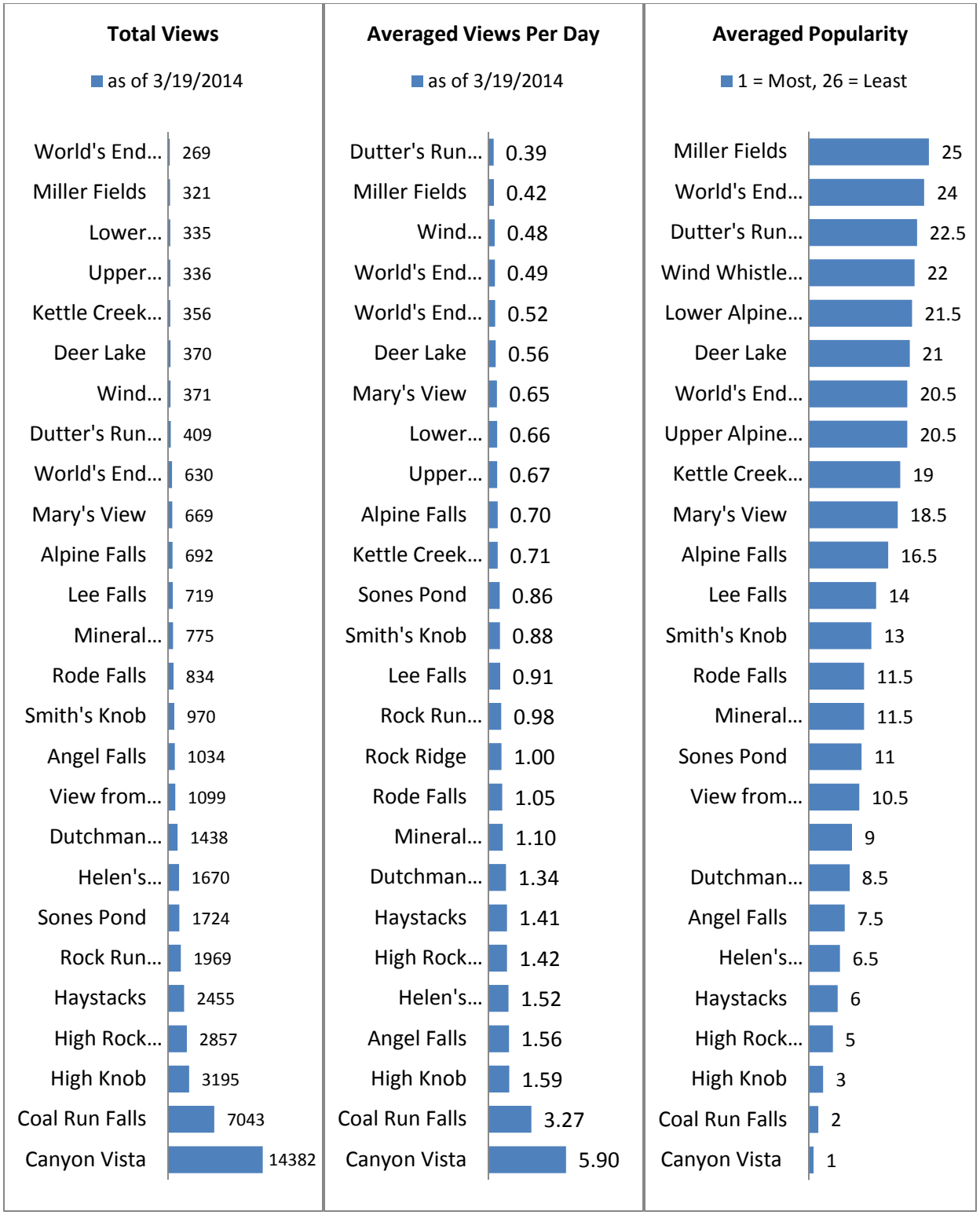


Figure 27 – Total number of views shown in Panoramio metadata as of March 19th, 2014

Figure 28 – Averaged views per day as of March 19th, 2014

Figure 29 – Averaged popularity, 1 being most popular and 26 being least popular, of the identified locations

For this study, the views per day will be the ordering method.

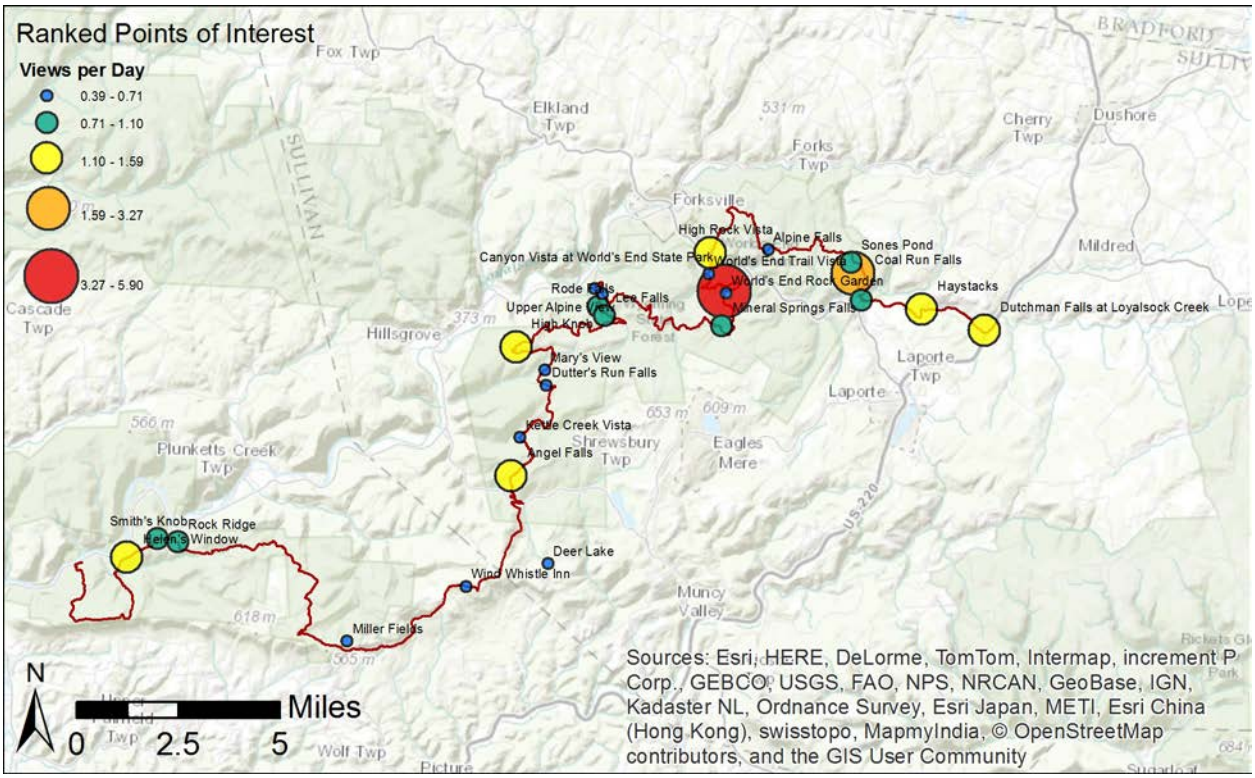


Figure 30 – Points of interest ranked by views per day

One consideration to keep in mind when looking for popularity and frequency of photos is accessibility to a location. Figure 31 and Figure 32 show the identified locations in proximity to programmed parking lots and road-trail intersections where people may access the locations via car as opposed to hiking the trail to that location.

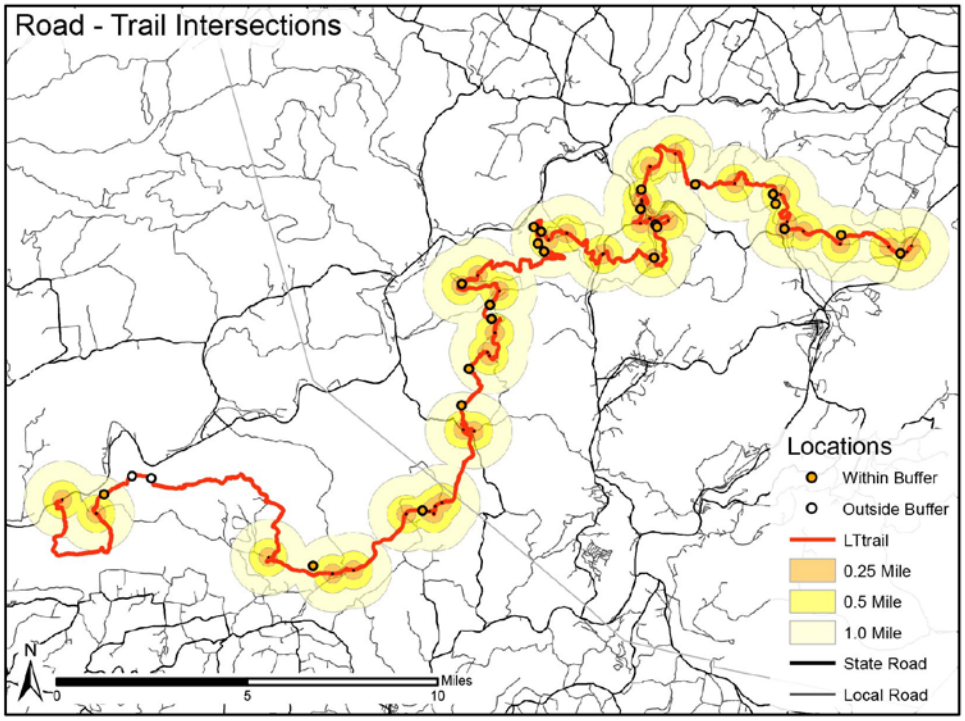


Figure 31 – Proximity of popular locations to road-trail intersection

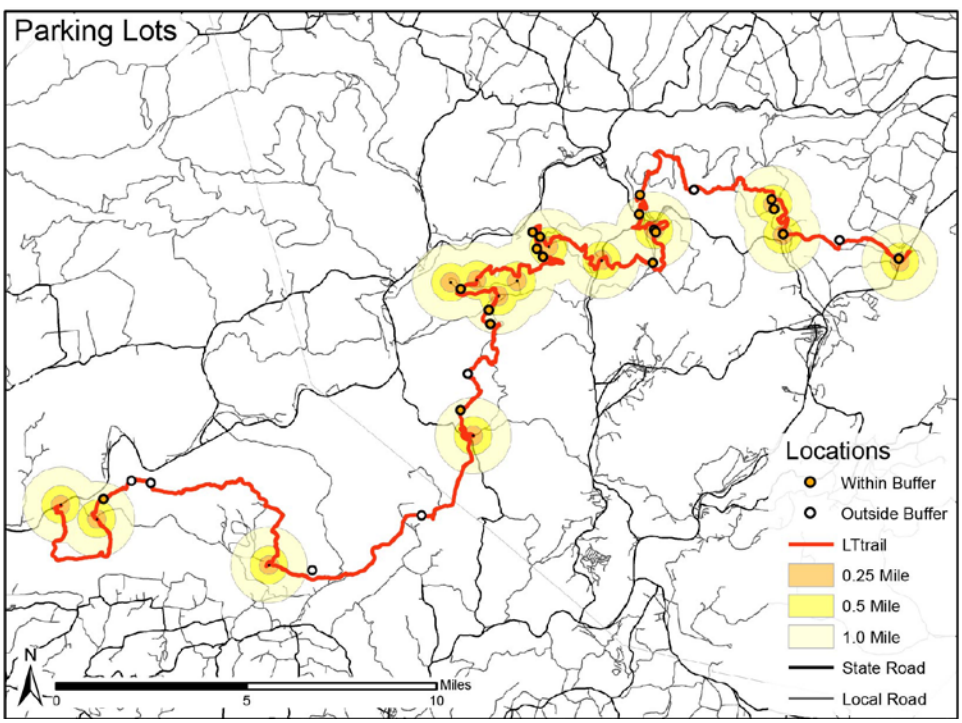
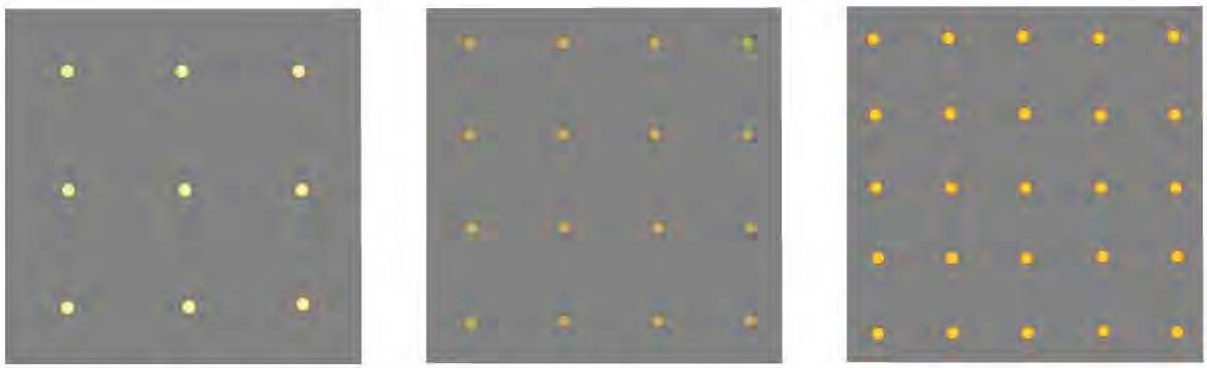


Figure 32 – Proximity of popular locations to parking lots

4.2. Formal Geospatial Models

4.2.1. Existing Well Locations and Projections

According to the nature conservancy, well pads average 3.1 acres with an additional 5.7 acres for associated infrastructure (roads, pipelines, water impoundments) for nearly 9 acres of land impact per well pad. (Johnson 2010) Another report by the nature conservancy also looks at the indirect impacts of all infrastructures and estimates an additional 21 acres of interior forest impact for newly created edge conditions. (The Nature Concervancy 2012) They project that 60,000 wells may be drilled by 2030 and depending upon the density of how many wells are placed on each pad, there may be between 7,000 and 16,000 new well pad sites. (Johnson 2010)



Low Scenario
10 wells per pad
Pads spaced ~5,200 ft apart

Medium Scenario
6 wells per pad
Pads spaced ~4,100 ft apart

High Scenario
4 wells per pad
Pads spaced ~3,350 ft apart

Figure 33 – Nature Conservancy density projections: Low = 5,000 – 6,000 new pads, Medium = 10,000 new pads, High = 15,000-16,000 (Johnson 2010) (The Nature Concervancy 2012)

As of 2013, there are 110 existing wells within the Loyalsock Trail viewshed and 210 within the five mile radius (Figure 34). Nature Conservancy projections for 2030 (Johnson 2010) would increase this number to 151 in the viewshed (+41) and 287 in the 5 mile radius (+ 77) at a low density projection (Figure 35), 192 in the viewshed (+82) and 362 in the 5 mile radius (+152) at a medium density projection (Figure 36), and 222 in the viewshed (+117) and 416 and in the 5 mile radius (+ 206) at a high density projection (Figure 37).

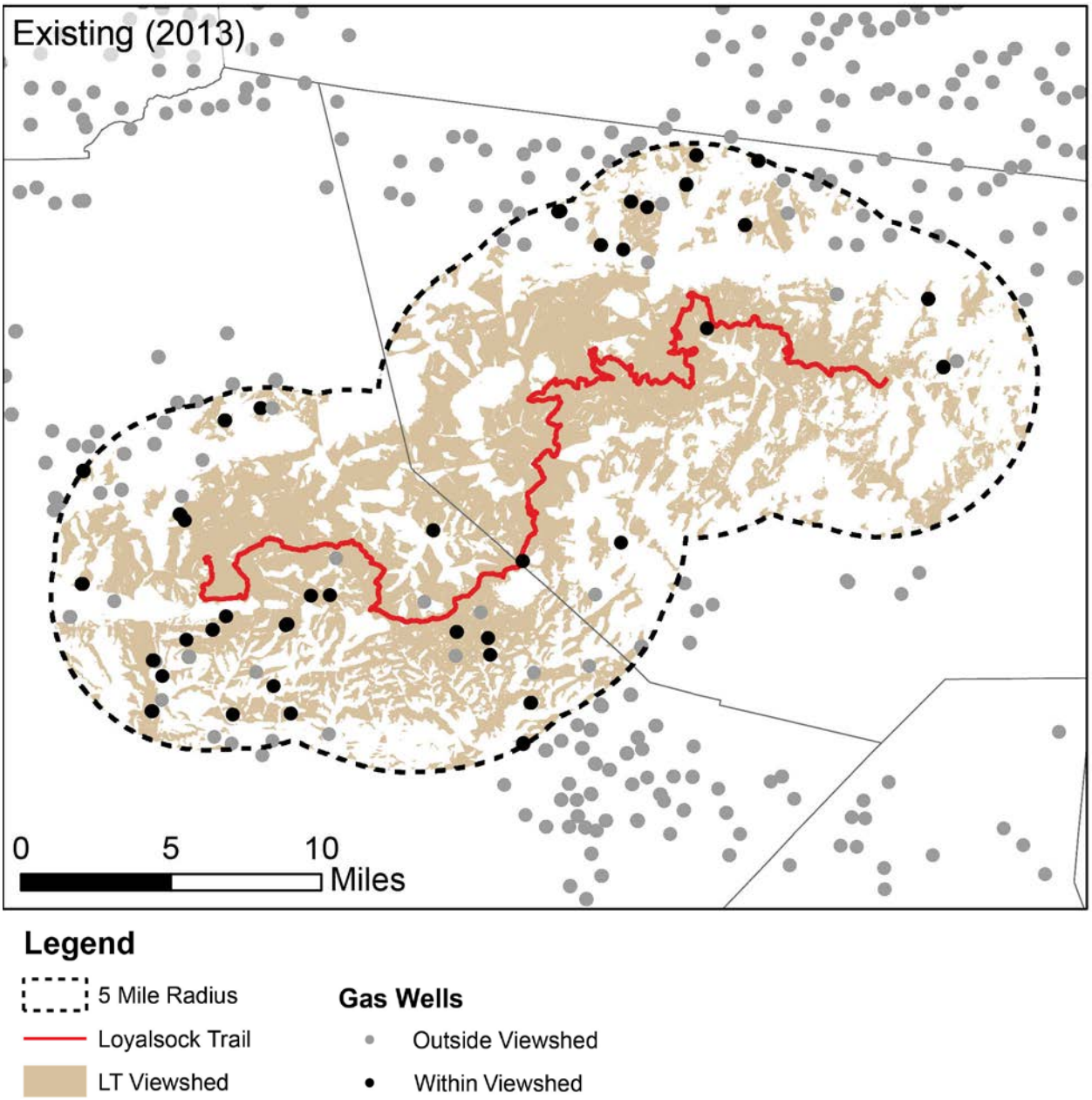


Figure 34 – Existing well locations (2013)

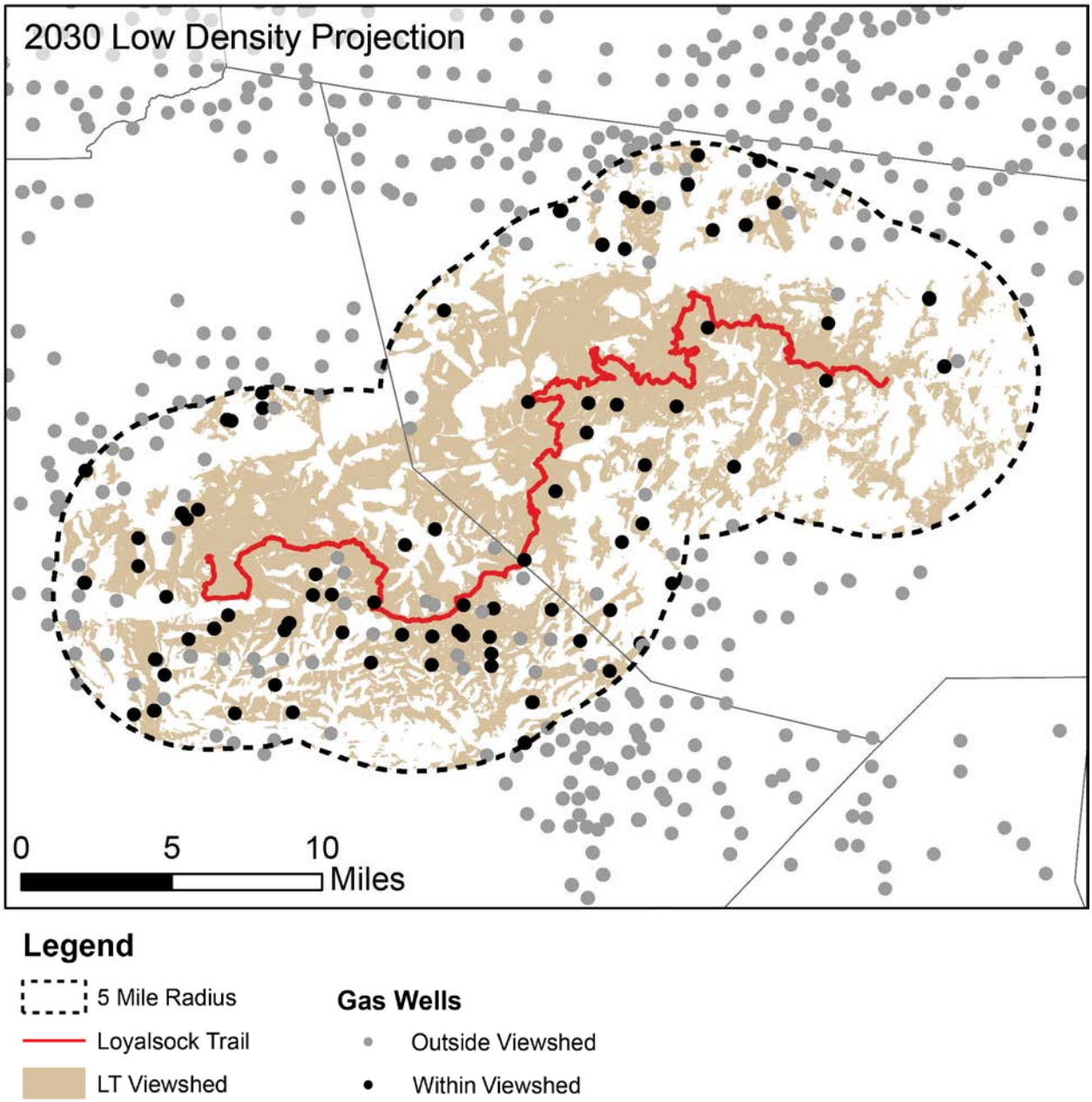


Figure 35 – Nature Conservancy well location low density projection (2030)

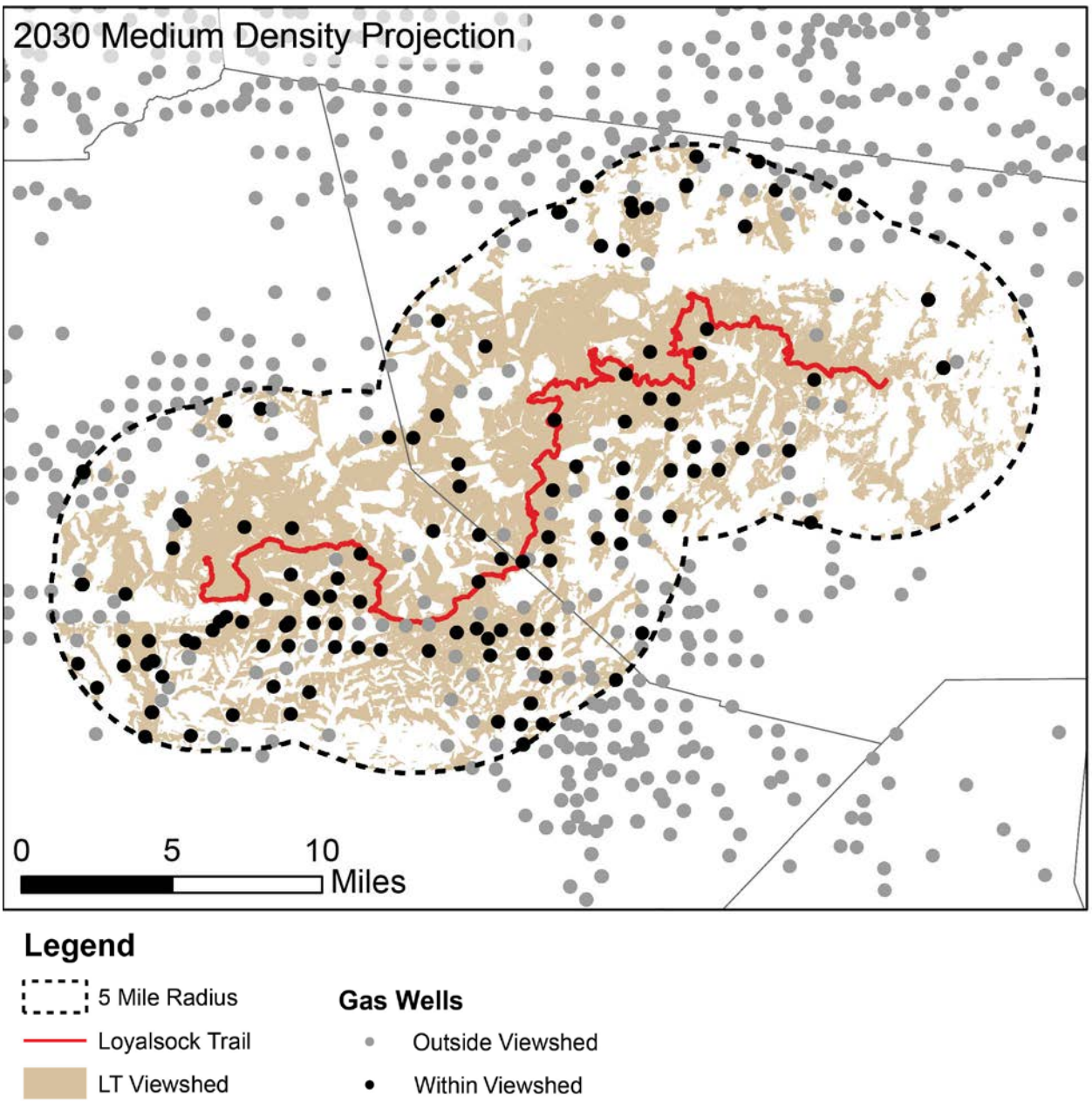


Figure 36 – Nature Conservancy well location medium density projection (2030)

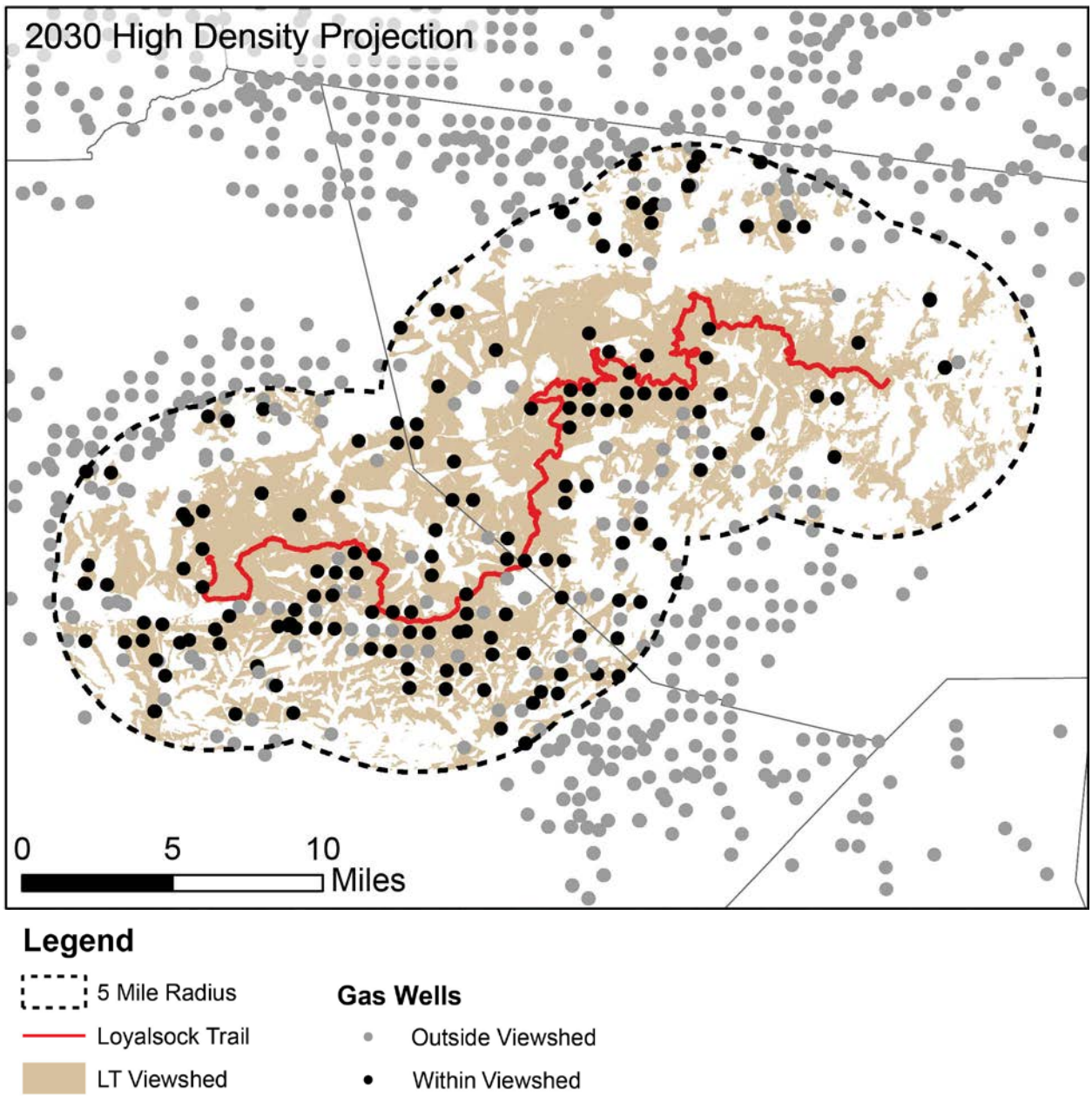


Figure 37 – Nature Conservancy well location high density projection (2030)

4.2.2. Pipelines and Right-of-Ways

As the Alpine Club of Williamsport mentioned on its website, the pipeline right-of ways are the most visually impactful aspect of the shale gas extraction process. Figure 38 shows an example of the evolution of a Pennsylvania farm throughout the process of shale gas extraction. The well pads are disruptive and an eyesore while the well is being drilled but the visual impact is not long lived. After drilling, which takes about a month, (shalereporter.com 2014) the size of the development is reduced to a small maintenance pad, an access road, and the drill rig is replaced with a “Christmas tree”. The real,

long lasting impact upon the land occurs when collection pipelines and right-of-ways are installed. The pipes will remain in place the entire life of the well and the right-of-ways above the pipes will need to remain clear-cut.

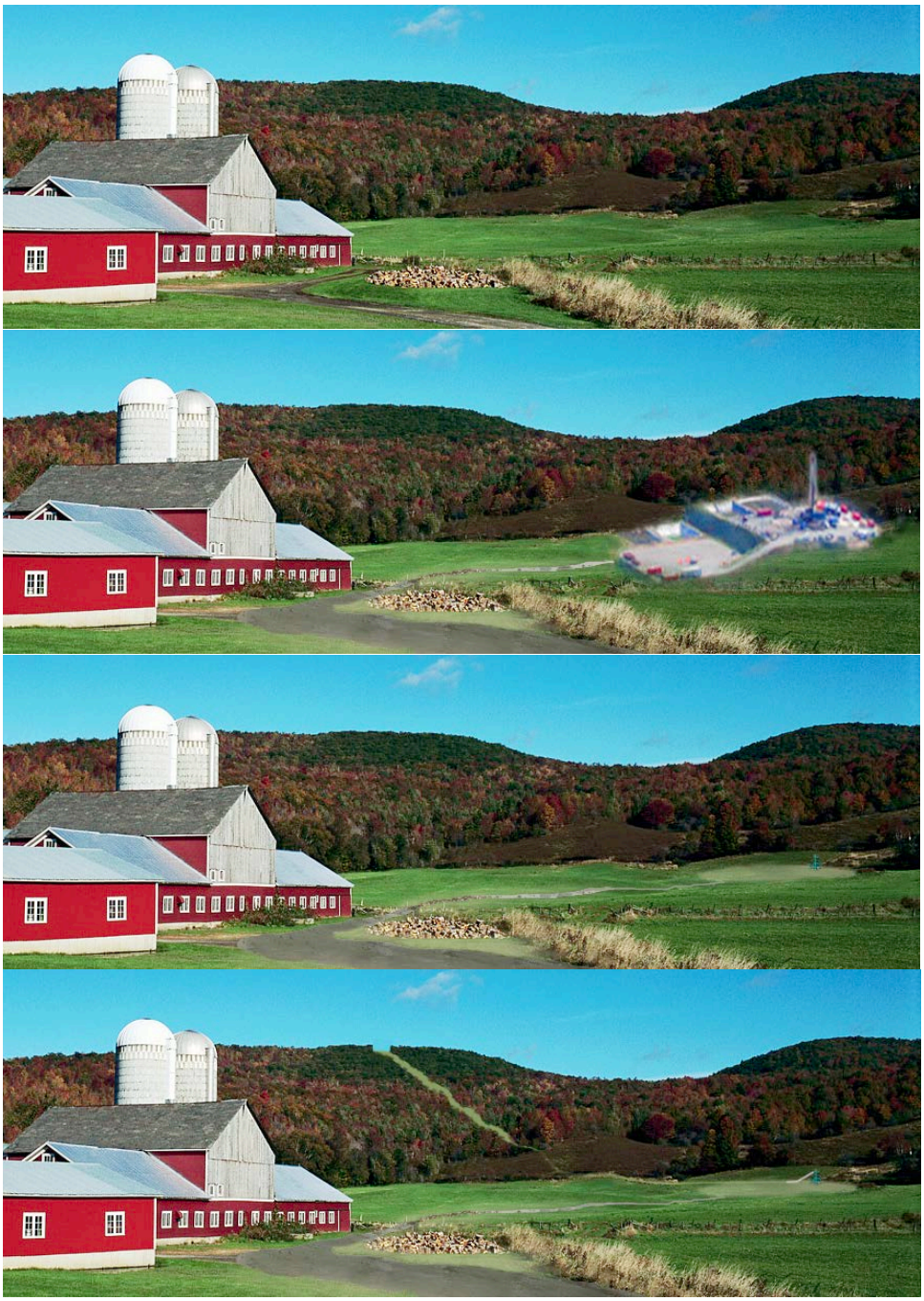


Figure **38 – Evolution of Pennsylvania farm: before s**hale **g**as **d**evelopment; during drilling and hydraulic fracturing; post drilling; during production with pipeline and right-of-way

4.2.3. Trail Viewshed

Within a five mile radius of the Loyalsock Trail, the viewshed covers more than 113,743 acres of land.

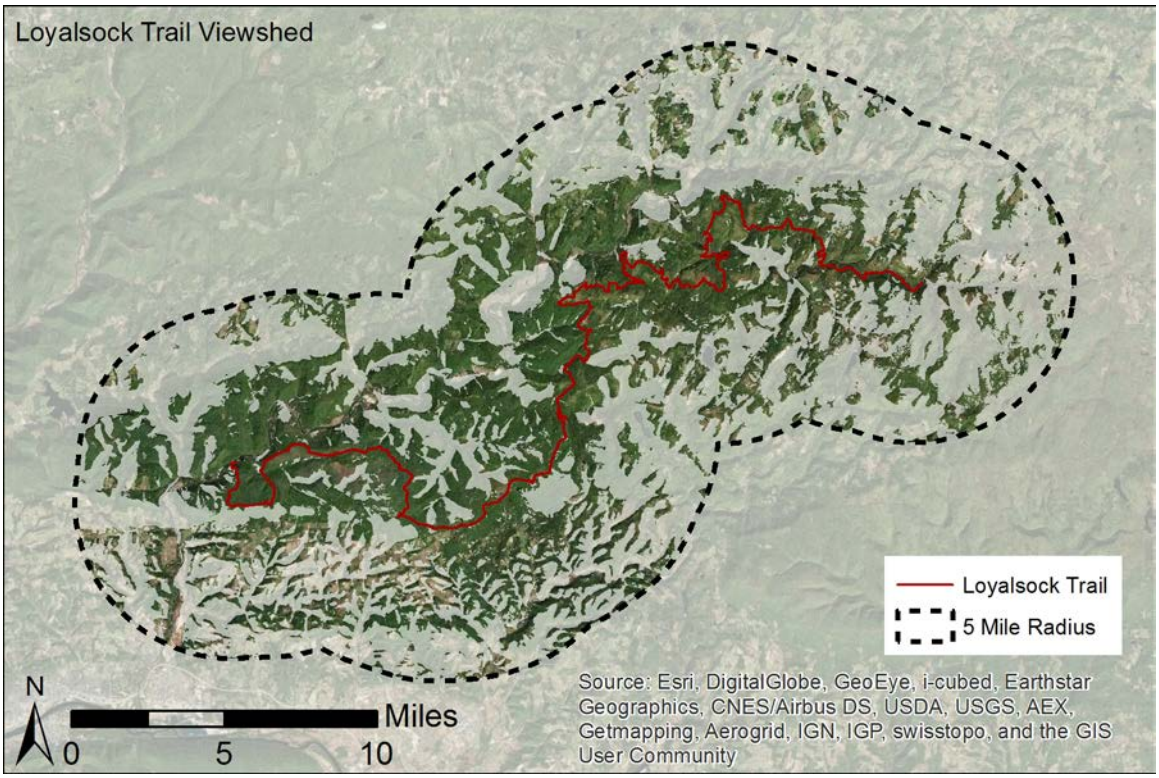
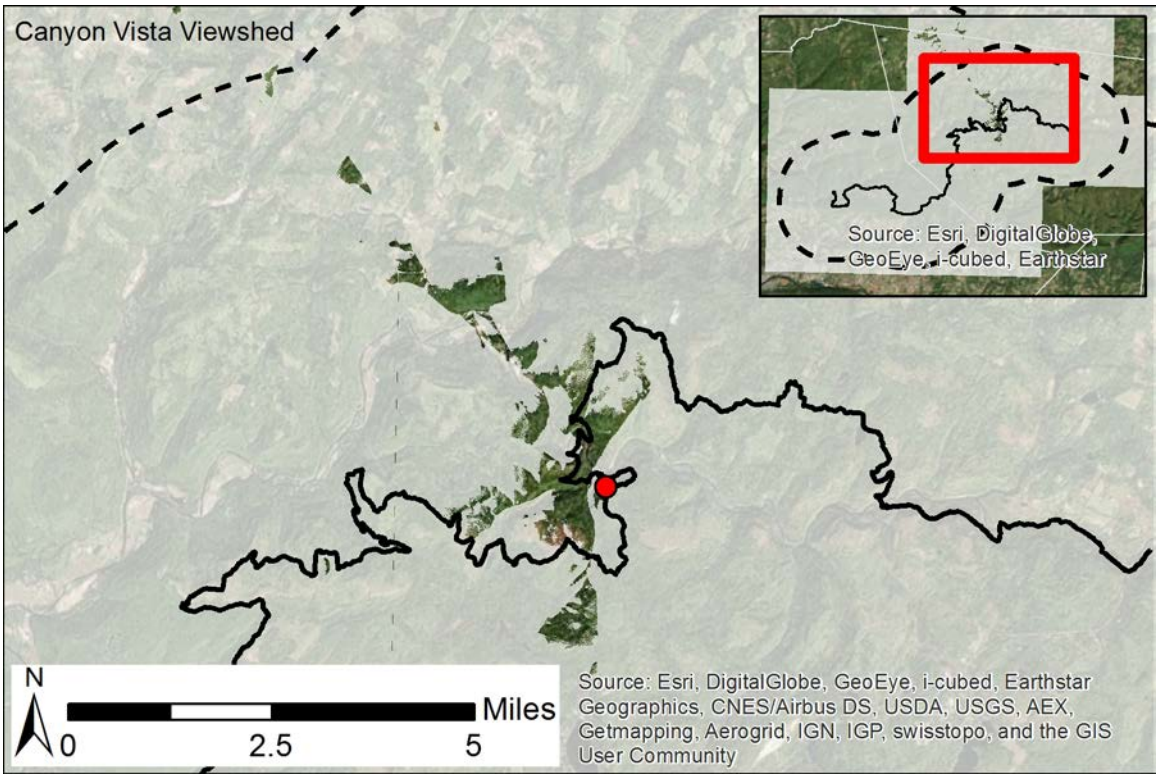
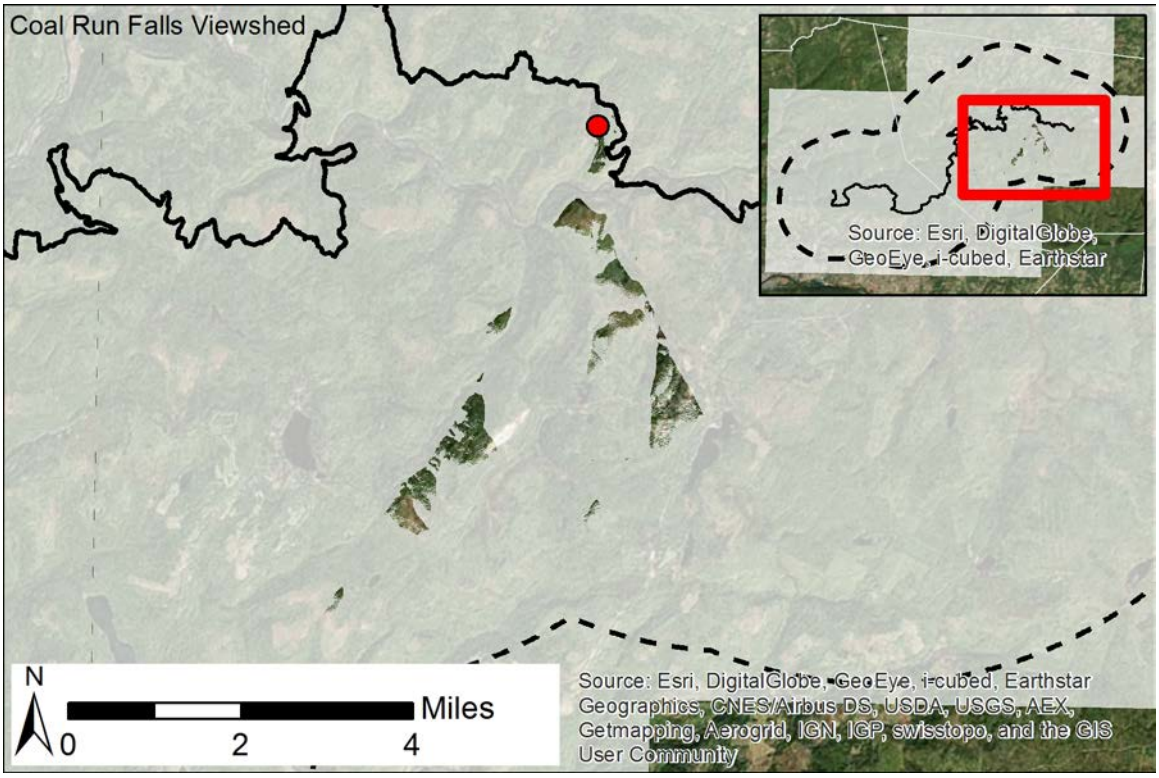


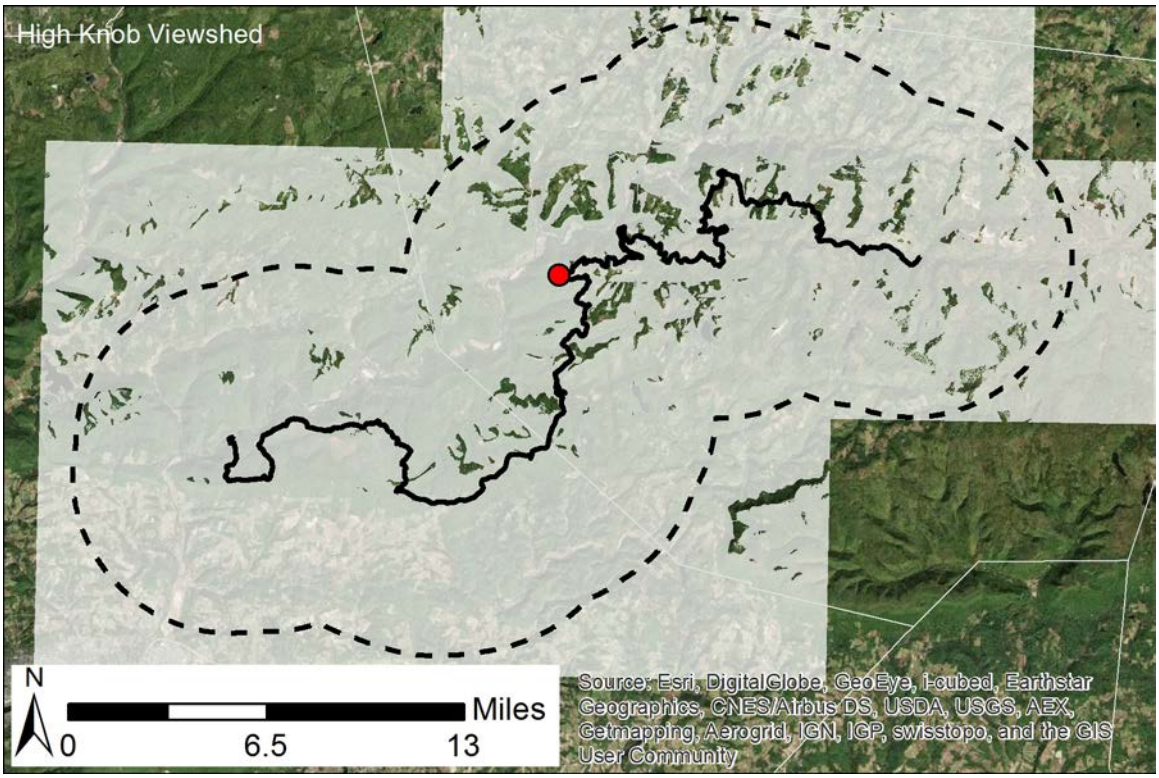
Figure 39 – The Loyalsock Trail viewshed

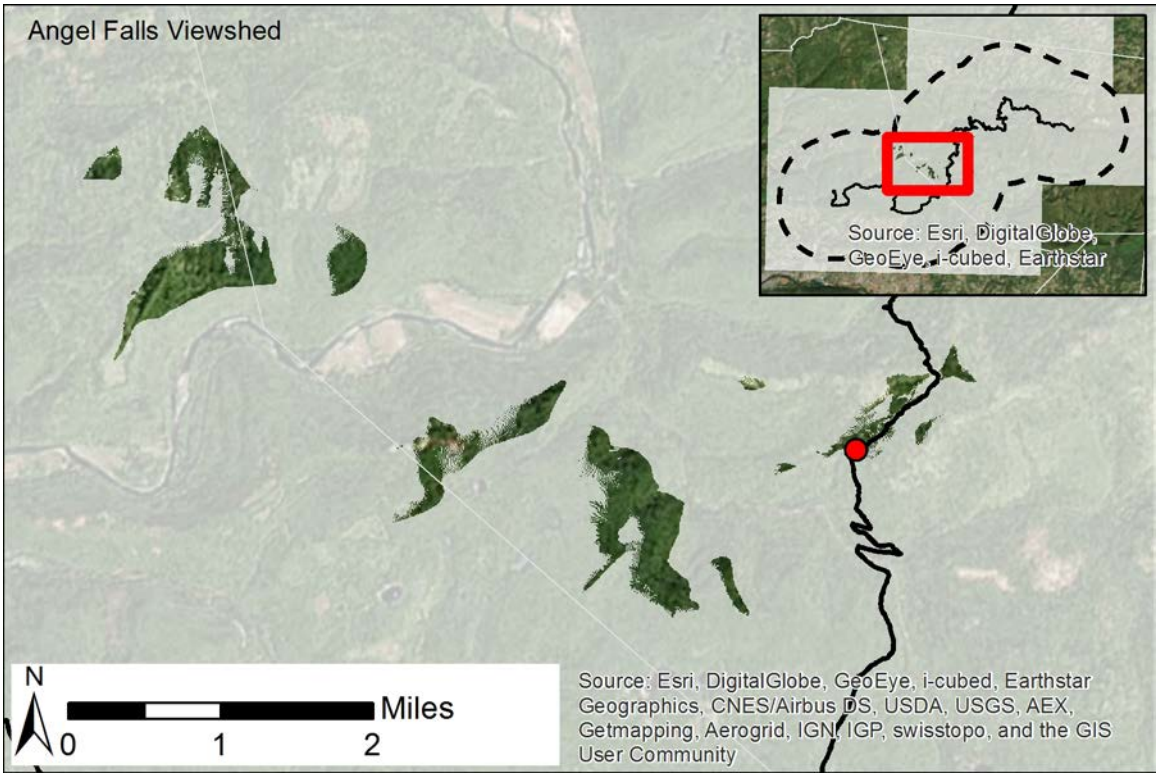
4.2.3.1. Individual Viewsheds

Rather than creating a viewshed protection ordinance that covers every bit of land seen from the trail, which would require compliance of all municipalities and both counties to enforce, and encompass 113,743 acres of land, one proposal is to look at the viewsheds of individual points of interest. Having established an order of importance with the crowdsourced data, views can be protected as time and funds allow and efforts can be concentrated around those more important to the visual experience of the trail and region. This also means that individual municipalities can decide which to which areas of conservation they will contribute, though in some cases it would still be necessary for multiple municipalities to band together to protect an entire point of interest's viewshed. The following maps show the viewsheds of the four most popular locations identified by average views per day. The viewsheds vary greatly in acreage and expansiveness even among the top four.


Canyon Vista Viewshed
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar
N
Miles
0
2.5
5
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Coal Run Falls Viewshed
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar
N
Miles
0
2
4
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


High Knob Viewshed
N
Miles
0
6.5
13
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Angel Falls Viewshed
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar
N
Miles
0
1
2
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

4.2.4. Land Use

This section looks at the landuse patterns surrounding the Loyalsock Trail to see if there is any one land use type that can be conserved in particular, and also to see if a land use type is more common among the individual viewsheds to predict which land people would be more likely to find visually pleasing or valuable. Most of the trail passes though vegetated forestland, but because of the topography, many areas offer extensive views of the surrounding landscape. Figure 40 shows land use patterns that occur within the viewshed of the Loyalsock Trail and the immediate surrounding area. Though there is some variation among the viewsheds, deciduous forest cover, evergreen forest cover, and mixed deciduous/evergreen forest cover are the dominating land use types in all viewsheds.

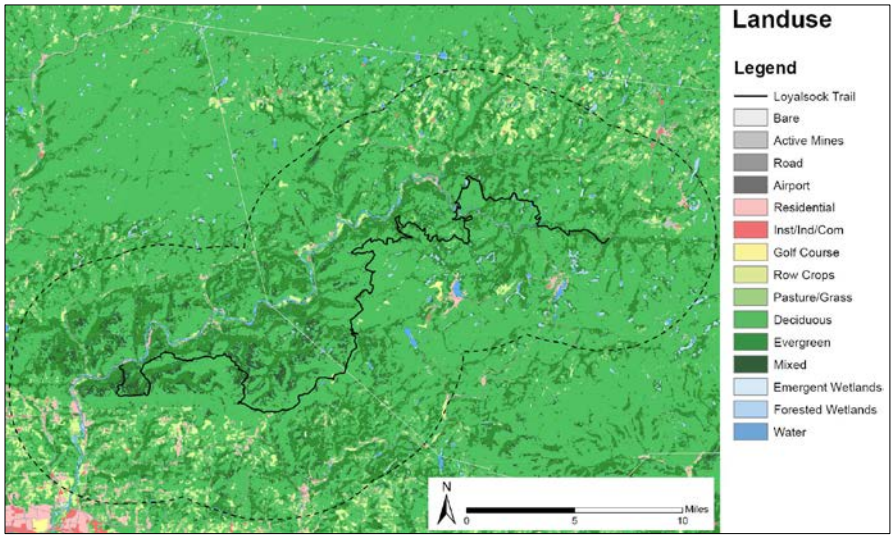


Figure 40 – Landuse

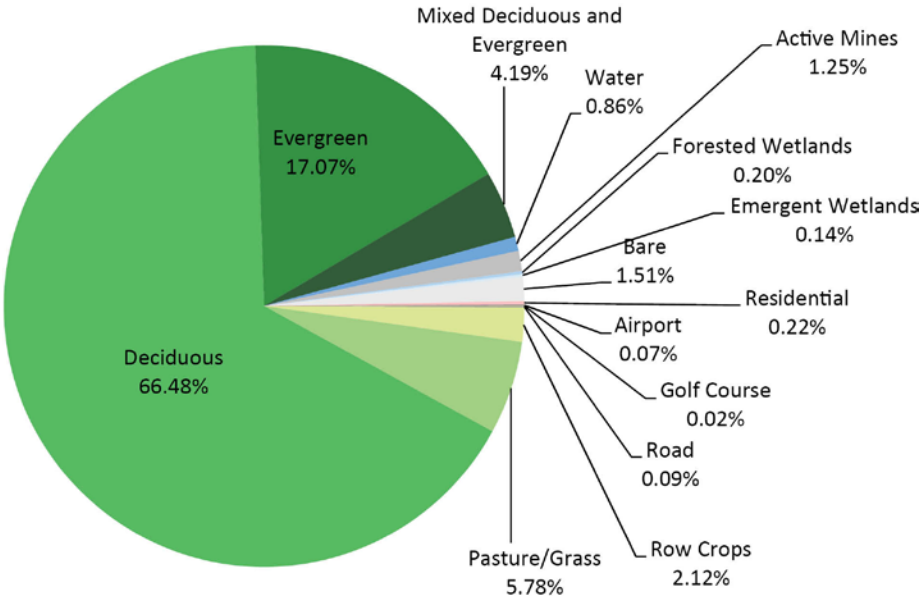
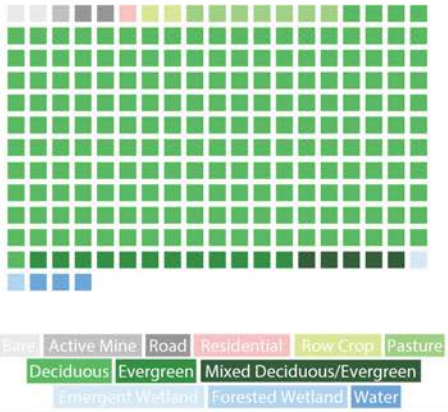
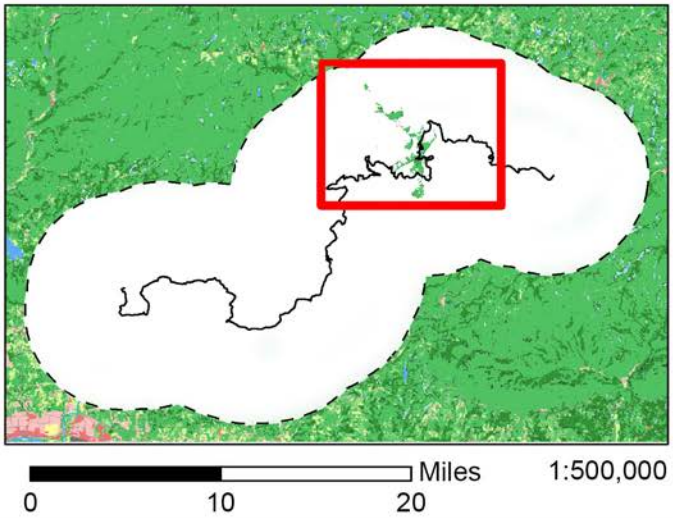
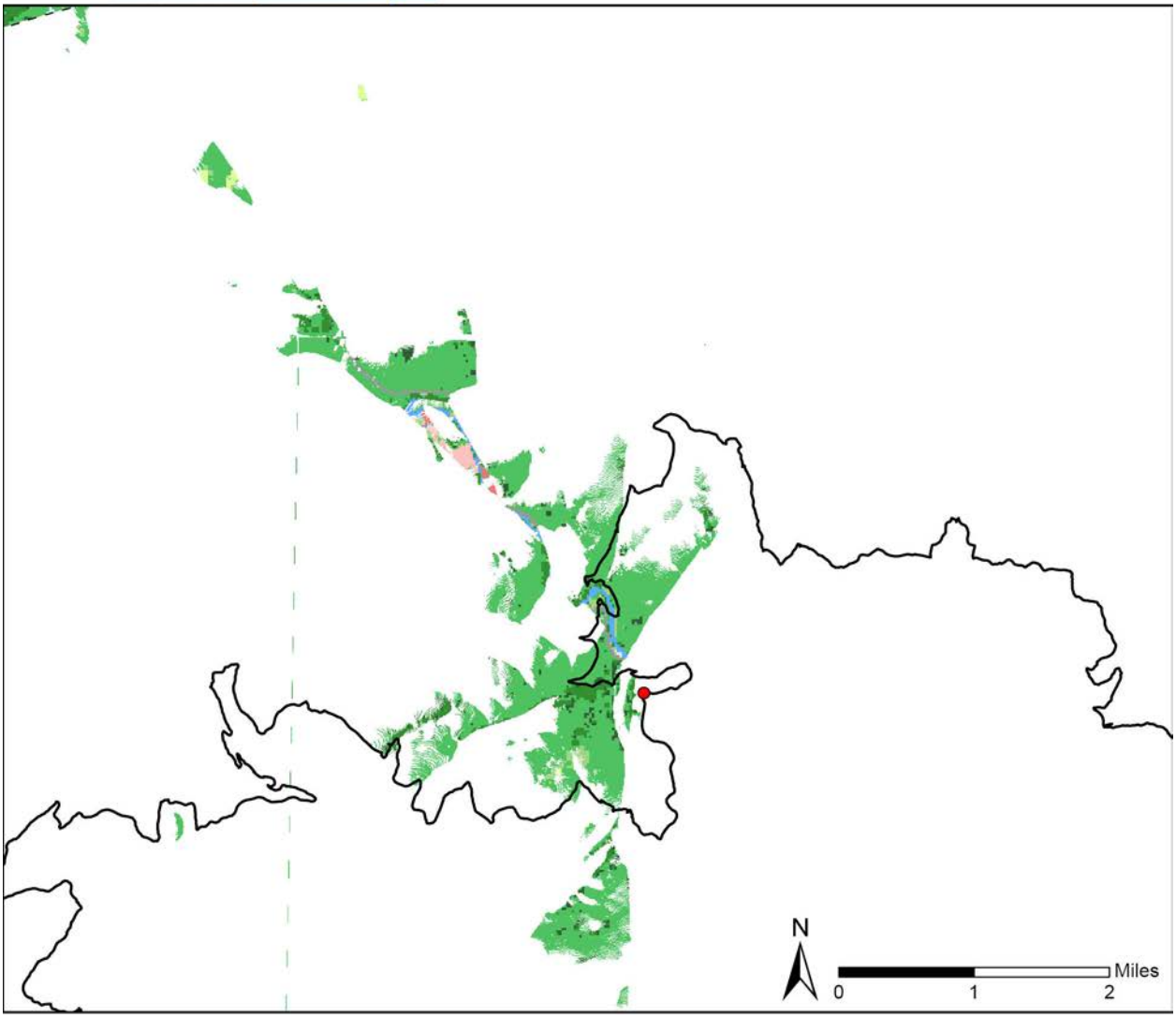


Figure 41 – Percent Landuse/Landcover for entire Loyalsock Trail viewshed

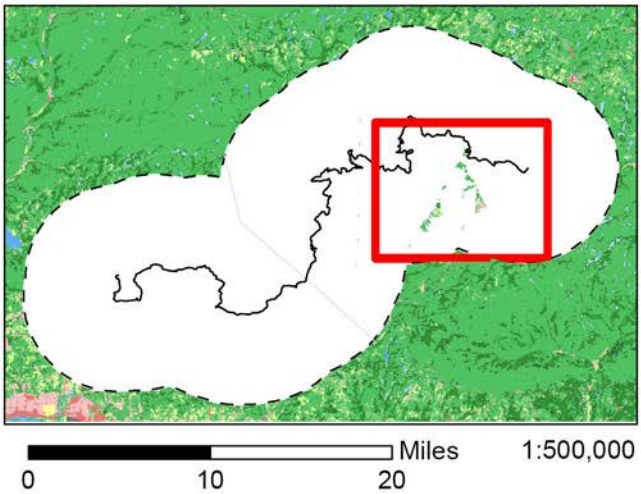
Canyon Vista Viewshed

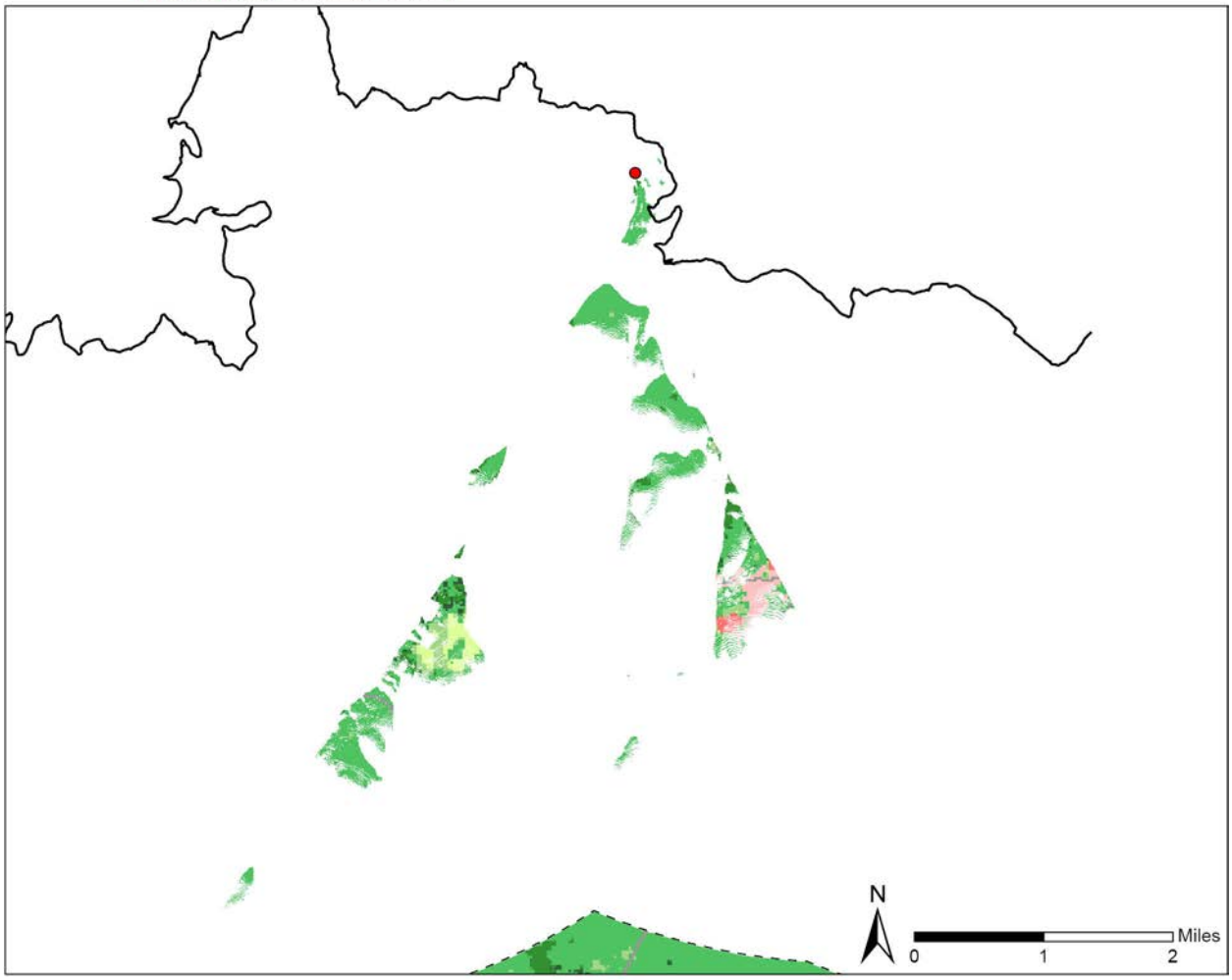




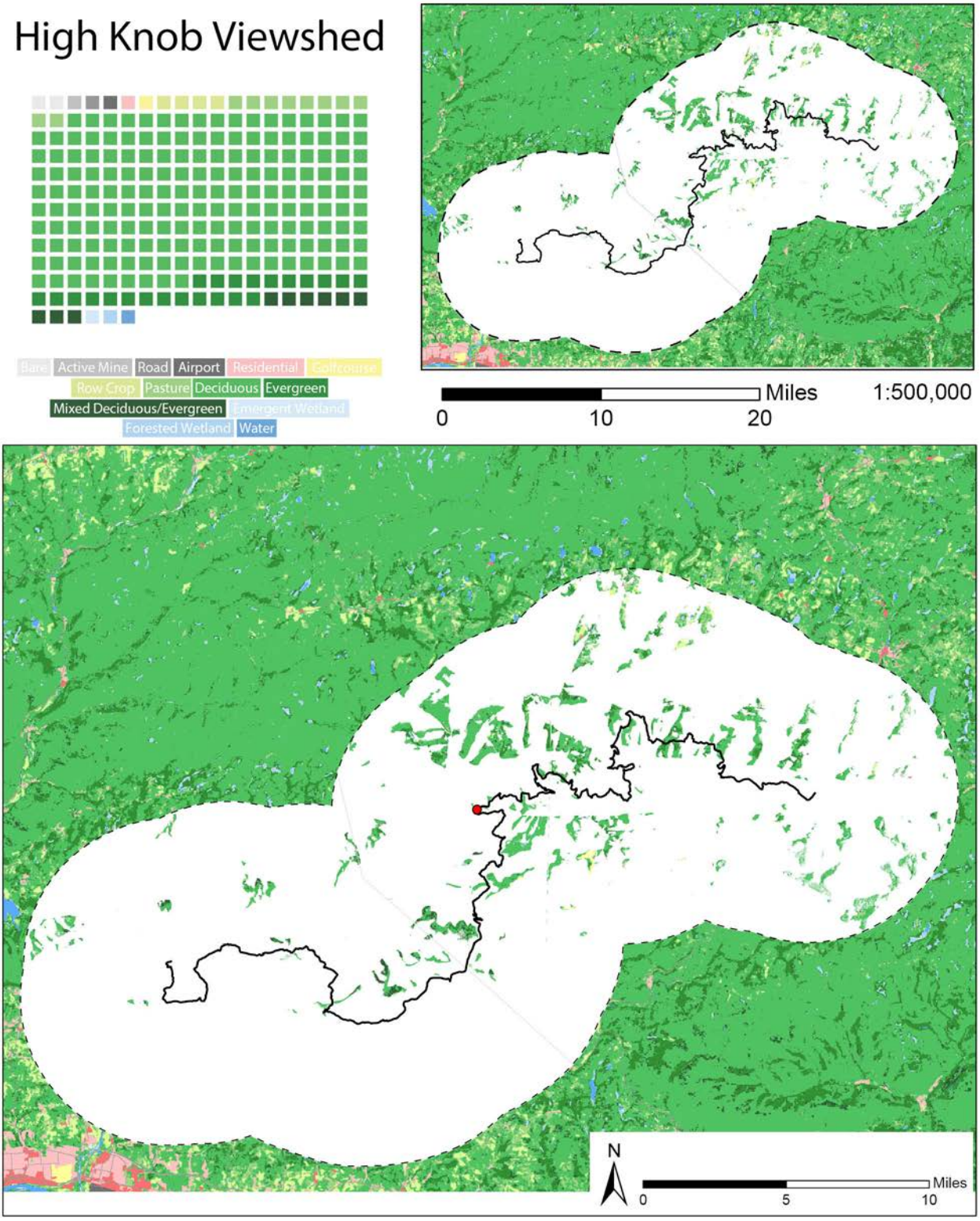


Coal Run Falls Viewshed

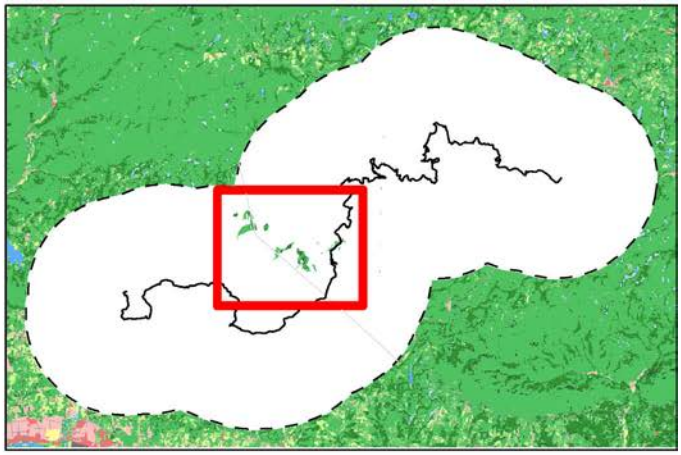




High Knob Viewshed

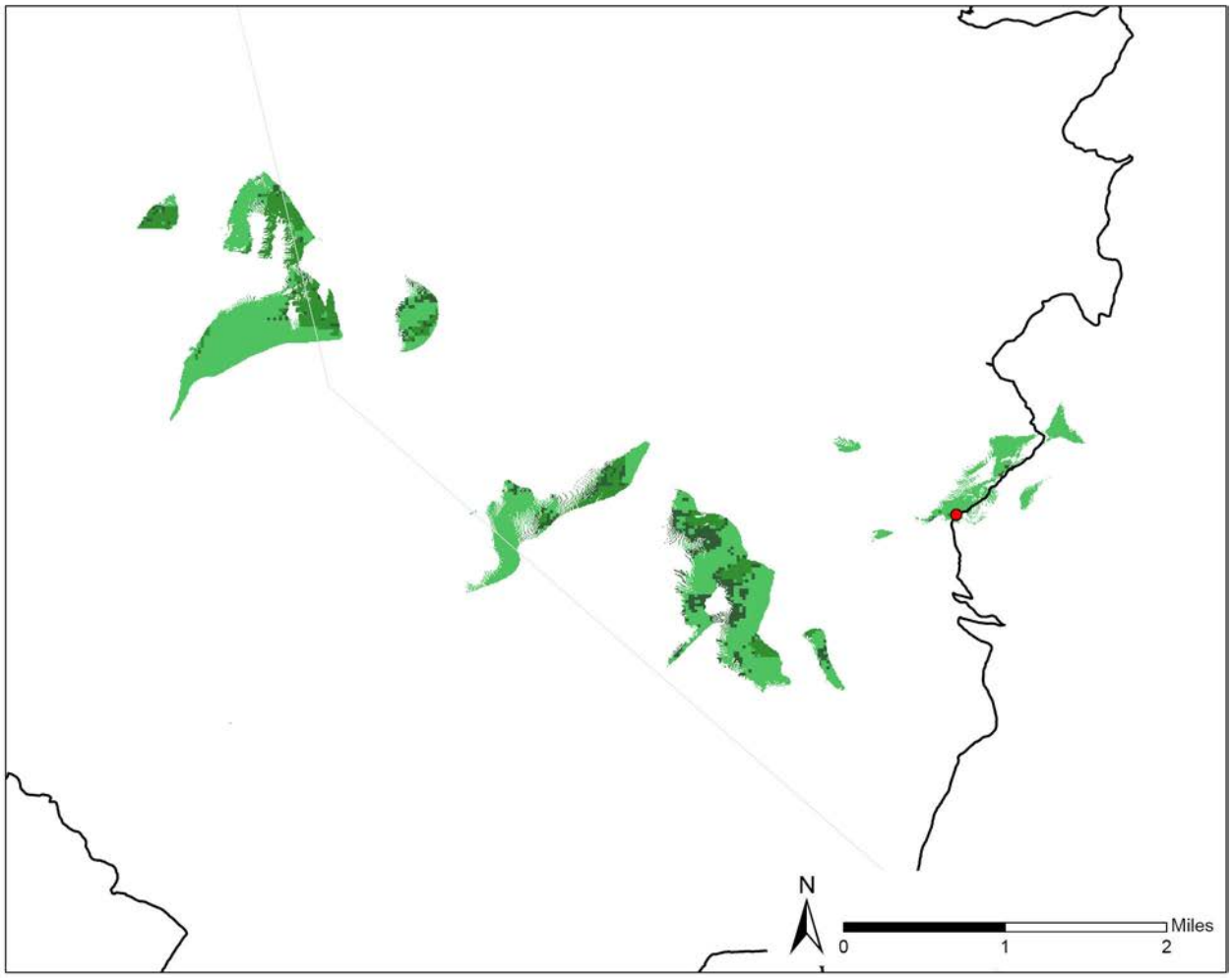


Angel Falls Viewshed



Pasture | Deciduous | Evergreen | Mixed Deciduous/Evergreen

0 10 20 Miles 1:500,000



4.2.5. Slope

In the Napa Valley Viewshed Protection Program, a steep slope ordinance was part of their scenic conservation strategy. (County of Napa Planning, Building, and Environmental Services 2012) Prohibiting development on steep slopes is meant to minimize grading and land disturbance which are not only ecologically harmful but also aesthetically impactful as steeper slopes are more visible to the viewer from a distance than flatter slopes. To see if enacting a slope ordinance would make sense for the study area, Figure 42 shows the existing well locations in and around the Loyalsock Trail viewshed. The slopes were broken down into four classifications; 0-8% or flat to mildly sloping, 8-15% moderately sloping, 15-30% steeply sloping, and 30+ or extremely sloping. In this sample there are 616 wells. 367 wells or 59.5% of the wells are on flat to mildly sloping land. 182 wells or 29.5% of the wells are on moderately sloping land. 67 or 10% of the wells were built on steeply sloping land. No wells were constructed on the extremely sloping land. From these observations, a steep slope ordinance may aid in visual conservation but on its own it is not sufficient. A very small percent of well pads are being constructed on steep land.

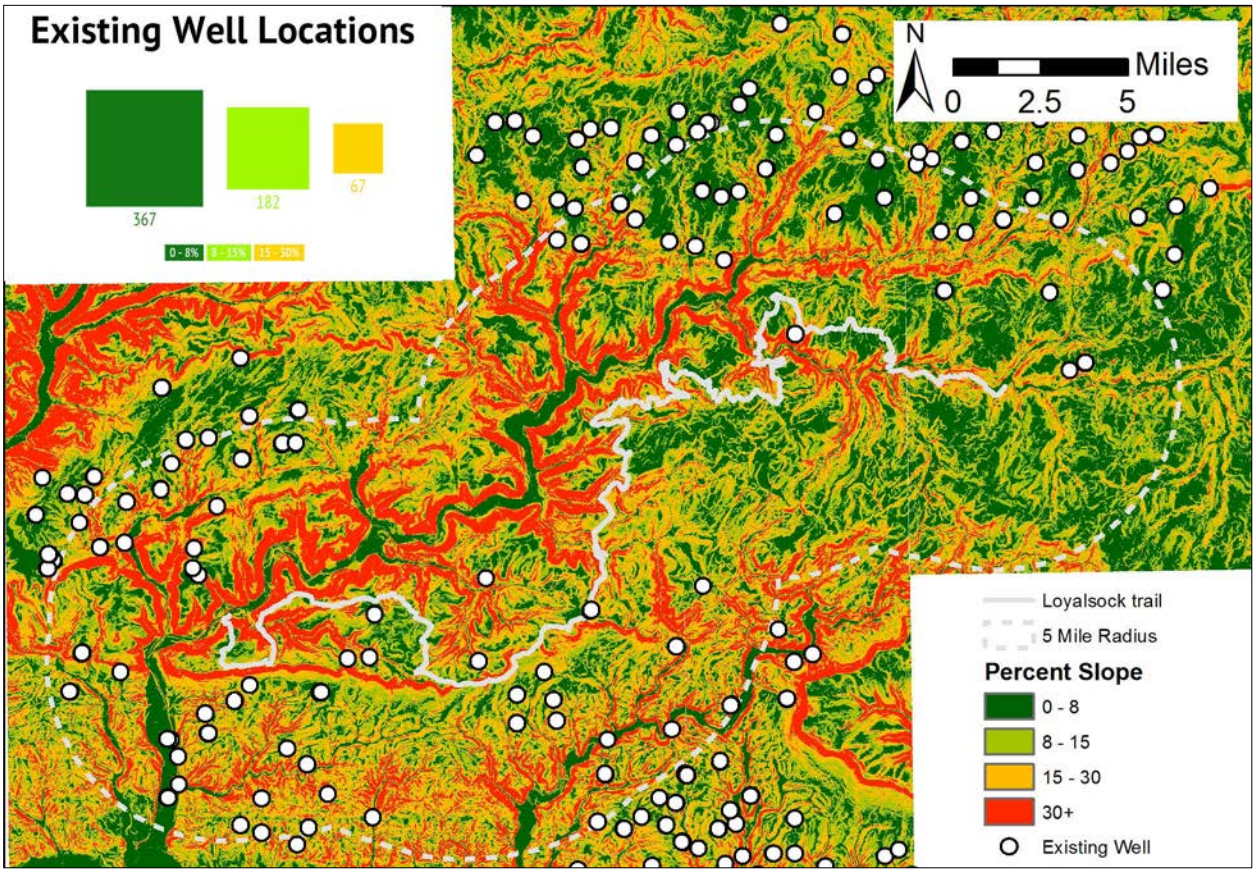


Figure 42 – Existing well locations and their corresponding slopes in the Loyalsock Trail study area

4.2.6. Ridgeline

To determine the ridgelines within the study area I used the same process for determining stream order but began by multiplying the digital elevation model elevations by -1 to get the inverse of the elevations (i.e. the highest point would be the lowest point and vice versa). The procedure can be found on ESRI's website at http://support.esri.com/fr/knowledgebase/techarticles/detail/39093. I defined 5 ridgeline categories, 1 being the least significant and 5 being the most significant. I then determined ridges classified as 3, 4, and 5 to be major ridgelines leaving those with values of 1 and 2 to be classified as minor ridgelines. For this project I am focusing on the major ridgelines.

After determining the ridgelines, I broke them down into the slope categories 0-8%, 8-15%, 15-30%, and 30%+, and used a basic rise over run (rise/run=slope) calculation to determine vertical distance from ridgeline measurements. These numbers were the rounded up to the nearest 10'. Figure 43 shows the results.

Slopes	0-8% = .08	8-15% = .15	15-30% =.3	30%+ = .35
50' vertical buffer	630' horizontal	340'hz.	170' hz	150'hz
100" vertical buffer	1250' hz.	670' hz.	340' hz.	290' hz.

Figure 43 – Horizontal Calculation for Vertical Distance from Ridgeline Buffers

Figure 44 shows the results for the Loyalsock Trail viewshed as well as the surrounding study area. It also looks at the location of existing well pads in relation to the ridgelines. Of the 940+ wells in Lycoming and Sullivan County: 367 are within 50 vertical feet of a ridgeline; 564 are within 100 vertical feet of a ridgeline.

If a ridgeline ordinance were to be enacted a great deal of land would be conserved.

Within the study area:

320,215 acres if 100 from major ridgeline;

141,208 acres if 50 vertical feet from major ridgeline;

Within the Loyalsock Trail viewshed:

152,047 acres if 100 vertical feet from major ridgeline;

65,664 acres if 50 vertical feet from major ridgeline;

With approximately 2/3 of the land being privately owned, this approach combining the viewshed and a ridgeline ordinance takes the least amount of land out of development while still providing for scenic conservation.

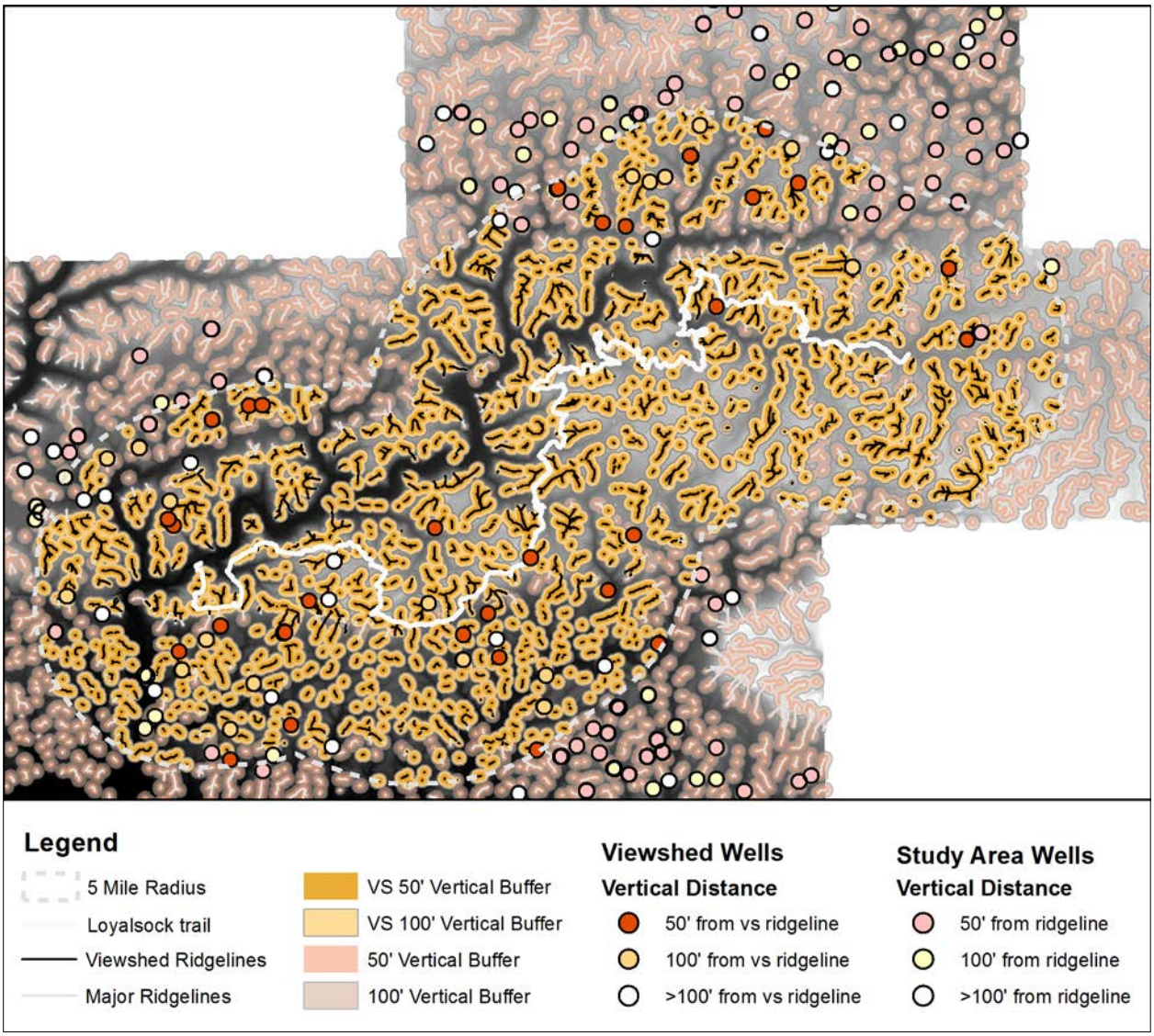


Figure 44 – Major ridgelines, vertical distance from ridgeline buffers, and relationship of existing well pad locations to the ridgelines.

Chapter 5

5. Results: Design and Planning outcomes
   5.1. Design Suggestions

It is quite clear that one single measure of conservation is not the answer, nor will any single combination of the previously discussed methods fit all scenarios. However, for the Loyalsock Trail case study it is clear that, because of the conservative nature of the resident landowners, putting all of the land under conservation is out of the question. Landowners fear government takeover and land acquisition. For this case, the less land that can be put under conservation by law, and still have a large visual impact, is the best solution. Using crowdsourcing to determine the popularity of locations helps to prioritize conservation efforts.

Judging from the content of the crowd-sourced images, the land use type that seems to be most aesthetically prized is the forested land. Though 3 of the 26 images include manmade elements (a farm field, a bridge, and an inn) and 11 include water elements (ponds, lakes or waterfalls), the main land use type in all of the individual point of interest viewsheds is deciduous forest. Attempts should be made to preserve the integrity and contiguity of existing forest. State designated wild and natural areas, game lands, forests, and parks should remain as is, if not increased in size and/or afforded more protection from encroachment. It is the "natural" nature aspect that people have pride in and come long distances to enjoy.

Vistas from programmed and informal overlooks should both be conserved. While those locations near parking lots and programmed overlooks tend to be the most visited due to their accessibility, many vistas from the visitor and hiker created overlooks are just as popular and culturally significant to the region.

Though few well pads are sited on steep slopes, it would still be advisable to institute protection of steep slopes because of the added benefits, not only visually, but also environmentally. The more sloped or vertical a landform is, the more visible it is from a distance.

As pipeline right-of-ways are the longest-lasting and most disruptive visual aspect of the gas extraction industry, they should have extra consideration and planning afforded to them. Though the most direct route between points may be the most cost-effective method of placing pipelines, vistas, prominent views, and ridgelines should be avoided because of their high visibility. These elements should be "skirted around", working with the contours of the land rather than straight up and over a slope. Right-of-ways should be hidden from view with plantings or landform to obscure them, either placing them on the side of a hill not facing an overlook or run amongst the trees, parallel to the ridgeline rather than in a straight line perpendicular to them.

   5.2. Ordinance Recommendations
      5.2.1. Ridgeline Ordinance

The average height of trees in Central Pennsylvania is 70 feet. (Wasser, et al. 2013) Assuming an average gas drill rig height of 85 feet (Upadhyah and Bu 2010), 15 feet is the absolute minimum vertical distance

from ridgeline needed for visual conservation. However, since trees may be shorter or in some cases, though rare, non-existent on barren ridges, and for parts of the year when there is no foliage on the trees, I am inclined to disregard tree cover altogether in calculations for vertical distance from ridgeline and rely solely on landform to obscure undesirable structures or land form alterations (see Figure 45). That being said, I would advise a liberal application of the ordinance and suggest 100 vertical feet from the ridgeline to insure any shale gas related development would be hidden from view.

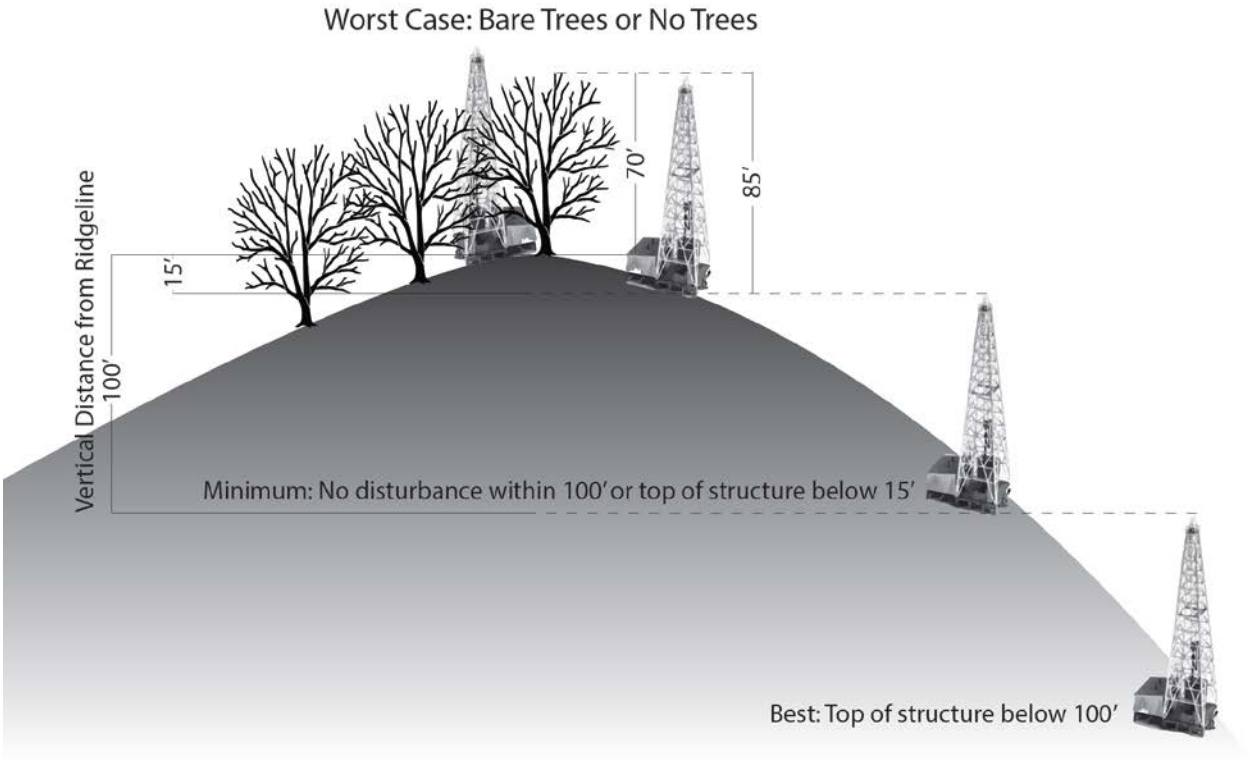


Figure 45 – Distance from ridgeline diagram

This ordinance should read:

1. The municipality shall determine designations of major and minor ridgelines in the impact area based on visual prominence and relation to cultural and natural visual amenities;
2. No shale gas related development is to occur within 100 vertical feet of a ridgeline; this includes, but is not limited to, landform grading, clear-cutting or removal of trees, installation of roadways, pipelines, retention ponds, or well pads;
3. The top of any structure (buildings, drill rigs, towers, etc.) are not to extend above the 100 vertical feet from ridgeline buffer

This ordinance would protect the major ridgelines, the highest, most visible areas of the landscape, from development. Allowing development on minor ridgelines provides areas that are not steeply sloped but also not prominent on the horizon.

Figure 49 shows this ordinance represented in the Loyalsock Trail study area.

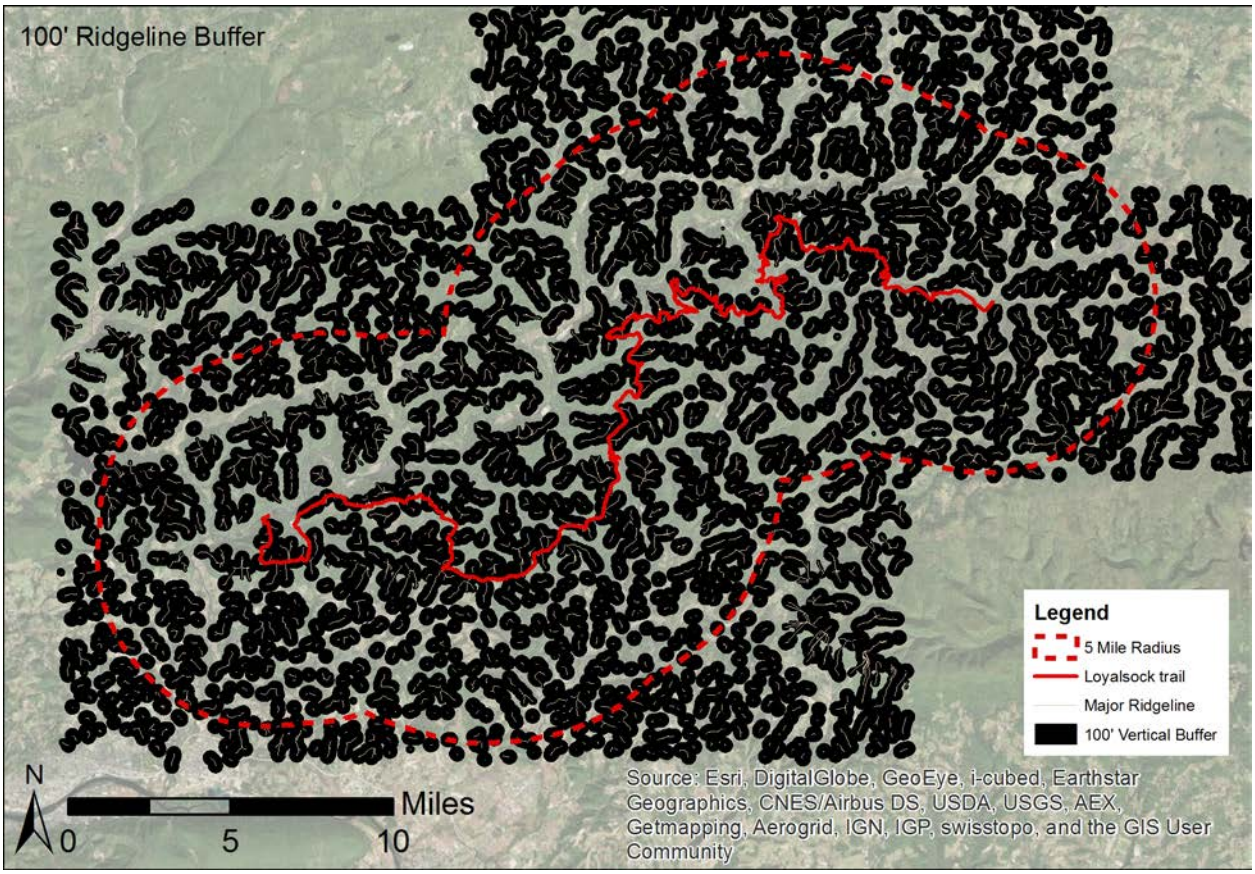


Figure 46 – 100' vertical buffer ridgeline ordinance in the Loyalsock Trail study area

Figure 47 shows a more conservative 50' alternative. This would ensure existence of enough vegetation to visually obscure any development.

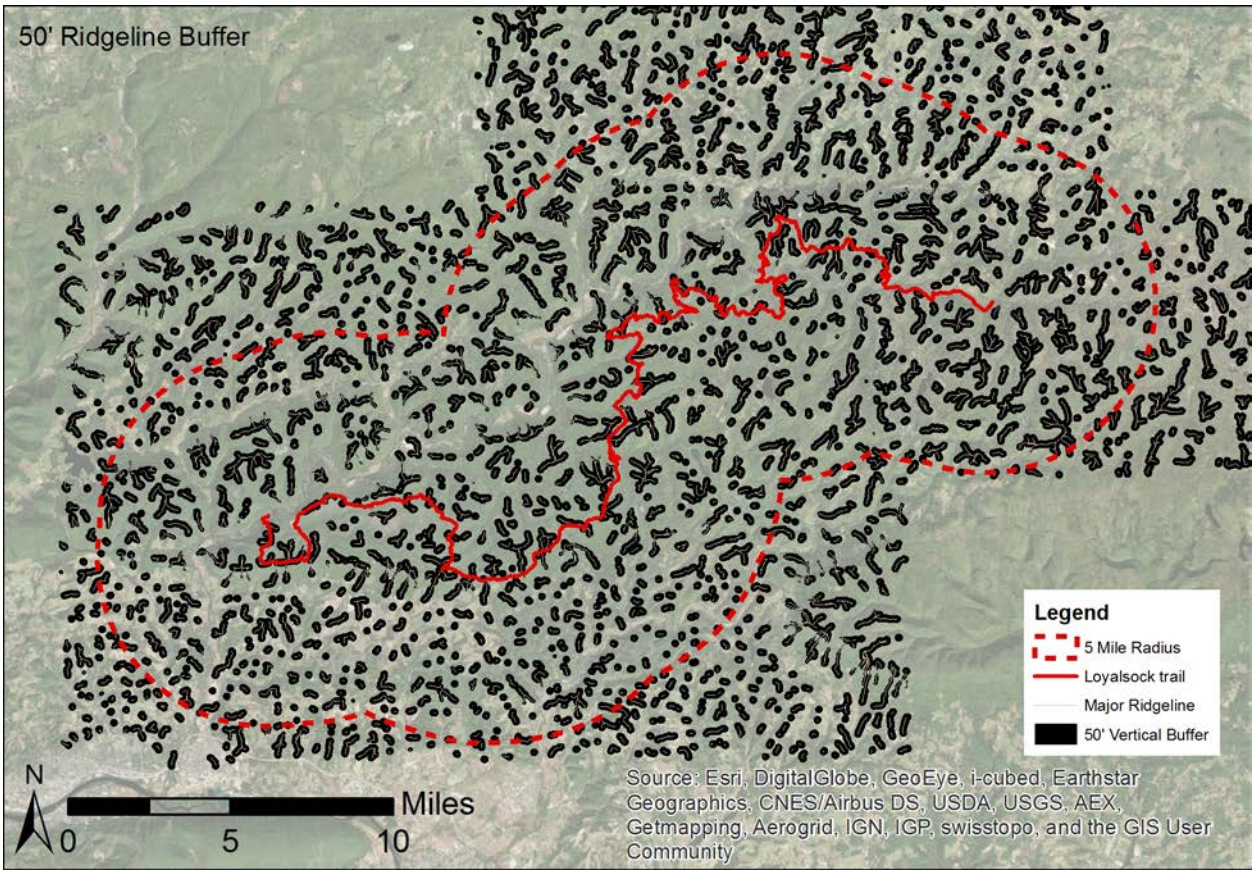


Figure 47 – 50' vertical buffer ridgeline ordinance in the Loyalsock Trail study area

5.2.2. Steep Slope Ordinance

In the study area, only 10% of wells have been constructed on land that is 15% or greater in slope. With well pads averaging 3 – 5 acres, this amounts to approximately 270 acres of steeply sloped land that has been drastically graded. Though this is a small fraction of the study area, the impacts are still significant and should be prevented.

The ordinance should read:

1. No shale gas related development is to occur on land with slopes greater than 15%

As mentioned before, grading on significantly sloped land is highly visible from afar and has drastic negative impacts both financially and environmentally. This ordinance will protect the surrounding landscape, environment, municipalities, and residents, from easily viewed, highly impactful steep slope development.

Figure 48 shows this ordinance represented in the Loyalsock Trail study area.

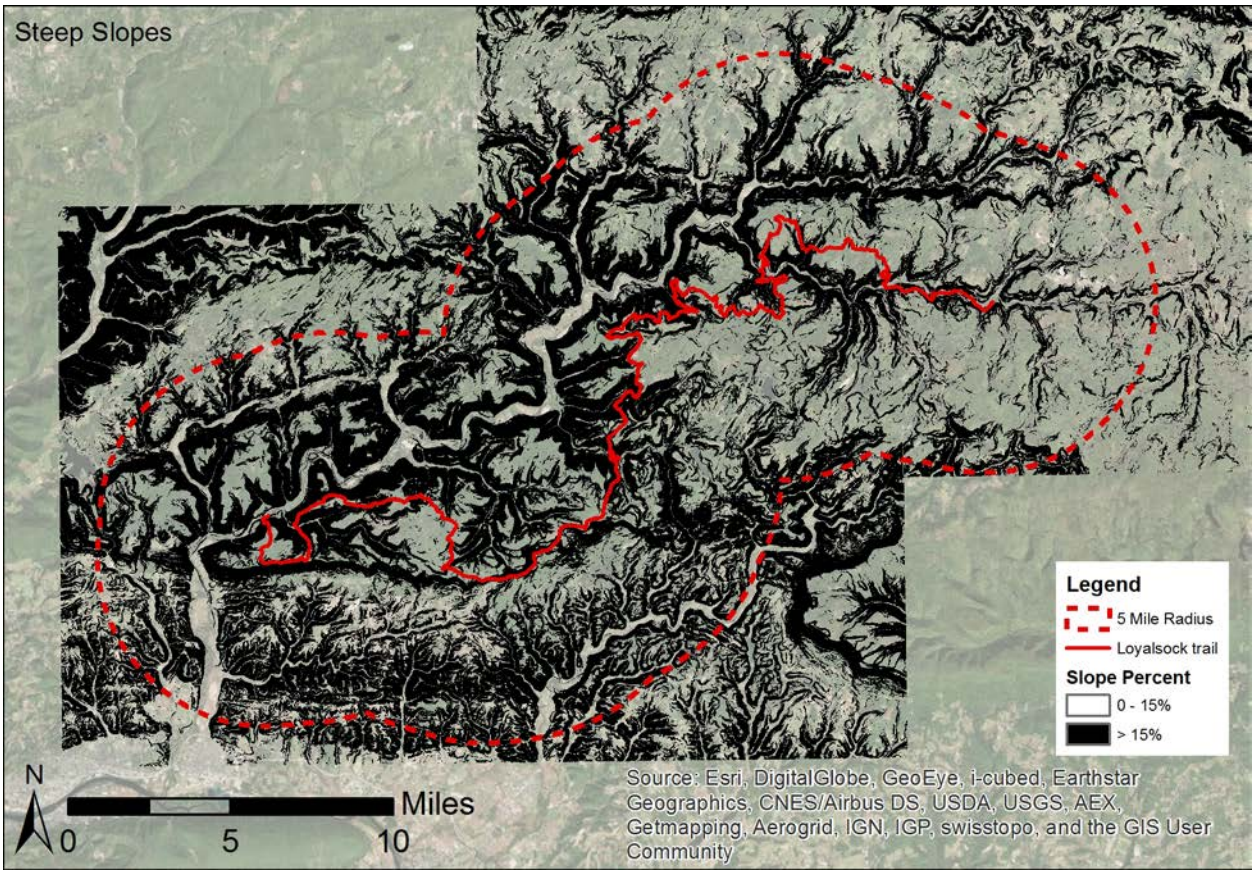


Figure 48 – Steep slope ordinance in the Loyalsock Trail study area

5.2.3. Important observation points from which viewsheds would then be derived would need to be chosen by the municipalities enacting the ordinances. These observation points can be singular locations or linear elements such as a trail, road, or waterway.

The ordinance would read:

1. No shale gas related development is to occur within [designated viewshed] where it would be visible from [designated observation point or linear element].

This ordinance would protect all areas visible from a particular identified location or linear element. It can be all encompassing, such as everything visible from the entire length of the Loyalsock Trail, or more discretionary, such as choosing only particular points of observation from along the trail.

Figure 49 shows the entire viewshed of the Loyalsock trail, a more liberal approach to the viewshed ordinance. Figure 50 shows only the viewsheds of the top four most popular locations, a more conservative approach.

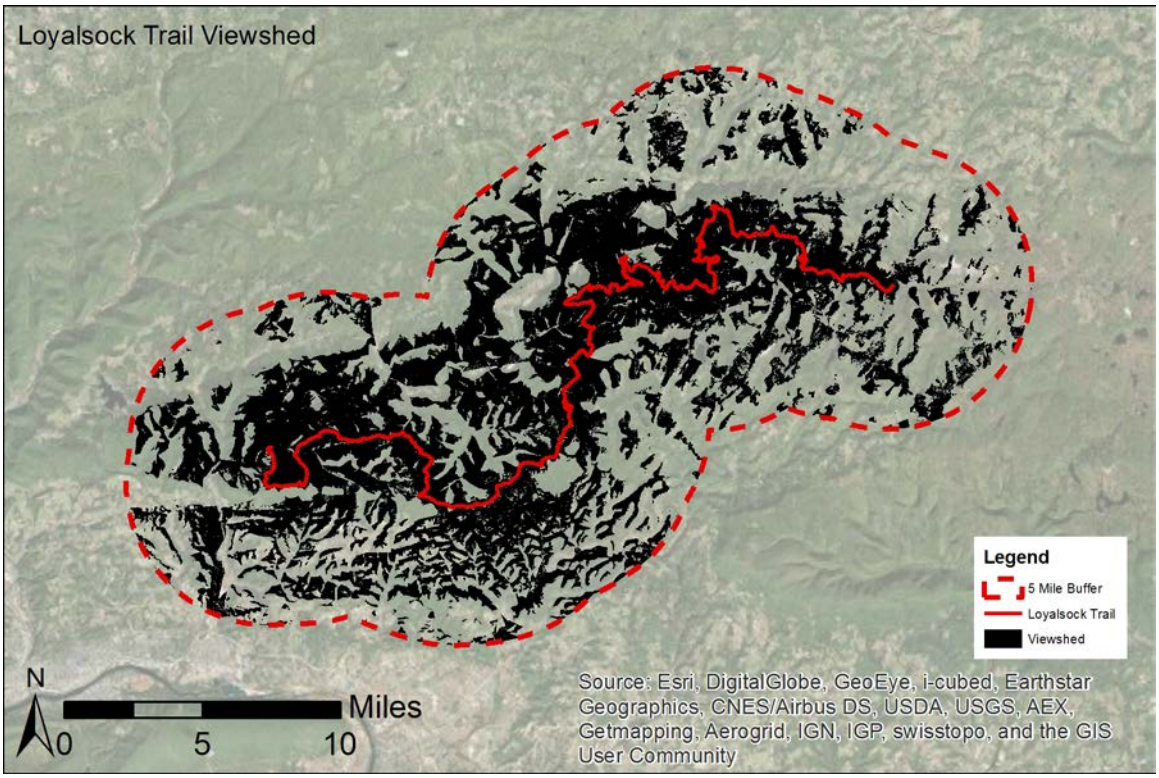


Figure 49 – Loyalsock trail viewshed

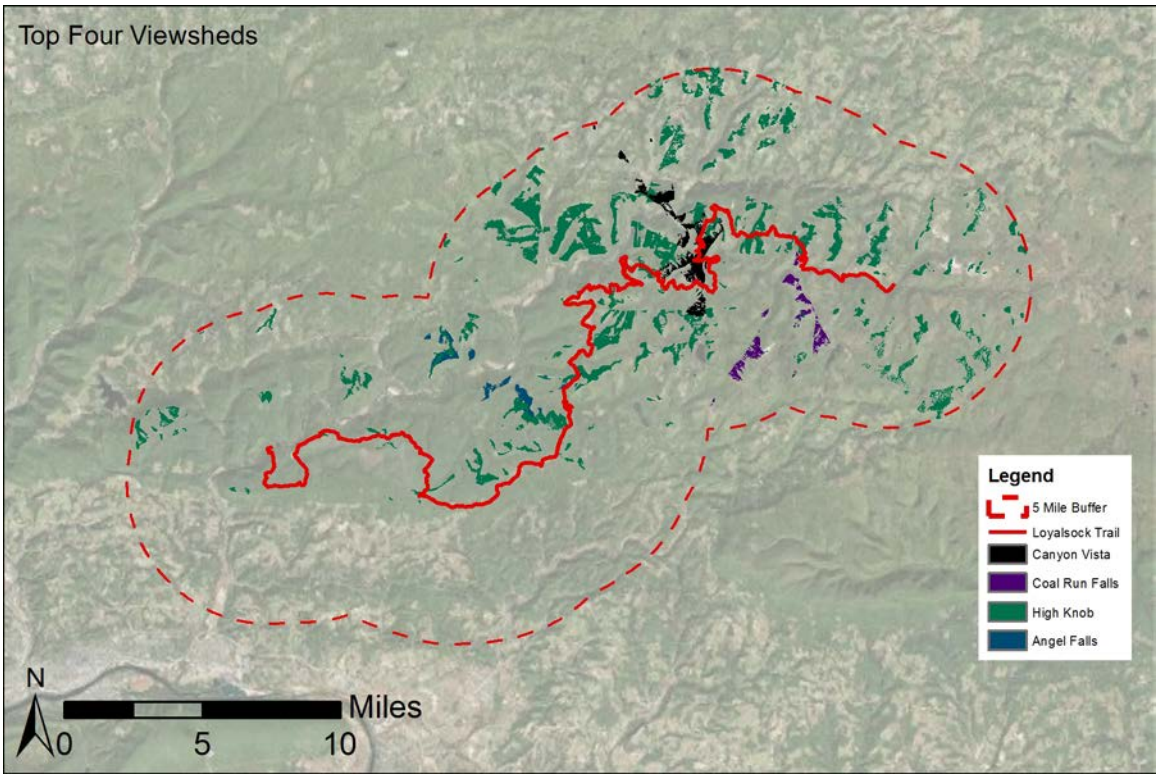


Figure 50 – Viewsheds of top four most popular locations

5.2.4. Combining Ordinances

The best design is combining several ordinances to achieve the most visual conservation. Figure 51 shows a liberal approach using the entire Loyalsock Trail viewshed combined with the 100' vertical distance from ridgeline buffer ordinance and the steep slope ordinance. Figure **52** shows a more conservative combination using the viewsheds of the top four most popular locations, Canyon Vista, Coal Run Falls, High Knob, and Angel Falls, the 50' vertical distance from ridgeline ordinance, and the steep slope ordinance.

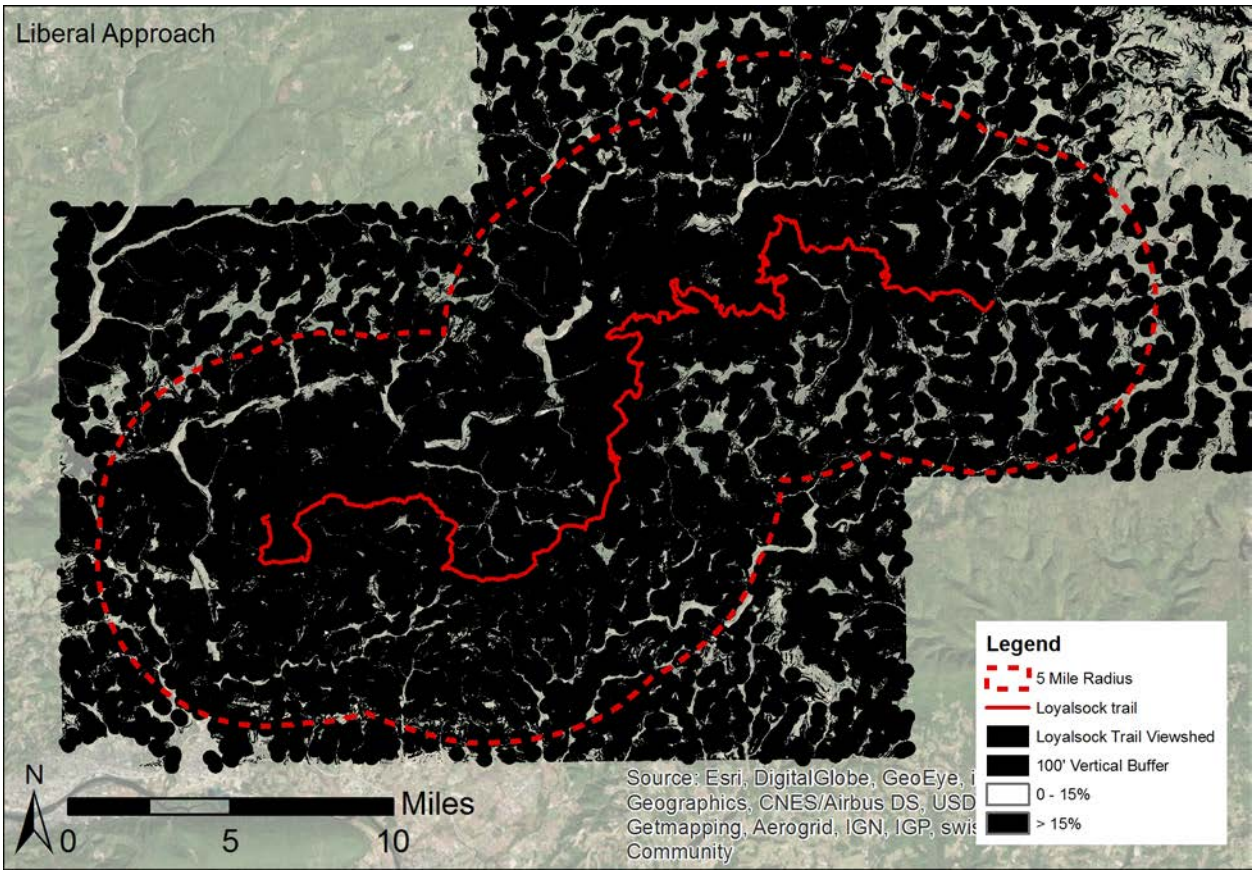


Figure 51 – Liberal approach combining steep slope ordinance, 100' vertical ridgeline buffer, and entire Loyalsock Trail viewshed

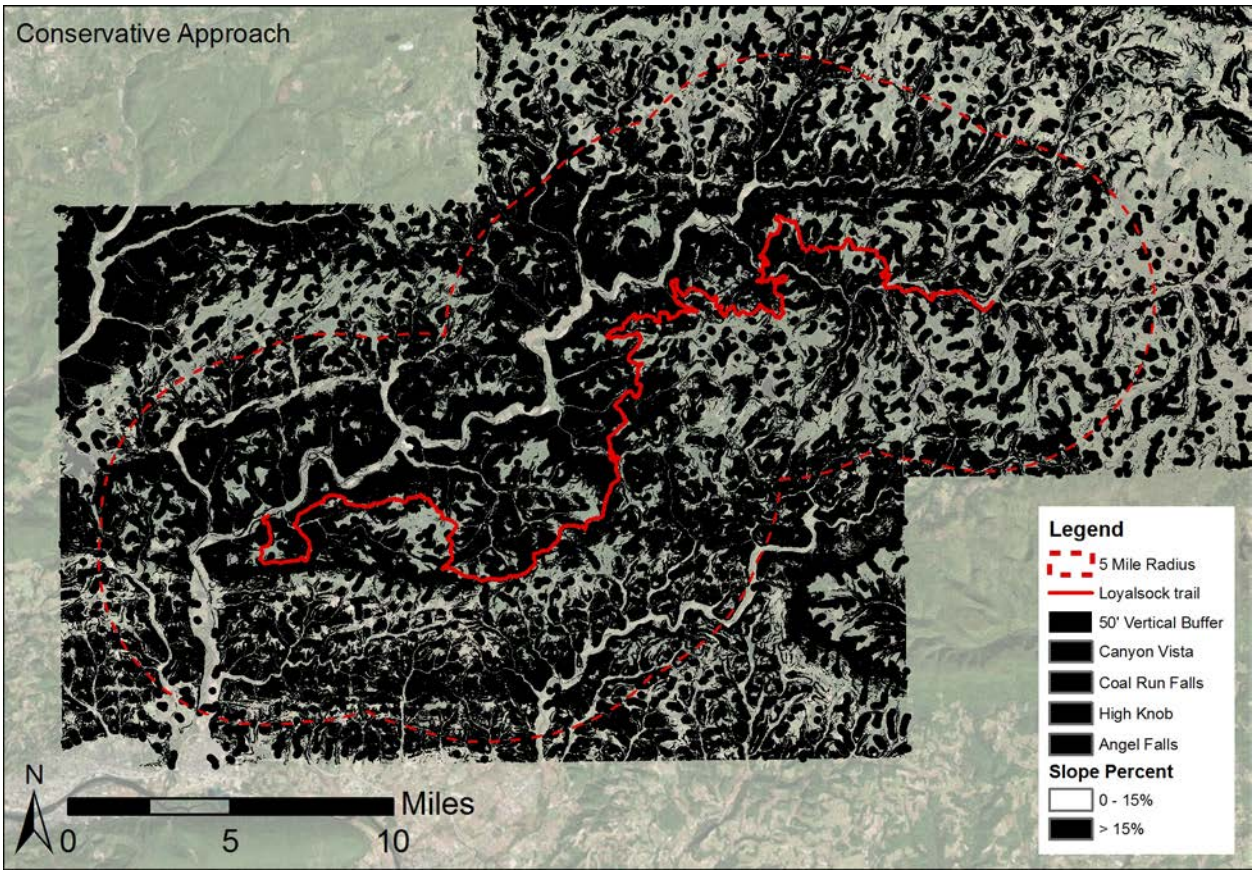


Figure 52 – Conservative approach combining steep slope ordinance, 50' vertical ridgeline buffer, and the Canyon Vista, Coal Run Falls, High Knob, and Angel Falls viewsheds

It is important to remember the impacts that these ordinances will have upon the ability of the private land owners to use their land. Figure 53 and Figure 54 show the impacts, in acres, upon private land in the study area and within the 5 mile buffer, respectively. In the study area, the liberal approach impacts 290,068 acres or 453.23 sq. miles and the conservative approach impacts 222,532 acres or 347.71 sq. miles, a difference of 67,536 acres or 105.52 sq. miles. Within the 5 mile radius, the liberal approach impacts 161,333 acres or 252.10 sq. miles and the conservative approach impacts 123,841 acres or 193.50 sq. miles, a difference of 37,492 or 58.60 sq. miles.

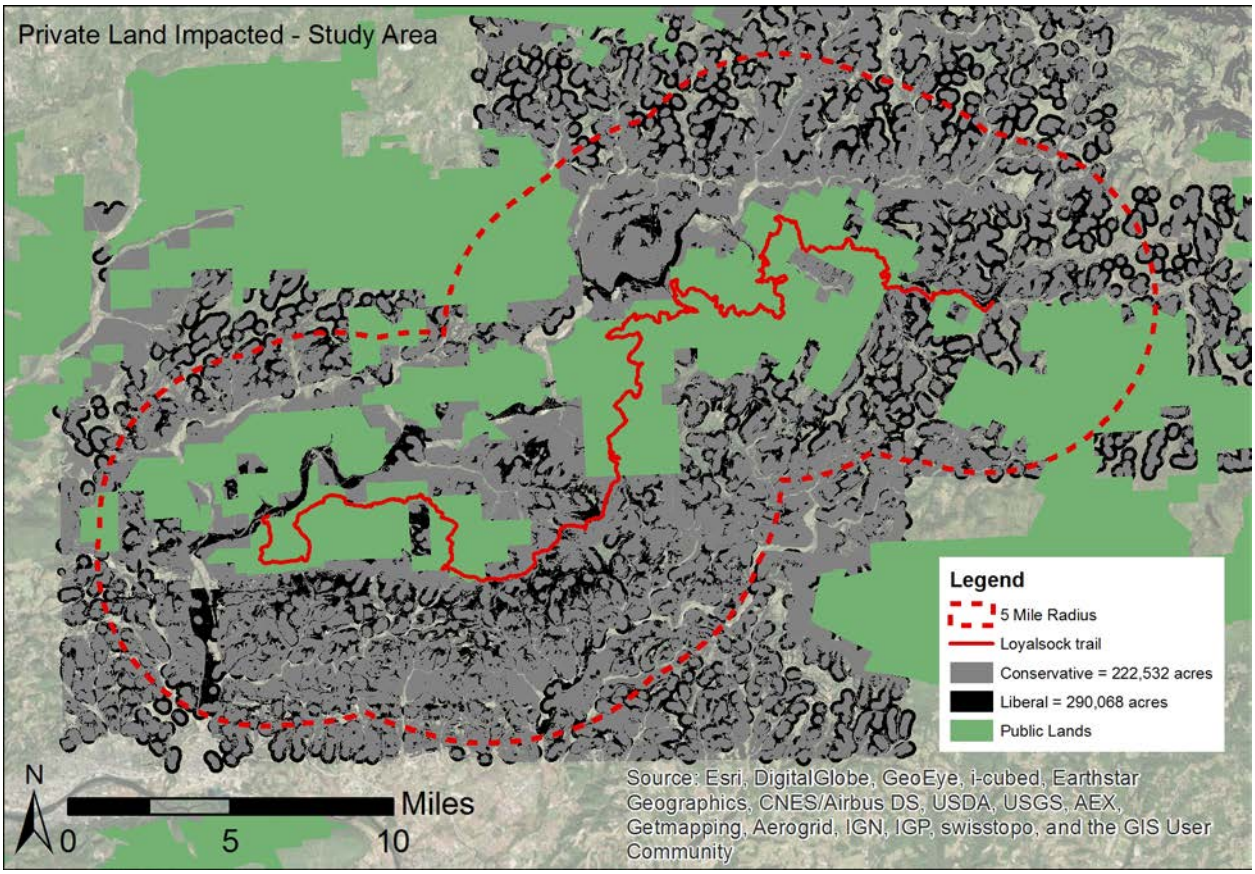


Figure 53 – Ordinance impacts upon private land in study area

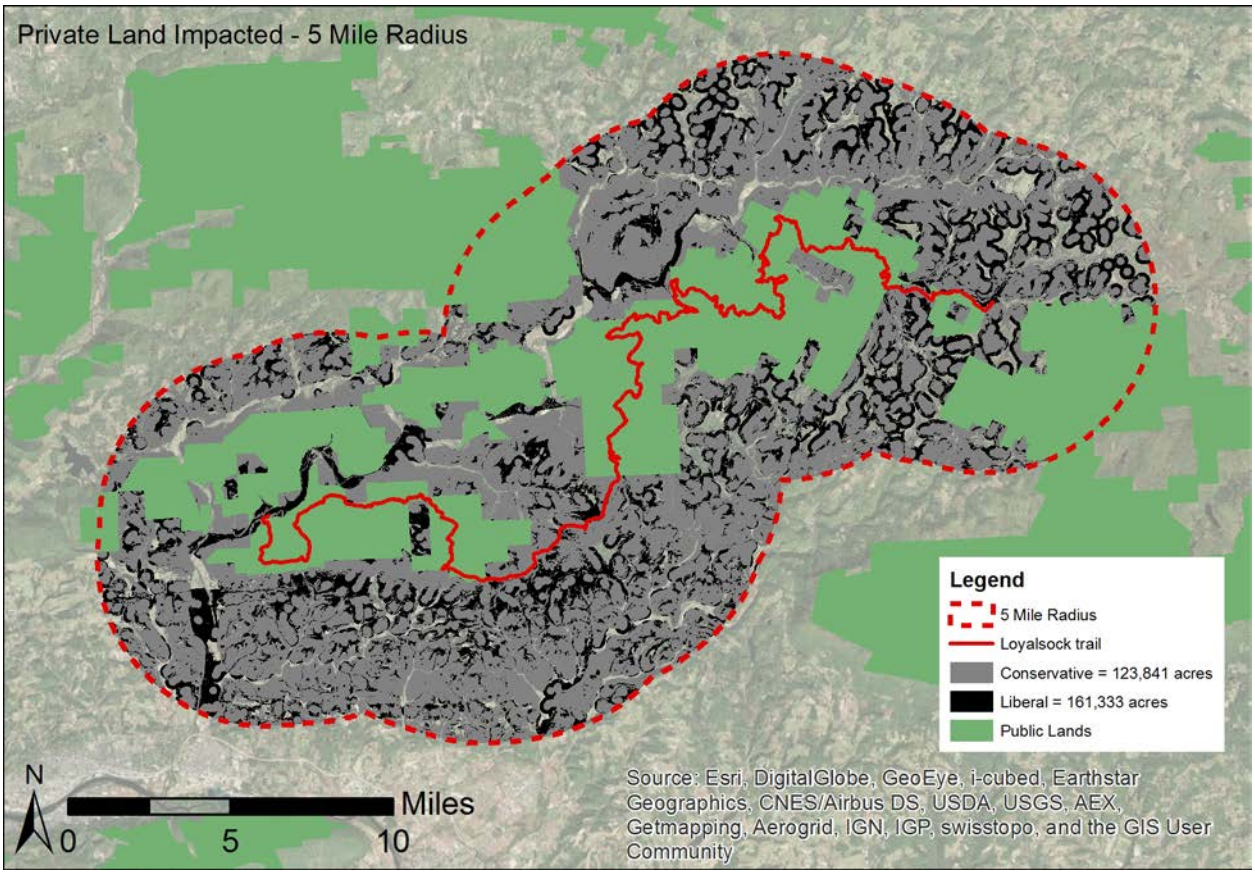


Figure 54 – Ordinance impacts upon private land in 5 mile radius

Chapter 6

6. Discussion and Conclusions
   6.1. List of Accomplishments

Using widely accepted natural and cultural amenities as a cornerstone for conservation is a great way to bring together groups who may disagree on land use practices. In this study, both pro- and anti-Marcellus shale groups can realize the importance of the identified locations, not only within their communities but also in the greater context of the region and beyond.

My hope for this study is that the information is thorough and easily understood so that, in turn, its underlying concepts and methods can be transferred to other similar situations, easily implemented, and readily enforced. It is also important that, particularly in an areas like central Pennsylvania where people hold strong opinions of land ownership and have conservative views about control of privately owned land, that these suggestions will not alienate the private land owner, but that a compromise can be reached for the betterment of the region and for the value of the private citizen's land.

6.2. How well the guidelines and recommendations address the problem

Steep slope ordinances are advisable in many situations, not just in this study, because of the cost, both financial and ecologic, that steep slope development incurs. The negative impacts include, but are not limited to, loss of vegetation, unnecessary and expensive re-grading of the land, extreme erosion and sedimentation, reduced downstream water quality, increased loads on stormwater infrastructure due to excessive run-off, and flooding of roads and homes.

Ridgeline ordinances afford the most visible land in hilly or mountainous regions visual protection. The severity of conservation can be adjusted to accommodate the slope of the land and also the vegetation cover. For example, in areas where average canopy height is 75 feet, prohibiting development within 75 feet of the ridgeline would ensure that the vegetation would be tall enough to obscure any visual impacts made to the landscape. One also needs to take into consideration the height of any structures associated with the development. If the ordinance states that no development may occur within 25 vertical feet of a ridgeline but a 100 foot tall structure is situated just beyond that buffer, even with 50 feet of canopy height, there would still be 25 feet of the structure visible above the ridgeline. Therefore the ordinance must either compensate for this height, or include that the highest point of the structure is to remain below the vertical buffer.

With so many counties and municipalities covered in this study it is difficult to know how and where to start scenic conservation design. Crowdsourced data is a powerful means to capture broad community and constituent input. It is not totally representative of the population but neither is holding a public meeting. Collecting a wide range of views helps to delegate and prioritize conservation efforts within the region.

6.3. How this translates to other applications

In Pennsylvania, there are two National Scenic Byways, the Historic National Road, and the Great Lakes Seaway Trail (U.S. Department of Transportation Federal Highway Administration, 2012), and fourteen Pennsylvania Scenic Byways, West Branch Susquehanna River, Crawford Lakelands, Bucktail Trail, Viaduct Valley Way, Seaway Trail, National Road, Longhouse National, Laurel Highlands, Lake Wilhelm, Kinzua, High Plateau, Grand View, Governor Casey, and Gateway to the Endless Mountains (visitPA.com, 2014), that pass through part of the Marcellus shale formation. While the general principles applied here in developing model ridge protection ordinances are widely applicable to similar amenity landscapes, a novel but also widely applicable component of this study was the use of crowdsourced data as a means of making preliminary judgment on the salient scenic values to be protected within a landscape. This method can also be used for gathering the public's input into other forms of conservation. People can identify where particular species are living or migrating such as the Precision Conservation study by the Nature Conservancy[1]. (The Nature Conservancy, 2014) They can show where negative impacts are occurring, such as the photos[2] shown on FrackTracker.org. (FrackTracker.org, 2013) This method can be used to identify landmarks, buildings, and landscapes for historical preservation such as the National Trust for Historic Preservations's Asian Pacific Islander Americans in Historic Preservation's Mapping Project[3] (National Trust for Historic Preservation, 2014).

In conclusion, the knowledge and opinion of the public at large are invaluable resources, and with the ease and availability with which this information is able to be gathered and vetted, it is imperative that designers utilize this data in any and all public design and planning projects. Crowdsourced data as a design tool has proved to have a plethora of uses. In this study, crowdsourced data was used to identify and prioritize cultural and natural amenities for scenic conservation. In the Marcellus shale and other regions these methods could be applied to the protection of amenity value along scenic byways and waterways, as well as other hiking trails, scenic overlooks and wilderness areas. Combined with precedent conservation ordinances, such as steep slope and ridgeline protection, crowdsourced data helps to prioritize and streamline conservation design.

[1] http://www.conserveca.org/our-stories/all/7-spotlight/132-precision-conservation#.U6hKWaPD-EU
[2] http://www.fractracker.org/projects/photos/
[3] http://www.preservationnation.org/forum/newsroom/apiahips-new-project-invites.html

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Figures