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An Assessment of the Potential Impacts of High Volume Hydraulic Fracturing (HVHF) on Forest Resources

Tioga County, New York

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Executive Summary

Throughout its history, New York has invested in its forest resources. Reduced to less than 25% of total land cover in the late 1800's, a series of policy decisions starting with the Forest Preservation Act in 1885, coupled with long term investment of tax dollars, has resulted in the successful restoration of our forest resources. Today, New York has 19 million acres of forest and is the most heavily forested state in the Northeast. Representing 63% of the state's land area, forests are the most extensive habitat type in the state.

In addition to filtering clean water for millions of residents, removing greenhouse gases from the atmosphere and producing oxygen, our forests contribute directly to the economy, providing thousands of jobs and generating more than $12 billion annually in the forest, recreation and tourism industries. (New York State Forest Resource Assessment and Strategy, DEC, 2010). New York State's forests are an invaluable resource and are an insurance policy for clean water and clean air for future generations. Keeping them healthy and intact is an important strategy as we confront the emerging challenges of global climate change.

New York State is currently in the process of developing a regulatory process to oversee and manage high volume hydraulic fracturing (HVHF or "hydrofracking") for natural gas. The New York State Department of Environmental Conservation (NYS DEC) recently released its Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) that describe the impacts and proposed mitigations for HVHF in the Marcellus Shale in New York's Southern Tier. Natural gas development is a landscape scale, industrial activity that will occur in predominantly rural areas of the state's Southern Tier that has not yet experienced heavy development. Currently, about 57% of this area is forested and about 28% is grassland/agriculture land. Given that forest is the most common cover type, the development of Marcellus Shale would have a substantial impact on forest habitat and species (RDSGEIS, pp. 6-74).

According to estimates by the NYS DEC, tens of thousands of natural gas wells may be developed in New York State once HVHF is permitted. Direct impacts on habitat from this activity include land clearing that will be required to create well pads, thousands of miles of roads, pipelines and other industrial infrastructure that will be developed (RDGGEIS pp. 6 – 68). Indirect impacts will occur also, as remaining natural areas are modified and degraded by the presence of nearby development. Direct habitat loss and habitat degradation through forest fragmentation— and loss of connectivity due to widespread activities like oil and gas development— pose a threat to forest habitat and wildlife. New York's forests provide clean water, clean air, flood protection, wildlife habitat and diversity, and recreational opportunities. Without careful planning and protections, our forests may be divided and degraded, diminishing the valuable functions they provide today for nature and people.

Evaluating the impacts of HVHF on a site-by-site basis is not sufficient to understand and manage the potential impacts to forest resources. To effectively evaluate the impacts of habitat loss, conversion, and fragmentation, it is necessary to look at the cumulative effect of direct and indirect impacts and to make quantitative assessments of those combined impacts prior to development in order to assess whether the impacts are sustainable or not.

The purpose of this assessment is to look at the potential cumulative impacts of gas well development in one New York county, as an example of how an assessment of cumulative impacts to forests can be carried out. The Nature Conservancy conducted a spatial analysis to make an initial assessment of the potential impacts to forest land in Tioga County, New York. Due to its location in the Marcellus Shale fairway and its proximity to active gas drilling in neighboring counties in Pennsylvania, Tioga County is expected to be one of the first counties to experience a high level of natural gas development in the Marcellus region according to the Economic Assessment Report (EAR) prepared for the NYS DEC and included in the RDSGEIS (EAR pp.4-5.).

The analysis presented in this report is based on the assumptions presented in the RDSGEIS and relies on the development scenarios presented in the EAR. In order to model the cumulative impact of HVHF for natural gas on forest resources, the analysis considered and then modeled the number of well pads expected to be constructed, the number of spacing units, natural land cover, and new road infrastructure to Tioga County.

From this analysis, several key findings emerged:

- Almost 61% of Tioga County is forested. While Tioga County's forest habitat has already experienced fragmentation, there are important healthy forest habitats remaining.
- Current remaining forest patches are significant in number and size and provide substantial ecological, economic and social benefits including water quality protection, clean air, flood protection, wildlife habitat and diversity and recreational opportunities. These forest patches are at risk of additional fragmentation and degradation from HVHF activities.
- Natural gas development will further fragment the remaining forest habitat and could, under an average development scenario, reduce forest habitat in the county by 18,674 to 21,667 acres (9% - 11%). In a high development scenario, forest habitat would be reduced or degraded by 27,920 to 32,341 acres (14% - 16%). The degree of development determines the potential for negative environmental impact. Given that Tioga County is in the region that DEC has identified as most likely to experience a high degree of natural gas development (Region A – Tioga, Broome and Chemung Counties), the high development scenario values for forest impact are most likely.
- Under the high development scenario, disturbance to key forest areas will be extensive, as almost none (1%) of the large, intact forest patches escape some level of impact from drilling (i.e., at least one well pad).
- Depending on development scenario, (low to high) between 21 (15%) and 132 (96%) of the 138 large forest patches (>500 acres) in Tioga County are predicted to have multiple well pads drilled on them.
- The amount of new roads built to access drilling sites will vary substantially, depending upon the development scenario and could range from 70 miles of new roads to 450 miles. Under the high development scenario, new roads would be built within Tioga County that could carry large trucks the equivalent distance of driving from Buffalo to Boston.

- A survey of fragmentation-sensitive species in the scientific literature identified 56 species that occur within the Marcellus Shale area. Of these, 16 are Species of Greatest Conservation Need (SGCN) in the Comprehensive Wildlife Conservation Strategy and four are designated as Species of Special Concern in New York. The Marcellus Shale region covers a portion of the known distribution of ten federally listed threatened and endangered species. While the impact of forest habitat loss on these species is difficult to predict, it is plausible that it could be significant, as populations for some species are already declining.
- Limited baseline data are available with which to analyze changes in forest habitat and forest-dependent species due to gas development activities. New York State has no well-defined thresholds for acceptable levels of change in forest habitat or forest dependent species, nor does it have in place the necessary monitoring to document loss of forest habitat or forest dependent species.
- Cumulative assessments based on a range of build-out scenarios are necessary. Such assessment are important to inform a number of key decisions, including but not limited to evaluating the potential range of impacts from HVHF on forest habitat, avoiding impacts on forest resources as much as possible, considering alternatives, planning for adequate restoration and potentially to compensate for habitat loss. Only with a greater understanding of the long-term cumulative impacts of development will NYS DEC be able to make well-informed management decisions and regulate the potential range of impacts of natural gas development on New York's forest resources.

Natural Gas Development in New York

The Marcellus Shale is an ancient rock formation some 5,000 feet below the surface that spans 150,000 square miles under five states, including New York, Pennsylvania, Ohio, Maryland, and West Virginia. In New York, Marcellus Shale underlies much of the Southern Tier, stretching from Chautauqua and Erie Counties in the west to the counties of Sullivan, Ulster, Greene and Albany in the east, to the approximate location of the east-west portion of the New York State Thruway between Schenectady and Auburn.

Geologists have long known about this shale formation and the natural gas it contains, but until recently this formation was considered too deep and inaccessible to be drilled. New advances in technology have changed circumstances dramatically. The merging of two existing drilling techniques – horizontal drilling and hydraulic fracturing – gave rise to a process called "high volume hydraulic fracturing (HVHF)" – "hydrofracking" for short.

Hydrofracking makes it possible to extract gas previously considered too deep and too tightly bound in the shale to be available. The Marcellus Shale formation is now considered one of the largest and potentially most productive gas-bearing shale formations in the United States. Utica Shale, lies below Marcellus, spans an even larger area, and may also be exploited in the future.

New York State is currently in the process of developing a regulatory process to oversee and manage HVHF and has developed a Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) to describe its impacts and proposed mitigations.

According to the RDSGEIS, HVHF may someday be used in sedimentary rock formations that span the Vermont/ Massachusetts border to the St. Lawrence/Lake Champlain region, west along Lake Ontario to Lake Erie and across the Southern Tier and Finger Lakes Regions. (RDSGEIS pg. 2 – 7). Therefore, the potential for an even greater footprint exists should other shale formations be exploited.

Natural Gas Development and Habitat Loss


Scarlett Tanager ©Mark Diedrich

The loss and fragmentation of habitats and ecosystems have become the most significant threat to biological diversity. (Wilcove *et al.*, 1998) In New York, as well as across the U.S development that directly alters or degrades natural areas is the main driver of habitat loss. While residential and commercial development has been responsible for the most significant footprint in recent years, the exploitation of energy sources poses a significant additional threat to the natural environment and wildlife habitat, leading to what is termed energy sprawl".

Natural gas development is a landscape scale activity and will occur in parts of New York State's Southern Tier that have not yet experienced heavy development. Currently, about 57% of this area is forested and about 28% is grassland/agriculture land. Given that forest is the most common cover type, it is likely that development of Marcellus Shale will have a substantial impact on forest habitat and species. Direct, indirect, and cumulative impacts may include increased wildlife mortality, increase of edge habitats, altered microclimates, loss of genetic diversity, species isolation, and declines in populations of species that are sensitive to noise, lighting, human activity, increased predation and an increase in invasive species. (RDSGEIS, pp. 6-68)

Impacts of Natural Gas Development on Forests

The development of Marcellus Shale gas will have a large footprint. (RDSGEIS, pp. 6-67) Land grading and clearing and construction of well pads, roads, pipelines and other infrastructure associated with gas drilling will cause short- and long-term loss, conversion, and fragmentation of habitats. In addition to direct loss of habitat, constant activity on each well pad from construction, drilling, and waste removal will last for four to ten months, further affecting species. Well pads that support multiple wells are likely to be active over the span of many years, as wells are unlikely to be activated simultaneously. (RDSGEIS pp. 6-136)

Gas Well Development in Centre County, PA

The construction and operation of natural gas wells affects forests in numerous ways. Construction of well pads and other HVHF infrastructure results directly in loss of habitat. The broader effects to ecosystems, however, go beyond direct habitat loss to include the damage caused by changes in the size, shape, and connectivity of the habitat that is not directly lost. Species rely on continuous unfragmented forest habitat for movement, breeding habitat, foraging and dispersal.

Any forest clearing creates an associated edge effect—the creation of a 100-300 meter wide zone in which increased light and wind exposure creates different vegetation dynamics and which is avoided by some species of birds, mammals and amphibians. (Gibbs, 1998; Flashpohler et al., 2001; Marsh and Beckman, 2004; Villard, 2008) The edge effect increases the amount of interior forest habitat lost when development cuts into a forested area.

Disturbed edges are more vulnerable to invasive plants (Meekins and McCarthy, 2001; Harper, *et al.* 2005), particularly when invasive seeds or plant material are introduced by construction equipment or fill material, and have higher nest predation rates from cowbirds and small mammals. (Donovan, *et al*., 1997) Additional, largely unknown, factors that should be considered are the lights, noises and odors associated with a well pad, which could travel considerable distances and disrupt an animal's reproductive or foraging behaviors. (Longcore and Rich, 2004; Francis *et al.,* 2009)

Large, contiguous forest patches are particularly important because they support wide-ranging forest species and provide habitat for species that inhabit forest interiors. Large forest patches are more resistant to the spread of invasive species and provide more ecosystem services, such as water filtration and air purification than smaller patches. Important large forest patches in the New York's Southern Tier are identified in the RDSGEIS as "Forest Focus Areas." (RDSGEIS, pp. 7-80) Outside these large forest

blocks, smaller forest patches are also important, as they provide “stepping stones” of natural land cover between large forest blocks, enabling the movement of wildlife from one area to another.

The number and variety of plants and animals, or biodiversity, in a region is often considered a measure of the health of an ecosystem. New York State is rich in biodiversity, and yet these resources are threatened by habitat loss and degradation. There are 92 mammal species in New York – more than any other state in the Northeast – and of those, 56 species are protected and 22 are listed as “species of greatest conservation need (SGCN)”. The New York State Comprehensive Wildlife Conservation Strategy lists a total of 538 SGCN and estimates that nearly 50% of these species rely on New York State’s forests.


Black-throated Warbler ©Jeff Nadler

A survey of fragmentation-sensitive species in the scientific literature identified 56 species that occur within the Marcellus Shale area. Of these, 16 are SGCN in the Comprehensive Wildlife Conservation Strategy and four are designated as Species of Special Concern in New York (Blue-spotted Salamander, Cerulean Warbler, Northern Goshawk, and Red-shouldered Hawk). (NYSDEC, 2005) U.S. Fish and Wildlife Service reports that the Marcellus Shale region covers a portion of the known distribution of ten federally listed threatened and endangered species (U.S. Fish and Wildlife Comment on the 2009 RDSGEIS) For some species of birds, forest patches may need to be over 500 hectares (1200 acres) in order to support reproduction. (Rosenberg, et al., 1999; Burke and Nol, 2000; Goodrich et al., 2002) When setting the necessary size for forest reserves in the Northeast, The Nature Conservancy determined that 10,000-25,000 acres are needed to withstand large catastrophic disturbance events and maintain stable populations of forest birds. These requirements are met by a limited number of forest lands in the state, and those that are not already under protection are vulnerable to loss and fragmentation both by gas well development and by the indirect stimulation of development in neighboring areas.

Even when individual patches of forest can support one or more breeding adults, healthy populations require interbreeding within a small population, usually at least 25 individuals, in order to maintain genetic vigor. (Frankham, et al., 2002). It is particularly important for smaller patches to be embedded in a predominantly forested landscape that allows movement among patches. Small forest patches that become isolated may appear unchanged for some time, but will gradually lose diversity as populations decline and disappear. A connected network allows individuals to access shifting resources, avoid disturbances, and expand into new territories. For some wide-ranging migratory species, long-distance movements between large forest reserves are necessary for survival.

For all species, climate change may make connectivity even more important as local conditions become unsuitable and ranges shift in sometimes unpredictable ways. While some individuals of more adaptable species will move through agricultural or developed areas, or even attempt to cross highways, there is a

cost to fitness and survival incurred from extensive travel through these less-hospitable landscapes. Other species are more reluctant to leave the safety of forest cover and even the creation of a forest road or power line right-of-way may prevent movement. Increases in traffic volume can also create a barrier on otherwise crossable roads, particularly when traffic is sustained throughout the day and night as may occur at an active drilling operation. Roads may also need to be improved or widened to bear the increase in heavy truck traffic, which would decrease their cross-ability.

Tioga County, NY: An Assessment of Surface Disturbance from Natural Gas Wells on Forest Resources

To better understand the potential impacts of natural gas development on New York's forest resources, The Nature Conservancy conducted a spatial analysis based on the assumptions presented in the RDSGEIS. Our analysis relied on the development scenarios presented in the Economic Assessment Report (EAR) prepared for the NYS DEC and included in the RDSGEIS (Economic Assessment Report for the Supplemental Generic Environmental Impacts Statement on New York's Oil, Gas and Solution Mining Regulatory Program, August, 2011, Ecology and Environment Inc.).

Methodology

Assumptions: The EAR presents three possible development scenarios based on low, average and high rates of development defined by the number of vertical and horizontal wells projected to be drilled annually. (See Table 4-1). All three scenarios assume a consistent pace of development and production for a period of 30 years.

The scenarios are based upon information provided to DEC by the Independent Oil and Gas Association of New York (IOGA-NY). IOGA-NY started with an estimated average rate of development, using the following assumptions:

- Approximately 90% of wells will be horizontal wells with an average spacing unit of 160 acres each; (EAR, pp. 4-3)
- Approximately 10% of wells will be vertical wells with an average spacing unit of 40 acres per well; (EAR, pp. 4-3)

- It is assumed that 6 horizontal wells would be drilled per well pad (RDGEIS, pp. 6-78, footnote 59)

Major Development Scenarios - *Table 4-1 (EAR pg. 4-2)*

	Low	Average	High
Total Wells Constructed (Year 1 to Year 30)			
Horizontal	9,461	37,842	56,508
Vertical	1,071	4,284	6,273
Total	**10,532**	**42,126**	**62,781**
Maximum Number of New Wells Developed per Year (Year 10 to Year 30)			
Horizontal	371	1,484	2,216
Vertical	42	168	246
Total	**413**	**1,652**	**2,462**

According to the EAR, these development scenarios are designed "to provide order of magnitude estimates for the socioeconomic analysis and are in no way meant to forecast actual well development levels in the Marcellus Shale or Utica Shale reserves in New York." The report also states that the scenarios should be viewed as "a best-estimate" of the range of possible amounts of development that could occur in New York State." (EAR, pp. 4-4)

The Nature Conservancy used this "best-estimate" of the range of possible development to make an initial assessment of the potential landscape impacts in Tioga County, which is expected to be one of the first counties to experience a high level of natural gas development in the Marcellus region. We modeled and mapped all three development scenarios for the purposes of comparison. Models for the gas well projections in Tioga County under the different scenarios are found in Appendix I (low development scenario), Appendix II (average development scenario) and Appendix III (high development scenario).[4]

Estimating Cumulative Impact on Tioga County's Forests

To model the cumulative impact of HVHF on forest resources, we used the projections of well pad development provided in New York State's RDSGEIS and applied them to Tioga County.

[4] In conducting our assessment we discovered inconsistencies between the assumptions provided and the resulting development scenarios presented in the EAR. We found that the average scenario for Region A (21,087 wells) will result in 6,741 wells in Tioga County. An assumed spacing unit size of 640 acres (RDGEIS, pp. 6-79) will result in 523 spacing units in Tioga County. Placing 6,741 wells on 532 units will result in 12.9 wells per pad, which is double the number assumed in the RDSGEIS (6 per pad) (pp. 6-78). It is not clear how this reconciles with the statement in the RDSGEIS that "a single well pad with 6 to 8 horizontal gas wells could access all 640 acres (RDSGEIS, Executive Summary pp. 7). The EAR's assertion that "90% of the wells would be horizontal wells with an average of 160 acres per well" also presents inconsistencies (EAR, p. 4-3). With this spacing, there would be 4 wells per square mile, resulting in 2,092 wells, rather than the 6,741 projected. Since the development scenarios presented are the basis of the economic projections in the EAR and the RDSGEIS, we used the projections provided despite these inconsistencies.

According to the EAR, an average development scenario anticipates 42,126 new wells drilled in a 30-year period (EAR pp. 4-2) throughout the Marcellus region. Region A, which contains Broome, Chemung, and Tioga counties, is expected to contain roughly half, or 21,063, of the wells. At 523 square miles Tioga County is 31.7% of Region A, placing an estimated 6,677 wells within the boundaries of the county.

The next step in our analysis was to determine the number of individual well pads that will be constructed. Horizontal drilling allows for several wells to be drilled on a single pad. Based on current practices, the RDSGEIS states that 6 to 10 wells per pad is the likely distribution (RDSGEIS pp. 3-3). New York's regulations allow a spacing unit of one pad per square mile (640 acres), which is the legal maximum acreage for multi-well pads (RDSGEIS pp. 6-79). However, this does not mean that all spacing units will be this large. (RDSGEIS pp. 5-22)

The size of spacing units is defined by law in New York by ECL s 23-0501(1)(b)(1)(vi). The law defines 640 acres as the largest spacing unit for one multi-pad well. DEC "anticipates that multi-well pad horizontal drilling (which results in the lowest density and the least land disturbance) will be the predominant approach" and that the use of multi-well pads "significantly reduces the number of needed well pads and associated roads" (RDSGEIS pp. 5-22). The RDSGEIS also acknowledges that "if spacing units are less than 640 acres, or if there are less than 6-8 horizontal wells per pad, the percentage of land disturbance could be greater" (RDSGEIS pp. 6-79).

Spacing unit sizes will in fact be based on availability of land for leasing, topography and other constraints. It is anticipated that spacing unit sizes will vary, and can be as small as 40 acres. The size and shape of spacing units are created by gas companies and are dependent on the pattern and amount of land that the company has leased. The gas companies submit their spacing units to the state for approval, so the final arrangement and number of spacing units permitted in a 30-year time period is impossible to map precisely.

To develop a map of surface disturbance impacts consistent with the RDSGEIS estimates, we chose to keep the number of wells per pad constant at 6, and altered the number of pads and the size of spacing units to match the projected number of wells under each of the three scenarios in the EAR.

Major Development Scenarios from the Economic Assessment Report

Major Development Scenarios From the EAR			
	Low	Average	High
Projection of Gas Wells	10,532	42,126	62,781
Projection of Gas Wells in Tioga Cty.	1,669	6,677	9,951
Projection of Well Pads in Tioga Cty. (6 wells/pad)	278	1,112	1,658

Points were placed with a maximum density of one well pad per 160 acres using Geostatisical Modeling Environment 0.5.2, (Hawthorne Beyer, 2011). While the model placed the points randomly, it evenly distributed the pads across the county, with a minimum distance between pads of 600 m. This serves as an illustrative analysis of what these build-out scenarios would look like. We recommend future assessments could rerun these randomly distributed models many times (e.g., hundreds to thousands of times) to generate estimates that also captured the degree of variability (e.g., mean and standard deviation) of each build-out scenario. This initial effort also eliminated areas where well pads would be unlikely to be sited – steep slope areas, developed areas, and areas with environmental restrictions. Prohibited areas and areas identified in the RDSGEIS as restricted or requiring additional review were also avoided. These include:

- 100 year floodplains (Executive Summary pp. 22)
- Primary aquifers, with a 500 ft. buffer (Executive Summary pp. 20)
- Public drinking water supply, with a 2,000 ft. buffer (Executive Summary pp. 21-22)*
- Private drinking water wells, with a 500 ft. buffer (Executive Summary pp. 22)*
- Certain state owned lands (Executive Summary pp. 21)
- NYC and Syracuse watersheds, with 4,000 ft. buffer (Executive Summary pp. 22)

- Restricted or needs additional level of review:
- Streams, storm drains, lakes, and ponds, with a 150ft buffer (RDSGEIS pp. 7-76)
- Principal aquifer, with a 500 ft. buffer (Executive Summary p. 21)
- Tributaries of public water supplies, with a 500ft buffer (Executive Summary p. 21)

** Some of the drinking water data layers were not available to map or are too detailed to map at the county level.

Tioga County is largely an agricultural county, and still has a significant amount of forest land. After removing non-natural land cover and fragmenting features such as roads and power lines, Tioga is still nearly 61% forested. The remaining forest cover while fragmented still maintains numerous forest blocks that are large enough to provide significant habitat. The RDSGEIS uses 150 acres as a threshold minimum size for forest patches that can be expected to support a relatively diverse assemblage of forest breeding birds. (RDSGEIS pp. 7-87) Current remaining forest patches in Tioga County are significant in number and size. These forest patches are of a size and quality that provide substantial ecological, economic and social benefits including water quality protection, clean air, flood protection, wildlife habitat and diversity and recreational opportunities, and are at risk of fragmentation and degradation from HVHF activities.

As already described, large forested patches are important for the success of many plant and animal species, which can be impacted by development at least 100 meters in from the developed edge

(RDSGEIS pp. 6-75). The further fragmentation of forest lands from development like natural gas drilling can have significant impacts on the remaining forest and the species that depend on them. We used the existing natural land cover of the county and the modeled placement of the estimated number of well pads to estimate the amount of forest land that would be affected in the average and high development scenario (1,112 and 1,658 well pads respectively).

Average Spatial Disturbance for Horizontal Hydraulic Fracturing Gas Wells	
Forest cleared for well pads(direct impacts)	7.4 acres
Indirect forest impacts from new edges *2.5 acres for each acre of direct impact	18.5 acres
Total direct and indirect impacts	25.9 acres

The RDSGEIS estimates that there will be 7.4 acres of direct impact per well pad and associated infrastructure (RDSGEIS pp. 6-79). If all wells were placed on forest land, the direct impact could be as much as 8,229 acres of land conversion. However, since many of the well pads are expected to be developed on agriculture lands, this estimate would be too high. Our model placed equal weight on forest lands and agricultural lands for well pad placement. Our model placed 65% of the well pads on forest lands, close to the percent of the county that is forested. This development pattern would result in a direct impact of 5,335 acres of forest land cleared.

The indirect impact due to edge effect would affect greater acreage. (Appendix IV shows interior forest cover in average development scenario.) The RDSGEIS estimates that an additional 2.5 acres of forest will be indirectly impacted for every acre directly impacted, resulting in an average of 18.5 acres (RDSGEIS pp. 6-81) of indirect impact per pad. If we combine the direct impacts (7.4 acres per pad) and indirect impacts (18.5 acres per pad), we see an overall impact of up to 18,674 acres, which represents the loss or degradation of 9% of the county's forest.

For the high development scenario, this same calculation results in 27,920 acres of direct and indirect impacts, and represents a loss/degradation of 14% of the county's forest.

In Pennsylvania, The Nature Conservancy measured the spatial disturbance of well pads in a forested context. Their analysis concluded that an average of 9 acres of habitat was removed for each well pad and that the total for direct and indirect impacts is 30 acres on average. New York's RDSGEIS states that direct land disturbance in New York *may* be lower, but that this would depend on the size of spacing units utilized and the number of wells per pad. Since both these factors are likely to vary, the RDSGEIS concludes that land disturbance could be greater than the estimates used in the impact statement. (PP 6-79) For this reason, we also used TNC-PA's forest disturbance estimate of 30 acres per well pad to evaluate potential forest impacts in Tioga County. Using this estimate in the average development scenario results in 21,667 acres of impact, or an 11% loss/degradation of forest. In the high development scenario the acreage is 32,341 acres or almost 16%.

Estimate of Total Direct and Indirect Impacts		Low Scenario	Average Scenario	High Scenario
RDGEIS (25.9 acres)	Acres	4,680	18,674	27,920
	Percentage	2%	9%	14%
The Nature Conservancy/PA (30 acres)	Acres	5,421	21,667	32,341
	Percentage	3%	11%	16%

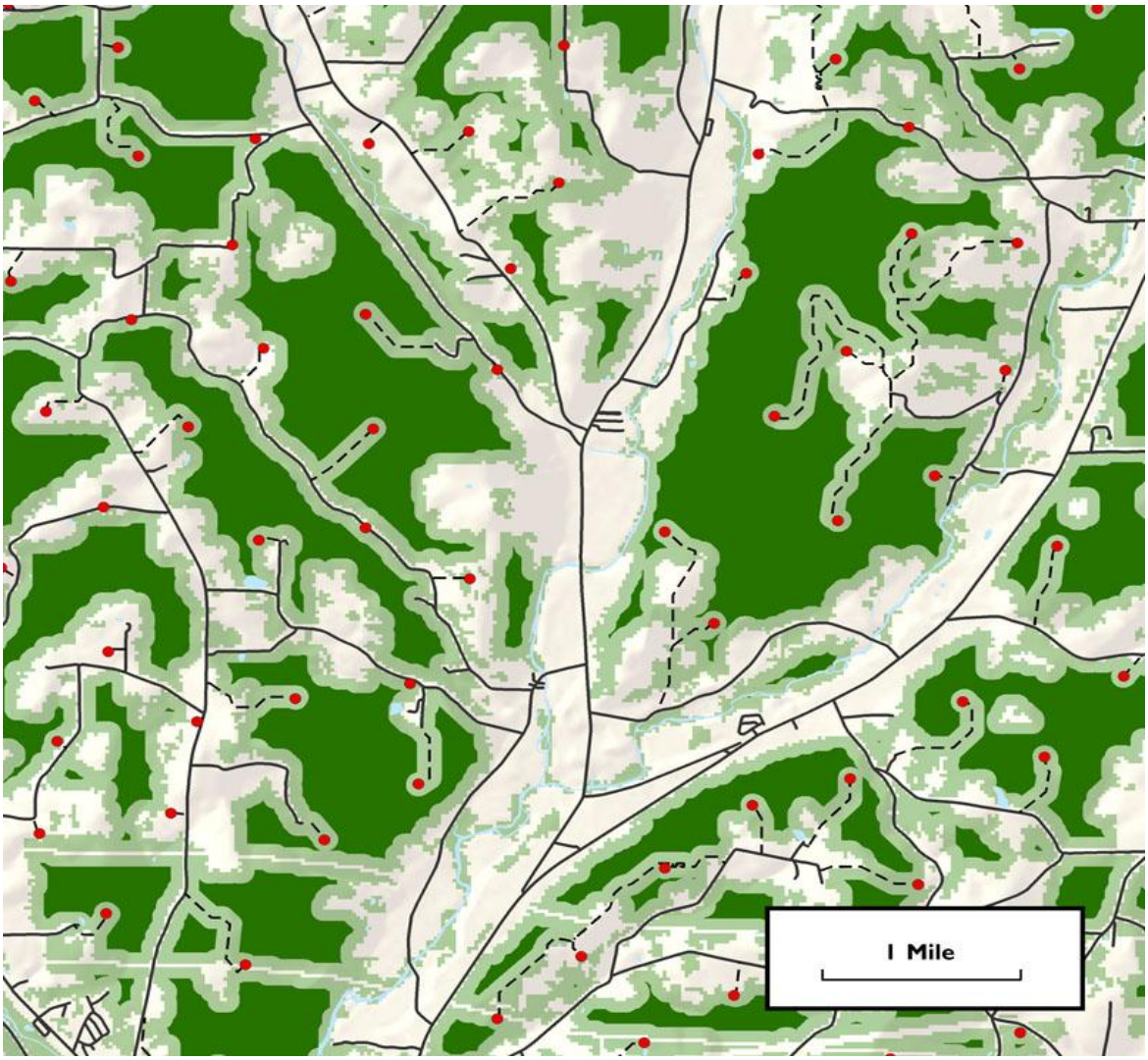
It should be noted that both estimates use 100 meters as the zone of impact or "edge effect", where habitat conditions change and often can no longer support sensitive wildlife and plant species that depend on interior forest conditions. Impacts associated with noise, light and odor may exceed these distances.

To account for new road infrastructure, we connected the modeled well pads with the nearest existing road. These new roads were restricted to avoid steep slopes and the restricted environmental features that were considered in the placement of the well pads. With the range of development scenarios, there would be there would be between 70 miles (low scenario) to 450 miles (high scenario) of additional miles of roads created in the county in our model.

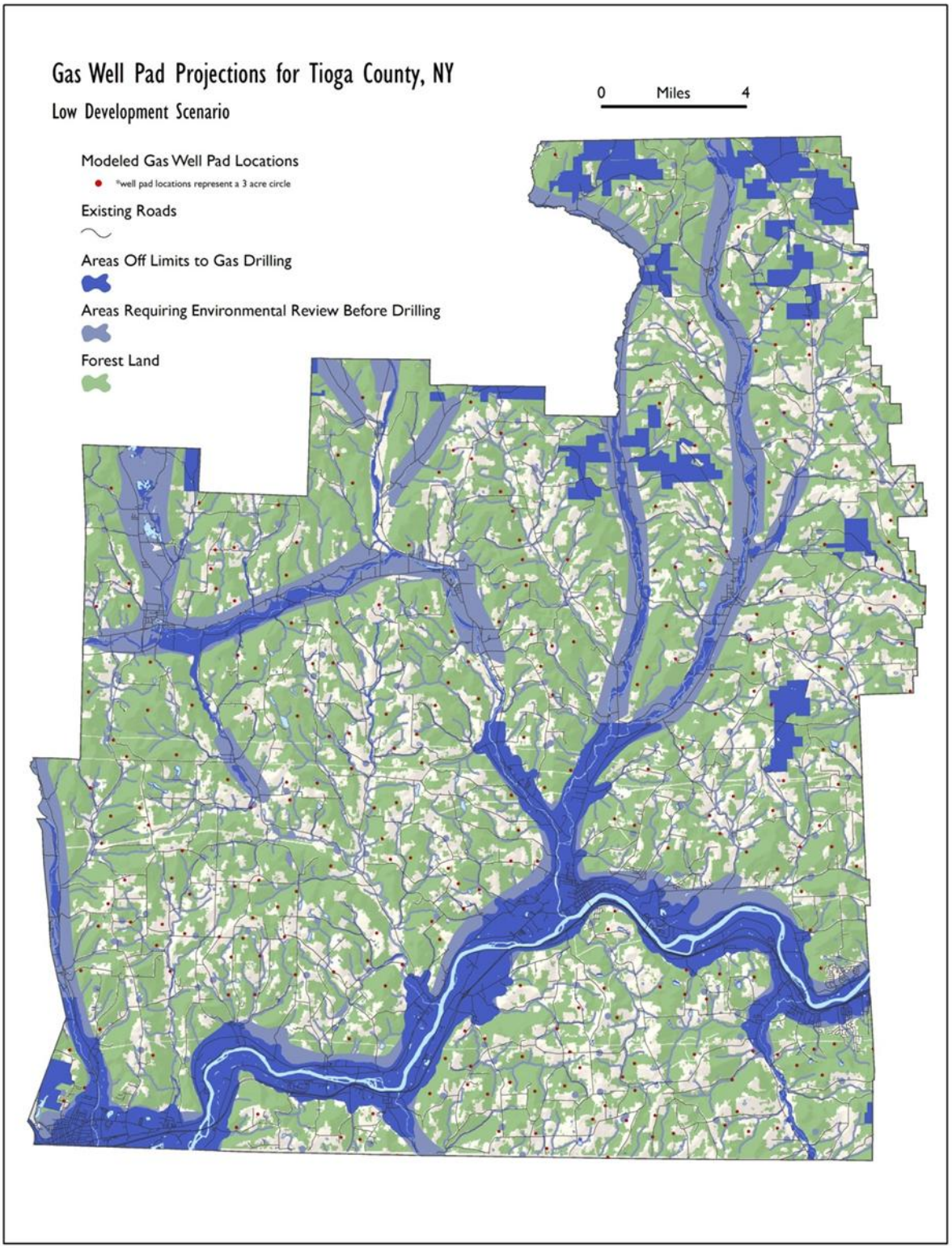
Our analysis shows that there are over 300 forest patches in Tioga County that are 150 acres or larger, over 200 patches that exceed 300 acres in size and over 100 forest patches that exceed 500 acres in size. Under the high development scenario, disturbance to key forest areas will be extensive, as almost none (1%) of the large, intact forest patches escape some level of impact from drilling (i.e., at least one well pad). Depending on the development scenario, between 21 (15%) and 132 (96%) of the 138 large forest patches (>500 acres) in Tioga County are predicted to have multiple well pads drilled on them.

Number of Patches w/ Multiple Well Pads		**Low Scenario**	**Average Scenario**	**High Scenario**
>150 Acre Patches	Percentage	8%	54%	73%
	Number of Patches	24	167	225
>500 Acre Patches	Percentage	15%	85%	96%
	Number of Patches	21	117	132

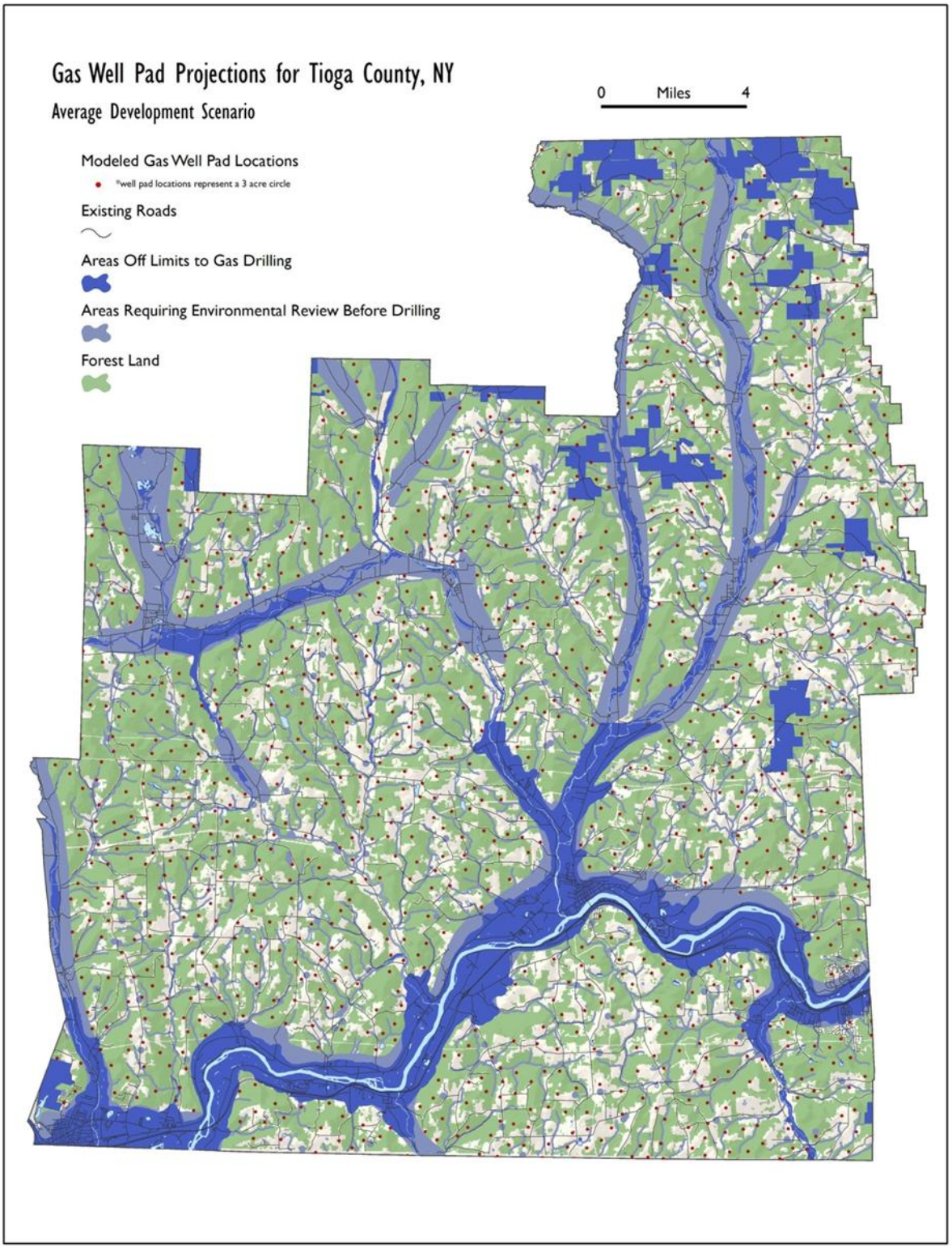
This modeled example shows potential fragmentation of existing forest patches by well pads and new roads. The red dots represent randomly placed gas well pads and the dotted lines show modeled access roads that would be created to connect to existing roads. Green patches show existing forest cover and dark green patches show 100 meter buffered interior forest cover after gas well development. Light green is forest edge habitat.



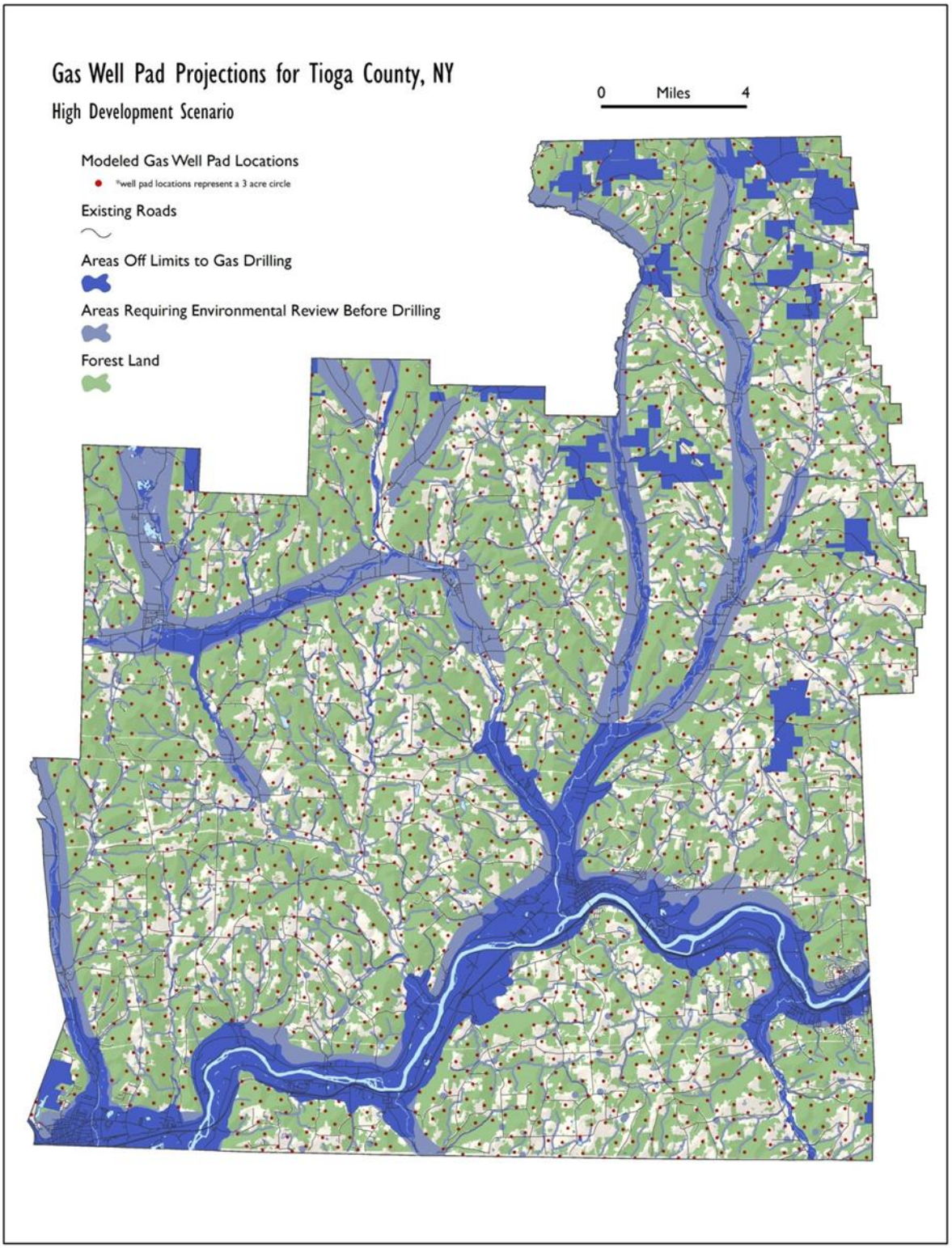
Low Development Scenario



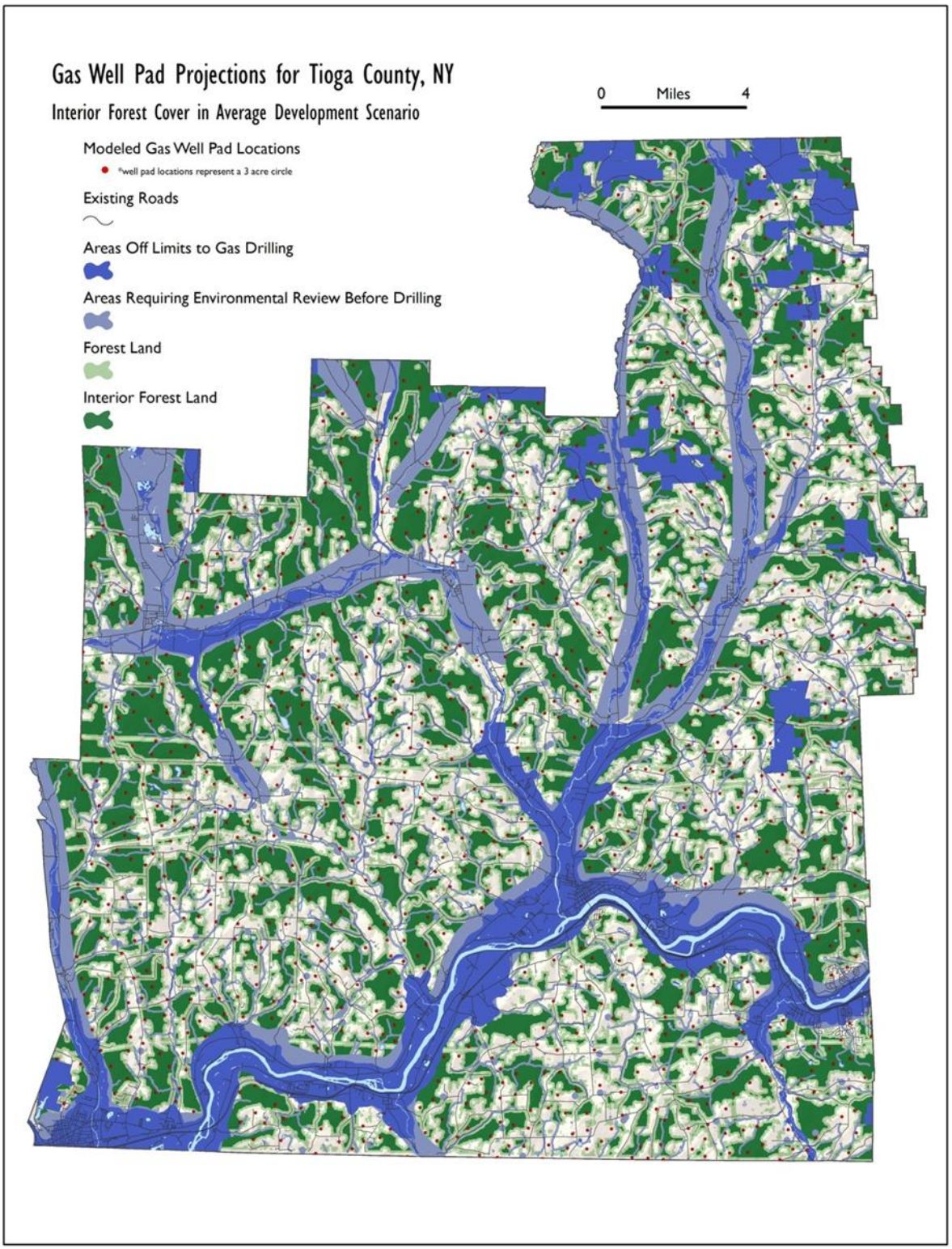
Average Development Scenario



High Development Scenario



Interior Forest Cover in Average Development Scenario



Gas Wells ©Nels Johnson/TNC

A Call to Action: Assessing Cumulative Impacts of High Volume Hydraulic Fracturing on New York Forests

Currently, the state of Pennsylvania is the "epicenter" of Marcellus gas development. In the absence of a state-led cumulative impact assessment, The Nature Conservancy in Pennsylvania recently conducted an assessment of the impacts of hydrofracking development on forest resources. The study looked carefully at the total land area required for existing well pads in the state and projected the area of associated roads, storage, parking and water impoundments. The Conservancy's study found that between 38,000 and 90,000 acres could be cleared for the 60,000 new well pads that are anticipated to be developed by 2030. They projected that these clearings would disrupt forest ecosystems and had the potential to disrupt sensitive forest interior species in an additional 91,000 to 220,000 acres of adjacent forest. In addition, the assessment of associated pipelines projects 16,480 miles of "gathering" pipelines. Cleared ROWs for these pipelines are usually 100 feet wide and result in 12 acres of additional disturbance for each mile of ROW, or an additional 197,760 acres. These lands, because of their location and sheer size, contain nearly 40% of Pennsylvania's globally rare and threatened species. This is sobering news, and raises questions about forest and wildlife sustainability at the scale of development expected in Pennsylvania. (Johnson, N., 2010 Pennsylvania Energy Impacts Assessment, Report 1: Marcellus Shale Natural Gas and Wind, 2010 Report 2: Wood Biomass, Natural Gas Transmission and Electric Transmission, in draft)

In regards to the impacts of forest fragmentation, the RDSGEIS makes the point that "biological systems are exceedingly complex, and there can be serious cascading consequences when these systems are disturbed. Little baseline data are available with which comparisons can later be made in the attempt to document changes, or lack thereof, due to oil and gas development. In cases where serious adverse consequences may reasonably be expected, it is prudent to err on the side of caution". (RDSGEIS pp. 6-69). New York State has no well-defined thresholds for acceptable level of change in forest habitat or forest dependent species, making determinations about adverse impacts difficult to assess.

Establishing impact thresholds requires looking beyond impacts at individual sites, and making cumulative assessments that include the combined impact of direct and indirect impacts. It is important to make a quantitative assessment of those combined impacts prior to development, in order to assess whether the impacts are sustainable or not. A full cumulative assessment would look at impacts to water, air, habitats, ecosystems, community character, human health and more. Such an assessment would be a complex job, but is nonetheless being done routinely as a requirement of the National Environmental Policy Act (NEPA) in relation to oil, gas and mineral development in other parts of the country, through a process called "Reasonably Foreseeable Development" (RFD) scenarios. New York State's own version of the NEPA law, the State Environmental Quality Review Act (SEQRA) also requires consideration of cumulative impacts.

Although NYS DEC does project how many gas wells may be developed in areas underlain by Marcellus Shale, it does not include a cumulative impact assessment that would allow a quantitative assessment or estimate of the potential overall disturbance of natural habitat. This is a deficiency in the RDSGEIS and the state's proposed program for managing HVHF. Without cumulative impact assessment it is not possible to evaluate the scale, magnitude or intensity of impacts on habitat and wildlife populations. If the state were to conduct a cumulative impact assessment of impacts on habitat, it would make it possible to consider sustainable degrees of development. It will allow for a more deliberate and sound evaluation of alternatives that might include the phasing of development, impact monitoring and adaptive management of resources.

The fundamentals of cumulative impact assessment for habitat include understanding the geographic scope of the activity, knowing the planning horizon for the anticipated activities, identifying constraints, identifying the type and quantity of surface disturbance, and identifying key resources that might be affected. A build-out analysis which shows different scenarios is a very useful tool to understand the spatial aspects of the impacts and can reflect the full scope of the impacts on key resources that may be in the path of development. Assessing the amount of habitat lost or degraded can also serve as the basis of compensation as a mitigation strategy.

Findings and Recommendations

Findings

- Almost 61% of Tioga County is forested. While Tioga County's forest habitat has already experienced fragmentation, there are important healthy forest habitats remaining.

- Current remaining forest patches are significant in number and size and provide substantial ecological, economic and social benefits including water quality protection, clean air, flood protection, wildlife habitat and diversity and recreational opportunities. These forest patches are at risk of fragmentation and degradation from HVHF activities.

- Natural gas development will further fragment the remaining forest habitat and could, under an average development scenario, reduce forest habitat in the county by 18,674 acres to 21,667 acres (9% - 11%). In a high development scenario, forest habitat would be reduced or degraded by 27,920 to 32,341 acres (14% - 16%). The degree of development determines the potential for negative environmental impact. Given that Tioga County is in the region (Region A – Tioga, Broome and Chemung Counties) that DEC has identified as most likely to experience a high degree of natural gas development, the high development scenario values for forest impact are most likely.

- As the maps illustrate, under the high development scenario, disturbance to key forest areas will be extensive, as almost none (1%) of the large, intact forest patches escape some level of impact from drilling (i.e., at least one well pad).

- The amount of forest disturbance is highly dependent upon the development scenario, as between 21 (15%) and 132 (96%) of the 138 large forest patches (>500 acres) in Tioga County are predicted to have multiple well pads drilled on them.

- The amount of new roads built to access drilling sites will vary substantially, depending upon the development scenario and could range from 70 miles of new roads to 450 miles. Under the high development scenario, there will be enough new roads within Tioga county to carry large trucks an equivalent distance of driving from Buffalo to Boston.

- A survey of fragmentation-sensitive species in the scientific literature identified 56 species that occur within the Marcellus Shale area. Of these, 16 are Species of Greatest Conservation Need (SGCN) in the Comprehensive Wildlife Conservation Strategy and four are designated as Species of Special Concern in New York (Blue-spotted Salamander, Cerulean Warbler, Northern Goshawk, and Red-shouldered Hawk). US Fish and Wildlife Service reports that the Marcellus Shale region covers a portion of the known distribution of ten federally listed threatened and endangered species. While the direct and indirect impact of a 9-16% loss of forest habitat is difficult to predict, it is plausible that it could be significant for these species, as their populations are already declining.

- Limited baseline data are available with which to analyze changes in forest habitat and forest-dependent species due to gas development activities. New York State has no well-defined thresholds for acceptable levels of change in forest habitat or forest dependent species, nor does it have in place the necessary monitoring to document loss of forest habitat or forest dependent species.

- Inconsistencies in assumptions about the size of spacing units and the number of wells per pad make projections about future habitat disturbance uncertain.

Recommendations

- Further research is needed to better link degradation of forest habitat due to habitat fragmentation and loss and those interior forest species of greatest conservation need (SGCN) and federally listed species known to rely on forest habitat in New York's Southern Tier. Forest protection thresholds to sustain these forest-dependent species should be established.

- Cumulative ecological impact assessments based on a range of build-out scenarios are needed for a variety of reasons. These include but are not limited to evaluating the potential range of impacts on forest habitat; reducing impacts on forest resources as much as possible; considering siting alternatives that reduce impacts to forested habitat and forest resources; identifying adequate restoration efforts to reverse forest degradation and establishing appropriate mitigation to compensate for habitat loss.

- Best management practices (BMPs) for siting could reduce impacts on forest resources. The state's program should make it a priority to reduce siting in forest lands. The BMPs outlined in the RDSGEIS are not explicit about specifically taking steps to shift siting out of forest lands to the maximum extent practicable.

- Inconsistencies in the assumptions underlying the development scenarios must be reconciled to provide a more realistic set of projections about the number of wells that will be developed provide a realistic analysis of how closely they are likely to be spaced.

- Using a realistic estimate of spacing units, NYS DEC should develop a robust spatial analysis to project anticipated land disturbance and impacts on forest habitat in the Marcellus region similar to the analysis presented in this report. This should include multiple build-out scenarios and multiple iterations of each scenario in order to better understand the likely impacts of development decisions.

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