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# The Implications of Multi-Well Pads in the Marcellus Shale

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## What is the Issue?

The number of wells drilled in each location can dramatically influence the ecological footprint of natural gas operations. The ability of energy developers to drill multiple natural gas wells from a single location (or "pad") has been touted as a major technological breakthrough driving natural gas development in the Marcellus Shale. The utilization of so-called "multi-well pads" also has large environmental and socio-economic implications, as the landscape disruption of as many as 12 or more natural gas wells and associated pipeline infrastructure can be concentrated in a single location. Furthermore, the total amount of industrial activity can be compressed as these wells can be drilled in rapid-succession and the technology now exists to perform hydraulic fracturing stimulations on multiple wells simultaneously.

A 2010 Nature Conservancy report estimated that – if current development trends continue through 2030 –10,000 development locations in Pennsylvania critical forest habitat could be eliminated by drilling an average of 10 wells-per-pad compared to an average of 4 wells-per-pad (Johnson 2010). In New York, the benefits of multi-well pad development are a critical assumption made by New York State Department of Environmental Conservation's (NYS DEC) proposed natural gas drilling regulations, particularly with respect to issues such as forest fragmentation and road use (NYS DEC 2011a). NYS DEC expects that between 6 and 10 wells will be drilled per pad if Marcellus Shale development occurs in New York (NYS DEC 2011b).

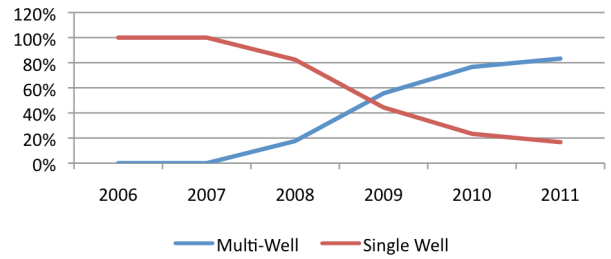
## Factors Influencing Multi-well Pad Development

The ability of energy developers to drill large numbers of wells on a single pad requires that they have large contiguous lease holdings, a capital outlay that will support the expense of a prolonged drilling and completion timeline, and the ability to overcome on-the-ground logistical challenges (Kuntz et al. 2011). If confronted with enough of these constraints, energy companies may instead find it easier to develop an array of single or small-number multi-well pads. Market pressures can also incentivize the development of singular wells in order to quickly secure long-term rights to the mineral acreage (an industry practice termed "hold by production"). Conversely, factors like difficult terrain or leases that do not allow surface occupancy can discourage the development of single well pads and instead encourage the development of multi-well locations.

## Has the number of wells per pad changed?

Despite the development of over 3,000 Marcellus Shale wells in the Commonwealth of Pennsylvania since 2006, this is the first analysis of the distribution of single-well vs. multi-well pads in Pennsylvania. ArcGIS software was used to locate all well locations within 250 feet of each other, which were assumed to be on a single pad. Utilizing GIS proximity analysis provides a unique and comprehensive picture of actual Marcellus Shale development practices across Pennsylvania. Data from the Pennsylvania Department of Environmental Protection (DEP) shows that the number of wells drilled per pad increased between 2006 and August 2011[1]. By the end of 2007, during the early exploration of the Marcellus Shale, each of the 18 wells drilled in Pennsylvania was developed on its own well pad. In 2008, 18% of the 165 wells drilled were developed on new multi-well pads or previously constructed well pads. In 2009, 56% of the 703 wells were drilled on multi-well pads. By 2010, multi-well development comprised 77% of the 1,373 Marcellus wells drilled. Of the wells drilled on a multi-well pad in 2010, 88% or 931 wells were constructed on new multi-well pads. As of August 10, 2011, 83% of the Marcellus wells drilled in 2011 were located on a multi-well pad. Also increasing in 2011 is the number of wells drilled on previously constructed well pads with just over 16% of all the multi-well development occurring on previously constructed well pads.

**Figure 1: Composition of Marcellus Shale Well Pads in Pennsylvania. January 1, 2006–August 10, 2011**




Source: Pennsylvania Department of Environmental Protection, 2006-2011

## How Many Wells Per Pad?

While the prevalence of multi-well pads has increased over the past five years, the overall ratio of wells-per-pad remains low: since 2006, over 1,553 Marcellus well pads have been developed to support 3,279 Marcellus wells in Pennsylvania indicating a well-to-pad average of

1 DEP has been criticized in the past for poor data management (Maykuth 2011), and during this analysis nearly 3,500 duplicate well permits and 350 duplicate wells were found in the official DEP databases from 2006 through August 10, 2011. As a wide variety of organizations utilize these databases for information on drilling activity, it is likely that this duplicated information is erroneously reported as factual in many instances.

2.11. The data show that this ratio is increasing: in 2009 the average was 1.53 wells per pad, and in 2010 the average was 2.15.

When well pad development in Pennsylvania State Forest and Allegheny National Forest leases is compared to privately held lands, roughly 96 well pads and 319 wells have been developed on state or national forest leases, a ratio of 3.32 wells per pad, compared to 1,457 well pads and 2,960 wells developed outside the state and national forest lands, or a ratio of 2.03. It is unknown from this preliminary analysis whether the discrepancy is due to regulatory incentives, pipeline availability, lease construction, or differences in the terrain.

**Figure 2: Marcellus Shale Well Pads Pennsylvania through August, 2011**

| Wells per pad | Number of pads |
|---|---|
| 1 | 864 |
| 2 | 295 |
| 3 | 144 |
| 4 | 74 |
| 5 | 49 |
| 6 | 76 |
| 7 | 23 |
| 8 | 19 |
| 9 | 3 |
| 10 | 4 |
| 11 | 0 |
| 12 | 1 |

Source: Analysis of PA DEP Spud Reports

## Discussion

The Marcellus Shale development picture reveals a strong trend toward multi-well pad drilling with just over 83% of all wells drilled in 2011 appearing on a multi-well pad. However, the trend toward multi-well pads is tempered by the reality that the number of wells per well pad is still hovering between two and three state-wide. This is less than half of the minimum amount regulators predict will be drilled in New York State (NYDEC 2011b). While it is technically feasible to drill 12 wells or more per pad, thus far the vast majority of well pads contain 1, 2, or 3 wells

A common perception in Pennsylvania is that a single well may be initially drilled to hold a drilling block by production and as drilling matures a rig may return to the pad to drill additional wells. However, after four years of significant development, once a drilling rig moves on to another location, there appears to be a small probability that it will return to drill additional wells on the same pad. As of December 31, 2010, only 13% of single well pads have seen a drilling rig brought back to drill additional wells. For example, in 2009 the average number of wells drilled on pads developed that year was 1.53, and by mid 2011 the average on those same pads had increased to 1.70. Thus far, the majority of multi-wells pads that exist in Pennsylvania were initially developed that way, and most have contained only a small number of wells.

Energy companies indicate that they are still in the early stages of development of one of the largest gas fields in the world – covering as much as 95,000 square miles – so it is possible they will eventually shift their strategy towards drilling additional wells on existing pads. In fact, further analysis suggests that in most cases operators are not drilling single wells instead of multi-well pads, as only about 6% of pads with 1, 2, or 3 wells were drilled within 1500 of feet of another well pad. The lack of nearby wells may indicate the early stages of a longer term infill strategy.

## Conclusion

The practice of drilling multiple wells on a single location holds great benefit for reducing ecological and other impacts from development of the Marcellus Shale, but the evidence of this practice being performed thus far in Pennsylvania remains mixed. Current evidence of infill on previously constructed well pads and the overall number of wells per pad remains low. However, Marcellus development is still in its early stages in Pennsylvania and the number of multi-well pads is increasing.

Natural gas development in the Marcellus Shale is constantly evolving and changing, and most experts believe that it will continue to do so for many years. This preliminary analysis does not take into consideration a number of contributing well pad construction factors such as pipeline locations, drilling permits, lease holdings, drilling block (conservation or forced) pooling, and surface terrain. As development practices change and the Marcellus Play matures, monitoring the number of wells drilled on each well pad should be a strong consideration in both data gathering and policy development.

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