



## Avoiding and Mitigating Soil Compaction Associated with Natural Gas Development

**N**atural gas well development is an increasingly common sight across Pennsylvania's farms and forests. While the landowner may receive potentially lucrative financial returns in terms of lease and royalty payments, understanding the short- and long-term impact of well drilling and pipeline installation activities on your soils and their future productivity is important.

### Compaction, the Invisible Thief

Soil compaction is the reduction of soil volume due to external factors; this reduction lowers soil productivity and environmental quality. While Pennsylvania farmers have long understood the impact of increasingly heavier agricultural field equipment, this pales in comparison to the magnitude of size and weight of equipment commonly used by the natural gas industry. Complicating factors related to soil compaction include differences in soil types and their associated drainage characteristics, the volume of topsoil and subsoil disturbed in the drilling and reclamation process, and weather conditions (i.e., soil moisture during development activities). Distinguishing between topsoil and subsoil compaction is important. Topsoil compaction is likely to severely reduce plant productivity in the short term, whereas subsoil compaction is likely to

modestly reduce productivity for decades in the future. Surface compaction is caused by the contact pressure (determined by tire pressure) while subsoil compaction is caused by axle load (very high in gas drilling operations). Topsoils are subject to freeze-thaw and wetting-drying cycles and biological forces such as root growth and macro- and microbial activity that can alleviate the effects of soil compaction over time. However, this is not the case for subsoils. Research shows that subsoil compaction is not alleviated by freeze-thaw and wetting-drying cycles on any soil type and can lead to potential environmental degradation caused by decreased water percolation. This will cause increased periods of saturated conditions in the soil and increased surface runoff. Due to lack of aeration, root growth and biological activity will be inhibited in saturated soils. Runoff will cause increased erosion and nutrient and pesticide losses to surface waters. Refer to the publications listed at the end of this fact sheet for a more extensive discussion and understanding of these issues and the soil properties involved.

### Soil Compaction and Your Gas Lease

Only you can decide if signing a natural gas lease is right for you. Undoubtedly, many things will affect your decision, and it is im-

portant to carefully consider how a lease may affect your personal finances, the value of your remaining property rights, and the future productivity of your land. While topsoil compaction can have an effect lasting from one year on sandy soils to five years on clay soils, deep subsoil compaction is virtually permanent on all soil types and should be avoided at all costs.

If you decide to lease, there are a number of important addenda that you should try to negotiate into your lease agreement to minimize the extent of soil compaction and alleviate it as much as possible where it does occur. These addenda should be clearly stated in the lease agreement before you sign it. Utilizing the services of an attorney familiar with natural gas lease agreements can be valuable in ensuring that you have the best lease agreement for your specific concerns.

Suggested addenda include:

- Clear owner input and approval of well sites, access roads, pipelines, and associated tanks, compressors, etc., limiting the area affected by drilling and pipeline-laying activities; limit drilling activities to periods of expected drier soil conditions—remember that late winter/early spring is usually the time with the highest soil moisture conditions
- Clearly defined terms for repairs on damages to existing tile drainage and the potential need for new tile systems
- Restoration of soil surface to original or improved contour
- Alleviation of severe compaction by subsoiling (done by the lessee prior to replacing topsoil); subsoiling operation should be as deep as compaction depth

### **Strategies for Dealing with Previously Compacted Areas on Existing Well and Pipeline Sites**

For many, preventative measures to limit soil compaction are no longer an option and the only course of action is attempting to alleviate existing compaction. This generally involves identifying where and how deep the layer(s) of compacted subsoil are using a penetrometer or test pit, determining the most appropriate deep tillage tool to attempt fracturing those layers, and designing a management plan to use appropriate vegetation and/or cropping strategies to prevent future compaction.

It is important to remember that alleviation and fracturing of deep subsoil compaction involves the use of heavy equipment and the horsepower required to pull it. Subsoiling will also bring up rocks and may not be desirable in excessively rocky soils. Choices of tillage shanks include straight and parabolic shanks capable of reaching the compacted layer. In the case of soil that has been severely compacted and disturbed, using parabolic or straight shanks with wide tips is recommended.

Surface disturbance by subsoilers needs to be limited in normal agricultural operations, but this is not a concern on disturbed sites that need to be leveled. Parabolic shanks take less power to pull and cause more disturbance of the soil, which in this case is the desired effect. To cause fracturing, the subsoiling operation should be done at optimal soil moisture conditions, which is neither too wet (no shattering would be caused) nor too dry (to avoid pulling up big blocks of soil that need to be pulverized by secondary tillage). These deep tillage treatments should not exceed 30 inches apart. Remember that there is no justification for attempting to fracture below the compaction layer. To avoid deep tillage efforts under wet conditions, the best time to subsoil is in summer or fall.

Reestablishing vegetation on disturbed sites is critical for minimizing erosion, developing new macro channels resulting from roots and their decay, and rebuilding soil organic matter. Remember that the effects of subsoiling are



temporary—the pore space created by subsoiling operations needs to be occupied by living roots and biological organisms to remain in effect. Cropland options will vary with the time of year; perennial forage vegetation is appropriate for spring and early summer. Forage radish also shows potential for establishing deep, short-lived taproots. Fall grains are best suited for autumn planting. Reforestation efforts and perennial grass plantings should be discussed with a qualified professional forester, biologist, or extension educator.

In some cases, landowners have deliberately decided that certain affected areas are not worth the cost of restoration and are better utilized as temporary storage sites for round bales or silage bales/bags. In other cases, these areas have been left to revert or developed for wildlife habitat. Depending on the location and accessibility of the affected site, this is often the most economical and logical use of these sites.



Additional recommended sources of information are available through the Penn State Cooperative Extension office in your county or on the Penn State College of Agricultural Sciences Publications Web Site ([pubs.cas.psu.edu](http://pubs.cas.psu.edu)). The following extension publications may also be helpful:

- *Effects of Soil Compaction*
- *Avoiding Soil Compaction*
- *Diagnosing Soil Compaction Using a Penetrometer (Soil Compaction Tester)*

Prepared by Sjoerd W. Duiker, associate professor of soil management and applied soil physics, and Gary W. Micsky, associate extension educator in sustainable agriculture and natural resources.



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