Fuels Planning: Science Synthesis and Integration

Fact Sheet # 70

Fuels Reduction and Compaction

Synthesizing Information about the Environmental Consequences of Fire & Fuels Treatments

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What is compaction?

Moving equipment and logs over the surface of forest soils causes gouges and ruts in the mineral soil, displaces organic matter, and can cause compaction. Compaction is measured by pore volume (the size spaces between soil particles), bulk density (soil weight per unit volume), soil aeration (the amount of air in the soil), water infiltration (rate of water movement into the soil), and saturated hydraulic conductivity (the ability of soil to transmit water). Compaction is the component of soil productivity most influenced by forest management, but the degree to which soils may be compacted depends upon initial soil bulk density. For example, low bulk density soils (such as volcanic ash-cap soils) are much easier to compact than those soils with a high baseline bulk density.



Mechanized equipment can cause compaction, which some soils may take decades to recover from. Photo credit: Han-Sup Han.

Why is it important?

Concern over changes in soil productivity after forest management activities is a topic debated by forest managers and the public. Important components of this debate include the use of mechanized equipment to extract timber products, the number of times equipment enters a stand, and the subsequent soil compaction and recovery times. One potential consequence of severe soil compaction is serious reduction in site productivity. Ultimately, the degree of compaction caused by harvesting or site preparation is affected by existing soil properties (e.g., texture, organic matter, and water content).

Changes in soil water content from compaction affect temperature flux, which alters microclimatic conditions and leads to reduced root growth and stand productivity, because compacted soils have smaller pore sizes than non-compacted or undisturbed soils. However, direct correlations of compaction and forest plant growth are frequently unclear because compaction is often associated with other soil disturbances such as soil displacement, mixing, rutting, and changes in susceptibility to weed invasion.

Can forest soils recover?

Various studies have shown that once compacted, it can take forest soils decades to return to undisturbed levels of bulk density or soil strength (the ease with which an object can be pushed into the soil). However, some forest soils can recovery rather

quickly. Recovery rates are dependent on many things, but chief among them are the number of repeated stand entries, soil moisture conditions during harvest, soil texture, and rock-fragment content (Page-Dumroese et al. 2005). Figure 1 shows the relationship of texture to recovery after 5 years.



A research program has been chartered to address concerns over possible losses of soil productivity. Photo credit: Han-Sup Han.

What's being done?

Mandates (like the National Forest Management Act of 1976) have directed the USDA Forest Service to protect the productive capacity of federally managed lands. The North American Long-Term Soil Productivity (LTSP) study started in 1989 to examine the long-term consequences of soil compaction and organic removal on fundamental forest productivity (Powers et al. 1990). There are now more than 100 sites composing the world's largest coordinated research network addressing basic and applied science issues of forest management.

Selected References

Page-Dumroese, D., Jurgensen, M., Tiarks, A., Sanchez, F., Fleming, R., Kranabetter, M., Powers, R., Ponder, F., Stone, D., Elioff, J., Scott, A. In review. Soil physical property changes on the North American Long-Term Soil Productivity (LTSP) study sites: 1 and 5 years after treatment. Canadian Journal of Forest Research.

Powers, R. F., Alban, D. H., Miller, R. E., Tiarks, A. E., Wells, C. G., Avers, P. E., Cline, R. G., Fitzgerald, R. D., and Loftus, N. S., Jr. 1990. Sustaining site productivity in North American Forests: problems and prospects. *In*: Sustained productivity of forest soils. Proc. 7th North Am. For. Soils Conf. *Edited by* Gessel, S. P., et al., Vancouver, B.C. pp. 49-79.

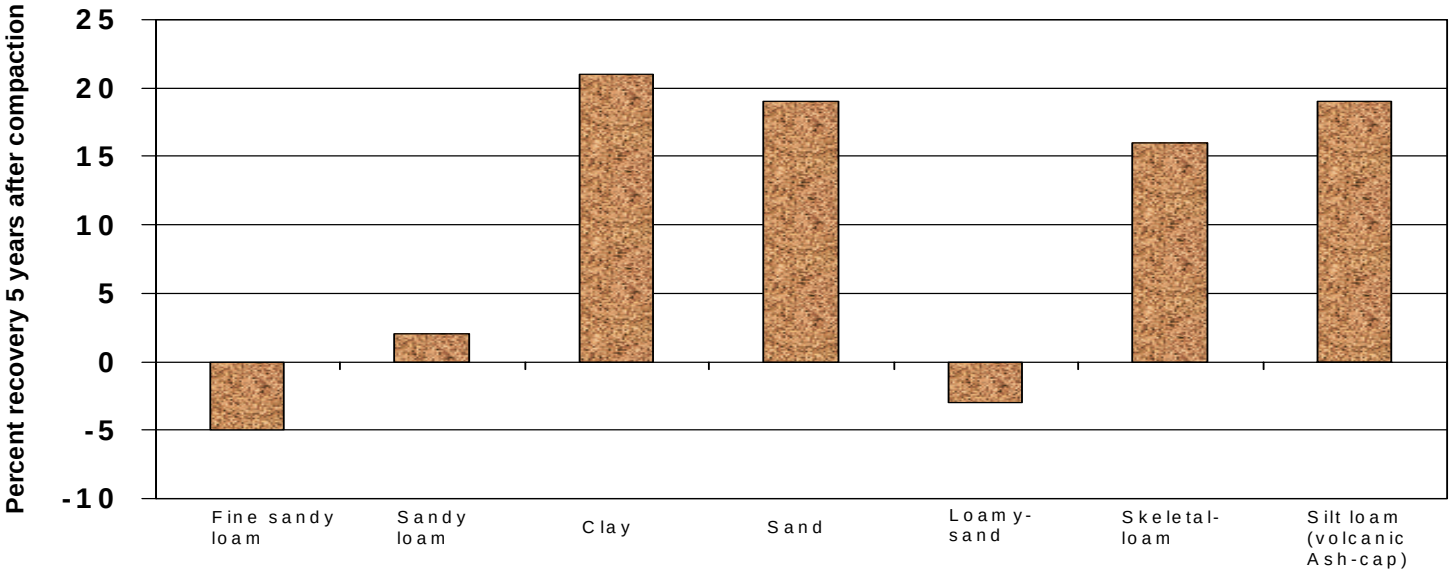


Figure 1. Soil recovery 5 years after compaction. The 0% line represents pre-harvest conditions.

Environmental Consequences Fact Sheets

Look for fact sheets from the environmental consequences team on topics such as the effects of fire on terrestrial wildlife, understory plants and weed populations, and soil erosion, as well as the fire effects information system (FEIS), and the first order fire effects model (FOFEM).

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This fact sheet is one in a series being produced as part of a larger project supported by the USDA Forest Service to synthesize new knowledge and information relevant to fire and fuels management. Fact sheets address topics related to stand structure, environmental impacts, economics, and human responses to these factors. Information in the fact sheets is targeted for the dry forests of the inland West, but is often applicable across broad regions of the country. For more information, please visit our website at: **www.fs.fed.us/fire/tech_transfer/synthesis/synthesis_index**.

The Fuels Planning fact sheets are based on preliminary findings. Information from fact sheets will be synthesized in an upcoming publication.