United States Department of Agriculture

NRCS
Natural Resources Conservation Service
Moscow Soils Office
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To: Bill Warren, Clearwater County Extension

From: Brian Gardner, USDA-NRCS

Re: Compaction hazard related to moisture content for Klickson and similar soils

This is in response to your recent inquiry for a field method to evaluate compaction hazard for soils/sites where logging is being planned. I found some resources to help guide evaluations of compaction hazard on-site. The first couple of slides below are from a presentation by Greg Schwab and Lloyd Murdock, Extension soil specialists with the Univ. of Kentucky. The slides show how compaction increases with increasing moisture content and/or applied load. The second shows the optimum moisture content for achieving compaction on a silt loam soil in KY. I have also included a table from a paper in Transactions of the ASAE by Wagner et al. They show how soils with similar particle size and organic matter content to Klickson have an Optimum Water Content for compaction at ~18%. I am using the 14-18% range as an approximation of where the max compaction hazard would be for Klickson and similar soils.

The next couple of pages are from USDA-NRCS Program Aid No. 1619 'Estimating Soil Moisture by Feel and Appearance'. I have clipped out the portion that is specific to silt loam soils. The moisture content is expressed as a percent of the Available Water Capacity for the soil. I have calculated that for Klickson, 25 to 75 percent available water is ~14-18% water content by volume. The 25 to 50 percent class is highlighted in yellow to show .that compaction hazard is present and increasing within this moisture class. The 50 to 75 percent class is highlighted in red to show that max hazard occurs at the lower end of the class.

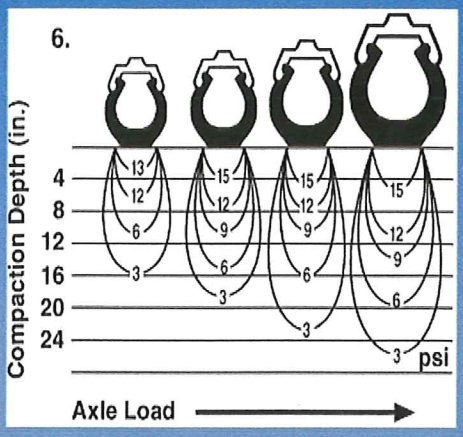
The description highlighted in green would be the soil moisture condition with the least danger of soil damage. The unhighlighted descriptions for moisture contents exceeding 75 percent available have reduced compaction hazard but increased puddling and rutting hazard.

Based on the slide from Schwab & Murdock, I'd suggest digging to 12 inches and examining the soil from the surface to that depth. Take a sample of soil and make a ball or hand mold. Bounce the ball 2 or 3 time in the hand and compare to the pictures/descriptions shown. If the moisture state is >25 percent available, as depicted in Program Aid 1619, then I'd expect compaction or other soil disturbance to be a hazard. This can be offset a little by the presence of rock fragments in the surface soil. They will serve to armor the soil and reduce compaction if numerous enough.

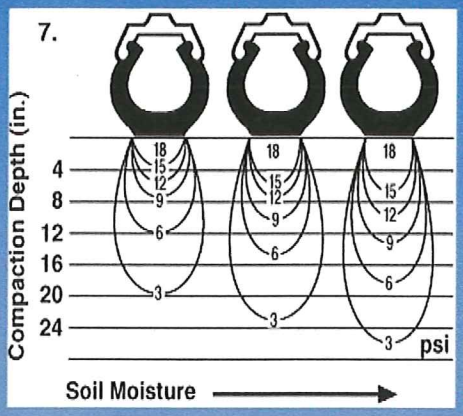
I am afraid that our spring conditions might lead to soils being in a susceptible condition. My suggestion would be to use the known BMP's for reducing soil disturbance (as shown in OSU Extensions publication EM9023). I'm sure you know the recommendations for these practices.

Hope this is helpful. Please call if you have further questions or concerns.

Depth of compaction as (6) axle load and (7) soil moisture increases

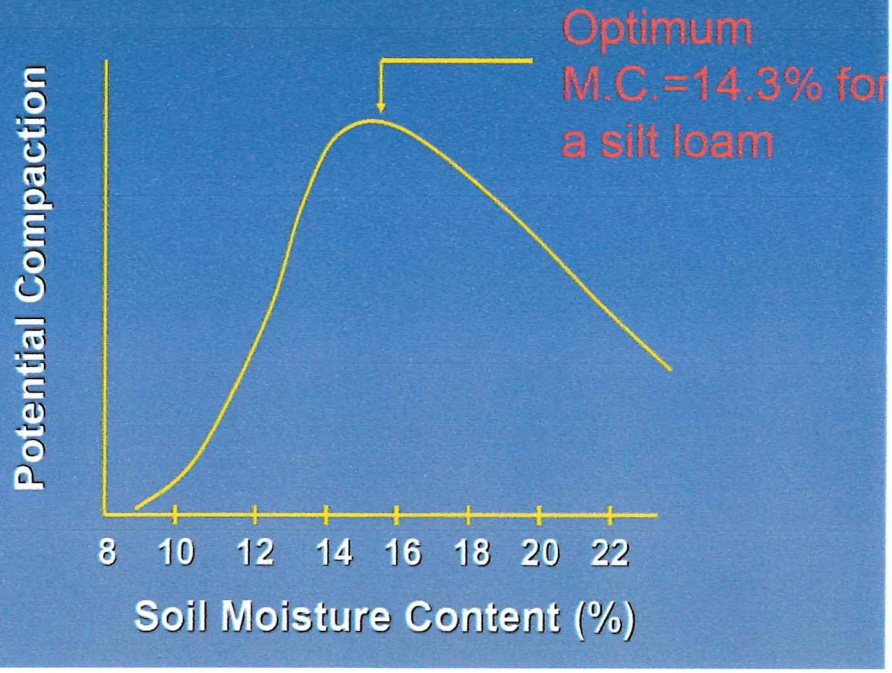


(Tire pressure remained at 12 psi for all tire sizes)



(Tire size 11 x 28, load 1,650 lbs, pressure 12 ps

Proctor Compaction Curve



Appearance of sandy clay loam, loam, and silt loam soils at various soil moisture conditions.

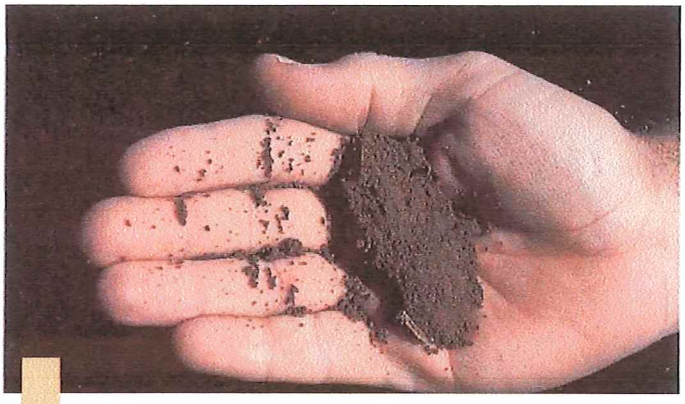
Available Water Capacity 1.5-2.1 inches/foot

Percent Available: Currently available soil moisture as a percent of available water capacity.

In/ft. Depleted: Inches of water currently needed to refill a foot of soil to field capacity.

0-25 percent available
2.1-1.1 in./ft. depleted

Dry, soil aggregations break away easily, no staining on fingers, clods crumble with applied pressure. (Not pictured)



25-50 percent available
1.6-0.8 in./ft. depleted

Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.

50-75 percent available
1.1-0.4 in./ft. depleted

Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon between the thumb and forefinger.

75-100 percent available
0.5-0.0 in/ft. depleted

Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.

100 percent available
0.0 in/ft. depleted (field capacity)

Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers. (Not pictured)

Guidelines for Estimating Soil Moisture Conditions

	Coarse Texture- Fine Sand and Loamy Fine Sand	Moderately Coarse Texture Sandy Loam and Fine Sandy Loam	Medium Texture - Sandy Clay Loam, Loam, and Silt Loam	Fine Texture- Clay, Clay Loam, or Silty Clay Loam
	Available Water Capacity (Inches/Foot)			
	0.6-1.2	1.3-1.7	1.5-2.1	1.6-2.4
Available Soil Moisture Percent	Soil Moisture Deficit (SMD) in inches per foot when the feel and appearance of the soil are as described.			
0-25	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure. SMD 1.2-0.5	Dry, forms a very weak ball, aggregated soil grains break away easily from ball. SMD 1.7 -1.0	Dry. Soil aggregations break away easily. no moisture staining on fingers, clods crumble with applied pressure. SMD 2.1-1.1	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure SMD 2.4-1.2
25-50	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers. SMD O.9-0.3	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away. SMD 1.3-0.7	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away. SMD1.6-0.8	Slightly moist, forms a weak ball, very few soil aggrega-tions break away, no water stains, clods flatten with applied pressure SMD 1.8-0.8
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon. SMD O.6-0.2	Moist, forms a ball with defined finger marks. very light soil/water staining on fingers. darkened color, will not slick. SMD O.9-0.3	Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger. SMD 1.1- 0.4	Moist. forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger. SMD I.2-0.4
75-100	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon. SMD O.3-0.0	Wet, forms a ball with wet outline left on hand, light to medium water staining on fingers, makes a weak ribbon between thumb and forefinger. SMD O.4-0.0	Wet, forms a ball with well defined finger marks, light to heavy soil/water coating on fingers, ribbons between , thumb and forefinger. SMD O.5 -0.0	Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily between thumb and forefinger. SMD O.6-0.0
Field Capacity (100 %)	Wet, forms a weak ball, moderate to heavy soil/ water coating on fingers, wet outline of soft ball remains on hand. SMD 0.0	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking,medium to heavy soil/water coating on fingers. SMD 0.0	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers. SMD 0.0	Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky. SMD 0.0

Table 1. Soil classification data

Soil Series Name	NSSL ID	Clay (%)	Sand (%)	OM (%)	OWC $(\%)_{g/g}$	MDD (Mg/m^3)	K_l	K_h
Mexico	89p1135s	22.1	4.6	1.55	19.5	1.58	0.0156	–0.0240
Tifton	89p1136s	4.7	86.5	0.43	8.0	1.91	0.0100	–0.0270
Bonifay	89p1137s	3.7	91.9	0.25	10.0	1.77	0.0023	–0.0165
Cecil	89p1139s	33.6	51.8	0.66	17.5	1.73	0.0393	–0.0249
Opequon	89p1141s	32.9	12.1	1.50	21.0	1.55	0.0201	–0.0163
Fredrick	89p1142s	16.8	22.0	1.23	18.5	1.59	0.0196	–0.0140
Manor	89p1143s	24.6	44.2	0.97	19.5	1.65	0.0216	–0.0140
Caribou	89p1144s	14.2	46.0	1.84	20.0	1.60	0.0142	–0.0280
Collamer	89p1145s	17.0	4.8	1.06	18.0	1.65	0.0194	–0.0228
Miamian	89p1146s	30.5	30.4	2.01	19.0	1.65	0.0065	–0.0220
Miami	89p1148s	15.9	4.4	0.79	18.0	1.68	0.0108	–0.0261
Grenada	89p1149s	20.4	3.5	0.99	17.5	1.65	0.0093	–0.0282
Acadamy	89p962s	13.6	63.0	0.34	13.0	1.93	0.0381	–0.0308
Los Banos	89p964s	49.4	15.7	1.45	23.5	1.53	0.0046	–0.0147
Whitney	89p966s	6.7	75.0	0.27	10.0	1.99	0.0175	–0.0401
Sverdrup	89p970s	22.6	46.9	1.54	15.5	1.67	0.0145	–0.0093
Amarillo	89p972s	7.5	86.5	0.14	9.0	1.92	0.0190	–0.0240
Barnes	89p974s	25.3	42.4	2.52	20.5	1.59	0.0155	–0.0218
Williams	89p976s	26.9	41.8	1.61	15.0	1.79	0.0166	–0.0240
Pierre	89p978s	48.7	11.5	1.35	26.0	1.47	0.0129	–0.0171
Palouse	89p980s	22.1	8.3	1.35	18.0	1.65	0.0116	–0.0207
Woodward	89p984s	12.0	48.5	0.75	12.5	1.79	0.0140	–0.0289
Zahl	89p986s	29.8	46.4	1.70	17.0	1.67	0.0204	–0.0166
Sharpsburg	89p990s	41.0	2.4	1.70	23.5	1.48	0.0040	–0.0127
Portneuf	89p994s	9.7	16.1	0.77	20.5	1.53	0.0072	–0.0280
Keith	89p996s	17.8	47.3	0.94	18.5	1.63	0.0144	–0.0447
Inavale	91z349s	5.0	85.1	0.42	10.0	1.92	0.0162	–0.0401
Harney	91z350s	30.5	12.3	1.00	18.5	1.64	0.0237	–0.0219
Fargo	91z351s	47.4	12.1	3.13	26.0	1.46	0.0057	–0.0147
Smolan	91z352s	32.3	9.1	1.35	19.0	1.65	0.0117	–0.0221
Richfield	91z353s	26.2	28.9	0.97	18.0	1.68	0.0176	–0.0280
Lincoln	91z354s	15.8	58.1	1.04	12.5	1.82	0.0237	–0.0240
Dalhart	91z355s	7.5	75.1	0.68	9.0	1.83	0.0301	–0.0312
Reading	91z356s	25.1	7.2	1.50	18.5	1.63	0.0087	–0.0223
New Cambria	91z357s	42.4	12.7	1.91	22.0	1.57	0.0120	–0.0223
Santanta	91z358s	8.5	71.5	0.77	11.0	1.90	0.0176	–0.0401
Carr	91z359s	3.6	74.7	0.47	16.0	1.63	0.0074	–0.0325
Wymore	91z360s	25.2	10.5	1.31	17.0	1.67	0.0122	–0.0210
Hanie	91z361s	5.9	61.4	0.64	15.5	1.64	0.0141	–0.0243