United States Department of Agriculture | Forest Service | Beaverhead National Forest

REPLY TO: 2550/2210 Date: 1-27-87

SUBJECT: Ruby Allotment Soil Compaction

TO: District Ranger, Wisdom RD

On October 29, Stu Herkenhoff and I took some reconnaissance level measurements of soil bulk density at four locations on this allotment. This information was wanted to help monitor the potential vegetative production on the allotment, versus actual production.

The four areas sampled were Issac Meadows, Cow Creek, West Fork Ruby, and Sawpit. Only one to two points were sampled at each location because of a limited number of weighing cans. Surface soil at these points was excavated to a depth of about 10cm, and the volume of the excavation was determined with a volume-displacement apparatus. From 10-25cm, a cylinder was driven, and a relatively undisturbed core was extracted. The soil from each was sealed in weighing cans for determination of oven dry weight; bulk densities were then calculated for each depth. Particle size and organic matter determinations were not made, but I estimated both from the soil collected in the weighing cans. Total % pore space was derived from the bulk density and a particle density constant of 2.60 g/cubic cm. No determination can be made of pore size distribution without additional sampling data.

In the range of soils sampled in these areas, the growth limiting bulk density is between 1.40 and 1.45 grams per cubic centimeter for the textural classes encountered. However, these limiting densities were derived from research on soils with less than three percent organic matter. Some of the allotment soils have an estimated organic matter fraction of 10%, or more. Because organic rich soils have low bulk density, the actual growth limiting bulk density for these soils would be closer to 0.9 to about 1.2 g/cubic cm.

Examining the table, it can be seen that Issac Meadows probably has had little or no impact from soil bulk density increases. The bulk density is fairly low, and total pore space (TPS) at 72% is high, although the pore size distribution (percentage of macro and micro pore space) is not known. For a soil in this taxonomic family, 60-65 TPS would still be in the normal range.

Some of the other sites did not look as good, however. The Cow Creek sample appears to be compacted in the 0-10cm depth. Bulk density of 1.34 and TPS at less than 50%, is of concern. The subsoil (10-25cm) doesn't look too bad. The second site at Cow Creek is similar to the first. The West Fork Ruby samples, especially the second site, is significantly compacted in the surface 10cm. The Sawpit site surface 10cm has had some increase in bulk density.

To determine the extent of compaction in the allotment, a more rigorous and statistically valid sampling is recommended, along with a search for an acceptable benchmark soil to serve as a control. The effect on potential vegetative production should then be quantified. This field season, I will collect the data needed to input the Cannon/Nielsen model. The model gives the long term potential production for Mollisols, which most of these soils are. Eventually, compaction will not only result in a reduction of annual biomass, but also will directly influence the composition of the plant community that the soil will support.

Soil compaction is a long term impact on productivity. Research in Region 4 has shown that compacted soils had not reverted to their natural density after 60 years. In grazing management, we certainly don't want to cause further compaction, or impact any more area. Preferably, the allotment management plan should allow complete rest for one or more pastures annually. The soil on June 16 (the normal on-date), in most years, is probably too damp to begin grazing without increasing soil density, with the exception of Issac Meadows. I recommend setting the on-date back to early July and utilizing the Issac Meadows areas first. If a three-pasture deferred rotation system is implemented, the on-date should be moved back at least two weeks in most years. A two pasture deferred rotation system probably wouldn't help much in preventing compaction, and so is not recommended.

Average Bulk Density (db) and Total Pore Space (TPS) by Depth

	db (g/cm3)	TPS (%)
Issac Meadows		
0-7 cm	.72	72.3
7-22cm	.71	72.7
Cow Creek		
0-10 cm	1.34	48.5
10-25cm	.92	64.5
Cow Creek		
0-7 cm	1.22	53.1
7-22cm	.94	63.9
West Fork Ruby		
0-9 cm	1.07	58.9
9-24cm	1.08	58.5

West Fork Ruby

0-11 cm	1.40	46.2
11-26cm	1.01	61.2

Sawpit

0-10 cm	1.15	55.8
10-25cm	.81	68.8

Sawpit

0-10 cm	No Data	No Data
10-25cm	.87	66.5

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DAN SVOBODA
Soil Scientist

Average Density by Depth

and total pore space (TPS)

Area — Average Density (d_b) by Depth

Area	Depth		7-22 cm
Issac Meadows	0-7 cm	d_b: .72 g/cm³	.71 g/cm³
—		TPS: 72.3 %	72.7 %
SP Cow Creek	Depth: 0-10 cm	d_b: 1.34 g/cm³	10-25 .92 g/cm³
		TPS: 48.5 %	64.5 %
SP Cow Creek	Depth: 0-7 cm	d_b: 1.22 g/cm³	7-22 .94 g/cm³
		TPS: 53.1 %	63.9 %
SP West Fork Ruby	Depth: 0-9 cm	d_b: 1.07 g/cm³	9-24 cm 1.08 g/cm³
		TPS: 58.9 %	58.5 %
SP West Fork Ruby	Depth: 0-11 cm	d_b: 1.40 g/cm³	11-26 cm 1.01 g/cm³
		TPS 46.2 %	61.2 %
SP Sawpit Cr.	Depth: 0-10 cm	d_b: 1.15 g/cm³	10-25 cm .81 g/cm³
		TPS: 55.8	68.8
SP Sawpit Cr.	Depth: 0-10 cm	d_b: No data	10-25 cm .87 g/cm³
		TPS: —	66.5 %

USFS
Density Tests - Ruby Valley

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$g cm^{-3} = Mg\ m^{-3}$

USFS
DENSITY TESTS - RUBY VALLEY

TEST NO.	LOCATION		MOIST	A.G.R.	MOIST PCF	MOIST g/m3	WET DEN PCF	DRY DEN PCF	DRY DEN g/m3	%MOIST
1.	LEWIS CREEK	OUTSIDE	0896	1.075	8.3	0.13	77.6	69.3	1.11	10.7
	ENCLOSURE	TOP	0919	1.100	9.0	0.14	82.62	73.60	1.18	10.9
	AVERAGE				8.7	0.135	80.1	71.45	1.15	10.8
2.	LEWIS CREEK	OUTSIDE	1069	1.156	13.4	0.21	93.70	80.3	1.29	14.3
	ENCLOSURE	7" DEPTH	1027	1.180	12.3	0.20	98.50	86.2	1.38	12.5
	AVERAGE				12.9	0.205	96.10	83.25	1.34	13.40
3.	LEWIS CREEK	INSIDE	0900	1.069	8.6	0.14	76.46	67.86	1.09	11.25
	ENCLOSURE	TOP	0892	1.083	8.4	0.13	79.23	70.83	1.13	10.60
	AVERAGE				8.5	0.135	77.85	69.35	1.11	10.93
4.	LEWIS CREEK	INSIDE	1017	1.110	11.9	0.19	84.80	72.9	1.17	14.03
	ENCLOSURE	6" DEPTH	1016	1.114	11.9	0.19	85.50	73.6	1.18	13.92
	AVERAGE				11.9	0.19	85.15	73.25	1.18	13.98
5.	BEAVER BENCH	TOP	0937	1.109	9.6	0.15	84.5	74.7	1.20	11.3
			0932	1.091	9.5	0.15	80.9	71.4	1.14	11.7
	AVERAGE				9.6	0.15	82.7	73.2	1.17	11.5
6.	BEAVER BENCH	6.5" DEPT	0946	1.133	9.7	0.16	89.1	79.4	1.27	10.9
			0931	1.128	9.5	0.15	88.1	78.6	1.26	10.7
	AVERAGE				9.6	0.16	88.6	79.0	1.27	10.8
7.	POISON CREEK	OUTSIDE	0937	1.073	9.6	0.15	77.25	67.7	1.08	12.4
	ENCLOSURE	TOP	0936	1.109	9.6	0.15	84.5	74.9	1.19	11.4
	AVERAGE				9.6	0.15	80.88	71.3	1.14	11.9
8.	POISON CREEK	OUTSIDE	0906	1.143	8.7	0.14	91.2	82.5	1.32	9.5
	ENCLOSURE	6" DEPTH	0952	1.133	10.0	0.16	89.4	79.4	1.27	11.2
	AVERAGE				9.4	0.15	90.3	80.95	1.295	10.1
9.	POISON CREEK	INSIDE	0795	1.046	5.7	0.09	71.91	66.2	1.06	8.6
	ENCLOSURE	TOP	0829	1.070	6.5	0.10	76.66	70.2	1.12	8.5
	AVERAGE				6.1	0.10	74.29	68.2	1.09	8.6
10.	POISON CREEK	INSIDE	0908	1.114	8.7	0.14	85.5	76.8	1.23	10.2
	ENCLOSURE	6" DEPTH	0933	1.120	9.4	0.15	86.6	77.2	1.24	10.8
	AVERAGE				9.1	0.15	86.1	77.0	1.24	10.5
11.	POISON CREEK	TOP	0854	1.109	7.3	0.12	84.5	77.2	1.24	8.6
	ROAD		0849	1.102	7.2	0.12	83.0	75.8	1.21	8.7
	AVERAGE				7.3	0.12	83.8	76.5	1.23	8.7

12. POISON CREEK ROAD	6" DEPTH	1039	1.203	12.4	0.20	103.0	90.6	1.45	12.0
		1025	1.251	12.0	0.19	112.5	100.5	1.61	10.6
AVERAGE				12.2	0.20	107.8	95.6	1.53	11.3
13. E. FORK RUBY CREEK	TOP	0962	1.170	10.4	0.17	96.5	86.1	1.38	10.9
		0984	1.153	10.9	0.17	93.0	82.1	1.32	8.5
AVERAGE				10.7	0.17	94.8	84.1	1.35	9.7
14. E. FORK RUBY CREEK	6" DEPTH	0969	1.168	10.5	0.17	96.0	85.5	1.37	10.9
		0947	1.222	9.7		106.5	--VOID--		
15. E. FORK RUBY ABOVE	TOP	1006	1.053	11.5	0.18	73.3	61.8	0.99	15.7
		1044	1.038	12.6	0.20	70.3	57.7	0.92	17.9
AVERAGE				12.1	0.19	71.8	59.8	0.96	16.8
16. E. FORK RUBY ABOVE	6" DEPTH	1063	1.110	13.3	0.21	84.5	71.2	1.14	15.7
		1033	1.108	12.2	0.20	84.5	72.3	1.16	14.4
AVERAGE				12.8	0.21	84.5	71.8	1.15	15.1
17. DRY FAWN CREEK GRASS	TOP	0953	1.017	10.0	0.16	66.2	56.2	0.90	15.1
		0909	1.014	8.7	0.14	65.6	56.9	0.91	13.3
AVERAGE				9.4	0.15	65.9	56.6	0.91	14.2
18. DRY FAWN CREEK GRASS	6" DEPTH	0923	1.089	9.3	0.15	80.5	71.2	1.14	11.6
		0877	1.150	8.4		92.5	--VOID--		
19. DRY FAWN CREEK SAGE	TOP	0932	1.000	--VOID, ORGANICS--					
		0919	1.008						
20. DRY FAWN CREEK SAGE	TOP	0886	1.057	8.2	0.13	74.1	65.9	1.06	11.1
		0947	1.036	9.8	0.16	69.9	60.1	0.96	14.0
AVERAGE				9.0	0.15	72.0	63.0	1.01	12.6
21. DRY FAWN CREEK SAGE	6" DEPTH	0906	1.081	8.6	0.14	79.6	71.0	1.14	10.8
		0935	1.083	9.5	0.15	79.8	70.3	1.13	11.9
AVERAGE				9.1	0.15	79.7	70.7	1.14	11.4

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Job Title United States Forest Service By William H. Anderson Date October 30, 1990 Job No. N/A

Subject Soil Moisture and Density Checked _____ Sheet 1 of 3

NOTES: Equipment: C-100, Seaman Nuclear
Untouchable Mode
60 Sec. Count.
Air Gap Method
TESTS: AASHTO T238, T239

Op. Moisture N/A Maximum Density N/A

Station	Moisture (CPM)	Density Ratio	Moisture (PCF)	Wet Den. (PCF)	Moist. Con. (%)	Dry Den. (PCF)	Dry Den. g/cm³
Pole Creek Surface	1082	1.093	13.8	81.2	20.47	67.4	1.08
Pole Creek #1 6" Depth	1184	1.118	16.8	86.4	24.14	69.6	1.11
Long Creek #4 Surface	1168	1.073	16.3	77.25	26.74	60.95	0.98
Long Creek #4 7" Depth	1154	1.146	15.9	91.6	21.00	75.7	1.21 ✓
Divide #2 Surface	1107	1.114	14.4	85.5	20.25	71.1	1.14 -
Divide #2 6" Depth	1116	1.110	14.8	84.5	21.23	69.7	1.12
Divide #1 Surface	1325	1.037	20.7	69.8	42.16	49.1	0.79
Divide #1 ~~Surface~~ 6" Depth	1278	1.059	19.3	74.2	35.15	54.9	0.88
Shovel Sta. 1 Surface	1028	1.106	12.2	83.9	17.02	71.7	1.15 -
Shovel Sta. 1	0993	1.126	11.2	87.9	14.60	76.7	1.23 ✓

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Subject Soil Moisture and Density Checked _____ Sheet 2 of 3

NOTES: Equipment: C-100, Seaman Nuclear
_____ Mode
__ Sec. Count.
Air Gap Method

TESTS: AASHTO T238, T239

Op. Moisture _____ Maximum Density _____

Station	Moisture (CPM)	Density Ratio	Moisture (PCF)	Wet Den. (PCF)	Moist. Con. (%)	Dry Den. (PCF)	Dry Den. g/cm³
Cole Creek #1 Surface	1126	1.147	14.9	92.0	19.33	77.1	1.24 ✓
Cole Creek #1 6" Depth	0985	1.150	10.9	92.5	13.36	81.6	1.31 ✓
Basin Creek #1 Surface	1074	1.156	13.4	93.9	16.65	80.5	1.29 ✓
Basin Creek #1 6" Depth	1024	1.111	12.1	84.5	16.71	72.4	1.16 -
Poison Creek #1 Surface	0967	1.126	10.8	87.9	14.01	77.1	1.24 ✓
Poison Creek #1 6" Depth	0932	1.139	9.4	90.4	11.60	81.0	1.30 ✓
Westfork #1 Surface	1334	1.134	20.7	89.4	30.13	68.7	1.10
Westfork #1 6" Depth	1290	1.207	19.6	103.9	23.25	84.3	1.35 ✓
Dog Creek #1 Surface	1011	1.184	11.7	99.4	13.34	87.7	1.40 ✓
Dog Creek #1	1001	1.147	11.4	92.0	14.14	80.6	1.29 ✓

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Subject Soil Moisture and Density Checked _____ Sheet 3 of 3

NOTES: Equipment: C-100, Seaman Nuclear
_____ Mode
__ Sec. Count.
Air Gap Method

TESTS: AASHTO T238, T239

Op. Moisture _____ Maximum Density _____

Station	Moisture (CPM)	Density Ratio	Moisture (PCF)	Wet Den. (PCF)	Moist. Con. (%)	Dry Den. (PCF)	Dry Den. g/cm³
Cottonwood #1 Surface	1470	1.183	29.4	99.0	42.24	69.6	1.11
Cottonwood #1 6" Depth	1487	1.233	30.4	108.9	38.73	78.5	1.26 ✓

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