Assessing off-road and harvest trail trafficability at the time of field operations: a case study

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Abstract. This report describes how GIS terrain layers and a daily hydrology/rutting model were used to assess machine-specific off-road soil trafficability within a harvested forest plot (ACFOR Inc.) near Boisetown, New Brunswick. Field work on and beside terrain-optimized cut-to-length wood-forwarding trails within this plot included measuring depth-to-compaction, post-harvest rut depth, particle size distribution (sand, silt, clay), soil organic matter (SOM), and gravimetric soil moisture content (SMC). The site was located on the generally well-drained not easily rutted Sunbury soil that developed on a coarse-textured sandy till, is well drained (sand ≈85%), and has coarse fragments at ≈50% of soil volume). The provincially available bare-earth DEM (1-m resolution) was used to delineate the perennial flow-channel networks and associated depth-to-water (DTW) variations for the plot and adjacent surroundings. The resulting DTW raster was subsequently classified to determine the local soil drainage extent from very poor to poor, imperfect, moderate, and well to excessive. In addition, the topographic position index (TPI) helped to further shape the probability distribution of recurring soil wetness and dryness across the hummocky terrain. Daily precipitation and mean daily air temperature were used to model how soil moisture and machine-specific rutting depth varied daily over the last four years. Doing so included the time of the harvesting operation.

Introduction. The case study involves a 38.7 ha forest plot in New Brunswick (ACFOR, Figures 1, 2) that was harvested in October 2025 based on local best forest management practices, with the intent to optimize long-term C-sequestration efficiently, and to minimize wildlife disturbances and soil disturbance. The latter included cut-to-length slash-pile supported machine forwarding across the terrain involving 68 to 112 m elevation differences from across the 600x700 m wide area. This was done to minimize soil rutting along steep slope, and ephemeral and perennial flow channel wood-harvest extraction trails (Figure 1). A pre- and post-harvest field survey was done at the same time to observe and evaluate the extent on soil disturbance along the trails. Doing so led to the development of the DEM-generated plot-based soil wetness recurrence probability map (SWP; Snow et al. 2024). This map was in part used to layout the trail pattern to operationally avoid steep slopes and likely areas prone to significant soil rutting. A hydrology model was used to ascertain the daily variations in soil moisture as they occurred at the time of operation (Yin & Arp, 1993).

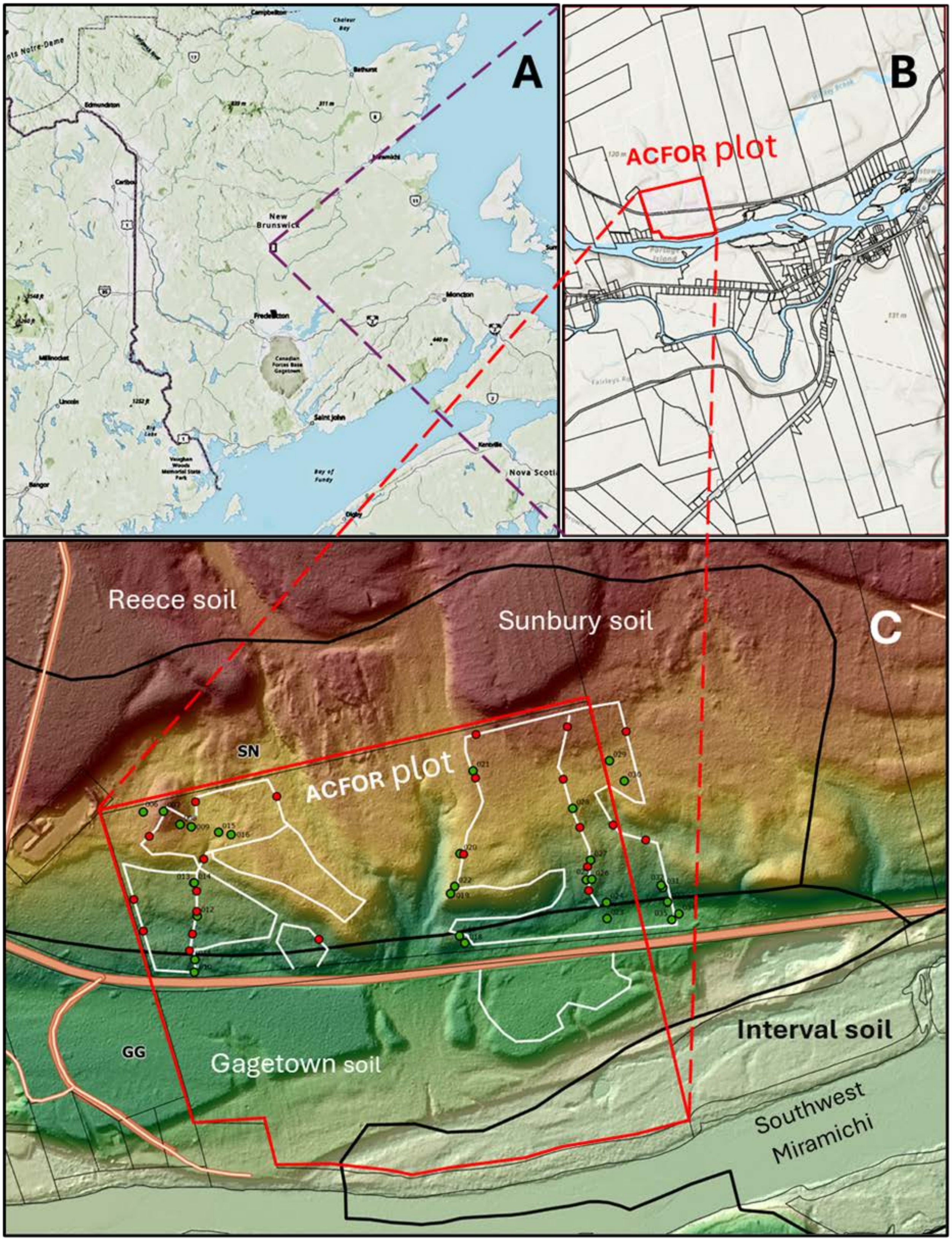

Figure 1. Location of the ACFOR plot in New Brunswick (Panel A), within the provincial property delineation lines (Panel B), and as it overlays the local digital elevation model (59 < DEM <112 m; Panel C: (i) planned wood-extraction trails (white lines), (ii) pre- (red dots) and post-harvest (green dots) soil sampling locations along these tracks and along additional post-harvest tracks, and (iii) soil types with borders (black lines.

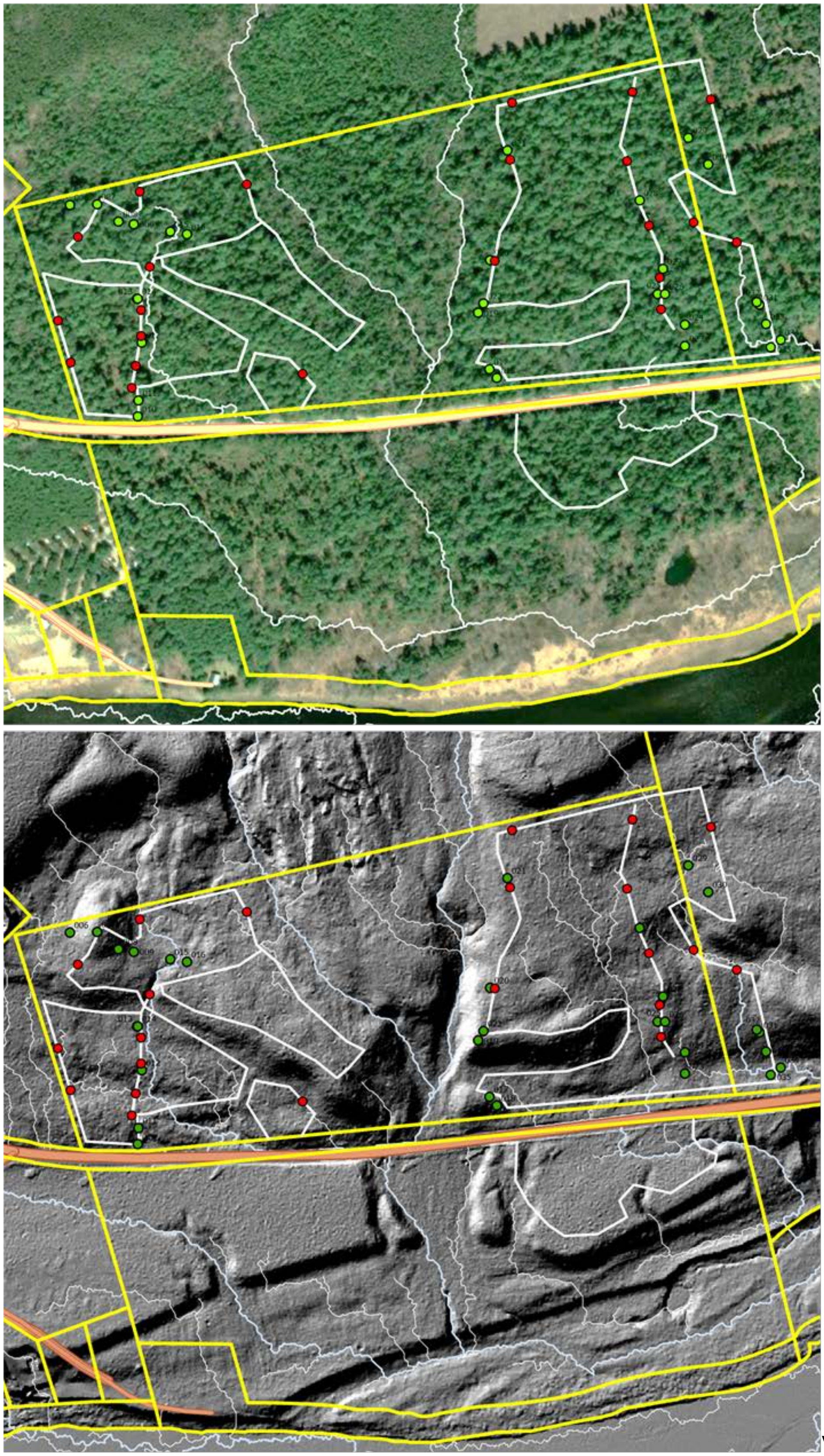

Figure 2. ACFOR plot: surface image (top) and hillshaded 1-m DEM (bottom), overlaid by (i) property borders (yellow lines), (ii) harvest extraction trails (thick white lines), (iii) DEM-derived flow channels (thin white lines) with > 4 ha upslope flow accumulation areas, an (iv) roads (orange lines). And pre- (red) and post-harvest (green) sampling plots.

Methods. Tree harvesting was done using a Ponsse's Scorpion Forest Harvester (weight = 23,200 kg; max. load = 1,150 kg) and a Forwarder (weight = 16,300 kg; max. load = 12,000 kg) with same wheel and tire specifications, i.e., 8 wheels; widths = 710 mm, diameters = 38.96 inches, section heights = 320 mm, tire pressures 44 to 58 PSI. The wheel specifications are used to determine the overall footprint pressure per machine as these move along the tracks. The footprint determinations are tire specific for the four front wheels, and the four eco-tracked back wheels.

Soil sampling involved using hand augers, photographing the extracted sample, weighing these samples before and after drying to determine soil bulk density and moisture content, and weighing them again after heating for 24 hours at 500 ˚C to determine their organic weight loss on ignition (LOI, in %). Depth of trail penetration into the mineral soil below the forest floor and related soil moisture contents were determined within and along side the harvesting trails. Also determined were the % weight % of sand, silt, clay and coarse fragments for each extracted sample.

The 1-m resolution DEM was used to determine slope %, the 50-m topographic position index (TPI50m), the local flow channels with > 1 and 4 ha upslope flow accumulation for each DEM cell (using the continuous D8 algorithm for flow direction and accumulation) across the ACFOR plot and surroundings using ArcGIS Pro. In turn, the flow channels and slope layers were used to estimate (i) the topographic extent of the dept- to-water-table (DTW, in m) by way of the ArcGIS Pro cost distance tool next to the DEM-derived flow channels (Murphy et al., 2012), and (ii) the probability index for recurring soil wetness as indicator of likely soil rutting following the formula (Snow et al., 2024; see Figure 3 for the mapping details):

$$\text{Soil Wetness Probability (SWP)} = 1/\left[1 + \exp\left(0.022 + 1.04\ \text{DTW>4ha}\right) + 6.4\ \text{TPI50m}\right)\Big]. \qquad \text{Eq.1}$$

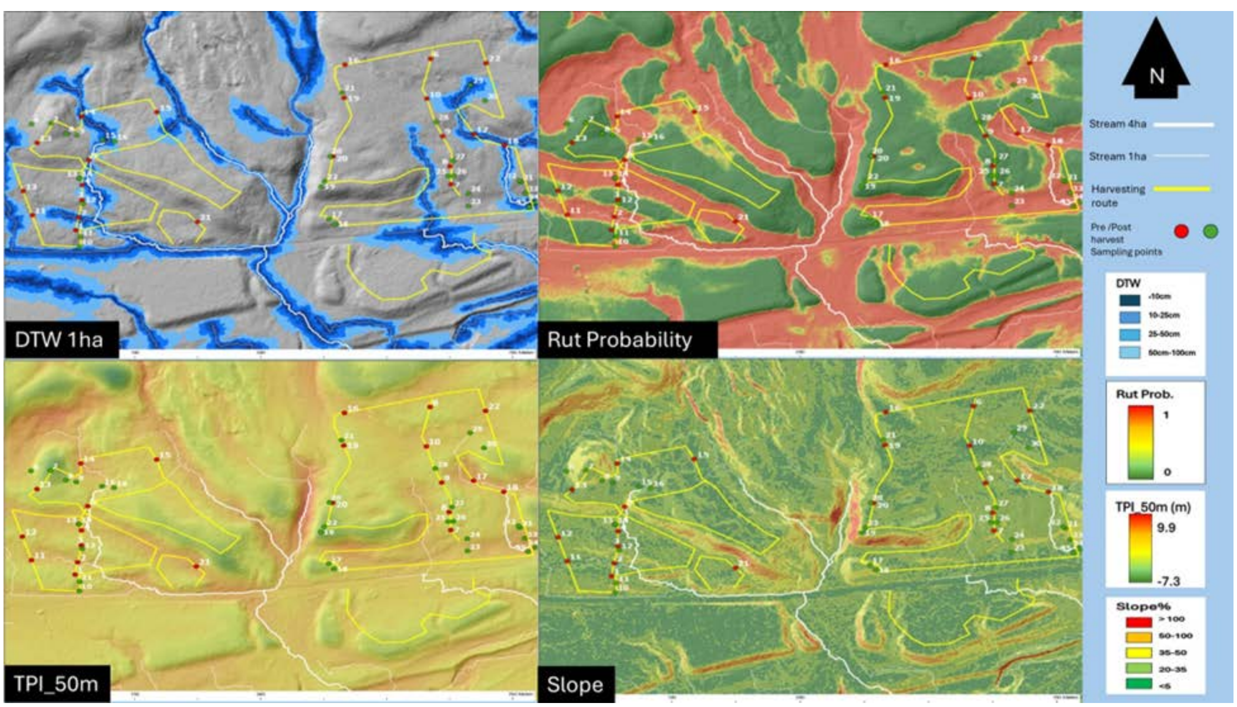

Figure 3. DEM- generated data layers overlain by the >1ha DEM-derived flow channels, the harvest trail layout, and the soil sampling locations. Dominant tree harvesting occurred along and near the harvest trails including areas that are generally (i) not too steep and (ii) projected not to be recurringly wet as revealed the red SWP ≈ 1 colour. Top left: DTW>1ha. Top right: SWP. Bottom left: TPI50m. Bottom right: Slope %.

A STELLA-based forest hydrology model (Oja et al. 1995) was used to simulate the moisture variations for the well-drained portion of the Sunbury soil within the ACFOR plot. The resulting moisture simulations track the daily variations in weather-recorded precipitation and mean daily temperatures, and subsequently modelled changes in actual evapotranspiration, soil infiltration as further affected by soil permeability. The soil moisture variations so computed were then combined with the soil texture and machine footprint specifications to determine likely soil rutting depths after 1, 5 and 10 machine passes along the same trail (Vega-Nieva et al. 2006).

Results and Discussion. Figures 4 presents the sampling locations by sample number along the wood-extraction trails within the SWP display for the ACFOR plot and its immediate surroundings. The mineral soil colors so revealed are generally related to the topographically determined SWP index as follows: (i) light brown with signs on podsolization along the higher SWP areas, (ii) darker brown along foot slopes close to the red SWP areas, (iii) grey due to gleying within the red SWP areas.

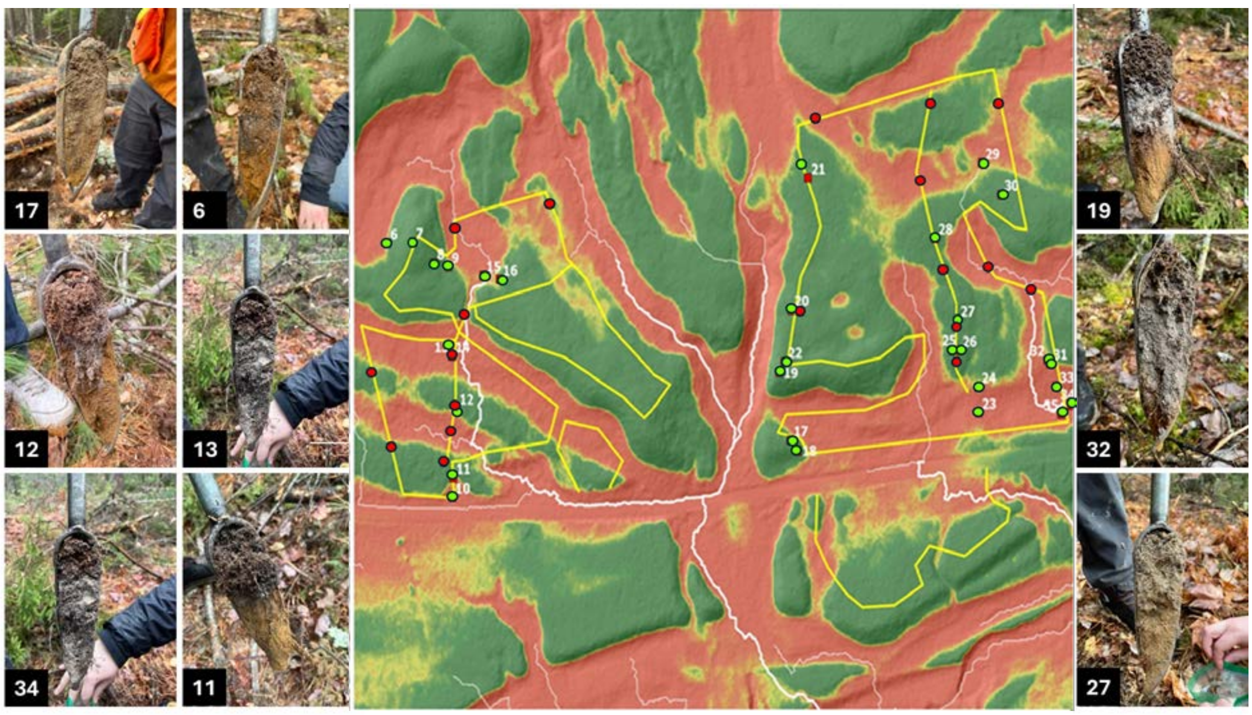

Figure 4. Augered post-harvest soil sample photographs by sampling location (green dots), with the harvest trails (yellow) overlaid on the hill-shaded green to red SWP areas, and with the red areas reflecting recurring soil wetness.

Figure 5 presents the extent of post-harvest soil disturbance along the wood extraction trails as marked by numbered soil sampling locations, and by view direction. These show: (i) dark mineral and organic soil exposure where the photographed soil samples and the SWP layer indicated the presence of generally wet soils with deeper organic forest floor layers, (ii) exposed podzolized soil along the upper ridges and where the organic forest floor layers were generally thin, and (iii) dark-brown mineral soil exposure along the foot slopes. For the most part, the soil disturbances were marked (i) by the generally sharp back-wheel eco-tracks, and (ii) by readily noticed weight-induced forest floor indentations, mostly confined to the easily compacted organic matter accumulations on top of the mineral soil. In addition, the machines tended to scrape roots and root-uplifted soil near tree stumps, and sideways along steeply rising microtopography (mounds).

Figure 5. Photographs for eight soil sampling locations in Figure 4, together with view direction.

The basic statistics for all the soil sampling locations and related topographic and rut depth evaluation efforts are summarized in Table 1.

Table 1. Plot-specific data summary for the soil conditions within the ACFOR plot.

Category	Variables	Units	Mean	Std. Dev.	Min.	Max.
DEM determinations	DEM	m	89	7.0	76	102
	Slope	%	10.3	6.1	1.5	23.5
	TPI 50m	cm/cm	0.05	1.21	-3.2	2.72
	DTW > 4ha	cm	608	395	6.0	1479
	DTW > 1ha	cm	299	233	0.0	832
	Rut probability	%	43	38	0.0	100
Soil properties	Forest Floor	cm	1.9	0.8	0.5	4.1
	Soil depth	cm	3.5	10.8	20	60
	Bulk density	g/cm^3	144	0.1	1.33	1.74
	Pore space %	cm^3/cm^3	41.3	3.2	31	43.4
	Sand %	g/g	84.1	4.4	74.8	90.5
	Silt %	g/g	12.5	3.9	64	21.3
	Clay %	g/g	3.5	1.4	1.7	7
	SOM %	g/g	6.5	2.7	2.7	13.6
	CF %	cm^3/cm^3	47	23.1	0.0	90
	SP %	g/g	29	3.9	0.2	0.3
	FC %	g/g	16.9	4.6	31	23.7
	PWP %	g/g	6	0.3	5.4	6.8
	Soil Resistance	PSI	144	21	90	175
Rut depths	Left track	cm	4.1	3.8	0.0	15
	Right track	cm	3.4	6.9	2.0	22
SMC %	Beside the trail	g/g	12.6	3.9	5.7	25.4
	Middle of trail	g/g	11.4	4.0	3.9	18.5
	In the tracks	g/g	11.8	3.6	5.6	18.9

SOM: Soil Organic Matter; CF: Coarse Fragments; SP: Saturation Point; FC: Field Capacity; PWP: Permanent Wilting Point
SMC: Soil moisture content

The soil was generally dry and near the permanent wilting point (PWP) at the time of operation. This dryness, in combination with the high sand and coarse fragment of the soil limited the extent of machine-induced penetration into the mineral soil to remain within a rutting depth of 2 to 5 cm. The overall cone-tested pre-harvest resistance to soil penetration increased with increasing clay content, i.e.,

$$\text{Cone penetration resistance (PSI)} = 116 + 9.3\ \text{Clay\%};\ R^2 = 0.43;\ \text{RMSE} = \pm 15. \qquad \text{Eq.2}$$

In addition, the pre-harvest soil moisture content (SMC, in cm^3/cm^3) was related to the soil organic matter content as follows:

$$\text{SMC}\ (cm^3/cm^3) = \text{FC} \times [1-\exp(-0.4 \times \text{OM\%})]^{2.5};\ R^2 = 0.34;\ \text{RMSE} = \pm 3.2 \qquad \text{Eq.3}$$

The corresponding actual versus best-fitted scatter plots for Eqs. 2 and 3 are shown in Figure 6.

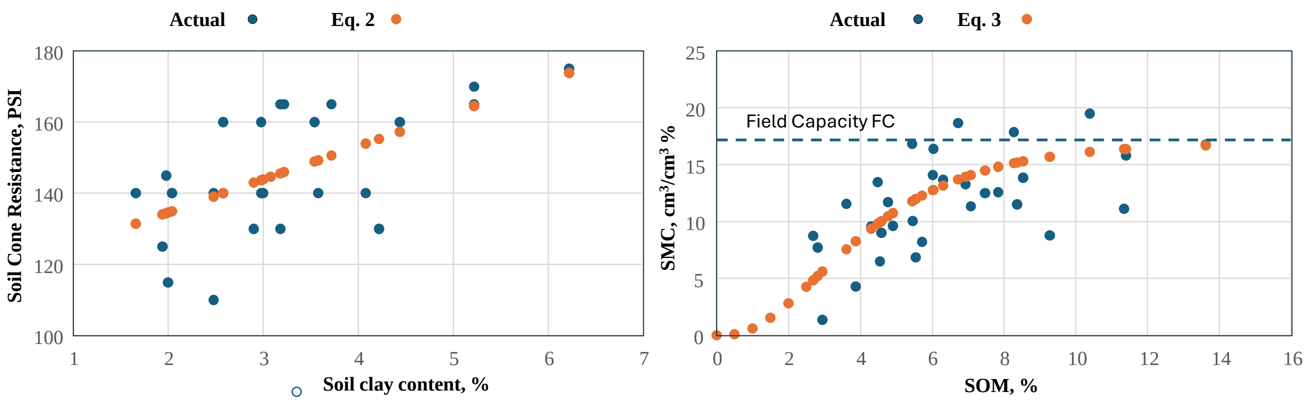

Figure 6. Actual versus best fitted values for pre-harvest soil cone penetration resistance (left panel), and pre-harvesting volumetric soil moisture content, obtained along the tracks within the ACFOR plot at the time of cut-to-length wood harvesting.

The weather-modelled soil moisture variations (SMC) done over the course of four years (1. January 2022 to 31., December 2025) overlaid on the soil water saturation (SP), field capacity (FC) and permanent wilting points (PWP) levels in Figure 7. As shown, the soil would remain saturated when frozen during winter, would drain towards field capacity after snowmelt, and would subsequently fluctuate between the field capacity and the permanent wilting point during the growing season due to evapo-transpiration. At the time of harvesting (October 2025), the soil was particularly dry due to a prolonged drought condition.

The machine-induced penetration depths into the mineral soil were, for the most part, estimated to be dependent on the variable coarse fragment content of the soil, as illustrated in Figure 8. While the penetrations would drop to zero to soil freezing during the winter month, they would generally rise with in the fall towards winter as soil moisture recovers towards field capacity and beyond. Soil penetration depth would be largest as the soils become unfrozen and are subject to soil-saturating snowmelt infiltrations. During summer to fall, soil moisture and penetration depths fluctuate towards their generally lowest values in autumn.

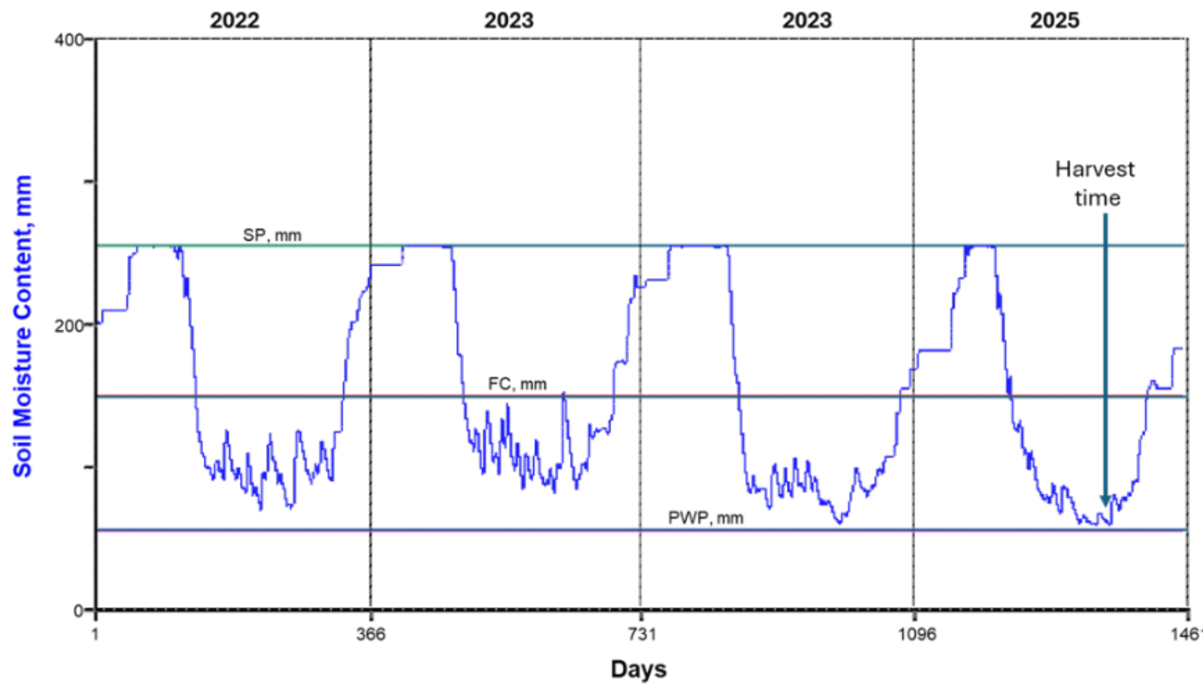

Figure 7. Model-generated variations in daily soil moisture over four years from January 1, 2022 to December 31, 2025, based the average soil property data in Table 1.

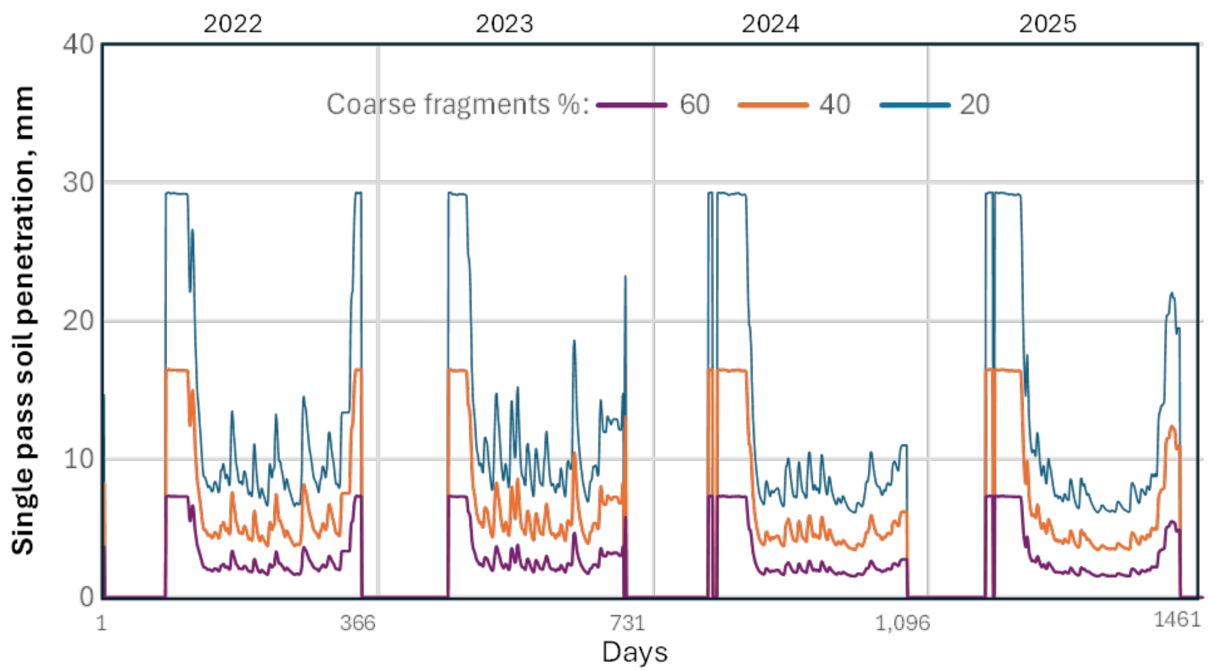

Figure 8. Daily machine-induced soil penetration depths as modelled using the weather records for precipitation and mean daily temperatures as applicable to the ACFOR plot based on the machine-affected and field-determined soil conditions in Table 1, and varying soil-contained coarse fragments from 20 to 60 % by volume.

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Appendix

Preharvest soil data by sampling points

Location			Surveyed								Estimated from surveyed						GIS DEM derived					
ID	X	Y	Forest Floor	Sand	Silt	Clay	SOM	Soil Depth	Soil Resist.	SMC %	Dp	BD	SP %	PS %	FC %	PWP %	DTW 1ha	DTW 4ha	Elev.	TPI 50m	Rut prob.	Slope
	m	m	Depth, cm	g/g %	g/g %	g/g %	g/g %	cm	PSI	m3/m3	g/cm^3	g/cm^3	g/g	m^3/m^3	g/g	g/g	cm	cm	m	m/m	0 to 1	%
1	2503930	7495600	2.5	83.42	12.14	4.44	7.48	20	160	12.5	2	1.37	0.31	0.43	15.2	6.2	110.7	166.8	80.8	0.6	0.0	6.6
2	2503930	7495620	1.4	79.92	13.86	6.22	6.73	20	175	18.7	2.44	1.38	0.31	0.43	15.3	6.4	19.1	99.5	80.4	-1.7	1.0	7.7
2	2503930	7495620	0.5	79.88	13.90	6.22	4.49	40	175	13.5	2.49	1.55	0.24	0.38	18.6	6.3	134.5	127.6	84.7	0.4	0.0	20.1
3	2503940	7495660	4.1	87.34	7.44	5.22	11.34	20	165	11.1	2.34	1.34	0.32	0.43	10.6	6.8	44.3	42.4	86.1	-0.5	1.0	9.9
4	2503940	7495680	1	87.80	8.48	3.72	4.91	20	165	9.6	2.48	1.40	0.31	0.43	20.6	6.2	24.3	32.4	90.0	-0.8	1.0	23.5
5	2503950	7495730	1	78.94	15.84	5.22	5.46	20	170	10.0	2.47	1.40	0.31	0.43	16.9	6.0	622.0	1478.7	101.3	1.2	0.0	4.9
6	2504470	7495920	3	85.84	10.94	3.22	6.93	20	165	13.3	2.43	1.38	0.31	0.43	16.8	6.1	622.0	1478.7	101.3	1.2	0.0	4.9
6	2504470	7495920	3	86.34	10.48	3.18	6.04	40	165	16.4	2.45	1.52	0.25	0.38	18.3	6.0	622.0	1478.7	101.3	1.2	0.0	4.9
7	2504500	7495680	2.1	83.20	12.58	4.22	6.02	20	130	14.1	2.45	1.39	0.31	0.43	17.4	6.1	397.4	814.3	81.9	1.2	0.0	21.1
7	2504500	7495680	3	89.20	7.62	3.18	4.78	40	130	11.7	2.48	1.55	0.24	0.38	21.1	6.1	397.4	814.3	81.9	1.2	0.0	21.1
8	2504490	7495720	2	75.30	20.18	4.52	5.45	20	125	16.8	2.47	1.40	0.31	0.43	15.7	5.7	233.6	710.8	84.9	0.8	0.0	17.0
9	2504480	7495770	2	89.38	8.64	1.98	10.39	20	145	19.5	2.36	1.35	0.32	0.43	12.7	6.2	292.8	527.8	89.6	0.6	0.0	5.9
10	2504460	7495840	1.5	86.34	11.08	2.58	4.59	20	160	9.0	2.49	1.41	0.31	0.43	20.6	5.8	104.7	1003.3	94.4	-0.6	0.9	1.5
10	2504460	7495840	2	82.84	13.62	3.54	2.82	40	160	7.7	2.53	1.60	0.23	0.37	22.1	5.7	104.7	1003.3	94.4	-0.6	0.9	1.5
11	2503860	7495630	1.3	85.24	11.18	3.58	6.31	20	140	13.7	2.45	1.39	0.31	0.43	17.6	6.1	122.9	355.0	81.9	-0.8	1.0	7.7
11	2503860	7495630	2.4	89.30	8.12	2.58	3.61	40	140	11.5	2.51	1.58	0.24	0.37	23.0	5.9	122.9	355.0	81.9	-0.8	1.0	7.7
11	2503860	7495630	3	87.34	10.18	2.48	2.69	60	140	8.7	2.53	1.74	0.18	0.31	23.7	5.7	122.9	355.0	81.9	-0.8	1.0	7.7
12	2503850	7495670	1.5	84.68	12.84	2.48	8.37	20	110	11.5	2.40	1.36	0.32	0.43	14.3	5.9	229.2	444.7	85.9	0.5	0.0	7.3
13	2503870	7495760	2	81.68	16.66	1.66	5.72	20	140	8.2	2.46	1.39	0.31	0.43	17.4	5.4	149.9	610.9	95.7	1.8	0.0	5.0
14	2503940	7495810	2	75.84	21.26	2.90	11.40	20	130	15.8	2.33	1.34	0.32	0.43	6.8	5.7	0.0	238.0	92.8	-3.2	1.0	1.5
15	2504050	7495820	1.5	85.46	11.56	2.98	3.88	20	140	4.3	2.50	1.42	0.31	0.43	21.4	5.8	83.8	281.7	93.7	0.0	0.4	2.6
16	2504340	7495910	2	83.50	14.50	2.00	8.28	20	115	17.9	2.40	1.37	0.32	0.43	14.0	5.7	434.3	1278.8	98.8	-1.0	1.0	4.3
17	2504530	7495780	3	74.84	18.18	6.98	13.62	20	130	16.8	2.29	1.32	0.32	0.42	3.1	6.7	19.4	204.3	86.6	-2.9	1.0	4.9
18	2504580	7495760	1.5	89.96	8.10	1.94	9.28	20	125	8.8	2.38	1.36	0.32	0.43	14.6	6.1	6.5	5.8	85.5	-1.9	1.0	6.1
19	2504330	7495840	2.5	81.42	15.60	2.98	8.54	20	160	13.8	2.40	1.36	0.32	0.43	13.0	5.8	266.7	964.0	95.8	0.4	0.0	4.5
20	2504320	7495740	1.5	82.84	15.12	2.04	5.55	20	140	6.9	2.46	1.40	0.31	0.43	18.0	5.5	608.6	819.8	92.4	2.7	0.0	13.0
20	2504320	7495740	1	78.88	18.12	3.00	2.95	40	140	1.4	2.53	1.60	0.23	0.37	20.6	5.4	608.6	819.8	92.4	2.7	0.0	13.0
21	2504110	7495620	1	83.28	14.68	2.04	7.08	20	140	11.3	2.43	1.38	0.31	0.43	15.8	5.7	626.0	568.3	81.5	-2.9	1.0	8.7
21	2504110	7495620	1	87.92	8.00	4.08	4.55	40	140	6.5	2.49	1.55	0.24	0.38	21.1	6.2	626.0	568.3	81.5	-2.9	1.0	8.7
22	2504550	7495910	2	88.02	8.98	3.00	7.84	20	90	12.6	2.41	1.37	0.32	0.43	16.2	6.2	252.5	1031.6	97.5	-0.6	0.9	8.9
22	2504550	7495910	1.5	90.52	6.40	3.08	4.31	40	90	9.6	2.49	1.56	0.24	0.37	22.3	6.1	252.5	1031.6	97.5	-0.6	0.9	8.9

Postharvest data by soil sampling points

Location			Surveyed		GIS DEM derived						Track sampled SMC					Rut depth	
ID	X	Y	Soil Resist.	Coarse Fragments	DTW 1ha	DTW 4ha	Elev.	TPI 50m	Rut prob.	Slope	Left of trail	Left track	Middle of trail	Right track	Right of trail	Left track	Right track
	m	m	PSI	%	cm	cm	m	m/m	0 to 1	%	g/g %	g/g %	g/g %	g/g %	g/g %	cm	cm
6h	2503863	7495797	160	80	189	757	96.1	0.8	0.3	12.7	CF	Slash	CF	Slash	Slash	Slash	Slash
7h	2503892	7495798	175	80	ID	960	101.6	0.0	0.2	10.4	CF	Slash	CF	Slash	Slash	Slash	Slash
8h	2503915	7495779	175	55	476	507	97.1	0.0	0.3	18.1	5.7	Slash	9.5	Slash	Slash	Slash	Slash
9h	2503931	7495776	165	60	240	270	94.8	0.1	0.4	4.0	6.1	Slash	7.2	Slash	Slash	Slash	Slash
10h	2503936	7495570	165	45	63	240	77.1	1.0	0.4	12.8	CF	11.7	TP	Slash	Slash	Slash	Slash
11h	2503936	7495588	170	50	268	303	79.0	0.9	0.4	21.2	5.8	11.7	8.0	CF	16.2	2.0	4.2
12h	2503940	7495650	165	75	194	176	84.1	0.1	0.4	15.1	12.4	16.9	11.9	CF	10.1	3.0	3.5
13h	2503935	7495696	165	80	107	105	87.2	1.0	0.5	10.7	9.5	14.9	8.4	CF	9.9	2.0	Slash
15h	2503970	7495768	130	45	34	115	93.1	0.8	0.5	6.9	17.5	17.3	13.3	15.8	11.8	2.0	4.5
16h	2503988	7495765	125	45	76	191	93.5	0.1	0.4	10.6	9.1	13.3	16.8	16.7	13.7	Slash	Slash
17h	2504312	7495621	145	40	615	593	80.6	0.0	0.3	16.6	14.8	16.2	15.1	9.2	16.0	3.5	2.5
18h	2504320	7495612	160	30	605	619	79.5	0.0	0.3	20.3	15.5	6.4	16.3	6.9	12.7	4.00	5.0
19h	2504300	7495682	160	35	832	956	90.7	0.0	0.2	3.6	12.6	5.7	17.7	9.2	10.1	Slash	Slash
20h	2504313	7495737	140	60	647	774	92.0	0.0	0.3	12.4	22.5	Slash	7.5	Slash	Slash	Slash	Slash
21h	2504331	7495855	140	80	242	1,008	96.2	0.0	0.3	7.3	12.8	9.6	11.9	11.4	10.9	Slash	Slash
22h	2504305	7495691	140	65	806	942	90.8	0.0	0.2	3.5	9.9	12.5	12.1	10.2	8.7	2.5	2.0
23h	2504521	7495646	110	30	228	206	76.1	1.0	0.4	7.0	12.3	8.9	9.8	10.3	14.2	2.0	Slash
24h	2504521	7495669	140	20	534	511	78.6	0.7	0.3	17.5	14.3	10.4	6.2	15.0	14.4	3.5	Slash
25h	2504492	7495701	130	45	267	746	83.6	0.0	0.3	12.0	ND	ND	ND	ND	ND	0.0	Slash
26h	2504498	7495728	140	0	321	703	83.9	0.0	0.3	11.8	16.2	10.9	10.3	9.3	11.3	3.5	2.0
27h	2504473	7495801	115	50	355	683	86.3	0.0	0.3	14.3	13.0	18.9	10.7	10.2	12.6	3.5	4.5
28h	2504525	7495869	130	80	250	797	92.3	0.0	0.3	13.2	13.4	12.8	18.5	Slash	14.4	4.0	Slash
29h	2504546	7495840	125	30	4	1,099	95.4	1.0	0.3	1.6	12.1	7.0	10.8	CF	15.4	3.5	2.0
30h	2504600	7495690	160	50	122	1,084	95.4	0.0	0.2	9.2	7.1	15.6	Slash	Slash	Slash	Slash	Slash
31h	2504598	7495693	140	20	330	337	80.1	1.0	0.4	23.2	ND	ND	ND	ND	ND	ND	ND
32h	2504608	7495669	140	40	261	251	80.6	0.9	0.4	19.9	ND	ND	ND	ND	ND	ND	ND
34h	2504623	7495652	140	25	3	2	73.7	1.0	0.9	1.4	10.2	11.2	3.9	5.6	12.7	12	18
35h	2504613	7495644	140	0	21	16	73.9	1.0	0.7	0.9	10.6	15.2	14.4	ND	25.4	15	22

Metadata

AcFOR Metadata			
Location	FI		Sample ID
	x	m	NAD83(CSRS) / UTM zone 20N
	y	m	NAD83(CSRS) / UTM zone 20N
Surveyed	Forest Floor	cm	Forest Floor depth
	Sand%	g/g	Sand content, in weight %
	Silt%	g/g	Sily content, in weight %
	Clay%	g/g	Clay content, in weight %
	OM%	g/g	Soil Organic Matter content, in weight %
	Probe_MC%	g/g	Soil Moisture Content, in weight %
	Soil_Depths	cm	Soil layer depths: 0 to 20; 20-40; 40 - 60 cm
	Soil Resistance	PSI	Soil resistance to cone penetration
Estimated from survey	Dp	g/cm^3	Average soil particle density
	BD	g/cm3	Soil bulk density
	SP %	g/g	Saturation point, in weight %
	PS %	cm^3/cm^3	Pore Space, in volume %
	FC %	g/g	Field Capacity, in weight %
	PWP %	g/g	Permanent Wilting Point, in weight %
	SMC %	cm^3/cm^3	Volumetric water (moisture) content, in %
GIS DEM derived	DTW>1ha, DTW>4ha	cm	Depth-to-water: flow channels with > 1 ha upslope accumuation area serve as 0 reference
	DEM	m	Digital Elevation Model, 1 m rfesolution
	tpi50m	m/m	Topographic Poisition index, using a 50 annulus
	Rut probability	0 to 1	Rutting occurrence probability , based on TPI50 m and DTW> 4ha
	Slope	%	Cell-to-cell steepest decent, in rise over run %
Rut Depth	Left track	cm	Rut depth on one side
	Right track	cm	Rut depth on the other side
Postharvest SMC	Beside trail %	g/g	Outside track soil moisture content, in weight %, e.g., on one sides
	Middle of trail %	g/g	Inside track soil moisture content, in weight %, e.g., on one side
	Below he tracks %	g/g	In-between track soil moistur content, in weight

Upslope flow accumulations areas for flow channels: ephemerals > 1 ha; perennials>4 ha