Investigating the causes and consequences for soil properties of gorse encroachment at Troopers Hill

Group 3 – in association with Friends of Troopers Hill

2427979, 2418866, 2573594, 2600823, 2623064, 2418893

Word Count: 7909

Reference list

Acton-Campbell, R. (2006) A brief history of Troopers Hill. Friends of Troopers Hill. Available at: https://www.troopers-hill.org.uk/history/TH_History.pdf (Accessed: 01 April 2026).

Altamirano, A., Cely, J.P., Etter, A., Miranda, A., Fuentes-Ramirez, A., Acevedo, P., Salas, C. and Vargas, R. (2016). The invasive species Ulex europaeus (Fabaceae) shows high dynamism in a fragmented landscape of south-central Chile. *Environmental Monitoring and Assessment*, 188(8). doi:https://doi.org/10.1007/s10661-016-5498-6.

Avon Project (2024) To what extent does soil pH vary across Troopers Hill, and what factors influence these variations? University of Bristol. Available at: https://www.troopers-hill.org.uk/research/AvonProject2024.pdf (Accessed: 01 April 2026).

Avon Project (2025) Would a soil scrape be an appropriate form of management to prevent natural succession and re-establish heathland vegetation at a site on Troopers Hill? University of Bristol. Available at: https://www.troopers-hill.org.uk/research/AvonProject2025.pdf (Accessed: 01 April 2026).

Barrow, N.J. and Hartemink, A.E. (2023). The Effects of pH on Nutrient Availability Depend on Both Soils and Plants. *Plant and Soil*, 487, pp.21–37. doi:https://doi.org/10.1007/s11104-023-05960-5.

Beighton, R. (2013) Heavy metals in soils: Investigation into an urban area in Bristol. Undergraduate dissertation. Plymouth University. Available at: https://www.troopers-hill.org.uk/Flora/SoilsInvestigation.pdf (Accessed: 01 April 2026).

Broadfield, N. and McHenry, M.T. (2019). A World of Gorse: Persistence of Ulex europaeus in Managed Landscapes. *Plants*, 8(11), p.523. doi:https://doi.org/10.3390/plants8110523.

Brouder, S.M., Hofmann, B.S. and Morris, D.K. (2005). Mapping Soil pH. *Soil Science Society of America Journal*, 69(2), pp.427–442. doi:https://doi.org/10.2136/sssaj2005.0427.

Burghardt, W. (1994). Soils in urban and industrial environments. *Zeitschrift für Pflanzenernährung und Bodenkunde*, 157(3), pp.205–214. doi:https://doi.org/10.1002/jpln.19941570308.

Buurman, P., Pape, Th. and Muggler, C.C. (1997). LASER GRAIN-SIZE DETERMINATION IN SOIL GENETIC STUDIES 1. PRACTICAL PROBLEMS. *Soil Science*, 162(3), pp.211–218. doi:https://doi.org/10.1097/00010694-199703000-00007.

Cobb, S. (2024). *Teaching Laboratories Manual of Field and Laboratory Methods*. Edited by R. Dejardin. University of Bristol.

Critchley, C.N.R., Chambers, B.J., Fowbert, J.A., Sanderson, R.A., Bhogal, A. and Rose, S.C. (2002). Association between lowland grassland plant communities and soil properties. *Biological Conservation*, [online] 105(2), pp.199–215. doi:https://doi.org/10.1016/s0006-3207(01)00183-5.

Da Re, D., Tordoni, E., Naranjo-Cigala, A., Padrón-Mederos, M.A., González, M., González-Montelongo, C. and Arévalo-Sierra, J.R. (2024). Assessing the impacts of land use and climate change on the distribution patterns of Ulex europaeus L. (Fabaceae) in the Canary Islands. *Biological Invasions*, 26(12), pp.4363–4379. doi:https://doi.org/10.1007/s10530-024-03452-w.

Drescher, G.L., Slaton, N.A., Ahmad, U., Smartt, A.D., Roberts, T.L. and Gbur, E.E. (2024). Soil moisture and probe characteristics affect core integrity and soil test results. *Soil Science Society of America Journal*, 88(4), pp.1216–1233. doi:https://doi.org/10.1002/saj2.20696.

Edmondson, J.L., Davies, Z.G., McHugh, N., Gaston, K.J. and Leake, J.R. (2012). Organic carbon hidden in urban ecosystems. *Scientific Reports*, 2(1). doi:https://doi.org/10.1038/srep00963.

Egunjobi, J.K. (1971). Ecosystem Processes in a Stand of Ulex Europaeus L.: II. The Cycling of Chemical Elements in the Ecosystem. *The Journal of Ecology*, 59(3), p.669. doi:https://doi.org/10.2307/2258132.

Eldridge, D.J., Bowker, M.A., Maestre, F.T., Roger, E., Reynolds, J.F. and Whitford, W.G. (2011). Impacts of shrub encroachment on ecosystem structure and functioning: towards a global synthesis. *Ecology Letters*, [online] 14(7), pp.709–722. doi:https://doi.org/10.1111/j.1461-0248.2011.01630.x.

Flint, A. M. (2018) A temporal and spatial analysis of species co-occurrence patterns within a chalk heath community. PhD thesis. University of Brighton. Avaliable at: https://cris.brighton.ac.uk/ws/files/6413098/Amanda_Flint_PhD_2018.pdf (Accessed: 25 March 2026).

Flores-Ramírez, E., Abel, S. and Nehls, T. (2018). Water retention characteristics of coarse porous materials to construct purpose-designed plant growing media. *Soil Science and Plant Nutrition*, 64(2), pp.181–189. doi:https://doi.org/10.1080/00380768.2018.1447293.

Friends of Troopers Hill (2026a) Conversation with Avon Project Group 3, 12 March

Friends of Troopers Hill (2026b) Conversation with Avon Project Group 3, 19 January

Galappaththi, H.S.S.D., de Silva, W.A.P.P. and Clavijo Mccormick, A. (2022). A mini-review on the impact of common gorse in its introduced ranges. *Tropical Ecology*, [online] 64, pp.1–25. doi:https://doi.org/10.1007/s42965-022-00239-9.

Grubb, P.J., Green, H.E. and Merrifield, R.C.J. (1969). The Ecology of Chalk Heath: Its Relevance to the Calcicole--Calcifuge and Soil Acidification Problems. *The Journal of Ecology*, 57(1), p.175. doi:https://doi.org/10.2307/2258215.

He, L., Sun, X., Li, S., Zhou, W., Chen, Z. and Bai, X. (2023). The vertical distribution and control factor of microbial biomass and bacterial community at macroecological scales. *Science of the total environment*, 869, pp.161754–161754. doi:https://doi.org/10.1016/j.scitotenv.2023.161754.

Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil nutrients [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/7055965b-7fe5-442b-902d-63193cbe001c

Hisashi Kato-Noguchi, Kato, M., Hisashi Kato-Noguchi and Kato, M. (2025). The Impact of Life History Traits and Defensive Abilities on the Invasiveness of Ulex europaeus L. *Diversity*, [online] 17(11), pp.805–805. doi:https://doi.org/10.3390/d17110805.

Hoogsteen, M.J.J., Lantinga, E.A., Bakker, E.J., Groot, J.C.J. and Tittonell, P.A. (2015). Estimating soil organic carbon through loss on ignition: effects of ignition conditions and structural water loss. *European Journal of Soil Science*, 66(2), pp.320–328. doi:https://doi.org/10.1111/ejss.12224.

Joshi, N., Kaur, R., Fahad, S. and Nawaz, T. (2026). Chapter 10: Effects of soil texture and structure on nutrient chemistry and plant uptake. In: S. Saud, S. Fahad, D. Wang and T. Nawaz, eds., *Sustainable Soil Chemistry and Plant Nutrition*. Elsevier, pp.251–270.

Leary, J.K., Hue, N.V., Singleton, P.W. and Borthakur, D. (2005). The major features of an infestation by the invasive weed legume gorse (Ulex europaeus) on volcanic soils in Hawaii. *Biology and Fertility of Soils*, 42(3), pp.215–223. doi:https://doi.org/10.1007/s00374-005-0018-9.

Maddock, A. (2008). *UK Biodiversity Action Plan Priority Habitat Descriptions (Acid Grassland)*. [online] JNCC Resource Hub. Available at: https://data.jncc.gov.uk/data/902cafcb-578f-43de-8a99-7143f00d79a2/UKBAP-BAPHabitats-26-LowlandDryAcidGrass.pdf.

Magesan, G.N., Wang, H. and Clinton, P.W. (2012). Nitrogen cycling in gorse-dominated ecosystems in New Zealand. *New Zealand Journal of Ecology*, [online] 36(1). Available at: https://www.jstor.org/stable/24060871 [Accessed 10 Apr. 2026].

Meng, F., Hu, K., Feng, P., Feng, G. and Gao, Q. (2022). Simulating the Effects of Different Textural Soils and N Management on Maize Yield, N Fates, and Water and N Use Efficiencies in Northeast China. *Plants*, 11(23), pp.3338–3338. doi:https://doi.org/10.3390/plants11233338.

Met Office (2026). *January 2026 weather stats: A regional breakdown*. [online] Met Office. Available at: https://www.metoffice.gov.uk/blog/2026/january-2026-regional-weather-stats.

Mitchell, R.J., Marrs, R.H., Le Duc, M.G. and Auld, M.H.D. (1997). A Study of Succession on Lowland Heath in Dorset, Southern England: Changes in Vegetation and Soil Chemical Properties. *Journal of Applies Ecology*, 34(6), pp.1426–1444.

Neina, D. (2019). The Role of Soil pH in Plant Nutrition and Soil Remediation. *Applied and Environmental Soil Science*, [online] 2019(5794869), pp.1–9. doi:https://doi.org/10.1155/2019/5794869.

Nie, Kun & Xu, Ming & Zhang, Jian. (2023). Changes in soil carbon, nitrogen, and phosphorus in Pinus massoniana forest along altitudinal gradients of subtropical karst mountains. PeerJ. 11. e15198. 10.7717/peerj.15198.

Ordnance Survey (2025). *Troopers Hill, Bristol- Geology*. Digimap Geology.

Ortiz, S.K. and Wolf, A.A. (2024). Nitrogen-fixing plants increase soil nitrogen and neighbouring-plant biomass, but decrease community diversity: A meta-analysis reveals the mediating role of soil texture. *Journal of Ecology*, 112(10), pp.2374–2385. doi:https://doi.org/10.1111/1365-2745.14402.

Penn, C.J. and Camberato, J.J. (2019). A Critical Review on Soil Chemical Processes that Control How Soil pH Affects Phosphorus Availability to Plants. *Agriculture*, [online] 9(6), p.120. doi:https://doi.org/10.3390/agriculture9060120.

Potash, E., Guan, K., Margenot, A.J., Lee, D., Boe, A., Douglass, M., Heaton, E., Jang, C., Jin, V., Li, N., Mitchell, R., Nictor Namoi, Schmer, M., Wang, S. and Zumpf, C. (2023). Multi-site evaluation of stratified and balanced sampling of soil organic carbon stocks in agricultural fields. *Geoderma*, 438, pp.116587–116587. doi:https://doi.org/10.1016/j.geoderma.2023.116587.

Reyes, O. and Casal, M. (2004). Effects of forest fire ash on germination and early growth of four pinus species. *Plant Ecology formerly `Vegetatio'*, 175(1), pp.81–89. doi:https://doi.org/10.1023/b:vege.0000048089.25497.0c.

Robinson, D.A., Campbell, C.S., Hopmans, J.W., Hornbuckle, B.K., Jones, S.B., Knight, R., Ogden, F., Selker, J. and Wendroth, O. (2008). Soil Moisture Measurement for Ecological and Hydrological Watershed-Scale Observatories: A Review. *Vadose Zone Journal*, 7(1), pp.358–389. doi:https://doi.org/10.2136/vzj2007.0143.

Rotich, B., Chabari, S., Soi, B. and Kipkulei, H. (2025). Influence of elevation, soil depth and climatic variables on soil physicochemical properties: a case study of farmlands on the eastern slopes of Mount Kenya. *Discover Soil*, 2(1). doi:https://doi.org/10.1007/s44378-025-00102-y.

Sahrawat, K.L. (2008). Factors Affecting Nitrification in Soils. *Communications in Soil Science and Plant Analysis*, 39(9-10), pp.1436–1446. doi:https://doi.org/10.1080/00103620802004235.

Schimel, J.P. and Schaeffer, S.M. (2012). Microbial control over carbon cycling in soil. *Frontiers in Microbiology*, 3. doi:https://doi.org/10.3389/fmicb.2012.00348.

Soto, B. and Diaz-Fierros, F. (1997). Soil water balance as affected by throughfall in gorse (Ulex europaeus, L.) shrubland after burning. *Journal of Hydrology*, 195(1-4), pp.218–231. doi:https://doi.org/10.1016/s0022-1694(96)03232-5.

Tarayre, M., Bowman, G., Schermann-Legionnet, A., Barat, M. and Atlan, A. (2007). Flowering phenology of Ulex europaeus: ecological consequences of variation within and among populations. *Evolutionary Ecology*, 21(3), pp.395–409. doi:https://doi.org/10.1007/s10682-006-9109-9.

Tibbett, M. (2019). Long-term acidification of pH neutral grasslands affects soil biodiversity, fertility and function in a heathland restoration. *CATENA*, [online] 180, pp.401–415. doi:https://doi.org/10.1016/j.catena.2019.03.013.

Udo, N., Tarayre, M. and Atlan, A. (2016). Evolution of germination strategy in the invasive speciesUlex europaeus. *Journal of Plant Ecology*, p.rtw032. doi:https://doi.org/10.1093/jpe/rtw032.

Van Auken, O.W. (2009). Causes and consequences of woody plant encroachment into western North American grasslands. *Journal of Environmental Management*, 90(10), pp.2931–2942. doi:https://doi.org/10.1016/j.jenvman.2009.04.023.

Vitousek, P.M., Cassman, K., Cleveland, C., Crews, T., Field, C.B., Grimm, N.B., Howarth, R.W., Marino, R., Martinelli, L., Rastetter, E.B. and Sprent, J.I. (2002). Towards an ecological understanding of biological nitrogen fixation. *Biogeochemistry*, 57(1), pp.1–45. doi:https://doi.org/10.1023/a:1015798428743.

Wardle, D.A. (2004). Ecological Linkages Between Aboveground and Belowground Biota. *Science*, 304(5677), pp.1629–1633. doi:https://doi.org/10.1126/science.1094875.

Weil, R.R. and Brady, N.C. (2017). *The nature and properties of soils*. Harlow Essex: Pearson Education Limited.

Wessex Ecological Consultancy (2019). *Troopers Hill Local Nature Reserve Management Plan*. [online] Available at: https://www.troopers-hill.org.uk/plan/ManPlan2019.pdf [Accessed 12 Apr. 2026].

Wessex Ecological Consultancy (2021). *Troopers Hill Local Nature Reserve photographic Monitoring*. [online] Available at: https://www.troopers-hill.org.uk/Photos/PhotoReport2021.pdf [Accessed 12 Apr. 2026].

Yao, H., Gao, Y., Nicol, G.W., Campbell, C.D., Prosser, J.I., Zhang, L., Han, W. and Singh, B.K. (2011). Links between Ammonia Oxidizer Community Structure, Abundance, and Nitrification Potential in Acidic Soils. *Applied and Environmental Microbiology*, 77(13), pp.4618–4625. doi:https://doi.org/10.1128/aem.00136-11.

Zhang, X., Xiang, D.-Q., Yang, C., Wu, W. and Liu, H.-B. (2022). The spatial variability of temporal changes in soil pH affected by topography and fertilization. *CATENA*, 218, p.106586. doi:https://doi.org/10.1016/j.catena.2022.106586.

Appendix A.

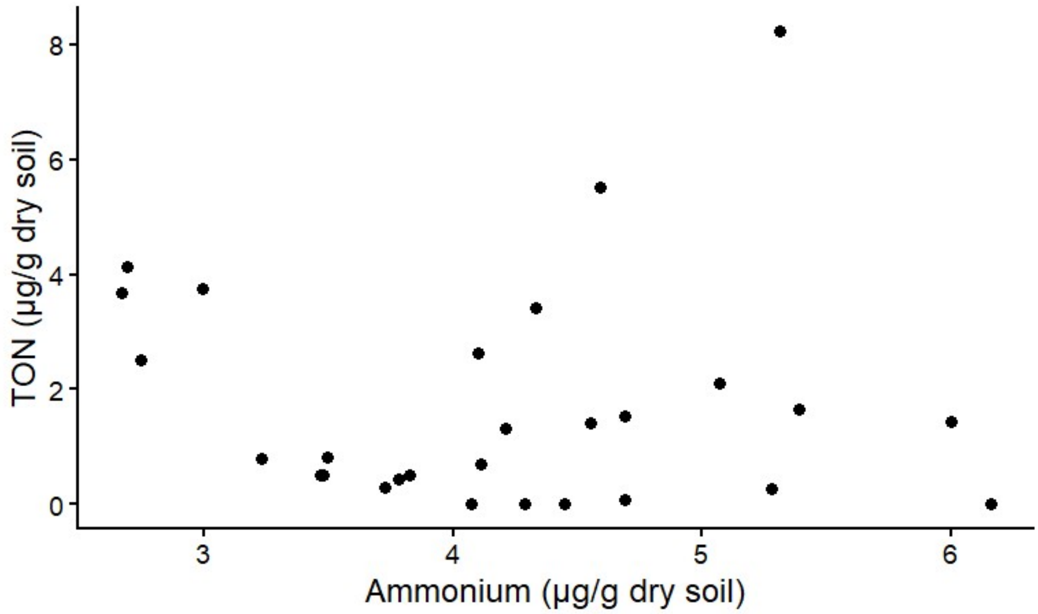

Figure 1: Scatter graph showing minimal relationship between TON and Ammonium

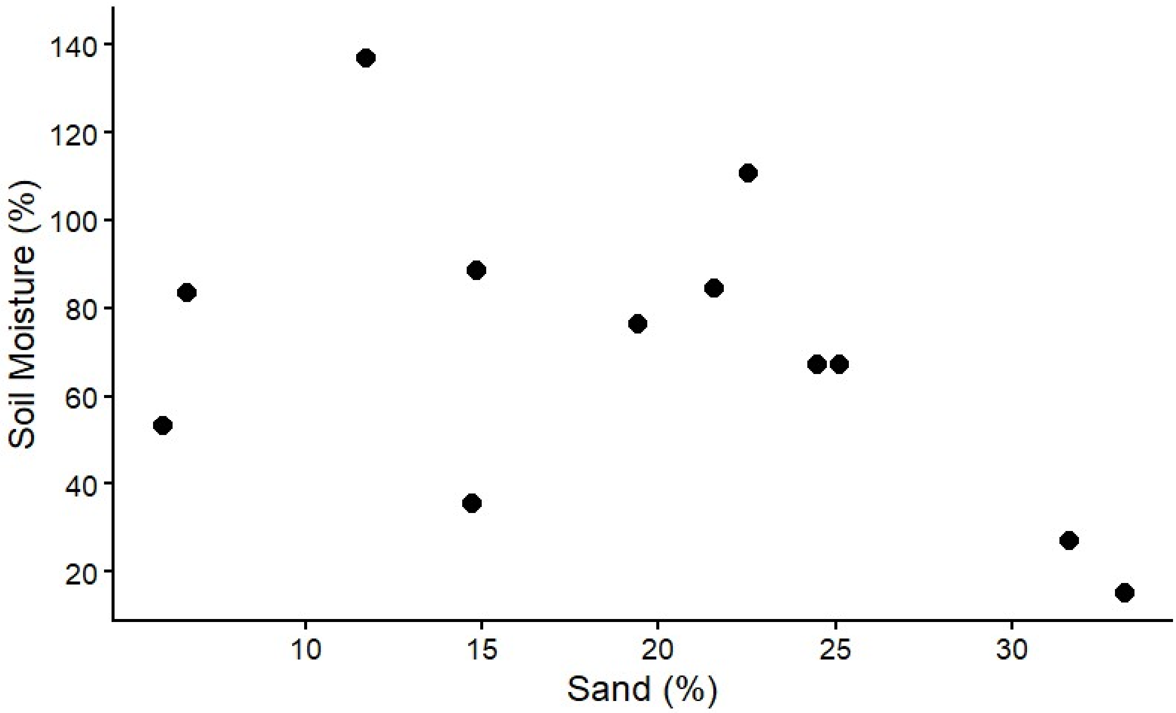

Figure 2: Scatterplot showing minimal relationship between Soil Moisture (%) and Sand (%) (R2 = 0.1298, p-value = 0.1489)

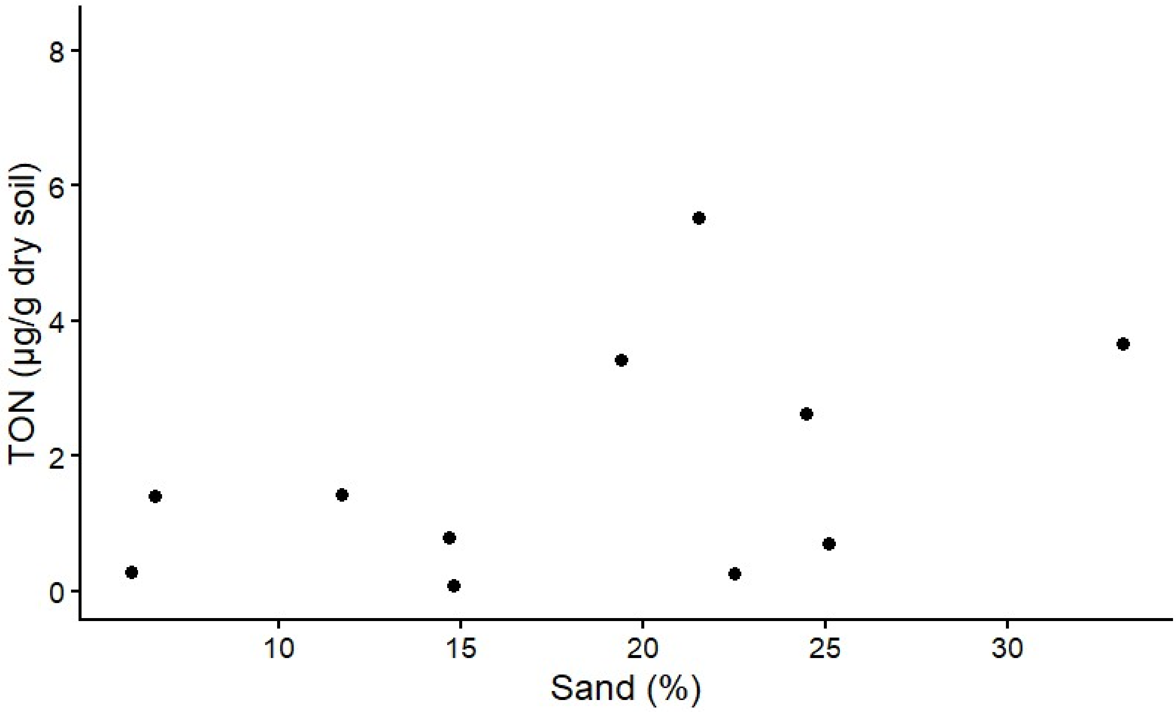

Figure 3: Scatterplot showing minimal relationship between TON and Sand (%) (R2 = 0.1263, p-value = 0.1386)

Appendix B.

Complete dataset:

Sample	Gorse Cover	Site	Latitude	Longitude	Elevation (m)	Volumetric Soil Moisture (%)	Gravimetric Soil Moisture (%)	pH
1.1	Established	1	51.455	-2.533702	NA	13.04	15.31	4.694
1.2	Established	1	51.45498	-2.533693	NA	20.84	15.36	4.581
1.3	Established	1	51.45498	-2.533703	NA	18.28	27.15	4.238
1.4	Established	1	51.45499	-2.533713	NA	17.62	26.29	4.464
1.5	Established	1	51.45498	-2.53371	48.4	17.4	17.19	4.25
2.1	Established	2	51.4552	-2.534457	NA	53.64	84.75	4.436
2.2	Established	2	51.45517	-2.534465	NA	36.24	88.6	4.768
2.3	Established	2	51.45423	-2.534364	NA	29.58	67.42	4.616
2.4	Established	2	51.45519	-2.534467	NA	34.5	44.01	4.739
2.5	Established	2	51.45444	-2.534663	49.6	41.34	73.6	4.525
3.1	Early-stage	3	51.45524	-2.534717	NA	30.18	83.71	4.648
3.2	Early-stage	3	51.45524	-2.534683	NA	33.14	55.81	4.731
3.3	Early-stage	3	51.45523	-2.534721	NA	36.2	111.03	4.769
3.4	Early-stage	3	51.4552	-2.534668	NA	41.48	102.49	4.691
3.5	Early-stage	3	51.45516	-2.534707	48.4	47.54	114.2	4.659
4.1	Early-stage	4	51.45389	-2.525538	NA	25.02	67.41	4.043
4.2	Early-stage	4	51.45496	-2.534595	NA	33.26	65.69	4.189
4.3	Early-stage	4	51.45492	-2.534615	NA	36.72	88.82	4.465
4.4	Early-stage	4	51.45493	-2.534648	NA	41.72	79.57	4.445
4.5	Early-stage	4	51.45456	-2.534	43.6	46.38	142.1	4.233
5.1	Control	5	51.45514	-2.534859	NA	42.24	76.44	4.601
5.2	Control	5	51.45524	-2.534831	NA	51.82	70.95	4.362
5.3	Control	5	51.45513	-2.534838	NA	48.08	136.92	4.609
5.4	Control	5	51.45512	-2.534871	NA	37.74	141.88	4.441
5.5	Control	5	51.45514	-2.534853	44.8	41.5	111.31	4.483
6.1	Control	6	51.45518	-2.535135	NA	49.14	53.24	4.915
6.2	Control	6	51.45438	-2.535848	NA	39.98	44.34	5.113
6.3	Control	6	51.45518	-2.53511	NA	43.9	35.56	4.847
6.4	Control	6	51.4552	-2.534996	NA	42.18	57.49	5.076
6.5	Control	6	51.45523	-2.535133	46.7	44.94	44.81	4.757

Sample	Organic Matter (%)	Phosphate	Ammonium	TON	Clay	Silt	Sand
1.1	11.45	6.628397	2.670293	3.676122	3.542	63.286	33.17
1.2	11.73	2.131	2.692575	4.123862	NA	NA	NA
1.3	20.39	2.680719	3.018325	21.6727	2.698	65.72	31.584
1.4	14.95	1.7377	2.993028	3.746411	NA	NA	NA
1.5	13.96	1.105878	2.746909	2.510512	NA	NA	NA
2.1	30.96	2.037912	4.592304	5.522992	2.286	76.17	21.536
2.2	28.75	1.931936	4.690089	1.543711	NA	NA	NA
2.3	27.42	4.632843	4.099865	2.623644	2.778	72.74	24.48
2.4	18.83	1.978607	3.477258	0.510821	NA	NA	NA
2.5	28.71	3.182673	4.287297	0	NA	NA	NA
3.1	31.86	1.993286	4.553475	1.420898	4.278	89.094	6.622
3.2	25.85	1.839572	3.783776	0.444472	NA	NA	NA
3.3	36.54	2.271172	5.279422	0.270509	3.054	74.436	22.51
3.4	41.69	2.471499	5.070667	2.108985	NA	NA	NA
3.5	NA	5.342963	5.390198	1.643587	NA	NA	NA
4.1	29.09	1.940438	4.109838	0.69808	2.07	72.834	25.092
4.2	24.83	1.665231	4.071397	0	NA	NA	NA
4.3	34.57	4.219506	4.692736	0.091338	2.546	82.618	14.83
4.4	29.46	1.941208	4.448271	0	NA	NA	NA
4.5	47.85	3.995737	6.158405	0	NA	NA	NA
5.1	28.09	9.570176	4.334264	3.426503	2.212	78.376	19.398
5.2	24.25	2.824511	4.212495	1.320686	NA	NA	NA
5.3	43	2.980727	6.001433	1.439421	2.446	85.804	11.722
5.4	47.41	NA	NA	NA	NA	NA	NA
5.5	41.76	2.348567	5.314071	8.238743	NA	NA	NA
6.1	16.79	1.339078	3.728891	0.295962	4.314	89.746	5.946
6.2	14.73	1.356297	3.470043	0.502526	NA	NA	NA
6.3	9.78	0.835089	3.231846	0.802163	4.744	80.558	14.702
6.4	18.27	2.699821	3.824086	0.513851	NA	NA	NA
6.5	14.37	1.30279	3.49497	0.813578	NA	NA	NA

TON (µg/g of dry soil) Secondary Dataset:

Our Data	Avon Project 2024	Avon Project 2025
3.676122499	4.56580212	3.322253435
4.123861994	9.169716694	0.912366348
21.67270067	6.85449126	2.098192518
3.746411104	4.450425085	2.746890048
2.510512272	8.356712826	1.464629105
5.522992437	3.941396498	1.24370884
1.543711292	3.318842397	0.152355536
2.623643812	2.244105916	3.433965695
0.510821139	3.309420372	4.400665029
0	2.539820434	9.150431193
1.420897674	0	12.5929952
0.444471522	6.72816994	6.896186879
0.270509449	0.15781095	8.722367982
2.108984917	0.123759909	11.06973419
1.643586734	0	5.335694177
0.698079993	0	9.489103054
0	0	0.600954526
0.091338325	8.538814474	0.884428189
0	0	1.104087646
0	0	0.867079632
	6.521922466	4.394355723
	0.746169118	2.27575681
	1.052860415	0.992892158
	0.305115899	0.831848974
	0.296389903	6.867444895
		1.401573663
		2.022196945
		1.466738857
		0.530388293
		0.975304288

Ammonium (µg/g of dry soil):

Our Data	Avon Project 2024	Avon Project 2025
2.670292705	0.941559609	6.147664977
2.692575488	0.734533925	3.795815262
3.018325208	0.569328349	5.654590525
2.993027684	0.596376262	5.158598479
2.74690851	0.983853338	4.354862881
4.592303584	6.241822167	6.666799038
4.690089168	6.118861515	2.979372849
4.099864954	6.103112698	3.052621037
3.47725799	3.637970193	12.95058873
4.287297144	3.800291536	6.576643206
4.553475424	4.3174343	11.09406403
3.783775564	1.238846531	11.97881286
5.27942218	2.693443983	10.98256171
5.070667401	1.490280339	5.602298051
5.390197947	1.056280526	26.43342272
4.109838199	0.750157792	11.05977567
4.07139666	0.875657557	11.03700129
4.692736192	2.819959169	13.04321056
4.448271262	1.27154103	11.62230364
6.158404587	0.953530924	1.93559833
	2.508902646	31.04089021
	5.410426572	9.844511853
	3.339614781	4.227684639
	1.533324334	3.742077782
	1.004656902	34.72372636
		9.649139386
		3.533179204
		5.335184185
		4.048765957
		5.25017499

Phosphate (µg/g of dry soil) Secondary Dataset:

Our Data	Avon Project 2024	Avon Project 2025
6.628397206	0.754436726	0.106143548
2.130999714	2.059857845	0.070343121
2.680718703	1.06009811	0.085637845
1.737699655	3.059408907	0.233567961
1.105878363	1.473841267	0.429514535
2.037912134	0.158870218	0.032251443
1.93193591	0.3702441	0.073910798
4.632842907	0.134773458	0.479872741
1.978607211	0.129759956	0.443372093
3.182673346	0.080424926	0.403398698
1.993285998	0.201798032	0.609467724
1.839572481	1.006577241	0.294518339
2.271171569	0.618568785	0.85027482
2.471499294	0.139616886	0.180718647
5.342962955	0.162735434	1.777393138
1.940437966	0.172293462	1.300370945
1.665231438	0.023218234	0.600954526
4.219505929	0.793990653	0.884428189
1.941207692	0.066669859	1.104087646
3.99573691	0.033301767	0.867079632
	1.820729181	4.394355723
	0.145310942	2.27575681
	0.151160593	0.992892158
	0.072408296	0.831848974
	0.018497067	6.867444895
		1.401573663
		2.022196945
		1.466738857
		0.530388293
		0.975304288

pH secondary data:

Other Studies	AP (2024)	AP (2025)	Our Data
4.4	6.044	5.281	4.694
4.6	6.808	5.078	4.581
4	7.1	5.603	4.238
5.9	6.758	5.045	4.464
4.1	6.785	4.945	4.25
5.4	5.245	4.951	4.436
4.7	5.14	4.86	4.768
4.1	5.28	4.248	4.616
3.85	5.494	6.225	4.739
3.5	4.346	5.45	4.525
4.5	4.992	6.384	4.648
3.4	3.875	5.972	4.731
4.4	6.531	5.935	4.769
3.9	5.623	6.678	4.691
4.3	4.571	5.594	4.659
4.7	4.463	5.108	4.043
	4.315	4.623	4.189
	4.279	4.83	4.465
	4.445	4.606	4.445
	4.281	4.688	4.233
	4.747	5.395	4.601
	5.505	5.29	4.362
	5.185	4.562	4.609
	5.75	5.706	4.441
	5.696	6.296	4.483
		6.505	4.915
		6.841	5.113
		6.726	4.847
		6.617	5.076
		6.298	4.757

Mastersizer raw data:

Size (µm)	1.1 Average	1.3 Average	2.1 Average	2.3 Average	3.1 Average	3.3 Average	4.1 Average	4.3 Average	5.1 Average	5.3 Average	6.1 Average	6.3 Average
0.01	0	0	0	0	0	0	0	0	0	0	0	0
0.0114	0	0	0	0	0	0	0	0	0	0	0	0
0.0129	0	0	0	0	0	0	0	0	0	0	0	0
0.0147	0	0	0	0	0	0	0	0	0	0	0	0
0.0167	0	0	0	0	0	0	0	0	0	0	0	0
0.0189	0	0	0	0	0	0	0	0	0	0	0	0
0.0215	0	0	0	0	0	0	0	0	0	0	0	0
0.0244	0	0	0	0	0	0	0	0	0	0	0	0
0.0278	0	0	0	0	0	0	0	0	0	0	0	0
0.0315	0	0	0	0	0	0	0	0	0	0	0	0
0.0358	0	0	0	0	0	0	0	0	0	0	0	0
0.0407	0	0	0	0	0	0	0	0	0	0	0	0
0.0463	0	0	0	0	0	0	0	0	0	0	0	0
0.0526	0	0	0	0	0	0	0	0	0	0	0	0
0.0597	0	0	0	0	0	0	0	0	0	0	0	0
0.0679	0	0	0	0	0	0	0	0	0	0	0	0
0.0771	0	0	0	0	0	0	0	0	0	0	0	0
0.0876	0	0	0	0	0	0	0	0	0	0	0	0
0.0995	0	0	0	0	0	0	0	0	0	0	0	0
0.113	0	0	0	0	0	0	0	0	0	0	0	0
0.128	0	0	0	0	0	0	0	0	0	0	0	0
0.146	0	0	0	0	0	0	0	0	0	0	0	0
0.166	0	0	0	0	0	0	0	0	0	0	0	0
0.188	0	0	0	0	0	0	0	0	0	0	0	0
0.214	0	0	0	0	0	0	0	0	0	0	0	0
0.243	0	0	0	0	0	0	0	0	0	0	0	0
0.276	0	0	0	0	0	0	0	0	0	0	0	0
0.314	0	0	0	0	0	0	0	0	0	0	0	0
0.357	0	0	0	0	0	0	0	0	0	0	0	0
0.405	0	0	0	0	0	0	0	0	0	0	0	0
0.46	0	0	0	0	0	0	0	0	0	0	0	0
0.523	0	0	0	0	0	0	0	0	0	0	0	0
0.594	0	0	0	0	0	0	0	0	0	0	0	0
0.675	0	0	0	0	0	0	0	0	0	0	0	0
0.767	0	0	0	0	0	0	0	0	0	0	0	0
0.872	0	0	0	0	0	0	0	0	0	0	0	0
0.991	0.12	0	0	0	0	0	0	0	0	0	0	0.17
1.13	0.272	0.12	0.07	0.118	0.17	0.146	0.09	0.1	0.07	0.074	0.194	0.372
1.28	0.466	0.3	0.224	0.3	0.464	0.348	0.23	0.278	0.22	0.24	0.478	0.632
1.45	0.68	0.524	0.436	0.536	0.832	0.596	0.406	0.498	0.428	0.47	0.838	0.918
1.65	0.898	0.764	0.664	0.788	1.222	0.856	0.586	0.728	0.642	0.712	1.214	1.198
1.88	1.106	0.99	0.892	1.036	1.59	1.108	0.758	0.942	0.852	0.95	1.59	1.454
2.13	1.306	1.204	1.114	1.284	1.946	1.352	0.918	1.144	1.052	1.178	1.96	1.68
2.42	1.49	1.412	1.348	1.544	2.31	1.608	1.078	1.35	1.252	1.42	2.348	1.894
2.75	1.674	1.626	1.606	1.826	2.698	1.886	1.244	1.564	1.47	1.692	2.766	2.11
3.12	1.848	1.836	1.886	2.12	3.104	2.176	1.422	1.804	1.694	1.996	3.198	2.336
3.55	2.014	2.044	2.176	2.416	3.498	2.476	1.61	2.058	1.922	2.31	3.616	2.558
4.03	2.17	2.242	2.454	2.698	3.856	2.764	1.808	2.326	2.138	2.628	3.992	2.79
4.58	2.322	2.436	2.734	2.962	4.176	3.056	2.018	2.62	2.342	2.944	4.316	3.042
5.21	2.474	2.642	3.022	3.222	4.466	3.35	2.246	2.95	2.556	3.274	4.598	3.33
5.92	2.632	2.866	3.326	3.474	4.734	3.656	2.5	3.322	2.782	3.62	4.838	3.656
6.72	2.786	3.108	3.638	3.728	4.982	3.964	2.778	3.736	3.026	3.984	5.038	4.022
7.64	2.94	3.366	3.958	3.968	5.196	4.262	3.072	4.174	3.294	4.352	5.188	4.396
8.68	3.078	3.616	4.264	4.176	5.354	4.516	3.368	4.608	3.568	4.704	5.276	4.744
9.86	3.184	3.844	4.534	4.342	5.438	4.698	3.65	5.004	3.836	5.014	5.294	5.02
11.2	3.254	4.008	4.742	4.434	5.426	4.772	3.902	5.314	4.074	5.252	5.222	5.172
12.7	3.274	4.082	4.858	4.424	5.292	4.714	4.1	5.496	4.262	5.38	5.062	5.152
14.5	3.234	4.034	4.846	4.302	5.032	4.5	4.218	5.518	4.364	5.374	4.798	4.934
16.4	3.132	3.844	4.698	4.052	4.636	4.142	4.246	5.348	4.364	5.218	4.438	4.52
18.7	2.97	3.522	4.392	3.688	4.124	3.658	4.168	4.988	4.248	4.894	3.996	3.946
21.2	2.758	3.078	3.938	3.234	3.52	3.096	3.986	4.456	4.012	4.43	3.488	3.276
24.1	2.522	2.568	3.358	2.716	2.864	2.51	3.71	3.788	3.684	3.856	2.936	2.6
27.4	2.278	2.034	2.704	2.182	2.202	1.954	3.364	3.06	3.304	3.216	2.372	2.002
31.1	2.046	1.548	2.036	1.664	1.582	1.472	2.982	2.334	2.936	2.572	1.814	1.552
35.3	1.842	1.154	1.428	1.21	1.05	1.086	2.61	1.698	2.632	1.984	1.302	1.262
40.1	1.672	0.902	0.964	0.866	0.646	0.818	2.278	1.214	2.438	1.498	0.858	1.126
45.6	1.538	0.802	0.696	0.676	0.39	0.662	2.014	0.93	2.356	1.15	0.518	1.094
51.8	1.444	0.862	0.65	0.672	0.28	0.616	1.828	0.854	2.364	0.958	0.302	1.132
58.9	1.404	1.04	0.8	0.86	0.292	0.672	1.716	0.96	2.406	0.906	0.212	1.212
66.9	1.426	1.282	1.088	1.2	0.38	0.816	1.652	1.174	2.414	0.964	0.252	1.318
76	1.528	1.532	1.416	1.62	0.498	1.016	1.608	1.396	2.34	1.09	0.386	1.422
86.4	1.704	1.734	1.702	2.018	0.614	1.232	1.566	1.556	2.154	1.226	0.56	1.488
98.1	1.932	1.848	1.888	2.3	0.688	1.414	1.514	1.592	1.876	1.316	0.712	1.492
111	2.176	1.866	1.936	2.4	0.71	1.53	1.458	1.5	1.554	1.318	0.792	1.416
127	2.404	1.788	1.852	2.302	0.68	1.574	1.414	1.288	1.25	1.22	0.782	1.276
144	2.598	1.666	1.668	2.036	0.608	1.568	1.402	0.996	1.022	1.044	0.69	1.094
163	2.748	1.566	1.436	1.672	0.518	1.556	1.436	0.68	0.87	0.82	0.554	0.898
186	2.84	1.556	1.216	1.306	0.43	1.566	1.504	0.418	0.794	0.606	0.398	0.706
211	2.864	1.676	1.058	1.016	0.36	1.602	1.602	0.254	0.754	0.434	0.26	0.54
240	2.788	1.91	0.982	0.854	0.314	1.644	1.714	0.226	0.732	0.332	0.16	0.436
272	2.582	2.188	0.97	0.828	0.276	1.656	1.786	0.316	0.714	0.292	0.094	0.406
310	2.216	2.4	0.976	0.896	0.238	1.59	1.774	0.478	0.69	0.282	0.076	0.432
352	1.708	2.442	0.958	0.978	0.184	1.416	1.634	0.636	0.64	0.276	0.08	0.468
400	1.116	2.258	0.868	0.994	0.106	1.128	1.358	0.716	0.562	0.244	0.078	0.472
454	0.522	1.842	0.702	0.892	0.018	0.764	0.972	0.678	0.44	0.176	0.05	0.41
516	0.018	1.268	0.482	0.666	0	0.386	0.558	0.52	0.294	0.066	0.022	0.272
586	0	0.674	0.252	0.382	0	0.052	0.14	0.304	0.14	0.016	0	0.134
666	0	0.088	0.076	0.12	0	0	0	0.102	0.05	0	0	0.022
756	0	0	0.01	0	0	0	0	0	0.026	0	0	0
859	0	0	0	0	0	0	0	0	0.024	0	0	0
976	0	0	0	0	0	0	0	0	0.022	0	0	0
1110	0	0	0	0	0	0	0	0	0.02	0	0	0
1260	0	0	0	0	0	0	0	0	0.016	0	0	0
1430	0	0	0	0	0	0	0	0	0	0	0	0
1630	0	0	0	0	0	0	0	0	0	0	0	0
1850	0	0	0	0	0	0	0	0	0	0	0	0
2100	0	0	0	0	0	0	0	0	0	0	0	0
2390	0	0	0	0	0	0	0	0	0	0	0	0
2710	0	0	0	0	0	0	0	0	0	0	0	0
3080	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C.

```
setwd("C:\\Users\\larap\\OneDrive - University of Bristol\\Documents\\Year 2\\Lab and Field
Methods\\Avon Project\\R plots")
Troopers_data <- read.csv("Troopers Hill Dataset.csv")
#Normality of each variable
hist(Troopers_data$Volumetric.Soil.Moisture....,
   breaks = 15,
   xlab = "Soil Moisture (%)",
   main = NULL)
shapiro.test(Troopers_data$Volumetric.Soil.Moisture....)
hist(Troopers_data$Gravimetric.Soil.Moisture....,
   breaks = 15,
   xlab = "Soil Moisture (%)",
   main = NULL)
shapiro.test(Troopers_data$Gravimetric.Soil.Moisture....)
hist(Troopers_data$pH,
   breaks = 15,
   xlab = "pH",
   main = NULL)
shapiro.test(Troopers_data$pH)
hist(Troopers_data$Organic.Matter....,
   breaks = 15,
   xlab = "Organic Matter (%)",
   main = NULL)
shapiro.test(Troopers_data$Organic.Matter....)
Site_1 <- Troopers_data[Troopers_data$Site == "1", ]
Site_2 <- Troopers_data[Troopers_data$Site == "2", ]
Site_3 <- Troopers_data[Troopers_data$Site == "3", ]
Site_4 <- Troopers_data[Troopers_data$Site == "4", ]
Site_5 <- Troopers_data[Troopers_data$Site == "5", ]
Site_6 <- Troopers_data[Troopers_data$Site == "6", ]
shapiro.test(Site_1$Organic.Matter....)
shapiro.test(Site_2$Organic.Matter....)
shapiro.test(Site_3$Organic.Matter....)
shapiro.test(Site_4$Organic.Matter....)
shapiro.test(Site_5$Organic.Matter....)
shapiro.test(Site_6$Organic.Matter....)
shapiro.test(Site_1$pH)
shapiro.test(Site_2$pH)
shapiro.test(Site_3$pH)
shapiro.test(Site_4$pH)
shapiro.test(Site_5$pH)
shapiro.test(Site_6$pH)
shapiro.test(Site_1$Gravimetric.Soil.Moisture....)
```

```
shapiro.test(Site_2$Gravimetric.Soil.Moisture....)
shapiro.test(Site_3$Gravimetric.Soil.Moisture....)
shapiro.test(Site_4$Gravimetric.Soil.Moisture....)
shapiro.test(Site_5$Gravimetric.Soil.Moisture....)
shapiro.test(Site_6$Gravimetric.Soil.Moisture....)
shapiro.test(Site_1$Volumetric.Soil.Moisture....)
shapiro.test(Site_2$Volumetric.Soil.Moisture....)
shapiro.test(Site_3$Volumetric.Soil.Moisture....)
shapiro.test(Site_4$Volumetric.Soil.Moisture....)
shapiro.test(Site_5$Volumetric.Soil.Moisture....)
shapiro.test(Site_6$Volumetric.Soil.Moisture....)
shapiro.test(Site_1$TON)
shapiro.test(Site_2$TON)
shapiro.test(Site_3$TON)
shapiro.test(Site_4$TON)
shapiro.test(Site_5$TON)
shapiro.test(Site_6$TON)
shapiro.test(Site_1$Ammonium)
shapiro.test(Site_2$Ammonium)
shapiro.test(Site_3$Ammonium)
shapiro.test(Site_4$Ammonium)
shapiro.test(Site_5$Ammonium)
shapiro.test(Site_6$Ammonium)
shapiro.test(Site_1$Phosphate)
shapiro.test(Site_2$Phosphate)
shapiro.test(Site_3$Phosphate)
shapiro.test(Site_4$Phosphate)
shapiro.test(Site_5$Phosphate)
shapiro.test(Site_6$Phosphate)
hist(Site_3$Organic.Matter...., breaks = 15)
hist(Site_6$Gravimetric.Soil.Moisture....)
Old <- Troopers_data[Troopers_data$Gorse.Cover == 'Established', ]
new <- Troopers_data[Troopers_data$Gorse.Cover == 'Early-stage', ]
control <- Troopers_data[Troopers_data$Gorse.Cover == 'Control', ]
shapiro.test(Old$Organic.Matter....)
shapiro.test(new$Organic.Matter....)
shapiro.test(control$Organic.Matter....)
shapiro.test(Old$pH)
shapiro.test(new$pH)
shapiro.test(control$pH)
shapiro.test(Old$Gravimetric.Soil.Moisture....)
shapiro.test(new$Gravimetric.Soil.Moisture....)
shapiro.test(control$Gravimetric.Soil.Moisture....)
shapiro.test(Old$TON)
shapiro.test(new$TON)
```

```
shapiro.test(control$TON)
shapiro.test(Old$Ammonium)
shapiro.test(new$Ammonium)
shapiro.test(control$Ammonium)
shapiro.test(Old$Phosphate)
shapiro.test(new$Phosphate)
shapiro.test(control$Phosphate)
shapiro.test(Old$Sand)
shapiro.test(new$Sand)
shapiro.test(control$Sand)
shapiro.test(Old$Silt)
shapiro.test(new$Silt)
shapiro.test(control$Silt)
shapiro.test(Old$Clay)
shapiro.test(new$Clay)
shapiro.test(control$Clay)
hist(new$Ammonium,
   breaks = 10,
   xlab = "Ammonium (\u00B5g/g dry soil)",
   main = NULL)
hist(new$Gravimetric.Soil.Moisture....,
   breaks = 10,
   xlab = "Soil Moisture (%)",
   main = NULL)
hist(control$pH,
   breaks = 10,
   xlab = "pH",
   main = NULL)
hist(Site_3$Organic.Matter...., breaks = 15)
hist(Site_6$Gravimetric.Soil.Moisture....,
   breaks = 8,
   xlab = "Soil Moisture (%)",
   main = NULL)
Particle_size <- read.csv("Particle size percentage.csv")
Troopers_data <- read.csv("Troopers Hill Dataset.csv")
if(!require(dplyr)) install.packages("dplyr")
library(dplyr)
if(!require(magrittr)) install.packages("magrittr")
library(magrittr)
gsm_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
 summarise(GSM_mean = mean(Gravimetric.Soil.Moisture....),
       GSM_sd = sd(Gravimetric.Soil.Moisture....),
       min = min(Gravimetric.Soil.Moisture....),
       max = max(Gravimetric.Soil.Moisture....)) %>%
 as.data.frame()
```

```
gsm_av$range <- gsm_av$max - gsm_av$min
gsm_av <- Troopers_data %>% group_by(Gorse.Cover) %>%
  summarise(GSM_mean = mean(Gravimetric.Soil.Moisture....),
        GSM_sd = sd(Gravimetric.Soil.Moisture....),
        min = min(Gravimetric.Soil.Moisture....),
        max = max(Gravimetric.Soil.Moisture....)) %>%
  as.data.frame()
gsm_av$range <- gsm_av$max - gsm_av$min
vsm_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
  summarise(VSM_mean = mean(Volumetric.Soil.Moisture....),
        VSM_sd = sd(Volumetric.Soil.Moisture....)) %>%
  as.data.frame()
om_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
  summarise(OM_mean = mean(Organic.Matter...., na.rm = T),
        OM_sd = sd(Organic.Matter...., na.rm = T)) %>%
  as.data.frame()
om_av <- Troopers_data %>% group_by(Gorse.Cover) %>%
  summarise(OM_mean = mean(Organic.Matter...., na.rm = T),
        OM_sd = sd(Organic.Matter...., na.rm = T),
        min = min(Organic.Matter...., na.rm = T),
        max = max(Organic.Matter...., na.rm = T)) %>%
  as.data.frame()
om_av$range <- om_av$max - om_av$min
pH_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
  summarise(pH_mean = mean(pH),
        pH_sd = sd(pH)) %>%
  as.data.frame()
TON_Troopers <- Troopers_data[Troopers_data$TON < 20 & !is.na(Troopers_data$TON), ]
TON_av <- TON_Troopers %>% group_by(Gorse.Cover, Site) %>%
  summarise(TON_mean = mean(TON, na.rm = T),
        TON_sd = sd(TON, na.rm = T),
        min = min(TON),
        max = max(TON))%>%
 as.data.frame()
TON_av$range <- TON_av$max - TON_av$min
TON_av <- TON_Troopers %>% group_by(Gorse.Cover) %>%
  summarise(TON_mean = mean(TON, na.rm = T),
        TON_sd = sd(TON, na.rm = T),
        min = min(TON),
        max = max(TON))%>%
  as.data.frame()
TON_av$range <- TON_av$max - TON_av$min
amm_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
  summarise(Ammonium_mean = mean(Ammonium, na.rm = T),
        Ammonium_sd = sd(Ammonium, na.rm = T),
```

```
        min = min(Ammonium, na.rm = T),
        max = max(Ammonium, na.rm = T)) %>%
  as.data.frame()
amm_av$range <- amm_av$max - amm_av$min
amm_av2 <- Troopers_data %>% group_by(Gorse.Cover) %>%
  summarise(Ammonium_mean = mean(Ammonium, na.rm = T),
        Ammonium_sd = sd(Ammonium, na.rm = T),
        min = min(Ammonium, na.rm = T),
        max = max(Ammonium, na.rm = T)) %>%
  as.data.frame()
amm_av2$range <- amm_av2$max - amm_av2$min
pho_av <- Troopers_data %>% group_by(Gorse.Cover, Site) %>%
  summarise(Phosphate_mean = mean(Phosphate, na.rm = T),
        Phosphate_sd = sd(Phosphate, na.rm = T),
        min = min(Phosphate, na.rm = T),
        max = max(Phosphate, na.rm = T)) %>%
  as.data.frame()
pho_av$range <- pho_av$max - pho_av$min
sand_av <- Particle_size %>% group_by(Gorse.Cover) %>%
  summarise(Sand_mean = mean(Sand, na.rm = T),
        Sand_sd = sd(Sand, na.rm = T)) %>%
  as.data.frame()
silt_av <- Particle_size %>% group_by(Gorse.Cover) %>%
  summarise(Silt_mean = mean(Silt, na.rm = T),
        Silt_sd = sd(Silt, na.rm = T)) %>%
  as.data.frame()
clay_av <- Particle_size %>% group_by(Gorse.Cover) %>%
  summarise(Clay_mean = mean(Clay, na.rm = T),
        Clay_sd = sd(Clay, na.rm = T)) %>%
  as.data.frame()
Particle_size <- read.csv("Particle size percentage.csv")
Troopers_data <- read.csv("Troopers Hill Dataset.csv")
Troopers_data$Site <- as.factor(Troopers_data$Site)
Nutrients$Site <- as.factor(Nutrients$Site)
if (!require(ggplot2)) install.packages("ggplot2")
library(ggplot2)
ggplot(data = Particle_size,
    aes(x = Gorse.Cover, y = Silt, colour = Gorse.Cover)) +
  geom_line() +
  stat_summary(fun = min,
         geom = "crossbar",
         width = 0.25,
         fatten = 0) +
  stat_summary(fun = mean,
         geom = "crossbar",
```

```
          width = 0.15,
          fatten = 0) +
 stat_summary(fun = max,
          geom = "crossbar",
          width = 0.25,
          fatten = 0) +
 geom_point(size = 2.5) +
 labs(
  x = "Gorse Cover",
  y = "Silt (%)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(60, 90, 5)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none")
ggplot(data = Particle_size,
    aes(x = Gorse.Cover, y = Sand, colour = Gorse.Cover)) +
 geom_line() +
 stat_summary(fun = min,
          geom = "crossbar",
          width = 0.25,
          fatten = 0) +
 stat_summary(fun = mean,
          geom = "crossbar",
          width = 0.15,
          fatten = 0) +
 stat_summary(fun = max,
          geom = "crossbar",
          width = 0.25,
          fatten = 0) +
  geom_point(size = 2.5) +
 labs(
  x = "Gorse Cover",
  y = "Sand (%)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(0, 35, 5)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none",
     axis.text.x = element_text(margin = margin(t = 5)),
     axis.text.y = element_text(margin = margin(r = 5)),
     axis.title.x = element_text(margin = margin(t = 7)),
     axis.title.y = element_text(margin = margin(r = 7)))
```

```r
ggplot(data = Particle_size,
    aes(x = Gorse.Cover, y = Clay, colour = Gorse.Cover)) +
 geom_line() +

 stat_summary(fun = min,
       geom = "crossbar",
       width = 0.25,
       fatten = 0) +
 stat_summary(fun = mean,
       geom = "crossbar",
       width = 0.15,
       fatten = 0) +
 stat_summary(fun = max,
       geom = "crossbar",
       width = 0.25,
       fatten = 0) +

 geom_point(size = 2.5) +
 labs(
  x = "Gorse Cover",
  y = "Clay (%)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(2, 5, 0.5)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none")
ggplot(data = Troopers_data, aes(x = Gorse.Cover, y = pH, colour = Gorse.Cover)) +
 stat_summary(fun = min,
       geom = "crossbar",
       width = 0.25,
       fatten = 0) +
 stat_summary(fun = mean,
       geom = "crossbar",
       width = 0.2,
       fatten = 0) +
 stat_summary(fun = max,
       geom = "crossbar",
       width = 0.25,
       fatten = 0) +
 geom_line() +
 geom_point(size = 2) +
 labs(
  x = "Gorse Cover", y = "pH",
  color = "Gorse Cover"
```

```
 ) +
 scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none")
ggplot(data = Troopers_data, aes(x = Site, y = pH, colour = Gorse.Cover)) +

  stat_summary(fun = min,
         geom = "crossbar",
         width = 0.3,
         fatten = 1) +
 stat_summary(fun = mean,
         geom = "crossbar",
         width = 0.25,
         fatten = 1) +
 stat_summary(fun = max,
         geom = "crossbar",
         width = 0.3,
         fatten = 1) +

 geom_line() +
  geom_point(size = 2) +
 labs(
  x = "Site",
  y = "pH",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Site, y = Gravimetric.Soil.Moisture...., colour =
Gorse.Cover)) +

 stat_summary(fun = min,
         geom = "crossbar",
         width = 0.3,
         fatten = 1) +
 stat_summary(fun = mean,
         geom = "crossbar",
         width = 0.25,
         fatten = 1) +
 stat_summary(fun = max,
         geom = "crossbar",
         width = 0.3,
         fatten = 1) +
```

```
  geom_line() +
  geom_point(size = 2.5) +
  labs(
    x = "Site", y = "Soil Moisture (%)",
    color = "Gorse Cover"
  ) +
  scale_y_continuous(breaks = seq(0, 160, 20)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic() +
  theme(legend.position = "none",
        axis.text.y = element_text(margin = margin(r = 1)),
        axis.title.x = element_text(margin = margin(t = 1)),
        axis.title.y = element_text(margin = margin(r = 2)))
ggplot(data = Troopers_data, aes(x = Gorse.Cover, y = Gravimetric.Soil.Moisture...., colour = Gorse.Cover)) +

  stat_summary(fun = min,
               geom = "crossbar",
               width = 0.25,
               fatten = 1) +
  stat_summary(fun = mean,
               geom = "crossbar",
               width = 0.2,
               fatten = 1) +
  stat_summary(fun = max,
               geom = "crossbar",
               width = 0.25,
               fatten = 1) +

  geom_line() +
  geom_point(size = 2.5) +
  labs(
    x = "Gorse Cover", y = "Soil Moisture (%)",
    color = "Gorse Cover"
  ) +
  scale_y_continuous(breaks = seq(0, 160, 20)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic() +
  theme(legend.position = "none")
ggplot(data = Troopers_data, aes(x = Site, y = Organic.Matter...., colour = Gorse.Cover)) +

  stat_summary(fun = min,
               geom = "crossbar",
               width = 0.3,
               fatten = 1) +
```

```
 stat_summary(fun = mean,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +
 stat_summary(fun = max,
          geom = "crossbar",
          width = 0.3,
          fatten = 1) +

 geom_line() +
 geom_point(size = 2) +
 labs(
  x = "Site", y = "Organic Matter (%)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(0, 50, 10)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(axis.title.y = element_text(margin = margin(r = 7)))
ggplot(data = Troopers_data, aes(x = Gorse.Cover, y = Organic.Matter...., colour = Gorse.Cover))
+
  stat_summary(fun = min,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +
 stat_summary(fun = mean,
          geom = "crossbar",
          width = 0.2,
          fatten = 1) +
 stat_summary(fun = max,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +
  geom_line() +
 geom_point(size = 2) +
 labs(
  x = "Gorse Cover", y = "Organic Matter (%)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(0, 50, 10)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none")
Nutrients <- Troopers_data
Nutrients_TON <- Nutrients[Nutrients$TON < 20, ]
```

```
ggplot(data = Nutrients_TON, aes(x = Site, y = TON, colour = Gorse.Cover)) +

 stat_summary(fun = min,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +
 stat_summary(fun = mean,
        geom = "crossbar",
        width = 0.2,
        fatten = 1) +
 stat_summary(fun = max,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +

 geom_line() +
 geom_point(size = 2) +
 labs(
  x = "Site", y = "TON  (\u00B5g/g dry soil)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(0, 10, 2)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(legend.position = "none",
    axis.title.x = element_text(size = 9),
    axis.title.y = element_text(size = 9, margin = margin(r = 7)))
ggplot(data = Nutrients, aes(x = Site, y = Phosphate, colour = Gorse.Cover)) +

 stat_summary(fun = min,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +
 stat_summary(fun = mean,
        geom = "crossbar",
        width = 0.2,
        fatten = 1) +
 stat_summary(fun = max,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +

 geom_line() +
 geom_point(size = 2) +
 labs(
```

```
  x = "Site", y = "Phosphate  (\u00B5g/g dry soil)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(0, 10, 2)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic()
ggplot(data = Nutrients, aes(x = Site, y = Ammonium, colour = Gorse.Cover)) +

 stat_summary(fun = min,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +
 stat_summary(fun = mean,
        geom = "crossbar",
        width = 0.2,
        fatten = 1) +
 stat_summary(fun = max,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +

 geom_line() +
 geom_point(size = 2) +
 labs(
  x = "Site", y = "Ammonium  (\u00B5g/g dry soil)",
  color = "Gorse Cover"
 ) +
 scale_y_continuous(breaks = seq(2, 7, 1)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
 theme_classic() +
 theme(axis.title.x = element_text(size = 9),
    axis.title.y = element_text(size = 9, margin = margin(r = 7)))
ggplot(data = Nutrients_TON, aes(x = Gorse.Cover, y = TON, colour = Gorse.Cover)) +

 stat_summary(fun = min,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +
 stat_summary(fun = mean,
        geom = "crossbar",
        width = 0.2,
        fatten = 1) +
 stat_summary(fun = max,
        geom = "crossbar",
        width = 0.25,
```

```
          fatten = 1) +

  geom_line() +
  geom_point(size = 2) +
  labs(
   x = "Gorse Cover", y = "TON  (\u00B5g/g dry soil)",
   color = "Gorse Cover"
  ) +
  scale_y_continuous(breaks = seq(0, 20, 4)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic()
ggplot(data = Nutrients, aes(x = Gorse.Cover, y = Phosphate, colour = Gorse.Cover)) +

  stat_summary(fun = min,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +
  stat_summary(fun = mean,
          geom = "crossbar",
          width = 0.2,
          fatten = 1) +
  stat_summary(fun = max,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +

  geom_line() +
  geom_point(size = 2) +
  labs(
   x = "Gorse Cover", y = "Phosphate  (\u00B5g/g dry soil)",
   color = "Gorse Cover"
  ) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic()
ggplot(data = Nutrients, aes(x = Gorse.Cover, y = Ammonium, colour = Gorse.Cover)) +

  stat_summary(fun = min,
          geom = "crossbar",
          width = 0.25,
          fatten = 1) +
  stat_summary(fun = mean,
          geom = "crossbar",
          width = 0.2,
          fatten = 1) +
```

```
  stat_summary(fun = max,
        geom = "crossbar",
        width = 0.25,
        fatten = 1) +

  geom_line() +
  geom_point(size = 2) +
  labs(
   x = "Gorse Cover", y = "Ammonium  (\u00B5g/g dry soil)",
   color = "Gorse Cover"
  ) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic() +
  theme(legend.position = "none")
particle_means_bar <- read.csv("Particle Size Means bar.csv")

particle_means_bar$Proportion <- particle_means_bar$Percentage/100

ggplot(data = particle_means_bar, aes(x = Gorse.Cover, fill = Grain.Size)) +
  geom_bar(aes(weight = Percentage), position = "fill") +
  labs(
     x = "Gorse Cover",
     y = "Grain Size Percentage",
     fill = "Grain Type"
     ) +
  scale_y_continuous(expand = c(0, 0)) +
  scale_fill_manual(values = c("brown", "#F2D75C", "#D2A15A")) +
  geom_text(aes(label = Grain.Size),
        size = 3,
        position = position_stack(vjust = 0.5)) +
  theme_classic() +
  theme(axis.title.y = element_text(margin = margin(r = 8)))
ggplot(data = particle_means_bar,
     aes(x = Gorse.Cover, y = Proportion, fill = Grain.Size)) +
  geom_bar(stat = "identity", position = "fill") +
  geom_text(
   data = subset(particle_means_bar, Proportion >= 0.05),
   aes(
    label = scales::percent(Proportion, accuracy = 0.1)
   ),
   position = position_stack(vjust = 0.5),
   size = 3
  ) +
  geom_text(
```

```
   data = subset(particle_means_bar, Proportion < 0.05),
   aes(
    label = scales::percent(Proportion, accuracy = 0.1),
    y = 1.01
   ),
   inherit.aes = TRUE,
   vjust = 0,
   size = 3
  ) +
  labs(
   x = "Gorse Cover",
   y = "Percentage",
   fill = "Grain Type"
  ) +
  scale_y_continuous(expand = expansion(mult = c(0,
0.05)),label=scales::percent_format(accuracy=1)) +
  scale_fill_manual(values = c("brown", "#F2D75C", "#D2A15A")) +
  theme_classic() +
  theme(axis.title.y = element_text(size = 10),
      axis.text.x = element_text(size = 7, margin = margin(t = 5)),
      axis.text.y = element_text(size = 8, margin = margin(r = 5)),
      axis.title.x = element_text(size = 10, margin = margin(t = 7)),
      legend.text = element_text(size = 8),
      legend.title = element_text(size = 9)
Troopers_data <- read.csv("Troopers Hill Dataset.csv"
Troopers_data$Site <- as.factor(Troopers_data$Site)
IQR = IQR(Troopers_data$TON, na.rm = TRUE)
Q3 = quantile(Troopers_data$TON, 0.75, na.rm = TRUE)
dif = max(Troopers_data$TON, na.rm = TRUE) - Q3
dif/IQR
2.62 + (8.7 * 2.18)
if(!require(dunn.test)) install.packages("dunn.test")
library(dunn.test)
kruskal.test(Organic.Matter.... ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Organic.Matter....,
     g = Troopers_data$Site)
kruskal.test(Organic.Matter.... ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Organic.Matter....,
     g = Troopers_data$Gorse.Cover)
kruskal.test(pH ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$pH,
     g = Troopers_data$Site)
kruskal.test(pH ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$pH,
     g = Troopers_data$Gorse.Cover)
```

```
kruskal.test(Volumetric.Soil.Moisture.... ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Volumetric.Soil.Moisture....,
      g = Troopers_data$Site)

kruskal.test(Volumetric.Soil.Moisture.... ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Volumetric.Soil.Moisture....,
      g = Troopers_data$Gorse.Cover)
kruskal.test(Gravimetric.Soil.Moisture.... ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Gravimetric.Soil.Moisture....,
      g = Troopers_data$Site)
kruskal.test(Gravimetric.Soil.Moisture.... ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Gravimetric.Soil.Moisture....,
      g = Troopers_data$Gorse.Cover)
shapiro.test(Troopers_data$Sand)
hist(Troopers_data$Sand, breaks = 20)
kruskal.test(Sand ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Sand,
      g = Troopers_data$Site)
kruskal.test(Sand ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Sand,
      g = Troopers_data$Gorse.Cover)
kruskal.test(Silt ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Silt,
      g = Troopers_data$Site)
kruskal.test(Silt ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Silt,
      g = Troopers_data$Gorse.Cover)
kruskal.test(Clay ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Clay,
      g = Troopers_data$Site)
kruskal.test(Clay ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Clay,
      g = Troopers_data$Gorse.Cover)
kruskal.test(Ammonium ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Ammonium,
      g = Troopers_data$Site)
kruskal.test(Ammonium ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Ammonium,
      g = Troopers_data$Gorse.Cover)
kruskal.test(Phosphate ~ Site, data = Troopers_data)
dunn.test(x = Troopers_data$Phosphate,
      g = Troopers_data$Site)
kruskal.test(Phosphate ~ Gorse.Cover, data = Troopers_data)
dunn.test(x = Troopers_data$Phosphate,
      g = Troopers_data$Gorse.Cover)
```

```
Nutrients <- Troopers_data
Nutrients_TON <- Nutrients[Nutrients$TON < 20, ]
kruskal.test(TON ~ Gorse.Cover, data = Nutrients_TON)
dunn.test(x = Nutrients_TON$TON,
      g = Nutrients_TON$Gorse.Cover)
kruskal.test(TON ~ Site, data = Nutrients_TON)
dunn.test(x = Nutrients_TON$TON,
      g = Nutrients_TON$Site)
Troopers_data <- read.csv("Troopers Hill Dataset.csv")
if (!require(ggplot2)) install.packages("ggplot2")
library(ggplot2)
Nutrients <- Troopers_data
Nutrients <- Nutrients[!is.na(Nutrients$TON), ]
Nutrients_TON <- Nutrients[Nutrients$TON < 20, ]
ggplot(data = Troopers_data, aes(x = Elevation..m., y = Gravimetric.Soil.Moisture...., colour =
Gorse.Cover)) +
 geom_smooth(method = "lm", col = "black", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Elevation (m)",
  y = "Gravimetric Soil Moisture (%)",
  title = "Relationship between Elevation and Soil Moisture",
  colour = "Gorse Cover") +
 scale_x_continuous(breaks = seq(43, 50, 1)) +
 scale_y_continuous(breaks = seq(0, 150, 20)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#00441B")) +
 theme_classic() +
 theme(plot.title = element_text(hjust = 0.5, margin = margin(b = 10)))
ggplot(data = Troopers_data, aes(x = Volumetric.Soil.Moisture...., y =
Gravimetric.Soil.Moisture....)) +
 geom_point(cex = 2) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 labs(
  x = "Volumetric Soil Moisture (%)",
  y = "Gravimetric Soil Moisture (%)") +
 scale_x_continuous(breaks = seq(0, 55, 10)) +
 scale_y_continuous(breaks = seq(0, 150, 20)) +
 theme_classic() +
 theme(plot.title = element_text(hjust = 0.5, margin = margin(b = 10)))
gsm_vsm <- lm(data = Troopers_data, formula = Gravimetric.Soil.Moisture.... ~
Volumetric.Soil.Moisture....)
summary(gsm_vsm)
ggplot(data = Troopers_data, aes(x = Organic.Matter...., y = Gravimetric.Soil.Moisture....)) +
 geom_smooth(method = "lm", col = "black", lty = 1, lwd = 0.75, se = FALSE) +
 geom_point(aes(colour = Gorse.Cover)) +
```

```
  labs(
  x = "Organic Matter (%)",
  y = NULL,
  colour = "Gorse Cover") +
  scale_x_continuous(breaks = seq(0, 50, 10)) +
  scale_y_continuous(breaks = seq(0, 160, 20)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#095D2C")) +
  theme_classic() +
  theme(axis.text.x = element_text(margin = margin(t = 2)),
     axis.text.y = element_text(margin = margin(r = 2)),
     legend.text = element_text(size = 8),
     legend.title = element_text(size = 10),
     axis.title.x = element_text(size = 9))
ggplot(data = Troopers_data, aes(y = pH, x = Gravimetric.Soil.Moisture....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
  x = "Soil Moisture (%)",
  y = "pH"
  ) +
  scale_x_continuous(breaks = seq(0, 150, 40)) +
  scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
  theme_classic()
ggplot(data = Troopers_data, aes(x = Organic.Matter...., y = Volumetric.Soil.Moisture....)) +
  geom_point(cex = 2) +
  geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE) +
  labs(
  x = "Organic Matter (%)",
  y = "Soil Moisture (%)") +
  scale_x_continuous(breaks = seq(0, 50, 10)) +
  scale_y_continuous(breaks = seq(0, 55, 10)) +
  theme_classic()
ggplot(data = Troopers_data, aes(x = Volumetric.Soil.Moisture...., y = pH)) +
  geom_point(cex = 2) +
  geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE) +
  labs(
  x = "Soil Moisture (%)",
  y = "pH") +
  scale_x_continuous(breaks = seq(0, 55, 10)) +
  scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
  theme_classic()
```

```
ggplot(data = Troopers_data, aes(x = Organic.Matter...., y = pH)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE) +
 geom_point(cex = 2) +
 labs(
 x = "Organic Matter (%)",
 y = "pH") +
 scale_x_continuous(breaks = seq(0, 50, 10)) +
 scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Sand, y = Gravimetric.Soil.Moisture...., colour =
Gorse.Cover)) +
 geom_smooth(method = "lm", col = "black", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2.5) +
 labs(
 x = "Sand (%)",
 y = "Soil Moisture (%)",
 colour = "Gorse Cover") +
 scale_x_continuous(breaks = seq(10, 40, 5)) +
 scale_y_continuous(breaks = seq(0, 150, 20)) +
 scale_color_manual(values = c("#B8E186", "#31A354", "#00441B")) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Silt, y = Gravimetric.Soil.Moisture....)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
 x = "Silt (%)",
 y = "Soil Moisture (%)") +
 scale_x_continuous(breaks = seq(60, 90, 5)) +
 scale_y_continuous(breaks = seq(0, 150, 20)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Clay, y = Gravimetric.Soil.Moisture....)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
 x = "Clay (%)",
 y = "Soil Moisture (%)") +
 scale_x_continuous(breaks = seq(2, 5, 0.5)) +
 scale_y_continuous(breaks = seq(0, 150, 20)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Sand, y = Organic.Matter....)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Sand (%)",
```

```
  y = "Organic Matter (%)") +
 scale_x_continuous(breaks = seq(10, 40, 5)) +
 scale_y_continuous(breaks = seq(0, 50, 10)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Silt, y = Organic.Matter....)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Silt (%)",
  y = "Organic Matter (%)") +
 scale_x_continuous(breaks = seq(60, 90, 5)) +
 scale_y_continuous(breaks = seq(0, 50, 10)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Clay, y = Organic.Matter....)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Clay (%)",
  y = "Organic Matter (%)") +
 scale_x_continuous(breaks = seq(2, 5, 0.5)) +
 scale_y_continuous(breaks = seq(0, 50, 10)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Sand, y = pH)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Sand (%)",
  y = "pH") +
 scale_x_continuous(breaks = seq(10, 40, 5)) +
 scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Silt, y = pH)) +
 geom_smooth(method = "lm", col = "red", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Silt (%)",
  y = "pH") +
 scale_x_continuous(breaks = seq(60, 90, 5)) +
 scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
 theme_classic()
ggplot(data = Troopers_data, aes(x = Clay, y = pH, colour = Gorse.Cover)) +
 geom_smooth(method = "lm", col = "black", lty = 1, lwd = 0.75, se = FALSE, fullrange = TRUE) +
 geom_point(cex = 2) +
 labs(
  x = "Clay (%)",
```

```
    y = "pH",
    colour = "Gorse Cover") +
  scale_x_continuous(breaks = seq(2, 5, 0.5)) +
  scale_y_continuous(breaks = seq(4, 5.5, 0.25)) +
  scale_color_manual(values = c("#B8E186", "#31A354", "#00441B")) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Ammonium, x = Gravimetric.Soil.Moisture....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Soil Moisture (%)",
    y = "Ammonium (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(0, 150, 40)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Ammonium, x = Organic.Matter....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Organic Matter (%)",
    y = "Ammonium (\u00B5g/g dry soil)"
    ) +
  scale_x_continuous(breaks = seq(0, 50, 10)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()

amm_om <- lm(formula = Ammonium ~ Organic.Matter...., data = Nutrients)
summary(amm_om)
ggplot(data = Nutrients, aes(y = Ammonium, x = pH)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "pH",
    y = "Ammonium (\u00B5g/g dry soil)"
    ) +
  scale_x_continuous(breaks = seq(4, 5.5, 0.25)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = Gravimetric.Soil.Moisture....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Soil Moisture (%)",
    y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(0, 150, 20)) +
```

```
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()


ggplot(data = Nutrients, aes(y = Phosphate, x = Organic.Matter....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
  x = "Organic Matter (%)",
  y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(0, 50, 10)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = pH)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "pH",
    y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(4, 5.5, 0.25)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Gravimetric.Soil.Moisture....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Soil Moisture (%)",
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(0, 150, 20)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Organic.Matter....)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Organic Matter (%)",
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(0, 50, 10)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = pH)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "pH",
```

```
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(4, 5.5, 0.25)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Ammonium, x = Sand)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Sand (%)",
    y = "Ammonium (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(10, 40, 5)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Ammonium, x = Silt)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Silt (%)",
    y = "Ammonium (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(60, 90, 5)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Ammonium, x = Clay)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Clay (%)",
    y = "Ammonium (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(2, 5, 0.5)) +
  scale_y_continuous(breaks = seq(2, 7, 1)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = Sand)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Sand (%)",
    y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(10, 40, 5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = Silt)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Silt (%)",
```

```
    y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(60, 90, 5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = Clay)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Clay (%)",
    y = "Phosphate (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(2, 5, 0.5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Sand)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Sand (%)",
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(10, 40, 5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Silt)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Silt (%)",
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(60, 90, 5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Clay)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "Clay (%)",
    y = "TON (\u00B5g/g dry soil)") +
  scale_x_continuous(breaks = seq(2, 5, 0.5)) +
  scale_y_continuous(breaks = seq(0, 10, 2)) +
  theme_classic()
ggplot(data = Nutrients_TON, aes(y = Phosphate, x = TON)) +
  geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
  geom_point() +
  labs(
    x = "TON (\u00B5g/g dry soil)",
```

```
  y = "Phosphate (\u00B5g/g dry soil)") +
 scale_x_continuous(breaks = seq(0, 10, 2)) +
 scale_y_continuous(breaks = seq(0, 10, 2)) +
 theme_classic()
ggplot(data = Nutrients_TON, aes(y = TON, x = Ammonium)) +
 geom_point() +
 labs(
  x = "Ammonium (\u00B5g/g dry soil)",
  y = "TON (\u00B5g/g dry soil)"
  ) +
 scale_x_continuous(breaks = seq(2, 7, 1)) +
 scale_y_continuous(breaks = seq(0, 10, 2)) +
 theme_classic()
ggplot(data = Nutrients, aes(y = Phosphate, x = Ammonium)) +
 geom_smooth(method = "lm", lty = 1, lwd = 0.75, se = FALSE, col= "red") +
 geom_point() +
 labs(
  x = "Ammonium (\u00B5g/g dry soil)",
  y = "Phosphate (\u00B5g/g dry soil)") +
 scale_x_continuous(breaks = seq(2, 7, 1)) +
 scale_y_continuous(breaks = seq(0, 10, 2)) +
 theme_classic()
om_gsm <- lm(data = Troopers_data, formula = Gravimetric.Soil.Moisture.... ~
Organic.Matter....)
summary(om_gsm)
pH_secondary <- read.csv("pH Secondary Dataset.csv")
if(!require(ggplot2)) install.packages("ggplot2")
library(ggplot2)
if(!require(dunn.test)) install.packages("dunn.test")
library(dunn.test)
ggplot(data = pH_secondary,
    aes(x = factor(Group, levels = c("Our Data", "Other Studies", "Avon Project (2025)", "Avon
Project (2024)")),
      y = pH, fill = Group)) +
  geom_boxplot(staplewidth = 0.5) +
 labs(
  y = "pH",
  x = NULL
 ) +
 scale_fill_manual(values = c("deeppink", "orange" ,"red", "#31A354")) +

 theme_classic() +
 theme(legend.position = "none")
kruskal.test(pH ~ Group, data = pH_secondary)
dunn.test(x = pH_secondary$pH,
```

```
       g = pH_secondary$Group)
library(tidyverse)
library(dplyr)
Phosphate_secondary <- read.csv('P.Secondary.Data.csv')
Ammonium_secondary <- read.csv('A.Secondary.Data.csv')
TON_Secondary <- read.csv('TON.Secondary.Data.csv')
TON_Secondary_2 <- TON_Secondary[TON_Secondary$TON < 20, ]
Ammonium_secondary_2 <- Ammonium_secondary[Ammonium_secondary$Ammonium < 20, ]
Phosphate_secondary_2 <- Phosphate_secondary %>% filter(!(Group == "Avon Project (2025)"
& Phosphate > 4))
if(!require(ggplot2)) install.packages("ggplot2")
library(ggplot2)
if(!require(dunn.test)) install.packages("dunn.test")
library(dunn.test)
ggplot(data = Phosphate_secondary_2,
     aes(x = factor(Group, levels = c("Our Data", "Avon Project (2025)", "Avon Project (2024)")),
        y = Phosphate, fill = Group)) +
 geom_boxplot(staplewidth = 0.5) +
 labs(
  title = "",
  y = "Phosphate µg/g of dry soil",
  x = NULL
 ) +
 scale_fill_manual(values = c("deeppink", "orange", "#31A354")) + scale_y_continuous(breaks =
seq(0, 8, 2), limits = c(0, 8)) +

 theme_classic() +
 theme(legend.position = "none",
      plot.title = element_text(hjust = 0.5, margin = margin(b = 10)),
      plot.margin = unit(c(20, 20, 20, 5), "pt"))

kruskal.test(Phosphate ~ Group, data = Phosphate_secondary_2)
dunn.test(x = Phosphate_secondary_2$Phosphate,
       g = Phosphate_secondary_2$Group)

ggplot(data = Ammonium_secondary_2,
     aes(x = factor(Group, levels = c("Our Data", "Avon Project (2025)", "Avon Project (2024)")),
        y = Ammonium, fill = Group)) +
 geom_boxplot(staplewidth = 0.5) +
 labs(
  title = "",
  y = "Ammonium µg/g of dry soil",
  x = NULL
 ) +
```

```
 scale_fill_manual(values = c("deeppink", "orange", "#31A354")) + scale_y_continuous(breaks =
seq(0, 14, 2), limits = c(0, 14)) +

 theme_classic() +
 theme(legend.position = "none",
      plot.title = element_text(hjust = 0.5, margin = margin(b = 10)),
      plot.margin = unit(c(20, 20, 20, 5), "pt"))

ggplot(data = TON_Secondary_2,
      aes(x = factor(Group, levels = c("Our Data", "Avon Project (2025)", "Avon Project (2024)")),
        y = TON, fill = Group)) +
 geom_boxplot(staplewidth = 0.5) +
 labs(
   title = "",
   y = "TON µg/g of dry soil",
   x = NULL
 ) +
 scale_fill_manual(values = c("deeppink", "orange", "#31A354")) + scale_y_continuous(breaks =
seq(0, 14, 2), limits = c(0, 14)) +


 theme_classic() +
 theme(legend.position = "none",
      plot.title = element_text(hjust = 0.5, margin = margin(b = 10)),
      plot.margin = unit(c(20, 20, 20, 5), "pt"))
```