The effect of trampling on species composition on the local nature reserve, Arnhall Moss, in June 2017.

by
Advanced Higher Biology Class 2017/18, Westhill Academy

INTRODUCTION

Continued urbanisation puts increasing pressure on our open spaces and in particular, our local nature reserves. It is well documented that construction of housing and industrial units and farming practices can influence drainage patterns in the natural areas they surround (Aberdeenshire Council, 2013; Scottish Parliament, 2015). Arnhall Moss was designated a local nature reserve in 1992 due to its variety of habitats hosting a range of wildlife, within one of the few remaining raised bogs in Scotland (James Hutton Institute, 2015). It is well-used by the local community for recreation (walking, jogging etc.,) as well as for enjoying and learning about wildlife (Aberdeenshire Council, 2015). These uses put pressure on the balance between nature conservation and leisure provision for local people. Recent management plans have included the improvement and construction of new paths for school pupils and workers to access the newer retail and commercial developments to the south of the nature reserve (Aberdeenshire Council, 2013). However, over the past four years it became noticeable that further short-cut paths had been produced by people wishing to walk from the southern end of Arnhall Moss towards the commercial units (A. Sutherland,--Aberdeenshire Countryside Ranger and M Docherty--biology teacher, personal communication) and we were concerned enough to want to survey the area to provide information to feed into the Arnhall Moss management plan. This observation became the focus of study for the Advanced Higher Biology class of Westhill Academy in June 2017.

The effects of trampling on plant species is well documented in Roovers *et al.* (2004) and Pescott and Stewart (2014). Anyone who has walked in the peat landscapes around the world, including Highland Scotland, is aware of how trampling can directly damage plants on and adjacent to a path, churn the peat and affect the ability of vascular plants, in particular, to recover (Robroek *et al.,* 2010). Indirect effects of trampling have also been identified e.g. an increase in soil compaction/bulk density which may lead to poorly oxygenated soils and water-holding capacity which can affect plant root growth as well as microbe growth, survival and the nitrogen-cycle processes they are involved in (Roovers *et al.,* 2004). Some researchers have also found changes to the pH of trampled soils (Stohlgren and Parsons, 1986, Roovers *et al.,* 2004).

METHOD

The AH Biology class planned the fieldwork to tie in with the project-planning and data-analysis criteria (unit 3) and sampling methods (unit 2) of the CfE AH Biology course. A pilot survey was carried out on 15/6/17 to assess precision and accuracy of methods and precision of results. Evaluation of collected results resulted in an alteration to some sampling methods to provide more reliable results. The main survey, reported here, was conducted on the afternoon of 21/6/17. The “short cut” track that was sampled heads roughly south from the constructed path (between the dry heath and woodland) to the A944. The track is not uniformly trampled and is not the same width along its length. As we did not have any baseline data one major assumption made was that plant species composition was homogeneous prior to people trampling and making paths (Roovers *et al.,* 2004).

The hypotheses for this work were:

1. Soil moisture would be lower and soil compaction higher at the centre of the trampled track.
2. There would be no difference in light intensity across the track.
3. Plant species richness, % cover of individual species and total % cover would be lower at the centre of the trampled track.

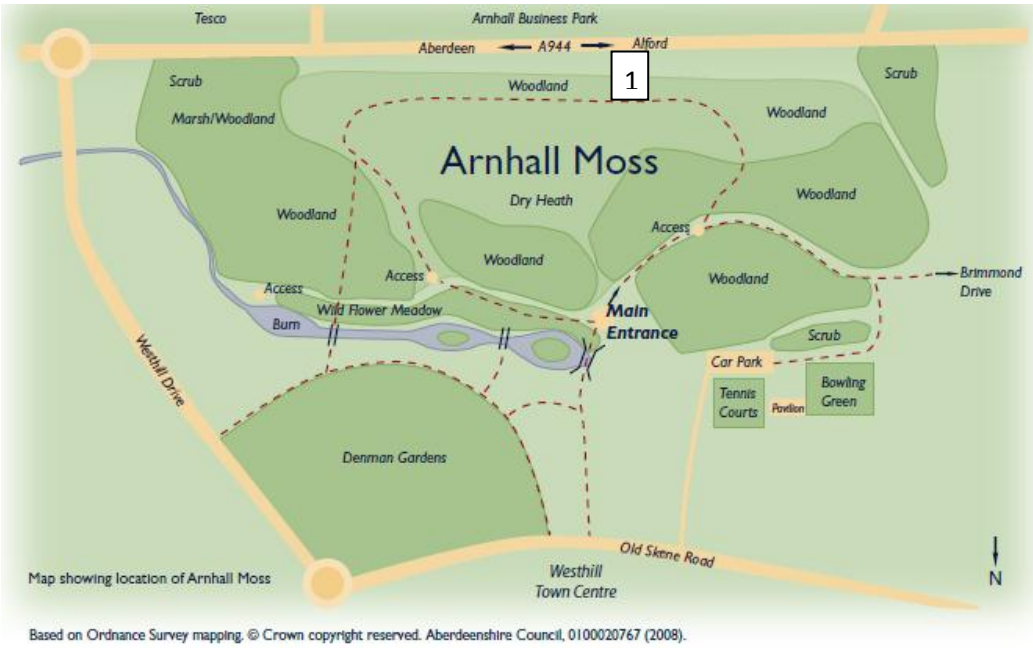

Figure 1: Map showing the location of Arnhall Moss and the track sampled.

Although the aim was to set up belt transects every 10m along the path, due to obstructions such as trees and slopes some belts were set up 5m apart, and others were set up 12 m apart (appendix 3). The first and last 3m of the track were avoided as these “edges” were more trampled that the rest of the path due to being on corners/where people congregate (figure 2).

Figure 2: Photograph showing the location of the track through the birch woodland

Figure 3: One of the 3.5m belt transects across the track.

Each belt measured 3.5m in width which allowed 7x0.5m quadrates to fit side-by-side. Pupils assessed % cover of different plant species using quadrats (figure 3). To aid precision of measurement, during the pilot study, each pupil assessed the % cover of each plant species within a quadrat twice (from opposite sides of the quadrat). To calibrate their results to get close to the true value, 2 pupils compared results for the same quadrat and, when compliant, recorded the results [N.B. % cover can be greater than 100% due to having different canopy layers of plants]. Pupils measured abiotic factors such as soil moisture (pilot study only—see figure 4, due to equipment breakage) and light intensity (using a light meter). In addition, soil compaction was measured as soil penetration depth, by dropping a home-made penetrometer from the same 1m

height each time and measuring the depth the probe penetrated the ground, using a ruler (figure 5).

Figure 4: Measuring soil moisture

Figure 5: Measuring soil penetration (soil compaction)

For light intensity, pupils took 3 measurements at a height of 1m and 3 at ground height in each quadrat. Soil compaction was measured 2 times, at random locations in each quadrat. Unfortunately, due to lack of working equipment, the pH of the soil could not be measured.

RESULTS

Graphs presented in this section are mean results ± standard deviation of the mean. **Statistically significantly different results [for purposes of the AH biology syllabus] occur when standard deviation "error" bars do not overlap for two mean results compared**. No other statistical testing was carried out on this data. All raw data can be found in the appendices.

1. Path width

The width of bare ground in the path was measured every 10m over the length of the path. The mean width of the path was 1.5 ± 0.75m which shows there is a lot of variation due to people walking round obstacles e.g. trees, which consequently widens tracks.

2. Soil compaction

Measuring the soil penetration shows the compaction of the soil due to trampling. The relationship between the soil penetration and the soil compaction is that the lower the soil penetration the higher the soil compaction. At the track centre the soil penetration was at its lowest with a mean soil penetration of 25mm (figure 6). This shows that at the track centre soil compaction was at its greatest. As the distance increased from the track centre the mean soil penetration increased i.e. soil compaction decreased. The mean soil penetration at the track centre was statistically significantly lower compared to the mean soil penetration at 1 and 1.5 metres to the left and right of the centre of the track.

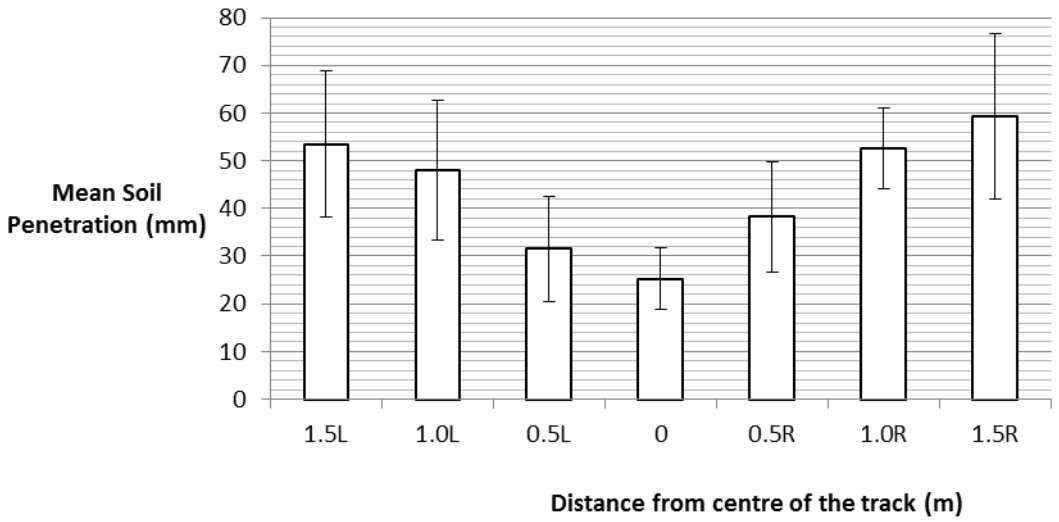

Figure 6: Mean soil penetration across the track.

3. Light intensity

Figure 7 shows that as the distance from the centre of the track increased, both to the left and to the right, light intensity increased slightly, but not significantly different.

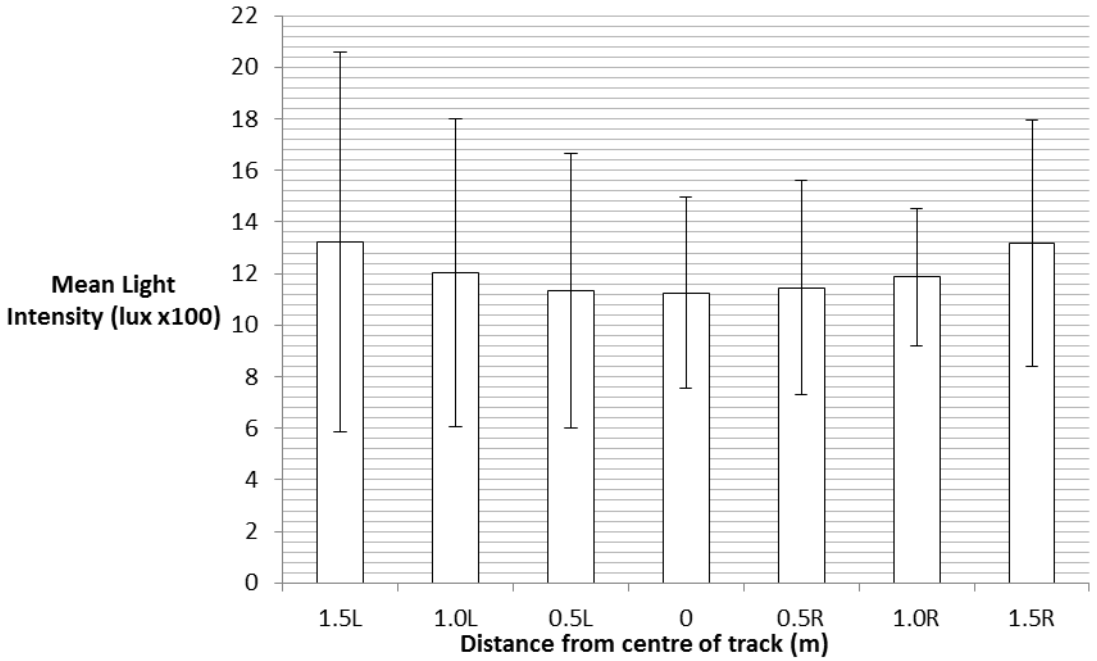

Figure 7: Mean light intensity across the track.

There was a lot of variation in these results (see large error bars), some of which could be due to the blustery weather conditions. For example, during measurements of the 3rd belt, the clouds began to clear which allowed an outburst of sun, causing results to range from 1000 lux to 3500 lux. Towards the end of the field work cloud cover changed every few minutes, causing huge variation within the results.

4. Plant species Richness

As the distance increased from the centre of the track to 1.5m right and left the species richness increased (figure 8) though the results were not statistically significantly different.

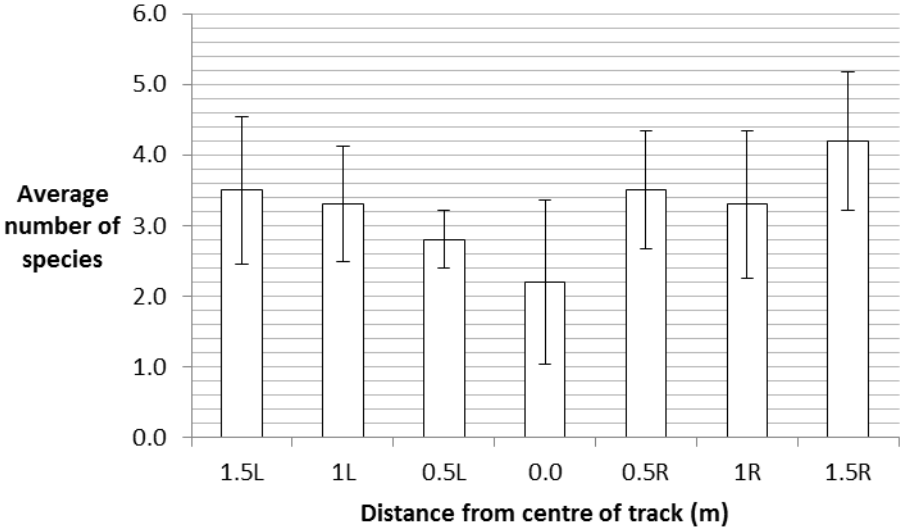

Figure 8: Mean number of plant species across the track.

5. % cover of plants

As the distance from the centre of the track increased the mean total cover (%) also increased. The mean total % cover was only statistically significantly higher 1-1.5m to the right of the track centre (figure 9).

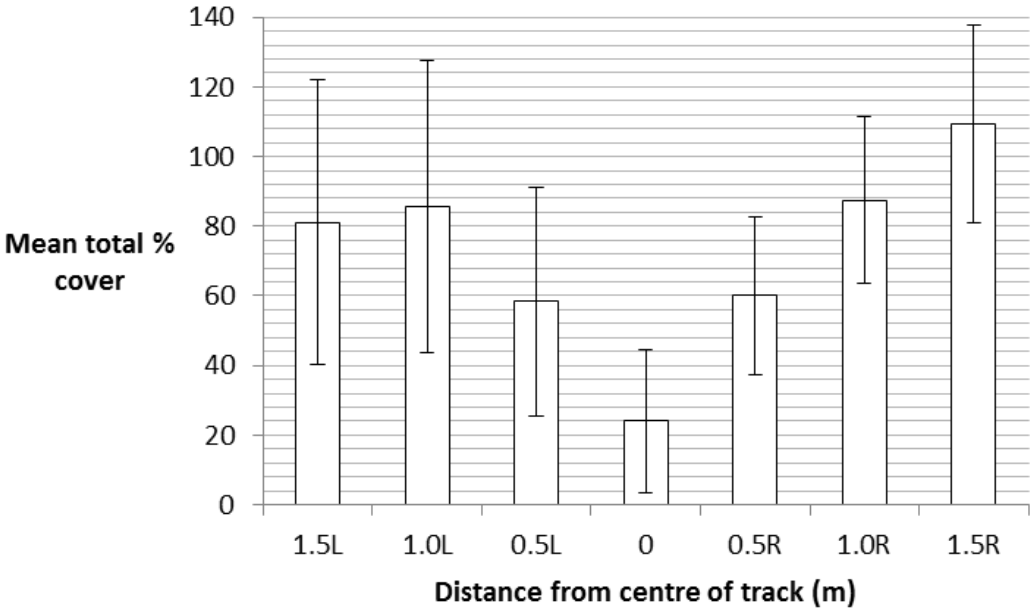

Figure 9: Mean total % cover of plants across the track.

Pupils found it difficult to identify grass species accurately hence why results for all grass species were pooled. Grasses were a predominant group of plants found in the areas measured, comprising around 40% of total % plant cover. Although the lowest mean total % cover appears in the track centre, there is no statistically significant difference between it and the three distances from the track centre (figure 10).

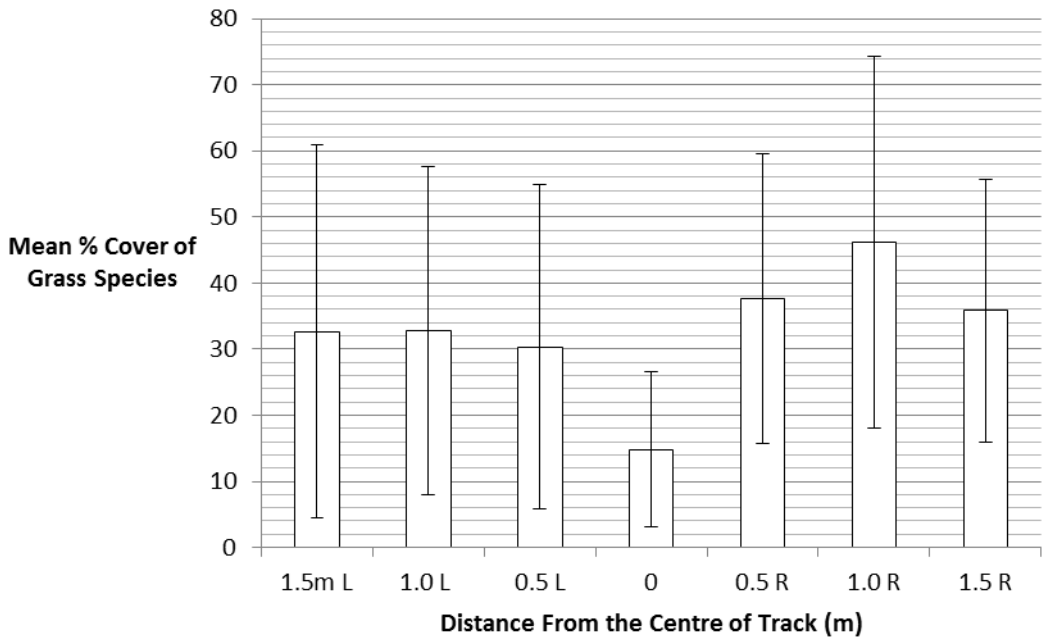

Figure 10: Mean total % cover of grass species across the track.

The mean % cover of moss increased as the distance from the centre of the track increased (figure 11) but these were not statistically significant differences. The mosses tended to grow in patches, closer to trees and tree roots.

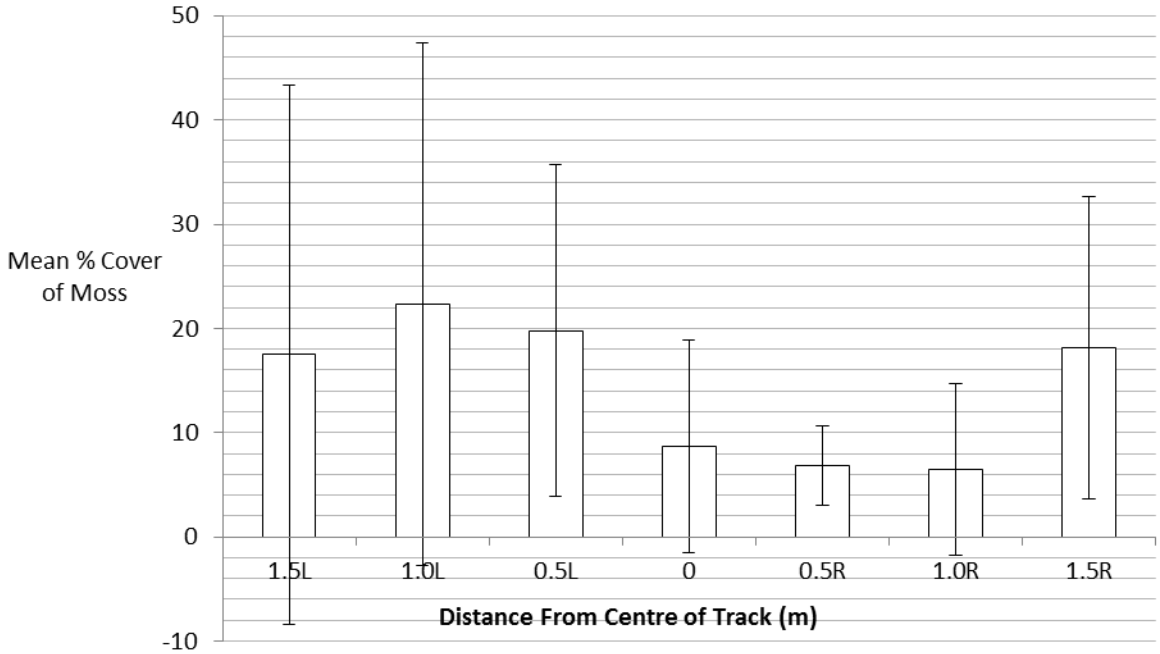

Figure 11: Mean total % cover of moss species across the track.

In figure 12 it can be seen that as the distance from the centre of the track increased the mean percentage cover of common wood sorrel also increased but the results are not statistically significantly different.

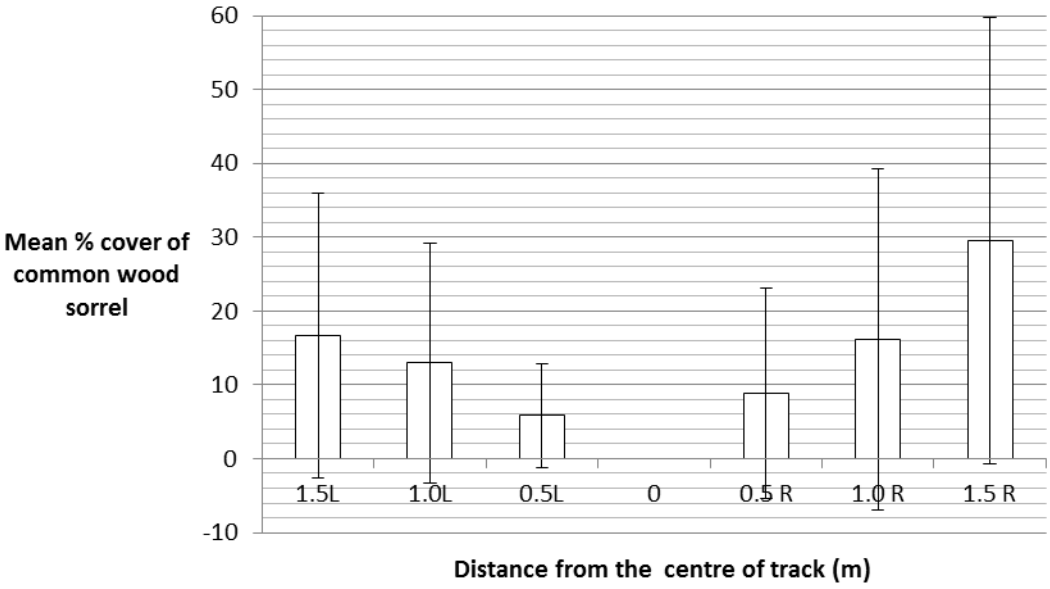

Figure 12: Mean total % cover of Common wood sorrel across the track.

A few other, less abundant species were found at specific distances along the track. Rosebay willowherb was only found at 4m along the track. Blaeberry, the most abundant of the less-common species, was only found in the first half of the track. Raspberry was found at each end of the track although bramble was only found in the interior. No relationship was found between light intensity and raspberry abundance. The same was true for soil compaction and the abundance of raspberry. Due to the low abundance of these species, there was no detectable relationship between the distance from the track centre (i.e. within a belt transect) and the distribution of each of these less common species.

6. % cover of leaf litter

As the distance from the centre of the track increased the mean % cover of leaf litter decreased, although this trend was not statistically significant (figure 13).

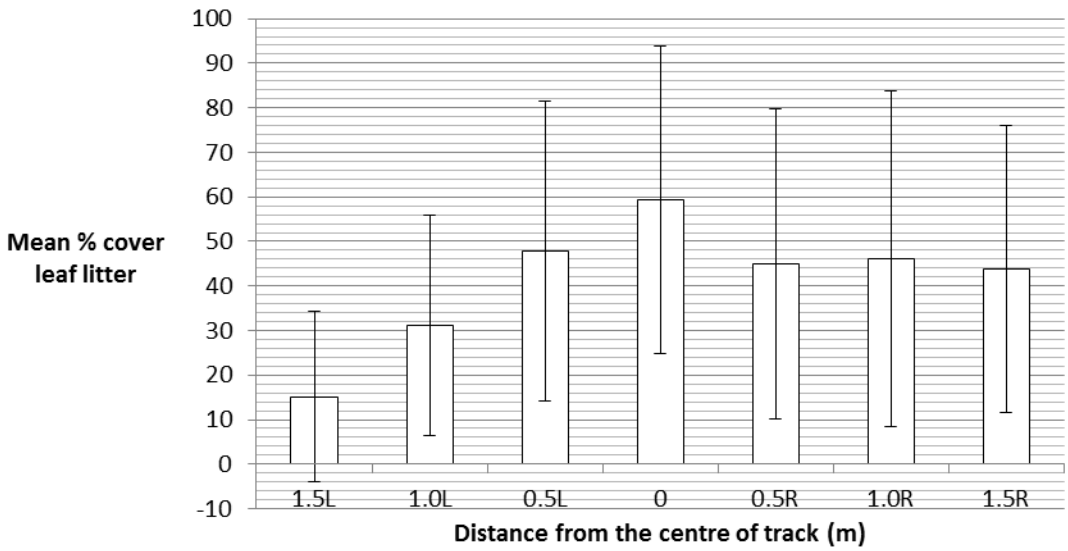

Figure 13: Mean total % cover of leaf litter across the track.

CONCLUSION

Trampling can have direct effects on plants e.g. breaking stems and the growing points of some plants, damaging the photosynthetic organs (leaves), damaging above-ground reproductive parts etc., or indirect effects such as soil compaction, with its associated effects (FSC, 2009). This study could not measure the direct effects however; the statistically significant increase in soil compaction towards the path centre was expected. This could affect a plant's seed germination and root growth. It could also affect whole plant growth due to changes in water availability and nutrients (due to alterations in nutrient cycling by invertebrates and microbes in the soil). As these hypotheses were outwith the scope of the present study they would be potential research projects for our pupils or citizen science programmes (http://www.environment.scotland.gov.uk/get-involved/) and local conservation groups.

It is obvious from just looking at the track winding through the birch woodland that there was a lower total % plant cover at the track centre. However, due to the large variation in results, this decrease in % plant cover was not statistically significant. There was a negative correlation between mean % plant cover and mean soil compaction, although this does not necessarily mean the relationship is causal. As there were no differences in the light intensity across the track it is unlikely to have caused the reduction in total % plant cover across the track. It is more likely that physical damage by feet on plants or indirect effects of soil compaction have caused these differences. Gremmen *et al.* (2003) also noted a decrease in total % plant cover in peaty soils across a track. Their study also found a decrease in plant species richness with trampling intensity which was also found between the most intensely trampled section (centre of track) compared to 1m either side. The Arnhall Moss study should be repeated later in the summer, to determine if this is consistent for plant species which appear later in the year.

Several authors have recorded decreases in the % cover of several moss species in more trampled areas of paths (Gremmen *et al.* 2003, Jägerbrand & Alatalo 2015) but that was only found partly in this study. Moss cover was not ubiquitous throughout the track, possibly due to competitive interactions with other plant species, microclimate differences and how well adapted their growth form is to these conditions (Glime, 2013).

Few studies have found an effect of trampling on grass % cover, probably due to the ability of their low growing point to resist damage (Gremmen *et al.* 2003), although one study showed a decrease in grass cover due to trampling (Roovers *et al.* 2004). In Arnhall Moss, mean total % cover of grass species varied but not significantly across the track.

The lovely woodland indicator species, Chickweed wintergreen, shares a similar asexual reproductive strategy to grasses—it often uses underground stems called rhizomes to increase its population. These rhizomes could be sensitive to damage directly from trampling or indirectly from soil compaction. This species was patchily distributed in our 6 belt samples across the track so we are unsure whether its abundance was linked to the presence of other species and microclimate variations or affected by trampling. Our study would require many more sampling points if we were to look for any trends associated with this species.

Jägerbrand and Alatalo (2015) recorded an inverse relationship between % plant cover and levels of leaf litter, with the latter being higher in the more trampled sections of the path, which was also found in this study. This increased leaf litter cover may primarily be due to the increased area of plant-free ground for litter accumulation. Additional factors may include the physical trampling which may consolidate the litter into a thicker (less mobile) layer, as well as possible influences of soil compaction on worm activity.

Not all plant species are equally affected by a level of trampling (Pescott & Stewart, 2014) suggesting that some species are more vulnerable to damage than others, therefore management plans need to take account of the effects on individual plant species. It is evident though that trampling is detrimental to overall plant cover and that this damage is not just restricted to the path centre.

There is no evidence to suggest that the creation of more bare ground at the track centre has caused different, less competitive, species to colonise. More detailed sampling in smaller sections of the track would need to be carried out to reduce the large variation in results from our 46m track sampling. The pupils had already attempted to reduce variation in their plant results by learning plant identification during the pilot study and assessing each other's % cover results. However, they could not standardise the terrain which may have contributed to the high variation. For example, the track sloped at various points, 1.5m to the left or right of the track. This may have created little microclimates, thus influencing the distribution of plants more than any impact of trampling.). The high level of variation may be also be linked to the tree canopy coverage and competition with trees for moisture and nutrients. Soil penetration measurements may have been affected by the presence of underground plant roots. It would have been unethical to check this by digging up sections of the woodland. Obvious "root stops" were excluded and sampling re-done in a slightly different part of each quadrat. The major influence in light variation was the constantly changing cloud cover. Pupils could return on a day of similar cloud cover though time has run out.

The assumption of plant species homogeneity prior to trampling was thought, by the pupils, to be unlikely. Desire paths, such as this short cut, would likely follow a path of least resistance (SNH, 2017) for the walker. Tall thorny vegetation e.g. bramble or raspberry are known to deter walkers from making or taking a particular path (Littlemore and Barker 2001). If any local people know about the track we would be grateful for some information. Observations from the teachers suggested that the ground was much drier underfoot than the same time last year, though this could not be measured due to both moisture meters breaking early in the sampling. However, soil compaction was higher this year than last year. Al-Kaisi and Licht (2005) suggest that soil moisture lubricates the movement of a penetrometer through soil which may explain the above observation and measurements.

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ACKNOWLEDGEMENTS

Sincere thanks to Alison Sutherland, Aberdeenshire Countryside Ranger, for providing helpful information on Arnhall Moss and helping with plant species identification. The fieldwork on the day could not be completed without Mr Scott Struthers Depute Head Teacher Westhill Academy who helped supervise pupil work. Mr Ian Humphries, technician Westhill Academy, excelled himself in the precision manufacture of 2 equal-mass soil penetrometers, for which we are extremely grateful.

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APPENDIX 1: LIST OF PLANT SPECIES FOUND IN THE WOODLAND

Chamerion angustifolium (Rosebay willowherb)
Epilobium montanum (Broad-leaved willowherb)
Vaccinium myrtillus (Blaeberry)
Rubus ideeus (Raspberry)
Dryopteris dilatata (Broad Buckler fern)
Trientalis europaea (Chickweed-wintergreen)
Oxalis acetosella (Common Wood sorrel)
Potentilla erecta (Tormentil)
Lonicera periclymenum (Honeysuckle)
Rubus fruticosus (Bramble)

GRASSES
Holcus lunatus (Yorkshire Fog grass)
Festuca species
Poa pratensis
Other unidentified species

MOSSES
Rhytidiadelphus squarrosus
Dicranum scoparium
Polytrichum commune
Hypnum jutlandicum
Kindbergia praelonga
Byrum argentum
Rhytidiadelphus triquetrus

APPENDIX 2: SOME MORE PHOTOS

1. Thinking and working hard

2. Checking out something interesting in the undergrowth

3. Counting and identifying plants and measuring light intensity

4. How much fun can we have fieldworking?

5. Some lovely plants

Chickweed-wintergreen (*Trientalis europaea)*

Common Wood sorrel *(Oxalis acetosella)*

Appendix 3 Plant species abundance at 4m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	4	0	0	5	0	12
Broad-leaved willowherb	5	0	0	0	0	0	10
Blaeberry	0	0	0	0	8	11	37
Honeysuckle	0	0	0	0	0	0	0
Bramble	0	0	0	0	0	0	0
Raspberry	15	10	3	0	0	0	0
GRASS; All Species	8	12	10	8	2	0	15
Broad Buckler fern	0	0	0	0	0	37	0
MOSS: All Species	20	24	27	3	8	0	40
Chickweed-wintergreen	0	0	0	0	0	0	0
Common Wood sorrel	0	0	0	0	0	0	0
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	0	0	0	0
BARE GROUND	0	0	0	0	0	0	5
LEAF LITTER	0	65	71	95	70	95	85
ROOTS	0	6	3	4	2	0	0
Total % cover	48	121	114	110	95	143	204

Appendix 4 Plant species abundance at 16m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	0	0	0	0	0	0
Broad-leaved willowherb	8	0	0	0	0	0	0
Blaeberry	11	0	0	0	18	17	15
Honeysuckle	0	0	0	0	0	0	0
Bramble	0	0	0	0	0	0	0
Raspberry	0	0	0	0	0	0	0
GRASS; All Species	8	10	9	2	58	73	21
Broad Buckler fern	0	0	0	0	0	0	0
MOSS: All Species	6	14	5	0	10	7	10
Chickweed-wintergreen	6	9	1	0	2	4	6
Common Wood sorrel	0	0	0	0	0	0	7
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	0	0	0	0
BARE GROUND	0	2	4	21	0	0	0
LEAF LITTER	36	27	85	18	16	24	49
BARE ROOTS	0	3	3	16	0	0	0
Total % cover	75	65	107	57	104	125	108

Appendix 5 Plant species abundance at 22m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	0	0	0	0	0	0
Broad-leaved willowherb	0	0	0	0	0	0	0
Blaeberry	0	0	0	0	0	0	0
Honeysuckle	0	0	0	0	0	0	0
Bramble	0	0	0	0	0	0	0
Raspberry	0	0	0	0	0	0	0
GRASS; All Species	28	30	12	9	27	28	58
Broad Buckler fern	0	13	0	0	3	0	0
MOSS: All Species	0	5	14	0	5	0	21
Chickweed-wintergreen	0	0	0	0	0	0	0
Common Wood sorrel	28	35	7	0	36	58	62
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	0	0	0	0
BARE GROUND	0	0	0	0	0	0	0
LEAF LITTER	42	37	73	94	86	71	58
Roots	0	8	6	3	0	0	0
Total % cover	98	128	112	106	157	157	199

Appendix 6 Plant species abundance at 28m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	0	0	0	0	0	0
Broad-leaved willowherb	0	0	0	0	0	0	0
Blaeberry	0	0	0	0	0	0	0
Honeysuckle	0	0	0	0	0	0	0
Bramble	0	0	0	0	0	0	0
Raspberry	0	0	0	0	0	0	0
GRASS; All Species	33	27	31	11	32	46	21
Broad Buckler fern	0	0	0	0	0	0	0
MOSS: All Species	11	21	38	17	8	12	28
Chickweed-wintergreen	0	0	0	0	0	0	0
Common Wood sorrel	45	31	12	0	13	27	48
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	2	1	0	0
BARE GROUND	0	0	0	0	0	0	0
LEAF LITTER	13	8	14	54	28	16	11
Roots	4	0	0	17	0	0	2
Total % cover	106	87	95	101	82	101	110

Appendix 7: Plant species abundance at 33m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	0	0	0	0	0	0
Broad-leaved willowherb	0	0	0	0	0	0	0
Blaeberry	0	0	0	0	0	0	2
Honeysuckle	0	0	0	0	0	0	0
Bramble	30	45	10	0	0	2	2
Raspberry	0	0	0	0	0	0	0
GRASS; All Species	85	78	65	29	47	70	60
Broad Buckler fern	0	0	0	0	0	0	0
MOSS: All Species	0	0	0	7	0	0	0
Chickweed-wintergreen	0	0	0	0	0	0	0
Common Wood sorrel	27	12	16	0	4	12	60
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	0	0	0	0
Leaf litter	0	0	4	20	0	0	0
Total % cover	142	135	95	56	51	84	124

Appendix 8 Plant species abundance at 45m along the track

	% Cover at a distance from path centre (m)						
Species	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
Rosebay willowherb	0	0	0	0	0	0	0
Broad-leaved willowherb	0	0	0	0	0	0	0
Blaeberry	0	0	0	0	0	0	0
Honeysuckle	6	2	0	1	1	15	10
Bramble	5	14	0	0	0	25	40
Raspberry	0	7	0	0	0	0	0
GRASS; All Species	34	40	55	30	60	60	40
Broad Buckler fern	0	0	0	0	0	0	0
MOSS: All Species	68	70	35	25	10	20	30
Chickweed-wintergreen	0	0	0	0	2	1	1
Common Wood sorrel	0	0	0	0	0	0	0
Dandelion	0	0	0	0	0	0	0
Bush Vetch	0	0	0	0	0	0	0
Sycamore	0	0	0	0	0	0	0
Tormentil	0	0	0	0	0	0	0
Total % cover	113	133	90	56	73	121	121

Appendix 8 Light intensity raw data along the track

1M FROM GROUND
Light Intensity (LUX x100)

Distance along track (m)	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
4	13	9	11	12	14	15	13
	12	9	11	13	14	15	13
	12	10	10	13	14	15	13
16	14	14	15	17	17	14	22
	14	14	15	18	17	16	21
	13	13	15	16	17	16	22
22	33	27	24	16	17	14	15
	35	28	25	15	18	14	15
	32	28	24	15	17	15	15
28	8	8	8	9	7	11	11
	8	8	8	9	9	12	12
	8	8	8	9	10	11	12
33	11	12	10	9	9	10	11
	11	12	10	9	9	10	10
	11	12	10	9	9	10	11
45	13	12	12	13	15	15	17
	13	11	12	13	15	15	18
	13	11	10	13	15	16	18

GROUND LEVEL
Light Intensity (LUX x100)

Distance along track (m)	1.5L	1.0L	0.5L	0	0.5R	1.0R	1.5R
4	13	10	12	14	10	8	13
	11	11	12	14	12	8	13
	11	10	12	16	12	8	13
16	17	12	12	15	17	15	19
	16	14	13	14	17	13	18
	17	15	13	14	16	16	17
22	20	18	17	12	11	12	10
	21	19	17	11	11	12	12
	21	19	17	11	10	12	11
28	5	5	5	4	4	9	6
	6	4	5	5	4	8	6
	5	5	5	5	5	9	5
33	6	5	4	5	4	6	3
	6	5	4	5	4	5	3
	6	5	4	4	4	5	6
45	7	10	6	10	10	12	16
	7	11	6	9	9	11	17
	7	10	6	10	9	13	17

Appendix 9 Soil penetration raw data along the track

	Distance from centre of track (mm)						
Distance (metres)	**1.5L**	**1.0L**	**0.5L**	**0**	**0.5R**	**1.0R**	**1.5R**
4	84	68	36	35	64	60	55
	60	59	30	33	60	35	48
	40	74	44	35	45	29	53
	42	66	36	34	50	79	56
16	24	20	21	16	19	42	69
	29	33	30	22	22	33	58
22	66	52	20	29	34	56	83
	74	44	11	22	43	69	76
28	55	59	34	28	31	52	44
	55	61	42	29	33	55	49
33	48	37	24	12	45	54	40
	48	37	30	21	44	60	32
45	52	42	76	30	37	53	83
	54	54	40	20	41	56	72
	76	57	35	20			
	80	46	36	20			