

Chapter (non-refereed)

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Changes in tensile strength loss of cotton strips with season and soil depth under 4 tree species

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1 Summary

Seasonal changes in tensile strength loss of cotton strips (CTSL), used as an index of potential organic matter breakdown, were determined in stands of 4 tree species at Gisburn (Bowland Forest), Lancashire.

In general, decomposer potential is greater under alder (*Alnus* spp.) and pine (*Pinus* spp.) than under oak (*Quercus* spp.) and spruce (*Picea* spp.). The seasonal pattern under oak (with a mid-season decline in activity) is very different from the seasonal curves for the other species. CTSL also declines rapidly with depth under oak and spruce, remaining relatively high at all depths under the alder and pine. This higher potential for decomposition at depth under alder and pine is possibly related to the appreciable populations of earthworms (Lumbricidae) under these 2 tree species; conversely, earthworms are rare in oak and spruce stands.

It has also been observed that feeding roots of oak and spruce tend to proliferate near the surface, but are distributed more evenly with depth in alder and pine, these patterns being related to those for CTSL.

2 Background

The background to the study and a description of the site are given by Brown and Harrison (1983) and Brown (1988). Briefly, the Gisburn study area consists of an experimental planting of 4 tree species planted in 0.2 ha plots, both as monoculture stands and in all possible combinations of 2-species mixtures. These 10 treatments are replicated in 3 blocks. The four species are Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), alder (*Alnus glutinosa*) and sessile oak (*Quercus petraea*). The aim of the study was to use the cotton strip assay to test the hypothesis that the 4 monoculture stands were altering the potential for cellulose decomposer activity in the soils in which the biomass of earthworms and the distribution of fine roots were also found to differ.

3 Method

Organic matter decomposer activity is known to vary with both soil depth and season (Swift *et al.* 1979). In using the cotton strip assay under the different tree species, we wished to determine whether there was also any species interaction in cellulose decomposition with either of these sources of variation. Although the standard cotton strip assay gives information on depth differences, it is necessary to repeat the assay at intervals to provide seasonal information. To this end, assays were repeated on 9 oc-

casions, at 6-weekly intervals (ie for just over a year) in the monoculture plots of pine, spruce, alder and oak for each of the 3 replicate blocks. Assay periods of 12 weeks were used, thus leading to an overlapping time series of assays. Ten strips per plot were used for each test on each occasion, distributed on a systematic basis throughout each tree plot. The Shirley Soil Burial Test Fabric (1976 batch) was used, the first assay period starting on 5 January 1978, the last finishing on 26 February 1979. The methodology of Latter and Howson (1977) was used throughout, providing tensile strength loss (CTSL) data for 5 depths at 4 cm intervals down the soil profiles. The data were also calculated as cotton rotting rate (CRR), after Hill *et al.* (1988).

Cloth control tensile strength was 47.4 kg for the batch of cloth used on occasions 1–4 and 54.4 kg for the subsequent batch used on occasions 5–9.

To provide comparisons between cotton assay data and other site parameters for the different tree stands, data on earthworm populations and the standing crop of fine roots are also presented. The earthworms were sampled during 1981 using a dung bait method (Brown & Harrison 1983) for 2 of the 3 blocks, but excluding oak stands. Some preliminary data on distribution of live roots \leq one mm were obtained during 1983 by hand-sorting replicate soil cores from the pine and spruce stands only.

4 Results and discussion

The results from the cotton strip assay indicated that there were clear seasonal patterns of cellulose decomposer activity associated with the different tree species plots (also discussed by French 1988). Because these results were consistent between the separate blocks, the data have been combined from the 3 blocks to give means based on 30 strips per tree species. CTSL or CRR averaged for all 5 depths, ie representing whole strips, provides a summary of the changes in decomposer activity with time in each forest stand (Figure 1).

Statistically significant differences for CTSL ($P < 0.001$ on first, second, fifth, sixth occasions, and $P < 0.01$ for the other 4 occasions) occurred on all except the last sampling occasion of the series. It is evident that, overall, cellulose decomposer activity was in the sequence alder = pine > oak > spruce. Activity rose to a peak in late summer/early autumn in alder, pine and spruce stands, but with the pattern under oak being very different. Because the successive assay periods

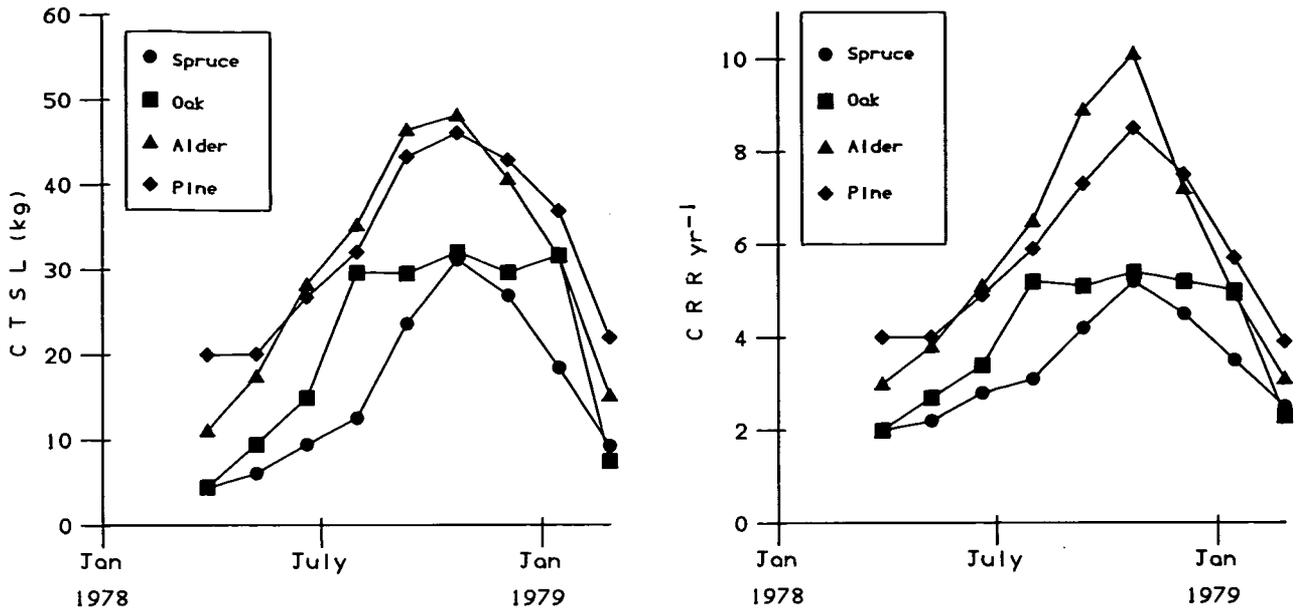


Figure 1. Changes with season in tensile strength loss of cotton strips, CTSL and CRR, following insertion under 4 tree species, at Gisburn, 1978–79. Nine overlapping burial periods, each of 12 weeks; means of all depths (ie whole strip averages) for 3 blocks combined, points being placed on the retrieval date (for a 3D presentation of the oak data, see Walton 1988)

were of identical length, the seasonal curves for CTSL and CRR are essentially similar. Only alder shows a slight discrepancy, when TS values were excessively low in summer (cf Walton 1988).

The seasonal patterns for the separate depths under each tree species (Figure 2) show that the different pattern for oak became more accentuated with depth, being similar to those for other species only at the surface. At 16–20 cm, the oak curve was clearly bimodal, with a secondary minimum at the time at which the other species reached their seasonal maxima.

Inspection of the 4 sets of seasonal curves also reveals that the decline in CTSL with depth, during the season of high activity at least, was slight in alder and pine stands, but very marked under oak and spruce. This contrast between alder and pine, on the one hand, and oak and spruce, on the other, is possibly linked with differences in both earthworm populations and the distribution of the fine (ie the main feeding) roots. Figure 3 shows that alder and pine not only had relatively high numbers of earthworms, but that many of them were *Lumbricus rubellus*, a partially burrowing species. The remainder consisted of surface-dwelling species (Brown & Harrison 1983). In contrast, the spruce stands had very few earthworms and negligible *Lumbricus rubellus*. From observation, populations of earthworms in the oak plots were judged to be at least as low as those of spruce. It is, therefore, possible that there has been more transport both of organic matter and of its decomposer organisms into the soil profiles of alder and pine stands through earthworm activity; and that this is reflected in the relatively high levels of CTSL at all sampled depths.

Conversely, where the possibility of such mixing and transport down the profile has only been slight, as in spruce (and oak) stands, there has been a concomitant rapid fall-off of cellulose decomposer activity down the profile.

Similar reasoning could also explain the contrast in fine root distribution between pine and spruce (Figure 4). Under pine, with little reduction in cellulose decomposer activity (and concomitant nutrient release) with depth, feeding roots likewise tend to occur at all depths, with least at the surface where other environmental conditions, such as susceptibility to drought and temperature fluctuations, are likely to be least suitable for root activity. In contrast, because cellulose decomposer activity in the spruce stands was very much greater at the surface than at depth, the feeding roots were concentrated at the main source of nutrients made available. Because of the resulting surface-rooting of spruce under such conditions, this species is typically more prone to drought than the deeper-rooting pine.

It must be emphasized, however, that these interpretations now require testing in order to distinguish cause from effect.

5 Acknowledgements

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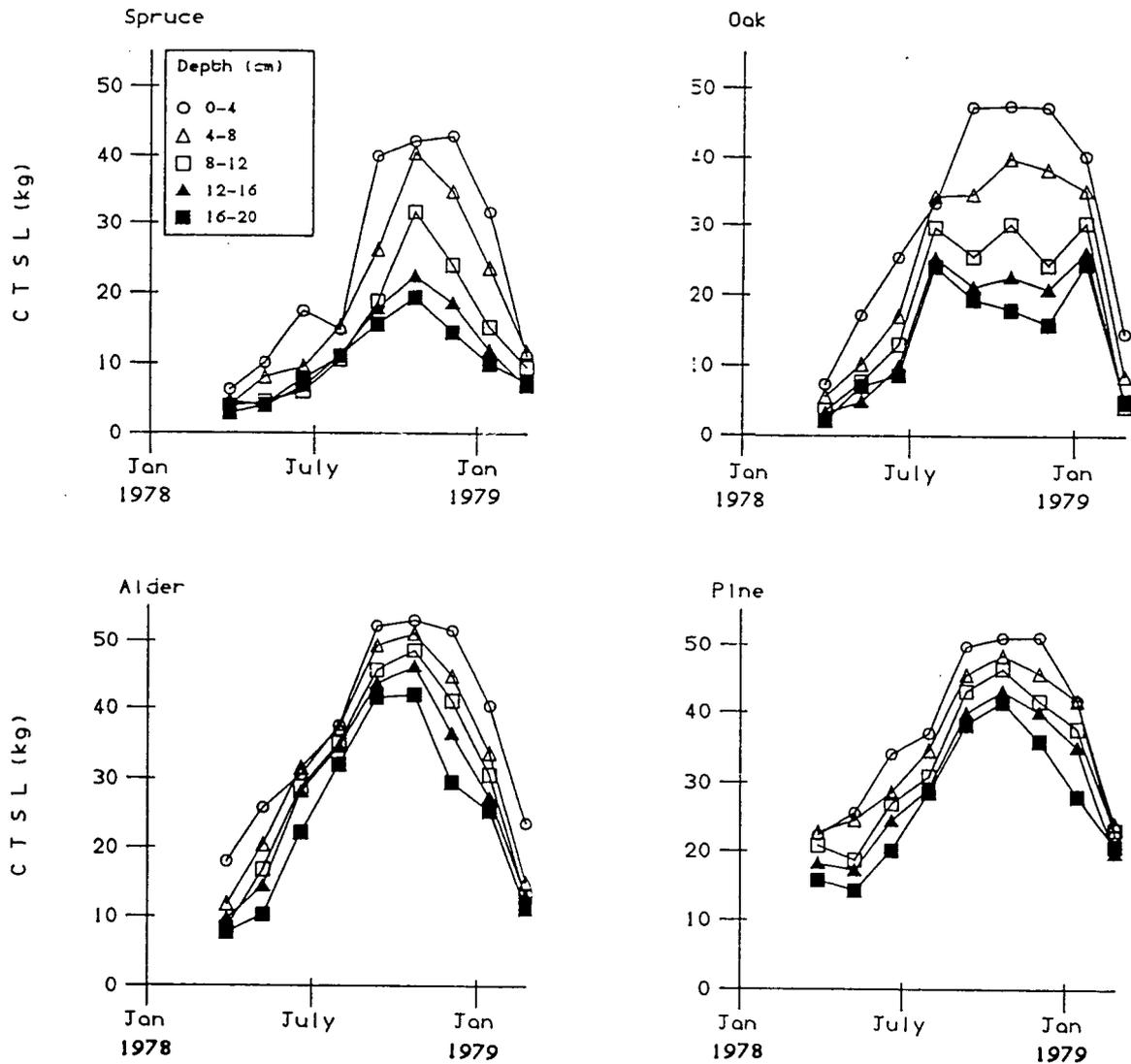


Figure 2. Changes with depth of the seasonal curves for tensile strength loss under 4 tree species

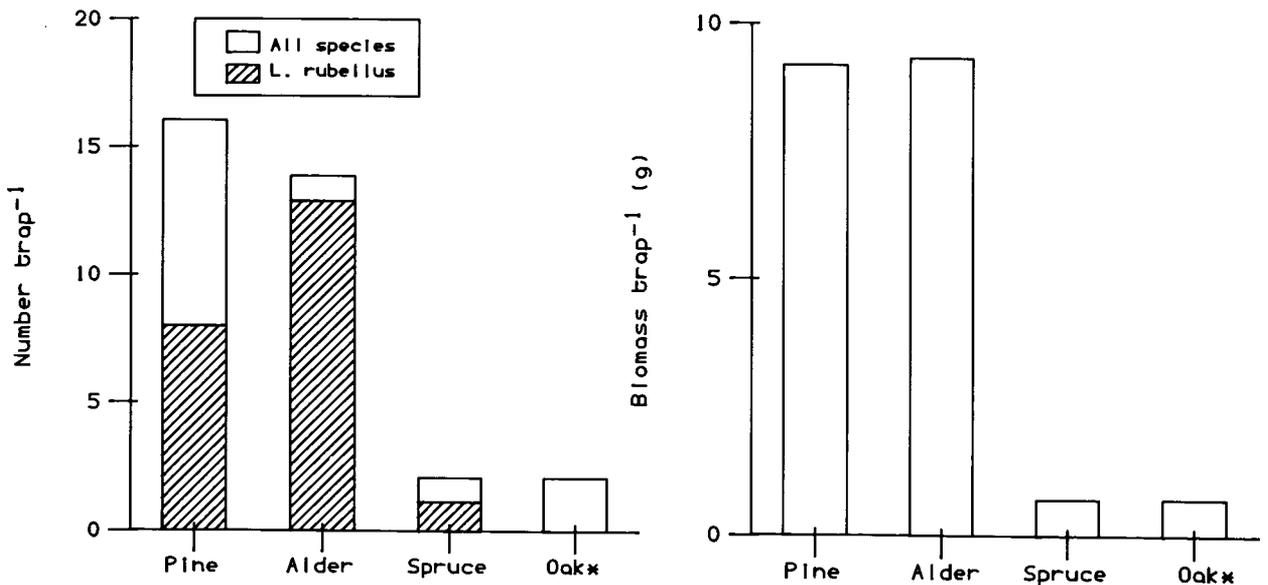


Figure 3. Mean numbers and biomass (preserved fresh weight) of earthworms per trap under 4 tree species. Two trapping periods and 2 blocks, combined, at Gisburn, 1981 (*oak estimated from observation)

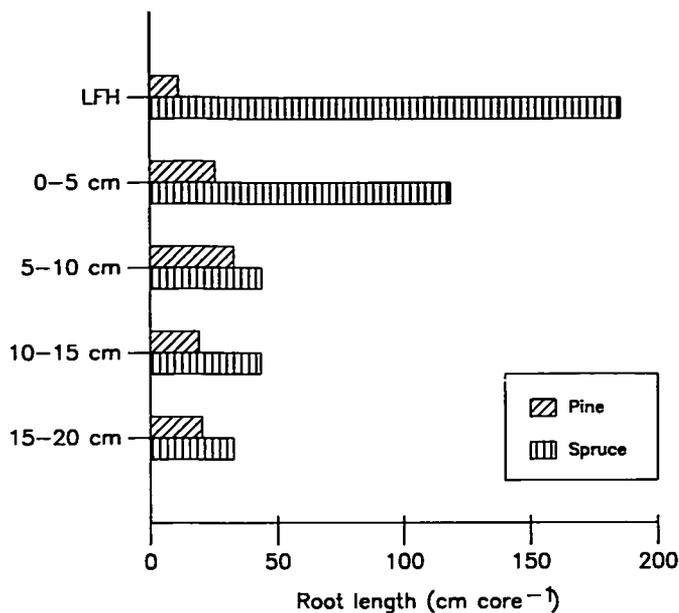


Figure 4. Mean lengths of live roots (≤ 1 mm) in soil cores of 24 mm diameter at 5 depths under Norway spruce ($n = 12$) and Scots pine ($n = 20$), at Gisburn, 1983 (source: J M Sykes & S M C Robertson unpublished data)

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