Lawson, G. J.. 1988 Using the cotton strip assay to assess organic matter decomposition patterns in the mires of South Georgia. In: Harrison, A. F.; Latter, P. M.; Walton, D. W. H., (eds.) *Cotton strip assay: an index of decomposition in soils.* Grange-over-Sands, NERC/ITE, 134-139. (ITE Symposium, 24).

Using the cotton strip assay to assess organic matter decomposition patterns in the mires of South Georgia

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1 *Summary*

A large number of cotton strips were inserted on 4 mire types and a fellfield site on South Georgia during 1975 and 1976. Overlapping series of strips permitted an assessment of the effects of season, site, depth, duration of insertion and soil temperature on tensile strength loss. Whilst the sites demonstrate considerable differences, they are all amongst the most actively decomposing habitats in the tundra biome. Despite major seasonal changes, there is a strong indication of peak decomposition at depths of 8–14 cm. This pattern is unlike that reported for northern hemisphere mires, where decomposition peaks closer to the surface.

2 *Introduction*

Cotton strips have been used several times to assess potential organic matter decomposition patterns in different habitats on the South Atlantic island of South Georgia (54–58°S, 36–38°W). This paper presents research data on decomposition of cotton strips during 1974 and 1975 on 5 sites, typical of widespread mire and fellfield communities on the island.

3 *Site description*

The 5 selected sites are within or adjacent to the International Biological Programme (IBP) study area described by Lewis-Smith and Walton (1975). The climate of the sites includes sub-zero mean monthly temperatures for 4–5 months in the year, and around 170 snow-free days at sea level. The vegetation, altitude, water table and soil pH characteristics of these sites are summarized in Tables 1 and 2 (Plate 10). Further information, including maps and photographs of the 2 principal sites, is presented in Lewis-Smith (1981) and Lawson (1985).

Table 1. Summary characteristics of the 5 study sites

Site	Altitude (m)	Vegetation	Water table (cm)	pH	Notes
Seepage slope (SS)	85	Sparse *Rostkovia magellanica*	0–4	6.0	Deep snow, thin ice crust
Basin bog (BB)	60	Dense *R. magellanica* *Polytrichum alpestre* *Chorisodontium aciphyllum* *Cladonia* sp.	0–22	4.7	Shallow snow, thick ice crust, early melt
Steep flush (SF)	84	Dense *Juncus scheuchzerioides* *Calliergon sarmentosum* *Philonotis acicularis*	Rapid sub-surface flow	6·8	Deep snow, thin ice crust, late melt
Gentle flush (GF)	60	Sparse *J. scheuchzerioides* Sparse *Acaena magellanica* *Drepanocladus uncinatus*	Moderate water flow	5.9	Thin snow, thick ice crust, early melt
Fellfield (FM)	2	Stunted *R. magellanica* *Polytrichum alpinum* *Conostomum pentasticum* *Cladonia* sp.	Thin mineral soil, freely draining	5.7	Medium snow depth, late melt

Table 2. Soil temperature comparison (°C, spot thermistor measurements at noon, n = 27 at all sites)

		Depth (cm) 2	5	10	20	40	Mean
Seepage slope (SS)	Mean	6.33	4.64	3.67	3.27	3.32	4.25
	Minimum	–0.85	–0.44	–0.06	0.27	0.61	–0.01
	Maximum	20.13	15.05	10.45	9.41	7.57	12.52
Basin bog (BB)	Mean	4.27	4.05	2.70	2.76	2.91	3.34
	Minimum	–3.18	–2.90	–2.18	0.09	0.33	–1.57
	Maximum	15.90	14.80	9.65	7.75	7.31	11.08
Steep flush (SF)	Mean	6.27	5.07	3.99	3.21	3.34	4.38
	Minimum	–1.39	–0.74	–0.21	0.18	0.24	–0.38
	Maximum	21.50	14.48	11.38	8.93	8.51	12.96
Gentle flush (GF)	Mean	4.54	4.60	3.69	3.12	3.18	3.83
	Minimum	–1.47	–1.47	–0.71	–0.09	0.33	–0.68
	Maximum	13.99	14.92	11.33	8.93	9.12	11.53
Fellfield (FM)	Mean	4.08	3.44	2.60	Rock	Rock	
	Minimum	–2.50	–2.18	–1.08			
	Maximum	13.04	11.33	8.06			

4 *Materials and methods*

The method of cotton strip preparation described in Latter and Howson (1977) was followed, using a domestic pressure cooker as an autoclave. The cloth used was the unbleached calico used for the earlier IBP studies (Heal *et al.* 1974).

A total of 540 strips were inserted in soil profiles, and seasonal differences were investigated using combinations of discrete and overlapping strip series (Figure 1). Greater numbers of strips were placed on the

Plate 10. Sites on South Georgia used for cotton strip assay:
i. seepage slope ii. basin bog
(Photographs G J Lawson)

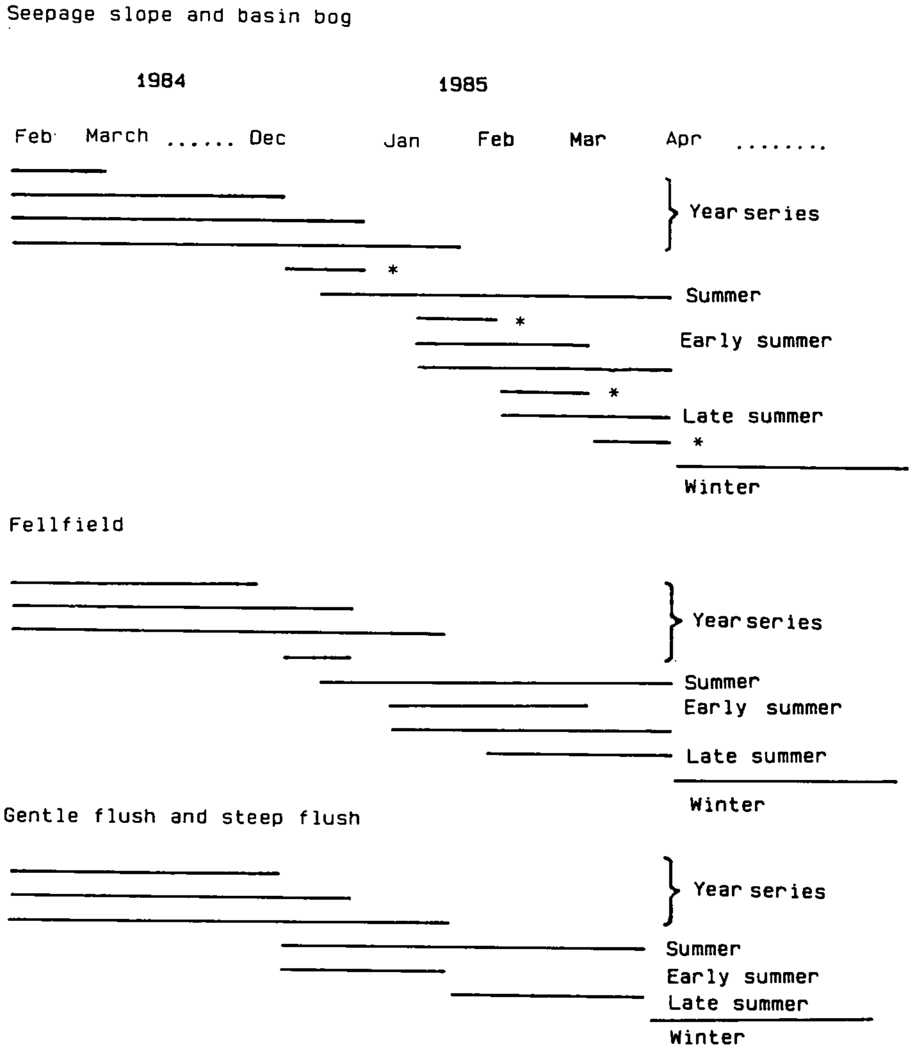

Figure 1. Cotton strip assay periods during seasonal sequence in 1974 and 1975 (10 strips for each assay period)

seepage slope and basin bog sites, where other studies of decomposition and nutrient cycling have been carried out (Lawson 1985).

Insertions were made at all sites using a flat-backed spade, leaving 6–8 cm of the strips exposed above the moss surface. This procedure could not be followed at the fellfield (FM) site, because of the shallow soil, and both ends of the strip were therefore inserted to increase replication and to anchor the cloth more firmly in position. Cloth control strips of washed and sterilized strips were retained, and each series included field control strips, which were inserted and removed immediately.

The cotton strips were carefully washed by hand, air dried, and cut into 4 cm wide substrips at depths related to the moss surface. On the 2 principal sites, it was also necessary to note the depth at which recognizable moss stems gave way to ombrogenous peat. This zone was presumably associated with high microbial activity. It occurred at a constant depth of 8 cm under the moss carpet of the seepage slope (SS), but below the irregular surface of *Polytrichum alpestre* turves at the basin bog (BB) its depth varied from 1 cm to 15 cm. This discontinuity was termed the limit of recognizable vegetation (LRV), and was not present at the fellfield or flush sites.

Soil temperatures were not measured during the study period, but data for 1978 were available for all sites (Table 2).

5 *Results*

5.1 Between-site comparisons

5.1.1 *The complete year*

One series of cotton strips was inserted at all 5 sites in January 1974 and retrieved after approximately 12 months. Though decomposition proceeded well beyond the optimum for tensile strength measurements, differences in tensile strength loss of cotton (CTSL) could be shown between the sites (Figure 2 i). The basin bog (BB) demonstrates least overall CTSL, and a markedly lower loss at greater depths. The middle portions of strips from the other sites, particularly the steep flush (SF), were often completely disintegrated.

5.1.2 *The early summer*

This series of strips was inserted in mid-December 1974, after a late thaw. The assay period was 28 days at the basin bog, the seepage slope (SS) and the fellfield (FM) sites, but 65 days at the 2 flush sites (GF

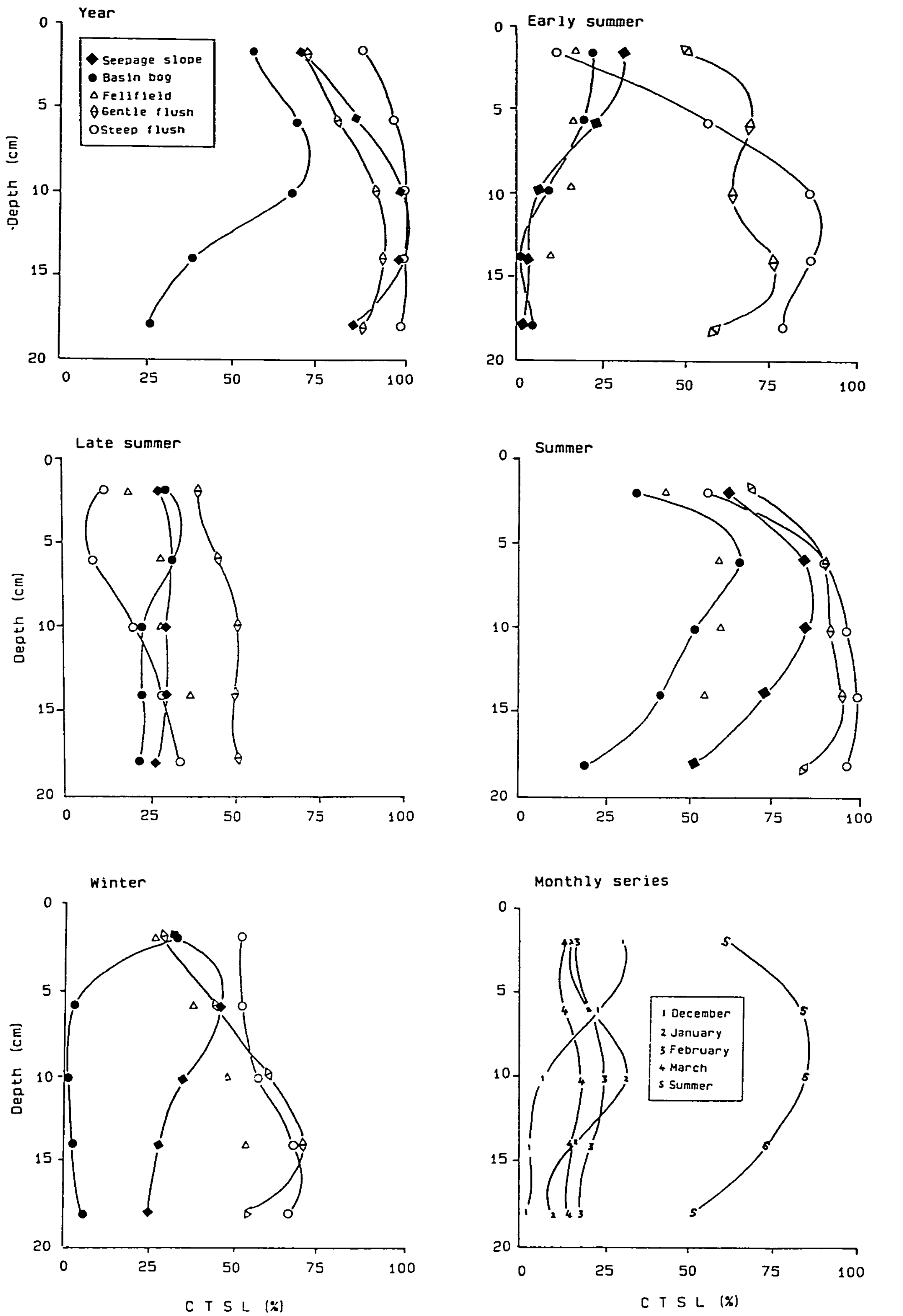

Figure 2. Patterns of tensile strength loss of cotton (CTSL) with depth in soil profiles over entire year and for the seasonal assay periods (Figure 1) at 5 sites on South Georgia. For the seepage slope site, the seasonal trends for 4 discrete assay periods (in Figure 1) are also compared to an entire summer assay period*

and SF). Data from the flush sites have, therefore, been adjusted linearly to express the data on the same 28 days' timescale as the other sites (Figure 2 ii). These 2 flush sites clearly show maximum decomposition at 10–14 cm during the first 2 months of summer. Over a shorter period after thaw, the other sites showed maximum decomposition close to the surface, and very little below 10 cm.

5.1.3 *The late summer*

The assay period for the late summer series was 54 days, starting on 21 February 1975. It showed much smaller differences in decomposition with depth in the profiles in all sites. There is an indication that CTSL is lowest close to the surface of the flush sites, and losses appear to increase slightly with depth in the fellfield, seepage slope and basin bog sites (Figure 2 iii). Water flows through both flushes at all depths, but the surface of the steep flush (SF) resembles a stream, which may explain the unusually low decomposition recorded for this site.

5.1.4 *The complete summer*

The assay period for all sites was 114 days, starting on 23 December 1974. The period covers approximately the sum of the periods displayed in Figures 2 ii and 2 iii, and might be expected to integrate rates of decomposition during the 2 periods, bearing in mind that the CTSL is not linear with time. There are some qualitative indications that the patterns of decomposition down soil profiles from this series (Figure 2 iv) do reflect the sum of Figures 2 ii and 2 iii.

Decomposition generally decreases with depth in early summer at the fellfield site, but increases in late summer. Over-summer strips record a maxima at 4–8 cm, which is consistent with combining the 2 trends.

The 60–70% CTSL near the surface of the steep flush does not, however, correspond to the smaller losses shown in Figures 2 ii and 2 iii. Similarly, the clear maxima at 6–10 cm in the seepage slope and basin bog sites do not conform well to the sum of early summer and late summer trends. Nevertheless, in both cases, the pattern of CTSL down the profile for the summer period matches that for the whole year (Figure 2 i).

5.1.5 *Overwinter*

Overwinter CTSL approaches 70% at 14–18 cm in the flush sites, despite low temperatures, but is insignificant below 6 cm in the basin bog. The seepage slope is intermediate between the other sites and shows a pattern of declining decomposition with depth (Figure 2 v).

5.2 Seasonal comparisons

Cotton strips were placed at the basin bog and the seepage slope sites to cover the entire summer in 4, approximately monthly, intervals. The data for the seepage slope are illustrated (Figure 2 vi), and show that the sum of the monthly series does not necessarily match the pattern observed in the strips which remained in place over the whole summer. There is some evidence that the decomposition maxima are close to the surface immediately after thaw, but move down the profile as the season proceeds. At the end of the season, no significant differences with depth are apparent.

6 *Discussion*

This summary paper provides only a superficial review of the data available from one of the largest sets of cotton strips to be inserted at closely adjacent sites. These data are to be analysed after being reworked to a standardized timescale and temperature base in degree-days, and adjusted to account for the variable depth of turf-forming mosses. The details of these analyses will be reported elsewhere.

The general pattern of potential decomposition showed that the highest recorded CTSL was from 10–14 cm at the steep flush site, and exceeded 90% after only 65 days in the first half of summer. This rate is greater than the 100% CTSL in a 100-day period predicted for a South Georgian dwarf-shrub community by Smith and Walton (1988), and confirms their suggestion that peat formed from greater rush (*Juncus scheuchzerioides*) has a particularly active microflora (Smith and Walton 1985). The pH recorded from this site averaged 6.8, which may explain why the decomposition rate there is similar to that recorded from the surface of base-rich grassland in the UK and Ireland (64% loss in 52 days and 100% loss in 63 days, respectively (Heal *et al.* 1974)).

Heal *et al.* (1974) collated information from 24 IBP tundra biome sites, and it is interesting to note that only in the antarctic sites has there been any previous indication of CTSL increasing with depth. The present study shows that decomposition frequently peaks at depths between 8 cm and 14 cm. Even the fellfield site, with its comparatively dry mineral soil, shows the same trend of increasing decomposition with depth. Walton (1985) confirmed the above patterns in another South Georgian mire, but reported quite different trends for a dry grassland and moss bank. Whilst considerable differences exist between the 5 sites, even the comparatively cold and acid basin bog shows a higher rate of decomposition than 22 of the 24 IBP tundra sites (Heal *et al.* 1974).

Both the rate and pattern of decomposition undergo marked changes at different times of year. During thaw, for example, some sites retain greatest activity close to the surface (SS, FM and BB), whilst the flush sites (SF and GF) show a higher CTSL at greater depth. As the summer proceeds, the patterns of decomposition down soil profiles at all sites tend to become more similar.

Differences between the sites partially follow the observed patterns of temperature and pH (lowest at BB and highest at SF), but there are several anomalies which cannot be explained by temperature alone. For example, the GF and BB sites, because of shallower snow covers, have lower surface temperatures than the SF and SS sites, yet the 2 most active sites are SF and GF. Average temperature declines with depth, at all sites, in a negative exponential manner. Yet there is a clear decomposition peak at 8–14 cm. This peak is, therefore, likely to be caused by humification and fermentation processes at this soil depth, sustained by an increased population of decomposing micro-organisms. At the flush sites, there is little indication that the water flow significantly increases average temperature, but it may considerably increase the supply of available nutrients at this depth, possibly stimulating decomposition there.

Both series of strips, inserted in soils at intervals through the summer, present interesting pictures of the interplay between temperature and moisture, in changing the decomposition of the cotton strips. They have also shown depth-related changes in the biological characteristics of the peat and the speed with which decomposing micro-organisms can colonize organic materials, even in the harsh antarctic environment. Clearly, the use of the cotton strip assay has been able to show the patterns of decomposer activity. There are, however, many complex interactions between the decomposition processes and the environmental factors, as indicated by this assay, which still need further evaluation.

7 *Acknowledgements*

The considerable assistance of D W H Walton is noted with thanks.

8 *References*

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