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## PEAT DEPTH OF SIERRA NEVADA FENS, AND PROFILE CHANGES FROM 1958 TO 1972 IN MASON FEN

Don C. Erman<sup>1</sup>

**ABSTRACT.**— Peat cores along transects of seven minerotrophic peatlands (fens) in the Sagehen Creek basin were made in 1972. The areas were all shallow, sloping peatlands from 67 to 206 cm in maximum depth. Cores from one fen contained layers of charcoal and clay that suggested fire followed by fen regeneration. Profiles from Mason Fen suggested that the peat mass was moving downslope, creating splits and ridges with surface pools at right angles to the slope. Comparison of a profile made in 1958 with 1972 showed further evidence of downslope mass movement and expansion of the surface area.

The natural features of peatlands have received little attention in California. A coastal fen type near Ft. Bragg was recently described (Baker 1972) and Rigg (1933) gave an early description of a bog in a nearby upper coastal terrace. In 1958 Professor Herbert Mason and Dr. Jean Langenheim mapped and surveyed a peatland (now named Mason Fen) at the Sagehen Creek Field Station in the Sierra Nevada near Truckee, California. This area and many others in the Sagehen Creek basin are minerotrophic (Heinselman 1970) or rheotrophic peatlands (Moore and Bellamy 1973) or simply, fens. The new terms emphasize the key features of high mineral content and flowing water that characterize such peatlands.

The purposes of this paper are to present peat depth profiles of seven of the Sagehen Creek fens, to compare a profile of Mason Fen made in 1958 by Mason and Langenheim with a profile made in 1972, and to suggest causes for changes in peat profiles.

### STUDY AREA

Detailed descriptions of the study area have been presented elsewhere (Erman 1973; Erman and Erman 1975). Studies and descriptions of the flora (Rae 1970; Savage 1973), fauna (Erman and Erman 1975), physical-chemical conditions (Erman 1973), and secondary production (Erman and Erman 1975) have focused on the original peatland described by Mason and Langenheim but included six other peatlands (referred to as fens 1-6 in Erman and Erman 1975 and in this study).

The Sagehen Creek Field Station is 12.8 km north of Truckee, California, on

the east slope of the Sierra Nevada. The seven fens are all located on sloping hill-sides and were originally described as "hanging bogs" (Storer and Usinger 1964). They range in area from 0.2 to 2.9 ha and in mean peat depth from 17.3 to 84 cm (Erman and Erman 1975). Comparisons of area, mean and maximum depth, elevation and exposure are given in Table 1. Species of plants and animals are very similar on all the fens. The primary substrate is a mixture of mosses *Drepanocladus aduncas* (Hedw.) and *Cratoneuron filicinum* (Hedw.) and several species of *Carex* (Rae 1970).

### METHODS AND MATERIALS

Maps of the areas were traced from enlarged aerial photographs. Peat depth was determined to the nearest 0.5 cm with a Hiller type peat borer. I twisted the corer through the peat until I detected firmness or, more often, scraping against the auger-tip caused by clay, sand, or rock. The point of transition from peat to clay or other mineral bottom-layers was measured to the fen surface marked on the handle.

Core transects were made along a long axis in the direction of slope and some at right angles to the slope. On Mason Fen one of the transects was relocated as carefully as possible on the positions established in 1958 by Mason and Langenheim. Their original starting point, however, a snag, was no longer present, and some of their more permanent markers could not be found. In the present study I placed markers on all transects. Detailed descriptions are on file at the Sagehen Creek Field Station.

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TABLE 1. Some physical features of seven fens in the Sagehen Creek basin, California (data in part after Erman and Erman 1975).

Environmental factor	Mason	Fen					
		1	2	3	4	5	6
Elevation (M)	1,943	1,943	1,943	2,001	2,066	2,111	2,173
Area (Ha)	2.7	1.7	0.74	2.2	2.6	0.19	0.80
Mean peat depth (cm)	58.7	87.4	81.4	57.5	17.3	41.6	42.0
Max. peat depth (cm)	104.5	206.0	193.0	416.0	67.0	74.0	80.0
Exposure	North	North	North	North	South	South	North

## RESULTS

**CORES FROM FENS 1-6.**—Maps of the fens and the location of transects are given in Figure 1. All of the fens have developed near springs and seeps that provide abundant water rich in Ca and Mg ions. The locations of major springs and some seeps are indicated on the maps. All but Fen 6, which has a gentle slope, have moderate gradients; Mason Fen has a maximum change in slope of 1 m in 6 and an average change of 1 in 20 (Rae 1970). In general the peat develops downslope from a major spring, and the fens have an elongate form.

Profiles of peat depth are given in Figure 2. The deepest core (206 cm) was made in Fen 1 (Fig. 2, Table 1) although Fen 2 had a slightly greater average peat depth (Fig. 2, Table 1). Maximum depths occurred at ends as well as near the center of longitudinal transects.

Some of the cores from Fen 6 revealed a complex history of peat development (Fig. 2). Cores at points 2 and 3 on transect *c* and 4 and 5 on transect *a* all contained a narrow (2 to 2.5 cm) charcoal layer (the layers of core 4 and 5 are shown in Fig. 2). Directly above the charcoal was a slightly thicker (2.5 to 6 cm) clay layer, and below the charcoal was fibrous peat and eventually the clay bottom. Aerial photographs of Fen 6 show a dark central area that corresponded to the deep area of the transect from 60 to 130 m.

**CORES FROM MASON FEN.**—Transects of Mason Fen are shown in Figure 3. Peat profiles along the long axes are shown in Figure 4, and a comparison of the Mason and Langenheim transect of 1958 with the 1972 profile is shown in Figure 5. Surface elevation of Mason Fen decreased 13.4 m along transect *c*, and dropped sharply at the 85 m core station where peat depth decreased sharply from

70 cm to 44.5 cm. A permanent pool (pool 2) has existed at about 215 m since at least 1957 (Fig. 4). From 1969 to 1973 a second, shallower pool (pool 1) was present at about 180 m (Fig. 4). Both pools were situated directly upslope from a sharp decrease in peat depth. They showed clearly on special aerial photographs (Ektachrome Infrared Aero) taken in 1969 by Rae (1970). The elongated pools lay at a right angle to the direction of slope (Fig. 3). In contrast, transect *a* decreased 8.5 m in elevation. No sharp changes in elevation and no pools were present on this arm of Mason Fen.

Large changes in peat profile have occurred along transect *b* since 1958 (Fig. 5). Maximum peat depth decreased from about 121 to 105 cm, and the deepest peat was 15 m farther downslope in 1972 than in 1958. Peat was deeper at the ends of the transect and had extended at least 3 m farther downslope in 1972 than in 1958. Surface elevation decreased about 1.58 m along the 1958 transect.

Between 11.5 m and 39 m the 1972 profile was shallower than in 1958 and beyond 46 m the 1972 profile was deeper than in 1958. By counting squares on coordinate paper, I estimated that the area between the lines of the two years from 11.5 to 39 m and from 46 to 70 m were approximately equal. The mean peat depth along transect *b* was 73.4 cm in 1958 and 70.6 cm in 1972.

## DISCUSSION

Fens 2, 3, 4, and Mason all seem to be a fusion of at least two closely situated peatlands. Fen 1, although considered as a single unit, still maintains a short separation of dry ground between the upper and lower sections. The water for the lower section originates in part from springs in the upper section and flows along the western margin. In time these

two sections will probably unite. At present a separation also extends to the sundews on Fen 1. *Drosera anglica* occurs on the upper section while *D. rotundifolia* L. occurs on the lower section. They occur together on Mason Fen now al-

though they were distinctly separated on Mason Fen at the time of Mason and Langenheim's mapping in 1958. According to Rae (1970) *D. anglica* occupies sites relatively wetter than those of *D. rotundifolia*.

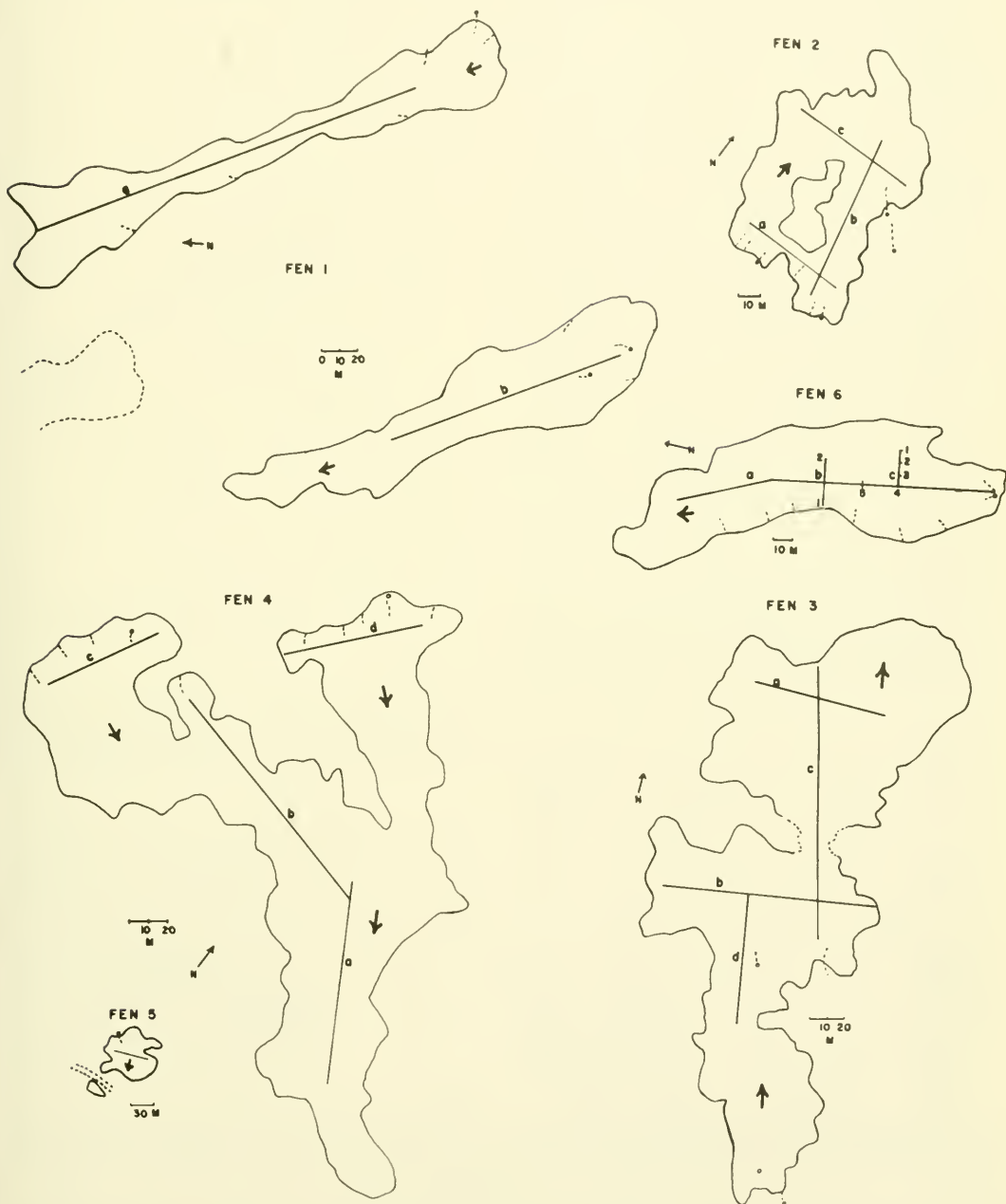


Fig. 1. Maps of six fens in the Sagehen Creek basin. Lines are transects for core samples. Short dotted lines at edges indicate springs or seeps, and arrows indicate direction of slope. The upper drawing of Fen 1 is repositioned; its actual location is shown by the dotted outline nearby.

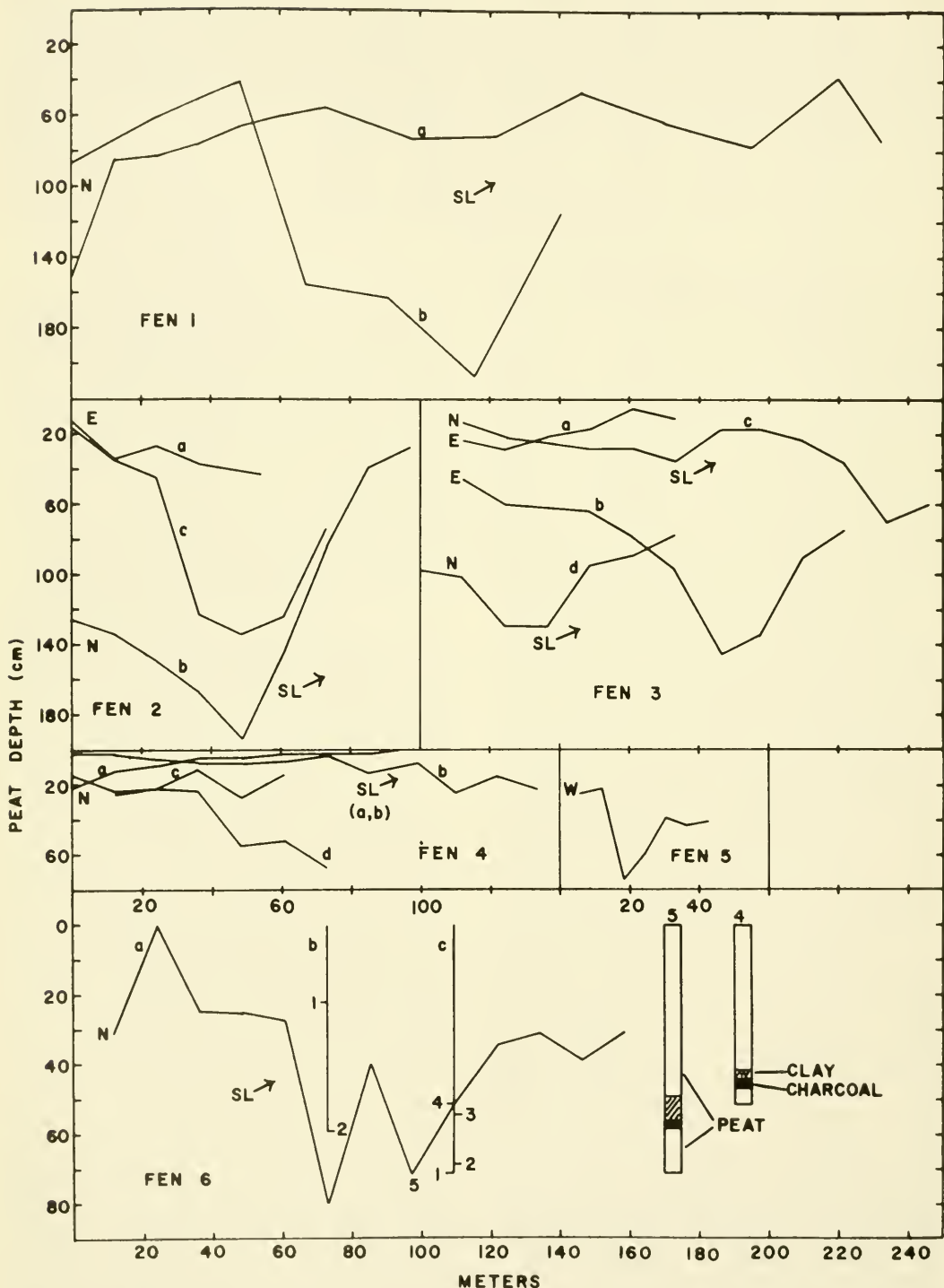


Fig. 2. Peat profiles of Fens 1-6 in the Sagehen Creek basin. Capital letters at left edge of profile indicate direction. SL with arrow indicates the direction of slope of longitudinal transects. Small letters identify transects shown in Fig. 1. Cores 4 and 5 from Fen 6 are drawn to show layers of peat, clay and charcoal that suggest fire, erosion and fen regeneration.

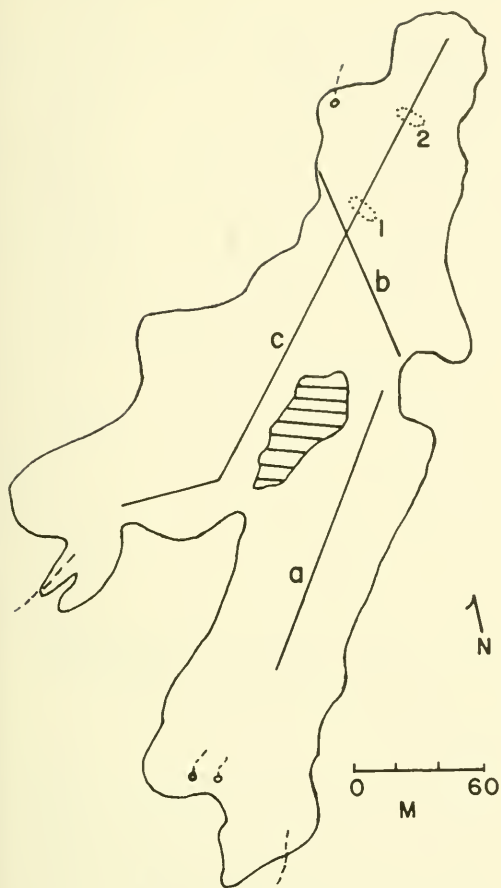


Fig. 3. Map of Mason Fen showing transects (a, b, c) and pools (1, 2). Slope is to the north-east along transects a and c. Transect b was the same transect used by Mason and Lagenheim in 1958.

The fens have a wide range of peat depths. The average peat depth was shown previously to have effects on daily changes in water level, rates of change of temperature, and the production of fen invertebrates (Erman 1973; Erman and Erman 1975). The deeper the peat, the slower the rates of change in environmental factors and the greater the invertebrate production.

Because the vegetation, particularly the dominant mosses, and the water quality are very similar on all the fens (Erman and Erman 1975), one might expect similar rates of peat accumulation for all these fens. Rae (1970) estimated the rate of peat accumulation in Mason Fen by measuring the distance between basal rosettes along the rootstocks of *Drosera*

and by comparing photographs of a downed tree taken in 1957 and in 1969. He concluded that the major portion of the fen (excluding certain marginal area) was rising at a rate of 3 cm/yr.

However, a more complicated development has occurred on some of the fens. In Fen 6 a history of fen regeneration was indicated following a fire. Frequent forest fires are common in the Sierra Nevada (Wagner 1961), and the Donner Ridge fire burned part of the basin in 1960 (Johnson and Needham 1966). This fire burned all of the forest and shrub land around Fen 5 and most of the slope above the upper part of Fen 1, but no evidence of a charcoal layer has been found. Whether the charcoal layer seen in Fen 6 was missed in other fens (unlikely, I believe) and whether the fen surface itself was burned are both unknown. The deposit of clay over the charcoal suggests that at least for some period either the fen was not growing or else erosion was intense. Fen 6 is also unusual because it is the only fen in which the water level is perched 1-2 cm above the moss surface at all times. The other fens have a daily cycle of water level fluctuation; during warm summer days the water level drops 2-3 cm below the surface and then returns to the surface near midnight (Erman 1973). Thus the moss surface would not be dried out completely and would not likely burn.

However, if charcoal and clay washed in, the fluctuations of water level would also affect the deposition and reworking of surface deposits. Such action is apparent each spring on Mason Fen. After spring thaws, the swollen rivulets overflow their channels and carry peat debris, organic detritus, and silt out onto the fen surface away from the streams. This material is obvious in silty patches from late May to early June. By mid-July, after the large daily water-level fluctuations occur, these deposits disappear, presumably reworked down into the peat.

The peat profiles in Mason Fen suggest another factor in peat development. Along transect c three sharp changes in peat depth occurred (Fig. 4). The first change, at 85 m, is related to an abrupt decrease in elevation. The lower two changes are associated with surface pools. One hypothesis of peat development on

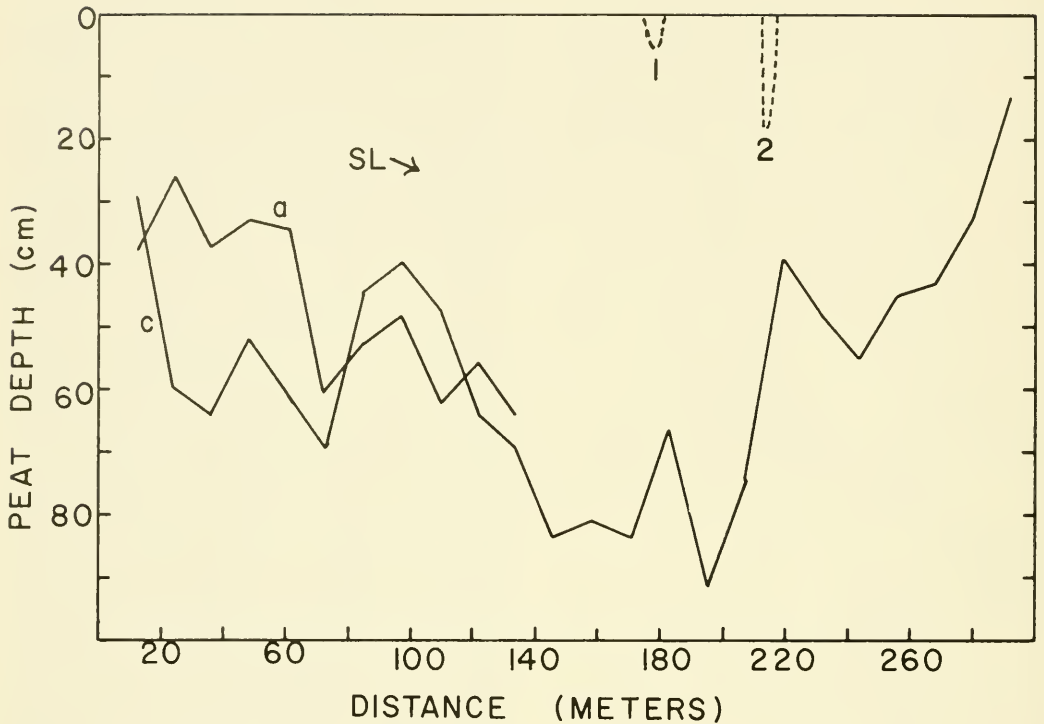


Fig. 4. Peat profiles along the longitudinal transects in Mason Fen. Dotted areas 1 and 2 show location of pools.

sloping ground is that gravity pulls the peat mass downward like a semiliquid (Pearsall 1956). Slow movement and unbalance may eventually result in a split in the peat mass, and slumping. In the resulting gap, and possibly also from the downslope ridge, an elongated pool forms at right angles to the slope (Moore and Bellamy 1973). The profile along transect *c* conforms to this hypothesis.

Additional support of downslope movement of the peat mass is given in the comparison of the profiles of 1958 and 1972 along transect *b* (Fig. 5). Slopes are to the north along the transect as well as across it to the east. Since 1958 peat has accumulated about 16 cm on both ends, but the bulk of the peat mass apparently has shifted downslope to the north and east with a resultant decrease in maximum peat depth. The most obvious evidence of fen growth has been the downslope extension of Mason Fen beyond the limits mapped by Mason and Langenheim and the death of numerous lodgepole pines (*Pinus murrayana* Grev.

& Balf.) by peat encroachment. But increases in peat depth along a sloping transect are more or less balanced by decreases elsewhere.

Peatlands are repositories of considerable ecological history. The preserved remains of vegetation can be used both to reconstruct past surrounding communities and to give some indication of climate and chronology. They also contain evidence of their own succession. But the interpretation of such remains requires some understanding of the way the peatland grows, changes, and functions (Walker and Walker 1961). Peat profiles given in this paper and previous studies help to show the processes of the fens in the Sagehen Creek basin.

#### ACKNOWLEDGMENTS

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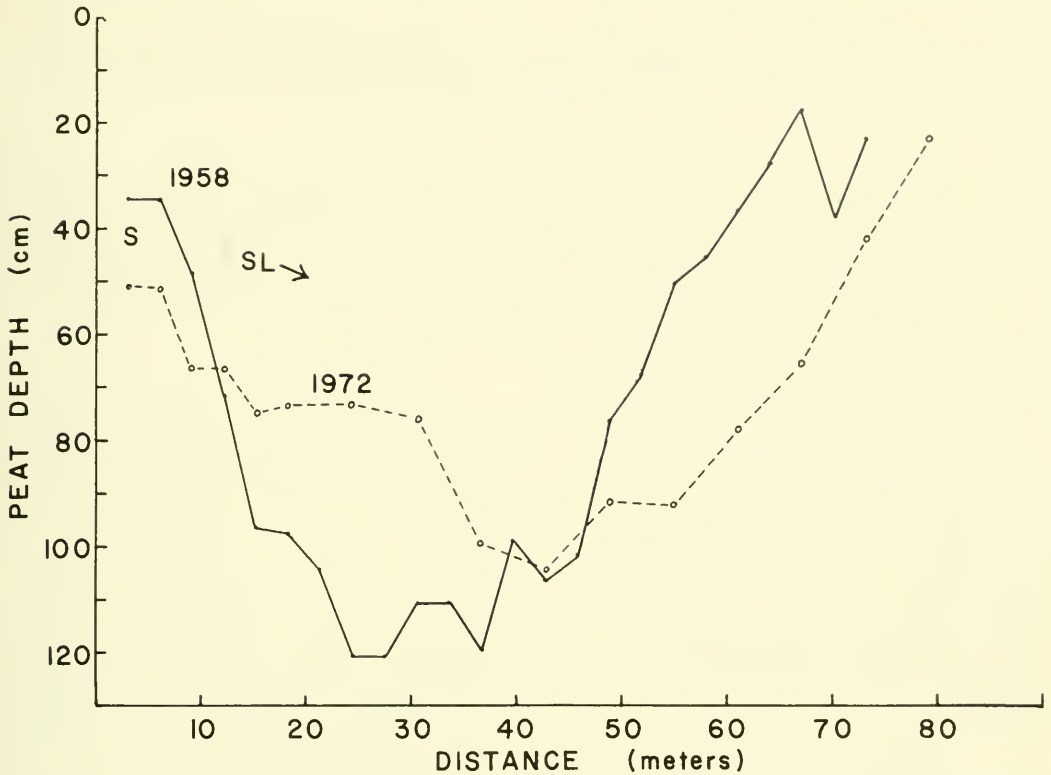


Fig. 5. Peat profile along transect *b* in 1958 and 1972. Slope is from south to north and surface elevation changes 158 cm along the transect.

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