# THE EVOLUTION OF SNOWCOVER IN EAST CENTRAL ONTARIO WITH SPECIAL REFERENCE TO THE INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES (IFYGL) AND TO STRATIGRAPHY

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This is an account of the development of the 1972/73 (IFYGL) snowcover at Peterborough, Ontario, with comparative reference to the snowcovers of 1970/71 and 1973/74. The sites referred to are within the catchment of the Otonabee River which is a tributary of the Trent, a major river of the Lake Ontario basin.

The focus of the paper is the stratigraphic evolution of the cover as seen in data obtained at a permanent time profile stratigraphic site in a forested location within an interdrumlin swale at the Trent University Field Station, three miles north of Peterborough, that is 30 miles north of Lake Ontario. The stratigraphic data are discussed with reference to the general evolution of the cover as shown in depth, 'density' and water equivalent measurements along a 12-point snowcourse at the Station and with reference to climatological data recorded at the site. The time profile site is reasonably representative of forested locations in the Peterborough region generally and the snowcourse provides a meaningful sample of snowcover conditions in the area (Frye 1973, Mathewson 1972). The general character of the area is shown in Figure 1, the time profile and snow survey techniques used are described in Adams and Barr (1974). All snowfall values were obtained from Nipher Gauge measurements, twice daily readings, and all snowcourse work was undertaken with a Canada Atmospheric Environment Service Snow Sampler.

The work is part of a snow research programme designed to improve knowledge of stratigraphic and spatial aspects of snowcover in an area where these have considerable recreational significance as well as being important for hydrologic and biological reasons. The 1972/73 work was designated as IFYGL Project No. 49.

A secondary objective of the paper is the illustration of the possibilities and limitations of standard snowcourse data as a basis for portraying snowcover characteristics in an area.

## CLIMATOLOGICAL CHARACTERISTICS OF THE WINTERS

Indications of the general climatological characteristics of the winters (November-April) are presented in Tables I-VII with reference to long-term means. The ranking of temperature, rainfall, snowfall and overall precipitation values in Table VI gives an indication of the relative standing of the three winters concerned.

None of the winters was exceptional in terms of mean monthly temperature, all of the means listed fall within the range of official 1941-70 values for Peterborough. The IFYGL winter, 1972/73, was quite 'normal' in terms of the overall mean temperature for the six winter months used here (Table I). However, the development of snowcover is greatly affected by fluctuations within a winter and it is notable that 1972/73 was, among the three study winters, relatively cold in November and relatively warm in January and March (Table VI).

The three winters were somewhat less normal in terms of precipitation received. While the overall winter values for rainfall and snowfall lie within the 30 year extremes (Table II, III and IV), four individual months, two of them in the IFYGL, had exceptional receipts (Table VI). Record high snowfall was measured in February

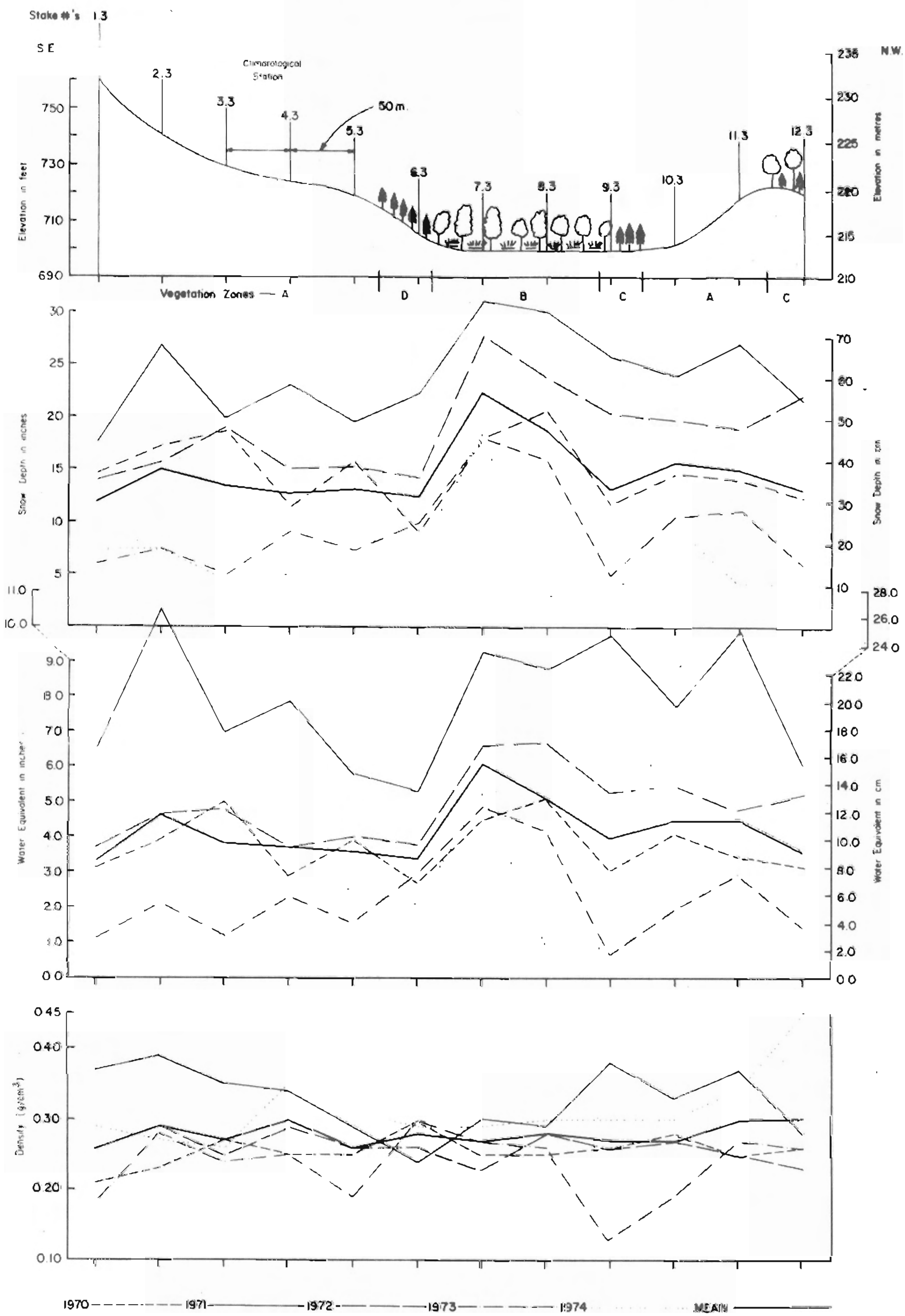
Table I: Mean daily temperatures (°F), winters 1970/71, 72/73, 73/74, Trent Field Station, with reference to 30 year mean values.

| Month | 1941-70 Means: High Mean | Mean | Low Mean | 70/71 | 72/73 | 73/74 |
|---|---|---|---|---|---|---|
| Nov. | 41.8 | 36.1 | 29.2 | 38.9 | 33.3 | 36.1 |
| Dec. | 31.6 | 21.7 | 12.0 | 18.6 | 22.5 | 22.1 |
| Jan. | 24.9 | 16.6 | 8.3 | 13.2 | 21.2 | 19.4 |
| Feb. | 26.4 | 18.5 | 11.7 | 21.6 | 16.6 | 14.8 |
| Mar. | 39.6 | 28.4 | 17.7 | 24.6 | 37.3 | 27.4 |
| April | 50.4 | 42.8 | 35.1 | 39.4 | 43.7 | 45.0 |
| Winter Means | -- | 27.4 | -- | 26.1 | 29.1 | 27.5 |

Table II: Monthly rainfall (inches), winters 1970/71, 72/73, 73/74, Trent Field Station, with reference to 30 year means.

| Month | 1941-70: High | Mean | Low | 70/71 | 72/73 | 73/74 |
|---|---|---|---|---|---|---|
| Nov. | 5.16 | 2.07 | 0.64 | 2.21 | 2.01 | 2.78 |
| Dec. | 2.81 | 0.89 | 0.00 | 0.42 | 2 62 | 0.98 |
| Jan. | 2.06 | 0.49 | 0.00 | 0.23 | 0.70 | 1.08 |
| Feb. | 1.82 | 0.49 | 0.00 | 1.66 | 0.51 | 0.34 |
| Mar. | 3.17 | 1.02 | 0.00 | T | 4.49 | 1.47 |
| April | 4.77 | 2.12 | 0.72 | 0.78 | 2.70 | 3.99 |
| Winter Total | -- | 7.08 | -- | 5.30 | 13.03 | 10.64 |

Fig. 1. Location of Trent Snow Course with peak snow data for 1969/70, 70/71, 71/72, 72/73, and 73/74.



and March of 1970/71 and record high snowfall and rainfall were recorded in December and March, respectively, of 1972/73 (the IFYGL). All of these months, except March 1971, were also record high precipitation months. Among the three study winters, 1972/73 had notably high receipts of snow up to and including December with notably low snow receipts thereafter with the exception of April. Rainfall receipts in the IFYGL winter were above average in terms of the longterm record and were 'high' and 'median' in terms of the study years.

Details of the climatological characters of the study winters are portrayed in parts A and B of Figs. 2, 3 and 4 and are incorporated into the accounts of snow-cover development, below.

## GENERAL EVOLUTION OF THE SNOWCOVER

The evolution of the snowcover is discussed here with particular reference to parts C, D and E of Figs. 2, 3 and 4. Selected data relating to general snowcover conditions are presented in Table VIII.

### 1972/73 (Fig. 2)

The IFYGL winter was notable for above average receipts of rain in every month except November, with record high rainfall in March. It was also notable for high snowfall in November, December and April, with December a record high month, and for low snowfall in January, February and March. In terms of the three winters considered here, the IFYGL (1972/73) recorded the highest precipitation receipts including two record high months.

The early winter was relatively cold, mean temperatures fell consistently below the freezing point in mid November, approximately one week before the general snow cover was initiated. There were significant above-freezing spells in late November (resulting in bare patches in open areas), late December and mid January before the general rise above freezing at the beginning of a very warm and cloudy March. Bare patches appeared around 9th March but the general cover persisted for another week or so as a result of frequent falls of snow and sleet, low radiation and wind (Table VII). Snow persisted in the bush until April.

The cover became established relatively early as a result of the low November temperatures and the relatively high snowfall of that month but a good deal of the precipitation received in November was lost during the warm spell toward the end of the month. Thereafter, the accumulation of snow proceeded rapidly in response to the record snowfall of December so that an early peak of 3.00 inches, water equivalent, was achieved early in January. This snowcover had a depth of 12.2 inches so that its mean density was 0.24 $gm/cm^3$, a very high density for Peterborough at that time of year. This mean subsumes layers of even higher density. However, the second half of the winter was relatively warm, its snow receipts notably low and its rainfall distinctly above average (including the record high for March) so that there was a rapid decline and early disintegration of the cover.

At its peak, the cover contained less than 50% of the precipitation which had fallen since its initiation, in fact it represented appreciably less than the total received in snowfall alone (Table III). By March, when the final melt began, the mean snowcover had shrunk by a further 0.7 inches of water despite receipts of twice that amount of precipitation in February. Thus the final 'spring melt' involved only 41% of the snow receipts of the snowcover season, that is 24% of the total precipitation receipts of the whole winter period.

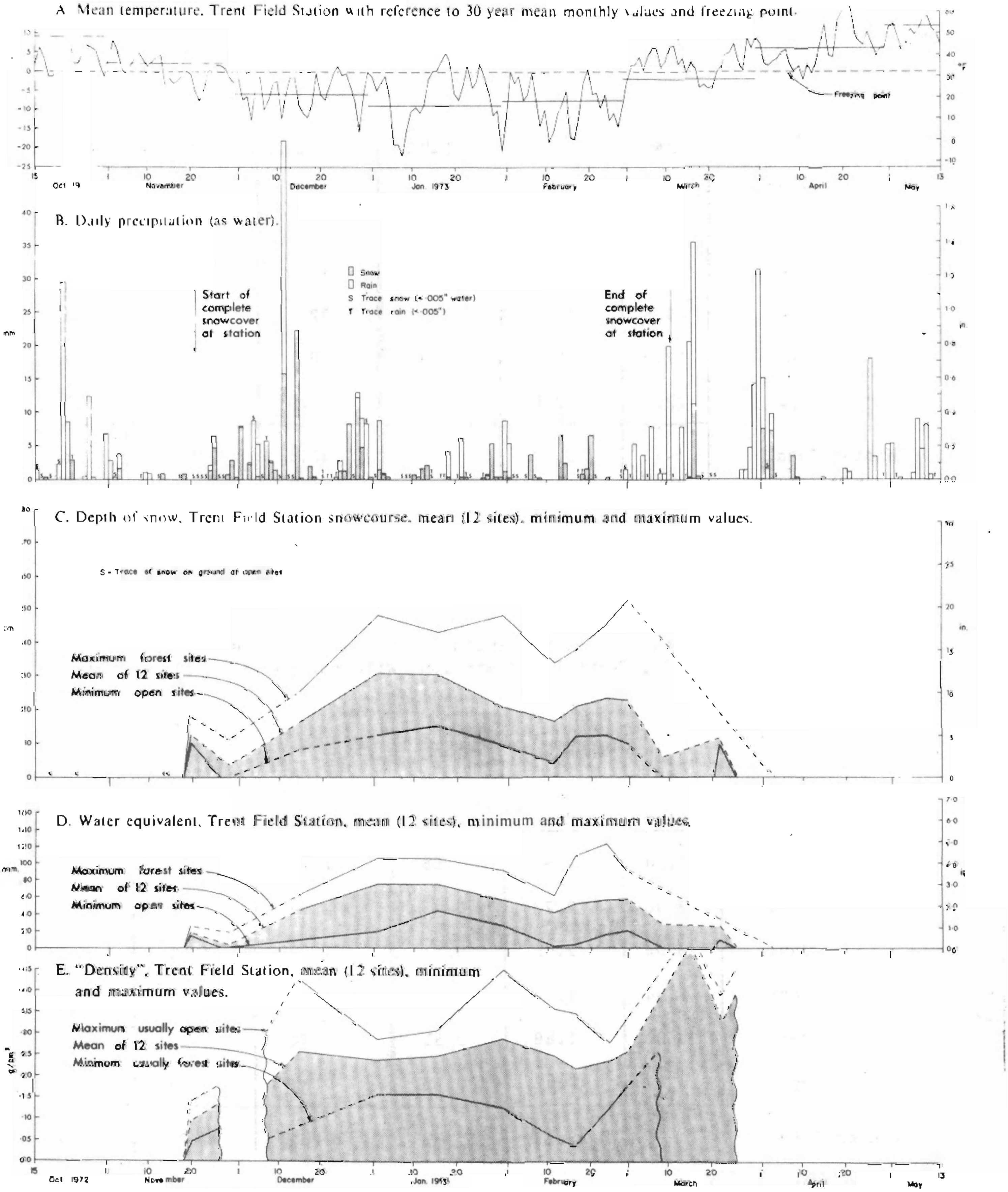
Table III: Monthly snowfall (inches), winters 1970/71, 72/73, 73/74, Trent Field Station, with reference to 30 year means.

| Month | High (1941-70) | Mean (1941-70) | Low (1941-70) | 70/71 | 72/73 | 73/74 |
|---|---|---|---|---|---|---|
| Nov. | 13.6 | 5.3 | T | 1.9 | 7.5 | 5.8 |
| Dec. | 33.3 | 13.4 | 3.8 | 23.2 | 35.0 | 23.4 |
| Jan. | 30.6 | 15.7 | 3.8 | 16.6 | 6.5 | 17.7 |
| Feb. | 29.6 | 14.7 | 3.0 | 32.9 | 9.7 | 10.9 |
| Mar. | 17.0 | 8.3 | 0.3 | 18.0 | 5.6 | 13.3 |
| Apr. | 22.9 | 2.6 | 0.0 | 0.9 | 7.4 | 1.7 |
| Winter Total | -- | 60.0 | -- | 93.5 | 71.7 | 72.8 |

Table IV: Monthly total precipitation (inches), winters 1970/71, 72/73, 73/74, Trent Field Station, with reference to 30 year means.

| Month | High (1941-70) | Mean (1941-70) | Low (1941-70) | 70/71 | 72/73 | 73/74 |
|---|---|---|---|---|---|---|
| Nov. | 5.24 | 2.63 | 1.55 | 2.40 | 2.76 | 3.36 |
| Dec. | 3.96 | 2.23 | 0.45 | 2.74 | 6.12 | 3.32 |
| Jan. | 3.59 | 2.05 | 0.51 | 1.89 | 1.35 | 2.85 |
| Feb. | 3.44 | 1.96 | 0.53 | 4.95 | 1.48 | 1.43 |
| Mar. | 3.80 | 1.88 | 0.51 | 1.80 | 5.05 | 2.80 |
| Apr. | 4.87 | 2.42 | 0.72 | 0.87 | 3.44 | 4.16 |
| Winter Total | -- | 13.17 | -- | 14.65 | 20.20 | 17.92 |

Fig. 2. Evolution of snowcover 1972-73 with selected climatological variables.



1973/74 (Fig. 3)

The snowcover period of 1973/74 can be described as the most 'normal' of the three discussed here in terms of mean temperature and precipitation values although, like the IFYGL, it received above average precipitation, especially rain, in November, January and March. February was an exceptionally cold month being nearly 2°F below the January mean. Although snowfall for the winter as a whole was above average, there were no months of exceptional snowfall such as were experienced in the previous study years. Fluctuating temperatures and above average rainfall in November delayed the initiation of the general cover until 6th December (17 days later than in the IFYGL) which was close to the date of the general decline of mean daily temperatures below freezing (24 days later than in the previous year). Again, there were significant periods with above freezing temperatures during the winter, in late December, late January and early March, each with associated rainfall and with bare patches in open areas during the last two. The cover ceased to be 'general' on 3rd April, a week later than the previous year after a March which had higher snowfall and lower rainfall and temperatures than the IFYGL. Snow persisted in the bush well into the middle of April, mean daily temperatures rose above freezing at the end of March.

Peak snowcover was measured on 23rd January, three weeks later than in the previous year, but with the same magnitude (3.00 inches of water) and with similar depth and density values. The amount of precipitation received during the build-up season 5.10 inches of water (3.97 snow, 1.13 rain) was less than in the previous year but a higher proportion of it was retained. There is a steady rise in water equivalent (Fig. 3D) from the date of initiation to peak snowcover.

After the peak, the pack again declined rapidly especially in open areas in response to a warming trend at the end of January. An exceptionally cold first three weeks in February along with low precipitation receipts resulted in only minor fluctuations in the snowcover during the month. The rain of 4th March produced extensive open areas for ten days but renewed snowfall later in the month revived the cover until it was finally broken up by the heavy rain of late March and early April.

If 30th March is taken as the date of the start of the major melt and runoff period, there was only 1.00 inch of water available in the pack for spring runoff despite precipitation receipts of 11.48 inches during the snowcover season. In fact, there were two major runoff peaks that spring, both involving major melt and rainfall components, one in early March which involved more than 1.7 inches of the average 1.9 inches which then existed. All open areas became free of snow at that time.

1970/71 (Fig. 4)

This was a winter in which mean monthly temperatures fluctuated between relatively high and relatively low values with notably low temperatures in December and January and March. Rainfall was low except in February while snowfall was moderate except for very high values in February and March (Table III). The low rainfall (only 21 precipitation days with rainfall alone) and the large number of days with measureable snowfall (59) combined with a cold winter to produce a snowcover which contrasted markedly with the other two discussed here.

The general cover was initiated on 3rd December, close to the date on which mean daily temperatures fell below the freezing point. This is essentially the same as in 1973/74, that is considerably later than in IFYGL. However, peak snowcover was not achieved until 15th March, approximately seven weeks later than in 1973/74, nine weeks later than in the IFYGL. The mean water equivalent at that time

Table V: Monthly snowfall as a percentage of total precipitation, winters 1970/71, 72/73, 73/74, Trent Field Station, with reference to 30 year means.

| Month | 1941-70 Mean | 70/71 | 72/73 | 73/74 |
|---|---|---|---|---|
| Nov. | 20.2 | 7.9 | 27.2 | 17.3 |
| Dec. | 60.1 | 84.7 | 57.2 | 70.5 |
| Jan. | 76 6 | 87.8 | 48.1 | 62.1 |
| Feb. | 75.0 | 66.5 | 65.5 | 76.2 |
| Mar. | 44.1 | 100 0 | 11.1 | 47.5 |
| Apr. | 10.7 | 10 3 | 21.5 | 4.1 |
| Winter Means* | 45.6 | 63.8 | 35.5 | 40.6 |

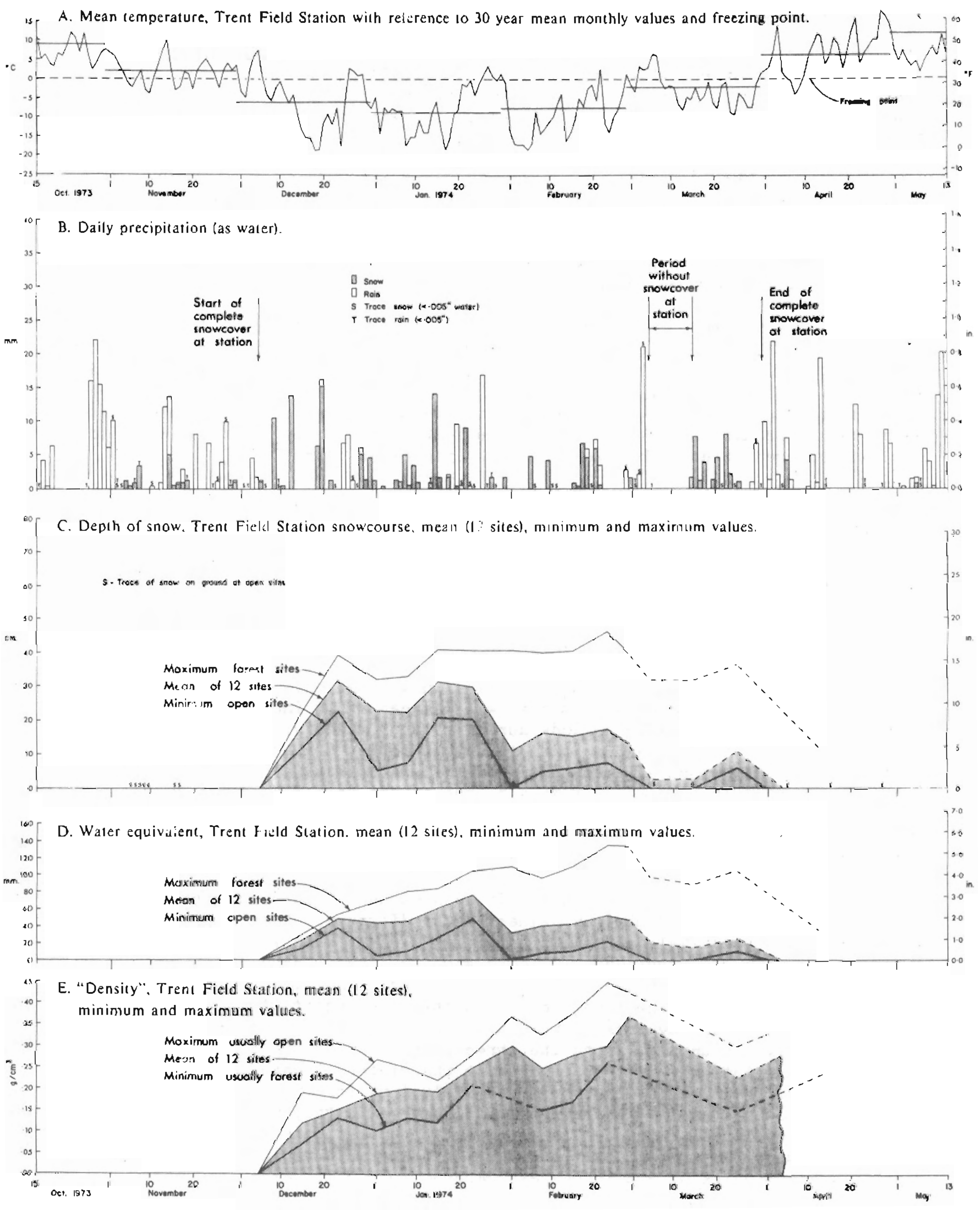
* From Total Values not from Total Months / 6 .

Table VI: Mean values in tables I-IV ranked as H (high), M (medium) or L (low) to give an impression of the relative warmth, snowiness and raininess of the winters concerned.

| | 1970/71 | | | | 1972/73 | | | | 1973/74 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Mean Temp. | Rain-fall | Snow-fall | Total Precip. | Mean Temp. | Rain-fall | Snow-fall | Total Precip. | Mean Temp. | Rain-fall | Snow-fall | Total Precip. |
| Nov. | H | M | L | L | L | L | H | M | H | H | M | H |
| Dec. | L | L | M | L | M | H | H* | H* | M | M | M | M |
| Jan. | L | L | M | M | H | M | L | L | H | H | M | H |
| Feb. | H | H | H* | H* | M | M | L | M | L | L | L | L |
| Mar. | L | L | H* | L | H | H* | L | H* | M | M | H | M |
| Apr. | L | L | L | L | M | M | H | M | H | H | M | H |
| | L | L | H | L | H | H | M | H | M | H | M | M |

* indicates value higher than the 30 year monthly maximum.

Fig. 3. Evolution of snowcover 1973-74 with selected climatological variables.



was 7.9 inches from 10.79 inches of precipitation received (8.48 inches snow) since initiation of the cover.

From peak water equivalent, there was a general decline during the second half of March despite appreciable snowfall. An interesting feature of this winter was the early (i.e., mid February) peak in snow depth with only a secondary depth maximum coinciding with peak water equivalent. The late peak in the latter reflects a gain of almost one inch of water from rain late in February.

There was a rapid decline in depth and water equivalent of the cover after 1st April with bare patches appearing around 11th April. Snow persisted in the bush for another week despite rain. Almost 7.00 inches of water were involved in the final melt, derived from 12.03 inches of precipitation received furing the snowcover period. This was much higher than in either of the other two years both as an absolute amount and as a proportion.

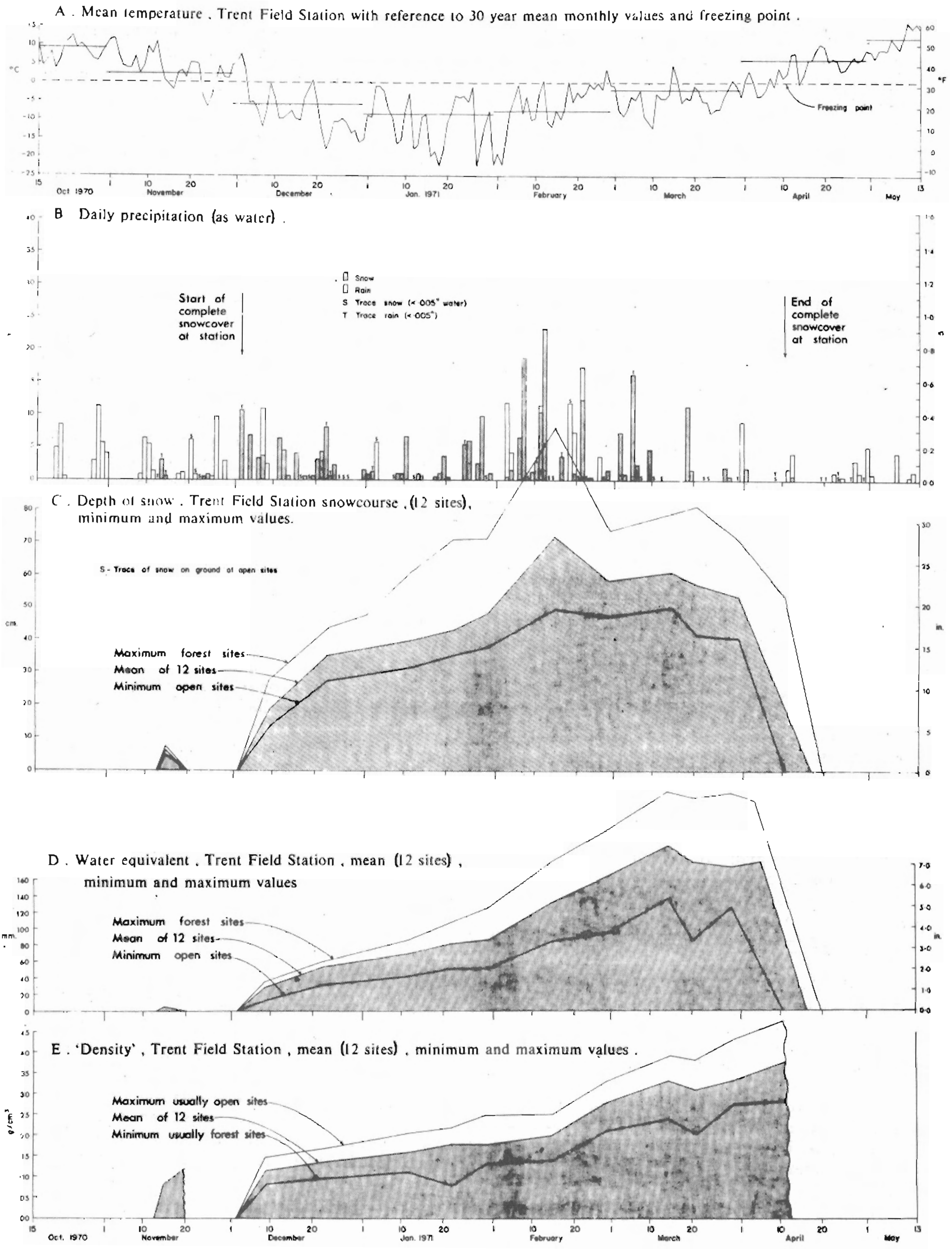
This winter forms a considerable contrast to the others in that there was a continuous snowcover for 133 days. The snow accumulated steadily throughout the winter at all sites with almost classic patterns of increase of water equivalent and mean density as the winter progressed. There were no long spells of above freezing temperatures in mid winter, there was little rain and wind conditions were 'average'. Under these circumstances the general behaviour of the cover was quite similar at open and covered sites. This was not so in the other years.

## SNOWCOVER AT SHELTERED AND OPEN SITES

The maximum and minimum values in parts C, D and E of Figures 2, 3 and 4 give an impression of conditions at sheltered and open sites as the extreme limits of cover conditions existing along the snowcourse. The regime of snowcover at such locations is clearly very different.

In the IFYGL and 1973/74, open sites had consistently low snowcover in terms of water equivalent (a peak of less than 2 inches as compared with peak means of 3 inches) and, as a result of high densities in mid season, an even shallower cover in terms of depth (8 inches as compared with a mean of 16 inches). Bare patches were present for appreciable periods during each of these winters. The open areas were more exposed to wind and to radiation than forested areas and it would appear that they were also more affected by rainfall. This last may be partly due to the interception of rain by trees but is also due to the thinness of the open snowcover which can be entirely penetrated by rainfall. The late January decline of 1973/74 provides an excellent example of this (no loss in forested areas, bare patches in some open sites, very high densities in others).

The role of forested sites in retaining snowcover is brought out by the contrast between maximum and minimum values in the diagrams. Peak cover in the bush in terms of water equivalent, in IFYGL and in 1973/74, with the open peak in parenthesis, in inches of water, was 4.9 (1.8) and 5.3 (1.9). Both of the sheltered site peaks were much later than the 'mean' peaks discussed above and were thus much more closely associated with the final melt. In the bush, rainfall is more likely to contribute to the pack by increasing density without destroying the cover. As mentioned, 1970/71 was unusual among the three years in that the trend of depth measurements was relatively similar throughout the winter at both open and sheltered sites and that the peak in terms of water equivalent for the forest sites, the open sites and the mean all occurred on 15th March. In that year, a sufficiently thick cover developed in open areas to withstand appreciable rainfall but in spite of this the water equivalent of the cover increased more rapidly in the bush to reach a maximum value of 9.3 inches as compared to 5.3 inches in the open.


A . Mean temperature . Trent Field Station with reference to 30 year mean monthly values and freezing point .
°C
°F
Freezing point
Oct 1970
November
December
Jan. 1971
February
March
April
May
B Daily precipitation (as water) .
Snow
Rain
S Trace snow (< ·005" water)
T Trace rain (< ·005")
Start of complete snowcover at station
End of complete snowcover at station
C . Depth of snow . Trent Field Station snowcourse , (12 sites), minimum and maximum values.
S - Trace of snow on ground of open sites
cm.
in.
Maximum forest sites
Mean of 12 sites
Minimum open sites
D . Water equivalent . Trent Field Station , mean (12 sites) , minimum and maximum values
mm.
in.
Maximum forest sites
Mean of 12 sites
Minimum open sites
E . 'Density' , Trent Field Station , mean (12 sites) , minimum and maximum values .
g/cm³
Maximum usually open sites
Mean of 12 sites
Minimum usually forest sites
Oct. 1970
November
December
Jan. 1971
February
March
April
May

The relationships between snowfall, rainfall and snowcover depth and density are brought out well at several points in the diagrams. The late February period of rain and sleet in 1970/71, with its associated decline in depths but with a rise in density and water equivalent, is one example.

A possibly more typical example can be seen during the period of rain in late December 1973 (Fig. 3). The mean snow depth and water equivalent declined whilst the density increased. At the forest site, in response to the decline in depth resulting from the rain, the water equivalent and density increased as compared to a decline in both water equivalent and density of the shallow snow pack at the open site.

A fall of new snow results in an initial rise in depth, a lowering of mean density and a rise in water equivalent. A good example of this can be seen between 8th and 15th January 1974 (Fig. 3). Plots of daily snow increments for that period would show the decline in depth and increase in density which follow densification of the fresh fallen snow. These effects are somewhat concealed here by the low frequency of measurements but the general upward trend of mean density in the graphs is a reflection of them.

For most of a normal season, the lowest mean densities occur at forested locations but the density of snow at some open sites appears to fall during the final stages of disintegration of the snowcover. This reflects the rapid removal of melt water from snow at those sites at which the pack ripens very early and becomes very granular (Figs. 2 and 3).

In Peterborough, open sites commonly contribute moisture to the air and to the ground in considerable quantities throughout the winter. The forested sites retain moisture and contribute heavily to the spring flood.

The forested sites have a greater depth of snow at a generally lower density for a longer period of time. During the cold periods, this keeps up the ground temperature (see below), during warm periods it keeps ground temperature down. Both of these roles are important for survival plants and animals. The reduction of snow depth and increase in mean density at bush sites by snowmobiles is increasingly common nowadays. Fig. 8 is an example of the variations of temperature in and beneath a snowpack, in this case for a sheltered site during the 1972/73, IFYGL.

The exact role of snowcover at a forested site in this regard and others depends to a considerable extent not on the average characteristics of the cover but on the stratigraphic characteristics which are subsumed by snowcourse values. The stratigraphic evolution of the cover at sheltered sites is discussed, with some reference to open site stratigraphy, below.

## STRATIGRAPHIC EVOLUTION OF THE SNOWCOVER

Figures 5, 6 and 7 are plots of the evolution of stratigraphy at a forested site located close to point 6.3 in vegetation type D on Figure 1. The climatological data plotted against the stratigraphy are derived from the nearby Trent Field Station. The techniques of measurement and plotting used here are described in Adams and Barr (1974), they follow the standard (UNESCO 1970) procedures.

The idea of a time profile is that it allows a continuous evaluation of the condition of a snowcover. The diagrams presented here should be considered with reference to Figures 2, 3 and 4 which show the overall evolution of snowcover in the area concerned. The stratigraphic site is subsumed in the "forest sites" category of parts C, D and E of those diagrams.

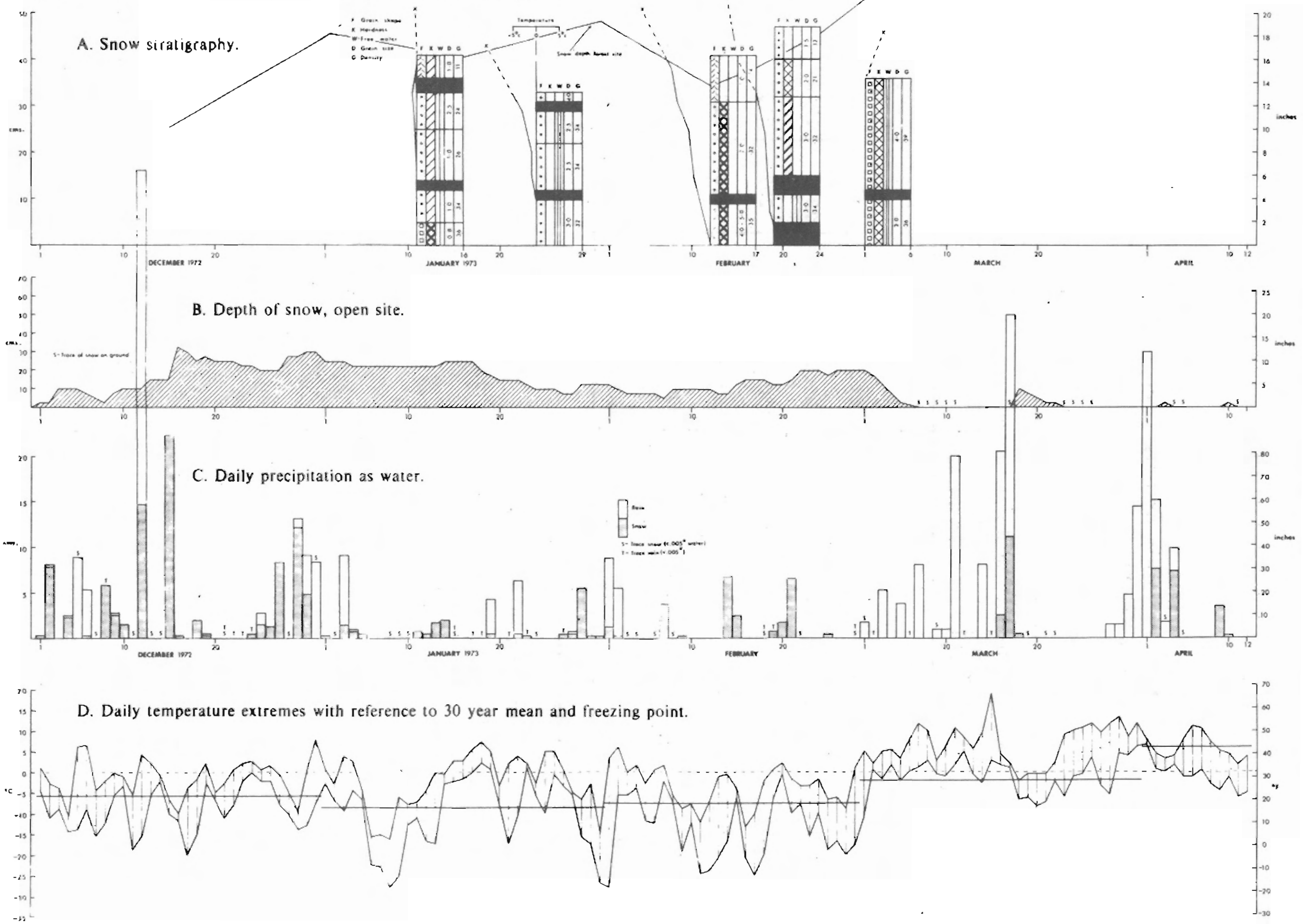
Table VII: Monthly totals of bright sunshine hours and mile of wind at 1 m., winters 1970/71, 72/73, 73/74, Trent Field Station.

| | Bright Sunshine (Hours) | | | | Wind at 1 m. level (miles) | | |
|---|---|---|---|---|---|---|---|
| Month | Max. Possible | 70/71 | 72/73 | 73/74 | 70/71 | 72/73 | 73/74 |
| Nov. | 292 | 61.5 | 49.4 | 78.6 | n/a | 1169 | 2291 |
| Dec. | 279 | 94.6 | 37.0 | 61.5 | n/a | 1307 | 2171 |
| Jan. | 290 | 129.2* | 128.3 | 92.1 | 2165 | 2381 | 2708 |
| Feb. | 293 | 68.0 | 141.0 | 150.8 | 2268 | 1252 | 2107 |
| Mar. | 368 | 157.4 | 90.7 | 153.3 | 2021 | 1605 | 3191 |
| Apr. | 402 | 198.5 | n/a | 206.4 | 1978 | 2929 | 3270 |
| Monthly Means | 320.7 | 118.2 | 89 3+ | 123.8 | 2108.0+ | 1773.8 | 2623.0 |

* Estimated

\+ Missing Data

Fig. 5 Trent Field Station stratigraphic time profile, forest site, 1972-73.



The IFYGL (1972/73) and 1973/74 show a similar pattern of snow on the ground at open sites (part B of Figs. 5 and 6). There a peak (of less than 15 inches) in the first half of the snow season followed by low snow depths in January and February, with only intermittent snowcover in March and April. In both winters, above freezing mean daily temperatures were recorded at various times during December and January although considerable variation in temperature is apparent.

However, the detailed evolution of snow stratigraphy is quite different in the two years largely as a direct and indirect response to rainfall receipts. The very heavy rain of December 1972 and the intermittent rain which was a feature of the 1972/73 winter had the effect of producing and sustaining very high densities in the IFYGL pack. The density at the base of the pack was already 0.36 $g/cm^3$ in early January when only the newfallen surface layer was below 0.20 $g/cm^3$. A mean density of 0.25 is commonly achieved only towards the end of the snow season in this area.

High density values are associated with high thermal conductivities so that this particular snowpack reacted rapidly, throughout its depth, to changes in air temperature and provided a poor insulation for the underlying ground. This is reflected in the overall pattern of temperature for the pack on soil (Fig. 8) and in the evolution of stratigraphy within the pack.

With regard to stratigraphic evolution, well developed constructive crystal forms were already present in a thin basal layer by mid January, a response to steep nival temperature gradients during the preceding cold spell. However, on the actual profile date, the entire profile had warmed up to close to the freezing point and the following warm spell, with rain on the thin pack, removed all trace of constructive forms. There was some evidence of constructive metamorphism present at the time of the early February profile, which followed another cold spell, however another period of warm weather, including a trace of rain, effectively removed these also before 24th February. The late February cold spell drastically changed crystal structure throughout the profile.

The basal layer of ice of 24th February suggests considerable percolation of water, possibly from a neighbouring location.

By contrast, the early high densities in the lower layer of the 1973/74 diagram decrease steady in January and February in response to a steady increase in constructive forms. The 23rd January temperature profile shows isothermal conditions at the freezing point in response to maximum air temperatures rising above freezing over the previous three days. The 6th February temperature profile, which shows the effect of mean air temperatures of c. -17°C over the previous five days is probably more typical of air-snow relationships at that time of that winter. Conditions favourable to constructive growth dominated in February only for the resulting forms to be obliterated by the warmth and rain of late February-March.

The important effect of rain in the stratigraphy of the IFYGL pack also shows up in the number and persistence of ice layers in that season. The lower ice layer in the first profile persisted throughout the winter, considerably modifying growth conditions in the basal layer. A good example of the formation and development of an ice layer is shown in the profile for 10th February. This can be traced to the rainfall of 4th/5th February. Once established, in conditions of rapidly fluctuating temperatures, an ice layer within the pack can act as a barrier to downward movement of moisture. The rain of 26th February does not appear as an individual, new, ice layer in the profile of 5th March but as a thickening of the existing upper ice layer shown in the profile of 25th February. Thus even given isothermal conditions, the ice layer prevented percolation into the lower layer of the pack.

Table VIII: Selected data relating to evolution of mean snowcover.

| | 1970/71 | IFYGL 1972/73 | 1973/74 | Notes |
|---|---|---|---|---|
| (1) Generally subfreezing mean daily temperatures begin | 3 Dec. | 12 Nov. | 5 Dec. | |
| (2) General cover initiated | 3 Dec. | 19 Nov. | 6 Dec. | 1970/71 ignores |
| (3) End of general cover | 18 Apr. | 27 Mar. | 3 Apr. | period of cover |
| (4) Period of general cover (days) | 133 | 128 | 118 | in November |
| (5) Number of days with bare patches | 0 | 15 | 10 | |
| **ACCUMULATION PERIOD** | | | | |
| (6) Date of peak cover | 15 Mar. | 9 Jan. | 23 Jan. | |
| (7) Period of accumulation (initiation to peak), days | 102 | 51 | 48 | |
| (8) Peak water equivalent (ins. water) | 7.90 | 3.00 | 3.00 | |
| (9) Rainfall during accumulation period (ins. water) | 2.31 | 3.03 | 1.13 | |
| (10) Snowfall during accumulation period (ins. water) | 8.48 | 4.38 | 3.97 | |
| (11) Total precipitation during accumulation period (ins. water) | 10.79 | 7.41 | 5.10 | |
| (12) Depth at peak (ins.) | 24.00 | 12.20 | 12.00 | |
| (13) Density at peak ($gm/cm^3$) | 0.33 | 0.24 | 0.25 | |
| **PERIOD OF DECLINE** | | | | |
| (14) Period of decline (peak to end of general cover), days | 27 | 77 | 70 | |
| (15) Rainfall of decline period (ins. water) | 0.56 | 4.51 | 3.82 | |
| (16) Snowfall of decline period (ins. water) | 0.68 | 2.06 | 2.56 | |
| (17) Total precipitation of decline period (ins. water) | 1.24 | 6.57 | 6.38 | |
| (18) Date of start of major melt | 1 Apr. | 1 Mar. | 30 Mar. | March melting |
| (19) Water present at start of major melt (ins. water) | 6.90 | 2.30 | 1.00 | early March 73/74 |
| (20) Depth at start of major melt (ins.) | 21.00 | 9.00 | 4.22 | |
| (21) Density at start of major melt (ins.) | 0.33 | 0.26 | 0.23 | |
| (22) Total rainfall of period of general cover (ins. water) | 2.87 | 7.54 | 4.95 | |
| (23) Total snowfall of period of general cover (ins. water) | 9.16 | 6.44 | 6.53 | |
| (24) Total precipitation of period of general cover (ins. water) | 12.03 | 13.98 | 11.48 | |

Fig. 6 Trent Field Station stratigraphic time profile, forest site, 1973-74.

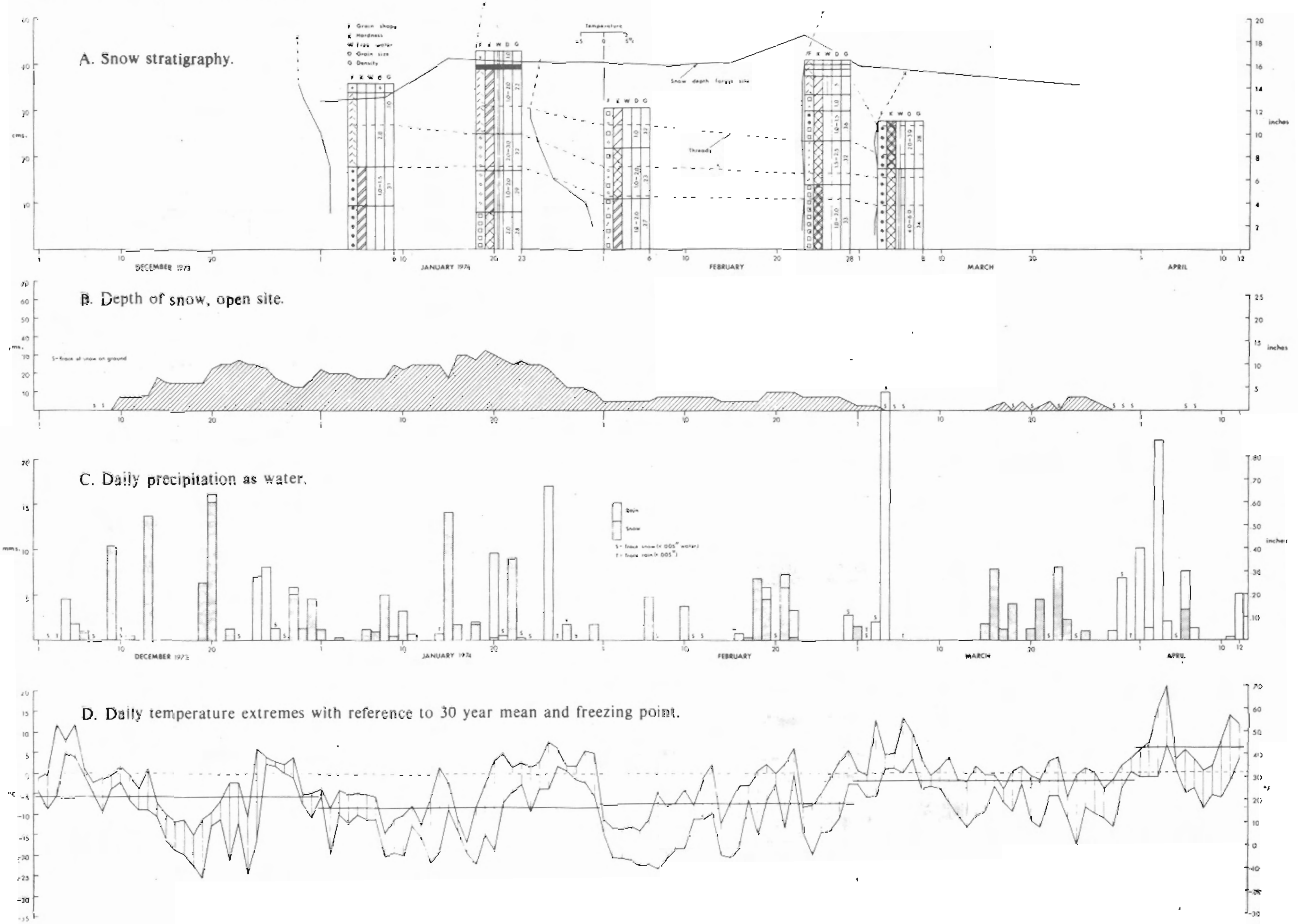


Fig. 7 Trent Field Station stratigraphic time profile, forest site, 1970-71.

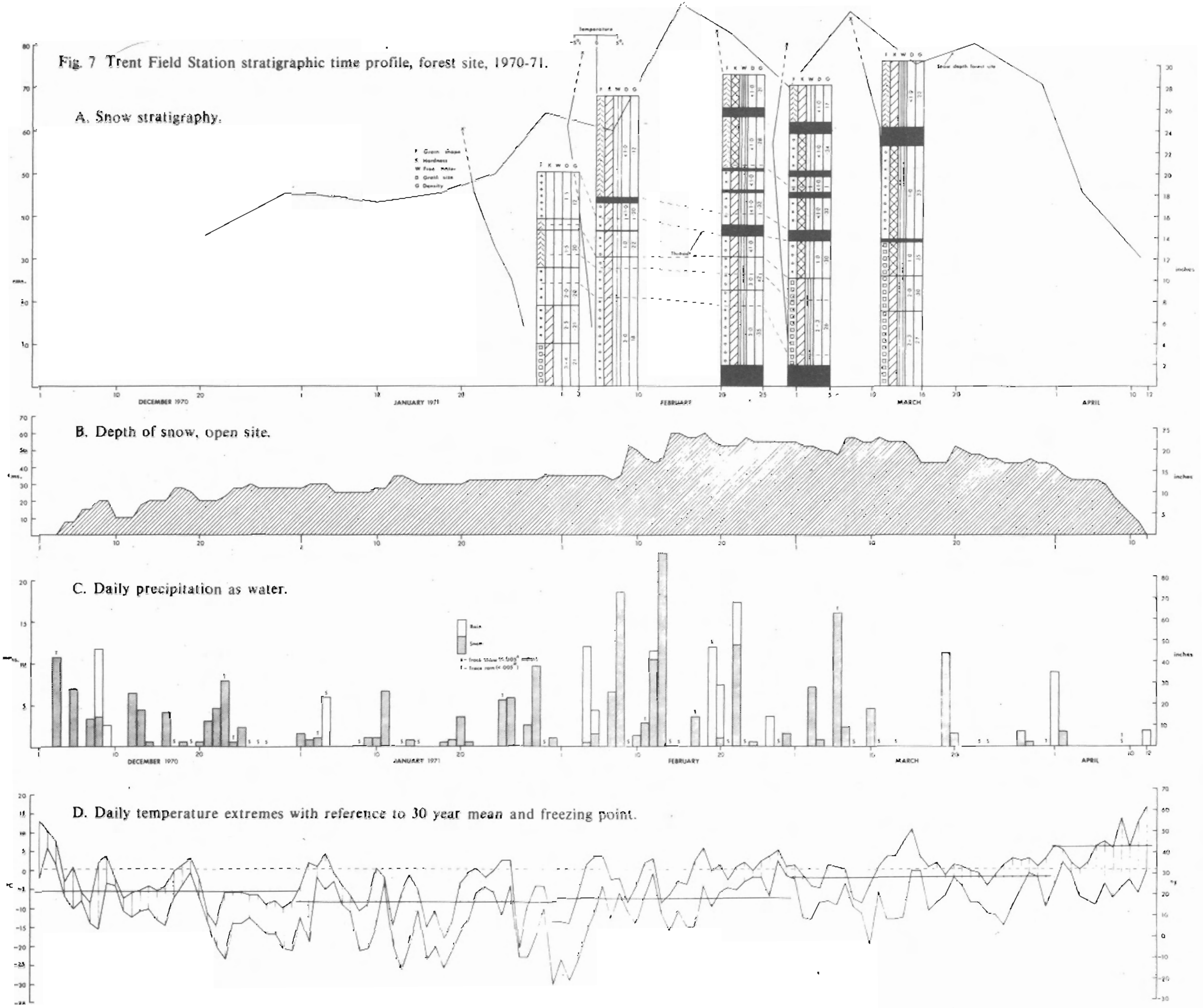
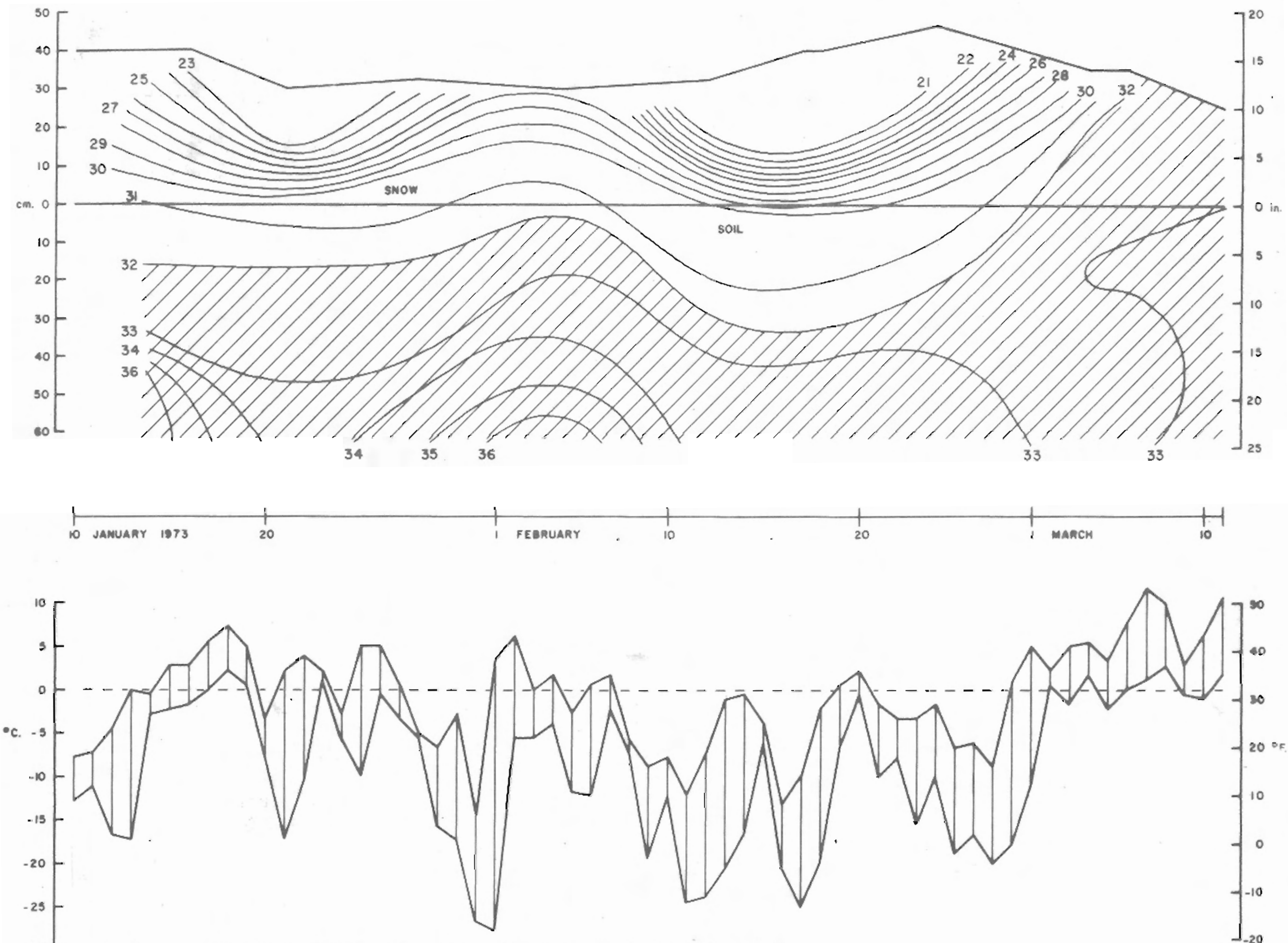


Fig. 8. Sub nival and soil temperatures (°F) at Profile Site 1972–73.




Daily temperature extremes with reference to freezing point

Thus, two years of superficially similar snowcover produced quite different snowcovers in terms of stratigraphy. Conditions for life under the snow, for plants and animals, were very different. The IFYGL was, in this area, a hard one for plants and animals which exist in the subnival environment.

By contrast, the 1970/71 time profile (Fig. 7), which portrays the snowcover of a much colder year than either of the other two, suggests a more congenial subnival environment. The pack was established relatively early, increased in depth steadily until mid March and then persisted well into April at sheltered sites.

Rain in February formed the greatest hazard to subnival life, obliterating constructive crystal forms developed during cold spells under a relatively thin cover, and producing marked layers of ice which may have persisted until the end of the season. However, renewed cold weather produced further constructive metamorphism, accentuated by the presence of freezing melt water at the base of the profile. During this winter, the depth of ground freezing was slight.

## CONCLUDING REMARKS

The 1970/71 winter is the most distinctive of the three compared here and it was in fact an abnormal year, in terms of snowcover, for the Peterborough area. Snowfall receipts that winter were notably, although not quite exceptionally, high. However, the distribtuion of snowfall receipts during the winter--especially the record receipts of February and March--and the persistently low temperatures combined to produce an exceptional snowcover year. The proportion of precipitation which fell as snow was exceptionally high (Table V). There was a continuous and generally increasing snowcover from December through to March. Thus almost seven inches of water was present on the ground at the start of the major spring melt as compared with 2.30 and 1.00 inches of water respectively for 1972/73 and 1973/74 (Table VIII, line 19), and yet winter totals of precipitation were very similar for the three snow seasons (Table VIII, line 24).

This distinctive pattern of overall snowcover evolution is clearly reflected in the stratigraphy for 1970/71. It shows the classic pattern of constructive metamorphic evolution with depth hoar gradually extending up from the base of the cover to encompass half of the profile (Fig. 7).

The IFYGL (1972/73) was generally more similar to 1973/74 than to 1970/71 and was, in fact, more typical of snowcover evolution in the Peterborough area. Warm spells with rain interrupted the steady evolution of the cover (there were 15 days with bare patches, Table VIII, line 5) and the pack has lost a great deal of mass before the final spring melt began (Table VIII, line 19 etc.). The IFYGL cover was initiated relatively early but was brought to an abrupt end in March by unseasonally high temperatures and rainfall. In fact, rainfall was a notable feature of all the main snowcover months of 1972/73, as is apparent from the stratigraphic diagram (Fig. 5). The proportion of total precipitation which fell as snow was low in every winter month except November and April during the IFYGL (Table V). This appears to be a critical measure of winter climate from the point of view of evolution of snowcover in this area.

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