AN EVALUATION OF MOBILE THERMO DEW-POINT RECORDING IN THE SPRING CREEK BASIN, ALBERTA

BY

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ABSTRACT

Mobile thermo dew-point recording was carried out in the Spring Creek basin in central Alberta to assess the ability of the method to delineate homogeneous temperature regions. Traverses were run around sunrise and sunset and near the peak heating period on days in early May. The method proved useful for detecting areas with higher and lower humidities and temperatures in the study area. This assisted in the placement of isotherms between recording climatic stations and in establishing the representativeness of a station.

RESUME

Les auteurs ont effectué des enregistrements des points de rosée sur thermomètre mobile dans le bassin hydrographique de Spring Creek situé en Alberta central, afin d'estimer si la méthode peut délimiter les régions de température homogène. Des lignes de cheminement ont été suivies à l'aurore et au crépuscule et aux heures où le soleil réchauffe le plus le jour, lors des premiers jours de mai. La méthode s'est avérée efficace pour détecter les régions a humidité et température élevées et basses de la région étudiée. Ceci a servi à tracer les isothermes entre les stations d'observation climatique et à determiner la représentativité d'une station.

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INTRODUCTION

Forest and rural climatic stations are frequently not very representative of their area. Recording of climatic parameters at climate stations is influenced by the adjacent terrain and vegetation characteristics, forcing the researcher to evaluate, often subjectively, the area represented by the station and between stations. Isohyetal maps based upon these existing observation stations are in many cases inaccurate and of little value to the agriculturalist, forester, or recreationist.

Extensive studies in urban environments by Middleton and Millar (1936) demonstrated the effectiveness of mobile detection in delineating urban heat island boundaries, and the method has been used considerably since in studies of urban environments. Little comparative work has been conducted in rural environments. Four studies are, however, worthy of mention, three of them from Alberta. MacPhail (1966) traversed a number of routes north from Lake Ontario to illustrate the dependence of temperature on topography as distance increased from the lake. Longley and Louis-Byne (1967) demonstrated that the patterns of temperature in the Pigeon Lake area of Alberta are repetitive during calm, clear nights. Hayter (1972) used the method to assess the spatial variation of minimum temperatures around six climatological stations in northeast-central Alberta. In the Spring Creek basin of Alberta, Longley [1968] attempted to correlate the temperature variations with the underlying surface variations. However, because of the rising and falling temperatures experienced during the times of the mobile traverses, few definite correlations were drawn except for the fact that temperatures are affected by topographic change. Variations of 2-3°C in temperature with less than 60 m change in elevation were experienced on July 21 and 22, 1967.

In this study mobile thermo dew-point recording was again attempted in the Spring Creek basin from May 6 to 10, 1969, to assess the ability of the method to delineate homogeneous temperature regions. Spring Creek basin serves as an adequate test area because it has suitable topographic variations and climatic instrumentation along the 51.5-km traverse route. Similar traverses in four other areas of central Alberta were made during the same summer and have been briefly reported by MacIver (1970).

STUDY AREA

Spring Creek basin is located southwest of Valleyview, Alberta, at 54°55'N and 117°55'W in Townships 68 and 69, Ranges 24, 25, 26 W.5th (Fig. 1). The basin served as an International Hydrological Decade Experimental Basin to determine the hydrological impact of agricultural practices on virgin land, under the coordination of the Alberta Department of the Environment.

Topographically the basin varies from above 760 m in elevation in the northern portion to 610 m in the west where Spring Creek flows to a confluence with the Simmonette River just outside the research basin. Aspen to a general height of 7.5-9.0 m and willows adjacent to most swampy areas typify the vegetation of the study area.

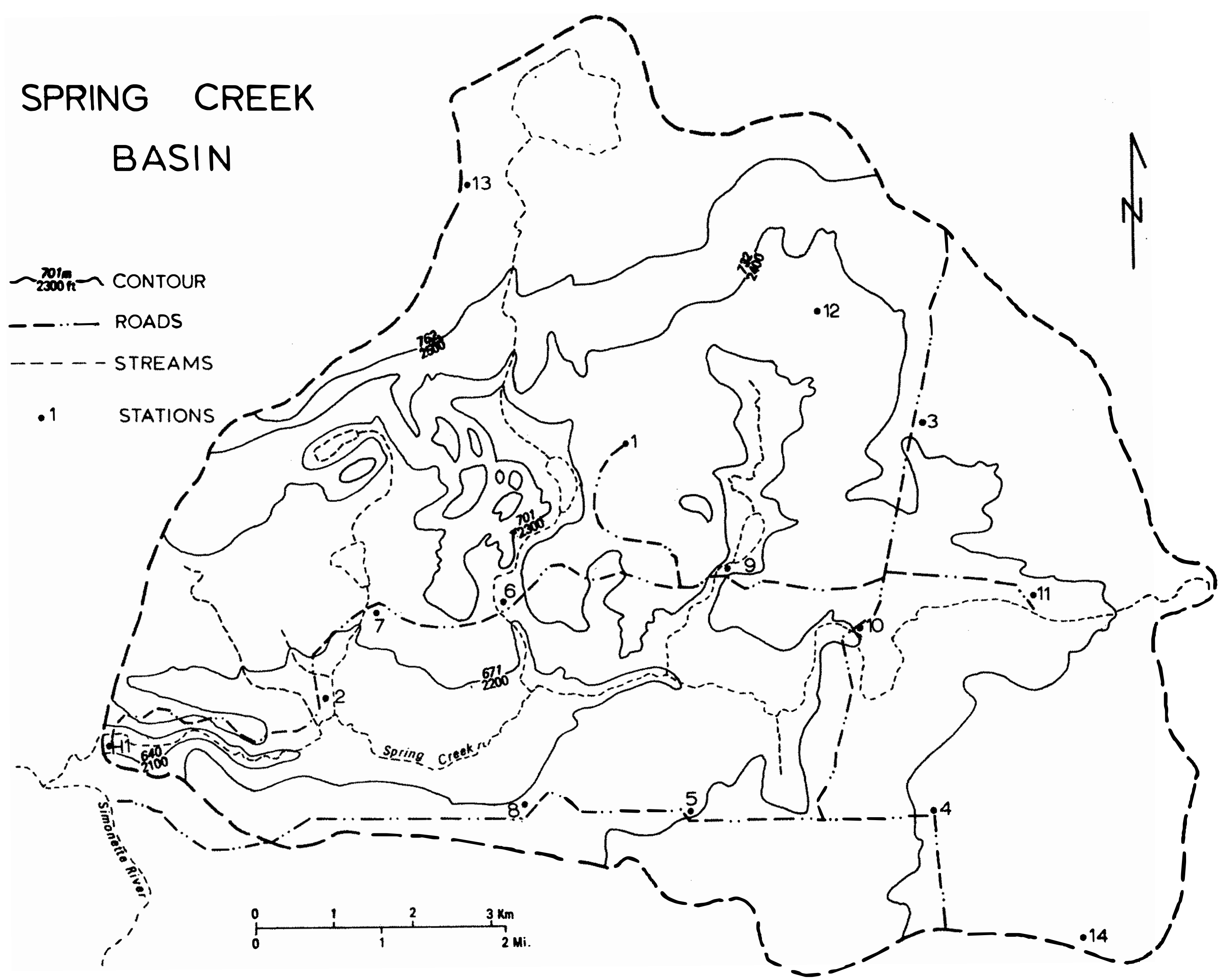

SPRING CREEK
BASIN
701m 2300 ft CONTOUR
ROADS
STREAMS
1 STATIONS
N
13
12
1
3
9
6
7
11
10
2
1
8
5
4
14
762 2500
732 2400
701 2300
671 2200
640 2100
Spring Creek
Simonette River
0 1 2 3 Km
0 1 2 Mi.

Figure 1

METHOD

The recording instrument mounted on the front of an automobile was a Foxboro thermo dew-point sensor unit attached to a recorder firmly mounted inside the vehicle (Fig. 2). A portable battery supply with an output of 117 V.A.C. 60 cycles and an operating life of 4 h before recharging ensured mobility.

Temperature was measured by a platinum resistance sensor which responded electrically to any temperature change. The dew-point sensor for moisture determination is based on the fact that for any water-vapour pressure about a saturated salt solution (lithium chloride) there is an equivalent equilibrium temperature. The term "dew-point" is applied to this equilibrium temperature of the solution, which is the same as the dew-point of the area. As a result, any decrease in the water vapour pressure causes the solution to dry out, decreasing the flow of electricity so that the element cools to a new moisture equilibrium. Consequently, the dewcel element cannot record below 11% relative humidity at high temperatures (>37^{o}C) or below 30% relative humidity at very low temperature (-40^{o}C). Since these combinations of temperatures and humidities are rare in forested areas the thermo dew-point instrument was satisfactory for the present study.

In test runs it was found that the speed of the vehicle affected the accuracy of the readings. At speeds within 0-24 km/h, temperature readings were affected by engine heat. This was amply evident for the dew-point traces when the vehicle is stationary (Fig. 3). The dry-bulb

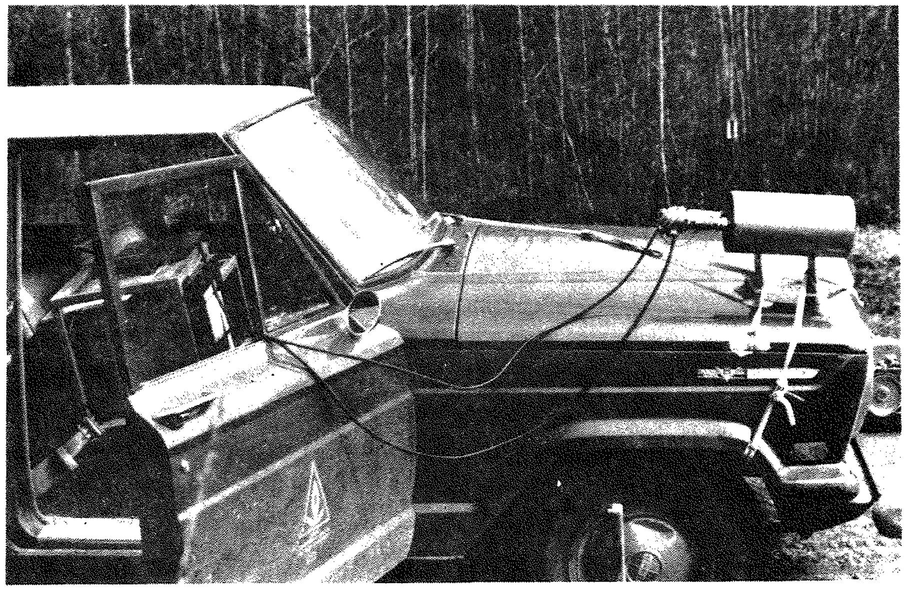


Figure 2

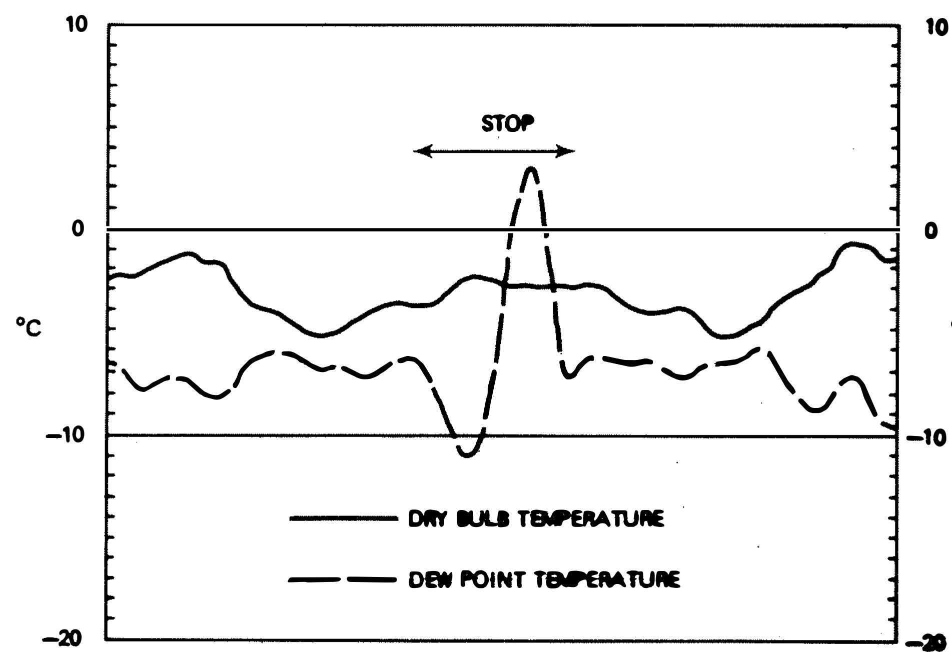


Figure 3

temperature readings showed only minor increases of approximately 1^{o}C as compared to the noticeable variations recorded by the dew-point sensor. At speeds about 65 km/h the instrument failed to accurately record small cold or hot pockets because the lag response time of the instrument is approximately .7 sec. Speeds between 32-48 km/h appeared to be optimal. During the traverses a constant speed of 37-40 km/h was maintained. It is imperative that a constant vehicle speed be maintained if the recorded temperature and dew-point values are to be correlated with the topographic and vegetational features. A tape recorder was used to note time checks, odometer readings, and reference points along the route to aid in later interpretation of the data.

The traverse route selected in the Spring Creek basin is illustrated in Fig. 1. Beginning north of station 3 the traverse went south to station 4, then westward toward the Simmonette River beyond station 8, returning back along the same road to station 10, then eastward to station 11. It then turned westward past stations 9, 6, 7, 2 to H1, tying in with station 1 and returning along the same road but branching north again past station 3 to complete the traverse. Poor road conditions south of station 4 and east of station 11 prohibited further traversing in those directions because maintenance of a constant speed was impossible. Each route selected was travelled, weather permitting, four times: near sunrise (the time of minimum heating), between 1330 and 1530 h when temperatures are at their maximum, at sunset, and at sunrise on the following day. Each traverse, for the outward and return trip, took about 2 h. For approximately 1 h before sunrise to ½ h after sunrise, the minimum temperature is at a relatively constant temperature. An additional ½ h of traversing by automobile is available after sunrise under the forested areas owing to the delay in penetration of the sun's rays through the forest canopy. Only clear mornings were selected to evaluate the change in temperature with topography, thereby eliminating any cloud influences.

The maximum heating traverse was equally time-spaced about the time of maximum temperature each afternoon. The thermograph charts indicated the maximum to occur around 1445 h on clear or partly cloudy days. Attempts were made to traverse on relatively cloudless afternoons to eliminate the influence of cloud shading, although this was not always possible, as often there is a build-up of cloud during the day. Sunset traverses were equi-spaced about the time of sunset. Traverses at this time of day gave an indication of the rate of increasing relative humidity and decreasing temperature in the forested region once the sun had set.

Two thermographs at stations 1 and 2, plus additional wet- and dry-bulb thermometers at stations 3, 6, and H1 served as checks on the accuracy of the mobile instrument. The thermographs and thermometers were read on each traverse.

RESULTS AND DISCUSSION

Figure 4 illustrates the definite correlation found between the temperature dew-point traces near sunrise and the associated

SPRING CREEK BASIN - SUNRISE TRAVERSES

MAY 7,8,9 1969

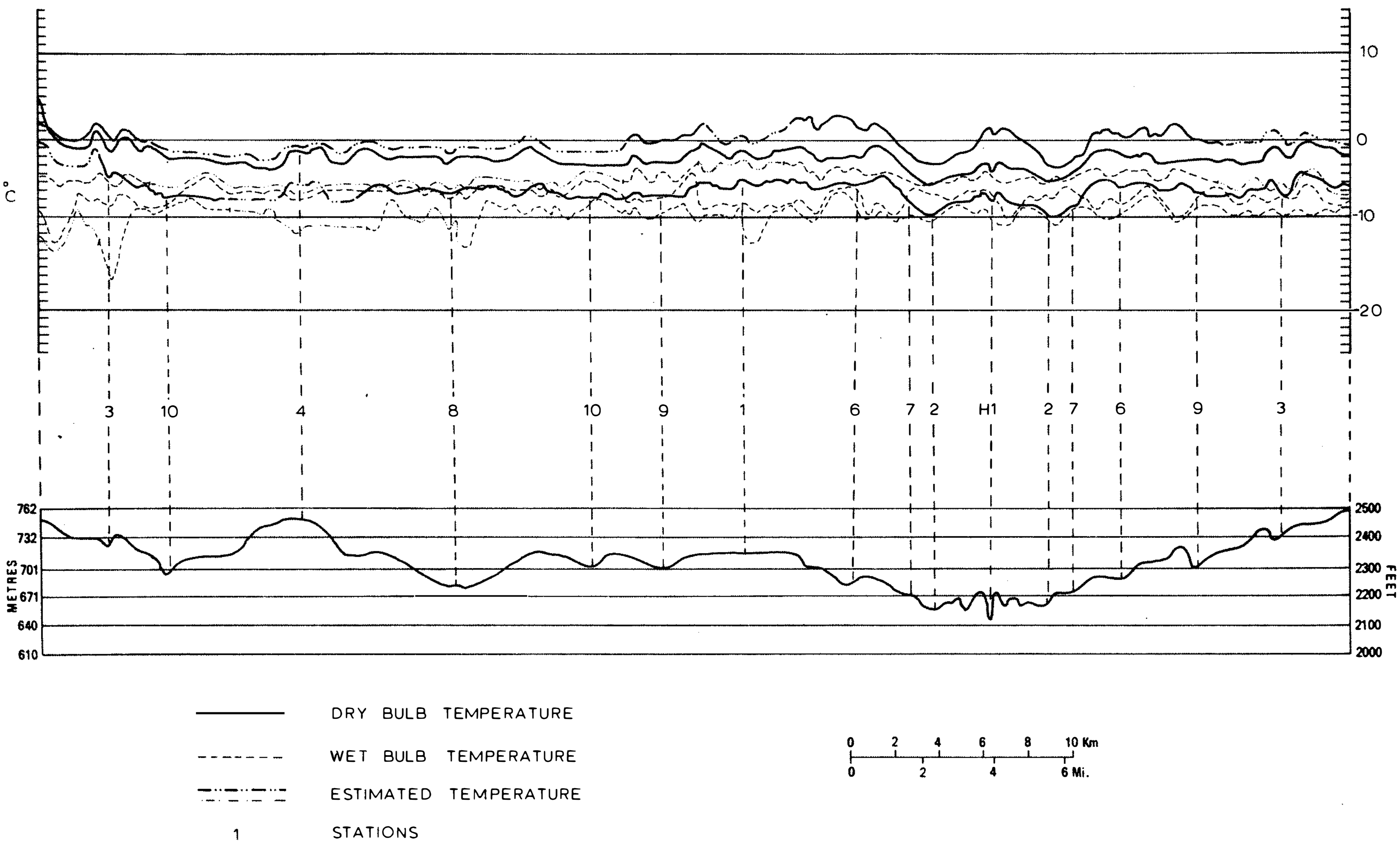


Figure 4

topographic change. The top trace represents the temperature for May 9, the middle trace for May 8, and the bottom trace for May 7. In the depression (61 m) from station H1 to station 2, a drop of 4^{o}C in dry-bulb temperature was recorded, indicating the presence of a cold pocket of air. Increased relative humidity was noted in the proximity of Spring Creek as the dew-point and dry-bulb traces overlapped (100% relative humidity). Similarly, increases in the dew-point trace (increasing R.H.) were noted whenever a creek or pond was crossed near stations 6, 7, and 9.

MacPhail (1966) noted that when returning over the same route within 10-15 min any cold spots previously recorded had been eliminated by the disturbance of the air strata as the vehicle passed. This phenomenon was not evident in the traverses conducted in the Spring Creek basin and elsewhere in Alberta (MacIver 1970). As illustrated in Fig. 5, identical return traces were recorded through station H1 after a time lapse of less than 15 min. This evidence suggests that the traverses are as accurate on the return route as on the initial traverse, with the vehicle having little or no warming or disturbing effect on the observations.

Increases in the spread between the dew-point and dry-bulb traces are evident at the time of maximum heating (Fig. 6). Not unexpectedly, the afternoon relative humidity is low; station 2 on May 7 experienced an air temperature of 15.6^{o}C with a relative humidity of 13%, yet at the same station at sunrise on May 7 the air temperature was -9.4^{o}C with a relative humidity of 92%. Each of these

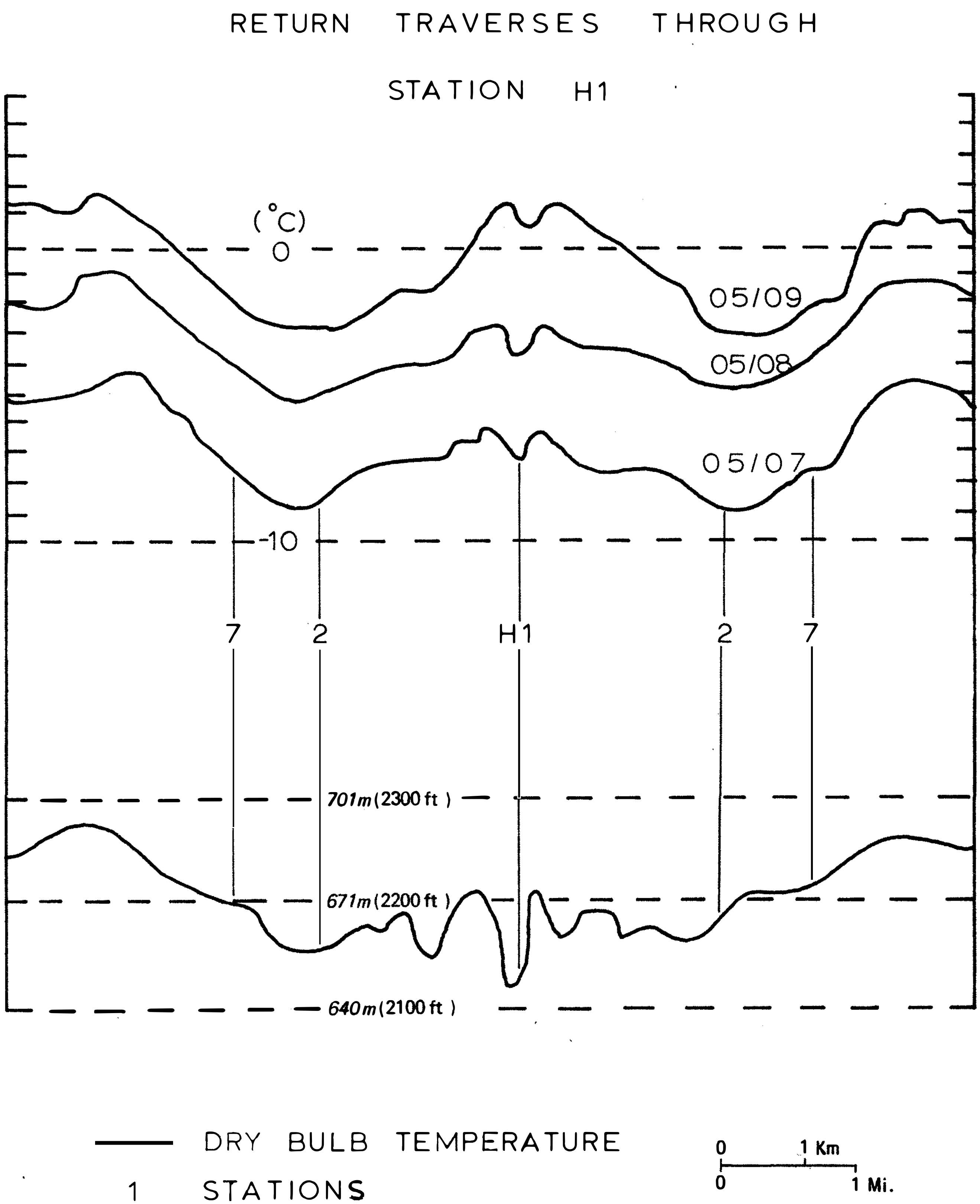
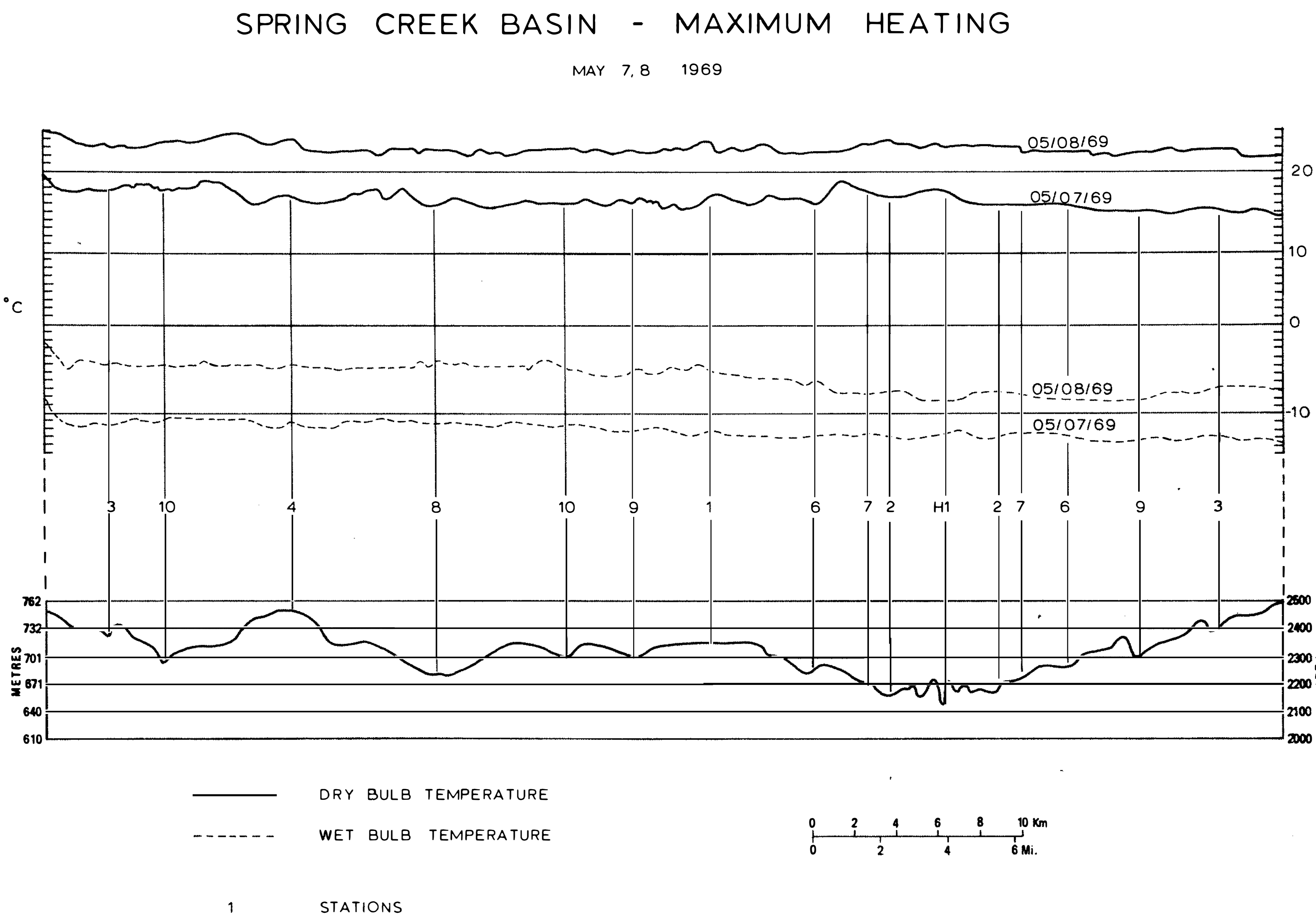

RETURN TRAVERSES THROUGH
STATION H1
(°C)
0
-10
05/09
05/08
05/07
7
2
H1
2
7
701m (2300 ft)
671m (2200 ft)
640m (2100 ft)
DRY BULB TEMPERATURE
1 STATIONS
0 1 Km
0 1 Mi.

Figure 5



SPRING CREEK BASIN - MAXIMUM HEATING
MAY 7, 8 1969
05/08/69
05/07/69
20
10
0
-10
°C
3 10 4 8 10 9 1 6 7 2 H1 2 7 6 9 3
762
732
701
671
640
610
METRES
2500
2400
2300
2200
2100
2000
FEET
DRY BULB TEMPERATURE
WET BULB TEMPERATURE
1 STATIONS
0 2 4 6 8 10 Km
0 2 4 6 Mi.

Figure 6

traverses occurred under a relatively dense forest cover, yet over 12 h a difference of 79% in relative humidity was experienced. This difference was apparent on all the traverses under clear, calm morning and afternoon conditions. The proximity of Spring Creek had little apparent effect on the humidity of the surrounding air at the time of maximum heating at station 2.

Sunset traverses, as illustrated in Fig. 7, resembled quite closely the sunrise traces, especially once the sun had set (station 10). On May 7 clear, calm conditions again prevailed in the basin and relative increases in air temperature with topography and increases in the spread of the traces were evident once the sun had set. In contrast, on May 8, a breeze of approximately 16 km/h mixed the air strata sufficiently to minimize any marked variation of temperature with topography. Interpretation of the traces became increasingly difficult as additional climatic influences dominated. In comparison with the sunrise traverses, the air temperature at station 2 was 6.3^{o}C with a relative humidity of 41% adjacent to Spring Creek once the sun was below the horizon.

Interpolation of temperature between existing climatic stations is extremely general and in many cases inaccurate. McKay (1965) pointed out that "isotherms [are] very approximate and incomplete in unsettled areas." Iostherms of mean daily temperatures for the Spring Creek basin based on the maximum and minimum temperatures recorded on May 7 are given in Fig. 8. The solid lines enclose areas

SPRING CREEK BASIN - SUNSET TRAVERSES

MAY 7, 8 1969

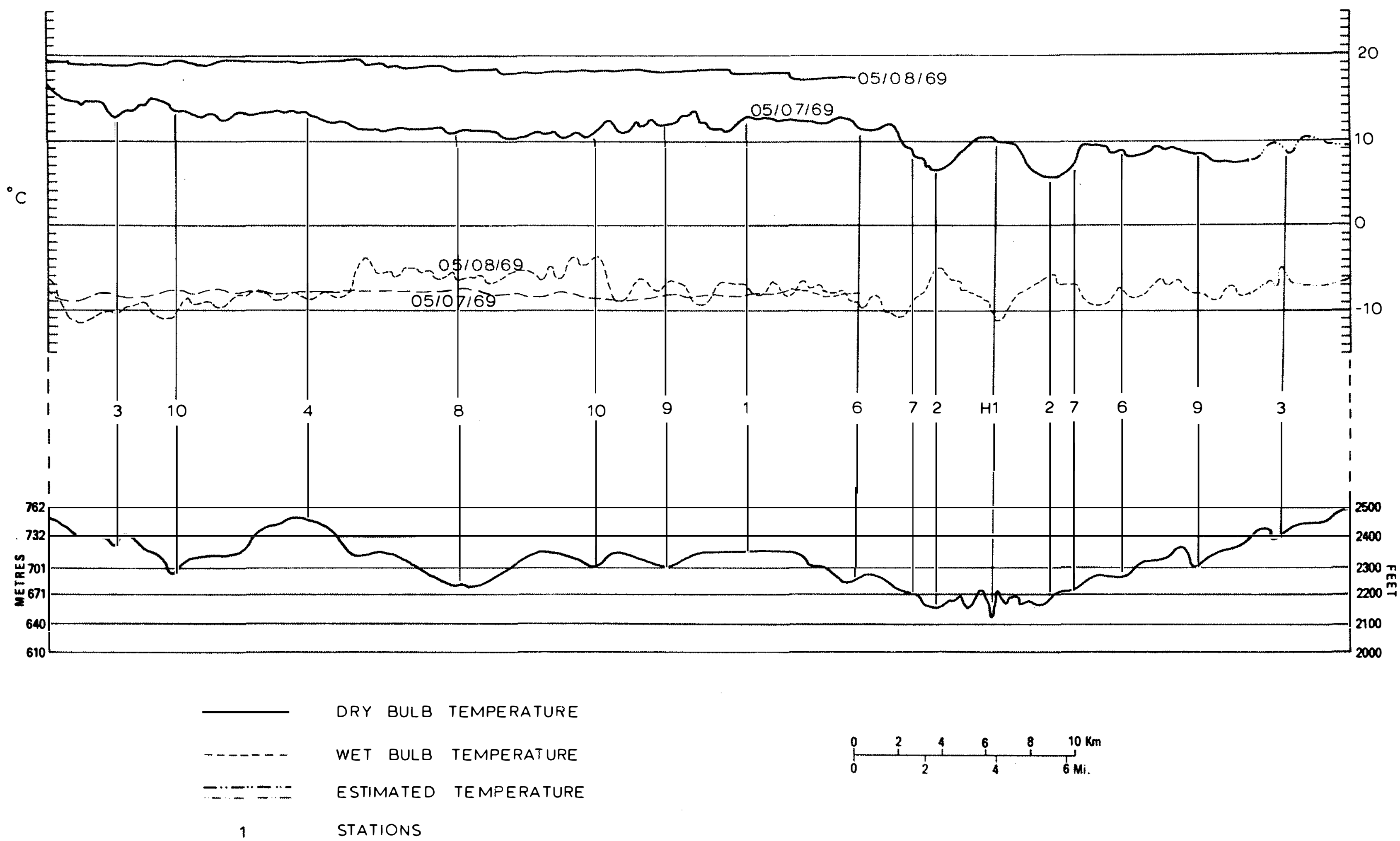


Figure 7

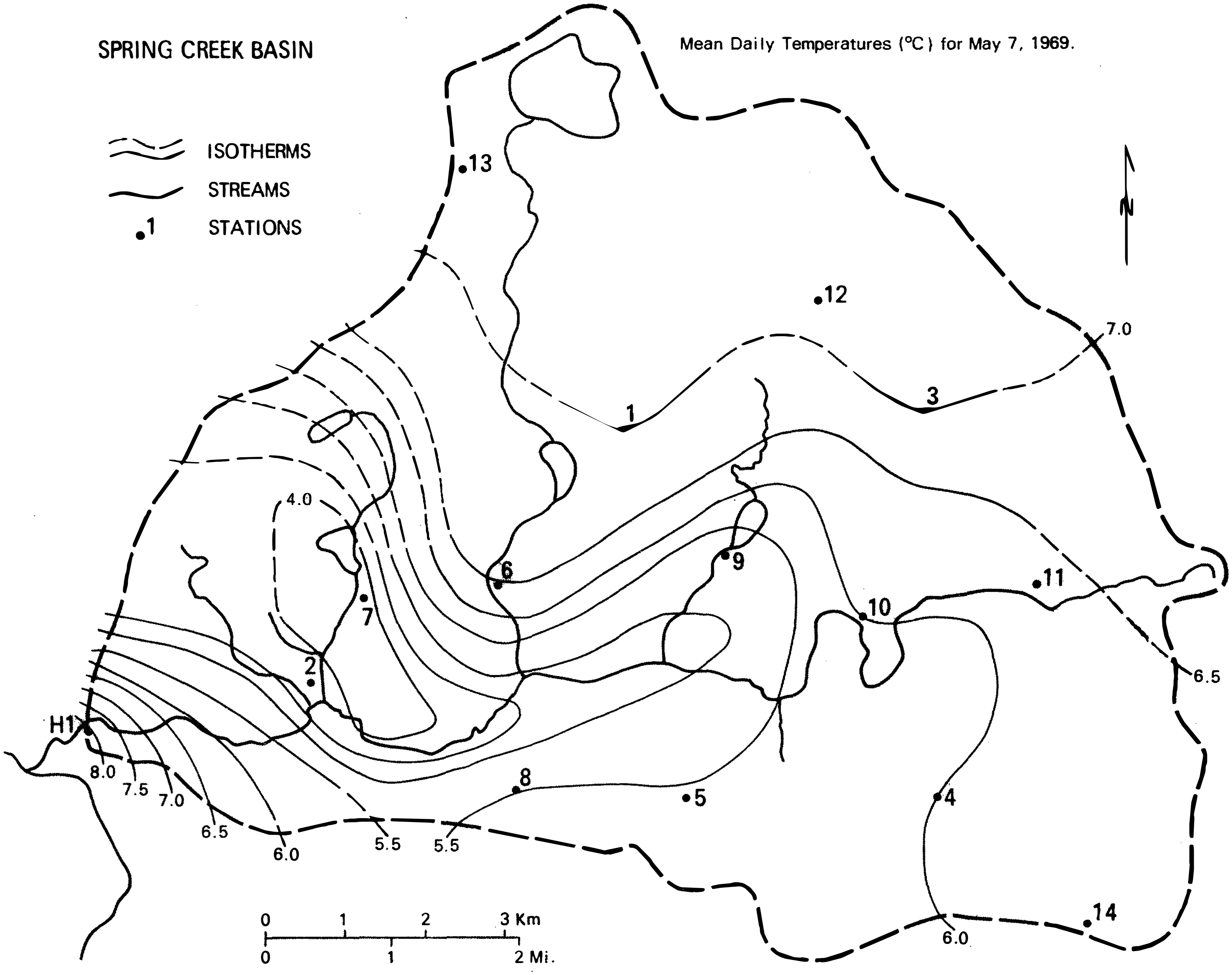

SPRING CREEK BASIN
Mean Daily Temperatures (°C) for May 7, 1969.
ISOTHERMS
STREAMS
1 STATIONS
N
H1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
4.0
5.5
5.5
6.0
6.0
6.5
6.5
7.0
7.0
7.5
8.0
0 1 2 3 Km
0 1 2 Mi.

Figure 8

of high thermal confidence and the dashed lines enclosed areas of low thermal confidence where traverse data were lacking. The nearest permanent climatological stations outside the Spring Creek basin, Economy Lookout and Snuff Mountain, reported mean daily temperatures of 8.3^{o}C and 9.0^{o}C respectively on May 7. In the basin the highest mean temperature reached was 8.0^{o}C at station H1 with the rest of the basin as much as 4^{o}C less. Therefore the basin area differs significantly from that indicated by the nearest regular climatic stations. By linking the existing stations by means of mobile traverses, more accurate isotherms can be located for the intervening area, taking into account the relation of topography and vegetation to temperature or other measured climatic parameters.

CONCLUSIONS

1. The mobile thermo dew-point recording technique provides an excellent method by which to link existing climatic stations in an area for the purpose of climatic interpolation, provided that an adequate road network is available.
2. The technique records the micro-thermal and moisture changes varying with topographic change extremely accurately, thereby detecting cold and hot pockets as well as areas of high and low humidity.
3. The technique is as accurate on the return traverse as on the initial traverse, assuming similar climatic conditions.
4. The main advantage of this technique is its ability to link the numerous long-term forest lookout stations whose isolated locations tend to create dubious data for isothermal mapping.

ACKNOWLEDGEMENT

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