MICROCLIMATES IN A FOREST FARM PLANTATION

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Abstract

Detailed recordings have been taken at four climate stations within the forest farm plantation at Pouto to study the influence of young *Pinus radiata* on the microclimate. This paper gives a brief summary of the results from daily recordings from July 1972 to July 1973, and from June 1974 to June 1975 of wind speed, soil moisture, relative humidity, precipitation, air temperature, and soil temperature. Note is made of the importance of the lowest 2 m of the atmosphere, the zone in which most plants and animals live. Finally it is pointed out that, by planting trees, the forest farmer is altering his environment and that he must consider the consequent effects.

INTRODUCTION

IN THE ever-increasing volume of literature on the concept and use of forest farming, one of the common benefits listed as accruing from this two-tiered land management system, is a systematic improvement in the physical environment as a result of planting trees. In varying degree's a forest will affect light, solar radiation, air and soil temperatures, wind, humidity, precipitation, and transpiration. The vertical structure of a forest to a large extent determines the effect on local atmospheric. conditions. Much of the climate influence of a forest can thus be explained in terms of its simple geometry, for example, morphological characteristics including the amount of branching, periodicity of growth, size, density, and leaf structure (Barry and Chorley, 1971) .

Most forest meteorological studies have been in true forest stands. The forest farm environment represents a different situation as the trees are planted further apart and are subjected to heavy thinning and high pruning. It has been suggested that trees planted under such regimes will still provide! high and low shelter, temper the extremes of climate, slow the runoff of heavy rain, and improve the microclimates in many ways (Pouto Forest Farm Development Ltd, 1970; Farnsworth, 1973; I.P.M. McQueen, pers. comm.) .

This paper briefly summarizes the results of a recent and continuing study on the influence that trees planted under a forest farm regime have on the microclimate, which here refers to the climate in the lowest 2 m of the atmosphere.

EXPERIMENTAL

This study was first set up in July 1972 by M. C. Farnsworth in an attempt to show any change in the local microclimate resulting from the planting of semi-developed pasture land in radiata pine (Farnsworth, 1973). The study has since been extended by the present authors.

Daily climatic recordings have been made at three planted sites (of *Pinus radiata* trees of different ages) and an unplanted control site, all with similar aspect, exposure, slope, and soils.

The six climate parameters selected were:

(1) Wind speeds at 2 m, at 1 m, and at 10 cm above the ground.

(2) Soil moisture at a depth of 5 cm.

(3) Relative humidity at 1 m above the ground.

(4) Precipitation.

(5) Air temperatures at 1 m and at 10 cm above the ground.

(6) Soil temperatures at 5 cm and at 10 cm below the ground surf ace.

These particular elements were initially selected as being capable of reasonably accurate measurement with the instruments available. The three planted sites were stands of trees planted in 1971 (Site 1), in 1970 (Site 2), and in 1968 (Site 3). Even though the sites were selected so that they had similar aspect, slope, and exposure, and the planted sites had similar row alignment, row spacing, and tree spacing, it was clearly recognized that each of the sites had definite physical limitations which could influence the data collected.

Each of the sites had the same instrument layout (Fig. 1) and the same measurements were made at each. The sites were read daily at 1500 hours.

RESULTS

The following brief summary of results was for two measuring periods: July 1972 to July 1973, and June 1974 to June 1975.

WIND REGIMES

Results to date show a reduction in average wind velocity that can be directly related to the age of the tree stands (Table 1) —

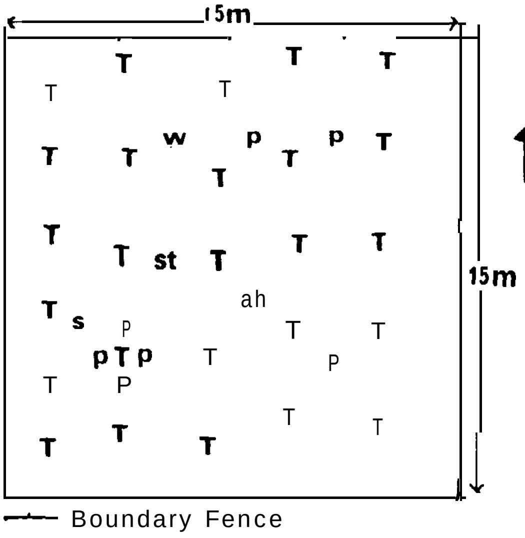


FIG. 1: Instrument layout.
a — air temperature sensors; st — soil temperature sensors; h — humidity sensor; s soil moisture sensors; w wind speed sensor; p precipitation recorder; t — free location.

i.e., as the tree age of the sites increased there was a corresponding reduction in wind velocity between the 2 m and 10 cm recording levels, with the exception of Site 3 which showed a slight increase in wind velocity from the 1 m to the 10 cm recording level. The 10 cm recording level in this site was measuring wind velocities below the canopy zone in an area characterized by increasing wind velocities (Farnsworth, 1973).

SOIL MOISTURE

Soil moisture regimes for the 1972-3 recording period displayed a regular variation between the four sites (Fig. 2). During periods

TABLE 1: AVERAGE WIND SPEED (km/h)

Recording Level	*May 1973*				*June 1973*			
	Control	*Site 1*	*Site 2*	*Site 3*	*Control*	*Site 1*	*Site 2*	*Site 3*
2 m	27.88	25.55	21.15	8.85	19.77	16.56	10.80	4.60
1 m	23.00	17.05	10.62	3.22	16.32	11.26	6.44	1.61
10 cm	16.17	11.10	8.53	4.79	10.60	5.45	3.69	2.30

Source: Farnsworth, 1973.

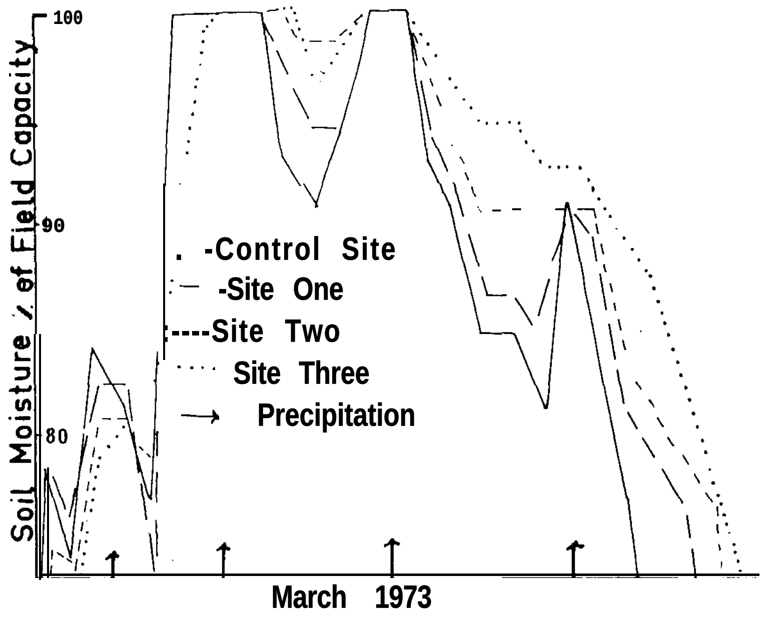


FIG. 2: *Soil moisture regimes.*

of precipitation the level of soil mosture rose rapidly in the Control Site and Site 1, but in Sites 2 and 3 a lag reaction occurred. This was most noticeable in Site 3 and could be related to the greater amount of shelter there. Conversely, during drying periods there was a greater retention of soil moisture in the planted sites. Here again there was a simple progression of retention, with greatest retention of soil moisture occurring in Site 3.

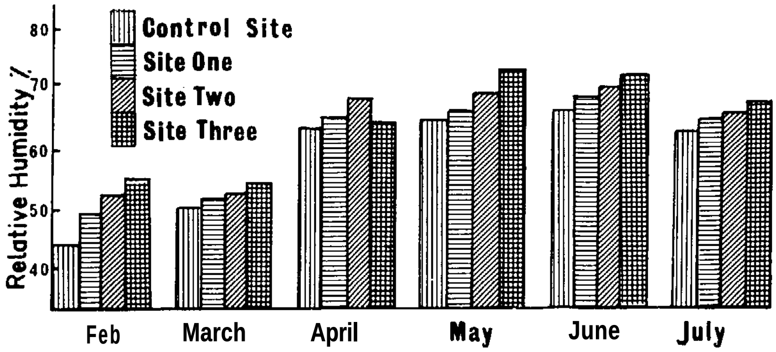
The 1974-5 measuring period, although showing the same general trend, was plagued by instrument trouble.

RELATIVE HUMIDITY

Analysis of data showed that in general there was an increase in relative humidity from the unplanted Control Site to the planted sites (Fig. 3). Once again this relationship could be related to the different tree ages.

PRECIPITATION

Precipitation data showed the expected — *i.e.,* the trees were creating shelter which was intercepting and so reducing the amount of rain being collected by the rain gauges. In general, there



Month

FIG. 3: *Mean monthly relative humidities, 1973.*

TABLE 2: PRECIPITATION RECORDS, OCT.-DEC. 1974 (mm)

	October	*November*	*December*
Control	80.30	30.40	32.00
Site 1	74.00	22.20	22.80
Site 2	78.50	41 .00	32.00
Site3	45.60	32.00	24.50

was a reduction in the amount of precipitation collected in the planted sites as compared with the Control Site (Table 2) with the exception of Site 2 which for some months showed an increase in the amount of precipitation being collected.

AIR TEMPERATURE

Analysis of air temperature data showed that for both measuring periods, although air temperature regimes in each site followed the same road patterns, each site had its own particular characteristic's with little direct relationship occurring between sites (Fig. 4). This lack of relationship can be explained by the different positions of the sensors relative to the trees on each of the planted sites and thus measurements being made of different microclimates (Fig. 5) (Farnsworth, **1973).**

In the 1972-3 measuring period the annual air temperature range increased with an increase in tree age on the sites (Table 3). The 1974-5 measuring period showed an increase in annual air temperature range from the Control Site to Site Two and a decrease in annual air temperature range in Site Three (Table 3).

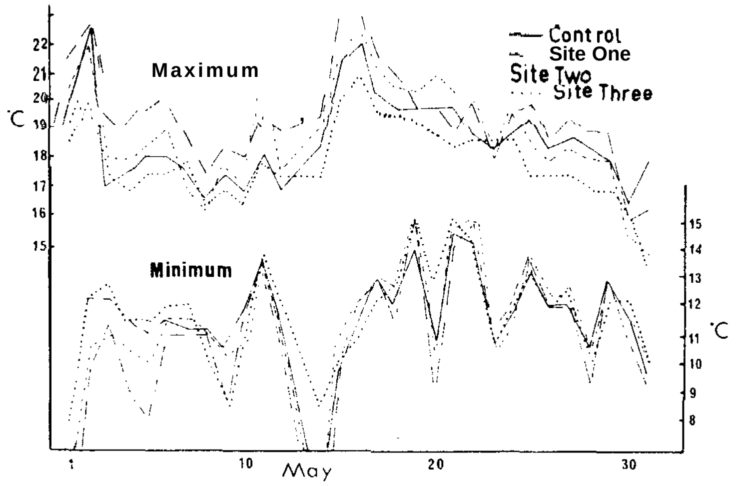


FIG. 4: *Daily air femperature regimes, May 1975.*

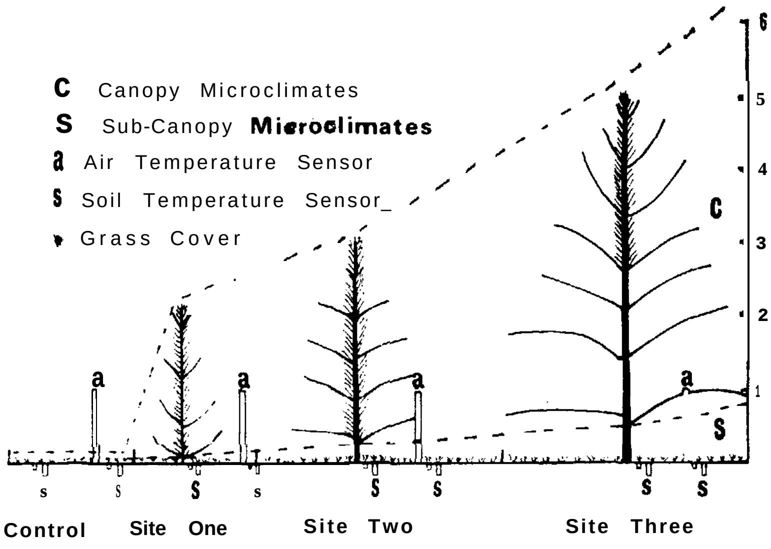


FIG. 5: *Forest farm microclimates.*

TABLE 3: ANNUAL TEMPERATURE RANGES (°C)

	1972-3	1974-5
Control	32.00	34.25
Site 1	35.25	36.00
Site 2	38.75	35.00
Site 3	37.00	27.50

SOIL TEMPERATURE

Soil temperature regimes in each site for the 1972-3 measuring period closely paralleled the air temperature regimes of each site, but with the increase in tree age this correlation was not as great. It also appeared that planting of trees had been instrumental in reducing the annual soil temperature ranges (Table 4).

TABLE 4: AVERAGE ANNUAL SOIL TEMPERATURE RANGE, 1972-3 (°C)

	5 cm Depth	*10 cm Depth*
Control	14.53	12.65
Site 1	14.13	12.58
Site 2	10.68	10.00
Site 3	9.93	9.89

Source: Farnsworth, 1973.

DISCUSSION AND CONCLUSION

Comparisons between sites cannot be exact owing to the small differences of surface configuration and exposure between them and to the rapid natural fluctuations of the selected climatic parameters. Nevertheless, for the six climatic parameters studied, differences between the four sites were demonstrated and these differences could be related to the differing age of the trees and to tree growth.

Climate is perhaps the most difficult to manage of all factors in the agricultural environment. Weather elements so interact that it is almost impossible to isolate them, and control of one component of the environment may result in unexpected or even undesirable changes in another. In a review of the role of traditional techniques of husbandry on microclimates Wilken- (1973) noted that the art of exploiting microclimates is not new. Many of the husbandry techniques practised are means of adjustment to or manipulation of microclimate even though the solution adopted may be empirical rather than calculated. Caborn (1973) pointed out that practices such as the use of frost protection generators, wind breaks, and mono-molecular film to reduce evaporation are all means of modifying microclimate.

The Pouto microclimate study is demonstrating that by planting trees, the forest farmer is altering microclimate and he must consider the effects of doing so. Farnsworth (1975) reviewed some of the effects that the planting of trees would have on the physical environment. For example, temperatures exert a profound influence on physiological activities by controlling the rate of chemical reactions. Small alterations in temperature (1 to 2" C) can result in a change' of distribution of both plants and animals (Treshow, 1970). Hancock (1951) in a study on the direct influence of climate on milk production noted that cattle, to counter a falling body temperature, will seek shelter from wind and rain, and, to counter rising body temperatures, will seek shade. If shelter is provided against wind and rain a cow caa withstand cold weather without loss of production or increases in feed consumption. Caborn (1973) was able to construct a diagram which showed that the thermal balance of warm-blooded animals was strongly linked to surrounding microclimates. The importance of the lowest 2 m of the atmosphere to all plants and animals was realized early this century and the need arose for the detailed study of what Geiger (1965) termed the "climate near the ground". It is in this lowest 2 m of the atmosphere that most plants and animals live.

The Pouto study represents only the first stage in the study of the influence trees planted under a forest farm regime may have on microclimate. Further intensive research is needed.

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