

THE EFFECT OF PRESCRIBED FIRE ON THE MICROCLIMATE OF FOREST FLOOR

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ABSTRAK

Penelitian ini dilakukan untuk mempelajari pengaruh pembakaran buatan terhadap perubahan lingkungan fisik di dasar hutan (forest floor). Akibat langsung dari proses pembakaran hutan adalah berubahnya pantulan dari permukaan tanah. Permukaan tanah yang lebih gelap memudahkan dalam penyerapan radiasi surya, akibatnya suhu tanah dan udara menjadi lebih tinggi, sehingga kelembaban udara berubah menjadi lebih kering.

ABSTRACT

This observation was conducted to study the effect of prescribed fire on the physical condition of the forest floor. Prescribed fire resulted in the change of radiation balance of the forest floor. Darker soil surface enhanced absorption of radiation, hence soil and air temperature increased. Air above the soil surface become drier as showed by the lower relative humidity. Condition as aspect of location also had influence.

INTRODUCTION

In discussing the effects of fire in forestry, a distinction must be made between wildfires, swaling and prescribed burning. Wildfires, which occur during the driest parts of summer, are not caused deliberately and usually only devastate. Swaling is an old form of agriculture. In addition to burning the area, it included some primitive tilling of the soil. Swaling is planned and prepared in advance. Prescribed burning is a means of preparing and improving a forest site for a new generation of trees. The main purpose of prescribed burning in forestry is to improve the factors that regulate the growth of trees-water, temperature, and nutrients (Viro, 1974). Ground fire in forest may result in total destruction of litter layer (Philip, 1965). Consequently, there may be marked changes in soil surface temperature regimes even down to the depths of 15 cm. The marked decrease in albedo and increase in temperature, net radiation and exposure to wind following fires are likely to lead to increase evaporative losses.

This observation was done to study the effects of prescribed fire on the physical parameters important to the functioning of plants: soil temperature, relative humidity, air temperature, and incoming radiation balance. Discussion is emphasized on soil temperature and relative humidity as these two parameters are very important in determining the growth of seeds on the forest floor. Geiger (1957) indicated that in high mountains with their generally low temperatures, plant can thrive only in the zone close to ground level where the soil acts as a heat reservoir and provides the necessary microclimate. If the soil is covered with very thick litter, the temperature underneath (where the seed is laid) could be very low and hence there is no possibility for the seed to grow. Fire will therefore solve this problem.

MATERIALS AND METHODS

This observation was done on Oct 6 and 7, 1989 at the Brisbane Forest Park, Bellbird Grove, Australia to study the effects of prescribed burning on the microclimate of the forest floor. Three different sites were chosen and the description of sites were as follows:

Site A

This site is unburnt, easterly facing site with aspect of 60°. About 60-70% of ground covered with the grass *Themeda australis*, and the rest with a litter layer consisting dry eucalypt leaves, twigs and some grass. Soil was stoney, shalow and very dry. Foliage cover of the over storey was 73% and 63% of incoming radiation was intercepted by the canopy leaves and branches.

Site B

This site was almost identical to site A, except that it had been burnt about two weeks before measurement were made. Consequently there was no grass or litter cover. Tussocks of *Themeda australis* were just beginning to grow. The aspect of this site is 60° east.

Site C

This site was burnt. Foliage cover was 69% and 74% of incoming radiation was intercepted by the canopy, leaves and brances. This site is steeper than sites A and B and its aspect is 1° west.

Within each site, there was a transect of 20 m down the slope. For each transect there were 5 points at which observations were made, one at the top and then the other four points were at 5 m intervals down the slope. Measurement was made at one-hourly interval. Air temperature and relative humidity were measured using wet and dry bulb thermometer. Surface temperature was measured using infrared thermometer and thermocouple. Net radiation and incoming shortwave were measured at the same time intervals using net radiometer, and albedometer.

RESULTS AND DISCUSSION

Temperature is an important growth factor in the temperate climate region, and its effect is greater in the place where differences between summer and winter temperature are large. Soil temperature depends primarily on air temperature, but it can also be affected artificially, for instance, by fire. In Table 1, it is shown the mean air temperatures at day time compared to soil temperatures at the three sites: A, B and C.

Table 1. Mean air and soil temperatures at the burnt (B) and unburnt (A and C) sites (°C).

Date	Burnt Site		Unburnt Site			
	Soil B	Air B	Soil A	Soil C	Air A	Air C
October 6	36.9	27.3	35.9	34.5	27.8	<u>29.0</u>
October 7	30.9	23.1	29.7	27.9	23.4	<u>23.9</u>
Mean	33.9	25.2	32.8	31.2	25.6	26.5

It is shown that although there is no difference in air temperature at three sites, air temperature of site C was almost always higher during the observation (Fig. 1). This site had a denser forest floor vegetation and bigger trees (although not necessarily higher canopy cover) and therefore heat was probably trapped under the canopy resulted in higher air temperature. Comparing site A to B, higher air temperature of site B was due to burning. The soil temperatures were markedly different between burnt and unburnt sites. Site C had the lowest soil temperature due to the unburnt condition and also due to its aspect (1° west) which resulted in lower incoming radiation, while the difference between site A and B merely due to burning because overlayer condition and aspect of these two sites are almost the same.

In places where the soil temperature under the forest is always low or moderate, an improvement in the thermal conditions of the soil usually benefits fertility of the site. Viro (1974) found that raising the temperature from 6° to 12.5°C doubled the CO_2 evolution of forest humus in an incubation experiments in a laboratory, and raising it to 20°C quadrupled it.

This preliminary result is in agreement with Philips (1919, in Cass et al., 1984) who found that in his grass burning experiments, the temperature of bare soil (due to burning) during both day and night was considerably greater than that of soil covered with vegetation. Soil blanketed by vegetation did not exhibit the extremes of temperature found in bare soil.

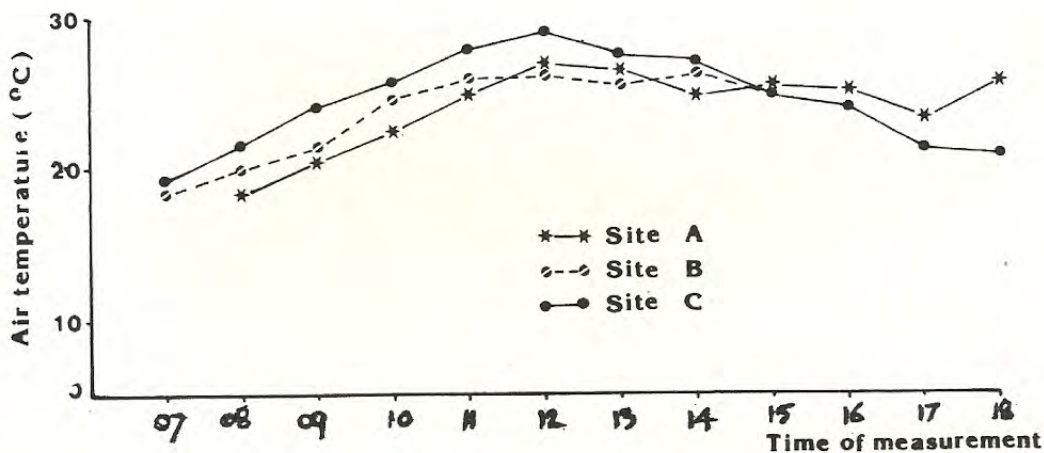


Figure 1. Air temperature at burnt and unburnt site (measured on Oct. 7, 1989).

Viro (1974) indicated that to benefit the soil temperature, it is extremely important to ensure that at least all the living moss is destroyed by burning. Optimum burning is that which consumes about half of the humus layer, in addition to killing the living vegetation of the forest floor, and the minimum requirement is that the moss layer will be totally destroyed (Viro, 1974).

The increase of soil temperature due to burning is probably due to the decrease in the humuslayer of the burnt site. Viro (1974) found that the thickness of the humus layer was 3 cm at the burnt sites, while the thickness of humus and moss layer was 9 cm in the unburnt clearings. Humus layer was a good insulator (Viro, 1974). The temperature under the humus layer was quite low, especially under the canopy. This soil temperature influences the vital processes in the forest floor greatly, particularly on microbial activity and nutrient uptake.

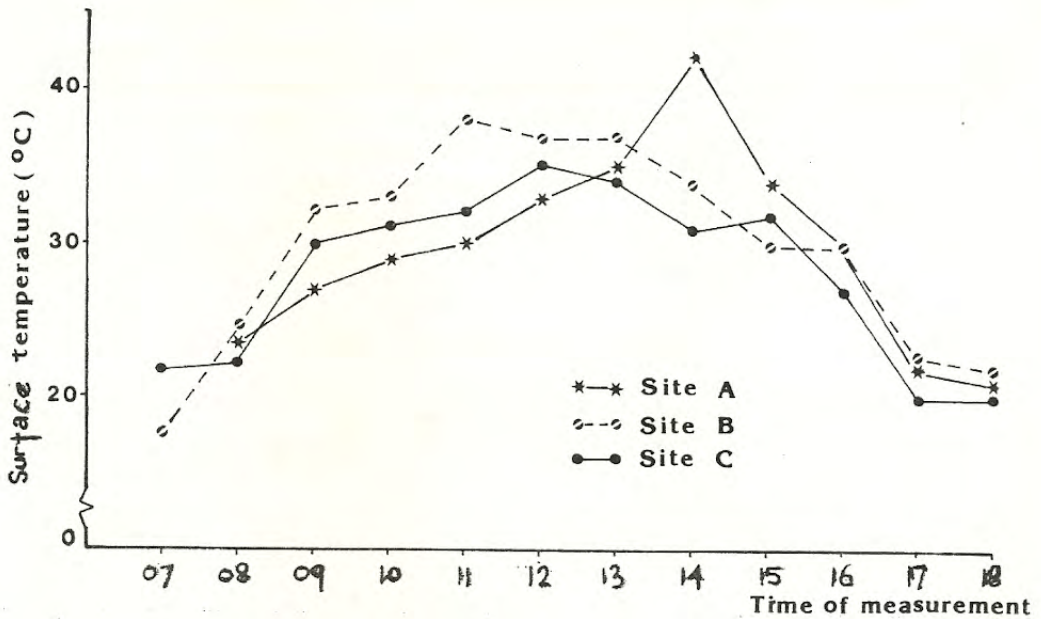


Figure 2. Surface temperature at burnt and unburnt sites (measured) on October 7, 1989)

Figure 2 shows surface temperature at the three sites during the day of observation. Most of the time site B had the highest temperature. At 2 pm soil temperature in site A became markedly increased, probably due to the sudden increase in incoming radiation through the canopy opening and strike the location of the soil temperature sensor.

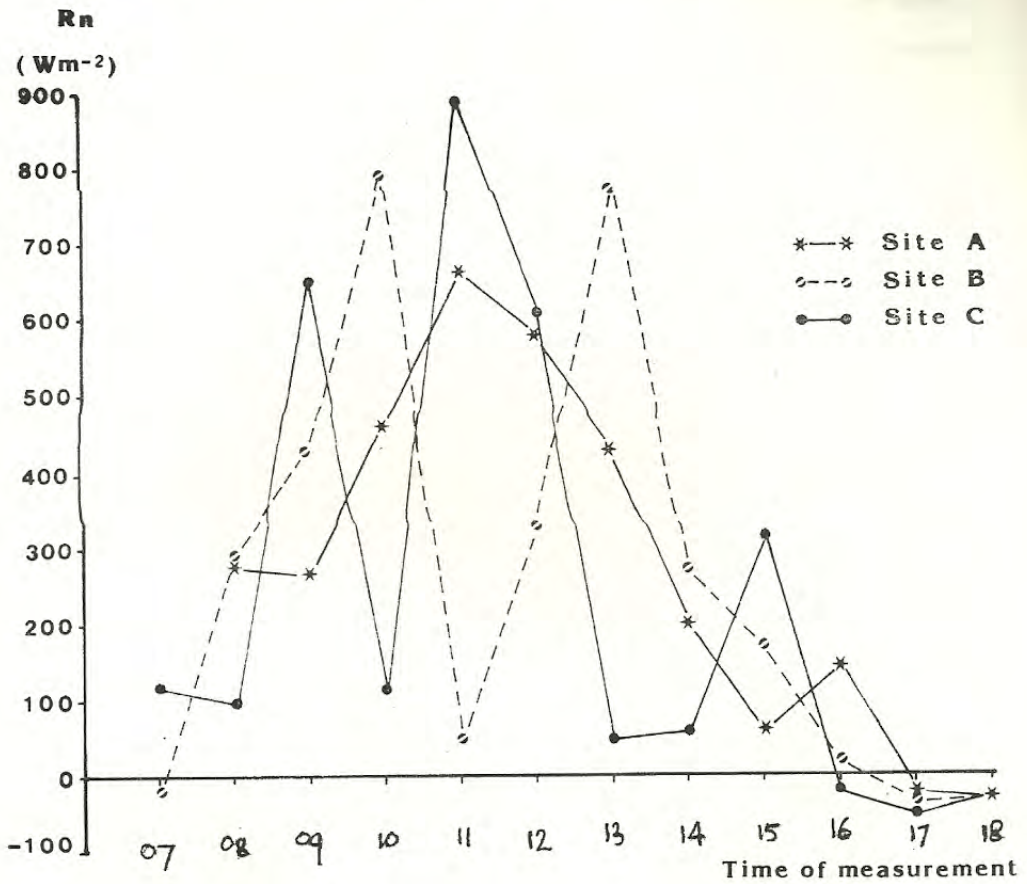


Figure 3. Radiation balance on burnt and unburnt sites (measured on parallel to the surface) on October 7, 1989.

The dark surface of burnt site effectively absorbs solar radiation, consequently the surface layers of the burnt site were warmer during the day than of unburnt sites, especially those under the canopy. The highest R_n (Figure 3) measured at the surface of burnt site was $858 Wm^{-2}$, while at the unburnt site (same aspect) was $809 Wm^{-2}$, while the R_{sw} (incoming shortwave radiation did not differ greatly (Fig. 4) with maximum value of $830 Wm^{-2}$ at both site.

Removal of plant, blackening of the ground and exposure of light coloured mineral soil and rocks will change the input and reflectance of light and hence influence the soil temperature of the burnt site. Harrison (1978) measured the mean reflectivity (r) of burnt and unburnt pastures for one month after a spring burn. He found that 13 days after the burning, the reflectivity of the burnt site was nearly 7% compared with nearly 13% for the unburnt site. The reflectivity of the burnt site increased to 8% within 16 days after the fire. On the 24th day it was measured as 10% and on the 45th day as 12%. The reflectivity of the unburnt site varied between 13 and 14% over the 45 days period.

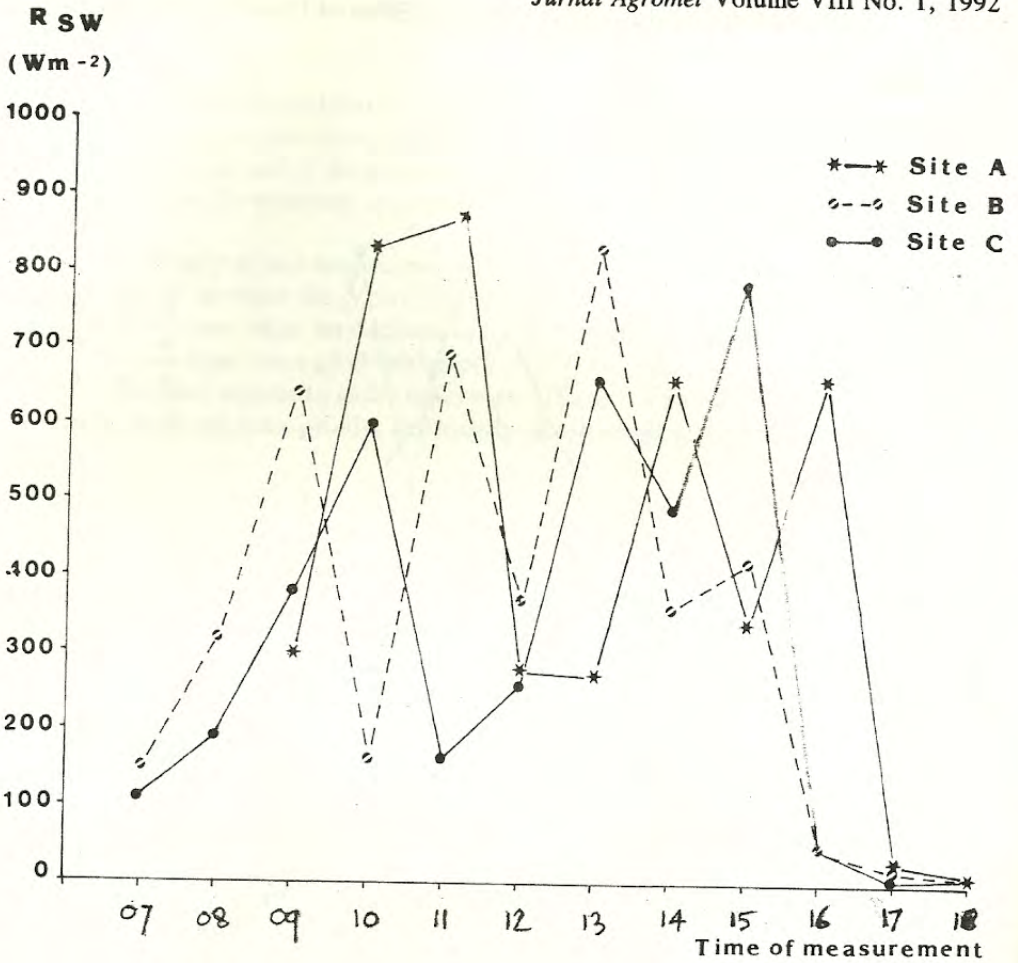


Figure 4. Shortwave incoming radiation on burnt and unburnt sites on October 7, 1989 (measured on horizontal).

The lower reflectivity of the burnt site, will increase the amount of radiation received by the surface, and hence its temperature will increase, as found in this experiment.

Burnt site (B) tend to be drier than the unburnt site (A) as indicated by the relative humidity in Figure 5. Because of different aspect, site C cannot be compared with the burnt site. This was also caused by the decrease in humus layer due to fire. In forest soils with a deep ground water table, the moisture conditions depend largely on the humus layer. The effect of the humus layer on soil moisture is two folds when it is dry, the living moss and humus layers sometimes imbibe large amounts of water, so that only heavy rains can reach the tree roots; during dry periods, the humus layer effectively hinders evaporation from the soil. Both water holding capacity and the ability to hinder evaporation are much smaller for burnt sites than the unburnt ones. In addition, the higher temperature of a burnt site tends to increase evaporation. Hence the burnt site is drier than the unburnt site.

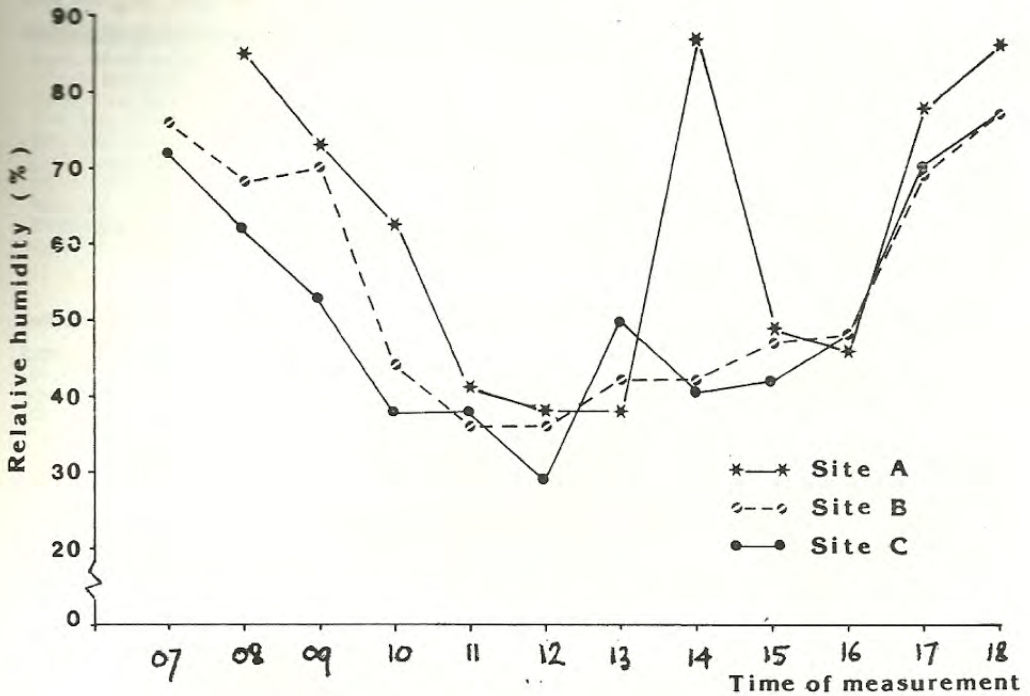


Figure 5. Relative humidity at burnt and unburnt sites (measured) on October 7, 1989).

Relative humidity is directly related to temperature and wind. Bendell (1974) studied temperature and humidity on a newly burnt and a nearby older burn with dense regrowth in Cedar, Hemlock, Douglas fir forest on Vancouver island. He found that the open burnt was strikingly drier throughout the day than the dense regrowth. As with temperatures, the open cover showed the widest fluctuations in humidity and was drier by day than the dense regrowth. Hence dense cover was cooler and more humid by day and warmer by night than the younger and more open regrowth.

The layer of forest greatly modifies the windspeed (Spurr, 1964). After fire, there may be an increase in the frequency and velocity of winds over the burnt. Winds probably have their greatest affect in convert with temperature and humidity as winds will affect soil evaporation. As wind is getting stronger soil will evaporate more and become drier, hence lower humidity and higher temperature than the unburnt sites. Unfortunately, windspeed was not measured in this particular observation.

CONCLUSION

Burning affects the microclimate of the forest floor by changing the surface reflectivity of the soil, soil temperature and relative humidity. These physical changes eventually will develop a favourable conditions for seeds under the forest floor to grow and regenerate. In this observation, aspect and vegetation in the forest floor seems to influence the measured parameter.

REFERENCES

- Bendell, J.F. 1974. Effect of fire on birds and manimals. In *Fire and Ecosystems*. Kozlowsky, T.T. and C.E. Ahlgren (Eds). Academic Press. New York.
- Cass, A., M.J. Savage, and F.U. Wallis. 1984. The effect of fire on soil and microclimate. In *Ecological effects of fire in south African ecosystems*. Booysen, P.V., and N.M. Tainton (Eds). Springer-verlag.
- Geiger, R. 1957. *The climate near the ground*. Harvard University Pres Cambridge. 414pp.
- Harrison, T.D. 1978. Report on maximum temperature measurements during the Nylsvley veld fire of 5 Sept. 1978 and on post fire micrometeorological measurements. Unpublished report to the national programme for environmental sciences, CSIR, Pretoria, 19pp.
- Spurr, S.H. 1964. *Forest ecology*. Ronald Press. New York.
- Viro, P.J. 1974. Effects of forest fire on soil. In *Fire and ecosystems*. Kozlowsky, T.T., and C.E. Ahlgren (Eds). Academic Press. New York.