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# TREE MICRO-CLIMATE EFFECTS ON UNDERSTOREY VEGETATION: THEIR IMPACT ON SPATIAL AND TEMPORAL MODELLING OF PASTURE PRODUCTION IN QUEENSLAND

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## INTRODUCTION AND EXPERIMENTAL DESIGN

A near real-time spatial model of pasture growth and use by stock is being developed by the Queensland Department of Primary Industries. This pasture production model uses a wide variety of input information about soils, vegetation, stock and climate. Climatic data are interpolated from standard Bureau of Meteorology data collected in treeless sites using Stephenson screens. Whilst extrapolation of these data to other open places is reasonable, it is not possible to extrapolate the data to the understorey of tree communities. This is a problem because 56% of Queensland has tree cover ranging from arid-savanna to rainforest vegetation.

A standard experimental design was set up for each of 18 sites located in south Queensland. Each site contained an 'open area' that was at least 250 m from the 'treed area'. The meteorological equipment was set up semi-randomly in each site. The representative sites were chosen in different communities along a rainfall gradient varying from 1300 mm, near Brisbane, to 300 mm, west of Quilpie.

## RESULTS AND DISCUSSION

### Solar Radiation

As expected, we obtained a linear ($R^2$ = 0.82) decrease of net radiation with increasing foliage projective cover. Net radiation decreased by as much as 90% in rainforest sites. For low tree densities (foliage projective cover, FPC, around 10% or tree basal area ranging from 2.5 to 6 $m^2$/ha) we observed a decrease of around 9% depending on the site, the season and tree species. Standard errors were much higher in open savannas due to less uniform tree canopies than in closed woodlands or rainforests. Net radiation decrease was highest in the summer ($y = 0.93x$ with $R^2$ = 0.87), but no significant differences were observed in winter and spring.

### Evaporation

Evaporation decreased highly significantly with increasing FPC and tree basal area, but less significantly with increasing tree densities. Tree density only gives information on the number of trees, while tree basal area incorporates a notion of the size and thus volume of the trees, but FPC gives information on the canopy structure. Since radiation is the main factor influencing the microenvironment underneath trees, it is reasonable that this measure gives the best regressions. It is also the only tree factor that varies with seasons.

The value of $R^2$ (0.45) for the relationship between FPC and evaporation decrease is relatively low, due to the fact that we worked along a rainfall gradient and hence in different ecosystems. Seasonality also interferes with the linearity of the equation. That evaporation is affected by wind (correlation $r$ = 0.69), radiation ($r$ = 0.71) and vapour pressure also reduces the strength of the relationship. Grass yield was also correlated, but negatively, with evaporation ($r$ = -0.4). When taken separately, evaporation decrease was significantly highest in January ($y = 0.96x$ and $R^2$ = 0.6).

### Soil Moisture and Soil Temperature

We were not able to find a significant difference in soil moisture between open and treed sites at any of the three depths studied (0-10 cm, 10-20 cm, 20-50 cm). This was partly due to the limitation of having to use gravimetric determinations and to the limited time available to collect samples. Heavy rainfalls occurred between some field trips and data were consequently biased.

A relatively small decrease (y = 0.18x) in soil temperature was recorded with increasing FPC. Considering the relation between FPC and tree basal area (TBA) as linear ($R^2$=0.8), it is not surprising that there was also a small decrease in soil temperatures with increasing TBA. Similar results were obtained when measuring soil temperatures at 5 cm and 15 cm. The relatively low values of both $R^2$ and the slope of the equation were mainly due to the measurements being made while soil moisture contents (up to 16-18%) were relatively high at many sites due to heavy rainfalls. In contrast, during the dry season, we obtained a better regression and a much higher slope ($R^2$=0.5 and y = 0.9x).

**Air Temperature**
For low values of FPC we did not observe significant differences between open and treed plots, while for higher tree densities, significant decreases in maximum air temperatures inside the forest were observed. As a result, a curvilinear regression fitted much better than did a linear one. We suggest that for low tree densities, the effect of radiation decrease can be stronger than the effect of wind, evaporation and vapour pressure reduction. We observed a general increase in minimum temperatures with increasing tree cover (y = -0.27x and $R^2$ = 0.32). The same comments apply to minimum temperatures, which did not differ between open and treed sites for low tree densities. Air temperature at 9 am and 3 pm also decreased (y = 0.32x and y = 0.15x respectively) with increasing FPC.

**Vapour Pressure**
An increase in vapour pressure at 9 am was recorded with increasing FPC. We did not observe significant differences between open and treed sites for vapour pressure at 3 pm.

The relative humidity regression was more linear than the vapour pressure equation since it also took into account the decrease in air temperature. Vapour pressure decrease at 3 pm in September and November was significantly higher than in January (y = -0.5x and y = -0.1x respectively). A strong correlation (r = 0.77) was found between soil moisture at 10 cm and vapour pressure at 3 pm during the summer, indicating another possible source of interference. Vapour pressure was also influenced by both wind ($R^2$ = -0.44) and green cover ($R^2$ = 0.35).

## CONCLUSIONS

The relatively poor relationships between FPC and variables measured may be explained to some extent by data values obtained under 'atypical' conditions. The principal reasons for the low $R^2$ values were:

1. the variability of the climate and seasons, especially rainfall, which affected soil moisture and soil thermal conductivity and hence vapour pressure, evaporation and temperatures.
2. the difference in ecosystems, and so the difference in tree types and canopy structure. This was why we always obtained better regressions if using foliage projective cover (%) rather than tree basal area ($m^2$/ha) or tree density (stems/ha).
3. topographic effects which, although we tried to avoid them, sometimes strongly interfered with tree effects.
4. the fact that every forest creates its own microclimate and interactions between the different microclimatic variables inside the forest-stand are very difficult to extrapolate.
5. a methodology that was restricted so that data could easily be incorporated into the pasture-growth model.

In most of the cases, however, we were able to relate tree cover to micrometeorological variables, especially net radiation, the key variable. In general, we conclude that microclimatic effects caused by trees are too important to not incorporate them into models which use climatic data. For development of more accurate relations between tree cover and microclimate, automatic meteorological stations would be required.