Assessment of the UVR Protection provided by different Tree Species

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Abstract: The use of shade as a strategy in the reduction of human exposure to solar ultraviolet radiation (UVR) has increased markedly in importance in SunSmart campaigns in recent years. Reduction of UVR exposure in early life is very important and the provision of shade structures at schools has become a key strategy in sun protection. Trees are also important in the provision of shade, either as the main shade provider or to augment shade structures and increase the UVR protection provided to the general population. A study to measure the protection provided by a range of trees commonly used in Australian urban environments was undertaken during the summer of 2004/05. The solar UVR beneath the trees was measured using UVR sensitive polysulphone (PS) badges positioned horizontally within the tree shade. These shaded readings were compared to measurements in full sunshine to provide protection factors (PFs) for each of the trees. Measurements were repeated on sunny days for the months January to April to assess whether the shade cover provided by the trees changed with season as a result of changing foliage and sun angle.

Introduction and Methods

The study examined 6 main species, with 4 examples of each type of tree. The species were both native and non-native urban trees. The natives were brush box, white cedar and kurrajongs while the non natives were jacarandas, nettles and golden rain. The only evergreen was the brush box, while the kurrajong, white cedar and jacaranda were semi-deciduous and the nettle and golden rain were deciduous.

Figure 1. The experimental setup showing the placement of traffic cones with PS badges around the trees.

UVR shading exposures took place near solar noon, with a duration of 2 hours. As an additional measurement, volunteer subjects wore PS badges for 1 hour, to assess how much solar UVR they received while positioned in the tree's shade. The experimental methodology was trialled at the Waite Institute Arboretum to determine how best to gather the data. PS badges were placed horizontally beneath the trees at a height of 0.5m and 1 metre from the trunk on the north, east, south and west sides. On the north side a vertical PS badge was also used to measure the UVR incident vertically. A simple arrangement using traffic cones with PS badges attached allowed rapid, reliable and repeatable setup of PS badges beneath each tree. Ambient solar UVR was also measured by the ARPANSA Solar Light UVBiometer 501 meter based in central Adelaide, approx 5 kms away.

The study also used some simple, inexpensive, easy to use UV meters to assess the UVR PFs of trees. If these simple UV meters can be shown to provide reliable results, similar to the PS film data, then extending the study to include collection of a large amount of data by Local Governments across Australia is possible. UV meters would be provided to local councils for on the spot assessments. Data would be gathered on thousands of trees and numerous tree species across Australia.

Previous studies of trees and UVR protection such as Parsons et al (1998) in Queensland obtained horizontal UVR PFs for Eucalypts of 3.5 while Norfolk Island pines had a PFs of 3.7 and dense shade trees (Mangos and Chinese elms) had PFs of 5.5. Grant (2002) measured a PFs of 6 to 10 for a grove of trees and found PFs of 2 to 5 for single trees. Parisi & Kimlin (1999) measured shade ratios, giving PFs of 3 to 6. Another study by Parisi et al (2000) found shade ratios of 0.16 to 0.49 giving PFs of 2 to 6. Diffey & Diffey (2002) measured PFs of 8 to 50 for single trees, with a PF of 100 in woods.

Results

The results of the measured PFs for the six tree species of this study are shown in Table 1. There is significant change in the measured PFs with season as can be seen in the variation in data from month to month. This is partly due to observable changes in tree canopy in spring and summer, but is also due to changing sun angle, with the PFs increasing when the sun is highest in the sky in December and January. Initial results with the simple UV meters gave reasonable agreement with PS film for trees with PFs < 10 but responses for mature trees in the arboretum with PFs > 30 agreement was less satisfactory, due to low UV levels. Further evaluation is planned.

Table 1. UV Protection Factors (PFs)[1] of 6 different Tree Species

Date Zenith Angle	25 Oct	11 Jan	17 Feb	8 Mar	12 Apr
White Cedar	5.0 ± 1.4	9.5 ± 1.1	9.3 ± 1.7	8.3 ± 1.3	4.7 ± 2.0
Jacaranda	2.3 ± 0.2	6.3 ± 0.9	10.4 ± 3.9	8.1 ± 2.5	6.4 ± 2.1
Kurrajong	4.9 ± 1.9	5.3 ± 2.5	5.6 ± 2.5	4.4 ± 1.5	3.3 ± 1.6
Brush Box	6.5 ± 0.9	7.5 ± 1.3	8.2 ± 1.5	6.3 ± 1.1	4.1 ± 1.3
Celtis (Nettle)	8.0 ± 2.7	8.2 ± 4.9	8.9 ± 4.5	6.6 ± 4.7	4.1 ± 2.0
Golden Rain	5.1 ± 2.1	8.1 ± 2.7	7.9 ± 2.6	6.7 ± 2.3	4.8 ± 2.8

1 PFs calculated from the average of the 4 horizontal measurements taken around each of 4 trees (n = 16)

Table 1 also shows significant differences in the UVR protection between tree species. Street trees provide UVR PFs similar to many purpose built structures ie PFs less than 10. Shade needs to be used in conjunction with other personal protection strategies, such wearing hats, sunglasses and clothing and using sunscreens. The study also found that tree architecture (height, width and shape of canopy) is more significant than individual species performance. The results also indicate that tree management strategies to increase UVR protection in an urban setting are a possibility. It is planned to implement the lessons learned from this study on an Australia wide basis.

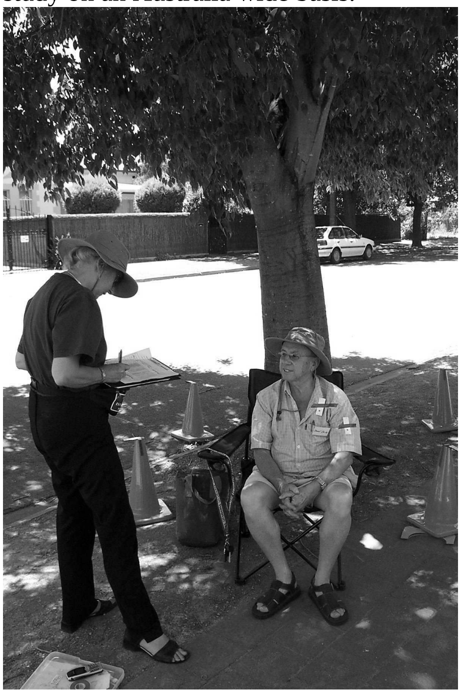

Figure 2. A volunteer with PS badges attached to his hat, lapel and sleeve.

UVR exposures for the human subjects ranged from from 4 to 20 % of ambient (PFs 25 to 5) atop their hats, while UVR exposures at the sleeve and lapel ranged from 4 to 14 % of ambient (ie PFs 25 to 7). UVR exposures decreased from January to April while the percentage of ambient increased ie as the sun was lower in the sky, the trees provided less shading to the subjects.

Conclusions

The results are in agreement with previous studies on UVR protection provided by trees. This study shows significant differences in the UVR protection between tree species. Street trees also provide UVR PFs similar to many purpose built structures. Shade needs to be used in conjunction with other personal protection strategies, such as sunscreens, and wearing hats, sunglasses and clothing. The results also indicate that tree management strategies to increase UVR protection in an urban setting are a possibility.

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