

greater) was on the roof at 3 p.m. on July 21. Figure 1 demonstrates the needed tree heights at various distance from a 12-foot roof house in order to achieve a 15-foot shadow. The technique followed the solar azimuth and altitude formulae of Griffiths (1976). Figure 2 demonstrates tree heights and azimuths to achieve optimum roof shading. Electrical data were obtained from the City of College Station electrical department. These data in kilowatt hours were converted to a value per square foot to correct for the varying sizes of living (cooled) area. Records for the cooling seasons of 1977, 1978, and 1979 were used.

Table 1 displays the results of the study. Electrical data for each home in the sample were used as a dependent variable in a statistical analysis software system (SAS). In each of the tree study years there was a significant difference at the 0.01% level between shade-classes 1 and 4. Observations on wall and roof color revealed that

homes with light colored roofs and walls used significantly less kwh than those with dark colored roofs. A SAS General Linear Model Procedure computed the following F values: shade 45.06, wall color 20.10, roof color 5.81. Thus, shade from trees proved to be the most highly significant variable.

Discussion

Although the large variation between homes and occupants was difficult to accept, the analysis of data revealed a positive effect of tree shade on energy reduction. As shown in Table 1, the effects of shade appear less in 1978. In 1978, College Station experienced an extremely hot and dry summer in which the higher air temperatures may have negated the cooling effect of the shade. In 1979, there was a serious defoliation of post oaks in the spring by cankerworms. Young live oaks were observed to have severely shortened twig elongation and leaf density throughout the grow-

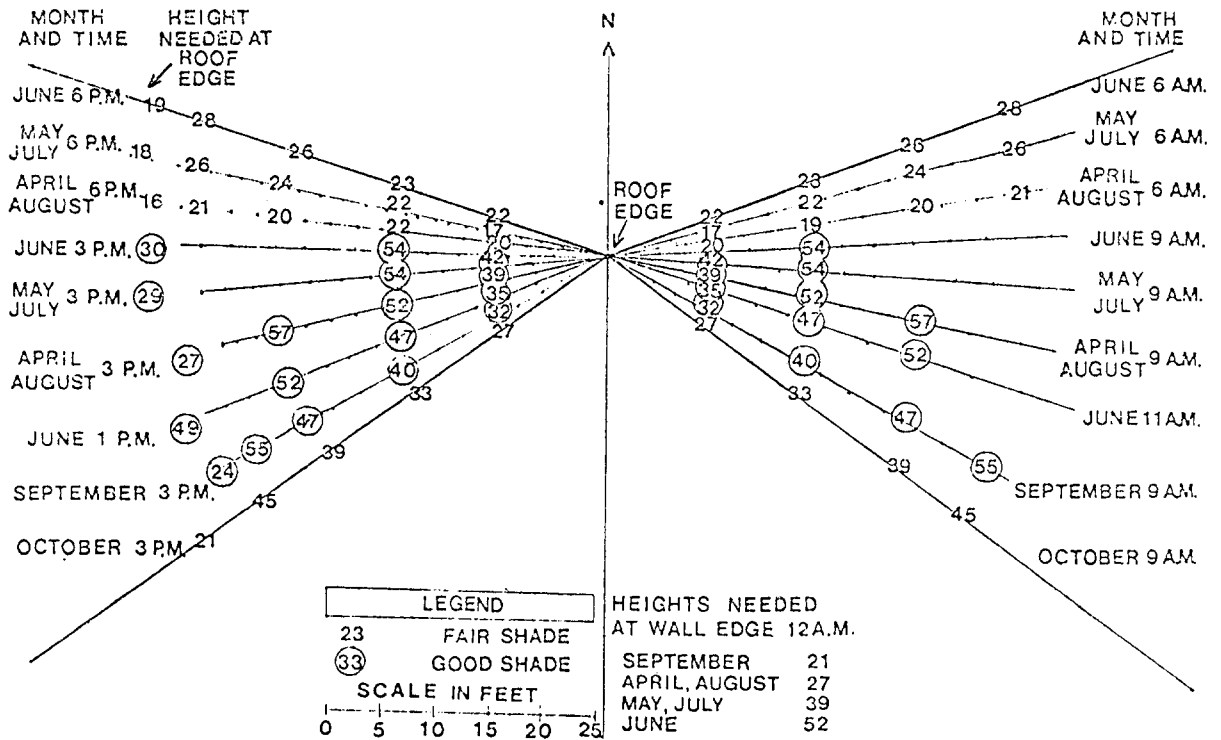


Figure 2. Diagram of tree heights needed for shading at different azimuths for a twelve foot roof.

Table 1. June through September average kilowatt hour electrical usage per square foot of air conditioned area for four shade classes in a selected residential neighborhood in College Station, Texas.

Year	Shade Class	N	Mean June-Sept. monthly usage	Mean winter monthly usage	Mean June- Sept. temp.
1977	1	8	4.244	.390	
(18% increase of class 4 over class 1.)	2	17	4.374	.385	82.8
	3	33	5.221	.423	
	4	35	5.019	.378	
1978	1	7	4.550	.403	
(10.94% increase of class 4 over class 1.)	2	17	4.563	.388	84.4
	3	33	5.288	.428	
	4	37	5.048	.380	
1979	1	5	3.114	.378	
(27.01% increase of class 4 over class 1.)	2	20	3.900	.390	79.5
	3	35	4.168	.416	
	4	35	3.958	.379	

Shade class 1 is most shaded as defined and shade class 4 is a treeless category.

ing season. Many trees had difficulty leafing out completely. Also a growing awareness of energy conservation was apparent. Absolute energy usage in 1979 was the lowest of the three years. These factors may explain the lack of significant difference in shade-classes in that year except for shade-class 1.

We believe that this study adequately demonstrates the value of shade trees in the home landscape in reducing cooling energy costs, and illustrates that optimum position for trees in relation to a home setting.

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