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OF WHAT COMFORT VALUE, A TREE?

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Abstract. The 'value' of a tree can be stated in economic and sometimes aesthetic terms. This study attempted to determine a quantitative measure of the 'human thermal comfort value' of a row of evergreen trees. It demonstrated that a person standing beside a row of *Picea glauca* (white spruce) in Southern Ontario experienced a longer period of thermal comfort throughout the test year than a person standing in the open, all other things held constant. The south side of the trees created a microclimate that provided comfortable conditions for an additional 34 complete days, as well as 48 lunchtime periods. The microclimate on the north side of the trees provided the equivalent of 17 additional days of comfortable conditions as well as 25 additional lunchtime periods. In future this approach might provide 'comfort values' for individual species of trees.

Résumé. La valeur d'un arbre peut être évaluée en termes économiques et parfois esthétiques. Cette étude vise à déterminer une mesure quantitative de la "valeur humaine de confort thermique" originant d'une rangée de conifères. L'étude a démontré qu'une personne se tenant debout à côté d'une rangée de *Picae glauca* (épinette blanche) dans le sud de l'Ontario expérimentait une plus longue période de confort thermiqueau cours de l'année de l'étude qu'une personne se tenant debout, à découvert, tous les autres facteurs étant constants. Le côté sud des arbres a créé un microclimat qui a procuré des conditions confortables pour 34 jours complets additionnels, de même que 48 périodes de dîner. Le microclimat du côté nord des arbres a procuré l'équivalent de 17 jours additionnels de conditions confortables, de méme que 25 périodes de dîner. Dans le futur, cette approche pourrait offrir des "valeurs de confort" pour des espèces individuelles d'arbres.

In attempting to determine the 'value' of a tree researchers have used measures based on economics or aesthetic benefit (7). Anyone who has walked under a tree or sat beside one on a hot day has a sense of its additional value in modifying personal comfort levels. Little work has been done to date in quantitatively describing the value of a tree or trees in terms of the thermal comfort it creates for people.

The inherent difficulty in this type of investigation is that the thermal comfort offered by trees varies with the time of day, the time of year, and the current weather conditions, as well as with the clothing and activity level of the person (1). This means it is not possible to state the comfort value of a tree in one discrete value as might be possible with an economic evaluation. In an attempt to deal with this complexity it was determined that an investigation should be undertaken that would provide for the testing of different sets of conditions, allowing the 'value' of the trees to be stated in terms of the improvement or detriment to comfort that the tree might offer.

Method

The goal of this study was to conduct an initial investigation into determining the 'comfort value' of a row of *Picea glauca* (white spruce). A system was developed which utilized hourly climate data for a complete year (1986) for Toronto, Canada. These data were appropriately modified to represent the climate at the level of a standing person by generating wind profiles down to a level of 1.5 m (3). A quantitative human thermal comfort model called COMfort FormulA (or COMFA) (1) was used to determine hourly comfort levels based on the climate data. The overall computer model was designed to be interactive so that a test could set specific conditions.

An example would help to illustrate the procedure used in the study. The comfort levels for a person standing in the open wearing a T-shirt, pants, and a light windbreaker, from 6:00 A.M. to 6:00 P.M. were determined for every day in the month of April. The model estimated the percentage of the test period that the person would be (1) too cold,(2) too cool, (3) comfortable, (4) too warm, and (5) too hot. This was graphed to illustrate the comfort level of a person on an open plane under the stated conditions (see Figure 1).

The next step was to insert into the model a row of white spruce trees running east to west and have the same person, in the same clothing, stand on the north side and then on the south side of these trees for the given time period. The model estimated the microclimate created for the person by the trees through use of quantitative and empirical relations in the literature as follows. Radiation received by the person was estimated from the data using solar transmissivity values for trees and a procedure from the literature (4, 6). Wind was estimated using profile equations (3) and empirical measurements of wind reduction behind rows of trees (2, 5). The same time period as in the open was tested and the percentage of time the person was in each of the comfort categories while standing on the south and then the north

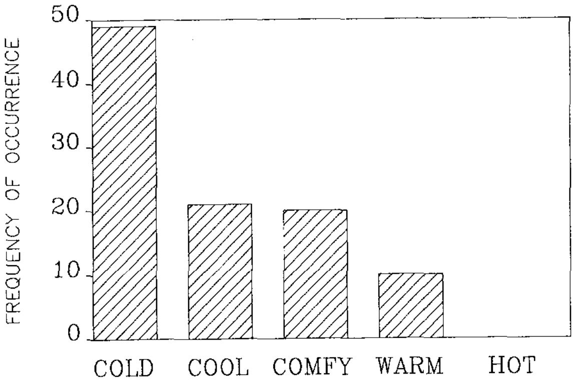

Figure 1. Frequency of occurrence of comfort categories for a person standing in an open site at Toronto, 6:00-18:00, April 1986.

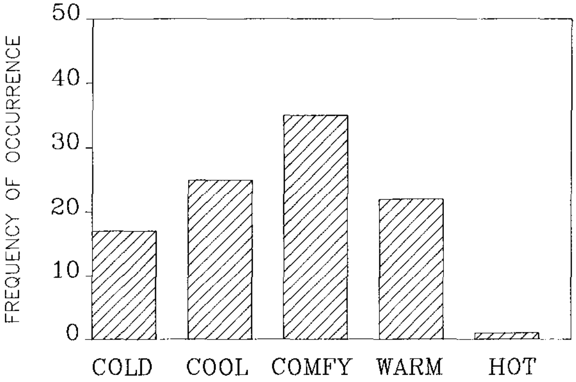

Figure 2. Frequency of occurrence of comfort categories for a person standing on the south side of a row of White Spruce at Toronto, 6:00-18:00, April 1986.

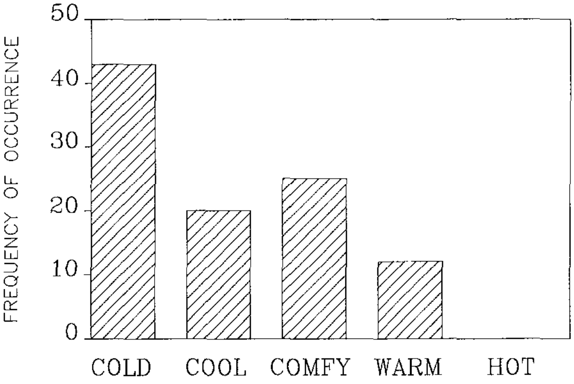

Figure 3. Frequency of occurrence of comfort categories for a person standing on the north side of a row of White Spruce at Toronto, 6:00-18:00, April 1986.

side of the row of trees was determined and graphed (see Figures 2 and 3). By comparing the graph of comfort levels with and without the row of trees, the value of the trees could be determined.

Two time periods were evaluated in the tests: 1) from 6:00 A.M. to 6:00 P.M. for every day of the year (with clothing appropriate to the season) and 2) from 11:00 A.M. to 1:00 P.M. for every day of the year (to correspond to the lunch break period, clothing again appropriate to the season).

Results

Results were tabulated in terms of the percentage of the time that a person would experience each of the comfort levels during the test time period in each of the test environments. These values were translated into the number of hours that the test environment was more comfortable than the open site (see Table 1).

In the first test period (6:00 A.M. to 6:00 P.M. every day of the year) a person standing on the south side of the row of trees experienced a net improvement of 413 hours or approximately 34 days (using a 12-hour day, the test period), while a person on the north side experienced an improvement of 201 hours or 17 days. The improvement became even more significant when viewed on a seasonal basis (see Figure 4).

The location on the south side of the trees provided a comfortable environment for an additional 14.5 12-hour days in winter, 12 days in spring,

Table 1. Hours of improved comfort conditions for each month of the year.

	*All day**		*Noon***	
	South	*North*	*South*	*North*
J	53	18	15	7
F	78	32	18	10
M	42	79	10	10
A	98	22	22	5
M	79	28	12	7
J	-35	-34	-7	-7
J	-43	10	-10	-3
A	-34	-4	-9	0
S	24	92	4	7
O	84	-45	17	1
N	31	-27	8	1
D	36	30	16	15
Net	413	201	96	53

* Based on 12-hour days (6:00-18:00)
**Based on 2-hour days (11:00-13:00)
Note that negative values mean less comfortable conditions

and 12.5 days in fall, while worsening the situation for 4.5 days in summer. The north side of the trees improved the comfort levels in winter by 11 days, in spring by 1.5 days, and summer by 8 days, while worsening conditions by 3.5 days in fall. The net result was that the south side of the trees offered an additional 466 hours (39 12-hour days) of comfortable situations in fall, winter and spring, the times that people really appreciate an improvement in the microclimate of southern Ontario.

In the second test (11:00 A.M. to 1:00 P.M. every day of the year) the results were similar to the first test, but more pronounced. The net im-

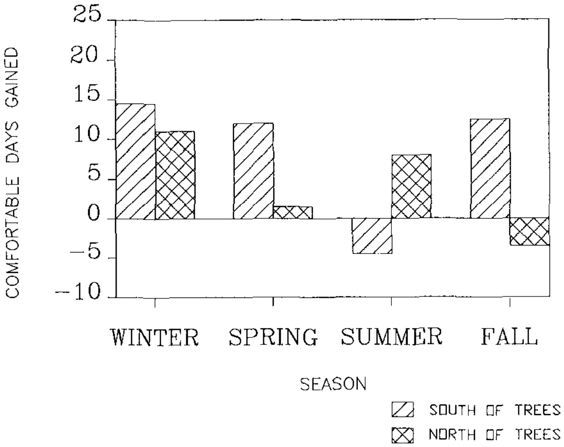

Figure 4. Number of comfortable days gained by standing on the south and north sides of a row of White Spruce at Toronto, 6:00-18:00, 1986 (by season).

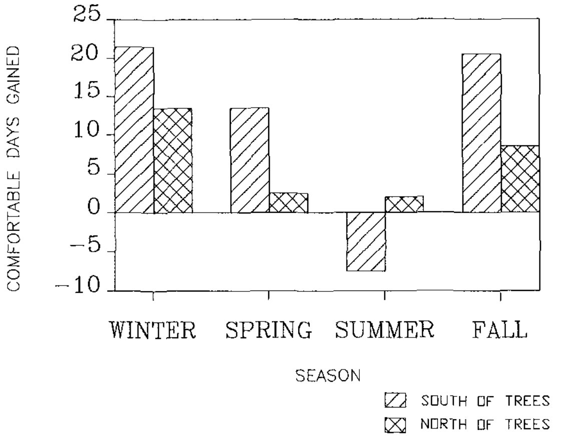

Figure 5. Number of comfortable days gained by standing on the south and north sides of a row of White Spruce at Toronto, 11:00-13:00, 1986 (by season).

provement was 48 days (using a 2-hour day, the test period) for the south side of the trees and 26.5 days for the north side. On a seasonal basis (see Figure 5) the south side afforded comfortable conditions for an additional 21.5 days in winter, 13.5 days in spring, and 20.5 days in fall, while worsening the conditions by 7.5 days in summer. The north side increased the number of comfortable days in all seasons, with improvements of 13.5 days in winter, 2.5 days in spring, 2 days in summer, and 8.5 days in fall.

Discussion

The results of these tests were not surprising, and can be readily explained in terms of micrometeorological theory. For example the increase in comfort at lunch time in winter on the south side of the row of trees is a result of blocking the predominantly north wind while allowing the person to experience maximum solar input. In summer the row of trees acted in much the same way by blocking any potentially cooling winds from the north while allowing a full input of solar radiation, thus increasing the heat load on a person.

A significant result of this study is that a quantitative measure is placed on the value of a row of white spruce trees in terms of the human thermal comfort provided. This is particularly significant in that it is based on a measure that every person can understand.

Another significant aspect of this study is that the computer model can be modified to allow testing of other situations. Future tests could include individual deciduous trees. Additional information required as input to the model would include solar transmissivity of canopies in different seasons, and the effect of a single deciduous tree on wind flow. Once this has been determined the model should provide comparison of the comfort values of different species of trees. An interesting comparison would be between *Gleditsia triacanthos* var. *inermis* (thornless common honeylocust) and *Acer platanoides* (Norway maple). Based on microclimatic theory the honeylocust, with its 'light' shade should be more valuable in spring and fall, while the Norway maple with its 'dense' shade should provide more comfort in summer.

Information on the 'comfort values' of trees will be of considerable interest to a wide range of people, from nurserymen to landscape architects, as well as to individuals trying to find the right tree for a space in their yard.

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