CAN WINDBREAKS REDUCE ENERGY USE IN A MOBILE HOME PARK?

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Abstract. Effects of a coniferous windbreak on electrical energy use in a 66-unit mobile home park in central Pennsylvania were studied during the winters of 1981-82 and 1982-83. A 100-m long, single-row windbreak of white spruce *(Picea glauca)* trees with an average height of 6 m was artifically erected on the upwind edge of the park in 1981-82. During the winter of 1982-83 no windbreak was present. Wind speeds in the mobile home park were reduced by the windbreak by 9% at 3H downwind from the windbreak (H = windbreak height), by 8% at 13H downwind, and 0% at 30H downwind. Using equations relating electrical energy use to climatic variables, the energy use of 13 homes was found to be similar between the 2 winters, 8 homes displayed a significantly lower energy use with the windbreak in place, and 20 homes showed a higher energy use with the windbreak in place. Differences in energy use between winters were not attributable to the windbreak; rather, they were due to changes in behavior of the occupants. If the windbreak had reduced wind speed by 50% rather than 0-9% and other factors were constant, total winter electrical energy use would have been reduced by an estimated 6.6%.

Windbreaks can be of benefit to homeowners in reducing cold winter air infiltration into their homes and saving money on their heating bills. DeWalle and Heisler (2) have shown that air infiltration rates for a small mobile home in Pennsylvania were reduced by over 50% with a single-row windbreak of white pine *(Pinus strobus)* trees. Reduced air infiltration rates translated into a 12% reduction in heating energy bills for an entire winter heating season. Other estimates of windbreak energy savings for home heating in the literature range from 3 to 22% (1) for a variety of estimation techniques, dwelling types, climatic conditions, etc. Thus, it appears that an individual homeowner can probably save 10% on his home heating bill through the proper use of a windbreak.

Economically, the use of windbreaks to reduce home heating costs makes good sense. DeWalle (1) and Heisler (4) have both shown that planting a windbreak can save enough energy for a single home over a 20-year period to pay back initial costs for purchase and planting of windbreak trees. When coupled with the fact that a windbreak provides other benefits, such as beautification, screening, and wildlife habitat, the investment in a windbreak is worth considering.

The question then arises whether a single windbreak can be used to reduce heating energy needs for multiple dwellings such as found in a mobile home park, thereby making use of a windbreak even more appealing economically. Armed with experience from our earlier studies on individual dwelling units we sought to answer this question by evaluating total energy use in a 66-unit mobile home park with and without the effects of a coniferous windbreak artifically-constructed upwind of the park. The results of this experiment were rather surprising and point to the need for careful selection of windbreak planting sites and to the difficulties introduced when working with research data influenced by human behavior.

Study Site

The study site chosen was a mobile home park located near State College, Pennsylvania (latitude 40° 48′, longitude 77° 55′). The mobile home park was located at a windy site surrounded by agricultural fields. There were 66 mobile homes consisting of single- and double-dwelling units along four drives as shown in Figure 1. The single-dwelling units were of the regular mobile home type where one family lives in the trailer. The double units were an end-by-end duplex type of mobile home, with two separate residences in the

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same mobile home.

The mobile homes were fairly recent models; they had a wooden frame construction, were fully insulated (R-21 insulation according to the park manager), had exterior walls of metal siding and a one-piece metal roof. All homes had the option of removable storm windows. Their average dimensions were 4 meters wide by 20 meters long. The mobile homes were all-electrical units, which allowed electrical energy use to be measured by periodically reading electric meters for each home.

The mobile home park was situated on gently rolling terrain, with elevations ranging from 373 to 384m toward the north. Abundant vegetation was present in the park and consisted mainly of medium height trees and small shrubs. The position of the trees is indicated on Figure 1. On this figure, note the row of arborvitae *(Thuja occidentalis)* shrubs running along half the western edge of the park; these shrubs were about 1m high and 50cm wide, and spaced 1m apart. The park was located on the eastern side of a large field (not cultivated in winter) which provided an unobstructed upwind distance of at least 150m for the prevailing westerly winds. The windbreak was placed on the western side of the mobile home park, 3H from the closest mobile home (H is the height of the windbreak). The windbreak was composed of a single-row of 39 white spruce *(Picea glauca* (Moench) Voss.) trees, with 3 meters spacing between the trees, and an average tree height of 6 meters in place (Figure 2). The trees were cut on University experimental plots, transported to the study site, put in 60cm deep holes, and guyed with wires. The trees were in place at the mobile home park from December 15, 1981 through March 21, 1982.

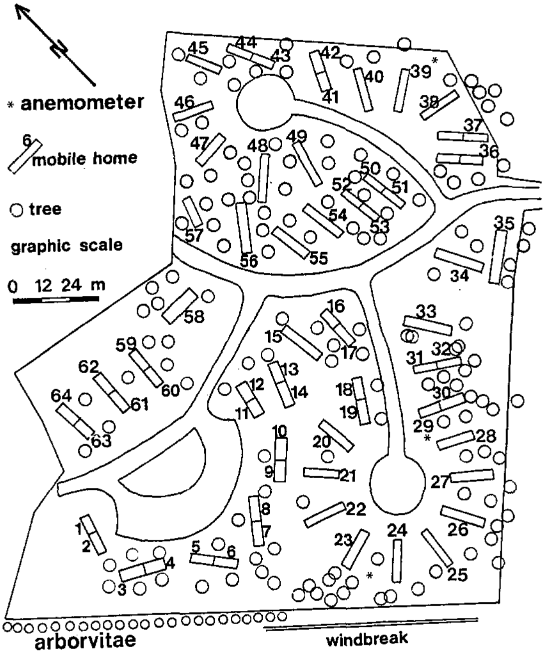

Figure 1. Layout of the mobile home park, homes, existing landscape vegetation and the windbreak.

Figure 2. White spruce windbreak erected along the western border of the mobile home park.

Study Methods

Electrical energy use in the mobile homes was compared with an without protection by the windbreak. The windbreak was used the first winter of the study (Dec. 15, 1981 - Mar. 21, 1982), but to provide reference measurements, no windbreak was present the second winter (Nov. 24, 1982 - Mar. 30, 1983).

Measurements taken every 3 days during both winters included electrical energy use readings for the homes as well as meteorological observations. Electricity use was measured by reading electric meters. The meteorological variables measured were wind speed, wind direction, minimum and maximum exterior air temperature and solar radiation. Wind speed was monitored at 4 locations on a line perpendicularly-bisecting the axis of the windbreak. Anemometers were located at 10H upwind from the windbreak and at 3, 13, and 30H downwind. The 30H position coincided with the eastern or downwind edge of the park. Wind direction and outside air temperatures were measured 10H upwind from the windbreak. Solar radiation was measured at a short distance (8 km) from the park at a site with similar topography.

Statistical Analysis

To determine the windbreak effects on energy use for each home, a regression equation was developed between energy use and climatic variables. The data from both winters were used in a single stepwise regression equation for each of the mobile homes, and the dependent variable used in the program was: E = mean energy use, in kilowatt-hours per hour, averaged over each 72-hour period.

The independent variables were:

T = mean exterior temperature, in degrees centigrade, for each 72-hour period, subtracted from an assumed thermostat setting of 20°C inside the trailers,

W = mean wind direction in degrees minus 137°, the azimuth of the windbreak, to indicate the angle between the windbreak and the wind direction,

U = mean wind speed at 10 H upwind from windbreak, in meters per second, for each 72-hour period,

S = mean solar radiation, in Watts per square meter, for each 72-hour period,

X = indicator variable indicating first or second winter season and the presence or absence of the windbreak

X = 1, first winter when windbreak was present

X = 0, second winter when windbreak was not present

and the interaction variables U^2X, TX, U^2TX, WX, SX, and UX. If the indicator variable was retained in the final step of the stepwise regression, and therefore was found to be statistically significant, it was assumed that this variable indicated a difference in response between winters, possibly due to a windbreak effect on the energy use in the mobile homes. Individual regression equations were developed for 41 mobile homes. Data for 25 homes were not used because of changes in occupants between winters. If the indicator variable was not retained in the stepwise regression equation, it was concluded that both winter seasons were similar and the windbreak had no effect on the energy use of the mobile home. Differences in climate between the two winters were accounted for in this analysis, as energy use was regressed on the same climatic variables in the same fashion both winters, so that a variation in a climatic variable modified the resulting energy use in a consistent way.

Results and Discussion

Effect of the windbreak on wind velocity. Windspeeds upwind and downwind from the windbreak were compared to each other for the winters with and without the windbreak. The topography and existing vegetation at the mobile home park were responsible for major reductions in wind speed between upwind and downwind locations. In the absence of the windbreak, relative to wind speeds at 10H upwind, the wind velocity was 35% less at 3H downwind, 32% less at 13H downwind, and 10% less at 30H downwind.

Wind speeds were reduced further by the presence of the windbreak (see Figure 3). At 3H downwind the wind velocity was reduced an additional 9% by the windbreak to 44% compared to the wind velocity at 10H upwind. At 13H downwind the wind velocity was reduced an additional 8% by the windbreak to 40%. At 30H downwind wind speeds were still 10% less than the windspeed at 10H upwind, that is, the presence of the windbreak did not affect the reduction of windspeeds at 30H downwind.

In other studies, much greater reductions in wind speed due to a windbreak have been found. DeWalle et al. (3) found a 54% wind reduction at 2H downwind due to the presence of a white pine windbreak, and a 42% reduction at 4H downwind.

The substantial reduction (35%) in windspeed between upwind and downwind locations in the absence of the windbreak is probably mainly due to the pre-existing air flow patterns over, around, and through the park. The collective effect of the homes, existing landscape vegetation, and slight topographic rise upwind of the park would cause air to be deflected up and over the park. Thus the placement of the windbreak only produced a small additional wind velocity reduction (9%) within the park, compared to results for windbreaks upwind from homes isolated from interference by surrounding obstacles.

Effect of the windbreak on energy use. The stepwise regression approach yielded very different results among the 41 mobile homes studied. There was no significant indicator variable in the regression equation developed for 15 mobile homes, so for these homes, the energy use was shown to be similar during both winters, and no windbreak effect was apparent. The location of these homes is shown in Figure 4.

The energy use in 8 mobile homes was significantly lower during the first winter (when the windbreak was present) than during the second winter; for 22 homes, the energy consumption was significantly higher during the first winter. As can be verified on Figure 4, the homes seem to be randomly distributed (spatially and by type) according to their electricity use pattern between winters. The independent variables retained in the stepwise regression equation varied from home to home, T being the most frequently encountered. The R^2 values ranged from 39.79% to 92.55%, with a mean of 73.90%.

These results do not support the hypothesis that a windbreak upwind from mobile homes will reduce energy use in those homes. The 8 homes in which electricity use was lower with the windbreak in place were scattered in all areas of the park, whereas energy use savings would be expected primarily in homes immediately downwind from the windbreak. Therefore, it was impossible to attribute their low energy use in the first winter to the presence of the windbreak. Moreover, the majority of the homes experienced an increase in electricity use with the windbreak in place; again, this characteristic was found across the entire park and was not restricted to a particular type of mobile home, and therefore no general cause could be invoked to explain the behavior of all the mobile home occupants. Several individual events, however, could be the cause of higher energy use for some mobile homes during the first winter.

Two electricity rate increases occurred between the 2 winters studied. Rate hikes would probably influence some occupants to turn down their heating thermostat to prevent greater utility expenses the second winter. This behavior was even more expected because the first winter had been extremely cold and therefore very expensive in terms of heating energy, so that the general attitude the following winter was likely to be more energy conserving.

For some individual homes, it was possible to associate a change in occupant behavior with an increased energy use during the first winter. During the summer between the 2 winters studied, all occupants were sent some information about the study, along with their winter electricity use compared to the average, highest, and lowest uses in the park. This information allowed some occupants (such as the ones in home 3) to become aware of their unusually high electricity use, so that the next winter they used electricity more conservatively.

It was not possible in this study to control the behavior of the mobile home occupants, and unfortunately their behavior probably had the most important effects on energy use between winters and the results of this study. In mobile home 11, the occupants used a kerosene heater the second winter, but not the first. This obviously reduced their electricity use the second winter. Some other mobile homes displayed a higher energy use the first winter simply because their occupants left town most of the second winter.

Energy use reduction computation. In another aspect of this study, the energy use of each mobile home was regressed on the climatic variables, separately for each winter. In other words, no indicator variable was used to tag the

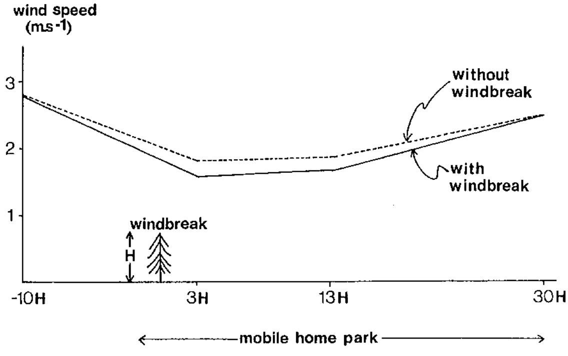

Figure 3. Wind velocity at the 4 anemometer locations for average winter conditions with and without the windbreak.

presence of the windbreak, but 2 different equations were developed for each home. All homes for which the prediction equation (for the winter without the windbreak) contained a windspeed term were examined to determine the energy use reduction that would result from a hypothetical windspeed reduction of 50%. A hypothetical reduction of 50% was chosen because it is representative of the reductions induced by windbreaks found in other studies (1,2). Average values for both winters were computed for each climatic variable and used to predict an average energy use for each mobile home. The wind speed value was then reduced by 50% to simulate a windbreak effect of that magnitude and new energy use data were generated for all homes. For all 64 mobile homes in the park (including the homes with no windspeed term), the energy use reduction accompanying a windspeed reduction of 50% averaged 6.6%.

Further examination of regression equations revealed that the percentage of energy used to heat the mobile homes averaged 60% of the total energy use. Therefore, if the total energy use reduction associated with a 50% reduction in wind velocity is 6.6%, the corresponding heating energy use is 6.6%/60% or 11%, a reasonable estimate compared to the 12% found in a study of windbreak effects on an isolated mobile home in central Pennsylvania (2).

Conclusions and Recommendations

No actual energy savings attributable to the windbreaks were found in the mobile homes monitored. The vegetation present in the park was probably already saving energy, and the existing landscaping and windflow patterns in the mobile home park had already reduced wind velocity compared to the wind velocity in the open field. Therefore, the addition of a windbreak added little to windspeed reductions.

The occupants probably did not maintain the same energy use patterns over the two years of the study. There was no control possible on changes in family size or permanent movings of occupants. However, even on the mobile homes for which there was information, i.e. no family change nor move, no effect of the windbreak was observed. There was furthermore no possible control on the use of any supplementary heating devices such as kerosene heaters in the mobile homes. All these factors probably contributed to the failure of verifying the hypothesis that a windbreak reduces energy use in mobile homes. The mobile homes used in this study were also particularly well insulated, and mobile homes elsewhere would most likely be more sensitive to wind speed reductions.

Before installing a windbreak in a mobile home park, a simple meteorological analysis of the site is recommended. Such a test would check the existing wind flow patterns within and around the mobile home park to determine whether wind velocities remain naturally high at the park edge or are decreased due to the presence of pre-existing obstacles.

For mobile home park owners and managers, and for mobile home owners, it is recommended that they consider the financial aspect of putting up a windbreak before making a decision about landscaping their mobile home park. If there are no features at the site that offer wind protection to the homes, a windbreak could be a valuable investment. With a 50% reduction in wind velocity, total energy use savings in this study would have

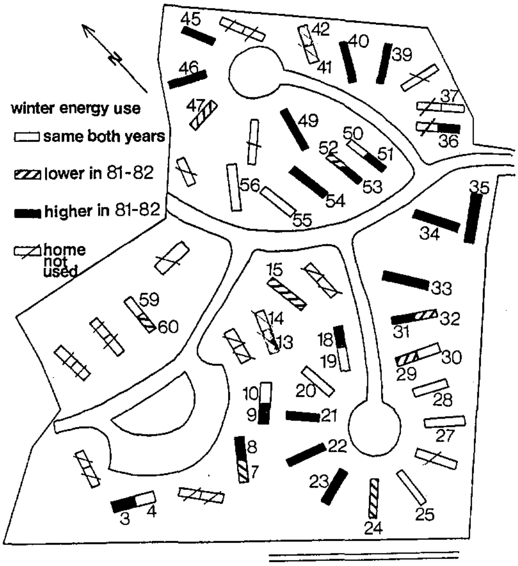

Figure 4. Change in energy use in mobile homes between winters. Windbreak was in place in '81-'82.

been 6.6%. The savings are modest but may be appealing when added to the many other advantages of a windbreak: aesthetic appeal, noise barrier, wildlife habitat, and visual screen.

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ABSTRACTS

CORLEY, W.L. 1984. **Re-evaluating the value of amending planting holes with organic material.** Am. Nurseryman 159(6): 113-116.

For more than two centuries the ideal planting hole for landscape shrubs and trees was considered to be one that had been organically amended to provide optimum rhizosphere conditions, thereby enhancing root development and plant growth. However, a search of literature on the subject reveals that this practice is based on custom and apparent logic rather than research data. Since 1975, the Georgia Agricultural Experiment Station, Experiment, Georgia, has been the site of three major tests to determine the value of organically amended backfill in Cecil clay. Researchers followed customary cultural installation and maintenance practices of fall planting, adding fertilizer to the planting holes regularly, liming acid soils, irrigating, and mulching. Increasing a hole's size produced more growth than using backfill amendments. Azalea, holly, shore juniper, and white dogwood did not respond significantly to backfill amended with pine bark during three growing seasons. The highest mortality rates in all species occurred in amended holes, whether mulch was present or not.