RESEARCH NOTE NC-137

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE
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The Effect of Overstory Removal Upon Surface Wind in a Black Spruce Bog

ABSTRACT.—Wind passage was measured over a black spruce canopy, at the surface under the canopy, and in a clearcut strip in a northern Minnesota bog. During a 40-day period wind below the canopy was 10 percent of that above the canopy while the wind in the clearcut strip was 45 percent of the total above the canopy. Wind at the surface of the clearcut strip was of longer duration and greater velocity than under the black spruce canopy.

OXFORD: 181.23:111.73:174.7 *Picea mariana* (776): 221.22. KEY WORDS: clearcutting, strip cutting, evapotranspiration, air exchange, energy.

Wind, as a physical factor of the environment, is both influenced by, and influences, forests. Some effects of forests upon windspeed have been summarized by Geiger (1965) and Daubenmire (1959). Some important effects of wind upon vegetation include carbon dioxide exchange, plant morphology, air and surface temperature, and the distribution of plant diseases and insects. However, of prime importance to the watershed manager is the influence of wind upon evapotranspiration. This influence is exerted through the advection of both water vapor and energy. It is generally recognized that increasing windspeed may increase the rate of evapotranspiration primarily through the removal of water vapor. However, it is seldom recognized that when humidity and radiational load are high, increasing wind may decrease in the rate of evapotranspiration (Gates 1968).

The removal of a forest overstory may increase the surface wind and significantly affect evapotranspiration from the understory vegetation, particularly where the water table is high. This situation was tested in north central Minnesota when an experimental stripcut treatment was made in a black spruce bog.

SITE AND METHODS

The bog studied is on the Marcell Experimental Forest and is approximately 1,850 by 450 feet, oriented lengthwise north and south. East-west oriented strips, 100 feet wide, were clearcut, leaving 150-foot-wide strips of the black spruce stand. The stand was 62 years old and had a stem density of 1,665 trees per acre and a basal area 122 square feet per acre. The average tree height was about 29 feet, with a fairly dense, live canopy depth of about 10 feet. Scattered dead branches occurred on the trunks down to ground level.

Windspeed was measured by 3-cup "Forester" anemometers (Western Fire Equipment Company)[1] connected to totalizing counters and recorded on a stripchart events recorder. The anemometers were mounted 3 meters above the forest canopy and at a height of 1 meter in the center of the clearcut and noncut strips. In order to reduce the relatively high starting speed of these instruments, they were thoroughly cleaned and balanced before the start of this study and routinely oiled during service. Data were collected from August 17 through September 24, 1970.

RESULTS

The total wind passage measured above the canopy during the 40-day period was 2,040 miles. At the surface of the clearcut strip, 917 miles of wind were recorded, 45 percent as much as above the canopy. The surface wind within the stand was 10 percent of that above the canopy, with a total of 211 miles of wind passage.

[1] *Mention of trade names does not constitute endorsement by the USDA Forest Service.*

Wind was recorded at the surface of the clearcut strip every time it was recorded above the forest canopy. However, gusts up to 7 miles per hour were measured above the canopy when no wind was measured at the surface below the canopy. Under steady wind conditions, there appeared to be a threshold ranging from 1.0 to 3.2 m.p.h. of wind above the canopy before wind was recorded below the canopy.

The wind passage recorded on the events recorder was tabulated by 1-hour intervals and the average miles of wind passage per hour calculated for each anemometer. The data were then subdivided by assumed temperature gradients into lapse conditions (6:00 a.m. to 6:00 p.m.) and inversion conditions (6:00 p.m. to 6:00 a.m.), and the number of hour periods during which surface wind passage was recorded were tabulated by temperature gradient class:

	Cut strip	*Noncut strip*
Lapse	212	182
Inversion	133	76
Combined	345	258

As there appeared to be a linear relationship between surface wind and wind above the forest canopy, regression equations with the form

$$\text{Surface wind} = a\ (\text{above canopy wind}) + b$$

were calculated for each class (table 1). The analysis included only those observation periods in which surface wind was recorded. The relatively low r^2 values and high standard deviations can be attributed to wind direction, which, in north central Minnesota, tends to be distributed around the compass during the summer (U.S. Department of Commerce 1968).

Table 1. — Constants for the equation: Surface wind = a (above canopy wind) + b, with r^2 values and standard deviations

Temperature gradient	Cut strips				Noncut strips			
	a	b	r^2	s.d.	a	b	r^2	s.d.
Lapse	0.509	+0.128	0.592	0.554	0.420	-0.699	0.681	0.313
Inversion	.462	-.044	.748	.462	.354	-.542	.717	.320
Combined	.505	+.027	.665	.539	.383	-.588	.682	.320

The regression lines for these equations (fig. 1) show both the higher windspeed in the cut strip for any above-canopy windspeed and the movement of air at the surface of the cut strip with low above-canopy wind when there is essentially

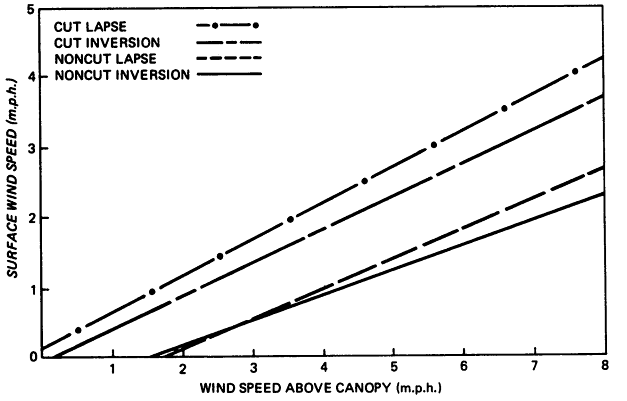

Figure 1.—Relationship between wind above the canopy and at the surface of the cut and noncut strips, lapse and inversion conditions.

no air movement under the canopy. This may be particularly significant for evapotranspiration from wetland areas because it provides a mechanism for the advection of energy, removal of water vapor, and an influx of drier air which would result in a steepening of the surface-to-air vapor pressure gradient. On the other hand, lack of air movement within the black spruce stand under low above-canopy wind velocity would depress evapotranspiration from the understory vegetation. While average above-canopy hourly wind velocities were recorded up to 7 m.p.h. during this study, low wind velocities were the rule, as illustrated by the 40-day average above-canopy wind velocity of 2.1 m.p.h. Thus, removal of the forest overstory increases both the surface wind velocity and duration and provides a mechanism for increased evapotranspiration from the surface vegetation.

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