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Flannigan, M.D., et al.

Pages 65-71 *in* MacIver, D.C., et al., eds.
Proc. 10th Conf. Fire and Forest Meteorol., April, 17-21, 1989, Ottawa

An Extensive Blowdown Occurrence in Northwestern Ontario[1]

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Abstract

Severe surface winds were experienced in eastern Manitoba and northwestern Ontario in the evening and overnight on June 24-25, 1988. Four general areas of forest blowdown occurred in northwestern Ontario. Within each general area, contiguous areas of blowdown ranging from a few hectares to over a thousand hectares were observed. Isolated occurrences of private property damage were reported, but the main areas of blowdown were sparsely populated.

The cause of the severe surface winds was investigated using meteorological data from the period June 23-26, 1988. It was found that a vigorous cold front, associated with a fast moving low pressure system, provided the mechanism for higher wind speeds aloft to reach the surface. The high wind speeds aloft were associated with an upper level jet stream over the region.

These blowdown areas are of serious concern to fire managers in the region. Very heavy coniferous fuel loadings were concentrated on the blowdown sites, with a large proportion of fine aerial fuels. As the downed material cures, an increasing amount will be available for combustion. The fuel arrangement will also hamper conventional ground attack should a fire occur. A similar, but more extensive blowdown occurred in the same region in 1973 and was followed by a wildfire in 1974 that burned 32,000 hectares of blowdown fuel.

Résumé

Dans la soirée du 24 juin 1988 et la nuit du 24 et 25, de violents vents de surface ont sévi dans l'est du Manitoba et le nord-ouest de l'Ontario. Dans cette dernière région, il y a eu quatre zones générales d'abattage d'arbres par le vent. Dans chacune des régions générales, on a observé des zones contigués d'abattage par le vent, allant de quelques hectares à plus de 1 000 hectares. On a signalé des cas isolés de dégâts aux biens privés, mais, heureusement, les principales zones d'abattage par le vent n'étaient que peu peuplées.

On a étudié la cause des vents violents de surface, en utilisant les données météorologiques disponibles de la période allant du 23 au 26 juin 1988. On a constaté qu'un front froid vigoureux, lié au système de basse pression à déplacement rapide, a fourni le mécanisme suivant lequel des vents de vitesse élevées, en altitude, sont parvenus à la surface. Ces vents étaient liés à un courant-jet de haute altitude qui soufflait au-dessus de la région.

Ces zones d'abattage préoccupent beaucoup les responsables de la lutte contre l'incendie de la région. De très fortes charges de combustibles de conifères sont concentrées dans les lieux d'abattage, ainsi qu'une grande proportion de fins combustibles aériens légers. Quand les matériaux abattus seront secs, il y aura une quantité d'autant plus importante disponible pour la combustion. La disposition des combustibles rendra aussi très difficile la lutte classique, au sol si un, incendie avait lieu. Un cas analogue de vaste abattage par le vent, survenu dans la même région en 1973, fut suivi, en 1974, par un feu de friches qui a brûlé 32,000 hectares de combustibles en majeure partie abattus par le vent.

[1] Presented at the 10th Conference on Fire and Forest Meteorology, April 17-21, 1989, Ottawa, Canada.

Introduction

During the evening of June 24 and the early morning of June 25, 1988, strong surface winds resulted in areas of extensive blowdown over northwestern Ontario. Blowdown occurred in the Dryden, Sioux Lookout, and Ignace Districts (Figure 1). The blowdown area totals 21 000 ha and includes 13 000 ha of wind damaged forests in the Dryden and Sioux Lookout Districts with an additional 8 000 ha in the Ignace District (House and Applejohn 1988). Figure 2 shows three prominent pockets of blowdown, connected by many smaller areas of damage, that give rise to a 90 km band of damage that runs southeast from Anishinabi Lake, south of Lac Suel, and then continuing southeast. The path of damage reappears about 70 km farther southeast, at the north end of Ignace District.

The purpose of our study was threefold: i) to investigate the cause of the extensive blowdown, ii) to demonstrate a mapping methodology that readily depicts this scale of forest damage, and iii) to consider the impact of the blowdown areas on fire management.

The region of northwestern Ontario where the blowdown was observed is part of the Boreal Forest Region of Ontario (Rowe 1972). The forest is primarily composed of jack pine (Pinus banksiana Lamb.), black spruce (Picea mariana (Mill.) B.S.P.) with mixtures of white spruce (Picea glauca (Moench) Voss), balsam fir (Abies balsamea (L.) Mill.), trembling aspen (Populus tremuloides Michx.), and white birch (Betula papyrifera Marsh.) (Rowe 1972). The mosaic of patterns in this forest are the result of a disturbance regime, primarily fire, but wind also plays an important role. This part of the boreal forest is on a portion of the Canadian Shield with a rough, rolling topography although relief is not great. The region has shallow soils with many lakes and rock outcrops. The region has a continental climate with a mean annual precipitation of 600-700 mm (Atmospheric Environment Service 1982) and a mean annual temperature of 1.5°C (Atmospheric Environment Service 1982).

The occurrence of blowdown in the forest is not a rare event. Blowdown results from strong surface winds generated by a variety of processes ranging from tornadoes, thunderstorms, hurricanes, and synoptic scale features like cold fronts. Tornadoes occur approximately at a rate of 0.4 to 0.8 per $10^4 km^2$ per year in this part of Ontario (Newark 1983). This results in a probability of tornado damage of about .02% annually which is 1/10 of the area burned by forest fires each year in Ontario (Harrington and Donnelly 1978). Harrington and Newark (1986) detailed the interaction of a tornado with rough terrain and its associated forest cover. Foster (1988 a,b) described how catastrophic windstorms have played an integral part in the diversity of the temperature forest. Wind speeds of 90-125 km/h (25-35 m/s) occur every 5-10 years in northwestern Minnesota (Simiu et al. 1979, 1980, Baker 1983), just south of our region of interest. Similar statistics could be assumed for northwestern Ontario, with blowdown being a fairly regular event. This is particularly true when considering the shallow soils common to this area, which suggests a greater frequency of blowdown.

Extensive blowdown did occur in 1973 in the same general area when 40 000 ha of standing timber were severely wind damaged (Stocks 1975). The interesting aspect of that event was that 32 000 ha of the blowdown area burned in a lightning-caused wildfire the following year. This aspect of susceptibility to fire and the associated fire management problem will be presented after the discussion of the weather conditions associated with the 1988 blowdown.

Weather Conditions Associated with the Blowdown Event

The blowdown took place during the evening of June 24 and the early hours of June 25, 1988. Meteorological data for the period June 23-26, 1988 were obtained from the Atmospheric Environment Service of Canada. This data included upper air analyses from 250, 500, 700, 850 hPa, surface analyses, tephigrams from Churchill, The Pas, Trout Lake, and International Falls (see Figure 1), and hourly weather observations from stations in Northwestern Ontario, eastern Manitoba and northern Minnesota. Detailed examination of the meteorological data was undertaken to discover how and why this disturbance occurred.

Upper air analyses show a west-to-east jet stream (250 hPa level) with wind speeds in excess of 180 km/h moving directly over the blowdown area during the period (June 24, 1800 CDT - June 25, 0600 CDT). The 500 hPa analysis (Figure 3) at 1800 CDT June 24, 1988 depicts a strong zonal flow over southern sections of northwestern Ontario, with a significant shortwave trough moving through Manitoba. A slowly deepening surface low pressure system associated with the upper air trough moved rapidly eastward (Figures 4-6) across our region during the time of interest. A warm front extended from the low southeastward and a cold front from the low southeastward. In the warm sector, the airmass was hot, moist, and unstable, with temperatures above 30°C and dewpoints as high as 22°C. Thunderstorms were associated along the cold and warm fronts. Vigorous thunderstorms developed near the frontal wave at the center of the surface low by June 24 1800 CDT. A tornado was reported at Gimli, Manitoba at 1849 CDT June 24. Strong gusty winds from the northwest were reported along the cold front, with speeds of up to 120 km/h.

Two separate mechanisms may have been responsible for the strong surface winds associated with this system:

1) severe thunderstorms including tornadoes, and
2) a lobe of high wind speeds extending down from the upper level jet stream to the earth's surface.

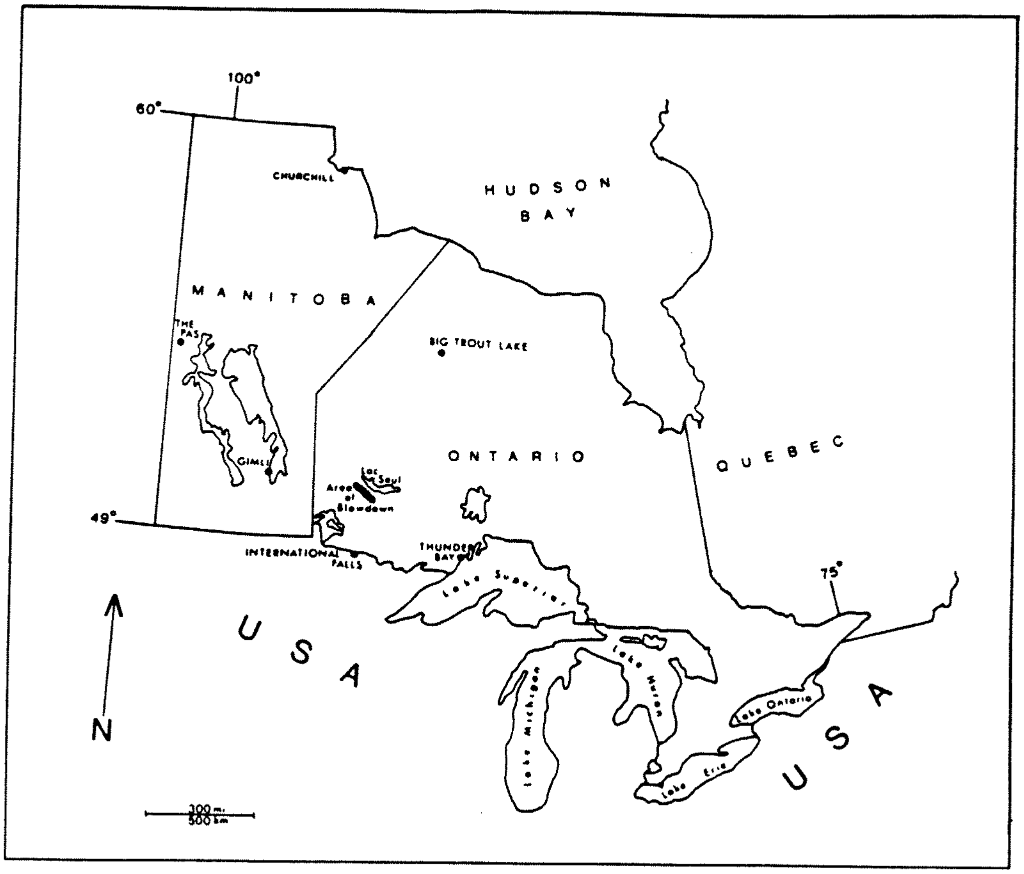

FIG 1. Ontario Ministry of Natural Resources Districts of northwestern Ontario where the blowdown occurred.

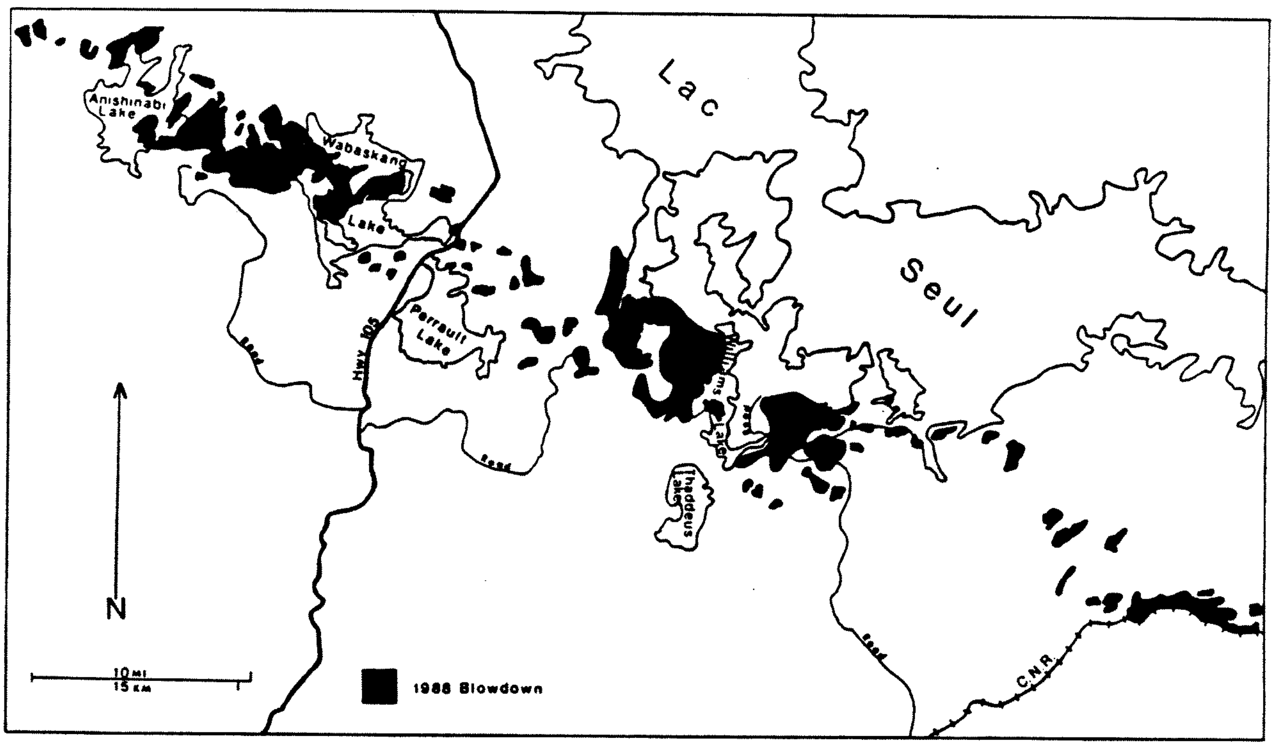

FIG 2. Areas of blowdown over northwest Ontario.

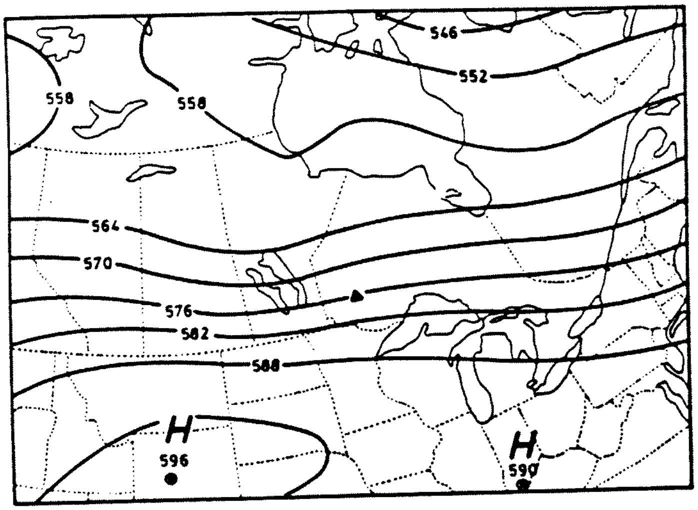

FIG. 3. The 500 hPa analysis at 1800 CDT June 24, 1988. Contour heights are in decameters drawn at intervals of 60 m. The general area of blowdown is indicated by the '▲'.

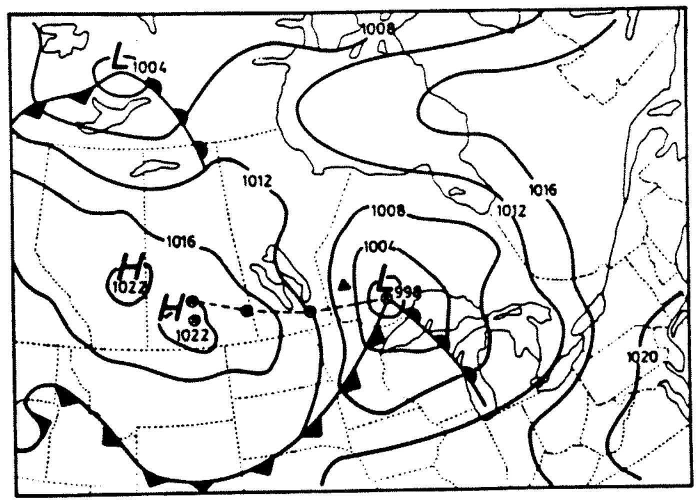

FIG. 5. Surface pressure analysis at 0000 CDT June 25, 1988.

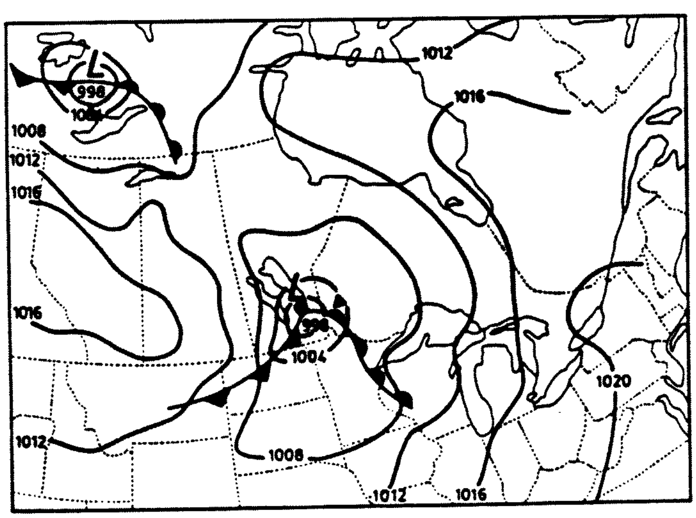

FIG. 4. Surface pressure analysis at 1800 CDT June 24, 1988. Isobars are drawn at intervals of 4 hPa.

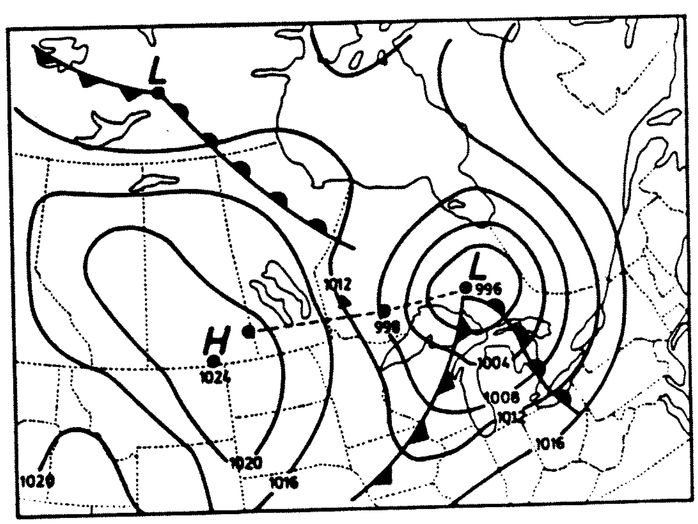

FIG. 6. Surface pressure analysis at 0600 CDT June 25, 1988.

The first mechanism is well known; the second is somewhat obscure. Strong winds are associated with severe thunderstorms and tornadoes. These winds can result in blowdown of forested areas. Strong surface winds associated with the upper level jet stream have been documented. Flannigan and Harrington (1987) found that a coupling of the surface wind with a jet stream aloft through the action of strong thermal convection generated strong surface winds. Stocks and Flannigan (1987) found that strong surface winds that resulted in a major run of an Ontario wildfire (Red Lake #7/86) were associated with an upper level jet stream overhead. Figure 7 shows the vertical wind profile and hodograph* for the radiosonde at International Falls at 0600 CDT June 25, 1988. The strongest winds passed to the north of International Falls some 3 to 6 hours prior to the ascent at 0600 CDT. However, from this figure we see strong winds extending from the jet stream down to within a few thousand metres of the surface. Note also that the wind direction at all levels is nearly the same -- northwesterly.

Strong surface winds were responsible for forest damage along a 160 km corridor. Large scale forest change like this blowdown event can be effectively monitored using satellite imagery which is the subject of the next section.

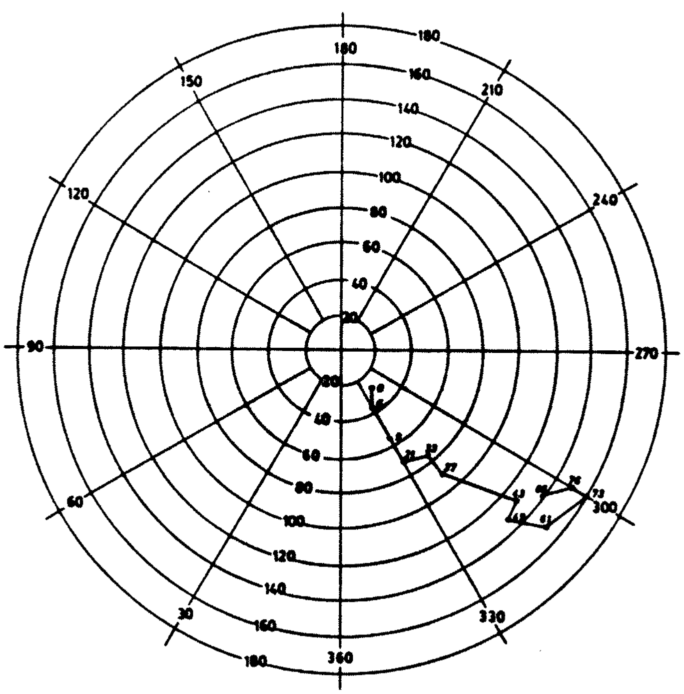

FIG. 7. Vertical wind profile and hodograph for International Falls, Minnesota for 0600 CDT June 25, 1988. Wind speed is indicated by the concentric circles in km/h. Wind direction is in degrees. The height is indicated in hundreds of meters by the number beside each data point.

Mapping Methodology

The intent in mapping the blowdown area was to demonstrate a reliable methodology for mapping large scale forest change, as well as providing fire managers with a comprehensive product that could provide some information on the extent of the 1988 blowdown. Banner and Lynham (1981) reported on an effective method for mapping forest depletion resulting from forest cutovers using two Landsat Multi-Spectral Scanner (MSS) images of the same area. Images were taken before and after the occurrence of forest cutovers. By combining band 5** (0.6 to 0.7 um) data from both images they were able to produce a colour composite that depicted the areas of change as red. A similar procedure was chosen to map areas of the 1988 blowdown in northwestern Ontario.

Landsat MSS data from June 11, 1984 was selected to represent the forest area before the blowdown event on June 24, 1988. For post-blowdown imagery, Landsat MSS data for June 30, 1988 was available. Both images were geometrically corrected on an Aries II image analysis system (at the Ontario Centre for Remote Sensing, Toronto, Ontario) to be compatible with National Topographic System (NTS) maps. A colour composite was created on a colour monitor by taking band 5 data from June 11 and assigning it to both the blue and green guns of the monitor, while the band 5 data from June 30 was added to the picture using the red gun. With band 5 Landsat data, bare ground appears much brighter than the surrounding forest. Because only the post-blowdown image had bright patches due to the blowdown, the patches showed red in the colour composite. The rest of the surrounding forest appeared in gray tones.

Although this technique causes area of blowdown to appear red on a colour composite, any other areas of change (e.g., cutovers or roads) also appear red. The areas of blowdown were identified on the basis that the reflectance from them was unique (i.e., they had lower reflectance values than the cutovers or roads), resulting in a darker red than for other types of forest change. Verification of blowdown areas was achieved by using the aerial reconnaissance mapping completed by the Forest Insect and Disease Survey, Forestry Canada, Ontario Region (House and Applejohn 1988; see figure 1). In addition, sketch maps and video tape, produced by the authors (taken in July 1988) and the Ontario Ministry of Natural Resources, were used to confirm the mapped areas of blowdown.

Discussion

The analysis of information leads us to believe that the blowdown was the result of strong winds from the lower extremity of an upper level jet stream being

*A Hodograph is a graph of wind speed and direction as a function of height.

**Lansat Band 5 closely resembles black and white panchromatic film.

mixed down to the surface. Severe thunderstorms werepresent near the vicinity of the wave but the pattern of the blowdown trees is not typical of a thunderstorm event. That is, the trees blown down were all pointing along the same axis, northwest to southeast, except one small region near Hudson. The path of damage was also oriented in a northwest-southeast orientation. Surface weather stations in Manitoba observed winds around 100 km/h along and behind the cold front, with no thunderstorm activity present. The authors flew over the blowdown area, and one section near Hudson had a pattern of toppled trees that may have been the result of a severe thunderstorm or a tornado. However, the topography in this region is rugged so the pattern of toppled trees could have been due to the interaction of strong winds with rough terrain. Unfortunately, we have not found any eye witnesses who can confirm the possibility that strong winds responsible for the blowdown were associated with thunderstorms. However, additional information including radar and lightning data is being gathered to verify our hypothesis.

Strong northwest surface winds were associated with strong winds aloft being mixed down to the surface. This mixing was achieved by the action of the cold front and by instability during and after passage of the cold front. Blowdown occurred in exposed areas on hills and ridges. Trees were uprooted as well as snapped. Webb (1988) shows that snapping and uprooting are a function of tree size and not tree species, with the larger trees being snapped.

These blowdown areas are of serious concern to fire managers. A similar blowdown event in 1973 was followed by a large wildfire in 1974. McRae (1980) reported pre-burn fuel loads for small and medium slash pieces (0-6.99 cm in diameter) of 2.5 to 4.4 kg/m² for jack pine and lowland black spruce sites that were logged conventionally[a] versus fuel loads of 3.0 kg/m² for balsam fir stands where the standing forest was tramped. The same report indicates pre-burn fuel loads for heavy slash fuels (7.0 cm in diameter or greater) of 5.6 to 7.3 kg/m² for jack pine and lowland black spruce sites that were logged conventionally versus fuel loads of 18 kg/m² for the tramped balsam fir stands. Blowdown areas will have similar fuel loads, in the fine and medium slash size classes, as sites that have been logged conventionally; however, blowdown areas will have much greater fuel loads in the heavy size classes than conventionally logged cutover sites.

Reducing fuel loads is a difficult task. Salvage operations would be difficult because of lack of access, obstructions from the downed timber, and snapped, cracked, or twisted boles. Prescribed fire would be hard to contain with such heavy fuel loads. The fuel continuity and the amount of fuel would intensify fire behaviour and impede conventional ground attack, possibly resulting in an uncontrollable wildfire. However, the Alberta Forest Service[aa] has successfully reduced fuel loads in blowdown areas by burning on days with lower indices of the Canadian Forest Fire Weather Index System (Canadian Forestry Service 1984, Van Wagner and Pickett 1985, Van Wagner 1987). By burning during lower indices the threat of an escaped fire is reduced.

The susceptibility of blowdown areas to fire ignition, as compared to the standing forest, is unknown. Lightning risk is random across northwestern Ontario. There is little expectation of human-caused ignition due to the lack of access to most of the blowdown. The exception is the area west of Hudson where the blowdown cut across a logging road.

Summary

Strong surface winds, associated with thunderstorms and the lower extremity of an upper level jet stream being mixed to surface, resulted in 21 000 ha of forest blowdown. Blowdown events are fairly common and constitute a significant portion of forest disturbance.

Blowdown areas are a concern to fire managers. Their large and complex fuel loads makes fires difficult to control. The potential for extreme fire behaviours exists given the high fuel loads and severe fire weather. Little can be done to alleviate the current situation from a fire control viewpoint. However, fire managers should be aware of the potential problems and should carefully monitor blowdown areas during the fire season.

Acknowledgements

The authors wish to thank Dennis Larmand and staff of the Ontario Ministry of Natural Resources, Northwestern Region for providing transportation and other assistance during field examination of the blowdown area.

Our appreciation is extended also to Dr. S. Pala, D. White, and staff of the Ontario Centre for Remote Sensing (Ministry of Natural Resources) for the use of the Centre's facilities and for their guidance during Landsat image analysis.

[a]In the process of conventional logging, trees are topped and delimbed where they are felled and the log is skidded to a roadside landing.

[aa]Personal communication, Terry Van Nest, Alberta Forest Service.

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