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Windthrown Trees on the Kings River Ranger District, Sierra National Forest: meteorological aspects

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Blowdown in shelterwood, sanitation cuts, and other partial cuts on the Kings River Ranger District, Sierra National Forest, are due to Mono winds. Both winter storm and Mono winds were considered as causes of winter blowdown. All evidence, e.g., direction of tree-fall and occurrence of high wind events, point to Mono wind events as the cause of blowdown. Only 12 percent of Mono wind events cause blowdown. Windspeed during a Mono wind (northeast winds) blowdown averages 50 mi/h with gusts to 100 mi/h. The probability of a blowdown occurring is about once per year, with some years having multiple blowdowns and other years having none.

Retrieval Terms: windthrow, silviculture, Mono winds, Kings River Ranger District, Sierra National Forest, California

During winters 1983–1984 and 1984–1985, substantial numbers of fir trees were either uprooted or snapped off by wind in shelterwood as well as sanitation and other partial cuts on the north and northeast sides of Patterson Mountain, in northern California. Specific dates of the blowdown are undetermined because a deep snowpack precluded winter access. As a result, dates and specific meteorological events resulting in the blowdown must be inferred.

Two possible meteorological events which produce strong winds were identified—winter cold front storms and Mono winds over central and southern Sierra Nevada. Winter cold front storms approach the Sierra Nevada from the west. These storms are accompanied by prefrontal southwest winds at ground level, then by west or northwest winds once the storm front has passed. A strong near-ground jet stream of southerly winds also accompanies these storms along the western face of the Sierra Nevada.[1] Mono winds, the second suspected meteorological cause, are northeast or east winds, which vary markedly in intensity, across the crest of the Sierra Nevada. Mono winds tend to be strongest on exposed ridges and peaks.

Wind penetration into dense forest canopies decreases rapidly from a clearing edge:

Distance from edge (m)	Outside windspeed (pct)
50	55-75
70	24-27
100	7
200	2

The density of the foliage in the canopy also alters the wind penetration from the top of the canopy. Windspeeds in a stand with little foliage may be twice that in stands with dense foliage.[2] The effects of wind in openings (e.g., clearcuts and rights-of-way) and where small groups of trees have been removed depend on the size of the opening. In large openings, strong winds readily reach the ground and exert strong forces on the windward side of the clearing. Also, considerable turbulence is generated by the opening (*fig. 1*). In addition, the wind direction is for the most part opposite that in the opening. A whirl forms between surrounding, protective old stands and causes frequent reversal of wind direction at ground level. The upper wind extends inward only partially. In contrast, a thinned stand allows greater wind penetration and is less able to generate turbulence than a dense forest, but is more prone to strong gusts reaching lower levels in the canopy.[3] Wind direction in a right-of-way or long narrow cut is relative to cut orientation (*fig. 2*). The wind whirl in a clearing formation (*fig. 1*) can also be observed in a cutting. In this case, the

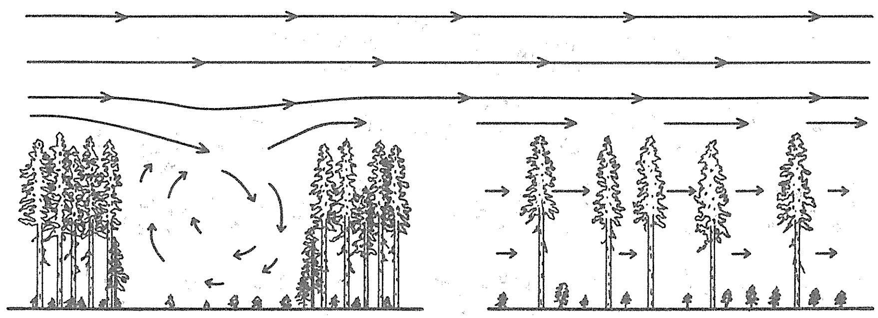

Figure 1—Wind movement in an opening and in a thinned strip. The windspeed under the thinned strip averaged 1½ times greater than in the opening.[3]

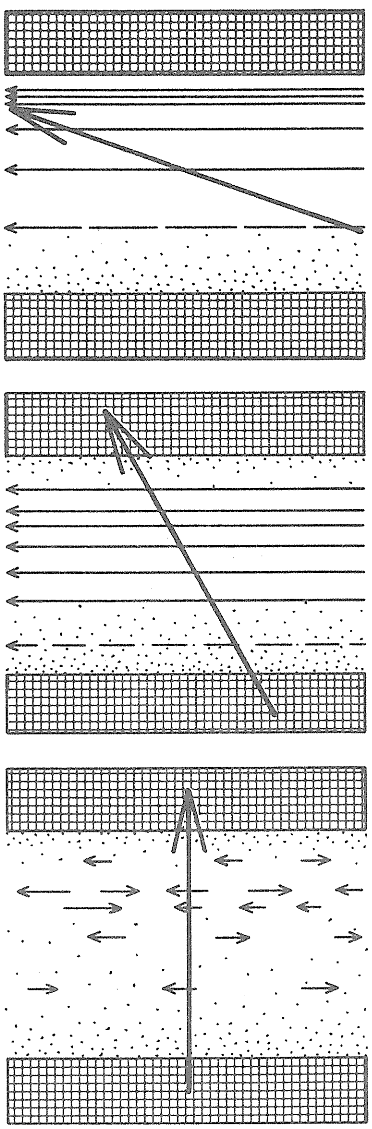

Figure 2—Wind motion in a forest cutting in relationship to the upper wind shows schematically the results of Geiger's measurements.[3] The stronger the winds, the closer the lines.

wind at ground level blows opposite to the general wind direction.

Windthrow is more directly related to wind fluctuations (turbulence) than to total windspeed. The standard deviation of windspeed is about one-half the total windspeed[2] for either winter storms or Mono winds. That is, wind fluctuating plus or minus one standard deviation about the mean windspeed shows a range of windspeeds equal to the mean windspeed. The time interval over which the fluctuation occurs is from a few seconds to a few tens of seconds. Chances of windthrow are increased if trees are shallow-rooted, not wind-hardened, in moist soil, and exposed to turbulence through thinning or openings in the stand. Pure stands are more sensitive than stands of mixed species.[4, 5]

The Beaufort wind scale[6] of force 10 (55 to 63 mi/h) is seldom experienced, but trees are uprooted. Using the Beaufort wind scale as an indicator of mean windspeed, and the variation about the mean,[2] gusts as high as 100 mi/h should be expected.

This research note reports a study of windthrown trees in the Sierra National Forest, in northern California, and the meteorological events which cause them. Winter cold front storms and Mono winds are identified and described as possible causes. The extent of windthrow is determined largely by windspeed and wind penetration in relation to forest density, aspects of hardiness, and species mix in a stand.

OBSERVED WINDTHROW PATTERNS ON PATTERSON MOUNTAIN

To determine the meteorological events during the blowdown periods of interest, indirect indicators of wind direction had to be used. Wind direction was assumed to be parallel to the direction of the fallen trees, with the wind blowing from the roots toward the crown. The tree-fall patterns on the north and northeast sides of Patterson Mountain were fairly uniform, indicating northerly winds in the shelterwood, sanitation cuts, and other partial cuts (*fig. 3*).

Tree-fall patterns were examined in uncut areas on both Patterson Mountain and the north side of McKinley Grove, the road opposite Patterson Mountain. Downed trees in uncut areas were far fewer and showed more variation in wind direction. Even so, most downed trees indicated a north-northeast wind direction. We also attempted to locate trees which had been downed for a long period of time. These old, downed trees (rotten logs) also showed the north-northeast wind pattern in both uncut and old cut areas, suggesting that north-northeast winds had produced blowdown over a long period. Such indirect data on wind direction patterns suggest that blowdown occurred during Mono winds rather than during winter storms.

DATING STRONG WIND OCCURRENCES

No direct evidence suggests dates of blowdown. As with wind patterns, I relied on indirect data. In this case, records from the Sierra Summit ski area were examined for dates on which the ski lifts were closed due to strong winds. These data supplemented accounts of strong wind occurrences by forestry personnel. This second method has drawbacks, since it is dependent on association, and therefore does not include all strong wind cases. A total of six strong wind occurrences between 1982 and 1985 were identified by these means. In all six cases, the macroscale weather pattern was that of a Mono wind situation.[7]

PROBABLE OCCURRENCE OF MONO WINDS

Though no statistics of occurrence have been compiled, it is known that Mono winds occur under the same macroscale weather conditions as Santa Ana winds in

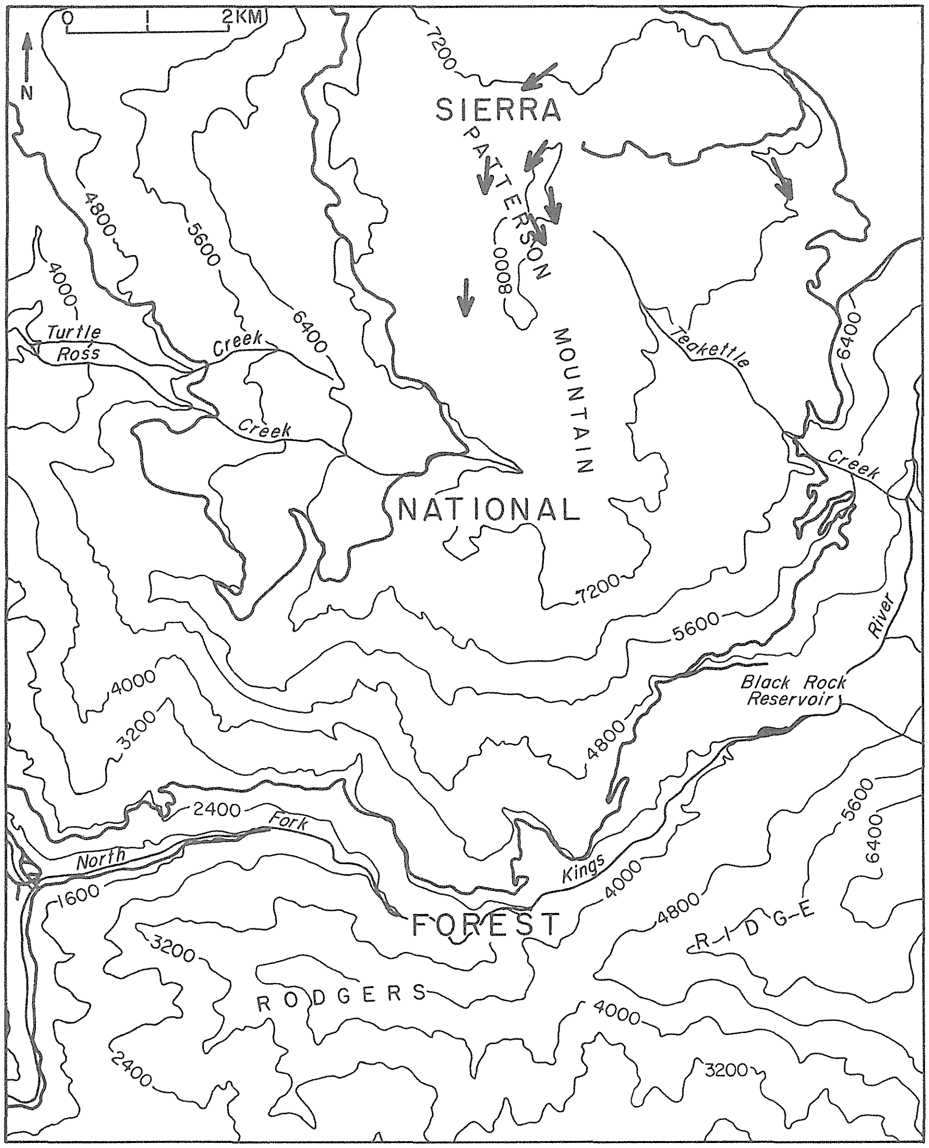

Figure 3—Predominant root-to-crown direction of fallen trees on the Sierra National Forest in California. Arrows indicate wind direction during blowdown.

southern California. Owing to their significance in fire management, Santa Anas are well documented.[8] The occurrence of Santa Anas over a 10-year period (1951–1960) were aggregated by month:

Month	Frequency (10 years)
January	7
February	10
March	17
April	8
May	7
June	4
July	2
August	0
September	11
October	19
November	26
December	18

These data for Santa Ana winds may be extrapolated to Mono winds based on the corresponding macroscale weather conditions for both wind types. Estimates of severity of either Mono winds or Santa Anas are not available. An undoubtedly low estimate can be made from the six cases of severe Mono winds between 1982 and 1985 compared against the Santa Ana data. These limited data suggest that about 12 percent of the Mono wind cases would have strong winds associated with them. Strong winds are not precisely defined here because of the range of conditions which can influence blowdown, such as moist soils, stand density, and root depth. A strong wind might be estimated at 100 mi/h, and predicted average wind might be 50 mi/h. These statistics are based on approximately one event per year, though in fact, several events occur in a single year and no events occur in other years.

IMPLICATIONS

Central and southern Sierra Nevada plays host to the Mono winds. In southern California, these winds are known as the Santa Anas. In Oregon, Washington, and northern California, they are known as east winds. These are geographically distinct names for the same phenomenon pervasive throughout the west coast major mountain ranges of the Sierra Nevada and Cascades. However, the statistics of occurrence vary. For Mono winds, areas prone to high wind include high elevation ridges and peaks and, to a lesser extent, canyon mouths. Finally, the effects of Mono winds should be considered in cutting practices, with specific regard to wind penetration, cut orientation, and wind direction most likely to cause blowdown.

END NOTES AND REFERENCES

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