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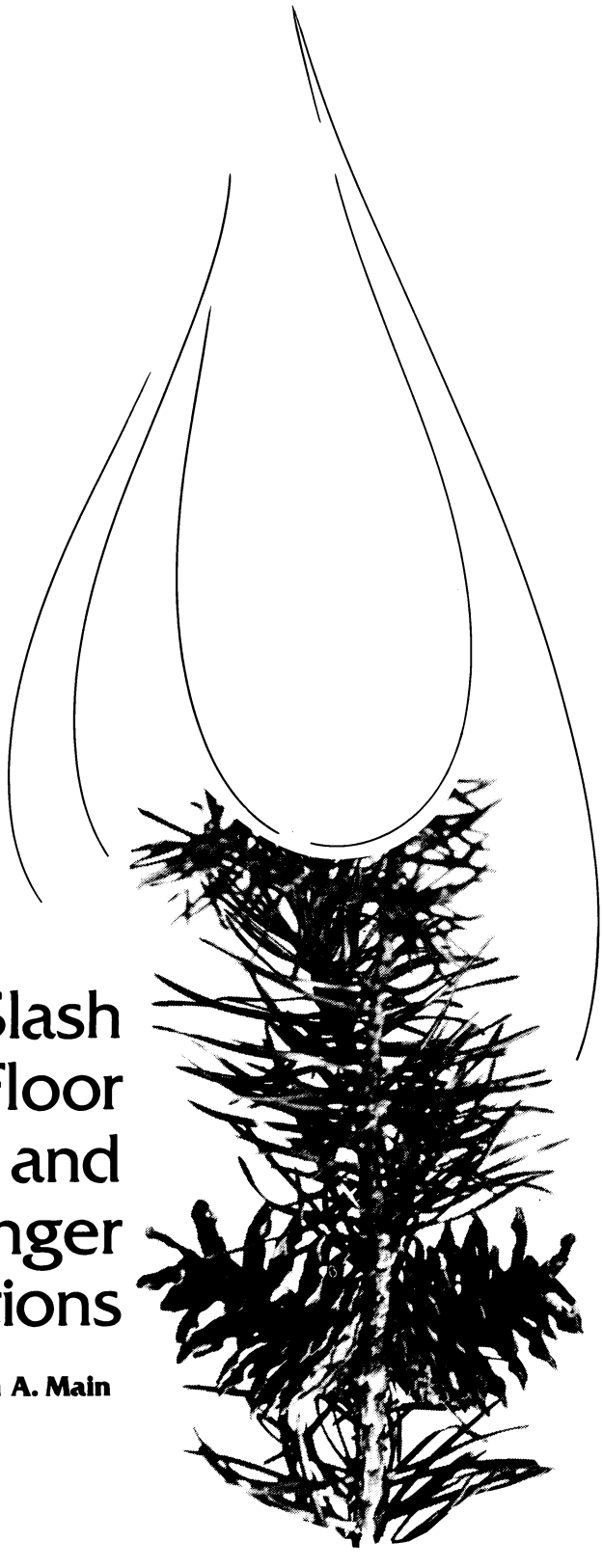

Comparing Jack Pine Slash and Forest Floor Moisture Contents and National Fire Danger Rating System Predictions

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Relations between certain slash and forest floor moisture contents and the applicable estimated timelag fuel moistures of the National Fire Danger Rating System were investigated for 1-year-old jack pine fuel types in notheastern Minnesota and central Lower Michigan. Only approximate estimates of actual fuel moisture are possible for the relations determined, thus emphasizing the need for on-site measurements when fuel moisture may be critical.

KEY WORDS: Forest fuels, fire hazard.

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COMPARING JACK PINE SLASH AND FOREST FLOOR MOISTURE CONTENTS AND NATIONAL FIRE DANGER RATING SYSTEM PREDICTIONS

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Thousands of acres of jack pine are clear-cut in the Lake States each year (fig. 1). Prescribed fire to reduce fuel amounts and prepare the site for planting or seeding frequently follows this cutting. The land manager must select the time when fuel and weather conditions will produce a fire that will accomplish the desired results and assist in planning burning operations (Deeming *et al.* 1977). The National Fire Danger Rating System (NFDRS) estimates and interprets fuel moisture, a critical variable in fire behavior. Information is limited as to the actual fuel moisture content of natural fuels in relation to NFDRS moisture content estimates. Our study reports the moisture content of specific fuels found on 1-year-old jack pine clear-cut areas in relation to NFDRS 1-hour, 10-hour, and 100-hour timelag fuel moisture content estimates.[1]

RESULTS

We found only a general relation (significant, but with much variation) between the moisture content of certain naturally occurring fuels on 1-year-old jack pine slash areas and NFDRS fuel moisture estimates. Statistically significant but low correlation exists between actual and NFDRS-estimated moisture content for Fines and 1-hour timelag fuels (fig. 2); between L-layer and 1-hour timelag fuels (fig. 3); and between F-layer and 100-hour timelag fuels (fig. 4).[2] The actual moisture content of Fines and of L-layer almost always exceeded the estimated 1-hour timelag fuel moisture. We examined each of these relations using the paired t-test. In all cases, the null hypothesis was rejected—the mean of the population differences was not zero.

THE STUDY

Two study areas were selected on the Superior National Forest in Minnesota. The previous summer, 55 cords per acre of jack pine pulpwood had been harvested by clear-cutting. The soils were well-drained loamy sands. We selected a third study area on State land near Roscommon, Michigan, where clear-cutting had removed about 15 cords per acre of jack pine pulpwood the winter preceding the summer study. This site had well-drained sandy soil.

[1]*This study was designed by Rodney Sando (formerly with the North Central Forest Experiment Station) who was responsible for data collected in Minnesota.*

[2]*Fines consist of jack pine slash needles and twigs less than ¼ inch in diameter aerially exposed at one foot or more above ground; L-layer consists of forest floor loose surface needles, leaves, grass, twigs, etc.; F-layer consists of the forest floor layer beneath the L-layer—the compacted decomposing organic materials still identifiable as to source.*

Figure 1.—*Thousands of acres of jack pine are clear-cut in the Lake States each year.*

Actual fuel moistures were measured for Fines, for forest floor L-layer and for forest floor F-layer from fuel sample collections taken: June 9 through September 9, 1968, in Lake County, Minnesota; and June 13 through September 3, 1969, in St. Louis County, Minnesota; and June 12 through September 17, 1975, in Roscommon County, Michigan.

On-site weather instruments and records were maintained to provide data to compute NFDRS fuel moisture values. Samples were collected daily except on weekends or when fuels were wet from rainfall at collection time. We had no 10-hour timelag fuel moisture sticks so this value for the NFDRS was computed.

In Minnesota a steel sampling cutter was used to remove 2-inch diameter circular samples of forest floor materials, and in Michigan a 5-inch diameter sampling cylinder was used. Five samples of slash and 10 samples each of the forest floor layers were collected daily, 15 samples of the F-layer were collected beginning the second summer because of the variability found the first year. We determined moisture content by oven drying the samples at 105°C for about 24 hours. The observations and measurements were made during early or mid-afternoon to relate closely with time of basic fire weather observations.

Covariance analysis indicated 1968 and 1969 data should not be combined for regressions. Data for these two years (locations) came from apparently similar areas in Minnesota. Because of differences in moisture response—moisture estimate relations, a similar data set was obtained in Michigan in 1975 and each year (location) was considered separately.

DISCUSSION

The NFDRS fuel classes relate directly to dead, round wood. They relate only "roughly" to portions of the forest floor. The aerially exposed slash studied is a 1-hour timelag fuel while forest floor fuel components are not clearly defined in terms of timelag (Deeming *et al.* 1977). Sticks (½-inch pine dowels) are an excellent source of 10-hour timelag fuel moisture estimates and contributed to the 1-hour timelag fuel moisture estimate in the 1978 system. These fuel moisture sticks integrate effects of the meteorological environment including day length and cloudiness. Stick weight measurements were not available so 1-hour and 10-hour timelag fuel moistures were computed. Without stick moisture measurements, the system has an adjustment for 1-hour timelag moisture estimates based on state of weather. Temperature and relative humidity adjustments of shelter observations (4.5 feet above ground) are made to better estimate the temperature of fuels on the ground and the relative humidity at their level before computing an equilibrium moisture content.

Because 1-hour and 10-hour timelag fuel moistures are "multiples" of each other when stick moisture contents are not available, we considered only the 1-hour estimates related to the actual moisture content of Fines and the L-layer actual. However, the 10-hour timelag fuel moisture also could have been used. The L-layer probably has between a 1-hour and 10-hour timelag response. Fosberg (1971) reported the NFDRS 100-hour timelag fuel moisture estimates are inapplicable for duff and litter. This study found significant, but low correlation between the 100-hour estimates and the F-layer moisture contents. The F-layer response had slightly higher correlation with the 100-hour than with the 10-hour timelag fuel moisture estimates.

This study did not determine a timelag response value for the fuel components, but does show their relation to NFDRS timelag fuel moisture values.

The moisture content of the Fines and L-layer was almost always equal to or greater than the estimated NFDRS 1-hour timelag fuel moisture. The regression lines are distinctly above the 1-hour timelag estimates.

Similar discrepancies have been reported by others. Hough and Albini (1978) found NFDRS

(Deeming *et al.* 1972) estimates of 1-hour and 10-hour timelag fuel moisture inadequate to estimate dead fuel moisture for their palmetto-gallberry fuel model. Actual moisture content of field plot L-layer ranged from 9 to 33 percent while 1-hour estimates ranged from 5 to 11 percent and 10-hour estimates ranged from 6 to 14 percent.

The NFDRS 1-hour timelag fuel moisture predictions are unlikely to be exactly the same as those found for various naturally occurring 1-hour timelag fuels. NFDRS predictions are based on equilibrium moisture content for wood while the fuels we observed included needles, leaves, bark, and grasses in addition to wood. Investigators have shown equilibrium moisture content for such other materials to be slightly higher than for wood (Dunlap 1932, Blackmarr 1971, VanWagner 1972, Anderson *et al.* 1978).

Some interacting variables influencing moisture content are not directly considered in the national system. Forest floor and surface soil temperature and moisture gradients; fuel amounts, composition and potential equilibrium moisture contents; wind speed, aspect, slope, stability, and the radiation absorption and emission characteristics of the fuels and surrounding environment contribute to NFDRS fuel moisture value variation.

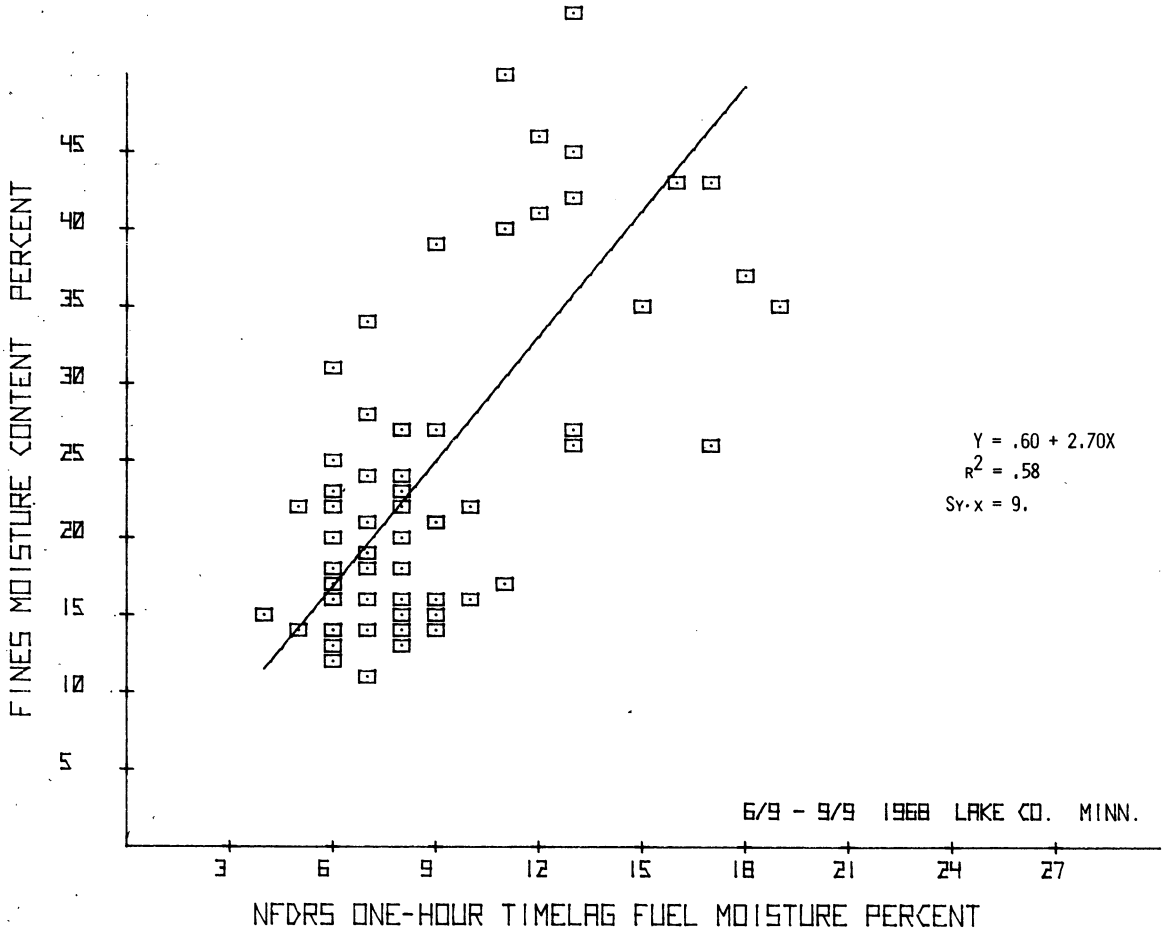
A clear division between L-layer and F-layer, and between F-layer and H-layer usually does not exist. In addition, forest floor and upper soil moisture is influenced by vegetative roots contributing to a transpirational drain. Because the Fines were the most uniform and uniformly exposed materials, they had the smallest standard errors of estimates.

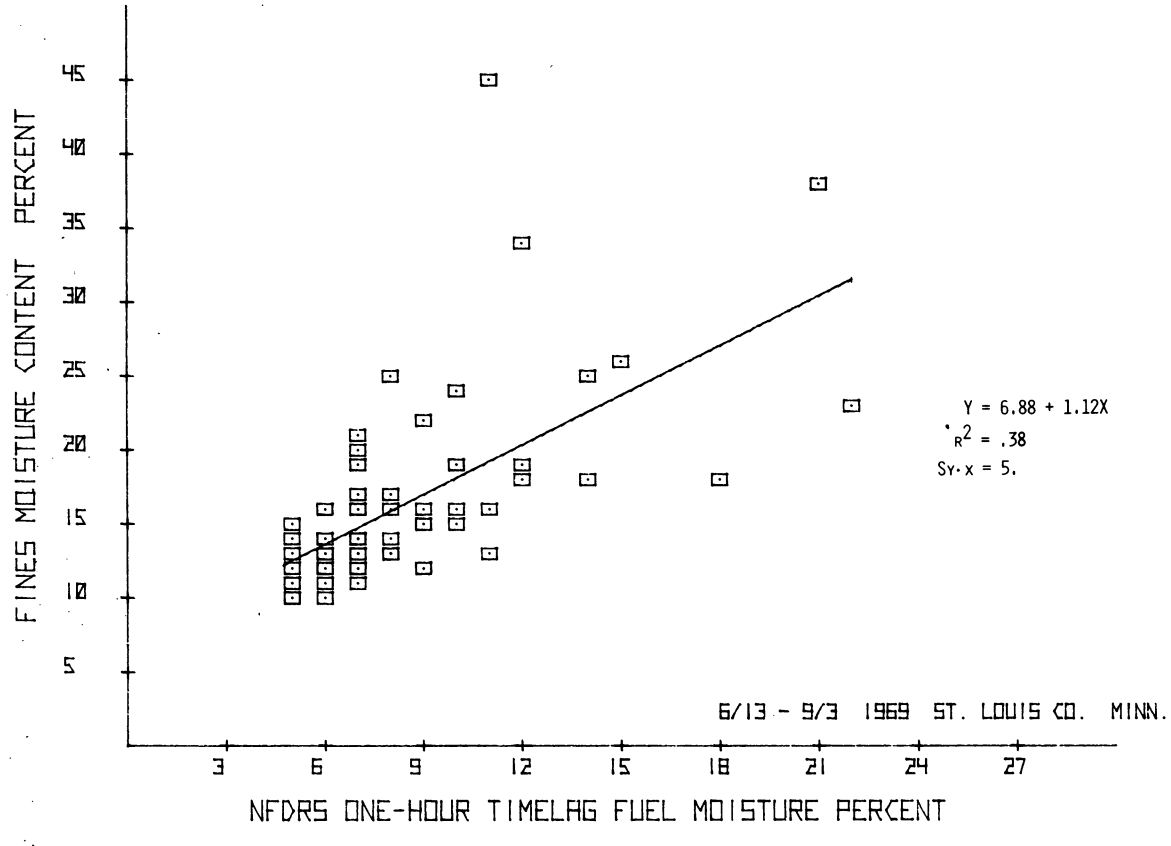
A question arises as to whether the low correlations result from natural variability or a poor relation between forest floor moisture content and NFDRS predictions. To check the data, we compared it to the Canadian Fire Weather Index (FWI) which VanWagner (1975) reports is related to forest floor moisture content. This independent comparison resulted in an r^2 (coefficient of determination) of 0.71 when the FWI Fine Fuel Moisture Code was regressed against L-layer moisture content.

These results indicate that natural variability of the data was not the underlying cause of low correlations.

SUMMARY

This study emphasized the range and variability in moisture response for various slash and forest floor fuels associated with 1-year-old jack pine slash areas in Minnesota and Michigan when the moisture values were related to NFDRS fuel moisture estimates. Our results indicate the National Fire Danger Rating System, which rates fire danger for the worst possible conditions—on south or southwesterly aspects, based on aerially exposed woody material (Deeming *et al.* 1977)—does not work well for litter and duff on the forest floor. Only approximate estimates can be made for the moisture content of Fines, L-layer, and F-layer using NFDRS estimates of the moisture content of 1-hour and 100-hour timelag fuels. These results emphasize the value of on-site fuel moisture measurements when fuel moisture content may be critical.


FINES MOISTURE CONTENT PERCENT
45
40
35
30
25
20
15
10
5
Y = .60 + 2.70X
R2 = .58
Sy·x = 9.
6/9 - 9/9 1968 LAKE CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE-HOUR TIMELAG FUEL MOISTURE PERCENT


FINES MOISTURE CONTENT PERCENT
45
40
35
30
25
20
15
10
5
Y = 6.88 + 1.12X
R2 = .38
Sy·x = 5.
6/13 - 9/3 1969 ST. LOUIS CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE-HOUR TIMELAG FUEL MOISTURE PERCENT

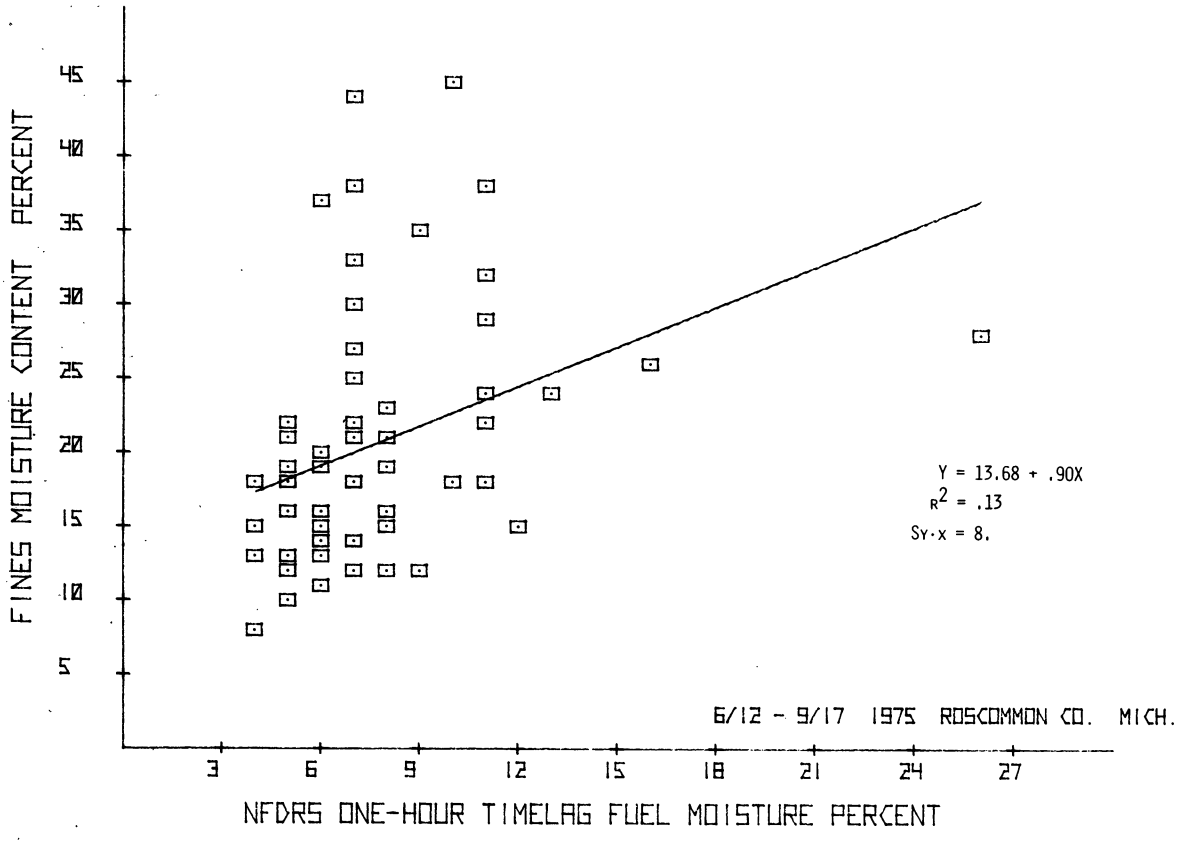
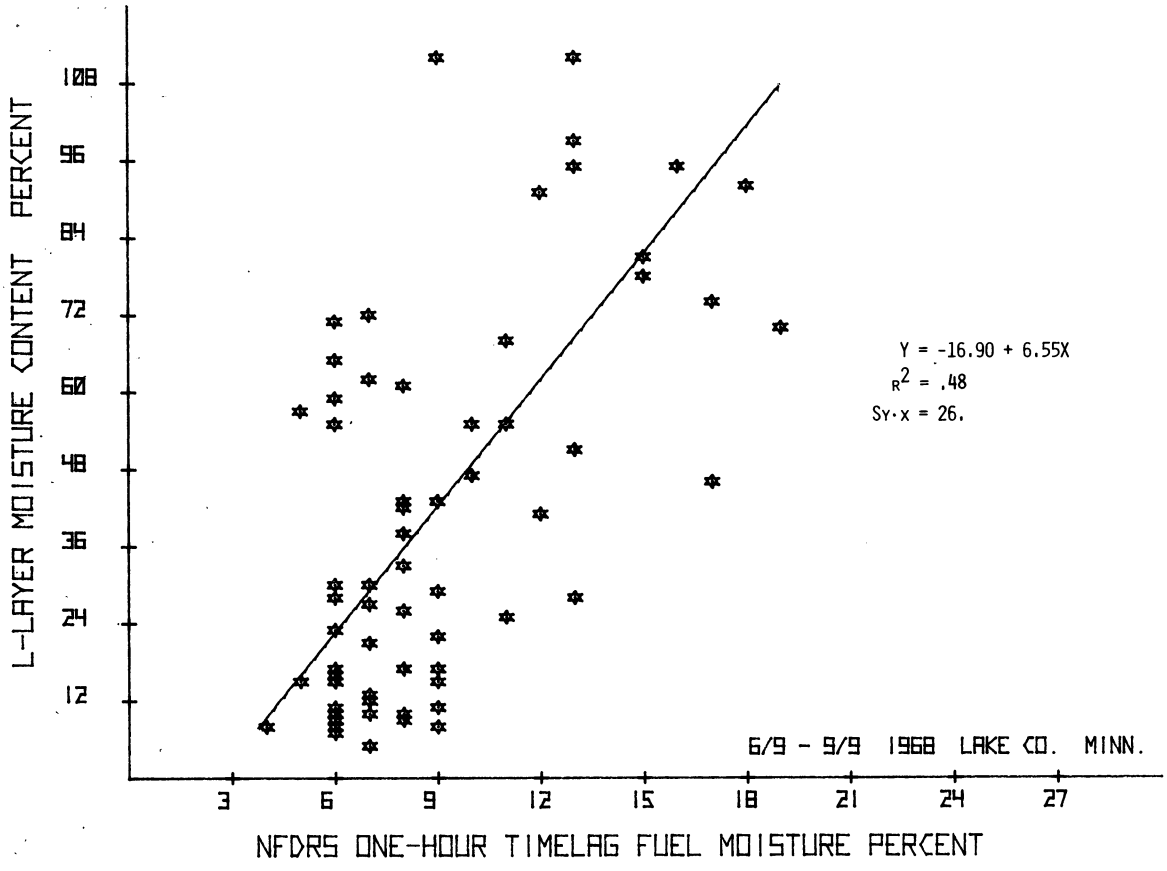
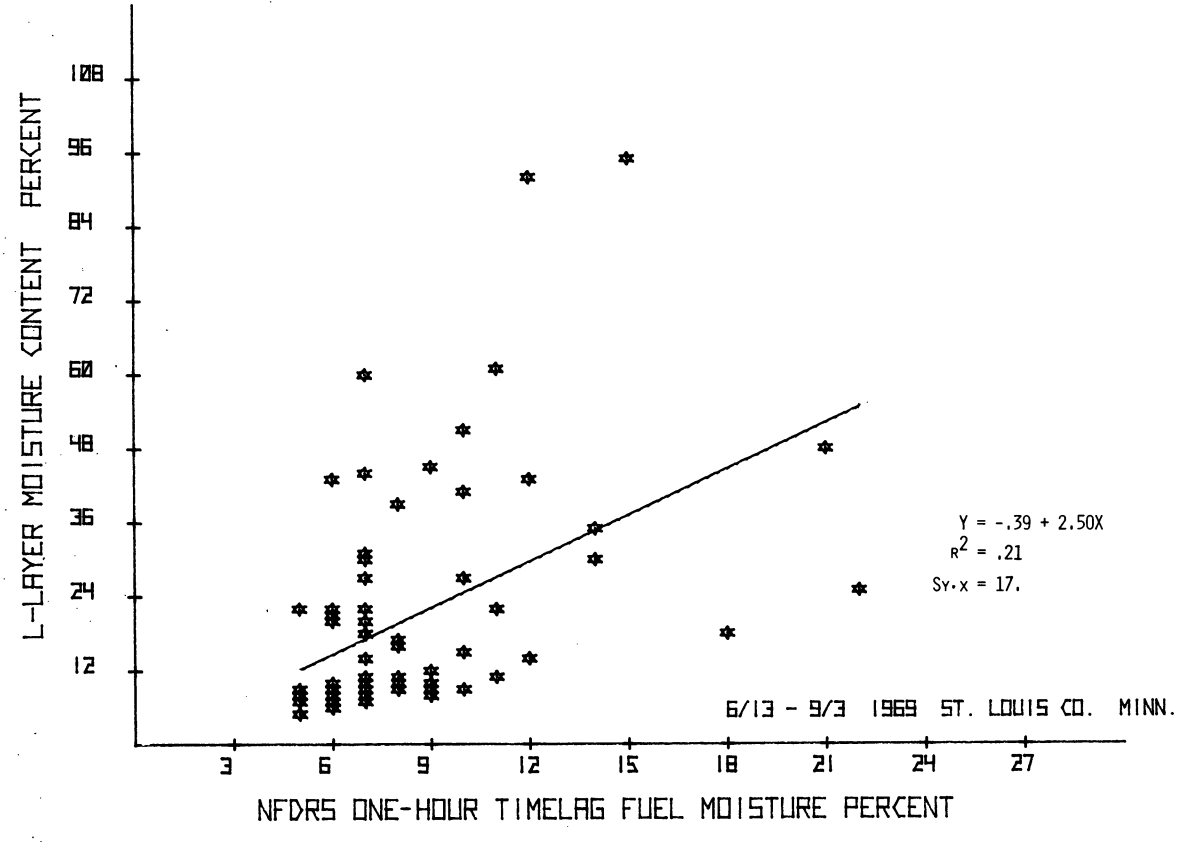


Figure 2.—*Aerially exposed (1 foot or more above ground) slash needles and twigs (equal to or less than ¼ inch in diameter), (Fines) moisture content—National Fire Danger Rating System (NFDRS) 1-hour timelag fuel moisture relations from 1-year-old jack pine slash area.*


L-LAYER MOISTURE CONTENT PERCENT
108
96
84
72
60
48
36
24
12
Y = -16.90 + 6.55X
R2 = .48
Sy·x = 26.
6/9 - 9/9 1968 LAKE CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE-HOUR TIMELAG FUEL MOISTURE PERCENT


L-LAYER MOISTURE CONTENT PERCENT
108
96
84
72
60
48
36
24
12
Y = -.39 + 2.50X
R2 = .21
Sy·x = 17.
6/13 - 9/3 1969 ST. LOUIS CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE-HOUR TIMELAG FUEL MOISTURE PERCENT

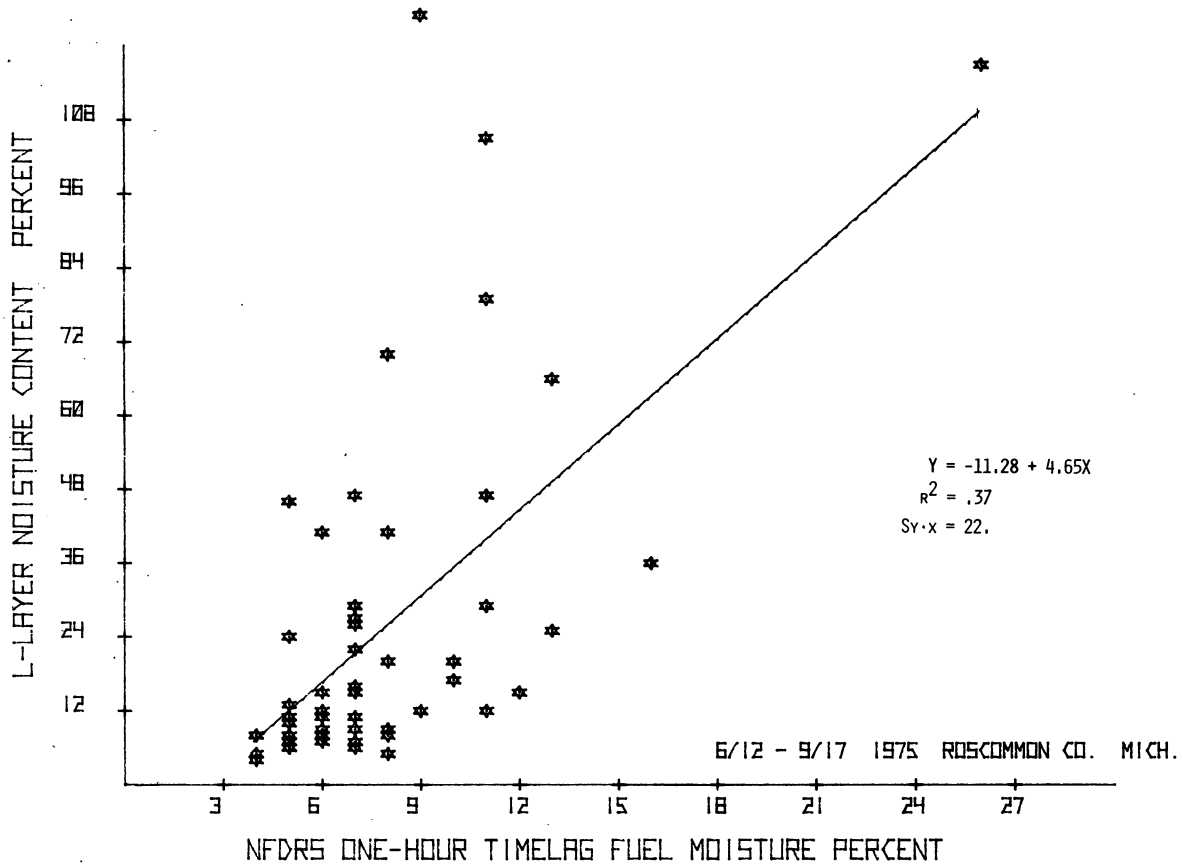
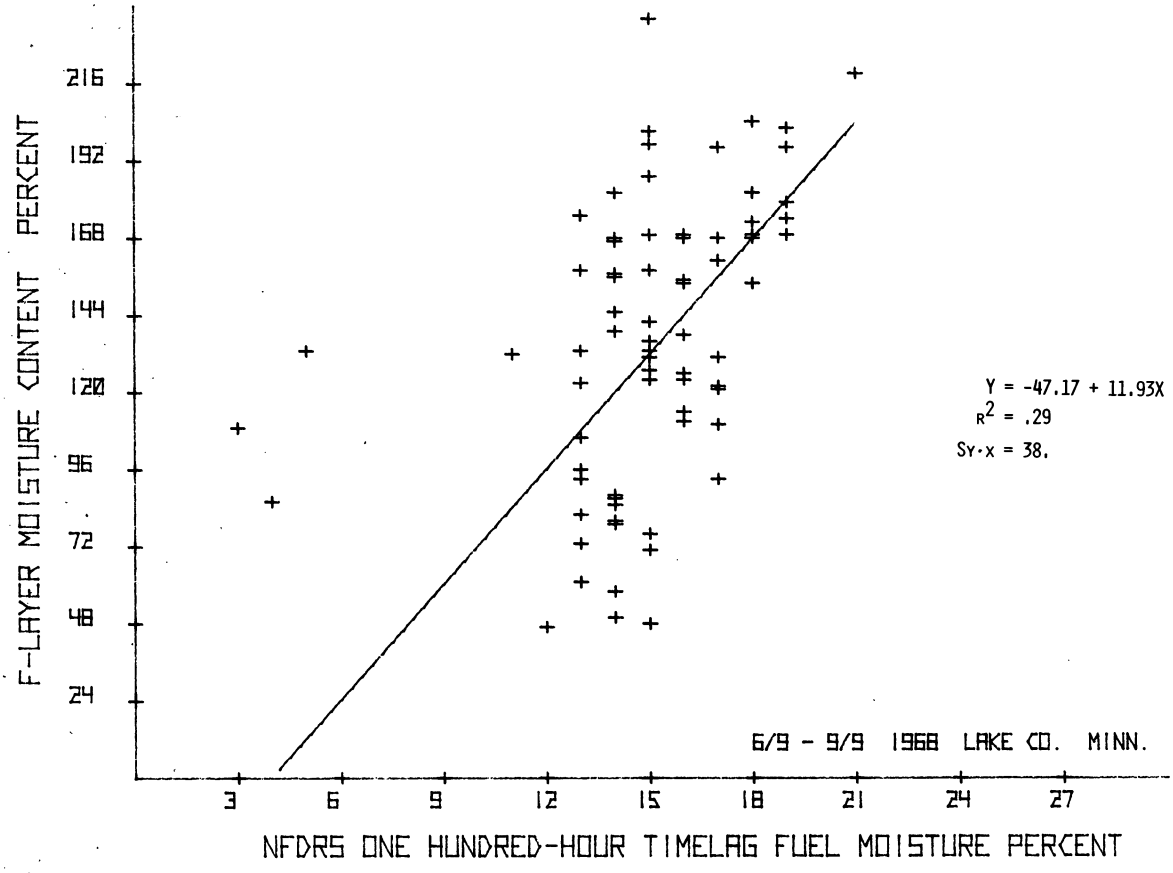
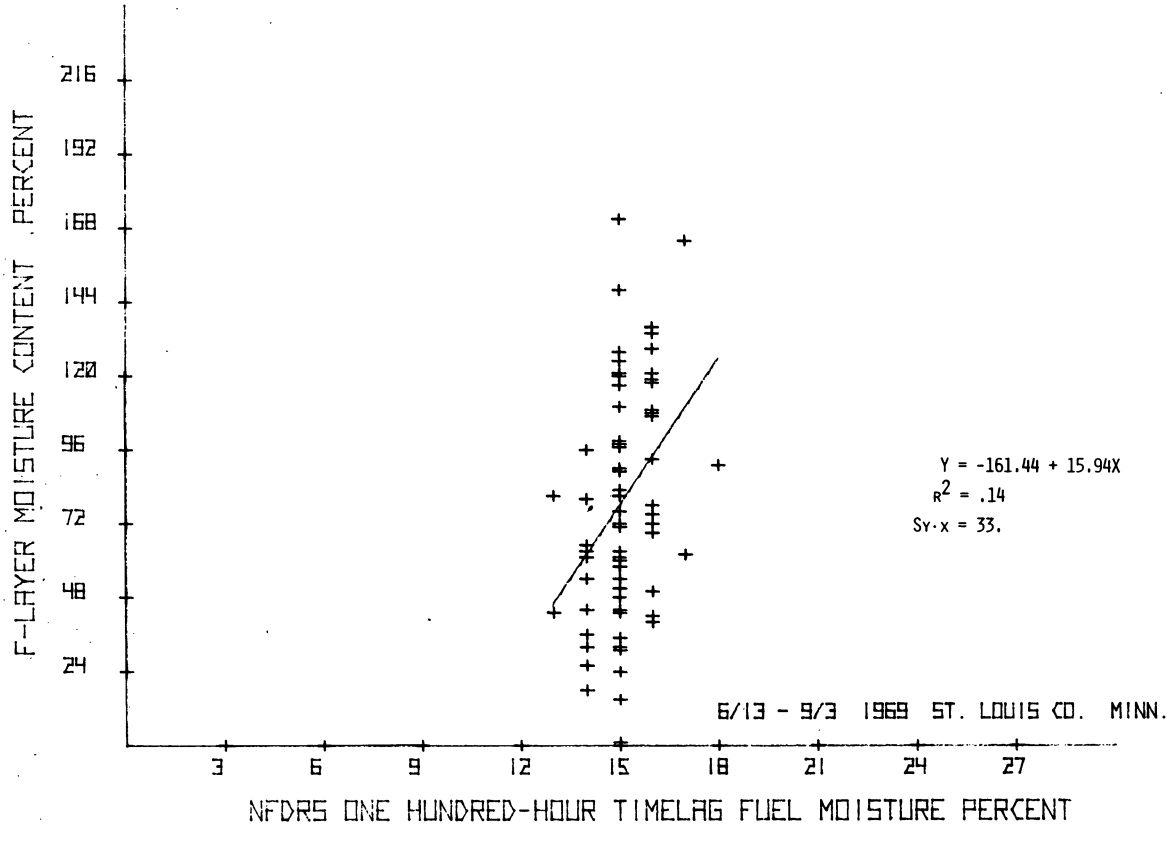


Figure 3.—*Forest floor L-layer moisture content— National Fire Danger Rating System (NFDRS) 1-hour timelag fuel moisture relations for 1-year-old jack pine slash area.*


F-LAYER MOISTURE CONTENT PERCENT
216
192
168
144
120
96
72
48
24
Y = -47.17 + 11.93X
R2 = .29
Sy·x = 38.
6/9 - 9/9 1968 LAKE CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE HUNDRED-HOUR TIMELAG FUEL MOISTURE PERCENT


F-LAYER MOISTURE CONTENT PERCENT
216
192
168
144
120
96
72
48
24
Y = -161.44 + 15.94X
R2 = .14
Sy·x = 33.
6/13 - 9/3 1969 ST. LOUIS CO. MINN.
3
6
9
12
15
18
21
24
27
NFDRS ONE HUNDRED-HOUR TIMELAG FUEL MOISTURE PERCENT

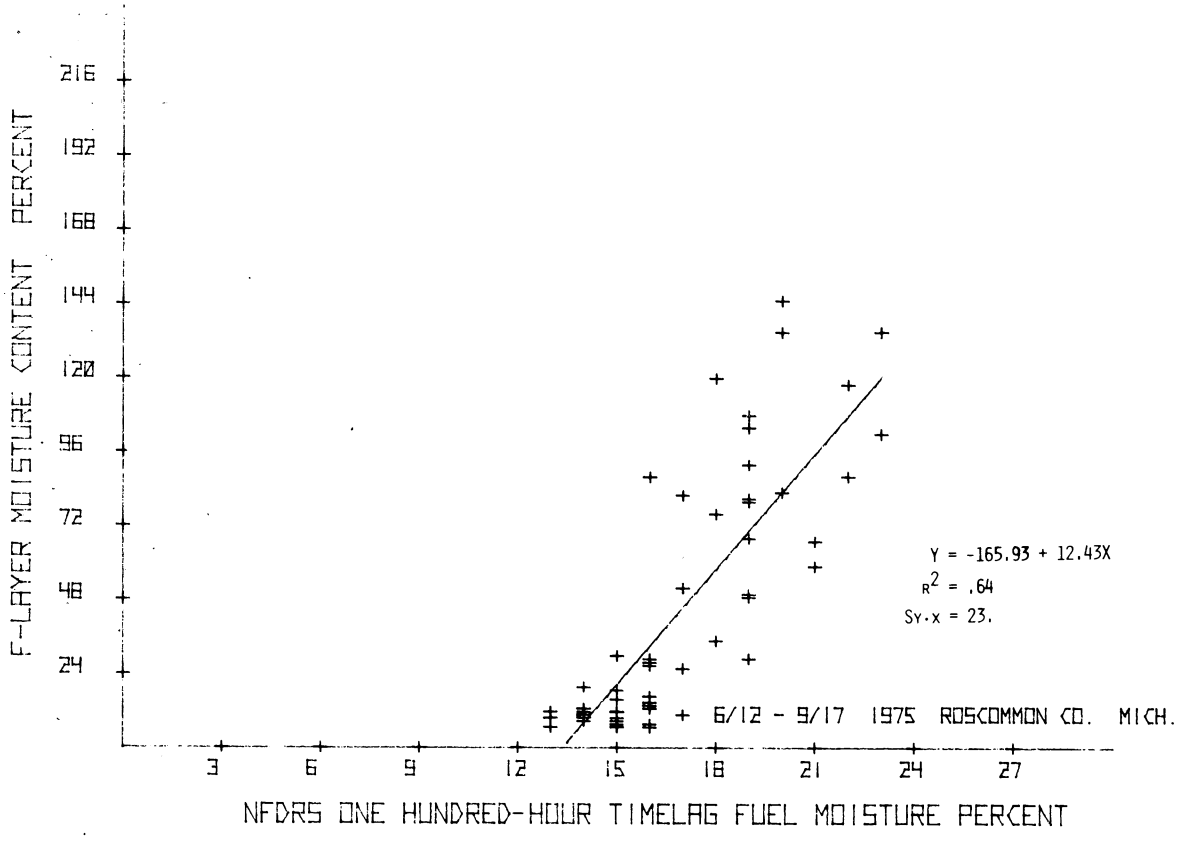


Figure 4.—*Forest floor F-layer moisture content— National Fire Danger Rating System (NFDRS) 100-hour timelag fuel moisture relations for 1-year-old jack pine slash area.*

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