NORTH CENTRAL FOREST EXPERIMENT STATION

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SEASONAL VARIATIONS IN ASH CONTENT OF SOME MICHIGAN FOREST FLOOR FUELS

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ABSTRACT.—Samples from the forest floor litter layer were collected seasonally from under medium to fully stocked large sapling to sawtimber stands in Lower Michigan to study seasonal ash content changes. The total ash and silica-free ash content of tree foliage in the upper part of the litter layer differed little from season to season. Differences in ash content due to species were generally more important than those due to season. The total ash content of an entire northern hardwood-oak-hickory forest litter layer increased significantly (0.01 level) through the year; however, silica-free ash content did not. Bracken fern did not change significantly in either total ash or silica-free ash content.

KEY WORDS: Fuel modeling, fuel characteristics.

The National Fire-Danger Rating System (Deeming *et al.* 1977) and Albini (1976) fire behavior models are used by fire managers to predict fire behavior. These systems utilize the Rothermel (1972) fire behavior model, which includes total ash and the silica-free ash content of fuel as variables. The ash (or noncombustible) constituents of organic material are of concern to the fire manager because they usually reduce the combustion rate. Not all of them are equally effective, however. And one of them, silica, is completely inert in the combustion process—hence the special interest in silica-free ash.

Forest floor litter (L-layer)[1] is a primary fuel of wildland fires in many ecosystems, so its silica-free and total ash content are needed in using the above systems to predict fire behavior. Further, it is important for the fire manager to know whether ash content of litter varies from season to season. Therefore, we conducted a study of the seasonal influence on ash content for certain forest floor fuels in Lower Michigan.

METHODS

The study was done in Ingham, Roscommon, and Wexford Counties. From the forest floor litter layer we collected leaves of 10 tree species: white oak *(Quercus alba* L.*)*, northern red oak *(Quercus rubra* L.*)*, northern pin oak *(Quercus ellipsoidalis* Hill*)*, American beech *(Fagus grandifolia* Ehrh.*)*, largetoothed aspen *(Populus grandidentata* Michx.*)*, sugar maple *(Acer saccharum* Marsh.*)*, shagbark hickory *(Carya ovata* (Mill.) K. Koch*)*, red pine *(Pinus resinosa* Ait.*)*, white pine *(Pinus strobus* L.*)*, and jack pine *(Pinus banksiana* Lamb.*)*. In addition, bracken fern *(Pteridium aquilina)* and the entire litter layer under a mixed northern hardwood-oak-hickory stand were sampled.

[1]*The litter, or L-layer, is the uppermost layer of the forest floor and consists of loose, dead needles, leaves, grass, twigs, etc.*

Samples were collected five times between June 1973 and July 1974: in the early summer (June-July), late summer (August-September), fall (October-November), spring (April), and again in early summer (June-July). (Late summer samples were not collected for all species.) Most of the materials collected were less than 1 year old and were at the top of the litter layer.

Each sample consisted of about 10 grams of material; 3 to 10 samples were collected per species at each location. Samples were obtained under medium to fully stocked large sapling to sawtimber stands.

Samples were oven dried for 72 hours at 70°C and then ground in a Wiley Mill to pass a 20-mesh screen. Ash content was determined according to standard methods (American Society for Testing and Materials 1971, Association of Official Analytical Chemists 1965).

Total ash and silica-free ash content were determined by season for (1) tree foliage, by species, found at the top of the litter layer; (2) the entire litter layer of a mixed northern hardwood-oak-hickory stand; and (3) cured bracken fern (table 1).

The t-test was used to examine ash content differences related to species, location, and season.

RESULTS AND DISCUSSION

Silica-free ash content reduces combustion rate and is independent of heat content (Philpot 1968). Total ash increases with time (Kucera 1959) and also reduces combustion rate. As the litter layer merges with the lower forest floor, the ash content generally increases (Hough 1969, Hough and Albini 1978, Roussopoulos[2]).

[2]*Information on file at the North Central Forest Experiment Station, East Lansing, Michigan.*

Table 1.—*Average total and silica-free ash content of certain dead litter fuels in Michigan*[1]

Species of leaves	County	Fall			Spring			Early summer			Late summer		
		Sample size	Ash content	Standard deviation	Sample size	Ash content	Standard deviation	Sample size	Ash content	Standard deviation	Sample size	Ash content	Standard deviation
		No.	*Percent*		*No.*	*Percent*		*No.*	*Percent*		*No.*	*Percent*	
White oak	Ingham	5	5.7 (3.0)	0.3 (0.2)	5	6.9 (3.4)	0.3 (0.5)	10	8.1 (3.1)	0.4 (0.2)	4	9.2 (4.2)	0.5 (0.3)
Northern red oak	Ingham	5	4.3 (3.1)	1.0 (.9)	5	4.9 (3.0)	.2 (.2)	10	6.0 (3.0)	.3 (.1)	5	6.8 (3.4)	.6 (.5)
	Wexford	5	3.9 (2.8)	.2 (.2)	10	4.8 (2.8)	.2 (.1)	10	5.3 (2.7)	.3 (.1)	—		
Northern pin oak	Roscommon	5	3.7 (2.7)	.5 (.3)	5	3.7 (2.3)	.2 (.2)	10	3.8 (2.1)	.3 (.1)	5	4.1 (2.7)	.1 (.1)
American beech	Ingham	4	7.7 (2.3)	.2 (.2)	5	8.9 (1.9)	.4 (.3)	10	11.1 (2.6)	.9 (.3)	5	10.9 (2.7)	.7 (.4)
Large-toothed aspen	Roscommon	5	3.7 (2.0)	.6 (.4)	10	5.4 (2.8)	.3 (.2)	10	6.2 (3.5)	.5 (.3)	—		
Sugar maple	Wexford	5	7.1 (4.6)	.1 (.1)	10	9.2 (3.6)	.5 (.2)	3	10.3 (4.0)	.6 (.2)	—		
	Ingham	3	8.5 (4.6)	.2 (.1)	3	12.2 (5.2)	1.2 (.5)	4	13.1 (5.4)	1.2 (.4)	—		
Shagbark hickory	Ingham	3	8.1 (6.9)	.6 (.7)	3	9.6 (7.6)	.9 (.7)	—			—		
								—			—		
Red pine	Roscommon	5	2.1 (1.6)	.1 (.1)	4	2.3 (1.6)	.1 (.1)	5	2.3 (1.7)	.1 (.1)	—		
	Wexford	5	2.5 (2.0)	.2 (.1)	5	3.0 (2.3)	.1 (.1)	5	2.6 (1.6)	.6 (.7)	—		
White pine	Ingham	5	2.4 (1.8)	.1 (.0)	5	2.7 (1.8)	.2 (.2)	5	2.7 (1.7)	.1 (.1)	3	2.5 (2.0)	.1 (.2)
Jack pine	Roscommon	3	2.7 (1.7)	.1 (.1)	3	2.5 (1.3)	.2 (.1)	3	2.7 (1.4)	.1 (.1)	3	3.3 (2.4)	.9 (.9)
Mixed hardwood forest floor (L-layer)	Ingham	5	7.2 (3.3)	.8 (.6)	5	14.5 (3.7)	1.8 (.3)	5	11.3 (3.4)	1.7 (.3)	5	15.6 (3.7)	1.1 (.4)
Bracken fern (above ground plant parts)	Roscommon	5	5.4 (1.6)	.9 (.2)	5	5.5 (1.5)	1.1 (.2)	5	6.2 (1.4)	.8 (.2)	—		

[1]Silica-free ash content values in parentheses.

Mineral content generally increases with time because breakdown of the organic portion usually proceeds faster than leaching of minerals. Plant material decomposition is controlled by the chemical make-up of the material and by environmental factors. Therefore, many variables and interactions are involved in the process.

Species appear to have more effect than season or location on ash content and thus on fire behavior. T-tests for seasonal differences in ash content for each species by location were inconclusive,[3] but total ash content increased with time since foliage fell more than did silica-free ash. Examination of effects of season, by species of foliage, on predicted fire reaction intensity (Btu/ft²/min) and rate-of-spread (ft/min) indicated seasonal intensity differences that ranged from 0 to 4 percent for total ash and from 0 to 5 percent for silica-free ash content. Predicted intensity differences due to species differences within seasons ranged from 6 to 10 percent for total ash and from 5 to 12 percent for silica-free ash content.

Total ash content of the combined northern hardwood-oak-hickory litter layer significantly increased from fall to late summer, but the silica-free ash content did not. Bracken fern showed no significant changes in either total or silica-free ash content from fall through early summer.

Total ash content and silica-free ash content, in general, differed between species and increased with passage of time following leaf fall, although not always significantly. Species of foliage litter material is usually more important for predicting fire behavior than seasonal differences in ash content.

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[3]*The t-test would not conclusively justify combining locations when the same species of foliage was involved.*