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Distribution of ferns in the Maple-Beech Forest at the Cedar-Sauk Field Station

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DISTRIBUTION OF FERNS IN THE MAPLE-BEECH FOREST AT THE CEDAR-SAUK FIELD STATION

This report is another in a series of plant studies under investigation at the UWM Cedar-Sauk Field Station. Most of the previous studies were concerned with seed plants and only limited attention was given to the fern flora. In this study, carried out chiefly in the summer of 1970, the fern species were evaluated to determine their importance, distribution and ecological relationships in the maple-beech forest.

METHOD OF STUDY

Because ferns are less common and more widely dispersed than other understory plants, they cannot be adequately sampled in random quadrats. The line intercept method of sampling (Oosting, 1956) seemed to be the best technique to use. In this method, fourteen parallel transect lines, oriented W-E and parallel to the north boundary of the woods, were laid out by means of a staff compass and marked with bailing twine. The lines were approximately 100 feet apart and were initiated at the western boundary fence and extended to the eastern end of the wooded tract. The fern species were recorded whenever they intercepted these lines or occurred within 0.5m on either side of the lines. Each cluster of fronds from a common center was considered as one individual, and only one frond had to be in the intercept area to be counted. The species were tabulated as to their frequency, relative abundance and general distribution within the sampled area.

Environmental factors which were observed or analyzed included light intensity, pH and soil moisture. Each was determined from readings or samples taken wherever a "patch" of ferns was located. Light readings were taken be-

tween the hours of 10:00 a.m. and 2:00 p.m. on sunny days. The hydrogen ion concentration was determined by sifting a sample of soil, preparing a 4% suspension in distilled water and reading the pH value to the nearest 0.1 using a Beckman pH Meter. Soil moisture was recorded as a percentage of the moisture in the original soil sample after drying and reweighing. Voucher specimens were also collected and are filed in the Field Station herbarium.

DISCUSSION

Seven fern species were present in sufficient numbers to be recorded and evaluated: Rattlesnake Fern (*Botrychium virginianum* (L.) Sw.), Lady Fern (*Athyrium felix-femina* (L.) Roth), Cinnamon Fern (*Osmunda cinnamomea* L.), Spinulose Shield Fern (*Dryopteris spinulosa* (O.F. Muell.) Watt), Maidenhair Fern (*Adiantum pedatum* L.), Fragile Fern (*Cystopteris fragilis* (L.) Bernh.) and Bracken Fern (*Pteridium aquilinum* (L.) Kuhn). To indicate how widespread each species is in this woods, their frequencies were computed. The frequency of each species was determined as a percentage of the total number of lines in which it was tallied (Table 1.). The Rattlesnake Fern is the most widespread species, occuring in all of the transect lines (100%). The Lady Fern ranked second, occurring in 64.3% of the lines, and was followed by the less widespread species of Maidenhair Fern (28.6%), Cinnamon Fern (28.6%), Spinulose Shield Fern (21.4%), Fragile Fern (14.3%) and the Bracken Fern (7.1%). These frequency values for the Rattlesnake Fern and the Lady Fern are in general agreement with similar studies by Curtis (1959) and his students who found the average frequencies of the Rattlesnake Fern and the Lady Fern were 65% and 49%, respectively, in other southern mesic forests of Wisconsin.

These species have a similar relationship as to their abundance, which is also shown in Table 1. Abundance of each species was calculated as a percentage of the total number of all plants recorded, and represents the density of individuals of a particular species in the sample area. Again, Rattlesnake Fern ranks first as 60.8% of the plants tallied were of this species. Lady Fern ranked second with an abundance of 12.7%, while the others were sparsely present as indicated by abundance percentages ranging from 2.4% to 9.6%.

Although the above data indicate quantitatively the variation in numbers and spatial distribution of these fern species, it is necessary to consider some of the environmental factors for possible reasons for these patterns. Some of these possible relationships may be obtained from the environmental data collected and shown in Tables 2, 3, and 4.

The extensive distribution of the Rattlesnake Fern is probably due to its adaptability to the environmental conditions associated with a mature upland hardwood forest. It thrives in the low light intensity produced by the almost complete canopy, on various sites with variation in soil moisture (4.1% to 10%) and it tolerates a pH range from 5.2 to 7.5. Its distribution in the stand, however,

Table 1. Frequency and Abundance of Each Fern Species.

Species	*Frequency (%)*	*Abundance (%)*
Rattlesnake Fern	100.0	60.8
Lady Fern	64.3	12.7
Maidenhair Fern	28.6	6.4
Bracken Fern	7.1	9.6
Fragile Fern	14.3	5.6
Cinnamon Fern	28.6	2.6
Shield Fern	21.4	2.4

Table 2. Number of Individuals of Each Species in Relation to Light Intensity.

Light Intensity (foot-candles)	Rattlesnake Fern	Lady Fern	Maidenhair Fern	Cinnamon Fern	Shield Fern	Bracken Fern	Fragile Fern
0-50	5	1			1		
51-100	12	5	2	1			
101-150	5						
151-200	3	2	1				
201-250				1			1
251-300	3	1	2	1			
301-350	1						
351-400	4	1					
401-450							
451-500	1				2	1	
501-550							
551-600	2	1	1				
—							
951-1000	1						
1001-1500							
1501-2000				1			
2001-2500							
2501-3000		1					
3001-3500				1			
3501-4000							
4001-4500							
4501-5000	1						
5001-5500							
5501-6000	1						
—							
8001-8500		1					

Table 3. Number of Individuals of Various Species Observed in Relation to Soil Moisture Percentages.

Soil Moisture (%)	Rattlesnake Fern	Lady Fern	Maidenhair Fern	Cinnamon Fern	Shield Fern	Bracken Fern	Fragile Fern
4.1 - 4.5	1	1					
4.6 - 5.0	1	1			1		1
5.1 - 5.5	2	1					
5.6 - 6.0	3	1					
6.1 - 6.5	1		2				
6.6 - 7.0	4	2	1			1	
7.1-- 7.5	5		1				1
7.6 - 8.0	4		1				
8.1 - 8.5	3		1				
8.6 - 9.0	1	1					
9.1 - 9.5	4	1					
9.6 - 10.0	1	1					
10.1 - 10.5		1					
10.6 - 11.0							
11.1 - 11.5							
11.6 - 12.0				1			
—							
14.6 - 15.0			1	1			
15.1 - 15.5				1			
—							
19.6 - 20.0			1				
25.6 - 26.0		1					

is not uniform. It is sparse on exposed slopes which are too dry and in the open aspen grove at the east end of the area where the soil moisture is extremely low and the light intensity is very high.

The Lady Fern shows a similar, but somewhat greater, range of variability for these factors. It occurs where the soil moisture ranges from 4.1% to 26.0%, the pH ranges from 4.3 to 7.2 and in light conditions similar to those favorable to the Rattlesnake Fern. Except for the Bracken Fern, the other species have similar light preferences but appear to have different soil moisture or pH preferences. The Shield Fern and the Cinnamon Fern have higher soil moisture requirements (11.6% to 20.0%) and were noted chiefly in low moist areas of the woods, while the Maidenhair Fern and the Fragile Fern have a greater affinity for more alkaline soils as evidenced by their presence in sites where the pH ranged from 6.8 to 7.5.

The Bracken Fern was the least frequently observed species, as it was recorded only in an aspen grove at the extreme eastern edge of the study area. Curtis (1959) considers both the aspen tree and the Bracken Fern as species which quickly invade burned over areas. This fern thrives under higher light

intensities than the others, and spreads readily by means of a rapidly growing rhizome. It appears to have a long life-span and may persist, but not spread significantly, as the shade increases when trees invade the area.

These environmental factors not only affect the distribution of the mature fern plants (sporophytes) but, undoubtedly, influence the entire life-cycle of these plants. Spores, the propagules produced by ferns, are viable for only a short time and depend upon the wind for dispersal. In a dense forest wind velocity is greatly reduced and spores produced on the undersides of fronds, as in the Lady Fern, Maidenhair Fern, Fragile Fern and Bracken Fern, have a poorer chance for effective dispersal than those borne on upright spikes, as in the Rattlesnake Fern and the Cinnamon Fern, because an animal or a slight breeze may cause sufficient motion to project the spores some distance from the parent plant. If the spores

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Table 4. Number of Individuals of Each Species Observed in Relation to Hydrogen Ion Concentrations (pH).

pH	Rattlesnake Fern	Lady Fern	Maidenhair Fern	Cinnamon Fern	Shield Fern	Bracken Fern	Fragile Fern
4.3		1					
4.5		1					
—							
5.2	1						
5.3	1						
5.4		1					
5.5	1	1			1		
5.6							
5.7	1						
5.8	2	1					
5.9	1			1	1		
6.0	1						
6.1	2			2			
6.2		1					
6.3	1	1		1		1	
6.4	2				1		
6.5	1						
6.6	1				1		
6.7		1					
6.8	5		1				
6.9	2	1					
7.0	1	1					
7.2	3	1					1
7.3			2				
7.4	1						1
7.5	1		1				

land in a habitat with favorable moisture and absence of competition, they germinate rapidly and produce chlorophyllous gametophytes. The Rattlesnake Fern has another feature which is not present in the other ferns of this stand. It produces a subterranean achlorophyllous gametophyte, which may enable it to disperse more readily because it can tolerate lower moisture requirements and lower light conditions for survival.

Although the relationships with other understory plants were not investigated, some observations were made which may be significant for the numbers and distribution of ferns in this woods. In those portions of the stand where the canopy was densest, and where cool moist microclimatic and reduced light conditions existed, the ferns appeared to thrive best with little competition from herbaceous seed plants. In disturbed areas grasses and shrubs were generally present and ferns were notably absent, probably because of the higher light intensities and drier soils. Ferns were also absent where the understory consisted of dense sapling growth or the canopy was so dense that the forest floor was covered only with leaf litter.

Ferns, although not as abundant or as extensively distributed as herbaceous seed plants, are quite sensitive to light, soil moisture and pH variations, and are of some significance in demonstrating the variation of these environmental factors within a plant community such as this maple-beech woods.

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