Minnesota Forestry Research Notes

No. 250
April 15, 1974

Some Synecological Characteristics of the Prairie-Forest Transition Zone in Minnesota[1/]

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In the mid-1800's the prairie-forest transition in Minnesota existed in the southern and western portions of the state as shown in Figure 1. The presence of prairie vegetation in Minnesota was originally the result of the dry climate following Pleistocene deglaciation. Subsequently, the climate of the region became moist enough to support forest vegetation but prairie and transition vegetation were maintained by a complex of factors including climatic, edaphic, biologic, and anthropogenic. The single most important factor was probably anthropogenic fire. Currently there is very little prairie and transition woodland vegetation in Minnesota due to widespread agricultural activity. Protection from fire has also permitted some prairies to succeed to forest vegetation and the transition woodlands to develop a more closed structure.

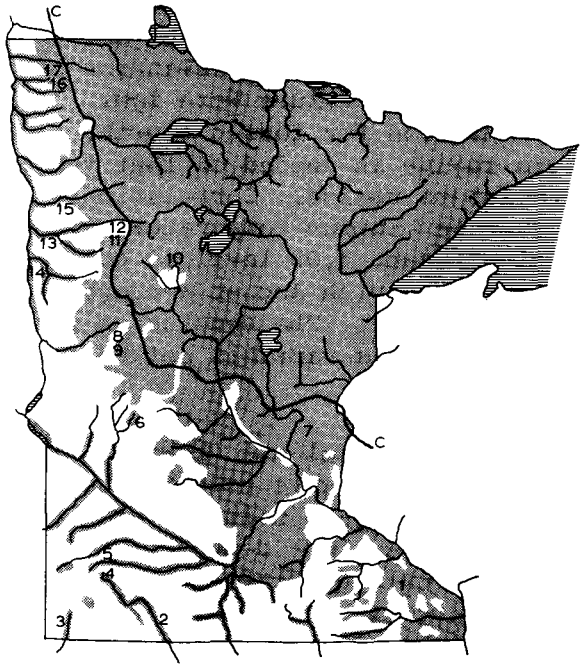

Figure 1

Original forests and prairie in Minnesota. Shaded area delimits forest land; C marks the approximate southern limits of pines, spruces, and fir. Based on Upham (1884) and Clements, Rosendahl and Butters (1912). The numbers shown indicate the position of the study stands.

Seventeen stands of prairie (3), savanna (3), and forest (11) vegetation were examined in the region of the transition (Figure 1) to determine species presence and general stand characteristics. Communities of the prairie-forest transition exist on a range of topographic conditions from bluff to level plain; soils range from rocky and sandy to clay and loam and may be dry to moist. Within the transition region, species number is greater in prairie and savanna stands than in the closed forest types. The compilation of species present permitted the calculation of stand synecological coordinate values and the plotting of the stands in the forest ecosystem space of Minnesota (Bakuzis, 1959, 1966). The position of the study stands in the moisture-nutrient and heat-light spaces are shown in Figure 2 and indicate that upland communities of the transition have an environment that is dry to moist, moderate to high in nutrients, moderately high in heat, and moderately high in light in comparison with Minnesota forest types. This position in the forest ecosystem space of Minnesota is attributed to the presence of prairie species. Coordinate values for species not listed by Bakuzis (1966) were determined by Bakuzis and Drew and are found in Drew (1973).

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Published by the College of Forestry, University of Minnesota, St. Paul, Minnesota 55101

Bur oak (Quercus macrocarpa Michx.) is the most common tree species throughout most of the transition in Minnesota, but quaking aspen (Populus tremuloides Michx.) is most common in the northwestern part of the state. Six bur oak stands in the region of the transition were examined for specific vegetation characteristics. They averaged 101.5 sq. ft. of basal area per acre, with trees up to 25.9 inches in diameter, 60 feet tall, and at least 137 years old. There were usually very few trees in the 1-4 inch diameter class found in these stands, although individuals of the seedling to 1 inch class were common. A dense shrub understory was common in bur oak woods of the transition (up to 48,436 individuals per acre were encountered). Three stands of the aspen parkland type were examined (two were areas of invasion in a bur oak savanna and a prairie) and averaged 85.8 sq. ft. of basal area per acre. Individual trees ranged up to 10.6 inches in diameter, 65 feet tall, and 37 years of age. Aspen in the 1-4 inch diameter class were present, but no seedlings were found. Bur oak trees and reproduction were present in two of the three stands. Again, a dense shrub understory was common in this transition type (up to 33,077 individuals per acre). Two bur oak savannas were examined and averaged 29 sq. ft. of basal area per acre, with trees up to 20.4 inches in diameter, 35 feet tall, and at least 85 years old. Trees less than 4 inches in diameter were uncommon. The understory is usually open in the savannas with prairie species dominating. Most prairies which are not being invaded by forest vegetation have been mowed periodically or grazed lightly to maintain the prairie structure. The common initial shrub invaders of prairie are Rhus glabra L., Symphoricarpos occidentalis Hook., and Corylus americana Walt. Quaking aspen may also invade prairie by its sprouting from lateral roots.

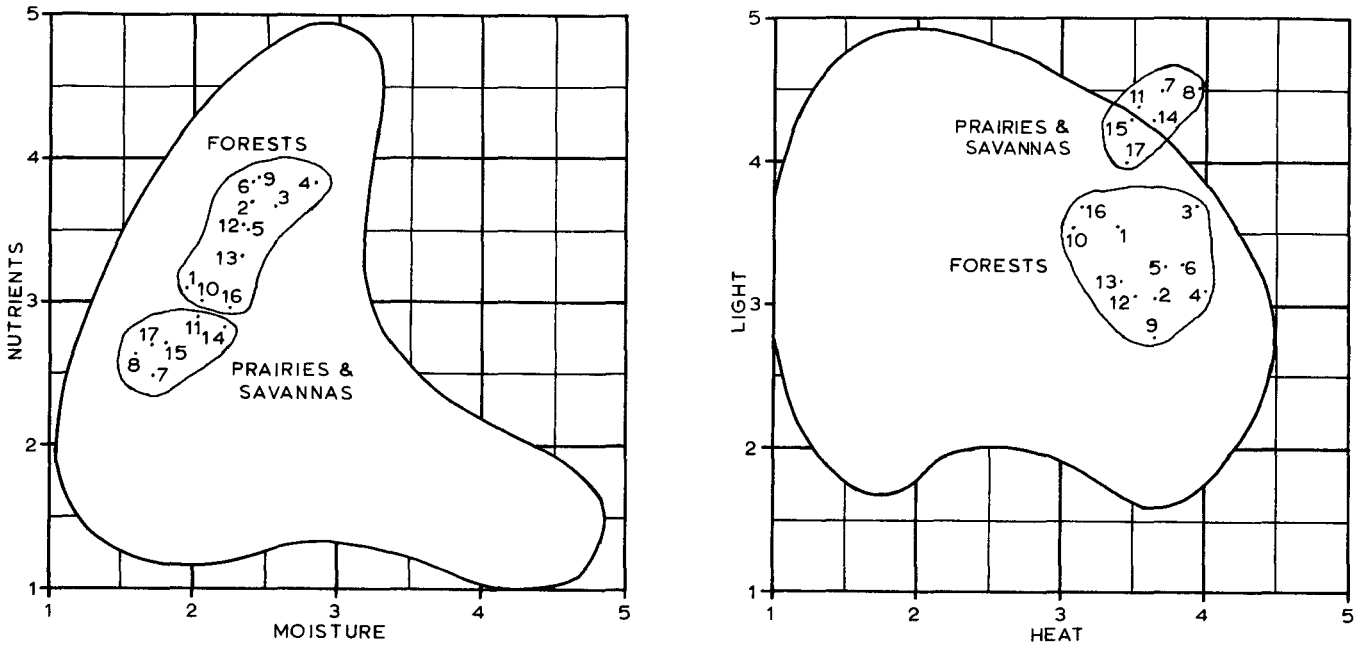
Correlations were used to test the relationship between recorded climatic data and stand synecological coordinate values for moisture and heat. The light variable was not tested because of the relative uniformity of light conditions over the region and the confounding of the variable by the formation of stories in forest stands. Eleven years of climatic data (1961-1971) from the weather station nearest to and of approximately the same elevation as each study stand were used. The correlations of monthly and annual precipitation with stand moisture coordinate values were low. Since precipitation throughout the state is generally adequate for forest growth, the conclusion is that another measure of the moisture regime is needed or that the moisture coordinate values are poor measures of the moisture regime. Correlations of monthly and annual average, average maximum, and average minimum temperature with stand heat coordinate values were for the most part significant (.05 level of comparison) to highly significant (.01 level); the best correlations were with August average temperature (0.789) and May average maximum temperature (0.740). The conclusion is that heat coordinate values reflect relative differences in this variable between stands.

Soils of 11 of the 17 study stands were examined on a physical and chemical basis at depths of 0-6, 6-12, 12-18, 18-24, and 36 inches. These data were used for testing the relationships of stand moisture and nutrient regimes with stand moisture and nutrient coordinate values. Percent organic matter at the 6-12 inch depth correlated significantly with stand moisture coordinate value, as did bulk density at the 0-6 inch depth. Percent silt and clay and moisture characteristics of the soil (15 bar and 1/3 bar tension, and percent available water) all correlated significantly or highly significantly with stand moisture coordinate value. It is concluded that stand moisture coordinate values may be used as a relative measure of the moisture regime.

There was a wide degree of correlation of individual soil chemical properties with stand nutrient coordinate values. Percent nitrogen at 12-18, 18-24, and 36 inch depths, hydrogen (ppm) at 0-6, 6-12, and 12-18 inch depths, and potassium (ppm), sodium (ppm), and percent silt and clay at all depths correlated significantly or highly significantly with stand nutrient coordinate values. Correlations of available phosphorus (ppm), calcium (ppm), magnesium (ppm), pH, percent organic matter, cation exchange capacity (MEQ/100g), and percent base saturation with

Figure 2

Position of the study stands in moisture-nutrient and heat-light forest ecosystem space in Minnesota (after Bakuzis, 1959). Stands 1, 2, 3, 4, 5, 6, 9, 10, 12 and 13 are bur oak woods; Stand 16 is aspen parkland; Stands 7, 15 and 17 are bur oak savannas; Stands 8, 11 and 14 are prairies.



stand nutrient coordinate values were non-significant. Multiple correlations of nitrogen, phosphorus, and potassium with stand nutrient coordinate values were significant or highly significant at all depths except at 36 inches; the highest correlation was 0.926 at the 0-6 inch depth. Using nitrogen, phosphorus, potassium, calcium, magnesium, and sodium in the multiple correlation, significant or highly significant values were obtained except at the 6-12 and 36 inch depths; the highest correlation was 0.977 at the 18-24 inch depth. By using a cumulative depth of 0-24 inches and performing the multiple correlations with the nutrients listed above, highly significant values were obtained. It is concluded that the relative nutrient regime of stands may be assessed by use of the method of synecological coordinates.

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Published as Sci. Jour. Ser. Paper No. 8688 of the Univ. of Minn. Agr. Expt. Sta.