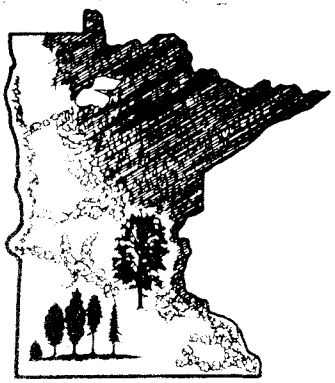

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SYNECOLOGICAL LIGHT COORDINATES: A VERIFICATION BY LIGHT MEASUREMENTS

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Abstract -- Among a wide range of forest types and within a single jack pine stand in northern Minnesota synecological coordinate light values were a positively related percent of full sunlight, as measured by single day readings totalized with ozalid paper packets.

Development of the synecological coordinate system provided an easy method for quantitatively evaluating forest sites. On a basis of literature observations, individual species were assigned relative values for the environmental factors of moisture, nutrients, heat and light. Individual species values were then adjusted on a basis of their association with all other species as determined in a survey of the forest region of Minnesota (Bakuzis and Hansen, 1959). Stand coordinate values for moisture, nutrients, heat and light may thus be calculated according to the presence or dominance of all species within the stand.

The present study was undertaken to see how actual light measured in the forest relates to the assigned synecological light coordinate values. The first phase covered a wide range of light and stand conditions; the second phase was concerned with microsite variation within a single stand.

Single day light was totalized by exposing ozalid paper packets in a variation of the method described by Friend (1961). Protective plastic coverings were not used. The number of papers exposed is a logarithmic function of total foot-candle minutes; ozalid paper (maximum sensitivity peaks sharply at 410 mu) automatically accumulates light intensity over time. The sample papers were calibrated by comparison with standards exposed for a known length of time to light measured with a selenium cell. Observations were made in north central Minnesota in the Itasca State Park region in August 1966.

In the first phase, three forest types were studied: jack pine (Pinus banksiana Lamb.), red pine-balsam fir (P. resinosa Ait.--Abies balsamea (L.) Mill.) and northern hardwoods. These vegetation types were selected to give a wide range of light and vegetation conditions. For replication, two stands in each type were selected and numbered arbitrarily.

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Hardwood stand 1 was dominated by mature basswood (Tilia americana L.), with some elm (Ulmus americana L.) and paper birch (Betula papyrifera Marsh.) present. A dense shrub layer of hazel (Corylus cornuta Marsh.) was present in parts of the stand. Hardwood stand 2 was dominated by sugar maple (Acer saccharum Marsh.), but contained many other northern hardwood representatives, including Quercus rubra L., Tilia americana L., and Betula papyrifera Marsh. The red pine-balsam fir stands were dominated by overmature red pine, with a discontinuous understory of balsam fir and paper birch. The red pine site index for stand 1 was 53, for stand 2 it was 45. Jack pine stand 1 contained a discontinuous shrub layer of Corylus cornuta; the jack pine site index was 68. Jack pine stand 2 contained no shrub layer; the site index there was 49. Site index was based upon curves developed by Gevorkiantz (1956 and 1957).

Within each of these six stands, eight circular plots, each two milacres in size, were systematically selected. Lists and cover estimates of species were compiled on each plot for computing synecological coordinates. Light measurements were taken over a full day under a clear sky. At each plot four packets were attached equidistantly along a four foot long horizontal lath supported 24 inches above the ground. Controls were set out at three locations in open fields so that light intensity could be expressed as a percentage of full sunlight.

Accidentally, the papers from three plots in red pine-fir stand 1 were labeled alike. These plots were handled by averaging the synecological light coordinates and plotting the points as overlapping in Figure 1. This resulted in a loss of some degrees of freedom.

In the second phase, microsite variation within a single stand (0.9 acre) was investigated in a 56 to 61 year old volunteer jack pine stand growing on a glacial kettle having a relief of 22 feet. Average site index for the area was 63. The range in total height for the dominant and co-dominant trees was from 57 to 79 feet and was independent of the 6-year range in age.

Within the area four microsites, each of about 150 milacres, were selected on the basis of aspect and total tree height. Within each microsite three measurement centers were located in vegetational cover which appeared typical. Light measurements were taken 24 inches above the ground at three points systematically located four feet from the measurement center. Two packets were exposed at each point during the daylight hours of a day that was overcast in the morning and partly cloudy during the afternoon. The changing cloud cover was representative of usual lighting conditions. Synecological light coordinates were calculated on a presence basis for each entire microsite. Light was expressed as percent of full sunlight as determined by packets located in an open field.

The relationship between coordinate values and integrated sunlight for six stands is shown in Figure 1. Two plots from the red pine-fir stands were omitted from the calculation of stand averages and correlation coefficients. One plot was omitted because it contained only six species; the other because it fell at the edge of a 30-year-old clear-cut strip and received much more light than any other plot in the stand. There was little overlap of values between the jack pine and northern hardwood stands. The red pine balsam fir stands overlapped both and had the most variability. This variability may be attributed to the discontinuous second story of balsam fir which probably resulted from fairly recent disturbance. Some plots fell beneath a dense fir canopy while others fell in relatively well-lit spots. Another reason for the variability is that few species were found beneath the 24-inch height in the dense shade of the red pine-balsam fir forests. On plots with few species the synecological coordinates are less meaningful.

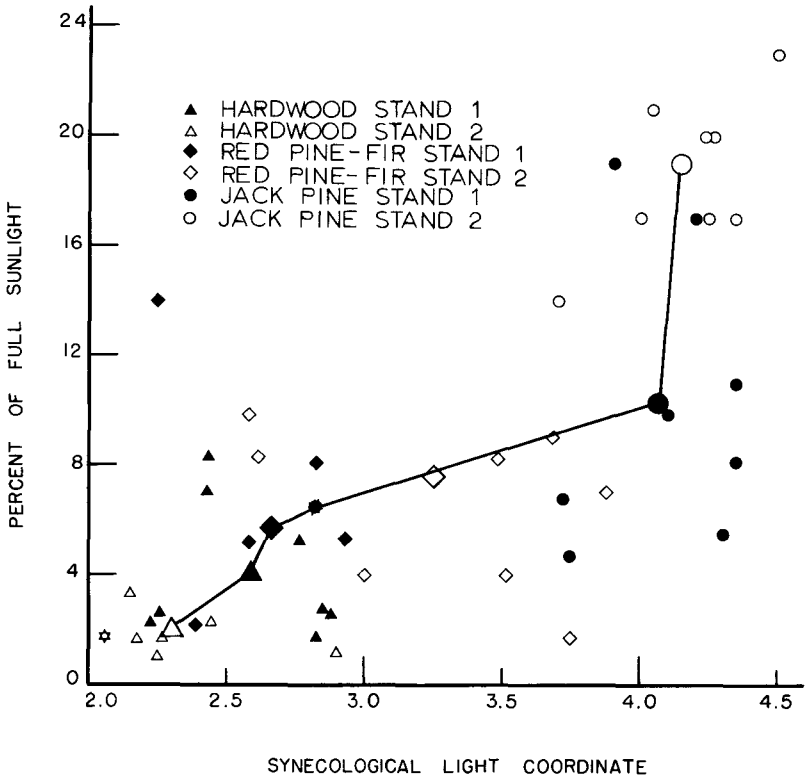

Figure 1. Relationship between measured light and synecological light coordinates (presence basis) for six forest stands. The large symbols represent stand averages.

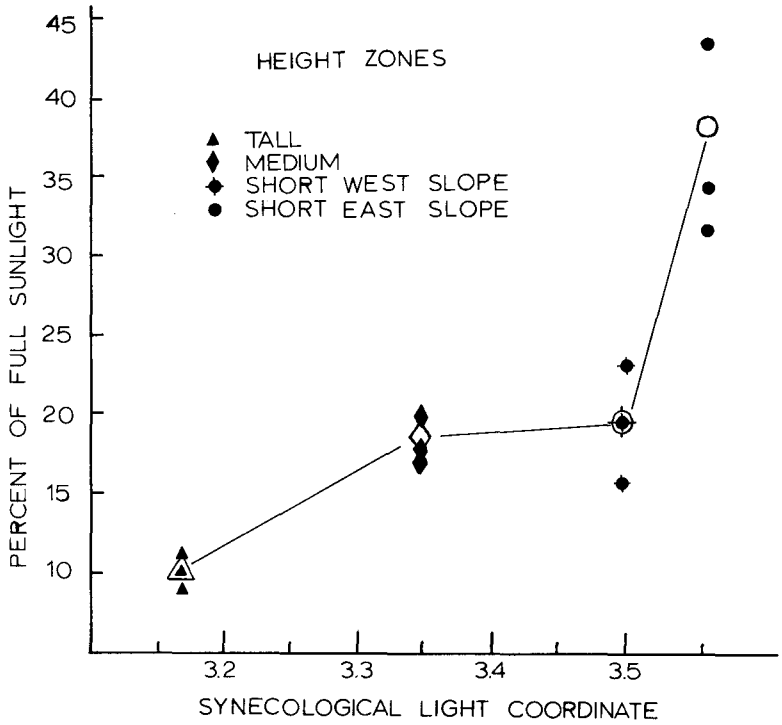

Figure 2. Relationship between measured light and synecological light coordinates for four microsites in a 59-year-old jack pine stand. The large symbols represent microsite averages.

Stand averages for the six stands are shown by the larger symbols in Figure 1. With 2-milacre plots as the units the linear correlation coefficient was 0.87 between synecological light coordinates computed on a presence basis and average percent of full sunlight. The linear correlation coefficient between light and coordinate values dropped to 0.66 when dominance was used to compute the coordinates. Both values were significant at the 5 percent level of confidence. Within stands, except for one jack pine stand, there was little relation between coordinates and readings.

Figure 2 shows variation by microsite within the 59-year-old jack pine stand. The light values plotted are the mean of the 6 packets near each measurement center. The coordinate value is computed from the entire 150 milacre microsite on a presence basis. The plot suggests the relationship between the variables may be non-linear, but even linear correlation gave a significant (5%) coefficient of 0.82 between measurement center means and microsite coordinates.

The synecological coordinate system was developed without directly measuring the environment; therefore, before the system can be widely applicable, the relationship between coordinate values and the effective environment must be shown. This study demonstrated a close relationship between synecological light coordinates based on species lists and measurements of percent of full sunlight above the herb level. Future work will have to test many variables including seasons of the year, computation with vegetation found only below the 24-inch level, and number of light readings.

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