VEGETATION FOREST ISLAND EDGES: A PRELIMINARY REPORT

INTRODUCTION

As the original native forest has been dissected by roads and replaced by farms or towns, the amount of forest edge relative to the area of forest interior has greatly increased. Today forest edge communities are widespread in many man-modified landscapes. However, the role the edge community plays in the regional landscape, and the extent of and variation in the edge community are relatively undefined.

In many regions, forested landscapes have been reduced to woodlots, often widely dispersed, fencerows, and urban forests (Pollard 1973). One example of this declining forest base was described for southcentral Wisconsin by Curtis (1956). Only 0.8 per cent of the original forest cover of Cadiz Township (Green County) remained in a seminatural state in 1950. Forest remnants represent the seed source on which the native forest depends for continued existence and for seeding into abandoned and naturally regenerating sites.

The importance of edge to wildlife has long been accepted. Leopold (1933) outlined the concept of "edge effect" as it relates to wildlife, and developed the principles of the "law of interspersion" of habitat types as related to wildlife abundance and distribution. This concept evolved into a quantitative measure of edge effect using the ratio of edge length to interior area. This ratio is still widely used, although somewhat modified (Patten 1975).

Most phytosociological studies are not designed to examine the edge community. In fact, most explicitly exclude the edge. For example, Borman and Buell (1964) studied an old-growth hemlock-hardwood forest in Vermont, but located all sample points at least 20m from the forest boundary. In sampling Wisconsin plant communities, Curtis (1959) specifically excluded a boundary zone 30m in width at the periphery of stands being studied. This effort to avoid the vegetation at the forest margin implies that the edge community is different from the forest interior.

Relatively few studies have dealt with the vegetation of the forest edge. Barick (1945, 1950) examined the vegetation of ten different types of forest edges with particular concern for their comparative habitat values. He interpreted forest edge as the ecotone between two forest types. A different interpretation of edge, a forest-field transition, was used by Gysel (1951) in his study of the encroachment of woodlot borders into surrounding open fields in southern Michigan. Wales (1972) studied the north and south edges of the Hutcheson

Memorial Forest in New Jersey. Statistical analyses led him to conclude that the forest edge was 5-10m wide on the north exposure and 10-20m wide on the south.

Recent studies have applied the concepts of island biogeography to habitat islands in terrestrial ecosystems (Diamond 1975, Forman et al., 1976). Others have investigated the vegetation of forest islands in agricultural landscapes (Levenson and Matthiae 1975, Elfstrom 1976, Suhrweir and Tramer 1976). Each study examined the effects of island size on species richness using mathematical models and assumptions. These studies have stimulated reevaluation of the importance and role of forest edge communities.

As forest islands get smaller, younger or more disturbed, functionally the entire island becomes edge (Schmid 1975, Levenson 1976). At some point, the forest island becomes sufficiently small that the edges from all sides merge at the island center and the forest edge and forest interior communities are the same (Levenson 1976).

Edge communities are not restricted to the forest border. Gaps within the forest function in much the same manner as edge. A high frequency of gaps can make even a large island no more than a highly convoluted edge. In the metropolitan Milwaukee region most upland forest islands are of relatively small size. When a large tree dies or is windthrown, the island's structure and composition may change rapidly. This condition can result from selective cutting or natural events. When holes are created in the canopy, the mesophytic environment within the stand is degraded.

If the concept of edge is expanded to include the canopy, isolated forest islands are completely surrounded by a protective edge. When examining the interactions between the isolated forest islands, the environment and the regional ecosystem, an analogy with living cell seems appropriate. The edge functions much like a semipermeable membrane (Levenson 1976). The edge and canopy moderate the extremes of temperature, humidity, and air circulation while filtering light levels in much the same manner as a cell membrane meters incoming compounds. Geiger (1966) reported daily maximum temperatures just above the ground surface were much higher along the forest edge than in the forest interior. Conversely, by reducing outgoing radiation at night, the forest edge and canopy form an effective screen against extreme minimum temperatures (Christy 1952).

The drying effect of wind influences forest edges more than interiors (Curtis 1959, Geiger 1966, Lowry 1967). The extent of the drying is dependent on the edge. Small or heavily disturbed forest stands may be sufficiently permeable to wind so that xeric conditions extend throughout the stand. These conditions may be evidenced by changes in species composition (Auclair and Cottam, 1971).

The amount of light which penetrates to the forest interior helps to determine stand characteristics; i.e., species composition, stem density, etc. Light penetration decreases with increasing stem and leaf density and the number of structural strata (Geiger 1966, Wales 1967).

The purpose of this study is to determine the nature of forest edge communities. The specific objectives of the study are to: (1) quantitatively survey and assess the forest edge community; (2) determine how forest edge vegetation differs from that of the forest interior; (3) determine if the directional aspect affects the edge vegetation and (4) present guidelines and suggestions for the management of forest habitat islands, particularly as they relate to the edge community.

STUDY AREA

Metropolitan Milwaukee, an area of about 525 km^2, includes Milwaukee County, southern Ozaukee County, and the eastern portions of Waukesha and Washington Counties. Located in southeastern Wisconsin (Fig. 1), the metropolitan region lies in the Great Lakes section of the Central Lowlands Province (Fenneman 1938). The entire area is east of the Saint Lawrence-Mississippi subcontinental divide.

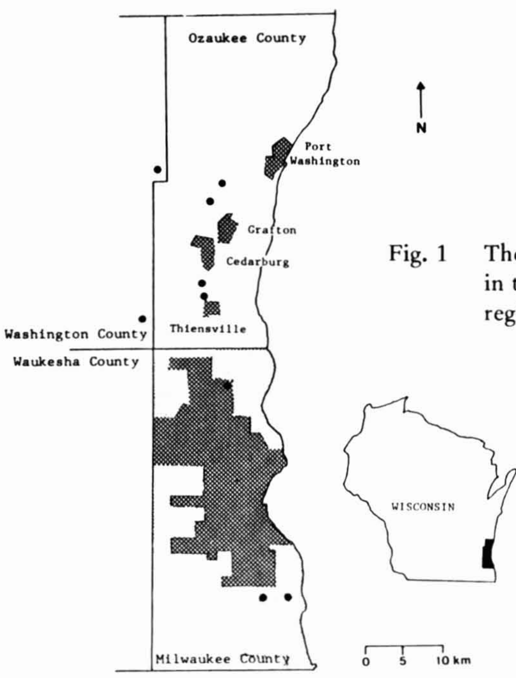

Fig. 1 The location of the study sites in the metropolitan Milwaukee region of southeastern Wisconsin.

Southern mesic and dry-mesic forest is the dominant native vegetation on the uplands of metropolitan Milwaukee now and was prior to settlement. The general characteristics of these Wisconsin forest communities have been described by Curtis (1959). Whitford and Salamun (1954) and Levenson (1976) have made detailed analyses of southern forest in the Milwaukee area. The nature of this plant community, its role in the regional landscape, and the availability of high quality information suggested the type as ideal for an edge study.

Primary study sites were limited to those stands previously sampled by Levenson (1976). The criteria used in selecting stands for that study required that the stands be of the southern mesic forest type, isolated from neighboring stands, and original remnants of the upland vegetation. Only islands that were relatively undisturbed, containing all structural strata of the southern mesic forest, and (of particular significance for this study) that had a "mature forest edge" at their periphery (Levenson and Matthiae 1975) were included.

METHODS

From within the group of forest islands that met the above criteria, stands dominated by sugar maple or beech were selected. Selection was based on the results of the cluster analysis and ordination performed by Levenson (1976). Potential sites were surveyed on foot to determine suitability.

Specific forest edges were selected using the following six criteria: 1) the edge should face in a cardinal direction; 2) the vegetation bordering the edge should be dominated by herbaceous or agriculatural plants; 3) transition from the edge to the border should be abrupt; 4) the edge should be well established and free from severe human or natural disturbance; 5) the edge should be linear for a minimum of 100m; and 6) topography should be flat to gently rolling.

In each edge selected, the woody vegetation was sampled using a modification of the line-strip method developed by Lindsey (1955). Canopy, sapling or understory, shrub, and groundlayer strata were sampled with a series of nested plots. Samples were centered on a 30m transect from the extreme edge to the interior. For trees and saplings, the presence or absence of "edge-growth-form" was noted. The definition of edge tree used follows that of other authors (Wales 1972, Levenson 1976) which states that edge trees exhibit an asymmetrical growth form, with many lateral branches on the exterior (open grown) side of the bole (Figure 2).

RESULTS AND DISCUSSION

Observation suggests that the way in which the edge is managed or maintained is a critical factor in determining the nature and extent of the edge community. Wales (1972) defined a "stabilized edge" as one which is well established and maintained in a permanent position by continued usage of adjacent land.

Fig. 2 An edge tree with the characteristic asymetric growth form.

Very different is the "unstabilized edge" which advances into the surrounding landscape as a result of abandonment or discontinued maintenance of the adjacent land (Wales 1972). We have observed another form where a new edge has recently been created. In this case, the edge extends into or encroaches upon the forest interior. The unstabilized encroaching edge is the type that can most significantly affect the species composition and microclimate of the forest interior. It appears that the way the edge is maintained is one of the most significant factors affecting the biota of the entire forest island.

Time is another critical factor affecting the composition and structure of forest edges. Settlement of metropolitan Milwaukee began about 150 years ago. This places an upper limit on the age of the edges we sampled. Loucks (1970) has suggested that successional patterns may take from 100 to 300 years to fully develop. Edges used in this study are still in the process of developing. In addition, each structural stratum of the forest responds to disturbance on different time and space scales. Groundlayer and shrub strata respond to disturbance much more quickly than other strata, and are sensitive to weaker or more localized types of disturbance, such as windfall openings (Gysel 1951, Bray 1956). In contrast, the tree stratum responds to disturbances of a much different time scale, in periods approaching the length of the life cycle of the arboreal species. The effects of non-catastrophic disturbance on the tree layer may take several decades or longer to be manifested while we are trapped at a single point in successional time. The observations and conclusions we make about the edge system and the response of forest communities to isolation and size reduction must take into account this time factor.

Keeping in mind the constraints imposed by the factors of both edge maintenance and time, our preliminary results and observations follow: (1) species richness in all strata decreases from the edge to the interior; (2) stem densities of all strata decrease from edge to the interior; (3) species richness and density of the sapling layer (2.5-10 cm dbh) are the most efficient indicators of edge conditions; (4) no precise boundary can be drawn to separate edge from interior. However, a discontinuity occurs at approximately 10-15 meters from the physical edge that appears to separate edge from interior; (5) time and edge maintenance appear to have more effect on the general structure of the edge than directional aspect; (6) Basswood *(Tilia americana)* and ash *(Fraxinus spp.)* play a more significant role in the edge than in the interior. Beech *(Fagus grandifolia)* is less important in the edge system than in the typical mesic forest interior.

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