Sugar Maple: Abundance and Site Relationships in the Pre- and Post- Settlement Forest

Gordon G. Whitney[1]

Abstract

A review of the available historical evidence provides a picture of sugar maple's site relationships in the presettlement forest and its changing status over the last 300 years. Sugar maple was widely distributed throughout the Northeast during the presettlement period. It was particularly abundant on the richer, better drained, silt-rich sites. A comparison of the early land survey records and more recent forest inventory data suggests that sugar maple has increased its abundance on a variety of sites, including a number of more marginal sites. The resulting off-site conditions may partially explain sugar maple's recent decline and its inability to exploit some old field sites.

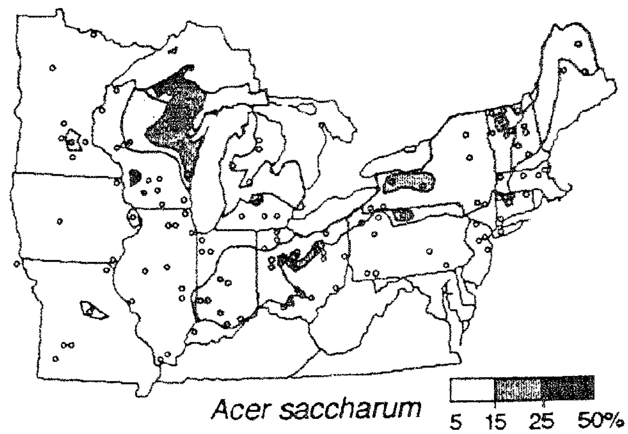

Figure 1.—Map showing abundance of sugar maple in presettlement forest as percent of trees noted in early land survey records. Each circle represents a land survey record, generally encompassing a township or a county. Slightly modified from Whitney (1994).

Introduction

There is an increasing recognition that humans are an integral part of many ecosystems (Grumbine 1997). This has generated an interest in quantifying the degree to which humans have altered those ecosystems. The cutting and forest clearance accompanying European settlement entailed a major reorganization of North America's forests (Whitney 1994). Sugar maple *Acer saccharum* Marsh., was and is a dominant of the beech-sugar maple forest region and the hemlock-white pine-northern hardwood forest region, which cover much of the northeastern United States (Braun 1950). The present paper represents a brief overview of sugar maple's occurrence in the presettlement forest, its relationship to various site factors and its response to European settlement. I will start by summarizing our knowledge of existing sugar-maple site relationships and presettlement site relationships. I will then compare the early land survey records with more recent twentieth century forest inventory data to gain an idea of sugar maple's changing abundance. I will close with a brief discussion of some of the management implications of sugar maple's exacting site requirements and its postsettlement increase.

Existing Soil-site Relationships

Although sugar maple occupies a variety of sites, it makes its best growth on moderately fertile soils that are deep and well-drained (Godman 1957). Brand (1985) noted that sugar maple was associated with the more nutrient rich sites across a wide variety of U.S. Forest Service plots in Michigan and Minnesota. It dominates the melanized silt-rich, loamy, often gentle or moderately sloping soils of the Midwest and New England (Archambault and others 1989; Leak 1978; Lindsey 1998; Pregitzer and Barnes 1984; Wilde 1976). It is particularly abundant on lower slope positions or coves that are enriched by leaf litter, colluvium, or nutrient rich water moving from upslope (Leak 1982; Pregitzer and others 1983; Smith 1995). Foresters have recognized it as an overstory dominant of the fertile *Acer/Arisaema, Acer/Osmorhiza-Hydrophyllum, Acer/Viola*, and *Quereus rubra-Acer saccharum/Caulophyllum* site types (Archambault and others 1989; Pregitzer and Barnes 1984; Smith 1995).

Most weathered soils in the unglaciated portion of sugar maple's range are low in extractable nutrient base cations. As a result it is not surprising that south of the glacial border, sugar maple reaches its best development on soils that are influenced by base cations in the bedrock (Bailey and others 1999; Nigh and others 1985; Pearson 1962), the addition of silt on terraces and floodplains or nutrient enriched seep water from upslope (Jennings 1936).

Presettlement Abundance And Site Relationships

Counts of witness or corner trees in the early land survey records have frequently been employed to assess the abundance of various tree species in the presettlement forest (Whitney 1994). Although they are subject to surveyor and sampling biases, most investigators believe that they provide a fairly reliable quantitative estimate of the species composition of the forest (Bourdo 1955; Whitney 1994). A compilation of these records in the Northeast (Figure 1) indicates that although sugar maple was well distributed throughout the region, it infrequently accounted for more than 15 percent of the witness trees even in the glaciated portion of its range. Here again it was associated with more fertile site conditions. Sugar maple probably reached its greatest abundance in the hemlock-northern hardwood forest region of northern Wisconsin and the Upper Peninsula

[1]Department of Biology, Allegheny College, Meadville, PA.

Table 1.—Relative density or percent representation of all trees reported in pre- and post- settlement (twentieth century) forests.

Location	Presettlement	Postsettlement	Source
N. Maine	5.4	6.5	Lorimer 1977
N. Vermont (Chittenden Co.)	15.8[a]	23.5	Siccama 1971
Catskill Mts., NY	12.8	23.2	McIntosh 1962 McIntosh 1972
N. Pennsylvania (Allegheny Natl. Forest)	5.3	13.3	Whitney 1990
N. lower Michigan (Crawford Co.)	2.1	6.0	Whitney 1987
N. Wisconsin (T35N, R14E)	29.3	43.6	Stearns 1949
S. Wisconsin (Cadiz Twp.)	3.4	28.2	Sharpe and others 1987
Northeastern Ohio (Wayne Co.)	4.2	6.0	Whitney and Somerlot 1985
Northwestern Ohio	8.9	9.5	Gysel 1944

[a]Upper estimate of percentage as includes some red maple a well as sugar maple.

of Michigan directly to the west of beech's range limit. On the richer, loamy soils of the region (Albert 1995; Barrett and others 1995), it occasionally accounted for over 50 percent of the trees reported (Bourdo 1955). Sugar maple was also abundant (15 to 20 percent of the trees) in the more calcareous till derived soils of upstate New York south of Lake Ontario (Marks and others 1992). Braun (1950) stated that the boundary between the mixed mesophytic forest region and the beech-maple forest region coincides with the Wisconsin glacial boundary. In northeastern Ohio, however, sugar maple was fairly common (18% of the trees present) on the alkaline (10-15% carbonate) late Wisconsinian Hiram till. Its abundance dropped precipitously to 3.5 percent on the older more deeply leached (no natural lime within 5 feet) late Wisconsinian Hayesville and Navarre tills (Bureau and others 1984; White 1967; Whitney 1982). On the more acidic, residual soil south of the glacial border, sugar maple represented only 2.6 percent of the trees. Here it was confined to lower slope positions and the richer alluvial soils of floodplains (Whitney 1982). Sugar maple was likewise rare (<2 percent of the trees) and confined to the richer, more calcareous soils of the valley floors in the unglaciated Ridge and Valley Province of central Pennsylvania (Abrams and Ruffner 1995).

Soil texture and nutrients appear to have been major determinants of sugar maple's abundance in the Midwest. Sugar maple was positively associated with the richer loams and sandy loams of the morainal areas of northern lower Michigan (Harman and Nutter 1973; Whitney 1986) and the Upper Peninsula of Michigan (Barrett and others 1995). Sugar maple was a sure sign of rich, fertile soils to the early settlers (Whitney 1994). In southern Michigan, Indiana and northern Ohio, sugar maple exhibited a preference for the richer, somewhat finer textured (silt and clay rich) loams of the till plains and the end moraines (Crankshaw and others 1965; Dodge 1987; Kapp 1978; Medley and Harman 1987; Whitney 1982). Sugar maple is a fairly drought-sensitive species (Bahari and others 1985). Its shift to the finer textured loam in the lower Midwest may have compensated for the greater evaporative stress to the south.

Drainage and landscape position also influenced sugar maple's occurrence on the beech and sugar maple dominated till plains. As it requires an adequate air supply for the growth of its roots, it reached its greatest abundance on the better drained soils of the swells and the slopes of the till plains. Beech was more a species of the poorly drained swales (Gilbert and Riemenschneider 1980; Lindsey 1998; Shanks 1953).

Changing Status

Comparisons of sugar maple's abundance in the early land survey records with more recent forest surveys suggests that sugar maple has at least maintained and in many cases increased it relative density in the postsettlement forest (Table 1). It showed major gains relative to other species in northern Vermont, in the Catskills, in northwestern Pennsylvania, in Michigan, and in Wisconsin. Significant increases were also noted in the relative importance value (another measure of abundance (Ward 1956)) of sugar maple in the Gogebic Iron Range of northern Wisconsin (Mladenoff and Howell 1980), and in a variety of soils in northern lower Michigan (Harmon and Nutter 1973). The increase has variously been attributed to the cessation of fire (Sharpe and others 1987), to sugar maple's ability to resprout when cut and its prolific seed production (White and Mladenoff 1994) and to sugar maple's plasticity and its ability to reproduce and grow successfully in the understory as well as large and small gaps in the canopy (Canham 1988; Frelich and Lorimer 1991; Stearns 1949). Although sugar maple is very sensitive to crown and ground fires (Simpson and others 1990), other disturbances in the form of blowdowns or the death of a canopy tree favored sugar maple in the presettlement forest (Frelich and Lorimer 1991; Hough and Forbes 1943). Likewise sugar maple's shade tolerance and its vigorous seed and sprout reproduction made it "the most aggressive reproducer" of the cutover northern hardwood forest (Illick and Frontz 1928).

Management Implications

Sugar maple's high site requirements (Hornbeck and Leak 1992) and its significant postsettlement increase on a variety of soils and sites (Harman and Nutter 1973) suggests that sugar maple may now occupy a number of marginal sites, i.e., sandy nutrient poor soils, shallow acidic soils on ridges, and soils with impeded drainage. Sugar maple typically has slow growth, deteriorates at an early age, or succumbs to fungi and cankers on these sites (Nowak 1996; Ward and others 1966; Wilde 1976). "Off-site" conditions may partially explain the recent decline of sugar maple on a number of acidic shallow, nutrient poor sites across the Northeast (Horsley and others, this volume; Kolb and McCormick 1993; Wargo and Auclair 1999[1]).

Sugar maple is a fairly nitrophilous species. Sugar maple reached its greatest abundance in Indiana's presettlement forests on soils with a high total (Kjeldahl) soil nitrogen level (Crankshaw and others 1965). Nitrogen availability and nitrogen mineralization rates are high in most woodland ecosystems dominated by sugar maple (Pastor and others 1982; Zak and Pregitzer 1990). Several investigators have suggested a deficiency of nitrogen could limit sugar maple's establishment on many old field sties, where plowing and erosion reduced the organic matter and nitrogen content of the soil (Ellis 1974; Lennon and others 1985). Much of the marginal farmland of the northeastern United States has been abandoned over the last 100 years (Whitney 1994). Sugar maple's exacting site requirements could explain its inability to capture many of these old field sites relative to its more successful but less nitrogen demanding congener, red maple.

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