A Five-year Record Mast Production and Climate in Contrasting Mixed-oak-hickory Forests on the Mashomack Preserve, Long Island, New York, USA

Authors: Abrams, Marc D., and Scheibel, Michael S.

Source: Natural Areas Journal, 33(1) : 99-104

Published By: Natural Areas Association

URL: https://doi.org/10.3375/043.033.0112

RESEARCH NOTE

•

A Five-year Record Mast Production and Climate in Contrasting Mixed-oak-hickory Forests on the Mashomack Preserve, Long Island, New York, USA

Marc D. Abrams[1,3]

[1]307 Forest Resources Building
Department of Ecosystem Science and Management
Penn State University
University Park, PA 16802

Michael S. Scheibel[2]

[2]The Nature Conservancy
Mashomack Preserve, P.O. Box 850
Shelter Island, New York 11964

•

[3] Corresponding author:
agl@psu.edu

Natural Areas Journal 33:99–104

ABSTRACT:
This five-year study (2007-2011) investigated year-to-year variation in the oak (*Quercus* spp.) and hickory (*Carya* spp.) mast production in five different variations of mixed-oak-hickory forests at the Mashomack Preserve on Shelter Island, Long Island, New York. All seven species (six oaks and one hickory) had one to three mast years during the five year study, with black oak (*Quercus velutina*) having the highest number of mast years and producing the largest number of acorns. Pignut hickory (*Carya glabra*) had a similarly high overstory importance value to black oak in the study stands but had only one mast year and produced less than half of the nuts produced by black oak. White oak (*Quercus alba*) was the third ranking tree species in term of overstory importance and mast production, having two mast years during the study. There was a large amount of year-to-year and stand variation in mast production. The highest amount of mast was produced in 2009 and 2010, yet there was a 3-4 fold difference between the least and most productive stands in each year. The year 2011 was unique for having very low mast production and no mast year for any of the six tree species. This is attributed to a significant drought in 2010 that persisted through the summer of 2011. The 2010 drought did not reduce mast production in that year.

Index terms: acorns, black oak, Coastal Plain, drought

INTRODUCTION

Acorn and nut production (mast) is known to widely vary from year-to-year in forests of the eastern United States. (Sork et al. 1993; Healy et al. 1999). The timing of mast production is often synchronized among many individuals in a region. When this occurs, it is called a mast year. This results in a huge number of seeds produced in one or more species relative to non-mast years. Mast years can impact the number of viable seedlings produced, via predator satiation, as well as impact the fecundity of animal species that depend on mast as a food source (Steiner 1995; Wolff 2006). Despite the recognition of mast years and their ecological importance to the fields of forestry and wildlife, long-term information about mast production exists for only a few locations in the eastern United States. For example, no such studies, to our knowledge, have been conducted in the northern mid-Atlantic (including eastern New York) or southern New England.

The Nature Conservancy (TNC) Mashomack Preserve in southeastern New York contains one of the premier oak- (*Quercus* spp.) dominated coastal plain forests in the northeastern U.S. Typical of most oak forests in the eastern U.S., however, there exists a scarcity of oak regeneration at the preserve (Abrams and Hayes 2008). The majority of oak and hickory (*Carya spp.*) species have low to moderate shade tolerance, are early to mid-successional, are fire adapted/dependent, and are replaced by other tree species (e.g., red maple (*Acer rubrum*)) in the absence of proper management or ecological conditions (Abrams 1992; Nowacki and Abrams 2008). The loss of these historically dominant tree species represents one of the major conservation biology issues in the eastern forest.

The replacement of oak and hickory species on sub-xeric sites is likely due to multiple factors, including a lack of periodic understory burning in recent decades, intensive browsing on oak seedlings by white-tailed deer (*Odocoileus virginianus*), acorn predation, and forest succession to more shade tolerant tree species. However, the frequency and intensity of mast production may also be playing a role in the establishment and success of oak and hickory seedling at the preserve, as mast years result in the production mast seedlings (Kelly 1994). Therefore, we initiated a five-year study starting in 2007 to investigate year-to-year variation in the oak and hickory mast production in five different variations of mixed-oak-hickory forests that exist within the preserve. This study provides new information about long-term mast production in southeastern New York, how juxtaposed forests of varying overstory composition differ in year-to-year mast production, and how climate may impact mast production. It will also provide information on whether mast production is a limiting factor to oak and hickory seedling production on the preserve.

Study Area Description

The 810 ha Mashomack Preserve is located on the coastal plain of Shelter Island, N.Y. (41.106°N, 72.233°W), off the eastern end of Long Island. Two major oak-dominated areas on Mashomack are the interior forest (270 ha) and the maritime forest (235 ha) that differ in their past land-use history and overstory composition (Abrams and Hayes 2008). The interior forest forms the central core of Mashomack and was not used extensively, if at all, for agriculture. However, this forest was logged and burned several times since European settlement, starting in the early 1600s (Abrams and Hayes 2008). In contrast, the maritime forest developed following agricultural abandonment after 1870 and was used for livestock grazing. The extent of the maritime forest is easily recognizable today because it is covered in dense thickets of greenbriar (*Smilax* spp.) not present in the interior forest. The naming of the two forests types on Mashomack as interior versus maritime was done to describe their location within the preserve; in the broader sense, both types are, in fact, maritime or coastal plain forests. For this study, we monitored oak and hickory mast production within three contrasting areas within the interior mixed-oak forest (oak-hickory, oak-hickory-beech (*Fagus grandifolia*), and mixed-oak) and two maritime forests (mixed-oak and oak-hickory). During the fall of 2007, two ha blocks in two interior forests and two maritime forest locations were thinned of about 100-200 trees per ha to promote regeneration of the oak and hickory trees (that were not cut). Red maple, black cherry (*Prunus serotina*) and sassafras (*sassafras albidum*) comprised most of the thinned trees. These thinned blocks were locations used to monitor mast production for this study. The interior mixed-oak stand was not thinned.

The average annual high and low temperature on Shelter Island is 21 ˚C and 7 ˚C, respectively. Average annual precipitation totals 116.6 cm, which is evenly dispersed throughout the year (monthly precipitation averages range from 8.0 to 11.7 cm (Warner et al. 1975). The average elevation on the island is 15 m above sea level. All of the soils found on Shelter Island are typical of terminal moraines, including Montauk, Riverhead, and Plymouth sandy loams, as well as Carver and Plymouth sands (Warner et al. 1975). In general, these soils series are well-drained to excessively well-drained, have low natural fertility, and have moderately coarse to coarse texture. The Montauk sandy loam soil is the most prevalent throughout the Mashomack Preserve, while the Carver and Plymouth sands are generally found on higher elevation sites.

METHODS

The overstory in the five different forest locations was surveyed in 2007. A 400-m^2 circular plot was used at six sampling points in each forest type to inventory all tree species > 2.5 cm dbh (diameter at breast height). Species, diameter, and crown class were recorded for all trees. For each forest type, tree data were used to calculate a relative importance value from the average of the relative frequency (the number of plots in which a tree species was recorded in each forest type), relative density (total number of trees recorded divided by the number of plots surveyed), and relative dominance (basal area; Abrams and Hayes 2008).

Acorn and hickory nut production was monitored annually from 2007 to 2011 at four random points beneath a cluster of oak and hickory trees within each of the five interior and maritime forests. In late October to early November of each year (after seed fall), the number of oak acorns and caps and hickory nuts were counted by species in three, 2-m^2 permanently located plots at the four points within the five forests. In a few cases, the number of acorn caps exceeded the number of acorns counted (as a result of animal predation). In those cases, the number of caps was used for the acorn density presented here. Mast counts were also made in smaller seed traps at each plot to further assess the impact of seed predation at the preserve. We found that the results were highly similar between the open plot and seed traps, and we have chosen to report only the plot data for this paper. For the purposes of this paper, a mast year for a tree species is simply defined qualitatively as years when an abundance of acorns or nuts are produced. In general, this represented a 3-10 fold increase in nut production during mast versus non-mast years.

Results and Discussion

Within the interior forest, the oak-hickory stand was comprised of 61.5% oak and 28.7% pignut hickory (*Carya glabra*; Table 1). The oaks present were white oak (*Quercus alba*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), and red oak (*Q. rubra*). The oak-hickory-beech stand of the interior forest contained 40% oak, 21.7% pignut hickory and 20.2% beech (*Fagus grandifolia*). The mixed-oak stand of the interior forest was dominated by 45.7% oak, 20% red maple, 14.6% pignut hickory, and 11% dogwood (*Cornus florida*). This stand had the highest tree density and the highest amount of red maple due to the lack of thinning (total density of 547 trees/ha versus 112-312 trees/ha in the four other stands). The oak-hickory stand in the Maritime forest contained 42% oak and 36.7% pignut hickory. The mixed-oak section of the Maritime forest had 71% oak (including post oak (*Q. stellata*)) and only 5.7% hickory.

Between 2007 and 2010, at least one oak or hickory species had what we consider to be a mast year (Table 2, Figure 1). However, there was a large amount of stand-to-stand variation in acorn/nut production for a given species even during mast years. In 2007, white oak had high mast production in the interior oak-hickory and mixed-oak stands and the maritime mixed-oak stand, but not in the other two stands. White oak also had high mast production in 2010 in the interior oak-hickory stand, not seen in the other stands. In 2007, black oak had high mast production in the interior and maritime mixed-oak forests, but not in the other three stands. In 2008, pignut hickory had a mast year in the two maritime stands and moderately high production in two of the three interior stands. While mast years are generally synchronized among most individuals of a species within a region, not all trees participate (Smith and Scarlett 1978; Sork et al. 1993).

Table 1. The relative importance value (%) and total tree density in 2007 in two ha forest stands within the Interior and Maritime forests at Mashomack Preserve, New York. All stands were thinned in the fall of 2007 except for the Interior mixed-oak forest.

Species	Interior forest			Maritime forest	
	oak-hickory	oak-beech-hickory	mixed-oak	oak-hickory	mixed-oak
Carya glabra	28.68	21.75	14.6	36.65	5.7
Quercus alba	20.56	6.65	9.72	4.53	16.63
Quercus coccinea	17.96	0	0	5	4.72
Quercus velutina	10.68	1.71	20	28.16	41.44
Quercus rubra	8.28	21.65	2.2	4.18	0
Quercus prinus	3.98	10.01	13.75	0	2.92
Cornus florida	7.63	0	10.98	3.7	2.6
Acer rubrum	2.24	10	19.97	0	0
Fagus grandifolia	0	20.22	6.38	0	0
Ostrya virginiana	0	8.03	0	0	0
Prunus spp.	0	0	0.2	14.52	2.49
Nyssa sylvatica	0	0	0	3.58	0
Sassafras albidum	0	0	1.2	0	12
Betula pendula	0	0	0.91	0	6.36
Quercus stellata	0	0	0	0	5.14
Trees/ha	308	312	547	112	237

Black oak had its highest mast production of all species in 2009 followed by 2010 (Table 2, Figure 1). All five stands had their highest black oak mast density in 2009, led by the maritime mixed-oak and maritime oak-hickory stands. Red oak had a mast year in 2009 in the interior oak-hickory-beech and interior mixed-oak stands, as did post oak in the maritime oak-hickory stand. Chestnut oak had its highest acorn production in 2010 in the three interior stands (Table 2). In 2010, black oak mast remained very high in the maritime mixed-oak stand, but had a large decrease in the other four stands relative to 2009. The year 2011 was unique, having the lowest mast production across all five stands. Across all five years and stands, black oak produced the largest amounts of acorns/nuts (5228 acorns/120 m^2), followed by pignut hickory (2198), white oak (1697), red oak (1084), chestnut oak (761) and post oak (344). Higher average acorn production in black oak (versus white oak and red oak) was also reported by Sork et al. (1993).

During this five year study, five of the six tree species had one mast year, whereas black oak had two or possibly three mast years (Figure 1, Table 2). Three tree species had mast years in either 2009 or 2010; black oak had the highest mast in both years. It is typical of eastern oak species to have one or two mast years in a five-year period, including the possibility of back-to-back mast years (Smith and Scarlett 1987). Mast years can also be synchronized among two or more tree species in a region. Mast production in our study stands is typical of other eastern oak forests, which have reported about 10-50 acorns per m^2 of crown area (Healy et al 1999; Lombardo and McCarthy 2008). No tree species had a mast year in 2011. A five year (2007-2011) record of the Palmer Drought Severity Index (PDSI) indicated that a moderately-extreme drought (negative PDSI values) occurred on Long Island, N.Y., from April through December 2010 that persisted until September 2011 (Figure 2). We believe this prolonged, significant drought is the most likely cause of the very low mast production exhibited by all the tree species in 2011. A study of oak species in Missouri reported that summer drought had a negative effect on mast production in the same year (Sork et al. 1993). In contrast, we found that the 2010 drought did not have a negative impact on mast production in that year. Indeed, three of the six tree species we studied had a mast year in 2010, possibly due to the abundant precipitation in late 2009 and early 2010. More mild droughts occurred in late 2007, early 2008, and early 2009 that had less discernible effects on mast production.

On average, the most productive stands for mast yield were the two maritime sites. They produced an average of 767 and 506 acorn-nuts per 24 m^2 per year versus 373 and 287 per 24 m^2 per year in the Interior stands (Table 2). However, in 2007, the interior mixed-oak stand led in mast production among the five sites, although that was second lowest year over-all. The unthinned, interior mixed-oak stand, on average, produced more mast than did the two other interior stands (that were thinned in 2007) over the five-year study period. This suggests that thinning of non-oak or hickory trees did not stimulate mast production in residual trees as was reported in other studies (Lombardo and McCarthy

Table 2. Total number of oak acorns and hickory nuts recorded in plots by species for various forest types at the Mashomack Preserve, eastern Long Island, NY, during 2007-2011.

	2007		2008		2009		2010		2011	
	per $24m^2$	per m^2	per $24m^2$	per m^2	per $24m^2$	per m^2	per $24m^2$	per m^2	per $24m^2$	per m^2
Red Maple Block										
Black oak	69	2.88	70	2.92	355	14.79	130	5.42	2	0.08
White oak	209	8.71	26	1.08	66	2.75	370	15.42	10	0.42
Chestnut oak	0	0	1	0.04	13	0.54	224	9.33	1	0.04
Pignut hickory	7	0.29	109	4.54	1	0.04	0	0	5	0.21
Total	285	11.88	206	8.58	435	18.13	724	30.17	18	0.75
Interior Oak-Beech-Hickory										
Chestnut oak	25	1.04	45	1.88	24	1	184	7.67	2	0.08
Black oak	3	0.13	70	2.92	140	5.83	74	3.08	0	0
Red oak	0	0	3	0.13	457	19.04	96	4	0	0
White oak	58	2.42	0	0	0	0	68	2.83	0	0
Pignut hickory	4	0.17	170	7.08	1	0.04	0	0	6	0.25
Mockernut hickory	0	0	5	0.21	0	0	0	0	0	0
Total	90	3.75	293	12.21	622	25.92	422	17.58	8	0.33
Maritime Oak-Hickory										
Black oak	67	2.79	1	0.04	535	22.29	258	10.75	26	1.08
White oak	24	1	4	0.17	0	0	0	0	0	0
Post oak	0	0	17	0.71	310	12.92	0	0	17	0.71
Pignut hickory	226	9.42	865	36.04	40	1.67	95	3.96	45	1.88
Total	317	13.21	887	36.96	885	36.88	353	14.71	88	3.67
Maritime Mixed-Oak										
Black oak	278	11.58	22	0.92	1374	57.25	1129	47.04	121	5.04
White oak	177	7.38	45	1.88	16	0.67	71	2.96	8	0.33
Chestnut oak	0	0	3	0.13	0	0	7	0.29	0	0
Pignut hickory	0	0	570	23.75	12	0.5	0	0	2	0.08
Total	455	18.96	640	26.67	1402	58.42	1207	50.29	131	5.46
Interior Mixed-Oak										
Black oak	186	7.75	126	5.25	216	9	0	0	0	0
White oak	441	18.38	4	0.17	6	0.25	94	3.92	0	0
Chestnut oak	49	2.04	23	0.96	23	0.96	135	5.63	4	0.17
Red oak	0	0	0	0	292	12.17	224	9.33	10	0.42
Pignut hickory	0	0	17	0.71	0	0	17	0.71	1	0.04
Total	676	28.17	170	7.08	537	22.38	470	19.58	15	0.63
Grand Total	1823	75.96	2196	91.5	3881	161.71	3176	132.33	260	10.83

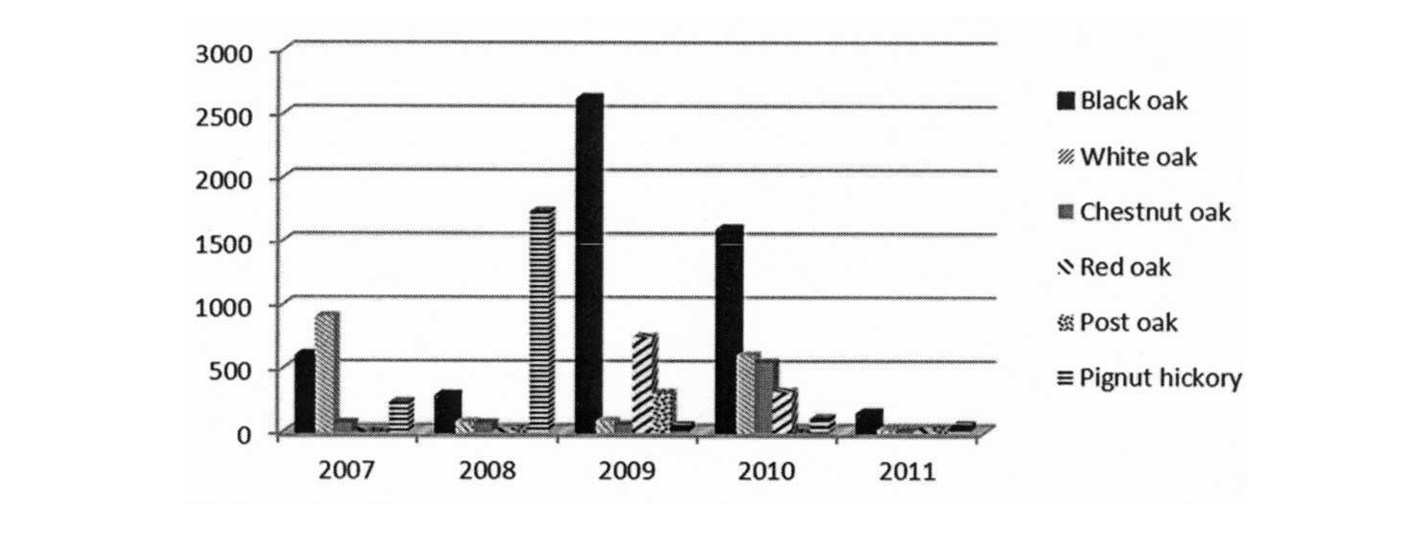

Figure 1. The total number of acorns/nuts recorded each year in plots totaling 120 m^2 in area under oak and hickory trees at the Mashomack Preserve, southeastern NY.

2008). However, a study conducted in central Massachusetts reported that oak trees in the thinned forest produced more acorns, but that this difference was small compared with individual tree and annual variation (Healy et al. 1999).

The results of our study support the idea of high annual, species and point-to-point variation in mast production in most

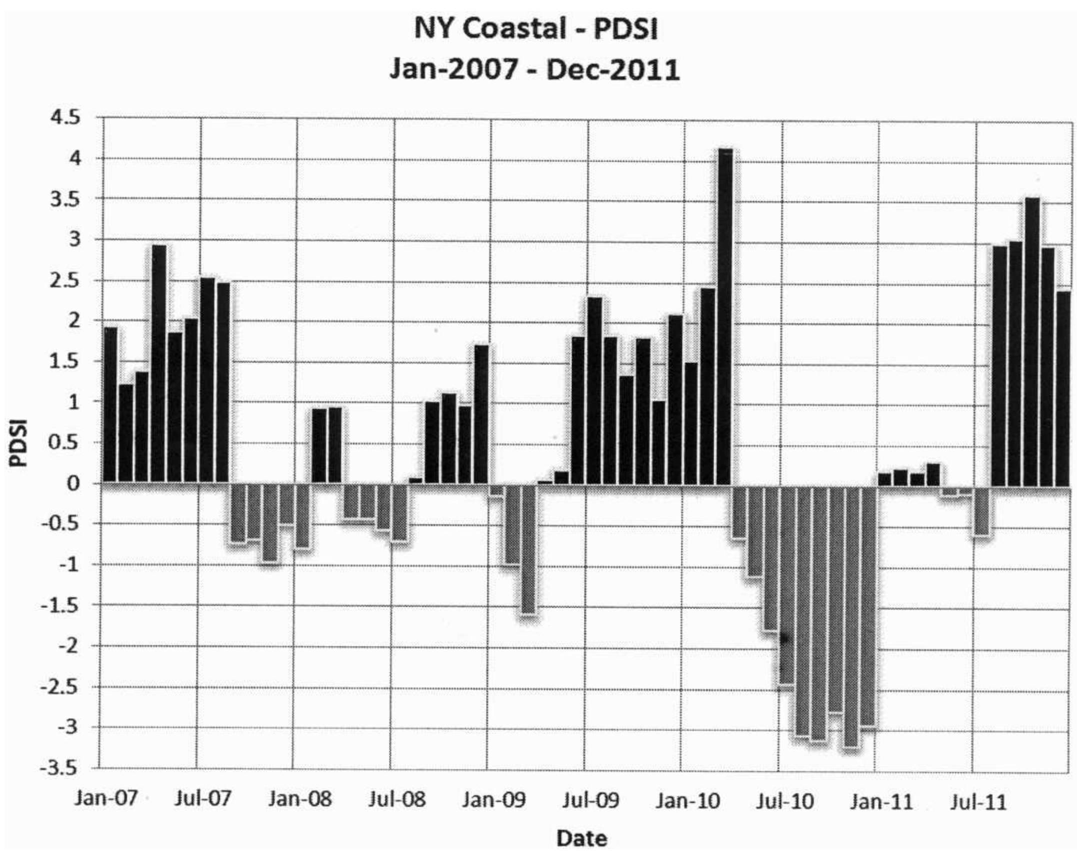

Figure 2. Palmer Drought Severity Index (PDSI) for multiple weather stations on Long Island New York for 2007 to 2011. Positive values indicate moist conditions, whereas negative values indicate drought conditions of increasing magnitude. (http://www1.ncdc.noaa.gov/pub/orders/CDODiv5547665439637.txt)

years. Some, but not all, of the stand-by-stand variation in mast production can be explained by the variation in relative importance of the various trees species. For example, in the maritime mixed-oak stand, black oak dominated the overstory as well as mast production in most years. The same can be said for black oak and pignut hickory in the maritime oak-hickory stand. Alternately, red oak was a minor component of the interior mixed-oak forest, yet it led in mast production in two of four years (excluding 2011). Similarly, pignut hickory was a dominant species in the two interior forest stands, but displayed low mast production relative to that in the maritime stands (Table 2). In addition, significant and prolonged drought events can impact mast production, as seen in 2011. The lack of oak and hickory regeneration at the Mashomack Preserve, as with most eastern forests, can be attributed to a suite of factors such as lack of understory fire, deer browsing, acorn predation, and forest succession (Abrams and Hayes 2008). The results of this study suggest that a lack of acorn/nuts produced by the trees over a five-year period is not a contributing factor to the regeneration problem.

ACKNOWLEDGMENT

We thank The Nature Conservancy, Mashomack Preserve, for providing funding for this study. We also thank Dr. William Zitek and Connie Fischer for their help with collecting acorn data used in this study.

Marc D. Abrams is the Steimer Professor of Forest Ecology and Tree Physiology in the Department of Ecosystem Science and Management at Penn State University, University Park, PA.

Michael S. Scheibel is the Natural Resource Manager at the Mashomack Preserve on Shelter Island, New York.

LITERATURE CITED

Abrams, M.D. 1992. Fire and the development of oak forests. Bioscience 42:346-353.

Abrams, M.D., and V.L.W. Hayes. 2008. Impacts of contrasting land-use history and soils on the composition and dynamics in mixed-oak, coastal plain forests on Shelter Island, New York, USA. Journal of the Torrey Botanical Club 135:37-52.

Healy, W.M., A.M. Lewis, and E.F. Boose. 1999. Variation of red oak acorn production. Forest Ecology and Management 116:1-11.

Kelly, D. 1994. The evolutionary ecology of mast seedling. TREE 9:465-470.

Lombardo, J.A., and B.C. McCarthy. 2008. Silvicultural treatment effects on oak seed production and predation by acorn weevils in southeastern Ohio. Forest Ecology and Management 255:2566-2576.

Nowacki, G.J., and M.D. Abrams. 2008. Demise of fire and mesophication of eastern U.S. forests. BioScience 58:123-138.

Smith, K.G., and T. Scarlett. 1987. Mast production and winter populations of red-headed woodpeckers and blue jays. The Journal of Wildlife Management 51:459-467.

Sork, V.L., J. Bramble, and O. Sexton. 1993. Ecology and mast-fruiting in three species of North American deciduous oaks. Ecology 74:528-541.

Steiner, K.C. 1995. Autumn predation of northern red oak seed crops. Pp. 489-494 *in* K.W. Gottschalk, and S.L.C. Fosbroke, eds. Proceedings, 10th Central Hardwood Forest Conference. General Technical Report NE-197, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Radnor, Pa.

Warner, J.W., Jr., W.E. Hanna, R.J. Landry, J.P. Wulfrost, J.A. Neeley, R.L. Holmes, and C.E. Rice. 1975. Soil survey of Suffolk County, New York. U.S. Department of Agriculture, Soil Conservation Service, New York.

Wolff, J.O. 2006. Population fluctuations of mast-eating rodents are correlated with production of acorns. Journal of Mammalogy 7:850-856.