

Vegetation and two indices of fire on the Delmarva Peninsula

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KIRWAN, J. L. (College of Natural Resources, Virginia Tech, Blacksburg, VA 24061), and H. H. SHUGART (Department of Environmental Sciences, Univ. of Virginia, Charlottesville, VA 22903). Vegetation and two indices of fire on the Delmarva Peninsula. *J. Torrey Bot. Soc.* 127:44–50. 2000. Vegetation, soil charcoal, and fire modeling measurements were used to test the hypothesis that beech (*Fagus grandifolia* Ehrh.) is an indicator of long-term fire history on the Delmarva Peninsula. Three forest communities were determined using principal components analysis, and beech and red maple (*Acer rubrum* L.) were shown to correlate negatively and significantly with fire. These results confirm the observations of early ecologists who recognized disturbance as a major influence on southeastern coastal plain forests.

Key words: fire, Delmarva Peninsula, beech, red maple, southern mixed hardwoods, oak-hickory forest, oak-pine forest, soil charcoal, fire modeling.

Ecologists have long considered fire to be an important disturbance in eastern deciduous forests. Evidence for fire is largely based on accounts of early explorers who described widespread Native American burning practices and open pre-settlement vegetation (reviewed by Russell 1983). A second line of evidence is the transitional nature of vegetation from fire-tolerant species, such as the oaks (*Quercus* spp.) to more fire-intolerant species, such as maple (*Acer* spp.) in the absence of fire (Abrams 1992). However, lack of physical or quantitative evidence and weaknesses in the historical record have led some ecologists to discount the role of fire (Russell 1983; Clark and Royall 1996).

Our research compares modern-day vegetation with two logical, but imperfect, indices of fire — soil charcoal and fire frequency based on modeling. Specifically, we test the hypothesis that American beech (*Fagus grandifolia* Ehrh.) on the Delmarva Peninsula is negatively correlated with the two indices of fire. Beech is very sensitive to fire (Burns and Honkala 1990) and is present in low volumes on the Peninsula and throughout the south Atlantic coastal plain (Beltz et al. 1992). This has led some ecologists to postulate a climax community in the absence of fire characterized by beech and other fire sensitive species (reviewed by Quarterman and Keever 1962).

Delmarva Peninsula forests have been de-

scribed in Maryland by Shreve et al. (1910) and Brush et al. (1980). Shreve et al. cited soil drainage classes and the latitudinal range limits of key tree species as the primary influences on vegetation. On well-drained upland soils loblolly pine (*Pinus taeda* L.) predominates with admixtures of various oaks. On poorly drained upland soils and on all soils near the northern range limit of loblolly pine, the importance of deciduous species increases. Brush et al. also noted similar trends in soil drainage classes and latitude. They described a basket oak (*Quercus michauxii* Nutt.)–loblolly pine association for the southwestern eastern shore region closest to Virginia, and a willow oak (*Quercus phellos* L.)–loblolly association for the central region. Both authors found nearly pure stands of loblolly pine in areas adjacent to tidewater, and in early-successional forests. Neither author discussed fire as an influence, although Brush (1986) found stratigraphic evidence for fires in the Chesapeake region between 1000 and 1200 AD.

North and south of Delmarva, ecologists have recognized fire as an important influence on the vegetation, noting a predominant pine species and its adaptation to fire. To the south, the coastal pine belt has been described as a fire sub-climax (Weaver and Clements 1929; Garren 1943) based largely on the presence of fire-tolerant longleaf pine (*Pinus palustris* Miller), fire-tolerant oaks and herbaceous vegetation. To the north, the New Jersey Pine Barrens and Pine Plains are believed to have developed under the

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influence of repeated fires, resulting in the predominant pitch pine (*Pinus rigida* Mill.) and fire-tolerant oaks (Little 1979). Shreve et al. (1910) compared these regions, and found the floristic elements of the Pine Barrens and the pine belt are lacking in Maryland, but considered Delmarva's forests to be an uninterrupted extension of the southeastern pine belt.

Methods. STUDY AREA. The Delmarva Peninsula consists of Delaware and the Eastern Shore counties of Maryland and Virginia. Accomack County, Virginia, was chosen as the study area because it has a digitized soil survey (Peacock and Edmonds 1994) from which a geographic information system (GIS)-based fire model could be developed. Accomack County is bordered to the west by Chesapeake Bay, to the east by the Atlantic Ocean, and to the north by Worcester County, Maryland.

Topographically, Accomack can be divided into three regions. A high (8–16 m) central terrace of mid-Pleistocene origin is bordered to the east and west by two lower terraces of late-Pleistocene origin. Discontinuous escarpments, which mark the border between terraces, represent ancestral shorelines of the Chesapeake Bay and Atlantic Ocean, respectively. The upland soils of these terraces can be divided into two general classes: well-drained soils and those that have a water table at or near the surface for part of the year (hydric soils). Forest stands on hydric soils typically have patches of standing water during the spring fire season in Accomack County.

STAND SELECTION. A stand is defined in this study as a forested area of homogeneous character (floristic composition, soil type) that is large enough to provide 10 basal area plots. To select stands, the county was subdivided into three transects that represented north, south, and central sections. Each transect consisted of three adjacent (east to west) soil survey sheets taped together for easy field reference. Each transect was further subdivided into three topographic positions — bay side, central terrace, and sea side; this resulted in nine subdivisions. Three stands were selected per subdivision, for a total of 27 stands.

Stands were selected by driving each road on a transect until naturally regenerating forest stands could be found for each major upland soil type. Where roadside stands were not found, interior locations were investigated. In each case,

the first stand to meet these requirements was selected. Because most well-drained soils on Delmarva have been converted to agriculture, these soil types were underrepresented.

SAMPLING. Within each stand, 10 plot centers were uniformly selected to measure vegetation and charcoal. The first plot center was located by walking 40 m from the edge of the road on a right-angle azimuth. Two parallel lines of five plot centers were subsequently located by following an azimuth parallel to the main axis of the stand, with plot centers at 30-m intervals. At each plot center, the variable-radius method (Avery 1975) was used to determine basal area and frequency of tree species (basal area factor = 10). Seedlings, herbs, and shrubs were also measured on 10 m² plots, but the data were not used in this analysis.

CHARCOAL. A soil core was removed at each plot center using a standard soil probe/tube sampler. A 3 cm × 1 cm plug was removed at the 30-cm depth from each core and taken to the lab for charcoal analysis. The 30-cm depth was chosen because it typically marks the top of the B soil horizon in Accomack County (Peacock and Edmonds 1994), where fine-sized charcoal pieces would be expected to accumulate. We also expected charcoal at this depth to represent an older source than at the surface and to provide a longer-term index of fire history. A total of 270 soil plugs were investigated.

In the laboratory, the 10 soil plugs from each forest stand were combined, washed, dried, and passed through a series of sieves to remove all but the 200- to 250-micron particle size class. From this material, a subsample of approximately 3300 particles, mostly sand grains, was observed with a 40×-dissecting microscope. Darkly stained sand grains, amorphous black pieces, and black cellular material were all counted as "charcoal" based on evidence from experimental fires with leaf litter (Kirwan 1998).

FIRE FREQUENCY MODELING. The fire-spread model *Farsite* (Finney 1996) was used to experimentally grow fires on the landscape. Between 40 and 43 ignitions were made uniformly across each transect (120 total), and fires were allowed to grow for four days using April fire weather conditions (Michaels pers. comm.). A fire frequency number was assigned to each forest stand based on the number of times its grid cell burned during the 120 simulations.

The fire model requires five data layers, or

themes. Our fuels theme was developed directly from the soil survey polygons, with well-drained soil types combined and assigned USDA fuel model #9—hardwood litter (Andrews 1986). Hydric soil types were assigned a custom fuel type, using actual measurements of fuel loads and matching spread rates of historic fires described in Virginia Department of Forestry (VDOF) records. Marsh and stream lowlands were combined and treated as water. Grid cell size was set to 100 m so that a 50-m stream lowland would act as a barrier (Windisch 1987). Topographic themes of elevation, slope, and aspect were set to zero following the technique used by Green et al. (1995) in a similar area of low relief. Canopy cover was set to level one (20–40%) based on observations of leafing-out of trees and an estimate of 10–15% loblolly pine cover in the presettlement landscape (Shreve et al. 1910).

April fire weather was used to grow fires because this is the most active fire season under current climate conditions in terms of number of fires and acreage burned (Kirwan 1998). We agree with Russell (1983) that the often-cited fall circle hunts conducted by native Americans were probably limited in extent. Likewise, summer fires spread slowly under a full forest canopy, which reduces mid-flame wind speed (Finney 1996).

Norfolk Municipal Airport data indicate southwest winds characterize 40% of April wind speed and direction, and dominate periods without rain. A weather stream was created to capture this feature, plus the passing of a cold front with northwest winds, characteristic of extreme weather conditions. The model period was limited to four days because of the increasing length of computational time required between time steps and because the period was long enough to capture the greatest variability in wind speeds. Wind speeds increased from 5 to 20 mph during the period.

Principal components analysis was used to interpret plant community data and to provide a correlation matrix of stand variables. Frequency values for each species were used as stand variables, following the recommendation of Bakuzis and Kurmis (1978). Soil charcoal and fire frequency values were also included as stand variables so that they would appear in the correlation matrix of species. This allowed a statistical comparison of individual species' loading on the two independent indices of fire: presence

of soil charcoal and fire frequency based on modeling.

We used an *a-priori* ranking of species from the fire tolerance literature (Kirwan 1998) as a basis for evaluating the two indices. In order from low to high tolerance, the rankings were: *Fagus*, *Ilex*, *Nyssa*, *Pinus taeda*, *Liquidambar*, *Acer r.*, *Lireodendron*, *Ulmus*, *Sassafras*, *Cornus*, *Q. alba*, *Q. coccinea*, *Q. falcata*, *Q. velutina*, *Carya* spp., and *Q. stellata*.

Results. Principal components analysis (Fig. 1) shows three distinct community types clustered along axes of soil drainage (factor 1) and nutrients (factor 2). The *southern mixed hardwood* (SMH) type is characterized by 16 stands with factor 1 scores < -10 that are underlain by hydric soils. The *oak-pine* (OP) and *oak-hickory* (OH) types are characterized by seven stands with factor 1 scores > 100 that are underlain by well-drained soils. The remaining four stands (three SMH and one OP) hold intermediate positions along the factor 1 axis and are underlain by moderately well drained soils.

Nutrient status of stands was evaluated using plant indicator values from Bakuzis and Kurmis (1978) and Brand (1985), and nutrient strategy theory by Monk (1970). Stands in the upper half of the factor 2 axis have a larger component of high nutrient indicator species, such as the hickories, compared with the lower half of the axis. Likewise, stands in the lower half of the factor 2 axis have a larger evergreen component, suggesting a strategy for conserving limited nutrients. The single stand at the upper left of Figure 1 was unique in having the greatest amount of standing water in terms of area covered and depth. Frequency of major tree species in each community type (Table 1) is expressed as the percentage of plots in which a tree was tallied using the combined data from all the stands in the type. We compared these frequencies with the ecological literature and labeled the types accordingly. The Southern Mixed Hardwood stands resemble Quarterman and Keever's (1962) type of the same name, with a mixture of hardwood species sharing dominance with the needle-leaved evergreen, loblolly pine. The Oak-Pine stands resemble Braun's (1950) type, with four oak species sharing dominance with loblolly pine. Likewise, the Oak-Hickory stands resemble Braun's (1950) type and are dominated by the same oaks as the Oak-Pine group, with the addition of two hickories. Beech is dominant only in the SMH group.

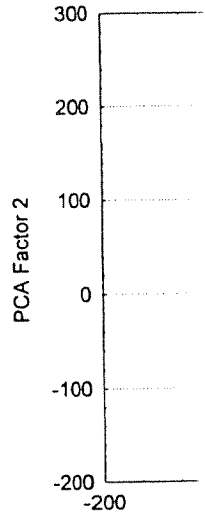


Fig. 1. Forest stands as nutrients (see frequency $\geq 50\%$)

Fire index score community type. The lowest average number of both indices exist in these types.

All but two species with the charcoal lower (intolerant) or were not ranked positively correlated with the *a-priori* list. Impo

Table 1. Frequency by community type and micron size class (and range) of timber

Southern mixed hardwood (19 stands)	
Trees	
<i>Acer rubrum</i>	(83)
<i>Pinus taeda</i>	(79)
<i>Liquidambar styr.</i>	
<i>Quercus alba</i>	(55)
<i>Nyssa sylvatica</i>	(3)
<i>Quercus falcata</i>	(1)
<i>Ilex opaca</i>	(32)
<i>Fagus grandifolia</i>	
<i>Quercus michauxii</i>	
Pieces of soil charcoal	
Ave.	= 29 (9–10)
Modeled fire frequency	
Ave.	= 4.2 (2–8)

frequency based on
 ranking of species from
 (Kirwan 1998) as a
 two indices. In order
 the rankings were:
Pinus taeda, *Liquidambar*,
Cornus, *Sassafras*, *Cornus*,
Q. falcata, *Q. velutina*.

components analysis (Fig.
 community types cluster
 drainage (factor 1) and
 nutrients (factor 2). Three
 clusters correspond with
 community-types. Filled
 circles are stands with a
 high frequency ($\geq 50\%$)
 of beech.

Fire index scores ranged
 widely within each
 community type. Although
 the SMH stands had the
 lowest average charcoal
 count and the lowest
 average number of times
 burned, their ranges for
 both indices exceeded
 that of the other two
 types.
 All but two species that
 negatively correlated
 with the charcoal index
 (Table 2) are from the
 lower (intolerant of fire)
 half of the *a-priori* list,
 or were not ranked.
 Similarly, seven of the
 eight positively correlated
 species agree with the
a-priori list. Importantly,
 beech is negatively cor-

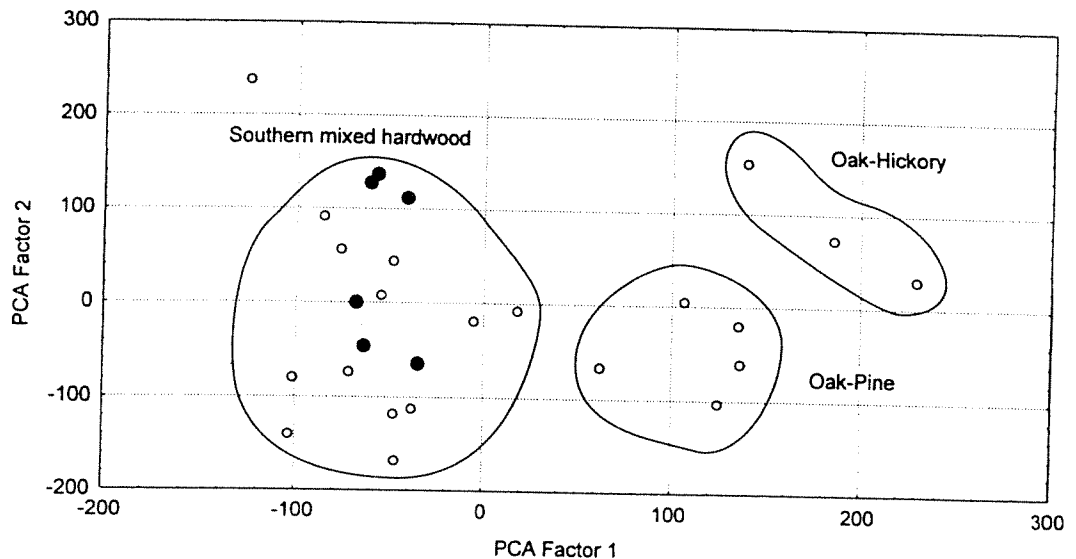


Fig. 1. Forest stands as they appear in ordination space. PCA factor 1 is interpreted as soil drainage; factor 2 as nutrients (see text). Three clusters correspond with community-types. Filled circles are stands with a high frequency ($\geq 50\%$) of beech.

related with charcoal, and the correlation is significant.

All but two species that negatively correlated with the fire-modeling index (Table 3) are from the lower (intolerant of fire) half of the *a-priori* list, or were not ranked. All of the six positively correlated species agree with the *a-priori* list. Beech has a strongly negative and highly significant correlation, as hypothesized.

Discussion. Principal components analysis of stand vegetation data revealed three community

related with charcoal, and the correlation is significant.

Discussion. Principal components analysis of stand vegetation data revealed three community

Table 1. Frequency of major tree species (percentage of occurrence across all sample plots) and fire indices by community type. Charcoal values are average number (and range) of pieces counted in the 200- to 250-micron size class taken from soil samples at forest stands. Fire frequency values represent the average number (and range) of times a stand burned during simulated fires.

Southern mixed hardwood (19 stands)	Oak-pine (5 stands)	Oak-hickory (3 stands)
Trees		
<i>Acer rubrum</i> (83)	<i>Pinus taeda</i> (78)	<i>Quercus alba</i> (77)
<i>Pinus taeda</i> (79)	<i>Quercus alba</i> (58)	<i>Quercus falcata</i> (60)
<i>Liquidambar styraciflua</i> (56)	<i>Quercus falcata</i> (58)	<i>Carya glabra</i> (43)
<i>Quercus alba</i> (55)	<i>Cornus florida</i> (38)	<i>Quercus coccinea</i> (43)
<i>Nyssa sylvatica</i> (34)	<i>Quercus coccinea</i> (36)	<i>Quercus velutina</i> (43)
<i>Quercus falcata</i> (33)	<i>Quercus velutina</i> (36)	<i>Carya tomentosa</i> (37)
<i>Ilex opaca</i> (32)	<i>Acer rubrum</i> (34)	
<i>Fagus grandifolia</i> (29)		
<i>Quercus michauxii</i> (29)		
Pieces of soil charcoal		
Ave. = 29 (9-105)	Ave. = 82 (27-122)	Ave. = 50 (26-68)
Modeled fire frequency (number of times burned during 120 simulations)		
Ave. = 4.2 (2-8)	Ave. = 5.0 (3-7)	Ave. = 5.3 (3-7)

Table 2. Correlation of tree species with soil charcoal.

Tree species	Correlation	Significance
<i>Nyssa sylvatica</i>	-0.466	0.007
<i>Acer rubrum</i>	-0.323	0.050
<i>Magnolia virginiana</i>	-0.320	0.052
<i>Fagus grandifolia</i>	-0.318	0.053
<i>Ilex opaca</i>	-0.301	0.063
<i>Quercus michauxii</i>	-0.270	0.087
<i>Oxydendrum arboreum</i>	-0.231	0.123
<i>Liquidambar styraciflua</i>	-0.216	0.057
<i>Quercus phellos</i>	-0.189	0.173
<i>Ulmus americana</i>	-0.109	0.295
<i>Quercus alba</i>	-0.056	0.388
<i>Pinus taeda</i>	-0.040	0.422
<i>Quercus nigra</i>	-0.032	0.437
<i>Quercus stellata</i>	-0.026	0.449
<i>Sassafras albidum</i>	+0.027	0.447
<i>Quercus falcata</i>	+0.170	0.198
<i>Pinus virginiana</i>	+0.178	0.188
<i>Carya glabra</i>	+0.231	0.123
<i>Carya tomentosa</i>	+0.312	0.057
<i>Quercus coccinea</i>	+0.427	0.013
<i>Prunus</i> spp.	+0.504	0.004
<i>Quercus velutina</i>	+0.544	0.002
<i>Liriodendron tulipifera</i>	+0.560	0.001
<i>Cornus florida</i>	+0.806	0.000

types that respond to gradients of soil drainage and nutrients. The division of community types along an axis of soil drainage matches the findings of Shreve et al. (1910) and Brush (1980) in their descriptions of Delmarva forests in Maryland. Our SMH type resembles Brush's basket oak-loblolly pine association and shares characteristics with Shreve et al.'s two clay loam upland forest types. Our oak-hickory also resembles Shreve et al.'s deciduous upland forest beyond the northern range limit of loblolly pine.

Individual species' correlation with the soil charcoal and modeled fire frequency index were in general agreement with the *a-priori* ranking based on fire tolerance literature. Most species ranked as intolerant of fire correlated negatively, and those ranked tolerant correlated positively. However, most of the individual species' correlations were weak and insignificant. We consider this to be consistent with the idea that two independent indices, soil charcoal and modeled fire frequency, are imperfect. Nonetheless, when two imperfect indices are taken together and are in agreement, as in this case, we have greater confidence in their predictability. If a species is ranked similarly by both indices, the likelihood that it is correlated with fire is enhanced.

The soil charcoal and modeled fire frequency index confirm the observation that beech is an indicator of long-term fire history and is a cli-

Table 3. Correlation of tree species with modeled fire frequency.

Tree species	Correlation	Significance
<i>Acer rubrum</i>	-0.526	0.003
<i>Fagus grandifolia</i>	-0.406	0.022
<i>Quercus falcata</i>	-0.292	0.079
<i>Ulmus americana</i>	-0.280	0.088
<i>Quercus michauxii</i>	-0.252	0.112
<i>Quercus stellata</i>	-0.220	0.146
<i>Liriodendron tulipifera</i>	-0.214	0.152
<i>Liquidambar styraciflua</i>	-0.188	0.184
<i>Ilex opaca</i>	-0.161	0.222
<i>Nyssa sylvatica</i>	-0.116	0.290
<i>Quercus alba</i>	-0.054	0.394
<i>Pinus taeda</i>	-0.015	0.470
<i>Prunus</i> spp.	-0.005	0.490
<i>Magnolia virginiana</i>	+0.010	0.479
<i>Quercus phellos</i>	+0.054	0.394
<i>Sassafras albidum</i>	+0.097	0.316
<i>Pinus virginiana</i>	+0.176	0.190
<i>Oxydendrum arboreum</i>	+0.219	0.146
<i>Carya glabra</i>	+0.226	0.139
<i>Carya tomentosa</i>	+0.228	0.136
<i>Quercus velutina</i>	+0.229	0.135
<i>Cornus florida</i>	+0.235	0.129
<i>Quercus nigra</i>	+0.250	0.114
<i>Quercus coccinea</i>	+0.338	0.049

max species in the absence of fire. In our study area, beech occurred in nine of the 27 stands. Of the nine, six (2/3) were on the bay side of the Peninsula, where the Chesapeake Bay limits the source area for fires driven by westerly winds. Both indices indicated a higher fire frequency on the central terrace and seaside, where beech was generally absent, compared with the bayside. However, beech was absent from a number of sites with low fire indices. On hydric soils, we attribute beech absence to its intolerance for anaerobic soil conditions (McKnight et al. 1981). In other words, we believe beech exists where there is protection from fire but soil conditions are not excessively wet.

Red maple also appears to be a useful indicator species of long-term fire history. We placed this species higher than beech in *a-priori* rankings because red maple's sprouting ability enables it to survive repeated burning. Thus, its significant and positive correlation was a surprise. However, burning of oak and pine forests before European settlement has been cited as a key factor limiting maple's domination (Abrams 1992) and foresters regard it as a plant pest that is increasing in abundance as a result of fire protection policies (Dierauf pers. comm.). Red maple has also been cited as a co-dominant (with beech) in a theoretical climax on the southeastern coastal plain (Wells 1928.)

Both indices co- oak (*Quercus coc* suggests that this spe- cator of fire histo- thin bark and is - orous sprouter and that have a fire - 1990). Also, the - gradually buildin- been cited as thei- tage in a regime - viewed by Crow - subgenera produ - spring (after the - year's growth be - fires.

Confidence in - pered by poor - production, trans - particular, mech - soil profile. For - cluding charcoal - and thus over-req - well-drained soil - ally high water - movement of sn - horizon and res - However, moun - over-trees were - the resultant chu - ondary means o - pared charcoal - hydric soil site - ence (Kirwan 19 - pieces for south - 1) provides fur - and does accun - cm depth.

The modeled - pered by a po - regimes and pa - example, that r - the Delmarva P - up the streams - emergent veget - forested swam - 1997). This we - that bayside hy - frequent) woul - than our model - erentially burn - and local popu - make deer scar - ingly, our hig - found on a per

species with modeled

Correlation	Significance
0.526	0.003
0.406	0.022
0.292	0.079
0.280	0.088
0.252	0.112
0.220	0.146
0.214	0.152
0.188	0.184
0.161	0.222
0.116	0.290
0.054	0.394
0.015	0.470
0.005	0.490
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0.235	0.129
0.250	0.114
0.338	0.049

fire. In our study of the 27 stands, the bay side of Peake Bay limits are by westerly higher fire frequency seaside, where compared with the absent from a sites. On hydric sites to its intolerance (McKnight et al.) we believe beech exist from fire but soil et.

a useful indicator of fire history. We believe in *a-priori* routing ability of fire. Thus, its presence was a survival pine forests have been cited as a plant pest that result of fire promotion. Red maple dominant (with the southeast-

Both indices correlate positively with scarlet oak (*Quercus coccinea* Muench.), which suggests that this species is a useful positive indicator of fire history. Although scarlet oak has thin bark and is susceptible to fire, it is a vigorous sprouter and is better represented in stands that have a fire history (Burns and Honkala 1990). Also, the ability of oaks to compete by gradually building below-ground resources has been cited as their principal competitive advantage in a regime of regular surface fires (reviewed by Crow 1988). Species in the red-oak subgenera produce seeds that germinate in spring (after the fire season); this allows a full year's growth before the first chance of spring fires.

Confidence in the soil charcoal index is hampered by poor understanding of soil charcoal production, transport, and preservation and, in particular, mechanisms of accumulation in the soil profile. For example, organic material, including charcoal, should be better preserved, and thus over-represented in hydric soils than in well-drained soils. On the other hand, a seasonally high water table should slow downward movement of small particle pieces into the B-horizon and result in an under-representation. However, mounds and depressions from blown over-trees were common on hydric soil sites, and the resultant churning of soil may provide a secondary means of downward transport. We compared charcoal at 10- and 30-cm depths from a hydric soil site and found no significant difference (Kirwan 1998). The wide range of charcoal pieces for southern mixed hardwood sites (Table 1) provides further evidence that charcoal can and does accumulate in hydric soils at the 30-cm depth.

The modeled fire frequency index is hampered by a poor understanding of historic fire regimes and patterns of ignition. We know, for example, that native American populations on the Delmarva Peninsula were concentrated well up the streams and rivers where fresh water and emergent vegetation were available, and that forested swamps were of little use (Rountree 1997). This would logically lead us to assume that bayside hydric sites (where beech is most frequent) would have received fewer ignitions than our model imposed. Peninsulas were preferentially burned for hunting (Rountree 1989), and local populations were sufficiently large to make deer scarce (Rountree 1997). Not surprisingly, our highest soil charcoal levels were found on a peninsula, but the model gave con-

flicting data (low frequency) because the site was protected on three sides by water.

Our fire model did not address the influence of fires that occur outside of the spring fire season. Summer lightning fires have been proposed as an important influence on vegetation in the mid-Atlantic region (Ruffner and Abrams 1998). Fall wild fires are also known to burn large areas during drought years. It is unclear how the spread and direction of these fires would differ from our model. A still larger question is how do we merge the different regimes into a logical, comprehensive model that captures the additional variability.

Conclusions. The vegetation of the Delmarva Peninsula in Virginia is similar to that described for Maryland, with plant community types largely following soil drainage classes. Within community types, certain species appear to have been affected by a long-term fire regime. Beech and red maple are negatively and significantly correlated with fire and may have been reduced or eliminated from certain locations by fire. Scarlet oak is positively and significantly correlated with fire.

The two fire indices used in this study, soil charcoal and modeled fire frequency, produced results that are in general agreement with the ecological and silvicultural literature on fire. A better understanding of soil/charcoal dynamics and historic fire regimes will be necessary if their usefulness is to be extended.

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