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# Hardwood Forests of Virginia's Southern Blue Ridge: A Second Look

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## ABSTRACT

Discovery of errors in data entry for an earlier vegetational ordination (M. Farrell and S. Ware, 1988, Virginia J. Sci. 39:250-257) made necessary a reanalysis of vegetation data from 16 forest stands along the Southern Blue Ridge escarpment in Virginia. Despite differences in details, reanalysis confirmed essentially all previous conclusions. *Quercus prinus*, *Q. rubra*, and *Q. velutina* were dominants, and *Acer rubrum* and *Oxydendron arboreum* were the major non-oak species. The last two species plus *Cornus florida* were important in the understory; none of the oaks were. Overall *Carya* spp. were much less important, and *Q. alba* more important, than northward in the central Blue Ridge, and *Quercus coccinea* was much less important than on ridges of the Ridge and Valley Province to the west. Despite correlation of elevation with the first axis of the new ordination (r = 0.5238), no dominant species showed association with either higher or lower elevation sites. Somewhat higher soil mineral content (Mg, Ca) in stands dominated by *Q. velutina* and *Oxydendron arboreum* did not show statistical significance at 0.05 probability level, and transformed aspect values (direction of exposure) failed to correlate significantly with abundance of any species.

## INTRODUCTION

In an earlier publication Farrell and Ware (1988) presented a vegetational ordination of 16 second-growth, predominantly hardwood stands along a 56 km section of the Southern Blue Ridge escarpment in Virginia, from Roanoke Mountain south to Mabry's Mill. In 1996 a summary table of the vegetational data collected during that study was given to Harold S. Adams for use in a Blue Ridge-wide survey he was coordinating. In using the data, he came upon some errors in the summary table which he called to my attention. Original field data sheets from the Farrell and Ware (1988) study have been used to determine the correct numbers, and appropriate corrections have been made in the summary table. The errors occurred when two-letter acronyms for species were misread during the transfer of data from stand summary sheets to the grand summary table. Margaret Farrell's hand-printed "Qv" and "Qr" are virtually indistinguishable, so that values listed for Qv (=*Quercus velutina*) were sometimes entered in the summary table under Qr (= *Quercus rubra*). Further, she twice misread her hand-printed "Oa" (= *Oxydendron arboreum* ) as "Qa" (= *Quercus alba*). These errors caused over-representation of *Quercus rubra* and *Quercus alba* in our summary table, and under-representation of *Quercus velutina* and *Oxydendron arboreum*. Farrell also merged data for *Betula lutea* and *Betula lenta* because of their identical "Bl" acronyms, and confounded the data for *Carya ovata* and *C. ovalis* (both "Co") for the same reason.

These findings offer good arguments for more recently accepted practice of using highly distinguishable four-letter acronyms combining the first *two* letters of both the genus and the species in acronyms (QUVE vs. QURU, OXAR vs. QURU, BELU vs. BELE; though a still identical CAOV for *Carya ovata* and *C. ovalis*). More importantly, these findings mean that the ordination presented in Farrell and Ware (1988) was based on a summary table which contained errors. Since I participated in the gathering of the data and was co-author of the paper, I felt it was my responsibility to re-do the ordination using corrected data, and make any necessary additions, deletions, or reconfirmations to the results and discussion presented in our previous publication. The corrected analysis is presented here.

## METHODS

In our original study we sampled stands that were predominantly hardwood, lacked evidence of recent disturbance by selective cutting, and did not have high abundances of *Liriodendron tulipifera* or *Robinia pseudo-acacia*, both of which usually indicate past cultivation in the Blue Ridge (Braun 1950). All sampled stands were presumably post-timbering second growth. Sampling was by the combined Bitterlich-circular quadrat method (Levy and Walker 1971) now widely used in studies of Virginia forest vegetation (Ware 1991). Importance values (I.V., in percent) for overstory (> 10 cm diameter breast high) were averages of relative density and relative basal area; for saplings or understory (2.5 - 10 cm dbh), relative density alone was used as a measure of abundance. Nomenclature and authorities follow Harvill et al. (1992). For details of stand selection, sampling methods, and measurement of environmental variables (elevation, direction of exposure, degree of slope, pH, Ca, Mg, K, and P), see Farrell and Ware (1988). In the previous analysis we grouped direction of exposure (aspect) into 24 directional categories (N, NNE, NE, ENE, E, ESE, etc.) for Chi square association analysis. In this reanalysis, direction of exposure in degrees was transformed into an aspect index, using first a transformation yielding a symmetrical distribution of aspect values around the compass, from zero at SW to 2.00 at NE (Beers et al. 1966); and for comparison, a transformation yielding an asymmetrical distribution of aspect values around the compass, from zero at SW to 2.00 at N (E. Crone and S. Ware, unpublished). Such aspect indices transform direction of exposure from radial to linear values, allowing aspect to be tested directly for correlation with ordination axes, something that cannot be done with aspect in degrees. In this reanalysis detrended correspondence analysis (DCA) was carried out using the PC program CANOCO (ter Braak 1988) rather than the mainframe program DECORANA used in the previous analysis (Hill 1979).

## RESULTS

The errors in the data in our original ordination affected the ordination positions of individual stands in relation to one another, so in the new DCA ordination these have changed somewhat (particularly on the second axis; Figs. 1 and 2). Nevertheless, the new analysis confirms nearly all our original conclusions, though the details supporting these conclusions vary somewhat from the original analysis. A corrected table of abundances of the major species is presented in Table 1, with adjustments for the errors in the summary table on which the original Table 1 of Farrell and Ware (1988) was based, and with corrections of some additional typographical errors in their table. The

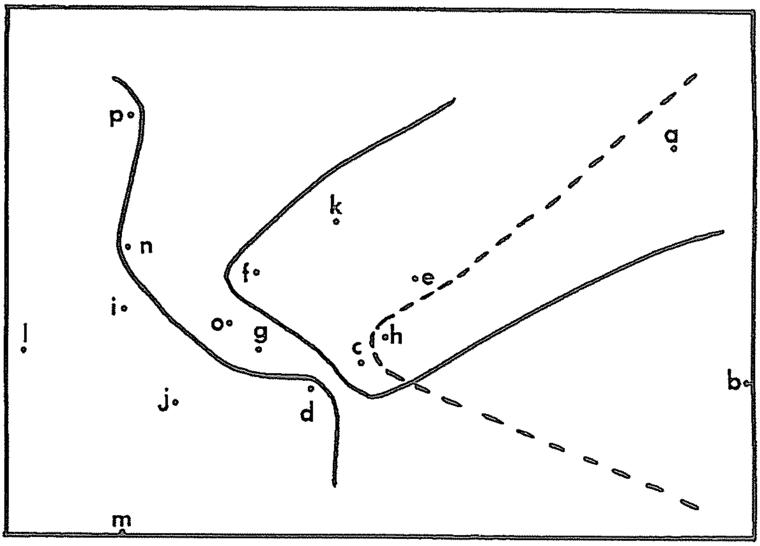

FIGURE 1. DCA ordination of 16 stands on the southern Blue Ridge escarpment in Virginia. The eigenvalues are 0.4776 for the first axis and 0.1530 for the second axis. The left solid line enclosures to the left the six stands with highest *Quercus rubra* I.V. (> 10); the right solid line encloses to the right the six stands with highest *Quercus velutina* I.V. (> 10); the right dashed line line encloses the three *Quercus alba* stands with I.V. > 10.

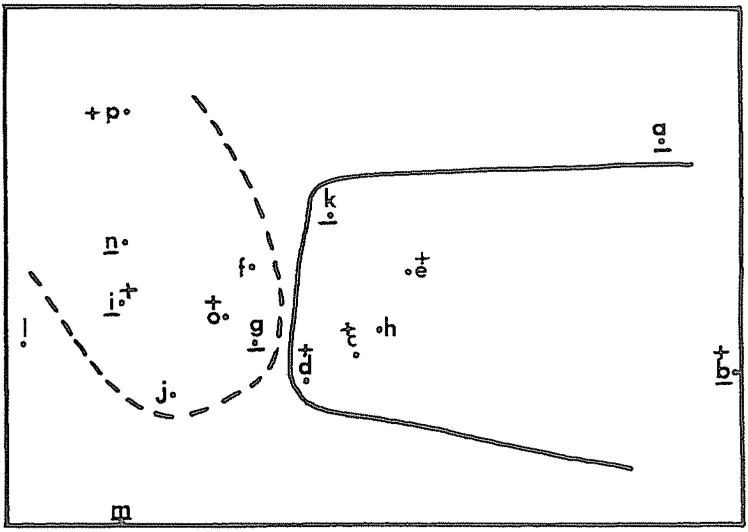

FIGURE 2. DCA ordination as in Fig. 1. The left dashed line encloses the seven stands with highest *Acer rubrum* I.V. (> 9). The right solid line encloses the five stands (b,c,d,e,k, but not h) with highest *Oxydendron arboreum* I.V. (>10). An underlined letter marks the seven stands where *Acer rubrum* reached an understory relative density of >10%. A plus sign beside a letter indicates the seven stands where *Oxydendron arboreum*

TABLE 1. Summary of the presence, abundance, and rank in importance of major species in 16 stands along southern Blue Ridge in Virginia. All species reaching I.V. ≥ 10 in any stand or ranking at least third in any stand are included. *Carya ovalis* and *Nyssa sylvatica* are included for clarification of confounded data in Table 1 of Farrell and Ware (1988), and *Ilex montana* for its importance in the understory. For the four major understory species, numbers in parenthesis are given to indicate additional stands where that species had relative density > 10 in the understory though it lacked I.V ≥ 10 in the overstory, or was present in the understory though not in the overstory.

| Species | Number of Times Ranking | | | Number | Number | Highest I.V. |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | I.V≥10 | Present | Obtained |
| *Quercus prinus* | 11 | 2 | - | 14 | 16 | 56.2 |
| *Quercus rubra* | 3 | 2 | 3 | 6 | 13 | 42.6 |
| *Quercus velutina* | - | 4 | 2 | 6 | 14 | 21.8 |
| *Quercus alba* | 1 | - | 2 | 3 | 13 | 46.4 |
| *Acer rubrum* | - | 3 | 4 | 6 (+ 4) | 15 | 23.5 |
| *Oxydendron arboreum* | - | 2 | 2 | 5 (+ 3) | 8 (+ 1) | 21.9 |
| *Liriodendron tulipifera* | - | 1 | - | 1 | 10 | 18.4 |
| *Quercus coccinea* | - | 1 | - | 1 | 9 | 10.3 |
| *Carya glabra* | - | 1 | - | 1 | 4 | 17.5 |
| *Carya ovata* | - | - | 1 | 1 | 5 | 11.9 |
| *Carya ovalis* | - | - | - | - | 9 | 6.4 |
| *Betula lutea* | - | - | - | 1 | 3 | 12.2 |
| *Betula lenta* | - | - | 2 | - | 4 | 9.1 |
| *Pinus rigida* | 1 | - | - | 1 | 2 | 41.3 |
| *Nyssa sylvatica* | - | - | - | - | 13 | 9.4 |
| *Cornus florida* | - | - | - | - (+10) | 7 (+ 5) | 8.8 |
| *Ilex montana* | - | - | - | - (+ 3) | 3 (+ 4) | 5.0 |

values of environmental variables given in Table 2 of Farrell and Ware (1988) were correct, and are not repeated here.

*Quercus prinus* (chestnut oak) was the overwhelming dominant in the sampled stands at all elevations and exposures, forming a background against which the importance of other species varied.

*Quercus rubra* (northern red oak) was the second most abundant species, with I.V. > 10 in six stands (not nine as reported previously). *Quercus velutina* (black oak) also had I.V. > 10 in six stands, falling at the opposite end of the ordination from stands where northern red oak was most important (Fig. 1). *Quercus alba* (white oak) reached high I.V. at the same end of the first axis as black oak. In the corrected data, white oak reached I.V. > 10 in three rather than four sites, and did not show the two-stand overlap with northern red oak we erroneously reported earlier (Farrell and Ware 1988). The use of transformed aspect values and the deletion of a SSW-facing stand from those reported to have high white oak I.V. eliminated the supposed evidence of association of white oak with low aspect values (more xeric exposures) noted in the previous analysis.

The most important non-oaks were *Acer rubrum* (red maple) and *Oxydendron arboreum* (sourwood), with I.V. > 10 in 6 and 5 sites, respectively. High I.V. of these two species was dissociated in the overstory, as we noted in our earlier analysis, but the dissocation is not strong if both understory and overstory are considered. In the understory sourwood reached 10% relative density in three of the seven stands within the red maple overstory contour (Fig. 2), and red maple achieved an understory relative density > 10% in two of the five stands with high sourwood I.V. in the overstory.

The corrected vegetational data produced a rearrangement of stands on the new DCA ordination that yielded a significant correlation of elevation ($r = -0.524$, $P < .05$) with the first axis of the ordination, a relationship not revealed in the previous analysis. This correlation must be viewed with caution, however, since neither of the two major species concentrated at that end of the ordination show a requirement for higher elevation; northern red oak reaches I.V. > 10 in three stands with higher than median elevation and three with lower than median elevation, and red maple reaches I.V. >10 in two stands with higher than median elevation and four stands with lower than median elevation. The possible relationship between red maple abundance and direction of exposure mentioned in our previous analysis disappears when either of the aspect transformations employed in this reanalysis are applied.

Data correction removed some stands with low aspect values (southerly and westerly exposures) from the set of stands with high I.V. of northern red oak. Five of the six remaining stands with high northern red oak I.V. have higher (> 1.0) aspect using the Crone and Ware transformation, and four of the six do so using the Beers et al. (1966) transformation. Further, transfer of those low aspect stands to the set of stands with high I.V. of black oak means that five of the six stands in the black oak enclosure have lower (< 1.0) aspect values. Because of the small number of observations (stands) involved, no statistically significant association (Chi square) of either species with aspect can be demonstrated. This same sample size limitation applies to the finding that 5 of the 6 black oak stands have higher than median Ca and Mg values, as do 4 of the 5 stands with high sourwood I.V., both mentioned in our previous analysis. Since median values for both soil Ca and soil Mg are rather low in any case (Table 2 of Farrell and Ware 1988), their values in the black oak and sourwood stands are higher only in the relative sense, and our previous analysis no doubt made too much of these.

Five hickory species (*Carya ovata*, *C. glabra*, *C. ovalis*, *C. tomentosa*, *C. cordiformis*) were encountered (four each in stands P and D), but only two (*C. ovata* in stand A, *C. glabra* in stand L) had I.V.≥ 10 in any stand (Table 1). Combined *Carya* spp. I.V. was ≥ 10 in only one other stand (E, with *C. tomentosa* and *C. ovalis*). Though occurring in more stands (9) than any other hickory, *Carya ovalis* did not have I.V. ≥ 10 in any stand, contrary to a statement in Farrell and Ware (1988). Since stands with abundant *Liriodendron tulipifera* (tuliptree) were regarded as post-cultivational and avoided during sampling, this species reached an I.V. >10 in only one stand (I.V. = 18.4), not in two stands as reported in the earlier analysis. The only other species to reach I.V. > 10 in any stand were *Quercus coccinea* (scarlet oak, in stand O), *Betula lutea* (stand P), and *Pinus rigida* (stand B). *Nyssa sylvatica*, though present nearly everywhere (13 stands) failed to reach I.V. ≥ 10 in even one stand.

Though not reaching I.V. ≥ 10 in the overstory in any stand, *Cornus florida* (dogwood) had an understory relative density > 10% in in ten of the 16 stands, more often than any other species. High dogwood understory density overlapped broadly with high understory density of the other two major understory species, red maple (relative density > 10 in seven stands, including four where it did not have an overstory I.V. > 10) and sourwood (also with relative density > 10 in seven stands, including three where it did not have an overstory I.V. > 10). Thus dogwood was not dissociated from either species. *Ilex montana*, with relative density > 10 in three stands spread broadly across the ordination, was the fourth (and only other) species to reach understory relative density > 10 in more than two stands. Thus, understory densities did not seem to be responding to the same factors that led to segregation of high abundances of species in the overstory (Rheinhardt 1992).

## DISCUSSION

The reanalysis confirmed essentially all the points made in the discussion by Farrell and Ware (1988), but indicated that aspect is not, and soil mineral content may not be, as strongly associated with distribution of major canopy species as supposed in our previous analysis. The newly discovered significant correlation of the first axis of the ordination with elevation could not be strongly related to the abundance of any of the major species. As we noted in 1988, our study area was within the elevational range where chestnut oak is normally dominant over northern red oak, which at this elevation is likely to exceed chestnut oak only at more mesic aspects (Johnson and Ware 1982). White oak, though reaching high I.V. in three rather than four stands, is nevertheless both present and important in a larger percent of stands in the southern than in the central Blue Ridge, something also noted by Johnson and Ware (1982). Black oak was much more important in our stands than either Braun (1950) or Johnson and Ware (1982) reported for the central Blue Ridge; and as we pointed out in our previous analysis, scarlet oak was much less important than reported for the ridges of the Ridge and Valley Province to the west (Stephenson 1974, 1982).

Hickories did not show the high importance reported in former chestnut-dominated forests of the central Blue Ridge (Johnson and Ware 1982) and elsewhere (McCormick and Platt 1980, Stephenson 1982), but red maple (in both overstory and understory) and *Cornus florida* (in understory) were important in our area, in contrast to Johnson and Ware's (1982) report of their low importance in the central Blue Ridge. The much higher importance of species like red maple, sourwood, and dogwood in our area as compared with theirs may well be related to differences in timbering history. Normally important only in the understory in Virginia upland forests (Ware 1992), red maple, sourwood, and dogwood can respond to the more open canopy produced by timbering with rapid growth until a closed canopy is reestablished. This period of rapid growth may allow understory species like these to reach a large enough diameter to be recorded in sizable numbers in the overstory sample (Glascock and Ware 1979).

As we noted in our earlier analysis, our stands were post-timbering stands no doubt subjected to more disturbance than most of the older stands sampled by Johnson and Ware (1982). Since oaks were not reproducing well, and since dogwood, sourwood, and red maple are unlikely to become major canopy dominants in upland forests in Virginia (Ware 1992), it is impossible to extrapolate from our understory data to future canopy composition in these forests.

## ACKNOWLEDGMENTS

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