CHARACTERIZATION OF A COMPLEX PECAN-WATER HICKORY POPULATION IN SOUTHERN LOUISIANA

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Abstract.--Techniques of multivariate analysis were used to study the pattern of variation in leaf traits among pecan, water hickory and intermediate types growing on a disturbed site near Baton Rouge. Parental types were well-differentiated and a range of intermediate or hybrid phenotypes were encountered. A multidimensional plotting technique (MDPLOT) was used to explore the possibility that the hybrid trees were a mixture of F_1's and backcrosses to pecan. Analyses showed that the population has many of the characteristics of a hybrid swarm, and viable seeds were collected from the hybrid trees. The hybrid has potential as a timber tree.

Additional keywords: Hybridization, backcrossing, hybrid swarm, multivariate analysis, Carya illinoensis, aquatica, C. x lecontei.

Bitter pecan, Carya x lecontei Little, is the natural hybrid between pecan, C. illinoensis (Wangenh.) Koch, and water hickory, C. aquatica (Michx. f.) Nutt. It is found in bottomlands throughout the lower Mississippi Valley where the parental species are sympatric. Mature, forest-grown hybrids over 100 feet tall with good timber form have been identified on a number of sites in southern Louisiana (Adams and Thielges 1974). Seedlings grown from seed collected from these open-pollinated trees were 60% taller than pecan seedlings in a progeny test at age 2 (Adams 1976).

The taxonomy, distribution and ecological aspects of pecan-water hickory-bitter pecan populations were studied by Rousseau (1976). Distinctive nut characteristics aided in the preliminary identification of mature parental and hybrid types, and a supplementary method of individual tree validation based on leaf and leaflet characteristics was developed (Rousseau and Thielges 1977).

During these initial studies, it became obvious that hybrid trees were much more common than had been reported earlier. Also, trees validated as hybrids were fertile and produced viable open-pollinated seed (Rousseau 1976) which represent F_2 or backcross seedling progenies. The viability of these hybrid progenies suggests the distinct possibility for development, in nature, of genetically complex populations or hybrid swarms of these Carya species.

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Such a population was encountered during a search for hybrid seed in the vicinity of Baton **Rouge**, Louisiana. This paper reports the results of an exploratory analysis of population structure.

MATERIAL AND METHODS

A Carya complex is located just south of the Baton Rouge campus of Louisiana State University. It is a 100 acre site on the primary flood plain of the Mississippi River, between a high ridge or terrace (elev. 42 ft.) on the northeast and low flats before the river levee (elev. 18 ft.) on the southwest. The topography of the site is a series of parallel flats, sloughs and lcw ridges. The azonal bottomland soils vary with this topography and range from silty clay loams of the Commerce series on higher ridges to heavy, very fine clay soils of the Sharkey series on low flats and sloughs. The parental species are generally distributed according to site differences with pecan occupying the ridges and water hickory the low, wet flats and sloughs. The hybrid types tend to occupy intermediate sites, higher, better-drained flats and low ridges.

The site has been subjected to disturbances. Urbanization has isolated this population. Before that, the land was subject to periodic flooding by the Mississippi River. Moisture relations have been altered by successive phases of levee construction. Other major disturbances included initial land clearing, cycles of cropping, and grazing and abandonment. Road construction further altered drainage patterns. More recently, selective timber cutting and oil exploration and production have caused minor disturbances.

Unlike previously studied areas where hybrid trees were of approximately the same age, this population is unevenaged. Tentative identification of 44 trees were made on the basis of seed morphology. Twenty pecan, 11 water hickory, and 13 intermediate types were located for sampling.

Branches were collected from the four cardinal aspects at mid-crown on each tree. Two compound leaves were sampled from each of the four branches. The number of leaflets per leaf, rachis length (to the nearest 1.0 mm) and rachis diameter (to the nearest 0.1 mm) were determined on each of the eight leaves per tree. Six leaflets per leaf were selected for determination of number of serrations per 2 cm of leaflet edge, and amount of undersurface pubescence (visually estimated on a scale of 0-3).

These five traits had been previously determined to discriminate among pecan, water hickory, and hybrid types (Rousseau and Thielges 1976). Analysis of variance revealed highly significant differences among parental and intermediate types for all five traits. Results of these analyses were used to assign relative weights to each of the traits in the construction of a hybrid index. Two-dimensional scatter diagrams were plotted by using various combinations of traits as the X- and Y- axes.

Additional multivariate analyses were obtained by employing the multi-dimensional plotting technique developed by Andrews (1972) and programmed in ASA FORTRAN IV for the UNIVAC 1108 computer by Nance, et a]. (1975). This technique, referred to as MDPLOT, provides for graphic, two-dimensional plotting of multi-dimensional (multivariate) data. Unlike scatter diagrams which are limited to

two-dimensional (bivariate) data in their interpretation, the MDPLOT also provides information on means (centroids) and interpoint distances in multidimensional space.

RESULTS AND DISCUSSION

A graphic presentation of hybrid index scores illustrates the distribution of individual phenotypes in the population (Figure 1). Scores ranged from 0 to 30 with the extremes representing classic or archetypal water hickory and pecan. The index effectively separated the parental species. The hybrid type is differentiated from water hickory. One tree, initially identified as hickory on the basis of its seed, was shown to be a hybrid.

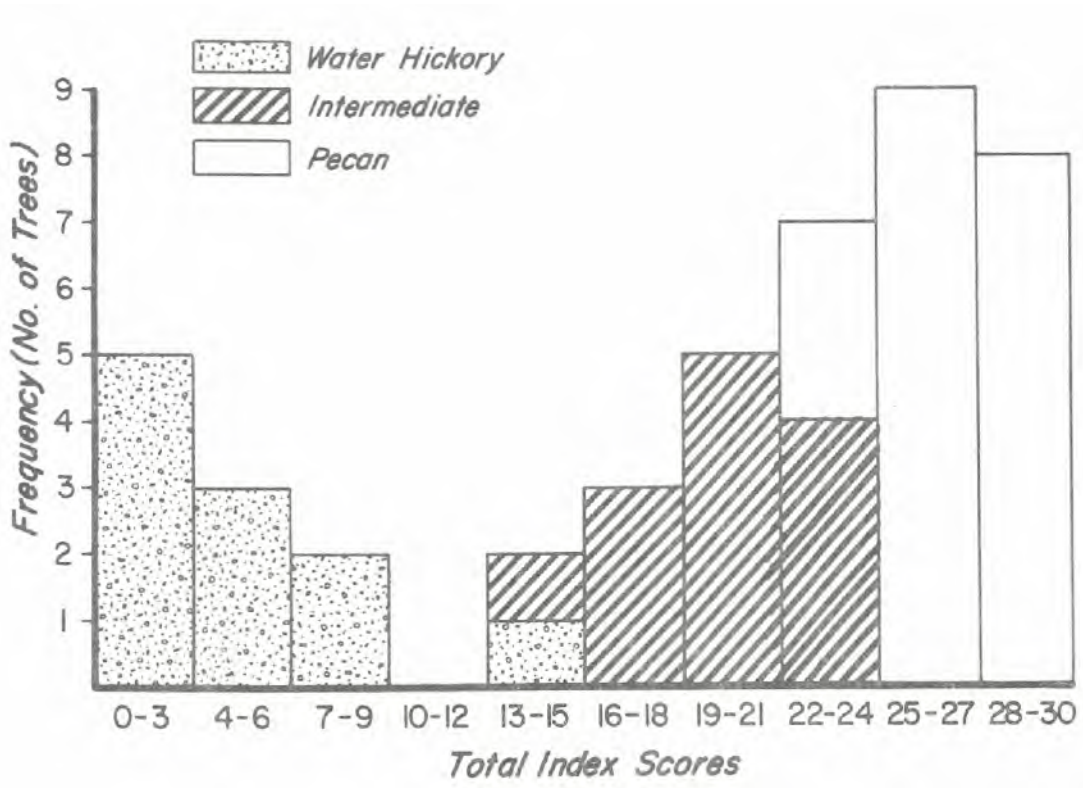

Figure 1.--Separation of parental and hybrid types in Carya complex on basis of hybrid index scores. Scores are based on (a) number of leaflets per leaf, (b) rachis length, (c) rachis diameter, (d) number of serrations per 2 cm of leaflet edge, (e) amount of undersurface pubescence; and (f) nut appearance.

There is a degree of overlap between pecan and the intermediate type and this pattern is again evident in the two-dimensional scatter diagrams (Figure 2). Parental types are well-separated and the misidentified water hickory plots squarely amidst the intermediate types.

The general relationships of Figure 2 were maintained when other combinations of traits were used as the X- and Y-axes in two-dimensional plotting. In viewing this spectrum of plots, a clustering of hybrid types was noted, eight of them (those between 6.2 and 7.3 serrations in Figure 2) tending toward intermediacy on all plots, while the other six were more generally scattered among the pecan parental types. This situation implies variable degrees of hybridity, specifically, F_i's and backcrosses to pecan.

To explore this possibility, the population was separated into four groups: pecan (20 trees), water hickory (10 trees), "F_i's" (3 trees), and "backcrosses" (6 trees). The latter two groups included those trees with hybrid seed type, but which varied from intermediacy to similarity to pecan in leaf and leaflet traits. Group means for all five variables were calculated from individual tree values, and the MDPLOT technique was applied to these data.

The computer-generated plots are illustrated in Figure 3. Major differences between plotting vectors for pecan (vector A) and water hickory (vector D) are evident in Figure 3A, and the hybrid vectors (B and C) are obviously intermediate. Separation of the "Fi" (vector C) and "backcross" (vector B) is also achieved at several points, notably at 0.06 on the X-axis.

From reference to tables of linear functions (Nance, et al. 1975), it was determined that the variables providing the strongest separation of the "F_1" and "backcross" vectors were number of serrations, degree of pubescence, and number of leaflets. The MDPLOT of these three variables provided better separation of the two hybrid vectors (Figure 3B). It must be emphasized that MDPLOTS of the 44 individual tree vectors do not result in such clear-cut separation of these four groupings. Pecan and water hickory are distinctly separated and hybrid types are, in general, intermediate. However, there is substantial overlap among individual trees of the two intermediate groups.

The techniques employed to this point do not provide positive validation of varying degrees of genetic intermediacy for individual trees, but they do supply evidence of backcrossing to pecan in this population that is discernible through multivariate analyses. Further evidence of backcrossing is provided by age and spatial distributions of intermediate types on the site and by the fecundity of these trees. Seeds were collected from 10 of the inteimediate trees in this population and, while germination was only 20-35 percent as compared to 70-75 percent for pecan, all of them yielded viable progeny.

Some morphological and anatomical leaflet traits used in previous analyses (Rousseau 1976; Rousseau and Thielges 1977) were omitted from this study because they were found to contribute relatively little to differentiating among parental and hybrid types. However, it is possible that these additional variables would aid in discriminating between F1 and backcross individuals. Nut characteristics such as weight, dimensions, color and texture may also be of value when included in multivnriate nnalyses. These traits, as well as floral and phenologtcal eharacLcristies, wILL be included in turther analyses. More positive information

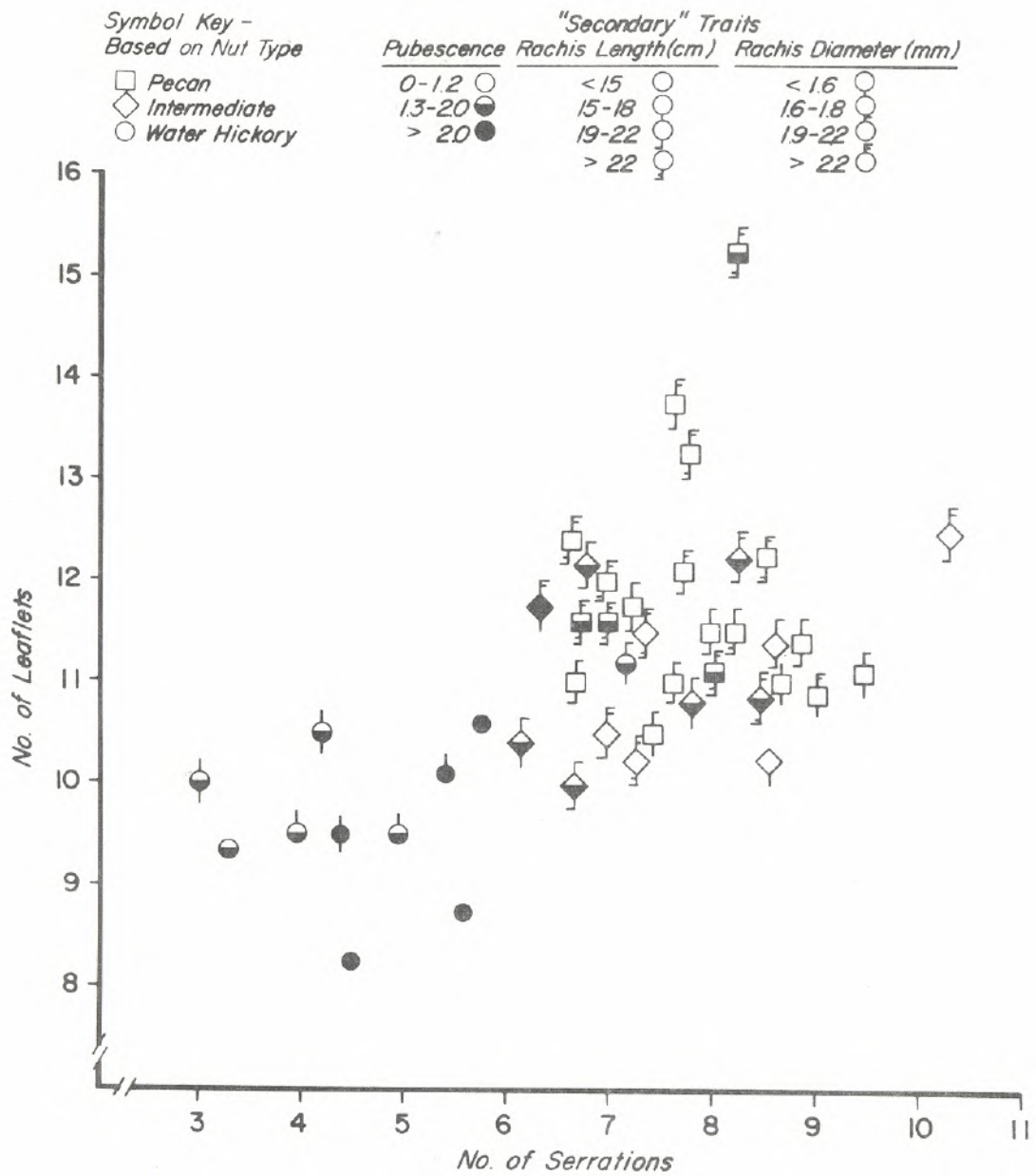

Figure 2.--Two-dimensional separation of parental and hybrid types in Carya complex on basis of leaf and leaflet traits.

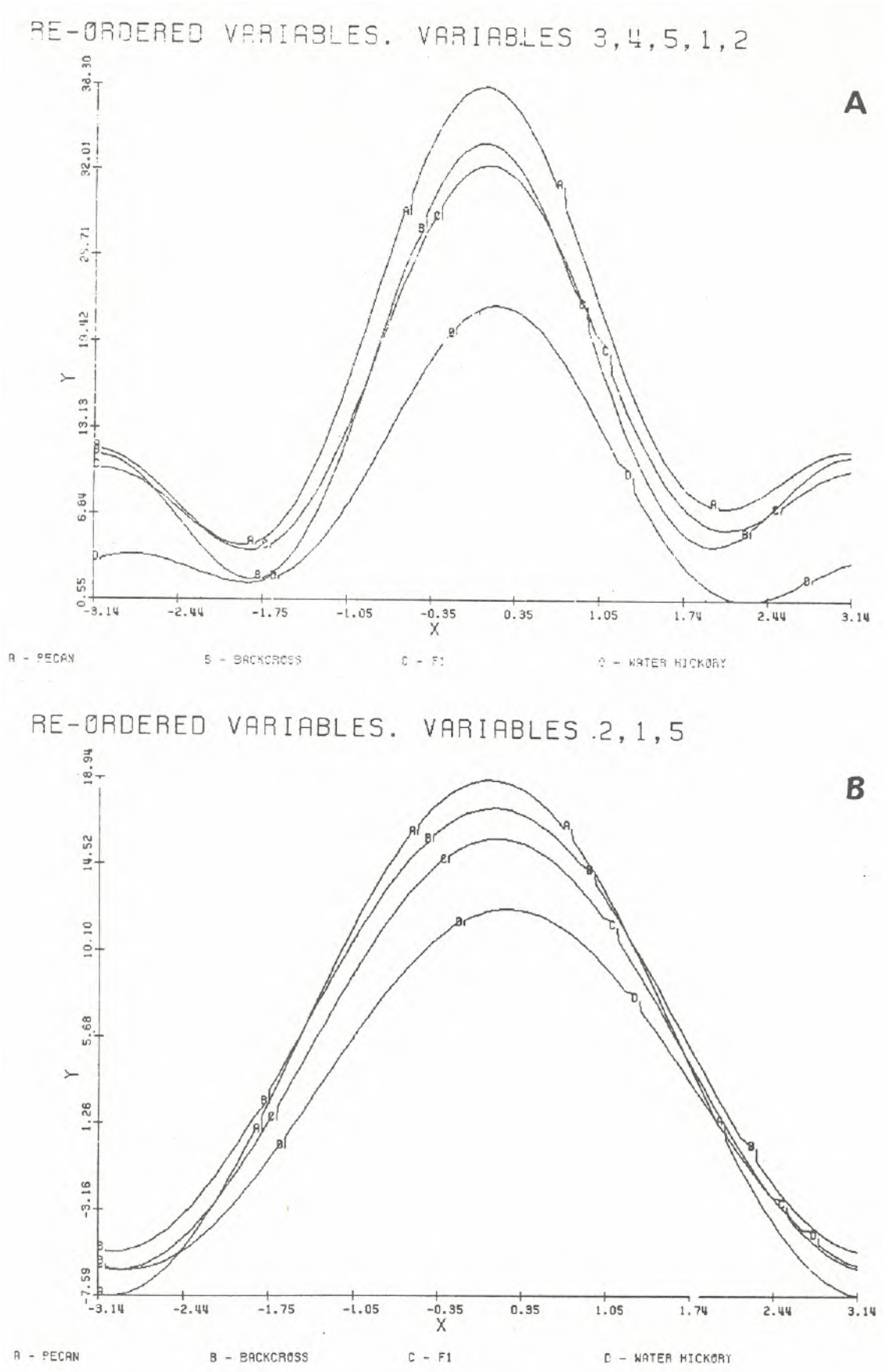

Figure 3.--Computer-generated MDPLOTs separating parental species and hybrid types in Carya complex. A - all five variables plotted. B - three variables plotted.

on degree of hybridity could be obtained through production of F1, backcross and F_2 progenies through controlled pollination. These progenies would provide base-line data or standards for each trait which could be used to evaluate intermediate types in wild populations.

This large population of intermediate types suggests that isolating mechanisms between pecan and water hickory are of an environmental rather than genetic nature. Hybrid trees are fertile and produce viable progeny. Moreover, the tendency of hybrid individuals to occupy intermediate areas of this disturbed site closely fits the criteria for the classical hybrid swarm described by Anderson (1949). More intensive studies will aid in determining if there is introgression in this population.

From a more practical standpoint, hybrid progenies appear to have good potential for wood production. Further characterization of the genetic makeup of parent trees and observation of test progenies should provide useful information for selection and breeding programs.

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