FOREST TREE IMPROVEMENT IN MISSOURI

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Abstract.--Forest tree improvement in Missouri is experiencing a renaissance. A statewide forest tree improvement program plan has been developed, and first- and second-priority species have been identified. Of all the species in the program, black walnut has undergone the most intensive level of improvement to date, and preliminary eight-year progeny test results indicate significant growth gains over nursery run stock. Desirable traits, improvement strategies, and current status of all first-priority programs are reviewed. While second-priority program plans have been developed, their initiation has been delayed since funding is currently not available.

Additional keywords: Modified recurrent selection, synthetic varieties, multiple-stage selection, Juglans nigra, Pinus echinata, Carya illinoensis, Populus deltoides.

Forest tree improvement efforts in Missouri were initiated in 1967 by the State Department of Conservation. This was a cooperative effort between the Department and the U.S. Forest Service, and was conducted under authority of Title IV of the Agricultural Act of 1956. Black walnut (Juglans nigra L.) received the lion's share of attention, with shortleaf pine (Pinus echinata Mill.), eastern cottonwood (Populus deltoides Bartr.), and eastern redcedar (Juniperus virginiana L.) accounting for the remaining improvement effort.

Then, in 1974, the assigned tree improvement specialist was promoted and the program lost the personnel needed to carry out the daily activities. Nursery personnel and foresters across the state helped in maintaining established projects; but, because there was no one assigned person, the program lost continuity.

With the preparation of the statewide forest resource plan in 1979, the importance of a progressive tree improvement program was realized and a full-time forest geneticist was hired to rebuild the program.

FIRST-PRIORITY PROGRAMS

Rebuilding the program has involved many aspects, the most important of which has been determining which species will receive what share of the time and money available. Four forest tree species have been selected for immediate genetic improvement based upon ongoing projects, the species' commercial value to the state, and surveys conducted within related state and federal agencies (Stelzer, 1980).

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Black Walnut (J. nigra)

Juglans nigra is the most valuable commercial species in Missouri. Besides its highly praised veneer qualities, this species also has a very high horticultural value due to the demand for the nut by the eastern black walnut shelling industry. Annual demand for seedlings from the state nursery is right at 500,000 and this demand level has been projected through the year 2000. Desired traits include good vigor, form, and fecundity.

Improvement strategy.--A modified form of recurrent selection was initiated in the late 1960's and will continue to be the improvement strategy for black walnut. Recurrent selection is used to concentrate genes for a particular quantitative trait in a population, such as vigor or fecundity, without a marked loss of genetic variability (Funk, 1970) .

Basically, the procedure (Fig. 1) is to phenotypically select a number of individuals from the wild for the characters under consideration. Open-pollinated seed from these select trees are used to establish half-sib progeny tests which will serve as a base population for selection in the next generation. Superior progeny will be used to establish a clonal orchard designed to maximize cross pollination in all possible combinations. Open-pollinated seed from this orchard is then used to establish another half-sib base population to start the first recurrent selection cycle. Trees superior for the desired characters are again selected, asexually propagated in an isolated orchard so as to maximize outcrossing, and the resulting seed is used to establish the half-sib base for the second recurrent selection cycle. This process will be repeated as long as improvement is shown in the characters being selected for.

The half-sib progeny tests and the clonal orchards that are established along the way will serve as production orchards, and they will be managed for maximum seed production.

As new, superior phenotypes are identified in wild stands, the open-pollinated seed will be collected and placed in the most convenient half-sib progeny test. In this way, only if the selection is able to pass its superior qualities on to its offspring will it be retained in future selection cycles.

Current status.--As stated earlier, this improvement strategy was initiated in the late 1960's with over 150 selections made across the natural range of the species. The period of time from 1970 to 1977 saw the establishment of seven, half-sib progeny tests throughout the state totalling 73 acres. Currently, the program is at that point in the original selection cycle where superior half-sib progenies are being identified and the clonal orchard is being established.

Eight-year data have been collected on some of these half-sib progenies and are undergoing statistical analysis at the present time to determine heritabilities and to estimate genetic gain for the traits under selection. Preliminary results from the Honey Creek test, located 25 miles northwest of St. Joseph, Missouri, indicate average gains of 16 percent for height, 20 percent for diameter, and 25 percent for survival by the select walnut families over nursery check plots.

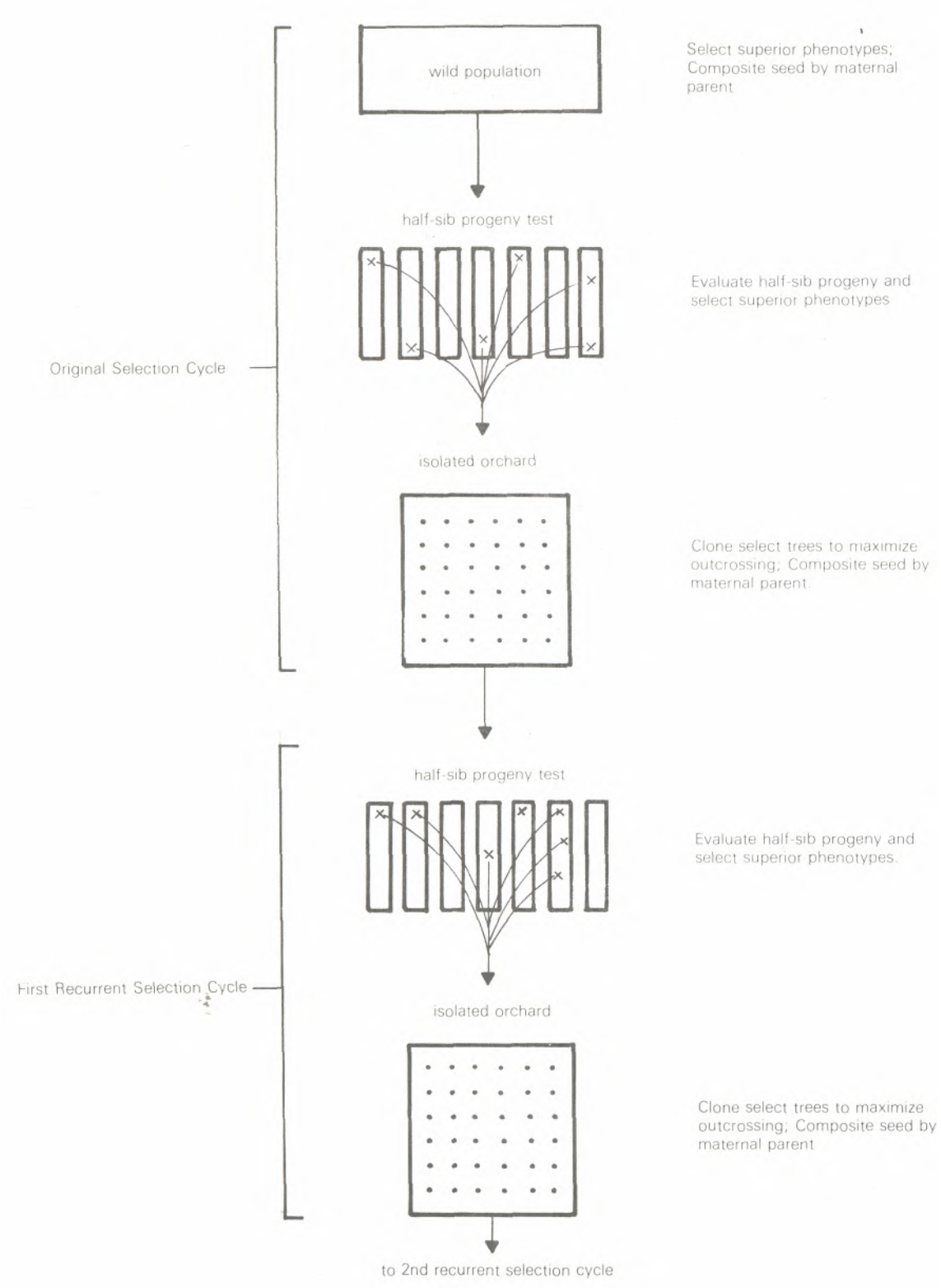

Figure 1.--The improvement strategy for black walnut is a modified form of recurrent selection.

Shortleaf Pine (P. echinata)

Shortleaf pine is the only member of the genus Pinus native to the state, and is the most widely planted forest tree species in Missouri. Today, shortleaf pine products include posts, poles, sawtimber, and pulpwood. Approximately 2.5 million seedlings are sold annually. The demand is projected to increase to 3.0 million by 1985 and remain at that level through the year 2000. Desired traits include good vigor, form, resistance to eastern gall rust (Cronartium quercuum (Berk.) Miyabe), and good fecundity.

Improvement strategy .--The improvement strategy for improving shortleaf pine is very similar to that of compounding synthetic varieties as found in forage crop breeding. The term, synthetic variety, as used in relation to forages, refers to a mixture of open-pollinated seed from a select group of clones (Poehlman, 1959) .

Before deciding how the synthetic is to be compounded, the performance of each clone is tested. Only clones that exhibit good general combining ability are put into the synthetic. This procedure distinguishes a synthetic from simple mass selection, in which seeds or plants are bulked without prior testing of progeny. It also distinguishes a synthetic from line breeding, in which progenies are grown and established lines are composited on the basis of progeny performance of the lines tested individually.

The procedure (Fig. 2) involves selection of 50 to 60 phenotypically superior trees from the wild, asexual propagation of these individuals in an isolated orchard, and simultaneous establishment of open-pollinated progeny tests. As soon as the trees in the orchard begin producing seed, controlled-pollinated (full-sib) progeny tests are established with seed obtained from a series of disconnected diallel crosses. Disconnected diallels allow some type of general combining ability and specific combining ability estimates to be obtained on the various clones for the desired traits while holding down the number of required crosses.

Based upon both the open- and controlled-pollinated progeny test results, inferior clones will be removed from the orchard and future seed harvests will contain the desired mixture of seed from superior clones. In addition, individuals will be selected from the control-pollinated progeny tests to serve as a base population for advanced generations of synthetic varieties.

Current status .---Work on this program has been confined to the evaluation of superior phenotypes in the wild, preparation of the orchard site, and preparation of rootstock so as to begin orchard establishment in 1982. The improvement of this species is anticipated to proceed at a faster pace, compared with some of the other species undergoing improvement, primarily due to the extensive work that has already been done with the genus Pinus.

Pecan (Carya illinoensis (Wangehn.) K. Koch)

Pecan is another valuable nut tree species with high commercial value for quality saw and veneer logs. In addition, this species provides excellent food for wildlife. Annual seedling production of 125,000 by the state nursery has

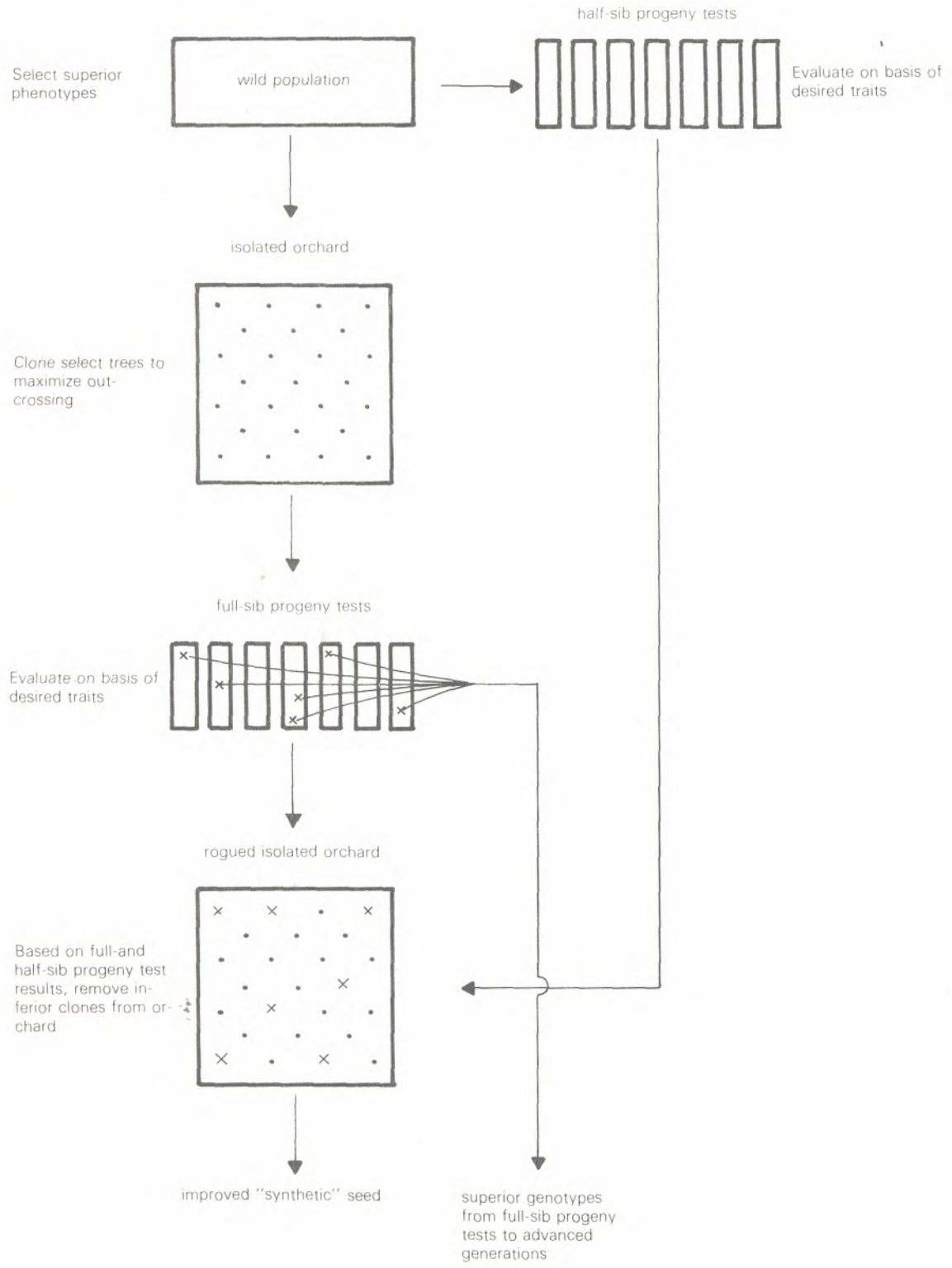

Figure 2.--The improvement strategy for shortleaf pine is similar to the production of synthetic varieties in forage crop breeding.

not been enough to meet the demand for several years now; production is expected to increase to 500,000 seedlings by the year 2000. Desired traits are the same as for black walnut, namely good vigor, form, and fecundity.

Improvement strategy.--Due to the similarity in silvicultural requirements, desired traits, and demand projections, the improvement strategy for pecan essentially follows the same logic as the strategy for black walnut. One deviation from this modified form of recurrent selection might be a limited controlled crossing program within the isolated orchard. The objective of this crossing program would be to bring the climatic adaptability of native selections and the superior nut characteristics of the improved varieties together in one individual. Funding levels will determine how far this program deviates from the pure sense of recurrent selection.

Current status.--The improvement of this species has been limited to the selection of superior phenotypes in wild stands and the selection of progeny test sites. As soon as 75 select trees have been identified, half-sib progeny tests will be established statewide. With 21 superior trees already located, it is hoped that the progeny tests will be in the ground by 1984.

Eastern Cottonwood (P. deltoides)

Cottonwood is Missouri's fastest growing native tree species, and it is found throughout the state. Some of the many products derived from this species include excelsior, crates, barrel staves, and veneer for boxes and baskets. Populus deltoides is also becoming increasingly important as a source of wood pulp for making paper, especially in the state's southeast delta region. Currently, the nursery produces a combination of 5,000 seedlings and cuttings annually. Demand for this species is expected to increase and by the year 2000, it is anticipated that 75,000 plants will be needed on an annual basis. Desired traits include good vigor, form, resistance to septoria canker (Septoria musiva Pk.), and to the poplar borer (Saperda calcarata Say.).

Improvement strategy.--Because cottonwood can be vegetatively propagated with relative ease and the willingness of the nursery personnel to shift in the direction of cuttings rather than seedling stock, the improvement strategy employed will be a form of multiple-stage selection. This strategy consists of preliminary evaluation of many genotypes followed by one or more stages of intensive evaluation of the genotypes that appear best (Cooper, 1976).

Phenotypically selected individuals are asexually propagated in the nursery in order to increase their numbers and provide suitable material for cuttings to be used in a preliminary clonal test (Fig. 3). Superior clones are identified in this test and cuttings from these selections are established in new multiplication beds at the nursery. Advanced clonal tests are then established. Results from both the preliminary and advanced clonal tests are used to select those clones that will be utilized in the crossing program and in distribution to the public. As with shortleaf pine, the crossing program will involve a series of disconnected diallels in order to hold the number of crosses to a managable level. The resulting hybrid seed will be evaluated in the same way the original parents were increased and evaluated. This

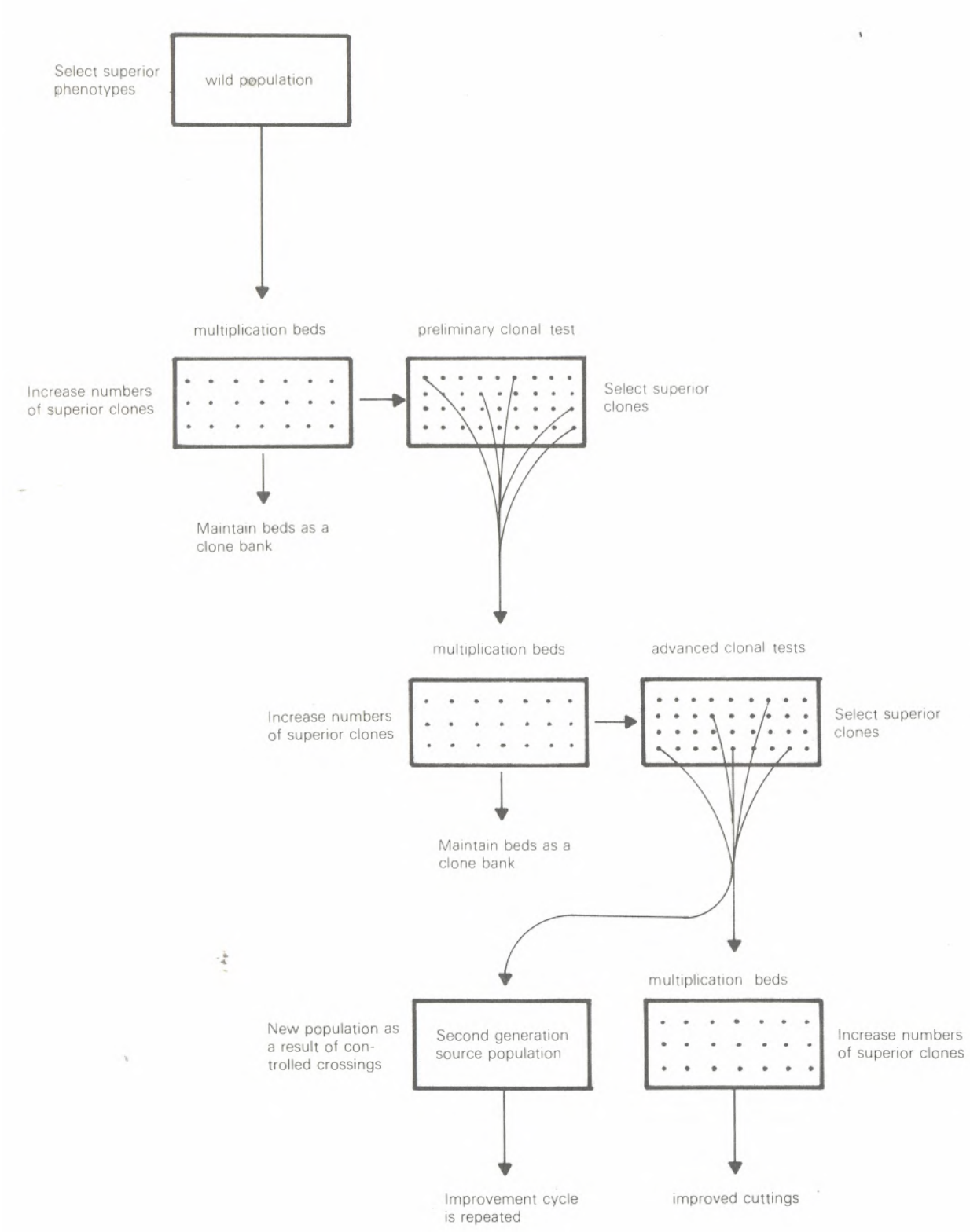

Figure 3.--The improvement strategy of eastern cottonwood is one of multiple-stage selection.

crossing program provides the genetic recombination required to produce the variability needed for further improvement.

Current status .--The original selections have all been made, the multiplication process is complete, and this winter will see the establishment of the preliminary clonal test. This program should be the most progressive of the first-priority programs due to the fact that the species involved is very fast growing and the majority of the reproduction is asexual.

SECOND-PRIORITY PROGRAMS

Four second-priority programs have been identified in Missouri's overall tree improvement program (Stelzer, 1980). These programs involve eastern redcedar (J. virginiana), Scotch pine (Pinus sylvestris L.), American sycamore (Platanus occidentalis L.), and eastern white pine (Pinus strobus L.). While improvement strategies have been developed for these species, their initiation has been delayed since funding is not available at the present time; In the meantime, the tree improvement effort is centered around identifying the best possible seed source for all second-priority species and for all the other forest tree species grown at the nursery as well.

SUMMARY

With the forest tree improvement program plan, the Missouri Department of Conservation has established a strong base upon which to build a progressive tree improvement program. Original selection results from the black walnut program will start coming in late this year, with preliminary clonal test results from the cottonwood program to follow shortly thereafter. Information from the shortleaf pine and pecan improvement programs are still a few years off. But, the enthusiasm and cooperation that exists within the Department and among related outside agencies will go a long way in helping all programs realize their goals.

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