Problems in Managing Hardwood Seed Production Areas

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Most nurserymen in northeastern United States will agree that we can improve on present methods of obtaining hardwood tree seed. Recurrent problems in seed collection and the generally poor quality of hardwood plantations established in the past 50 years serve to emphasize the point. Although many of our plantation failures can be blamed on poor site selection and inadequate early care, the poor performance of others must be laid to failure to understand the importance of a good seed source. The policy of obtaining seed "where it is easiest and cheapest to get" has not been laid to rest. We must stop "getting" seed of indifferent quality, and begin "producing" high quality seed.

Nurserymen have several alternatives to consider as they decide how to obtain tree seed and must eventually compromise between maximum seed quality and minimum cost. Seed production areas .[2/] offer an opportunity to improve seed quality significantly without greatly increasing expense.

For the hardwood species planted in the Northeast, seed production areas should provide better seed than that purchased on the open market or collected in unmanaged stands; cost may be higher than for seed collected from wild trees, but still much less than for orchard-grown seed.

Nurserymen can expect seed from production areas to be better both genetically and physiologically. Genetically, the seed may not be much better than that from good natural stands (Ga.nsel 1967) , but should be superior to seed from roadside and street trees of uncertain origin. The principal benefits expected from seed production areas

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1 / Much of the information in this paper is taken directly from the recommendations in Limstrom's (1965) "Interim Forest Tree Improvement Guides for the Central States", which also includes data on several coniferous species and offers good advice on seed orchard establishment.

2/ Seed production areas is defined as: Natural trees or stands or ones planted mainly for timber production that have been developed and managed specifically for seed production.

arc an increase in seed size, soundness, germinability, and uniformity. The nurseryman can use such seed more efficiently, sow beds more sparsely, and still obtain seedling stands of good density.

Seed Production Areas and Seed Collection Zones:

Nurserymen in many states have already set up regional zones for seed collection and grow seedlings from each zone in separate beds for return to the same part of the st-ate. At least one seed production • area (s.p.a..) should be established within each collection zone for each of the major species to be planted in the zone. As a rule of thumb, seedlings grown from production-area seed should not be shipped more than 150 miles north of the s.p.a. (to avoid cold temperature damage) nor more than 100 miles south (to take advantage of faster growin.g southern seed sources). The zones set up by Lim Strom (1963, 1965) and Rudolf (1956) represent a good starting place for nurserymen in the Central and Lake States.

Size and Number of Seed Production Areas:

Seed yield per tree; seed crop frequency (Table 1); inbreeding effects; and protection from. fire, pest outbreaks, and localized climatic variation should be considered by nurserymen as they decide how many seed production areas to establish and how large they should be.

Some inbreeding is likely in small s.p.a.'s with less than 50 seed-producing trees, but this should not be a problem because other parents will. be selected and used in the tree-improvement program in future generations. Despite the smaller minimum number necessary for some species, most s.p.a. 's will probably contain at least 50 trees for one or more reasons: the trees may not be mature and in full production, it is awkward to collect all the seed from each tree so more than the minimum will be needed, and small s.p.a.'s are less efficient and more expensive to manage.

It seems reasonable to have two or more s.p.a. 's for each species in each seed collection zone. This increases the genetic diversity of the seed collected and protects against complete crop failure caused by localized late frosts, pest outbreaks, and the like. Although this may seem like a large number of s.p.a. '5, a single tract of land can be managed for many different species where they grow in mixed stands or have been planted together.

Table 1. --Flowering and seeding habits of selected hardwood trees. (Limstrom 1965; Fowells 1965; Schreiner, et. al. 1965; Ettinger and Gerhoid 1968; U.S.D,A. 1948)

Species	Flowering habit	Frequency: of good seed crops	Mature seed trees: needed to product 100,000 seedlings-2 1/	Optimum seed bearing age
		Years	Number	Years
Alder, European	monoecious	1 - 2	1	10-
Ash, green	dioecious	1	10	
Ash, white	dioecious	3	15	40-100
Cherry, black	perfect 2/	3-4	6	25- 75
Cottonwood, eastern	dioecious	1	1	40-
Locust, black	perfect 2/	1	25	15- .40
Maple, silver	polygamo-dioecious 2/	1	5	
Maple, sugar	polygamous- 2/ 3/	2-5	**15**	70-150
Oak , northern red	monoecious	3	100	50-200
Oak, white	monoecious	5	200	75-200
Sweetgum	monoecious	2	20	30-150
Sycamore, American	monoecious	3		25-200
Walnut, black	monoecious	2	50	30+
yellow-poplar	perfect 2	2	5	20-200

1/ The estimated number of seed trees is based on production in good crop years and on collecting all seed from each tree; multiply this figure by the frequency of Brood seed crops to arrive at the total number of trees necessary to produce seed for storage, and use in poor seed years. Further, to insure good cross pollination and genetic diversity, each s..p.a.. should contain a minimum of 15 seed-bearing trees.

2/ Insect-pollinated; other species in table are wind-pollinated,

3/ Both perfect and unisexual flowers occur on the same tree.

Locating Potential Seed Production Areas:

A few rather obvious points must be considered in selecting natural stands and plantations for seed production areas:

Latitude, altitude, and climate of the s.p.a. should approximate those of the area to be planted.

Land ownership should be stable, and there should be no nearby stands of the same species that cannot be rogued to prevent contamination by undesirable pollen.

The site should be good enough for trees to grow well and flower abundantly until past the optimum age for seed production.

Ideally, the trees should be less than, but approaching, optimum seed-bearing age (Table 1).

The stand should contain many trees of above average vigor and form, but they need not all be perfect< The s.p.a. is primarily intended to produce a dependable supply of sound seed; the genetic quality should be better than that of seed collected from ordinary roadside trees, but not be as good as will later be produced in orchards containing parent trees that have been tested and proved to be superior. Perhaps half of the native stands and a fourth of the *well* stocked plantations should contain. enough good trees to be suitable for seed production areas. Avoid natural stands that appear to have regenerated from only one or a few trees, and plantations grown from single seedlots. Inbreeding in such stands may reduce or eliminate genetic gains made by selecting s.p.a. parent trees.

Choosing areas that are easily accessible, or can be made so, will pay off many times in the future. The initial roguing of the stand, the cultural operations required to put the area into maximum production, and repeated seed collections can all be handled more efficiently where access is convenient. Cost of establishing seed-production areas is relatively small. For species in which seed is collected from the tree, the harvesting cost is the only important component. For species with large seeds that can be collected from the ground (such as oaks and walnut) , the greatest expense involves tending the stand (Kislova 1967) o Both of these costs will be less if s.p.a..'s are located on gentle terrain, near good roads, and close to a nursery or other sources of men and equipment.

S.P.A. Management and Problems:

Even though we all may agree that hardwood s.p.a. 's are desirable and that it should be possible to locate suitable stands to develop for seed production, we still don't have all the answers on management. The research program necessary to get the answers depends in part on your cooperation; as I mention some of the problems and areas of ignorance in s .p.a. management, I hope that you will recognize opportunities for us to work together to get some good information.

Roguing:

Once a stand is selected for development as an s.p. a. , the problem of roguing becomes simpler than it has sometimes been described. It is merely a matter of determining the appropriate number of trees to leave and then selecting the best ones. Tree form, vigor, and pest resistance should be considered; but, as a rule, the actual selection of "leave" trees should be based on no more than two traits (Wright 1962) , with the other characteristics required to be no more than "satisfactory", Crown development, tree location, and current seed production will also influence the choice of trees for the s .p.a. Selection standards are suggested for some of the species discussed individually at the end of the paper.

Spacing:

Determining the number of trees to leave depends on two factors. First, the spacing that yields maximum seed production per acre is much closer than that giving maximum seed production per tree (Florence and McWilliam 1956). But pollen production per tree also increases with wider spacing, resulting in a higher percentage of viable seed. Second, thinning to very wide spacing, leaving only the best phenotypes, raises the average quality of the selected trees and improves the chance for significant genetic gain. Until we have better information on the effect of spacing on seed production for some of our important hardwood species, wide spacing to allow unrestricted crown development is recommended. In areas where the total number of good quality trees is sufficient, thin to leave 2 feet for each inch of average diameter plus 5 feet between trees.

Understory Control:

Removing brush and small trees facilitates equipment operation and seed collection. Control of herbaceous vegetation. sometimes stimulates diameter growth (and presumably crown development), but potential soil erosion must also be considered. Pending further research, the best bet is to follow fruit orchard practice, such as regular mowing of the entire s.p.a. and complete weed control under the crowns of the selected seed trees. Mowing at-the end of the growing season also helps protect the area from wildfire.

Isolation Zones:

Most wind-borne tree pollen is not carried more than 250 feet (Wright 1962), and 400 feet is generally accepted as a. suitable width for an s.p.a. isolation zone. For insect-pollinated species, 200 feet should be sufficient. All. undesirable phenotypes (only male trees in the case of dioecious species) should be rogued, and no seed collected from isolation zone trees.

Fertilization:

We need much more information on competition for nutrients between seed production and wood production. Nemec (1956) estimated that European beech used several times as much mineral elements during a seed year as was required for annual production of wood.. The need for liberal fertilization of tree-seed crops such as pecans is generally recognized. For instance, Ware (n. d.) recommends the following program for pecan production in Alabama: grow a legume crop through the winter, disc it down and leave grass sod through the summer with grazing or mowing to keep the grass short through the growing season, apply 400 pound per acre 0-12-12 fertilizer in early fall, followed by 500 pounds 8-8-8 in early spring. If no winter legume is grown, an. extra 800 pounds of 8-8-8 will be needed in late spring. Although we are not yet able to recommend specific fertilizer rates for each hardwood species, adequate fertility must be maintained in order to push young trees to flowering size at the earliest possible age, and then to increase seed production to the maximum practical level.

Pruning:

Although little work has been done with hardwoods, topping selected seed trees should increase flower development and seed production on lower branches. For species in which the seed must be picked from the tree, the increase in safety and convenience should justify the effort.

Irrigation:

Irrigation is expensive and will probably not be practical unless a good water supply is convenient. Even so, adequate soil moisture may be important to promote filling of the current year's seed crop (Crane 1949). On the other hand, late spring drought seems to be related to good development of flowers for the next year's seed crop of acorns (Sharp and Sprague 1967) and beechnuts (Holmsgaard and Olsen 1966) .

Pest Control:

Insects , diseases, birds , and squirrels may all cause trouble in s.p.a. 's and most will have to be dealt with on an individual basis. Many pests seem to become more troublesome (or at least more noticeable) in intensively managed stands, partly because of the cultural practices themselves. For instance, root rots can be spread from decaying stumps in heavily thinned stands and then be aggravated by too deep cultivation. Indirect control of squirrel pilferage by using wide metal bands around the trunks of seed trees should be effective in orchards where wide spacing prevents rodents jumping from tree to tree (Tackle 1957) .

Individual Species Recommendations and Comments:

European Alder - Alder is precocious, flowering as early as age 3, and sometimes bearin g heavy seed crops by the fifth or sixth year. There is a good opportunity to convert young plantations into s.p.a . 's. Seed can be collected as soon as catkins turn brown.

In Ohio trials, the fastest growing and best formed trees came from the German seed collection zone 11/12. 1/ Seed size is also

3 / Funk, David T. Growth and development of alder plantings on Ohio stripmine banks. (In preparation for publication, Int. Syrup . , Reveg. , Drastically Disturbed Areas Proc.) .

important in European alder; [4] select trees producing larger-than-average seed. Emphasize single-stem tendency when roguing plantations.

Green Ash - Since ash trees are dioecious, do not rogue stands for conversion into s.p. a . 's except during flowering season when male and female trees can be recognized. If seedlings are to be planted on droughty sites such as spoil banks, s.p. a. 's should probably be established to the northwest of the planting area (Meuli and Shirley 1937). Straightness and freedom from forking should be considered when. roguing.

White Ash - Although seed production in white ash plantations sometimes begins as early as 5 or 6 years, the seed in these young stands is often blank. Soundness is easily tested by cutting. As with green ash, trees to be retained in s .p. a. 's should be selected only during the flowering season.

Black Cherry - Cherry appears to be strongly self-incompatible (Stairs and Hauck 1968); no special precautions should be required to promote cross-fertilization. When roguing, select for good central-stem tendency to improve ability to recover from ice-storm damage.

Eastern Cottonwood - Cottonwoods are also dioecious, and sex ratio in natural stands is usually about 1:1. Since male trees tend to be slightly larger than female trees (Farmer 1964) , s p. a. roguing can only be done during a flowering season lest too few seed--bearing trees be chosen. S.p.a. establishment in clonal plantations is impractical unless many clones are included. Seed can be collected when pods are just beginning to split open. Pest resistance should be given top priority when selecting trees to be retained in the s.p.a. It may be necessary to establish special s.p.a. 's in intensively managed plantations (or natural stands) in order to produce seedlings for growing under similar culture. A strong interaction between growth of cottonwood clones and fertilization was reported by Curlin (1967) . He found that some unfertilized clones grew slowly, but were among the best when. fertilized.

4 / Personal. communication from Richard McNabb, July 10 1969 .

Black Locust -_Genetic improvement has been slow despite the wide range of natural variation present in locust (Wollerman 1969) Numerous large black locust plantations in the northeastern and central states provide good opportunity for rigorous selection in s.p. a. establishment. Rogue trees on the basis of insect resistance' and bole straightness .

Silver Maple -_Genetic difference in cold-temperature hardiness may explain the great variation in multiple-stem tendency (Limstrom 1965) . Seed should not be moved more than 100 miles north of its origin and multiple-stemmed trees Should be removed during s.p.a. establishment.

Sugar Maple -_Mixed stands of typical sugar maple and the black maple subspecies might be converted into s.p.a.'s with hopes of incorporating good form of black maple with drought resistance of sugar maple. Typical "northern hardwood" stands produce seedlings more susceptible to leaf scorch than seedlings from more southern mixed hardwood stands (Kriebel 1957) . Sap sweetness is heritable and may be considered when roguing.

Northern Red Oak
White Oak -_Pest control is essential in oak s.p.a. 's to reduce squirrel pilferage and insect damage to acorns. Thin white oak s .p.a. 's in several stages, discriminating against trees with excessive bole sprouting.

American Sycamore -_With intensive management, sycamore-may produce good seed crops before age 10 (Ike 1966) . Collect seed only from well stocked stands to avoid poor germination (Webb and Farmer 1968) . Favor trees with resistance to anthracnose and late spring frost damage when roguing.

Black Walnut -_Plantations are more likely to be used as s . p. a. 's for walnut than with most other species, since walnut is usually not abundant in natural stands. Individual trees vary widely in filled seed percentage (larger, Farmer, and Taft 1969) and seed from each tree should be tested separately before selecting final trees to be retained in the s .p.a. There is a good correlation between seed size and seedling size; trees that bear big nuts should be favored. Consider stem straightness and spring frost hardiness when roguing.

Yellow-Poplar -_Filled seed percentage is usually low for yellow-poplar, but can reach 30 to 40 percent if compatible trees are crossed (Boyce and Kaeiser 1961). Natural crossing depends on insect pollination, and properly managed bees should promote a good increase in seed quality (Clarke 1956, Istratova 1966). S. p. a. 's should be thinned lightly enough that all bearing trees will be closely surrounded by several other trees, thus increasing the chance for cross pollination by insects. Seed can be shaken from the tree when ripe or cones can be picked before they shatter -- as early as the last week in September in southern Ohio.

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