quality of the seed produced, but the orchard has a ceiling determined by the best material used in establishment.

Seed orchards are a considerable investment and require adequate budgeting and efficient work scheduling. They are production jobs where production methods are essential. Generalities cannot be applied but specific details of operation must be worked out for each seed orchard. The importance of sound and complete planning cannot be over-emphasized since one weak link in the chain of events leading to seed production may cause undesirable results or complete failure of the project.

ORCHARD ESTABLISHMENT

Objective.--The orchard must be designed to supply the seed needed for a definite silvicultural goal. This might range from conversion of present stands to superior tree stands, conversion of species within stands, or the production of superior tree seed for current reforestation needs. Species, tree selection standards, final product, and the desired number of selections are some of the factors for consideration in establishing a seed orchard. The species will generally determine the orchard location which should be within the species natural range. Tree selection standards will determine the time needed to complete this phase of the program and completion of orchard establishment. The number of selections will determine the degree of roguing possible after progeny tests prove the relative genetic worth of the selections. A smaller number of selections will restrict freedom of choice for removal from the orchard in the roguing operation and still maintain a sufficiently broad genetic base.

Size.--The orchard size will be determined by the volume of seed needed to gain the silvicultural objectives within prescribed time limits. For example, if the orchard production is planned only for use in current reforestation efforts, the orchard acreage will be computed upon the basis of annual seed needs, modified by the known periodicity of cone crops by species. However, if the orchard seed production is designed to convert present stands to superior tree stands within some time limit, such as a management rotation, additional acres may be needed. The size of the silvicultural job and the time allotted to do that job are major considerations in determining seed orchard size.

Another consideration is the future roguing planned. The less desirable trees will be removed from the orchard based upon observations of the plants within the orchard or progeny tests. The roguing will reduce the volume of seed produced by elimination of seed-producing trees. The magnitude of this reduction will be determined by the severity of the roguing. Increased orchard size is a means of compensating for predicted loss of seed production through roguing.

Type of orchard.--A decision on the type of orchard to be used must be made prior to initiation of the tree improvement program. Will the orchard be a seedling or clonal orchard? A seedling orchard is composed of the progeny of selected parent trees. A clonal orchard is composed of vegetatively propagated ramets of selected parent trees. Although both methods are used, here in the South, most orchards are clonal. Considerable controversy has developed over the relative merits of each type of orchard. However, time does not permit a full scale discussion of each type. Therefore, I will only give a listing of two advantages and disadvantages of each. No one type of orchard may be satisfactory for all conditions and all species.

CLONAL ORCHARD

Disadvantages

1. Transplanting grafts into orchard are more expensive than planting seedlings into the orchard.

2. Due to present inadequate knowledge about clonal and progeny performance relationships, progeny tests are necessary.

Advantages

1. With the exception of white pine and longleaf, the clonal orchard can be established sooner than the seedling orchard.

2. Earlier seed production is possible because flowers are produced on grafts earlier than on seedlings.

SEEDLING ORCHARD

Disadvantages

1. Since the orchard itself is the progeny test, there is no opportunity for tests on a variety of sites and conditions normally encountered on the land where the seed is to be used.

2. Pollinating selected parent trees scattered over a wide geographic area is costly and time consuming because of the many trips to each tree necessary for determining the presence of flowers, receptivity of of the flowers, need for protection from animals, diseases and insects, and cone harvest.

Advantages

1. Avoidance of incompatibility in grafting is important because of cost and decreased chance of age differentials among individual trees in the orchard.

2. The seedling seed orchard presents the opportunity to apply selection within generations as well as recurrent selection in different generations.

Isolation.--To maintain species and racial identity and the level of parent selection criteria, effective restriction of pollen contamination is necessary. Contamination can come from both inside and outside the orchard. The isolation to minimize contamination from inside an orchard containing more than one geographic source or species is possible by the assigned location of each species. For example, in an orchard containing slash, longleaf, and loblolly, it would be desirable to locate the slash pine between the longleaf and loblolly to prevent cross-pollination. However, if all species and geographic sources within the orchard will readily cross-pollinate, the use of the different species as buffers is not possible. Then other means of buffering such as open areas or hardwood trees must be used between species and sources.

Outside contamination can be minimized by an isolation zone around the perimeter of the orchard. This zone can be water, open areas, hardwood trees or pine trees of a species that disperses pollen at a time different than those species in the orchard.

Since pollen dispersion has been reported as occurring over great distances, the possibility of contamination cannot be eliminated. It can only be minimized. The amount of pollen contamination reaching an area is inversely proportional to the distance from the pollen source. An isolation zone 400 to 500 feet wide has been recommended. At this distance, the pollen contamination will be 2 to 5 percent of the source frequency. The effect of this level of contamination will be further reduced by the mass of pollen available from within the seed orchard.

Understock.--Due to the ease of grafting and availability of understock, species of understock different from that of the grafted material is sometimes used. This practice is of questionable value because of the possibility of delayed incompatibility between the rootstock and grafted scions. Another possibility of detrimental effect is the disturbance of the flowering pattern. Several studies have shown that physiological changes may occur, resulting in abnormal flowering sequence. Use of the same species and geographic source for both the understock and scions is recommended.

The vigor of the understock is a key to grafting success. More vigourous understock will increase the chances of grafting success. In most of the southern pine species, 1-0 understock is satisfactory. The exceptions are longleaf with 1-2 or 3-0 understock, white pine with 3-0 and shortleaf with 1-1 or 2-0.

Grafting.--No one method of grafting can be recommended for all seed orchards. Each orchard must determine which method is best for them, bench grafting in pots, nursery bed grafting, or field grafting. The only species that is limited to one method for optimum results is longleaf. With the tremendous root system developed by longleaf at an age suitable for grafting, lifting and transplanting from a nursery bed or pot is less desirable. Excessive shock to the understock and permanent damage to the root system results from transplanting.

Each orchard manager should determine the optimum time for grafting each species. Certain periods result in successful grafting for each species. This can be determined for the individual orchard by keeping detailed records on date of grafting and survival. When the optimum period is determined, the grafting should be concentrated in this time interval.

An important reason for completing the grafting as soon as possible is to minimize the age differential among ramets. The age differential that can be tolerated is dependent upon the spacing between ramets. A greater difference in age can be tolerated with wider spacing. If too great an age differential exists, the younger trees will never reach full cone production because of suppression from adjacent trees. An outstanding example of the effect of age differential is demonstrated on the George Walton Experimental Forest at Cordele, Georgia. A slash pine plantation was established at a spacing of 12-foot x 12-foot. One year later, alternate rows were planted to reduce the spacing to 6-foot x 12-foot. Fifteen years later, every tree planted in the alternate rows was dead.

Incompatibility.--Since incompatibility is a general term used to describe grafting failure, it takes many forms. This term should not include poor grafting techniques where the cambiums are not matched. One form of incompatibility is a flattened graft union and the needles on the scion turn yellow. Death of the graft may be delayed, but is inevitable. When these symptoms appear, the tree should be replaced even before it dies. Another form is the absence of a flattened graft union but the entire crown is yellow. Although the tree may persist for several years, it will eventually die. This condition should not be confused with adverse growing conditions which may produce the same symptoms. This can be checked by applying fertilizer. If the yellowing is due to low fertility, the symptoms will disappear after the application of fertilizer. In the absence of response to fertilization, the tree should be replaced.

Incompatibility is also used to describe those trees that are incapable of being grafted despite the best grafting procedures. To determine if grafting failure is due to this condition, unsuccessful grafting must occur for 2 or 3 years when successful grafts are made on other trees under the same conditions. All trees with definite signs of incompatibility should be replaced as soon as possible in the initial phases of orchard establishment.

Most incompatibility in the southern pines occurs during the first growing season following grafting. However, there are some exceptions, such as white pine when it first becomes evident after 3. years, longleaf after 2 years, and shortleaf after 3 to 4 years.

ORCHARD MAINTENANCE

Grass sod establishment and erosion control.--For mobility of mechanized equipment during periods of inclement weather and for the prevention of erosion, the establishment of a sod cover on the seed orchard is essential as soon as possible after land clearing. For maintenance of the sod cover, weed control is necessary by mowing, chemical control, or fertilization. In highly erosive soils, weeds can retard sod development and cause the start of erosion in areas where water is concentrated. Before the sod cover is established, water control structures, such as check dams or diversion ditches, may be necessary. After the sod establishment, an annual application of fertilizer is needed to keep the grass sufficiently vigorous to resist the encroachment of weeds and less desirable grasses.

The type of grass used should be a species successfully tested locally as a pasture sod. Probably the best source of information on the most desirable grass species can be obtained from the local County Agricultural Agent.

Many times gully erosion will occur before the sod can be established. Later, when the sod is satisfactorily established and the gullies healed by grass, the inactive gully depressions will create problems in movement of vehicles and equipment. These gully depressions should be filled and re-sodded to prevent damage to equipment and injury to personnel.

Protection.--Because of the large investment necessary for tree selection and orchard site preparation and establishment, special consideration in fire protection is needed for this area. The fire organization should give the seed orchard top priority in pre-suppression and suppression plans. Fire control can be facilitated and the hazard minimized by the construction of fire breaks. These fire breaks should be covered with grass species that are green during the fire season. Another important phase of fire protection is an effective information and education program.