And for the lessons Thou dost teach us daily, we give Thee thanks. We too, prone to unfruitfulness, are in great need of Thy pruning shears. We too, weak and struggling, are in need of the sustaining fertility of Thy love, the nurture of Thy cultivation and care. Our minds and hearts are beset with devastating diseases, from which only Thy healing and restorative power can save us. God of All Trees and All Men, as these trees grow sturdy and strong in our nursery rows, so help us to grow in Thy nursery. Amen.

I want to go right on and will turn the meeting over to our first moderator, Steve O'Rourke from Michigan State University. His panel will discuss the propagation of pines.

MODERATOR O'ROURKE: Will the members of the panel please come up? Roy Nordine, Aart Vuyk, Hoy C. Grigsby, Hans Hess, and Jim Wells. Dr. O'Rourke presented the following talk.

THE PROPAGATION OF PINES

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Plant propagators serve both horticulture and forestry in the production of pines. Superior forms must be selected and multiplied, from seed if possible, if not, by vegetative methods. Whether the ultimate use is for utilitarian or for ornamental purposes, the objective is the same; to perpetuate the desired characteristics of *a genetic strain or a selected individual tree.*

BY SEED

Seed from pine trees, like seed from most other woody plants, should be gathered when mature and only from well-nourished trees of the desired type (3). The seeds are usually removed from the cones by Kiln-drying and may be stored in sealed containers at 32^{o} to 41^{o} F for 10 years or more without loss of viability (31). In a series of germination tests with several species of northern pines, Heit and Eliason (14) noted that different lots taken from the same species of pine reacted differently. They attributed these responses to poor Kiln-drying, to injury incurred in extraction or in handling, or to high temperature of high humidity in storage.

Unlike the seed of many deciduous woody plants, pine seed will germinate without cold-moist stratification but slowly and continuing over a period of several months. The resulting seedlings therefore differ in uniformity of growth at the end of the growing season. Barton (2), in 1928, reported that the germination of southern pine seed could be hastened and made more uniform by cold-moist stratification at 41^{o} F for 30 to 60 days. In more recent experiments Wakely (33) found that a period of 15 to 30 days would usually suffice in stimulating quick and uniform germination. The U. S. Forest Service (31) has listed 30 species of pine in which seed stratification, ranging from 15 to 90 days according to species, is considered beneficial. Usually seed which has been stored for a long period of time will

benefit more from stratification than freshly-gathered seed.

A simple method of stratification of pine seed has been reported by Hosner et al. (16), Lehto (19) and Malac (21). It consists of thoroughly wetting 5-pound lots of seed, pouring each into a polyethylene bag and placing in a 34°-38°F cold room for 15 days. Larger lots of seed in one bag did not germinate as well. According to Hosner et al. (16) no differences in germination were apparent between loblolly pine seed soaked in plain water and in a fungicidal suspension of Captan 50 at the rate of 2 lbs. per 100 gallons of water before placing in polyethylene bags for 60 days.

Kozlowski and Gentile (18) found that removal of the seed coat of white pine seed, or even puncturing with a razor blade, accelerated germination. They indicated that the seed coat was a barrier to oxygen diffusion and water absorption. Fowler (10) reported more rapid germination either by removing the seed coat or by soaking in aerated water for 3 days. Gudcev and Romanov (13) reported "vernalization" and 10 days earlier germination of Scots pine seed by soaking in water for 9 days at room temperature and then storing on ice at 34° F for 30 days before planting.

Many nurserymen plant pine seed in the fall of the year so that it is stratified naturally in the seed bed over winter. Fall planted seed must be protected from the elements by sufficient mulching and from birds and rodents by screening or other devices as described by Vuyk (32).

BY VEGETATIVE METHODS

The vegetative propagation of the pines is well discussed in the excellent review paper of Nienstaedt et al. (27) which cites 181 references. Much of the investigational work has been carried out by forest tree plant breeders in order to multiply selected clones for future hybridization and to establish "seed orchards" of clonal material in isolated areas to serve as a source of superior seed in future years (27, 29).

By Cuttings and Marcots

A number of investigators (8, 15, 23, 24, 36) have resorted to air-layering (marcottage) not only to produce new plants from a selected clone but also to study the factors relating to root initiation and development which are the same irrespective as to whether the girdled branch is still attached to the tree as in layerage, or entirely removed as in cuttage.

The most dominant factor is the age of the tree from which cuttings are taken or marcots made. Rooting is highest on very young trees and gradually decreases with the age of the trees. (4, 5, 6, 23, 24, 27, 28, 30). Cuttings from many mature and senile trees do not form roots under any known method (4, 6, 27, 28, 30).

Cuttings taken and marcots made on the lower portions of the tree usually root better than those on the upper branches (27, 28, 30), apparently due to the residual "juvenility" or retention of a younger

meristem in the lower epicotyledonary region (28, 30). The percent success with either marcots or stem cuttings of any species of pine to date has been too small to justify any commercial use of these methods.

Investigations with cuttings of Pinus strobus by Deuber (4) showed that rooting varied markedly from tree to tree within a similar age class and that while rooting decreased with tree age, it was possible to root a few cuttings from some specific clones 40 to 60 years of age. Deuber also noted that rooting was higher when the resin exuding at the base of the cutting was not removed. Farrar and Grace (7) reported 60 percent rooting with white pine cuttings taken in August from the lower portions of 15-year old trees. Doran (6), however, indicated that cuttings taken in late winter root more quickly.

Cuttings taken from branches of maritime pine (P. pinaster) which were girdled and left on the tree until callus formed were compared with uncallused cuttings by Mangenot (22). The amount of water taken up by the callused cuttings in the bench was much greater than by the uncallused and consequently, the callused cuttings did not dry out nearly as much as the uncallused ones.

One of the more recent phases of plant propagation with pines has been the use of needle-bundles as cuttings (17, 37). A needle-bundle cutting is somewhat similar to a leaf-bud (single eye) cutting with woody deciduous plants as a small piece of stem tissue is removed with the needle fascicle. Zak and McAlpine (38) rooted P. elliottii as high as 58 percent from needle-bundles but only a few of these developed shoots and survived.

According to Ishikawa and Kusawa (17) shoot buds may be developed on needle bundles if the new growth leader is cut back the previous year. This type of pruning is a standard horticultural practice to induce lateral buds and branches. The "predeveloped" leaf-bundles when treated with indole-butyric acid rooted well and developed strong shoots.

By Grafting

The horticulturist is interested in multiplying the various selected clones of pines that have unique characteristics which make them desirable for landscape purposes. Since the rooting of cuttings and layers is not commercially practicable, these pines are usually grafted on potted rootstocks in the greenhouse.

In 1891 Fuller (11) stated that "varieties are propagated by veneer grafting under glass in August." He advised using either P. nigra or P. resinosa as stocks for the two and three-needle species and P. strobus for the five-needle group. Bailey (1) advocated P. sylvestris and P. nigra for the two and three-needle pines and P. strobus for the five-needle ones.

More recently Wells (34) has reported that P. sylvestris was superior to either P. nigra or P. densiflora as a stock for P. sylvestris fastigiata; that the stocks should be potted nearly a year preceding grafting; that grafting is best done in late February or early March; that the side graft is much superior to the veneer graft; that the caliper of the scion should not be less than pencil thickness and that aftercare on an open bench in a cool (60° F) greenhouse is superior to a double-glassed case.

The forester has also been concerned with the multiplication of selected clones, but usually in order to establish a stand of uniform clonal trees in a "seed orchard". This area is isolated from other plantings to prevent contamination from undesirable pollen and thus is expected to produce seed of higher quality (27, 29). Grafting is commonly used to establish the desired clone on seedling stocks. Usually it is done outside rather than in the greenhouse and consists either of the use of dormant scions in the spring or of soft-tissue succulent scionwood in the summer.

Zak (35) working with P. echinata scions and stocks in the greenhouse in February reported 76 percent survival from veneer grafts and 75 percent from side grafts. Methods to remove or hold back resin by the use of blotting paper, warm water, or cold storage markedly reduced the number of successful grafts. Cleft grafting out-of-doors in early summer with succulent soft-tissue scions resulted in "takes" of 72 percent with shortleaf and 80 percent with loblolly pines.

Fowler (9) achieved 96 percent survival with cleft-grafts of several Pinus species on P. mugo stocks made July 16 in the nursery by covering the grafts immediately with an inner pliofilm bag and outer kraft paper "shade" bag. Mowat and Silen (26) also used the double bag method with success on P. ponderosa, leaving the bags on for 2 months after grafting.

Greene and Reines (12) used the bottle-graft method on slash and loblolly pine in summer. The cut-end of the scion rested in a bottle of water to which Ferbam had been added to prevent decomposition. Survival was 50 percent with bottle grafts and 10 percent with soft-tissue grafts covered with moist sphagnum moss and pliofilm. Mergen (25) reported 95 percent success with bottle grafts of slash pine in the open under partial shade.

In Finland, Leskinen (20) reported that approximately 85,000 grafts of pine have been made since 1949, principally for seed orchards. Summer grafting from June 20 to July 15 has been superior to spring grafting; scions must be grafted immediately after collection; survival is higher when grafted on the leader of the current seasons growth; rubber strips are slightly better than spring clothes-pegs for holding scions; and warm weather is superior to cool.

The success achieved by the investigators mentioned above and many others which are not listed due to limitations of time and space, indicate that grafting both within species and between species of pine

is commercially feasible. The variations in form and color in many of the species should stimulate plant propagators to select and graft clones having unique landscape value.

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MODERATOR O'ROURKE: I will now ask Mr. Roy Nordine to present his portion of the program.

SOME UNUSUAL PINES

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The genus Pinus contains about 70 species that range throughout the Northern Hemisphere from the Arctic Circle to Mexico, the West Indies, and North Africa. This genus is the largest and most important of the coniferous group. They have long been very useful and valuable plant material for both large and small plantings, and unlike spruces and firs, their beauty increases with age, and they become more picturesque.

The usual plant forms, such as prostrate, globe, spreading, dwarf umbrella-like, columnar, pyramidal, weeping, and colored foliage are found in about a dozen species. Occasionally a new plant is found.

There are four very excellent books on conifers. One is by Murray Hornibrook: DWARF AND SLOW GROWING CONIFERS, published in London in 1923. This book lists and describes many forms that were found in Europe and now do not exist or, because of quarantine regulations, were never brought to this country. Another equally fine book is L. H. Bailey's CULTIVATED EVERGREENS, published in 1925. This book also contains a number of dwarf forms that have now apparently been lost. Two later books are CONIFEREN by Peter den Ouden, *published in Holland in 1949; the text is in Dutch.* And the latest