perature, 40°F. or below, during their dormant season if they are to be healthy and grow well the next year. Deciduous viburnums respond well to fertilizer after they become established in the soil. They should be irrigated frequently, but they also require good drainage. It is advisable to dip the root system in a mud slurry or other wetting agent to keep the roots from drying while transplanting.

PROPAGATION OF *QUERCUS VIRGINIANA* CUTTINGS

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Traditionally live oak (*Quercus virginiana*) trees are propagated by seed. But oaks are wind-pollinated and are heterozygous by nature, so they often exhibit genetic variation in a great variety of characteristics, only some of which are visible.

Obvious differences can be found among individual live oaks in branching habit, height, leaf shape, even color. It is likely that other sources of variations may occur, such as in susceptibility to insects and diseases, response to fertility, vigor, and winter hardiness. Attaining the ability to select outstanding trees and successfully propagate them for their inheritable characteristics would represent a significant contribution to the landscape industry. Development of practical means of vegetative propagation is an important step toward that end.

Propagation by cuttings is generally regarded as the most important method of vegetatively increasing both deciduous and evergreen species. It is a means by which the parent plant is usually reproduced exactly with no genetic change (6). Yet propagating trees by cuttings often is more easily described than performed due to many factors one of which is juvenility.

Juvenility and rooting. It is not juvenility that causes concern to plant propagators. Instead it is the loss of juvenility that is coincident with the onset of the *adult* or *mature* phase in plant development. This physiological change typically occurs when flowers first begin to appear and the plant gradually shifts from a strictly vegetative to a reproductive condition. During this transformation, rooting of cuttings becomes more difficult in many woody plants. As a plant ages, it generally becomes more physiologically mature. Oak species vary widely in how old they must be before beginning flower produc-

tion. A shumard oak (*Q. shumardii*) may not bear fruit until it is 20 years old, and a laurel oak (*Q. laurifolia*) typically does not mature before age 15 (11). A live oak (*Q. virginiana*), in contrast, may reach sexual maturity as a 2-year-old liner, or as late as its fifth growing season (personal observation). Regardless of the age of a woody plant, however, its basal portion, nearest the root crown, will remain juvenile, while the upper branches, though chronologically younger but producing flowers, may be mature physiologically and difficult to root. This phenomenon is known in the horticultural literature as *topophysis*; its consequences are that basal sprouts, or suckers, on an older tree can often be rooted easily while new growth higher in the trees cannot. The interactions of juvenility and plant propagation are examined in greater detail in the IPPS *Proceedings* by Davies (4) and by Kester (7), and elsewhere by Zimmerman (12), Borchert (1), and Hackett (5).

Tree age and rooting cuttings. The physiological, or *ontogenetical*, age of live oaks is of great importance in propagation, as recent research indicates.

Studies (10) have shown that even high concentrations (15,000 mg/liter) of indolebutyric acid (potassium salt), will not significantly influence rooting of cuttings taken from the upper portion of sexually-mature live oak trees. In one experiment uniform stem-tip cuttings were collected from field trees 5, 6, 7, and 8 years old at 1.5 m (5 ft.) heights. Ten cuttings were taken from each of 5 trees per age group and placed in a mist bench. Rooting was low among cuttings from all ages of the mature trees, but poorest among the oldest trees. An inverse linear relationship was found to exist between rooting success and increasing tree age ($r=-0.98$).

In a related study (10), I found that rooted live oak cuttings maintained under greenhouse conditions could also be used as stock plants for cuttings, perhaps indefinitely. Also, cuttings taken from the stock plants rooted better than cuttings taken from a field-grown tree originating from the stock plants. Other investigators (2,3) have had similar successes with several other woody plant species. Obtaining cuttings from such stock plants is known variously as "hedging", "repropagation" and "maintaining juvenility", depending on authority. Such results suggest that repropagation may be useful in the vegetative propagation of physiologically mature trees whose original cuttings root poorly. I have applied these practices to a few adult live oak trees and repropagated them in our greenhouses.

Among the live oak trees I have repropagated (Figure 1) are clones both susceptible and resistant to the gall-making activities of a small cynipid wasp (8), several trees evidence

drooping or weeping branches, and trees that exhibited vigor and cold tolerance. The sudden freeze of December, 1983 killed hundreds of southern-grown live oaks in North Texas, yet several of the experimental clones in our fields survived without serious injury.

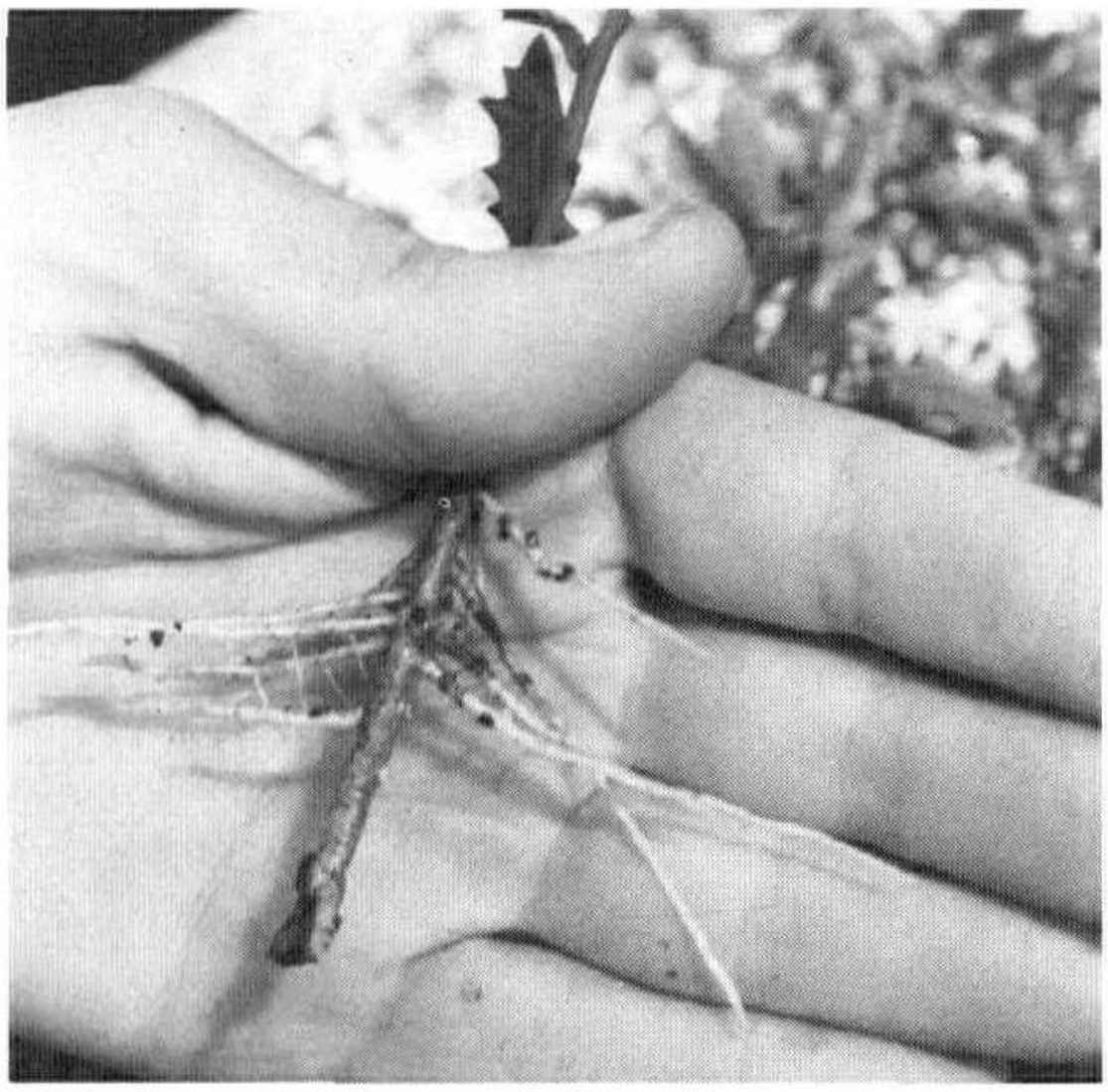

Figure 1. This live oak cutting produced roots in 5 weeks under mist. It is a clone of a field tree shown to be highly susceptible to the gall formation by an insect. It has been repropagated for further studies examining the differences between susceptible and resistant tree genotypes. Resistant clones also have been increased by cuttings.

I also found that the heterozygosity in a tree can influence rooting behavior of its cuttings (9). Live oak trees of the same age grown in a South Texas nursery (which collected them from a single location) can be separated into categories of low (0-6%), intermediate (7-24%), and high (25-71%) rooting.

What the grower can expect. Only through some means of vegatative propagation can the nursery consistently produce superior trees. To date, only increase by cuttings has been successful in live oaks. Little work has been done in other oak species. A tree's genetics may create an outstanding specimen tree that not only exhibits great vigor but also can be rooted well, even through the transition period between juvenility and maturity. With such a tree, the grower has additional time both to observe the tree critically as it ages and to establish a stool bed for repropagation, by maintaining juvenility in a clone of an otherwise maturing plant.

Propagating live oak trees by cuttings may never be as popular as growing from seed. However, for select growers the rewards of producing predictably better-adapted trees for metropolitan landscapes may outweigh the difficulties involved.

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PROPAGATION OF UPRIGHT JUNIPERS

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Some of the upright growing junipers have been a problem for propagators for as long as both have been around. Grafting has been the conventional method of propagating many of these, but it is a very costly and labor intensive method. Rooting of these junipers is gaining more and more momentum as more experiments with various rooting hormones continue. I will, therefore, focus this report on rooting some of the upright junipers — *Juniperus chinensis, J. scopulorum,* and *J. virginiana* cultivars.

Cuttings of all cultivars are prepared from about November through February. Although January and February are the best times, we cannot produce enough to meet our requirements in two months. Cuttings are collected from our own