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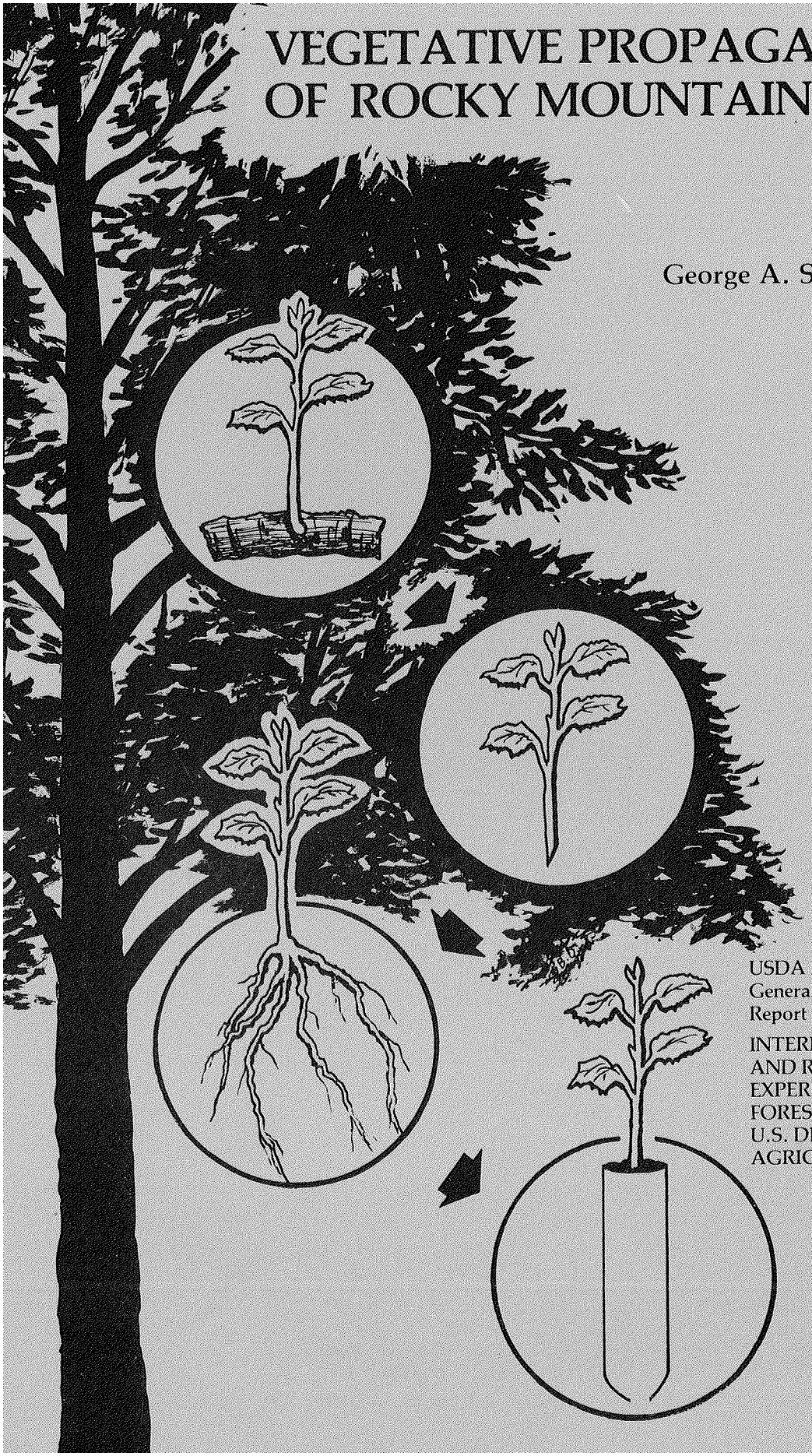

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INTERMOUNTAIN FOREST
AND RANGE
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RESEARCH SUMMARY

Described in detail are the author's procedures for vegetatively propagating aspen (Populus tremuloides Michaux). The procedures are an adaptation of Larsen's original methods. Roots are taken from clones having desirable phenotypic characteristics. Segments are treated with a fungicide, their ends are sealed with paraffin, and they are planted in moist vermiculite. Suckers develop within 6 weeks. The bases of sucker cuttings are treated with indolebutyric acid (IBA) and inserted in a moist vermiculite:perlite medium. Cuttings are rooted under an intermittent mist or in a high-humidity, polyethylene chamber. Well-developed root systems develop in 2 to 3 weeks. Rooted cuttings are planted in containers with a peat moss:vermiculite mixture and fertilized with a complete fertilizer. Supplemental lighting can be used to extend the growth period. Chilling requirements of the cuttings are satisfied by natural cold during winter months or by storage in a cold room. In the spring, dormant cuttings are outplanted or transferred to large pots. Aspen shows considerable clonal variation in suckering and rooting ability.

INTRODUCTION

Quaking aspen (*Populus tremuloides* Michaux) has become a popular ornamental tree in the Rocky Mountain region. There is also a great deal of interest in planting aspen on wild lands to restock deteriorating natural stands and to revegetate strip mines in areas where aspen originally grew. Wildlings have been successfully used in landscaping. However, a large-scale nursery system will be necessary to meet increasing demands for aspen planting stock.

Because aspen is a highly variable species, it is usually propagated asexually so that the unique characteristics of desirable genotypes are reproduced. In comparison to the relatively high rooting ability of stem cuttings from the closely related balsam (for example, *P. balsamifera* and *P. trichocarpa*) and black poplars (for example, *P. nigra* and *P. deltoides*), aspen cuttings are difficult to root (Hicks 1971). However, Larsen (1943), working with European aspen (*P. tremula* L.), found that aspen could be rooted with ease if cuttings were taken from young, succulent suckers (adventitious shoots) that arise from excised roots. This has become the standard procedure for propagating the species. Various adaptations have been reported by Barry and Sachs (1968), Benson and Schwalbach (1970), Farmer (1963), Hicks (1971), Starr (1971), and Zufa (1971).

Described here are my procedures for vegetatively propagating aspen. They were developed over 8 years while I was studying the species in Utah and adjacent States. These procedures resulted from a synthesis of the literature, personal communications, and my own experiences. There are numerous instances where I have given factual information without citing references. This information is from unpublished personal observations and experimental results on file at the Forestry Sciences Laboratory in Logan.

CLONE SELECTION

Because of its ability to reproduce vegetatively from root suckers, aspen occurs in clones of a few to thousands of genetically identical individuals (Barnes 1966). Although most clones in the central and southern Rocky Mountains range in size from 0.04 to 2.0 ha, clones from 4 to 80 ha are not uncommon (Kemperman and Barnes 1976).

Local populations of aspen show considerable phenotypic variation in morphological and phenological traits (Barnes 1969). After a little experience, one can easily distinguish stems of one clone from stems of a neighboring clone. Characteristics that can be used to identify clones are sex (normally, male and female flowers are on separate trees), leaf morphology, time of bud burst, time of autumn leaf fall, fall leaf coloration, bark color and texture, stem form, and branching and pruning ability. Of course,

some traits are seasonal (fall leaf coloration) or can be recognized more easily during one season than others (sex-flowering in spring). There are also clonal differences in some less easily recognized but important characteristics, such as disease resistance (Copany and Barnes 1974; Wall 1971) and growth rate (Garrett and Zahner 1964; Zahner and Crawford 1965).

Clones having desirable characteristics are selected for vegetative propagation. Because the expression of a trait is the result of an interaction of the genotype and the environment where the clone is growing, the trait may change quantitatively, qualitatively, or both when the clone is grown in a new environment. This change can be quite large under conditions of intensive culture (abundant nutrients and water) or if aspen is grown as an ornamental outside of its natural habitat. Traits under a high degree of genetic control will be least affected by environmental change. Although clonal selection and testing have not been performed for aspen, estimates of intraclonal variation in natural clones indicate that many of the traits listed above are under a high degree of genetic control (Barnes 1966).

Clones selected for vegetative propagation should be from sites near or similar to the sites where the rooted cuttings will be planted. Until progeny from various sources can be tested, planting stock propagated from local aspen is likely to show the best adaptability to the planting site. This criterion is more important for selecting clones for reforestation than for ornamental purposes, because in the latter case such cultural methods as fertilization, irrigation, and pest control can compensate to varying degrees for site deficiences.

ROOT COLLECTION

Suckers can be produced from root cuttings collected at any time of the year. Suckers are fewest in the spring during the flush in shoot growth when high concentrations of endogenous auxins in roots inhibit sucker formation (Schier 1973, 1975). Generally, I have avoided collecting roots during the brief flushing period. Sucker production from roots excised from dormant trees in late summer or fall is often as high or higher than it is in other seasons.

One of the best times to collect roots is in the spring, soon after the snow has melted. Early collections provide sufficient time to grow good-sized plants from rooted sucker cuttings before the onset of dormancy during the shortening days in late summer. Also, moist soils at this time of year make digging easier and lessen the chances of root damage.

When collections are made late in the growing season, rooted cuttings will not grow much before they go dormant. However, artificial lighting can be used to extend day lengths and enable sucker growth to continue into the fall. With late summer or fall collections, it is probably best to store roots and delay propagation of suckers until the following winter or spring.

Equipment helpful in collecting aspen roots are gloves, spade, pruner (anvil type), trowel, and large cloth sacks. A spade is preferable to a shovel because it can be used with more precision and so results in less root damage. The anvil type of pruner works better than the shear type for cutting thick aspen roots. Although sacks of any type of material can be used for root collecting, I have found cloth sacks very useful. They are strong and can be moistened before use to prevent the root sections from drying out.

Lateral roots 1 to 2.5 cm in diameter usually produce the largest number of suckers per unit root length. There is considerable variation in suckering ability among a clone's lateral roots (Schier 1978). For example, the mean number of suckers produced from lateral roots of a single clone ranged from 1 to 23 suckers per 10-cm segment. Therefore, it is wise to collect cuttings from a large number of lateral roots, taking a few roots from each, rather than taking many cuttings from a few lateral roots that may have poor suckering ability.

In aspen clones with regeneration in the understory, roots may be found by digging at the base of suckers. Sometimes, if the soil is moist, roots can be exposed by grabbing a sucker and pulling up the roots. Where regeneration is scarce, it will be necessary to probe for roots with the spade. Roots generally can be found more easily in clones that have a high density of trees. Occasionally, clones are found where shallow lateral roots of a suitable size are difficult to find. In this case, the best chance of finding roots is to dig around the base of mature stems. The difficulty one can have finding aspen roots in the Rocky Mountains would be unusual in the Lake States where shallow roots are generally abundant (Schier and Campbell, 1978).

If roots are not immediately prepared for sucker propagation, they can be stored for brief periods in a cold room or a cool, shaded place after they are wetted down and covered.

ROOT PREPARATION

The most suitable place to prepare roots for sucker propagation is at a sink. Wash off most of the soil from the roots under a stream of tapwater. Then cut off all secondary roots with a single-edged razor blade or a sharp knife. Again, rinse the roots. A soft brush that will not damage the bark is helpful in removing the soil. The lateral roots are then ready for cutting into segments. The length of the segments, generally 10 to 20 cm, should make the most economical use of space in the flats where the suckers are propagated. When cutting the roots, discard portions with such defects as torn bark, scars, cankers, or decay. Root segments may be planted without further treatment or treated to protect them and any emerging suckers from pathogens. I have produced good crops of suckers from "unprotected" cuttings.

Fungi and bacteria can be a considerable problem during the cultivation of root segments. Complete lots of roots can be lost. Major causes are unsanitary conditions, such as accumulations of plant material in the propagating area, unclean tools and plant trays, and contaminated media. The problem is compounded by high temperatures and humidity.

Root cuttings may be protected from pathogens by treating them with fungicides and coating the ends with paraffin. Benson and Schwalbach (1970) recommended dipping root segments in a standard Captain solution (2.5 g/liter). I have treated roots by immersing them for one-half hour in an aqueous slurry of 0.1 percent benomyl (2 g/liter of commercial mixture that contains 50 percent active ingredients), a systemic fungicide.

Paraffin for protecting cuttings should be heated in a container to a temperature just above its melting point. Blot moisture from the end of the root segment with paper toweling and then dip the end in paraffin. Seal exposed tissue by rubbing solidifying paraffin against paper toweling on a hard surface. Repeat the procedure to protect the other end.

Generally, experimental results with growth regulators have been too variable and inconsistent to recommend for stimulating sucker formation. The cytokinins are the most promising group of growth regulators to use in sucker propagation because they are known to induce adventitious buds on roots of many species (Peterson 1975). However, in numerous tests with cytokinins, such as kinetin and benzyladenine, I got little or no increase in sucker production. Apparently, cytokinins that occur naturally in roots were at optimum levels and so outside sources had no effect on suckering.

By soaking excised roots of an aspen clone that showed little natural suckering in kinetin solutions (1 and 5 p/m), Barry (1969) got a significant increase in numbers of suckers appearing on root segments. Thus, it appears that growth regulators can be successfully used in clones having a low suckering capacity (0-2 sucker/10-cm cutting). However, it may be better not to bother with these clones unless they have particularly desirable characteristics.

Root segments should never be treated with auxins (rooting hormones), such as indoleacetic acid (IAA) or indolebutyric acid (IBA), because they inhibit sucker development.

It may be desirable to store aspen roots for varying lengths of time before starting sucker propagation. For example, in the Rocky Mountains, where the snowpack normally makes it difficult to collect roots until May, roots could be collected in October, ahead of snowfall, stored, and planted in February or March. Roots of many clones can be stored for as long as 6 months at 1° to 5°C without any loss in suckering ability. For long-term storage it is probably better to treat root segments with a fungicide, such as Captain or benomyl. To store roots, wrap 5 to 10 segments in moist paper toweling from which excess water has been squeezed and then put them in plastic bags.

SUCKER PROPAGATION

Coarse and fine sands, vermiculite, and mixtures of sand and vermiculite are media that have been used in sucker propagation (Barry and Sachs 1968; Benson and Schwalbach 1970; Maini and Horton 1966; Tew 1970). I have had good success with vermiculite (fig. 1).

Plastic trays with holes for drainage are better than wooden flats for growing suckers because they can be easily washed and sterilized by dipping in 10 percent Clorox. If flats are used, they should be treated with a wood preservative such as Cuprinol.

Figure 1.--Suckers growing from aspen root segments planted in vermiculite.

The following procedure is used for planting root cuttings in vermiculite:

1. Label tray with clone designation.
2. Spread dry vermiculite evenly in moistened tray (prevents vermiculite from falling through holes) and pack it down with a block of wood so that the level is 3 cm from top of the tray.
3. Lay out root segments approximately 1 cm apart on vermiculite. Press large diameter segments into vermiculite.
4. Cover segments with vermiculite. Bring vermiculite to the top of the tray after spreading and packing. The segments will be at a depth of 1 to 2 cm.
5. Wet down vermiculite thoroughly using a spray nozzle.

Suckers will grow over a considerable temperature range (Zasada and Schier 1973). For best growth, daytime temperatures probably should be between 20° and 30°C. Nighttime temperatures can be lower, but should not fall below 10°C.

Planted root cuttings should be given only enough water to keep them from drying. There is a tendency for most people to overwater, which increases the risk of disease.

The maximum number of suckers are produced in about 5 to 6 weeks (fig. 2). Height growth also levels off by this time. Delay in harvesting can result in losses caused by root decay. Decay can occur after suckers emerge and can be so serious on roots of some clones that large numbers of suckers are lost. The susceptibility of roots to decay varies considerably among clones. I have found the proportion of segments with decay to range from 0 to 75 percent.

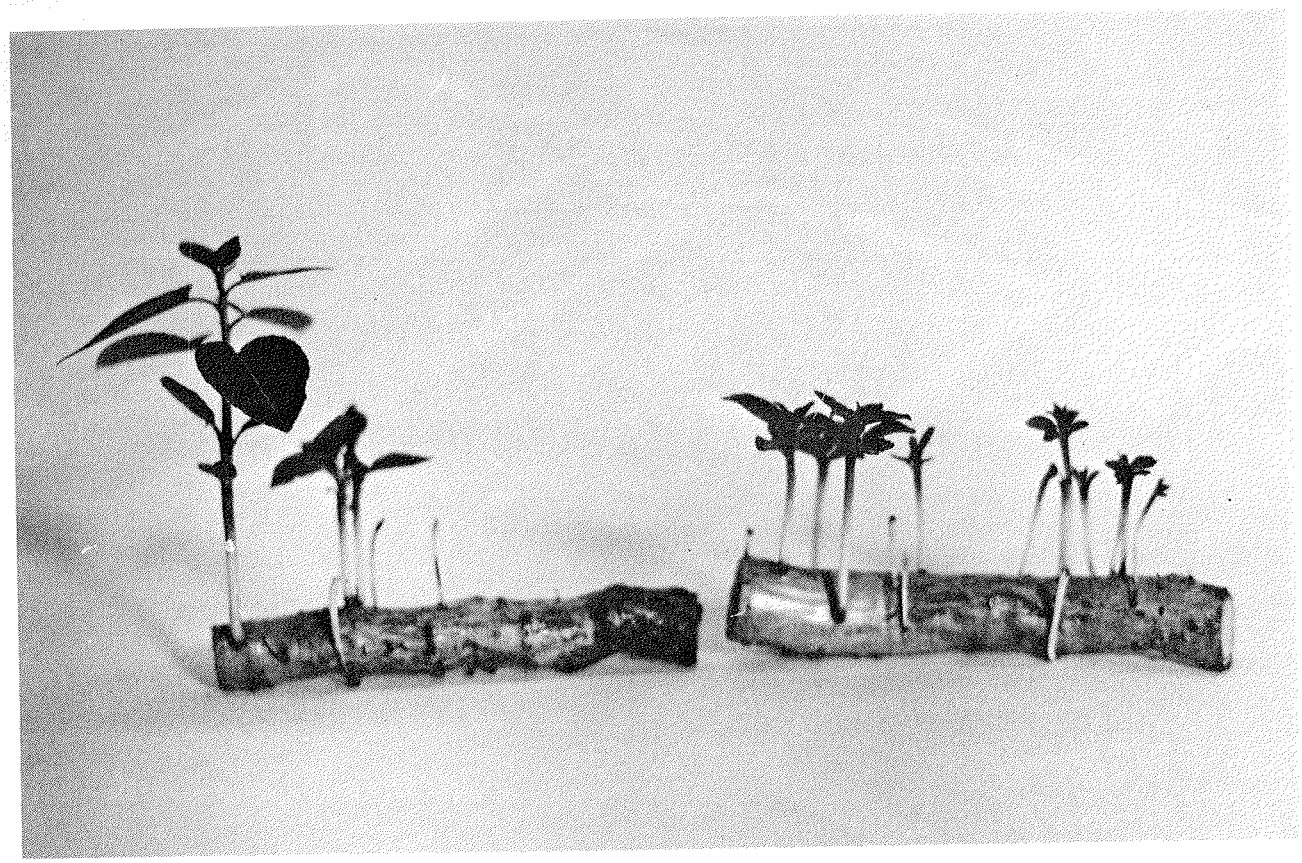

Figure 2.--Aspen suckers on 8-cm root segments from two different clones.

Clonal variation in sucker production from aspen root cuttings has been widely reported (Farmer 1962; Maini 1967; Schier 1974; Steneker 1972; Tew 1970; Zufa 1971). Comparing roots from 20 clones collected in September on the Cache National Forest in northern Utah, I found that sucker production ranged from 4 to 21 suckers per 10-cm cutting. A clone may also show a considerable seasonal variation in sucker production (Schier 1973). The greatest change I found in sucker production from one date to another for a clone was from 2.7 suckers/10-cm cutting in August to 18.5 suckers/10-cm cutting in October.

Once desirable clones are under propagation, sucker cuttings may be obtained from suckers induced by decapitating potted aspen plants. Suckers arising from the roots of these plants are larger and more vigorous than suckers from excised roots.

ROOTING SUCKER CUTTINGS

Cut suckers 2 cm and larger in height from root segments with a sterilized razor blade or Exacto cutting knife and place them in a tray of water. Do not remove more suckers than can be planted in the rooting media during the same day. Mottled areas appear on leaves of sucker cuttings held in water for more than 1 day. These later become necrotic and increase losses during rooting.

Coarse sand (Farmer 1963), shredded sphagnum moss (personal communication, Burton V. Barnes, University of Michigan), mixtures of sand and vermiculite (Benson and Schwalbach 1970), or perlite and vermiculite (Barry and Sachs 1968) are media that have been used for rooting sucker cuttings. I have had good success with a 1:1 perlite-vermiculite mixture; it has sufficient porosity to allow good aeration, a high water-holding capacity and, yet, it is well drained. The rooting medium is placed in well-drained sterilized trays, treated wooden flats, or small containers for single cuttings. I use 19.5- by 27.5-cm plastic trays that will hold 120 cuttings (2.3- by 1.8-cm spacing).

If space is not limited in the rooting area or if only a small number of rooted cuttings are desired, single cuttings can be rooted in small containers. The advantage of this method is that cuttings need not be transplanted once they develop roots. Thus, the roots are not disturbed and a propagation step is eliminated. However, it is difficult to find a medium that is good for both rooting and growth of the cutting. B. V. Barnes (personal communication) reports that he has successfully propagated single aspen in Jiffy-7 peat pots (peat enclosed in a plastic net, 4.4 cm in diameter by 5.4 cm in height). Because of its high water-holding capacity, there is a danger that the peat will become too wet under a mist and cause the newly formed roots to deteriorate.

It is good practice to treat sucker cuttings from all clones with indolebutyric acid (IBA), a root-promoting growth regulator (hormone) This auxin increases the percentage of cuttings rooting for clones with low-rooting capacities and increases the number of roots on cuttings of all clones (Farmer 1963). IBA increases root number by causing roots to be initiated on a larger area of the sucker stem.

Cuttings can be treated by dipping the basal ends into talcum powders containing IBA or by quickly dipping the ends into solutions of IBA. Commercial powder preparations of IBA, such as Hormodin,[1] at various concentrations are available. Although powders containing 0.1 percent IBA are usually recommended for succulent cuttings, I have had better success with concentrations of 0.3 to 0.8 percent. Concentrations as high as 1.6 percent do not inhibit sucker initiation but may cause a reduction in root growth. IBA powders should be stored at 0° to 5°C in tightly sealed containers. Allow the container to come to room temperature before opening it to avoid condensation of moisture.

The cuttings should not be dipped into the entire stock of IBA powder because foreign material and moisture may contaminate the hormone and cause it to deteriorate. Instead, place a small sample of hormone powder on wax paper, in a bottle cap or a jar cover. After treating the cuttings, discard any powder that remains. Procedures for treating sucker cuttings with rooting powders and planting them in the rooting media are as follows:

1. Remove excessive water from the base of a cutting by blotting it with paper toweling.
2. Dip and rotate base of cutting in powder until a length of 1 to 2 cm (greater length on taller cuttings) is covered. Tap the cutting lightly to remove excess powder.
3. Make a small hole in rooting medium with a narrow spatula, ice pick, spoon handle, or similar tool. Insert cutting to a depth of 1 to 3 cm so that one-half to one-third of the stem is in the medium. Be careful not to brush off the powder. Press in side of hole so the medium holds the cutting firmly.
4. Plant cuttings at an approximate 2- by 2-cm spacing.

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[1]Rootone, containing napthaleneacetic acid (NAA), IBA, and other auxins, may also be suitable.

Quick-dip solutions for treating sucker cuttings are prepared by dissolving IBA crystals (available from chemical supply houses) in 50 percent alcohol (ethanol or isopropanol). They generally give more uniform results than IBA powders. Testing the effects of solutions containing 0, 1,000, 2,000, 4,000, 8,000, and 16,000 p/m IBA on rooting, I found that the percentage of suckers rooting and number of roots initiated increased with IBA concentration. IBA did not stimulate root elongation. At 16,000 p/m there was a slight inhibition. Barry and Sachs (1968) found that concentrations of IBA higher than 1,000 p/m caused deterioration of sucker cuttings from California clones and less vigorous root growth. The differences in our results may be due to differences in methods or to clonal variation in response to IBA.

A small volume of 4,000 p/m (0.4 percent) quick-dip solution can be prepared by dissolving 400 mg of IBA in 100 ml of 50 percent alcohol. Only a small portion of this should be used in treating cuttings. Remove excess water from cutting and dip basal 1 to 2 cm in solution for about 5 seconds. Plant as described above. The IBA solution should be tightly sealed and stored at 0° to 5°C when not in use.

As in the propagation of suckers, control of pathogens is important for successful rooting. The best way to achieve this is to maintain sanitary conditions in the rooting area and to use sterilized tools and equipment. Although generally I have found it unnecessary, cuttings can be treated with systemic fungicides, such as benomyl. Some commercial rooting powders contain fungicides (for example, Rootone F).

A misting bench is the most suitable place to root sucker cuttings. In our greenhouses, we use a misting schedule that varies from 1 minute of mist every 5 minutes during the warmest part of the day to 1 minute every 20 minutes during the night. Temperatures should probably be kept between 20° and 25°C, although night temperatures can be slightly lower.

For those who do not have misting facilities, sucker cuttings can be rooted under polyethylene sheeting. Rooting chambers can be built by constructing a wooden frame and covering it with sheeting. The simplest chamber can be made by sealing a rooting tray in a polyethylene bag (Benson and Schwalbach 1970). High humidity within the rooting chamber will keep the succulent cuttings turgid. The chambers should be kept out of direct sunlight so that temperatures within do not become too high. A major disadvantage of rooting chambers is the lack of ventilation, which can cause problems with pathogens.

Sucker cuttings from most clones produce well-developed root systems in 2 to 3 weeks (fig. 3). Keeping cuttings under mist for longer periods increases the danger that necrotic areas will form and leaves will abscise. As might be expected, there is considerable clonal variation in root development. This is caused by an interaction of natural rooting ability (Schier 1974) and sensitivity to the rooting hormone.

To remove sucker cuttings from the rooting medium so that loss of fragile roots is kept to a minimum, the medium should be saturated with water and the cuttings carefully lifted with a small spatula. With trays, this can be easily accomplished by nesting the rooting tray in an empty tray without holes and adding water until the rooting tray overflows. The rooted cuttings should be held in water until they can be planted.

Figure 3.--Rooted sucker cuttings from a single aspen clone showing various types of adventitious root development. Cuttings were treated with 0.2 percent indolebutyric acid in powder and rooted under mist for 3 weeks.

CULTIVATING ROOTED CUTTINGS

Rooted cuttings can be planted in pots or in the types of containers widely used in producing container-grown coniferous seedlings for reforestation. I have grown aspen cuttings in a number of large containers and have been satisfied with the results (fig. 4). One of their major advantages is that a number of plants with deep root systems can be grown in a small area. The size of the largest tube is 5.2 cm in diameter by 25 cm in length. After one growing season, the containers are filled with roots and the cuttings can be outplanted or transferred to large pots.

A good potting medium is a 1:1 vermiculite-peatmoss mixture. The mixture should be moistened to the point where a few drops are released when it is squeezed. When the rooted cuttings are planted, care should be taken to make sure that the roots are well spread. A good practice in planting most cuttings is to form the medium into a dome near the top of the container, spread the roots around it, and then add more medium.

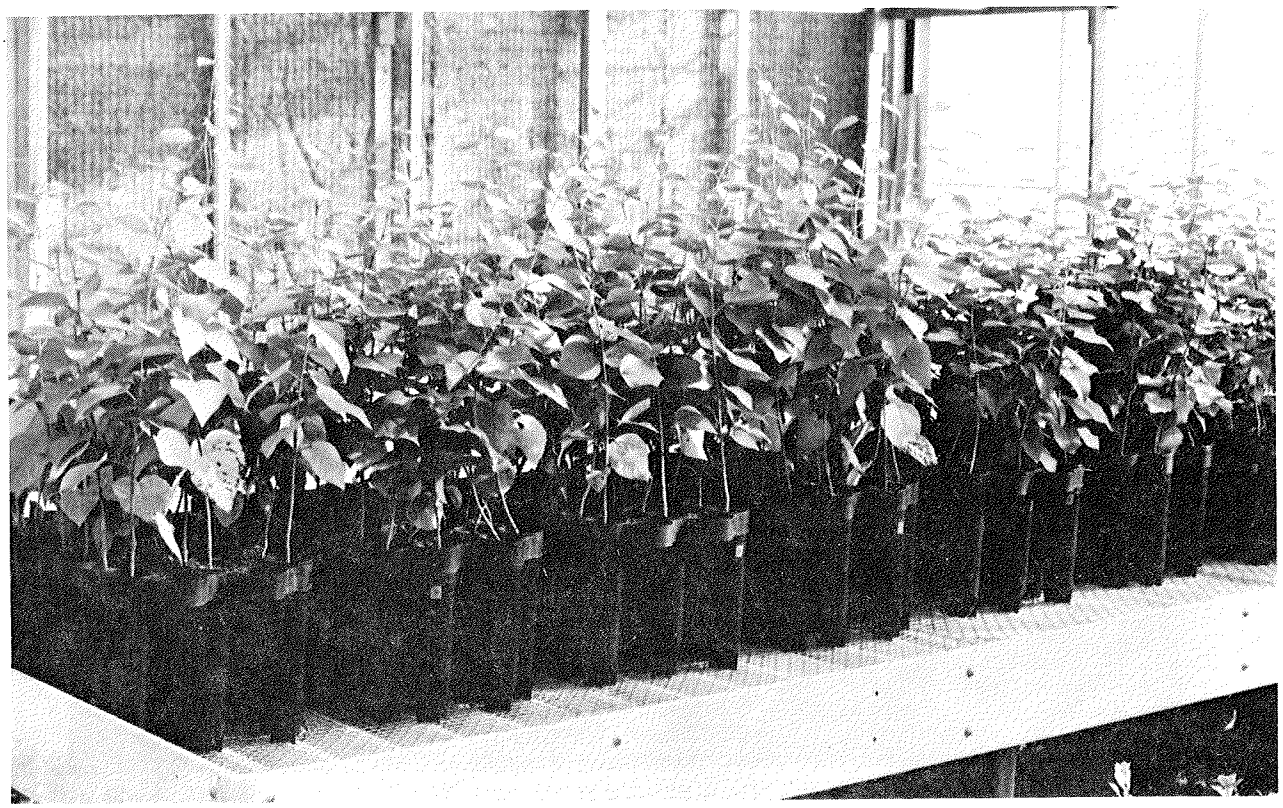

Figure 4.--Aspen growing in tubes (top diameter, 5.2 cm; length, 25 cm)--November 5, 1976. Rooted cuttings were planted July 19 to 23. They were given supplemental lighting from August 1 to November 1.

Shortly after the cuttings are planted, they should be fertilized with a complete commercial fertilizer. We have produced vigorous, healthy plants with Scotts 20-4-8 Shrub and Tree Fertilizer that contains all the essential micronutrients. One-fourth teaspoon of this fertilizer is applied to the tubes (described above and shown in figure 4) at planting time, after 1 month, and in the fall.

While the sucker cuttings are becoming established and still soft and succulent, direct sunlight should be avoided. Watering should be done with care. Too much water can be as harmful as too little because it can result in mortality caused by damping-off fungi.

To obtain maximum growth of the cuttings ahead of dormancy, it is often necessary to extend day lengths with artificial lighting. We generally put on the lights to extend the day length to 16 hours during the first week in August and take them off in early November. B. V. Barnes (personal communication) has successfully extended the growing season of aspen with continuous light. Intermittent light, such as 1 minute of incandescent light every 15 minutes through the night, may be more effective for maintaining growth (personal communication, R. W. Tinus, Rocky Mountain Forest and Range Experiment Station).

In November, the cuttings are moved to a section of the greenhouse where the temperatures range from 2° to 10°C. These temperatures satisfy the cold requirements

of Utah aspen as indicated by a normal spring bud break. In plants whose cold requirements have not been satisfied, the terminals and upper laterals remain dormant while the lower laterals flush out. If plants are moved outdoors for overwintering, they should be moved in late September so that they will have adequate time to harden-off. So that plants do not flush out before outplanting, it may be necessary to move them to a cold room in early spring. This is a common practice when trees grown at low elevations are to be outplanted on high elevation sites where lingering snow cover prevents early planting.

Some mortality can be expected after rooted cuttings are planted in containers. Also, some cuttings make little shoot or root growth even when given supplemental lighting. Buds form during rooting and a cold treatment is necessary before shoot growth will continue. Early bud set occurs with greater frequency in some clones than in others. Cuttings that do not grow much the first growing season must be held in the containers for another year before they can be outplanted. For certain purposes, this might be considered an undesirable characteristic; so such clones are eliminated from future propagation plans.

Pest problems we have encountered with aspen grown in containers are aphids, red spider mites, and powdery mildew. Aphids can be controlled with Isotex. Kelthane is very effective against mites. Insect pests in greenhouses can also be controlled by fumigating with various chemicals. Powdery mildew can be stopped from spreading if all plants are immediately sprayed with benomyl when the mildew is first detected. Once it becomes established, I know of no way to get rid of it before autumn leaf fall.

OUTLINE — VEGETATIVE PROPAGATION PROCEDURES

1. Select clones with desirable phenotypic characteristics.

2. Excavate roots. Be sure to take cuttings from a large number of lateral roots.

3. Wash soil from roots, remove all secondary roots, and cut into lengths suitable for planting.

4. Treat root segments with a fungicide and then seal ends with paraffin.

5. Plant segments to a depth of 1 to 2 cm in vermiculite in trays. Moisten vermiculite.

6. Place trays in a greenhouse where the diurnal air temperature ranges between 25° and 15°C and water lightly each day.

7. After 6 weeks, remove suckers 2 cm and larger from root segments.

8. Treat basal ends of sucker cuttings with indolebutyric acid (IBA) in powder or 50 percent alcohol.

9. Insert sucker cuttings in moist vermiculite:perlite (1:1) so that one-half to one-third of the stem is in the medium.

10. Place sucker cuttings on a misting bench or in a high-humidity, polyethylene chamber.

11. After 2 to 3 weeks, remove rooted cuttings from rooting medium.

12. Plant rooted cuttings in containers with a peat moss:vermiculite (1:1) mixture and fertilize with a complete fertilizer.

13. Grow aspen in an environment where the approximate temperature range is 15° to 25°C. Provide supplemental lighting so growth will be prolonged during short days.

14. During the winter, satisfy the chilling requirements of the cuttings by placing them outdoors or at a temperature of 2° to 10°C.

15. In the spring, outplant dormant cuttings or transfer them to large pots.

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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Described in detail are the author's procedures for vegetatively propagating aspen (Populus tremuloides Michx.). Roots are taken from clones having desirable phenotypic characteristics. Suckers are cultured from root segments. Sucker cuttings, treated with growth regulators, are rooted under humid conditions and planted in containers.

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