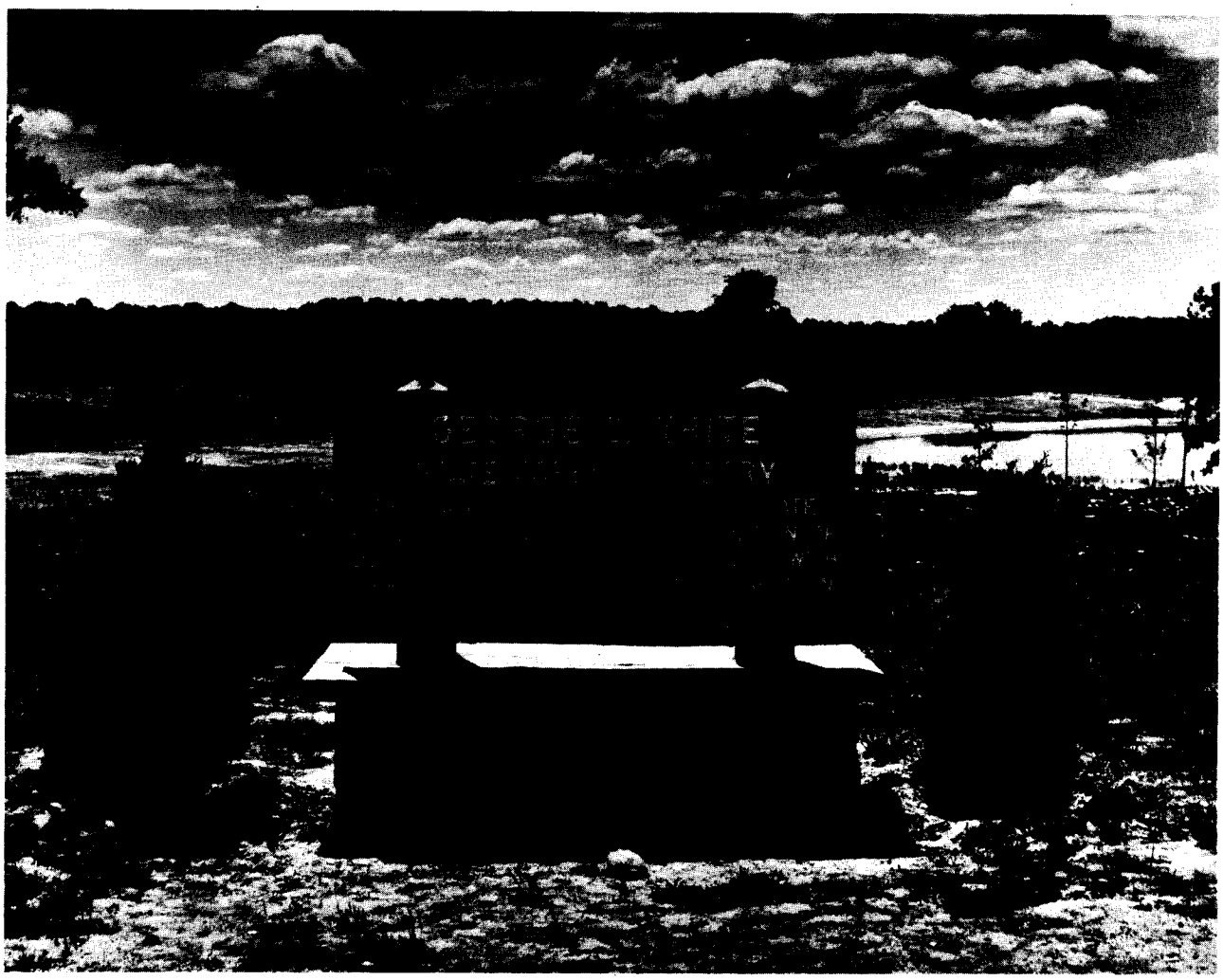
The Nurseryman's Manual



by Delbert G. Mugford
Forest Nursery Superintendent

Missouri Department of Conservation

Contents

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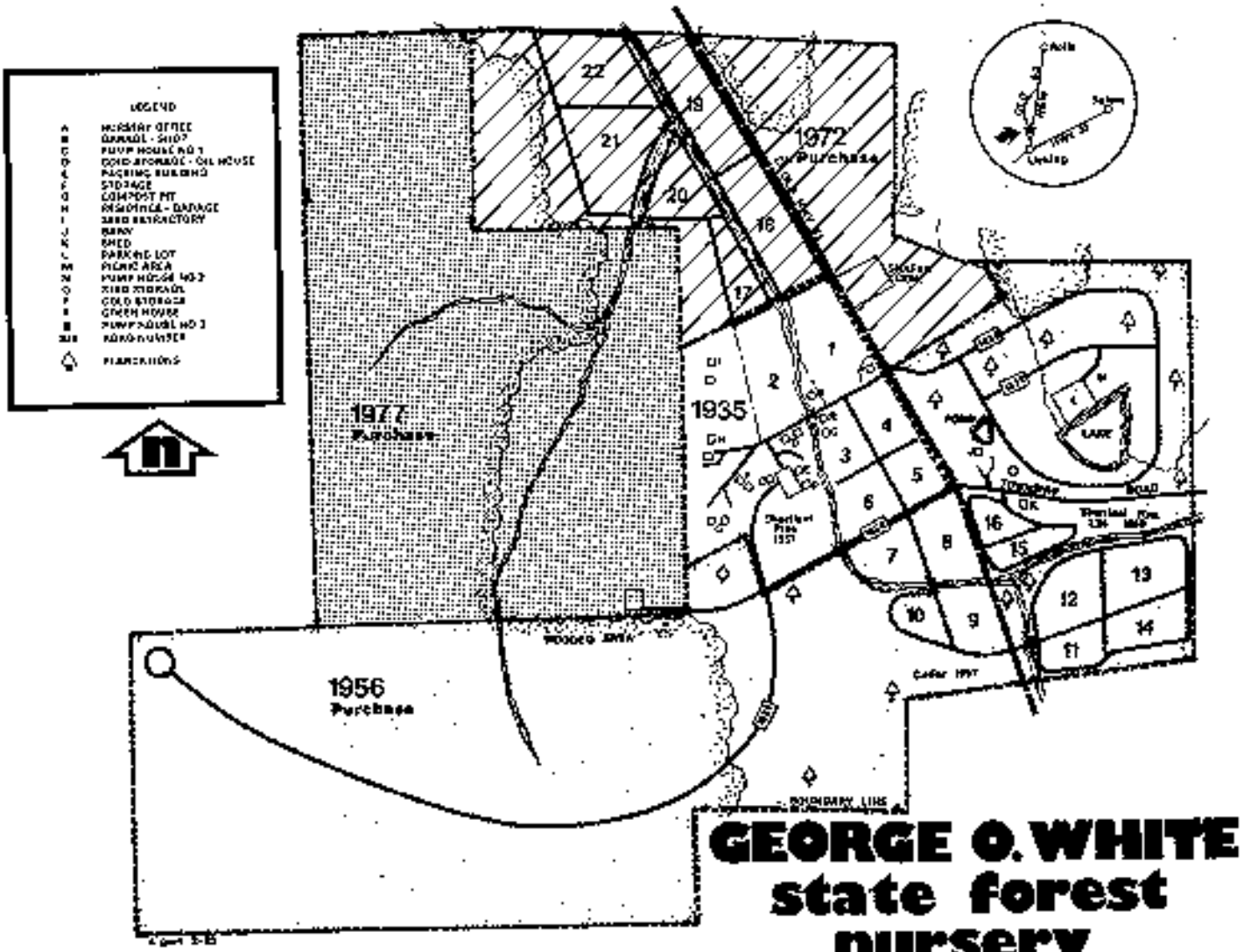
9/84



GEORGE O. WHITE state forest nursery

Historical Record

The nucleus of what is now the George O. White State Forest Nursery at Licking originally was purchased and operated by the U.S. Forest Service.

The property initially was inspected in April, 1934, by a Forest Service employee who eventually became the first state forester of Missouri. The nursery was renamed and dedicated in honor of this man, George O. White, upon his retirement January 1, 1960. A copy of the original boundary survey map is included in the Appendix.

Based on White's recommendation, 24 acres of the tract were purchased on January 10, 1935, at a cost of $1,430. Sellers were John C. and Lucie Kofahl. On February 28, 1935, an additional 16 acres were purchased from the Kofahls at a cost of $930. At that time, $10.00 of the purchase price was retained to ensure payment of the 1935 taxes.

The nursery was constructed over the next few years and operated successfully with the aid of Civilian Conservation Corps (CCC) enrollees, Work Projects Administration (WPA) labor, and other local labor as needed. At the time of completion, permanent improvements included the nursery office, nurseryman's residence, shop and warehouse, deep well (1,675' depth) and overhead irrigation system, pump house with toilet and bathing facilities, cold storage, oil house with gasoline pump, cone storage shed, and refrigerated seed storage building. Additions to accommodate a CCC camp included two barracks-type buildings, a kitchen and mess facility and a small structure used as a camp PX. Two large concrete compost pits also were constructed and operated for several years, but the small volume of material produced and the high cost of labor caused these to fall into disuse after several years.

With the advent of World War II, the loss of the CCC Program and the loss of funds for reforestation, the nursery was closed. It was leased for farm crop production during the war years, with a civilian caretaker occupying the residence.

Since our sea-going routes to Southeast Asia were cut by the Japanese, rubber became a scarce item, causing tire rationing and other inconveniences to the general public. The entire above-ground irrigation system at the nursery was removed and taken to California in an attempt to produce Guayule, a natural rubber-producing plant. The advent of synthetic rubber soon made this project expendable.

With the cessation of hostilities, the federal government again began production of shortleaf pine seedlings, on a limited basis. Several units of Block 3 were sown in the spring of 1947, but with limited personnel, it soon became evident that the large production capacity of the Licking Nursery would not be necessary.

On August 29, 1947, the regional forester, Region Nine, U.S. Forest Service, Milwaukee, Wisconsin, and Irwin T. Bode, Director of the Missouri Department of Conservation, signed a special use permit for the Licking Nursery. Effective for 25 years, the permit allowed the Department of Conservation full use of the nursery plant, with few restrictions. The main clause of the agreement stated that the Conservation Department would produce up to 2½ million 1-0 shortleaf pine seedlings annually for the National Forests in Missouri. At the time the permit was signed, the hand tools, office furniture and some of the specialized nursery equipment were included in the arrangement. Maintenance of existing facilities was also the Department's responsibility. Seedlings were to be produced and direct costs recorded for each seedling crop. These costs were reimbursed to the Department of Conservation after delivery.

When the Department assumed operation, the nursery contained 27 acres of seedbed area identified as Blocks 1 through 6. Though the Forest Service holdings totaled 40 acres, the special use permit defined only 34 acres to be managed by the Department. This was done mostly as a matter of convenience, as there were no improvements on the remaining six acres.

Since the overhead irrigation lines at the Licking Nursery had been removed, nursery personnel traveled to Keokuk, Iowa, dismantled the overhead lines of a surplus federal nursery and hauled them back to Licking. All underground mains and vertical supports had been left in place at the Licking Nursery. The renovation chore amounted to reassembling the horizontal lines, positioning oscillators and replacing nozzles.

On November 16, 1956, the Conservation Department purchased an additional 414 acres of adjoining land from John W. and Cora Teters, at a price of $28,000. This allowed the nursery to add Blocks 7 through 16, for a total seedbed area of 65 acres.

In 1957, the packing building in use today was built, and an additional well was drilled in 1963. In 1966, a seed storage building was added.

With the increased production capability at the Licking Nursery, it was soon apparent that the Department's Meramec Nursery at Meramec State Park was no longer needed. With the lifting of the last crop (multiflora rose) in the spring of 1963, the Meramec Nursery was closed.

On June 19, 1972, an additional 99 acres bordering Blocks 1 and 2 on the north were purchased from Ruth Shafer at a cost of $41,949. The land was progressively prepared for nursery use, but funding was not available for expansion into the new land for several years. Hay was cut from the fields west of old Highway 63 for several years through bids to local farmers. A quonset for tractor and machine storage was built in 1975.

As the 25-year period on the special use permit diminished, great efforts were made by both the U.S. Forest Service and the Department of Conservation to transfer the original site to the State of Missouri. Various appraisals, some as high as two million dollars, were made of the 34 acres and improvements. Since many of the improvements had been refurbished at high cost to the Department of Conservation, both parties felt that these

costs should be considered in final valuation of the property. From 1972 until an agreement was finalized, the Department operated the nursery under annual extensions to the original permit. On July 16, 1976, the U.S. Forest Service and Department of Conservation agreed to a land exchange which gave the Forest Service title to various properties within the Cedar Creek purchase unit of the Mark Twain National Forest and gave the Department title to the original 40 acres of the nursery, including all improvements.

Since the spirit of cooperation between the Department of Conservation and the U.S. Forest Service had been so good, nursery personnel were barely aware of the property transfer. Nothing changed. We were still living by many of the articles of the original special use permit, still producing planting stock for the National Forests of Missouri.

On September 7, 1977, 201 acres of land bordering the original nursery site were purchased from Ernest K. and Wilma J. Poulsen. The price was $70,000. The Poulsen property was of no value to the Department as nursery seedbed space, but provided additional land for seed production areas and wildlife plantings. It also did away with the right-of-way to the Poulsen property which ran directly through a busy section of the nursery seedbed area.

With passage of the referendum creating a 1/8 percent conservation sales tax, funding became available for development of the Shafer Tract purchased in 1972. Work was initiated in December, 1977, and continued through the fall of 1979. The addition included Blocks 17 through 22, bringing the total seedbed area to the 100-acre mark, or 2,127,786 square feet of seedbeds. Total acreage of the entire property is now 748.

During the fall of 1978, construction of the new seedling cold storage plant was begun. Adverse weather and soil conditions during construction delayed phases of concrete work. The 50' x 150' plant was finally available for use in the fall of 1979 and has been invaluable in carrying out the seedling distribution program of the Forestry Division, Department of Conservation. A quonset hut was built in 1979 for storage of bulky items.

The George O. White State Forest Nursery has evolved into a virtual tree and shrub production center, taking more than 45 years to grow from 27 acres to over 100 acres of seedbed production area. Growth will certainly not stop here, as various changes and additions are being planned. The packing building is rapidly becoming outmoded and overcrowded. The irrigation system could be much improved by the addition of a third deep well and pumping system, plus the replacement of much of the overhead system by modern sprinklers. The shop must be up-graded or replaced. The office, long overcrowded, should be enlarged or replaced. Locating a computer terminal at the nursery would allow streamlining of many administrative procedures.

Because of the foresight and support received in the past, the Department of Conservation is in an excellent position to meet planting stock needs which will result from the "Design for Conservation" program. As other Department programs are developed, support to carry on a modern Nursery program surely will continue.

Chapter One

Soils Management

Soil Description

Soils in the seedbed area of the George O. White State Forest Nursery are residual and often are referred to as "mountain soils" because of their in-place formation from parent material. The most prevalent series, covering 95 percent of the seedbed area, is the Huntington Silt Loam, an alluvial soil derived from limestone. Although this series is productive, it is quite heavy and must be managed carefully to maintain productivity.

A small portion of the seedbed area is comprised of the Hanceville Fine Sandy Loam Series. This soil is formed from alternate beds of sandstone and limestone, is much lighter and is far superior to the Huntington Silt Loam as a nursery soil. The northern one-third of Block Three is of the Hanceville Series, as is the northern one-third of Blocks Nine and Ten. Block Seven is a sandy loam soil, probably of the Hanceville Series, but seems to be underlain with an impervious subsoil, preventing good internal drainage during wet periods.

Table 1: State Nursery Soils-Physical properties*

Soil Series	% Sand	% Silt	% Clay
Huntington Silt Loam	40	45	15
Hanceville Fine Sandy Loam	80	10	10

*Above data derived from various soil testing laboratories and rounded for clarity.

Table 2: Standard Soil texture size classes (USDA standards)

Name	Diameter	No. Particles Per Gram
Very coarse sand	2.00-1.00 mm	90
Coarse sand	1.00-0.50 mm	722
Medium sand	0.50-0.25 mm	5,777
Fine sand	0.25-0.10 mm	46,213
Very fine sand	0.10-0.05 mm	722,074
Silt	0.05-0.002 mm	5,776,674
Clay	below 0.002 mm	90,260,853,860

Maintaining Good Soil Drainage

The heavy soils at the nursery pose drainage problems which must be addressed or little can be expected from attempts at tree seedling production. The following practices will ensure proper drainage:

All nursery blocks should be graded to drain in the direction of seedbed alignment. The grade is normally 1 percent. Though some blocks may vary below 1 percent, this grade should be maintained or pockets of water will collect causing seedling mortality.

A raised seedbed must be formed, elevating the bed surface above the level of water in the drainageways.

Paths between seedbeds and adjacent to irrigation lines must be kept open to carry away excess moisture.

Drainage ditches and culverts must be open at all times. A check of all such drainageways should be made following heavy rainfall and all obstructions removed.

Following each soil preparation operation (plowing, disc'ing, roto-tilling, fumigation), drainage-

ways should be restored to original condition.

All machine operations should be performed upgrade: lifting of seedlings in particular. Soil erodes down-grade and should be returned by every possible means.

Plowing of units should be either in a counter-clockwise direction if the soil is being plowed to the riser line, or in a clockwise direction if plowing is to the center of the unit. Subsequent disc-ing should always be in the opposite direction. Each implement moves soil in the direction of tractor travel and one must balance the other.

Desired Soil Fertility Levels

One objective of soils management is to ensure the availability of necessary nutrients in appropriate amounts for good seedling growth. This requires not only that the necessary nutrients be present but also that other soil conditions be conducive to nutrient uptake by the seedlings. Table 3 describes what is generally required in the soil for good seedling growth.

As Table 4 shows, objectives may vary from species to species, but an appropriate range can be pursued without seriously deterring growth of most seedlings.

Though all of these conditions are interactive and essential to plant growth, three primary concerns can be identified—organic matter content, mineral nutrients and pH level.

Maintaining Soil Organic Matter Content

Under normal conditions a rotation of two years in seedling production, followed by one year in a well-fertilized green manure crop, will maintain organic matter (OM) near the 3 percent level, suitable to insure friable soil conditions. The application of oak sawdust or planer shavings as a seedbed mulch undoubtedly contributes to the total level of OM incorporated into the soil. The application of hydro-mulch will also add to the OM buildup.

Attempts to raise the OM content above the 3 percent level have met with limited success. Higher levels have been achieved for short periods of time, but the long growing season, high temperatures and the moisture regime soon return OM content to 3 percent or below.

Table 3: Average Desired Soil Fertility Levels

Total nitrogen	0.13 percent
Available nitrogen	40 lbs. per acre (ammonia & nitrate)
Organic matter	2.5 percent
Available phosphorus	150 lbs. per acre P_2O_5
Available potash	250 lbs. per acre K_2O
Cation exchange capacity	12.0 milliequivalents/100 gms.
Replaceable calcium	10.5 milliequivalents/100 gms.
Replaceable magnesium	2.4 milliequivalents/100 gms.
Total replaceable bases	14.2 milliequivalents/100 gms.
pH for conifers	5.5-6.3

Table 4: Fertility Levels for Selected Species

	Scotch Pine	White Pine	Hardwoods
Total nitrogen	0.12%	0.14%	0.20%
Available nitrogen	30 lbs./acre	35 lbs./acre	45 lbs./acre
Available phosphorus, P_2O_5	50 lbs./acre	80 lbs./acre	150 lbs./acre
Available potash, K_2O	150 lbs./acre	200 lbs./acre	275 lbs./acre
Cation exchange capacity	8.0 milliequivalents/ 100 grams	10.0 milliequivalents/ 100 grams	14.0 milliequivalents/ 100 grams
Replaceable calcium	3.0 milliequivalents/ 100 grams	5.0 milliequivalents 100 grams	8.5 milliequivalents/ 100 grams
Replaceable magnesium	1.0 milliequivalents/ 100 grams	1.5 milliequivalents/ 100 grams	2.5 milliequivalents/ grams
pH	5.4 milliequivalents/ 100 grams	5.4 milliequivalents/ 100 grams	5.8 milliequivalents/ 100 grams

how best to prevent this potential nitrogen deficiency. Our only experience has been application of 1,000 lbs. per acre of ammonium nitrate, plus 500 lbs. of treble superphosphate per acre to a three-inch layer of sawdust, with the entire application plowed into the soil and harrowed well. A green manure crop should immediately follow any such application, mainly to act as an indicator crop. Apparent nitrogen deficiencies should be corrected immediately, using ammonium nitrate well irrigated into the soil. No deficiencies appeared following the above procedures. Since the mineral nutrients applied with the sawdust were for the breakdown of the sawdust entirely, 300 pounds of a well balanced 1-3-5 fertilizer were distributed for the benefit of the green manure crop.

Providing Mineral Nutrition

Mineral nutrient levels of seedbed soils have been maintained at the 1-3-5 ratio of N, P_2O_5, K_2O for many years. Fertilizers are bagged and marked clearly as to the content of the three principle nutrients. Nitrogen is expressed as a percentage of elemental nitrogen, phosphorus is expressed as the percentage of P_2O_5, and potassium as the percentage of K_2O. Since we are concerned with the elements in this form, this labeling fits the program well.

Unfortunately, companies do not offer a mixed fertilizer in the 1-3-5 ratio, because this mixture is not commonly used in agriculture. The alternative is to maintain supplies of the individual elements and mix them to attain the 1-3-5 ratio. Fertilizers are sold in various chemical forms, are readily available and may be mixed to achieve the desired ratio. A few common fertilizers are listed in Table 5, showing the percentage of N, P_2O_5 and K_2O present, where relevant.

Table 5: Contents of Some Common Fertilizers

Name	N	P_2O_5	K_2O
Anhydrous ammonia	82	0	0
Ammonium nitrate	33	0	0
Ammonium sulphate	20	0	0
Potassium nitrate	12	0	44
Potassium sulphate	0	0	48
Potassium chloride	0	0	50
Normal superphosphate	0	up to 22	0
Treble superphosphate	0	40+	0

Occasionally, fertilizers are described in terms of elemental nutrients and Table 6 is required to compute the correct ratio.

Table 6: Conversion Factors for Various Fertilizer Elements

Pounds P_2O_5 X 0.45	=	pounds elemental P
Pounds elemental P X 2.22	=	pounds P_2O_5
Pounds K_2O X 0.83	=	pounds elemental K
Pounds elemental K X 1.20	=	pounds K_2O

Ammonium nitrate is a readily obtainable form of nitrogen. Since it is packaged in plastic sacks, it may be stored for long periods of time without caking. Care must be exercised in storage, however. Ammonium nitrate should not be stored over eight sacks in height, should have ventilation between stacks and should be kept away from areas containing petroleum products. Several instances have been recorded where ammonium nitrate has exploded spontaneously due to improper handling or storage conditions. Ammonium nitrate is marketed as 33-0-0 fertilizer, and is literally 33 percent nitrogen (elemental), half of which is ammonia N, the other half nitrate N.

Phosphatic fertilizers are sold in various forms, the most common being treble superphosphate, normally marketed as 0-46-0 fertilizer. It contains 46 percent P_2O_5. Storage of this material poses no problem, although a dry area is necessary. Moisture would eventually decompose the paper sack and cause some caking of the fertilizer.

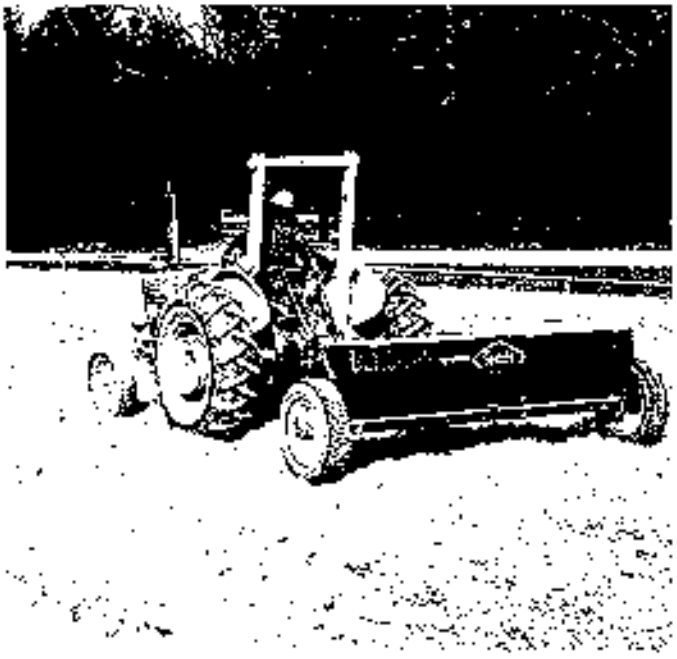
Potash is available in several usable forms, the most common being Potassium sulphate, marketed as 0-0-48 fertilizer. It contains 48 percent K_2O. This also requires dry storage, but otherwise will store easily for long periods of time. Potassium sulphate, contains 18 percent sulphur; which may or may not be desirable if soil pH is a concern. Potassium chloride is available as 0-0-60 fertilizer, but at high levels, the chloride may be toxic.

Each shipment of fertilizer must be clearly marked as to the percentage of each mineral nutrient it contains (N-P-K). Shipments may vary, but the analysis shown is the minimum value.

As an example, consider beginning with 100 lbs. of ammonium nitrate. Since this is listed as 33-0-0, or 33 percent nitrogen, the amount of elemental N available is 33 lbs. To calculate the second segment of our 1-3-5 formula, 99 lbs. of P_2O_5 will be required. If the superphosphate on hand is listed as 0-40-0 fertilizer, 247.5 lbs. will be needed. (99/.40 = 247.5). To compute the third segment of the

Following two years of seedling production, which may be two crops of 1-0 pine, one crop of 2-0 pine or two crops of 1-0 hardwoods, the soil should be retired for rebuilding. At this time, all mineral fertilization is applied either in conjunction with the drill sowing of the green manure crop or separately by the fertilizer spreader.

Following proper plowing and discing, the cover crop should be sown in May as soon as danger of a killing frost is past. May 20 is the average date for the last killing frost in this area. Hybrid sorghum-sudan grass is sown at the rate of 19 pounds per acre in conjunction with 500 pounds of mineral fertilizer (1-3-5). As stated previously, the seed and fertilizer may be sown simultaneously with the grain and fertilizer drill or individually by utilizing the fertilizer spreader and the grain drill. When spread separately, fertilizer should be lightly disced into the soil, prior to the sorghum-sudan sowing.

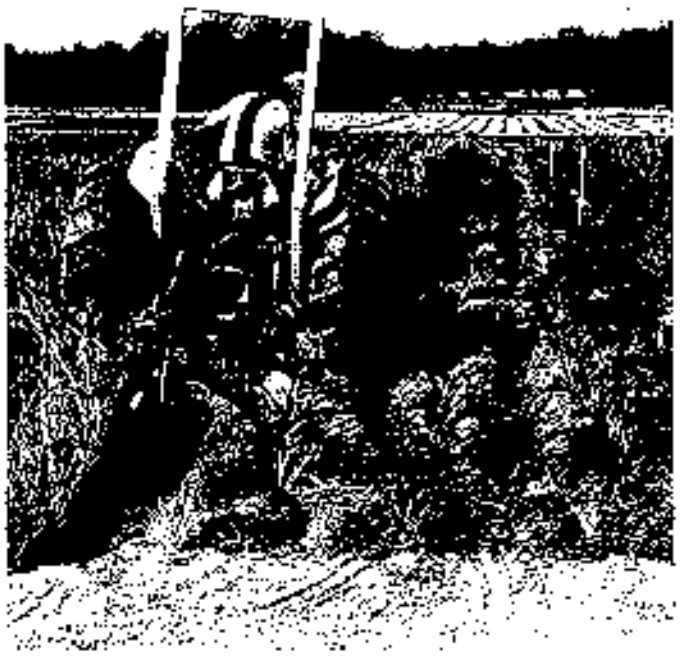


Fertilization prior to sowing green manure crop.

Generally, the green manure crop will reach a height of five feet or more in three to four weeks, at which time it should be bush-hogged and allowed to resprout. If allowed to continue growth, the stalks become large and tough, causing difficulty in plowing and slowing decomposition. In most years the crop should be plowed under in mid-July, to allow for a 45 day period of decomposition prior to fumigation with methyl bromide. Some light discing may be necessary during the decomposition period to discourage resprouting and to make certain that all of the woody material is well covered with soil.

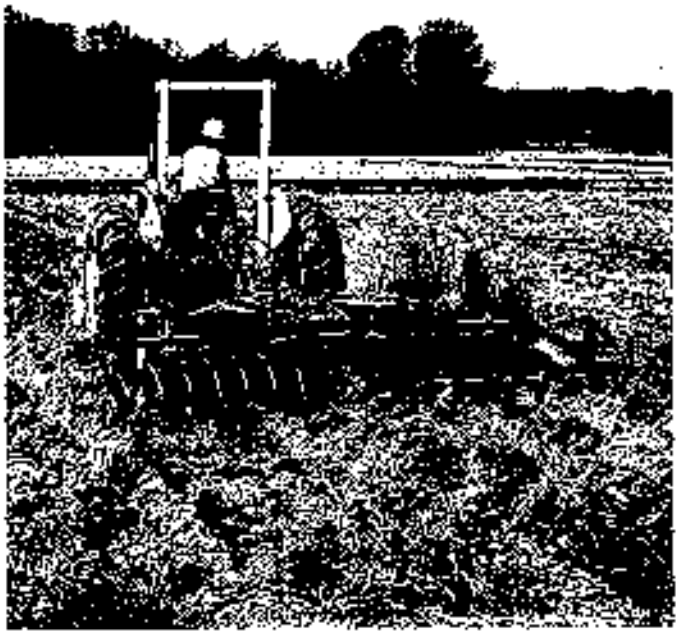
Due to time and weather constraints, machinery sometimes must be used in the seedbeds at times when soil structure damage can occur. Should soil in an area become unworkable because of a loss of soil friability, a heavy application of organic matter will bring the area to normal. If the area is small, say one or two units, heavy applications of compost will return the area to productive capacity. Six inches of well composted material have been added to such soils in the past, with excellent results. Fumigation should follow, as compost is not a weed-free medium.

Larger areas suffering from soil structure loss must be treated in a different manner, since the supply of composted material is limited. Sawdust may be incorporated at a rate of 400 cubic yards per acre or to a three-inch depth. New or old sawdust—either oak or pine—may be used. Incorporating this quantity of sawdust directly into the soil will cause a serious drain on the nitrogen balance which must be corrected. Some discrepencies exist concerning



Plow down of cover crop.

Discing cover crop to speed decomposition.



formula 1-3-5, we will need 165 lbs. of K_2O. If the potash on hand is 0-0-48 fertilizer, 343.75 lbs. will be needed. The final formulation would amount to 691.25 lbs. of fertilizer containing 33 lbs. of N., 99 lbs. of P_2O_5 and 165 lbs. of K_2O, formulated at the 1-3-5 ratio. The final analysis would be 4.77 - 14.32-23.87, an unwieldy figure, but necessary for the growth of a wide range of tree seedlings. Various formulations of premixed fertilizers lend themselves to alteration to reach the 1-3-5 ratio. For example, 8-24-8 fertilizer is readily converted to 8-24-40 by the addition of the proper amount of K_2O, or 6-24-24 is altered by the addition of small amounts of N and K_2O. To work through another example, 8-24-8 fertilizer requires an additional 32 lbs. of K_2O per 100 lbs. to achieve the 1-3-5 ratio, or 66.67 lbs. of 0-0-48 fertilizer (32/.48 = 66.67 lbs.). 6-24-24 fertilizer is altered by the addition of two lbs. elemental N per 100 lbs. of fertilizer, or 6.06 lbs. of 33-0-0 fertilizer, ammonium nitrate, (2/.33 = 6.06 lbs.). An additional 16 lbs. of K_2O will be necessary, or 33.33 lbs. of 0-0-48 potassium sulphate (16/.48 = 33.33 lbs.). The above calculations will not create a true 8-24-40 formulation, because of fillers in the various components, but the ratio of nutrients is correct. Five hundred pounds of a 1-3-5 fertilizer, applied prior to the green manure crop, or between 1-0 seedling crops, will provide adequate plant nutrition, all other soil factors being correct.

The computations above have been carried to exact figures for the sake of illustration and clarity. In practice, fertilizer can be mixed in quantities which are measured in terms of 50-pound sacks, one-half sacks or one-quarter sacks. Accuracy beyond this is too time consuming and expensive. After computing the amount of material needed for each component, the starting point could be 100 lbs. N, 200 lbs. or 500 lbs. Any combination which requires a definite part of a sack will be advantageous. Care must be exercised as to the total size of the final batch, as larger batches are difficult to mix thoroughly which could result in placing large quantities of some elements in small areas during spreading. The individual elements *must* be well mixed.

Maintaining pH Levels

Maintenance of soil pH is especially critical. Soil reactions, which are influenced by soil acidity, must occur within specific pH limits, or elements could be either tied up or leached away, depending on the pH reading. The availability of phosphorus, potash, calcium and magnesium is reduced as pH is lowered. Iron, zinc, aluminum and manganese become more soluble at lower pH readings and may become toxic under these conditions. On the other hand, phosphorus availability is also reduced at pH 7.0 and above. Many fertilizers contain acid-forming elements which will, in effect, lower pH to points detrimental to good seedling nutrition. Very low pH readings may cause nitrogen to leach away, make phosphorus unavailable for plant nutrition and tie up minor elements in insoluble forms. Under these conditions, toxic combinations which lead to seedling mortality may be produced. Readings on conifer-producing areas should range from pH 5.0-5.5. Hardwoods fair better at pH 6.0-6.5. These are ideal ranges, but you do have some flexibility in exceeding these limits in practice.

In most instances, if plentiful nutrients are available, the pH ranges listed above will produce healthy, plantable nursery stock. Soils above the low or high limit should be corrected immediately. In order to radically change the pH of a soil, sulphur or ground limestone must be added.

Various charts are available for the amount of each chemical needed to raise or lower pH, but experience has shown that each soil has a set of characteristics which might tend to buffer sulphur additions or perhaps react too strongly to the recommended dosage. Sulphur additions or ground limestone should be added well in advance of seeding, or problems could develop. Conifers might develop poor root systems in the presence of high sulphur concentrations or could develop damping-off disease when ground limestone has not been fully neutralized. Seedling crops should be sown no less than six months after the application of sulphur or ground limestone.

Table 7 is a guideline only. Radical changes in pH should not be undertaken at one time, but gradually, over several years if need be. Experience has shown sulphur to be much more efficient in lowering of pH than the table might indicate.

In our experience, one-half of the indicated amount usually has accomplished the desired change. Addition of ground limestone for raising the pH level has not been necessary, but as stated elsewhere, pH in hardwood blocks, due largely to fertilization practices, has been creeping lower and eventually will need correction.

Table 7: To alter pH in Huntington Silt Loams Incorporate Recommended Amounts of Ground Limestone or Sulphur to a Six-inch Depth By Rototilling

To Raise pH levels				To Lower pH levels			
Present pH	+	Pounds/Acre of Ground Limestone	= Desired pH	Present pH	+	Pounds/Acre of Sulphur	= Desired pH
4.5		3,000	5.0	7.0		400	6.5
5.0		8,000	5.5	6.5		600	6.0
5.5		2,500	6.0	6.0		800	5.5
6.0		1,500	6.5	5.5		2,000	5.0
6.5		1,500	7.5	5.0		1,200	4.5

The above table is for actual ground limestone and does not reflect basic calcium or percentage of calcium contained. Soil recommendations will reflect pounds of calcium required to bring the soil to a suitable pH level, and the chemical composition of the limestone must be known in order to compute the actual amounts necessary.

Soil Testing

The maintenance of soil fertility will depend upon the results of accurate soil testing by a competent forest soils testing laboratory. Practices recommended thus far will be satisfactory for several years, probably as long as five, but eventually a good series of soil tests will show what minor adjustments must be made. Elements may build to excessive quantities, pH may change drastically or organic matter content may fall to a low level. Since all factors of soil conditions interact, the nurseryman should rely on soil testing practices. Services performed are comprehensive and normally include the following information:

- % Organic Matter
- Cation Exchange Capacity
- Soil Reaction (pH value)
- Texture (% sand, % silt, % clay and texture name)
- Concentrations of N, P, K, Ca, Mg, Mn, Na, Fe, Zn, and Al
- Recommendations for additions necessary to produce coniferous or hardwood seedling plants.

The facilities of the University of Missouri Agricultural Extension Service may be helpful for rapid soil testing, should the need arise. Testing must be prearranged as agricultural soil testing is seasonal and may not agree with the nurseryman's schedule.

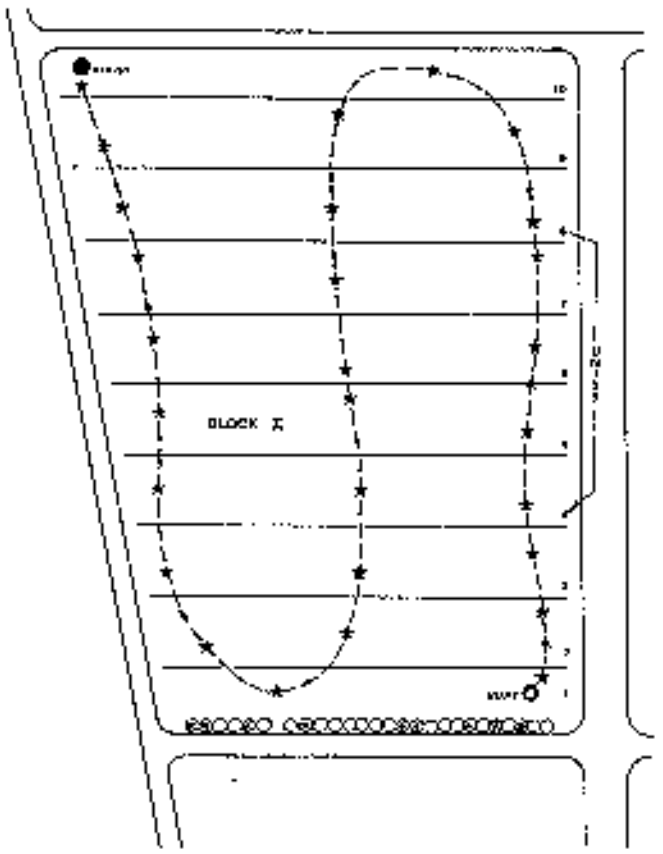
The following information is available from the Extension Service Soil Testing Laboratory:

- Cation Exchange Capacity
- Soil Reaction (pH value)
- % Organic Matter
- Concentrations of P_2O_5, K_2O, Mg., Ca., H

Notice that the available N is not recorded. Conferences with Extension Service personnel and other sources have concluded that each 1 percent of organic matter present furnishes a minimum of 30 pounds of available N per acre. This figure may be used as the starting point of the 1-3-5 ratio for determining the phosphate and potash needs. (3 percent OM would furnish a minimum of 90 lbs. elemental N per acre). A great deal more N is present, but this is the amount available for plant growth. Since results from the Extension Service are designed for agricultural crops, certain values will not be compatible for tree seedling growth. P_2O_5 determination is the area which seems to vary significantly from forest soils laboratory results. Agricultural crops can utilize the phosphates better than tree seedling crops, and results for P_2O_5 derived from the labs vary distinctly, largely because of the P_2O_5 extraction method. The agricultural labs use a strong acid for phosphate determination, while the forest soils labs use a weak acid. Experience has shown that P_2O_5 determinations from an agricultural laboratory should be reduced to 20 percent of the available P_2O_5 reported. This will bring the factor in close agreement with reports from forest soils labs. The agricultural lab determinations for K_2O and other factors are acceptable and accurate.

No matter which testing facility is used, care must be exercised to ensure that the collected soil sample is representative of the area under investigation. The most propitious time for sampling would be at least 60 days following green manure crop plow-down. Samples also should be taken in a few areas following a crop of 1-0 seedlings and in a few areas which are in the second continuous year of seedling reproduction (two crops of 1-0 seedlings or one crop of 2-0 seedlings). Such checks are of value in reviewing the current fertilization program and changing any phases of it as necessary.

Figure 1. Method of selecting sites for soil sampling



A representative sample is generally taken from one nursery block, although portions of a block or a single unit may be under investigation. At least 35 core samples should be taken in each block, walking a zigzag pattern over the entire area, making certain that samples are taken at random and that the entire area will be represented in the composite sample. (See Figure 1.) A soil sampling tube should be pressed into the soil to a depth of six inches and individual cores should be placed in a clean plastic bucket. Never use a metal bucket for core collection or any container previously used for chemical or fertilizer mixing. Avoid all means of contamination. Upon completion of core collection, the entire collection may be mixed, using a clean, non-metallic instrument. Avoid stirring with bare

hands, as this may be a source of contamination. If the resulting sample is too moist for shipment, place it in a clean kraft paper bag, fold down the top and allow to dry for several days in a dust-free atmosphere.

When ready for shipping, one quart of each representative sample should be placed in a clean, non-metallic break-proof container. Sample containers should be well tagged inside and out with nursery name, date of sampling, block or unit location, and notes stating the present status of seedling production (1-0 pine, 2-0 pine, 1-0 hardwoods, green manure crop, etc.)

Early fall would be the best time for sampling as most of the nutrients assimilated by a crop have been removed and fertilization prior to green manuring has been assimilated by the sorghum-sudan and returned to the soil through decomposition. With the enlargement of the nursery to 100 acres, single blocks have been treated as separate entities. Unless a severe problem develops in a small area, all soil management practices are more readily carried out and records simplified by the standard treatment of the overall nursery seedbed soils.

Blocks must be considered either conifer or hardwood, due primarily to the differences in soil elements required to adequately produce good quality planting stock. The main concern is the variation between pH in production of conifers and hardwoods. Although the present ranges of pH are acceptable for either conifer or hardwood production, the trend is for pH to drop to lower levels with time. An eventual adjustment will be needed.

Deficiency Symptoms

Although soil testing should be the basis for making decisions on fertilizer deficiencies, visual examination of growing seedlings often will show areas in need of one of the three basic elements.

Nitrogen Nitrogen adds to total growth of a seedling, lending the lush green so prevalent in healthy plants of all species. Excess nitrogen will result in dark green coloration and, in some cases, burning and eventual death of seedlings. Seedlings suffering from an oversupply of nitrogen are generaly fleshy and are not in the hardened-off stage at the time of the first killing frost. Soils supplied with the proper amount of phosphates and potash will not be subject to an oversupply of nitrogen. Good fertilization all season long will produce healthy, mature seedlings at the end of the normal growth period.

Nitrogen deficiency can be recognized by stunted growth and light yellow leaves or needles. Hardwood leaves will tend to be smaller than normal and may fall from the plant. Some cases of nitrogen deficiency cause a dishing effect, with smaller, yellow seedlings in the bed center and large, normal seedlings at the edge of the bed. In coniferous seedlings, the needles may be chlorotic overall or near the tip. Chlorosis of shortleaf pine during late July and early August should not be mistaken for nitrogen deficiency, especially if the seedlings are in full, normal growth. The seedling eventually will overcome this interruption and become green and healthy with the advent of cooler weather. The condition is usually encountered when a portion of the seedling stand begins a flush of growth and others in the stand do not. The chlorosis is not general, but confined to seedlings in full flush of growth.

Nitrifying bacteria are necessary in the nitrogen chain, largely for the transition of ammonia nitrogen to the nitrate form. Fumigation of seedbeds with methyl bromide gas has an alarming effect on these silt loam soils, causing a breakdown in the nitrification chain, a buildup of ammonia nitrogen and a decrease in the nitrate nitrogen. In past years, fertilization was initiated after fumigation of seedbeds and just prior to seeding. Stunting of seedlings, both conifers and hardwoods resulted. Leguminous species were seriously stunted. Early studies by Dow Chemical Co. found this to be true in "mountain" or residual soils. The interruption of the nitrogen chain resulted in the build-up of ammonia nitrogen plus a form of nitrite, which was extremely toxic. At season's end, the conifers and hardwoods were no more than one inch tall.

Soil tests and seedling tissue testing revealed nothing remiss, and seedling roots appeared to be fully mycorrhizal compared to those of healthy seedlings. Since fumigation was destroying the beneficial soil organisms, the addition of fertilizer was actually harmful. The problem was solved with the addition of necessary fertilizers prior to the green manure crop which allowed for the complete breakdown of the various elements. The retention of the fertilizer by the crop and its eventual return to the soil in useable form, prior to the fumigation, is an added benefit of this procedure. Since that time, no further stunting has developed. Fertilization of the second 1-0 crop following the fumigation has not been detrimental to the seedlings.

Phosphorus Phosphorus is necessary for good root development and for seedling maturity and is said to be counteractive to excess nitrogen. Phosphorus is made more available in the presence of organic matter, is more available between pH 6.0 and 7.0 and must be in good supply, as little of the soil phosphorus present is available for plant growth. Phosphorus deficiency is generally apparent in coniferous stock with the appearance of purpling in spring and early summer. Late fall purpling of shortleaf pine, jack pine and Virginia pine is a normal coloration and should not be confused with phosphorus deficiency. Normal discoloration of the needles will begin to show purple at the tips of new growth if phosphorus is not available. Many times the deficiency will be noted soon after germination. Application of a high phosphate fertilizer in solution will correct the deficiency. Deficiency symptoms in hardwood stock are not so pronounced. Leaf veins may appear chlorotic with the balance of the leaf area remaining green, tending toward purple. Some redness may also appear in the stems of hardwoods.

Potash Potash is said to be necessary for the formation of stout, woody stems, and for disease resistance. It is beneficial in the formation of seedlings which are well hardened-off prior to the coming of winter. Potash is readily lost by leaching in sandy soils, but fares quite well in silt loams of the nursery. Deficiencies of potash show up rapidly in top die back of hardwood seedlings left over winter in seedbeds. Deficiencies are visually apparent when yellowing occurs at the tips of needles and at the edges of leaves. Pine needles may show a distinct line between the yellow and green portions, or distinct, alternate bands of yellow and green may appear.

Micronutrients Magnesium, calcium, sulphur and various micronutrients are necessary for good plant growth, for good top-to-root ratios and generally vigorous planting stock. Determination of deficiency can be made through visual examination, but is more precisely made with the aid of a competent soil testing laboratory.

Chapter Two

Seed

Collection

Seeds of various trees and shrubs can be collected locally, generally during periods of low nursery activity. Doing so helps to conserve funds, assure the nursery of a continuous supply of fresh seed and certify the source of seedlings being produced, plus it provides a backup supply to cover production needs in case there's a crop failure.

Since many seeds cannot be stored due to bulk and/or fleeting germinative capacity, it is not possible to have a stock of seed on hand to meet all annual production requirements. Acorns, black walnuts, cottonwood, pecans and river birch are among seeds that cannot be stored. Many other native species, though, can be collected and stored for many years under proper conditions.

The major consideration in seed collection is crop maturity, since immature fruit from most trees and shrubs will not produce viable seed. Several excellent publications are available which describe fruit maturation requirements, seed dispersal dates, number of seeds per pound, stratification requirements, type of dormancy normally present, etc. "Seeds of Woody Plants in the United States," published by the U.S. Department of Agriculture, Forest Service, Agriculture Handbook No. 450, is obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 0100-02902. Refer also to "Hardwood Nurseryman's Guide," U.S. Department of Agriculture, Forest Service, Agriculture Handbook No. 473, also available from the Superintendent of Documents.

Since birds, squirrels and other wild creatures remove ripe fruit quite rapidly, all seed collection should be done at maturity. Stands must be scouted in advance and visited regularly to ascertain the condition of the crop. Collection should begin as soon as conditions are proper. Most species, particularly nut species, are ready for collection at the time of fruit fall; others have various criteria of ripeness. River birch must be collected as soon as the strobiles begin to break apart on the trees, as the seed is rapidly dispersed following this condition. Germinative capacity of this species is fleeting, so sowing soon after collection is necessary.

Handling

After seed collection, proper handling prior to storage is essential. Seed must be delivered to the nursery promptly. If it is allowed to stand in air-tight containers for long periods of time, molds, mildews and heating of the fruit will contribute to a lower germinative capacity. Fleshy-fruited species deteriorate rapidly under such conditions. If such fruit is not going to be processed immediately, it should be spread on dry canvas tarps or in screens until extraction. Seeds with high moisture content will heat rapidly in packed, closed containers and should be spread to prevent this problem. Sacks of fruit may be kept in cold storage (32° - 36° F) for several days prior to extraction. Freezing of species with high moisture content should be avoided, as many of these fruits will not tolerate freezing. Sacks or other containers of seed should not be stacked for any period of time, as rapid heating will occur, even under cold storage conditions. Sacks must be separated, allowing complete circulation of air around each sack.

Extraction of Fleshy-Fruited Species

Seed extraction for most fleshy-fruited species is best accomplished using a macerator, which will depulp the seed cleanly without causing damage. Care must be exercised in the cleaning process, as severe shock during the extraction will destroy the germinative ability of most seeds. The severe action of some walnut hullers has destroyed black walnut seeds. Even though there was no physical evidence of damage to the shell, the nuts rotted in the seedbed soon after sowing, creating an aroma reminiscent of rotten eggs. The viability of multiflora rose seed has been destroyed by the severe shock caused by a hammer mill operated at too high a speed. Dogwood seed has been cracked and damaged by the same machine when operated at high speed. The shock of dropping a radish seed from a height of 10 feet onto a concrete floor is said to be enough to destroy the seed, although physical damage to the seedcoat isn't necessarily apparent.

The use of the Dybvig seed cleaner removes the possibility of seed damage during extraction, since friction provides the abrasion needed for pulp removal. During extraction with the Dybvig, water is used to carry away the macerated pulp, but water also acts as a buffer to protect the cleaned seed from shock damage. Fleshy fruits cleaned by the Dybvig cleaner include flowering dogwood (*Cornus florida*), deciduous holly (*Ilex decidua*), wild plum (*Prunus americana*), various types of hawthorn (*Crataegus*), persimmon (*Diospyros virginiana*), autumn olive (*Elaeagnus umbellata*), Russian olive (*Elaeagnus angustifolia*), blackberry (*Rubus allegheniensis*), as well as those of many species which have fleshy berries, drupes or pomes.

When large quantities of fleshy-fruited species are to be extracted, the hammer mill is the best choice. Several precautions should be exercised when using the hammer mill:

1. Maintain the speed of the gasoline engine at as low an rpm as possible without stalling under full load. Some authorities specify a speed less than 400 revolutions per minute. This may be too high for some soft-seeded species.
2. Maintain two full streams of water from 3/4-inch hoses during actual extraction, both to wash away the macerated pulp and to act as a buffer for the seed.
3. The screen selected for the mill should be small enough to keep the clean seed from falling through, but large enough to allow the pulp and water to pass through. An indication of complete maceration is passage of clean water through the mill. The screen then can be dumped into the re-

tainer box and another batch of seed put into the hopper for macerating.

4. NEVER open the mill for any purpose while the engine is engaged or the mill is running! Shut down the engine by declutching, and wait for the mill to stop completely before opening to inspect or to remove the clean seed.

Cottonwood seed can be cleaned using the hammer mill, with the following differences:

1. Cottonwood capsules should be well dried and easily broken by finger pressure. Most capsules in the lot should be open and showing white cotton, or should be dry enough to pop open readily and show white cotton when squeezed between the thumb and forefinger.
2. Batches of cottonwood are run through the mill in a dry state.
3. The screen must be large enough to allow the seed to pass readily, or damage to this small, soft seed will result. All precautions regarding high speed of the mill should be followed. A screen with holes 1/8 inch in diameter works well with most batches.
4. Do not run the mill long after it is apparent that the bulk of the seed has been removed. When sections of the capsules begin to pass through the screen, stop the mill, remove the seedbox containing the extracted seed and clean the cotton and trash from the mill. For some reason, the action of the mill allows clean seed to pass through the large-holed screen while keeping the fluffy cotton and trash inside the mill.
5. A small amount of hand cleaning, generally using hand screening, will be necessary to produce well-cleaned and free-flowing cottonwood seed.

Extraction of Dry-Fruited Species

Many tree seeds are produced in conelike structures, ball-like structures, or pods which must be merely broken apart for nursery sowing. Tulip-poplar (*Liriodendron tulipifera*), sycamore (*Platanus occidentalis*), bald cypress (*Taxodium distichum*) and black locust (*Robinia pseudoacacia*) are a few such seed structures. All must be broken apart, since the seed is either part of the structure or contained within parts of the fruit.

Tulip-poplar cones may be separated into individual samaras by using the hammer mill for a short period of time. A screen small enough to contain all of the samaras should be used, otherwise samaras attempting to pass through a larger screen will be damaged, possibly to the point of destroying the enclosed seed.

Bald cypress is readily broken apart in the same manner. Cone scales contain the seed, and further separation of the seed from the scale is not necessary or advisable.

Sycamore fruits may be broken apart in the hammer mill, although an irritating dust is associated with extraction. Masks should be worn by personnel while extracting sycamore seed in order to prevent irritation to the eyes, nose and throat. Sycamore may be processed in the same manner as recommended for cottonwood. Use a screen large enough to allow the clean achenes to pass but still retain the hairs and trash within the mill. If this does not seem to result in satisfactory separation, a smaller-sized screen should be used to separate the achenes from the hairs and dust before final separation in the fanning mill.

Extraction of Coniferous Seeds

Shortleaf pine (*Pinus echinata*) our native pine, is produced in quantities far above all other conifers and, for the most part, is collected locally. Since shortleaf pine produces bumper crops infrequently, enough seed must be collected at that time to carry nursery production until the next such bumper crop.

Shortleaf pine produces a few cones each year, but good production years only occur about once every 10 years. Excellent cone crops were most recently recorded in 1957, 1967 and 1968. In off years, fewer cones are produced, there are fewer seeds per cone, and the germination percentage of seeds extracted is quite low. Extraction of seed during a low-production year generally will produce one-half pound of clean seed per bushel of green cones, with a germination percentage of 50 percent. On the other hand, seed extracted in a bumper-crop year will average from three-quarter pound to 1¼ pound of clean seed per bushel of cones, with a germination percentage of 85 percent or higher. It is advantageous to collect seed during the bumper-crop year and store it during the interim poor crop years, because seed is becoming very expensive. Seed collected locally is also of known origin, meets our requirements for future tree improvement plans and is of good, sound quality.

Shortleaf pine cones can be collected normally after October 20 in most years; however, cones have been ready in central Missouri as early as September 25. The following items should be checked prior to collection or purchase of shortleaf pine cones:

1. Seventy-five percent of the freshly collected cones should float in 20W non-detergent motor oil. Samples should be taken from a wide area, not from just a few trees in a small area. (Have other foresters check all areas of the normal range if possible.)
2. Cut several cones through the central axis to expose the seed. The seed of shortleaf pine is mature when the endosperm is firm and is cream-colored, and the seed coat has turned brown. Seed collected prior to this will not continue maturing to sound, viable seed.
3. When these criteria are met, collection or purchase from the general public may proceed. Cones picked prior to maturity generally can be distinguished by the rapid drying and shrinking of the cone and the browning of the cone scales associated with drying. Mature cones would be completely open and the seed dispersed at this point of drying.

At the time of collection, cones are rather green, with cone scales beginning to discolor, but still containing a great deal of moisture. During this period, cones kept in sacks or closed containers will heat, mildew, become case-hardened and otherwise deteriorate. Cones must be placed in screens for further drying, to remove excess moisture and to cut down the total time in the dry-kiln. When screens are not available, cones can be spread on a *dry* floor, no more than one foot deep, until screens are available, or until drying comes about through other means. Cones stored in this fashion must be stirred daily.

literally turning the bottom cones to the top and vice versa. Cones have been stored in this fashion for several months, and then placed directly into the dry-kiln for extraction. When this type of storage is used, make certain that the floor is well constructed, with no openings which might allow the seed to escape should the cones begin to open during the pre-drying period. Concrete floors are excellent places to store cones if completely covered and dry.

Some concrete floors sweat during periods of high humidity and rapid temperature change. These should be avoided but when storage capacity is needed, any protection is considered better than none. Cones have been stored in burlap sacks, 50 percent filled to capacity, which then were hung from building rafters to permit air circulation and to protect the seed from rodents. This type storage is useful when other means are not available. Care must be exercised to make certain that room is available for expansion of the cones when drying. Cones will at least double in size from the green condition to the fully opened condition. If cones are restricted so that they cannot open when they are ready, they will remain closed permanently and the seed cannot be extracted.

After cones have been stored in screens at least 30 days, loading into the kiln can proceed. Each kiln tray should be loaded with no more than three-quarter bushel of cones during the early days of extraction. At this stage the cones have not fully opened but as they do so will raise the cone trays to the top of the kiln making removal extremely difficult. As extraction progresses, cones open further prior to loading into the kiln and one full bushel may be placed in each kiln tray. The normal kiln run for well-dried shortleaf pine cones is six hours at a temperature of 130° F. Early in the season, some cones will not open readily in six hours and longer runs may be necessary. If this condition persists, it is possible that live steam is leaking into the kiln, water is leaking into the kiln or the top blower is not operating properly to remove the moisture released by the cones. Free moisture in the kiln near the end of a six-hour run is almost certainly a sign of a leak.

Since a kiln charge is 50 bushels, and four charges are run per 24-hour day, 200 bushels of cones can be processed per 24-hour day. Normal operation is to run the kiln 24 hours per day, seven days per week.

When a charge comes from the kiln, it should be run through the shaker immediately, while still warm. One stack of trays may be run through the cone shaker at a time. The remaining stack should be covered with canvas or other material to hold heat as long as possible and should be run through the shaker immediately after the first stack. Seed removed from the shaker should be placed in a closed container and removed to the seed storage for de-winging and cleaning as soon as possible. As the seed leaves the dry kiln, it has a moisture content of 4-to-6 percent and additional moisture from the atmosphere would be detrimental to long-time storage.

Caution should be exercised when running cones through the shaker, for several reasons. Cones should not be forced into the shaker too rapidly, but should be fed at a rate which will allow individual cones to tumble freely. Large volumes of cones will traverse the shaker screen, but valuable seed is entrapped in this volume of cones and is lost. This is a dangerous operation, as an explosive dust which can be ignited by an electrical spark or open flame is present when shaking cones. Several extractories have exploded and burned for the lack of a dependable dust-collection system. Use the dust-collection system at all times when the shaker is operating. Close the bottom seed removal door to make certain that all dust is removed from the system.

As seed is removed from the shaker, it will contain many large impurities such as aborted cones, pieces of cones, rocks, bottle caps, etc. These impurities are brought to the nursery in the containers in which the cones were originally collected and must be removed prior to further cleaning or de-winging, or damage to cleaning machinery may occur. A scalping or screening of the material is necessary for removal of these impurities.

The next process is to de-wing the seed in some manner which is not detrimental. Machinery often cracks seed coats if used improperly or if drastic means are necessary to accomplish de-winging. The natural way to de-wing would be to dampen the winged seed slightly and dry. As drying occurs, the wings separate readily from the seed and can be blown off easily by the fanning mill or by allowing the seed and wings to pass through any blast of air such as that created by an electric fan. Seeds are de-winged the same way in the outdoors. The cone opens on the tree and the winged seeds are dispersed rapidly and far by wind, eventually reaching the earth. Rains and heavy dew dampen the seed, the sun eventually dries the winged seed and the wing is released. A clever pincerlike mechanism holds the seed in place and when dampened and dried, the pincer opens, thereby releasing the seed. One bushel of winged pine seed dampened with one cup of water, well distributed by tumbling in a concrete mixer, then dried in a drying cabinet or on screens will separate wings and seed for further cleaning in the fanning mill. The dampening and further drying of pine seed for de-winging adds another drying step to the extraction process. Moisture content should not be above 8 percent for long-term cold storage or storage failures will result.

The most rapid method of de-winging pine seed is using the Crippen De-winger, an agricultural machine used for polishing grain. Care must be exercised as the de-winger can damage pine seed, especially by cracking the seed coat. The Crippen De-winger consists of a horizontal drum with a corrugated rubber lining. Brushes attached to a central shaft rub against the corrugated rubber, and this action in effect rubs the wing away from the seed. As the mixture progresses, it falls through an adjustable air blast. The wings, being lighter than the seed, are blown out through an exhaust stack, while the seed falls through to a collection box.

Careful adjustment of the machine is the key to recovering unharmed seed. Prior to starting the first batch to be de-winged, remove all tension from the brushes, using the special wrench provided by the manufacturer. Add a small amount of winged seed to the hopper and adjust the brushes a small amount at a time, carefully checking discharged seed after each adjustment. When seed is completely de-winged, examine some of the seed under a hand lens to assure that no seed coat cracking has occurred. If de-winging has occurred without damage, the machine is properly set. Certain lots of shortleaf pine seed are difficult to de-wing and leave a small amount of the wing attached to the seed coat. This is considerably better than attempting to further tighten the brushes and risk damaging valuable seed.

Cleaning Seed

The seed cleaner used is a basic two-screen fanning mill with a final adjustable air blast for separation of small materials lighter than seed and removal of hollow, undeveloped seed.

The top screen should be sized to allow the free passage of all seed, but remove items larger than the seed. The bottom screen should be sized to barely retain all seed, but allow material smaller than the seed to pass through. As the seed passes over the bottom screen, it falls through the adjustable air blast. All materials which are lighter than the seed may be removed at this point with proper adjustment of the air stream. Since well-filled seed is heavier, it will pass through the air stream and fall into the seed-collecting box or the seed auger, whichever is being used. The air blast can be adjusted by increasing or decreasing the speed of the fan, by changing the belt position on the pulleys, or by opening or closing the air ports. Pine seed can be separated into hollow or filled seed by adjusting the air stream. Adjustment should be such that a small amount of filled seed is blown out along with the hollow seed. Since the filled seed is heavier than unfilled seed, it will fall into the container at the end of the air blast spout, while the unfilled seed will be blown clear of the machine. Rerunning this small amount of unseparated seed which falls near the machine will retrieve additional filled seed.

This operation also removes all additional foreign materials from the seed lot. Many times materials which are the same size and density as the seed will still be present. The final separation then can be made by pouring the seed on the inclined cotton belt manufactured by nursery personnel. Since the seed of most species is round or oval, it will roll down the inclined plane, even though the belt is running upgrade. The foreign material, not being uniform in shape, will adhere to the belt and fall free at the top of the traverse.

Many seeds and impurities can be separated by using the Sutton and Steele Gravity Separator, although there must be a decided difference in density of seed and impurities before a clear separation will result. The action of the Gravity Separator is controlled by the speed of the exhaust fan which blows air through the separation table, the side slope and the end slope of the table. Several trials at various adjustments may be necessary before the desired separation will be achieved. For a clean separation, the table must be completely covered with material at all times and be fed at a constant rate.

The Gravity Separator also can be used to separate various sizes of seed from the same lot. This allows more controlled sowing rates in the nursery seedbeds. Small seeds attain initial growth slower and are soon over topped by seedlings of larger, vigorous seeds. If the seeds are sown separately, the seedlings germinate uniformly, grow uniformly and will result in more desirable planting stock. Seedlings grown in this fashion undoubtedly will produce more plantable seedlings per pound of seed sown, will require less grading and will result in lower production costs. Adjustment in the sowing rate must accommodate the number of seeds per pound for uniformity and density. Efforts to separate the native shortleaf pine seed found the variation of seed size so negligible that separation was not warranted, although future lots may be found which will require separation.

Drying Seed

Storing seed at 20° F. requires that moisture content be below 8 percent. Since the seed storage is maintained at this temperature, moisture content must be carefully monitored.

After processing seed in the Dybvig Seed Cleaner or the hammer mill, where water is used to wash away pulp and other debris, the material must be spread in a thin layer on screens to be dried in the sunlight or, barring this, in a heated room. Dryness usually can be judged by rubbing a portion of the material between the hands. Dry seed causes a sharp feeling when rubbed in this manner, much as clean, sharp sand does. At this point, further separation of the material can proceed using the fanning mill.

A test for moisture content should be the next step prior to storage. Moisture content is determined according to the following formula:

$$\frac{\text{Wt. of wet seed} - \text{Wt. of dry seed}}{\text{Wt. of dry seed}} \times 100 = \% \text{ moisture content}$$

A representative sample of the seed lot should be obtained using the seed probe. Take seed from various portions of the drum. Treat each drum of seed as an individual lot when a large volume of seed is involved. Following these steps:

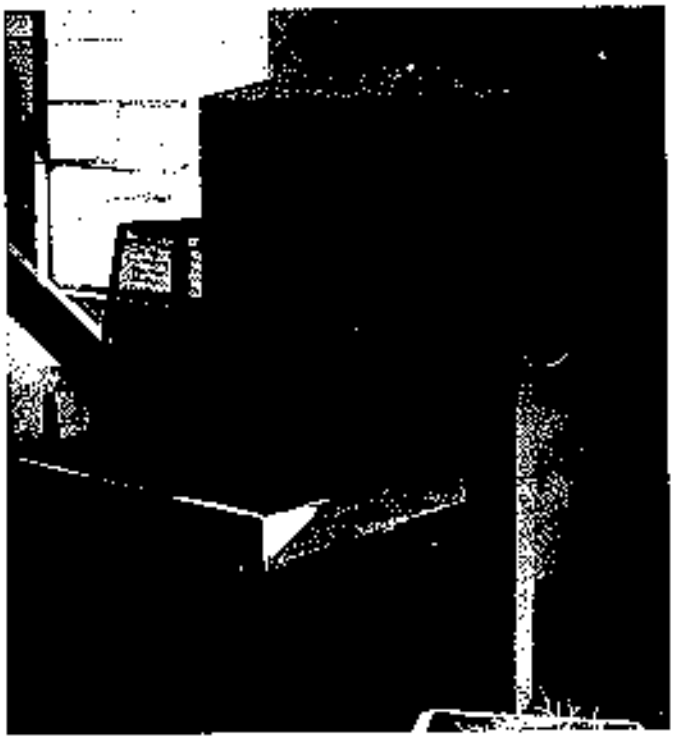
1. Weigh each sample taken for testing (consider all the seed taken from one drum as a sample).
2. Place each sample in drying oven at 220° F. for 24 hours.
3. Remove samples from oven and place in airtight glass containers until seed is at room temperature.
4. Weigh dried sample.
5. Using formula quoted above, compute moisture content.
6. If moisture is above 8 percent, dry further in direct sunlight, or in the drying cabinet if lot size will allow.

Moisture content may be readily determined by using a Radson Moisture Meter Model 20 and TR 30, if charts are available for the species of seed being tested. Because the Radson Meter was designed to test agricultural crops, determination of moisture content for tree and shrub seeds requires use of a conversion chart. The meter requires a five-ounce sample, operates on electrical conductivity and gives a numerical reading which must be converted to percent of moisture content by using a prepared chart which lists Radson readings and comparable moisture content percentages for individual species.

If charts are not available for the species in question, they may be prepared as follows:

1. Remove about 2¼ pounds of seed from the lot, making sure the sample is representative of the total lot.
2. Place the entire sample in the drying oven at 220° F. for 24 hours, or until the sample no longer loses weight.
3. After cooling for two hours, divide the sample into five-ounce subsamples.
4. Remember: Do not handle any containers, when drying or cooling, with bare hands, as perspiration will increase the weight.

5. Place one dried five-ounce sample (0 percent Moisture Content (MC)) into the Radson and record the reading. Assume we wish to find further Radson readings corresponding to 5 percent MC, 10 percent MC, 15 percent MC, 20 percent MC and 25 percent MC. This will provide a good set of data to build the curve of Radson readings over actual percentages of moisture content.

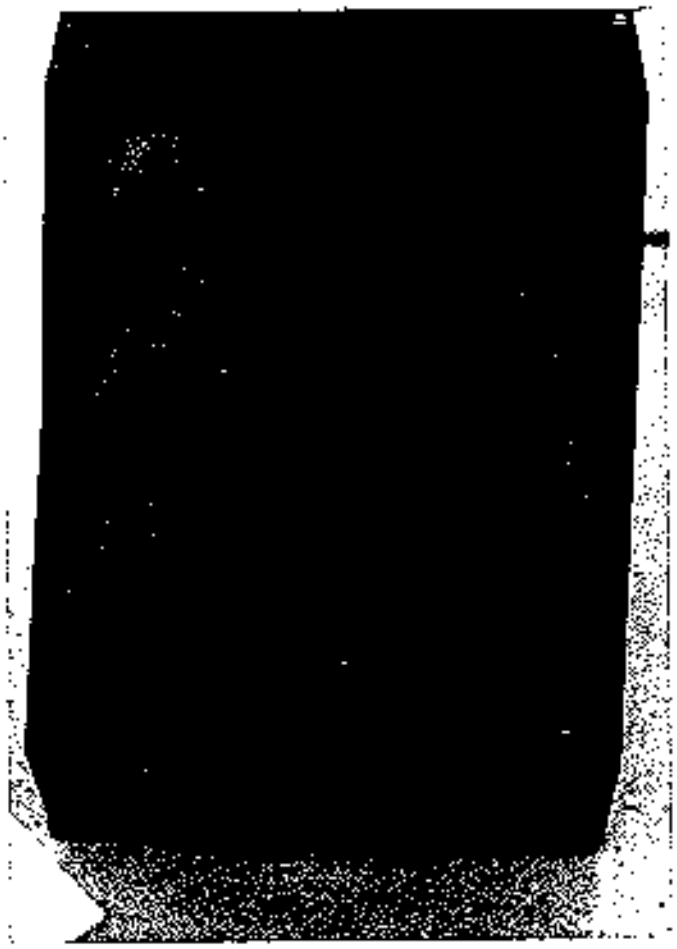


Electrically heated, forced-air seed drying cabinet.

6. Since the weight of the subsamples (dry seed) is five ounces, the amount of water to be added is easily determined.

		Amount of Water to add
5% of 5 oz.	=	0.25 oz
10% of 5 oz	=	0.50 oz
15% of 5 oz	=	0.75 oz
20% of 5 oz	=	1.00 oz
25% of 5 oz	=	1.25 oz

7. Each subsample should have the proper amount of water sprayed well into the seed to assure complete coverage. Water should be added while the sample is on the scale to ensure accurate weight.
8. Subsamples should be covered tightly and allowed to stand for 24 hours, to make certain all moisture has been absorbed.
9. Since moisture has been added to each subsample, each weighs over five ounces and must be reduced to exactly five ounces for testing in the moisture meter.
10. After reduction, place samples in the meter and record the meter readings.
11. Prepare a smooth curve on graph paper which shows the relationship between Radson readings and actual moisture contents, from 0 percent MC to 25 percent MC.



The Radson Moisture Meter was developed for agriculture but can be used for nursery species.

12. Future moisture content determinations can be made only for the species covered by this chart; a complete table for all other moisture contents may be interpolated, if such refinement is necessary.

Although the above process destroys the seed samples, it is all-inclusive for all future moisture content determinations of this species.

Should the process be too destructive for a very small lot of seed, one five-ounce sample may be dried to 0 percent MC and the necessary amount of water added daily to achieve the 5 percent to 25 percent MC levels. The process would be time consuming, as each level would require a 24-hour waiting period between each moisture addition.

The following example will fully illustrate the procedure:

One pound of seed was withdrawn from storage for the Radson chart construction. Three subsamples of five ounces each were taken from the pound lot, after the seed had been dried at 220° F. for 24 hours.

The first five-ounce sample, at 0 percent moisture content after drying, was placed in an airtight container and cooled for two hours. The sample then was placed in the Radson meter and the reading was recorded. The sample was returned to the remaining five-ounce samples and water was added to each sample in ¼-ounce increments. The first sample received one-quarter ounce of water (5 percent MC) the second sample ½ ounce of water (10 per-

cent MC) and the third sample ¾ ounce of water (15 percent MC). All three samples were placed in separate airtight glass containers and allowed to stand for 24 hours. Since it was necessary to transfer the samples from various containers during the wetting, weighing, etc., the actual weight of moisture absorbed by the seed was determined by reweighing the samples prior to placing them in the Radson Meter. Actual moisture content was determined at this point. The following data was obtained from the samples:

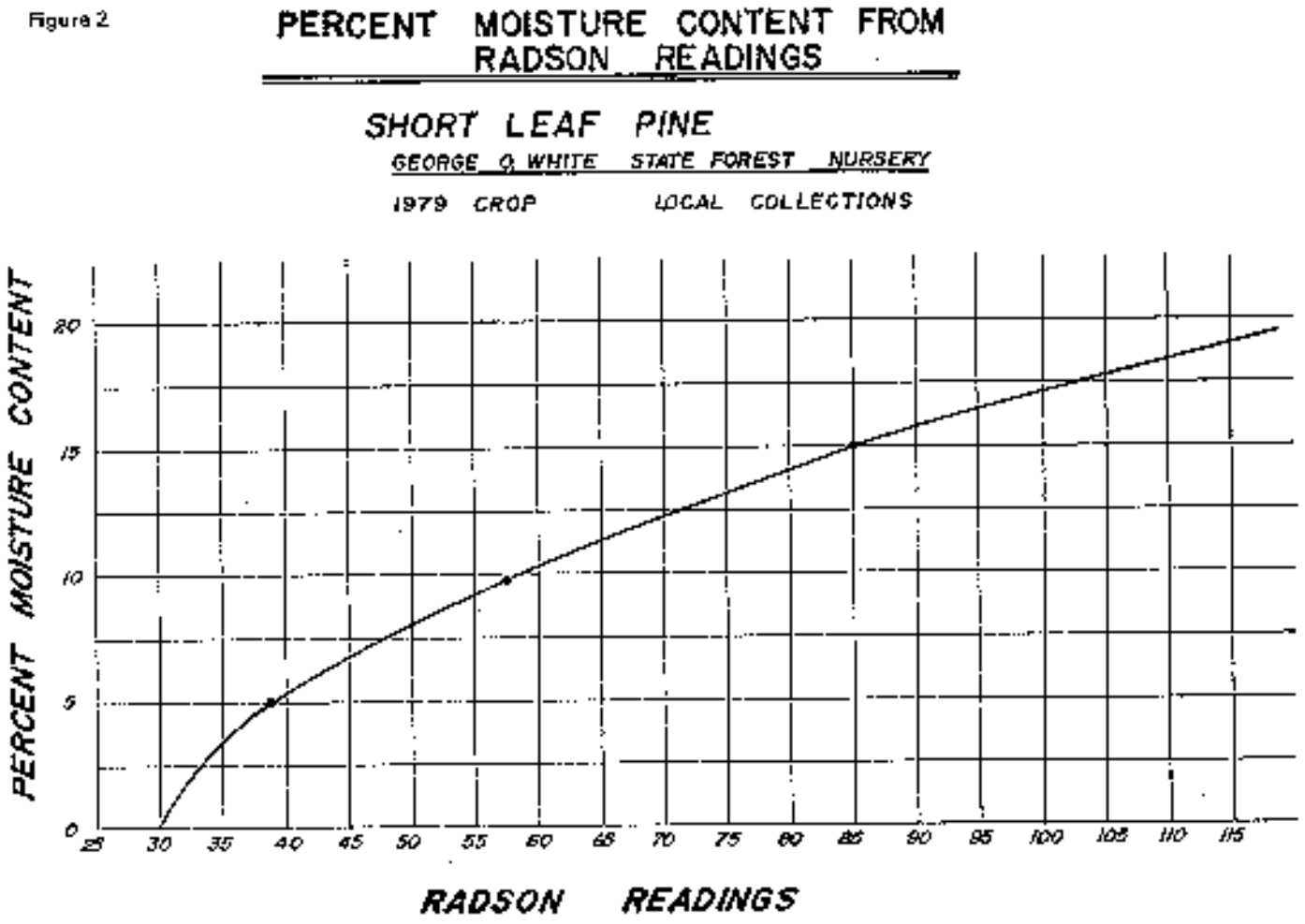
% M.C.	Radson Reading
0.0%	30
5.1%	39
9.7%	57
15.0%	85

Plotting these moisture contents and Radson Meter readings produced the curve in Figure 2.

The chart below was produced from the curve.

Moisture Content	Radson Reading
0.0%	30.0
1.0%	31.0
2.0%	32.5
3.0%	34.2
4.0%	36.5
5.0%	39.0
6.0%	42.0
7.0%	45.2
8.0%	49.0
9.0%	53.0
10.0%	57.5
11.0%	62.5
12.0%	67.0
13.0%	73.0
14.0%	79.0
15.0%	85.0
16.0%	91.5
17.0%	98.2
18.0%	106.0
19.0%	114.0

Figure 2



If a programmable calculator is available, you can compute a least squares regression formula using the two sets of data (moisture content and Radson readings.) In this case, the regression formula was:

% Moisture Content = -42.71 + 2.2972(x) - .0346(x^2) + .0018331(x^3) where (x) equals any particular Radson Reading. A program can then be written to compute moisture content by simply entering the Radson reading. The Appendix contains charts of moisture content over Radson readings for pertinent species of seeds.

Cold Storage of Seed for Prolonged Periods

Mature seed, under conditions of proper temperature, humidity and a supply of oxygen, carry on a process called "respiration." Seeds take in atmospheric moisture and oxygen and expel carbon dioxide. This process depletes all available stores of food necessary for germination, in essence destroying the seed.

To store seed for long periods of time, the respiration process must be lowered to a negligible amount, or stopped completely. To do this, the following conditions must be met:

1. Make certain that seed to be stored has a moisture content of 8 percent or less. Normal storage of shortleaf pine seed has been nearer to a 5 percent MC.
2. Store in airtight containers.
3. Store in a refrigerated unit at a temperature below 35° F. Storage at lower temperatures will afford a buffer, should mechanical failures occur. Storage at 0° F. is quite successful if the requirement for moisture content is met. Past experience suggests that 20° F. is an excellent compromise. Lower temperatures place an impossible load upon refrigeration equipment, especially during heat spells in Missouri.
4. Regardless of storage temperature chosen, it should not vary more than 3° to 4°. Once seed dormancy has been induced, the process should not be allowed to change by highly fluctuating temperatures.
5. Check the seed storage building daily to make certain all equipment is operating properly.
6. Should mechanical problems interfere with maintaining the proper temperature, do not open the door to the freezer room, but save the cold condition of the room and its contents for as long a period as possible. Call the service repairman immediately and explain the emergency nature of the service call.
7. Seeds which require a high moisture content for normal germination should not be stored at 20° F. until further studies specify the methods and precautions needed. Such seed may be stored for short periods at 32° to 36° F., or until such time as soil conditions will allow sowing. Such species of seeds include soft maple (*Acer* saccharinum); oaks (*Quercus* spp.); hickories (*Carya* spp.); cottonwood and aspens (*Populus* spp.).

Conditions may be altered to allow storage of these species for periods as long as one year, but experience to date does not justify the attempt.

Determining Germination Percentage

The ability to control the density of seedlings in the nursery seedbed is of prime importance to the nurseryman. Seedlings of a very high seedbed density will not meet minimum grading standards, and seedlings growing at a low density will become too large for economical handling, packaging, shipping and planting. The principal quantitative factor necessary for controlling seedbed density is "Germination Percentage." Uniformity of testing methods must be taken into account, since other factors (tree percentage) which will affect density for ensuing seed lots are based on percentage data.

The most uniform method of seed testing is the National Seed Testing Laboratory at Macon, Georgia. Changes are made for each test, but results are indisputably correct. The following may be requested for each sample submitted for testing:

1. Germination percentage
2. Purity percentage
3. Number of seeds per pound
4. Sowing data required to obtain desired seedbed densities
5. Percentage of sound seed
6. Moisture content

Samples of each seed lot must be taken by using the seed probe, making certain that the probe is inserted into the seed mass in the closed position, opened only after reaching the deepest portion of the seed lot and closed gently before withdrawing. Should seed lodge in the tube while you are attempting to close the probe, do not force it, as some seed will be damaged. Remove the probe, with the opening side of the probe upward, and gently empty the enclosed seed into the container being used for sample collection. Since a rather large sample is needed for testing purposes, it may be necessary to fill several probes with seed. One-fourth pound of most coniferous seeds is sufficient for the tests normally required by the nurseryman.

Seeds sent to the laboratory for testing should be shipped in an airtight, moisture-proof container. Atmospheric moisture will alter the true moisture content of the seed sample, and loosely capped containers might allow the seed to dry, also confusing test results. Seed samples should be marked inside and out, with species, nursery requiring the testing, seed lot number, date of shipment and any other pertinent information. Samples should be shipped to the following address:

NATIONAL TREE SEED LABORATORY
P.O. Box 819
Macon, Georgia 31298
Phone: (912) 744-3311

If time does not permit a laboratory test, several other options might be explored prior to sowing a new, untested seed lot.

A cutting test of a new seed lot, although useless in determining the germinative capacity of the seed, will aid in determining potential quality of the lot in question. If the cutting test reveals that the entire lot contains dried and shriveled embryos, further work with the seed lot would be a waste of time. Seeding of the seed lot would only compound the waste.

Some species of seeds show little or no dormancy. Counting several sublots of 100 seeds each and placing

them in a proper germination medium under the proper temperature with proper lighting will give the nurseryman valuable information. Sycamore (*Platanus occidentalis*) can be tested readily by floating a determined number of seeds in water under the proper temperature and lighting conditions. As the sycamore seeds germinate, they should be removed with a tweezer and counted. Several days of exposure will generally determine the total germinative capacity required for sowing this species.

A complete test, including moisture content, number of seeds per pound, purity percentage and germination percentage can be carried out at the nursery when time permits. Small seed lots would best be handled on a local basis. Larger, more expensive seed lots which will be stored for several years should be tested by the National Laboratory. The following discussion outlines what tests can be conducted at the nursery.

Using the seed probe, remove a sample from the seed lot large enough to furnish a five-ounce subsample for use in the Moisture Meter. The same five-ounce sample can be used for other tests, as the Moisture Meter is not a destructive test. If charts are not available for the species in question, a separate five-ounce sample should be obtained for an oven test for moisture content.

A subsample (½ ounce to one ounce) must be obtained to determine the number of seeds per pound. The original sample must be thoroughly mixed on a clean surface. While mixing, form the sample into a conical pile. Divide the sample into smaller and smaller subsamples by cutting the conical pile in a vertical plane with a sharp edged instrument. A knife or perhaps a piece of paper would suffice for some species of seeds. Subdivide until the proper subsample size is obtained. Use of a gram scale is helpful. The gram scale will record to the nearest one-tenth of a gram. Since 28.35 grams equal one ounce, a sample near to 14 grams will be needed. Weigh the sample carefully to the nearest one-tenth gram and record. Count the entire selected sample, drawing seeds from the sample in groups of five. A small penknife or a wood tag is useful for separating of the seeds into these groups. Record each 100 seeds counted. Remove only clean seed from the sample as counting progresses, leaving groups of 100 seeds which may be kept intact for use in the final germination test. When the final number of seeds in the sample is determined, divide the number by the number of grams in the sample to obtain the number of seeds per gram; multiply by 28.35 and then by 16 to obtain the number of seeds per pound.

Purity percentage is determined by weighing all foreign material which remains after counting the number of clean seeds in the sample. Weight of the clean seed divided by the weight of the original sample X 100 will give the purity percentage.

$$\frac{\text{Weight of clean seed} \times 100}{\text{Weight of original sample}} = \text{Purity percentage}$$

Germination percentage can be determined by placing a predetermined number of seeds into a germination tray and furnishing the proper amount of moisture, the optimum temperature and the optimum amount of light. Seeds are normally placed in the germination tray in units of 100. The germination tray in use at the nursery is an aluminum cake pan, measuring 13" X 9" X 2", with a clear plastic cover. The cover snaps into place and is tight enough to prevent severe moisture loss, but will allow the passage of atmospheric oxygen necessary for germination.

For the germination test, various mediums have the physical properties necessary to provide moisture to the seeds. Horticultural peat has been useful in many tests, as it is rather free of pests, but the wettability of peat presents a problem. Wetting the peat prior to placing it into the germination tray may be a solution. Horticultural ground mica also is an excellent medium and presents none of the problems associated with peat. Clean sand can be used as a medium, although sand should be fumigated thoroughly or be subjected to high temperatures before use. Fungi or other disease organisms may be associated with sand and these would nullify the validity of the test. Every precaution should be taken to insure sterility of the germination trays, the growing medium and all instruments used.

Moisture provided to the growing medium should be sufficient to germinate seed, but free moisture should not be present. With too much moisture, seeds may suffer from a lack of oxygen or be destroyed by molds, mildews or other pathogenic organisms. Once the tray is prepared, watered and the lid in position, no further addition of moisture should be necessary.

Species which exhibit dormancy can be tested in the same manner; however, the tray should be prepared as usual, the lid set in place and the entire tray placed in cold storage at 32° to 36° F. for the recommended stratification period. A properly regulated refrigerator can serve as a stratification chamber. Test the refrigerator prior to use to determine the range of temperatures: 32° to 40° F. would be satisfactory, although the temperatures recommended would be less conducive to formation of molds, mildews or other organisms.

Following the stratification period, check for moisture availability and add moisture if necessary.

Where the status of dormancy is unknown in a seed lot, several germination trays of the same lot should be prepared. Testing should begin immediately with the first tray, the second should be stratified as recommended for 30 days and the third tray stratified for 60 days. If the first tray does not germinate properly, or germinates unevenly, over a long time period, begin testing the second tray after the 30-day stratification period. If results are similar, begin testing the third tray following the 60 day stratification period. Failure of all three tests would lead to the conclusion that the seed lot is of no value, although this may not be true. Seed lots may require 90-120 days of cold stratification and may require a period of warm stratification followed by a period of cold stratification. Some seed is almost impossible to test, due to the stringent germination requirements associated with the species.

Seeds which require complicated predetermination treatments should be turned over to the National Seed Laboratory for testing, as the local equipment is not designed to carry out such demanding procedures.

Test conditions for most species produced at the nursery normally would include eight hours of light, a temperature of 86° F. during the light hours and 68° F. during the dark hours. Most species which show little or no dormancy will begin germination within a few days, although some will require nearly three weeks. When germination is initiated, viable seed lots germinate rapidly,

building the daily germination rate to a peak within a few days and falling to a low daily germination rate rapidly, ending testing within a short period of time. Other seed lots take longer to complete germination, but the pattern will be the same; a buildup to a maximum daily germination rate and dropping of the daily germination rate to zero in approximately the same amount of time. Seed lots which seem to struggle on forever without a definite pattern to the daily germination rate would best be helped by pregermination treatment which would cause all seedlings to germinate almost simultaneously.

As germination begins, seedlings are counted daily, removed from the tray as counted and recorded on the "Seed Germination Record" card. Complete records of all known data regarding the seed lot are recorded faithfully, as this will become a permanent record, available for recall at any time the information might be needed. Page 27 shows a sample Seed Germination Record card.

This data should be transferred to the "Seed Inventory Record Card" which also becomes a permanent record. Often seedlings from particular plantations exhibit characteristics which might be advantageous and information regarding the source of the seed would be invaluable. On the other hand, traits might appear which would cause total loss of a plantation and further production of seedlings from that source would be undesirable.

SOWING RATES

Seedbed density is of extreme importance in the production of nursery planting stock, as it affects seedling quality, which affects seedling survival after planting. Excellent survival may be followed by poor growth the first years after planting. This also may be attributable to poor quality seedlings. Many factors affect seedling quality, including fertilization, irrigation, soil structure, disease and insect control, but density is most important. Low density in the seedbed generally will add to the quality of seedlings produced, but extremely low density will lead to shortfalls in production. Extremely high density will lead to poor-quality seedlings, which must be graded out, at a great expense in time and labor.

The following guidelines will be useful in computing sowing formulas:

Age Classification	Density Desired
Conifers 1-0	20 to 30 per sq. ft.
Conifers 2-0	50 to 60 per sq. ft.
Conifers 3-0	40 to 50 per sq. ft.
Hardwoods 1-0	6 to 10 per sq. ft.
Wildlife Shrubs 1-0	10 to 20 per sq. ft.

The formula for determining number of pounds of seed necessary to produce a desired density per square foot of seedbed area is expressed as:

$$S = \frac{A \times D}{N \times G \times P \times T}$$

S equals quantity of seed in pounds; A is the seedbed area in square feet and D equals the desired density per square foot. N equals the number of seeds per pound, G equals germination percentage, P equals purity percentage and T equals tree percentage.

Tree percentage for each species is obtained under the same nursery seedbed conditions over a period of years. Each nursery has soil conditions which will affect the percentage of trees produced from a given quantity of viable seed.

Care must be taken to assure that tree percentage has not been unduly influenced by such factors as high density or losses through diseases or insects.

Using the above formula with 400 square feet as the seedbed area (100 lineal feet of seedbed x 4-foot width), which is normally used for testing of the nursery seeder, we obtain the following:

$$S = \frac{400 \times 30 \text{ (desired density)}}{45{,}820 \times 85\% \times 98\% \times 42\%}$$

$$S = \frac{12{,}000}{38{,}168}$$

$$S = .315 \text{ lbs.}$$

$$\text{Or } S = 5.04 \text{ Oz.}$$

Some nurseries consider 75 percent to 80 percent to be an excellent figure for introducing tree percentages into the sowing-rate formula. While the 42 percent used in the above formula may seem low, each nursery must determine the local conditions which influence tree percentage, attempt to improve conditions until tree percentage climbs as near to 1.0 as possible and take this figure into account when computing sowing data. Germination tests are performed under controlled conditions and field conditions are uncontrollable, so we must accept germination test data as a statement of the total capability of a seed lot, but realize that adjustments for field conditions must be entered into our computations or data will be meaningless.

Assume that the following data is available to us from a sowing of 125 lbs. of Scotch pine (*Pinus sylvestris*)

No. of seeds per lb.	75,000
Germination percentage	87%
Purity percentage	97%.
Total No. of seeds sown	9,375,000
Total viable seeds sown	7,911,562 (9,375,000 x .87 x .97)
Total seedlings produced (cull percentage disregarded)	4,556,000 (When culls are caused by density)
Tree Percentage	$\frac{4{,}556{,}000}{7{,}911{,}562} = 58\%$

Sowing data for Scotch pine with seed of this excellent quality should include a tree percentage factor of 58 percent.

Seed lots having high germinative energy will have correspondingly high tree percentage factors. There also seems to be a correlation between number of seeds per pound and the tree percentage factor. Species with very large seeds will produce a greater percentage of plantable seedlings per pound of seed than species characterized by very small seeds.

Fig. 3 lists several species which have been sown in the past and tree percentage data for each. Germination percentage for each species was 85 percent or more.

Figure 3

Species	Average Seeds/lb.	Tree Percentage
Loblolly Pine *Pinus taeda*	18,200	93%
White Pine *Pinus strobus*	25,500	70%
Shortleaf Pine *Pinus echinata*	45,000	50%
Scotch Pine *Pinus sylvestris*	75,000	40%
Jack Pine *Pinus banksiana*	131,000	30%

These figures were computed from crops grown prior to changes which are prevalent in most forest tree nurseries. Seeding machinery has been improved. Mulching of seedbeds is practiced almost universally. The advent of hydro-mulching techniques, better insecticides and fungicides, and the use of herbicides for weed control all help raise the tree percentage factor.

A computation of the factor should be attempted for one or two species each production year. It is an excellent system for keeping track of efficiency of nursery production methods. If tree percentage were to fall drastically in one to two years, investigation should begin immediately to determine the cause. A constant rise in the tree percentage factor would be valuable information for the nurseryman.

Many times seed lots arrive from suppliers too late for any physical determination of germination. The nurseryman must refer to past experiences, literature regarding the species, or communication with fellow nurserymen. Many times the only information available is from a casual cutting test. Sowing of an unknown seed lot of any species is a hazardous and expensive undertaking, but must be faced at one time or another. The best information available must be used, but the practice of sowing expensive quantities of seed with little or no information should be discouraged.

The practice of maintaining a supply of seed to cover a three-year production period is advantageous. The nursery will be in a position to maintain production of important species through years when seed crops fail, but more important, seed in storage can be tested thoroughly, well in advance of the time for sowing and seedbed density control can be assured.

Sowing and Pre-sowing Recommendations

The general rule for depth of sowing is that it should not exceed four times the minimum diameter of the seed being planted. Since some of the species normally sown are very small in diameter, sowing on the soil surface is almost mandatory.

Due to rapid crusting of silt loam soils following rainfall or ordinary irrigation, mulching of the seedbed is necessary to maintain mellow, friable conditions for germination. The size of the seed being sown will dictate the depth of mulching. Black walnuts must be mulched deeply (3" to 4") while sycamore seed would withstand little more than ¼" of mulching. Use of the hydro-mulcher makes it easier to control the depth of mulches. All coniferous seed being sown will be treated with anthraquinone, using Dow methocel, or equivalent, as an adhering agent. Anthraquinone is a non-toxic material used to repel birds and is effective because of its crystaline structure. Birds are repulsed by the glinting of light from individual crystals on the emerging seed coats. By the time the seed coats are shed, the danger of damage by birds is gone.

Stratification normally is carried out by soaking seed in water 24 to 48 hours, placing wet seed in sealed polyethylene bags of at least 4 mil material, and placing in the cold storage at 32° F to 36° F for the period specified. Seed with impermeable seed coats cannot absorb the necessary moisture prior to stratification, and wet sphagnum moss mixed with the seed on a 50 percent to 50 percent by volume basis must be sealed in the bag for stratification. Oaks, pecans, hickories and other nut fruits must be treated in this fashion.

Following are some general instructions for the variety of seedlings grown at the nursery.

CONIFERS

Austrian Pine *Pinus nigra*
Dormancy - Not present
Sow in spring, April 15 or as soon as soil conditions allow.

Eastern Redcedar *Juniperus virginiana*
Dormancy - Severe, due to embryo dormancy and perhaps impermeable seed coat.
Sow in August. If conditions will not permit, sow in spring, following 48-hour soak in water, stratification for 90-120 days. Sow April 15 or as early as possible to allow complete germination prior to temeratures reaching 70° F.

Bald Cypress *Taxodium distichum*
Dormancy - Present
Sow in fall, November. Or soak in water three weeks, drain excess water, stratify for 30 to 60 days and sow May 15 or as soon as soil conditions allow.

Jack Pine *Pinus banksiana*
Dormancy - Not present
Sow in spring, April 15 or as soon as soil conditions allow, in fumigated soil. (Prone to damping-off disease)

Loblolly Pine *Pinus taeda*
Dormancy - present in most seed lots
Sow in fall, October 20 or later. Or soak in water for 24 hours, drain excess water, stratify for 30 to 60 days and sow in spring, April 15 or as soon as soil conditions permit.

Scotch Pine *Pinus sylvestris*
Dormancy - Not present
Sow in spring, May 15, to avoid late spring frosts. Sow in fumigated soil. (Very prone to damping-off disease, both pre-emergent and post-emergent.)

Shortleaf Pine *Pinus echinata*
Dormancy - Present in some seed lots, but seldom found in native Missouri seed sources
Sow in fall, October 20 or later, whether a dormant seed

lot or not. Or sow in spring, April 15, or as soon as soil conditions allow. If seed lot shows dormancy, soak in water for 24 hours, drain excess water and stratify for 30 days. Sow May 1, or as soon as possible to produce good, well-balanced stock.

White Pine *Pinus strobus*
Dormancy - Present to a high degree in Southern Appalachian sources.
Present or totally lacking in Lake States sources.
Southern Appalachian sources: sow in fall, October 20 or as soon as soil conditions will allow. Or sow in spring, following 48-hour soak in cold water, drain excess water and stratify for 90 to 120 days. Sow April 15 or as soon as soil conditions will allow. Sow in fumigated soil. (Prone to damping-off disease, both pre-emergent and post-emergent, plus various root rot organisms in the 1-0 stage)
Lake States sources: Sow in fall, November, to forestall early germination during warm periods often experienced in January and February. Or sow in spring, following 24-hour soak in water, drain excess water and stratify for 30 days. Sow April 15, or as soon as soil conditions will allow. Sow in fumigated soil to forestall conditions for white pine listed above.

HARDWOOD TREES AND WILDLIFE SHRUBS

Autumn Olive *Elaeagnus embellata*
Dormancy - Present
Sow in fall, October 20, or as soon as possible.
Or sow in spring; following 24-hour soak in water, drain excess water and stratify for 60 days. Sow April 15, or as soon as soil conditions will allow.

Aromatic Sumac *Rhus aromatica*
Dormancy - severe, due to impermeable seed coat and embryo dormancy.
Sow in fall, October 20 or later, following 45-minute soak in concentrated H_2SO_4 (sulfuric acid). Drain, rinse thoroughly and sow.
Or sow in spring; following recommended sulphuric acid treatment, stratify for 90 to 120 days. Sow April 15, or as soon as soil conditions will allow.

Black Alder *Alnus glutinosa*
Dormancy - Not present in fresh, undried seed. Present in seed dried to 8% to 9% moisture content.
Sow in fall, October 20, or later when stored, dried seed is on hand.
Or sow in spring; following 24-hour water soak, stratify for 90 to 120 days. Sow May 1 or later. Seed must not be covered too deeply, as there is no endosperm available to sustain the seed after radicle emergence. Fresh, undried seed may be sown without pre-sowing treatment.

Blackberry *Rubus alleghaniensis*
Dormancy - Severe, due to embryonic and hard seed coat dormancy
Sow in July. Or soak in water for 72 hours, warm stratify at room temperature for 90 days and sow in November.
Or warm stratify at room temperature for 90 days, cold stratify for 90 days and sow in early spring, April 15 or as soon as possible.

Black Cherry *Prunus serotina*
Dormancy - Present
Sow in late fall, late October or November

Black Gum *Nyssa sylvatica*
Dormancy - Slight
Do not soak in water as presowing treatment, submersion is detrimental.
Sow untreated seed in fall, October 20 or later.
Spring seeding is preferred method, following 30 to 60 days of stratification.
Sow May 1st or as soon as soil conditions permit.

Black Haw *Viburnum prunifolium*
Dormancy - Present. Generally takes two years to germinate. Radicle emerges first summer, epicotyl emerges second spring.
Sow in spring, April 15 or when soil conditions permit. Germination the following spring.

Black Locust *Robinia pseudoacacia*
Dormancy - Severe, due largely to impermeable seed coat. Soak in concentrated sulphuric acid for at least 45 minutes. Drain and rinse thoroughly with clean cold water for at least 10 minutes. Excessive soaking in the acid eventually will remove the seed coat of a few of the seeds. This stage does not seem to have any damaging effects on the balance of the lot being treated, but is an excellent gauge of the time needed for further treatment of batches in the same seed lot. After treatment of three or four batches of seed, discard the acid and continue with a fresh supply. **Never** return used acid to the supply of unused acid. Use every precaution when handling concentrated sulphuric acid. It will readily burn eyes, skin, clothing and leather shoes. Wear protective rubber gloves and boots, aprons and eye shields.

When seed so treated has been thoroughly dried, black locust seed may be returned to the seed storage until needed. Seed lots have been kept for several years following treatment without loss of viability. Sow in spring, June 15 or later, to control height of this rapid-growing species.

Black Walnut *Juglans nigra*
Dormancy - Present.
Sow in fall, as soon as received.
Unhulled walnuts, stockpiled because of adverse soil conditions, have been sown in January or early February with excellent to medium success.
Or sow in spring, following 90 to 120 days of stratification. For bulk stratification, walnuts should be hulled. Stratification can be outdoors in a pit, with sand or sphagnum moss as the medium. Volume should be ⅓ walnuts and ⅔ sand or moss. (In bulk stratification, heating will occur if not properly stratified and the nuts will rot.
Stratification in plastic bags is possible for small lots of hulled nuts and is satisfactory should storage space be available in the cold storage building.

Bush Honeysuckle *Lonicera maackii, morrowii,* or *tatarica.*
Dormancy - Present.
Sow in fall, October 20 or later.
Or sow in spring, following 48-hour soak in water, plus 60

days stratification in plastic bag. Sow after April 15 as soon as soil conditions permit.

Buttonbush *Cephalanthus occidentalis*
Dormancy - Not present.
Sow in spring, after May 15, as soon as soil conditions permit.

Catalpa *Catalpa sp.*
Dormancy - Not present.
Store over winter in cloth sacks. Do not freeze; store in cool, dry room.
Protect from rodents during storage.
Sow in spring, after May 1.

Chestnut *Castanea sp.*
Dormancy - Present.
Sow in fall, September or October. Store chestnuts at 32° to 36° F. until seeding time. Do not allow to dry before sowing.
50/50 percent DAMP moss and chestnuts mixture. Too much moisture may cause rotting.

Chickasaw Plum *Prunus angustifolia*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, May 1 or later, following 90 to 120 days of stratification in plastic bag.

Buckbrush (Coralberry) *Symphoricarpus orbiculatus*
Dormancy - Severe.
Sow in fall, following 90 to 120 days of warm stratification. Sow in late October or November.
Or sow in July. Germination should occur the following spring.

Corkwood *Leitneria floridana*
Dormancy - Not present.
Sow in mid-summer, as soon as seed dispersal begins. Do not clean.
Sow only fresh seed.

Cotoneaster *Cotoneaster acutifolia*
Dormancy - Severe, due to radicle emergence during the first summer, epicotyl emergence the following spring.
Sow in late May or early June; mulch well the following winter. Epicotyl emerges the next spring.

Cottonwood *Populus deltoides*
Dormancy - Not present. Germination, fleeting.
Sow in spring as soon after seed extraction as possible. Sow on soil surface. Keep damp with intermittent irrigation until germination is complete.

Crown Vetch *Coronilla* var. *Penngift*
Dormancy - Not present.
Sow in spring, after May 15.

Deciduous Holly *Ilex decidua*
Dormancy - Severe, requires two years to germinate.
Sow in August. Germination will occur the second spring. *Ilex sp.* are severely dormant as a general rule. *Ilex opaca* will not germinate until the third spring after August sowing.

Dogwood *Cornus florida*
Dormancy - Present.
Sow in September. Stored seeds should be irrigated following sowing and soil moisture maintained until frost.

Eastern Wahoo *Euonymus atropurpureus*
Dormancy - Severe, requires warm stratification followed by cold stratification.
Sow in August.
Freshly collected seed can be sown later in fall, if seed has not dried.
Or sow in spring, after April 15 as soon as soil conditions allow, following 60 to 90 days of warm stratification plus 90 to 120 days of cold stratification.

Elderberry *Sambucus canadensis* (common) or *Sambucus pubens* (red)
Dormancy - Present.
Sow in fall, September or early October.
Or sow in spring, following 60 days of warm stratification and 90 days of cold stratification. Sow after April 15, as soon as soil conditions permit.

Green Ash *Fraxinus pennsylvanica* var *lanceolata*
Dormancy - Present.
Sow in fall, October or November.
Sow in spring (preferred); following 10-day soak in water, drain and stratify for 30-60 days or until soil conditions permit removal and sowing is possible.

Hackberry *Celtis occidentalis*
Dormancy - Present.
Sow in fall, late October or early November.
Or sow in spring following 60 days of stratification in plastic bag with 50/50 wet moss and hackberry mixture. Sow April 15, or as soon as soil conditions permit.

Sugar Maple *Acer saccharum*
Dormancy - Present.
Sow in fall, late October or early November.
Or sow in spring, after April 15 as soon as possible, following 30 to 45 days of stratification. Germination may occur during stratification should the period be extended.

Downy Hawthorn *Crataegus mollis*, and
Washington Hawthorn *Crataegus phaenopyrum*
Dormancy - Present.
Sow in fall. A warm period is generally beneficial. Sow in October if possible, or prior to frost if soil conditions permit.
Or sow in spring; following a 48-hour soak in water, drain and stratify for 90 to 120 days.

Hazelnut *Corylus americana*
Dormancy - Present.
Sow in fall, late October or November. Store at 32° to 36° F. prior to sowing.
Or sow in spring after 120 days of stratification in plastic bag, 50/50 damp moss and hazelnut mixture. Sow after May 15 as soon as soil conditions permit.

Hickory *Carya* sp.
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, following 90 to 120 days of stratification, 50/50 moist moss and seed mixture. Sow after April 15 as soon as soil conditions permit.

Highbush Cranberry *Viburnum trilobum*
Dormancy - Severe, due to radicle emergence following warm period of exposure in seedbed and epicotyl emergence the following spring.
Sow in May or early June, protect following winter by mulching. Epicotyl emerges the following spring.

Honeylocust *Gleditsia triacanthos* and var. *inermis*
Dormancy - Severe, due to impermeable seed coat.
Sow in spring, May or later, following two-hour soak in concentrated sulphuric acid. If possible, sow immediately while seed coat is soft from acid treatment. If drying and storage is necessary following acid treatment, soak in water until seed coat is softened and sow immediately.

Common Lilac *Syringa vulgaris*
Dormancy - Variable among seed lots.
Sow in fall, late October or November.
Or sow in spring; following 24-hour soak in water, drain, stratify 30 to 60 days in plastic bag. Sow after May 15.
Nondormant seed lots may be sown after April 15 as soon as soil conditions permit.

Mimosa *Albizia julibrissin*
Dormancy - Present, due to impermeable seed coat.
Sow in spring, after May 15, following a 15- to 20-minute soak in concentrated sulphuric acid. Seed dried and stored after acid treatment will benefit from soaking in water until seed coat softens.

Mulberry *Morus* sp.
Dormancy - Variable among seed lots and species.
Sow in fall, late October or November.
Or sow in spring, after May 15; following a 24-hour soak in water, drain, stratify for 30 days.

Multiflora Rose *Rosa* sp.
Dormancy - Present, variable in fresh seed lots, general among older, stored seed lots.
Sow in fall, late October or November.
Or sow in spring; following 24-hour soak in water, drain and stratify for 60 to 90 days. Sow after April 15 as soon as soil conditions permit.

Nanking Cherry *Prunus tomentosa*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after April 15 as soon as soil conditions permit, following 60 to 90 days of stratification in plastic bag, 50/50 mixture of wet moss and seed.

Ninebark *Physocarpus opulifolius*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, May 15 or later; following 24- to 48-hour soak in water, drain, stratify for 30 days.

Oaks *Quercus* sp.
Dormancy - Present among most species. White oaks germinate immediately after fall sowing. Oaks require a cold stratification period in the seedbed. Sow in fall, October 20 or later, into November. Sow white oak group as soon as received or store at 32° to 36° F. until soil conditions permit sowing.
Or sow in spring, after April 15, as soon as soil conditions permit and following stratification over winter in plastic bag, 50/50 wet moss and acorn mixture.

Osage-orange *Maclura pomifera*
Dormancy - Slight.
Stored seed may be sown in fall, late October or November.
Fresh seed may be sown in spring, following a 30-day stratification period. Sow after April 15 as early as possible.

Paper Birch *Betula papyrifera*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after April 15 as soon as soil conditions permit, following 30 to 60 days of stratification.

Pawpaw *Asimina triloba*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after April 15 as soon as soil conditions permit, following 60 days of stratification in 50/50 wet moss and seed mixture.

Pecan *Carya illinoiensis*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after April 15 as soon as soil conditions permit, following 60 to 90 days of stratification in a 50/50 wet moss and seed mixture. Check during stratification to make certain sufficient moisture is present.

Persimmon *Diospyros virginiana*
Dormancy - Severe at times.
Sow in fall, immediately following fruit maturity (killing frost).
Or sow in spring, after April 15 as soon as soil conditions permit, following 60 to 90 days stratification in 50/50 wet moss and seed mixture.

Redbud *Cercis canadensis*
Dormancy - Present due to impermeable seed coat.
Sow in spring, April 15 or later, following 30-minute soak in concentrated sulphuric acid. If seed must be dried and returned to seed storage following acid treatment, soaking in water until seed coat softens, just prior to sowing, will hasten germination.
If soaking in sulphuric acid is not possible, soaking in warm water will produce rapid germination. Sow immediately.

River Birch *Betula nigra*
Dormancy - Not present.
Sow in spring, May 15 or later to avoid late spring frosts.

Sow on seedbed surface, cover lightly with sand or mulch. Keep lightly irrigated until germination is complete and seedlings are established.

Rocky Mountain Juniper *Juniperus scopulorum*
Dormancy - Severe. Requires warm and cold stratification. Sow in early September, or sow in spring, following 60 days of warm stratification followed by 90 days of cold stratification. Sow April 15 or soon thereafter. Will not germinate well when air temperature rises above 70° F. Some seed lots will not germinate until the second spring following sowing. Other seed lots germinate partially the first spring, with the balance germinating the second spring. Seed lots sown at the same time as *Juniperus virginiana* (August), have reacted well on occasion, but several lots treated in this manner germinated prematurely in January when temperatures rose above 65° F. The newly germinated seedlings were lost during freezing weather.

Russian Olive *Elaeagnus angustifolia*
Dormancy - Present, due to embryo and at times seed coat.
Sow in fall, late September or early October.
Or sow in spring, following 60 to 90 days of cold stratification, 50/50 wet moss and seed mixture. Sow after April 15 or as soon as soil conditions permit.

Sassafras *Sassafras albidum*
Dormancy - Present
Sow in fall, late November. Store clean seed in cold storage until time to sow. Fresh, clean seed will germinate if sown in early fall.
Or sow in spring, after May 1 or as soon as conditions allow, following 60 to 90 days of stratification in 50/50 moss and seed mixture.

Serviceberry *Amelanchier canadensis*
Dormancy - Severe.
Sow in fall, late September.
Or sow in spring, after April 15 as soon as soil conditions permit; following 48-hour soak in water, drain, stratify 90 to 120 days.

Shrub Lespedeza *Lespedeza bicolor, japonica intermedia,* or *thunbergii*
Dormancy - Not present.
Sow in spring, May 15 or later, to avoid late killing frosts. Addition of proper nitrogen innoculant at sowing time has been suggested.

Siberian Elm *Ulmus pumila*
Dormancy - Not present.
Sow in spring, after May 15, to avoid late killing frosts.

Smoketree *Cotinus obovatus,* (Native) *Cotinus coggygria* (European)
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after April 15 as soon as soil conditions permit, following a 30-minute soak in concentrated sulphuric acid and 60 days of stratification.

Silver Maple *Acer saccharinum*
Dormancy - Not present.
Sow in May as soon as seed is available. Do not allow heating or drying of seed prior to sowing, keep in cold storage (32° to 36° F.)

Sumac *Rhus copallina, glabra,* or *typhina*
Treatment as for aromatic sumac, *Rhus aromatica*
Or sow in spring. Placement in five times the volume of cold water as the volume of seed, heat until water reaches boiling point. Remove source of heat and allow to remain in water for 24 hours. Sow immediately.

Sweetgum *Liquidambar styraciflua*
Dormancy - Southern sources, little or no dormancy. Northern sources, dormancy present.
Sow in spring, after April 15 as soon as soil conditions permit, following 30 to 45 days of stratification. Four pounds aluminum powder/100 pounds of seed aids in sowing damp seed. Dormancy characteristics of seed lot will determine the need for stratification and length of period necessary to break dormancy.

Sycamore *Platanus occidentalis*
Dormancy - Not present.
Sow in spring, late May to avoid late spring frosts. Sow on surface, cover with sand or light mulch, keep damp by intermittent irrigation until germination is complete.

Tulip-Poplar *Liriodendron tulipifera*
Dormancy - Present.
Sow in fall, late October or November. (Seed is not normally available at this time.)
Or sow in spring, May 15 or later, to avoid late spring frosts, following 90 to 120 days of stratification. Sow on surface, mulch and keep damp by intermittent irrigation until germination is complete.

Water Tupelo *Nyssa sylvatica*
Dormancy - Slight.
Do not soak in water, as complete submergence may be detrimental. Sow in spring, after May 1 as soon as soil conditions permit, following 30 to 60 days of stratification. Keep seedbed surface damp by intermittent irrigation until germination is complete.

Vitex *Vitex agnus - castus* (Lilac Chaste Tree)
Dormancy - Variable among lots and within lots.
Sow in spring, after April 15 as soon as soil conditions permit. Stored seed lots should be soaked in water 24 hours, drained and stratified for 30 days prior to sowing. Stratification will cause germination to be more uniform and plant quality to respond equally to the earlier germination.

White Ash *Fraxinus americana*
Dormancy - Present.
Sow in fall, October 20 until mid-November.
Or sow in spring, after April 15 as soon as soil conditions permit; following a 24-hour water soak, drain and stratify for 60 days.

White Fringetree *Chionanthus virginicus*
Dormancy - Present. Requires 3 to 5 months of warm seedbed exposure, during which the radicle emerges. After

the cold of winter, the epicotyl emerges the following spring.
Sow in May, irrigate during regular irrigation schedule, protect during the following winter by remulching if necessary. Germination will occur the next spring.

Wild Plum *Prunus americana*
Dormancy - Present.
Sow in fall, October 20 or as soon as soil conditions permit.
Or sow in spring, following 90 to 120 days of stratification in 50/50 wet moss and seed mixture. Check during stratification to make certain sufficient moisture is present.

Winterberry *Ilex verticillata*
Dormancy - Severe.
Sow in early fall, August or September.
Germination will not occur until the second spring following sowing.

Winterberry *Euonymus bungeanus*
Dormancy - Present.
Sow in fall, late October or November.
Or sow in spring, after May 1 as soon as soil conditions permit; following 48-hour water soak, drain, stratify for 90 to 120 days.

Pelletizing of Seed

Birds can injure germinating pine seeds. As conifers germinate, the seed coat, containing the primary needles, is thrust out of the soil (epigeal germination). Birds pick off these seed coats, effectively killing the seedling. Various chemicals are available as repellents, the best of which seems to be anthraquinone. Anthraquinone is nontoxic and is crystalline. Although the material is pulverized to a fine state, the crystalline nature persists. Birds are said to be frightened by the glinting of light and sunshine from the individual crystals and will not venture near the seed coats. Crows do not seem to bother germinating conifer seed, but will prey on other large-seeded species such as germinating walnuts, pecans and acorns. Anthraquinone will deter crows for about 24 hours, after which they disregard the material. Arasan 42-S (thiram in emulsion form) will deter birds and some rodents, which makes it useful for direct seeding of conifers. The action of Arasan 42-S lowers the germinative capacity of coniferous seeds in nursery seedbeds, but the treatment is long lasting and necessary for the direct seeding of pines. Captan has been used for some time as a bird repellent to pelletize seed for sowing in nursery seedbeds, but the chemical is prone to form dust while being handled during all operations, from pelletizing to seeding. The dust is quite irritating to the nose, eyes and skin of some employees and should not be used.

Two commercial stickers have come into use for bonding the pesticide chemicals to the seed being treated. Dow Latex 512-R is used for treatment of coniferous seed for direct seeding, as well as for the pelletizing of seed to be sown in nursery seedbeds. A much simpler sticker, Dow Methocel, is more commonly used, especially when anthraquinone is applied to the seed.

Methocel is prepared by adding 10 ounces (dry weight) to five pints of hot water. After dissolving, the five pints are added to five gallons of water. Dow Latex 512-R may be diluted by mixing one part Dow Latex and nine parts water. This may also be used for pelletizing coniferous seed to control bird pilferage of germinating seed coats.

The most common method to treat coniferous seed is to apply the sticker and the repellent while the seed is being tumbled in a small cement mixer.

For application of methocel and anthraquinone for seeding in the nursery, the following method is used:

1. Place 10 lbs. of coniferous seed into the cement mixer.
2. Pour 12 fluid ounces of the prepared methocel sticker onto the seed while tumbling. Pour the sticker into the seed gradually, spreading the sticker over the entire seed lot. Allow the seed and sticker to tumble for one to two minutes, making certain that all seeds are well coated.
3. Place 1½ pounds of well-sifted anthraquinone into the mixer, adding gradually and tumble for five minutes. When the entire batch seems to be well coated, dump the mixer and spread the pelleted seed in a thin layer on a screen or clean canvas tarp, outdoors or in a well-ventilated building.
4. Stir the seed frequently, using a wooden paddle or other implement, making certain that seeds do not adhere to each other. Seeds stuck together can plug the seed tubes and shoes of the seeder.
5. Should large quantities of coniferous seed require application of bird repellents, the above quantities may be doubled or tripled. Past experience shows that the amount of seed involved may become too large for uniform treatment of individual seeds. Trial and error may be necessary to find the optimum batch size.
6. Four tablespoons of aluminum powder per 25 pounds of seed may be added after the repellent to improve fluidity of the treated seed.

The same basic procedures may be followed to prepare coniferous seed for pelletizing with Captan. Methocel or 10 percent Dow Latex 512R sticker may be used with Captan or anthraquinone, depending on the availability of the chemicals. Various sizes of coniferous seeds will require adjustment in the amount of sticker and repellent. Treatment of the first batch should be carried out by adding the sticker slowly, watching to determine when all seeds are completely coated and adjusting accordingly when the proper point is reached. The addition of the repellent should be carried out in the same manner. Add repellent until all seeds are well coated and then stop or add more should the treatment be incomplete for each seed in the batch.

Dow Latex may be used for the sticker when applying Captan, anthraquinone or Arasan. The following has been suggested as the method of application when using Dow Latex for pelletizing coniferous seed prior to sowing in nursery seedbeds:

1. Weigh out 20 lbs. of pine seed and place in cement mixer.
2. Weigh out the following and set aside.
   A. One pint of anthraquinone
   B. One pint Captan or Arasan (powdered form).

C. One pint of Dow Latex, 10%, (nine parts H_2O, one part latex).

3. Mix one pint of the diluted latex with the seed in the mixer, tumble one to two minutes.
4. Add one pint of Arasan or Captan, tumble five minutes.
5. Add one pint of diluted latex.
6. Add one pint of anthraquinone, tumble for two minutes. If seed is too wet in appearance, add a small amount of anthraquinone to absorb the excess moisture. If excess dry anthraquinone is evident, a small amount of diluted latex may be added to abosorb the dry chemical. A sample run will determine amounts of sticker necessary for further batches of seed.
7. Place on a screen or canvas to dry.
8. Four tablespoons of aluminum powder may be added to the above to increase fluidity. Add while tumbling and tumble one minute longer.

Since instructions for pelletizing coniferous seed with Captan or Arasan in the powdered forms have been included, warnings regarding the toxicity of both chemicals must be repeated. Use of either of these chemicals as repellents should be avoided unless there is an additional need for fungicide treatment of the seed. Both treatments, Captan, Arasan, or a combination of both will produce dust in handling which is irritating to the nose, eyes and lungs. Precautions should include masks and protective clothing.

Treatment of Coniferous Seeds for Direct Seeding

Preparing coniferous seed for direct seeding in the field is similar to preparing seed for use at the nursery. The main purpose of treatment would be for bird control, both prior to and immediately following germination. In direct seeding, additional pests, especially rodents, must be controlled before success can be expected. Arasan 42-S, is the most widely used repellent, largely because it can be handled more safely. Arasan 42-S is toxic to humans and all precautions should be taken. Avoid breathing the dust and avoid direct contact with the skin by wearing gloves and other protective clothing. Accidental swallowing of the chemical is serious and requires immediate medical attention.

Due to the long-lasting effect of Dow Latex 512-R sticker, it should be used exclusively in treatment of pine seed for direct seeding. Direct seeding may require that seed be sown in early winter, which means the seed will be exposed on top of the forest floor for several months. Chemicals which would be easily washed away by rains or melting snows would offer little protection from birds or rodents. Dow Latex and Arasan 42-S will withstand this type of exposure without serious loss or dilution and will provide repellency until germination is completed.

Proceed as follows for treatment of coniferous seed for direct seeding:

1. Divide five gallons of Arasan 42-S into two equal portions of 2½ gallons each.
2. To 2½ gallons of Arasan, add 25 fluid ounces of undiluted Dow Latex 512-R sticker. Mix thoroughly with a paint mixing rod attached to an electric drill.
3. Mix the two, 2½-gallon quantities of Arasan 42-S together by pouring back and forth into separate containers at least 10 times.
4. Place 20 to 25 lbs. of seed into the cement mixer, begin tumbling.
5. Add repellent to seed slowly, about three fluid ounces per each pound of seed being treated. Observe seed while Arasan is being added. If seed becomes overly wet by the addition of three full ounces per pound of seed, cut back on the amount of Arasan mixture added.
6. After seed has tumbled for a few minutes, add four tablespoons of aluminum powder for increased fluidity. Tumble for at least one minute following aluminum powder addition.
7. Spread seed in thin layers, outdoors or in a well-ventilated room for three to four hours.

Seed Germination Record

George O. White Nursery-MDC

Species_____ Lot #_____ Date_____ Stratified_____ Germ %_____

_____ (Source)

Seeds/lb._____

_____ (Supplier)

_____ (Amount on Hand)

_____ (No. of containers)

_____ (Sample size)

_____ (Strat. begin)

_____ (Strat. end)

_____ (Placed in Germ.)

Date											
Germ. Count											

Date											
Germ. Count											

REMARKS: _____

_____ (Species)

_____ (Source)

_____ (Supplier)

SEED RECORD

THE GEORGE O. WHITE
STATE FOREST NURSERY.

Date rec. _____
Date Coll. _____
Date extr. _____
Cost per lb. _____

Lot No. _____ Total lbs. in Lot _____

Date	Disposition	Lbs.	Date of Last Test	Germ Pct.	Amount Used	Bal. on Hand

Chapter Three

Seedbeds

Seedbed Preparation Formation

Seedbed areas first should be plowed and disced. After fumigation, the units may be lined into seedbeds by light discing and use of the lister plow if weather conditions have not altered the soil to the point that a second plowing and discing are required. When the area is placed into production for a second consecutive year following a crop of 1-0 seedlings, plowing and discing are necessary. Plowing should not be attempted until the soil has reached a mellow, friable condition; that is, a handful of the soil should break up readily when crushed between the fingers.

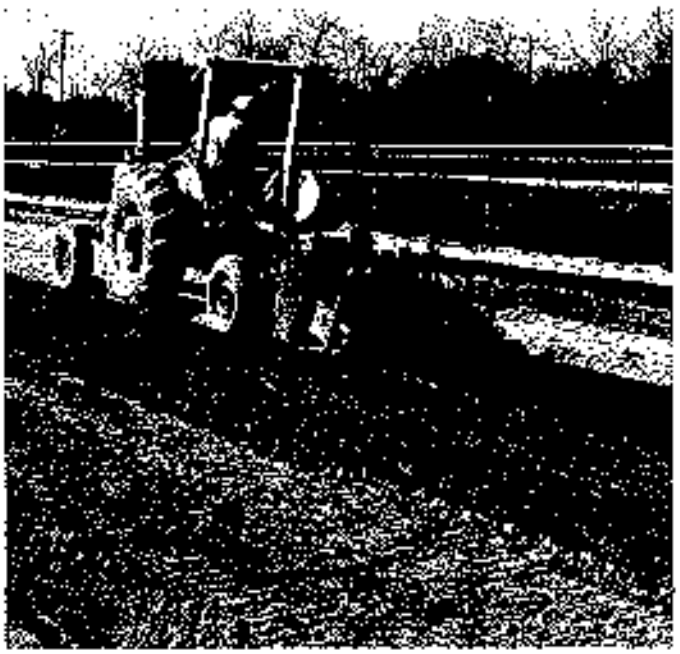
Lister plows should be spread to 68 inches, centered to follow the tractor wheels exactly. A stabilizer bar or sway bar should be used with lister plows to avoid side drift.

Units at the George O. White Nursery are 53 feet wide. There are nine seedbeds per unit to accomodate some of the machinery used in the seedbeds. The tractor operator traverses the unit with the lister plows set deep enough to form a path at least eight inches below the soil surface. Soil is brought from the deepest portion of the path by the plows and spread to each side, sometimes building the seedbed to a height greater than eight inches. This is not a problem, as farther seedbed treatment will bring about the desired height. The operator should gauge the distance from the irrigation line uprights and keep the wheels at the same distance through the entire unit, driving a straight line with the lister plows following at a constant depth. With the first two plow lines completed, the operator turns 180 degrees, places the left wheels of the tractor into the second plow line and plows the third line. Experienced operators can plow the lines on each side of the unit, moving to the center of each traverse and eventually plowing the center bed. Errors in placement of the tractor wheels during traversing can be corrected more easily by working toward the center. As one path is plowed for each total traverse, it probably would be wise and cost effective to provide a marker system for the lister plow. That way two rows would be plowed with each traverse, cutting the operation time in half. Plowing two pathways simultaneously would eliminate the necessity of adjusting the level of the lister plows with the leveling crank.

After plowing, the roto-tiller is used for final shaping of the seedbed. The roto-tiller should be raised to a position which allows the tines to penetrate the seedbed surface to a maximum depth of four inches. Tillage below this depth destroys soil structure and wastes energy. One pass of the roto-tiller is generally sufficient to pulverize, level and spread the surface of the seedbed to a 48-inch width. Hand dressing each end of the seedbed is necessary to assure uniform seedbed length, the opening of drainage ditches and the proper sloping of each end of the bed for easy access by the seeder.

As mentioned earlier, drainage must be provided prior to seedbed sowing or failures will result.

Lister plows are set 68 inches apart to create two plow lines.



A rotatiller is used for final shaping.

Seeding

Several items of equipment are used for sowing seedbeds. New items are being manufactured constantly to aid in the proper sowing of most forest and wildlife shrub seeds, and others are being constructed at various nurseries to solve individual seeding problems. The following items are available for sowing various species:

1. The Whitfield Eight-row Nursery Seeder
2. The (Moncrief) Seeder (adapted from the Minnesota Walnut Seeder)
3. The Gandy Four-foot Fertilizer Spreader
4. The Five-Row Seedbed Marker (for hand planting of species not especially suited to machine seeding)

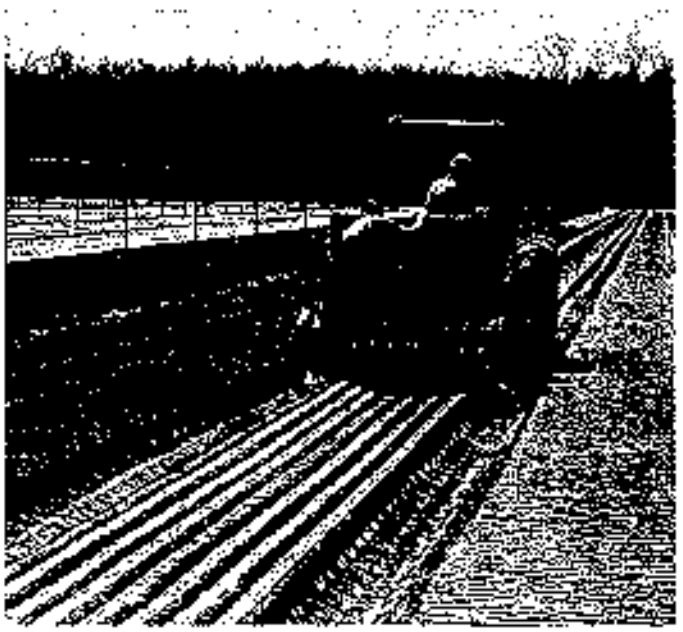
The Whitfield Eight-Row Seeder is a dependable and accurate seeder if properly used. The seeder generally will handle seeds ranging in size from 3,000 per pound to 300,000 per pound, although small seeds may require the addition of 50 to 100 percent (by volume) fine-screened dry sawdust to control density in the seedbed. The Whitfield seeder, purchased by the nursery in 1959, was undoubtedly geared for sowing the larger-seeded southern pines—slash, loblolly, longleaf and shortleaf. The gear ratio furnished with the seeder was 1:2, which sows the smaller-seeded species too densely. The drive gear was a 13-tooth cog, with the driven gear being a 26-tooth cog. A gear ratio of 1:3.5 was better suited to the nursery. A gear with 46 teeth was provided by the manufacturer to replace the 26-tooth driven gear and this was the proper gear ratio to sow the range of seeds per pound quoted above.

Basically, the Whitfield Seeder consists of eight seed cups fed from a common hopper and driven by the chain-and-cog systems described. The seed cups are connected to the ground units by a flexible tube. The ground units consist of a front and rear press wheel for each of the eight seed cups, with adjustable shoes suspended between. Devices following the shoe cover the seed, and the rear press wheel firms the soil over the seed.

The lift lever on the right side of the drill is used to lift the shoes when they are not needed and to adjust for the various heights of seedbeds. The lever transmits pressure through the lift rods, which are protected from undue pressure by a spring at the top of each rod. When in operation, the top collars should clear the lift cams by at least one inch. This assures equal pressure at all eight planting shoes and places the press wheels firmly in contact with the seedbed surface. Since the planting shoes are suspended between the press wheels, this assures uniform planting depth for the eight shoes.

When operating the seeder, make certain that all shoes are adjusted to the same level. The wing nuts may work loose, allowing a shoe to drop lower. Shoes should be raised as high as possible, dropped three notches and the wing nuts tightened securely. The shoes should all appear to be in the same plane. When the seeder is adjusted properly, sighting along the bottom of the shoes each time the seeder is lifted for turning at the end of each seedbed will indicate if a shoe has dropped. A dropped shoe will cause "missed rows" in a seedbed.

When the seeder is adjusted for the seeding rate prior to sowing, the lever should be brought to a point beyond the setting desired and then brought from right to left to the desired setting, eliminating all free play and preventing the seeder from slipping beyond the desired setting. The right edge of the adjusting lever is the pointer for the setting.



The Whitfield Seeder plants eight rows at a time.

Maintain seed in the hopper at a constant level over all eight seed cups. This is especially important when the supply of a seed lot is nearly gone. Brushing the remaining seed into each cup and keeping the supply to each cup uniform until runout will leave an abrupt line across the seedbed when the entire lot is sown.

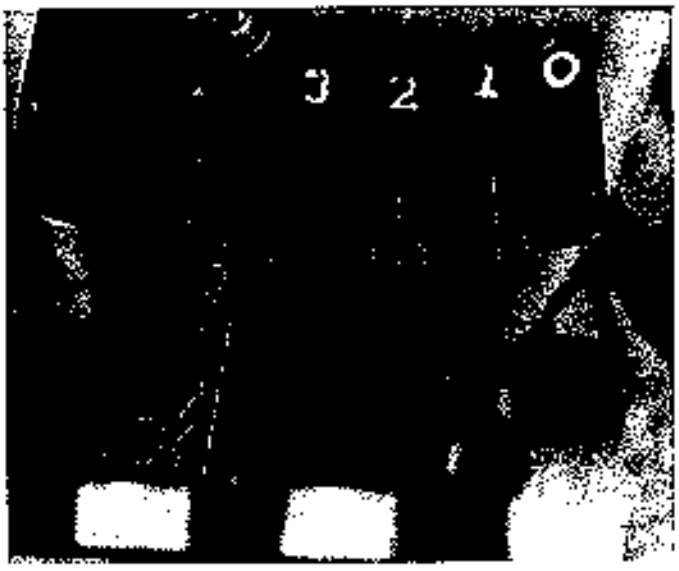
Monitor the bottom of the seed cups constantly, making certain that each cup is dropping seed into the tubes at a uniform rate. Carefully watch each planting shoe to make sure seed is clearing the shoe and is being covered properly. A blocked shoe will soon fill the seed tube, causing it to run over and creating missed rows. Missed rows stay with you for at least a year, sometimes two. This sometimes will occur regardless of precautions, but should be kept to a minimum.

There is a lapse between the time seed falls from the seed cup and the time it falls from the shoe into the seedbed furrow. Thus the seeder should be lowered to ground surface, allowing the drive wheel to come in contact with the soil at a distance of one to two feet from the beginning of each seedbed, seed will enter the furrows at the proper point instead of a foot or two from the beginning of the bed. The reverse is true for the end of the seedbed; the drive wheel should be raised from the soil surface about one foot from the end of the seedbed. As the seed cups stop dropping seed, there is still seed in the tubes to complete sowing of the last foot of the bed. Careful attention to these details by the tractor operator will assure that the entire seedbed surface is seeded properly with little waste.

Stratified and pelletized seed must be dried thoroughly, or poor flow from the hopper to the cups will result. Bridging across the cups occurs, which will cause skipped rows. Since all coniferous seed is pelletized with anthraquinone for control of damage by birds, stratified

seed must be dried prior to pelletizing and then dried again or seed in the hopper will not flow freely. Stratification causes the seed to swell to the extent that the seeder setting must be increased. Normally, raising the setting one-fourth will accommodate this increase. If stratification and pelletizing are used in presowing treatment, the setting may have to be increased by one-half. Stratified or pelletized seed should not be allowed to stand in the hopper overnight, as atmospheric moisture is absorbed and bridging of the seed cups will occur if seeding is continued early the following day. Remove the seed from the hopper and store in a dry, airtight container until seeding is resumed.

Rolling firms the seedbed surface after rototilling.



Drill setting at 3½ inches.

To ensure a level surface for the Whitfield Seeder, seedbeds should be rolled following roto-tilling. The ground units are pressed against the seedbed surface by spring tension and the soil is so loose after roto-tilling that it will not support the press wheels in the best manner. As a result, ruts are cut where the seed is sown. Heavy rains following seeding often will wash the ridges over the seed, resulting in too great a soil cover and sporadic germination.

The seeder should never be stopped during seeding. The time delay from seed cup to planting unit will cause a skip in the bed. Should conditions dictate that the seeder be stopped, the seeder should be lifted from the bed, the entire machine backed up a foot or two, the seeder lowered to the seedbed and sowing continued.

The seeder should never be allowed to travel in reverse while the ground units are in contact with the seedbed surface. The shoes become plugged with soil and skipped rows will result.

Proper seedbed density is controlled by proper calibration of the nursery seeder for each species and seedlot sown. The Whitfield Nursery Seeder in use has a scale and lever for changing rates of sowing and is accurate once it is properly set. The scale is marked in whole numbers from 0 to 4, with subdivisions of one-half and one-quarter.

For calibration, the drill should be connected to a tractor by the three-point hitch, brought indoors upon a clean floor and blocked up a few inches above the floor. This will allow free access to the planting shoes, seed hopper, seed tubes, scale and lever. Turning of the drive wheel by hand is necessary during calibration. Proceed as follows:

1. Pour the seed to be tested into the hopper, making certain that all eight seeding mechanisms are uniformly covered.
2. Remove the seed tubes from the planting shoes and place them in a plastic bucket or other clean container; four tubes to a bucket works well.
3. The drive wheel is the 12-spoked wheel on the left side of the drill and is connected to the seed cup drive shaft by a chain and cog. The drive wheel should be turned by hand until all seed tubes are dispensing seed. At this point, dump the dispensed seed back into the hopper and place the tubes in the buckets.
4. Turn the drive wheel a total of 14 and 11/12 revolutions counterclockwise when facing the wheel (the normal direction of travel when the drill is operational). Since the wheels of the drill are 12-spoked, the fractional turn presents no difficulty.
5. The revolutions turned equal 100 lineal feet of seedbed, or 400 square feet of four-foot wide seedbed.
6. The seed dispensed should be weighed carefully and the number of ounces recorded with the drill setting used in this calibration test. (See formula on page , Chapter 2.)
7. Increasing the drill setting by one-fourth will increase the seed dispensed per 400 square feet by three ounces. Likewise decreasing the drill setting by one-fourth will decrease the rate of seed dispensed per 400 square feet by three ounces.

If the amount of seed dispensed in the trial is six ounces short of the computed quantity desired, raising the drill setting by one-half generally will bring the quantity of seed dispensed per 400 square feet close to the quantity computed. Change the drill setting and rerun the test.

The (Moncrief) seeder is a Minnesota Walnut Seeder adapted to sow five rows of four-foot wide seedbed simultaneously. Since seedbeds are raised at the nursery, a lever was installed on the seeder to raise and lower the planting shoes to accommodate various heights of seedbeds. In addition, slight changes in the sowing rate adjustment were made to better distribute seeds much smaller than the hulled black walnuts for which the seeder was designed. The seeder has saved thousands of dollars in labor costs since first adapted by nursery employee George (Bob) Moncrief. Pecans, oaks, bald cypress, American plum and many other species previously sown by hand are now easily sown with this machine. Several other improvements to the seeder are being considered.

Moncrief seeder bring used to sow acorns.

The method of setting the sowing rate is rather crude. Improvement of this device would increase the value of the seeder several times. It will be necessary to provide a simple but dependable method of delivering seeds to the planting shoes at a uniform rate directly coordinated with the drive wheels in order to sow a desired number of seeds per row-foot of seedbed area. The ability to change sowing rates exists in the present seeder, but the accuracy necessary is lacking.

The planting shoes are adjustable for sowing depth, but once set, are in a stationary position. If the seedbed is of completely uniform height, the sowing depth is uniform. Should the seedbed vary in height, sowing depth will also vary, a factor which could be detrimental to germination. The shoes should be attached to a forward-mounted adjustable roller, with adjustment for sowing depth between the shoe carrier and the roller. Since the seedbeds are normally level when viewed from side to side, the shoe-carrying roller would cause the shoes to ride level, parallel to the seedbed surface, which would result in uniform sowing depth. These adaptations would bring the (Moncief) seeder up to the standard of commercially produced eight-row nursery seeders.

The Gandy Four-Foot Fertilizer Spreader, designed to apply fertilizer to the surface of a four-foot seedbed, also can be used to sow species with extremely small seeds, since most of these must be sown on the seedbed surface, with little or no soil covering. The spreader is highly adjustable, making it possible to sow a wide variety of species. Many nurseries use the Gandy as the primary method of sowing seed, although a system of covering with sand or other holding material is necessary. The basic idea of the Gandy as a seeder is sound, but the problem of keeping seed on the surface of the raised seedbeds until germination and establishment—through heavy rains, windstorms and other inclement weather—is almost insurmountable.

Many species of tree and shrub seeds are so minute that covering with soil is out of the question. A small amount of sand can be placed over the sown seed to deter loss by wind and also to maintain moisture until germination and establishment occur. Most of the seeds which are surface sown will germinate within a few days when temperature and moisture are optimum. Irrigation will keep the seedbed surface damp, but it should not be saturated.

Species which normally are surface sown include: Cottonwood *Populus deltoides*; River Birch *Betula nigra*; Sycamore *Platanus occidentalis*; Black Alder *Alnus glutinosa*.

A few species require hand sowing. Conditions also sometimes prevent machine sowing of a seed lot. Softness of a particular seed which machinery would damage during sowing and conditions which don't allow free flow of the seed, are examples requiring hand sowing. The operation is time consuming and expensive. Although hand sowing should be avoided when possible, many small lots of seed which will be utilized for research are best sown in this manner.

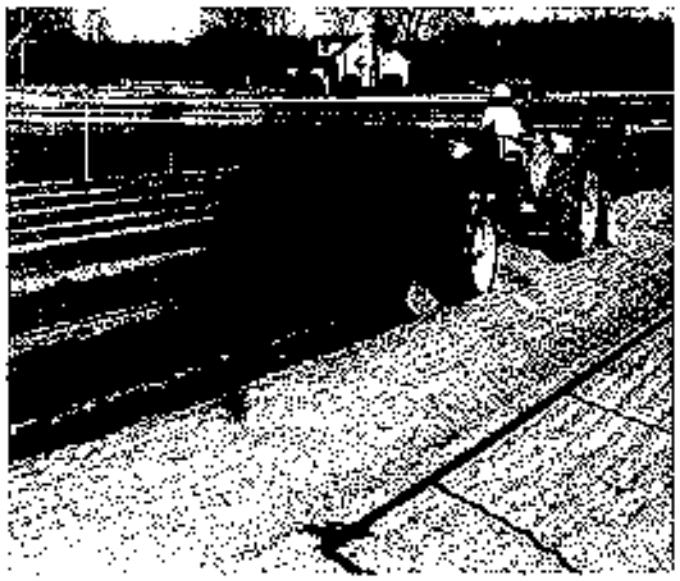
Mulching

Due to the heavy nature of the soil, seedbed mulching is necessary to allow emergence of germinating seedlings. Rains after seeding will cause the seedbed surface to puddle readily, forming an almost impenetrable barrier to the seedlings, especially when the surface begins to dry prior to germination. Mulching also will keep ungerminated seed from washing away during heavy rainstorms.

The use of oak header shavings once was economical. The material was quite stringy, held in place during windy periods and was an excellent mulch over winter or for spring seeding. Since the material was self-binding, there was no need for netting to hold it in place. The decline in whiskey barrel header mills in the area soon depleted this supply.

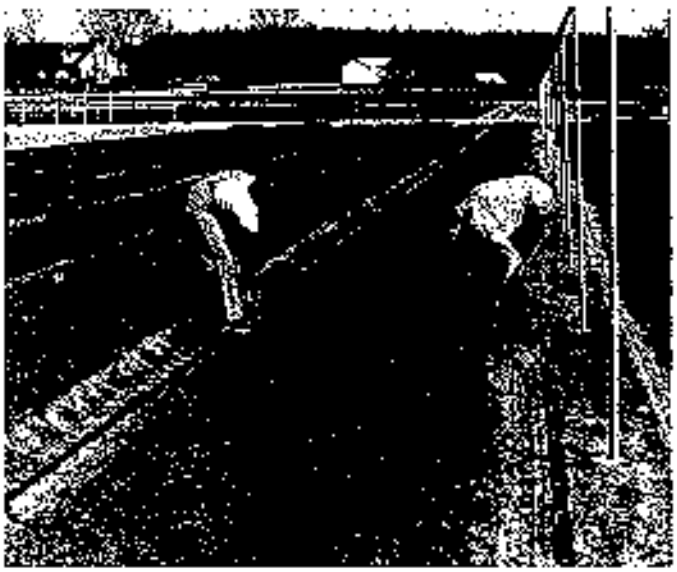
An excellent supply of sawdust and a dwindling supply of oak planer shavings are available, although this source of mulch is also in demand for use in heating plants. As energy costs climb, more of the wastes of sawmills and secondary conversion plants will find their way into heat-producing facilities.

Sawdust and planer shavings are excellent mulching materials but require the use of netting to hold the mulch in place until germination is complete. With the onset of



Sawdust makes an excellent seedbed mulch.

Netting must be used to hold sawdust in place.



germination, the netting must be removed, rolled and stored for future use. These are time-consuming, labor-intensive operations which ordinarily are necessary at inopportune times. As the availability of sawmill and pallet mill wastes diminishes and labor costs rise, other methods of mulching must be found, even though this type is necessary for some species and methods of seeding—black walnuts, unhulled, on a seedbed surface, for instance.

The nursery seedbed hydro-mulcher has solved many of the mulching problems, but various forms of mulch pose some problems. Some of the materials dissolve readily in cold water while others form wads which tend to clog the pump, piping and nozzle of the hydro-mulching machine.

Some mulch has an adhesive binding agent, other mulch requires the addition of binders. The binders hold the fibers together and bind the entire mass to the soil surface. Several of the mulches are pure wood fiber, others are reclaimed pulverized cardboard boxes. Reclaimed paper is available through the open market and is currently used with good-to-excellent results.

The amount of wood fiber mulch or any other material placed on the seedbed surface varies with time of year and seed size. Fall seeding normally would require a heavier application than spring seeding, with length of time for seedbed protection being the main consideration. It is important to make certain not to apply too much mulch, as seedling emergence—especially of small-seeded species—will be hindered by heavy applications. Irrigation must begin in early spring, to assure that newly germinated seedlings will emerge through the mulch with little or no difficulty.

Early hydro-mulching attempts used 3,000 pounds of wood fiber per acre of nursery soil. This is probably a sound practice if the bulk of mulching is for protection of fall-sown seedbeds. Spring-sown seedbeds, especially those sown to rapid-germinating species, probably could be well protected with 2,000 pounds of wood fiber per acre. The need for mulching rapidly disappears with complete germination of the seedbed, although the mulch may control erosion of the seedbed shoulders beyond this time. The wood fiber also adds organic matter to the soil.

The hydro-mulcher available for use at the nursery holds 800 gallons of water. When the tank is charged with six bags of mulch (360 pounds), the material will readily cover 1,600 lineal feet of seedbed. At this rate, approximately 2,450 pounds of hydro-mulch is being used per acre. Since the entire seedbed surface and the seedbed shoulders are being mulched, the rate is somewhat different, but this is a good reference number for planning and budgeting. A tank mix of four bags per 800 gallons of water will place approximately 1,633 pounds of hydro-mulch per acre. This may be sufficient for rapidly germinating spring-sown species, since the time needed for seedbed surface protection is limited.

Use of the hydromulcher eliminates the need for netting.

IRRIGATION

Irrigation water is produced from two deep wells, the original well drilled to a depth of 1,657 feet and a second well drilled to a depth of 1,080 feet. (At this writing, a third well was being drilled.) The original well is drilled through several layers of shale, which necessitated casing large portions of the drill hole. The aquifer for this well is the Lamotte Sands. The second well encountered solid rock in the drill hole at the 90-foot level and is drilled through this rock formation to the Potosi Sands aquifer. Since rock is the main formation through which the drill hole is bored, casing of the main drill hole was not necessary. The newest well is the best producer. Both wells are cased from the surface to the 300 foot level to exclude contamination by ground water seepage.

Both wells have turbine-type pumps which reach to a depth of 350 feet, plus the length of the pump bowls and the attached suction strainer. Water level during sustained pumping normally will not fall lower than 200 feet, which provides a buffer of at least 150 feet of water above the suction strainer. A test gauge is installed at each pump base for testing water level. A hand-operated pneumatic pump or other source of compressed air must be attached to the gauge and pressure built up to expel all water from the air line, which is installed between the pump column and the well casing. When the outer ring of the water-level gauge has been set properly (the actual depth of the air line in feet) and the water has been expelled, the pointer will read the depth of water from the surface. The gauge should never be forced more than one complete revolution from the stop pin. Movement of the pointer is clockwise as pressure is pumped into the air line.

With the maximum capability for each pump being 300 gallons of water per minute, the total capability would seem to be 600 gallons of water per minute. Due to the need for a water supply for drinking, residences and packing facilities at the nursery, a pressure tank has been installed which accommodates both pumps. A control system installed at pumphouse No. 1, in effect, alternates the operation of the pumps. This is critical in winter as the entire system is at the low point in the water schedule. The pumps are water lubricated and long periods of down time for either pump would cause drying of the rubber bushings surrounding the pump drive shaft.

Provision is also made for simultaneous operation of the pumps in the control system. In normal operation, a pump would come on line when the pressure drops to 70 P.S.I. The pump would then continue operation until the float in the water-level controller rose high enough to break contact. The next time the pressure dropped to 70 P.S.I., the alternate pump would repeat the operation. Should demand on the system be high, as during the irrigation season, and the pressure continue to drop with one pump in operation, the second pump would come on line when the pressure dropped to 65 P.S.I. Both pumps then would continue operation until the water level in the tank broke the circuit by raising the float in the water-level controller.

The tank has a 3,300-gallon capacity, but due to the necessity of an air ballast, it is never filled much beyond 50 percent capacity. Should pressure in the tank reach 90 P.S.I., an automatic air bleeder, controlled by a mercury switch in the control box, will open and exhaust excess air and pressure to the exterior of the pump house via a venting system.

Although both pumps are one-half mile apart, they are controlled by the system installed in pump house No. 1. A Rural "C" type telephone line joins the two control systems. A relay in the main control box at pumphouse No. 1 closes, shorting the telephone line, which carries a low voltage, direct current generated at the control box in pumphouse No. 2. When the circuit is completed in this manner, the starter in pumphouse No. 2 is activated and pump No. 2 comes on line.

Although the pumps are referred to as No. 1 and No. 2, the alternator in pumphouse No. 1 determines which pump will operate when the pressure drops below 70 P.S.I. and in this case, either of the pumps could be in the so-called No. 1 position.

It is possible to operate one or both pumps in the manual position, although maintenance of the necessary air ballast would suffer if both were in constant operation. As each pump cycles, a large volume of air is injected into the tank. The air, drawn into the pump column after pump shutdown, fills the pump column to the ambient water level in the well. Upon startup, this air is pumped into the pressure tank, prior to the arrival of water. This is necessary to maintain the air ballast, but the provision for expulsion of excess air must be in the controller.

Various options are available to meet the irrigation needs. When temperatures climb above 95° F, extra irrigation capabilities must be available. One pump may be placed in the manual mode and be on line continually, while the other pump is allowed to cycle in the automatic position. When a pump is allowed to run continuously, the irrigation supervisor must be certain that enough irrigation lines are open at all times to carry the volume of water being pumped or the entire system could be damaged severely or personnel injured by an explosion.

The nursery can be divided into two irrigation sections by closing the main valve located at the northeast corner of Block 7, opening the main valve located between Blocks 15 and 16 and irrigating the entire area encompassed by these blocks with pump No. 2 in manual (constant) operation. While this is happening, the balance of the nursery, Blocks 1 through 6, can be irrigated by pump No. 1 in the automatic position.

All water in the entire sysem is stored in the pressure tank contained in pumphouse No. 1. A separate two-inch water line is tapped into the system between the pressure tank and the main irrigation line valve. When the irrigation system is shut down and drained, water is available for drinking and sanitation purposes in the residences and other nursery structures. This two-inch line also furnishes water to the various fire hydrants located throughout the nursery. With the system at low demand, alternation of the two pumps becomes particularly relevant.

There are two types of irrigation equipment at the nursery. The original equipment, installed in Blocks 1 through 16, consists of White Showers oscillators and horizontal galvanized pipe along the edge of each block, supported at 12-foot intervals by vertical one-inch risers and roller-bearing hangers.

The more modern system, installed in Blocks 17 through 22, consists of the Rainbird Sprinklers, which are also placed along the edge of each block, but sprinkler heads are spaced at 50-foot intervals along the laterals. The

Rainbird sysem is entirely underground, with risers of galvanized iron pipe supporting the sprinkler heads at the stated intervals.

Plans are to replace the White Showers system with the Rainbird-style sprinkler heads as time and funding become available.

The White Showers system has nozzles spaced at three-foot intervals along the overhead lines. Each nozzle is designed to disperse seven gallons of water per hour at 60 P.S.I. The oscillating nozzle sprinkles an area 53 feet wide. At spacing of three feet, the area covered is 53 X 3 or 159 square feet requiring seven gallons of water per hour at the pump head. One pump, operating at capacity, will furnish 18,000 gallons of water per hour at the pump head. This will furnish water for 2,571 nozzles, or enough theoretically, to irrigate almost 9½ acres at a time. Since there is a great deal of head loss due to the distance of pumping and normal line losses, the total area to be irrigated will be considerably less than the amount calculated. Experience has shown that any of the blocks with White Showers equipment may be irrigated at one time when the system is operating at the maximum capability. Barring temperatures above 95°F over extended periods of time, two hours of irrigation with the White Showers system will saturate the soil surface and runoff will begin. If the block being irrigated contains five acres, which is a normal-sized block, 36,000 gallons of water will be spread over five acres, or 7,200 gallons per acre in two hours of irrigation. Since 27,150 gallons of water are required for one-acre-inch of water, we are applying approximately one-quarter inch of moisture in two hours. Under normal conditions, this would allow for irrigation of approximately 20 acres each eight hours of a normal work day. When the daily temperatures reach 90°F or higher for sustained periods, the irrigation schedule should be extended to 12 or 16 hours per work day, and continued through weekends.

Too much water has never been applied using this method. The addition of too little moisture is the major concern. If the soil reaches the wilting point, the point where soil water-holding capacity is greater than the plants' ability to take up moisture, a stagnation period of three weeks is imposed on the growth of nursery seedlings. This period of little or no growth occurs even though moisture is made available soon after the wilting point is reached.

The new nursery blocks are equipped with the Rainbird Sprinklers which demand more water per unit of area. The model 40B, full-circle sprinkler head has a 3/16-inch nozzle for the primary irrigation, plus a 1/18-inch spreader nozzle. This unit requires 11.6 gallons of water per minute (G.P.M.) at 60 P.S.I. Sprinkler heads near the boundary line of the blocks are model 35, part-circle sprinklers. These may be easily set to cover any portion of a circle, and are useful in containing irrigation within the seedbed portion of the block, keeping irrigation water from the roads surrounding each block. These require 7.82 G.P.M. at 60 P.S.I.

Each full-circle sprinkler covers an area 53 feet by 50 feet, or 2,650 square feet of nursery, requiring about 10 G.P.M. when the part-circle nozzles are included in the average flow. A pump which produces 300 G.P.M. will accommodate 30 of the Rainbirds or a total of 1.8 acres. Since irrigation with this system places water on the area much more rapidly than the White Showers system, a maximum of one hour under irrigation should be sufficient.

There is no mechanical method of predicting the need for irrigation, although moisture retention curves are being constructed which will aid in determination of irrigation schedules. Until such data is available, a schedule must be put into effect which utilizes visual examination, color of the seedbed soil and the condition of seedlings at the time of examination.

Since newly germinated seedlings are shallow rooted, extreme caution should be exercised in keeping the seedbed surface moist at all times. Surface-sown seeds, such as cottonwood, require surface dampness until germination occurs and through early growth stages. Seeds which are covered with little or no soil also require visual examination on a daily basis and more often when temperatures rise above 80°F.

When temperatures are between 75°F and 85°F, irrigation should be used if rainfall has not occurred in the past five days. Between 85° and 95°F, irrigation should be scheduled through each work day and weekend unless normal rainfall suggests that irrigation is unnecessary. If temperatures soar above 95°F for extended periods, the schedule should be extended beyond the normal work day, including weekends and holidays.

If the extended schedule appears to be over-irrigating and is making the nursery soil unworkable for passage of equipment or personnel, the schedule should be shifted until an increase or decrease is signaled by rainfall, lower temperatures, or a combination of both.

As the soil in the nursery dries out, a definite color change occurs. Well-moistened soil appears to be almost black, whereas drying soil begins to turn buff colored. This is an excellent indication of the need for irrigation, unless weather forecasts or conditions dictate otherwise.

Seedbed Protection

With the establishment of a stand of seedlings, the nurseryman must be prepared to protect the seedbeds from all damage, whether it be by birds, insects, diseases or quirks in the weather.

Fall-sown seedbeds undoubtedly will be the first to germinate should the temperature rise in early spring. Many of the fall-sown species begin germination in March. By and large, these are the hardy species which can withstand the few frosts and freezes encountered at late dates. Many of the hardwood species are not quite as hardy and require protection if a hard spring freeze is predicted. Bear in mind that these are late spring frosts and freezes which may be countered by action of the nurseryman.

Seedlings which may germinate in an unusual January warm-up will generally be lost, regardless of action taken, although mulching the germinated seedlings may still be advisable. Every precaution should be taken to ensure production of the species. If weather conditions following germination are severe, with temperatures well below 10°F, you may assume the crop is lost. If seed is available, a new lot should be stratified immediately and the crop resown as soon as stratification requirements of the seed lot are met. Time is of the essence in this situation, as many of the northern species must be germinated before ground temperatures reach 75°F. Eastern redcedar seems to require cool ground temperatures for early and complete ger-

mination, and attempts to grow this species will fail should temperatures rise too soon.

When the weather forecast indicates the possibility of a late spring frost and seedlings are in danger of being killed, the irrigation system can be used to protect the immature plants. Since the system is drained and shut down, only those valves to the blocks and units which require protection should be opened. The main valve at the pumphouse should be closed. The nurseryman, or his appointed employee should be in a position to monitor the temperature. If the predicted freeze materializes, the main valve should be opened, and the areas needing protection monitored to ensure coverage of the desired seedbeds. If the freeze is as predicted, irrigation should continue through the duration of the low temperatures, or until the plants being protected are well coated with ice. Plants coated with ice will withstand temperatures well below the freezing point and any further irrigation will not be necessary or prudent. Upon shut-down of the system, the main irrigation valve should be closed and all main lines and lateral lines drained to prevent freeze damage to the overhead and underground lines.

Damage to many of the coniferous plants by damping-off disease disappeared with the advent of methyl bromide. Care should be taken however, to ensure that the northern conifers are sown into newly fumigated soil, or the disease could become rampant and destroy a valuable crop. Scotch pine and white pine are especially susceptible to the disease and are destroyed in a matter of a few hours. Since the seedlings are grown at a high density and generally in rows, the disease spreads rapidly before detection. When detected, the damage generally has progressed to the point where action by the nurseryman does little more than salve the conscience.

Few soil pests are encountered with the use of methyl bromide, although white grubs will build up and become a nuisance approximately one year after fumigation in the 1-0 white pine seedbeds. Constant monitoring of the seedbeds in late summer is wise, as a few dead seedlings normally will alert the nurseryman to the problem. Damage is normally patchy in rows of seedlings, with the seedlings turning yellow and eventually brown. When grasped between the fingers, the seedlings are easily pulled from the soil and the complete lack of a root system can be noted. The entire area in which the grub damage is located should be sprayed immediately when the damage is discovered. Diazinon, at the recommended rate, should be sprayed and then irrigated into the soil to reach the grubs. Careful monitoring of the area should follow to ensure that all grubs have been killed. Instances have been noted when white grub damage occured in scotch pine, jack pine and less seriously in the southern pines, although the presence of the pest is always possible. Diazinon AG 500, at a strength of 4 pounds equivalent per gallon, should be sprayed at the rate of four fluid ounces per 1,000 square feet and irrigated into the soil immediately.

Root rot of 1-0 white pine seedlings, caused by the same organism which causes damping off, may become prevalent in late summer. The organism has been controlled by use of Captan, at the rate of 3 to 4 pounds per hundred gallons of water, spraying the seedbeds until drenched. A light irrigation after spraying is advisable.

Under constant monitoring, few pests are encountered in the production of coniferous stock which cannot be controlled rapidly. Staff members must be trained to report any unusual damage or unusual-looking seedlings to the nurseryman as soon as noted, as a few hours may be critical.

Pests of hardwood seedlings are more prevalent, although the incidence of such pests is low. Most damage is related to leaf-eating insects of one kind or other, but application of Malathion or Sevin at the proper rates will easily control these insects. The nurseryman should be certain of a good supply of the several pesticides registered by the Environmental Protection Agency for instant application. Fungus attacks, or attacks by molds and mildews are far more troublesome than insect attacks, but again, the nurseryman need only be certain of a good supply of several readily available fungicides. Listed below are several insecticides and fungicides along with the target pests and the usual hosts.

Malathion (57% active ingredient), mixed at the rate of 1½ pints per 100 gallons of water will control pine shoot moth, leaf hoppers, mites, aphids, leaf beetles, grasshoppers, lacebugs, scale insects and leaf rollers. Bagworms, a pest on landscape plants around buildings, also can be controlled with Malathion, using 2½ pints of the above per 100 gallons of water.

Sevin (50% active ingredient), wettable powder, (also known as carbaryl) is useful in many applications which would apply for Malathion. Bagworms can be controlled while in the active feeding stage, as can many other leaf-feeding insects and caterpillars. Sevin is rather short-lived, and for this reason, it finds favor near food crops, homes and near livestock or wildlife.

Lindane 20 EC is an especially useful insecticide, as it has the capability of controlling insects which are difficult to reach. Leaf miners, aphids and many borers can be controlled. Two quarts in 100 gallons of water is the proper mixture for such pests.

Fungicides are also on the list of supplies needed almost constantly. Fungus attacks may happen in the seedbed, in the cold-storage plant, in the bundle or bale awaiting shipment, or during shipment. Several fungicides are available to control a wide range of problems and the following are but a few that should be in storage at all times.

Benlate (benomyl) at 8 ounces per 100 gallons of water will control anthracnose of black walnut seedlings and powdery mildew, plus if sprayed weekly it is said to control phomopsis blight of eastern redcedar.

Captan 50 W, mixed at 4 pounds per 100 gallons of water, will treat one acre of seedbed for damping-off control and root rot of conifers. Captan is a good general fungicide; it is easily handled with caution, and should be on hand at all times.

Thiram, useful in the treatment of coniferous seed for direct seeding, also may be useful in the treatment of seed for damping-off control. The chemical is produced in an emulsion, under the trade name of Arasan 42-S. This form is especially useful to the nurseryman, as the original treatment of seed is accomplished in an almost dust-free situation. Arasan 42-S is deadly toxic, however, and all contact with the chemical should be avoided. Further handling of the treated seed should be avoided unless proper protective clothing is worn. If skin contact occurs, personnel should wash with soap immediately. Dust from treated seed must

not be inhaled. Wear a dust mask while handling treated seed.

Lime sulphur is registered for the control of powdery mildew. Wettable sulphur has also been used.

Methyl bromide, packaged as a 2 percent chloropicrin mixture for warning purposes, is a widely used soil sterilant. The chemical is deadly, and the gas is colorless, tasteless and odorless in the pure form. Chloropicrin (tear gas) is added as a warning agent, although chloropicrin has some pesticide value. Methyl bromide gas should be applied at the rate of one pound per 100 square feet, or 435 pounds per acre. The automatic injector and plastic tarp layer have been of great use in the application of methyl bromide, as previously used hand methods were costly and time consuming. The new method allows for treatment of a large area of seedbed in a short time, a definite advantage when trying to circumvent bad weather.

Care must be taken by all employees during fumigation with methyl bromide, as the gas is extremely toxic. Gas masks should be worn by all personnel directly employed for hand sealing of the plastic tarp at the start and finish of each run and also by the tractor driver during all operations of fumigation.

By operating the tractor at a speed of two mph and adjusting the pressure reducing valve to 30 P.S.I., the proper amount of methyl bromide should be applied. To increase the pressure, turn the adjusting valve clockwise, to decrease, turn counterclockwise.

Several items should be checked closely during fumigation and the proper adjustments made:

1. The drag board setting should allow the chisels to penetrate the soil at a six- to eight-inch level. When the drag board is operating properly, a soil seal is made following the chisel point applicators.
2. The hydraulic hitch mechanism should be operated in the POSITIVE CONTROL MODE, thereby assuring constant depth control of the chisels and the drag board.
3. The plastic should be placed on the surface of the seedbed area by proper adjustment of the roller. Expulsion of all air will aid in sealing the tarp and will help prevent movement of tarps during windy conditions.
4. The front opener disc should remove only enough soil to allow the plastic tarp to be well placed in the trench by the press wheel. The rear cover disc should be adjusted to return only enough soil to firmly weight the tarp in the trench and seal the gas underneath. Remember, all soil placed on the tarp surface is essentially unfumigated.
5. The row marker must be used consistently, to assure complete coverage of the fumigated area. Be certain that the next run of the tarp layer overlaps the preceding run, or weed seeds will survive and be scattered by seedbed cultivation. A small error in tarp placement during fumigation will allow skips which essentially will destroy the total process.
6. The tarps should remain in place for 24 to 48 hours before being removed. During removal, care should be taken to ensure that unfumigated soil is not returned to the fumigated area, or reinfection with weed seeds, insects or disease will occur.
7. Fertilization should not be attempted following fumigation with methyl bromide, as toxic forms of nitrogenous elements which hinder plant growth are created. All fertilization should be done before the green manure crop is sown and fumigation should not be started until 45 days after green manure plow-down.
8. When tarp removal and disposal is attempted, employees should be up-wind from the tarp and should wear rubber or plastic boots. Soil seems to retain some methyl bromide or chloropicrin, which tends to build up in leather shoes and causes severe foot burning. Tarps should be torn loose from the soil seal and allowed to aerate for a time before retrieval from the fumigated area is attempted.

Methyl bromide fumigation is expensive, but when properly applied, will easily repay the cost. Weed seeds are destroyed, diseases are eliminated and insects in all stages are destroyed. Should the use of herbicides eliminate the need for weed control, fumigation still may be beneficial in eradication of seedbed diseases and insects. Damping-off disease of the northern conifers would justify fumigation for this pest alone. Preventing infestations by nematodes (root knot) would also justify the fumigation of seedbed areas.

Weed Control

Weeds and grasses invade seedbeds at such a prolific rate that they must be controlled or growth of tree seedlings would be seriously hampered. Seedlings could even be completely choked out and killed by the rank growth. Weeds consume moisture, nutrients and space which are needed by seedlings during a relatively short growing season. There is also a possibility of weeds and weed roots emitting inhibitory materials which could seriously retard seedling growth. The allelopathic effect of fescue (*Festuca arundinacea*) on the growth of tree seedlings has been well documented.

Weeds are annual, biannual and perennial. Control of weeds should be undertaken with an understanding of the growth of the weed in question. The old saying that fall weeds are soon killed by frost may or may not be true, especially if the weed in question is a biannual or perennial plant. These two categories of weeds will bloom with great vigor the following spring and literally sow the entire nursery. Weeds must be removed or destroyed, regardless of the time of appearance in the nursery area. Delaying control may cause problems for several years should the weed be allowed to reach maturity and the seed be dispersed.

The old methods of hand weeding and hoeing are no longer satisfactory. Removing weeds from hardwood seedbeds prior to weed seed formation is impossible using hand methods. Other means must be found which will destroy weed seeds before germination or destroy all germinated weed seeds before the plant reaches maturity and forms a new crop of seeds.

Many herbicides are available to assist in the eradication of weeds. The battle should not only be carried out in the seedbed area but also in all surrounding areas which might infest the seedbeds. Lawns adjacent to

the seedbed, or close enough to allow dispersal of seeds, must be kept free of weeds. Headlands, roadways, areas between roadways and seedbed areas must be maintained as vegetative barrens. The possibility of invasion by weeds from these areas is real and must be considered in planning the weed-control program. Windbreak areas harbor weeds, and the constant cleanliness of these areas must not be overlooked. A total sanitation program for the eradication of weeds must be enforced.

Waterways must be located in such a manner that carrying weed seeds from adjacent areas by runoff during rainy periods is impossible. Entire blocks of seedbeds could be invaded by costly weeds if rainwater runoff is not carried away properly.

Several of the herbicides registered by the Environmental Protection Agency are now being used to great advantage for weed control. Some are specific for the control of broadleaf plants, some are useful as pre-emergent killers of weed seeds and others are specifically formulated for post-emergent control.

2-4 D is available as a broadleaf weed killer in established lawns and should be applied either by boom application to eliminate all but the lawn grasses, or as spot application. Spot application with various types of hand-operated wipers, killer canes or hand-carried sprayers may be sufficient to obliterate broadleaf weeds from lawns adjacent to or in the vicinity of seedbeds.

The removal of weeds from paths, headlands, drainageways, irrigation lines, roadways, windbreaks and all other areas near the seedlings can be accomplished with several different herbicides.

Roundup works well in post-emergent applications in the areas listed above. Roundup is the isopropylamine salt of glyphosate. Application may be by boom, applying 1 to 5 quarts per acre in 20 to 40 gallons of water. Do not apply over 10 quarts per acre per year. Hand-held sprayers should be charged with a 1 to 2 percent solution, wetting individual weeds but not to the dripping point. Hand-held wipers should use a 33 percent solution, or one part Roundup to two parts water.

Dual 2E can be used in like areas as a pre-emergent herbicide. Two to three pints per acre, well-mixed with water and agitated during spraying, should be applied. The herbicide should be mixed with water and sprayed at a minimum of 15 gallons per acre. Either boom or hand-held sprayer applications are permissable.

Herbicides applied directly to the seedbed are also available. Some are available for pre-emergent and post-emergent control in coniferous stock. Post-emergent herbicides for application to hardwood and deciduous species are difficult to identify and procure, although research is rapidly producing selective herbicides.

Dacthal W 75, or other formulations of Dacthal, consisting of dinoseb (dimethyl tetrachloro terephthate) are excellent for pre-emergent control of weed seeds in coniferous and deciduous seedling beds. Dacthal W 75 should be applied to weed-free seedbeds at the rate of 12 to 15 pounds actual material in 20 to 30 gallons of water per acre. Incorporation by the addition of ¼ inch to ½ inch of water by irrigation is suggested. Further disturbance of the soil area is not recommended.

Goal 2E is an excellent herbicide for application to coniferous seedbeds. Action is both pre-emergent and post-emergent. Seedbeds should not be sprayed until seedlings are at least five weeks old. Pre-emergent applications should consist of 1 to 4 pints of Goal mixed with 20 gallons of water per acre. Post-emergent applications should be done after weeds are four inches tall and at the rate of 1 to 2 pints per acre in 20 gallons of water.

Since herbicides are expensive on a per-gallon basis, the number of weeds present will dictate the method, the herbicide to use and whether the use of herbicides is economical. The time of year will also be influential. In the spring of the year, with a completely weed-free seedbed area, application of a pre-emergent herbicide to all seedbed areas and adjacent areas would be economical. Fall of the year or late summer would also be a propitious time for such application should the same conditions exist.

In spite of the excellent weed control available with various herbicides, some hand weeding will be necessary. Following application of a pre-emergent or post-emergent herbicide, a few weeds will persist and these should be removed by hand immediately, prior to seed formation. Hand weeding should include complete removal of weed roots and stem, placing them in a bucket or other tight container and removing the container from the general seedbed area. The ability of weeds to resuscitate when pulled and left in nursery paths or in the seedbed area is phenomenal.

Chapter Four

Seedling Harvest and Distribution

Inventory of Nursery Seedbeds

Inventory of nursery seedbeds is an exacting operation,as the total sales and disposition of much of the available planting stock depend on the accuracy of the inventory figures sent to the Central Office. Inventory is monitored by computer, but the data must be reasonably accurate initially. Monitoring the inventory helps to keep the public aware of what stock is available and gives the nursery superintendent an indication of species demands.

Since the composition of species and age classes of planting stock produced at the nursery is not uniform, it is difficult to develop standardized inventory procedures.

Conifers are grown to the one- or two-year age class, and hardwoods and wildlife shrubs generally are lifted as year-old stock. Over 50 different species are produced. Some are sown with the Whitfield Eight-row Nursery Seeder, some are broadcast on the seedbed surface with the Gandy Four-foot Fertilizer Spreader, some are seeded with the (Moncrief) Seeder and others are simply sown by hand in furrows. This tends to cause severe variations in seedbed densities, which are evident in the sample count taken at inventory time.

The following must be taken into consideration before inventory is undertaken:

1. Each species, age class and geographic seed source must be considered a separate inventory.
2. Separate estimates must be developed if there are variations such as seeding time (fall or spring), seed germination percentage, soil management practice or any other factor which will cause individual beds or groups of beds to be different from the standpoint of seedbed density, uniformity or general seedling quality.

The first consideration is the number of sample counts per seedbed, age class, species, etc. A sample count consists of counting all the seedlings within a randomly selected one-foot by four-foot section. The minimum number of sample counts per seedbed is three, when 100 or more like seedbeds are inventoried. The number of sample counts per seedbed increases rapidly as the number of seedbeds declines. The Southern Forest Experiment Station recommends 80 sample counts for one seedbed 4 feet X 400 feet containing 50,000 trees. If 100 such seedbeds are inventoried, only 400 sample counts should be taken, or four per seedbed. The Lake States Experiment Station recommends 17 sample counts (0.5 feet X 4 feet) for one 500 foot seedbed and one sample per bed if you have 50 or more like seedbeds. The Ontario Research Report #33, November, 1955, recommends 169 sample counts (1 foot X 4 feet) for one seedbed approximately 240 feet long. The number of sample counts remains essentially the same, with five sample counts per bed recommended for 40 beds (200 count total) or 240 foot length.

The sampling objective at the nursery is 5 percent accuracy. Accuracy of the sample is judged using a 95 percent confidence interval under a "Student 'T'" distribution curve. We want to be 95 percent confident that the true average seedling count of all seedbed sample plots falls within a range of values no greater nor less than 5 percent of the estimated average computed from a more limited number of seedbed sample plots.

The method required to compute confidence intervals and sampling accuracy can be found in any basic statistics textbook. Procedures are also outlined in these textbooks for determining how many additional samples are required to obtain the desired accuracy when the original sample count is not adequate.

Various methods have been advocated for the determination of sample point locations in the seedbed. The fully random sample probably would be best statistically. But since none of the seedbeds are the same length, neither the stratified random nor random methods are used. Systematic sampling points is the most efficient alternative for the nursery.

The total length of all seedbeds in the area to be inventoried determines the total number of sample counts. The total length of all seedbeds divided by the number of sample counts determines the uniform spacing between sample counts. A random start is used to begin placement of the first frame. From this point, each frame is placed at uniform spacing between sample counts. A random start is used to begin placement of the first frame. From this point, each frame is placed at uniform spacing, carrying over the spacing from bed to bed. If the end of the seedbed does not fit the spacing, the balance of the spacing is carried over to the next seedbed and the spacing continued. In order to avoid bias, personnel are instructed to place the frame at the appointed sample point, without paying attention to the seedbed. Counting of the sample is then begun.

Counting of seedlings requires personnel knowledgeable about the grading operations and the limits placed on each species regarding caliper, height, etc., as only plantable seedlings are included in the actual count.

Methods have been suggested whereby the total number of seedlings in the frame are counted and then a determination of the percentage of plantable seeds is made. The counting frame has 10 marks inscribed on one side and the tree nearest to each individual mark is graded as to its plantability or cull factor. Eventually, a plantability percentage is applied to the gross inventory to determine final inventory.

With the placement of a computer terminal at the nursery, the computations necessary to determine the accuracy of an inventory will become a simple matter. Each inventory then can be analyzed statistically and changes made, if necessary, to bring the final figures within the ± 5 percent accuracy desired.

Determination of Dormancy

At this time, dormancy is not a scientific measurement, although various instruments are available which will help in dormancy determination. The "Square Wave Generator" and other instruments under study are based on the electrical resistance of plant tissues prior to and

after dormancy. Most mechanical methods are in the research stage at this time, therefore it is up to the nurseryman to judge the characteristics of dormancy.

Dormancy normally follows one or more killing frosts. The following characteristics of dormant planting stock will aid in the determination of dormancy, although some winter hardy species will not follow the pattern:

1. Deciduous species will lose leaves, either gradually, following a series of light frosts, or rapidly, following a single heavy frost. The average date of the first killing frost in the Licking area is October 20. Killing frosts have been experienced as early as September 20 and as late as November 10.
2. Conifers may or may not show discoloration following a killing frost. Shortleaf pine has shown purpling of the upper needles, although this is not a good indicator for all conifers. Seedlings produced from native Missouri seed exhibit the fall purpling much more rapidly than seedlings grown from Arkansas seed sources.
3. Dormant seedlings almost invariably show a brownish-tan, woody stem. Hardwood seedlings often are defoliated by a killing frost, but may still present a green or light-green stem. Periods as short as one week following defoliation have changed the color from green to brown and have changed the fleshy appearance of the stem to a woody appearance.
4. Research in the northern sections of the United States and Canada shows that the roots of conifers must not be elongating greatly or dormancy has not arrived. Fine white roots longer than ½ inch indicate that conifers are in the active growing state and require more time until dormancy is reached.
5. There are a few hardy species which will not defoliate easily or produce the woody appearing stem until extreme low temperatures are reached. Some, such as autumn olive, will not defoliate until temperatures drop as low as 10° F. Flowering dogwood retains a greenish-colored stem long into winter. These species should be avoided as dormancy indicators. Black walnut, when properly defoliated and showing a brown woody stem, is an excellent indicator of dormancy. Scotch pine usually forms an excellent terminal bud long before dormancy, but the usual woody stem and coloration of the stem should be an indicator of dormancy. Shortleaf pine, unless submitted to severe temperatures (-10° F. or below), does not form the usual terminal bud, but forms a small rosette of needles in lieu of the bud. Extended warm periods during January or February often will cause elongation of the rosette. At the conclusion of this unusual growth, a new rosette is formed and dormancy again is renewed.
6. Stock which will be lifted in the fall must be dormant, or successful storage over winter is not possible.

Lifting

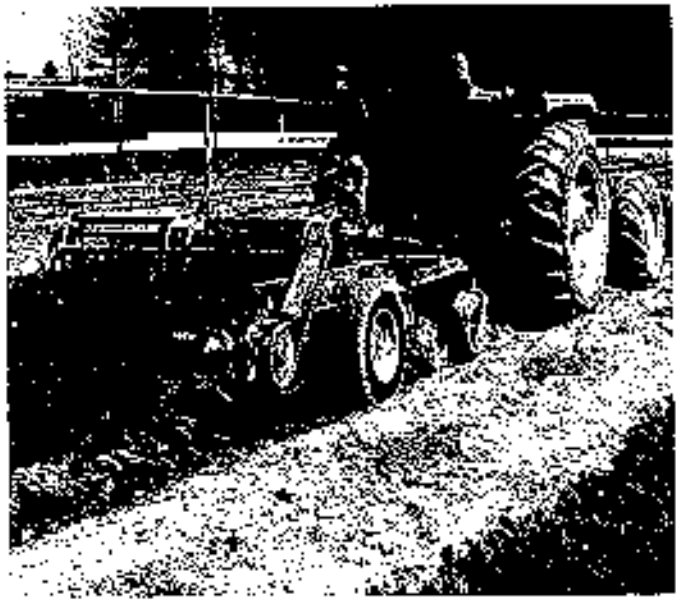
After planting stock becomes dormant, the next chore is to lift all hardwood stock possible. Conifers, being the most readily lifted of all the planting stock in the nursery, are usually left until spring, unless orders for fall shipment are on hand. Seedlings lifted in the fall must be handled carefully or all hope of shipping a viable seedling the following spring is lost.

Three machines are available for lifting seedlings—the plain nursery-built lifter blade with attached fingers for soil break-up; the Mann Saver agitator lifter; and the John Deere two-row potato digger. The machines are listed in the order of their utility. Soil conditions dictate which machine should be operated. Muddy conditions will practically eliminate the potato digger. Slightly wet soils are traversed readily by the Mann Saver lifter, although the amount of soil removed from the seedling roots may be minimal. In cases where seedlings must be lifted from soil so wet as to be called slime, the nursery-built lifter blade with fingers is the only alternative.

The optimum depth to run the lifter blade is deep enough to go beneath all seedling roots, thereby not pruning any roots. Care must be taken and trials conducted to make certain that the blade is set properly, as too deep a setting will result in poor agitation and little breakup of the soil surrounding the root systems. Great damage may result when employees attempt to remove soil from the seedling. Fine, fibrous roots can be severely damaged, greatly reducing chances for survival. In some instances, it may be better to root prune 25 percent of the root system in order to properly agitate the soil and protect the fibrous roots.

As rapidly as seedlings are lifted, they should be packed tightly into a container with the root system in the bottom and seedling tops in the vertical position. As containers are filled, they should be picked up by the retrieving crew and taken to the cold-storage plant, or to the packing building for immediate grading and counting. Seedlings which will not be graded and counted within a few hours after lifting, should be kept in cold storage.

The two-row potato digger will only operate in relatively dry conditions.



Seedlings delivered to cold storage or to the packing building for further operations should be kept damp at all times. Garden hoses, sprinkler cans or any other means available should be used to keep seedling roots moist. Seedlings should not be standing in free water following lifting or serious root rot and diseases will destroy them.

Seedlings which are delivered to the packing building should be graded and counted as rapidly as possible and then removed to cold storage immediately. Seedlings which will be stored over winter should be taken to the large cold storage building. Seedlings which will be baled for shipment in a short time can be stored in the packing building cold-storage room until baled and shipped.

Moisture and humidity in the cold-storage room are maintained largely by dampening material prior to placement in cold storage and then by maintaining free moisture on the concrete floors. This process appears to provide adequate humidity, as very little drying of planting stock occurs.

Seedlings should not be lifted or handled outdoors when temperatures are much below freezing. An old saying, which is valid, cautions: "Below 25 (degrees F.), they're not alive."

Personnel should not be subjected to working in temperatures below freezing, except to accomplish a specific goal, such as meeting a shipping deadline. Situations will arise when nursery personnel are asked to stretch their physical endurance to the limit, but supervisory personnel should be well aware of tolerable limits.

Grading Seedlings

The large number of species grown at the nursery complicates the standardization of grading. Therefore, the following standards will be applicable to most classifications of seedlings, but the nurseryman must use a great deal of common sense in order to adapt to the variety of situations.

Coniferous Stock 1-0

1. Stem caliper at one inch above the root collar should measure a minimum of 2/32 inch; 3/32 inch would be a better target and would increase the quality of planting stock considerably.
2. Tops should be a minimum of 4 inches, but not larger than 12 inches.
3. Roots should be a minimum of 6 inches, not longer than 10 inches.
4. Top-root ratio, determined by actual green weight, should not be less than 3:1.

Coniferous Stock 2-0

1. Stem caliper at one inch above the root collar should be a minimum of 4/32 inch. Increasing this to 6/32 inch would also contribute to the value of the planting stock.
2. Tops should be a minimum of 8 inches, but not larger than 16 inches.
3. Roots should be a minimum 10 inches, not longer than 12 inches.
4. Top-root ratio, determined by actual green weight, should not be less than 3:1.

Hardwoods 1-0

1. Variation in top growth of the various hardwoods will limit the ability of the nurseryman to set minimum and maximum standards. The minimum height for prime planting stock should be at least 15 inches, but species characteristics often will call for grading standards below this figure. Black walnut, ashes, oaks, sycamore, black locust, elms, cottonwood, mulberries, Osage-orange, bald cypress, soft maple, pecan and sweetgum are easily graded by the above standard, as their normal one-year growth usually reaches this minimum and beyond. The maximum length is usually dictated by other restrictions. (Length plus girth cannot exceed 100 inches to ship via the U.S. Postal Service, 90 inches length plus girth for United Parcel Service.)
2. Stem caliper should be a minimum ¼ inch, measured one inch above the root collar.
3. Roots must be the maximum length to produce well-balanced planting stock. Lifting operations should be carried out with the lifter blade placed as deep in the seedbed as possible, to retrieve all roots. Care should be taken to assure that the fibrous root system of the plant is not destroyed by hand pulling the seedlings after the lifting operation. Soil conditions may dictate the root system. Since hardwoods produce varying types of root systems, from long tap roots to diffuse fibrous systems, each species must be dealt with on an individual basis. If soil conditions (freezing, mud, etc.) prevent proper lifting, it should be shifted to a section of the nursery which may be properly worked.

Baling

All hardwoods and deciduous seedlings are counted and tied into bunches of 25, while all coniferous seedlings are counted and tied into bunches of 50. Size is the principal reason for the difference. Hardwoods and deciduous seedlings handle, store and bale much more efficiently in smaller bundles.

When bundles of graded and counted seedlings will be stored over winter, they can be stacked onto the carts as they come from the grading table, generally with the roots toward the center of the cart. Seedlings should be wetted thoroughly while being counted and stacked, and then placed in cold storage. Adding one of the super absorbant hydrolized starch materials to the water before wetting the roots appears to improve the condition of stock which is stored over winter.

Baling of the counted bunches is controlled by a listing of maximum-sized bales, developed over the years as the most convenient-sized bale of each individual species, and also the most convenient size and weight to fit the categories demanded by the U.S. Postal Service and United Parcel Service. U.S. Postal Service regulations will not allow a package to exceed 70 pounds or 100 inches in combined girth and length. The total number of parcels shipped to any individual at any one time is not limited. United Parcel Service regulations will not allow an individual package to exceed 50 pounds, or the combined girth and length to exceed 90 inches. In some other states, UPS limits the total amount shipped to one person in one day to 100 pounds and this must be checked should an out-of-state shipment be necessary.

Heavy-grade paper, reinforced with an inner layer of asphalt and glass scrim which is rather moisture resistant, normally is used for packaging. The jelly-roll type bale is used with all orders. Maximum-sized bales are slatted with oak slats and banded with steel banding machines. Smaller bales are tied by hand with heavy twine. An instruction card explaining care of the seedlings and planting methods is included. Packaging medium is well dampened (but not dripping wet) sphagnum moss. As the seedlings are placed on the baling table, a spray nozzle over the table sprays the roots prior to the top layer of moss being put into position, and the bale is rolled up for tying and strapping.

Seedling Storage Prior to Shipment

Seedlings are stored at several stages prior to being shipped to the customer—immediately after lifting, after grading, counting or packing into bundles of 25 or 50, or after being baled into a specific order to be shipped within the next day or two. Some are stored for only a day, others for several months over the winter.

Seedlings stored the longest are generally those that have been graded, counted and bundled, but not baled. A tag, designating species, number on the cart and date of placement in cold storage should be firmly attached. Totals of all such planting material should be kept by one person and given to the packing building foreman at the close of each work day. The packing building clerk enters these totals on a ledger, listing the number of each species graded that date and carrying a total graded and counted to date. The packing building ledger is useful to the foreman in determining the amount of each species ready for shipment and is also useful at season's end in determining the total number of each species shipped.

The temperature in the cold storage building is maintained at 32° to 36° F. during storage. Conifers will tolerate temperatures slightly below freezing, but research indicates that such temperatures will harm the root elongation potential of most "fine hardwoods" produced at the nursery.

The storage of seedlings over winter demands the following procedures which are not especially important in short-term storage (material baled for shipment in the next day or two.):

1. Carts should not be pushed so close to the wall that plants touch the wall, cutting down air circulation.
2. Carts should be spaced far enough apart to allow air circulation between carts.
3. Baled plants, placed on carts or pallets, should not be placed next to the wall, or be stacked in contact with each other. All bales should be well stickered, allowing complete air circulation between each bale. Protruding seedlings, as between carts or pallets, should never touch or come in contact with any item which will deter complete air circulation.
4. Small packages, such as those associated with the "Special Bundles" listed on the order blank, may be made up in advance and stored until shipment. These should not be stored on carts or pallets without separators. The cart bulkheads have lateral bars which can be used to build shelf-type separators. Stacking these packages over one foot in depth should be avoided, unless the material will be shipped in a short time. Long-term storage will result in deterioration of the bundles, caused mainly by molds and mildews, unless separated into thin layers.
5. Dating the material placed in cold storage will allow the nurseryman to practice "first in, first out" when shipping begins.

Distribution

Tree and shrub distribution has been computerized, making the bookkeeping simple and streamlined for nursery personnel.

Order blanks are available to the general public about November 15 each year. The order blank is revised each shipping season and is usable for only one season. The customer gets a list of seedlings available for the current year and the price. The minimum order for each individual species is 200. Orders for less than 200, in groups of 50 seedlings, are charged at the 200 rate. The customer has a choice of delivery method, either pickup at the nursery or prepaid shipping charges are included in the original quoted price of the seedlings, and the shipping address can be different from the customer's mailing address.

Shipping dates are listed on the order blank, and only these dates are recognized by the computer as valid. Customers requesting invalid shipping dates will be given the next valid shipping date, and will be notified of the change. Shipping begins about the middle of February and ends about the middle of May. Each month has various shipping dates which are those most often desired. Several shipping dates are entered into the computer for special programs, but are not listed on the order blank. Field service orders, due to their complexity, are scheduled on Thursdays only. A special date is entered for distribution of Arbor Day Seedling Bundles to elementary schools in the state.

An example of the shipping schedules listed on the order blank for spring of 1983 is included below:

February	9 - 14 - 16 - 22 - 23
March	1 - 2 - 7 - 8 - 9 - 16 - 21 - 23 - 28 - 29 - 30
April	5 - 6 - 11 - 12 - 13 - 19 - 26
May	3 - 4 - 10 - 17

1. Reviews address
2. Reviews "Shipping Date" and "County where trees are to be planted."
3. Completes "Office Use Only" area on order form. (Special coding for various types of customer use of planting stock.)
4. Stamps "Received and Date Received" on order form.
5. Stamps sequential number (fiscal number) on order form.
6. Batches order forms for the day and sends batch to Data Entry for processing.

In order to reduce the possibility of errors in computations, billing is not done unless the computer inventory list of species is valid. Items available are billed and items that are sold out are marked "Sold Out" on the Acknowledgement Card. The Acknowledgement Card has a detachable

section which includes the customer's fiscal number and the amount due. Upon receipt of this card, customers send a personal check or money order for the amount due to the Department's Fiscal Section in Jefferson City. The computer entry of payment will free the order for printing on the proper shipment list.

As the daily batches are entered, a listing of all orders is produced by sequential fiscal number. Lists of canceled orders and shipping date changes also are produced. All shipping date changes are advanced to the next valid shipping date automatically. If the customer wishes to change this shipping date, a request must be forwarded to the Data Entry Unit at least 10 working days prior to the shipping date requested. Changes also can be made by telephone, although the request must precede the actual shipping date by several days.

Ten working days prior to the first shipping date, and weekly thereafter, the following reports are generated for distribution to the nursery.

1. **A list of the total number of seedlings of each species required to fill orders on that shipping date.** Orders for Parcel Post and United Parcel Service are combined, with the number of seedlings required for nursery pickup reported separately. This is generally referred to as the "cheat sheet" by the foreman, as it aids considerably in planning lifting schedules prior to the shipping date.
2. **Copies of the customer order list for each shipping date, separated into three categories—Parcel Post, United Parcel or nursery pickup.** Each list is alphabetical, numbered on the right-hand side sequentially, beginning with number one for each shipment category. This number corresponds to the number printed on shipping tags. The United Parcel list contains the UPS zone for each customer, and each list ends with the total number of shipping tags printed (bales), which is useful when the shipment is picked up by the UPS driver. One copy of this printout, marked with the weight of each individual bale, is given to UPS at the time of pickup and is the basis for billing.
3. **An alphabetical list of all customer orders.** This list contains fiscal number and payment status. It provides a cross-reference for individual orders and must be updated weekly.
4. **Customer fiscal number list, numerically arranged for easy referral to individual orders.** This report is prepared as the individual orders are entered by data processing and is added to the preceding numerical listing.
5. **A seedling inventory report, which shows the status of all species listed for distribution.** Number of seedlings sold or obligated and the number of each remaining for distribution is included on this report.
6. **Tree shipping tags for each bale to be shipped, on each shipping date.** The tag includes the customer's name, address, amount of each species of seedling to be included in the bale, the method and date of shipment, Zip Code and the number originally assigned in the customer order list. This number is the one which generally indicates in what sequence seedlings were shipped (as opposed to the fiscal number which indicates in what sequence orders were received). UPS shipping tags also bear the UPS Shipper's Number and the Release Number (a UPS driver can leave the bales at the customer's residence without having the customer's signature). Shipping tags can be collated by the computer in any arrangement consistent with the desires of the nurseryman. All tags containing only one species can be stacked together. This will relieve packing building personnel from the chore of separating individual species into stacks for efficient operation of the baling room. Mixed bales can be arranged in the order best suited to the shipping operation.

As the weekly delivery of the above reports are received at the nursery, a copy of the printout of Parcel Post shipments for each date is delivered to the postmaster at Licking, a copy is sent to the packing building foreman and the remaining copies are retained at the nursery office on permanent file. Shipping tags also are sent to the packing building foreman. Two copies of the printout of UPS shipments for each date are delivered to the packing building foreman, along with pertinent shipping tags. A copy of the "Trees by Shipment" list (cheat sheet) is delivered to the packing building foreman, which alerts the foreman to the volume of each species which must be lifted, graded and counted to fill the orders on each shipping date.

A copy of the "Seedling Inventory Report" is retained at the nursery office for general information regarding the number of each species available for sale, general disposition of alloted plants and Special Bundles. The copy of the additional "fiscal number" list is added to the preceding reports. This numerical listing is invaluable for checking individual orders, especially when the fiscal number is available. An updated alphabetical list of customers is received weekly at the nursery office. This list is invaluable in cross-referencing individual orders, as the fiscal number, payment status and various other data are included.

Upon receipt of the pertinent forms and shipping tags, the nurseryman and the packing building foreman proceed with lifting, grading and counting of the various seedlings needed to fill orders. As the seedlings become available, the special bundles required will be baled and placed in cold storage until needed.

In the interim, the packing building clerk separates all of the shipping tags for each shipment date, places each tag into a self-adhesive plastic envelope, places a metal eyelet in the left hand portion of the envelope and hangs the tags for each species on a separate peg board. Where tags contain more than one species, each tag is assigned to a peg based on which of its species will be shipped in the least amount on that date. For example, if the printouts indicate that a total of 500 pecans will be shipped that date and that is the smallest number of any species being shipped out that day, all of the mixed tags with pecan will be sorted first and hung on one peg.

In the baling room, carts are brought from cold storage based on the amounts needed for that date. Species to be shipped in the least amount are brought out first. Orders are prepared by working on the set of tags from the

first peg, then the second, etc. This method allows an entire cart of one species to be removed as soon as the first set of tags are completed, then a second as the second set of tags are completed, and so on. The Parcel Post orders are prepared first, because the orders are delivered to the Post Office in early morning on the shipping date. United Parcel Service orders are prepared next, as these are picked up by United Parcel trucks and semi-trailers in early afternoon. Pickup orders are never baled until the customer appears for the order, unless the order is large, and then only by pre-arrangement with the nurseryman.

As bales leave the baling table, the proper shipping tag is attached and the bale is weighed. The weight is recorded on the bale with an indelible black marker, and on the shipping list. The shipping clerk must make certain that all items ordered by the customer are included. In the case of UPS shipments, one copy of the UPS shipping list, with the weight of each bale recorded legibly, is given to the UPS driver. The printout includes the UPS zone, the weight of each bale shipped and the total number of bales shipped on that date (computer generated and listed as the total number of shipping tags printed for that shipment). The printout is signed by the shipping clerk. A duplicate copy is retained for nursery files and substantiates the shipping of individual orders. UPS uses the printout for billing. As UPS orders are checked through, the bales are stacked on a cold storage hand truck and placed in cold storage. Each hand truck is clearly marked UPS and includes the shipping date.

Parcel Post shipments are handled in the same manner, with each bale marked with the weight and checked off the shipping printout for that date. Weight is also recorded on the shipping printout (one copy) and the printout retained in the nursery files for proof of shipment. The Post Office accepts the marked weight on each bundle or bale for computing total charges due for that shipping date. A trust fund is maintained at the Licking Post Office to cover these charges and a daily report of monies expended and balance remaining are provided the nurseryman. As Parcel Post shipments are checked off the shipping printout, the bales are placed into Post Office supplied canvas hampers on wheels which are clearly marked PP and include the shipping date. The hampers are placed in cold storage.

The Licking Post Office is very cooperative in handling this large seasonal shipment. In trade for our weighing of each bale, the postmaster arranges our shipments into individual hampers for each Zip Code included in the shipment. The pre-delivered shipping list for that shipping date enables him to arrange for extra labor if needed, and to arrange for the proper number of hampers to be on hand for disposition of the shipment. As the individual hampers filled with seedling bales are to be delivered to the same Zip Code destination, it is not necessary for these hampers to be processed through a Post Office Distribution Center.

Each hamper is delivered directly to the designated Post Office, thereby avoiding a per-package charge, which would be enforced if the shipments were not handled in this manner. Total cooperation between the local postmaster and the nursery results in reduced shipping charges for the shipping season.

Records

Budgetary Control

Early in January each year, a proposed budget is prepared by the nurseryman, requesting funds for the coming fiscal year, which begins July 1 and runs through June 31 the following year. The request includes funds for hourly labor, operations, repair and replacement. The funds for permanent and term employees need not be included in the request, as these are budgeted separately from a Division-wise administrative account. Funds for capital improvements are not included, as these are budgeted from a Department-wide account. Although the funds for these accounts are not requested in the nursery budget, they are included in all nursery cost accounting procedures to determine total program cost for the fiscal year. A copy of a typical proposed budget is included. Funds may not necessarily be granted in the amount requested, although the nursery has fared quite well over the years. Moderation on the part of the nurseryman and pre-planning with the nursery supervisor are the key to successful budget requests.

Typical Budget Request G.O.W. Nursery

PERSONAL SERVICE

Temporary			
Weeding	9600 hrs @ 3.42/hr.		$ 32,832.00
Grading	16000 hrs @ 3.35/hr.		53,600.00
Lifting	15300 hrs @ 3.42/hr.		52,326.00
Baling & Shipping	3840 hrs @ 3.42/hr.		13,133.00
	Temporary Labor	Total	$ 151,891.00

Operations

Utilities

Electricity	$ 650.00/month	$ 7,800.00
Telephone	160.00/month 6 mos.	960.00
Propane		6,000.00
Trash Hauling		500.00
	Utilities sub-total	$ 15,260.00

Shipping

Postage	$ 20,000.00
United Parcel Service	30,000.00
Shipping sub-total	$ 50,000.00

Grading, Baling and Shipping Supplies

Baling Paper	
200 rolls (20,000 yds) 2 feet	$ 3,400.00
300 rolls (30,000 yds) 3 feet	7,500.00
Terra Sorb 25 - 45# drums @ $192.93	4,825.00
Baling Twine	
Single-end 800# 16-50 lb reels	650.00
Multi-end 1500# 30-50 lb reels	1,215.00
Press on Envelopes 30M	800.00
Metal Eyelets	700.00
Baling Slats	
2 ft. 2,000 bd ft @ $150/M	
3 ft. 4,000 bd ft @ $150/M	900.00
Plastic Bags 4 mil	
32" x 48" 2M	660.00
24" x 36" 5M	400.00
8" x 16" 1M	50.00
Labels for Imprinter 50M	450.00
Grading, Shipping, Baling Supply sub-total	$ 21,540.00

Soil Treatment, Planting and Lifting Supplies

Soil and Seed Testing	$ 750.00
Fertilizer 30T	6,600.00
Cover Crop Seed	400.00
Methyl Bromide 5,000# @ $0.75/lb	3,750.00
Plastic Tarp 40 3300' rolls 1 mil @ $85.00/rl	3,400.00
Mulch for Hydroseeder 51T	10,260.00
Plastic Tubs for lifting 250 @ $12.00 each	3,000.00
Insecticides	
Diazinon 5 gal @ $34.50/gal	175.00
Fungicides	
Manzate D 50 lb @ $2.65/lb	135.00
Subdue 5 gal @ $1.33.00/gal	670.00
Banlate 100 lb @ $11.55/lb	1,200.00
Captan 50 lb @ $1.75/lb	200.00
Herbicides	
Dacthal 5G 3000#	3,000.00
Roundup 20 gal @ $76.80/gal	1,600.00
Goal 28 gal @ $58.00/gal	1,650.00
Dual 10 gal @ $49.75/gal	500.00

Pesticide Additives				250.00
Soil Treatment, Planting and Lifting Supplies sub-total				$ 37,540.00
Seed				
	Black Walnut	5000 bu	1.00	5,000.00
	Pecan	5000 lb	1.15	5,750.00
	N. Red Oak	2500 lb	1.00	2,500.00
	Pin Oak	2500 lb	1.10	2,750.00
	Tulip-poplar	750 lb	4.25	3,187.50
	Sweetgum	20 lb	40.00	800.00
	White Oak	2000 lb	1.10	2,200.00
	Hackberry	50 lb	15.00	750.00
	Hazelnut	50 lb	5.50	275.00
	Green Ash	50 lb	4.50	225.00
	White Ash	30 lb	4.25	127.50
	Thornless Honeylocust	60 lb	5.00	300.00
	Sycamore	40 lb	6.00	240.00
	River Birch	5 lb	30.00	150.00
	Black Locust	50 lb	5.00	250.00
	Nanking Cherry	50 lb	15.00	750.00
	Tartarian Honeysuckle	20 lb	15.00	300.00
	Bush Honeysuckle	40 lb	6.00	240.00
	Russian Olive	60 lb	5.00	300.00
	Osage-orange	50 lb	12.50	625.00
	Lilac	20 lb	35.00	700.00
	Crown Vetch	5 lb	24.00	120.00
	Aromatic Sumac	35 lb	32.00	1,120.00
	Chickasaw Plum	200 lb	10.00	2,000.00
	Downy Hawthorn	25 lb	10.00	250.00
	Washington Hawthorn	40 lb	18.00	720.00
	Siberian Elm	5 lb	20.00	100.00
	Highbush Cranberry	25 lb	14.50	362.50
	Cotoneaster	20 lb	36.00	720.00
	Shortleaf Pine	1000 lb	20.00	20,000.00
	Austrian Pine	75 lb	12.00	900.00
	Scotch Pine (Belgian)	40 lb	80.00	3,200.00
	Scotch Pine (French)	125 lb	35.00	4,375.00
	White Pine (Southern)	400 lb	35.00	14,000.00
	Jack Pine	30 lb	55.00	1,650.00
	E. Redcedar	25 lb	17.50	437.50
	Bald Cypress	500 lb	7.50	3,750.00
	Lesp. Japonica	25 lb	7.00	175.00
	Shellbark Hickory	500 lb	.80	400.00
	Shagbark Hickory	200 lb	1.00	200.00
	Red Pine	20 lb	110.00	2,200.00
	Loblolly Pine	100 lb	25.00	2,500.00
Local Seed Purchases Other than Black Walnut				
	Deciduous Holly	200 lb	2.00	400.00
	Redbud	600 lb	1.00	600.00
	Dogwood	500 lb	1.00	500.00
	E. Red Cedar	500 lb	2.00	1,000.00
			Seed sub-total	$89,100.00

Other Operational Items

24 x 16 Peat Tubs 200 @ 4.745	$ 950.00
2 gal Plastic Pots 500 @ 0.474	250.00
Paper towels, toilet tissue, brooms, cleaners, first aid supplies, etc.	1,500.00
Travel	2,000.00
Uniform Allowance	1,600.00
Personal protective clothing and supplies	750.00
Hand Tools	1,200.00
Grading by Rolla Area Sheltered Workshop	8,000.00
Maintenance of Vehicles, tractors, and machinery	5,000.00
Maintenance of pumps, irrigation system cold storage plants, etc.	5,000.00
sub-total	$ 26,250.00
OPERATIONS TOTAL	$ 239,700.00

REPAIR AND REPLACEMENT

Buildings and Grounds

Supplies and Materials for maintenance of fourteen structures	$ 1,500.00

Equipment

Replacement	
To replace 1967 550 oliver tractor with one like horsepower	12,000.00
Replace ½ Ton Ford pick-up	6,000.00
Replace worn-out 5' rotary mower	1,200.00
To replace Model 500 Economy label imprinter with more efficient and versatile Model 330	2,500.00
Replace wornout Saxmeyer Tying Machine	3,700.00
Repair parts	
Machinery, vehicles, and tractors	2,000.00
Pumps, coolers, irrigation systems	1,000.00
Repair and Replacement Total	$ 29,900.00
Grand Total (Excludes Permanent and Term Salaries)	$ 421,481.00

A printout of the entire budget, disbursement and balance remaining in each category is provided to the nurseryman at the end of each month. There is a time lag between submittal of invoices and other payment documents, which does not allow the printout to provide an up to date statement of actual expenditures. For this reason, ledgers are maintained at the nursery office, to cover daily submittal of invoices, payrolls, etc. The nursery ledger book is maintained at three levels:

1. A budgetary breakdown of expenditures, which contains the following columns: Supervision (salaries of permanent employees); Hourly Labor; Tree Improvement; Utilities; Travel; Misc. (soap, window cleaners, etc.); Packing materials; Seed; Fertilizer and Chemicals, Maintenance; Capital Improvements; Postage and United Parcel Service; and "Other Funds" (repairs by central repair shop, etc., for which Nursery Funds are not expended, but costs are recorded.)

The ledger is especially useful to the nurseryman at budget preparation time. Recording invoices as processed is also valuable for tracing accounts payable and for tracing original invoices to determine the actual items included on the invoice.

A second ledger is maintained for determining the cost per 1,000 seedlings produced. The ledger has columns for the following items:

1. 1-0 Pine
2. 2-0 Pine
3. 3-0 Pine
4. Hardwoods

5. Wildlife Trees and Shrubs
6. Operations
7. Timber Management
8. Tree Improvement Project

Items which have general planting stock applications are charged to the operations column. Chemicals, fertilizers, electricity, telephone, fuels for heating, motor vehicle fuel and packaging material are all these type of items. Any item which may be directly charged to a specific column is so charged. For example, pine seed, purchased or collected locally, is charged to "1-0 Pine." Acorns are charged to "Hardwoods." Labor is charged to the applicable category as it is expended. Operations expenditures are alloted to the various categories of planting stock according to the square footage each category occupies in the nursery at the beginning of the fiscal year. If 1-0 pine occupied 30 percent of all nursery bed space, 30 percent of all operations expenditures would be charged to 1-0 pine.

A third ledger is maintained on a daily basis, for determining monthly labor costs. The nursery foreman, at the close of each working day, furnishes the nursery clerk with a total number of man-days worked that day, (permanent personnel excluded). These figures are broken down, insofar as possible, into the number of man-days spent in each planting stock category (1-0 pine, etc.). At month's end, the total number of man-days of labor expended is divided into the total dollars spent, to determine the cost per man-day (term and hourly personnel.) The number of man-days spent on the individual categories of planting stock is determined for the month and carried forward in the ledger. Supervisory costs, essentially permanent personnel, are always considered to be an operational cost and are divided each month, according to the percentages assigned by area.

At the end of the fiscal year, the ledger containing all costs assigned to the various categories of planting stock, is used to determine actual costs per 1,000 plants produced. The annual computer printout, the packing building ledger of seedlings graded and counted, the inventory of 1-0 planting stock to be held over for 2-0 planting stock, the surplus stock, etc., are all balanced to determine total production for that year.

The cost of 2-0 pine is found by adding the costs incurred during the current season, plus the cost of 1-0 pine for the previous season. The cost of 3-0 pine would be the cost incurred in the current season, plus the cost of 2-0 pine the previous season, plus the cost of 1-0 pine two seasons prior.

Pest-Control Records

A record of all pest-control applications must be kept. Reports are necessary to state and federal offices responsible for the control of the various pesticides which may have an effect on the total environment. Unless these records are readily available, for reporting and for visual inspection, an accurate statement of pesticide usage would be impossible. The following should be recorded as pesticides are applied:

1. Trade Name, scientific name and EPA registration number, target pest and host species.
2. Dilution rate.
3. Area treated (block, unit and bed number, if applicable.)
4. Acreage treated.
5. Total amount of pesticide in this application. (actual)
6. Method of application (spray rig, gandy spreader, etc.)
7. Date and time of application.

Daily Diary of Nursery Operations

A daily diary should be written to cover all major accomplishments for each work day. The diary should reflect the activities on that date and is regarded as a permanent nursery record. Items to be entered should include the following:

1. Number of man-days spent on each project or category of planting stock. (1-0 Pine, Wildlife, etc.)
2. Seed collected, extracted and/or stored, by nursery personnel, plus the date collection of this species began.
3. Hours of irrigating for that date.
4. Seed purchased from individuals by amount and the date purchase of this species began.
5. Date that various major nursery operations began, such as lifting, grading, baling, seeding, etc.
6. Starting date of capital improvement or major repairs, plus the date of completion.
7. Dates of schools, meetings, or other reasons for absences by nursery personnel.
8. Name and affiliation of official visitors and the reason for their visit.
9. Transfer of major items of property and the disposition of such items.
10. Items taken to the central repair shop and the date such items are returned.
11. Major changes in the addition or subtraction of hourly employees, the date permanent employees reported for duty and all other items pertinent to the status of employees.
12. Extremes in weather conditions such as deep snow, excessive rainfall, extreme temperatures, etc.
13. Seeding accomplished that date, including species and square footage of each sown.
14. Unusual activities by nursery personnel, such as fire fighting, including the fire location, number of men involved and time expended.

Personnel Records

A current file folder is to be maintained for all permanent and term personnel. The folder should contain pertinent correspondence relating to the employee, such as full name, current address, date of original employment, birth date, social security number, date of original entry into the state retirement system, if different than date of employment, changes in pay status or grade, plus all records of motor vehicle accidents involving the employee, injuries sustained while on duty and the ultimate actions taken, etc. The file should also contain names of next of kin, family doctor and choice of medical care facility should an emergency arise.

For hourly employees, a file of names, addresses and social security numbers are the minimum that should be maintained.

Seeding Records

The Nursery Seeding record should be considered a permanent record. Many injuries regarding the source of seed lots have been answered by referring to past seeding records. This data can be confirmed by referring to the "Seed Record" cards, also maintained as a permanent file.

The following items should be kept in mind when filling in the Seeding Record:

1. Spring seeding would begin January 1, and end June 30. Fall seeding begins July 1 and ends on December 31. This will keep several species separated on the record for ready reference.
2. Each block in the nursery is treated as a separate entity on the seeding record and is kept in numerical sequence for fall and spring sowing.
3. All data regarding the seed lot being sown is recorded: source; supplier; crop year; lot number; seed treatment (stratification and length of same, temperature, etc.); plus chemicals used for pelletizing; soil amendments and other pertinent data if a variation from normal practice.
4. Method of sowing must be included. If the Gandy Fertilizer Spreader is used, "Gandy" should be listed in the "Seeder Set" area, plus the opening used for sowing. If the "Moncrief" Seeder is used, the opening of the drill, plus the speed of the tractor and the depth setting should be noted. Assume "Whitfield Nursery Seeder" if not otherwise specified.
5. Copies of the seeding record may be made for utility of the nursery foreman, etc., but the original copy, kept up to date daily, should never leave the nursery office except in the hands of the nurseryman.
6. Old copies of the seeding record should be stored in a dry, mouse-proof file cabinet for future reference.

Soil Amendments

A complete record of all soil amendments must be maintained, specifying block, unit and seedbeds covered by such amendment. The data should be maintained as a permanent record, not only for current reference, but also to the greater benefit of future nurserymen. Problems may develop which could be solved readily if the complete history of the soil in question were available. The record can be kept in diary form, in picture form, or a combination of both. Small maps of the nursery, showing each block and unit, are available to record the practices in effect for each growing season. A diary-type record accompanying the map and explaining various treatments would be beneficial, especially for a particular problem; i.e., raising or lowering of pH, addition of organic matter beyond the normal green manure practices, or the use of subsoilers to fracture the plow pan or other subsoil obstructions.

Purchase Orders

A current file of purchase orders should be maintained. The purchase order should be marked as invoices are received and processed. Partial invoicing is allowed, although the invoice should be marked "Partial Payment," making certain that only those items received are included on the invoice. A file of purchase orders for the current fiscal year should be on hand, plus files for past fiscal years. This file should be considered permanent.

Equipment Manuals, Parts Lists, Equipment Supplier

A file of all current equipment should be maintained. Instruction manuals for specialized equipment, plus all parts lists should be readily available for rapid repair of all nursery equipment. The name, address and phone number of the most advantageous repair parts depot should be included. As equipment is removed from the property inventory list, the manuals should be transferred with the equipment.

Special Transactions

Records of all transactions with other units of government should be maintained. Records of sales of planting stock to the U.S. Forest Service should be kept in a separate folder for each National Forest. Reports of planting stock delivered, seed required and seed remaining in storage should be readily available. Invoices for the above should be entered as processed. Invoices for special projects undertaken by nursery personnel and which will be financed by federal funding should be included, along with all other correspondence concerning the transaction.

Gasoline and Oil Records

A record sheet is located in the oil house for listing all gasoline and motor oil used. The record includes the date, license number, division or section receiving the material (Nursery, Operations, Engineering, etc.), gallons of gasoline or quarts of oil placed in the vehicle, meter reading on the pump after receipt of gasoline and the signature of the person receiving same. Unlicensed equipment, such as lawn mowers and chain saws are listed and data are entered as for a licensed vehicle. Diesel fuel is entered in the same manner, although a recording meter is not available for this tank. The meter does indicate the number of gallons per fill-up, but must be reset to zero after fill-up of each piece of equipment.

A record must be filled out monthly, listing the vehicles and other equipment and the number of gallons of each type of fuel used for each vehicle or type of equipment, plus the total fuel (unleaded gasoline, regular gasoline, diesel fuel), used during the month. Meter readings on the gasoline pumps at the first and last of the month, along with purchases added to each tank, should verify the total amount of each type of fuel expended during the month. The record is considered permanent. Both the original entry sheets and the record should be maintained in the active files for auditing.

Appendix One

SQUARE FOOTAGE OF SEEDBED AT THE GOW STATE FOREST NURSERY

BLOCK 1

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 2	1208	2416
2	1 - 9	1232	11088
3	1 - 4	1256	
	5 - 9	1582	12984
4	1 - 9	1588	14292
5	1 - 9	1582	14238
6	1 - 9	1578	14202
7	1 - 9	1545	13905
8	1 - 9	1476	13284
9	1 - 9	1420	12780
10	1 - 9	1362	12258
11	1 - 9	1298	11682
12	1 - 9	1234	11106
13	1 - 9	1174	10566
14	1 - 3	1104	3312
		Total, Block 1	158,113

BLOCK 2

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1408	5632
2	1 - 9	1408	12672
Thru			
13	1 - 9	1408	12672
14	1 - 4	1408	5632
		Total, Block 2	163,328

BLOCK 3

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1120	4480
2	1 - 9	1112	10008
3	1 - 9	1072	9648
4	1 - 9	1056	9504
5	1 - 9	1056	9504
6	1 - 9	1032	9288
7	1 - 9	960	8640
8	1 - 6	912	
	7 - 9	768	7776
9	1 - 9	768	6912
		Total, Block 3	75,760

BLOCK 4

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1020	4080
2	1 - 9	1021	9189
3	1 - 9	1016	9144
4	1 - 9	1010	9090
5	1 - 9	1005	9045
6	1 - 9	999	8991
7	1 - 9	994	8946
8	1 - 9	988	8892
9	1 - 9	983	8847
		Total, Block 4	76,224

BLOCK 5

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1010	4040
2	1 - 9	1034	9306
3	1 - 9	1054	9486
4	1 - 9	1051	9459
5	1 - 9	1048	9432
6	1 - 9	1045	9405
7	1 - 9	1041	9369
8	1 - 9	1040	9360
9	1 - 2	1040	2080
		Total, Block 5	71,937

BLOCK 6

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1	672	
	2	1200	1872
2	1 - 9	1752	15768
3	1 - 9	1776	15984
4	1 - 9	1752	15768
5	1 - 9	1696	15264
6	1 - 9	1598	14384
7	1 - 9	1460	13140
8	1 - 9	1312	11808
9	1 - 2	1230	2460
		Total, Block 6	106,428

BLOCK 7

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 2	880	
	3 - 4	1100	3960
2	1 - 9	1160	10440
3	1 - 9	1320	11880
4	1 - 9	1460	13140
5	1 - 9	1600	14400
6	1 - 9	1600	14400
7	1 - 9	1050	9450
		Total, Block 7	77,670

BLOCK 8

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1060	4240
2	1 - 9	1080	9720
3	1 - 9	1080	9720
Thru			
8	1 - 9	1080	9720
9	1 - 5	1080	5400
		Total, Block 8	77,680

BLOCK 9

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	440	1760
2	1 - 9	580	5220
3	1 - 9	792	7128
4	1 - 9	1000	9000
5	1 - 9	1108	9972
6	1 - 9	1108	9972
7	1 - 9	1108	9972
8	1 - 9	1012	9108
9	1 - 9	724	6516
10	1 - 5	400	2000
		Total, Block 9	70,648

BLOCK 10

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	216	864
2	1 - 9	340	3060
3	1 - 9	512	4608
4	1 - 9	688	6192
5	1 - 9	868	7812
6	1 - 9	984	8856
7	1 - 4	800	3200
		Total, Block 10	34,592

BLOCK 11

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1056	4224
2	1 - 5	1056	
	6 - 9	1284	10416
3	1 - 9	1488	13392
4	1 - 9	1436	12924
5	1 - 9	1380	12420
6	1 - 9	1324	11916
7	1 - 9	1272	11448
8	1 - 9	1220	10980
9	1 - 9	1140	10260
10	1 - 9	880	7920
11	1 - 2	672	1344
		Total, Block 11	107,244

BLOCK 12

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 3	1480	4440
2	1 - 9	1496	13464
3	1 - 9	1524	13716
4	1 - 9	1548	13932
5	1 - 9	1552	13968
6	1 - 9	1472	13248
7	1 - 9	1272	11448
8	1 - 9	1000	9000
9	1 - 9	796	7164
10	1 - 9	708	6372
11	1 - 2	680	1360
		Total, Block 12	108,112

BLOCK 13

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 2	1152	2304
2	1 - 9	1204	10836
3	1 - 9	1278	11502
4	1 - 9	1292	11628
5	1 - 9	1316	11844
6	1 - 9	1340	12060
7	1 - 9	1364	12276
8	1 - 9	1388	12492
9	1 - 9	1412	12708
10	1 - 9	1436	12924
11	1 - 9	1448	2896
		Total, Block 13	113,470

BLOCK 14

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 2	1376	2752
2	1 - 9	1360	12240
3	1 - 9	1324	11916
4	1 - 9	1284	11556
5	1 - 9	1244	11196
6	1 - 9	1204	10836
7	1 - 9	1164	10476
8	1 - 9	1124	10116
9	1 - 9	1084	9756
10	1 - 9	1044	9396
11	1 - 2	1024	2048
		Total, Block 14	102,288

BLOCK 15

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 2	190	380
2	1 - 9	276	2484
3	1 - 9	444	3996
4	1 - 9	608	5472
5	1 - 9	720	6480
6	1 - 9	772	6948
7	1 - 9	800	7200
8	1 - 9	796	7164
9	1 - 9	752	6768
10	1 - 9	640	5760
11	1 - 4	630	2520
		Total, Block 15	55,172

BLOCK 16

Unit	Bed Numbers	Square Feet Per Bed	Square Foot Per Unit
1	1 - 4	400	1600
2	1 - 9	580	5220
3	1 - 9	876	7884
4	1 - 9	1100	9900
5	1 - 9	1256	11304
6	1 - 4	1240	4960
		Total, Block 16	40,868

BLOCK 17

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	1072	4288
2	1 - 9	1080	9720
3	1 - 9	1076	9684
4	1 - 9	1076	9684
5	1 - 5	1076	
	6 - 9	1064	9636
6	1 - 6	1056	
	7	1052	
	8 - 9	1048	9484
7	1 - 8	1020	
	9	1016	9176
8	1 - 5	1052	
	6	1048	
	7	1044	
	8	1040	
	9	1036	9428
9	1	932	
	2 - 3	924	
	4 - 5	920	
	6	916	
	7	912	
	8	908	
	9	896	8252
10	1	888	
	2	880	
	3	872	

	4	864	
	5	856	
	6 - 7	848	
	8	844	
	9	840	7740
11	1	796	
	2	784	
	3	768	
	4	760	
	5	748	
	6	744	
	7	732	
	8 - 9	724	6780
12	1	708	
	2	696	
	3	676	
	4	668	2748
		Total, Block 17	96,620

BLOCK 18

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1	816	
	2	840	
	3 - 4	864	
	5	880	4264
2	1 - 9	900	8100
3	1 - 9	920	8280
4	1 - 9	916	8244
5	1 - 9	904	8136
6	1 - 9	892	8028
7	1 - 9	880	7920
8	1 - 9	876	7884
9	1 - 9	876	7884
10	1 - 9	876	7884
11	1 - 9	864	7776
12	1 - 9	852	7668
13	1 - 9	848	7632
14	1 - 9	848	7632
15	1 - 4	848	3392
		Total, Block 18	110,724

BLOCK 19

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 3	808	2424
2	1 - 3	824	
	4 - 9	816	7368
3	1 - 6	816	
	7 - 9	808	7320
4	1 - 3	808	
	4 - 9	820	7344
5	1 - 4	820	
	5 - 9	704	6800
6	1 - 5	704	
	6 - 9	664	6176

7	1 - 3	664	
	4 - 9	624	5736
8	1 - 3	624	
	4 - 9	640	5712
9	1 - 5	640	
	6 - 9	600	5600
10	1 - 9	600	5400
11	1 - 9	600	5400
12	1 - 5	600	
	6 - 9	620	5480
13	1 - 5	620	
	6 - 9	632	5628
14	1 - 9	632	5688
15	1 - 4	632	
	5 - 9	628	5688
16	1 - 9	628	5652
17	1 - 9	628	5652
18	1 - 4	628	
	5 - 6	664	
	7 - 9	618	5824
19	1	608	
	2	480	
	3	436	1524
		Total, Block 19	108,396

BLOCK 20

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1	756	
	2	800	
	3	812	
	4	844	3212
2	1	892	
	2	916	
	3	944	
	4	968	
	5	1012	
	6	1024	
	7	1056	
	8	1080	
	9	1100	8992
3	1	1132	
	2	1144	
	3	1172	
	4	1192	
	5	1204	
	6	1224	
	7	1244	
	8	1268	
	9	1284	10984
4	1	1304	
	2	1320	
	3	1328	
	4	1356	
	5	1364	
	6	1380	
	7 - 9	1400	12252

5	1	1400	
	2	1392	
	3	1376	
	4	1368	
	5	1352	
	6	1324	
	7	1316	
	8	1288	
	9	1264	12084
6	1	1220	
	2	1196	
	3	1152	
	4	1084	
	5	1064	
	6	1040	
	7	980	
	8	948	
	9	908	9592
7	1	868	
	2	840	
	3	824	
	4	768	
	5	744	
	6	712	
	7	684	
	8	656	
	9	624	6720
8	1	584	
	2	524	
	3	492	
	4	468	
	5	440	
	6	420	
	7	360	
	8	324	
	9	296	3908
9	1	260	
	2	232	
	3	208	
	4	132	832
		Total, Block 20	68,456

BLOCK 21

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 3	608	1824
2	1 - 5	608	
	6 - 9	806	6272
3	1 - 5	808	
	6 - 9	1008	8072
4	1 - 5	1008	
	6 - 9	1208	9872
5	1 - 5	1208	
	6 - 9	1272	11128
6	1 - 5	1272	
	6 - 9	1440	12120
7	1 - 5	1440	

	6 - 9	1638	13744
8	1 - 9	1638	14724
9	1 - 5	1638	
	6 - 9	1908	16812
10	1 - 5	1908	
	6 - 9	2064	17796
11	1 - 5	2064	
	6 - 9	2208	19152
12	1 - 4	2208	8832
		Total, Block 21	139,348

BLOCK 22

Unit	Bed Numbers	Square Feet Per Bed	Square Feet Per Unit
1	1 - 4	2408	9632
2	1 - 9	2408	21672
3	1 - 3	2408	
	4 - 9	2220	20544
4	1 - 9	2220	19980
5	1 - 9	2220	19980
6	1 - 9	2220	19980
7	1 - 3	2220	
	4 - 9	2276	20316
8	1 - 3	2276	
	4 - 9	2224	20172
9	1 - 2	2224	
	3 - 4	2192	
	5 - 9	800	12832
10	1 - 2	800	1600
		Total, Block 22	166,708

TOTAL SQUARE FOOTAGE IN GOW NURSERY----------2,127,796

Appendix Two

SEEDING RECORD

(Sheet____of___sheets)

Season & Year _____

BLOCK NO. ____

SPECIES	BED NO	Source of seed and date collected	GERM% TEST	DATE SOWN	Seeder Set	No. per sq.ft. seedling den. sown 1st last for season	No. of sq. ft. sown	Total lbs. of seed	SEED TREATMENT	GROUND TREATMENT

Appendix Three

FORESTRY DIVISION

NURSERY SEEDLING INVENTORY

Date

Species	Sq. Ft.	Ave.	Inventory	Estimate	Actual Count
Shortleaf Pine - State					
Shortleaf Pine - USFS					
Seqeeh Pine 2-0					
Seqeeh Pine 1-0					
White Pine 2-0					
White Pine 1-0					
Loblolly Pine					
E. Red Cedar 2-0					
E. Red Cedar 1-0					
Black Walnut					
Cottonwood Seedlings					
Cottonwood Cuttings					
Sycamore					
Tulip Poplar					
Black Locust					
Red Gum					
Dogwood					
Redbud					
Soft Maple					
Hard Maple					
Green Ash					
White Ash					
Pin Oak					
White Oak					
Red Oak					
Mulberry					
Persimmon					
Osage Orange					
Bald Cypress					
Autumn Olive					
Black Alder					
River Birch					
Bush Honeysuckle					
Shrub Loosestrife					
Dec. Holly					
Pecan					
Multiflora Rose					

Appendix Four

Seed Moisture Content Determination by Radson Model 20 Moisture Meter

Original data determination by Delbert G. Mugford and Janice Moloney, George O. White State Forest Nursery. Computer generated curve, regression formula and chart for shortleaf pine, deciduous holly, redbud, dogwood and autumn olive courtesy of Dr. Paul Johnson, NCFES, University of Missouri, Columbia, Missouri.
Regression formula and chart for blackberry, e. redcedar, Scotch pine, white pine, loblolly pine and jack pine by Delbert G. Mugford and Janice Moloney, George O. White State Forest Nursery.

All charts are delivered from regression formula pertinent to each species.

Percentage of Moisture Content by Species

Radson Reading	Shortleaf Pine	Jack Pine	White Pine	Scotch Pine	Loblolly Pine	E. Red Cedar
27						
28						
29						
30	0.1		0.92		.57	.98
31	0.7		1.17		.90	1.37
32	1.4	.58	1.43		1.23	1.75
33	2.0	1.12	1.68	.94	1.72	2.13
34	2.6	1.63	1.93	1.44	1.88	2.50
35	3.2	2.14	2.19	1.93	2.21	2.87
36	3.7	2.63	2.44	2.41	2.53	3.23
37	4.2	3.12	2.77	2.88	2.84	3.58
38	4.7	3.60	2.96	3.34	3.16	3.94
39	5.1	4.06	3.19	3.80	3.48	4.29
40	5.5	4.52	3.45	4.23	3.78	4.62
41	5.9	4.96	3.69	4.67	4.09	4.96
42	6.3	5.39	3.95	5.10	4.39	5.28
43	6.6	5.82	4.20	5.51	4.69	5.60
44	7.0	6.22	4.45	5.92	4.99	5.93
45	7.3	6.62	4.70	6.31	5.26	6.23
46	7.6	7.01	4.94	6.70	5.57	6.54
47	7.8	7.39	5.19	7.08	5.86	6.84
48	8.1	7.76	5.44	7.44	6.15	7.13
49	8.3	8.11	5.69	7.81	6.43	7.43
50	8.5	8.45	5.94	8.15	6.71	7.71
51	8.7	8.78	6.19	8.49	6.98	7.99
52	8.9	9.12	6.43	8.82	7.26	8.26
53	9.1	9.42	6.68	9.15	7.53	8.53
54	9.3	9.72	6.92	9.46	7.80	8.79
55	9.4	10.01	7.17	9.75	8.06	9.04
56	9.6	10.28	7.41	10.03	8.33	9.30
57	9.7	10.56	7.65	10.34	8.59	9.55
58	9.8	10.82	7.90	10.61	8.85	9.78
59	10.0	11.06	8.14	10.88	9.36	10.02
60	10.1	11.30	8.38	11.13	9.55	10.24
61	10.2	11.52	8.63	11.38	9.61	10.47
62	10.3	11.73	8.87	11.62	9.85	10.69
63	10.4	11.94	9.11	11.85	10.09	10.90
64	10.6	12.12	9.35	12.07	10.33	11.11
65	10.7	12.31	9.55	12.27	10.57	11.32

Appendix Four

Radson Reading	Shortleaf Pine	Jack Pine	White Pine	Scotch Pine	Loblolly Pine	E. Red Cedar
66	10.8	12.48	9.83	12.47	10.80	11.51
67	10.9	12.63	10.08	12.67	11.04	11.70
68	11.0	12.78	10.31	12.85	11.26	11.88
69	11.2	12.91	10.56	13.02	11.49	12.08
70	11.3	13.04	10.80	13.18	11.72	12.24
71	11.5	13.16	11.02	13.34	11.93	12.40
72	11.6	13.26	11.27	13.48	12.15	12.57
73	11.8	13.35	11.50	13.61	12.36	12.72
74	12.0	13.43	11.74	13.74	12.58	12.88
75	12.2	13.50	11.97	13.85	12.78	13.03
76	12.4	13.57	12.21	13.96	12.99	13.16
77	12.6	13.61	12.44	14.06	13.20	13.30
78	12.8	13.65	12.68	14.15	13.40	13.44
79	13.1	13.67	12.91	14.22	13.60	13.56
80	13.4	13.69	13.15	14.29	13.79	13.68
81	13.6	13.70	13.38	14.35	13.89	13.79
82	13.9		13.61	14.40	14.17	13.90
83	14.3		13.83	14.44	14.36	14.01
84	14.6		14.07	14.48	14.54	14.10
85	15.0		14.30	14.50	14.73	14.19
86	15.4		14.53	14.51	14.90	14.27
87	15.8		14.76		15.08	14.36
88	16.3		14.99		15.25	14.44
89	16.7		15.22		15.42	14.50
90	17.3		15.45		15.59	14.57
91	17.8		15.68		15.75	14.63
92	18.4		15.91		15.91	14.68
93	19.0		16.14		16.06	14.73
94	19.6		16.36		16.22	14.77
95	20.2		16.59		16.37	14.81
96	20.9		16.81		16.53	14.84
97	21.7		17.04		16.63	14.88
98	22.5		17.26		16.82	14.89
99	23.3		17.48		16.96	14.91
100	24.1		17.72		17.09	
101			17.94		17.20	
102			18.16		17.36	
103			18.39		17.48	
104			18.61		17.62	
105			18.83		17.74	
106			19.05		17.86	
107			19.27		17.98	
108			19.41		18.10	

Radson Reading	Dec. Holly	Redbud	Dogwood	Autumn Olive	Blackberry
27				0.0	
28			0.0	0.7	
29	0.00		0.4	1.4	
30	0.15		0.8	2.1	0.14
31	0.32		1.2	2.7	0.61
32	0.52		1.6	3.3	1.31
33	0.73		2.0	3.8	1.53
34	0.97		2.4	4.4	1.99
35	1.26		2.7	4.9	2.43

Radsen Reading	Dec. Holly	Redbud	Dogwood	Autumn Olive	Blackberry
36	1.50	0.53	3.1	5.3	2.87
37	1.80	1.30	3.5	5.8	3.29
38	2.10	2.00	3.8	6.2	3.72
39	2.40	2.70	4.2	6.6	4.13
40	2.70	3.40	4.5	6.9	4.54
41	3.00	4.00	4.8	7.3	4.94
42	3.40	4.70	5.2	7.6	5.26
43	3.70	5.30	5.5	7.9	5.73
44	4.00	5.80	5.9	8.2	6.11
45	4.40	6.30	6.2	8.5	6.48
46	4.70	6.90	6.5	8.7	6.84
47	5.10	7.30	6.8	8.9	7.20
48	5.40	7.80	7.1	9.2	7.54
49	5.80	8.30	7.5	9.4	7.89
50	6.10	8.70	7.8	9.5	8.22
51	6.4	9.1	8.1	9.7	8.45
52	6.7	9.4	8.4	9.9	8.87
53	7.1	9.8	8.7	10.1	9.17
54	7.4	10.1	9.0	10.2	9.49
55	7.7	10.5	9.3	10.3	9.78
56	8.0	10.8	9.6	10.5	10.08
57	8.3	11.0	9.9	10.6	10.37
58	8.6	11.3	10.2	10.7	10.63
59	8.8	11.6	10.5	10.9	10.91
60	9.1	11.8	10.8	11.0	11.18
61	9.3	12.0	11.0	11.1	11.43
62	9.6	12.2	11.3	11.2	11.68
63	9.8	12.4	11.6	11.3	11.92
64	10.0	12.6	11.9	11.5	12.21
65	10.3	12.8	12.2	11.6	12.37
66	10.4	12.9	12.4	11.7	12.60
67	10.6	13.1	12.7	11.9	12.80
68	10.8	13.2	13.0	12.0	13.01
69	11.0	13.4	13.2	12.2	13.20
70	11.1	13.5	13.5	12.3	13.40
71	11.3	13.6	13.8	12.5	13.59
72	11.4	13.7	14.0	12.7	13.76
73	11.5	13.8	14.3	12.9	13.93
74	11.7	13.9	14.5	13.1	14.08
75	11.8	14.0	14.8	13.3	14.24
76	11.9	14.1	15.0	13.6	14.38
77	12.0	14.2	15.3	13.9	14.53
78	12.1	14.3	15.5	14.1	14.66
79	12.1	14.4	15.7	14.4	14.78
80	12.2	14.5	15.9	14.8	14.89
81	12.3	14.5	16.2	15.1	15.01
82	12.4	14.6	16.4	15.5	15.10
83	12.4	14.7	16.6	15.8	15.20
84	12.5	14.8	16.8	16.3	15.29
85	12.5	14.9	17.0	16.7	15.35
86	12.6	15.0	17.2	17.2	15.45
87	12.7	15.1	17.4	17.6	15.51
88	12.7	15.2	17.6	18.2	15.57
89	12.8	15.3	17.8	18.7	15.62
90	12.9	15.4	17.9	19.3	15.67

Radson Reading	Dec. Holly	Redbud	Dogwood	Autumn Olive	Blackberry
91	13.0	15.5	18.1	20.0	15.70
92	13.1	15.6	18.2	20.6	15.73
93	13.2	15.8	18.4	21.3	15.75
94	13.3	15.9	18.5	22.0	15.77
95	13.5	16.1	18.6	22.7	
96	13.6	16.2	18.8	23.5	
97	13.8	16.4	18.9	24.4	
98	14.0	16.6	19.0	25.2	
99	14.2	16.8	19.1	26.2	
100	14.5	17.0	19.1	27.1	
101	14.7	17.2	19.2		
102	15.0	17.4	19.2		
103	15.3	17.7	19.3		
104	15.7	18.0			
105	16.1	18.3			
106	16.5	18.6			
107	17.0	18.9			
108	17.5	19.3			
109	18.0	19.7			
110	18.6	20.0			
111	19.3	20.4			
112	20.0	20.9			
113	20.8	21.3			
114	21.6	21.8			
115	22.5	22.3			
116	23.4				
117	24.4				
118	25.5				
119	26.6				
120	27.9				

Appendix Five

Refrigeration Units—Start-up, Shut-down, Controls.

Refrigeration units in the packing building and the new cold storage plant are thermostatically controlled. Thermostats open and close the solenoid valve in the liquid line and are not connected electrically to the balance of the refrigeration system. In operation, as the low temperature set on the thermostat is reached, the thermostat deactivates the solenoid valve (closes it). The compressor continues to run until it begins to pump a vacuum. When the pressure in the pressure control falls to 5 lbs./sq. inch, the pressure control disengages the compressor and shut-down occurs.

As the temperature rises in the cold storage, the cut-in point is eventually reached. When this occurs, the solenoid valve is reactivated (opened) and equalization of pressure in the liquid and return lines occurs. When pressure at the pressure control reaches 20 lbs./sq. inch, the compressor is reactivated and temperature pull-down again occurs.

All refrigeration units at the nursery operate in the same fashion. All compressor units are charged with Freon-12 Gas, with the exception of the seed storage compressor, which is charged with Freon-22. The high pressure setting on indoor units is set at 30 lbs./sq. inch, while outdoor units are set at 20 lbs./sq. inch.

All compressor units are protected by an oil pressure sensor unit, which will shut down the entire unit when oil pressure is not sufficient. At start-up time, nuisance trips of the oil pressure sensor can be expected. As soon as the pressure in the compressor crankcase becomes properly equalized, this problem will disappear. Resetting of the trip button may be necessary when units are started up each fall, except for the compressor unit in seed storage, which operates year-round.

Shut-down of the packing building cold storage unit is accomplished by placing the main disconnect and the control disconnect switches in the "OFF" position. Instructions for close-down of the new cold storage units are as follows:

1. Close the red-handled valve located on the lower left side of each outdoor compressor unit.
2. Make the compressor run with the valve closed, lowering the thermostat setting if necessary.
3. When pump-down of the liquid line is reached, the pressure control will begin to react to the vacuum being formed and shut down will occur when the low pressure point is reached.
4. At this point, most of the Freon has been returned to the receiver tank, making loss of Freon unlikely.
5. After shut-down, the main disconnect switch should be placed in the "OFF" position.

Instructions for start-up in the fall are as follows:

1. Place the toggle switch, located in the lower right corner of each compressor unit in the "OFF" position. This will remove the pressure control unit from the circuit and will not allow the compressor to operate.
2. Open the red-handled valve located in the lower left side of each compressor unit.
3. Place the main disconnect switch in the "ON" position.
4. This will allow the fans in the evaporator units to operate, the Freon gas to circulate in the system and the crankcase heaters in each compressor unit to be activated. Make certain that the thermostats are set at a temperature which will activate the solenoid valve located indoors in the refrigerant line.
5. After 24 hours, place the toggle switch in the "ON" position, which should activate the compressor.
6. Should the valves in the compressor unit rattle excessively, shut down the unit, using the toggle switch, and after a few minutes, again attempt to start the compressor. This may be necessary several times, until the Freon gas is equalized in the system. When the compressor runs freely, the system should be in operation.
7. Check temperatures inside the cold storage unit frequently to ascertain if proper temperatures are being maintained. Freezing temperatures will damage water pipes. The proper temperature should be 32° to 36° F.

The packing building cold storage unit should be started 24 hours in advance of expected usage. The small disconnect switch should be placed in the "ON" position. After 24 hours, the main disconnect switch should be engaged, which will begin operation of the compressor. Rattling of the head valves in this unit should be treated as advised above.

Appendix Five

Irrigation System, Pumps Motors etc.

Pump No. 1, Pumphouse, Northwest Corner, Block 3.

Motor: Fairbanks-Morse 50 H. P.
Frame: 4KV 365UP
Serial No. F357892
Type: 1032-4 KZKVW
F.L. RPM: 1755

Controller on Pressure Tank: (Water Level, Pressure Controller, Air Release Control, Alternator).

Automatic Control Company
955 University
St. Paul, Minnesota 55414
Tel. 612-553-4917

Westinghouse Life Line Starter:

H. P. 60 - NOM - Phase 3.
Volts 208-220 Cycles 60

Pilot Circuit Coil Rating:

208-220 Volts, 60 Cycles
Class: 11-700-NS3
Diagram Number: 30-B-4832 L1
Order Data: 1743102-C

Line Starter:

Class NR - 330
Size: AC-3 Poles 3
Drawing or Style: 1623159
Amp. 90 Enc. 100 open

Heater:

CB
Full Load Current of Motor: 80-90.4 A.
Heater Style No.: 1597 772
Current Rating at 40°C Room Temp. 103

Well No. 1

Depth: 1657'
Water Producing Formation: LaMotte Sands
10" Casing 0' to 233'.
8" Casing 464' to 708'.
6" Casing 1062' to 1374.5'.

Pump

Fairbanks-Morse, Pomona Turbine Pump.
Serial No. A2A2724
Figure 6927 (Enclosed Impeller, Water Lubricated).
Pump Setting: 310'.

Adjustment of Pump No. 1:

1. Unlock adjusting Nut, top of anti-reversing Ratchet, top of motor.

2. Raise impellers by tightening adjusting nut until plate cannot be turned by hand (no wrenches).

3. Lower impellers until plate can be turned freely by hand.

4. Lower impellers one full turn of adjusting nut.

5. Lock adjusting nut in place.

Pump No. 2 (East end of Blocks 15 and 16).

Motor: U. S. Electric, Division of Emerson Electric.

H. P. 50, phase 3, Cycles 60, 1800 RPM.
Serial No. NRR 3518750.
Frame: A 365UPH.
Design B.
Code F.

Starter: General Electric
Magnetic Starters, CR 106 F.
Heater Overloads, CR124F.

Relay: Automatic Control Company
Relay Control Serial No. 140331.
Consisting of:

1. Power Unit, Model [illegible].
   Input - 115 V, A. C., 50-60 Cycles, 20 VA.
   Output - 105V. D. C., at 100 M. A.
2. Relay Unit, Assembly No. 9202 A A.
3. Protection Unit, Assembly No. 9205 A A.
4. Control Transformer, Type S8W
   Catalog N. W050.
   KVA .050, Ser. A.
   Manufactured by: Hevi Duty Electric, Div. of Sola Basic Industries.
   Goldsboro, North Carolina 27530.

Well Number 2:

Depth; 1,080'.
Casing: 10" to the 300 ft. level, open drill hole to bottom.
Water Bearing Formation: Potosi Sands.

Pump Number 2, installed June 17, 1975 after failure of original pump.

Jacuzzi, Model No. S8MCA18/T 497, 18 bowls.
Serial No. 5D722055.
Pump setting: 360'.

Adjustment of Pump No. 2:

1. Unlock adjusting nut at top of anti-reversing ratchet.
2. Turn adjusting nut until impellers touch the extreme bottom position. Plate may not be turned by hand when this position is reached.

Appendix Six

Drill Settings for Whitfield Eight Row Nursery Seeder (Iron Wheel Model)

The following settings for various species are rough guides only. Each seed lot varies distinctively. Number of seeds per pound, germination percentage, density desired to some extent, and, treatment of seed lot will influence the final drill setting. The suggested settings may be useful for testing various species, especially when large variations of the seeding criteria are evident.

SPECIES	DRILL SETTING	OUNCES SOWN PER 400 SQ. FT.	SEED TREATMENT
Austrian Pine	2¼	21.50	Anthraquinone pelleted.
Jack Pine	½	11.90	" "
Loblolly Pine	2¾	35.90	" "
Scotch Pine	¾	12.40	" "
Scotch Pine	1	16.30	" "
Shortleaf Pine	1	15.90	" "
Shortleaf Pine	1½	20.60	" "
White Pine	2½	23.15	" "
E. Redcedar	⅛	14.00	NONE
Aromatic Sumac	⅜	16.50	H_2SO_4 45 Min.
Autumn Olive	¾	10.20	NONE
Black Alder	1	10.50	NONE
Blackberry	½	12.40	NONE
Black Gum	3¾	53.80	NONE
Black Locust	¾	19.10	H_2SO_4 45 Min.
Crown Vetch	¾	8.00	1:1 Dry screened sawdust
Dogwood (Flowering)	?	51.20	NONE
Deciduous Holly		11.60	NONE
Downy Hawthorn		44.60	NONE
Hackberry	1½	11.50	NONE
Highbush Cranberry	3	23.20	NONE
Lespedeza Jap. Int. (Thunbergii)	1	9.90	1:1 Dry screened sawdust.
Lilac	2	11.50	NONE
Nanking Cherry	3	41.00	NONE
Osage Orange	3	32.50	NONE
Redbud	2¾	44.80	H_2SO_4 30 Min.
Redbud	2¾	32.00	H_2SO_4 30 Min. + 12 Hr. H_2O soak.
Redgum	¾	9.70	NONE
Russian Olive	1½	29.80	NONE
Siberian Elm	¼	4.70	NONE
Tatarian Honeysuckle	¼	16.70	NONE
Vitex	¾	9.00	NONE
Washington Hawthorne	2	26.80	NONE

Appendix Seven

WHITE NURSERY

Pesticide Usage - Field Report

Date	Pesticide	Amount Used & Amt. Carrier	Additive	Amt	Species Treated	Area Treated	Target Pest

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