CHAPTER 2—SITE SELECTION

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SITE FACTORS

Selecting a site for a permanent forest tree nursery is not only a difficult task, but it is also the most important step in the production of tree seedlings. Good nursery sites are rare and are often superior, high-priced farm lands. Failure to select a favorable site will result in unsatisfactory production of some species and will sooner or later add to the cost of one or more of the nursery operations (Aldhous 1972; Stoeckeler and Jones 1957; Toumey and Korstian 1943; Wakeley 1954; and Wilde 1958). Factors to consider in selecting a nursery site are:

- Present and anticipated future capacity
- Geographical area
- Topography
- Soil
- Climate
- Water supply
- Access and services
- Labor supply
- Biotic factors
- Atmospheric pollution

See appendix 2-1 check list: Forest Tree Nursery Site Selection.

PRESENT AND ANTICIPATED FUTURE CAPACITY

The present and anticipated future capacity of the nursery will dictate the physiographic and land-use area where a nursery can be located. Most nurseries in the South have expanded their seedling production within a relatively short time after the nursery was established. However, it is very difficult to expand production from 10 to 25 million seedlings unless this increase was considered in the original selection of the site.

Species and type of crop rotation are major factors in determining acreage requirements. The normal range of densities for slash,[1] loblolly, shortleaf and Virginia pine seedlings varies from 25 to 35 seedlings per square foot. Longleaf pine seedlings are grown at densities of 12 to 20 seedlings per square foot. White pine seedlings usually are shipped as 2-0 stock, which require 2 years in seedbeds. Rotations such as 2:2, that is, 2 years in seedlings and 2 years in cover crops, require more seedbed acres than a 1:1 or 2:1 rotation. Also, space must be provided for roads, drainage, buildings and storage sites. These items will require about one-half as much area as that needed for seedbeds (table 2-1). A site for a 10-million seedling capacity nursery can be located more easily than one for a 30-million seedling nursery.

Table 2-1. – Minimum land requirements for nurseries of different production capacities and rotations.[1]

Capacity million seedlings	Acres: 1:1 or 2:2 rotation — seedbeds	seedbeds & cover crops	Other area + 50%	1:2 rotation — seedbeds & cover crops	Other area + 50%
10	13	26	39	39	59[2]
15	20[2]	40	60	60	90
20	26	52	78	78	117
25	33	66	99	99	149
30	40	80	120	120	180
35	46	92	138	138	207
40	52	104	156	156	234

1/ Based on 30 seedlings per square foot and 40 or 60 feet between sprinkler lines. This yield of 30 No. 1 and No. 2 grade seedlings is not attainable in many nurseries, especially new nurseries located on sandy and loamy sand soil types. Marginal grade minimum caliper seedlings cannot be expected to consistently be acceptable planting stock--which means lower seedbed densities. The calculated seedbed requirements per million seedlings for densities of 25 and 27 per square foot are 1.5 and 1.4 acres respectively.

2/ Fraction of an acre shown as total acre.

[1]A list of common and latin species names is included in appendix 2-2.

GEOGRAPHICAL AREA

The importance of the geographical area varies with the agency involved in the selection of the nursery site. State forestry agencies would prefer to locate their nurseries near the center of the seedling demand. Political considerations may outweigh other factors. Forest industries also prefer to locate nurseries near their planting sites. They can select over a broad geographical range when their holdings are scattered through three or four adjoining States. Some industries establish regional nurseries that provide seedlings for company lands in several States.

TOPOGRAPHY: SLOPE AND ASPECT

A nursery should be nearly level or on a very gentle slope with sufficient gradient (0.5 to 1 percent), to ensure good surface drainage without causing erosion. For light sandy soils, a nearly level site is preferable whereas on the finer-textured soils, a gentle slope is best. Slopes of more than 2 percent can present serious problems unless the surface can be reformed. Sites on deep, sandy soils and slopes up to 10 percent can be reformed using cuts and fills from 3 to 4 feet to provide the desirable slope pattern (Shih, Sowell and Kriz 1975; Davey 1976). This practice is not usually attempted with fine-textured soils—especially those with distinct textural differences between the soil horizons (see chapter 3).

Aspect does not play a major part in site selection in the South as slopes are seldom more than 10 percent in areas with potential for nursery sites.

SOILS

Texture

Southern pines will grow over a wide range of soil conditions. The texture of soils in existing nurseries ranges from sands to sandy clay loams or silty clay loams, with production of acceptable morphological grades of seedlings from all these soil textures (table 2-2).

Some nursery problems are peculiar to both coarse and fine-textured soils. Coarse-textured soils, i.e., sands and loamy sands, favor the use of mechanical seedling harvesters more than the fine-textured soils. Sandy soils warm early in the spring and can be worked within a few

Table 2-2. — Soil texture in five southern forest tree nurseries.

Nursery	Profile level	Sand	Silt	Clay	Textural Class	Geographic Location
		percent				
A	top soil	93	5	2	Sand	Florida
B	top soil	43	41	16	Loam	Arkansas
C	top soil	66	22	12	Sandy loam	
	sub soil	51	28	21	Sandy clay loam	Florida
	top soil	85	9	6	Loamy sand	
	sub soil	75	12	13	Sandy loam	
D	top soil	92	4	4	Loamy sand	
	top soil	65	19	16	Sandy loam	
	sub soil	52	17	31	Sandy clay loam	Alabama
	top soil	45	37	18	Loam	
	top soil	21	58	21	Silt loam	
E	top soil	60	19	21	Sandy loam	
	top soil	42	37	21	Loam	Georgia
	top soil	54	25	21	Sandy clay loam	
	top soil	14	53	33	Silty clay loam	

hours after a rain. Fine-textured soils have low permeability, freeze more readily, and are slow to dry sufficiently for the soil to be cultivated. These soils also crust and crack upon drying, and may cause seedling injuries because of more difficult lifting. More organic matter must be maintained in fine-textured soils than in the sands and loamy sands. Fine-textured soils have a higher exchange capacity, a higher water-holding capacity and generally are more fertile than are coarse-textured soils (chapter 1).

Since the 1960's the majority of nurseries in the South have been established on sandy or loamy sand soils with a maximum of about 15 percent clay or 15 percent silt. These soils are shown in the lower left hand corner of figure 2-1. The soil should be at least 4 feet deep and should not exhibit radical differences in textural composition between the A and B horizons. Subsoils should range from sands to sandy loams. While these coarse-textured soils usually retain little water or soluble nutrients, successful nurseries are not difficult to establish on them.

The species to be grown and the geographic location partly influence selection of the soil textural class. Sand pines should only be grown on sandy or loamy soils whereas white pine and shortleaf pine will tolerate finer-textured soils. Heavier soils are not suitable for longleaf, slash or Virginia pines. Loblolly pine seedlings can be grown on soils ranging from sands to silty clay loams. Large tracts of sandy soils are often more prevalent in

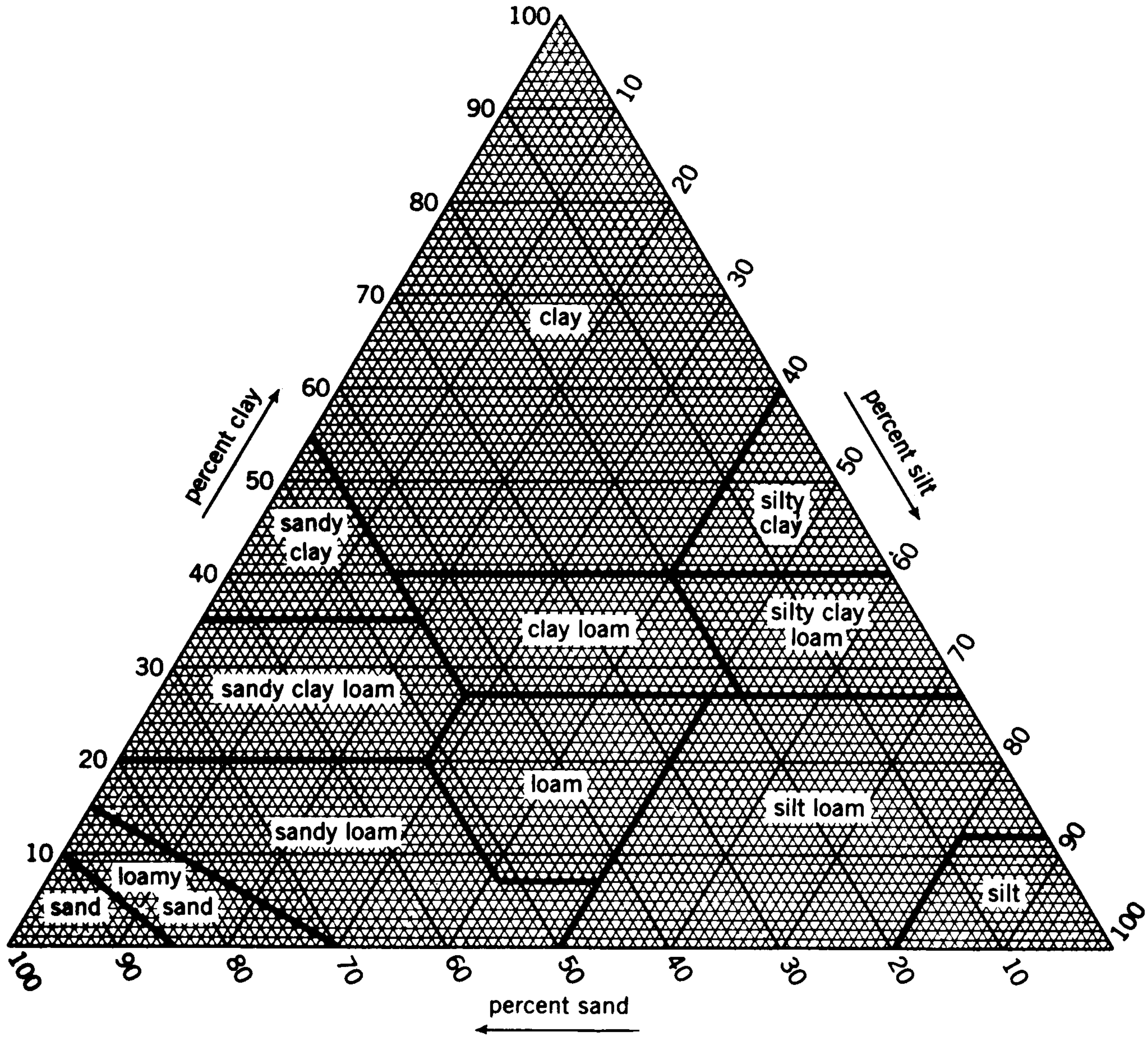

Figure 2-1. — Guide for textural classification. (USDA, SCS, May 1, 1950)

the lower coastal plain than in the upper coastal plain, the piedmont or the mountain regions. Considering present nursery management practices and knowledge, nurseries should be established on loamy sands where feasible.

Drainage

Drainage of the coarse or medium-textured soils varies from excessive to well-drained; the finer-textured soils range from well-drained to imperfectly drained. Soils that have a fragipan, claypan or some restrictive layer within 30 inches of the surface should be avoided. Loamy soils, especially those that have been in cultivation for some time, may have a compacted layer such as a claypan or plowpan inpeding internal drainage. Subsoiling and the use of deep-rooted cover crops will help to alleviate these conditions.

The minimum allowable depth to the ground water table should be about 5 feet. Caution is advised in using the dryness of the upper soil horizon to determine the normal position of the ground water, especially during the dry season.

Reaction and Fertility

Soil reaction (pH) and fertility vary widely in the South, depending on past land use and soil origin. These conditions can be modified, however, if there are no inherent problems. Old homesites and barnyards present problems and should be avoided for seedbed areas. Farm lands may have organic matter contents of less than 1 percent with high pH values and high nutrient levels, whereas virgin forest soils may have organic matter content of 5 to 7 percent, but low pH values and low nutrient levels.

A pine nursery developed on agricultural soils could present several problems. For example, one nursery located on an old alfalfa field had pH values of 7.0 to 7.7, with high calcium levels. Damping-off fungi killed about 75 percent of the seedlings until the pH was lowered with sulfur and ammonium sulfate.

Soil acidity is generally more variable in some of the east Texas and west Louisiana areas than in many other parts of the South. Soil acidity and available nutrient levels should generally be within the following ranges:

acidity (pH)	- 5.0 to 6.0
phosphorus (P)	- 20 to 80 pounds per acre
potassium (K)	- 100 to 200 pounds per acre
calcium (Ca)	- 300 to 1,200 pounds per acre
magnesium (Mg)	- 50 to 100 pounds per acre

High levels of available nutrients on some farm lands can create problems in the growing of pine seedlings unless the abnormal conditions are alleviated.

Aids in Soil Evaluation

The surveys of the USDA Soil Conservation Service are invaluable for locating potential nursery sites (U.S. Department of Agriculture 1951). After locating a potential site, a thorough examination of the soil profile over the entire tract must be made. Soil testing laboratories at most land-grant universities can perform analyses for physical and chemical properties of the soil. These analyses can also be done by commercial soil testing laboratories—often at comparable cost and a significantly shorter time. Techniques for sampling nursery soils are discussed in chapter 12. Also refer to the field guide to soil textural classes (U.S. Department of Agriculture 1975).

CLIMATE

Climate is not a major factor in growing pine seedlings in the South, other than local effects. The length of the growing season ranges from about 192 to 268 days. Mean annual precipitation ranges from about 38 to 63 inches. Dates of the first and last killing frosts range from about October 10 to November 25 and about March 2 to April 22, respectively. The climate near Paducah, Ky., does not differ much from that of Red Bay, Ala., or Chatsworth, Ga. The climate of Little Rock, Ark., is similar to that of Lufkin, Tex., and Glennville, Ga. (table 2-3).

Nursery operations influenced by climate are (1) sowing dates in the spring, (2) beginning of lifting in the fall, and (3) lifting operations which are hindered by frozen ground in the winter. Generally, longleaf pine seeds germinate at lower temperatures and slash pine seeds at higher temperatures than the other southern pine species. Generally, natural seedling dormancy is associated with early frost, although root growth rarely ceases unless the ground is frozen. Continuing low temperatures can freeze the soil, making it impossible to lift seedlings even though conditions for planting may be good at the planting sites. Therefore, in the coldest part of the region the nursery should be a little south of the planting site, whereas in the warmest part of the region the nursery should be somewhat north of the center of the area to be serviced.

High temperatures in spring and early summer may result in heat injury, slow growth, summer chlorosis, a high incidence of soil pathogens and heavy mortality. The maximum temperatures in 14 selected counties (table 2-3) are within the range of 104 to 112 °F, with the higher temperatures in Arkansas, Kentucky, Tennessee and Texas.

Table 2-3. — Weather conditions near some existing nurseries.

Location		Length of growing season	Killing Frost		Mean annual precipitation		Temperature			
State	County		Last in	First in			Max.		Min.	
		Days	Spring	Fall	MM	Inches	C°	F°	C°	F°
Alabama	Baldwin	268	3/2	11/25	1600	63	41	105	-18	0
	Marion	200	4/4	10/21	1270	50	41	105	-27	-16
Arkansas	Pulaski	241	3/17	11/13	1168	46	43	110	-24	-12
	Columbia	236	3/24	11/15	1219	48	44	112	-21	- 5
Florida	Alachua	260	3/7	11/22	1346	53	40	104	-12	10
Georgia	Tattnall	258	3/6	11/19	1168	46	41	106	-12	11
	Murray	192	4/15	10/24	1371	54	40	104	-23	-10
Kentucky	McCracken	200	4/4	10/24	1194	47	44	112	-27	-17
Louisiana	Beauregard	258	3/7	11/20	1372	54	41	106	-13	9
Miss.	Forrest	251	3/12	11/18	1524	60	41	105	-12	11
Tennessee	Madison	202	4/16	10/25	1245	49	43	110	-29	-21
Texas	Angelina	247	3/15	11/17	1143	45	43	110	-19	- 2
Virginia	Prince George	210	4/4	10/31	1092	43	42	108	-23	-10
	Augusta	180	4/22	10/19	965	38	41	106	-25	-13

[1]Source: Climate and Man. 1941 Yearbook of Agriculture. USGPO. Washington, D.C.

Extremely wet or extremely dry periods may occcur any time during the year. For example, in Forest County, Miss., mean annual precipitation exceeded 70 inches for 3 consecutive years, and the ground water table was frequently near the surface. Severe droughts developed in southwest Arkansas, east Texas and west Louisiana during the 1970's, resulting in water shortages in several nurseries. Sudden storms producing 5 to 10 inches of rainfall can occur fairly often and create havoc, especially during the spring and early summer. It is impossible to select a nursery site which will not experience extremes in climatic conditions. However, with well-drained soils and good surface drainage, the effects of inclement climatic conditions can be minimized.

WATER SUPPLY

A basic need for forest tree nurseries is a dependable water supply that will furnish the equivalent of 4 to 6 inches of rainfall a month over the entire seedling production area during the growing season. Water requirements for different size nurseries are given in table 2-4.

Water sources may be deep wells, streams, reservoirs, or a combination of these. Water for reservoirs may come from wells, streams, springs or surface flow. Deep aquifers in the lower Atlantic and central Gulf Coastal Plains usually enable wells to produce 500 to 1,000 gallons per minute (gpm). A well of 8 inches in diameter with a capacity of 500 gpm will supply 720,000 gallons per day (gpd). Alternatives are one large well (10 to 14 inches) or two smaller wells. Water for domestic use such as office, packing sheds, spraying, etc., is usually obtained from a separate source such as shallow wells or local water supplies.

A secondary water source for irrigation should always be included in the nursery plans. The secondary source is used when the principal source is down for repairs or produces too little water. The secondary source is often a pond or a larger domestic well. Also, fire insurance may be cheaper if there is an accessible pond.

Water Quality

Water for irrigation must not only be plentiful throughout the growing season, but it must also be of the right quality. Before a nursery site is selected the quality

Table 2-4. — Estimated weekly water requirements for a pine seedling nursery.[1]

Seedbed area	Amount per week		
	1 inch	1-1/2 inches	2 inches
Acres	thousands of gallons		
10	272	407	544
15	407	611	814
20	543	815	1,086
25	697	1,019	1,358
30	815	1,222	1,630
35	951	1,426	1,902
40	1,086	1,630	2,171

[1]If the cover crop is to be irrigated, increase these values by 50 to 100% depending on the ratio of seedbed to cover crop acreage.

of the irrigation water should be determined (tables 2-5 and 2-6).

The quality is determined by the following characteristics:

1. The total concentration of soluble salts
2. The amount of sodium in relation to calcium-plus-magnesium
3. The amount of bicarbonate
4. The presence of boron or other chemicals in amounts that may be toxic
5. The amount of total solids

Water from streams flowing through the region is generally safe for irrigation unless polluted by urban or industrial waste. However, surface water may contain many small seeds that plug nozzles and increase weed control costs. Therefore, well water is more attractive where the option exists.

In irrigation language, there is a saying, "Hard water makes soft land and soft water makes hard land." The explanation of this statement is that calcium and magnesium, the two principal cations that make water hard, help in creating desirable soil structure. Sodium, the dominant cation in soft water, disperses clay and humus and creates an undesirable structure. When the irrigation water contains a large amount of sodium and a low percentage of calcium and magnesium, the sodium is readily adsorbed on the surface of the clay and humus particles. The dispersed soil moves downward with the irrigation water and accumulates about 4 to 8 inches below the surface, forming a tight layer that can be impermeable to roots or water. Well water on the Atlantic and Gulf coasts and in west Louisiana, east Texas and southwest Arkansas may have a sodium content that is too high for irrigation use.

Two charactersitics of water must be known in order to estimate quality: (1) total concentration of salts and (2) the percent of sodium. Values for rating water quality are given in table 2-6. In addition to its effect on soil structure and permeability, sodium has been found to be absorbed by plants and cause leaf burn in some species. Bernstein (1967) has indicated that water having Sodium Adsorbtion Ratio (SAR) values of four to eight may injure sodium-sensitive plants.

Sediments, algae, or weed seeds (from surface water sources) in irrigation water may clog sprinkler nozzles. Water with a high silt or colloidal content may seal the soil surface and reduce aeration. Water containing 500 parts of calcium per million, or above a pH of 8.3, is likely to raise the pH value of the nursery soil. Likewise, water carrying 100 parts of calcium carbonate or 125 parts of calcium bicarbonate per million may also raise the soil pH value (Wakeley 1954).

Irrigation water should contain less than 200 parts per million of dissolved solids. This is equivalent to an electrical conductivity of about 330 micromhos per cm at 25 °C. The SAR value of the water should be less than 10, and the boron content less than one-half part per million (Stoeckeler and Jones 1957).

In general, the danger of spread of plant pathogens in irrigation water is so slight that it is usually ignored. Some plant pathogens, however, can survive and be transported

Table 2-5. — Criteria for evaluation of irrigation water quality.

Cations	Anions	Minor Constituents	Others
Calcium (Ca)	Carbonate (CO_3)	Aluminum (Al)	Total solids
Magnesium (Mg)	Bicarbonate (HCO_3)	Ammonium (NH_4)	Total anions
Sodium (Na)	Sulfate (SO_4)	Boron (B)	Dissolved solids (DS) 1/
Potassium (K)	Chloride (Cl)	Fluoride (F)	Electrical Conductivity 2/
	Nitrate (NO_3)	Hydrogen ion (pH)	Percent Sodium 3/
		Iron (Fe)	Sodium adsorption ratio (SAR) 4/
		Nitrite (NO_2)	Color Turbidity (sediment)
		Phosphate (PO_4)	
		Silica (SO_2)	
		Sulfide Sulfur (S)	

1/ DS = dissolved solids in ppm or tons per acre-ft.

2/ Electrical Conductivity is calculated from a measure of electrical resistance and expressed as (EC x 10^6 at 25°C.)

3/ Percent sodium = $\frac{Na \times 1000}{\quad}$, in which concentrations are in terms of equivalents, as e.p.m.

4/ Sodium adsorption ratio (SAR) = $\frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+}}}$, where the concentration of the cations are given in milliequavalents per liter.

Table 2-6. — Quality standards for irrigation water.[1]

Class of Water Rating	Grade	Total Concentration: Sodium EPM 2/	Total Concentration: Electrical Conductivity ECx10^6 @ 25°C	Sodium %
1	Excellent	< 2.5	< 250	< 20
2	Good	2.5-7.5	250-750	20-40
3	Permississible	7.5-20.0	750-2,000	40-60
4	Doubtful	20.0-30.0	2,000-3,000	60-80
5	Unsuitable	> 30.0	> 3,000	> 80

1/ From Wilcox X. (1948) and Salinity Laboratory Staff, U.S. (1954)

2/ Equivalent per million or milligram equivalents per liter (me./l) is the unit chemical equivalent weight of a constituent per million unit weights of solution. To change e.p.m to ppm - multiply the concentration of each radical in parts per million by its equivalent weight.

in irrigation water. Where runoff water from nursery seedbeds is used again for irrigation, there is a definite possibility that disease organisms will be spread from one field to another. Nematodes and *Pythium* spp. can be distributed by irrigation water. Pathogenic micro-organisms and toxic chemicals from municipal and industrial wastes may find their way into irrigation waters from streams and reservoirs. No nursery should be established until the water is tested by a qualified agency.

ACCESS AND SERVICES

A central location that is readily accessible allows for better service to the planting sites and minimizes transportation costs. If the planting area is extensive, access to an interstate or major highway is important. Electricity, telephone and mail service must be available. Nurseries can be an important part of the public relations program of any organization, especially when located along a public highway or near a thriving community. However, this function must not be an overriding criterion when selecting a nursery site. Soil properties are paramount.

LABOR SUPPLY

Nurseries are no longer considered labor intensive industries because most nursery operations are mechanized. The permanent nursery staff should include two to five skilled technicians—each of whom can handle all nursery operations. During peak seasons, i.e., during sowing, lifting, and weeding, seasonal laborers may be needed. Women and men are equally adept as technicians and seasonal laborers. In some situations labor from prisons has been used with good results.

BIOTIC FACTORS

Before a new crop of pine seedlings is established, evaluate the area for weeds, nematodes, parasitic fungi and insects. Weeds such as nutgrass, Johnsongrass, coastal bermudagrass and morning glory are difficult and expensive to control. Farm lands serve as a bank for a host of weed seeds which may remain dormant for years. Nematodes, root-rot fungi and insects, which may attack and kill young seedlings, are associated with many row crops. Mycorrhizal fungi best-suited for pines are sometimes absent from farm lands, but will invade the area with the establishment of pine seedlings (unless the nursery is established in a prairie area). The seedbeds also may be inoculated with specific fungi. Control of pests by fumigation or other pesticides may be costly, but is preferable to failure of the seedling crop.

ATMOSPHERIC POLLUTION

Air pollution has injured forest trees near large industrial sources. The most common air pollutants are sulfur dioxide, fluoride compounds and oxidants. Coal burning for generation of electricity is responsible for a large percentage of the sulfur dioxide in the air. Fluoride compounds in the atmosphere usually originate from brick plants, manufacture of phosphate fertilizer, aluminum reduction processes, pottery, glass and ferro-enamel works, steel manufacturing plants and refineries (Loomis and Padgett 1975; USDA Forest Service 1971). Air pollution may injure seedlings many miles from the nearest source. More subtle effects may occur such as retarded growth and weakness to the point that the seedlings become susceptible to attack by various insects and diseases. A nursery should never be located where it will come in direct contact with industrial pollutants.

STEPS IN THE SITE SELECTION PROCESS

Selection of a nursery site requires the service of a very knowledgeable individual and may take months of tedious work. A recommended procedure is:

1. Determine the ultimate production capacity of the proposed nursery.
2. Decide on the geographical region in which to locate the nursery.
3. Determine the names of all soil series or families that are suitable for a nursery within the region.
4. Using county soil surveys, locate on maps all sites with the appropriate soil series and acreage requirements.
5. If County Soil Surveys are not available, check with the District SCS office and the county agents.
6. Occasionally neither steps 4 or 5 are adequate. Travel on country roads and talk with local residents to obtain additional leads.
7. Locate two, three or more potential sites and obtain permission to examine them. Consider soil, topography, potential water supply, climate, accessibility, etc. (table 2-7).

Table 2-7. — Nursery site selection criteria.

Site Classification	Soil						Slope %	Water		
	Depth in inches	Sand	Silt	Clay	Permea-bility	pH		ph	Source	Quantity gpm
		percent								
1. Execellent	0-15 15-48	75-85 75-85	5-15 5-15	5-10 5-10	Good Good	5.0-6.5	1/2-1	5.5-8.0	well	500-1000
2. Very good	0-15 15-48	75-85 65-80	5-15 5-20	5-10 5-15	Good Good	5.0-6.5	1/2-1	5.5-8.0	well or surface	300-1000
3. Good	0-12 12-48	50-75 50-70	10-30 10-30	5-20 20-35	Good fair	5.0-6.5	1-2	5.5-8.0	well or surface	300-1000
4. Fair to Good	0-15 15-48	85-95 80-95	2-8 2-8	1-8 1-8	rapid rapid	5.0-6.5	1/2-1	5.5-8.0	well or surface	300-1000
5. Fair to Good	0-12 12-48	40-50 20-40	30-50 50-70	10-25 10-30	fair fair	5.0-6.5	1-2	5.5-8.0	well or surface	300-1000

8. Examine in detail the soil, topographic and drainage characteristics. This work may require the use of a topographic map.
9. Check on possible sources of irrigation water. The geology of the site may indicate if deep wells can be used.
10. Determine the value of the site, based on market value and use as a potential nursery site.
11. If soils, topography and other features are favorable, obtain permission for drilling a test well. An option to buy may be needed, based on a predetermined price.
12. If all the above features are favorable, proceed with acquisition or lease. This work will require skill, persuasion, and money.

REFERENCES

Aldhous, J.R. Nursery Practice. Forestry Commission Bulletin 43. London: Her Majesty's Stationary Office; 1972. 184 pp.

Bernstein, L. Quantitative assessment of irrigation water quality with reference to soil properties, climate, irrigation management and the salt tolerance of plants. A.S.T.M. STP-416. 1967.

Davey, C.B. Land shaping during nursery site preparation or renovation. In: Proceedings, 1976 Southeastern Area Nurserymen's Conferences. Atlanta, Ga: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1976: 13-15.

Loomis, Robert C.; Padgett, W.H. Air pollution and trees in the east. Broomall, Pa: U.S. Department of Agriculture, Forest Service, Northeastern Area; 1974. 28 p.

National Technical Advisory Committee on Water Quality Criteria. Irrigation water Supplies, In: Report of the National Technical Pollution Control Administration; 1968: 143-184.

Shih, Sun-Fu; Sowell, Robert S. and Kriz, George J. Computer program for land forming design of a nonrectangular field. N. Car, Agri. Expt. Sta. Technical Bul. No. 231. Raleigh, N.C.: North Carolina State University; 1975. 85 p.

Stoeckeler, J.H.; Jones, G.W. Forest nursery practice in the Lake States. Agric. Handb. 110. Washington, D.C.: U.S. Department of Agriculture; 1957. 124 p.

Toumey, James W.; Korstian, Clarence F. Seeding and planting in the practice of forestry: A manual for the guidance of forestry students, foresters, nurserymen, forest owners and farmers. 3rd. ed. New York: John Wiley & Sons, Inc.: 1943. 520 p.

U.S. Department of Agriculture. Yearbook of Agriculture: Climate and Man, Washington, D.C.: U.S. Department of Agriculture; 1941. 1,248 p.

U.S. Department of Agriculture. Soil Survey Manual. Agric. Handb. 18. Washington, D.C.: U.S. Department of Agriculture; 1951. 503 p.

U.S. Department of Agriculture. Diagnosis and improvement of saline and alkali soils. Agric. Handb. 60. Washington, D.C.: U.S. Department of Agriculture; 1954. 160 p.

U.S. Department of Agriculture. Soil taxonomy. Agri. Handb. 436. Washington, D.C.: U.S. Department of Agriculture; 1975. 754 p.

U.S. Department of Agriculture, Forest Service. A Forest Atlas of the South. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station; 1969. 27 p.

U. S. Department of Agriculture, Forest Service. Air Pollution and Trees. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area; 1971. 13 p.

Wakeley, Philip C. Planting the southern pines. Agriculture Monograph No. 18. Washington, D.C.: U.S. Department of Agriculture; G.P.O. 1954. 233 p.

Wilde, Sergius A. Forest soils: their properties and relation to silviculture. New York: The Ronald Press Co.; 1958. 537 p.

Wilcox, L.V. Quality of water for irrigation use. Technical Bulletin No. 962. Washington, D.C.: U.S. Department of Agriculture. 1948. 40 p.

APPENDIX 2-1: CHECK LIST: FOREST TREE NURSERY SITE SELECTION FOR PRODUCTION OF 25,000 TO 40,000 SEEDLINGS ANNUALLY[1]

1. Geographic Location—Southeastern Virginia. Tentative priority, in order, (1) Southampton County, (2) Greensville County, (3) Suffolk City, (4) Brunswick County, (5) Lower Sussex County, (6) Surry County. Locations also may be compared by adding total (combined) highway mileage between location and Waverly, location and Portsmouth, location and Lawrenceville.

2. Soil— (1) Suitability of texture
   (2) Drainage
   (3) Slope (2% to 3% desirable but deep sandy soils may be flat)
   (4) Subsoil (should be friable, well drained and without hardpan)
   (5) Fertility and previous use
   (6) pH (medium to low-medium range preferable)
   (7) Danger of flooding
   (8) Sewage disposal considerations

3. Water— (1) Available in reliable quantities for irrigation. (sufficient to provide ½ " over entire seedbed area in eight hours or less)
   (2) Water quality for irrigation (Should not contain harmful minerals, chemicals or organic substances.)
   (3) Cost of providing water to seedbeds (consider pumping distance, availability of electric power, heat, necessity of dam, reservoir, pond, etc.).
   (4) Availability of domestic (drinking) water supply

4. Climate— (1) Frost history
   (2) Climatology
   (3) Rainfall and summer storm patterns

5. Labor— (1) Adequacy of supply (1 Superintendent)
   (2 Foremen)
   (4 Forestry Aides)
   (5 Day Laborers)
   (5 to 25 Hourly Laborers)
   (2) Nearness to location
   (3) Competition (present and possible future needs for labor by local industries, farming, etc.)
   (4) Qualifications (Laborers with farming experience preferred. Women usually are better weeders and graders.)

6. Land Cost— (1) Purchase price
   (2) Cost of clearing, drainage, leveling, etc.
   (3) Consider a long-term lease from a forest industry
   (4) Value (or liability) of existing structures (possible residence for superintendent or foreman)

7. Total Area Available
   Primary Consideration—
   Should have 100-150 acres of area suitable for development into seedbeds. (For production of up to 40 million loblolly annually at a spacing not to exceed $30/F^2$, and crop rotation of 1-1 or 2-1. Includes roads and building areas.)

   Secondary Considerations—
   (1) Some additional area for possible future development, fuel wood, windbreaks, progeny testing or other aspects of the superior tree program.
   (2) Forest management area for research.

8. Access to Area
   (1) Accessibility to Interstate and major primary highways.
   (2) Driveways, farm roads (consider construction and rebuilding necessary).
   (3) Bridges, obstructions or road surfaces that might limit heavy or bulky loads.

[1]Checklist prepared by the Virginia Division of Forestry.

9. Power and Communications
    (1) Availability of 220/440 3-phase AC electric power.
    (2) Availability of dependable (private line) telephone service.
    (3) Coverage from VDF radio network.
    (4) U.S. Mail facilities.
    (5) United Parcel Service and scheduled truck freight lines.

10. Community Considerations
    (1) Proximity of good schools (public and private) and churches.
    (2) Availability of medical services.
    (3) General character of the community.
    (4) Proximity to stores, shopping centers, motels, restaurants.
    (5) Availability and quality of law enforcement; vandalism and pilferage incidents.

11. Public Relations Considerations
    (1) Proximity to a major highway.
    (2) Possibility for a demonstration area (planting, fuelwood).
    (3) Suitability for an environmental study area separated from seedbed area.
    (4) Group meeting possibilities.

12. Potential for Other Division Uses (Secondary)
    (1) County Forester Office.
    (2) Equipment depot.
    (3) Research projects.

APPENDIX 2-2: COMMON AND SCIENTIFIC NAMES FOR SOUTHERN PINE SPECIES.

	Scientific Name
Loblolly pine	*Pinus taeda*
Longleaf pine	*Pinus palustris*
Slash pine	*Pinus elliottii*
Shortleaf pine	*Pinus echinata*
Virginia pine	*Pinus virginiana*
Pitch pine	*Pinus rigida*
Pond pine	*Pinus serotina*
Sand pine	*Pinus clausa*
Spruce pine	*Pinus glabra*
Table-Mountain pine	*Pinus pungens*