What is a Soil Management Plan, and Why Would You Want One? -Part II

The first part of this article appeared in the January, 1995, issue; it covered the parts of a Soil Management Plan and how to organize the soil survey. This second part discusses how to conduct the survey and then analyze the results. The third and final part of this series will appear in the January, 1996, issue of FNN, and will show how to assess the production potential of your nursery soil and implement the Management Plan.

Conducting the survey. Because the soil sampling process causes considerable disturbance, it is usually best to only sample blocks that are in the fallow year of the crop rotation. The location of the sample points is established by laying out the sampling grid in a block based on the detailed soil map that you developed **(Figure C)** - see January, 1995, issue of FNN for details.

The actual survey will consist of two parts: on-site sampling, and collecting samples for laboratory analysis. Readily apparent soil characteristics, such as depth and texture, can be determined during the on-site sampling, whereas other characteristics, such as pH and mineral nutrient levels, must be measured later in a soils laboratory. Using the sampling criteria that you have identified as potentially limiting factors, decide whether they can be measured during the on-site sampling or laboratory analysis. When we surveyed the Colorado State Nursery in Ft. Collins, CO we identified 5 factors as most important:

1. *Soil depth*—measured during on-site sampling
2. *Soil texture*—measured during on-site sampling
3. *Soil reaction (pH)*—samples collected for laboratory analysis
4. *Electrical conductivity* (*EC)*—samples collected for laboratory analysis
5. *Calcium carbonate* (*$CaC0_3$*)-samples collected for laboratory analysis

The on-site sampling will require technical soils expertise, and unless the nursery has a person skilled in soil analysis on staff, it will be necessary to obtain assistance from a nursery soils consultant or soil survey personnel from the National Resource Conservation Service or State University Extension Service. The sampling procedure consists of digging a soil pit or auger hole at each location on the soil sampling grid. The soil pits

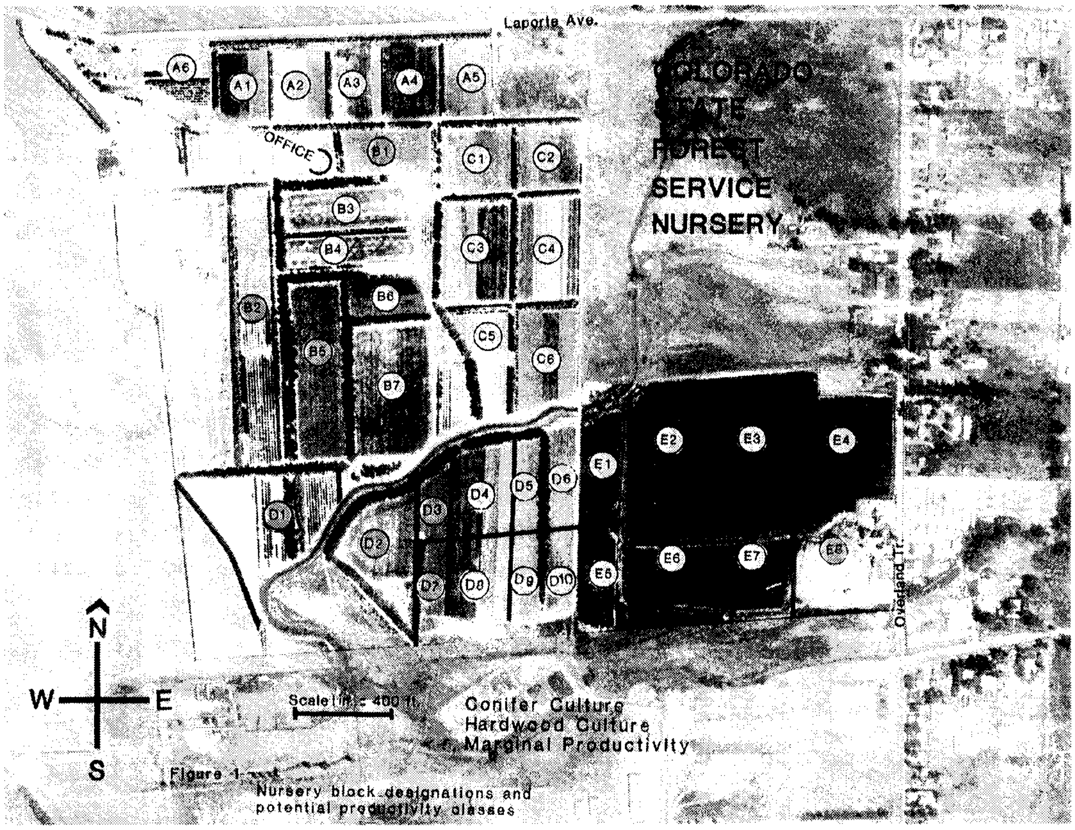

Figure C: A detailed map of the nursery blocks is the first step in the soil survey

must be deep and large enough to allow the manual determination of physical soil properties, such as texture and presence of compacted soil layers **(Figure D).** This information is recorded on a survey sheet for each location in the sampling grid.

After the on-site measurements have been made, soil samples are collected from the plow in each pit. Depending on your sampling criteria, subsoil sampling may also be required. A composite soil sample is recommended to provide an average for each sampling location, and to keep down the costs of laboratory analysis. Collect five separate samples from around the pit, place them in a bucket, mix the soil thoroughly, and then draw one soil sample and place it in a sack. Make sure that the sample bags are properly labeled with the proper pit location and use pencil or indelible ink, so that the labels do not fade or smear. The samples should be stored in a safe location until they can be shipped to the laboratory. One handy procedure is to place the samples in an insulated cooler; this both protects them and allows them to be easily carried around the field.

Figure D: Large soil pits made with a post-hole auger or backhoe make close examination much easier.

Laboratory Soil Analysis. There are many soil testing laboratories that do agricultural soil testing, but only a few that are experienced with forest nursery soils. Each laboratory has its own analytical procedures for testing soils and the results of some of the tests vary with the type of procedure (e.g. organic matter) or extracting solution (e.g. phosphorus) that is used. A set of standard laboratory procedures for testing forest nursery soils has been developed by a panel of experts (Bickelhaupt and others 1983). When contacting analytical laboratories, nursery managers should insist that these standard soil tests are used. Otherwise, it is impossible to compare tests results with published standards and those of different nurseries. The exact cost per sample will vary with the specific soil tests that are requested, but can range from $5 for a simple pH test, to $50 or more for a complete mineral nutrient analysis.

Analyzing Soil Survey Results. The next step is to analyze the data collected during the on-site survey, along with the results of the laboratory analysis, and determine how they affect seedling growth (Table 1). Each of these factors is analyzed against some set of ideal standards, which must be

Table 1. The results of the on-site sampling and laboratory analysis, such as these for the Colorado State Forest Service Nursery (CSFS) in Ft. Collins, CO, should be tabulated by nursery block for detailed analysis.

Nursery Block	Gross Acres	Depth (in)	Textural[1] Class	pH (units)	E.C. (mmhos)	CaC0$_3$ (%)	O.M. (%)	C.E.C (m.e.)
A-1	1.7	18+	Fi Sa Lo	6.2	1.0	---	1.7	11.4
A-2	1.6	12-18	Fi Sa Lo	7.4	1.3	---	1.7	10.6
A-3	1.7	10-11;	Fi Sa Lo	8.0	1.2	5.6	1.9	15.4
A-4	1.7	10-16	Lo	7.8	1.4	2.5	1.9	13.5
A-5	1.6	8-18	Lo	8.0	1.4	6.1	2.0	15.7
A-6	1.0	18+	Sa Lo	6.6	0.8	---	1.2	9.6
B-1	1.5	16-18	Gr Lo	8.0	0.8	1.9	1.7	9.6
B-2	2.2	Stool Blocks-Out of Production						
B-3	3.7	16-18	Fi Sa Lo	6.3	1.3	---	1.7	11.9
B-4	1.4	14-18	Lo	7.0	0.8	---	1.8	12.5
B-5	3.1	Stool Blocks-Out of Production						
B-6	1.2	10-18	Sa Lo	6.6	0.8	---	2.0	11.()
B-7	3.9	12-16	Lo	7.4	1.0	---	2.1	14.2
C-1	1.7	18+	Fi Sa Lo	7.0	1.1	---	2.0	11.5
C-2	1.4	10-16	Lo	7.8	1.3	3.1	2.1	13.4
C-3	2.4	14-18	Sa Lo	7.0	0.5	---	2.1	11.6
C-4	2.4	10-18	Sa Lo	6.6	0.6	---	1.6	11.1
C-5	1.5	16-18	Fi Sa Lo	7.2	0.6	---	2.2	11.5
C-6	2.2	18+	Fi Sa Lo	7.3	0.7	---	2.4	13.4

[1]Textural Class Code: Sa Lo=Sandy loam; Fi Sa Lo = Fine sandy loam; Lo = Loam; CI Lo= Clay loam; Gr Lo = Gravelly loam

appropriate for the local climatic and edaphic conditions. The standards in **Table 2** were developed for soils in the Interior Western US, where the dry climate causes soluble salts to accumulate in the surface soil horizons; this results in higher pH and EC values than would be found in soils with higher rainfall. Other soil standards should be used for nurseries with more acidic soils-for an example, see Youngberg (1984) and van den Driessche (1984)

For the purposes of discussion, let's look at one physical factor (soil depth) and one chemical factor (pH) for the CSFS nursery:

Soil Depth—Arable soil depth is important for the development of a good root system, as well as for standard soil tillage. Seedling size specifications typically call for a root system that is 8-10 inches long; therefore, the surface soil must be at least 12 inches deep to permit proper seedling culturing and lifting. Ideally, nursery soils should be from 1-2 feet deep **(Table 2),** which allows good soil tillage without the possibility of bringing up undesirable material from the subsoil. Soils at the Colorado State nursery are typically high in $CaC0_3$ **(Table 1),** which raises the pH to 7.0 or above, and causes mineral nutrient availability problems with many forest species. The presence of free $CaC0_3$ in surface soils is a unique characteristic of nurseries in semi-arid climates where evapotranspiration exceeds precipitation, and calcium is recurrently wicked to the soil surface by the strong evapotranspirative forces. In wetter climates, $CaC0_3$ is dissolved by rainfall, and is leached from surface soils along with other bases, resulting in more acidic soil conditions. Subsoils are even higher in $CaC0_3$ under arid conditions, so problems can result where calcareous subsoils are mixed with surface soils during deep cultivation or land leveling. Unfortunately, this often occurs during nursery soil development, and subsequently, nursery mangers have difficulty understanding and managing the wide variation of soil properties between different blocks **(Table 1).**

Table 2. Soil productivity targets for forest and conservation nurseries in the Interior West of the US

Physical and Chemical Properties	**Range**	**Units**
Soil Depth		
minimum	>12	inches
optimum	12-24	inches
Texture - loamy sands or sandy loams		
conifers	20-25	% silt + clay
hardwoods	25-35	% silt + clay
pH		
most conifers	5.5-6.5	-
hardwoods and junipers	6.5-7.5	-
Electrical Conductivity (E.C.)		
conifers	<2.0	mmhos/cm
hardwoods	<4.0	mmhos/cm
Organic Matter (O.M.)[1/]	2.0-5.0	
Cation Exchange Capacity (C.E.C.)	7-12	m.e./100g
Calcium Carbonate Equivalent ($CaC0_3$)	0	

The CSFS soil survey revealed that surface soil depth should not be a serious problem in most of the nursery blocks, although Block A-6 shows a minimum 8 inches, and several others are only 10 inches deep **(Table 1).** Therefore, ripping or deep plowing should be avoided in these blocks whenever possible.

Soil Reaction (pH) - The ideal soil pH for tree seedling nurseries varies with species from 5.5 to 6.5 for most conifer seedlings, to a 6.5 to 7.5 range for hardwoods and junipers **(Table 2).** Although most nursery managers are quite concerned about soil pH levels, soil pH is not as critical as some other chemical indexes, because the actual acidity or alkalinity in most nursery soils is not extreme enough to be directly damaging to tree seedlings. The actual pH reading merely gives an indication of the chemical action of other ions or minerals in the soil, such as CaC03 in alkaline soils. From a management standpoint, the indirect effect of pH on mineral nutrient availability and soil pathogens is most important.

At the Colorado State Nursery, the soil pH varies widely between different nursery blocks, ranging from a low of 6.2 in A-1 to a high of 8.0 in blocks A-3 and others **(Table 1).** This extreme variation of almost 2 pH units within one field emphasizes the need for a good soil management plan. The overall objective of pH management at the Colorado State Nursery is to gradually lower soil pH to the desired range over a long period of time. This gradual acidification should increase the availability of most nutrients, particularly phosphorus and iron, and also decrease the incidence of damping-off disease.

The management of soil pH should be done by nursery block, taking into consideration the planned use for that block. Blocks with lower pH values (less than 7.0) should be reserved for conifer seedling production. Most hardwoods and the junipers are more tolerant of alkaline soils, and they can be produced on soils of pH 7.0-8.0. For maximum nutrient availability, these nursery soils will require some degree of acidification. Lowering soil pH is a very slow process; however, it usually requires several crop rotations for any significant change. Acidification should be done in two phases: acidifying fertilizers should be used during seedling production, and flaked or prilled sulfur can be added during the fallow period. In nursery blocks that contain free $CaC0_3$ **(Table 1),** soil pH cannot be appreciably lowered until the $CaC0_3$ is oxidized to gypsum (Ca $S0_4$), which is soluble enough to be leached from the soil profile.

The presence of $CaC0_3$ emphasizes the need for a site specific soil survey that identifies potentially limiting factors that can be used as critical sampling criteria. If soil pH was surveyed without any attention to this often underappreciated soil factor, it would be impossible to develop an effective soil management plan.

In the January, 1996, issue, we will further discuss how to use this survey data to assess the production potential of your nursery soil block-by-block, and implement a comprehensive Soil Management Plan.

Sources:

Bickelhaupt, D.H.; Davey, C.B.; White, E. H. 1983. Laboratory Methods for Forest Tree Nursery Soil Analysis. Misc. Publ. No. 2. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 16 p.

Landis, T.D.; Boyer, D.S. What is a soil management plan and why wouldyou want one? Escanaba, MI: Northeastern Area Nurseryman's Conference and Nursery Soil Workshop; 1992 July 29-30. Portland, OR: USDA Forest Service, Cooperative Forestry. 12 p.

Meinert, D.; Viele, D.; Knoernschild, T.; Moore, M. 1994. Soil management plan for the G.O. White State Forest Nursery. In: Landis, T.D. tech. coord. Proceedings: Northeastern and Intermountain Forest and Conservation Nursery Associations. 1993 August 2-5; St. Louis, MO. General Technical Report RM-243. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 9-18.

van den Driessche, R. 1984. Soil fertility in forest nurseries. IN: Duryea, M.L.; Landis, T.D. eds. Forest Nursery Manual: Production of Bareroot Seedlings. Boston: Martinus-Nijhoff/Dr. W. Junk Publ. 75-80.

Youngberg, C.T. 1984. Soil and tissue analysis: tools for maintaining soil fertility. IN: Duryea, M.L.; Landis, T.D. eds. Forest Nursery Manual: Production of Bareroot Seedlings. Boston: Martinus-Nijhoff/Dr. W. Junk Publ. 75-80.