Soil Management Practices at the Big Sioux Nursery[1]

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Abstract: The Big Sioux Nursery was experiencing nutrient deficiencies brought on in part by the increased seedling production. A soil management plan was written to better utilize the resources available and give management a tool in which they can increase the potential and maintain the productivity of the soil.

Introduction

The Big Sioux Nursery has been producing conifer seedlings since 1957 and hardwoods since 1978. In this time period we went from around 600,000 seedlings of 6 different types of conifers to 2 million seedlings of 40 different species. This increased production and in particular the large increase in the number of tree species has placed an accelerated demand on the nursery's soil resource. Hardwood and conifer seedlings generally have different soil requirements and it is therefore important to identify the production potential of all management units.

The Big Sioux Nursery contains 154 acres of which 87.5 acres are into production ground. The land is divided into 18 production blocks varying from 2.5 to 13.8 acres. The majority of the blocks are in 4 acre increments.

Soils Inventory

As far as can be determined no intensive soil survey had been done until this plan was developed in 1982. Up until this survey, soil variation was not considered in the management of the nursery. Trees were sown in areas that had been out of production the longest. We experienced chlorosis, stunting, and irregular beds along with other various nutrient deficiencies. At this time we contacted Tom Landis and it was determined that a soil management plan needed to be written.

The first step in the soil management plan was to survey the soil. The nursery consist of two principal soil types with two inclusions for the nursery. The first soil type, Fordville-Renshaw soils are basically a fine sandy loam underlaid by coarse textured calcareous material. The second type, Egeland-Sioux soils are both finer-textured sandy loams on the surface but differ in subsoil texture. The Egeland subsoil is a heavy loam whereas the Sioux type contains sand and gravel in the subsoil; both are calcareous in nature. (USDA 66)

The second step was an intensive soil survey that was performed in 1982-83 with the USDA Forest Service. The nursery management units were analyzed individually for significant characteristics that would affect their productivity. A series of soil pits were dug in a regular pattern across the units. The analysis consisted of on site measurements of surface and subsurface soil texture, depth of arable soil, occurrence of restrictive layers and subsoil features relating to the presence of calcareous features. Soil samples were also collected from each management unit and one composite sample per unit was sent to Oregon State University for chemical analysis.

Physical and Chemical Soil Properties

As a guideline we used the soil productivity targets for the interior west. (Landis 1983) Soil texture is one of the most important properties of the nursery soil because it affects most other physical and chemical properties and because it is almost impossible to modify. The ideal nursery soil texture

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is a loamy sand or sandy loam. Out of the 18 management units at the nursery, 13 units were classified as loam and 5 as sandy loam. In general, the soil texture in most management units at the Big Sioux are slightly heavier than recommended but should prove to be acceptable for production of tree seedlings. The northern half is more suitable for conifer production than the southern half so this has played an important part in our planting plan.

Soil depth

The depth of the surface soil 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 to 10 inches long and therefore the production soil must be at least 12 inches deep to permit proper lifting. Root culturing practices also occur in this area so the soils need to be deep enough to avoid bringing up calcareous material from the subsoil. Our survey revealed only one management unit "A" with unsuitable soil depth. There are shallow spots in other areas of the nursery probably attributable to land leveling during nursery development that will have to be managed around.

Soil Reaction

The ideal soil pH for tree seedling nurseries varies from a range of 5.5 – 6.5 for most conifers to a 6.5 - 7.5 range for junipers and hardwoods. At the Big Sioux Nursery, the soil pH values ranged from a low of 6.6 in Unit K to 8.3 in Unit P. The overall objective of pH management at the Big Sioux Nursery is to lower pH gradually to the desirable ranges over a long period of time.

Organic Material

Organic matter levels are very good in all units ranging from 3.1 to 5.1 as compared to the recommended range of 2.0 to 5.0. No additional amendments have been made except for a green manure crop during the fallow year. Electrical conductivity has not been tested regularly because the initial test showed that all units were low. Considering the good internal drainage of the nursery's soil and with proper irrigation, salt buildup should not be a problem.

The cation exchange capacity was initially tested in 1983. The results showed the capacity of all management units at the nursery were very good, ranging from 13.2 to 21.1 meq compared to the recommended range of 7 - 12 meq. This is a reflection of the high organic content of the soil and the clay component of the loam soils. As long as the soil organic material is maintained, there should never be a problem with C.E.C. (Table 1)

Table 1. Physical and Chemical Soil Properties of Management Units at Big Sioux Nursery

Management Unit	Acres	Surface Soil		pH	E.C.	O.M.	C.E.C.	$CaC0_3$
		Texture	Depth (in)	units	(mmhos)	(%)	(m.e.)	(%)
A	4.3	Loam	12-15	7.3	0.08	5.1	21.1	-
B	4.3	Loam	12-15	7.5	1.10	4.3	17.0	2.5
C	4.4	Loam	15-20	8.1	0.70	3.1	15.2	3.6
D	4.2	Loam	15-20	7.7	0.60	4.2	19.2	2.3
E	3.9	Loam	15-20	7.4	0.60	3.3	15.9	-
F	4.3	Loam	15-20	7.2	0.40	3.4	14.0	-
G	4.1	Loam	15-20	7.5	0.50	3.8	16.1	1.9
H	4.2	Loam	15-20	7.4	0.90	4.3	18.1	-
I	6.8	Sandy Loam	10-15	7.4	0.35	3.9	14.5	-
J	6.3	Loam	10-15	7.3	0.90	3.5	17.0	-
K	3.6	Loam	10-15	6.6	0.50	3.8	13.2	-
L	4.0	Loam	12-15	7.7	0.60	3.7	14.1	2.3
M	4.1	Loam	12-15	6.8	0.90	3.5	14.9	-
N	4.1	Sandy Loam	10-15	7.4	0.30	5.0	16.6	-
O/P	13.8	Sandy Loam	15-20	7.0	0.40	4.1	14.6	-
Q	2.5	Sandy Loam	5-10	8.3	0.50	4.9	16.6	3.6
R	8.6	Loam	15-20	8.0	0.45	4.1	14.2	2.5

Present Practices

Now that we know what we have we can go about managing our soil to obtain its greatest potential. We began by changing how, when, and what types of fertilizer we used. When one management practice is changed it begins to affect many other areas, which in turn will need attention and is all part of fine tuning the operation.

Once we knew the physical properties of our soil we were able to look at the chemical properties. We concentrated our efforts in 5 areas, nitrogen, phosphorus, potassium, organic matter, and pH. (table 2)

Table 2. Macronutrient Levels in Management Units at Big Sioux Nursery

Management Unit	Total N [1/] (%)	P (ppm)	K (ppm)	Ca	Mg
A	-	22	105	15.4	5.2
B	-	23	86	15.1	4.3
C	-	20	109	17.0	3.7
D	-	14	90	15.3	4.7
E	-	13	109	13.5	4.3
F	-	15	105	12.0	3.8
G	-	12	117	14.2	4.1
H	-	22	94	14.8	4.4
I	-	5	51	12.1	3.7
J	-	9	82	13.2	3.7
K	-	21	86	10.3	3.0
L	-	14	78	13.1	3.5
M	-	21	74	10.2	3.0
N	-	8	66	15.9	4.4
O/P	-	5	59	11.4	3.4
Q	-	6	82	28.5	4.2
R	-	3	59	14.4	3.3
Recommended Ranges:		20-50	100-150	2.5-5.0	1.0-2.0

We do not test for nitrogen because the standard test is not a good indicator of what is available for the plants because of the many organic and inorganic forms of nitrogen in the soil. Secondly, the available nitrogen forms are very transient in the soil and can be lost to leaching.

Prior to having a management plan, nitrogen was applied 1 or 2 times a year in the form of ammonium nitrate (34-0-0). We now use ammonium sulfate (21-0-0) at the rate of 150 lbs. of actual nitrogen per acre divided into 5 or 6 applications per year. (table 3)

Table 3. Yearly Fertilizer Program for Big Sioux Nursery

Fertilizer	Analysis	Nutrients Supplied	Application Procedure		
			Rates/Acre	Timing	Method
1. Ammonium sulfate	21-0-0	21% N 24% S	720 lbs at 120 lbs/app'n	6 app'n/yr	top-dressing
2. Concentrated superphosphate	0-46-0	46% P_2O_5	178-478 lbs.[1/]	once in fallow year	incorporation
3. Potassium sulfate	0-0-54	54% K_2O 18% S	53-493 1bs.[1/]	once before sowing	incorporation
4. Sequestrene 138 iron chelate	0-0-0	6% Fe	48-72 lbs.	once before sowing	incorporation

Phosphorus and potassium levels at the Big Sioux were below the recommended levels in all management units. They were higher in the areas that were under cultivation showing us that the native soils were low in both chemicals. To determine the amount that is needed, we had the soil tested and then determined how much was needed by computing the difference between the soil Phosphorus and Potassium level and the recommended range. Since the tests are calculated in ppm we have to convert the ppm to lbs. per acre. At this time you must convert the P to $P_2 0_5$ and K to $K_2 0$ because these are forms in which the fertilizers are rated. Then you must figure in the % analysis, concentrated superphosphate (0-46-0) contains 46% $P_2 0_5$, so you will need to divide by .46 to get the actual rate needed. The recommendation for the Big Sioux nursery was to use triple superphosphate (0-45-0) because of it's high analysis and low gypsum content. Phosphorus is not mobile in the soil, so we try to incorporate the phosphorus into the plow layer during the fallow year or prior to sowing.

Potassium sulfate (0-0-54) is used also for its high analysis, low cost, and acidifying affect on the soil. We incorporate this just prior to seeding. (Landis 1983) In the beginning we had to apply large amount of phosphorus and potassium but in the last few years the amounts have been very minimal. We try to have at least the areas just coming out of production soil tested. We usually take our soil samples in October and have them analyzed at Oregon State University in Corvalis, Oregon.

Organic Matter

The next area of treatment is in maintaining the organic content of our soils. We do this in a couple of ways. We use Piper sudan grass as a cover crop. We sow this in the spring on all areas that will be out of tree production for the year. We will allow this to grow about 3 to 4 ft. and then cut it and stack it for later use as a mulch over the seedbeds. With irrigation we try to get at least 3 cuttings a year. After the final cutting the areas are left until spring to help cut down on winter erosion. In the spring we will then disc these areas and plant. The second way in which we add organic material is by leaving as much as possible of the mulch from the beds in the pathways. This has been very effective plus it cuts down on the weeds in the pathways. By fall this material has deteriorated enough where it causes no problems in the tree lifting operation.

As stated earlier we are also trying to lower the pH of our soils. This management has been done by unit, taking into consideration the planned use for that unit. Since 1983 we have dropped the pH from 8.3 to 6.5 in unit C. Other units have not been as dramatic, but have had reductions of .3 to 1.0 over the years. However, as the land is utilized and concentrated in one area more than another, we will notice the pH gradually start to increase. Again at this time we have concentrated our efforts on the highest pH ground and mainly in areas where the conifers are planted. The present strategy is to apply prills of sulfur at about 800 lbs. per acre during the beginning of the fallow year. We have experimented with liquid sulfur directly over newly planted seedbeds of pine and spruce to get a quicker acidification. At this time we have not determined whether this was effective or not.

Conclusion

By having a detailed soil management plan and being able to follow it we do not see the nutrient deficiencies, the beds are more uniform, and now that most of the blocks are in the recommended ranges we are not using as much fertilizer. Historically the nursery raised pine, eastern red cedar and Rocky Mt. juniper as a 3-0 seedling. Now we have consistently produced them in 2 years. We are also looking at cutting a year of production on several other species. To try to keep on top of our fertility we try to do soil tests on a yearly basis especially on those areas just coming out of tree production. By soil sampling and testing on a yearly basis we are able to track each block and are able to determine where we need more work. This has taken a lot of the guess work out of fertilizing and has enabled us to fine tune our operation.

Literature Cited

Landis, Thomas D. 1983. Soil Management Plan for Big Sioux Nursery, South Dakota Division of Forestry.

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