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Timber Volumes of Old Pennsylvania Surface Mine Reclamation Plantations

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Abstract. Surface mine reclamation plantings established in Pennsylvania from 1919 to 1934 were evaluated to determine merchantable volume, presence and volume of volunteer species, and soil development since planting. The evaluation showed that planted conifers had a total volume of 744 M bm on the 150 acres of reclaimed surface mines. In addition, there were 356 M bm of volunteer hardwood species on the area. Examination of soil profiles showed development of distinct soil horizons in all the plantations.

Pennsylvania bituminous coal operators have been practicing reclamation of surface mines for many decades. There were no legal requirements before 1945 to reclaim or replant lands disturbed by the mining activities, but individuals who had a "feeling" for the land practiced reclamation. The Bituminous Coal Open Pit Conservation Act in 1945 imposed specific reclamation requirements on coal operators.

Unfortunately, many of the old plantings were not documented, and we cannot reconstruct their history. In a few instances, there is documentation, and the growth and development of the plantations can be evaluated. The oldest known documented reclamation plantings include 22 plantations established by the Morris Run Coal Mining Company in Tioga County, Pennsylvania, from 1919 to 1938. The documentation consisted of maps subdivided into 22 lots; dates when each lot was planted; and number of seedlings, by species, planted in each lot. The lots ranged from 3 to 13 acres with a total area of 180 acres. Species planted were: jack pine (*Pinus banksiana*), pitch pine (*P. rigida*), eastern white pine (*P. strobus*), red pine (*P. resinosa*), Scotch pine (*P. sylvestris*), Norway spurce (*Picea abies*), and Japanese larch (*Larix leptolepis*). All seedlings were planted at a 4- x 4-foot spacing—2,600 seedlings per acre. The planting arrangement was not recorded in the mixed plantations. Observation, however, indicates that they were planted in multiple rows of a single species.

In March 1925, 18.4 acres of the plantations burned. This included lots 7, 8, 9, and 10. These lots were replanted in April 1925.

Plantation Evaluation

In the summer of 1979, we evaluated the Morris Run reclamation plantings. We made measurements and observations to determine: Volume per acre of planted species, species of volunteer vegetation, volume per acre of volunteer species, and soil development within the plantations.

We used the point-sampling system to inventory the planting sites. Point centers were located systematically in each plantation from a grid superimposed on a map of the area. The number of points in each plantation was based on the size of the plantation. Five points were established in plantations of 9 acres or smaller, and 10 points were established in plantations of 10 acres or larger. Tree counts were determined with a 10-factor wedge prism.

A volume table was made for each planted and volunteer species. Average dbh for each merchantable height class was measured from sample trees in each plantation. Volume was determined for each height class from standing tree volume tables. International 1/4-inch rule was used.

Basal area values were calculated and separated into planted versus volunteer species and merchantable versus nonmerchantable trees by species.

Visual soil evaluations were made on 19 sites. A 3-foot soil pit was dug at each sample site and the soil profile was examined. An emphasis was placed on the litter layers and "A" horizon. Observations were recorded on topography, slope, overstory, and understory.

Table 1.—Total merchantable volumes of planted species, in thousand board feet,[a] by plantation number, age and size

Number	Age (years)	Size (acres)	Norway spruce	Jack pine	Pitch pine	White pine	Scotch pine	Red pine
1	60	4	5.1	14.3	(b)	—	—	—
2	59	4	11.2	—	—	25.5	—	—
3	59	6	9.2	10.0	(b)	24.6	—	—
4	58	4	30.8	—	—	—	—	—
5	58	8	—	—	—	65.1	—	—
6	57	4	—	—	—	23.4	—	—
7	54	3	—	—	—	17.9	—	—
8	54	3	—	—	1.8	15.6	—	—
9	54	9	—	—	0.6	10.8	23.4	—
10	54	4	—	—	—	—	7.4	3.1
11	53	11	—	—	—	—	48.9	—
12	52	11	—	—	—	—	29.5	—
13	51	11	—	—	—	—	28.1	—
14	50	11	—	—	—	—	54.9	—
15	49	13	—	—	—	—	20.1	—
16	48	11	—	—	—	—	18.1	—
17	47	11	—	—	—	—	—	28.2
18	46	11	—	—	—	—	—	128.8
19	45	11	—	—	—	—	—	86.6
	Totals	150	56.3	24.3	2.4	182.9	230.4	246.7

[a]International 1/4-inch rule.
[b]Planted, but not recorded in cruise data.

Table 2.—Total merchantable volumes of volunteer species in thousand board feet,[a] by plantation number and size

Number	Size (acres)	Black cherry	Sugar maple	Red maple	Beech	Aspen
1	4	5.5	0.8	—	—	—
2	4	12.2	—	—	—	3.0
3	6	13.6	—	—	—	1.6
4	4	6.6	—	1.4	—	0.2
5	8	13.3	—	—	—	3.7
6	4	2.6	0.7	0.2	—	3.2
7	3	5.3	—	—	—	0.4
8	3	13.4	—	—	—	—
9	9	21.5	—	—	—	2.8
10	4	3.2	—	—	—	1.8
11	11	12.2	2.8	5.3	—	6.0
12	11	16.0	—	8.5	—	5.7
13	11	29.7	6.4	2.5	—	0.7
14	11	22.7	—	4.4	—	0.3
15	13	20.9	1.6	5.1	3.8	0.9
16	11	18.3	7.8	16.8	0.4	2.4
17	11	10.5	2.9	6.6	—	3.1
18	11	5.5	—	—	—	1.0
19	11	3.7	1.0	1.1	—	1.3
Totals	150	236.7	24.0	51.9	4.2	38.1

[a]International 1/4-inch rule.

Results

Human error and human activities in the planted areas influenced the evaluations slightly. Three of the twenty-two plantations were not delineated on the map. Attempts to locate the three plantations—youngest listed—on the ground were unsuccessful. Thus, the data are from 19 plantations that are 46 to 61 years old and total 150 acres.

Two plantations documented as white pine were actually Scotch pine. It was assumed that the planting dates were correct.

In several of the lots, there was evidence of logging activity. Examination of the stumps and logging debris indicated that harvesting was confined to volunteer hardwood species. No attempt was made to estimate the volume lost due to the harvest operations. Thus, the volumes are low for the volunteer hardwoods.

Volume per Acre of Planted Species

There was a wide range between plantations in the per acre volumes of planted species. Jack pine gave the highest volume, 10,567 board feet per acre. Red pine, though only included in the younger plantations, had 7,364 board feet per acre. White pine, Scotch pine, and Norway spruce volumes were 4,284, 4,577, and 4,688 board feet per acre, respectively. Pitch pine had the poorest volume with only 262 board feet per acre.

Species of Volunteer Vegetation

Volunteer species were recorded in all plantations. The volunteer species included: black cherry (*Prunus serotina*), red maple (*Acer rubrum*), sugar maple (*A. saccharum*), aspen (*Populus sp.*), and beech (*Fagus grandifolia*). Black cherry outnumbered the other volunteer species by about two to one. On four sites, the merchantable volume of black cherry was greater than or nearly equal to, that of the planted species.

Volume per Acre of Volunteer Species

The following data were recorded for volunteer species. Black cherry grew in all of the plantations; average volume was 1,606 board feet per acre. Aspen, the second most common volunteer species, grew in 17 of the 19 plantations; average volume was 271 board feet per acre. Sugar maple grew in 8 plantations and red maple in 10. Their volumes were 327 and 592 board feet per acre, respectively. Beech volume was less than 200 board feet per acre in the two plantations where it was recorded.

A summary of the cruise data shows a total merchantable volume of 1,100,000 board feet of timber on the 150 acres of reclaimed surface mines. Of this total, 744,000 board feet was from planted species and 356,000 board feet was from volunteer species. In addition, the cruise data show an average of 131 square feet per acre of basal area for all species. This includes 17 square feet per acre of less than merchantable-size planted species and 15 square feet per acre of less than merchantable-size volunteer species. Tables 1 and 2 summarize the merchantable volumes of planted and volunteer species. Tables 3 and 4 summarize the basal area data on planted and volunteer species.

Table 3.—Basal area per acre of planted species, in square feet, (merchantable size versus unmerchantable size) by plantation number

Number	Norway spruce	Jack pine	Pitch pine	White pine	Scotch pine	Red pine
1	22/28	34/2	[a]	—	—	—
2	18/25	—	—	33/6	—	—
3	10/2	11/4	[a]	23/3	—	—
4	52/34	—	—	—	—	—
5	—	—	—	55/16	—	—
6	—	—	—	46/34	—	—
7	—	—	—	44/36	—	—
8	—	—	5/2	29/25	—	—
9	—	—	1/0	6/6	16/5	—
10	—	—	—	—	23/10	10/2
11	—	—	—	—	55/12	—
12	—	—	—	—	33/17	—
13	—	—	—	—	33/10	—
14	—	—	—	—	63/15	—
15	—	—	—	—	26/7	—
16	—	—	—	—	22/20	—
17	—	—	—	—	—	26/4
18	—	—	—	—	—	133/24
19	—	—	—	—	—	92/34

[a]Planted, but not recorded in cruise data.

Table 4.—Basal area per acre of volunteer species, in square feet, (merchantable size versus unmerchantable size) by plantation number

Number	Black cherry	Sugar maple	Red maple	Beech	Aspen
1	56/0	2/0	—	—	0/4
2	15/3	—	—	—	4/0
3	14/1	—	—	—	2/0
4	9/4	0/1	2/0	—	1/0
5	12/0	—	—	—	3/1
6	3/0	3/1	1/0	—	5/1
7	12/6	—	—	—	1/4
8	25/3	—	—	—	—
9	14/2	—	—	—	2/3
10	11/12	—	—	—	5/2
11	15/5	3/0	8/13	—	6/2
12	15/3	—	12/12	—	5/2
13	29/1	—	5/3	—	5/1
14	23/9	—	8/4	—	1/3
15	21/13	4/6	7/3	3/1	1/3
16	17/5	10/14	21/5	1/0	2/1
17	11/7	6/17	9/12	—	5/2
18	7/4	—	—	—	3/7
19	8/8	3/8	2/4	—	1/6

Soil Development

A soil pit was dug in each plantation to examine and evaluate soil development of the mine spoils. Litter depth and the horizons of the profile were measured. Litter depths ranged from 0.75 inch to 3 inches. In 90 percent of the sample points, the depth was 2 inches or less; A and B horizons were measurable at all 19 sample points. Evidence of leaching, identified by streaking or color changes, was used to delineate the horizons. In many instances, the definition between horizons was only faintly expressed. Nevertheless, the presence of measurable litter and of faint horizons shows that soil profiles are developing under the plantations. At two sample locations, development of a hardpan was noted below the B horizons. At another location an accumulation of clay was recorded in the B horizon. This might be another hardpan developing. Identifiable topsoil was recorded in the lower horizons at only one location. Table 5 shows the measurements as taken in the field evaluations.

Ground cover evaluations were different in both type and density between lots. Types of ground cover included: ferns, mosses, grasses, annual weeds, woody shrubs, and small hardwood seedlings. There was a slight correlation between density of ground cover and litter depth. As density increased, litter decreased. There were more grasses, annual weeds, and woody plants in plantations with high proportions of volunteer hardwood tree species. Ferns and mosses were more common in the dense conifer plantations.

Discussion

The evaluation of old reclamation plantings on Tioga County surface mine spoils clearly demonstrates the potential of minesoil as a forest site. Most of the planted species have attained merchantable sizes and volumes per acre large enough to make commercial harvests.

Pitch pine was the only species that was not found on all the lots where it was planted. Over 3,000 pitch pine seedlings were planted in 1919 and 1920. None were recorded in the cruises of the plantations. A few pitch pine were recorded in the plantations that had burned.

A comparison of timber volumes on Tioga County minesoils with those in plantations established on old fields in western Pennsylvania shows that the minesoils have intermediate productivity. Grisez (1968) reported on growth and development of 37 plantations, 3 of which contained conifers; the plantations ranged from 39 to 54 years old. The western Pennsylvania plantations included the same species as those in the Tioga County plantings. Mean annual increment in board feet for the old field plantings ranged from 0 to 394 (two plantations failed). On the minesoils, the range of mean annual increment in board feet was 32 to 254. Because of age differences and differences in evaluation procedures, other comparisons would not be meaningful. However, the annual increments showed that growth on minesoils was within the range of growth achieved on undisturbed soil.

Table 5.—Soil profile measurements, in inches, by plantation number

Number	Horizon						
	0_1	0_2	A_1	A_2	B_1	B_2	B_3
1	1.50	0.25	0.25	0.50	1.25	5.00	9.00
2	1.25	0.75	1.50	3.50	1.50	5.00	—[a]
3	1.50	1.00	0.50	1.00	1.50	4.50	3.00
4	0.50	0.25	0.50	2.25	—	4.50	4.00
5	1.00	0.50	1.00	0.75	1.25	4.50	—
6	1.00	0.50	0.50	1.25	—	3.50	3.00
7	0.75	0.25	0.75	1.25	1.25	1.75	4.50
8	1.25	0.50	0.75	0.75	—	4.50	4.25
9	1.50	0.50	1.00	2.50	1.50	4.25	3.00
10	1.00	0.50	0.75	0.50	—	5.50	3.00
11	1.50	0.50	1.00	2.00	—	3.50	2.50
12	1.00	0.50	1.00	0.50	—	7.00	5.50
13	1.00	0.25	1.00	1.75	—	5.00	3.25
14	1.25	0.25	1.25	2.25	—	3.50	2.50
15	1.00	0.25	0.50	1.25	—	3.50	3.25
16	0.75	0.25	1.00	1.00	—	9.00	3.00
17	0.50	0.25	0.50	—	—	2.50	3.50
18	2.50	0.50	0.75	—	—	3.75	3.50
19	1.50	0.50	0.50	1.50	1.50	4.50	3.00

[a]Dash indicates horizon not well defined or absent in profile.

Invasion of the plantations by volunteer hardwood species, especially black cherry and sugar maple, is an indication that the site is capable of supporting more demanding hardwood species.

The accuracy of the cruise data and reported volumes of hardwood species was reduced due to logging activity in the plantations. Nevertheless, the recorded data show a substantial amount of merchantable volume plus a large quantity of growing stock.

It is not realistic to compare these growth data with those on more recent minesoil plantings because the coal stripping operations in early 1900 were considerably different from current practices.

Less overburden was removed in early 1900 and probably resulted in less toxic spoil material. The area mined was relatively flat; thus, spoils were nearly level—0 to 5 percent slope. Use of smaller equipment resulted in less compaction. Also, smaller acreages were disturbed and this allowed for prompt reforestation. Finally, there were no herbaceous plantings which would have reduced survival and growth of the tree seedlings.

If toxic materials are segregated and buried in the bottoms of the strip pits; if extreme compaction is avoided when replacing surface layers of spoil materials; and if tree plantations are established by using techniques to reduce competition from herbaceous cover plantings, future plantations may be equally successful.

Literature Cited

Grisez, Ted J. Growth and development of older plantations in northwestern Pennsylvania. 1968; USDA For. Serv. Res. Pap. NE-104. 40 p.

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