United States
Department of
Agriculture

Forest Service

North Central
Forest Experiment
Station

Research Note NC-350
1989

Rotation Length and Repeated Harvesting Influence *Populus* Coppice Production

Terry Strong

ABSTRACT.--A coppice and a first-rotation stand of hybrid poplar barely differed in biomass yields beyond age 4. Repeated harvesting of coppice stands under short rotation reduced yields.

KEY WORDS: Biomass, short-rotation, mortality, sprouting vigor, stump height.

Maintaining productivity over multiple cutting cycles is fundamental to short-rotation coppice forestry. The independent effects of rotation length and repeated harvesting on coppice yields have been documented in several studies (Anderson 1979, Harrington and DeBell 1984, Heilman and Peabody 1981). However, we do not know the combined effects of rotation length and repeated harvesting on coppice yields. Consequently, I monitored *Populus* growth and yield of coppice stands at various rotation lengths and compared these with yields from a non-coppiced stand.

METHODS

A plantation of hybrid *Populus* clone NE-299 (*P. betulifolia* x *P. trichocarpa*) grown at 0.6 by 1.2 m spacing was harvested when 3 years old. After this cut, the plantation was separated into 12 blocks, which each contained 63 stumps including a 15-tree core measurement plot. One of six harvest rotations (1-5 and 7 years) was assigned to each block. Each harvest rotation was replicated twice. The plantation was irrigated to keep the soil moisture tension below 0.7 bar, fertilized annually with 110 kg N/ha, and weeded when necessary.

At the end of the prescribed rotation in a particular block, the coppice was cut at 10 cm above the ground in late November or December. Height and diameter (d.b.h.) of the dominant sprout on each stump were measured, and mortality and the number of sprouts taller than 1.37 m were recorded. Sprouts from each stump were dried and weighed to the nearest 0.01 gm, and the combined weight of sprouts from all harvested stumps within a block was extrapolated to estimate biomass production per hectare.

I began this study after the first-rotation stand had been harvested, so the first-rotation yield data were not available. Therefore, in this study, coppice yields are compared to first-rotation yields from a similar stand (same clone, slightly higher density, located about 100 m from the coppiced stand).

RESULTS

Comparison of First- and Second-rotation Yield for a 7-year Harvest Cycle

Early yield in the second-rotation stand was much higher than early yield in the first-rotation stand (table 1). However, the difference in yield between first- and second-rotation stands decreased with increasing age. For example, the biomass yield in the first-rotation stand after 2 years was only 30 percent of the biomass yield in the second-rotation stand (4.4 mg/ha compared to 14.9 mg/ha). But, after 7 years the biomass yield in the first-rotation stand was greater than the biomass yield in the second-rotation stand at the same age (70.8 mg/ha

TERRY STRONG is a Research Forester with the North Central Forest Experiment Station, Rhinelander, WI.

Table 1.--*Comparison of first- and second-rotation growth and yield for a 7-year harvest cycle*

Tree age (years)	Rotation					
	First			Second		
	D.b.h.	Biomass	Stem/ha	D.b.h.	Biomass	Stem/ha
	cm	*mg/ha*		*cm*	*mg/ha*	
1	-	-	-	1.0	5.4	121,100
2	1.0	4.4	21,100	1.8	14.9	55,200
3	2.5	17.5	21,100	2.9	23.7	50,200
4	3.6	35.8	20,100	3.8	33.7	26,900
5	4.5	50.6	17,300	4.8	57.9	22,600
7	6.2	70.8	9,102	5.2	58.6	17,940

compared to 58.6 mg/ha). Even after 4 years the biomass yield in the first-rotation stand slightly exceeded the biomass yield in the second-rotation stand. Yield differences between stands after 4 years probably are not significant in this study.

The second-rotation stand was much more productive than the first-rotation stand at age 2 partially because the stems were larger, but mostly because there were more stems/ha (55,200 stems/ha compared to 21,100 stems/ha) (table 1). Because the number of stems/ha dropped more than 50 percent from the first to the second year in the second-rotation stand, productivity differences between the first- and second-rotation stands would have been even greater at age 1.

Although the productivity of the second-rotation stand was greater than that of the first-rotation stand in the early years, it appears that stand productivity differences at this spacing become negligible as the stands age. Both stands are approaching peak mean annual increment and have about the same productivity after 5 years (10.1 mg/ha/yr for the first-rotation stand and 11.6 mg/ha/yr for the second-rotation stand). Because average annual yields peaked at about age 5 in the second-rotation stand, harvesting on shorter rotations (1 to 4 years) would reduce productivity. Superior production in longer rotation coppice stands has also been reported for black cottonwood by Heilman and Peabody (1981), for a *Populus deltoides* hybrid by Laundrie and Berbee (1972), and for sycamore by Steinbeck and Brown (1976).

Effects of Repeated Harvests on Coppice Growth and Yield

Stump mortality increased with each subsequent harvest cycle except for the first two harvests at the 1-year cycle (table 2). Mortality was 94 percent after five rotations of a 1-year cycle and four rotations of a 2-year cycle. Mortality was lower in the third rotation of the 3-year cycle (30 percent). Harrington and DeBell (1984) and Jacobs (1955) also found increases in stump mortality with successive coppice cutting, and Heilman *et al.* (1972) found greater mortality in high density, short-rotation coppice stands. Stump mortality increased with repeated harvests; average height and diameter of the dominant sprout and the average number of sprouts per surviving stump decreased with repeated harvests on the 1- and 2-year cycles (table 3). Height and diameter of the dominant sprout also decreased with repeated harvest in the 3-year cycle, but the number of surviving sprouts per stump increased. Because of greater stump mortality and reduced growth, total biomass yields after 6 years from shorter coppice cycles were much less than from longer cycles (10.3 mg/ha for the 1-year cycle, 18.1 mg/ha for the 2-year cycle, 39.9 mg/ha for the 3-year cycle, and 57.9 mg/ha for the 5-year cycle). Also, average annual production increased with longer harvest cycles until age 7 when average annual production dropped (3.4 mg/ha/yr to 6.6 mg/ha/yr for 6 years in the 1-year harvest cycle and 3-year harvest cycle, respectively, 11.6 mg/ha/yr for 5 years in the 5-year harvest cycle, and 8.4 mg/ha/yr for 7 years in the 7-year harvest cycle) (table 3).

Table 2.--*Effects of repeated harvesting on stump mortality*
(In percent)

Rotation	Harvest cycle				
	1-year	2-year	3-year	5-year	7-year
First	0	0	0	0	0
Second	0	3	7	20	20
Third	0	47	30	-	-
Fourth	33	94	-	-	-
Fifth	94	-	-	-	-

The "wood grass" concept of maintaining high yield plantations on very short rotations probably would not work with this clone. Although the second-rotation stand appears as productive as the first-rotation stand for the longest observed harvest cycles, yields were dramatically reduced with the third- and fourth-rotations at shorter harvest cycles. If coppice plantations are to be established, clones should be selected that produce high coppice yields in addition to high first-rotation yields.

The large increase in stump mortality with subsequent harvests is puzzling because productive cutting orchards have been maintained with some clones for more than 10 years. Some researchers attributed similar increases in mortality without obvious disease symptoms to reductions in soil fertility (Wenger 1953, Poskin 1949), early stump senescence (Kormanik *et al.* 1973), poor rootstock (Steinbeck and Nwoboshi 1980), or change in sprouting from axillary and suppressed buds to adventitious buds (DeBell and Alford 1972).

DeBell and Alford (1972) found that sprouts in second-rotation stands originated from axillary and suppressed buds while sprouts in third-rotation stands and beyond originated from adventitious buds. The latter sprouts are usually less vigorous, take longer to develop, and are more prone to breakage than sprouts originating from suppressed buds. DeBell and Alford suggest that leaving a small portion of newer growth with each subsequent harvest may allow resprouting from suppressed buds rather than from adventitious buds. In this study I cut off all the new growth. If I had cut higher with each subsequent harvest, perhaps enough axillary and suppressed buds would have been present to maintain vigorous sprouting. If this is true, machinery with adjustable cutting heads will need to be developed to leave enough new growth to maintain a productive coppice stand.

CONCLUSIONS

1. Second-rotation yields were similar to first-rotation yields in a 5-year harvest cycle.
2. Multiple short-rotation harvests continuously decreased yields over 6 years.
3. Research is needed to identify good coppicing clones and to determine how to avoid the large increase in mortality with multiple harvests.

LITERATURE CITED

Anderson, H.W. 1979. **Time-related variation in the performance of hybrid cottonwood mini-rotation as influenced by spacing and rotation length.** In: Annual meeting North American Poplar Council; 1979 August, Thompsonville, MI: p. 35-45.

Harrington, C.A.; DeBell, D.S. 1984. **Effects of irrigation, pulp mill sludge, and repeated coppicing on growth and yield of black cottonwood and red alder.** Canadian Journal of Forest Research. 14: 844-849.

DeBell, D.S.; Alford, L.T. 1972. **Sprouting characteristics and cutting practices evaluated for cottonwood**. Tree Planters' Notes. 23: 1-3.

Table 3.--*Effects of repeated harvesting on coppice growth and yield*

Rotation	Dominant sprout Height	Dominant sprout D.b.h.	Sprouts	Biomass	Mean annual increment
	m	*cm*	*Number*	*mg/ha*	*mg/ha/yr*
		1-Year Harvest Cycle			
Second	2.7	1.0	9	5.4	5.4
Third	2.3	.8	9	3.6	3.6
Fourth	1.9	.5	5	1.3	1.3
Fifth	*				
Total				10.3	3.4
		2-Year Harvest Cycle			
Second	3.7	1.8	7	14.9	7.5
Third	2.7	1.1	4	2.5	1.2
Fourth	2.0	.9	3	.7	.3
Total				18.1	3.0
		3-Year Harvest Cycle			
Second	5.8	2.9	4	23.7	7.9
Third	3.8	2.0	8	16.2	5.4
Total				39.9	6.6
		5-Year Harvest Cycle			
Second	6.9	4.8	2	57.9	11.6
		7-year Harvest Cycle			
Second	7.8	5.2	2	58.6	8.4

* Almost all stumps had died by the fourth year of the 1-year harvest cycle. Biomass accumulation for the fifth and sixth rotations of the 1-year cycle is considered 0.0 because of the high mortality.

Heilman, P.E.; Peabody, D.V., Jr. 1981. **Effect of harvest cycle and spacing on productivity of black cottonwood in intensive culture**. Canadian Journal of Forest Research. 11: 118-123.

Heilman, P.E.; Peabody, D.V., Jr.; DeBell, D.S.; Strand, R.F. 1972. **A test of closed spaced, short rotation culture of black cottonwood.** Canadian Journal of Forest Research. 2: 456-459.

Jacobs, M.R. 1955. **Growth habits of the Eucalypts**. Canaberra, Australia: Forest Timber Bureau.

Kormanik, P.P.; Tyre, F.L.; Belanger, R.P. 1973. **A case history of two short-rotation coppice plantations of sycamore on southern piedmont bottomlands.** IN: Young, H.E., ed. IUFRO biomass studies; Orono, ME: University of Maine, College of Life Science and Agriculture: 351-360.

Laundrie, J.F.; Berbee, J.G. 1972. **High yields of kraft pulp from rapid growth of hybrid poplar trees.** Res. Note FPL-186. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 23 p.

Poskin, A. 1949. **Traite de sylviculture.** Gembloux, Librairie Agricola: 392-420.

Steinbeck, K.; Brown, C.L. 1976. **Yield and utilization of hardwood fiber grown on short rotations.** Appl. Polymer Symp. 28: 393-401.

Steinbeck, K.; Nwoboshi, L.C. 1980. **Rootstock mass of coppiced *Plantanus occidentalis* as affected by spacing and rotation length.** Forest Science. 26: 545-547.

Wenger, K.F. 1953. **The sprouting of sweetgum in relation to season of cutting and carbohydrate content.** Plant Physiology. 28: 35-49.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1989—755-115/91