IMPACTS OF HARVESTING BOTTOMLAND HARDWOODS[1/]

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Abstract--Forest managers can design harvests to minimize adverse bottomland forest site impacts and ensure that a productive stand develops. Management decisions that maximize bottomland hardwood productivity begin with a survey of the existing stand and soils. They delimit options such as stand improvement or regeneration. In either option the equipment chosen, the season of harvest, the control of residuals, and the layout of skid trails must be carefully considered to minimize loss of site productivity during the logging process.

Keywords: wetlands, regeneration, biomass

INTRODUCTION

The typical southern bottomland hardwood stand is dominated by low quality trees resulting from repeated, incomplete harvests. The practice of selective cutting and diameter-limit cuts (custom cutting) have been favored, largely due to short-term economic advantages. It is now known that for each tree harvested advanced-age, undesirable, shade-tolerant stems are released. It is rare when trees of acceptable species and quality fill the voids created during selective harvests.

The key to obtaining sufficient levels of natural hardwood regeneration is a comprehensive survey of the stand. Information needed includes condition and size-class distribution of overstory trees, quantity and condition of understory trees, including advance reproduction, seed crop and seed bed conditions.

STAND SURVEY

The decision to harvest must be based on a combination of biologic and economic factors. Based on yield and economics stands older than 40 years and having basal areas of $9m^2\ ha^{-1}$ or less of desirable trees should be considered for harvest and regeneration.

Estimates of gross per-hectare stumpage from fully stocked bottomland sites are presented in Table 1. Precise values can only be determined on a per-stand basis because of the variation in stocking and site conditions. Although some sites may contain many high-value stems, their total net worth may be low when the cost associated with logging the stumpage is considered. The total costs of operating bottomland harvesting systems is characteristically high and logging may become prohibitive when stocking of the stand drops below a specified threshold. Many of the poorly stocked stands are occupying space that could be converted to productive high-value timber, but the current economic situation often dictates that stands remain in an unproductive state.

REGENERATION

Most of the valuable hardwood species on bottomlands are intolerant to moderately shade-tolerant and are best regenerated naturally by an even-aged system. Research has shown that clearcutting combined with control of all nonmerchantable stems and in the absencce of site degradation results in abundant new seedlings, root and stump sprouts, and released advance regeneration. Table 2, provides early regeneraton counts and oak stocking for biological clearcuts for a variety of bottomland site types. For the above studies, regeneraton was abundant and consisted of commercially valuable species for timber and mast. Throughout all studies, residual control treatments increased the percentage of shade-intermediate and shade-intolerant species and increased height

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Table 1. Yields from even-aged Southeastern bottomland hardwood site types.

Site Type Age	Cumulative Yields: Basal Area (m^2/ha)	Total Height (m)	Pulpwood (m^3/ha)[2/]	Sawtimber Stacked Solid
Muck Swamp				
20 years	23.3	16.1	109.4	25.1
40 years	32.5	17.7	172.5	54.2
60 years	47.6	22.2	267.7	196.5
Red River				
20 years	19.0	18.6	110.5	17.1
40 years	26.1	20.4	151.1	77.1
60 years	36.9	21.6	211.2	210.7
Black River				
20 years	12.9	16.8	74.2	15.5
40 years	33.0	19.8	168.8	93.4
60 years	42.8	21.3	210.8	236.5
Branch				
20 years	18.8	18.6	98.3	21.3
40 years	28.2	19.5	157.7	75.1
60 years	34.3	20.7	172.8	110.4

1/ Assume 1 ft^3 = 5.5 bdft., International 1/4" Rule, 1 cord = 80 ft^3

Table 2. Regeneration following complete clearcutting

Site Type	Number of stems/hectare: Year 1 All Species	Year 1 Oak	Year 5 All Species	Year 5 Oaks
Wet Flat	17601	3861	14202	5560
Red River Bottom	23312	3087	13587	2319
Muck Swamp I	6669	62	6862	170
Muck Swamp II	17907	4169	8721	3320
Branch Bottom	8645	926	30010	2779
Piedmont Bottom	51870	1188	12226	72

growth compared with plots having nonmerchantable residuals. Chainsawing or shearing of residuals always resulted in stimulated sprout reproduction, while chemical residual control resulted in a stand dominated by seedlings (Wolgemuth and Lea, 1986).

On some very fertile bottomland hardwood sites, hard mast species do not readily regenerate themselves following clearcutting. This phenomenon is especially common on the major and minor bottomlands associated with the Mississippi River (Gottschalk, 1983; Johnson, 1979; Merritt, 1979). The key to successful oak establishment is the presence of oak advance regeneration in numbers and sizes that can outcompete the intolerants upon release. Manipulation of overstory light, underplanting or seeding prior to canopy removal has been demonstrated with success (Kennedy and Johnson, 1984). Seed tree and selection cuttings are very difficult to successfully apply due to the critical timing of each stage of canopy removal (Sander, 1980; Johnson and Krinard, 1983; Loftis, 1983).

BIOMASS REMOVAL

An efficient way to renovate poorly stocked stands is by utilizing the entire stand. Huge volumes of nonmerchantable residual stems and tops are often left on the site following conventional harvests. For example, a study in a productive cypress-tupelo stand in the Mobile River Delta with a preharvest basal area of 74 m^2 ha^{-1} produced over 48 Mg ha^{-1} (dry) of slash following a stem-only conventional harvest with residuals felled. Such slash volumes represent a valuable biomass source, but the feasibility of handling this material is frequently uneconomical. In the above study, approximately 10% of the residual slash was found in twigs less than 2.5 cm and most was less than 20 cm in diameter.

Whole-tree chipping operations are commonly practiced by corporations that have the need for biomass for power generation or that have the capability to digest the chips for paper manufacture. Whole-tree chipping provides excellent utillization and a biological clearcut in a single operation. Table 3 has biomass, caloric and nutrient yield estimates for fully-stocked, river bottomlands in the Southeast. The distribution and temporal variation of biomass and nutrients in the overstory have important management implications. Inclusion of crown biomass in a whole-tree harvest will increase dry weight yields 30 to 40 percent; however, nutrient removals are considerably greater with total utilization because of the relatively nutrient-rich foliage, twigs and small branches. For example, in the 40-year-old stands, 160, 120 and 95 percent more N, P, K, respectively, was removed in whole-tree compared to bole harvesting. Inclusion of saplings in a whole-tree harvest would further drain nutrients.

The inherent fertility of most bottomland hardwood sites makes them particularly suitable for intense forest production. However, stand nutrient distributions and accumlation patterns indicate a potential for removal of large quantities of nutrients if harvesting is complete and rotations are short.

Table 3. Dry weight, energy and nutrient contents of site pools in the river bottomland hardwood type

Age	Pulpwood-Sawtimber: Foliage	Branches	Bole 1/	Saplings	Understory-Ground Veg	Forest Floor	Above-Soil Total 2/	Soil 3/
	Dry Weight (Mg/ha)							
10	-	-	-	42.6	3.2	10.6	56.4	-
20	1.8	27.4	84.9	27.1	0.9	2.1	144.2	-
40	5.2	56.0	144.2	9.0	2.9	5.0	222.3	-
60	6.2	50.4	164.0	15.9	1.5	7.5	245.5	-
	Energy Content ($Kcal X 10^6$/ha)							
10	14.0	-	-	183.3	14.6	38.2	250.1	-
20	10.5	133.2	390.5	136.0	4.0	21.4	697.4	-
40	21.3	270.8	673.0	54.3	13.4	18.2	1051.0	-
60	25.1	179.0	774.4	86.2	3.9	16.9	1086.2	-
	(kg/ha)							
	Nitrogen							
10	-	-	-	141	17	115	273	-
20	25	54	79	42	11	18	229	-
40	101	158	160	20	19	56	514	-
60	93	162	186	36	10	59	546	-
	Phosphorus							
10	-	-	-	23	3	12	38	15
20	6	8	12	6	1	2	35	84
40	9	26	29	3	3	5	75	20
60	7	31	22	4	2	6	72	21
	Potassium							
10	-	-	-	110	9	53	172	63
20	15	39	96	35	4	5	194	313
40	44	115	168	13	19	22	381	119
60	45	116	232	27	6	17	443	170
	Calcium							
10	-	-	-	140	23	23	186	1989
20	19	97	170	103	7	16	412	2895
40	78	317	261	38	6	37	737	2230
60	66	321	734	71	14	91	1297	1636
	Magnesium							
10	-	-	-	21	3	21	49	288
20	8	14	33	13	1	5	74	332
40	16	47	35	5	5	8	116	339
60	22	61	28	14	2	13	140	231

1/ To 10 cm diameter outside bark. Values include stemwood and bark.
2/ Includes standing dead material
3/ Available P and exchangeable K, Ca and Mg in top 30 cm.

SOIL IMPACTS

Because of the increased demand for wood, especially with the extended utilization of hardwood, harvesting operations have become more mechanized. The interface between soil and harvesting equipment has become increasingly important. Components of a typical harvesting system include tree felling, in woods transportation, processsing at landing, loading, and transport to the final destination. Woods traffic resulting from harvesting equipment and skidders can impact soil properties and influence stand regeneration success and continuous site productivity.

Compaction of forest soils has been a matter of concern to foresters, equipment manufacturers and researchers for several years (Hassan, 1978; Miles, 1978; Sidle and Drlica, 1981; Greene, et al., 1983; Koger, et al., 1982; Froehlich, 1978; Froehlich, et al., 1981; Greacen Shoulders and Terry, 1978). Soil compaction causes serious productivity losses in wet

climates and regions where frost penetration does not occur or is less than 15 cm such as in the southeastern hardwood forests. Miles (1978) demonstrated that increases in soil bulk density from traficcing was greater for wet than dry soils. He concluded that heavy surface compaction could be reduced by operating equipment during the dry season. Soil compaction was also affected by the number of passes of the traction device, with the greatest rate of change in bulk density in the first three to five passes (Froelich, et al., 1981; Sidle and Drlica, 1981). Similarly, Koger and co-workers (1982) related soil compaction to vehicle slip percentage rather than tire size or inflation pressure.

Froehlich and co-workers 1981 found when logging, that when skid trials are restricted to 10% or less of the harvested stand that the the area of compacted soil could be reduced by at least two-thirds. Similarly Mellgren and Heidersdorf (1984) reported that use of high-flotation tires for forestry operations in wet soil improved vehicle performance, reduced site disturbance, improved regeneration by resulting in less soil compaction, and increased operating productivity by about 60%.

The blame for much of the damage to bottomland soils is typically placed with logging contractors and their employees. However, the accountability should rest with the land manager since his duties include planning and supervising of the sale. A responsible manager concentrates skidding on the better-drained soils to prevent disturbance of natural drainageways and streams. If fragile soils must be traversed amelioration of productivity can frequently be accomplished through tillage and fertilization. Managers should be cognizant to use equipment within its operational limitations and properly match it with site conditions. Rutting should be avoided or contained within landings and skid trails. A poorly timed harvesting operation under high soil moisture can cause soil deformation and result in elevated bulk density which ultimately impedes root regeneration and penetration, aeration and water infiltration.

OTHER CONSIDERATIONS

To minimize adverse effects of forest entry on coupled ecosystems and nontimber resources, forest Best Management Practices (BMP) should be mosaics within the watershed. The functional diversity driving successional landscape patterns can be artificially elevated by considering five basic elements: habitat diversity, interspersion, ecotones, coverts and juxtaposition (Harris, 1984). When these spatial elements are utilized in forest management, cumulative effects of management practices can be "softened" on coupled ecosystems and the nontimber resources fully enhanced.

Forestry's immediate challenge is to develop BMP guidelines which will effectively control activities so as to minimize cumulative impacts while minding the direct impacts. As bottomland forest managers, we must be knowledgeable of both natural and man's environmental influences which simultaneously act on the watershed.

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