LONG-TERM EFFECTS OF WETLAND HARVESTING PRACTICES ON PRODUCTIVITY AND CARBON POOLS

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Forested wetlands are valued for social and ecological benefits including filtering sediments, uptake of nutrients, carbon storage, reduction of flood depths, protection of shorelines and streambanks, and provision of terrestrial and aquatic wildlife habitat (Walbridge 1993, Kellison and Young 1997, Brady and Weil 2002). Although the importance of wetland functions are recognized, few studies examine long-term recovery rates of ecosystem functions such as forest productivity, sediment trapping, and carbon storage following disturbances in forested wetlands (Aust et al. 2006). Timber harvesting is an important commercial activity in forested wetlands and harvests have been common in US wetlands for centuries (Stine 2008). Harvest disturbances have in some instances been shown to have short-term negative consequences on site productivity, water quality, and carbon storage, but long-term patterns and relationships are uncertain.

Due to the paucity of long-term information, the primary goals of this study are to quantify the long-term effects of different harvest disturbances on two major wetland functions: productivity and carbon storage. This study evaluated the effects of three harvest related disturbances that were originally applied in 1986 to a tupelo (Nyssa aquatic)-cypress (Taxodium distichum) forested wetland in the Mobile-Tensaw River Delta of southwestern Alabama. The three original disturbances were 1. helicopter harvest (HELI), 2. skidder simulation where 50% of the site was rutted to a depth of 30 cm (SKID), and 3. helicopter harvest followed by glyphosate herbicide removal of all sprouts and seedbank regeneration for two years following harvest (GLYPH). A nearby mature area within the same original stand represented mature forest or reference conditions (REF). Above- and below-ground plant biomass, below-ground woody debris, soil carbon, soil deposition rates, and soil CO_2 efflux rates were measured in this study. Additional information regarding treatments and ecosystem recovery during the first 16 years was summarized by Aust et al. (2006).

Twenty four years after disturbances were applied, forest above-ground biomass and carbon levels were higher in areas disturbed by ground based SKID (77.1 Mg C ha^{-1}) as opposed to the HELI removals (55.7 Mg C ha^{-1}, Table 1). These results correspond with earlier trends following disturbance and are explained by the SKID trafficking effects on soil water, aeration and microtopography and species on the site. The original impact on soil conditions within the SKID treatments apparently reduced survival of competing species while favoring the tupelo coppice and the changed microtopography increased the heterogeneity of soil aeration. Below-ground biomass (to a depth of 60 cm) and carbon levels were also found to be greater in the SKID disturbance (12.8 Mg C ha^{-1}, Table 1). The below-ground carbon storage was primarily attributable to increased roots linked to the above-ground biomass. Non-root related soil carbon levels were not found to be significantly different for the disturbance treatments. Total soil CO_2 efflux measurements indicated that SKID treatments were releasing the least carbon (8.9 µM CO_2 m^{-2} s^{-1}) while GLYP treatments are releasing the most (12.8 µM CO_2 m^{-2} s^{-1}, Table 1). GLYPH disturbances originally created herbaceous dominated freshwater marsh, which has reverted to a low-density early succession forested wetland with a large herbaceous component (1021 stems ha^{-1} and 1.4 Mg C ha^{-1} of herbaceous vegetation, Table 1). This herbaceous vegetation and associated fine root turnover in GLYPH is contributing to annual root turnover and decay in the soil. Total forest carbon estimate SKID treatments are holding the most total carbon with 206.1 Mg C ha^{-1} while HELI and GLYPH treatments are holding 168.7 and 144.2 Mg C ha^{-1} respectively (Table 1). REF areas are currently holding 332.6 Mg C ha^{-1} (Table 1).

Overall, current long-term patterns of ecosystem above- and below-ground productivity and carbon storage indicate that harvest disturbances were relatively transitory in this ecosystem. Ecosystem biomass and carbon patterns of HELI

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and SKID are becoming more similar to the original site conditions represented by the REF areas. The resiliency of these highly disturbed treatments are explained by the frequent inputs of non-compacted, nutrient-rich sediments, presence of species that are well adapted to very poorly drained and aerated conditions, high rates of coppice regeneration, and the increase of microtopography within SKID treatments.

LITERATURE CITED

Aust, W. M., T.C. Fristoe, P.A. Gellerstedt, L.A.B. Giese, and M. Miwa, 2006. Long-term effects of helicopter and ground-based skidding of site properties and stand growth in a tupelo-cypress wetland. Forest Ecology and Management 226, 72-79.

Brady, N.C., and R.R. Weil, 2002. The Nature and Properties of Soil. 13th ed. Prentice Hall, NJ.

Kellison, R.C., and M.J. Young, 1997. The bottomland hardwood forest of the southern United States. Forest Ecology and Management 90, 101-115.

Stine, J.K., 2008. America's Forested Wetlands: From wasteland to valued resource, 1st ed. Forest History Society, NC.

Walbridge, M.R., 1993. Functions and values of forested wetlands in the southern United States. Journal of Forestry 91 (5), 15-19.

Table 1—Total forest C measurements by harvesting treatment and pool (significance determined using alpha = 0.05). SKID = Skidder simulation treatment, HELI = helicopter logged treatment, GLYPH = glyphosate treatment, and REF = reference area

	Treatment			
Measurement	**SKID**	**HELI**	**GLYPH**	**REF**
Above-ground C Pools (Mg C ha^{-1})				
Overstory ($p < 0.001$)	73.9 b	52.8 c	26.4 d	209.4 a
Lower Story ($p < 0.001$)	3.0 a	2.6 a	0.5 b	0.1 b
Herbaceous ($p < 0.001$)	0.2 bc	0.3 b	1.4 a	0.2 c
Total	77.1 (33.0%)	55.7 (33.1%)	28.3 (19.6%)	209.7 (63.0%)
Below-ground C Pools to a depth of 60 cm (Mg C ha^{-1})				
Roots	12.9	6.9	7.0	10.8
Buried Debris	12.5	8.2	13.8	11.2
Soil C	103.6	97.9	95.1	100.9
Total	129.0 (62.6%)	113.0 (67.0%)	115.9 (80.4%)	122.9 (37.0%)