SEDIMENT AND NUTRIENT ACCUMULATION IN FLOODPLAIN AND DEPRESSIONAL CYPRESS-GUM FOREST SOILS OF SOUTHWESTERN GEORGIA

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Abstract. Historical (125 yr, ^{210}Pb) and recent (30 yr, ^{137}Cs) rates of sediment and nutrient (C, N, P) accumulation were measured in open (floodplain) and closed (depressional) cypress-gum wetland soils to evaluate the effects of changing land use on nutrient, carbon and sediment retention. Over the past 125 yr, rates of sediment (1420 g/m^2/yr), C (78 g/m^2/yr), N (6.1 g/m^2/yr) and P (0.58 g/m^2/yr) accumulation were two to ten times higher in the floodplain forests as compared to the depressional wetlands (144 g sediment /m^2/yr, 46 g C/m^2/yr, 3.2 g N/m^2/yr, 0.22 g P/m^2/yr). In the depressional wetlands, there was no difference in sediment and nutrient accumulation during the past 30 years versus the past 125 years. However, in the floodplain forests, sediment and nutrient accumulation during the past 100 years were five to ten times higher as compared to the past 30 years. Higher historical rates of sediment, C, N and P accumulation in the floodplain forests probably reflect widespread land clearing for agriculture and grazing in southwestern Georgia during the late 19th and early 20th century.

INTRODUCTION

Freshwater wetlands are sinks for sediment and nutrients (N, P, organic C) on the landscape (Mitsch and Gosselink 1993, Craft and Richardson 1998). Floodplain and riparian wetlands are open ecosystems, receiving most of their water and nutrients from inundation by surface runoff from the regional watershed. These wetlands sequester large amounts of sediment and P and serve as sources of organic C to ecosystems downstream (Brinson et al. 1981). In contrast, depressional wetlands receive most of their water and nutrients from precipitation. Because of their small catchment area, these wetlands typically remove less sediment and P as compared to floodplain and riparian wetlands (Hopkinson 1992).

We compared recent (30 yr) and historical (125 yr) rates of sediment, organic C, N and P accumulation in three floodplain and three depressional cypress-gum wetlands of southwestern Georgia to evaluate the effects of changing land use during past 150 years. Since 1850, southwestern Georgia has seen a shift from an agrarian landscape dominated by livestock grazing and numerous labor intensive small farms to a landscape dominated by fewer, larger farms utilizing technology intensive center pivot irrigation of row crops (Baker County Historical Society 1991).

METHODS

The study was conducted at the Joseph W. Jones Ecological Research Center - Ichauway in Baker County, Georgia. Three floodplain wetlands, dominated by bald cypress (*Taxodium distichum*) and flood tolerant hardwoods, were sampled along Ichawaynochaway Creek, a 5th order black-water coastal plain stream with a watershed of 2600 km^2 (Stokes and MacFarlane 1988). The floodplain forests are characterized by episodic inundation, particularly during widespread, heavy rains in the winter. Three depressional wetlands, dominated by pond cypress (*Taxodium ascendens*) and black gum (*Nyssa sylvatica var. biflora*) also were sampled. The size of the depressional wetland catchments range from 1-10 km^2. The hydrology of the depressional wetlands is characterized by continuous seasonal inundation, beginning in late autumn or early winter and continuing into the spring (Golladay et al. 1997).

In each wetland, one soil core (8.5 cm diameter by 30 cm deep) was collected from the wetland interior. In the lab, the cores were sectioned into 2 cm depth increments. The increments were dried to calculate bulk density, then ground and sieved through a 2 mm mesh diameter screen.

Soil samples were analyzed for ^{137}Cs, ^{210}Pb, organic C and total N and P. Rates of recent (30 yr) and historical (125 yr) vertical soil accretion were determined by measuring ^{137}Cs and ^{210}Pb, respectively, using gamma spectrometry (Craft and Richardson 1998). ^{137}Cs is an impulse marker produced by "bomb blast" fallout from aboveground thermonuclear weapons testing during the 1950's and 1960's (Ritchie and McHenry 1990). The location of the ^{137}Cs maxima in the soil corresponds to approximately 1964, the time of maximum deposition of fallout ^{137}Cs. ^{210}Pb is a naturally occurring radionuclide (half life 22 yr) produced by radioactive decay of uranium-238. The activity of ^{210}Pb with depth in the soil is used to calculate rates of accretion over the past 100-150 yr using the constant activity model (Schleske et al. 1988). Soil depth increments were analyzed for total N, P and organic C as described by Craft and Richardson (1998).

RESULTS AND DISCUSSION

Total ^{210}Pb decreased monotonically with depth (Fig. 1a), indicating that ^{210}Pb is an effective dating technique in our southwestern Georgia wetlands (Craft and Richardson 1998). Likewise, ^{137}Cs exhibited a pronounced maxima in most of our soil cores (Fig. 1c), indicating that the ^{137}Cs technique is a reliable means to estimate vertical accretion of our wetland soils (Craft and Richardson 1998). Mean rates of vertical accretion were 0.6-0.8 mm/yr in the depressional wetlands and 0.3-1.9 mm/yr in the floodplain forests (Table 1). Historical (125 yr) rates of accretion were higher than recent rates.

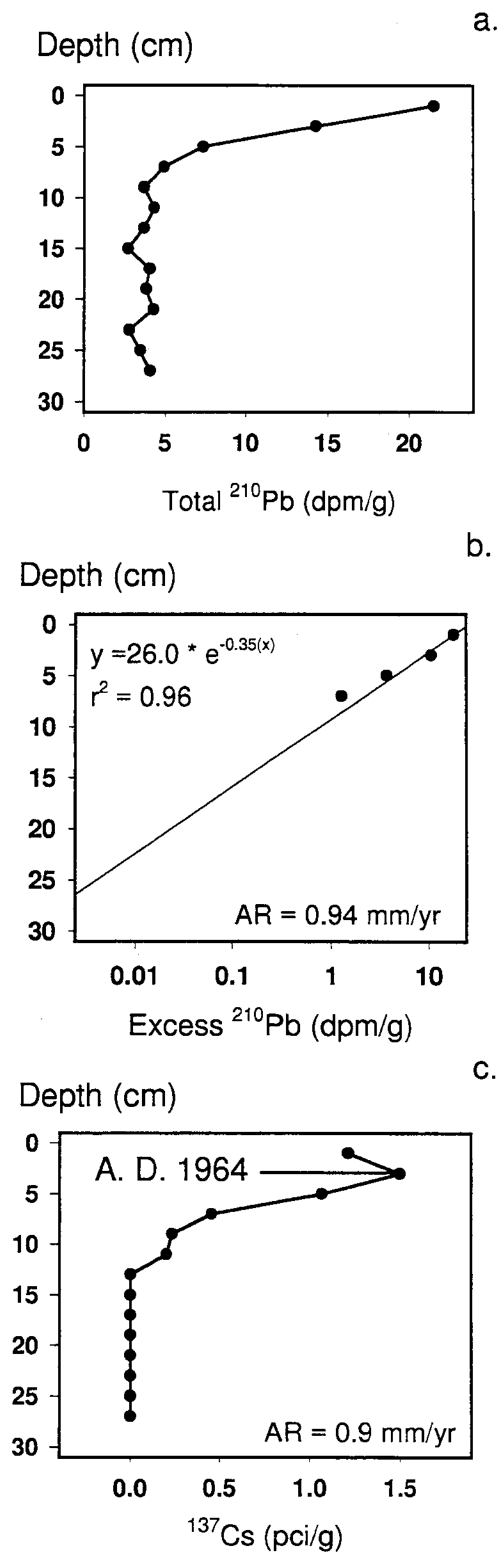

Figure 1. Depth distribution of (a) ^{137}Cs, (b) total ^{210}Pb and (c) excess ^{210}Pb in Predest Pond, a cypress-gum

Table 1. Mean (n=3) soil accretion rate (AR), bulk density, organic C, N and P (± 1 SE) of depressional and floodplain cypress-gum wetlands (0-30 cm depth).

	Depressional	Floodplain
AR (mm/yr)		
30 yr (^{137}Cs)	0.6 ± 0.30	0.3 ± 0.30
125 yr (^{210}Pb)	0.8 ± 0.20	1.9 ± 0.10
Bulk density (g/cm^3)	0.47 ± 0.01	0.96 ± 0.08
Organic C (%)	10.0 ± 1.3	4.1 ± 2.0
Nitrogen (%)	0.7 ± 0.1	0.3 ± 0.1
Phosphorus (ug/g)	720 ± 90	268 ± 100

Table 2. Mean 30 yr (^{137}Cs) and 125 yr (^{210}Pb) rates of sediment and organic C, N and P accumulation (± 1 SE) in depressional and floodplain cypress-gum wetland soils (n=3).

	Depressional		Floodplain	
	30 yr	125 yr	30 yr	125 yr
Sediment *(g/m^2/yr)*	64	100	84	1420
Organic C *(g/m^2/yr)*	31	46	13	78
Nitrogen *(g/m^2/yr)*	2.2	3.2	1.0	6.1
Phosphorus *(g/m^2/yr)*	0.12	0.22	0.09	0.58

Soil bulk density was higher and organic C, N and P were lower in the floodplain forests as compared to the depressional wetlands (Table 1). Higher bulk density and P concentrations in the floodplain forests likely represent greater deposition of mineral sediment and associated P during flooding. In the depressional wetlands, higher soil organic C and N are the result of increased organic matter accumulation in this low energy (non-alluvial) environment.

In both the floodplain and depressional wetlands, rates of sediment deposition and nutrient accumulation were higher since approximately 1875 (125 yr) as compared to the past 30 years (Table 2). In the floodplain forests, historical sediment deposition was ten times higher (1420 g/m^2/yr) and P accumulation was 6 times higher (0.58 g/m^2/yr) than in the recent past. Likewise, C and N accumulation were five to six times higher over the past 125 years as compared to the past 30 years (Table 2). In the depressional wetlands, historical rates of sediment and nutrient accumulation were only slightly higher than recent rates of accumulation (Table 2) and may reflect the low degree of disturbance of the local catchments during most of this century. The depressional wetlands are located on Ichauway, a 12,000 ha pine-wiregrass forest of mostly 60-80 year old trees which has been managed as a game (quail) reserve since 1930. Other than the use of prescribed fire (to maintain longleaf pine/quail habitat), Ichauway has not been actively managed for agriculture, which is in stark contrast to the intensive center pivot agriculture of southwestern Georgia.

Higher historical (125 yr) rates of sediment and nutrient accumulation, especially in the floodplain wetlands, likely was the result of widespread agriculture in the Ichawaynochaway Creek watershed during the late 1800's and early 1900's. During this time, there were twice as many people, seven times as many farms and two to three times as much livestock in Baker County (Table 3), a county representative of land-use in the watershed, as compared to 1980. Since 1920, the population of Baker County declined by half and the number of farms dwindled while the average farm size increased 10-fold (Table 3). The effects of widespread grazing and agriculture on stream water

Table 3. Demographic comparison of Baker County, Georgia in 1850, 1920 and 1980. From the Baker County Historical Society (1991)

	1850	1920	1980
Population	4985	8298	3808
Number of livestock [1]	58700	23400	17300 [2]
Number of farms	--	1407	178
Average farm size (acres)	--	86	860

[1] Sheep, hogs, milk cows and cattle.
[2] 1960 estimate.

quality (and increased wetland sediment and nutrient retention) likely were compounded by ignorance of best management practices (BMP's) (e.g. vegetated stream buffers, livestock exclusion from streams), for which there was little awareness or appreciation at that time.

SIGNIFICANCE TO WATER RESOURCES

Freshwater wetland soils offer a historical record of land use through their ability to trap sediment and sequester nutrients. The application of radiometric dating techniques (^{137}Cs and ^{210}Pb) to wetland soils and sediments enables one to qualitatively construct changes in land use (e.g. land clearing) and wetland/watershed water quality over the past century or more.

High historical (125 yr) rates of sediment deposition and nutrient accumulation in southwestern Georgia wetlands, especially in floodplain wetlands, reflects widespread agriculture without the use and benefits of BMP's in the late 1800's and early 1900's. The ability of floodplain and riparian wetlands to sequester sediment and P as well as their connectivity to regional watersheds dictates that these ecosystems be protected as a means to improve regional water quality.

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