

FLOODPLAINS, EQUILIBRIUM, AND FLUVIAL GEOMORPHIC IMPACTS OF HUMAN ALTERATIONS

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INTRODUCTION

Floodplains are commonly acknowledged, frequently flooded, fluvial/riparian features that occur along most alluvial streams. Although many definitions have been applied to this fluvial landform, the present paper defines a floodplain as: a flat to gently sloping alluvial surface that is inundated every one to three years by out-of-bank flooding, (Osterkamp and Hupp 1984). Floodplains achieve their greatest extent in North America on the Coastal Plain Physiographic Province, predominantly in southeastern United States. These floodplains typically are broad with low gradients that develop along meandering channels, many of which terminate downstream in tidal estuaries (Hupp 2000). Unlike floodplains that develop in relatively high gradient areas such as the Mid-Atlantic Piedmont where their extent may be limited (Walter and Merritts 2008), Coastal Plain systems develop broad bottomlands including floodplains that may regularly flood every year for prolonged periods. Several fluvial features may develop on these broad floodplains including relatively high elevation natural levees and low semi-permanently flooded backswamps. In southeastern United States, these floodplains are forested wetlands that support bottomland hardwood forests (Wharton et al. 1982, Sharitz and Mitsch 1993) along with bald cypress/tupelo swamps in low/wet areas. Floodplains with substantial hydrologic connection to streamflow may trap (riparian retention) large amounts of sediment and associated nutrients and other contaminants (Brinson 1988, Hupp et al. 1993, 2008, Noe and Hupp 2005, 2009). Unfortunately, these water quality functions or ecosystem services of floodplains may not apply where there has been widespread alteration of fluvial processes by human activity, e.g. dam construction, channelization, and concentrated land use (Sharitz and Mitsch 1993). In general, these alterations typically disrupt fluvial dynamic equilibrium (Hack 1960) such that the normal floodplain to streamflow connectivity may be decreased or increased (Hupp et al. 2009).

Human alterations to the landscape such as flow regulation through dam construction, land clearance with upland erosion and downstream aggradation, stream channelization, and canal and levee construction may lead to channel incision or filling and large changes in sediment supply conditions depending on the geomorphic setting. Most of the world's largest rivers have been dammed (Nilsson et al. 2005); the downstream impacts that most affect floodplain are typically severe reductions in peak stages, frequency and duration of over bank flows, and sediment transport, while simultaneously concentrating flows on mid- and low-bank slopes (Williams and Wolman 1984). Land clearance with upland erosion and downstream aggradation (legacy sedimentation dynamics, Jacobson and Coleman 1986, Pierce and King 2007) has led to channel and valley filling and sometimes-subsequent channelization. Additionally, stream channelization has been a common, albeit controversial, practice along many rivers in parts of the Coastal Plain (Simon and Hupp 1992, Hupp and Bazemore 1993) to reduce flooding and facilitate row-crop agriculture on floodplains; the impact on the riparian zone is a severe

reduction in overbank flow. Levee construction, particularly along the Mississippi River and large tributaries and distributaries has occurred over a long period and has had profound impacts (Mossa 1996, Biedenharn et al. 2000) on streamflow and sedimentation dynamics. In general, all of the aforementioned alterations heavily impact the connectivity of the floodplain to sediment-laden flood flow, either by reductions that compromise the trapping function of the ecosystem service or by anomalous increases that facilitate extreme sedimentation.

The purposes of the present paper include the description of floodplain sedimentation dynamics as part of equilibrated fluvial geomorphic processes and, alternatively, floodplain sedimentation dynamics in the face of human alterations to equilibrated systems. Human alterations considered in this report are flow regulation from dams, stream channelization, and levee and canal construction. We believe there are a few, linked common parameters (such as connectivity to streamflow) that better understanding may allow for an efficient approach to management.

DYNAMIC EQUILIBRIUM AND ECOSYSTEM SERVICE

Three important unifying concepts that may be parameterized include 1) hydraulic connectivity between streamflow and the floodplain, 2) spatially migrating impetuses/thresholds for rapid geomorphic change (migrating channel knickpoints), and perhaps most importantly, 3) dynamic equilibrium in fluvial systems. Dynamic equilibrium in geomorphology (Hack 1960) refers to the mutual adjustment of a catchment with its geologic underpinning and the streams that drain it such that a stream is capable of entraining, transporting, and storing the delivered sediment in fluvial landforms in a balanced fashion (typically no excessive net fluvial erosion or deposition, Fig. 1A). The concept of dynamic equilibrium offers a process oriented explanation for dramatic responses to human alterations and may also allow for prediction of the direction (erosion vs. deposition) and magnitude of the change. Equilibrium states with sustained characteristic fluvial landforms may occur on streams that maintain an erosional regime such steep mountain streams or on streams that maintain a sediment-storage regime such as most Coastal Plain streams (Fig. 1A); this equilibrium, by definition, is not static but dynamic. Streams that are not in dynamic equilibrium typically have been subjected to dramatic, usually rapid, regime shifts; this may happen naturally (e.g. earthquakes) or through human alteration, the subject of this paper.

Streams that have been affected by substantial human alteration usually exhibit an unstable regime shift (e.g. channel incision or severe aggradation). This instability normally initiates a complex but predictable sequence of process responses (Schumm and Parker 1973) back toward the original equilibrated state. Thus, an impetus for change following alteration (Hey 1979) may ensue at a site such as channel widening and filling following channel incision (Simon and Hupp 1992) or channel incision may follow severe floodplain aggradation (Pierce and King 2007). The magnitude of this impetus for change is likely governed by the severity of the alteration. However, like alteration, the impetus for change may attenuate either upstream or downstream or both of the area of greatest impact/alteration and move as a knick point in time and space.

Floodplain sedimentation dynamics, in particular riparian retention, are intimately associated with other water-quality components (Noe and Hupp, 2005; 2009) and provide for profound ecosystem services. The stream-floodplain flux and storage of macro nutrients (N and P), organic material (C), trace elements, and other contaminants that are mediated through sediment

dynamics (Fig. 1B) are likewise affected by these human alterations. Geomorphic analyses verify that riparian retention of sediment and associated material is a common fluvial process (Jacobson and Coleman 1986, Noe and Hupp 2005, Hupp et al. 2008), yet retention time of sediment and biogeochemical transformation (Noe and Hupp, 2009) during storage may be the most poorly understood, unquantified aspects of sediment (Hupp, 2000) and associated material budgets.

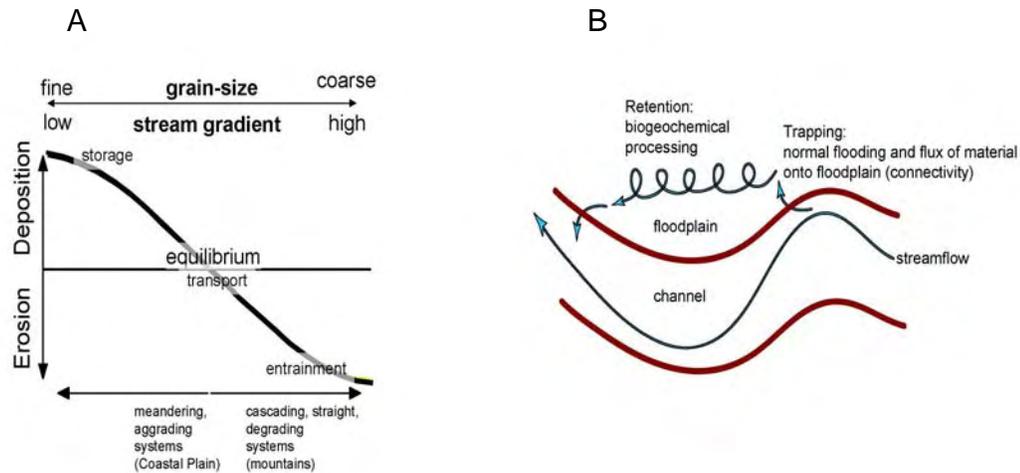


Figure 1. (A) Conceptual gradient of erosion and deposition in relation to channel gradient, sediment grain-size, channel pattern, and general physiography. The equilibrium area represents conditions where there is no significant net deposition or erosion. Most stream systems in equilibrium lie on either side of the equilibrium area. (B) Plan view diagram of generalized floodplain ecosystem services associated with riparian retention along streams in equilibrium.

HUMAN ALTERATIONS

The remainder of this paper will focus on a few studies of geomorphic processes and sediment and associated material deposition in systems that have suffered dramatic hydrologic alteration, including dam construction, stream channelization, and canal and levee construction. Fluvial geomorphic processes along Coastal Plain rivers in general (Hupp 2000) and forested wetland sediment deposition in specific (Kleiss 1996, Hupp et al. 2008) have received relatively little comprehensive study until the last two decades.

Dams

The downstream hydrogeomorphic effects of high dams have been documented for over 80 years (Lawson 1925, Petts and Gurnell 2005). Flow regulation often dramatically alters the regime of alluvial rivers through both confined water release scenarios that reduce the frequency and magnitude of high discharge events (Richter et al. 1996) and through substantial reductions in transported sediment below dams (Petts 1979, Williams and Wolman 1984, Church 1995, Brandt 2000). Channel beds and banks may undergo a wide range of adjustments to regulation

(Williams and Wolman 1984, Grant et al. 2003). Williams and Wolman (1984) suggest that certain aspects of regulated flow may decrease deposition including decreased sediment loads, decreased sediment delivery and storage, and channel degradation. Floodplains along regulated rivers are typically flooded much less frequently.

Few studies have documented, in detail, bank erosion along regulated Coastal Plain rivers (Ligon et al. 1995) and fewer with equally detailed floodplain sediment deposition information. Three high dams were completed along the Roanoke River, North Carolina, between 1953 and 1963. The largest of these forms the John H. Kerr Dam and Reservoir, which controls major water discharges downstream and is currently under evaluation through a Federal Section 216 study by the U.S. Army Corps of Engineers for flood control effects. One of the principal objectives of this study is to assess environmental and economic impacts downstream. Flood-control operations on the Roanoke River have had large impacts including the elimination of high-magnitude flooding and a greater frequency of both moderate and particularly low flow pulses.

Evidence of bank erosion along the lower Roanoke River is common where bank heights are substantial (> 2 meters), particularly along middle reaches. Net bank erosion (channel widening) was observed along most the river, while net deposition occurred on only 10 % of total reach (Hupp et al. 2009). This erosion exceeds that normally expected on an equilibrated channel and demonstrates the de-stabilizing effects of dams on channel geomorphology in downstream reaches (Grant et al. 2003). In general, erosion rates increased from the upstream reaches to the middle study reaches, and then diminished toward the downstream reaches (Fig. 2 A). Evidence of erosion may take the form of particle-by-particle erosion along straight and cut banks with concave upward profiles often leaving overhanging trees and shrubs, or mass wasting through bank failures that may carry large amounts of soil partly or completely down the bank slope (Hupp 1992). This material is subsequently entrained by flow and may form a large portion of the suspended sediment load that can be deposited on the floodplain downstream. Mass wasting, based on a bank erosion index (Hupp et al. 2009) also peaked in the middle reaches (Fig. 2A).

Entrainment of bank sediments may substantially increase stream water turbidity. Turbidity as measured by Secchi depths increased from near the dam toward the actively eroding middle reaches (Fig. 2A) and decreased slightly in the lowest reaches near brackish tidal water as is typical along Coastal Plain rivers (Hupp 2000). This trend in Secchi depth is expectedly and clearly inversely related to bank erosion (Fig. 2A). The water released from high dams is notoriously clear; suspended sediment is normally low or nonexistent as the reservoir is typically an effective sediment trap (Williams and Wolman 1984). Thus, suspended sediment in the Roanoke River downstream of the dams must come from tributary inputs or from erosion and entrainment of bed and bank sediments. Thus, with no tributary input, it is reasonable to assume that there is a direct relation between turbidity and channel erosion (Fig. 2A), most of which may be derived from the banks as noted in analogous situations by Simon and Hupp (1992).

The floodplain trapping of suspended sediment in forested wetlands is an important water-quality function. The floodplain along the lower Roanoke annually traps more than 2.5 million cubic meters of sediment (Hupp et al. 2009). Sediment deposition on floodplains increases dramatically and systematically from near the dam to the downstream reaches (Fig. 2B). This trend is expected given the general increases in bank erosion and mass wasting (Fig. 2A), at least

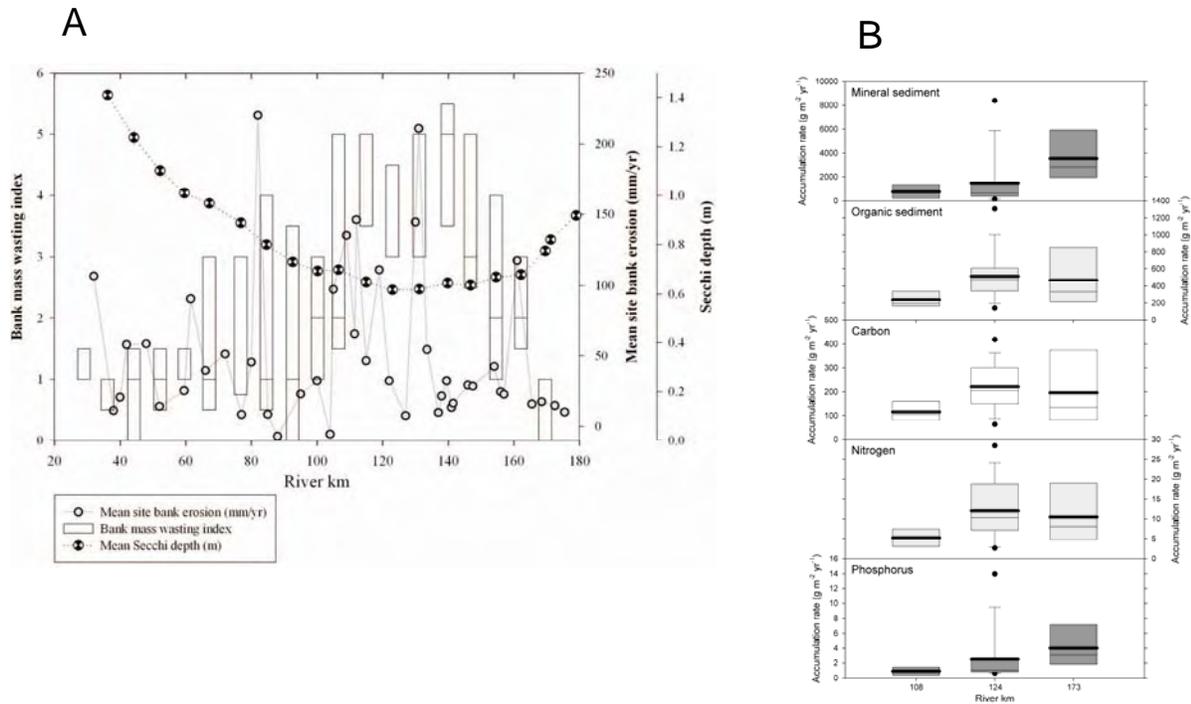


Figure 2. (A) Downstream trends in bank erosion, mass wasting, and turbidity along the lower Roanoke River. (B) Mineral and organic sediment, carbon, nitrogen, and phosphorus accumulation rates along three reaches of the lower Roanoke River.

to the middle reaches, which contributes to the sediment load and provides material for downstream deposition. Sediment budget analyses (Hupp et al. 2009) indicate that deposition substantially exceeds erosion in the lower Roanoke River, which may be substantiated in the reduction of turbidity in the downstream-most reaches (Fig. 2A). Thus, floodplain trapping removes most of the eroded sediment prior to flow reaching the Albemarle Sound and mitigates the erosional impact of the dams on estuarine ecosystems.

Sediment-associated nutrients expectedly follow similar trapping patterns as sediment. Nutrient accumulation rates, like sediment though not as pronounced, differed among the upper, middle, and lower floodplain reaches (Fig. 2B). Total sediment, mineral sediment, and phosphorus accumulation rates all increased from upper, to middle, to lower floodplain reaches, while organic sediment, carbon, and nitrogen accumulation rates were lowest along the upper reach compared to the similar middle and lower floodplain reaches (Fig. 2B). Along with sediment accretion rates, these patterns of sediment and sediment associated nutrient accumulation on the floodplain of the lower Roanoke River demonstrate that the role of the floodplain as a sink for sediment and nutrients has decreased immediately downstream of the dams

Long-term impacts of dam construction may compromise floodplain ecosystems services. Regulated flow (loss of flood peaks that build levees) may have forced most of the sediment and associated material trapping to occur in low, backswamp areas of the floodplain and not on the large natural levees along the lower Roanoke River, which ultimately may lead to a high floodplain with little to no topographic relief. As the floodplain surface rises in elevation relative to the widening channel, a negative feedback loop may develop such that the floodplain may trap

increasing less sediment over time. This situation appears to be in force along the river near the dam. These upper reaches have a wider channel (not the typical trend on alluvial rivers) and higher banks than downstream. The upper reach presumably began eroding soon after dam completion and presently the impetus for erosion has lessened locally and migrated downstream to the middle reaches; old though relatively stable remnants of slump blocks are still evident on upper reach banks. Also, regulated flow has likely increased bank erosion along most reaches including common straight reaches, which removes considerable critical riparian habitat.

Stream Channelization

Channelization is a common engineering practice aimed at controlling flooding and draining wetlands. Stream channelization in alluvial areas affects nearly all hydrogeomorphic forms and processes along, upstream, and downstream of the channelized reach (Simon and Hupp 1992). Many streams on the Coastal Plain of the U.S. have been channelized, which has affected fluvial-geomorphic processes at multiple spatial and temporal scales (Simon 1989, Shankman 1996).

Channelization increases stream power that facilitates sediment entrainment (erosion from bed and banks) and transport within the system (Happ et al. 1940, Shankman and Samson 1991). In the upper reaches of a channelized system, channel bank-failure and sediment transport typically occur. In contrast, lower reaches tend to accumulate large amounts of sediment because of decreased stream gradients and channel obstructions, such as debris jams, and slow water velocities facilitate deposition of the increased sediment load (Schumm et al. 1984, Simon and Hupp 1992). Over 260 km of West Tennessee streams were channelized; shortening them by 44%, lowering them by 170%, and increasing the stream gradient by 600% (Simon and Hupp 1992). The Obion-Forked Deer River system suffered considerable alterations while the impacts to the Hatchie River were restricted to its tributary system (Simon 1994); the mainstem Hatchie River is the only major river in West Tennessee largely unchannelized.

Channelization projects in West Tennessee lowered the bed level in stretches of the channels by as much as 5 m (Simon 1994) leading to headcutting and progressive degradation in upstream reaches. This degradation moved upstream of the limit of channel work at a rate of 2.6 km/yr on the South Fork Forked Deer River and resulted in approximately 2.6 m of incision from 1966 to 1967 (Simon 1994). Severe degradation occurred in all streams of that experienced bed-level lowering. Downstream reaches accumulated material eroded from upstream reaches. Deposition rates on downstream reaches of the Obion River ranged between 0.03 to 0.12 m/yr, while the South Fork Forked Deer River filled with 2.2 m of sediment over a 12-year period (Simon 1994).

Past land-use practices have led to erosion of the region's loess cap and have exposed and eroded the coarse alluvial sands that lie beneath the loess cap resulting in massive gully erosion (Happ et al. 1940, Hupp 1992, Saucier 1994). Historically, the high meandering rate and low gradient of the rivers did not allow for transport of the sand. However, channelization of all rivers in West Tennessee, except the main-stem of the Hatchie River, has greatly increased their stream power and facilitated sediment transport, resulting in dramatic geomorphic changes (Diehl 2000, Pierce and King 2007). Channel incision in the upper reaches of the channelized systems creates bank instability and continues to contribute a significant amount of sediment into the West Tennessee

stream systems. The accumulation of sediment in the lower reaches (Schumm et al. 1984) can lead to the formation of valley plugs (Happ et al. 1940, Diehl 2000, Pierce and King 2007).

Models have been developed to understand the geomorphic re-adjustments and recovery processes of channelized streams (Schumm et al. 1984, Simon and Hupp 1992). The Simon and Hupp model of channel predicts evolution/vegetation re-colonization following channelization. The final stages of this model involves aggradation and widening of the channel, leading to the recovery of both the vegetation and a meandering channel. Schumm et al. (1984) described similar stages and processes of channel recovery following channelization; however, their conceptual model of recovery includes all stages of recovery occurring simultaneously along the gradient of the channelized stream from the headwaters to the confluence with other streams. The aggradation and recovery stages of Simon and Hupp (1992) correspond to Schumm's low-gradient areas where the channel widens and becomes shallower because of accumulating sediment until the channel and banks become stabilized and quasi equilibrium may be attained.

Levee and Canal Construction

Many Coastal Plain floodplains are the last places for significant storage of riverine sediments and biogeochemical transformation of associated material before reaching saltwater and critical estuaries. Sediment accretion rates on these floodplains may be among the highest of any physiographic province in the U.S. (Hupp et al. 2008). Recent studies have shown that coastal lowlands may be an important sink for carbon (Ludwig 2001) and associated nutrients (Noe and Hupp 2005, 2009), which may be stored in these systems as organic rich sediment (nitrogen) or mineral sediment (in the case of phosphorus). This organic material presumably is from both autochthonous and allochthonous sources. Investigation of lowland fluvial systems may be critical towards our understanding of global carbon cycling, nutrient accumulation, and biogeochemical processes which in turn have direct implications for natural remediation, aquatic "dead zones", and global climate change (Hupp et al. 2008).

Over the past several decades the Atchafalaya Basin has experienced rapid and substantial amounts of sediment deposition. The entire suspended- and bed- sediment load of the Red River and as much as 35 percent of the suspended and a potential 60 percent of the bed sediment load of the Mississippi River (Mossa and Roberts 1990) is now diverted through the Atchafalaya Basin. Many open water areas in the Basin have now filled (Roberts et al. 1980, Tye and Coleman 1989, McManus 2002); regionally, the Basin provides a sharp contrast to most of the remaining Louisiana coastal area, which is sediment starved and experiences subsidence and coastal erosion. The Atchafalaya Basin is a complex of many meandering bayous and lakes that have been altered dramatically by natural processes and human impacts including channelization and levee construction for oil and gas exploration and transmission, timber extraction, flood control, and navigation (Hupp et al. 2008). The pervasive natural geomorphic process affecting the Basin is and has for the past few centuries been that of a prograding delta (Mississippi delta complex, Fisk 1952), which had filled much of the Basin by 1970 (Tye and Coleman 1989). The Grand Lake area, in the south, continues to fill as shown by rapid sedimentation in what was recently open lake. The Basin suffers simultaneously from exceptionally high sedimentation rates at sites with high connectivity to the main river and from hypoxia in stagnant areas with little connection to the main river.

Depositional patterns within the Basin vary and shed considerable light on understanding the factors that facilitate sedimentation (Figure 3A). Human intervention such as cutting new canals or plugging existing channels has resulted in highly altered flow paths that may conduct substantially more or less sediment-laden water than historically and in some cases have led to flow reversals depending on the flood stage (Hupp et al. 2008). Human alteration to flow can create unusual flow patterns. Levee sites that annually trap the least amount of sediment tend to be relatively high in elevation (short hydroperiod) and/or have a poor hydraulic connectivity to sediment-laden river water. Backswamp sites that have the highest rates of sediment deposition tend to be low in elevation and receive sediment-laden water (high connectivity) from two or more sources, which may create slow velocities through hydraulic damming (Fig. 3B, Hupp et al. 2008). The greatest percent organic material in the sediment tended to be in sites with low mineral-sediment deposition rates; this organic material is thus presumably autochthonous.

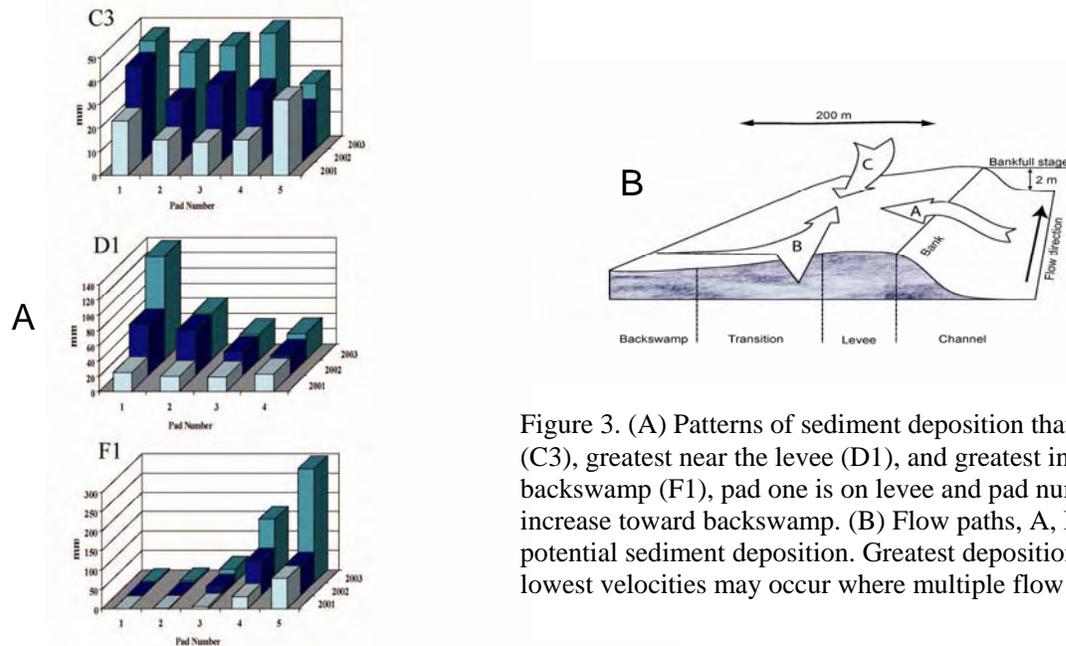


Figure 3. (A) Patterns of sediment deposition that are uniform (C3), greatest near the levee (D1), and greatest in the backswamp (F1), pad one is on levee and pad numbers increase toward backswamp. (B) Flow paths, A, B, C for potential sediment deposition. Greatest deposition and lowest velocities may occur where multiple flow paths meet.

However, in a few high-deposition rate sites organic material percents were also high, which suggests that some areas may be trapping large amounts of allochthonous organic material. High backswamp deposition rates are typically associated with sediment sources other than or in addition to the nearest channel (Fig. 3A and B).

The Atchafalaya Basin experiences some of the highest documented “normal” sedimentation rates in forested wetlands of the United States; some backswamp locations exceeded 110 mm/yr. Hupp et al. (2008) estimated an annual deposition of 13.4 kg/m² with a mean 12 % percent organic material trapped in the central part of the Basin; thus this area annually traps a net 6.72 million Mg of sediment, of which 820 thousand Mg are organic material. The annual sediment trapping rates of mineral and organic sediment in the Atchafalaya Basin correspond to 6.4·10⁸ kg

C/yr, $2.0 \cdot 10^7$ kg N/yr, and $7.5 \cdot 10^6$ kg P/yr, estimated using average floodplain sediment nutrient concentrations in mineral and organic sediments from other Coastal Plain floodplain studies (Noe and Hupp, 2005). These N and P accumulation rates represent 5% and 27%, respectively, of their annual loading rates to the Atchafalaya Basin (Goolsby et al. 2001). It should be noted that these are coarse estimates that do not account for movement of sediment within the Basin, separate autochthonous from allochthonous sources of nutrients, or account for long-term biogeochemical processing of nutrients in deposited sediments (Noe and Hupp 2005). The large amount of sediment in retention allows for important biogeochemical transformations that potentially reduce contaminant, nutrient, and carbon inputs into the Gulf of Mexico.

Human altered hydrologic patterns, from small scale opening or closing of single bayous to the diversion structure at the head of the basin on the Mississippi River, have increased severity of local non-equilibrium sedimentation patterns throughout the Basin. Although sediment trapping and aggradation are normal near the mouths of large alluvial rivers, hydrologic alterations have created areas with excessive deposition where there was once open water and conversely prevented river water from flowing in other areas that now experience periods of hypoxia. The impact of these alterations has been felt in the Basin for many decades, possibly as far back as the initial levee construction on the Mississippi River over 150 years ago. In addition to the ecosystem services the Atchafalaya provides, it serves as model for restoration of coastal areas where wetlands are receding, which as a wetland constructional process may provide for an important buffer in hurricane-prone areas.

SYNTHESIS

Fluvial geomorphic systems, by nature, tend to maintain a dynamic equilibrium among ambient sediment load, water discharge, and channel geometry (Osterkamp and Hedman 1977). Streams or reaches of streams are typically deemed “in equilibrium” when the stream and its hydro-geomorphic form and process are sufficiently (but not overly) competent to entrain, transport, and store the sediment provided by the associated catchment in a balanced fashion (Hack 1960). Equilibrium conditions may occur in a zone around the boundary between net erosion and deposition (Fig. 1A). For instance, streams in mountainous areas may have a naturally net erosion (entrainment) stream regime, while streams in the Coastal Plain tend to have a naturally net depositional (storage) stream regime (Hupp 2000). Streams in between these two geographic settings, such as the Piedmont, may have a sediment transport dominated regime as shown in the conceptual gradient of stream conditions (Fig. 1A). Sediment grain size, stream gradient, and channel pattern (meandering, cascading, and straight) may adjust along the conceptual gradient to maintain near equilibrium conditions. Human alteration within the catchment or along the stream that substantially alters one or more of these parameters may lead to disequilibrium conditions, in particular, stream gradient, which may initiate a period of pronounced adjustment and excessive erosion or deposition.

The hydraulic connectivity of a site (Fig. 1B) is critical to maintaining important ecosystem services of floodplains; many human alterations substantially affect this connectivity. Reduction of sediment load and confined discharges that result from dams may cause downstream reaches to be starved of sediment and facilitate channel erosion and bank failure. Channelization and levee construction affect fluvial systems in similar ways but are facilitated by increases in

channel gradient that affects flow velocity and erosion upstream, while downstream deposition may occur from constricted flow and high sediment loads. Loss of stream and floodplain connectivity in upper reaches and the reduced gradient of lower reaches force sediment and material trapping processes to move upstream (or downstream in the case of dams). As this process moves it represents geomorphic recovery of the system that may also reduce topographic relief and create relatively high floodplains with low internal relief. In other situations, the active floodplain may become restricted within highly incised banks reducing the original floodplain to terraces with little to no flooding, substantially reducing floodplain habitat. This negative feedback will reduce the sediment and material trapping function of the floodplain over time. The homogenized nature of floodplain surfaces may affect the hydroperiod, which, in turn, may affect nutrient loading and cycling with cascading negative effects on plants and wildlife.

Although human alterations to hydrology and geomorphology have had definitive impacts on floodplain ecosystems, the large Coastal Plain floodplains of the southeastern United States still have important functioning capacities to improve water quality. These systems annually accumulate very large amounts of mineral and organic sediment and its associated carbon, nitrogen, and phosphorus. Floodplain sedimentation rates are increased at some locations and decreased at other locations depending on the specific hydrogeomorphic alteration and setting. These trapping rates can translate into large percent retention of annual river loads (Noe and Hupp 2009). The C fluxes in the Atchafalaya and Roanoke floodplains, alone, represent about 1.3% of the total C sequestration of North American wetlands and about 14.6% of C sequestration by freshwater mineral wetlands in the conterminous U.S. as estimated by Bridgham et al. (2006), due in part to the high sedimentation rates observed in our focal systems. The high water quality and C sequestration functions of Coastal Plain floodplains suggests that natural resource managers should strive to protect these ecosystem services from the deleterious impacts of hydrogeomorphic alterations.

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