Headcuts and Their Effect on Freshwater Mussels

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Abstract. The mussels of the eastern tributaries of the Mississippi River south of the Yazoo River have been depleted, extirpated, or otherwise affected by headcuts. Channel modifications in the Mississippi River are implicated in the initiation or aggravation of the tributary degradation. The mining of point bars for gravel, and stream capture by overbank mines, can also result in upstream channel degradation, or headcuts. Such mining activites have eliminated or reduced the mussel fauna in portions of the Amite, Tangipahoa, Bogue Chitto, Buttahatchee, and Tombigbee rivers. Headcuts result in severe bank erosion, channel widening, and depth reduction. Since channel erosional stresses are greater during flood stage, such changes usually appear following seasonal flood periods and are often erroneously attributed to natural causes. The number of stream systems affected by headcutting and the extensive damage to local mussel populations are only now being understood.

Introduction

In recent years a number of papers have discussed the mechanics and processes of stream and river erosion as well as the impact of human activities on stream channel stability (e.g., Simons 1979, Whitten and Patrick 1981, Grisenger and Murphey 1982, Hey et al. 1982, Collinson and Lewin 1983, Smith and Patrick 1991). Stream erosion is part of the natural process of water seeking its base level. Changes in stream parameters such as base level, water slope, water or sediment discharge, or combinations thereof are usually accompanied and controlled by changes in meander form or other erosional processes that allow the channel to adjust and stabilize. When the natural dynamics of a stream are severely altered by localized human modification, the resulting channel adjustments can initiate extensive erosion throughout the system (Smith and Patrick 1991). Headcuts are the upstream progression of such erosion.

A stream that is actively, or that has been recently, headcut may be identified by combinations of the following characteristics: extensive bank erosion; wide, degraded channels; meander cutoffs; uniform, shallow flows; chute formation; numerous whole trees within the channel; quicksand, or otherwise loose, unstable sediments; perched tributaries at low water; and the absence of cypress and tupelo gum trees where these species are characteristic components of stable riparian ecosystems. Channel stabilization efforts around bridges (rip-rap), or bridge replacement, may also be the result of, or symptomatic of, severe channel degradation. Stream channels that have stabilized from past headcuts may no longer exhibit widespread or active bank erosion; they may, however, still be recognized by a combination of several of the characteristics listed above.

Hubbard et al. (in press) have summarized the available literature on the effects of channelization. The destructive effects on stream ecosystems include accelerated erosion; reduced depth; and loss of habitat diversity, substrate stability, and riparian canopy. The biological consequences include decreased species diversity, changes in species dominance, and decreases in biomass and growth in aquatic invertebrates and fish. Although headcutting streams exhibit similar changes in morphological and hydrological characteristics, there is only limited information on the biological consequences of this process. Hartfield and Ebert (1986) reported on the local decline of mussels in two southwestern Mississippi streams, Bayou Pierre and Homochitto River, apparently due to channel degradation. Ross et al. (1990) noted a relationship between a range extension for the bayou darter, *Etheostoma rubrum*, and channel erosion in Bayou Pierre, Mississippi.

The headcutting stream is increasingly becoming characteristic of southeastern lotic habitats where unconsolidated or weakly cemented sediments predominate. Over the past 10 years, I have observed the relationship between causes and progression of headcuts, stream degradation, and the decline or disappearance of freshwater mussels in several streams in Mississippi and Louisiana. As relatively immobile benthos, freshwater mussels are particularly vulnerable to channel degradation. The following is a synthesis of personal field notes, observations, and publications on headcuts that have occurred in certain southern streams. It is presented in order to encourage additional studies on this widespread phenomenon and the threat it presents to local mussels, as well as other components of fluvial and riparian communities.

Eastern Tributaries of the Mississippi River Below the Yazoo River

All major eastern tributaries of the Mississippi River below the Yazoo River are experiencing headcuts, or appear to have been severely degraded in the past. These include the Big Black, Bayou Pierre, Homochitto, and Buffalo rivers, and Coles and St. Catherine creeks (Figure 1). Flood control and navigation modifications to the Mississippi River have been implicated in the degradation of these streams. For example, bendway cutoffs shortened the river by 37.4 miles between the mouth of the Yazoo River and the Homochitto River and have resulted in local increases in slope and reductions in flood elevations in this reach of the Mississippi River (Winkley 1977). These changes may have contributed to tributary instability (Patrick 1989).

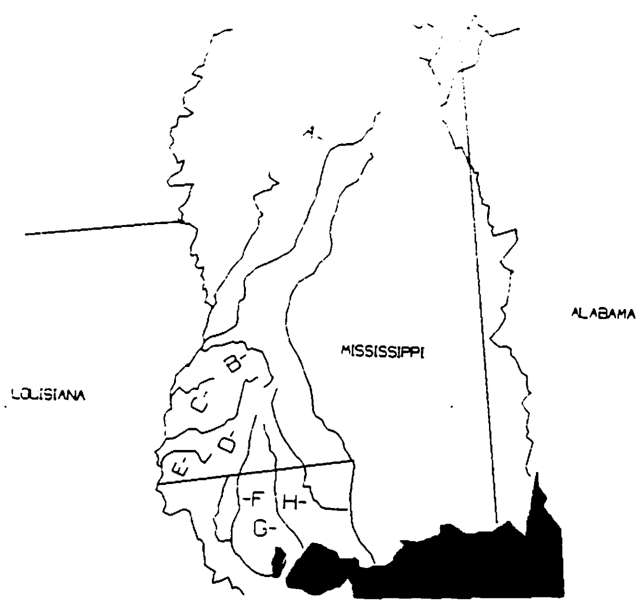

Figure 1. Drainages affected by headcuts. A: Big Black River, B: Bayou Pierre, C: Coles Creek, D: Homochitto River, E: Buffalo River, F: Amite River, G: Tangipahoa River, H: Bogue Chitto River, I: Buttahatchee River, J: Tombigbee River.

Hartfield and Cooper (1983), Hartfield and Rummel (1985), and Hartfield and Ebert (1986) provided records of 34 species of freshwater mussels from the lower Mississippi River drainages below the Yazoo River, including the Big Black River (29 species), Bayou Pierre (12 species), Homochitto River (8 species), Buffalo River (no mussels found), and Coles Creek (2 species) (Table 1). Hinkley

Table 1. Mussels from the eastern tributaries of the lower Mississippi River (1 = Yazoo; 2 = Big Black; 3 = Bayou Pierre; 4 = Homochitto; 5 = Coles Creek; FO = Fossil Record).

	Drainage				
Species	1	2	3	4	5
Actinonaias ligamentina	X				
Amblema plicata	X	X			
Anodonta grandis	X	X		X	
Anodonta imbecillis	X			X	
Anodonta suborbiculata	X				
Arcidens confragosus	X	X			
Cyprogenia aberti	FO				
Ellipsaria lineolata	X	X			
Elliptio crassidens	X	X		X	
Elliptio dilatata	FO				
Fusconaia ebena	X	X			
Fusconaia flava	X	X	X	X	
Glebula rotundata	X	X			
Lampsilis ovata	X	X	X		
Lampsilis siliquoidea	X	X	X	X	
Lampsilis teres	X	X	X		
Leptodea fragilis	X	X	X		
Ligumia subrostrata	X	X			
Ligumia recta	FO				
Megalonaias nervosa	X	X			
Obliquaria reflexa	X	X			
Obovaria jacksoniana	X	X			
Obovaria subrotunda	X	X	X		
Plectomerus dombeyanus	X	X			
Plethobasus cyphus	FO				
Pleurobema rubrum	X	X			
Potamilus ohiensis	X				
Potamilus purpuratus	X	X	X		
Quadrula cylindrica	X	X			
Quadrula nodulata	X	X			
Quadrula pustulosa	X	X	X		
Quadrula quadrula	X	X			
Strophitus subvexus	X		X		
Toxolasma parvus	X				
Toxolasma texasensis	X		X	X	X
Tritogonia verrucosa	X	X	X		
Truncilla donaciformis	X	X			
Truncilla truncata	X	X			
Uniomerus declivus	X			X	
Uniomerus tetralasmus	X	X			X
Villosa lienosa	X	X	X	X	
Corbicula fluminea	X	X	X		
Total unionid species	41	29	12	8	2

(1906), Grantham (1969), Cooper and Johnson (1980), and Miller et al. (1992), reporting on limited collections in the Yazoo drainage, have documented a fauna of at least 37 extant unionid mussel species from the Yazoo basin. The only records of the prehistoric lower Mississippi River mussel fauna occur in fossil shell middens within the Yazoo River basin. Recent excavations and surface examinations of these middens have resulted in the identification of 28 unionid species, including five species not currently known from the drainage (Bogan et al. 1987; Hartfield, unpublished data). Two of these (*Cyprogenia aberti, Plethobasus cyphus*) were not previously known to have occurred in Mississippi waters. The addition of these records indicates that the Yazoo River drainage, and potentially other eastern tributaries of the lower Mississippi River, at one time supported at least 41 species of unionid mussels (Table 1). As expected, this fauna is composed primarily of Mississippi Region species; however, it also contained components of Ohioan (*Plethobasus cyphus*), Ozarkian (*Cyprogenia aberti*), and Gulf Coast (e.g., *Glebula rotundata, Plectomerus dombeyanus*) faunal elements.

Big Black River

The Big Black River is the largest, least degraded of the lower Mississippi River tributaries. The Big Blacks' confluence with the Mississippi River is at the top of Yucatan cutoff, a natural cutoff that was allowed to form in 1929. The lower reach of the Big Black is a low-gradient, deeply entrenched channel in the Mississippi Alluvial Plain. The gradient increases where the river enters the Loess Hills but is stabilized by gravel and limestone outcrops. These geologic characteristics apparently protected the river from severe adjustments to the increase in slope at its confluence with the Mississippi River. Recently, however, there have been several ominous signs of degradation in the Loess Hills physiographic portion of the drainage. Many tributary streams are exhibiting considerable bank loss, and degradation has occurred in at least two locations in the main channel.

In 1985, a limestone bedrock shoal formed the bottom of the river about 1 mile above the U.S. Interstate 20 bridge. In spring 1992, it was observed that the channel had migrated east and cut below the shoal, leaving the limestone bedrock exposed at low water. The banks were severely eroded throughout this vicinity. This is also the type locality for *Lithasia hubrichti*, an aquatic snail endemic to the drainage. An extensive search of the area found no snails or mussels.

Approximately 10 km downstream, stranded mussels and washed up shells were commonly found on a gravel island during the mid-1980s. Only a single, eroded shell was found on this island during a visit to the area in the spring of 1992. The channel on both sides of the island had eroded considerably. A quantity of rip-rap had been applied to the eroding bank of a downstream meander, apparently in an attempt to protect a railroad bridge at this location.

Although there is no evidence that these minor, localized channel adjustments have had a severe impact on the mussel fauna throughout the drainage, localized extirpation of many species may have occurred in affected reaches.

Bayou Pierre

Bayou Pierre originates in the Pine Hills physiographic region, cuts through the Loess Hills, and flows across a narrow band of the Mississippi Alluvial Plain before joining the Mississippi River a few miles above the Rodney cutoff. The lower half of Bayou Pierre has apparently been affected by headcutting for a number of years. Patrick et al. (1991) have demonstrated that a headcut was active in the lower system prior to 1940. Between 1940 and 1990 the knickpoint migrated approximately 17,000 ft into the headwaters of the system.

During 1980–1983, mussel collections from the lower half of the drainage below the county road bridge at Smyrna resulted in only a single, old, live specimen of *Potamilus purpuratus* and a few badly weathered shells of four other species; 12 species were found alive at and above the bridge (Hartfield and Ebert 1986). In 1983, the knickpoint was apparently located some distance below the Smyrna bridge. According to Patrick et al. (1991), by 1985 the knickpoint had progressed 400 ft above the bridge (Figure 2), including the area where mussels previously occurred in greatest abundance, and by 1990 it was over 3,000 ft above the bridge. The migration rate has been about 560 ft per year in this vicinity, and it is likely to continue into the very headwaters of the system. Most tributaries in the affected portion of the drainage have experienced similar degradation. Repeated collecting trips since 1985 have found no live unionid mussels in the area where headcut-induced channel degradation has occurred and where 12 species were known to have previously survived.

Based on the current knowledge of the distribution of mussels in the system, at least five species of mussels were extirpated when the headcut passed the Smyrna bridge. It is likely that an unknown number of species had previously been extirpated from the lower portion of the system. Today, up to seven species of mussels are believed to tenuously survive in uneroded portions of the Bayou Pierre headwaters.

Homochitto River

The degradation of the Homochitto River has been documented by Wilson (1979) and discussed by Patrick et al. (1990). Meander cutoffs and channelization in the lower portion of the river between 1938 and 1940 initiated a headcut of spectacular proportions. Wilsons' comparison of U.S. Geological Survey data taken prior to channel modification approximately 40 miles above the mouth of the river with 1974 observations from the same location showed changes in the width of the low water channel from 96 ft, with an average depth of 4.5 ft, to 328 ft, with an average depth of 1.0 ft Wilson's data also show that the channel at this location degraded approximately 15 ft during this time and formed an eroded, sand-filled flood channel over 3,000 ft wide! (Figure 3) The degradation and bank loss extends into the very headwaters of the drainage.

Nothing is known of the unionids inhabiting this system prior to 1980, and only eight species of mussels have been documented since (Table 1). Four of the species had been collected only from a 100-m reach of a secondary tributary watered by an overflow from a U.S. Forest Service lake. In 1992 the lake had been drained for maintenance, drying the stream, and a search resulted in the collection of only *Anodonta grandis* (a new drainage record). The four species that were known only from this location are now apparently extirpated from the drainage; however, four other species that had also been collected at this location may continue to survive at other previously known sites in the extreme headwaters.

Coles Creek and Buffalo River

Both of these streams appear to have stabilized from past degradation events. Their channels are wide, sand-filled, and uniformly shallow. Substrates are generally unstable, and quicksand is common in both drainages. Only two species of mussels have been collected from a small tributary of Coles Creek.

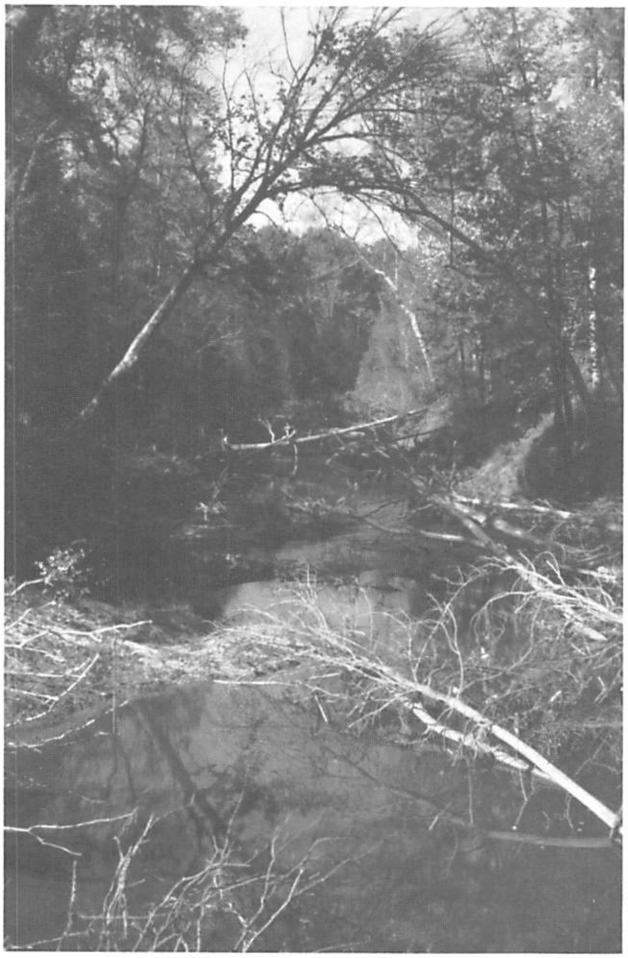

Figure 2: Bayou Pierre at Smyrna, Mississippi, in 1983 (top) and 1985 (bottom).

Figure 3: Degraded Homochitto River channel near Rosetta, Mississippi, 1982.

No mussels have been collected in any portion of the Buffalo River.

There are no historic or early records of the mussel faunas of the eastern tributaries of the Mississippi River below the Yazoo River. All, however, had the potential to support many of the 41 species historically known from the lower Mississippi River drainage. Streams of similar lengths and drainage areas in Gulf Coast drainages in Mississippi and Louisiana, and draining similar geologic strata, have diverse mollusk faunas.

Headcuts have been well documented in the Homochitto and Bayou Pierre drainages. There is little doubt of the consequences of headcutting on the mussel fauna in these streams. The Buffalo River and Coles Creek have channels characteristic of degraded streams. Although the evidence is circumstantial, it is likely that more diverse and extensive mussel faunas in these four streams were decimated by headcuts. The Big Black River fauna appears relatively intact; however, it may be threatened by similar processes.

Florida Parish Drainages, Louisiana

Although there has been limited channel modification in most of the river drainages of the Florida parishes of Louisiana, the primary cause of headcutting in this area appears to be instream gravel mining, and stream capture by overbank gravel mines. Headcuts are known to be progressing in the Amite, Tangipahoa and Bogue Chitto rivers in Louisiana. The mussel fauna of these drainages has been described by Stern (1976) and summarized by Vidrine (1985) (Table 2). Hartfield (1988, 1989) commented on the fauna of the Amite and Tangipahoa rivers and some factors affecting them.

Amite River

The Amite River drains portions of southwest Mississippi and the Florida parishes of Louisiana into Lake Maurepas. There has been some channel modification in the lower drainage for navigation; however, severe bank erosion becomes manifest in the middle reach of the river and above, remote from the modified channel. Abandoned and active gravel mines can be found sporadically within and along the river banks from U.S. Interstate 12 upstream to near the Louisiana/Mississippi state line. They are particularly concentrated for several miles up- and downstream of the state Highway 37 bridge, which bisects the drainage (Hartfield 1989). Mines occur along both banks in this vicinity, with overbank mines occasionally extending over one-half mile from the river's edge. It appears the river has been captured by overbank mines in several locations. The Amite River Sand and Gravel Committee (1992) estimates that 130 to 140 acres are mined annually along this river in Louisiana.

The mining of point bars and meander bends has been a common practice in the Amite River, resulting in severe local changes in river slope and channel morphology. The combined effects of stream capture by overbank mines and instream mining has resulted in bank collapse, degradation, widening and straightening of the channel, and a headcut that has progressed upstream to near the Mississippi state line (Figure 4). The Amite River Sand and Gravel Committee (1992) has documented a 10% reduction in channel length that occurred between 1940 and 1983 due to flood plain mining in a 27-mile reach of the river.

Vidrine (1985) noted records of 32 unionid

Table 2. Mussels of the Amite, Tangipahoa, and Bogue Chitto Rivers, Louisiana.

Species	Amite	Tangipahoa	Bogue Chitto
Amblema plicata	X	X	
Anodonta grandis	X	X	X
Anodonta imbecillis	X	X	X
Anodontoides radiatus	X	X	X
Arcidens confragosus	X		
Elliptio crassidens	X	X	X
Elliptio arca	X		
Fusconaia cerina	X	X	X
Glebula rotundata	X		
Lampsilis clarbornensis	X	X	X
Lampsilis hydiana		X	
Lampsilis ornata	X	X	X
Lampsilis teres	X	X	X
Leptodea fragilis	X	X	X
Ligumia subrostrata	X		
Megalonaias nervosa	X		
Obliquaria reflexa	X	X	
Obovaria jacksoniana	X	X	X
Obovaria unicolor	X	X	X
Plectomerus dombeyanus	X	X	
Pleurobema beadleanum	X	X	X
Potamilus inflatus	X	X	
Potamilus purpuratus	X	X	X
Quadrula apiculata	X		
Quadrula refulgens	X	X	X
Strophitus subvexus	X	X	X
Toxolasma parvus	X	X	X
Toxolasma texasensis	X		X
Tritogonia verrucosa	X	X	X
Truncilla donaciformis	X		
Uniomerus tetralasmus	X	X	X
Villosa lienosa	X	X	X
Villosa vibex	X	X	X
Corbicula fluminea	X	X	X
Total unionid species	32	25	21

species from the Amite River drainage. The most recent survey of the main channel in Louisiana resulted in the collection of 21 species: all 21 were collected from the lower river well below the area of intensive mining; 15, from a transition reach below the mines; 10, from the mined and headcut reach; and 12, above the degraded channel (Hartfield 1989). In the most intensely mined reach, a distance of over 10 miles, no live mussels were found, only some badly weathered shells. In the degrading channel above the mines, mussels were concentrated at a few isolated locations where the bank and bottom had been by-passed by the headcut. For example, where an island had been formed by a neck cutoff, the natural, or west, channel had been spared the severe degradation experienced both above, below, and in the new east channel. All 10 species of mussels collected in the degraded channel reach were found in this short stretch of protected channel. A similar situation was also encountered at another location where a chute cutoff had developed, leaving a small area of the channel temporarily protected from scour.

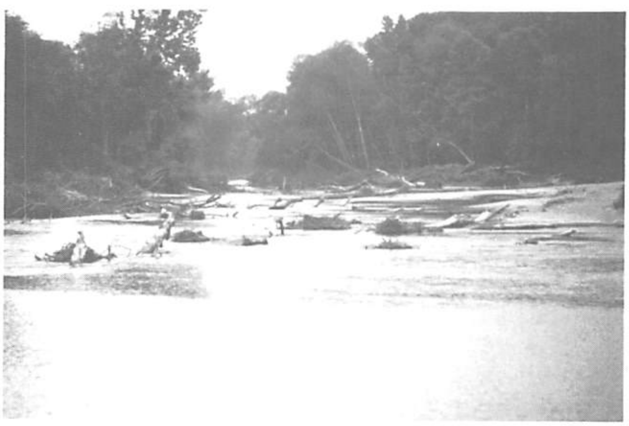

Figure 4: Amite River, 1988. Uneroded channel near the Mississippi/Louisiana State line (top); channel reach eroded by headcut south of Louisiana Highway 10 (bottom).

Once again, all 10 species were represented in this area. In other isolated upstream areas, a few species were occasionally taken from small, stable areas adjacent to the bank. Unfortunately, these areas where mussels continue to survive are in a state of transition and likely to be ultimately dewatered, filled, eroded, or otherwise destroyed as the headcut progresses.

Tangipahoa River

A mussel fauna of 25 species has been recorded from the Tangipahoa River (Vidrine 1985, Hartfield 1988). During a 1988 survey of bridge crossings and selected reaches along approximately 100 miles of the main channel, 20 mussel species were collected (Hartfield 1988). Although there was little active gravel mining in evidence along the Tangipahoa, abandoned mines occurred near most access points to the river.

The abundance and diversity of the mussel fauna appeared to be related to channel stability in 1988. Approximately 15 river miles of the lower river was described as stable, narrow, deep, and with wide meanders. Live mussels were locally abundant, and 12 species were collected alive. In a 15-mile reach above state Highway 22, bank erosion was evident, point bars were numerous, and only 22 live mussels representing four species were found. An additional eight species were represented by badly weathered shells. The channel continued to deteriorate for a distance upstream, becoming wider and shallower. At five collection locations along approximately 50 miles, the only bivalve shells found were a few badly weathered *Corbicula fluminea*. Old and recently active gravel mines were evident at most access points to the river. Further north, gravel mines and signs of active channel erosion diminished, and the channel appeared stable near the Mississippi/Louisiana state line. Mussels were found to be locally abundant in this area, and 17 species were collected alive.

Bogue Chitto River

The primary area of channel instability in the Bogue Chitto River occurs in the vicinity of gravel mines in Washington Parish, Louisiana. The channel shows signs of an actively headcutting stream around and above the mines: bank collapse, channel widening, shallowing, and a shifting sand and gravel bottom. The Bogue Chitto has also been bisected by the Pearl River navigation canal near its confluence with the Pearl River. It is not known whether this channel modification has contributed to the instability. Although the effects of erosion on the Bogue Chitto mussel fauna have not been documented, many of the 19 species may have been eliminated from the areas of active erosion.

Other Florida Parish Streams

Vidrine (1985) reports 19 species of unionid mussels from the Tickfaw River and seven species from the Tchefuncte River based on collections by Stern (1976). The condition of these streams and their mussel faunas has not been recently assessed.

Severely eroding channels in the streams of the Florida parishes are directly correlated with the presence and intensity of gravel mining activities. A clear correlation has also been shown between channel degradation resulting from inappropriate mining activities within and adjacent to the Amite and Tangipahoa rivers and the distribution and abundance of unionid mussels. The U.S. Fish and Wildlife Service (1991) considers stream erosion precipitated by gravel mining as the primary threat to the federally listed species *Potamilus inflatus* in the Amite River and a primary factor in its extirpation from the Tangipahoa River.

Buttahatchee River

The Buttahatchee River is a major tributary of the Tombigbee River in northeast Mississippi. The Buttahatchee supports a mussel fauna of 37 species and provides much of the remaining available habitat for federally listed species: *Epioblasma penita*, *Pleurobema taitianum*, *Lampsilis perovalis*, *Medionidus acutissimus*, *Pleurobema decisum*, and *Pleurobema perovatum* (U.S. Fish and Wildlife Service 1991, Jones 1991).

Recent studies indicate that the Buttahatchee River and its aquatic fauna have been adversely affected by construction of the Tennessee-Tombigbee Waterway, as well as by gravel mines in its lower reaches (Hartfield and Jones 1990, Jones 1991). Prior to construction of the waterway, the Tombigbee River at the confluence with the Buttahatchee was a narrow, deep, meandering channel in a heavily forested floodplain. The navigation canal of the waterway, into which the lower Buttahatchee River now drains, is wide and straight and flows into Columbus Lake. The morphology of the new channel and the extensive bank erosion that is evident along the canal in this area suggest that flood flows have been accelerated by these channel modifications. This would result in a lower flood profile in the waterway than under previous natural conditions, effectively increasing the slope of the lower Buttahatchee at higher flows. Although signs of active bank erosion in this lower reach of the Buttahatchee River are not extensive, meanders have been cut off, and the gravel shoals and riffles are obviously reworked. Changes in the molluscan fauna have also occurred. A comparison of a pre-waterway mussel survey (Yokley 1978) and a post-waterway survey (Hartfield and Jones 1990) found that mussel abundance had declined 95% in the lowermost 6 km of the Buttahatchee River and that mussel diversity had declined 60% (Jones 1991). No

Figure 5: Uneroded Buttahatchee River channel about 10 miles above the gravel mines (top); severely eroded channel about 1 mile above the mines, 1992 (bottom).

significant changes in abundance and diversity were noted in the upper reaches of the river.

Recent stream capture by gravel mines has also seriously altered stream hydraulics and channel configuration in the Buttahatchee River. During the spring floods of 1991, a levy failed that had separated the Buttahatchee River from an extensively mined area on the north bank of the river, in the vicinity of U.S. Route 45, Monroe County, Mississippi. This resulted in the formation of a new channel through the mines and left over 0.5 miles of the natural channel either dry or ponded. Extensive erosion is occurring in the new channel and above the new cutoff. In addition to the elimination of aquatic fauna and their habitat in the abandoned natural channel, gravel bar habitat about 2 miles downstream of the capture that formerly supported *Epioblasma penita*, as well as other species, was buried by loose sand and gravel, washed down from the now-eroding section of the river. A headcut is also progressing above the point of stream capture as the river channel attempts to adjust to the increase in slope (Figure 5). In spring 1992, the headcut extended over 2 miles upstream from the gravel mines. Bank failure, channel widening, and shoaling of sediments have been extensive. Several gravel shoals that previously supported endangered mussels and that are candidates for endangered status, as well as many other species, have been destroyed by erosion or buried by sediments. One of these shoals was the only location where *Pleurobema taitianum* has been observed alive since it was listed as an endangered species.

Figure 6: One of three unpermitted point bar mines within the mean high-water channel of the East Fork Tombigbee River, 1992.

Other Tombigbee River tributaries

The East Fork Tombigbee River was bypassed by the canal section of the Tennessee-Tombigbee Waterway. Gravel mining is also a problem on the East Fork and has caused extensive erosion and channel adjustments (U.S. Army Corps of Engineers 1991). During a September 1992 float through approximately 10 miles of the East Fork, the author observed three active mines that had completely removed large point bars (Figure 6). A short, upstream reach of river channel that will be affected by these mines provides habitat for the following federally listed species: *Pleurobema curtum*, *Pleurobema taitianum*, *Epioblasma penita*, *Pleurobema decisum*, and *Lampsilis perovalis*.

A 4-mile reach of the lower Luxapalila Creek is scheduled for channelization in 1993. At least 17 mussel species, including three species proposed for federal protection, continue to survive in this stream (Hartfield and Bowker 1992). Grade control structures are included in the project design and should prevent a headcut from occurring above the project area. However, the improved drainage efficiency of the channelized stream will increase the high water slope immediately above the project. It is possible that the benthic microhabitat will be affected by increased velocities and channel scour for several miles upstream of the project area, as occurred in the lower Buttahatchee River.

The gradient changes created by dredging and impoundment of the Tombigbee River have the potential to affect other tributary mussel communities as well. Bank erosion is evident along the riverine sections of the Tombigbee Waterway almost to the confluence with the Black Warrior River. Coal Fire Creek, Lubbub Creek, and the Sipsey River have extensive mussel faunas, including several federally listed species, and may be threatened by increased flood gradients in the lower portions of their drainages.

Summary

Two primary sources of headcuts have been identified: channel modifications for flood control or navigation, and gravel mining. Factors affecting hydrologic and channel parameters can also work in concert to precipitate or aggravate headcuts.

The mussel fauna of a stream is severely affected by headcutting, and other components of the aquatic community may be similarly affected. Although the actual extent of the molluscan faunal loss due to headcuts is unknown, their effects on several species are well documented. *Potamilus inflatus* is threatened to become extirpated from the Amite River by gravel mining activities. *Pleurobema curtum*, *Pleurobema* *taitianum*, and *Epioblasma penita* are in eminent danger of extinction due to headcuts initiated by gravel mining and channel modification. *Pleurobema decisum, Pleurobema perovatum, Lampsilis perovalis,* and *Medionidus acutissimus* are in danger of extirpation from significant portions of their remaining habitat due to the same activities. The aquatic snail *Lithasia hubrichti* may already be extinct due, at least in part, to channel degradation in the Big Black River.

Other economic and biologic consequences attributed to headcuts are readily apparent. Millions of dollars have been expended on road and bridge repair and replacement in degraded stream systems. Literally thousands of acres of land have been eroded in the Amite, Homochitto, and Bayou Pierre drainages alone. Timber resources on these eroded acres have also been lost. Reduced or lost recreational potential, aquatic productivity, fisheries, land value, and aesthetic value are additional public and private costs of headcutting.

Today, channel modification projects are usually designed with the consideration of potential upstream channel adjustments. Unfortunately, this consideration extends only to gross characteristics of channel morphology and does not consider the effect of moderate changes in stream dynamics on species such as mussels. As demonstrated by the faunal losses in the lower Buttahatchee River, upstream microhabitat alteration with severe biological impacts can occur with little apparent change in channel morphology. Additional studies are needed to document these changes and their effect on mussels and other faunal groups.

Gravel mining has been an industry in the Southeast for several generations. Recently increased demand for aggregates, along with new, readily available technology that has greatly improved the efficiency of gravel removal, has made the industry a primary threat to many riparian ecosystems. Inappropriately sited gravel mines may profit individual landowners and gravel mine operators, but offsite riparian landowners receive no compensation for aggregate resources that are eroded and washed downstream, timber lost to erosion, losses of recreational value and opportunities, or decreased property values when mine-induced headcuts move through their properties.

Current state surface mining laws are inadequate to protect riparian ecosystems in Louisiana and Mississippi. State agencies mandated to carry out existing regulations are understaffed and underfunded. Louisiana mining regulations have no restrictions on the mining of point bars and stream banks. Mississippi, however, requires permits for surface mines in excess of 4 acres, and sensitive biological features can be considered in the denial of permits. The aggregate mining industry is a powerful lobby in both of these states, and current regulations and monitoring agencies are unlikely to be strengthened without a concerted effort. Riparian landowners upstream of sand and gravel mines need to be apprised of potential causes and effects of stream erosion on their properties.

Federal regulations under Section 404 of the Clean Water Act apply to gravel mining activities only when dredged or fill material is discharged into waters of the United States. Regulations under Section 10 of the Rivers and Harbors Act, however, require a permit for dredging within the mean high water mark of a navigable stream. Although detection and prosecution under Section 10 is difficult, strict enforcement of Section 10 regulations has the potential to reduce, if not eliminate, the mining of point bars. In 1991, the New Orleans District of the U.S. Army Corps of Engineers issued a letter to gravel operators along the Amite River explaining the permit requirements of Section 10 as related to the mining of point bars. This letter and frequent inspection visits have curtailed point bar mining activities in this drainage. Permits have not been issued for mining within the river channel, due in part to the potential effects on the federally listed mussel *Potamilus inflatus*. Unfortunately, other drainages are not receiving this level of enforcement and protection. Section 10 of the Rivers and Harbors Act should be strictly enforced in all navigable streams, and the permitting process must consider the public, private, and ecological costs of sand and gravel mining.

Fisheries and riparian biologists also need to educate themselves and their students on the processes and consequences of stream degradation and headcuts. There has been little discussion of the significance of headcutting on the southeastern aquatic fauna in aquatic ecology literature, and only mention of the effects of erosion (Hackney et al. 1992). Unfortunately, in many parts of the southeastern United States streams have been headcutting for two generations, and many biologists consider the phenomenon part of the "natural" dynamics of regional drainages. Discussions of the signs and symptoms of headcutting streams with aquatic biologists in different regions indicate that this is not an isolated problem. Unconsolidated or partially cemented geologic sediments vulnerable to headcutting are in many other parts of the country where stream modification and gravel mining also occur. The extent of headcutting and stream degradation on other regional faunas should be thoroughly investigated.

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