2007 Status Update of the Cape Fear Shiner *Notropis mekistocholas*

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Scope and Methods

During June to October 2007 Robert J. Goldstein & Associates Inc. (RJGA) conducted a range-wide field survey for the federally endangered Cape Fear shiner *Notropis mekistocholas* (Snelson, 1971), a small minnow endemic to the upper half of the Cape Fear River basin in the Piedmont region of central North Carolina (Figure 1). The Cape Fear shiner's known range includes the Haw River and Rocky River in Chatham County, the Deep River in Randolph, Moore, Lee and Chatham Counties, the Cape Fear River in Chatham and Harnett Counties, and several tributaries of these four rivers. The purpose of this survey is to assess changes in relative abundance of local sub-populations, habitat quality, threats and conservation strategies for use in long-range species protection and recovery plans. This study was funded by the North Carolina Wildlife Resources Commission (WRC) using U.S. Fish and Wildlife Service Section 6 Endangered Species Grant-in-Aid funds.

This report presents the results of 49 collections, including 10 collections in the Haw River sub-basin, 11 in the Rocky River sub-basin, 14 in the Deep River sub-basin, and 14 in the Cape Fear River sub-basin (Table 1, Figure 2). We sampled upstream and downstream of previous known range limits in these four rivers, but did not sample in other river basins, nor in other counties beyond the shiner's known range. It is unlikely that Cape Fear shiners presently occur in other river basins or other counties based on state-wide fish community sampling by NC Division of Water Quality (DWQ) and numerous targeted shiner surveys by WRC, NC Museum of Natural Sciences (NCSM), and other biologists over the past 25 years. We also did not sample sites where Cape Fear shiners had been reported within the preceding few years, including the middle segment of Deep River near Carbonton (monitored following Carbonton Dam removal), and the lower Rocky and Deep Rivers near their confluence.

The survey was lead by Gerald Pottern of RJGA with assistance from two to four additional collectors each day, principally Brena Jones, Ryan Heise, Tom Fox and Megan McCormick of WRC. Other collecting assistants include Carol Price from WRC, Sarah McRae from NC Natural Heritage Program (NHP), Wayne Starnes from NC Museum of Natural Sciences (NCSM), Jason Mays from NC Department of Transportation (DOT), Tom Dickinson from Catena Group, and volunteers Jim Kupferschmidt, Victoria Ma and Rachel Pottern.

During the first two sampling days we tested and compared backpack electroshocking and seining as sampling methods, but discontinued shocking when it became apparent that seining was much more effective in capturing large schools of mixed shiners in which *N. mekistocholas* were often found. Most of the time we used a ten-foot long seine and a six-foot long seine, both with 3/16-inch mesh. Two collectors maneuvered the larger seine and one or two collectors maneuvered the smaller seine using a combination of upstream, downstream, and cross-current hauling techniques. This strategy made it possible to capture large schools of shiners in rocky pools and runs among riffles, where collection efforts in previous years had been most successful. If five or more Cape Fear shiner specimens were collected within the first 30 minutes at a site, we generally moved on to sample another site. If none was captured, we continued sampling for up to four hours if the river's physical characteristics and assemblage of other minnows suggested suitable habitat for Cape Fear shiners. Sampling effort thus varied between 30 minutes to four hours per collection site.

The extreme drought of 2007 facilitated sampling in bedrock and boulder dominated river segments that are extremely difficult to wade and sample during normal (higher) flow conditions. Flow during June to October 2007 generally ranged from 50 to 250 cfs in the Deep River at the Moncure USGS gage, and 80 to 400 cfs in the Haw River at the Bynum USGS gage, among the lowest flows on record at these gages. Tributary streams, even the largest ones, had negligible flow and yielded mainly fish species typical of headwater streams and lentic habitats. We surmised that fish species typical of larger flowing streams had moved downstream out of the creeks into rivers. Consequently we focused most of our sampling effort on the rivers and mouths of tributaries.

Table 1. 2007 Cape Fear Shiner Survey Sites in the Haw, Rocky, Deep and Cape Fear Rivers.

Fig 2 Map Num	Fig 2 River Segmt	Date 2007	CFS num coll	Collection Site Location and County
H01	H1	Oct 02		Haw River, upstr Chicken Bridge SR-1545, Chatham
H02	H1	Oct 02		Haw River, dnstr Chicken Bridge SR-1545, Chatham
H03	H1	Sep 20	1	Haw River, off River Rd upstr Terrells Cr, Mason prop, Chatham
H04	H1	Sep 20		Haw River, Rock Rest Rd, D+J Peterson prop, Chatham
H05	H2	Jun 15		Haw River at US-15-501, Chatham
H06	H2	Jun 14		Haw River, Bynum Dam headrace from 15-501 to Bynum, Chatham
H07	H2	Jun 14		Haw River at Old Bynum bridge below 15-501, Chatham
H08	H2	Jun 14		Haw River dnstr Old Bynum bridge to 2 mi downstream, Chatham
H09	H2	Sep 21		Haw River 2 mi upstr US-64, Sam Moon prop, Chatham
H10	H2	Sep 21		Haw River, at US-64 & dnstr, Chatham
R01	R1	Oct 17		Rocky River at SR-2170, Chatham
R02	R1	Aug 24		Rocky R at Jay Butler prop off SR-1506, Chatham (2.7 mi upstr 902)
R03	R1	July 11		Rocky R at NC-902, Chatham
R04	R1	Aug 24		Rocky R at NC-902, Chatham
R05	R1	July 10		Rocky R at SR-1010, Chatham
R06	R1	Aug 24		Rocky R at SR-1010, Chatham
R07	R2	July 10	3	Rocky R near SR-2156 below Rocky R Hydro Dam, Chatham
R08	R2	July 10		Bear Cr (Rocky R trib) at SR-2155, Chatham
R09	R2	July 10	2	Bear Cr (Rocky R trib) at SR-2156 dnstr to Rocky R, Chatham
R10	R2	July 10	5	Rocky R at SR-1953, Chatham
R11	R2	July 10	3	Rocky R at US-15-501, Chatham
D01	D1	Aug 08		Deep R below Ramseur Dam, SR-2615 Brooklyn Ave, Randolph
D02	D1	Aug 08		Deep R at SR-2656, Hinshaw Town Rd, Randolph
D03	D1	Aug 08		Millstone Cr (Deep R trib) at NC-22, Randolph
D04	D2	Aug 02	1	Deep R near NC-22-42 below Coleridge dam, Randolph
D05	D2	Aug 02		Richland Cr (Deep R trib) at SR-2873 Riverside Rd, Randolph
D06	D2	Aug 02		Fork Cr (Deep R trib) at SR-2873 Riverside Rd, Randolph
D07	D2	July 25		Deep R at SR-1456 Howards Mill Rd, Moore
D08	D2	Oct 17		Deep River at SR-1462 Cavinesstown Rd (Acorn Knoll), Moore
D09	D2	July 25		Bear Cr (Deep R trib) below dam at SR-1497 Reynolds Mill, Moore
D10	D3	Oct 17	5	Deep River at NC-22 Highfalls, Moore
D11	D3	July 25	30+	Deep R S of SR-1611 Charlie S Rd, Moore
D12	D3	July 25	4	Deep R at SR-1006 N of Glendon, Moore
D13	D4	July 11	7	Deep R at US-15-501, Chatham/Lee
D14	D6	July 11	40+	Deep R at US-1, Chatham/Lee

C01	C2	Oct 18		Cape Fear River below Buckhorn Dam, Chatham/Lee
C02	C2	July 06		Cape Fear R above Buckhorn Cr mouth, Chatham/Lee
C03	C2	Oct 18		Cape Fear River near Buckhorn Creek, Chatham/Lee
C04	C2	Oct 18		Buckhorn Creek (CFR trib) near Cape Fear River, Chatham
C05	C2	Oct 05		Cape Fear River below Parkers Cr, Agape Center, Harnett
C06	C2	Oct 05		Cape Fear River at mouth of Avents Cr, Raven Rock St. Pk, Harnett
C07	C2	Oct 05		Avents Creek (CFR trib) at SR-1418, Raven Rock St. Pk, Harnett
C08	C3	Aug 01		Cape Fear R islands upstr of Lillington Ross Rd boat ramp, Harnett
C09	C3	Aug 01		Cape Fear R 4,500 ft dnstr of Lillington Ross Rd boat ramp, Harnett
C10	C3	Aug 01		Cape Fear R 6,000 ft dnstr Buies Cr mouth, Harnett
C11	C3	Aug 01		Cape Fear R & Upper Little River confluence, Harnett
C12	C3	July 23		Cape Fear R from Erwin-Dunn RWI to Juniper Cr, Harnett
C13	C3	July 23	1	Cape Fear R dnstr NC-217 near Erwin, Harnett
C14	C3	Aug 01		Cape Fear R dnstr NC-217 near Erwin, Harnett

Cape Fear Shiner Habitat Characteristics and Ecology

The Cape Fear shiner is usually found in structurally complex rocky pools and runs adjacent to riffles in wide, shallow, rocky segments of rivers with an open forest canopy and abundant water willow (*Justicia*), riverweed (*Podostemum*), stream mosses (*Fontinalis*), and filamentous green algae. Areas among islands and braided channels with boulders, cobble and gravel yield the most specimens. This habitat type is abundant in rivers flowing through the Carolina Slate Belt and Raleigh Belt (NC Division of Land Resources, 1985; Figure 3). Adults and large juveniles may also occupy the lower reaches of some major tributary creeks, at least temporarily, including some creeks with a shady canopy and negligible aquatic vegetation. Most of the known creek occurrences are less than two miles from the confluence with a larger river. One exception is a 1962 report from Kenneth Creek, a Cape Fear River tributary eight miles above its mouth in Harnett County (discussed in the Cape Fear River section of this report).

Prior to extensive dam-building in the early 1900s it is likely that Cape Fear shiners extended farther upstream in the Deep River in Randolph County and farther upstream in the Haw River into Alamance County and perhaps Guilford County, based on habitat characteristics. As this fish was not recognized as an undescribed species until the 1960s, we may never know just how far upstream it formerly occurred in these rivers.

Fewer Cape Fear shiners are found in low-gradient sand-dominated rivers with minimal rocky riffle habitat, such as that found in the Deep River segment flowing through the Durham-Sanford Triassic Basin between Carbonton and US-15-501 along the Chatham/Lee County line (Figure 3). However, some movement of Cape Fear shiners presumably occurs across these sandy segments between isolated rocky patches. The river segments impounded by Buckhorn Dam on the Cape Fear River are mostly within the Triassic Basin, and probably supported few Cape Fear shiners prior to impoundment. The lowermost patch of rocky riffle habitat in the Cape Fear River is about two miles downstream of the NC-217 bridge near Erwin in Harnett County, where a “finger” of Slate Belt habitat extends southward into the Upper Coastal Plain/Sandhills region (NC Division of Land Resources, 1985). Below this point the river gradient flattens and river morphology becomes typical of a Coastal Plain river. Based on this habitat change below Erwin, it is unlikely that Cape Fear shiners occurred regularly or reproduced successfully in the lower half of the Cape Fear River watershed beyond the Harnett/Cumberland County line. No Cape Fear shiners have been reported from the Upper Little River or Lower Little River in Harnett County, both of which have Coastal Plain/Sandhills river morphology and biota.

Cape Fear shiner spawning is apparently limited to main river channels with abundant gravel and aquatic vegetation, based on observations and young-of-year collections (Howard, 2003; Pottern and Huish, 1985). Howard observed that non-spawning fish generally prefer depths of 30 to 50 cm and substrata of gravel, cobble, and small boulders. Spawning shiners move into shallower areas, typically 20 to 40 cm deep, with gravel preferred over other substrata. The smallest stream in which Cape Fear shiners were historically known to spawn (based on collections of nuptial males and gravid females during the 1970s) is Rocky River at NC-902, with 134 square miles of drainage basin area. Young-of-year have been found mainly in rivers, not in creeks, except for the lowermost 2,000 feet of Bear Creek adjacent to Rocky River.

Cape Fear shiners are usually found in mixed schools with other shiners, where they usually comprise a small fraction of the total fishes caught. They are rarely a dominant species. In slower-flowing pools they often mix with the highfin shiner *(Notropis altipinnis),* swallowtail shiner *(Notropis procne)*, and juvenile white shiner *(Luxilus albeolus)*. In faster pools and runs they are most often found with the sandbar shiner (*Notropis scepticus),* white shiner *(Luxilus albeolus),* spottail shiner *(Notropis hudsonius)*, comely shiner (*Notropis amoenus)*, satinfin shiner (*Cyprinella analostana)*, and whitefin shiner (*Cyprinella nivea*). Based on our sampling it appears that Cape Fear shiners prefer the lower strata within these mixed shiner schools, at least when pursued by net. Most specimens were captured by pulling the seine as deep as possible, close to the stream bed, whereas shallower seine hauls not hugging the stream bed tended to capture large numbers of sandbar, white, highfin and other shiners, but rarely any Cape Fear shiners.

The Cape Fear shiner has a long intestine and other gut features apparently adapted for herbivory, which is unusual among the primarily insectivorous *Notropis* shiners (Snelson, 1971). This adaptation may give the Cape Fear shiner an advantage over other sympatric shiners during the warmer months when algae is abundant but invertebrate prey become scarce, due to insect emergence patterns and increased metabolic demand of competing fishes. We qualitatively observed in 2007 and in 1984-86 that Cape Fear shiners are most common at sites where the total abundance of all minnows is relatively high, which lends support to this food-crunch adaptation hypothesis.

Rivers in the Carolina Slate Belt and Triassic Basin are particularly drought-prone and have naturally low baseflows (Weaver and Pope, 2001). This hydrologic pattern combined with wide, shallow, braided channels and abundant bedrock and boulders to support algae growth may be important factors in the evolution and continued survival of the Cape Fear shiner. Collection sites D11 and D14 where Cape Fear shiners were most abundant in 2007 also had notably abundant growths of filamentous green algae in pools, and the majority of Cape Fear shiners at these sites were caught in or near these algae-filled pools. John Alderman of WRC recorded similar observations in his 1992-94 collection field notes in the Deep River.

Cape Fear Shiner Collection History

The oldest museum specimen of the Cape Fear shiner was collected in 1949 in the Haw River below Bynum Dam by Duke professor Joseph Bailey's class, but it was not recognized as an undescribed species until the 1960s, after WRC and NC Museum of Natural History staff collected specimens from Robeson Creek (Haw River tributary), Parkers Creek and Kenneth Creek (Cape Fear River tributaries), and Rocky River.

The first comprehensive survey for the Cape Fear shiner was conducted by Gerald Pottern during 1984-86 prior to its federal listing as an endangered species in 1987 (Pottern and Huish,

1985, 1986, 1987; Biggins 1988). Following that survey, the only sites where *N. mekistocholas* appeared to be fairly common were in the lower 5.5 miles of Rocky River below Rocky River Hydro Dam and contiguous 3.8 miles of Deep River between the Rocky River confluence and the US-1 bridge near Moncure on the Chatham/Lee County line. Other populations yielded only a few specimens, including the upper Deep River in Randolph and Moore Counties, the upper Rocky River in Chatham County, and a Cape Fear River tributary in Harnett County. No Cape Fear shiner was found in the Haw River system, where construction of Jordan Lake in 1982 had impounded much of the historic habitat. In 1987 the long-term viability of *N. mekistocholas* sub-populations in the upper Deep River, upper Rocky River, Haw River and Cape Fear River appeared doubtful, based on extreme rarity or absence of specimens (Table 1).

Subsequent surveys from 1987 to 2006 by WRC, DWQ and others continued to yield numerous specimens from the lower Rocky River and lower Deep River sub-population, a few additional specimens from the upper Deep River between Coleridge and Highfalls in Randolph and Moore Counties, and numerous specimens from the middle segment of Deep River between Highfalls and Carbonton in Moore, Lee and Chatham Counties. The demolition of Carbonton Dam in December 2005 helped restore suitable habitat in several miles of the Deep River mostly in Moore County, about mid-way between Highfalls and Moncure. The Catena Group found several specimens of *N. mekistocholas* in this reach during post-dam-removal monitoring.

During 1992-93 John Alderman and Chris McGrath of WRC collected a few specimens at three sites in the Haw River upstream of Jordan Lake, revealing an extant population in a river where no specimen had been reported for 24 years. However, no specimen was found after 1986 in the Rocky River above Rocky River Hydro Dam in Chatham County, nor in the Cape Fear River or its tributaries below Buckhorn Dam in Chatham and Harnett Counties. Gerald Pottern and Ryan Heise spent two days surveying five sites in Neills Creek and Kenneth Creek in Harnett County in 2003, including the 1962 and 1986 historic collection sites, but did not find *N. mekistocholas*.

Cape Fear shiner collection history and relative abundance are summarized by river segment (Table 2, Figure 2). River segment endpoints are based on dams, river confluences, or habitat changes. The Haw River is divided into three segments: H1 from Saxapahaw Dam downstream to Bynum Dam; H2 from Bynum Dam downstream to the head of Jordan Lake pool; and H3 the segment impounded by Jordan Lake in 1982 (including the Robeson Creek historic collection site). The Rocky River is divided into two segments: R1 from Siler City downstream to Rocky River Hydro Dam; and R2 from Rocky River Hydro Dam downstream to the Deep River confluence. The Deep River is divided into six segments: D1 from Randleman Dam downstream to Coleridge Dam; D2 from Coleridge Dam downstream to Highfalls Dam; D3 from Highfalls Dam downstream to Carbonton Dam; D4 from Carbonton Dam downstream to the Rocky River confluence; D5 from the Rocky River confluence downstream to Lockville Dam; and D6 from Lockville Dam to US-1 bridge near Moncure. The Cape Fear River is divided into three segments: C1 is the impounded reach above Buckhorn Dam including the Haw River below Jordan Dam and the Deep River below US-1; C2 from Buckhorn Dam downstream to Lillington; and C3 from Lillington downstream to the last rocky riffles southwest of Erwin.

Abundance ratings of rare, uncommon or common used in this table are estimates based on numbers of Cape Fear shiners reported, and not necessarily adjusted for catch-per-unit-effort. Assigned ratings of “common” are most likely accurate, but ratings of “rare” or “uncommon” may in some cases be misleading, if little effort was expended, or river flow was high, or if the collectors moved on quickly after catching just a few specimens. We are more confident of the 1984-86 and 2007 abundance ratings based on Pottern’s collections.

Table 2. Summary of Cape Fear Shiner Collection History and Abundance by River Segment

River Segment (including tributaries)	miles	1949 -1983	1984 -1986	1987 -2006	2007
H1. Haw River, Saxapahaw to Bynum Dam	17.4	none	none	rare	rare
H2. Haw River, Bynum Dam to Jordan Lake	4.7	rare	none	rare	none
H3. Haw R/ Robeson Cr- Jordan Lake pool	4.9	uncommon	none	none	none
R1. Rocky River, Siler City to Rocky R Hydro	16.0	common	rare	none	none
R2. Rocky River, Rocky R Hydro to Deep R	5.5	common	common	common	common
D1. Deep River, Randleman to Coleridge Dam	21.6	none	none	none	none
D2. Deep River, Coleridge to Highfalls Dam	18.9	none	rare	uncommon	rare
D3. Deep River, Highfalls to Carbonton	21.9	none	rare	uncommon	common
D4. Deep River, Carbonton to Rocky River	22.0	none	uncommon	uncommon	uncommon
D5. Deep River, Rocky River to Lockville Dam	3.5	none	common	common	common
D6. Deep River, Lockville Dam to US-1	0.3	none	uncommon	uncommon	common
C1. Cape Fear-Deep-Haw, Buckhorn impound	12.7	none	none	none	none
C2. Cape Fear River, Buckhorn to Lillington	14.0	uncommon	rare	none	none
C3. Cape Fear River, Lillington to Erwin	11.5	none	none	none	rare

rare = average 1 to 4 per collection
uncommon = average 5 to 15 per collection
common = average 16 or more per collection

Survey Findings and General Recommendations

Twelve of our 49 collections in 2007 yielded one or more Cape Fear shiners (Table 1). These data indicate that Cape Fear shiners remain common in much of the Deep River between Highfalls Dam in Moore County downstream to US-1 at Moncure in Chatham County (47 river miles), and in the lower 5.5 miles of Rocky River between Rocky River Hydro Dam and Deep River. None was found in Rocky River upstream of Rocky River Hydro Dam, where it appears the Cape Fear shiner may now be extirpated. Populations in the Deep River upstream of Highfalls, the Haw River and the Cape Fear River all appear to be very rare, as evidenced by a single specimen found in each of these areas. The upper Deep River specimen was captured immediately below Coleridge Dam in Randolph County; the Haw River specimen was found four miles upstream of Bynum Dam; and the Cape Fear River specimen was caught near Erwin in southern Harnett County. The 2007 Haw River and Cape Fear River collection sites represent new upstream and downstream range limits, respectively, for this species.

The following sub-sections discuss Cape Fear shiner habitat quality and population status by river segment. They also include recommendations for protecting and restoring Cape Fear shiner habitat, protecting strong populations in the Deep River and lower Rocky River, and recovering tenuous or extirpated populations in the Haw River, upper Rocky River, upper Deep River, and Cape Fear River. The recommendations and opinions herein are those of Gerald Pottern, and are not necessarily those of WRC. General recommendations that apply to all occupied and historic habitat, plus waters draining to these rivers, are as follows:

Forested riparian zones throughout the Cape Fear River watershed upstream of Cumberland County should be protected, and previously cleared riparian zones should be re-forested wherever practicable. For protecting and recovering the Cape Fear shiner, the most important riparian areas are: 1) the Haw River and tributaries from I-85 near Graham to US-64 above Jordan Lake in Alamance, Orange and Chatham Counties; 2) the Rocky River and tributaries

from Siler City Reservoir to the Deep River in Chatham County; 3) the Deep River and tributaries from Ramseur Dam downstream to US-1 near Moncure in Randolph, Moore, Lee and Chatham Counties; and 4) the Cape Fear River from Buckhorn Dam to the Harnett/Cumberland County line in Chatham and Harnett Counties.

Forested buffers should be at least 50 feet wide to accommodate multiple rows of mature trees, and preferably 100 feet or wider. Narrower buffers that support only one or two rows of mature trees are sensitive to storm damage, which may cause large sections of stream-bank to collapse when these trees are blown over, especially when riparian soils are saturated. Reforestation of riparian lands with insufficient buffer vegetation and/or eroding stream-banks should be a priority.

Geomorphic restoration of incised or straightened streams should be considered where appropriate when developing plans to restore and replant riparian buffers. However, geomorphic restoration may not be beneficial along incised or straightened streams where riparian trees are well-established and the stream-banks are reasonably stable. The stream substratum and habitat quality adjacent to and downstream of the site, local land use, and stream-bank stability should be carefully assessed before deciding whether to alter stream geomorphology and remove existing bank-stabilizing trees. Preservation and restoration of river segments with abundant gravel and mixed gravel-cobble beds (10 to 50 cm deep at median flow) is especially important. Some streams draining urban areas and subject to flashy hydrographic conditions might best be left alone, as the potential damage from short-term construction impacts may be great. Removal of unused dams might also be beneficial in restoring habitat and reconnecting upstream and downstream Cape Fear shiner populations, as was done at Carbonton in 2005, but sediment dynamics and transport will need to be carefully investigated.

Improvements in erosion and sedimentation control, post-construction stormwater management and pollution prevention efforts in the watersheds listed above should also be high priorities. Federal and state agencies, regional planning councils, soil and water conservation districts, and local land trusts should coordinate these efforts among the affected counties, municipalities, homeowner associations, and other stakeholders responsible for land use decisions. We recommend that a comprehensive GIS-based stream corridor protection plan for the Cape Fear shiner should be developed, focusing principally on the areas outlined in Figure 4. The stream corridor protection plan should identify and prioritize instream habitats and riparian lands of greatest conservation importance, including damaged lands and stream habitats where ecological restoration could be most helpful. The Chatham County Conservation Partnership, comprising County staff, federal and state agencies, regional planning organizations and private land trusts is currently working toward similar goals in Chatham County, although not specifically targeting aquatic systems.

Due to the Cape Fear shiner's association with and apparent dependence on filamentous green algae and other aquatic plants, dams, development and other projects that could affect growths of macroalgae and macrophytes should be evaluated with these impacts in mind. Fine sediment and turbidity (from soil erosion and urban runoff), planktonic algae (from lakes), herbicides, metals and other pollutants, or unnatural flow regulation patterns (including abbreviated low flow periods) might reduce the availability of algae and plants that are nutritionally-suitable for Cape Fear shiners at critical times, and thus reduce the Cape Fear shiner's competitive advantage. The Cape Fear River and Haw River had notably less filamentous green algae and riverweed in 2007 than did the Deep River and Rocky River.

Amanda Howard Hewitt (Howard, 2003; Hewitt et al., 2006) monitored survival, growth, and contaminant uptake by Cape Fear shiners placed in cages at ten sites in the Haw, Rocky and

Deep Rivers. She found that caged shiners accumulated cadmium, mercury, lead, polychlorinated biphenyls (PCBs), DDT, and other contaminants, although not always in proportion to measured concentrations in the ambient water and sediments. The upper Rocky River and Haw River had generally higher levels of these pollutants, and lower shiner growth rates than those in the Deep River. Reducing these pollutant loads may be critical to recovering Cape Fear shiner populations in the upper Rocky River and Haw River. The same may be true in the Cape Fear River, which Howard did not sample.

H1 - Haw River from Saxapahaw Dam to Bynum Dam

The 2007 survey included four Haw River collections upstream of Bynum Dam, and yielded one Cape Fear shiner. This fish was taken in the northern channel of the Haw River River beside "Watermelon Island" (local name, unnamed on USGS quad) four miles upstream of Bynum Dam in Chatham County. This site is approximately 1.5 miles upstream of the Rock Rest area where NC-WRC collected several specimens in 1993 and one specimen in 2000. These three collections represent the only reported Cape Fear shiner collections upstream of Bynum Dam. It appears *N. mekistocholas* has been rare in this river segment for several decades.

Based on these collections the Cape Fear shiner should be considered "extant, but rare" in the 7.6 miles of Haw River segment H1 in Chatham County from the southeastern corner of Alamance County (1.4 miles upstream of SR-1545) to Bynum Dam. Apparently suitable habitat is common in most of this river segment, except in the short impounded segment just above Bynum Dam.

No Cape Fear shiner has ever been reported from Alamance County, but apparently suitable habitat is common in the 9.8 mile segment from Saxapahaw Dam downstream to the southeastern corner of Alamance County. The Cape Fear shiner may also be extant in this segment, as there is no dam or other physical barrier preventing movement between this lower Alamance County segment and the upper Chatham County segment. Whether or not the shiner is extant in Alamance County, the segment of Haw River below Saxapahaw should be given the same protection efforts as the occupied Chatham County segment. These two segments combined comprise 17.4 miles of contiguous habitat between Saxapahaw and Bynum.

Major tributaries of the Haw River between Saxapahaw and Bynum that may be occupied intermittently by Cape Fear shiners include the two Cane Creeks (one in Alamance County and one in Orange County), Collins Creek, Terrells Creek, Dry Creek, Wilkerson Creek and Pokeberry Creek. The lowermost two mile segments of these creeks are most likely to be used.

Upstream of Saxapahaw, the Haw River is fragmented by numerous small dams and the watershed has been urbanized for many decades. Given the long history of urban runoff, industrial and agricultural pollution, and inadequate wastewater treatment in past decades in the upper Haw River watershed, it is unlikely that an isolated Cape Fear shiner population persists upstream of Saxapahaw. We suspect the Cape Fear shiner was extirpated from these reaches due to urban and agricultural impacts long before the species was discovered. However, with modern wastewater treatment and stormwater management improvements in the upper Haw River watershed, water quality in the Alamance County segment of the Haw River may be better now than in past decades. It might thus be possible to reintroduce Cape Fear shiners into areas of suitable habitat where they probably occurred prior to urbanization. Enhanced efforts to promote low-impact development methods and effective stormwater quantity and quality controls will continue to be important. Removal of unused dams on the Haw River in Alamance County could further help species recovery in this region.

Major tributaries of the Haw River upstream of Saxapahaw that may be occupied intermittently by Cape Fear shiners include Alamance Creek, Back Creek, and Reedy Fork Creek. Stony Creek is dammed close to its confluence with the Haw River and is therefore probably not suitable for Cape Fear shiners.

H2- Haw River from Bynum Dam to Jordan Lake Pool

The 2007 survey included six collections in the 4.7 mile Haw River segment between Bynum Dam and the head of Jordan Lake, but yielded no Cape Fear shiner, despite an abundance of apparently suitable habitat. WRC collected three specimens in 1992 between US-15-501 (just below Bynum Dam) and US-64. Numerous other collections between 1987 and 2006 in the lower Haw River failed to yield any Cape Fear shiners. In 1982 Jordan Lake was filled, flooding the lower one mile of Robeson Creek east of Pittsboro where many specimens were collected during the 1960s and 1970s. Robeson Creek and 4.9 miles of Haw River were thus rendered unsuitable for Cape Fear shiners (see discussion of river segment H3).

The three specimens collected by WRC in 1992 plus the one collected in 1949 are the only Cape Fear shiner specimens known from the main stem of the Haw River below Bynum Dam. However, as this fish was common in the lower one mile of Robeson Creek prior to Jordan Lake, it may have been common in the poorly-sampled Haw River main stem as well. Prior to the 1984-86 status survey, most fish sampling efforts in large rivers used gear appropriate for larger fish species, and would not have been effective for sampling Cape Fear shiners. During the 1960s WRC conducted statewide surveys using rotenone and small-mesh nets appropriate for small minnows, but these were limited to smaller, wadable streams near road access points. The Robeson Creek, Parkers Creek, and Kenneth/Neills Creek populations of Cape Fear shiners were discovered during those surveys.

The Haw River from Bynum Dam to the head of Jordan Lake (about one mile south of US-64 bridge) is wide and rocky with many islands, braided channels and Justicia beds. Its large size, habitat complexity and prevalence of boulders and irregular bedrock make it very difficult to sample effectively, even during drought conditions. Considering these sampling limitations, it is certainly possible that Cape Fear shiners persist undetected at low abundance in this river segment. The Cape Fear shiner should be considered “possibly extant, rare” in the 4.7 mile Haw River segment H2 in Chatham County, based on the 2007 collection upstream of Bynum Dam and the absence of any significant habitat change or apparent water quality change or pollutant source downstream of the occupied reach. All other native species of shiners, chubs, darters, madtoms, killifish, and other small riffle-and-pool dependent fishes known from this river segment are extant based on our 2007 sampling.

Downstream movement of Cape Fear shiners from the population upstream of Bynum Dam is still possible, either over the dam or through the unused power plant. Since 1982 Jordan Dam prevents any natural migration of shiners between the lower Deep River and the Haw River above Jordan Lake.

It is not known whether introduced species in the Haw River including common carp (*Cyprinus carpio*), flathead catfish (Pylodictis olivaris), channel catfish (Ictalurus punctatus), rosefin shiner (*Lythrurus ardens*) or crescent shiner (*Luxilus cerasinus*) may be affecting the Cape Fear shiner population. The carp and channel catfish have been established in the Haw, Deep, and Cape Fear Rivers for many decades, while the flathead catfish, rosefin shiner and crescent shiner are relative newcomers. As only a few specimens of rosefin shiner and crescent shiner were

collected, it seems unlikely these two species could be affecting Cape Fear shiners. Our 2007 sampling methods were not effective for assessing the abundance of carp and large catfishes.

H3 - Haw River from Jordan Lake Pool to Jordan Dam

The 4.9 mile segment of Haw River from a point about one mile downstream of US-64 to Jordan Lake Dam was impounded in 1982, and is no longer suitable for Cape Fear shiners. We did not sample for shiners within the reservoir pool. The satinfin shiner (*Cyprinella analostana*) and golden shiner (*Notemigonus crysoleucas*) are the only shiner species that have persisted within the lake, based on reservoir fishery sampling by WRC, NCSU and other researchers. The Cape Fear shiner should be considered "permanently extirpated" from Haw River segment H3, and cannot be expected to recolonize.

This river segment contained extensive rocky riffle habitat and braided channels around islands prior to impoundment by Jordan Lake. Major tributaries impounded by the lake are the New Hope River and Robeson Creek. Cape Fear shiners were commonly collected in the lower one mile segment of Robeson Creek during the 1960s to 1970s. They presumably also occurred in the adjacent Haw River and lower few miles of New Hope River (based on USGS topographic map, Merry Oaks quadrangle). However, there are no collection records to verify this, due to the sampling limitations discussed in segment H2.

Without access to a large free-flowing river, the Cape Fear shiner population that formerly used Robeson Creek apparently died out. No specimen has been taken from Robeson Creek after Jordan Lake was filled. The un-impounded reaches of New Hope River tributaries upstream of Jordan Lake are apparently too small and have insufficient rocky riffle habitat to support Cape Fear shiners, based on the 1984-86 study. We did not sample Robeson Creek or the New Hope River tributaries in 2007, but numerous DWQ fish surveys in these streams over the past 20 years have never yielded Cape Fear shiners.

Under current conditions there is essentially no likelihood of Cape Fear shiners persisting or recolonizing in the river and creek segments impounded by Jordan Lake, nor in any tributary (other than Haw River main stem) draining directly into Jordan Lake. Construction of Jordan Lake has also effectively isolated the Haw River population from the Deep River population of Cape Fear shiners. Achieving shiner passage for this dam is currently not feasible. Even if a "fish ladder" device for shiners could be designed and installed at the dam, there is little chance that they would survive within the lake pool or find their way upstream to the free-flowing segment of the Haw River.

To protect and recover the downstream population of shiners in the Cape Fear River, releases from Jordan Lake should be operated to replicate the seasonal temperature and flow regimes that occurred prior to impoundment, to the extent that such operation is compatible with the reservoir's mandated purposes of flood control, water supply and recreational. Temperature and flow in the Haw River at Bynum and Deep River at Moncure may be used as guidance. It is unknown whether the outflow from Jordan Lake is significantly affecting temperature, nutrients, or other physical -chemical dynamics in the Cape Fear River below Buckhorn Dam, but it does appear that the Cape Fear shiner population downstream of Buckhorn Dam has declined since Jordan Lake was built. (See discussion of river segment C2).

The lowermost 4.2 mile segment of Haw River from Jordan Dam downstream to the confluence of the Haw, Deep and Cape Fear Rivers is impounded by Buckhorn Dam on the Cape Fear River, and is discussed in segment C1.

R1 - Rocky River from Siler City to Rocky River Hydro Dam

Cape Fear shiners were commonly collected in Rocky River at the SR-1010 and NC-902 bridges upstream of Rocky River Hydro Dam (Reeve's Lake) during the 1960s to 1970s. NCSM reported a decline in this population during the late 1970s, prompting the 1984-86 status survey that yielded only two specimens. All subsequent collection attempts by WRC and others upstream of Reeve's Lake have failed to reveal any Cape Fear shiners, including our six collections at four different sites in 2007. The Cape Fear shiner should be considered "probably extirpated" from Rocky River segment R1. It cannot be expected to recolonize without human intervention, as upstream migration of shiners past Rocky River Hydro Dam is probably impossible.

Rocky River upstream of Rocky River Hydro Dam is smaller than other rivers where Cape Fear shiners are known to reproduce, and this population may have been dependent on periodic recolonization from the larger river downstream. However, as Rocky River Hydro Dam has been impassable to shiners since it was built about 1920, this population must have been self-sustaining for about 60 years (Hugh Stoll, dam owner, pers.com). Urban and agricultural development, polluted stormwater runoff, inadequate wastewater treatment and spills, drought, and lack of access to a larger river may have contributed to the shiner's demise, but it is unclear why the Cape Fear shiner has declined drastically in this river segment while other species have not. All other native shiner, chub, darter, and other small riffle-and-pool dwelling fishes formerly reported from this river segment were still extant in 2007.

While urban development and water demand in the Siler City area are still growing, wastewater treatment and stormwater management are generally improving, as compared with conditions during the 1970s and 1980s when the Cape Fear shiner population decline was occurring. Agricultural best management practices are also more widely used now than in previous decades. As the Cape Fear shiner is still common just below Rocky River Hydro Dam (where the population has free access to the Deep River), it would be a simple and low-risk endeavor to collect and transport shiners from the lower Rocky River to the SR-1010 and NC-902 bridge sites in order to reestablish the upper Rocky River population. Chatham County, Triangle Land Conservancy, Friends of Rocky River and other organizations are also cooperating to establish riparian corridors along the Rocky River and Deep River, which would help ensure habitat protection for the reintroduced shiners. Maintaining adequate flows during dry weather via releases from Siler City reservoir will also be crucial to recovering this population.

Rocky River Hydro is owned and operated by Hoosier Hydroelectric of Harrisonburg VA, and sells its generated power to Progress Energy. Its three turbines can potentially generate up to 564 MWH annually during years of plentiful rainfall. However, if for some reason the hydroelectric plant is retired, then removal of this dam and restoration of free-flowing river habitat could be considered. If done properly, removal of this dam could also benefit several state-listed rare mussels and dragonflies known from the Rocky River.

R2 - Rocky River from Rocky River Hydro Dam to Deep River

The lowermost 5.5 miles of Rocky River downstream of Rocky River Hydro Dam, together with the contiguous Deep River, contains abundant habitat where Cape Fear shiners are common. The Cape Fear shiner should be considered "extant, common" in Rocky River segment R2. The shiner was also common in the lower Rocky River and Rocky/Deep confluence area during the 1984-86 status survey and several subsequent collections. Amanda Howard found them to be common in these river segments during her M.S. thesis research in 2001-02. In 2007 we caught a few Cape Fear shiners at all three sampling sites on the lower Rocky River within the first 10 to 20 minutes of sampling. Because this population has been well documented, we did not spend time to collect greater numbers of specimens at these sites.

D1 - Deep River from Randleman Dam to Coleridge Dam

No Cape Fear shiner has ever been reported upstream of Coleridge Dam, but a few specimens are known from the Deep River close below Coleridge Dam. We sampled two river sites and one tributary between Ramseur Dam and Coleridge Dam, and did not find any Cape Fear shiner. Much of this segment consists of long sandy runs and pools with minimal riffle habitat or aquatic vegetation, but the two river sites sampled do contain apparently suitable habitat. Cape Fear shiners may have occurred upstream of Coleridge Dam prior to urbanization and dam building in the early 1900s, but if so they were apparently extirpated prior to their recognition as a new species.

Upstream of Ramseur, the Deep River is fragmented by a series of small mill dams at Franklinville, Cedar Falls, Central Falls, and Worthville, and a new large water supply reservoir dam at Ramseur. There is little likelihood of Cape Fear shiners persisting in any of these short, mostly impounded reaches between Randleman and Ramseur, or farther upstream in the heavily urbanized headwaters of the Deep River. Given the severe degree of river alteration upstream of Ramseur, it is difficult to interpret whether these reaches may formerly have been suitable for Cape Fear shiners. The Cape Fear shiner population in Deep River segment D1 between Randleman and Coleridge should be considered "not reported, but within probable historic range, probably extirpated."

Like Jordan Reservoir Dam (river segment H3), flow releases from Randleman Dam should be operated to simulate the seasonal temperature and flow regimes (including flood and drought flows) that occurred in the Deep River prior to impoundment, to the extent that such operation is compatible with the reservoir's mandated purposes. Fish communities and physical-chemical parameters from Ramseur downstream to Highfalls should be routinely monitored to assess whether this new reservoir will affect the Cape Fear shiner population and habitat in the upper Deep River. We do not know whether the apparent decline of Cape Fear shiners in the Cape Fear River in Harnett County may be due in part to impacts from Jordan Reservoir (see discussion of river segment C2), but given this possibility it would be wise to monitor whether any similar changes occur downstream of Randleman Reservoir.

Removal of Ramseur Dam is not likely to benefit Cape Fear shiners, as they apparently do not occur in the Deep River segments upstream or immediately downstream of this dam. Ramseur Dam may also serve as a "sink" for silt, heavy metals, and other settleable pollutant inputs from the heavily urbanized Deep River watershed upstream of Ramseur. The potential for restoring habitat and reestablishing Cape Fear shiners upstream of Ramseur appears low, given past and expected urbanization.

D2 - Deep River from Coleridge Dam to Highfalls Dam

The 2007 survey included collections at three sites in the Deep River and three large tributaries between Coleridge Dam and Highfalls. These collections yielded only one specimen, captured at the toe of Coleridge Dam in Randolph County. The only other known specimens from this segment were three specimens collected in 1985 by Pottern (one in Fork Creek and two in the Moore County segment of Deep River) and approximately 30 specimens taken by John Alderman and Chris McGrath of WRC at various sites between Coleridge and Highfalls during seven days of sampling in 1992-94. Of these, 21 were taken in a single collection at SR-1456 in a "pool with much algae"; most other samples yielded only 1 to 3 specimens. Based on the 1992-94 and 2007 collections, the Cape Fear shiner population in these 18.9 miles of Deep River segment D2 should be considered "extant, uncommon to rare."

This river segment should be a high priority for long-term Cape Fear shiner population monitoring. It is downstream of the urbanizing High Point, Archdale and Asheboro areas and the new Randleman Reservoir, which may cause ecological changes in the river that could affect Cape Fear shiners. More importantly, this segment is upstream of the Cape Fear shiner's largest remaining population in the Deep River between Highfalls and Moncure. Early detection of any impending ecological problems upstream of Highfalls could be crucial to saving the lower Deep River population and the species.

The potential benefits to the Cape Fear shiner of removing Coleridge Dam are uncertain. Of the 7.5 river miles between Ramseur and Coleridge, the uppermost one to two miles contains shallow rocky habitat suitable for Cape Fear shiners, but the remainder appears predominantly narrow and deep with limited aquatic plant beds, based on topographic mapping and aerial photographs. Field evaluation of the river substratum in this segment should be investigated prior to developing plans for removal of Coleridge Dam.

D3 - Deep River from Highfalls Dam to Carbonton Dam

The 2007 survey included three Deep River samples in the upper half of the 21.9 mile segment of Deep River between Highfalls Dam in Moore County and Carbonton Dam on the Chatham/Lee County line. Cape Fear shiners were found easily at all sites, including 30+ specimens in a wide, slow-flowing side-channel area (site D11) with heavy growths of filamentous green algae. The Cape Fear shiner population in Deep River segment D3 should be considered "extant, common." Rocky habitat and aquatic plant beds are abundant near Highfalls, but become progressively less common toward Carbonton as the river gradient flattens and transitions from a Slate Belt stream to a Triassic Basin stream.

Carbonton Dam impounded approximately ten miles of the Deep River, mostly in Moore County, from its construction in 1921 until its demolition in December 2005. The Catena Group monitored the restored river segment during 2006 and 2007 and found small numbers of Cape Fear shiners at several sites within the former pool and downstream of the former dam. We did not sample this reach because of Catena Group's recent survey work. Patches of rocky habitat and aquatic plant beds are less common in this low-gradient reach, but Cape Fear shiners are using these scattered suitable patches wherever they occur. The removal of Carbonton Dam (about mid-way between Highfalls and Rocky River) creates 47 miles of continuous un-impounded Deep River habitat between Highfalls Dam and Lockville Dam near Moncure. The previously isolated shiner populations in river segments D3 and D4 can now move freely, which may improve genetic diversity and resistance to extirpation. If Highfalls Dam is eventually

removed, this would create 66 miles of un-impounded river from Coleridge Dam to Lockville Dam.

D4 - Deep River from Carbonton Dam to Rocky River

The 22.0 mile segment of Deep River from Carbonton (dam removed in Dec 2005) to Rocky River is in the Triassic Basin, and is predominantly sandy and low-gradient. Cape Fear shiners are probably uncommon in most of this segment, where rocky shoals and aquatic/emergent plant beds are generally sparse. However, collection efforts in this reach have also been less intensive than elsewhere in the Deep River, due to lack of promising-looking habitat. Our only sample in this reach in 2007 was at the US-15-501 bridge, near a log jam and small gravel/cobble bar and with only minor aquatic vegetation. Several Cape Fear shiners were collected, mainly in deeper pools around logs and branch piles. Previous collections at this site, at Cumnock-Rosser Road (SR 2153), and in the shoals just below Carbonton Dam also yielded small numbers of Cape Fear shiners. Based on these past and recent collections, the Cape Fear shiner population in Deep River segment D4 should be considered "extant, uncommon." Although suitable spawning habitat for Cape Fear shiners is rare in this segment, use of this segment may increase as a result of Carbonton Dam removal.

D5 - Deep River from Rocky River to Lockville Dam

This 3.5 mile segment of Deep River from the mouth of Rocky River to Lockville Dam contains extensive rocky shoals, gravel/cobble bars and aquatic plant beds, except in the lowermost 0.5 mile which is impounded by Lockville Dam. This segment is contiguous with the lower Rocky River habitat (R2). Together these reaches of Rocky River and Deep River total 9.0 river miles and support the largest known population of Cape Fear shiners. Researchers from NCSU and other institutions have conducted ecological and behavioral studies on Cape Fear shiners in this vicinity, due to the abundance and relative ease of finding and observing the shiners in this area. Triangle Land Conservancy and other local conservation groups have been working to acquire and protect riparian lands in this area since the 1980s. We did not sample this segment for Cape Fear shiners in 2007, as other researchers had confirmed their continued abundance here in recent years. The Cape Fear shiner population in Deep River segment D5 should be considered "extant, common."

A federally endangered annual plant also occurs in this segment of the Deep River downstream of the Rocky River. Atlantic River Harperella (*Ptilimnium viviparum*, a.k.a. *Ptilimnium nodosum, in part*), grows in moist sand and gravel deposits among rocks on islands or along sunny shorelines. Harperella blooms and sets seed in summer when river flow is generally low, interrupted by occasional, brief high flow events that may inundate it. This is also the time when young-of-year Cape Fear shiners are growing in the river's warm, shallow, algae-filled pools. Harperella and Cape Fear shiners are apparently both adapted to (and may benefit from) extended periods of low summer flow.

The 0.5 mile segment impounded by Lockville Dam, a hydroelectric power dam, does not appear to provide good habitat for Cape Fear shiners, although shiners may be carried into it or even through it (over the dam and/or into the hydroelectric plant headrace) during high flow events. In 1988 several specimens were collected in the headrace (NCSM records).

D6 - Deep River from Lockville Dam to US-1 near Moncure

Lockville Dam is located 0.3 mile upstream of the US-1 bridge near Moncure. Immediately below Lockville Dam is approximately 1,000 feet of rocky shoal habitat with abundant water willow, riverweed and filamentous algae, similar to the habitat areas in segment D5. Our 2007 sample here (site D14) yielded more than 40 Cape Fear shiners, most of which were seined in pools with extensive growths of filamentous green algae or in adjacent runs. The abundance of Cape Fear shiners found at site D14 is notable for two reasons: 1) This small segment of suitable habitat probably receives limited shiner recruitment from upstream (possibly flushed over the dam during high flows) and probably none from the Buckhorn Dam impoundment downstream. 2) The 2007 and 2002 droughts were among the most severe on record in the Deep River, according to the USGS gage at Moncure, suggesting that Cape Fear shiners in this small, isolated patch were not adversely affected by two severe droughts only five years apart.

The Cape Fear shiner should be considered "extant, common" in Deep River segment D6, despite the limited size of this habitat and its isolation between two impoundments. In the 1985 status survey Pottern speculated that the presence of Cape Fear shiners in this reach may depend on frequent wash-outs from the population upstream, rather than on-site reproduction. However, finding them in abundance at this site during a severe drought year suggests that this population may in fact be self-sustaining.

Removal of Lockville Dam would likely have negligible benefit to Cape Fear shiners, as it would restore only about 0.5 mile of free-flowing river habitat. Also, it could inadvertently kill many Cape Fear shiners during dam removal, as these fish have no where else to go but the 1,000 feet of suitable habitat immediately below the dam. However, if *both* Lockville Dam and Buckhorn Dam were removed, preferably with Buckhorn Dam removed first, this would reconnect suitable habitats in the Deep River and Cape Fear River and might benefit Cape Fear shiners in the long run, as discussed below under segment C1.

C1 – Cape Fear, Deep & Haw Rivers, Buckhorn Dam Impoundment

Buckhorn Dam, located on the Cape Fear River near the southeastern corner of Chatham County, impounds 12.9 river miles including the lowermost 2.8 miles of Deep River (below US-1 bridge), lowermost 4.2 miles of Haw River (below Jordan Lake Dam), and uppermost 5.9 miles of Cape Fear River. These river segments are mostly too deep for water willow beds except small patches along the shorelines, and contain no visible rocky or cobble/gravel shoal habitats. No Cape Fear shiner specimen has ever been reported in these reaches, but they obviously moved through these reaches prior to construction of Buckhorn Dam in the 1800s, based on their occurrence upstream in the Deep Rivers and Robeson Creek, and downstream in northern Harnett County. Segment C1 is not wadable and we did not sample here for shiners in 2007.

Cape Fear shiners that normally reside among the rocky shoals in Deep River segments D5 and D6 may occasionally get flushed into segment C1 during high flow events, particularly in the Deep River portion, but they have little chance of persisting long-term in the impounded reach. It is also possible that shiners from segment D6 may find temporary refuge downstream of the US-1 bridge during severe droughts (if the short reach of runs and pools they normally occupy dries up), or during extreme high flows, or during winter. The Cape Fear shiner should be considered "not reported, probably extirpated except for intermittent occurrence" in river segment C1.

The potential benefit to Cape Fear shiners of removing Buckhorn Dam is uncertain. This dam is no longer used for hydropower generation, but may be necessary to provide sufficient depth for operation of two industrial water intakes on the lower Haw River and Sanford's municipal water intake on the Cape Fear River. The impounded segment is low-gradient and mostly within the Triassic Basin (Figure 3), and would probably have minimal gravel/cobble shoal habitat after dam removal. Field evaluation of the river substratum in this segment should be investigated prior to developing plans for removal of Buckhorn Dam. However, if *both* Lockville Dam and Buckhorn Dam were removed, and the Deep River and Cape Fear River shiner habitats thus reconnected, this could benefit Cape Fear shiners in the long run even if rocky shoal habitat in the restored segment is sparse.

C2 – Cape Fear River from Buckhorn Dam to Lillington

In 2007 we spent three days and sampled seven sites on the Cape Fear River and two tributaries between Buckhorn Dam and Raven Rock State Park above Lillington. No Cape Fear shiner was found, despite many suitable-looking areas of rocky shoal habitats. However, gravel/cobble bars, aquatic plant beds, and shiner schools were generally less common in this segment of the Cape Fear River than in the Deep River or Haw River (qualitative observations). The water also appeared more turbid than in the Deep or Haw Rivers, despite low flows, especially in the upper one mile of the Cape Fear River closest to Buckhorn Dam. The sources or causes of this turbidity are unknown, but water quality and instream ecological processes in river segment C2 could be affected by releases from Jordan Lake, cooling water from a coal-fired power plant upstream of Buckhorn Dam, algal and cyanobacterial blooms in the Buckhorn Dam impoundment, or other factors. Cyanobacterial mats on the river bed (presumably *Oscillatoria* or *Phormidium*) are common in this area, and may affect the growth of aquatic vascular plants, mosses and filamentous green algae.

Only four collections of the Cape Fear shiner downstream of Buckhorn Dam were reported prior to 2007, based on NCSM and NHP databases: Parkers Creek in August 1962 (WRC, 16 specimens), Kenneth (Neills) Creek in August 1962 (WRC, 6 specimens), Cape Fear River below Daniels Creek in 1975 (CP&L, 1 specimen), and Neills Creek in December 1986 (Pottern, 15 specimens). Subsequent sampling between 1987 and 2007 in the river and tributaries in Harnett County by WRC, DWQ, and other biologists has failed to yield additional specimens, including seven samples by Pottern and Heise in Neills Creek during September 2003.

The Harnett County portion of the shiner's range is designated "recently lost" on the WRC website: [http://www.ncwildlife.org/pg07_WildlifeSpeciesCon/pg7b1b1_1.htm]. But in 2007 we captured a single specimen in Cape Fear River segment C3 near Erwin, ten miles downstream of Lillington. This specimen provides the only evidence after 1986 that Cape Fear shiners may still persist in segment C2. As there is no barrier between the Erwin collection site and Buckhorn Dam, small groups of Cape Fear shiners may occur in patches throughout this segment at very low density, with very low probability of detection. Based on the Erwin specimen and other recent collection data, the population in Cape Fear River segment C2 should be considered "very rare or possibly extirpated." However, given the habitat continuity from Buckhorn Dam to Erwin, there is potential for Cape Fear shiners to recover in segment C2 if habitat is protected and water quality is restored.

Removal of Buckhorn Dam might increase the movement of Cape Fear shiners from Deep River segment D6, where they are common, to Cape Fear River segments C1 and C2. At present segment C1 is impounded and is neither suitable nor passable to Cape Fear shiners. Although downstream movement of shiners from segment D6 could increase if the dam were removed, it

is uncertain whether enough of these fish would survive in segment C2 to contribute significantly to local species recovery.

C3 - Cape Fear River from Lillington to Erwin

We spent two days and made seven collections in 2007 on the Cape Fear River between the WRC boat ramp near Lillington and the NC-217 bridge near Erwin in Harnett County. Only one Cape Fear shiner was found among several thousand shiners examined in these collections. This fish was taken in a three foot deep pool with moderate flow adjacent to rocky riffles about 500 feet downstream of the NC-217 bridge. This site is ten miles downstream from the Cape Fear shiner's previous known range limit. The shiner was captured in a large mixed school dominated by sandbar, satinfin, whitefin, spottail and highfin shiners and juvenile spotted suckers. Water willow and other aquatic plants are sparse at this site. The Cape Fear shiner population in river segment C3 should be considered “extant, very rare.”

Cape Fear River segment C3 includes many areas of rocky shoal habitats, including some with suitable-looking gravel/cobble bars and aquatic plant beds, although plant beds were not as common as in the Deep River. The elevated turbidity and cyanobacterial mats noted in the upper portion of segment C2 appeared to have attenuated considerably in this lower reach, and water clarity appeared similar to the Haw and Deep Rivers (qualitative observation). Contaminants in the water or in sediments may be a factor limiting the survival of Cape Fear shiners in Cape Fear River segments C2 and C3, similar to the effects documented by Howard (2003) and Hewitt (2006) in other river segments where Cape Fear shiners are rare or extirpated. Contaminants may also affect the growth of aquatic plants and algae that Cape Fear shiners apparently rely upon.

Additional patches of rocky shoal habitats continue downstream to a point approximately 2.0 miles below the NC-217 bridge, as depicted on the USGS Erwin quadrangle and visible on aerial photography. We did not sample these lowermost shoal areas in 2007 due to lack of convenient access.

Upper Little River is the only tributary in segment C3 potentially large enough to support Cape Fear shiners in its lower reach. The lowermost 0.1 mile of this river contains rocky habitat similar to that in the adjacent Cape Fear River (but no water willow beds), and yielded similar fish species. Farther upstream it is a typical low-gradient sand-dominated stream of the Sandhills region. We examined Upper Little River at the first three bridges upstream from the mouth (Titan Roberts Road, Ross Road, and US-401) and it did not appear suitable for Cape Fear shiners. The fish community reported from Upper Little River comprises mainly Sandhills and Coastal Plain species, with few Piedmont species (Menhinick, 1991). The sandbar, satinfin, whitefin, white, and highfin shiners most often collected in schools with Cape Fear shiners appear to be rare or absent from Upper Little River, except in the immediate vicinity of its confluence with the Cape Fear River. However, a canoe survey along the lower few miles of this river might be worthwhile to determine whether any suitable habitat for Cape Fear shiners may exist that is not visible from public road bridges.

Summary and Conclusions

The Cape Fear shiner’s approximate known range extends from Chicken Bridge (SR-1545) on the Haw River in Chatham County and from Coleridge Dam on the Deep River in Randolph County downstream to the last riffles below Erwin on the Cape Fear River in Harnett County,

plus major tributaries including Rocky River in Chatham County. This overall range includes approximately 135 river miles along the main stems of these four rivers (excluding creeks). The 2007 survey demonstrates that the Cape Fear shiner remains extant over much of this known range, including the upper and lower endpoints listed above. However, it appears to be reasonably common only in the Deep River between Highfalls and Moncure (48 river miles) and the lower Rocky River (5 river miles). Jordan Lake and Buckhorn Dam have impounded 18 miles of the Haw, Deep and Cape Fear Rivers which no longer provide suitable habitat for this shiner. In the remaining 64 river miles, the Cape Fear shiner is apparently very rare or possibly extirpated, including the upper Rocky River above Rocky River Hydro Dam (no specimen since 1985), Haw River from Chicken Bridge to Jordan Lake (one specimen in 2007), upper Deep River from Coleridge to Highfalls (one specimen in 2007), and Cape Fear River from Buckhorn Dam to Erwin (one specimen in 2007).

The Cape Fear shiner may have historically extended upstream in the Haw River into Orange, Alamance and perhaps Guilford Counties (based on apparently suitable habitat), and upstream in the Deep River into northern Randolph County and perhaps southwestern Guilford County, but if so then it may have been extirpated from those areas before it was first recognized as an undescribed species in the 1960s. Numerous hydroelectric power and mill dams built during the late 1800s and early 1900's on the Haw, Rocky, Deep and Cape Fear Rivers have fragmented shiner habitat, altered sediment transport and water quality dynamics of these rivers, and prevented upstream recolonization. Impacts of dams and extensive land clearing, erosion, and urbanization in the upper Cape Fear River watershed over the past 200 years may have reduced the Cape Fear shiner's range long before the fish was discovered. More recently, several miles of occupied habitat in the lower Haw River and New Hope River were destroyed when Jordan Lake was constructed in the early 1980s.

The watershed areas of primary conservation importance for the Cape Fear shiner are depicted in Figure 4, principally those lands draining directly into occupied habitat or extirpated habitat where shiner recovery could reasonably be expected. Lands draining directly into habitats that are permanently lost due to impoundment (e.g., Jordan Lake) or densely urbanized headwater areas (e.g., Haw River above Graham and Deep River above Ramseur) are excluded. Riparian and instream habitat protection efforts should focus first and foremost on the Deep River and lower Rocky River segments where the Cape Fear shiner population appears strongest. Land acquisition, conservation easements, and buffer protection rules or incentives to maintain and restore stream-side forests are among the most efficient and cost effective means for habitat protection. Wastewater discharge and stormwater permit limits should be based on concentrations that will protect Cape Fear shiners and the aquatic plants and green algae that they depend on. Low-impact development strategies should be strongly encouraged in the primary conservation watersheds, and all new development or re-development should be required to install and maintain stormwater control BMPs that approximate the pre-development hydrograph. No new sand or gravel mining operations should be approved.

Implementation of these water quality and riparian protection measures in the remainder of the watershed could also benefit Cape Fear shiners, but is of secondary importance. These secondary areas include the Robeson Creek watershed, the New Hope River arm of Jordan Lake, Haw River watershed above Graham, Deep River watershed above Ramseur, Lick Creek watershed (tributary to Buckhorn Dam impoundment), and Upper Little River watershed (tributary to Cape Fear River near Erwin).

Critical Habitat

Critical Habitat as designated in the 1988 Cape Fear Shiner Recovery Plan (Biggins, 1988) includes only the immediate stream segments where Cape Fear shiners were collected during the 1984-86 surveys. The existing Critical Habitat segments include: 1) upper Rocky River from NC-902 downstream to SR-1010; 2) lower Rocky River from Bear Creek to the Deep River confluence; 3) lower Bear Cr from SR-2156 to the Rocky River confluence; 4) Deep River from the Rocky River confluence to 0.3 mile downstream of the Moncure USGS gage; 5) Deep River from Fork Creek to 2.5 mile downstream of SR-1456; and 6) Fork Creek from SR-2873 to the Deep River confluence. Given our current understanding of the Cape Fear shiner's distribution and the apparent role of water quality and sediment contaminants in limiting its survival, we recommend that Critical Habitat be expanded to include:

Haw River from 2.0 miles upstr of SR-1545 to 1.0 mile upstr of Bynum Dam (Chatham Co);
Haw River from Bynum Dam to 1.0 mile downstream of US-64 (Chatham Co);
Rocky River from SR-2170 to 1.0 mile downstream of SR-1010 (Chatham Co);
Rocky River from Hydro Dam to Deep River confluence (Chatham Co);
Bear Creek from SR-2156 to Rocky River confluence (Chatham Co);
Deep River from Coleridge Dam to Bear Cr confluence (Randolph & Moore Co);
Deep River from Highfalls Dam to 0.3 mile dnstr of Moncure gage (Moore, Lee, Chatham Co);
Deep River from Lockville Dam to 0.1 mile downstream of US-1 (Lee, Chatham Co);
Cape Fear River from Buckhorn Dam to 2.0 miles downstream of NC-217 (Harnett Co).

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Appendix A. Common and scientific names of fishes collected during the 2007 Cape Fear Shiner survey in the Haw, Rocky, Deep, and upper Cape Fear Rivers.

Lepisosteus osseus	Longnose Gar
Alosa sapidissima	American Shad
Dorosoma cepedianum	Gizzard Shad
Clinostomus funduloides	Rosyside Dace
Cyprinella analostana	Satinfin Shiner
Cyprinella nivea	Whitefin Shiner
Cyprinus carpio	Common Carp -**e**
Luxilus albeolus	White Shiner
Luxilus cerasinus	Crescent Shiner -**e**
Lythrurus ardens	Rosefin Shiner -**e**
Nocomis leptocephalus	Bluehead Chub
Notemigonus crysoleucas	Golden Shiner
Notropis alborus	Whitemouth Shiner
Notropis altipinnis	Highfin Shiner
Notropis amoenus	Comely Shiner
Notropis chiliticus	Redlip Shiner -**e**
Notropis hudsonius	Spottail Shiner
Notropis mekistocholas	Cape Fear Shiner
Notropis petersoni	Coastal Shiner
Notropis procne	Swallowtail Shiner
Notropis scepticus	Sandbar Shiner
Pimephales promelas	Fathead Minnow -**e**
Semotilus atromaculatus	Creek Chub
Catostomus commersoni	White Sucker
Erimyzon oblongus	Creek Chubsucker
Minytrema melanops	Spotted Sucker
Moxostoma collapsum	Notchlip Redhorse
Moxostoma macrolepidotum	Shorthead Redhorse
Moxostoma pappillosum	V-lip Redhorse
Scartomyzon sp.cf. lachneri	Brassy Jumprock
Ameiurus brunneus	Snail Bullhead
Ameiurus platycephalus	Flat Bullhead
Ameiurus natalis	Yellow Bullhead
Ameiurus nebulosus	Brown Bullhead
Ictalurus punctatus	Channel Catfish -**e**
Noturus insignis	Margined Madtom
Pylodictis olivaris	Flathead Catfish -**e**
Esox americanus	Redfin Pickerel
Esox niger	Chain Pickerel
Aphredoderus sayanus	Pirate Perch
Fundulus rathbuni	Speckled Killifish
Gambusia holbrooki	Eastern Mosquitofish
Lepomis auritus	Redbreast Sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill
Lepomis microlophus	Redear Sunfish -**e**
Micropterus salmoides	Largemouth Bass
Micropterus punctulatus	Spotted Bass -**e**
Pomoxis nigromaculatus	Black Crappie
Etheostoma sp.cf. flabellare	Fantail Darter complex
Etheostoma olmstedi	Tessellated Darter
Percina crassa	Piedmont Darter

e = exotic, not native in Cape Fear River basin

Appendix B. USGS Stream gages in or near the Cape Fear shiner's known range.

Surface Water Sites – HAW RIVER - Alamance, Chatham Co

02095681 REEDY FORK at OSSIPEE, NC, ALAMANCE CO
02096500 HAW RIVER AT HAW RIVER, NC, ALAMANCE CO
02096829 HAW RIVER AT SAXAPAHAW, NC, ALAMANCE CO
02096960 HAW RIVER NEAR BYNUM, NC, CHATHAM CO
0209699999 JORDAN LAKE, HAW RIVER ARM near HANKS CHAPEL, NC, CHATHAM CO
0209799150 JORDAN LAKE above US-64 at WILSONVILLE, NC, CHATHAM CO
0209801100 JORDAN LAKE at BELLS LANDING near GRIFFINS X-RDS, CHATHAM CO
02098197 JORDAN LAKE at DAM near MONCURE, NC, CHATHAM CO
02098198 HAW RIVER below JORDAN LAKE DAM near MONCURE, NC, CHATHAM CO

Surface Water Sites – ROCKY RIVER – Chatham Co

0210166029 ROCKY RIVER at SR-1300 near CRUTCHFIELD X-RDS, NC, CHATHAM CO
02101800 TICK CREEK above US-421 near MT VERNON SPRINGS, NC, CHATHAM CO

Surface Water Sites – DEEP RIVER – Randolph, Moore, Lee/Chatham Co

02100500 DEEP RIVER AT RAMSEUR, NC, RANDOLPH CO
02101001 BEAR CREEK AT NC-705 AT ROBBINS, NC, MOORE CO
0210102530 DEEP RIVER AT NC-22 AT HIGH FALLS, NC, MOORE CO
02102000 DEEP RIVER AT MONCURE, NC, LEE/CHATHAM CO

Surface-Water Sites – CAPE FEAR – Chatham, Harnett, Cumberland Co

02102192 BUCKHORN CREEK at NC-42 NEAR CORINTH, NC, CHATHAM CO
02102500 CAPE FEAR RIVER at US-401-421 at LILLINGTON, NC, HARNETT CO
02102634 UPPER LITTLE RIVER at SR-2021 near ERWIN, NC, HARNETT CO
02103000 LITTLE RIVER AT MANCHESTER, NC, HARNETT CO
02104000 CAPE FEAR RIVER AT FAYETTEVILLE, NC, CUMBERLAND CO

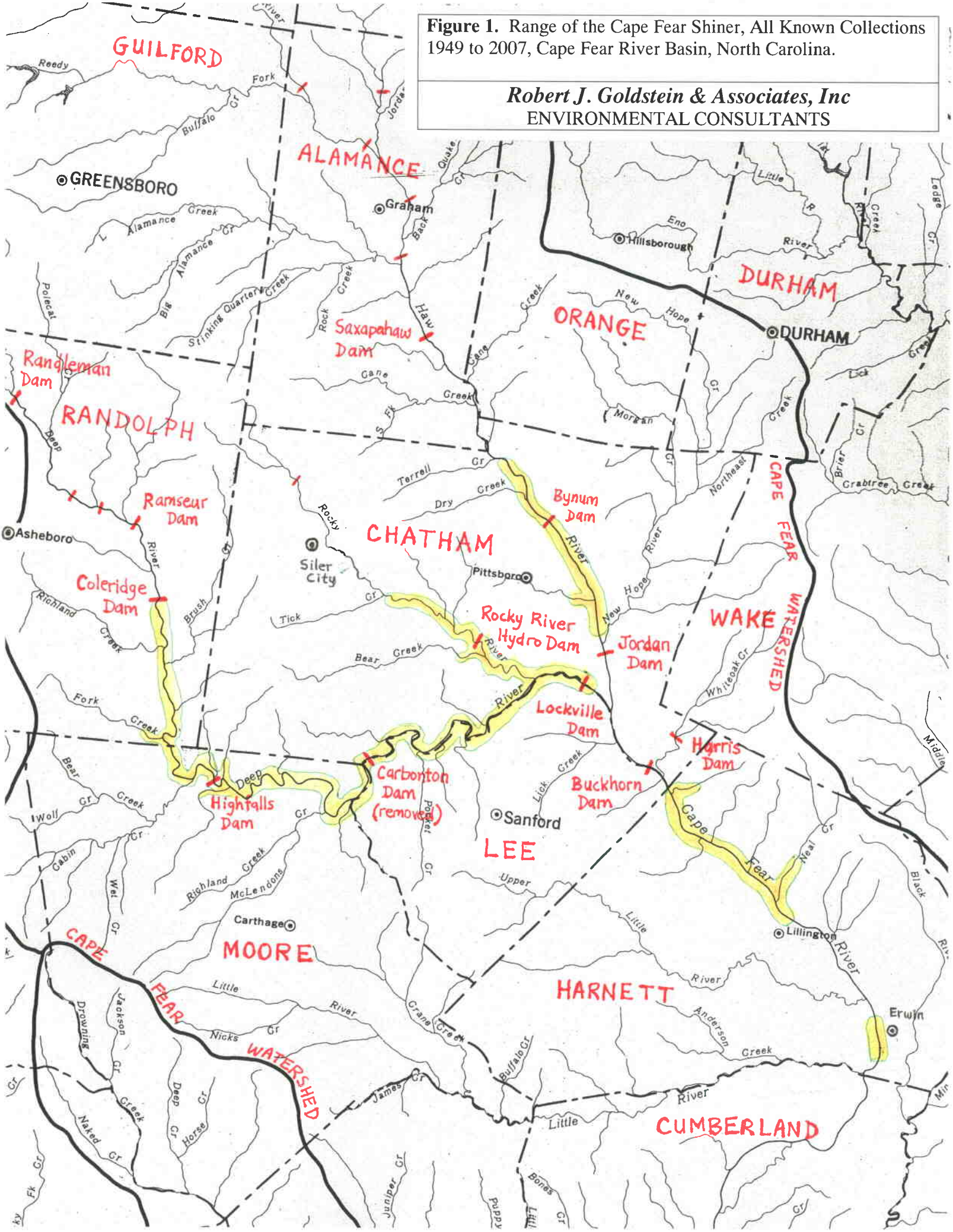

Figure 1. Range of the Cape Fear Shiner, All Known Collections 1949 to 2007, Cape Fear River Basin, North Carolina.

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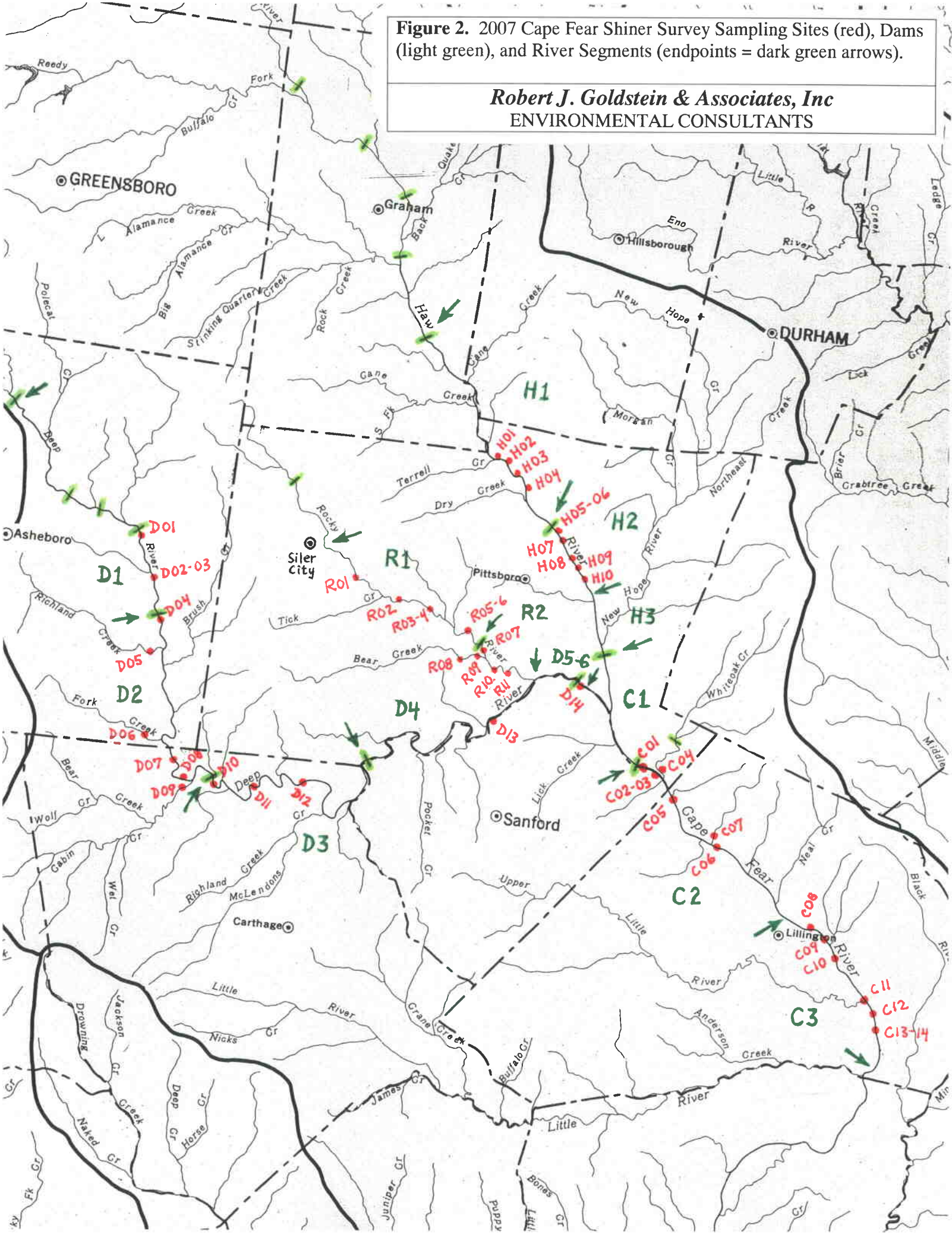

Figure 2. 2007 Cape Fear Shiner Survey Sampling Sites (red), Dams (light green), and River Segments (endpoints = dark green arrows).

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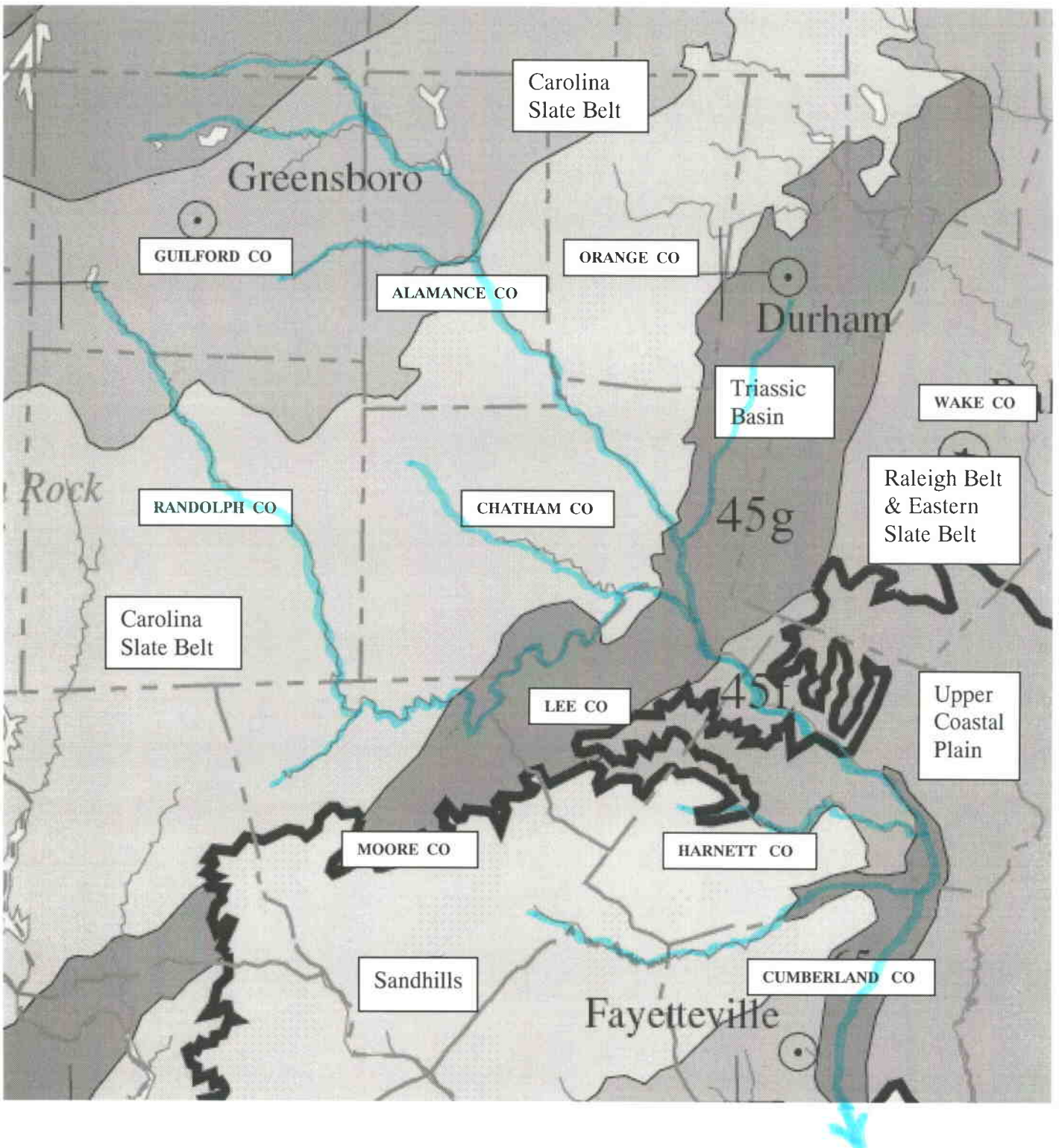

Figure 3. Geologic eco-regions of the upper Cape Fear River basin in central North Carolina, based on Griffith et al. (2002) *Ecoregions of North Carolina and South Carolina* and NC Division of Land Resources (1985) *Geologic Map of North Carolina*. Rocky stream beds most suitable for Cape Fear shiners occur principally in the Carolina Slate Belt and Raleigh Belt/Eastern Slate Belt regions. Rivers and creeks flowing through the Triassic Basin, Sandhills and Upper Coastal Plain have generally flatter gradients and sand/silt dominated substrata that are less suitable as Cape Fear shiner habitat. However, rocky rapids in the Cape Fear River main stem extend downstream past Erwin, almost to the Harnett/Cumberland County line.

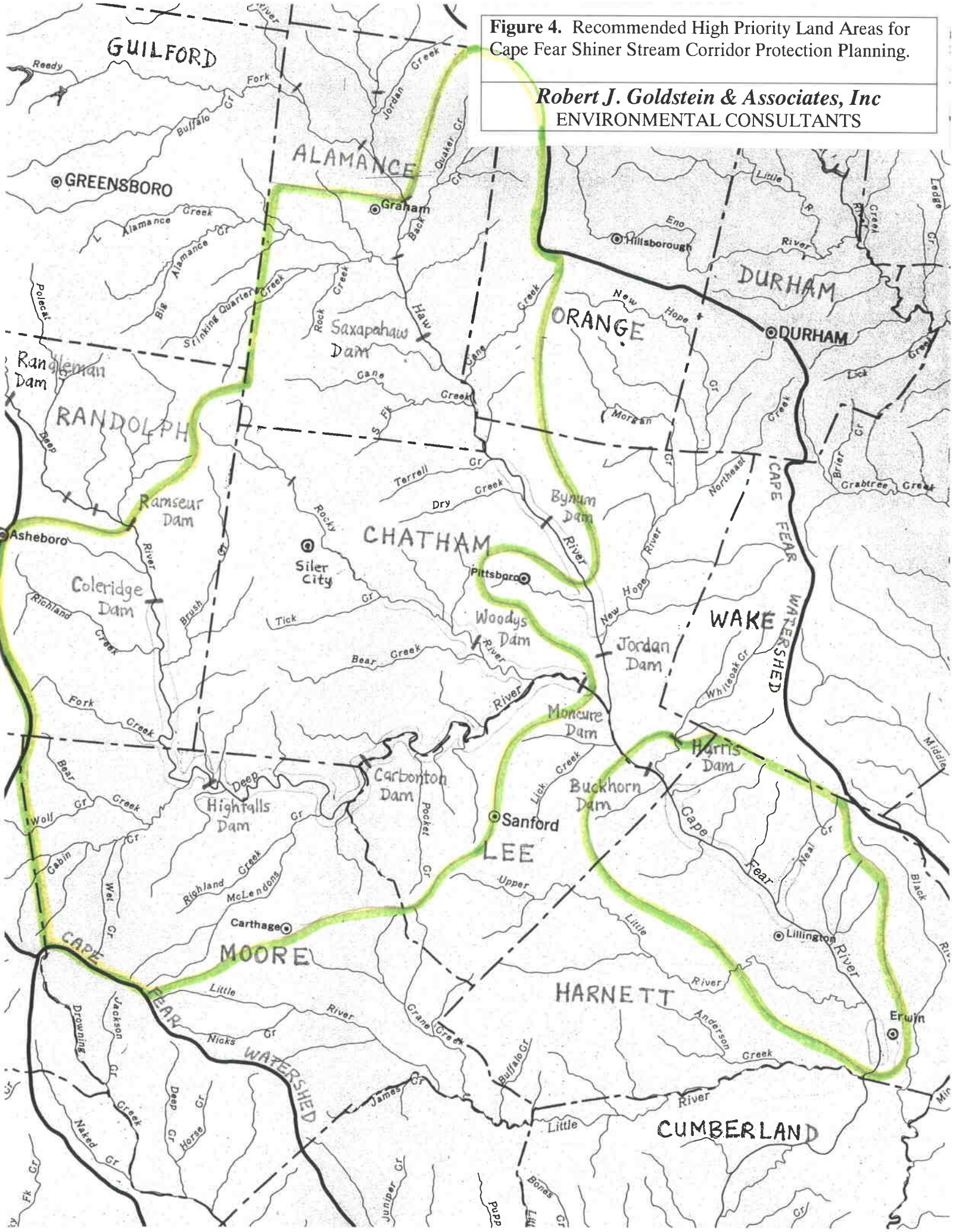

Figure 4. Recommended High Priority Land Areas for Cape Fear Shiner Stream Corridor Protection Planning.

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