Appendix E -

Watershed Analysis:

Determining Watershed Condition for Aquatic Sustainability and Cumulative Effects at the Planning Level for National Forests in Mississippi

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Appendix E
Table of Contents

List of Tables

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Appendix E - Watershed Analysis: Determining Watershed Condition for Aquatic Sustainability and Cumulative Effects at the Planning Level for National Forests in Mississippi

E.1 Introduction

This process paper is twofold; 1) it describes a process to address the cumulative effects of management activities on watershed condition. This fulfills a portion of the ecological condition requirement (specifically the watershed condition) and 2) addresses potential aquatic sustainability over time. This fulfills the determination of sustainable populations within the planning area.

E.1.1 Background

Aquatic habitats are unique in that they are primarily found in and adjacent to streams and lakes. The mobility of aquatic species is usually limited to these habitats. Habitat alteration is the major cause of decline of aquatic diversity in the South. Channelization, impoundment, sedimentation, and flow alterations are the most common physical habitat alterations associated with the decline of aquatic species (Walsh et al. 1995; Etnier 1997; Burkhead et al. 1997). Other human-induced impacts to aquatic species include pollution, introduced species, and over-harvesting (Miller 1989).

Habitat quality within a freshwater ecosystem is determined by activities within the watershed (Abell et al. 2000; Scott and Helfman 2002). Therefore, the influence of these activities upon habitats, or waterbodies, can be described to determine the condition of the habitat. The evaluation areas for aquatic species at the forest plan level are 5th level hydrologic units (watersheds are used interchangeable with hydrologic units).

There are 288 freshwater fish species in Mississippi (Ross, 2001); thus, it is impossible to determine sustainability for each individual species. As a surrogate, the sustainability of proposed, endangered, threatened, sensitive, and locally rare (PETS-LR) aquatic species are assessed and threats to their sustainability determined. Other wide-ranging generalist aquatic species are not considered at risk. If the habitat sustainability of species with special habitat needs or concerns are maintained, then more wide-ranging generalist species’ habitat needs will be met.

To determine if there is adequate habitat for these species, the condition of individual watersheds needs to be determined. Watershed condition is determined from the physical and anthropogenic interactions within the watershed. Ideally, watershed condition would be determined from stream surveys. However, the extent and detail required to address all watersheds, including private land, with stream surveys is not reasonable or available. To address habitat condition at the watershed level it is necessary to determine values from geographic data. These values are compared among the watersheds, and a condition or set of conditions is determined.

E.1.2 Methods

Watershed Condition

Hydrologic units or watersheds are defined as areas that drain to a common point. Fifth-level watersheds range between 40,000 and 250,000 acres. These units are queried against other geographic information layers. These layers include ownership, streams, roads, point sources, dams, and landuse.

These layers were intersected with the 5th level watersheds and determined as a percent of the watershed or as a density (e.g. miles per square mile). The following table shows the data layers, their use, source, and unit of measurement:

Table E 1. GIS data layers used for this analysis and their use, source and units of measure

Layers	Use	Source	Unit
watersheds	The planning unit	USFS	5th level HU
ownership	To determine the extend and location of Forest Service ownership within the watershed	USFS	percent
streams	To determine riparian areas	EPA River Reach files ver. 3	not applicable
roads	To determine watershed road density and riparian road density	Tiger census data	miles per square mile
landuse	To determine watershed and riparian area landuse	NLCD	percent
dams	To determine altered flow	EPA Basins III	number per square mile
point sources	To address point sources	EPA Basins III	number per square mile

This process was modified from the East-wide Assessment Protocol for Forest Plan Amendment, Revision, and Implementation (USDA Forest Service 2000). Individual condition factors were valued one to five (five being the best) identified by Jenk's optimization (natural breaks). This method identifies breaks between classes using a statistical formula (Jenk's optimization) within ArcView 3.2a. These values (or average of combined of values) were used to determine a range of conditions for each metric. This allows for a numerical ranking of condition among the watersheds. However, it does not suggest that a watershed with a score of 4 is twice as good as a watershed of 2, only that the watershed with a value of 4 is above average and the watershed with a value of 2 is below average.

The metrics and combinations of data used determine the metrics are outlined in the following list:

1. Sedimentation was assessed separately by the determining the percent increase above the baseline sediment levels by watershed as assessed with the Watershed Condition Ranking (WCR). This process is described in detail in the Fish Assemblage – Sediment Profile and Sediment Yield sections.
2. Point Source Pollutants (density of point sources).
3. Riparian Habitat (road density in the riparian area, and percent forest in the riparian area).
4. Altered stream flow (density of dams, road density in the riparian, and density of road crossings).

Each Forest identified the presence of PETS-LR species for each 5th level watershed across the planning area. These databases were combined into a single database and stressors assigned using area experts.

For each watershed and species, sensitivity to condition categories was assigned based on the species sustainability evaluation database, published literature and personal communications (USDA NF in Mississippi 2008). Species sensitivity to the four condition categories was compared with the condition of their respective watersheds to determine the threats to their persistence in the planning area.

Specific information is not available for the relation of individual species to point source, riparian habitat, or altered flows. Therefore, related groups were identified by Jenks Optimization to address this issue. This allows for a comparison of conditions among watersheds found on the forest. Additional information is available from the expert panels. The relationship of fish communities to anthropogenic sediment increases is definable and is discussed further in the Fish Assemblage – Sediment Profile section. Threats to aquatic species sustainability are not limited to these four variables; however, GIS coverages are not available for channelization, introduced species, and over-harvest. These and additional issues or threats were addressed by expert panels and can be found in the NFMS ESE, (2005).

Analysis results

The following tables display the results of the watershed condition assessment. Raw values as well as ranks (based on Jenks optimization for natural breaks) are provided. As discussed earlier risk levels or thresholds are not available for point sources, riparian health or hydrologic modification. Information related to these categories allows for a discussion of the ranges of modification and the relative position of individual watersheds within those ranges.

Table E 2. Watershed breakdown – ownership, use, modifications other than roads

5th Level Watershed Number	5th Level Watershed Name	Square Miles	Acres	% National Forest	% Forested Land use	% Agriculture And Urban	% Riparian Area Forested	Rcris	Pcs	Mines	Ifd	Dams	Point Per Sq Mile	Dams Per Sq Mile
				percent				number					#/sq mi	
316010203	Tallabinnela Creek	73.86	47,267	0.7443151	36.0	64.3	36.9			4		3	0.09	0.04
316010401	Upper Chuquatonchee Creek	207.43	132,757	9.4221938	43.2	56.3	46.2			1		23	0.59	0.11
316010402	Cane Creek - Houlka Creek	238.34	152,539	9.1496305	55.0	45.1	55.4	5	3	3	4	10	0.46	0.04
316010801	Sand Creek - Noxubee River	250.71	160,456	25.0882371	84.7	15.0	83.1	8		10	5	25	1.68	0.10
316010803	Yellow Creek - Noxubee River	159.57	102,125	0.0397210	72.8	27.2	69.0				1	16	0.03	0.10
317000301	Maynor Creek - Big Creek	145.51	93,126	23.6936720	89.1	10.1	94.7	2				2	0.67	0.01
317000302	Mason Creek - Big Creek	187.34	119,896	18.1292958	93.2	6.6	97.4					5	0.21	0.03
317000303	Byrd Creek - Chickasawhay River	134.82	86,285	7.4108859	91.7	7.2	94.4	1				2	0.07	0.01
317000304	Green Creek - Chickasawhay River	194.04	124,184	0.0202079	92.0	6.9	91.4	2	1		2	12	0.02	0.06
317000401	Ichusa Creek - Leaf River	210.48	134,708	25.8729840	84.4	15.5	87.4	5	1			11	1.09	0.05
317000402	Quarterliah Creek - West Tallaha	169.74	108,632	30.0858922	83.9	16.1	88.3		1	2		2	0.65	0.01
317000403	Hatchapaloo Creek - Oakohay Cree	246.20	157,568	14.8022501	77.0	22.6	85.9		1	2	2	8	0.37	0.03
317000501	Terrapin Creek - Tallahoma Creek	214.16	137,065	0.0000015	73.6	26.5	83.0	4	2	1	3	19	0.00	0.09
317000503	Heidelberg - Bogue Homo	278.27	178,091	5.7757628	81.0	18.8	90.5	4	3	1	7	25	0.03	0.09
317000504	Tiger Creek - Bogue Homo	142.99	91,515	28.1132869	89.2	10.5	92.6			1	1	7	0.39	0.05
317000505	Little Thompson Creek - Thompson	226.80	145,153	30.0838501	88.3	10.8	94.3			1	1	10	0.50	0.04
317000507	Piney Woods Creek - Gaines Creek	142.41	91,142	23.6066192	90.2	9.4	96.4					3	0.28	0.02
317000508	Beaumont - Leaf River	241.53	154,581	17.9745679	78.6	22.2	82.8	24	6	12	22	23	0.32	0.10
317000509	Leaf River - Atkinson Creek	152.13	97,366	11.5422400	94.0	5.7	97.4				1	3	0.20	0.02
317000601	Big Cedar Creek - Pascagoula Riv	315.00	201,599	14.7029714	80.1	19.0	92.1	1		2	2	13	0.08	0.04

5th Level Watershed Number	5th Level Watershed Name	Square Miles	Acres	% National Forest	% Forested Land use	% Agriculture And Urban	% Riparian Area Forested	Rcris	Pcs	Mines	Ifd	Dams	Point Per Sq Mile	Dams Per Sq Mile
				percent				number					#/sq mi	
317000602	Bluff Creek - Moungers Creek	134.36	85,991	5.7646570	90.1	8.4	89.7				1	4	0.09	0.03
317000701	Little Black Creek - Black Creek	339.63	217,366	1.9117714	72.3	27.7	88.4	1	4	1	8	31	0.03	0.09
317000702	Beaverdam Creek - Black Creek	223.41	142,981	54.4581315	89.8	10.2	95.5	9	1			7	1.07	0.03
317000703	Flint Creek - Red Creek	305.61	195,591	9.8745269	76.8	23.0	89.5	8	2	4	10	26	0.20	0.09
317000704	Bluff Creek - Red Creek	184.97	118,378	30.9576686	90.2	9.5	94.6			1		9	0.44	0.05
317000705	Hickory Creek - Black Creek	213.04	136,346	50.8409772	94.3	5.1	95.0	2				1	0.94	0.00
317000807	Black Creek - Escatawpa River	240.43	153,873	0.0261794	69.1	29.5	82.5	1			2		0.00	-
317000902	Crane Creek - Wolf River	159.91	102,340	0.0828552	73.3	24.7	81.5			3	1	9	0.01	0.06
317000905	Little Biloxi River - Biloxi Riv	270.26	172,964	15.3811346	85.8	13.8	93.3	3	3	7	6	26	0.14	0.10
317000906	Tuxachanie Creek - Tchoutacabouf	243.39	155,768	47.2183369	90.1	9.0	93.3	3	2		4	1	0.24	0.00
318000103	Tallahaga Creek	127.91	81,860	0.1564614	69.8	30.8	78.2	2	5	3	9	13	0.05	0.10
318000107	Sipsey Creek - Tuscolameta Creek	318.60	203,901	2.8533655	71.6	28.4	79.3	3	3		5	24	0.07	0.08
318000108	Shockaloo Creek - Tuscolameta Cr	249.24	159,517	13.5913156	72.1	27.8	80.7	4			1	27	0.16	0.11
318000109	Tibby Creek - Yockanookany River	286.91	183,623	0.0488731	85.4	14.6	83.8	2	1	4	5	11	0.04	0.04
318000201	Coffee Bogue - Pearl River	348.52	223,052	9.9839324	73.4	26.7	83.2			1	2	6	0.07	0.02
318000202	Pelahatchie Creek	237.32	151,883	0.6660393	72.1	28.6	78.5	5	6	4	6	14	0.01	0.06
318000205	Raspberry Creek - Strong River	317.14	202,967	19.1493078	76.8	23.1	84.4		1	2	1	11	0.49	0.03
801020706	Hurricane Creek - Muddy Creek	118.67	75,948	5.5852600	61.5	38.3	57.4	1	3	19	4	20	0.26	0.17
801020801	Porters Creek - Hatchie River	60.32	38,605	1.5336539	75.6	24.4	65.4	2		1	1	20	0.07	0.33
801021001	Indian Creek - Wolf River	216.92	138,830	8.8666459	67.3	32.6	79.4	2	1	17	3	29	0.42	0.13
803020102	Cane Creek - Mud Creek	87.40	55,934	1.8084615	44.5	55.1	43.0			47		3	0.17	0.03
803020103	Cypress Creek - Little Tallahatc	455.04	291,226	12.4659084	64.4	35.7	56.5	12	5	97	10	60	0.53	0.13

5th Level Watershed Number	5th Level Watershed Name	Square Miles	Acres	% National Forest	% Forested Land use	% Agriculture And Urban	% Riparian Area Forested	Rcris	Pcs	Mines	Ifd	Dams	Point Per Sq Mile	Dams Per Sq Mile
				percent				number					#/sq mi	
803020104	Shelby Creek - Tippah River	153.72	98,383	17.0458393	70.7	29.5	58.3	3	1	50	4	26	0.75	0.17
803020105	Snow Creek - Tippah River	221.95	142,047	33.0759576	78.2	21.8	75.1		2	69	4	38	1.32	0.17
803020106	Sardis Lake - Little Tallahatchi	450.30	288,191	2.3811215	74.1	25.2	70.8	2	2	11	1	51	0.13	0.11
803020203	Tillatoba Creek - Panola Quitman	222.15	142,174	3.5667312	50.5	49.7	49.1	1			2	32	0.16	0.14
803020301	Burney Branch - Yocona River	272.72	174,539	5.6012545	72.0	28.1	67.6	6	4	73	5	32	0.26	0.12
803020303	Bynum Creek - Yocona River	220.61	141,193	1.6735268	67.4	31.4	61.0					7	0.05	0.03
803020401	Lee Creek - Coldwater River	176.06	112,677	0.5145512	52.1	48.2	60.7	2		4	2	6	0.01	0.03
803020504	Persimmon Creek - Skuna River	382.39	244,730	5.3808627	70.3	29.4	63.1	2	1	2	1	43	0.19	0.11
803020506	Cane Creek - Yalobusha River	192.89	123,451	0.2650476	63.4	36.9	65.2	1	5	2	6	11	0.03	0.06
803020716	Silver Creek - Big Sunflower Riv	263.88	168,881	11.6592008	28.1	72.0	48.6		1			6	0.07	0.02
803020718	Big Sunflower River - Little Sun	224.63	143,765	27.5069312	53.6	46.2	62.6				1	3	0.12	0.01
803020800	Collins Creek - Yazoo River	196.86	125,990	1.3044888	63.7	36.6	66.3	5	3	1	6	2	0.02	0.01
806020301	Foster Creek - Bayou Pierre	377.51	241,605	0.3319052	78.6	21.5	81.4	11	5	5	3	13	0.02	0.03
806020305	Willis Creek - Little Bayou Pier	302.17	193,389	2.4048973	75.0	25.0	81.8	2			5	16	0.09	0.05
806020501	McCall Creek - Homochitto River	429.06	274,600	19.4966603	83.6	16.1	81.7	2		1	3	12	0.65	0.03
806020502	Middle Fork Homochitto River - H	386.31	247,241	35.1902295	90.2	9.0	85.6	2			2	5	0.53	0.01
806020503	Wells Creek - Homochitto River	407.63	260,884	17.1360895	81.2	18.3	82.5		3	4	2	27	0.17	0.07
806020601	Upper Buffalo River	142.07	90,923	0.8929649	89.3	10.4	90.3	1				2	0.04	0.01
806020602	Middle Buffalo River	104.59	66,935	0.4416352	92.6	7.1	89.9		2			2	0.02	0.02
807020201	West Fork Amite River	189.40	121,216	0.1606239	72.1	28.0	76.9	4			1	7	0.05	0.04
807020203	Woodland Creek - Beaver Creek	104.58	66,933	0.0085504	72.8	27.4	79.2		3		3	4	0.04	0.04

Table E 3. Watershed breakdown – roads, crossings, and watershed condition ranking

5th Level Watershed Number	5th Level Watershed Name	Riparian Road Density	Stream Crossing Density	Watershed Level Road Density	% US Forest Service	% Forested	% Ag Urban	% Rip Forest Lu	# Pt Source Sq Mi	# Dams Sq Mi	Riparian Rd Density	# Rd Crossing Density	Ws Road Density	Overall Watershed Condition	Risk levels for sediment (low, moderate, high)	Rank for Point Source Pollutants	Rank for Riparian Health	Rank for Hydrologic Modification
					rank (1-5 with 1 being the worst)											rank (1-5)		
						Watershed condition												
316010203	Tallabinnela Creek	1.09	1.57	2.31	1	1	1	1	5	4	1	1	2	2.00	High	5	1	2.00
316010401	Upper Chuquatonchee Creek	0.76	1.10	1.70	2	1	1	1	2	2	3	3	4	2.13	High	2	2	2.67
316010402	Cane Creek - Houlka Creek	0.91	1.62	2.06	2	2	2	2	3	4	2	1	3	2.38	Moderate	3	2	2.33
316010801	Sand Creek - Noxubee River	0.61	0.95	1.81	4	4	4	3	1	2	4	3	4	3.13	Low	1	3.5	3.00
316010803	Yellow Creek - Noxubee River	0.59	0.95	1.56	1	3	3	2	5	2	4	3	4	3.25	Moderate	5	3	3.00
317000301	Maynor Creek - Big Creek	0.49	0.74	2.17	4	5	5	5	2	5	4	4	2	4.00	Moderate	2	4.5	4.33
317000302	Mason Creek - Big Creek	0.53	0.75	2.17	3	5	5	5	4	4	4	4	2	4.13	Moderate	4	4.5	4.00
317000303	Byrd Creek - Chickasawhay River	0.59	0.97	2.28	2	5	5	5	5	5	4	3	2	4.25	Moderate	5	4.5	4.00
317000304	Green Creek - Chickasawhay River	0.66	0.82	2.28	1	5	5	5	5	3	3	4	2	4.00	Moderate	5	4	3.33
317000401	Ichusa Creek - Leaf River	0.73	1.07	1.78	4	4	4	4	1	3	3	3	4	3.25	Low	1	3.5	3.00
317000402	Quarterliah Creek - West Tallaha	0.56	0.88	1.40	4	4	4	4	2	5	4	4	5	4.00	Moderate	2	4	4.33
317000403	Hatchapaloo Creek - Oakohay Cree	0.77	1.15	2.11	3	4	3	4	3	4	3	2	3	3.25	Moderate	3	3.5	3.00
317000501	Terrapin Creek - Tallahoma Creek	1.09	1.60	2.66	1	3	3	3	5	2	1	1	1	2.38	High	5	2	1.33
317000503	Heidelberg - Bogue Homo	0.86	1.29	2.63	2	4	4	4	5	2	2	2	1	3.00	High	5	3	2.00
317000504	Tiger Creek - Bogue Homo	0.70	0.91	1.83	4	5	5	5	3	3	3	3	4	3.88	Moderate	3	4	3.00
317000505	Little Thompson Creek - Thompson	0.52	0.82	1.81	4	5	5	5	3	3	4	4	4	4.13	High	3	4.5	3.67
317000507	Piney Woods Creek - Gaines Creek	0.55	0.96	2.19	4	5	5	5	4	5	4	3	2	4.13	Moderate	4	4.5	4.00
317000508	Beaumont - Leaf River	1.41	2.21	3.42	3	4	3	3	4	2	1	1	1	2.38	High	4	2	1.33

5th Level Watershed Number	5th Level Watershed Name	Riparian Road Density	Stream Crossing Density	Watershed Level Road Density	% US Forest Service	% Forested	% Ag Urban	% Rip Forest Lu	# Pt Source Sq Mi	# Dams Sq Mi	Riparian Rd Density	# Rd Crossing Density	Ws Road Density	Overall Watershed Condition	Risk levels for sediment (low, moderate, high)	Rank for Point Source Pollutants	Rank for Riparian Health	Rank for Hydrologic Modification
					rank (1-5 with 1 being the worst)											rank (1-5)		
						Watershed condition												
317000509	Leaf River - Atkinson Creek	0.47	0.76	2.20	2	5	5	5	4	5	4	4	2	4.25	Moderate	4	4.5	4.33
317000601	Big Cedar Creek - Pascagoula Riv	0.63	0.93	2.22	3	4	4	5	5	4	4	3	2	3.88	Moderate	5	4.5	3.67
317000602	Bluff Creek - Moungers Creek	0.72	1.12	2.61	2	5	5	4	5	4	3	3	1	3.75	High	5	3.5	3.33
317000701	Little Black Creek - Black Creek	0.75	1.01	2.58	1	3	3	4	5	2	3	3	1	3.00	High	5	3.5	2.67
317000702	Beaverdam Creek - Black Creek	0.66	0.80	2.23	5	5	5	5	1	4	3	4	2	3.63	High	1	4	3.67
317000703	Flint Creek - Red Creek	0.70	1.07	2.47	2	3	3	4	4	2	3	3	2	3.00	High	4	3.5	2.67
317000704	Bluff Creek - Red Creek	0.56	0.87	2.18	4	5	5	5	3	3	4	4	2	3.88	Moderate	3	4.5	3.67
317000705	Hickory Creek - Black Creek	0.25	0.45	1.53	5	5	5	5	2	5	5	5	5	4.63	Low	2	5	5.00
317000807	Black Creek - Escatawpa River	1.28	1.45	2.46	1	3	3	3	5	5	1	1	2	2.88	Moderate	5	2	2.33
317000902	Crane Creek - Wolf River	0.71	1.01	2.50	1	3	3	3	5	3	3	3	2	3.13	Moderate	5	3	3.00
317000905	Little Biloxi River - Biloxi Riv	0.83	1.26	2.65	3	4	4	5	4	2	2	2	1	3.00	Moderate	4	3.5	2.00
317000906	Tuxachanie Creek - Tchoutacabouf	0.73	0.94	2.60	5	5	5	5	4	5	3	3	1	3.88	Moderate	4	4	3.67
318000103	Tallahaga Creek	0.79	1.22	2.26	1	3	3	3	5	2	3	2	2	2.88	High	5	3	2.33
318000107	Sipsey Creek - Tuscolameta Creek	0.82	1.12	2.13	1	3	3	3	5	2	2	3	3	3.00	High	5	2.5	2.33
318000108	Shockaloo Creek - Tuscolameta Cr	0.74	1.06	2.01	3	3	3	3	4	2	3	3	3	3.00	High	4	3	2.67
318000109	Tibby Creek - Yockanookany River	0.81	1.18	2.02	1	4	4	3	5	4	2	2	3	3.38	Moderate	5	2.5	2.67
318000201	Coffee Bogue - Pearl River	0.87	1.01	1.85	2	3	3	3	5	5	2	3	4	3.50	High	5	2.5	3.33
318000202	Pelahatchie Creek	0.87	1.34	2.39	1	3	3	3	5	3	2	2	2	2.88	High	5	2.5	2.33
318000205	Raspberry Creek - Strong River	0.74	1.08	1.95	3	3	3	4	3	4	3	3	3	3.25	High	3	3.5	3.33

5th Level Watershed Number	5th Level Watershed Name	Riparian Road Density	Stream Crossing Density	Watershed Level Road Density	% US Forest Service	% Forested	% Ag Urban	% Rip Forest Lu	# Pt Source Sq Mi	# Dams Sq Mi	Riparian Rd Density	# Rd Crossing Density	Ws Road Density	Overall Watershed Condition	Risk levels for sediment (low, moderate, high)	Rank for Point Source Pollutants	Rank for Riparian Health	Rank for Hydrologic Modification
					rank (1-5 with 1 being the worst)											rank (1-5)		
						Watershed condition												
801020706	Hurricane Creek - Muddy Creek	0.90	1.38	2.14	2	2	2	2	4	1	2	2	3	2.25	Moderate	4	2	1.67
801020801	Porters Creek - Hatchie River	0.42	0.88	2.00	1	3	3	2	5	1	4	4	3	3.13	Low	5	3	3.00
801021001	Indian Creek - Wolf River	0.72	0.94	2.07	2	3	2	3	3	2	3	3	3	2.75	Moderate	3	3	2.67
803020102	Cane Creek - Mud Creek	0.72	1.32	1.81	1	2	1	1	4	4	3	2	4	2.63	High	4	2	3.00
803020103	Cypress Creek - Little Tallahatc	0.72	1.05	1.93	3	3	2	2	3	2	3	3	3	2.63	Moderate	3	2.5	2.67
803020104	Shelby Creek - Tippah River	0.85	1.13	2.42	3	3	3	2	2	1	2	3	2	2.25	Low	2	2	2.00
803020105	Snow Creek - Tippah River	0.59	0.64	1.91	4	4	4	3	1	1	4	4	3	3.00	Low	1	3.5	3.00
803020106	Sardis Lake - Little Tallahatchi	0.54	0.68	1.73	1	3	3	2	4	2	4	4	4	3.25	Moderate	4	3	3.33
803020203	Tillatoba Creek - Panola Quitman	0.89	1.59	2.10	1	2	1	2	4	1	2	1	3	2.00	Moderate	4	2	1.33
803020301	Burney Branch - Yocona River	0.82	1.19	1.94	2	3	3	2	4	2	2	2	3	2.63	Low	4	2	2.00
803020303	Bynum Creek - Yocona River	0.99	1.85	1.79	1	3	3	2	5	4	1	1	4	2.88	Low	5	1.5	2.00
803020401	Lee Creek - Coldwater River	0.95	1.19	2.09	1	2	2	2	5	4	1	2	3	2.63	High	5	1.5	2.33
803020504	Persimmon Creek - Skuna River	0.78	1.21	1.75	2	3	3	2	4	2	3	2	4	2.88	Low	4	2.5	2.33
803020506	Cane Creek - Yalobusha River	0.68	1.05	2.26	1	2	2	2	5	3	3	3	2	2.75	Moderate	5	2.5	3.00
803020716	Silver Creek - Big Sunflower Riv	1.16	0.94	2.01	3	1	1	1	5	5	1	3	3	2.50	High	5	1	3.00
803020718	Big Sunflower River - Little Sun	0.31	0.49	0.96	4	2	2	2	4	5	5	5	5	3.75	High	4	3.5	5.00
803020800	Collins Creek - Yazoo River	0.85	0.76	1.75	1	2	2	2	5	5	2	4	4	3.25	Low	5	2	3.67
806020301	Foster Creek - Bayou Pierre	0.61	0.93	1.80	1	4	4	3	5	4	4	3	4	3.88	Moderate	5	3.5	3.67
806020305	Willis Creek - Little Bayou Pier	0.49	0.79	1.68	1	3	3	3	5	3	4	4	4	3.63	Moderate	5	3.5	3.67

5th Level Watershed Number	5th Level Watershed Name	Riparian Road Density	Stream Crossing Density	Watershed Level Road Density	% US Forest Service	% Forested	% Ag Urban	% Rip Forest Lu	# Pt Source Sq Mi	# Dams Sq Mi	Riparian Rd Density	# Rd Crossing Density	Ws Road Density	Overall Watershed Condition	Risk levels for sediment (low, moderate, high)	Rank for Point Source Pollutants	Rank for Riparian Health	Rank for Hydrologic Modification
					rank (1-5 with 1 being the worst)											rank (1-5)		
						Watershed condition												
806020501	McCall Creek - Homochitto River	0.55	0.77	1.80	3	4	4	3	2	4	4	4	4	3.63	Low	2	3.5	4.00
806020502	Middle Fork Homochitto River - H	0.68	0.63	1.73	5	5	5	4	3	5	3	5	4	4.25	Low	3	3.5	4.33
806020503	Wells Creek - Homochitto River	0.50	0.71	1.71	3	4	4	3	4	3	4	4	4	3.75	Low	4	3.5	3.67
806020601	Upper Buffalo River	0.38	0.43	1.41	1	5	5	4	5	5	5	5	5	4.88	Low	5	4.5	5.00
806020602	Middle Buffalo River	0.49	0.69	1.52	1	5	5	4	5	5	4	4	5	4.63	Low	5	4	4.33
807020201	West Fork Amite River	0.69	0.97	1.92	1	3	3	3	5	4	3	3	3	3.38	High	5	3	3.33
807020203	Woodland Creek - Beaver Creek	0.63	0.79	1.73	1	3	3	3	5	4	3	4	4	3.63	High	5	3	3.67

Aquatic Sustainability Determinations

Species of concern were related to the four environmental factors assessed in watershed analysis (point sources, riparian habitat, flow, and sediment). Sustainability for each PET-LR was determined for each watershed where a species occurs, because in many cases watersheds support separate populations, and factors affecting sustainability can vary considerably from watershed to watershed. Sustainability determinations incorporate elements of species distribution, abundance, and sensitivities to environmental factors; watershed condition relative to the species' environmental sensitivities; and the national forest role in the watershed. Sustainability determinations are:

> **Outcome 1**. Species occurs within the watershed with no impairment. Likelihood of maintaining sustainability is high.
>
> **Outcome 2**. Species sustainability is potentially at risk in the watershed; however, the extent and location of NFS lands with respect to the species is conducive to positively influence the sustainability of the species within this watershed. Therefore, likelihood of maintaining sustainability is moderate.
>
> **Outcome 3**. Species sustainability is potentially at risk within the watershed; however, the extent and location of NFS lands with respect to the species is NOT conducive to positively influence the sustainability of the species within this watershed. Likelihood of maintaining sustainability is low.
>
> **Outcome 4**. The species is so rare within the watershed (population is at very low density and/or at only a few local sites) that stochastic events (accidents, weather events, etc.) may place persistence of the species within the watershed at risk. The extent and location of NFS lands with respect to the species is conducive to positively influence the sustainability of the species within this watershed. Therefore, likelihood of maintaining sustainability is moderate to low.
>
> **Outcome 5**. The species is so rare within the watershed (population is at very low density and/or at only a few local sites) that stochastic events (accidents, weather events, etc.) may place persistence of the species within the watershed at risk. The extent and location of NFS lands with respect to the species is NOT conducive to positively influence the sustainability of the species within this watershed. Therefore, likelihood of maintaining sustainability is low.

E.2 Sediment Yields

In earlier planning efforts forests were directed to calculate sediment and water yield increases over time. This served as a surrogate of existing condition and provided a quantification of potential effects of forest actions. However, watershed condition was described in general physical terms, not in terms of health or vulnerability to management actions. With the current level of planning, available data layers, and GIS information there is an opportunity to specifically evaluate watershed condition and estimate the effects of management activities based on a number of watershed parameters. Sediment yield or an index of disturbance would still be used but the result would be directly related to overall watershed condition or health rather than just erosion potential. The following is a description of the process used to address Section (d) of the aquatic resources under 36 CFR, 219.23 planning rule (1982) and the associated cumulative effects for water quality and associated beneficial uses.

The purpose of this process is to estimate sediment yields and analyze the cumulative effects of proposed management actions on water quality. The process provides an objective process to systematically evaluate water quality conditions for watersheds covered in whole or part by forest plans. The process also provides results that can aid in aquatic sustainability analysis at the community scale.

The process builds upon the East-Wide Watershed Assessment Process, and provides for modifications based on local information. Interpretation of analysis results strives to describe objectives rather than "constraints" and provides the forests an opportunity to identify and focus on watersheds where there are "significant" opportunities to improve condition.

E.2.1 Cumulative Effects

"A cumulative effect is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

Sediment is an appropriate measure to determine the effects of management activities on water quality and its associated beneficial uses on forested lands (Coats and Miller, 1981). Sediment increases can adversely affect fish productivity and diversity (Alexander and Hansen, 1986), degrade drinking water and affect recreational values. There may be other cumulative impacts such as increases in water yield as a result of harvesting methods. However, water yield models do not characterize the impacts of all management activities such as road construction and the increase in water yield is generally less than the natural variability. Changes in water nutrients or nutrient fluxes within streams as a result of management activities are minor and not an appropriate consideration of cumulative effects at the forest plan level. This model uses predicted sediment yields as the surrogate for determining cumulative impacts for water quality.

Changes in land use and disturbance are modeled with respect to estimated increases in sediment and predicted impacts are summarized. The significance of predicted impacts are related to criteria designed to determine levels of watershed health (WCR) as described in a following section of this paper.

E.2.2 Bounding the Effects Analysis

A valid cumulative effects analysis must be bounded in space and time. For the purposes of forest planning, 5th level watersheds are the appropriate spatial bounds for cumulative effects. The implementation period for a forest plan is 5 to 15 years, however the appropriate time period captured for the sediment model is for 5 decades (50 years).

E.2.3 Modeling Sediment Yield

A detailed description of data sources and steps can be found in Data Sources and Manipulation. Following is a summary of the process:

- Using the National Land use Classification Data (NLCD), Digital Elevation Models (DEM), and Ecoregions data layers, a determination of combinations of land use, slope class, and physiographic zone were made for 30-meter grids. These values were tabulated for each watershed including non-Forest Service lands. Results were used to identify estimated erosion values for entire watersheds.
- Tiger Census Roads data, and Ecoregions were used to determine road surface type, physiographic zone and length. This information was used to estimate sediment values for each watershed.
- Using a combination of values from Forest Service prescriptions, slope class, and physiographic zones, these values were tabulated for each watershed
- Forest Service personnel provided values for the following categories;
    - The number of acres of prescribed fire planned by period (By ecoregion),
    - Miles of dozer fireline per acre burned,

  - Miles of temporary and permanent road constructed per acre regenerated,
  - Urban growth,
  - The rotation period on other forested lands, and
  - Other changes in land use activities or disturbances that individual forests felt were important such as oil and gas exploration, pasture conversion or strip mining.
- Coefficients for erosion were taken from the average and high erosion rates found in Dissmeyer and Stump (1978) for the appropriate physiographic zone. Recovery rates were determined from studies on the Ouachita National Forest. These recovery rates were determined through research and field observations.
- Erosion values (from land use activities) were multiplied by a sediment delivery coefficient based on watershed size determined from Roehl (1962). Sediment values from roads are part of the WEPP calculation. WEPP assumes that sediment values are delivered to the nearest channel. This model sums the total number of sediment tons from roads and calculates sediment from erosion delivered to the mouth of the watershed.
- Road (by surface type), and fireline sediment values were determined from field surveys using the WEPP model to determine sediment values. These values were converted to coefficients by physiographic zone and multiplied by the number of miles of road (by surface type), or fireline.
- All values were summarized in a spreadsheet by watershed for the baseline sediment yield and current sediment yield (Forest Service and private).
- The values from the Draft Timber Resource Program Suitability and Sustainability Analysis (USDA NF in Mississippi 2007) (total number of acres per planning period by physiographic zone, early succession class and slope class) are placed in the sediment spreadsheet for each period.
- Lastly the spreadsheet summarizes predicted management activities by watershed, and planning period.

This allows for a discussion of past, present and future activities for public and private lands by watershed for a time period of 50 years.

E.2.4 Data Interpretation

The summary worksheet of the sediment model calculates the baseline, current, and predicted sediment values for each watershed and period. To determine the potential cumulative effects of water quality and associated beneficial uses these sediment values are expressed as a percent increase over the baseline. The baseline assumes an undisturbed forest floor with no roads.

Watershed Condition Rank (WCR)

Watershed Condition Rank is a measure that characterizes the condition of 5th level watersheds with respect to current and future sediment load increases. In order to establish WCRs, the current sediment average annual yield is determined and expressed as a percent above the baseline conditions. This provides a relative measure to determine changes within watersheds. The next step in this process is determined by using fish community structure with respect to predicted sediment increases to create a fish assemblage – sediment profile. A discussion of this process is found in the Fish Assemblage – Sediment Profile section. This score is modified by a weighted average where the watershed occurs in more than one physiographic zone. Watershed condition is expressed in three categories of risk: high, medium and low. This does not necessarily translate into an excellent or poor watershed but categorizes the watersheds based on the sediment prediction/aquatic sustainability relationship.

From the WCR a series of determinations can be made that determine or assign additional Forest Objectives. The following section details the outcome of the WCR with respect to adverse effects on aquatic biota as they are related to forest management:

> Where a watershed risk level is low, the probability (or potential) is low for adverse effects to aquatic species. If the results of forest actions remain within this range there should be no adverse effect on water quality with respect to beneficial uses (fish communities). Forest Service objectives would be to maintain or improve aquatic health through the implementation of standards.
>
> Where a watershed risk level is moderate, the potential to adversely affect beneficial uses is moderate. Additional forest objectives would be considered. Examples of these additional objectives would be conducting watershed assessments during project planning to identify the source of the problem, and monitoring prior to project implementation to establish actual health of the biota.
>
> Where a watershed risk level is high, the potential to adversely affect beneficial uses is high. In addition to objectives listed above, Forest objectives at the project level would seek to maintain or restore watershed health and aquatic systems. An example would be to design project level activities to have no net increase in sediment yields.

The results of the WCR and other information can also be used to develop partnerships with other landholders or managers to improve overall watershed condition and improve aquatic health. This is one advantage of analyzing entire watersheds. Not only can Forest Service activities and contributing effects be isolated but other watershed effects can be identified as well.

Assumptions, uncertainties and limitations

Many assumptions are made throughout the sediment model and the WCR. Every effort has been made to describe those assumptions and minimize misrepresentation. With that in mind the application of the sediment model and associated WCR should not be taken as absolutes but as a method that can describe the effects from the range of actions and suggest where a greater risk with respect to water quality and aquatic biota exists. This process is developed for the forest plan level.

E.2.5 Data Sources and Manipulation

Data calculations and summary were derived from numerous sources. The following discussion identifies ArcView data layers, the source of those data layers and how they were manipulated or queried. The first step in any data manipulation is to place the data in a common projection. The projection chosen was State Plane Eastern Mississippi, NAD 27, feet.

Layers requested from the Forests include:

> **Watersheds**: Data were place in a common projection. Shared watersheds were assigned a common number when there were number conflicts.
>
> **Sustainability**: The prescriptions from each suitable area were converted to a 30-meter grid. Non-forest Service ownerships were deleted.

From the Tiger Census (2000):

Roads: Based on the CFCC data attribute road segments were assigned a road surface value of paved highway, paved local, gravel or native. These data were then intersected by watershed and ecoregion. Miles were calculated and summed by watershed, and ecoregion.

Land use and land cover factors were from:

NLCD (EPA): This information is in a 30-meter grid. The data were reclassified using the following classification.

Table E 4. Land Use and land cover data classification

Value	MRLC classification	Reclass	Mix
11	Open Water	1	Water
13	Perennial Ice/Snow	1	Water
21	Low Intensity Residential	2	Residential
22	High Intensity Residential	2	Residential
23	Commercial/Industrial/Transportation	2	Residential
31	Bare Rock/Sand/Clay	3	Quarry
32	Quarries/Strip Mines/Gravel Pits	3	Quarry
33	Transitional	4	Forest
41	Deciduous Forest	4	Forest
42	Evergreen Forest	4	Forest
43	Mixed Forest	4	Forest
51	Shrubland	5	Pasture
61	Orchards/Vineyards/Other	6	Cultivated
71	Grasslands/Herbaceous	5	Pasture
81	Pasture/Hay	5	Pasture
82	Row Crops	6	Cultivated
83	Small Grains	6	Cultivated
84	Fallow	6	Cultivated
86	Urban/Recreational Grasses	5	Pasture
91	Woody Wetlands	4	Forest
92	Emergent Herbaceous Wetlands	9	Wetlands

Digital Elevation Models provided:

Slope: Using Spatial Analysis Model Builder, discrete slope classes were identified based on percent slope. These values were then reclassified for individual forest assumptions. Slopes less than 20 percent were assigned a value of 0 and slopes greater than 20 percent were assigned a value of 1000.

From the EPA Basins data:

Ecoregions (Bailey): Physiographic zones were assigned a value of 100 – 400 (in increments of 100) and converted to a grid (30 meters).

Table E 5. Physiographic zone data values

Ecoregion	Value
Middle Coastal Plains	100
Lower Coastal Plains	200
Florida Coastal Lowlands	300
Mississippi Alluvial Basin	400

From these data sets the following queries were made for the sediment model:

Rd Inputs (Roads): – this is the sum the miles of roads (by surface type) for each watershed and ecoregion.

Lu Inputs (Land use): – this is the total number of grids summarized by ecoregion/land use/slope for each watershed.

Lu PVT Inputs (Private Land use): – this is the total number of grids from nonforest service lands (private) summarized by ecoregion/slope/slope for each watershed.

Tx Alt (A): – this is the combination of ecoregion/management prescription/slope for each watershed. This number is duplicated by the number of silviculture treatment options (usually 4). In addition treatments not found in the spectrum model are included such as prescribed fire and site preparation on national forest lands and silviculture and urban growth on private lands.

These data queries were placed in the sediment model.

E.2.6 Sediment Coefficients for Roads

The WEPP model for roads was used to develop the coefficients. This model was developed by the Rocky Mountain Research Station and San Dimas Technology and Development Center. Documentation of the WEPP:Road model is on the internet website http://forest.moscowfsl.wsu.edu/fswepp/.

Process

Forests or Ranger Districts identified roads that were representative of the roads on their respective units. Roads selected contained at least one stream crossing. All roads identified were graveled.

When possible an on-site survey was conducted to determine inputs for the WEPP:Road model. Road were divided into segments based on water diversions. Functioning waterbars, broadbased dips, wing ditches, and culverts were considered to be water diversions. If no water diversion was present and the water had created its own diversion, this also marked a segment break. Additionally, a crest in the road, where water ran off in two different directions, was considered a segment break.

Distances for road segment lengths, road widths, road fillslope lengths, and buffer lengths were paced off or visually estimated for each road segment. Road gradients, fillslope gradients, and buffer gradients were measured with a clinometer for each road segment to determine an average slope gradient. In areas where roads or trails occurred in the buffer below the road segment being inventoried, the buffer length and slope were calculated as if the road or trail in the buffer did not exist.

Measurements were then input into the WEPP:Road model on the interactive internet site http://forest.moscowfsl.wsu.edu/fswepp/. Thirty years of simulation were used. This was based on the WEPP documentation that states "[f]or climates with more than 500 mm of precipitation, 30 years of simulation is generally adequate to obtain an estimate of erosion" (Elliot et. al, 1999). The WEPP:Road model was calculated for each ecoregion. Most ecoregions were divided into two or more subdivisions. The subdivisions were determined by the geographical range of each ecoregion and National Forest.

For each ecoregion or ecoregion subdivision a sediment yield per mile of road was determined. Adding the amount of sediment from each road segment and then dividing by the total length of the road segments calculated this yield. This sediment yield, described in tons per mile, was used as the sediment coefficient in the cumulative effects model.

Sediment yields were determined separately for native surfaced, graveled, and paved roads. The same data was used to determine sediment yields for each road surface.

The same procedure used for roads was repeated with firelines and ATV trails. Only the native road surface was calculated for firelines and ATV trails.

The sediment coefficients for each ecoregion or ecoregion subdivision are shown in the attached data summary.

Assumptions, uncertainties, and limitations

Some assumptions were made due to limitations of the WEPP:Road model. These assumptions are as follows:

> Any road/trail/fireline gradient over 40 percent would yield the same results as a 40 percent gradient. WEPP:Road does not accept road gradients over 40 percent.
>
> Any road/trail/fireline gradient of less than one percent would yield the same results as a 0.3 percent gradient. WEPP:Road does not accept road gradients of less than 0.3 percent.
>
> The absence of fillslopes would yield the same results as fillslopes with a 0.3 percent gradient and a one-foot length. WEPP:Road does not accept fillslope measurements with less than a 0.3 percent gradient and one foot length.
>
> Any buffer length greater than 1000 feet was estimated with a regression.
>
> WEPP:Road does not accept road segment lengths greater than 1000 feet. Any distances above 1000 feet were estimated with a regression.

Table E 6. Road sediment coefficients

Ecoregion	Data Source	Sediment Coefficients				
		Native Road	Gravel Road	Paved Road	ATV Trail	Fireline
		tons of sediment per year per mile				
Middle Coastal Plains	Clingenpeel/Lee studies	5.6	23.5	26.5	10.0	10.0
Lower Coastal Plains	Clingenpeel/Curtis studies	5.5	7.0	5.7	7.1	7.1
Florida Coastal Lowlands		15.2	7.06	5.0	2.8	2.8
Mississippi Alluvial Basin	Texas studies	15.2	5.0	5.0	2.8	2.8

E.3 Fish Assemblage – Sediment Profile

We examined the relationship between stream fish assemblage and the cumulative sediment load modeled from watershed land cover. Our objective was to determine the functional form of the relationship and developed indicators of aquatic health. These indicators of aquatic health were used for identifying and prioritizing watersheds where the Forest Service can make a positive contribution its health. Our goal was to provide conservation planning tools that can guide sustainable management of landscapes and proactively protect the integrity of aquatic resources.

Fish collections were used because of the widespread availability of data and occurrence in all watersheds and ecoregions. This data is a surrogate for other aquatic biota such as mussels, crayfishes and aquatic insects where data are not available.

E.3.1 Methods

Fish collections used in these analyses were obtained from universities and natural resource agencies. The watershed above each collection site was modeled (by physiographic province) for sediment yield using current land-use information and road network.

Middle Coastal Plains – Fish were collected from 190 sites between 1999 and 2003, by the Aquatic and Terrestrial Fauna Team, Center for Bottomland Hardwoods Research, Southern Research Station in Oxford, MS. (Melvin L. Warren, Jr., Susie Adams, Wendell Haag, J. Gordon McWhirter, and L. Gayle Henderson).

Lower Coastal Plains– Fish were collected from 167 sites between 1999 and 2003, by the Aquatic and Terrestrial Fauna Team, Center for Bottomland Hardwoods Research, Southern Research Station in Oxford, MS. (Melvin L. Warren, Jr., Susie Adams, Wendell Haag, J. Gordon McWhirter, and L. Gayle Henderson).

Florida Coastal Lowlands – Fish were collected from 3 sites between 1999 and 2003, by the Aquatic and Terrestrial Fauna Team, Center for Bottomland Hardwoods Research, Southern Research Station in Oxford, MS. (Melvin L. Warren, Jr., Susie Adams, Wendell Haag, J. Gordon McWhirter, and L. Gayle Henderson).

Mississippi Alluvial Basin - – Fish were collected from 6 sites in 1998. Data sources were the Arkansas/Robison fish database and USGS NAQWA database.

We assigned as many of the fish species from each region to several ecological groups according to Warren et al. 2001. We included endemic and tolerance assignments, trophic, habitat, and reproductive guild classifications.

Endemic fish taxa were identified from the list of fishes from each ecoregion in the planning area. Fishes were determined to be endemic if their ranges did not extend beyond three river drainages, based on information published in Warren et al. (2000).

The total number of individual fish, in each ecological classification (Appendix A), was summed for each collection. This number was divided by the total number of fish captured in the sample to estimate the relative abundance of fish representing each ecological attribute.

We examined the bivariate relationships between sediment increases for each sample watershed and relative abundance of fishes collected for that site. We then examined sediment increase for each ecological attribute for a wedge-shaped pattern (Faust et al. 1984; Terrell et al. 1996). A wedge-shaped pattern in the data suggests that sediment may limit the ability of stream systems to support a particular ecological attribute. That is, the upper bound of the relationship decreases sharply with increasing sediment. The variation in the data below this upper bound is consistent with the concept of limiting habitat factors: while other factors (abiotic and biotic) may reduce the carrying capacity for fishes below this bound (Terrell et al. 1996), sediment increases appear to limit the maximum abundance of some species near this boundary.

The data from the wedge-shaped relationships were then broken into groups for each 500 percent increase in sediment. For each group, the values in the 99th percentile were used for the response variable. A boundary line analysis (Webb 1972) was used to regress the data to predict the maximum expected fish community response for a given increase in sediment. Using the y-intercept, relative abundance values were divided into quartiles and used to establish categories of risk. The upper quartile (the least disturbed) was considered a low risk. The next quartile was considered a moderate risk and the two bottom quartiles were considered the highest risk of an adverse biotic response to sediment increases. The low and moderate risk values for each indices for the Middle Coastal Plains and Lower Coastal Plains were averaged.

E.3.2 Results and Discussion

Wedge shaped patterns were observed for sediment increases and the following ecological attributes (Table E 7).

Table E 7. Ecoregions and ecological attributes

Guild		Ecoregion sections	
		Middle Coastal Plains	**Lower Coastal Plains**
Tolerance	Endemic[a]	Yes	Yes
	Intolerance	Yes	Yes
Trophic	Invertivore-piscivore[b]	Yes	
	BH[c]	Possible	Yes
	BI[c]	Yes	Yes
	BV[c]	Possible	
	IP[d]	Yes	Possible
	PIS[d]	Yes	Yes
	Benthic Feeder Guild[d]	Yes	Yes
	3 Trophic Food Types[d]	Yes	
	4 Trophic Food Types[d]	Yes	
Habitat	Benthic Habitat	Yes	Yes
Reproduction	CG[b]	Yes	Yes
	AT[b]	Yes	
	NA[b]	Yes	Yes
	BBC[e]	Yes	
	BCA[e]	Possible	Yes
	OBC[e]	Yes	Yes
	Veg Rep sub[d]	Yes	Yes

a - from Warren et al, 2000.
b - modified from McCormic et a,l in press.
c - modified from Halliwell et al, 1998.
d - modified from Smogor and Angermeier, 1998.
e - modified from Simon, 1998
BH= benthic herbivores; BI= benthic insectivore; BV= benthic invertivores; IP+invertivore/piscivore; PIS=piscivore or parasitic; CG=clean gravel/sand; AT=egg-attacher; NA=nest associate; BBC= Brood hiders, buriers, clean sand/gravel; BCA= Brood hiders, crevice, attachers; OBC= open, benthic, clean sand/gravel; Veg. Rep. Sub=vegetation or organic debris reproductive substrate.

Nineteen fish community indices were tested for relationships to sediment increases for the Middle Coastal Plains and Lower Coastal Plains. The Middle Coastal Plains and Lower Coastal Plains, respectively had 16 and 12 indices that exhibited a wedge shaped relationship. Table E 8 shows the risk of aquatic species for sediment increases. The Florida Coastal Lowlands and Mississippi Alluvial Basin has insufficient sample points to determine wedge patterns. However there was sufficient range of data points in the Florida to establish quartile breaks. The risk levels for the Mississippi Alluvial Basin were taken from the Delta region in Arkansas.

Table E 8. Risk levels and sediment increase by ecoregions

Risk Level	Ecoregion			
	Middle Coastal Plain	**Lower Coastal Plain**	**Florida Coastal Lowlands**	**Mississippi Alluvial Basin**
	percent above baseline			
Low	0 to 2,090	0 to 1,253	0 to 7,613	0 to 4,173
Moderate	2,090 to 4,179	1,253 to 2,506	7,613 to 15,226	4,800 to 9,601
High	> 4,179	> 2,506	> 15,226	> 9,601

Table E 9. Ecological attributes of fishes collected

		Tolerance		Trophic										Habitat	Reproduction						
Species	**Common name**	**Endemic[a]**	**Intolerance**	**Invertivore[b]**	**Insectivore-piscivore[b]**	**BH[c]**	**BI[c]**	**BV[c]**	**IP[d]**	**PIS[d]**	**Benthic Feeder Guild[d]**	**3 Trophic Food Types[d]**	**4 Trophic Food Types[d]**	**Benthic Habitat**	**CG[b]**	**AT[b]**	**NA[b]**	**BBC[e]**	**BCA[e]**	**OBC[e]**	**Veg. Rep. sub[d]**
Ambloplites ariommus	shadow bass	N	Y	N	Y	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N
Ameiurus melas	black bullhead	N	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N	N
Ameiurus natalis	yellow bullhead	N	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N	N
Ameiurus nebulosus	brown bullhead	N	*	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N	N
Amia calva	bowfin	N	*	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y
Ammocrypta beani	naked sand darter	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Ammocrypta meridiana	southern sand darter	Y	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Ammocrypta vivax	scaly sand darter	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Aphredoderus sayanus	pirate perch	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AplodiNtus grunniens	freshwater drum	N	*	Y	N	N	N	Y	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Carpiodes cyprinus	quillback	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Centrarchus macropterus	flier	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Cyprinella camura	bluntface shiner	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N
Cyprinella lutrensis	red shiner	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cyprinella venusta	blacktail shiner	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N
Cyprinus carpio	common carp	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N
Dorosoma cepedianum	gizzard shad	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	Common name	Endemic[a]	Intolerance	Invertivore[b]	Insectivore-piscivore[b]	BH[c]	BI[c]	BV[c]	IP[d]	PIS[d]	Benthic Feeder Guild[d]	3 Trophic Food Types[d]	4 Trophic Food Types[d]	Benthic Habitat	CG[b]	AT[b]	NA[b]	BBC[e]	BCA[e]	OBC[e]	Veg. Rep. sub[d]
Dorosoma petenense	Threadfin shad	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Elassoma zonatum	banded pygmy sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
Ericymba buccata	silverjaw minnow	N	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Erimyzon oblongus	creek chubsucker	N	*	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	Y	N
Erimyzon succetta	lake chubsucker	N	*	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	N
Erimyzon tenuis	sharpfin chubsucker	N	*	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	N
Esox americanus	grass pickerel	N	*	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y
Esox niger	Chain pickerel	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Etheostoma artesiae	redspot darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	Y	N	N	N
Etheostoma caeruleum	rainbow darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Etheostoma chlorosomum	bluntnose darter	N	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma fusiforme	swamp darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma gracile	slough darter	N	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma histrio	harlequin darter	N	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Etheostoma lachneri	Tombigbee Darter	Y	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma lynceum	brighteye darter	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	**Common name**	**Endemic[a]**	**Intolerance**	**Invertivore[b]**	**Insectivore-piscivore[b]**	**BH[c]**	**BI[c]**	**BV[c]**	**IP[d]**	**PIS[d]**	**Benthic Feeder Guild[d]**	**3 Trophic Food Types[d]**	**4 Trophic Food Types[d]**	**Benthic Habitat**	**CG[b]**	**AT[b]**	**NA[b]**	**BBC[e]**	**BCA[e]**	**OBC[e]**	**Veg. Rep. sub[d]**
Etheostoma nigrum	johnny darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Etheostoma parvipinne	goldstripe darter	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma proeliare	cypress darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma raneyi	Yazoo darter	Y	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Etheostoma rupestre	rock darter	Y	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	Y	N
Etheostoma stigmaeum	speckled darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Etheostoma swaini	gulf darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Etheostoma zonistium	bandfin darter	Y	*	Y	N	N	Y	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N
Fundulus catenatus	Northern studfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
Fundulus cf. sp. euryzonus	undescribed topminnow	Y	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fundulus chrysotus	golden topminnow	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
Fundulus Ntatus	blackstripe topminnow	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
Fundulus Ntti	southern starhead topminnow	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fundulus olivaceus	blackspotted topminnow	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
Gambusia affinis	mosquitofish	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Hybognathus hayi	cypress minnow	N	*	N	N	Y	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	Common name	Endemic[a]	Intolerance	Invertivore[b]	Insectivore-piscivore[b]	BH[c]	BI[c]	BV[c]	IP[d]	PIS[d]	Benthic Feeder Guild[d]	3 Trophic Food Types[d]	4 Trophic Food Types[d]	Benthic Habitat	CG[b]	AT[b]	NA[b]	BBC[e]	BCA[e]	OBC[e]	Veg. Rep. sub[d]
Hybognathus nuchalis	Mississippi silvery minnow	N	*	N	N	Y	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N
Hybopsis winchelli	clear chub	N	Y	Y	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	Y	N
Hypentelium etowanum	Alabama hog sucker	N	Y	Y	N	N	N	N	N	N	Y	Y	N	Y	Y	N	N	N	N	Y	N
Hypentelium nigricans	Northern hog sucker	N	Y	Y	N	N	N	N	N	N	Y	Y	N	Y	Y	N	N	N	N	Y	N
Ictalurus punctatus	channel catfish	N	N	N	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N	N
lamprey	unidentified lamprey	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Labidesthes sicculus	brook silverside	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepisosteus oculatus	spotted gar	N	*	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	Y
Lepisosteus osseus	longnose gar	N	*	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Lepomis cyanellus	green sunfish	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis cyanellusxmacrochirus	Lepomis hybrid	N	*	*	*	*	*	*	*	*	X	X	X	*	*	*	*	*	*	*	*
Lepomis gulosus	warmouth	N	*	N	Y	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N
Lepomis humilis	orangespotted sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis macrochirus	bluegill	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis marginatus	dollar sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis megalotis	longear sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis microlophus	redear sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	**Common name**	**Endemic[a]**	**Intolerance**	**Invertivore[b]**	**Insectivore-piscivore[b]**	**BH[c]**	**BI[c]**	**BV[c]**	**IP[d]**	**PIS[d]**	**Benthic Feeder Guild[d]**	**3 Trophic Food Types[d]**	**4 Trophic Food Types[d]**	**Benthic Habitat**	**CG[b]**	**AT[b]**	**NA[b]**	**BBC[e]**	**BCA[e]**	**OBC[e]**	**Veg. Rep. sub[d]**
Lepomis miniatus	redspotted sunfish	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Lepomis sp.	Lepomis hybrid	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Luxilus chrysocephalus	striped shiner	N	*	Y	N	N	N	N	N	N	N	N	Y	N	N	N	Y	Y	N	N	N
Lythrurus bellus	pretty shiner	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N
Lythrurus fumeus	ribbon shiner	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
Lythrurus roseipinnis	cherryfin shiner	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
Lythrurus umbratilis	redfin shiner	N	*	Y	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N
Micropterus punctulatus	spotted bass	N	*	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Micropterus salmoides	largemouth bass	N	*	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
Minytrema melaNps	spotted sucker	N	*	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	N	N
Moxostoma erythrurum	golden redhorse	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N
Moxostoma poecilurum	blacktail redhorse	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N
Moxostoma sp.	Redhorse genus	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	N	N	Y	N
Ncomis leptocephalus	bluehead chub	N	*	Y	N	N	N	N	N	N	N	Y	N	N	Y	N	N	Y	N	N	N
Ntemigonus crysoleucas	golden shiner	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Ntropis ammophilus	orangefin shiner	N	N	Y	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
Ntropis atheriNides	emerald shiner	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Ntropis baileyi	rough shiner	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	Common name	Endemic[a]	Intolerance	Invertivore[b]	Insectivore-piscivore[b]	BH[c]	BI[c]	BV[c]	IP[d]	PIS[d]	Benthic Feeder Guild[d]	3 Trophic Food Types[d]	4 Trophic Food Types[d]	Benthic Habitat	CG[b]	AT[b]	NA[b]	BBC[e]	BCA[e]	OBC[e]	Veg. Rep. sub[d]
Ntropis longirostris	longnose shiner	N	*	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
Ntropis maculatus	taillight shiner	N	*	N	N	Y	N	N	N	N	N	N	N	N	*	*	*	*	*	*	N
Ntropis rafinesquei	Yazoo shiner	Y	N	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Ntropis texanus	weed shiner	N	*	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N
Ntropis volucellus	mimic shiner	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
Nturus funebris	black madtom	N	Y	Y	N	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
Nturus gyrinus	tadpole madtom	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Nturus hildebrandi	least madtom	Y	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Nturus leptacanthus	speckled madtom	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Nturus miurus	brindled madtom	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Nturus Ncturnus	freckled madtom	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Nturus phaeus	brown madtom	N	Y	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Opsopoeodus emiliae	pugnose minnow	N	*	Y	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N
Percina maculata	blackside darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Percina nigrofasciata	blackbanded darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Percina sciera	dusky darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Percina shumardi	river darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N

		Tolerance		Trophic										Habitat	Reproduction						
Species	**Common name**	**Endemic[a]**	**Intolerance**	**Invertivore[b]**	**Insectivore-piscivore[b]**	**BH[c]**	**BI[c]**	**BV[c]**	**IP[d]**	**PIS[d]**	**Benthic Feeder Guild[d]**	**3 Trophic Food Types[d]**	**4 Trophic Food Types[d]**	**Benthic Habitat**	**CG[b]**	**AT[b]**	**NA[b]**	**BBC[e]**	**BCA[e]**	**OBC[e]**	**Veg. Rep. sub[d]**
Percina vigil	saddleback darter	N	*	Y	N	N	Y	N	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N
Pimephales Ntatus	bluntnose minnow	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N
Pimephales promelas	fathead minnow	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N
Pimephales vigilax	bullhead minnow	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N
Pomoxis annularis	white crappie	N	*	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Pomoxis nigromaculatus	black crappie	N	*	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
PteroNtropis signipinnis	flagfin shiner	N	*	Y	N	N	N	N	N	N	N	N	N	N	*	*	*	*	*	*	N
PteroNtropis welaka	bluenose shiner	N	*	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N
Pylodictis olivaris	flathead catfish	N	*	N	Y	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N
Semotilus atromaculatus	creek chub	N	N	Y	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	Y	N	N	N

a - from Warren et al, 2000.

b - modified from McCormic et a,l in press.

c - modified from Halliwell et al, 1998.

d - modified from Smogor and Angermeier, 1998.

e - modified from Simon, 1998

BH= benthic herbivores; BI= benthic insectivore; BV= benthic invertivores; IP+invertivore/piscivore; PIS=piscivore or parasitic; CG=clean gravel/sand; AT=egg-attacher; NA=nest associate; BBC= Brood hiders, buriers, clean sand/gravel; BCA= Brood hiders, crevice, attachers; OBC= open, benthic, clean sand/gravel; Veg. Rep. Sub=vegetation or organic debris reproductive substrate.

* = unknown

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