Missouri Clean Water Commission
Department of Natural Resources
Lewis and Clark State Office Building
LaCharrette/Nightingale Conference Rooms
1101 Riverside Drive
Jefferson City, Missouri 65102

May 2, 2012

2012 303(d) List

Issue: The Federal Water Pollution Control Act, Section 303(d) requires states to biennially submit to the U.S. Environmental Protection Agency a list of impaired waters for which adequate pollution controls have not yet been required.

Background: The Commission approved the 2012 Listing Methodology Document (LMD) on September 8, 2010. The Department developed and internally reviewed a proposed 2012 list by November 2011. This list was placed on public notice from November 28, 2011 until March 15, 2012. The Department held public meetings to discuss the list December 13, 2011 and February 10, 2012. A public hearing on the proposed list was held before the Clean Water Commission on March 9, 2012.

Public Comments: The Department received and responded to eight written comments on the proposed list, and as a result of the comments and additional data that was supplied, twelve waterbody/pollutant pairs on eight streams were removed from the list. No waters were added to the list as a result of public comments. Waters that appeared on the November public notice that we are proposing to remove from the list include:

-Mississippi River Water Body Identification (WBID) 1707.03 listed for bacteria which is being removed due to re-interpretation of bacteria water quality standards
-Mississippi River WBID 1707.02 listed for lead and zinc in sediment which is being removed due to approval of the Total Maximum Daily Load (TMDL)
-Straight Fork WBID 959 listed for chloride which is being removed after water quality based chloride limits imposed on wastewater discharge permit for City of Versailles (EPA approval pending)
-Crackerneck Creek WBID 3962 listed for chloride which is being removed due to a listing error
-Coldwater Creek WBID 1706 listed for dieldrin which is being removed due to a listing error
-Lost Creek WBID 1617 listed due to an impaired fish community is being removed after additional data was reviewed
-Dry Creek WBID 3418 listed due to an impaired fish community is being removed after additional data was reviewed
-Osage River WBID 1031 listed for total dissolved gases is being removed after receiving new data

-Joachim Creek WBID 1719 listed for lead, zinc and cadmium in sediments is being removed due to a listing error.

One comment resulted in changing the listed pollutant on Blackberry Creek from "Total Dissolved Solids" to "sulfate plus chloride", and another comment letter resulted in changing the name of some pollutant sources from "agriculture" to "rural nonpoint source" or similar source category names.

The proposed list being presented today is composed of 345 waterbody/pollutant pairs. Seventy-five of these are new to the list in 2012 and the remaining 270 listings are carried over from the EPA approved 2010 303(d) List. A total of 104 waterbody/pollutant pairs from the 2010 list are being proposed for de-listing. This group includes 45 lakes for which nutrient criteria that appeared in state water quality standards in 2010 but are now removed due to EPA disapproval. Of the 104 proposed delistings 46 are due to changes in state water quality standards, 22 now meet water quality standards, 13 now have either approved TMDLs or permits in lieu of TMDLs, 17 due to being originally listed in error, four due to data sufficiency issues and two due to changes in the definition of the pollutant or re-segmentation of the waterbody.

The six most common pollutant categories on the list are: bacteria (103 listings), low dissolved oxygen (67), heavy metals in water or sediments (59), mercury in fish tissue (36), biological impairments based on biomonitoring (21) and chloride (20). The five most common pollutant sources were: Unknown (92), rural nonpoint source (69), mining and smelting (61), urban runoff (49), and atmospheric deposition (37).

Recommended Action: The staff recommends the Commission approve this list as is, or with any changes deemed necessary.

List of Attachments

- Table 1, the proposed 2012 303(d) List
- Table 2, a list of waters on the 2010 303(d) List proposed for removal from the 2012 list
- Attachment 1, Administrative Record for Public Participation
- Administrative Record

Table 1. Proposed 2012 303(d) List

This list reflects changes made during the public notice period and is the list that will be presented to the Missouri Clean Water Commission for approval on May 2, 2012.

2012 Proposed List

Year First Listed	WBID	Water Body Name	Class	MDNR Proposed Impairment Size	MDNR Water Body Size	Size Units	Pollutant	Source	Impaired Uses	Other (Unimpaired) Uses	Upstream X	Upstream Y	Downstream X	Downstream Y	County Upstream/ Downstream	Comment
2012	2188.00	Antire Cr.	P	1.9	1.9	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	712451	4264469	710126	4264454	St. Louis	1
2012	2188.00	Antire Cr.	P	1.9	1.9	Mi.	pH (W)	Source Unknown	AQL	LWW, WBC B	712451	4264469	710126	4264454	St. Louis	1
2012	752.00	Bass Cr.	C	4.4	4.4	Mi	Escherichia coli (W)	Source Unknown	WBC A	AQL, LWW	565035	4297419	561522	4298652	Boone	1
2012	3240.00	Baynham Br.	P	4.0	4	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	379677	4092590	374820	4091654	Newton	1
2012	3265.00	Beaver Br.	P	2.0	2.0	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	371093	4059701	371016	4056979	McDonald	1
2006	2760.00	Bee Fk.	C	1.4	6.7	Mi.	Lead (W)	Fletcher Lead Mine/Mill	AQL	CLF, LWW, WBC A	668836	4145688	670779	4145991	Reynolds	1
2008	3966.00	Bee Fk.	U	0.8	n/a	Mi.	Lead (S)	Fletcher Lead Mine/Mill	GEN		667504	4145795	668836	4145688	Reynolds	1,5
2006	7365.00	Belcher Branch Lake	L3	55.0	55	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B	351065	4383634	351274	4382886	Buchanan	1
2006	444.00	Big Cr.	P	1.0	22	Mi	Ammonia, Total (W)	Bethany WWTP	AQL	DWS, LWW, WBC B	409703	4456645	409044	4455854	Harrison	1
2006	444.00	Big Cr.	P	6.0	22	Mi	Oxygen, Dissolved (W)	Bethany WWTP	AQL	DWS, LWW, WBC B	409703	4456645	408309	4451145	Harrison	1
2012	1250.00	Big Cr.	P	70.5	70.5	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	384117	4301048	422204	4249325	Jackson/Henry	1
2012	2673.00	Big Cr.	P	28.7	28.7	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	CLF, LWW, WBC B	602889	4121487	623380	4141676	Texas/Shannon	1
2010	2916.00	Big Cr.	P	1.8	34.1	Mi.	Cadmium (S)	Glover smelter	AQL	CLF, LWW, SCR, WBC A	704416	4150512	704712	4147823	Iron	1
2010	2916.00	Big Cr.	P	1.8	34.1	Mi.	Lead (S)	Glover smelter	AQL	CLF, LWW, SCR, WBC A	704416	4150512	704712	4147823	Iron	1
2010	1578.00	Big Piney R.	P	4.0	8	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	DWS, LWW, SCR, WBC A	579857	4108429	583131	4112462	Texas	1
2006	2080.00	Big R.	P	18.6	68	Mi.	Cadmium (S)	Old Lead Belt tailings	AQL	IND, LWW, WBC A	712102	4194405	701052	4226039	St. Francois	1
2006	2080.00	Big R.	P	18.6	68	Mi.	Zinc (S)	Old Lead Belt tailings	AQL	IND, LWW, WBC A	712102	4194405	701052	4226039	St. Francois	1
2012	111.00	Black Cr.	C	19.4	19.4	Mi.	Escherichia coli (W)	Shelbyville WWTF, Nonpoint Source	WBC B	AQL, LWW	581889	4405281	593146	4393284	Shelby	1
2012	111.00	Black Cr.	C	19.4	19.4	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	581889	4405281	593146	4393284	Shelby	1
2012	3825.00	Black Cr.	P	1.6	1.6	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR, WBC B	731265	4278201	732027	4276854	St. Louis	1
2012	3825.00	Black Cr.	P	1.6	1.6	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	SCR, WBC B	AQL, LWW, WBC B	731265	4278201	732027	4276854	St. Louis	1
2002	2769.00	Black R.	P	47.1	47.1	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, DWS, IRR, LWW, SCR, WBC A	729879	4078164	729374	4042275	Butler	1
2008	2784.00	Black R.	P	39.0	39.0	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, DWS, IRR, LWW, SCR, WBC A	697916	4112187	729879	4078164	Wayne/Butler	1
2006	3184.00	Blackberry Cr.	C	3.5	6.5	Mi.	Chloride (W)	Asbury Power Plant	AQL	LWW, WBC B	360855	4132389	361557	4128066	Jasper	1
2008	3184.00	Blackberry Cr.	C	3.5	6.5	Mi.	Sulfate plus Chloride (W)	Asbury Power Plant	AQL	LWW, WBC B	360855	4132389	361557	4128066	Jasper	1
2006	417.00	Blue R.	P	4.0	4	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, IND, LWW	371193	4329008	372993	4332275	Jackson	2
2006	418.00	Blue R.	P	9.0	9	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, IND, LWW, SCR	368407	4319629	371193	4329008	Jackson	1
2006	419.00	Blue R.	P	9.0	9	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC A	AQL, LWW, SCR	364901	4313172	368407	4319629	Jackson	1
2006	421.00	Blue R.	C	11.0	11	Mi.	Escherichia coli (W)	Runoff from Forest/Grassland/Parkland, Rural, Residential Areas, Urban Runoff/Storm Sewers	WBC B	AQL, LWW, SCR	380484	4301404	364901	4313172	Jackson	1
2012	1701.00	Bonhomme Cr.	C	2.5	2.5	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	709487	4282267	711335	4284026	St. Louis	1
2012	1701.00	Bonhomme Cr.	C	2.5	2.5	Mi.	pH (W)	Source Unknown	AQL	LWW, WBC B	709487	4282267	711335	4284026	St. Louis	1
2006	750.00	Bonne Femme Cr.	P	7.8	7.8	Mi	Escherichia coli (W)	Source Unknown	WBC A	AQL, LWW	560347	4298778	553841	4293824	Boone	1
2012	753.00	Bonne Femme Cr.	C	7.0	7	Mi	Escherichia coli (W)	Source Unknown	WBC B	AQL, LWW	565646	4303369	560347	4298778	Boone	1
2002	2034.00	Bourbeuse R.	P	136.7	136.7	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, DWS, IRR, LWW, SCR, WBC A	622853	4221435	684284	4252201	Phelps/Franklin	1
2012	7003.00	Bowling Green (Old) Lake	L1	28.2*	28.2*	Ac.	Nitrogen, Total (W)	Nonpoint Source	AQL	DWS, LWW, WBC B			656502	4356562	Pike	1
2012	7003.00	Bowling Green (Old) Lake	L1	28.2*	28.2*	Ac.	Phosphorus, Total (W)	Nonpoint Source	AQL	DWS, LWW, WBC B			656502	4356562	Pike	1
2012	1796.00	Brazeau Cr.	C	10.8	10.8	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	793971	4174893	806967	4172945	Perry	1
2002	1371.00	Brush Cr.	P	4.0	4	Mi.	Oxygen, Dissolved (W)	Humansville WWTP	AQL	LWW, WBC B	448658	4182387	444772	4187316	Polk/St. Clair	1
2012	3273.00	Buffalo Cr.	P	8.0	8	Mi.	Fishes Bioassessments (W)	Source Unknown	AQL	CLF, IRR, LWW, SCR, WBC A	369204	4075685	363942	4066061	Newton/McDonald	1
2006	1865.00	Burgher Branch	C	2.0	2	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	610212	4200276	611958	4199021	Phelps	1
2012	968.00	Burris Fork	P	13.2	13.2	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC A	528329	4260805	539737	4270178	Moniteau	1
2006	7057.00	Busch Lake #35	L3	51.0	51	Ac	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			697821	4288225	St. Charles	1
2010	7627.00	Busch Lake #37		34.0	34	Ac	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	GEN				691967	4287291	St. Charles	1
2006	3234.00	Capps Cr.	P	5.0	5	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CDF, IRR, LWW, SCR	408560	4082432	402565	4083048	Barry	1
2010	2288.00	Castor River	P	7.5	7.5	Mi	Escherichia coli (W)	Rural NPS	WBC A	AQL, IRR, LWW, SCR	760130	4115304	766458	4110867	Bollinger	1
2008	737.00	Cedar Cr.	C	7.9	37.4	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, SCR, WBC B	574525	4320028	573573	4311774	Boone	1

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2010	1344.00	Cedar Cr.	P	10.0	31	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	IRR, LWW, SCR, WBC A	419910	4170045	422889	4179237	Cedar	1
2008	1344.00	Cedar Cr.	P	10.0	31	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	IRR, LWW, SCR, WBC A	419910	4170045	422889	4179237	Cedar	1
2010	1357.00	Cedar Cr.	C	16.2	16.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	412830	4154260	419910	4170045	Cedar	1
2008	1357.00	Cedar Cr.	C	16.2	18.2	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	412830	4154260	419910	4170045	Cedar	1
2006	3203.00	Center Cr.	P	19.0	26.8	Mi.	Cadmium (S)	Tri-State Mining District	AQL	CLF, IND, IRR, LWW, SCR, WBC A	374188	4114507	356392	4112870	Jasper	1
2006	3203.00	Center Cr.	P	19.0	26.8	Mi.	Cadmium (W)	Tri-State Mining District	AQL	CLF, IND, IRR, LWW, SCR, WBC A	374188	4114507	356392	4112870	Jasper	1
2006	3203.00	Center Cr.	P	19.0	28.8	Mi.	Lead (S)	Tri-State Mining District	AQL	CLF, IND, IRR, LWW, SCR, WBC A	374188	4114507	356392	4112870	Jasper	1
2006	3203.00	Center Cr.	P	19.0	26.8	Mi.	Zinc (S)	Tri-State Mining District	AQL	CLF, IND, IRR, LWW, SCR, WBC A	374188	4114507	356392	4112870	Jasper	1
2008	3210.00	Center Cr.	P	21.0	21	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, IND, IRR, LWW, SCR	404363	4099549	383885	4107345	Newton/Jasper	1
2010	3214.00	Center Cr.	P	4.9	4.9	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CDF, IND, IRR, LWW, SCR	410293	4100642	404363	4099549	Lawrence/Newton	1
2006	3168.00	Chat Cr.	C	2.1	2.1	Mi.	Cadmium (W)	Baldwin Park Mine	AQL	LWW, SCR, WBC B	436447	4092367	432992	4092650	Lawrence	1
2012	1781.00	Cinque Hommes Cr.	C	8.3	17.1	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	779380	4178472	788085	4185604	Perry	1
2006	1333.00	Clear Cr.	P	15.5	15.5	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC A	402292	4186739	417798	4205707	Vernon/St.Clair	1
2008	1336.00	Clear Cr.	C	15.0	15	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	391893	4172786	402292	4186739	Vernon	1
2008	3238.00	Clear Cr.	P	11.1	11.1	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	410982	4088929	397845	4086317	Barry/Newton	1
2002	3239.00	Clear Cr.	C	3.5	3.5	Mi.	Nutrient/Eutrophication Biol. Indicators (W)	Monett WWTP	AQL	LWW, WBC B	415472	4086460	410982	4088929	Barry/Newton	1
2002	3239.00	Clear Cr.	C	3.5	3.5	Mi.	Oxygen, Dissolved (W)	Monett WWTP	AQL	LWW, WBC B	415472	4086460	410982	4088929	Barry/Newton	1
2002	7326.00	Clearwater Lake	L2	1635.0	1635	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC A			697869	4112199	Reynolds/Wayne	1
2006	1706.00	Coldwater Cr.	C	5.5	5.5	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	IND, LWW, WBC B	735019	4299846	741431	4301794	St. Louis	1
2008	1706.00	Coldwater Cr.	C	5.5	5.5	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, IND, LWW	735019	4299846	741431	4301794	St. Louis	1
2006	1706.00	Coldwater Cr.	C	5.5	5.5	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	IND, LWW, WBC B	735019	4299846	741431	4301794	St. Louis	1
2012	2177.00	Coonville Cr.	C	1.3	1.3	Mi.	Lead (W)	Source Unknown	AQL	LWW, WBC B	717462	4206553	717462	4206553	St. Francois	1
2006	1943.00	Courtois Cr.	P	2.6	32	Mi.	Lead (S)	Doe Run Viburnum Division Lead mine	AQL	CLF, LWW, SCR, WBC A	669877	4181454	670873	4184595	Washington	1
2006	1943.00	Courtois Cr.	P	2.6	32	Mi.	Zinc (S)	Doe Run Viburnum Division Lead mine	AQL	CLF, LWW, SCR, WBC A	669877	4181454	670873	4184595	Washington	1
2012	2382.00	Crane Cr.	P	13.2	13.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	CDF, LWW, SCR, WBC A	445954	4088238	456896	4081483	Stone	1
2012	2816.00	Craven Ditch	C	11.8	11.6	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	IRR, LWW	730992	4068607	730724	4052481	Butler	1
2006	1703.00	Creve Coeur Cr.	C	2.0	2	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	718162	4283169	718435	4287487	St. Louis	1
2006	1703.00	Creve Coeur Cr.	C	2.0	2	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	718162	4283169	718435	4287487	St. Louis	1
2010	1703.00	Creve Coeur Cr.	C	2.0	2	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	718162	4283169	718435	4287487	St. Louis	1
2006	1928.00	Crooked Cr.	P	3.5	3.5	Mi.	Cadmium (S)	Buick Lead Smelter	AQL	CLF, LWW, WBC A	662236	4174014	658207	4175647	Dent/Crawford	2
2006	1928.00	Crooked Cr.	P	3.5	3.5	Mi.	Cadmium (W)	Buick Lead Smelter	AQL	CLF, LWW, WBC A	662236	4174014	658207	4175647	Dent/Crawford	1
2006	1928.00	Crooked Cr.	P	3.5	3.5	Mi.	Lead (S)	Buick Lead Smelter	AQL	CLF, LWW, WBC A	662236	4174014	658207	4175647	Dent/Crawford	2
2008	3961.00	Crooked Cr.	U	5.2	n/a	Mi.	Cadmium (W)	Doe Run Buick Lead Smelter	GEN		665048	4187501	662236	4174014	Iron/Dent	1
2010	3961.00	Crooked Cr.	U	5.2	n/a	Mi.	Copper (W)	Doe Run Buick Lead Smelter	GEN		665048	4167501	662236	4174014	Iron/Dent	1
2006	2636.00	Current R.	P	124.0	124	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, IRR, LWW, SCR, WBC A	628643	4137634	696828	4041495	Shannon/Ripley	1
2006	219.00	Dardenne Cr.	P1	7.0	7	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	709437	4300131	713752	4304230	St. Charles	1
2010	221.00	Dardenne Cr.	P	15.0	15	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	692521	4289823	709437	4300131	St. Charles	1
2006	222.00	Dardenne Cr.	C	6.0	6	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	683306	4288823	692521	4289823	St. Charles	1
2006	690.00	Dark Cr.	C	9.1	9.1	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	535635	4374102	531818	4365676	Randolph	1
2012	3826.00	Deer Cr.	P	1.8	1.6	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR, WBC B	732027	4276854	733742	4275819	St. Louis	1
2012	3826.00	Deer Cr.	P	1.6	1.6	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	SCR, WBC B	AQL, LWW, WBC B	732027	4276854	733742	4275819	St. Louis	1
2002	7015.00	Deer Ridge Lake	L3	48.0	48	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B	683249	4288804	692465	4289831	Lewis	1
2008	36.00	Des Moines R.	P	29.0	29.0	Mi.	Escherichia coli (W)	Upstream/Downstream Source	WBC A	AQL, LWW, SCR	607490	4496653	633942	4471203	Clark	1
2006	3109.00	Ditch # 38	P	7	7	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	535629	4374096	531824	4365664	Dunklin	1
2006	3810.00	Dougar Branch	C	3.1	3.1	Mi.	Lead (S)	Aurora lead mining district	AQL	LWW	432992	4092650	428983	4092388	Lawrence	1
2006	3810.00	Dougar Branch	C	3.1	3.1	Mi.	Zinc (S)	Aurora lead mining district	AQL	LWW	432992	4092650	428983	4092388	Lawrence	1
2006	1180.00	Dousinbury Cr.	P	3.5	3.5	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	436409	4092394	434898	4092716	Dallas	1
2012	3178.00	Dry Fork	C	3.4	3.4	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	420021	4116472	420475	4111831	Lawrence	1
2008	3189.00	Dry Fork	C	10.2	10.2	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, LWW	381619	4123453	379519	4128244	Jasper	1
2012	1314.00	Drywood Cr.	P	3.8	29.9	Mi.	Total Dissolved Solids (W)	Acid Mine Drainage	AQL	LWW, WBC B	361695	4158073	361434	4162039	Barton	1
2006	3569.00	Dutro Carter Cr.	P	0.6	1.5	Mi.	Oxygen, Dissolved (W)	Rolla SE WWTP	AQL	LWW, WBC B	611958	4199021	612762	4199004	Phelps	1

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Year First Listed	WBID	Water Body Name	Class	MDNR Proposed Impairment Size	MDNR Water Body Size	Size Units	Pollutant	Source	Impaired Uses	Other (Unimpaired) Uses	Upstream X	Upstream Y	Downstream X	Downstream Y	County Upstream/ Downstream	Comment
2010	372.00	East Fk. Crooked R.	P	14.0	14	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	418037	4367621	423045	4349976	Ray	1
2006	457.00	East Fk. Grand R.	P	25.0	25	Mi	Escherichia coli (W)	Nonpoint Source	WBC A	AQL, DWS, IRR, LWW, SCR	611959	4199047	612751	4199024	Worth/Gentry	2
2008	608.00	East Fk. Locust Cr.	P	13.0	13	Mi	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	WBC B	AQL, LWW	610703	4198865	611959	4199047	Sullivan	1
2008	610.00	East Fk. Locust Cr.	C	0.4	13	Mi	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	WBC B	AQL, LWW	490928	4451855	490792	4450898	Sullivan	1
2008	610.00	East Fk. Locust Cr.	C	12.6	13	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	492637	4468112	490928	4451855	Sullivan	1
2008	610.00	East Fk. Locust Cr.	C	12.6	13	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	492637	4468112	490928	4451855	Sullivan	1
2006	1282.00	East Fk. Tebo Cr.	C	10.4	14.5	Mi.	Oxygen, Dissolved (W)	Windsor SW WWTP	AQL	LWW, WBC B	453461	4263213	446903	4257226	Henry	1
2006	2166.00	Eaton Branch	C	0.9	1.2	Mi.	Cadmium (S)	Leadwood tailings pond	AQL	LWW, WBC B	710950	4193696	712102	4194405	St. Francois	1
2006	2166.00	Eaton Branch	C	0.9	1.2	Mi.	Cadmium (W)	Leadwood tailings pond	AQL	LWW, WBC B	710950	4193696	712102	4194405	St. Francois	1
2006	2166.00	Eaton Branch	C	0.9	1.2	Mi.	Lead (S)	Leadwood tailings pond	AQL	LWW, WBC B	710950	4193696	712102	4194405	St. Francois	1
2006	2166.00	Eaton Branch	C	0.9	1.2	Mi.	Zinc (S)	Leadwood tailings pond	AQL	LWW, WBC B	710950	4193696	712102	4194405	St. Francois	1
2006	2166.00	Eaton Branch	C	0.9	1.2	Mi.	Zinc (W)	Leadwood tailings pond	AQL	LWW, WBC B	710950	4193696	712102	4194405	St. Francois	1
2002	2593.00	Eleven Point R.	P	22.7	22.7	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, IRR, LWW, SCR, WBC A	658817	4067447	663687	4040694	Oregon	1
2006	2597.00	Eleven Point R.	P	11.4	11.4	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CDF, LWW, SCR, WBC A	648225	4073793	658817	4067447	Oregon	1
2008	2601.00	Eleven Point R.	P	22.3	22.3	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, LWW, SCR, WBC A	626144	4076655	646225	4073793	Oregon	1
2006	1283.00	Elm Branch	C	3.0	3	Mi.	Oxygen, Dissolved (W)	Windsor SE WWTP	AQL	LWW, SCR, WBC B	455777	4264032	453820	4261492	Henry	1
2012	1704.00	Fee Fee (new) Cr.	P	1.5	1.5	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	720606	4290497	718651	4290795	St. Louis	1
2012	1704.00	Fee Fee (new) Cr.	P	1.5	1.5	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	720606	4290497	718651	4290795	St. Louis	1
2012	7237.00	Fellows Lake	L1	800.0	800	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	DWS, LWW, SCR, WBC A			479590	4129881	Greene	1
2012	3595.00	Fenton Cr.	P	0.5	0.5	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	723871	4265426	724548	4265278	St. Louis	1
2012	2186.00	Fishpot Cr.	P	2.0	2	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	715610	4270773	718141	4269480	St. Louis	1
2008	2186.00	Fishpot Cr.	P	2.0	2	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	715610	4270773	718141	4269480	St. Louis	1
2010	2168.00	Flat River Cr.	C	5.0	9	Mi.	Cadmium (W)	Old Lead Belt tailings	AQL	LWW, WBC B	717606	4190862	719851	4196761	St. Francois	1
2010	7151.00	Forest Lake	L1	573.0	573	Ac.	Chlorophyll-a (W)	Source Unknown	AQL	DWS, LWW, WBC A			529115	4446668	Adair	1
2010	7151.00	Forest Lake	L1	573.0	573	Ac.	Nitrogen, Total (W)	Source Unknown	AQL	DWS, LWW, WBC A			529115	4446668	Adair	1
2010	7151.00	Forest Lake	L1	573.0	573	Ac.	Phosphorus, Total (W)	Source Unknown	AQL	DWS, LWW, WBC A			529115	4446668	Adair	1
2006	747.00	Fowler Cr.	C	6	6	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	567703	4291355	568077	4285216	Boone	1
2012	1842.00	Fox Cr.	P	7.2	7.2	Mi.	Cause Unknown (W)	Source Unknown	AQL	LWW, WBC B	698961	4266797	702101	4258899	St. Louis	1
2008	38.00	Fox R.	P	42.0	42.0	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW, SCR	591699	4495650	619876	4469909	Clark	1
2010	7008.00	Fox Valley Lake	L3	89.0	89	Ac.	Phosphorus, Total (W)	Rural NPS	AQL	LWW, SCR, WBC B			604598	4483661	Clark	1
2010	7382.00	Foxboro Lake	L3	22.0	22	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B			644963	4249580	Franklin	1
2002	7280.00	Frisco Lake	L3	5.0	5	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			608340	4201511	Phelps	1
2012	1004.00	Gans Cr.	C	5.5	5.5	Mi.	Escherichia coli (W)	Source Unknown	WBC A	AQL, LWW	562848	4305349	558293	4303466	Boone	1
2002	1455.00	Gasconade R.	P	249.0	249	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	CLF, DWS, LWW, SCR, WBC A	543810	4120606	626322	4281833	Gascon./Wright	1
2006	2184.00	Grand Glaize Cr.	C	4.0	4	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	720452	4272251	721016	4270232	St. Louis	1
2010	2184.00	Grand Glaize Cr.	C	4.0	4	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B	720452	4272251	721016	4270232	St. Louis	1
2002	2184.00	Grand Glaize Cr.	C	4.0	4	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	720452	4272251	721016	4270232	St. Louis	1
2006	593.00	Grand R.	P	60.0	60	Mi	Escherichia coli (W)	Rural NPS	SCR, WBC B	AQL, DWS, IRR, LWW, WBC A	454151	4399076	490791	4359355	Livin./Chariton	1
2008	1712.00	Gravois Cr.	P	2.0	2	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	735409	4269271	737738	4270157	St. Louis	1
2006	1712.00	Gravois Cr.	P	2.0	2	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	735409	4269271	737738	4270157	St. Louis	2
2006	1713.00	Gravois Cr.	C	4.0	4	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	731092	4269825	735409	4269271	St. Louis	1
2006	1713.00	Gravois Cr.	C	4.0	4	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	731092	4269825	735409	4269271	St. Louis	2
2006	1009.00	Grindstone Cr.	C	1.5	1.5	Mi.	Escherichia coli (W)	Runoff from Forest/Grassland/Parkland, Rural, Residential Areas, Urban Runoff/Storm Sewers	WBC A	AQL, LWW	561338	4309123	558770	4308985	Boone	1
2012	97.00	Hays Cr.	C	2.0	2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	629824	4365290	630115	4368016	Ralls	1
2010	7152.00	Hazel Creek Lake	L1	151.0	151	Ac.	Chlorophyll-a (W)	Rural NPS	AQL	DWS, LWW, WBC B			531549	4461110	Adair	1
2008	7152.00	Hazel Creek Lake	L1	151.0	151	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	DWS, LWW, WBC B			531549	4461110	Adair	1
2008	848.00	Heath's Cr.	P	21.0	21.0	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	WBC B, LWW	481322	4306311	498371	4308099	Pettis	1
2006	3226.00	Hickory Cr.	P	4.9	4.9	Mi.	Escherichia coli (W)	Source Unknown	WBC A	AQL, LWW	381771	4079318	377864	4083983	Newton	1
2006	1008.00	Hinkson Cr.	C	18.0	18	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW, SCR	567737	4324918	557336	4308968	Boone	1

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2012	1011.00	Hominy Br.	C	1.0	1.0	Mi.	Escherichia coli (W)	Runoff from Forest/Grassland/Parkland, Rural, Residential Areas, Urban Runoff/Storm Sewers	WBC B	AQL, LWW, SCR	561245	4310831	560159	4310810	Boone	1
2010	3169.00	Honey Cr.	P	16.5	16.5	Mi.	Escherichia coli (W)	Rural NPS runoff	WBC B	AQL, LWW	441807	4098928	423428	4103961	Lawrence	1
2010	3170.00	Honey Cr.	C	2.7	2.7	Mi.	Escherichia coli (W)	Rural NPS runoff	WBC B	AQL, LWW	443604	4095825	441807	4098928	Lawrence	1
2008	1346.00	Horse Cr.	P	27.7	27.7	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	IRR, LWW, WBC B	404906	4166866	422140	4160187	Cedar	1
2010	1346.00	Horse Cr.	P	27.7	27.7	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	IRR, LWW, WBC B	404906	4166866	422140	4180187	Cedar	1
2002	7388.00	Hough Park Lake	L3	7.0	7	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			571190	4266070	Cole	1
2012	7029.00	Hunnewell Lake	L3	228.0	228	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B			597510	4395781	Shelby	1
2010	420.00	Indian Cr.	C	3.0	3	Mi.	Chloride (W)	Road/Bridge Runoff, Non-construction	AQL	IND, LWW, WBC A	360619	4311161	364589	4312667	Jackson	1
2002	420.00	Indian Cr.	C	3.0	3	Mi.	Escherichia coli (W)	Leawood, KS WWTP, Urban Runoff/Storm Sewers	WBC A	AQL, IND, LWW	360619	4311161	364589	4312667	Jackson	1
2012	1946.00	Indian Cr.	P	1.9	1.9	Mi.	Lead (S)	Doe Run Viburnum Division Lead mine	AQL	LWW, WBC B	668795	4178900	669877	4181454	Washington	1
2012	1946.00	Indian Cr.	P	1.9	1.9	Mi.	Zinc (S)	Doe Run Viburnum Division Lead mine	AQL	LWW, WBC B	668795	4178900	669877	4181454	Washington	1
2006	3256.00	Indian Cr.	P	9.7	30.8	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, IRR, LWW, SCR	390079	4072820	959	4065146	Newton/McDonald	1
2008	7389.00	Indian Creek Lake	L3	192.0	192	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B			440543	4416535	Livingston	1
2012	3223.00	Jacobs Br.	P	1.6	1.6	Mi.	Zinc (W)	Tri-State Mining District	AQL	LWW, WBC B	365485	4095649	365647	4097350	Newton	1
2012	3207.00	Jenkins Cr.	P	2.8	2.8	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, LWW	389301	4103154	386214	4105402	Newton/Jasper	1
2012	3205.00	Jones Cr.	P	7.5	7.5	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, LWW	388098	4099356	383685	4107345	Newton/Jasper	1
2012	3592.00	Kiefer Cr.	P	1.2	1.2	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	713477	4270033	714872	4269554	St. Louis	1
2010	3592.00	Kiefer Cr.	P	1.2	1.2	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	713477	4270033	714872	4269554	St. Louis	1
2002	7196.00	Knob Knoster St. Park Lakes**	L3	10.0	10	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			449403	4289099	Johnson	1
2012	2171.00	Koen Cr.	C	1.0	1	Mi.	Fish Bioassessments	Source Unknown	AQL	LWW	720083	4193036	719754	4194279	St. Francois	1
2002	7436.00	Lake of the Woods	L3	3.0	3	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			565549	4314857	Boone	1
2008	7629.00	Lake of the Woods	U	7.0	7	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	GEN		368609	4317228	368318	4317421	Jackson	1
2010	7054.00	Lake St. Louis	L3	525.0	525	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	WBC B, LWW			694070	4297116	St. Charles	1
2010	7212	Lake Winnebago	L3	350.0	350	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC A			382262	4297476	Cass	1
2006	847.00	Lamine R.	P	54.0	54	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, IRR, LWW, SCR	504057	4279960	513000	4314568	Morgan/Cooper	1
1998	3105.00	Lat. #2 Main Ditch	P	11.5	11.5	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	774308	4075742	773631	4058057	Stoddard	2
2008	3105.00	Lat. #2 Main Ditch	P	11.5	11.5	Mi.	Temperature, water (W)	Channelization	AQL	LWW, WBC B	774308	4075742	773631	4058057	Stoddard	1
2012	3137.00	Lee Rowe Ditch	C	2.3	6	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	824374	4076890	823414	4073568	Mississippi	1
2002	7020.00	Lewistown Lake	L1	29.0	29	Ac.	Atrazine (W)	Agriculture	DWS	AQL			600674	4439277	Lewis	3
2012	3575.00	Line Cr.	C	7.0	7	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	358974	4343374	360136	4335565	Platte	1
2008	1529.00	Little Beaver Cr.	C	3.4	3.5	Mi.	Sedimentation/Siltation (S)	Smith Sand and Gravel	AQL	LWW, WBC A	602344	4199334	600304	4195833	Phelps	1
2012	422.00	Little Blue R.	P	35.1	35.1	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW, SCR	372712	4309261	394909	4340608	Jackson	1
2012	1003.00	Little Bonne Femme Cr.	P	9.0	9	Mi.	Escherichia coli (W)	Source Unknown	WBC B	AQL, LWW	558293	4303466	553350	4296764	Boone	1
2006	1863.00	Little Dry Fk.	P	1.0	5	Mi.	Oxygen, Dissolved (W)	Rolla SE WWTP	AQL	LWW, SCR, WBC B	613259	4199799	616764	4199780	Phelps	1
2006	1864.00	Little Dry Fk.	C	0.6	4.5	Mi.	Oxygen, Dissolved (W)	Rolla SE WWTP	AQL	LWW, WBC B	612762	4199004	613259	4199799	Phelps	1
2008	1864.00	Little Dry Fk.	C	3.9	4.5	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	612998	4192820	612762	4199004	Phelps	1
2006	1325.00	Little Drywood Cr.	P	17	17	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	377089	4173190	378737	4191485	Vernon	1
2010	1326.00	Little Drywood Cr.	C	10.0	10	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	379795	4162807	377089	4173190	Barton/Vernon	1
2010	3279.00	Little Lost Cr.	P	5.8	5.8	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	362557	4060611	355721	4078287	Newton	1
2006	623.00	Little Medicine Cr.	P	40.0	40	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	416142	4124179	399901	4114249	Mercer/Grundy	1
2006	623.00	Little Medicine Cr.	P	20.0	40	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	421758	4107283	420784	4107591	Mercer/Grundy	1
2006	1189.00	Little Niangua R.	P	20.0	43	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	CLF, LWW, SCR, WBC A	499879	4188131	491897	4206840	Dallas/Camden	1
2008	3652.00	Little Osage R.	C	16.0	16	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	358275	4206134	378073	4204993	Vernon	2
2012	2229.00	Little Whitewater R.	P	24.2	24.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC A	759232	4159953	782131	4144237	Cape G/Bollinger	1
2006	606.00	Locust Cr.	P	36.4	84	Mi.	Escherichia coli (W)	Rural NPS	SCR, WBC B	AQL, DWS, LWW, WBC B	488070	4492450	485919	4450776	Putnam/Sullivan	1
2012	2763.00	Logan Cr.	P	6.1	36.0	Mi.	Lead (S)	Sweetwater Lead Mine/Mill	AQL	LWW, SCR, WBC A	666290	4135270	666157	4127465	Reynolds	1
2006	696.00	Long Branch Cr.	C	2.0	13	Mi.	Oxygen, Dissolved (W)	Atlanta WWTP	AQL	LWW, SCR, WBC B	543322	4416540	543714	4413999	Macon	1
2002	7097.00	Longview Lake	L2	930.0	930	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC A	370767	4304559	372708	4309235	Jackson	1
2006	3278.00	Lost Cr.	P	8.5	8.5	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, LWW, SCR	365734	4083852	355708	4076281	Newton	1

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2006	2814.00	Main Ditch	C	13.0	13.0	Mi.	pH (W)	Poplar Bluff WWTP	AQL	IRR, LWW, WBC B	732515	4068032	728380	4048616	Butler	1
2006	2814.00	Main Ditch	C	13.0	13.0	Mi.	Temperature, water (W)	Channelization	AQL	IRR, LWW, WBC B	732515	4068032	728380	4048616	Butler	1
2012	1709.00	Maline Cr.	C	0.6	0.6	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR, WBC B	741092	4291205	741520	4290480	St. Louis	1
2012	1709.00	Maline Cr.	C	0.6	0.6	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	SCR, WBC B	AQL, LWW, WBC B	741092	4291205	741520	4290480	St. Louis	1
2012	3839.00	Maline Cr.	C	0.5	0.5	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR	741520	4290480	742148	4290141	St. Louis	1
2012	3839.00	Maline Cr.	C	0.5	0.5	Mi.	pH (W)	Source Unknown	AQL	LWW, SCR	741520	4290480	742148	4290141	St. Louis	1
2010	3140.00	Maple Slough Ditch	C	16.0	16	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	820642	4090485	816884	4062825	Miss/New Madrid	1
2002	7033.00	Mark Twain Lake	L2	18600.0	18600	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	DWS, LWW, SCR, WBC A	591225	4370593	616549	4375850	Monroe/Ralls	1
2006	619.00	Medicine Cr.	P	36.0	36	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	490930	4451871	490963	4451293	Putnam/Grundy	1
2010	2183.00	Meramec R.	P	22.0	22	Mi.	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	WBC A	AQL, DWS, IND, LWW, SCR	718259	4269400	731938	4252474	St. Louis	1
2008	2183.00	Meramec R.	P	22.0	22	Mi.	Lead (S)	Old Lead belt tailings	AQL	DWS, IND, LWW, SCR, WBC A	718259	4269400	731938	4252474	St. Louis	1
2008	2185.00	Meramec R.	P	15.7	26	Mi.	Lead (S)	Old Lead Belt tailings	AQL	CLF, DWS, IND, LWW, SCR, WBC A	707844	4260833	718259	4269400	St. Louis	1
1994	1299.00	Miami Cr.	P	18	18	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	373089	4239543	382984	4222768	Bates	1
2012	2744.00	Middle Fk. Black R.	P	2.5	21	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC A	680284	4163599	682139	4161326	Reynolds	1
2006	468.00	Middle Fk. Grand R.	P	25.0	25	Mi	Escherichia coli (W)	Rural NPS	WBC A	AQL, IRR, LWW, SCR	385583	4488594	381780	4452480	Worth/Gentry	1
2010	3262.00	Middle Indian Cr.	C	3.5	3.5	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	400092	4074869	395454	4074061	Newton	1
2010	3263.00	Middle Indian Cr.	P	2.2	2.2	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	395454	4074061	392652	4075387	Newton	1
2008	3263.00	Middle Indian Cr.	P	2.2	2.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	395462	4074067	392653	4075386	Newton	1
2010	226.00	Missouri R.	P	179.0	179	Mi.	Escherichia coli (W)	Mult. Pt.& NPS	SCR, WBC B	AQL, DWS, IND, IRR, LWW, WBC B	285813	4496304	360959	4330925	Atchison/Jackson	1
2012	356.00	Missouri R.	P	129.0	129	Mi.	Escherichia coli (W)	Mult. Pt.& NPS	SCR, WBC B	AQL, DWS, IND, IRR, LWW, WBC B	360959	4330925	503506	4351395	Jackson/Saline	1
2008	1804.00	Missouri R.	P	100.0	100	Mi.	Escherichia coli (W)	Mult. Pt.& NPS	WBC B	AQL, DWS, IND, IRR, LWW, SCR	626315	4281840	749978	4300141	Gasconade/St. Charles	1
2010	7402.00	Mozingo Lake	L1	1000.0	1000	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	DWS, LWW, SCR, WBC B, GEN			348772	4467994	Nodaway	1
2008	853.00	Muddy Cr.	P	1.8	1.8	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	475958	4289290	476153	4291478	Pettis	1
2008	853.00	Muddy Cr.	P	62.2	62.2	Mi.	Chloride (W)	Sedalia Central WWTP	AQL	LWW, WBC B	458158	4281745	495118	4299761	Pettis	1
2006	674.00	Mussal Fork Cr.	C	29.0	29	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, DWS, LWW	509540	4450629	513876	4410414	Sullivan/Macon	1
2006	1170.00	Niangua R.	P	51.0	51	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, LWW, SCR	507120	4144342	512204	4176323	Webster/Dallas	1
2006	550.00	No Cr.	P	22.5	22.5	Mi	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	461943	4447521	451265	4415426	Grundy/Livin.	1
2010	550.00	No Cr.	P	22.5	22.5	Mi	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	461943	4447521	451265	4415426	Grundy/Livin.	1
2002	7316.00	Noblett Lake	L3	26.0	26	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC A			579891	4085042	Douglas	1
2010	279.00	Nodaway R.	P	60.0	60	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, IRR, LWW, SCR	328881	4493644	331843	4418710	Nodaway	1
2010	7109.00	North Bethany Lake	L3	78.0	78	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC A			412387	4463019	Harrison	1
2006	170.00	North Fk. Cuivre R.	C	8	8	Mi.	Fecal Coliform (W)	Source Unknown	WBC B	AQL, LWW	651684	4345260	656761	4337088	Pike	1
2006	170.00	North Fk. Cuivre R.	C	8	8	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	651684	4345260	656761	4337088	Pike	1
2008	3186.00	North Fk. Spring R.	P	17.4	17.4	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW, SCR	379528	4128246	363876	4125768	Barton	1
2006	3186.00	North Fk. Spring R.	C	1.1	55.9	Mi.	Ammonia, Total (W)	Lamar WWTP	AQL	LWW, SCR, WBC B	385711	4149177	387025	4148244	Barton	1
2008	3188.00	North Fk. Spring R.	C	55.9	55.9	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW, SCR	406711	4131507	379528	4128246	Dade/Jasper	1
2006	3188.00	North Fk. Spring R.	C	55.9	55.9	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	408711	4131507	379528	4128246	Dade/Jasper	1
2008	3260.00	North Indian Cr.	P	5.2	5.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	395484	4077534	390079	4072820	Newton	1
2008	3260.00	North Indian Cr.	P	5.0	5	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	395484	4077534	390079	4072820	Newton	1
2010	1293.00	Osage R.	P	39.3	39.3	Mi.	Oxygen, Dissolved (W)	Source Unknown	***	***	453701	4163192	444285	4187603	Vernon/St.Clair	1
2006	1373.00	Panther Cr.	C	7.8	7.8	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	482169	4115647	482554	4113028	St.Clair/Polk	1
2006	2373.00	Pearson Cr.	P	8.0	8	Mi.	Escherichia coli (W)	Livestock,Grazing or Feeding Operations, Urban Runoff/Storm Sewers	WBC A	AQL, LWW	486616	4121330	482572	4113046	Greene	1
2008	7628	Perry Phillips Lake	U	32.0	32	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	GEN				561277	4305658	Boone	1
2012	215.00	Peruque Cr.	P1	9.6	9.6	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	700330	4301725	704083	4307876	St. Charles	1
2012	216.00	Peruque Cr.	P	0.3	10.3	Mi.	Cause Unknown (W)	Lake St. Louis Dam	AQL	LWW, SCR, WBC B	693935	4297184	694195	4297616	St. Charles	1
2006	1755.00	Pickle Cr.	P	7.0	7	Mi.	pH (W)	Atmospheric Deposition - Acidity	AQL	LWW, WBC B	731000	4068596	732525	4088037	Ste. Genevieve	1
2010	2815.00	Pike Cr.	C	6.0	6.0	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	IRR, LWW	727565	4074153	732501	4058040	Butler	1
2010	312.00	Platte R.	P	138.0	138	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, DWS, IRR, LWW, SCR			471911	4194812	Worth/Platte	1
2012	1327	Pleasant Run Cr.	C	7.8	7.8	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	381361	4169526	376904	4174683	Vernon	1

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Year First Listed	WBID	Water Body Name	Class	MDNR Proposed Impairment Size	MDNR Water Body Size	Size Units	Pollutant	Source	Impaired Uses	Other (Unimpaired) Uses	Upstream X	Upstream Y	Downstream X	Downstream Y	County Upstream/ Downstream	Comment
2006	3120.00	Pole Cat Slough	P	12	12	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	599821	4447806	599813	4448472	Dunklin	1
2006	2038.00	Red Oak Cr.	C	10.0	10	Mi.	Oxygen, Dissolved (W)	Owensville WWTP	AQL	LWW, WBC B	631421	4239857	642012	4246718	Gasconade	1
2006	1710.00	River des Peres	C	2.6	2.6	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR	736570	4271519	738742	4268522	St. Louis	1,5
2012	1710.00	River des Peres	C	2.6	2.6	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	SCR	AQL, LWW	736570	4271519	738742	4268522	St. Louis	1,5
2012	3827.00	River des Peres	P	3.7	3.7	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR	733742	4275819	738561	4271521	St. Louis	1,6
2012	3827.00	River des Peres	P	3.7	3.7	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	SCR	AQL, LWW	733742	4275819	738561	4271521	St. Louis	1,6
2010	594.00	Salt Cr.	C	14.0	14.0	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	608375	4201573	608199	4201593	Livin./Chariton	1
2012	2113.00	Salt Pine Creek	C	1.2	1.2	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Barite tailings pond	AQL	LWW, WBC B	698660	4214456	697844	2216040	St. Francois	1
2008	91.00	Salt R.	P	29.0	29	Mi.	Oxygen, Dissolved (W)	Mark Twain Lake re-regulation dam	AQL	DWS, IRR, LWW, SCR, WBC A	703641	4150936	704394	4150521	Ralls/Pike	1
2002	103.00	Salt R.	P1	9.3	9.3	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	DWS, IRR, LWW, SCR, WBC A	616571	4375863	622770	4380468	Ralls	1,7
2006	2170.00	Shaw Branch	C	2.0	2	Mi.	Cadmium (S)	Federal tailings pond	AQL	LWW, WBC B	718516	4190248	718461	4191840	St. Francois	1
2008	3222.00	Shoal Cr.	P	41.1	41.1	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, DWS, IND, IRR, LWW, SCR	402084	4083441	356113	4099770	Newton	1
2006	399.00	Sni-a-bar Cr.	P	32	32	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	398862	4311016	416458	4333099	Jackson/Lafayette	1
2006	655.00	South Blackbird Cr.	C	5	13	Mi.	Ammonia, Un-ionized (W)	Source Unknown	AQL	LWW, WBC B	503697	4475340	518720	4469744	Putnam	2
2010	71.00	South Fabius R.	P	80.6	80.6	Mi.	Escherichia coli (W)	Nonpoint Source	WBC B	AQL, IRR, LWW	572794	4444457	627750	4417637	Knox/Marion	1
1994	142.00	South Fk. Salt R.	C	20.1	32	Mi.	Oxygen, Dissolved (W)	Mexico WWTP, Source Unknown	AQL	LWW, SCR, WBC B	420412	4108671	356381	4117687	Callaway/Audrain	1
2006	1249.00	South Grand R.	P	62.5	62.5	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW, SCR	425548	4101756	420412	4106671	Cass/Henry	1
2012	3259.00	South Indian Cr.	P	8.7	8.7	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	CDF, LWW, WBC B	399208	4067538	390081	4072621	McDonald/Newton	1
2008	3259.00	South Indian Cr.	P	8.7	8.7	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, CDF, LWW	399215	4067527	390079	4072820	Newton/McDonald	1
2012	224.00	Spencer Cr.	C	1.5	1.5	Mi.	Chloride (W)	St. Peters WWTP, Urban Runoff/Storm Sewers	AQL	LWW	708187	4298108	709436	4300127	St. Charles	1
2006	3160.00	Spring R.	C	61.7	61.7	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CLF, IND, IRR, LWW, SCR	420404	4108681	356391	4117697	Lawrence/Jasper	1
2010	3164.00	Spring R.	P	8.8	8.8	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CDF, IND, IRR, LWW, SCR	425938	4100912	420404	4108681	Lawrence	1
2010	3165.00	Spring R.	P	11.9	11.9	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, LWW, SCR	430995	4088419	425938	4100912	Lawrence	1
2012	2835.00	St. Francis R.	P	8.4	93.1	Mi.	Temperature, water (W)	Source Unknown	CLF	AQL, IRR, LWW, SCR, WBC A	725328	4181265	728433	4173620	St. Francois	1
2006	3138.00	St. John's Ditch	P	15.3	15.3	Mi.	Escherichia coli (W)	Rural NPS, Urban Runoff/Storm Sewers	WBC B	AQL, LWW, SCR	807942	4079151	817829	4057594	New Madrid	1
2006	3138.00	St. John's Ditch	P	15.3	15.3	Mi.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC B	807942	4079151	817829	4057594	New Madrid	1
2006	3135.00	Stevenson Bayou	C	14	14	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	513037	4255157	513136	4258619	Mississippi	1
2006	959.00	Straight Fk.	C	2.5	6	Mi.	Oxygen, Dissolved (W)	Versailles WWTP	AQL	LWW, WBC B	513047	4255147	514144	4263031	Morgan	1
2008	2751.00	Strother Cr.	P	6.0	6.0	Mi.	Lead (S)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC B	672405	4162651	680284	4163599	Iron	1
2010	2751.00	Strother Cr.	P	6.0	6.0	Mi.	Lead (W)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC B	672405	4162651	680284	4163599	Iron	1
2008	2751.00	Strother Cr.	P	6.0	6.0	Mi.	Nickel (S)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC B	672405	4162651	680284	4163599	Iron	1
2006	2751.00	Strother Cr.	P	6.0	6.0	Mi.	Zinc (S)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC B	672405	4162651	680284	4163599	Iron	1
2010	2751.00	Strother Cr.	P	6.0	6.0	Mi.	Zinc (W)	Buick Lead Mine/Mill	AQL	CLF, LWW, WBC B	672405	4162651	680284	4163599	Iron	1
2008	3965.00	Strother Cr.	U	0.9	n/a	Mi.	Arsenic (S)	Buick Lead Mine/Mill	GEN		671138	4161740	672405	4162651	Reynolds/Iron	1
2008	3965.00	Strother Cr.	U	0.9	n/a	Mi.	Lead (S)	Buick Lead Mine/Mill	GEN		671138	4161740	672405	4162651	Reynolds/Iron	1
2008	3965.00	Strother Cr.	U	0.9	n/a	Mi.	Nickel (S)	Buick Lead Mine/Mill	GEN		671138	4161740	672405	4162651	Reynolds/Iron	1
2006	3965.00	Strother Cr.	U	0.9	n/a	Mi.	Zinc (S)	Buick Lead Mine/Mill	GEN		671138	4161740	672405	4162651	Reynolds/Iron	1
2012	3965.00	Strother Cr.	U	0.9	n/a	Mi.	Zinc (W)	Buick Lead Mine/Mill	GEN		671138	4161740	672405	4162651	Reynolds/Iron	1
2006	686.00	Sugar Cr.	P	6.8	6.8	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	544663	4369674	538226	4368067	Randolph	1
2006	7399.00	Sunset Lake	L3	6.0	6	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, WBC B			569912	4268414	Cole	1
2010	7313.00	Table Rock Lake, White River Arm	L2	17240.0	17240	Ac.	Chlorophyll (W)	Mult. Pt.& NPS	AQL	WBC B,LWW,SCR			472162	4050084	Barry/Taney	1
2010	7313.00	Table Rock Lake, White River Arm	L2	17240.0	17240	Ac.	Nitrogen (W)	Mult. Pt.& NPS	AQL	WBC B,LWW,SCR			472162	4050084	Barry/Taney	1
2010	7297.00	Terre Du Lac Lakes ****	L3	103.0	103	Ac.	Chlorophyll-a (W)	Terre du Lac Subdivision	AQL	LWW, SCR, WBC A			708556	4197147	St. Francois	Lac Capri
2010	7297.00	Terre Du Lac Lakes ****	L3	103.0	103	Ac.	Nitrogen, Total (W)	Terre du Lac Subdivision	AQL	LWW, SCR, WBC A			708556	4197147	St. Francois	Lac Capri
2008	549.00	Thompson R.	P	5.0	65	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, DWS, IRR, LWW	432197	4492099	430910	4488381	Harrison	1
2012	3243.00	Thurman Cr.	P	3.0	3	Mi.	Escherichia coli (W)	Rural and suburban NPS	WBC B	AQL, LWW,	369320	4099003	367488	4097251	Newton	1
2012	3763.00	Tiff Cr.	P	2.1	2.1	Mi.	Fishes Bioassessments (W)	Source Unknown	AQL	LWW, WBC B	710827	4212454	708999	4214898	Jefferson	1
2006	1225.00	Trib. To Big Otter Cr.	C	1.0	1	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	437064	4228845	436283	4229898	Henry	1
2012	3963.00	Trib. To Chat Cr.	U	0.9	0.9	Mi.	Cadmium (W)	Baldwin Park mine	GEN		437568	4092534	436376	4092428	Lawrence	1
2010	3963.00	Trib. To Chat Cr.	U	0.9	0.9	Mi.	Zinc (W)	Baldwin Park mine	GEN		437568	4092534	436376	4092428	Lawrence	1

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2010	133.00	Trib. To Coon Cr.	C	1.0	1	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	552191	4364085	554306	4364133	Randolph	2
2010	3938.00	Trib. To Flat River Cr.	U	0.3	0.3	Mi.	Zinc (W)	Mill tailings (Aban.)	AQL		717159	4191123	717606	4190862	St. Francois	1
2008	3943.00	Trib. To Foster Br.	U	0.7	2.0	Mi.	Ammonia, Un-ionized (W)	Ashland WWTP	GEN		564699	4290776	656255	4290007	Boone	1
2010	1420.00	Trib. To Goose Cr.	C	3.0	3.0	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	437632	4110212	440716	4112975	Lawrence	1
2006	3490.00	Trib. To Little Muddy Cr.	C	1.0	1.0	Mi.	Chloride (W)	Tyson Foods	AQL	LWW, WBC B	473619	4290956	474708	4291636	Pettis	1
2010	2114.00	Trib. To Old Mines Cr.	C	1.5	1.5	Mi.	Sedimentation/Siltation (S)	Barite tailings pond	GEN	AQL, LWW, WBC B	699698	4215167	698464	4216954	St. Francois	1
2006	3360.00	Trib. To Red Oak Cr.	C	0.5	0.5	Mi.	Oxygen, Dissolved (W)	Owensville WWTP	AQL	LWW, WBC B	635584	4245145	636294	4244763	Gasconade	1
2006	3361.00	Trib. To Red Oak Cr.	C	1.1	1.9	Mi.	Oxygen, Dissolved (W)	Nonpoint Source	AQL	LWW	632991	4245779	634496	4245415	Gasconade	1
2006	3361.00	Trib. To Red Oak Cr.	C	0.8	1.9	Mi.	Oxygen, Dissolved (W)	Owensville WWTP	AQL	LWW	634496	4245415	635584	4245145	Gasconade	1
2006	956.00	Trib. To Willow Fk.	C	0.5	0.5	Mi.	Low D.O. (W)	Unknown	AQL	LWW	520023	4276037	520579	4275437	Moniteau	1
2006	3589.00	Trib. To Wolf Cr.	C	1.5	1.5	Mi.	Low D.O. (W)	Unknown	AQL	LWW, WBC B	727179	4185393	729121	4184286	St. Francois	2
2006	74.00	Troublesome Cr.	C	6.1	41.3	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, SCR, WBC B	366140	4107715	586188	4437669	Knox	1
2006	74.00	Troublesome Cr.	C	35.3	41.3	Mi.	Unknown	Unknown	AQL	WBC B,LWW	586188	4437669	356267	4109953	Knox/Marion	1
2012	751.00	Turkey Cr.	C	6.3	6.3	Mi	Escherichia coli (W)	Source Unknown	WBC A	AQL, LWW	565466	4300840	560347	4298778	Boone	1
2006	3216.00	Turkey Cr.	P	7.7	7.7	Mi.	Cadmium (S)	Tri-State Mining District	AQL	LWW, WBC B	366127	4107718	356268	4109958	Jasper	1
2006	3216.00	Turkey Cr.	P	7.7	7.7	Mi.	Cadmium (W)	Tri-State Mining District	AQL	LWW, WBC B	366127	4107718	356268	4109958	Jasper	1
2006	3216.00	Turkey Cr.	P	7.7	7.7	Mi.	Escherichia coli (W)	Rural and suburban NPS	WBC B	AQL, LWW	366127	4107718	356268	4109958	Jasper	1
2008	3216.00	Turkey Cr.	P	7.7	7.7	Mi.	Lead (S)	Tri-State Mining District	AQL	LWW, WBC B	366127	4107718	356268	4109958	Jasper	1
2008	3216.00	Turkey Cr.	P	7.7	7.7	Mi.	Zinc (S)	Tri-State Mining District	AQL	LWW, WBC B	366127	4107718	356268	4109958	Jasper	1
2008	3217.00	Turkey Cr.	P	6.1	6.1	Mi.	Cadmium (S)	Tri-State Mining District	AQL	LWW, WBC A	373131	4104203	366127	4107718	Jasper	1
2008	3217.00	Turkey Cr.	P	6.1	6.1	Mi.	Escherichia coli (W)	Rural and suburban NPS	WBC A	AQL, LWW	373131	4104203	366127	4107718	Jasper	1
2008	3217.00	Turkey Cr.	P	6.1	6.1	Mi.	Lead (S)	Tri-State Mining District	AQL	LWW, WBC A	373131	4104203	366127	4107718	Jasper	1
2008	3217.00	Turkey Cr.	P	6.1	6.1	Mi.	Zinc (S)	Tri-State Mining District	AQL	LWW, WBC A	373131	4104203	366127	4107718	Jasper	1
2006	3282.00	Turkey Cr.	P	2.4	2.4	Mi.	Cadmium (W)	Bonne Terre chat pile	AQL	LWW, WBC B	715483	4200142	714627	4203617	St. Francois	1
2006	3282.00	Turkey Cr.	P	2.4	2.4	Mi.	Lead (W)	Bonne Terre chat pile	AQL	LWW, WBC B	715483	4200142	714627	4203617	St. Francois	1
2006	3282.00	Turkey Cr.	P	1.2	2.4	Mi.	Zinc (W)	Bonne Terre chat pile	AQL	LWW, WBC B	715072	4201822	714627	4203617	St. Francois	1
2010	1414.00	Turnbeck Cr.	P	14.0	14.0	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CDF, LWW, SCR	742611	4165654	739598	4162978	Lawrence/Dade	1
2006	2579.00	Warm Fk. Spring R.	P	13.8	13.8	Mi.	Fecal Coliform (W)	Source Unknown	WBC A	AQL, IRR, LWW, SCR	627786	4054476	631872	4040311	Oregon	1
2006	1708.00	Watkins Cr.	C	3.5	3.5	Mi.	Chloride (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	744098	4294786	745384	4295397	St. Louis	1
2006	1708.00	Watkins Cr.	C	3.5	3.5	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	744098	4294786	745384	4295397	St. Louis	1
2012	1708.00	Watkins Cr.	C	3.5	3.5	Mi.	pH (W)	Urban Runoff/Storm Sewers	AQL	LWW, WBC B	744098	4294786	745384	4295397	St. Louis	1
2010	7071.00	Weatherby Lake	L3	194.0	194	Ac.	Chlorophyll-a (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR, WBC A			363437	4175258	Platte	1
2010	7071.00	Weatherby Lake	L3	194.0	194	Ac.	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	AQL	LWW, SCR, WBC A	357388	4172186	363437	4175258	Platte	1
2010	7071.00	Weatherby Lake	L3	194.0	194	Ac.	Nitrogen, Total (W)	Urban Runoff/Storm Sewers	AQL	LWW, SCR, WBC A			363437	4175258	Platte	1
	560.00	Weldon R.	P	42	42	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	477268	4461711	481600	4443207	Mercer/Grundy	1
2006	2755.00	West Fk. Black R.	P	2.1	32.3	Mi.	Lead (S)	West Fork Mine	AQL	CLF, LWW, WBC A	667316	4150995	669771	4151594	Reynolds	1
2008	2755.00	West Fk. Black R.	P	2.1	32.3	Mi.	Nickel (S)	West Fork Lead Mine/Mill	AQL	CLF, LWW, WBC A	667316	4150995	669771	4151594	Reynolds	1
2008	1317.00	West Fk. Drywood Cr.	C	8.1	8.1	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW, WBC B	357342	4172200	363431	4175253	Vernon	1
2006	613.00	West Fk. Locust Cr.	C	17.0	17	Mi.	Cause Unknown (W)	Source Unknown	AQL	LWW	477260	4461711	481625	4443186	Sullivan	1
2002	613.00	West Fk. Locust Cr.	C	17.0	17	Mi.	Oxygen, Dissolved (W)	Source Unknown	AQL	LWW	477260	4461711	481625	4443186	Sullivan	1
2010	1504.00	Whetstone Cr.	P	12.2	12.2	Mi.	Oxygen, Dissolved (W)	Livestock,Grazing or Feeding Operations	AQL	CLF, LWW, WBC B	556421	4116033	554003	4128699	Wright	1
2008	3182.00	White Oak Cr.	C	18.0	18	Mi.	Escherichia coli (W)	Rural NPS runoff	WBC A	AQL, IRR, LWW	415910	4124129	396445	4113579	Lawrence/Jasper	1
2010	1700.00	Wildhorse Cr.	C	3.9	3.9	Mi.	Escherichia coli (W)	Runoff from Forest/Grassland/Parkland, Rural, Residential Areas	WBC B	AQL, LWW	699014	4276142	699385	4279854	St. Louis	1
2012	3171.00	Williams Cr.	P	1.0	1	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, CDF, LWW	421762	4107279	420777	4107590	Lawrence	1
2010	3172.00	Williams Cr.	P	8.5	8.5	Mi.	Aquatic Macroinvertebrate Bioassessments (W)	Source Unknown	AQL	LWW, WBC A	432043	4105528	421762	4107279	Lawrence	1
2010	3172.00	Williams Cr.	P	8.5	8.5	Mi.	Escherichia coli (W)	Rural NPS	WBC A	AQL, LWW	432043	4105528	421762	4107279	Lawrence	1
2010	3594.00	Williams Cr.	P	1.0	1.0	Mi.	Escherichia coli (W)	Urban Runoff/Storm Sewers	WBC B	AQL, LWW	716794	4268174	716670	4269283	St. Louis	1
2012	3594.00	Williams Cr.	P	1.0	1.0	Mi.	pH (W)	Source Unknown	AQL	LWW, WBC B	716794	4268174	716670	4269283	St. Louis	1
2012	3280.00	Willow Br.	P	2.2	2.2	Mi.	Escherichia coli (W)	Rural NPS	WBC B	AQL, LWW	366145	4086268	364029	4084118	Newton	1
2010	955.00	Willow Fk.	C	6.5	6.5	Mi.	Oxygen, Dissolved (W)	Tipton WWTP, Source Unknown	AQL	LWW, WBC B	515568	4276519	522993	4273677	Moniteau	1
2006	2375.00	Wilsons Cr.	P	11.9	14	Mi.	Escherichia coli (W)	Nonpoint Source	WBC B	AQL, LWW	468505	4118821	464369	4102522	Greene/Christian	1

2012 Proposed List

Year First Listed	WBID	Water Body Name	Class	MDNR Proposed Impairment Size	MDNR Water Body Size	Size Units	Pollutant	Source	Impaired Uses	Other (Unimpaired) Uses	Upstream X	Upstream Y	Downstream X	Downstream Y	County Upstream/ Downstream	Comment

Comment

1: 2012 Assessment indicates impairment
2: Insufficient cause to delist
3: Assessed as unimpaired; expacted to be retained by EPA
5: Previously listed as WBID 1711
6: Previously listed as WBID 1711U
7: Previously listed erroneously as WBID 0091

Uses: AQL= Aq. Life Protaction, WBC A & WBC B=WBC Recreation, DWS= Public Drinking Water Supply, LWW= Livestock and Wildlife Watering, SCR= Secondary Contact Recreation
IRR= Irrigation, IND= Industrial Uses
Upstream X = X coordinate of upstream end of impaired water body (in UTMs)
Upstream Y = Y coordinate of upstream end of impaired water body (in UTMs)
Downstream X = X coordinate of downstream end of impaired water body (in UTMs)
Downstream Y = Y coordinete of downstream end of impaired water body (in UTMs)

* Misidentified in WQ Standards as Bowling Green New Lake. Acres shown on list are the actual acres.
** Lake Buteo is the only one of the Knob Noster S.P. Lakes on this list
*** This section of the Osage River inadvertently left out of WQ Standards, thus there are no designated beneficial uses.
**** Lac Capri is the only one of the Terre du Lac lakes on the list

Missouri Department of Natural Resources, Water Protection Program
5/2/2012

Table 2. Waters on the 2010 303(d) List but Proposed for De-Listing in 2012

WBID	Waterbody Name	Cls	County	Pollutant	Source	Reason for Delisting
2760	Bee Fk.	C	Reynolds	Lead (S)	Fletcher Mine	WQS now met
2916	Big Cr.	P	Wayne/Iron	Metals (S)	Mill tailings (Aban.)	List for Cd and Pb in sediments
3940	Big Cr., Trib.	U	Iron	Cadmium (W)	Glover Smelter site	TMDL 2006
3940	Big Cr., Trib.	U	Iron	Zinc (W)	Glover Smelter site	TMDL 2007
0035	Bobs Cr.	C	Lincoln	Low D.O.	Lincoln Co. PSWD #1	WQS now met, WWTP upgraded
1371	Brush Cr.	P	Polk/St. Clair	Org. Sediment	Humansville WWTP	data shows sediment is not high
1372	Brush Cr.	C	Polk	Low D.O.	Unknown	Listing Error, Site code was incorrect
737	Cedar Cr.	C	Boone/Callaway	Unknown	Unknown	TMDL 2004
3203	Center Cr.	P	Jasper	Bacteria	Rural NPS	WQS now met
935	Clear Fork	P	Johnson	Low D.O.	Unknown	Inadequate data for assessment
132	Coon Cr.	C	Randolph	Low D.O.	Unknown	Listing Error
221	Dardenne Cr.	P	St. Charles	Inorg. Sediment	Unknown	WQS now met
221	Dardenne Cr.	P	St. Charles	Unknown	Unknown	Data inconclusive
3168	Douger Branch	C	Lawrence	Cadmium (W)	Baldwin Park mine	Impaired portion now listed as Chat Cr.
3569	Dutro Carter Cr.	P	Phelps	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
2186	Fishpot Cr.	P	St. Louis	Low D.O.	Unknown	WQS now met
2184	Grand Glaize Cr.	C	St. Louis	Bacteria	Urban NPS	WQS now met
1713	Gravois Cr.	C	St. Louis	Low D.O.	Unknown	WQS now met
7384	Grindstone Res.	L1	DeKalb	Chlorophyll	Rural NPS	WQS now met
1747	Indian Cr.	C	Ste. Genevieve	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
3256	Indian Cr.	P	Newton	Unknown	Unknown	WQS now met
1719.00	Joachim Cr.	P	Jefferson	Cadmium (S)	Herculaneum smelter	Listing Error,
1719.00	Joachim Cr.	P	Jefferson	Lead (S)	Herculaneum smelter	Listing Error,
1719.00	Joachim Cr.	P	Jefferson	Zinc (S)	Herculaneum smelter	Listing Error,
7055	Lake Ste. Louise	L3	St. Charles	Bacteria	Urban Runoff/Storm Sewers	WQS now met
7336	Lake Wappapello	L2	Wayne	Nitrogen	Rural NPS	WQS now met
3490	Little Muddy Cr., Trib	C	Pettis	Color	Tyson Foods	WQS now met
3216U	Lone Elm Hollow	U	Jasper	Metals	Mill tailings (Aban.)	Listed in Error, unknown QA for data
2814	Main Ditch	C	Butler	Ammonia	Poplar Bluff WWTP	TMDL 2005
1709	Maline Cr.	C	St. Louis	Low D.O.	Urban NPS	WQS now met
7136	Marceline New Lake	L1	Chariton	Nitrogen	Rural NPS	WQS now met
2786	McKenzie Cr.	P	Wayne	Low D.O.	Piedmont WWTP	PIL TMDL Piedmont 2010
1841	Meramec R.	P	Franklin/Jefferson	Mercury (T)	Atmospheric Dep.	Note 1.
121	Middle Fk. Salt River	P	Macon/Monroe	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
3262	Middle Indian Cr.	C	Newton	Unknown	Unknown	TMDL 2004
3263	Middle Indian Cr.	P	Newton	Unknown	Unknown	TMDL 2004
1707.03	Mississippi R.	P	Jefferson	Lead (S)	Herculaneum smelter	TMDL 2010
1707.03	Mississippi R.	P	Jefferson	Zinc (S)	Herculaneum smelter	TMDL 2010
7402	Mozingo Lake	L1	Nodaway	Chlorophyll	Rural NPS	WQS now met
0853	Muddy Cr.	P	Pettis	Color	Tyson Foods	WQS now met
0942	North Moreau Cr.	P	Moniteau	Low D.O.	Unknown	TMDL 1999
1031	Osage R.	P	Miller	Total Diss. Gases	Bagnell Dam	WQS now met.
217	Peruque Cr.	P	St. Charles	Inorg. Sediment	Urban/Rural NPS	WQS now met
218	Peruque Cr.	C	St. Charles	Inorg. Sediment	Urban/Rural NPS	WQS now met
0785	Petite Saline Cr.	P	Cooper/Moniteau	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
2815	Pike Cr.	C	Butler	Temperature	Unknown	Listing Error, incorrect Type One Error rate
0743	Renfro Cr.	C	Callaway	Low D.O.	Unknown	WQS now met
0884	Richland Creek	C	Morgan	Low D.O.	Unknown	WQS now met
1710	River des Peres	C	St. Louis	Low D.O.	Unknown	WQS now met
3577	Sadler Br.	C	Polk	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
3231	Shoal Cr.	C	Barry	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
0913	South Davis Cr.	C	Lafayette	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
1361	Stockton Branch	C	Cedar	Low D.O.	Stockton WWTP	Note 2.
959	Straight Fk.	C	Morgan	Chloride	Versailles WWTP	PIL TMDL 2006
316	Todd Cr.	C	Platte	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate
3175	Truitt Cr.	C	Lawrence	Bacteria	Rural NPS	No E coli standard for this stream

WBID	Waterbody Name	Cls	County	Pollutant	Source	Reason for Delisting
3282	Turkey Cr.	P	St. Francois	Low D.O.	Unknown	TMDL 2005
0400	W Fk. Sni-a-Bar Cr.	P	Jackson	Low D.O.	Unknown	TMDL 2006
2879	Wolf Cr.	P	St. Francois	Low D.O.	Unknown	Listing Error, incorrect Type One Error rate

First 2012 303d List Public Meeting

December 13, 2011. Missouri DNR Elm Street Conference Center, Jefferson City

This meeting was included as part of the Clean Water Forum meeting. There was no formal presentation. John Hoke and John Ford of Missouri DNR Water Protection Program noted that the 2012 list and the 2014 Listing Methodology Document were on public notice and requested all interested parties to read and provide comments on the documents in the next few weeks so that these comments, and DNR responses, could be shared with other stakeholders. The following questions and comments were made at the meeting:

(1) Dorris Bender, City of Independence. Has all E. coli data for Little Blue River been reviewed and has the fact that much of the USGS data was purposefully collected during storm water conditions been taken into account when assessing the data for compliance with state standards. John Ford replied he would make sure they had all the available data from USGS and would also look at the issue of whether the USGS e coli data was representative of typical conditions in Little Blue River.

(2) Robert Brundage, of Newman, Comley and Ruth PCs. When the state proposes to remove waters from the 303(d) list, can they include the assessment category into which the state proposes to place these waters. Can the state prevail upon EPA to accept this assessment category? John Ford said "yes" to the first question, and "no" to the second.

(3) Trent Stober, Geosyntec Inc. The 2014 Listing Methodology Document (LMD) looks very similar to the 2012. Are there substantive changes? John Ford replied that the version on the website should have deletions from the 2012 LMD shown as strikeouts and additions as bold text. The major change was the addition of rules for judging impairment based on fish community sampling data collected by the Dept. of Conservation. Also the threshold sediment quotient value was raised from 0.5 in 2012 to 0.75 in 2014 to make it consistent with the method of establishing a threshold value for a single sediment pollutant as 150% of the PEL value.

(4) Leslie Holloway, Missouri Farm Bureau. Many of the listings from previous years where the pollutant source was previously listed as "rural nonpoint source" are now described as "agriculture". There were also several other new terms used. Also some pollutants that were previously described as "unknown" are now listed as "aquatic macroinvertebrate bioassessments" or "fish bioassessments". Why were these changes made? John Ford replied that they began using a new assessment database this year that was designed to download data directly to the EPA federal assessment database. This required using pollutant and source codes from the EPA database. In doing this, the department tried to use the code that provided the best fit or most information. He said that the actual assessments were done by three different people and they may not have all used the same code in similar situations. He will go over the list again looking for consistency errors in how these codes were applied.

(5) Nick Bauer, Metropolitan Sewer District. How will DNR assess e coli data from Mississippi River WBID 1707.02 now that EPA has disproved the secondary contact designation? John Ford replied he did not know at this time but would get an answer as soon as possible and let Mr. Bauer know.

Email 12/14/2011

To: Leslie Holloway, Missouri Farm Bureau

From: John Ford, Mo. DNR

Leslie, thanks for your comments on the list. This morning, I reviewed the list and found several entries where the source code names used were not consistent. For many of the dissolved oxygen listings in rural areas where it was not clear what the relative importance was of small point sources, versus rural nonpoint sources, versus natural low flow conditions we have listed the source as "source unknown". For the rural bacterial problems, most but not all of the problem appears to be related to livestock but contributions from other rural non-farm sources also occur, so we have now listed all of these sources in our list as "rural NPS". For Lewistown Lake which is listed for Atrazine, the source is now listed as "Agriculture" since the use of this chemical is associated solely with agricultural production and in our listing, we try to provide the most accurate (narrow) source category as possible. I've attached a copy of the working copy of the 2012 303d list which includes the edits I made this morning

Minutes of the Public Meeting on the Proposed 2012 Missouri 303d List and Proposed 2014 Listing Methodology Document, February 10, 2012.

The meeting took place in the Lewis and Clark State Office Building 1101 Riverside Drive, Jefferson City, from 10:00 AM to noon. In attendance were:

Nick Bauer – Metropolitan Sewer District of St. Louis, Jeff Wenzel- Missouri Dept. of Health and Senior Services, Dave Mosby – US Fish and Wildlife Service, Chris Zell, Trent Stober – Geosyntec Inc., John Redel – Jefferson County Sewer and Water, Robert Brundage – Newman, Comley and Ruth, PC., Mike McKee- Missouri Dept. of Conservation, John Hoke, Robert Voss, Rich Burdge, Mike Kruse and John Ford – Missouri Dept. of Natural Resources.

John Ford noted there will be a hearing before the Clean Water Commission in March on both the proposed 2012 303(d) List and the proposed 2014 Listing Methodology and that all comments on either should be submitted in writing by March 15, 2012. He then noted that the department was planning to remove five of the waters on the public notice version of the 303(d) List. These included:

(1) Mississippi River WBID 1707.02 for E. coli due to an error in our interpretation of state water quality standards following denial of the existing state standard by USEPA. (2,3) Mississippi R. for lead and zinc in sediment based on USEPA approval of a TMDL for these listings in 2010. (4) Straight Fork WBID 959 for chloride following the issuance of a water quality based chlorine limit in the discharge permit for Versailles, Missouri (USEPA approval of permit in lieu of TMDL is pending), (5) Crackerneck Creek WBID 3962 for chloride due to an assessment error. Some of the data used for the original listing was not on this stream. A reassessment indicated the stream was in compliance with the chloride standard.

There was a general discussion about the use of sediment contamination data and which values should serve as surrogates for narrative criteria. Several recent studies on sediment toxicity in Missouri due to metals were discussed and these will be emailed to meeting participants. DNR will reserve judgement on the appropriateness of our current assessment method until after the end of the public comment period, but our current opinion is to retain the current assessment method as our proposed method for 2014. Corrections to the LMD related to the calculation of the sediment PEC quotient were noted and will be made.

There was also a general discussion on biological data and its interpretation. Chris Zell asked if there were plans to include more specific information on assessment procedures for all types of biological data. John Ford replied that the kinds of biological data were so varied that it would be difficult to characterize them all and specify the exact analytical procedure that should be used. Trent Stober noted that some of the biological data used appeared to have high temporal variability at a given site and that other biological metric scores where heavily influenced by the absence of certain types of habitat and asked if this could or should be taken into consideration during the assessment process. John Ford noted that assessment of some biological data is difficult and that they tend to rely only on metric scores when the LMD gives procedures on how to assess data based on metric scores.

Nick Bauer of MSD noted that the dieldrin listing for Coldwater Creek was based on only one exceedence of the standard, which is contrary to the toxics rule in the LMD. John Ford agreed this was an error and that this listing will be removed from the proposed 2012 303(d) list. Mr. Bauer also noted that some bacterial listing for St. Louis area streams were made even though there was not adequate data in any given year to meet the current LMD requirements. John Ford noted that these were "legacy" listing from an earlier 303(d) list when the assessment method for bacteria were different, and since the recent data did not indicate "good cause" for de-listing, these waters must remain on the list. Mr. Bauer also noted that DO data on Grand Glaize Creek responsible for the 303(d) listing were predominantly from earlier years and that the most recent few years had few exceedences. John Ford ask him to investigate to see if there were any infrastructure or other changes in the watershed that could account for this temporal variation.

There was a general discussion about maximum data age and minimum sample size requirements in the LMD. John Ford noted that in the interests of having a smooth and consistent 303(d) listing process that the LMD tries to remain consistent with general USEPA guidelines on how water quality assessment should be done, and EPA does not approve of placing limits on data age or sample size. DNR uses discretion on both these issues and our decisions on both fall back onto sample representativeness.

Clean Water Commission Meeting, March 9, 2012

Item 2. Hearing on the Proposed 2012 Section 303(d) List.

John Ford of the Watershed Protection Section presented the list and discussed the public participation process for it, comments received from the public and department responses. The commission had no questions. Leslie Holloway of Missouri Farm Bureau noted her appreciation for changes made to the list based on comments she had supplied. Robert Brundage of Newman, Comley and Ruth PC said that he would provide all comments in writing. The department will receive and respond to comments through March 16, amend the list as needed in response to comments and present it for approval at the May commission meeting.

Item 3. Hearing on the Proposed 2014 Listing Methodology Document (LMD).

John Ford of the Watershed Protection Section presented the document, noted proposed changes from the 2012 LMD, and discussed comments and department responses on the proposed changes. Trent Stober of Geosyntec Inc. noted that the assessment of biological data needed to compare streams of similar size and that development of an appropriate tiered aquatic life designated use system could be beneficial in this regard. The department will receive and respond to comments through March 16, amend the document as needed in response to comments and present it for approval at the May commission meeting.

From: Dorris Bender [mailto:DBENDER@indepmo.org]
Sent: Tuesday, November 29, 2011 1:40 PM
To: Ford, John
Cc: Dick Champion; Eric D Christensen
Subject: Re: Public Notice for Proposed 2012 Missouri 303(d) LIst

I downloaded MDNR's data worksheet for Crackerneck Creek and forwarded it to Eric Christensen at the USGS Kansas City Subdistrict Office. USGS has been performing monitoring for the Independence MS4 permit under a joint agreement with the City of Independence.

Eric informed me that for MDNR's Crackerneck Creek table the 11/23/09 - 1/14/10 chloride values cited for the listing belong to another USGS sampling site 06893960, an unnamed Spring Branch tributary that is essentially the drainage ditch along Truman Road east of Yuma Avenue. The other data in the table are for Crackerneck Creek, site 06893940, so that the erroneous values appear to be inserted in the middle of the Crackerneck Creek data. Eric informed me that no data was collected by USGS at Crackerneck Creek between 9/24/2008 and 3/4/2010. Crackerneck Creek has not been sampled with chloride results as high as presented in the MDNR table nor has any other USGS gaged perennial stream site in Independence.

John, we may submit additional comments at a later time, but I wanted to forward this information to you so that you can re-check the data used to support the proposed 303(d) listing for Crackerneck Creek.

Dorris Bender
Environmental Compliance Manager
Water Pollution Control Department
City of Independence, MO
dbender@indepmo.org

Thanks Dorris, we'll go back to the original data source, correct any data/locations that are in error and re-do the worksheet

John Ford, Missouri DNR, Nov. 29, 2011

Dorris, I got on the NWIS website this morning and confirmed the four high chloride samples were from the tributary to Spring Branch and not from Crackerneck Creek. I have amended the master copy of the Crackerneck Creek worksheet and our main data files accordingly and removed Crackerneck Creek from our working copy of the 2012 303d list. These changes will not show up on the website, at least not until later in the public notice period, but since this was a locational error rather than an issue related to interpretation of data, I can state with assurance that Crackerneck Creek will not appear on the list we submit to the Clean Water Commission in March. I viewed an aerial photo of the site in question and as per your email it appears to be only a road ditch and therefore not the type of water conveyance that would be appropriate for the 303d list.

John Ford, Missouri DNR, Nov. 30, 2011

Email
To: Dorris Bender, City of Independence
From: John Ford, Mo. DNR
Date: Dec.16, 2011

Dorris, I located and pulled the USGS E coli data into our bacterial analysis worksheet. The sampling dates for both the USGS and the EPA data were biased in favor of storm water influenced flows (73% of samples) during recreation season) compared to the actual frequency of recreation season storm water flows in the L. Blue (2005-2011) which was 46% of days. I used a method to remove bias and the resulting estimated geometric mean during the rec. season for all years of data combined was 521. Thus, our recommendation will be to keep L. Blue on the list for E. coli. I've attached a copy of the revised worksheet.

Email 12/14/2011

To: Leslie Holloway, Missouri Farm Bureau

From: John Ford, Mo. DNR

Leslie, thanks for your comments on the list. This morning, I reviewed the list and found several entries where the source code names used were not consistent. For many of the dissolved oxygen listings in rural areas where it was not clear what the relative importance was of small point sources, versus rural nonpoint sources, versus natural low flow conditions we have listed the source as "source unknown". For the rural bacterial problems, most but not all of the problem appears to be related to livestock but contributions from other rural non-farm sources also occur, so we have now listed all of these sources in our list as "rural NPS". For Lewistown Lake which is listed for Atrazine, the source is now listed as "Agriculture" since the use of this chemical is associated solely with agricultural production and in our listing, we try to provide the most accurate (narrow) source category as possible. I've attached a copy of the working copy of the 2012 303d list which includes the edits I made this morning

From: Holloway, Leslie [mailto:lholloway@mofb.com]
Sent: Thursday, December 15, 2011 8:29 AM
To: Ford, John
Subject: RE: 303d comments

John: Thank you for re-reviewing the list. Please look at Big Creek (WBID 1250.00), too, for which agriculture is listed as the source and E.coli the pollutant.

Also, please review the sources listed as follows:
Blue River (WBID 421.00)—Livestock, Grazing or Feeding Operations, Urban Runoff/Storm Sewers
Pearson Creek (WBID 2373.00)—Livestock, Grazing or Feeding Operations, Urban Runoff/Storm Sewers
Whetstone Creek (WBID 1504.00)—Livestock, Grazing or Feeding Operations

Are these intended to be listed specifically for "livestock, grazing or feeding operations" rather than rural NPS or rural runoff like the following:
Grindstone Creek (WBID 1009.00)—Runoff from Forest/Grassland/Parkland, Rural, Residential Areas, Urban Runoff/Storm Sewers
Hominy Branch (WBID 1011.00)—Runoff from Forest/Grassland/Parkland, Rural, Residential Areas, Urban Runoff/Storm Sewers
Wildhorse Creek (WBID 1700.00)—Runoff from Forest/Grassland/Parkland, Rural, Residential Areas

Thank you—Leslie

Return Email Dec.16, 2011
From: John Ford, MDNR To: Leslie Holloway, Missouri Farm Bureau

Leslie, I've changed the source for Big Creek 1250 from "Agriculture" to "Rural NPS" to be consistent with other rural E coli listings. I looked at recent aerial photo coverage of the watersheds of the Little Blue 421, Pearson Cr. 2373 and Whetstone Creek 1504. Based on the aerial photo coverage, I've changed the source for Blue River 421 to "Runoff from Forest/Grassland/Parkland, Rural Resid. Areas, Urban Runoff, Storm Sewers". I have retained the current sources for Pearson and Whetstone because there appears to be a significant amount of pasture in both those watersheds. Again, thanks for your careful review of the list. These changes have been made on our "master list" but probably won't show up on our list on the website until later in the public notice period.

Comments on Proposed Missouri 2012 303(d) List

Joachim Creek – WBID 1719.00

The proposed 2012 listing for Joachim Creek (WBID 1719.00) for cadmium, lead and zinc in sediment should not be included for the following reasons:

- An impairment decision based on a single sample collected in 2001 at the Herculaneum Smelter stormwater outfall is not appropriate. A sample in or at an outfall should not be used in impairment determinations. Acute criteria only apply outside the Zone of Initial Dilution. The Chain-of-Custody associated with this sample identifies the location as "Herculaneum Stormwater Outfall near the treatment plant" but does not include GPS coordinates. The stormwater outfall at the Herculaneum smelter, Outfall 004, is located in a ditch that flows to Joachim Creek, but is not in Joachim Creek. The ditch flows approximately 20 yards before entering Joachim Creek.
- The next closest samples upstream and downstream do not indicate impairment.
- The concentration of toxic chemicals in sediment, such as metals, should not be used by itself to make an impairment determination, but rather they should be used to assess the need for further evaluation, such as aquatic communities. This is consistent with footnote 14 on page 19 of the 2012 Listing Methodology document which states: *"In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations..."*
- MacDonald, 2000 PELs are not appropriate for making impairment determinations by themselves. Site-specific PELs should be developed or additional information collected.

Mississippi River – WBID 1707.03

The 1998 listing for the Mississippi River (WBID 1707.03) for lead and zinc in sediment should be removed for the following reasons:

- The listing is based on a single sample at the Herculaneum Smelter 003 outfall collected in 2001 that exceeded MacDonald, 2000 PELs. A sample in or at an outfall should not be used in impairment determinations. Acute criteria only apply outside the Zone of Initial Dilution. Documentation of the exact location of this sample would need to be provided by DNR to understand its potential use in impairment determinations.
- The next closest samples upstream and downstream, which include samples in 2004, 2008, and 2009 do not indicate impairment.
- The concentration of toxic chemicals in sediment, such as metals, should not be used by itself to make an impairment determination, but rather they should be used to assess the need for further evaluation, such as aquatic communities. This is consistent with footnote 14 on page 19 of the 2012 Listing Methodology document which states: *"In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the <u>need for further evaluation</u> will be the Probable Effect Concentrations..."* (Emphasis added.)

- MacDonald, 2000 PELs are not appropriate for making impairment determinations by themselves. Site-specific PELs should be developed or additional information collected.

Middle Fork Black River

The proposed listing for the Middle Fork Blake River (WBID 2744.00) for aquatic macroinvertebrate bioassessment should not be included for the following reasons:

- The proposed listing identifies the Buick Lead Mine/Mill as the source, however the water column data showed no exceedances of criteria and sediment concentrations were not higher than thresholds (MacDonald, 2000 PELs) which the listing methodology employs to assess the need for further evaluation.
- The information in the table presenting 2004 and 2005 crayfish data in the Middle Fork Black River worksheet contains an inconsistency which requires resolution prior to its use to make an impairment determination. The data for site 2760/8.0 with a crayfish density of 2.2 per square meter indicates it is in Bee Fork 0.2 miles below the mine (assumedly referring to the Fletcher Mine/Mill). The data for site 2760/4.6 with a crayfish density of 20.8 per square meter indicates it is also in Bee Fork 0.2 miles below the mine. Our understanding is that the site identifier (2760/8.0 and 2760/4.6) represents the WBID and the river mile upstream from the mouth. These two sites appear to be at river mile 8.0 and 4.6 of Bee Fork, respectively. However they both have the same location description of "Bee Fork 0.2 mi. bl. Mine." If the 2760/4.6 site is actually 0.2 miles below the Fletcher Mine/Mill, then the 2760/8.0 site cannot also be 0.2 miles below the Fletcher Mine/Mill and must be 3.2 miles upstream of the facility. If this is the case, it would then be a reference site and should be used in the assessment accordingly. With a density of 2.2 per square meter at a reference site, the results of 6.9 and 5.2 per square meter in Middle Fork Black River below Strother Creek would not indicate an impairment.

Logan Creek – WBID 2763.00

The proposed 2012 listing for Logan Creek (WBID 2763.00) for lead in sediment should not be included for the following reasons:

- The concentration of toxic chemicals in sediment, such as metals, should not be used by itself to make an impairment determination, but rather they should be used to assess the need for further evaluation, such as aquatic communities. This is consistent with footnote 14 on page 19 of the 2012 Listing Methodology document which states: *"In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations..."*
- MacDonald, 2000 PELs are not appropriate for making impairment determinations by themselves. Site-specific PELs should be developed or additional information collected.

Coonville Creek

The proposed 2012 listing for Coonville Creek (WBID 2177) for lead in water should not be included for the following reasons:

- The most recent data indicating impairment is from 1994-1996. Data more than 10 years old should not be relied upon for making an impairment determination.
- The DNR did not account for higher hardness values at low-flow conditions.
- The worksheet erroneously states in the notes beneath the table of water quality data that the data indicating impairment was collected between 2004 and 2007.

Indian Creek

The proposed 2012 listing for Indian Creek (WBID 1946.00) for lead and zinc in sediment should not be included for the following reasons:

- The concentration of toxic chemicals in sediment, such as metals, should not be used by itself to make an impairment determination, but rather they should be used to assess the need for further evaluation, such as aquatic communities. This is consistent with footnote 14 on page 19 of the 2012 Listing Methodology document which states: "*In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations...*" While there is available biological community data in Indian Creek, it is outdated and not concurrent with the sediment data, with the most recent biological sampling conducted in 2002.
- MacDonald, 2000 PELs are not appropriate for making impairment determinations by themselves. Site-specific PELs should be developed or additional information collected.

STATE OF MISSOURI Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

March 30, 2012

Mr. Robert Brundage
Newman, Comley and Ruth, PC
P.O. Box 537
Jefferson City, MO 65102

Dear Mr. Brundage:

I have received your email of March 15, 2012, providing comments on the proposed 2012 303(d) List and 2014 Listing Methodology Document (LMD). As always, I appreciate your careful review and timely submission of comments. I provide the following responses to your comments which I have paraphrased below.

Comment: Joachim Creek should not be rated as impaired based upon one sediment sample at the Herculaneum outfall when the exact location of the sample appears to be uncertain.
Response: Since the outfall may be twenty yards removed from the creek and the precise location of the sample is unclear, the department agrees to eliminate this sample from consideration. A recalculation of the mean metals levels in sediments of Joachim Creek indicates levels do not reach those in the LMD required for listing a stream as impaired and we will remove the cadmium, lead and zinc listings for Joachim Creek from our proposed list.

Comment: Mississippi River, Middle Fork Black River, Joachim, Logan and Indian creeks should not be listed based solely on sediment PEC data. Footnote 14 says the threshold used to determine the need for further evaluation will be the PEC.
Response: Nothing in Footnote 14 disallows a listing based solely on sediment PEC values. The intent of the footnote was to explain that, as directed by the Clean Water Commission, we employ a "weight of evidence" approach in assessing impairment of narrative criteria, and it will be the department's policy to acquire, at the earliest practical date, additional data of another type, preferably biological data, whenever sediment PEC values are exceeded by 150 percent or more. Let me provide some clarification of your comments. First, Middle Fork Black River was listed based only on biological data, not sediment PEC data. Sediment PEC data used to list Indian Creek was supported by biological data on Indian Creek also showing impairment. On Logan Creek, the department began aquatic macroinvertebrate monitoring in the fall of 2011 and will re-sample this spring. We believe the promptness with which we scheduled and initiated this biomonitoring indicates our commitment to the "weight of evidence" approach. If the Logan Creek biomonitoring data shows no impairment and there is no additional biological data

Recycled Paper

indicating impairment, we would propose to remove Logan Creek from the next 303(d) list. The Mississippi River is not on the proposed 2012 303(d) List for heavy metals in sediment since a total maximum daily load (TMDL) has been approved by the U.S. Environmental Protection Agency (EPA).

Comment: Crayfish data on Bee Fork show data for two different sites (2760/8.0 and 2760/4.6), but both are described as 0.2 miles below the Fletcher Mine. If this description is accurate for site 2760/4.6, it means the other site, which has a crayfish density of 2.2/square meter is upstream of the mine and is thus a control site which shows lower crayfish diversity than the two listed sites on Middle Fork Black River.
Response: The worksheet did err in giving both sites the same name, i.e., "0.2 miles below the Fletcher Mine." We have corrected the master copy of the worksheet. However, both these sites are downstream of the Fletcher Mine. Site 2760/8.0 is closest to the mine and hence the poor crayfish abundance and the 2760/4.6 site is an additional 3.4 miles downstream and has a much better 20.8 crayfish/square meter abundance. Thus we believe the crayfish abundances shown on Middle Fork Black River (5.2 and 6.9/square meter) clearly indicate impairment.

Comment: On Coonville Creek the data used to make the assessment is more than ten years old. The department did not take high hardness values into account and the note at the bottom of the data erred in stating the years the impairment occurred.
Response: The data was more than ten years old but the LMD allows use of older data if it is still representative of current conditions. We contacted U.S. Geological Survey (USGS), the data generator, and asked about the accuracy of the data and any qualifications that their chemists placed on this data. Their response was there were no qualifications placed on the data and they considered it accurate. The department plans to do some additional metals monitoring on this stream, but pending those results, we consider the 1994 to 1997 data to be representative of current conditions since we know of no activities within that watershed that could have greatly altered water quality since most of it is within St. Francois State Park.

The department did not overlook any hardness values in our assessment. Water quality standards require the numeric lead standard be evaluated at the 25th percentile hardness value. Using the entire hardness data set for this stream, Excel software calculated a 20th percentile of 160 and 30th percentile of 190. I interpolated that to 175 for the 25th percentile value. After receiving your comments I recalculated by hand and found the actual 25th percentile was 160 mg/L (apparently Excel uses a different algorithm that I do and it can provide a different value when data sets are small) and the appropriate chronic lead standard would be 4.18 ug/L. Since this criterion value is more stringent than what we had previously calculated, the original assessment would still be correct.

We agree the note at the bottom of the data table in the assessment worksheet has the wrong dates and we have corrected that note on the master copy. Thanks for catching this error.

If you have any questions, please contact me at (573) 751-7024, by email at john.ford@dnr.mo.gov, or by mail at Missouri Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, MO 65102. Thank you.

Sincerely,

WATER PROTECTION PROGRAM

John Ford

John Ford, Chief
Water Quality Monitoring and Assessment Unit
Watershed Protection Section

JF:djs

The Empire District Electric Company

March 14, 2012

Mr. John Ford
Water Protection Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

Subject: Public Comments on the Listing of Blackberry Creek for Total Dissolved Solids in the Proposed 2012 303(d) List

Dear Mr. Ford:

The Empire District Electric Company (Empire) welcomes the opportunity to provide comments on the listing of Blackberry Creek for Total Dissolved Solids (TDS) currently on the proposed 2012 303(d) list ('list'). We have greatly appreciated the efforts of the Missouri Department of Natural Resources ('department') related to our ongoing studies regarding Blackberry Creek. The department has provided valuable support to develop our most recent water study designs, and to collect its own biological data, within the stream, with department resources. With these comments, we are requesting the department remove Blackberry Creek from the list. We support the department's decision to eliminate the "sulfate plus chloride" cause of impairment; however, we believe that inclusion of TDS as a cause of impairment, is not appropriate, and not supported by data collected by the department or other water quality studies completed within the past few years. The comments below summarize why the listing of Blackberry Creek for TDS is not supported by existing data, and why Blackberry Creek should be de-listed due to the healthy in-stream biological community. It is fully supporting of aquatic life beneficial uses.

Comment #1 – The department has no criterion for TDS that apply to the beneficial uses of Blackberry Creek and no TDS data has been collected to support this listing. TDS has been discounted as an appropriate constituent for the determination of impairment by most researchers. It appears that the department is attempting to use TDS synonymously with the "sulfate plus chloride" criterion of 1000 mg/L that is being eliminated with Missouri's water quality standards regulations. Our view is supported by a statement located in a listing worksheet for another listed water body (Drywood Creek) that states *"Since sulfate plus chloride does not appear as a pollutant type in federal databases, this pollutant is identified as "total dissolved solids" on the 303d list."* No specific TDS data is listed in the Blackberry Creek listing worksheet, only indirect references such as chloride, sulfate, and specific conductance. While these may be indirect indicators of TDS, they are not interchangeable. In addition, Missouri has not adopted a TDS criterion for protection of aquatic life in Missouri's current Clean Water Commission-approved water quality standards regulations. Therefore, we respectfully request the department eliminate TDS as impairment criterion and remove Blackberry Creek from the proposed 303(d) list.

Comment #2 – The department has recently acknowledged that the "sulfate plus chloride criterion" is not scientifically-defensible based on recent data provided by the USEPA, the State of Iowa, and the Empire District Electric Company. Empire has worked diligently alongside the department to address the scientific issues related to the recently eliminated sulfate plus chloride criterion. Studies have included in-stream bioassessments and numerous acute and chronic Whole Effluent Toxicity tests that demonstrate that the criterion is not needed for protection of aquatic life.

Comment #3 – The department's 2011 bioassessment survey performed on Blackberry Creek should be included in the listing dataset and demonstrates that the aquatic community is unimpaired. The report (Bioassessment Monitoring Report of Blackberry Creek, Jasper County, Missouri, 2010-2011) recently released by the department's environmental services program, indicated that the biotic community in Blackberry Creek was fully supporting for its designated aquatic life beneficial uses. A quote from the conclusions of that report stated that "*The MSCI scores were in the fully supporting range at both sampling stations during the fall 2010 and spring 2011 sampling seasons*." Empire believes this research should be given added value when evaluating the impairment of Blackberry Creek.

Comment # 4 – The listing methodology states that a water will be considered impaired, if the standard is exceeded more than once in the last three years that data is available. Since 2008, collected data has regularly shown that the chloride levels in Blackberry Creek have been below chronic levels. The listing worksheet for Blackberry Creek shows only one exceedance of the chronic criterion in the last three years. More recent data has shown the chloride levels in Blackberry Creek have been declining. Samples analyzed by MDNR during the department's bioassessment study during the fall of 2010 and spring 2011, were all below the acute and chronic levels established for chloride ranging from 49 to 190 mg/L. With the department's efforts, and Empire's background studies, to replace the outdated chloride and "sulfate plus chloride" criteria with the recently approved hardness-based criteria, we believe that Blackberry Creek will not exceed the established criteria. Empire looks forward to continue working with the department on this issue. Empire requests the department remove Blackberry Creek form the proposed 303(d) list based upon this criterion.

Having a primary receiving stream listed as not meeting state water quality standards is significant to the planning of our facilities. The impact is even greater when applying new watershed impact considerations. We appreciate the opportunity to provide these comments and acknowledge the department's work with respect to the 2012 303(d) list and ongoing Blackberry Creek studies. We are committed to continue working with the department to ensure that Missouri's waters are protected. Please contact me at 417-625-6510 or KStull@empiredistrict.com if you have any questions or would like to discuss these issues further.

Sincerely,

Kavan Stull
Environmental Coordinator
The Empire District Electric Company

Mr. Kavan Stull
Environmental Coordinator
Empire District Electric Company

Dear Mr. Stull:

I received your emailed letter March 15, 2012 providing comments on the department's listing of Blackberry Creek. I have attempted to paraphrase your comments below and provide responses to each.

Comment 1. Blackberry Creek is listed as impaired by Total Dissolved Solids (TDS) since there is no "sulfate plus chloride" pollutant category in the federal water assessment database. Since there is no state standard for TDS, this listing should be dropped from the 303(d) List.
Response: I agree this listing is confusing. We will amend the list to note that the pollutant of concern on Blackberry Creek is 'sulfate plus chloride' and will attempt to have the 'sulfate plus chloride' category added to our assessment database and the federal database to avoid this confusion in the future.

Comment 2. The department has acknowledged that the current sulfate plus chloride standard is not scientifically defensible. Empire has worked with the department to develop an improved standard. Response: The department has acknowledged its support of a new sulfate plus chloride standard and intends to proceed with rule-making to amend 10 CSR 20-7.031 to replace the current standard with a new hardness based standard. However the development of the 303(d) List must be based on the current water quality standards, rather than anticipated future standards, so we must continue to use the 1000 mg/L criterion until a new criterion becomes effective in our standards.

Comment 3. The department's 2010-2011 macroinvertebrate study of Blackberry Creek should be taken into consideration in making the current assessment of Blackberry Creek. Response: I agree. At the time the initial 303(d) List was developed, the results of this study were not available. After this study was released we did make a reassessment of Blackberry Creek that included all the biological and chemical data presented in that report.

Comment 4. *Since 2008, chloride levels in Blackberry Creek have been declining, chemical data from the DNR lab study shows compliance with the chloride standard and Empire is confident that the stream will meet the new proposed chloride standard.* Response: When the department reassessed Blackberry Creek after receiving the macroinvertebrate report, we also looked at all chemical data collected since 2008, including sulfate and chloride data collected since the fall of 2010 by the DNR Water Protection Program staff. This new data documented exceedences of both the chloride and the sulfate plus chloride standards in October 2010 and June and October 2011. These exceedences would require us to retain Blackberry Creek on the proposed 2012 303(d) List. I've included a copy of the revised worksheet.

Thank you for taking the time to comment on the proposed 303(d) List.
Sy jf (attachment).

From: John Ford, Missouri DNR
To: Michael Bollinger, AmerenUE
Sent: Monday, March 19, 2012

Mike, I just received the 2011 Annual Report data. After reviewing this data and based on your comment that "normal" or "routine" operations began in 2010 after the four new turbines had been installed and one year of testing of the venting systems on them, I'd agree that we should only look at 2010 and 2011 data as representative of current conditions. Our policy is to accept and review new data even at this late date if it shows that an assessment decision should be changed. In this case, it does indicate that the lower Osage does now appear to be in compliance with the TDG water quality standard, so we will propose to drop this listing from the proposed 2012 303d list. This means WBID 1031 Osage River will not appear on the 303(d) List. As you are probably aware, based on aquatic invertebrate monitoring, we still consider a portion of the river near Bagnell dam to be impaired, probably due to hydrological and physical factors related to hydropower operations. This section of the river appears on our "305b" List, which are those waters which we consider impaired but not qualifying for the 303(d) List.

From: Bollinger, Michael F [mailto:MBollinger@ameren.com]
Sent: Friday, March 16, 2012 11:12 AM
To: Ford, John
Cc: Sullivan, Alan D; Pozzo, John C; Bollinger, Michael F
Subject: 2012 303(d) listing of impairment for TDG for WBID 1031 (lower Osage River below Bagnell Dam)

John –

Following up on your presentation at the Public Hearing on the Draft 2012 303(d) List, at last Friday's Missouri Clean Water Commission Meeting, I took one more look at the TDG listing for the lower Osage River below Bagnell Dam. Unless it is just too late in the process for the 2012 list, I thought you might consider including the 2011 dataset. On March 7th we mailed the 2011 Water Quality Certification Annual Report (including the data files) to John Rustage. It was labeled to your 'attention' although the report might not have reached you as yet.

I noted that the TDG impairment listing for WBID 1031 is based on a spreadsheet apparently compiled on December 23, 2010. It includes a Table summarizing TDG data with columns headed "Number of Measurements"; "No. Greater Than 110%"; and "Annual Percent < 5 mg/l"; for both the Hwy 54 and Tuscumbia monitoring stations (A and B respectively). Presumably the third column should actually be labeled "Annual Percent > 110%". Compliance at Tuscumbia is not of concern and in fact we discontinued monitoring at Station B in 2011.

However, if we were to include the most recent data, the last four years of TDG data at Hwy 54 (Station A) would show the following annual percentages > 110%: 2008 - 16.5, 2009 - 11.8, 2010 – 9.9 and 2011 – 2.8. The four year average would be 10.25%, with rounding, essentially equal to the 10% criteria. As you know, two Voith aerating (main) turbines were installed in early 2008 and two more in early 2009. Initial monitoring following these installations, reflects the period when the enhanced venting control system was being learned and refined. As Osage Plant staff have explained, during this period we tended to default toward excess aeration (to fully understand the venting capacity of the new turbines), while we have more recently been able to fine tune the system to optimize both DO and

TDG. If you consider just the last two years, which Ameren believes would better predict future performance, the average annual percentage of measurements of TDG > 110% would be 6.4%, resulting in an unimpaired conclusion.

If 2011 data can still be included, at a minimum it would update the characterization of TDG conditions in the lower Osage below Bagnell Dam. It might even support delisting. If not, we are confident that the 2010-2011 dataset along with future data from continued monitoring will support delisting in 2014.

Please let me know your thoughts regarding this matter. Thanks - mfb

MICHAEL BOLLINGER : : Principal Environmental Scientist, Environmental Services :
: T 314.554.3652 : : C 314.550.2875
Ameren Services : : 1901 Chouteau Avenue, MC 602 : : St. Louis, MO 63166-6149

Metropolitan St. Louis
Sewer District
2350 Market Street
St. Louis, MO 63103
MSD

2012 FEB 21 PM 1:43
WATER PROTECTION PROGRAM

February 17, 2012

Mr. John Ford
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, Missouri 65201

Dear Mr. Ford:

The Metropolitan St. Louis Sewer District has reviewed the St. Louis portion of the proposed 2012 Section 303 (d) List for Missouri. We would like to provide the Department with several comments.

Comment #1: There appears to by a typographical error on row 72 of the Antire Creek Excel worksheet. The comment notes that, "Ten of 50 dissolved oxygen measurements (20 percent) failed to meet state standards. Since this is more than the allowable ten percent exceedance rate, this stream is judged to be impaired by low pH." Dissolved oxygen should be changed to pH.

Comment #2: Coldwater Creek has been listed as impaired for Dieldrin for the protection of aquatic life (AQL). A single data point (0.003 mg/L on March 4, 2004) was used to determine an average value (0.0003 mg/L), which was higher than the limit for Human Health Protection – Fish Consumption (0.000076 mg/L). Table 1.1 of the Department's *Methodology for the Development of the 2012 Section 303(d) List in Missouri* states that for the protection of AQL from toxic chemicals, there must be no more than one occurrence of an acute toxic event in three years. According to the table, an average should not have been used, and with only one exceedance of this limit, the water body should not be impaired by Dieldrin.

Following our discussion during the February 10, 2012 public meeting, you agreed with this error and stated the impairment would be removed from the list.

Comment #3: The term "WBID 1703" has been omitted from row 247 of the Creve Coeur Creek Excel worksheet. To clarify, I believe that the terms "this stream" should be removed, and the line should read, "Thus, WBID 1703 is judged to be impaired by bacteria."

Comment #4: The Mississippi River (WBID 1707.02) has been listed as impaired by E. coli for WBC B. In the current Water Quality Standards this segment is not protected for WBC B. According to your discussions with John Hoke and John Madras of the Department, when the EPA disapproved SCR, the standard should have reverted to the previous use for the water body. You indicated that In this case there was no previous Whole Body Contact use, but there was a Boating use. Since the Secondary Contact Use is established to protect for boating and other water uses with limited contact to the water, we feel the 1134 colonies/100 ml is the appropriate E coli criterion for assessment purposes until a new standard is promulgated. The last three years of data show no geometric mean which exceeds this standard; thus, the impairment of WBC B by E. coli should be removed.

The Metropolitan St. Louis Sewer District appreciates the Department's commitment to transparency and the use of sound data and analysis in protecting Missouri's waterways. Thank you for the opportunity to provide comments during this process.

If you have any questions or comments, please feel free to contact Nick Bauer at (314) 436-8762 or John Lodderhose at (314) 436-8714.

Sincerely,

Susan M. Myers
General Counsel

cc: John Lodderhose
Nicholas Bauer

Ms. Susan M. Myers, General Counsel
Metropolitan St. Louis Sewer District
2350 Market Street
St. Louis, Mo. 63103

Dear Ms. Myers:

On February 21, 2012 I received your letter providing comments on the department's proposed 2012 Section 303(d) List and on Excel worksheets posted on our website that are the basis for Section 303(d) listings. This letter provides the department's responses to your four comments.

Comments One and Three in your letter pertained to possible errors in Excel worksheets. We have reviewed the two worksheets in question and agree with your comments. The master copies of these two worksheets have been corrected.

Comment Two pertained to our listing of Dieldrin as a pollutant in Coldwater Creek. We agree this listing was made in error and it has been removed from the list we plan to present to the Clean Water Commission at their March meeting.

Comment Four noted that MSD agreed with the method used by the department to assess bacterial data in the Mississippi River WBID 1707.02. We appreciate your comments on this issue.

As always, I greatly appreciate the time taken by you and other MSD staff to participate in the 303(d) List process and your careful review of the proposed list and supporting documentation.

Sy jcf.

Email
To: Nicholas Bauer, Metropolitan Sewer District of St. Louis
From: John Ford, DNR Water Protection Program
Date: Dec. 15, 2011

Nick, regarding your question at the Clean Water Forum meeting: what is the current E coli standard for WBID 1707.02? I've discussed with John Hoke and John Madras. Their interpretation is that with the EPA disapproval of the Secondary Contact use, the standard would revert to the previous use for that waterbody. In this case there was no previous Whole Body Contact use, but there was a Boating use. Since the Secondary Contact Use is to protect for boating and other water uses with limited contact to the water, we feel the 1134 counts/100 ml is the appropriate E coli level for assessment purposes until a new standard is promulgated. Thus we will amend our assessment worksheet and remove this section of the Mississippi River from our proposed 2012 303d list. Obviously, EPA in their review of our 2012 list may have a different interpretation of what the appropriate level of bacterial protection should be for this section of the river.

February 28, 2012

EPA Comments on the draft 2012 Missouri Section 303(d) List and 2014 LMD

- Waters being delisted for EPA approved TMDLs, in the case of these water bodies the EPA would ask the state to address the issues outlined for each water body (two water bodies).

Big Creek Tributary, aka Scroggins Branch (WBID 3940) while the Big Creek TMDL was approved by the EPA and has acute WLAs for the metals for which this tributary is impaired, the public notice of this TMDL was only for Big Creek (WBID 2916). In a previous instance where an EPA-approved TMDL was applied to waters which were not explicitly identified in the public notice of that TMDL, Missouri had re-public noticed the TMDL with the additional waters identified explicitly. The EPA would hope that in this case a similar procedure could be performed. In the case of this water body, even the 303(d) public notice did not identify the TMDL which was being used to delist this water.

Whetstone Creek (WBID 1505U) this water body has an EPA-approved TMDL for biological oxygen demand but not for ammonia. As this TMDL did not allocate ammonia it does not apply to the pollutant currently impairing Whetstone Creek.

- Waters with EPA-approved or established TMDLs which are still listed

Mississippi River (WBID 1707.03) there is an approved TMDL for both Lead (s) and Zinc (s). The TMDL was approved on December 9, 2010.

- Waters proposed to be removed from the state's § 303(d) list because the water body is now meeting water quality standards (five water body segments).

Clear Creek (WBID 3239) this water body is identified as being impaired for low dissolved oxygen in the state's spreadsheet. The spreadsheet identifies nutrients as the cause of the low dissolved oxygen condition and the water body is 303(d) listed for nutrients. While dissolved oxygen is a unique case in that it in itself is not a pollutant, it is an EPA-approved water quality standard which is not being met. As such, the state must list the water body for this condition.

Clear Fork (WBID 0935) this water body does not have accompanying data in the public notice. The EPA's review of data for this site indicates continued impairment based on the 2011data obtained from Missouri's web-based data retrieval system. The EPA would like to review the assessment of this water body.

Dardenne Creek (WBID 0221) this water body is proposed for removal from the list based on the same analysis the state used for the 2010 Missouri § 303(d) List. This segment continues to be listed as impaired by low dissolved oxygen in 2012. The EPA approved of the delisting of segment 0222 for an unknown pollutant of Dardenne Creek in its action on the 2010 Missouri § 303(d) List in response to the dissolved oxygen listing. In the case of this segment (WBID 0221) the low dissolved oxygen and inorganic sediment listings could serve to address the previously identified unknown biological impairment consistent with the action on segment 0222. As for the delisting of the inorganic sediment impairment, the EPA questions pooling of data between segments 0221 and 0222 for comparison with control streams to determine impairment, consistent with the EPA's review of previous Missouri § 303(d) lists.

Lone Elm Hollow (WBID 3216U) the EPA would like some discussion of the QA/QC issues involved with this data and the reason the state no longer considers this data acceptable.

Peruque Creek (WBID 0217 and 0218) these water bodies are proposed for removal from the list based on the same analysis the state used for the 2010 Missouri § 303(d) List. Both of these segments of Peruque Creek were listed as impaired by inorganic sediment on the 2008 Missouri§ 303(d) List. In its evaluation and public notice of its decision to add these segments to Missouri's 2008 List, the EPA relied on data from the Missouri Department of Conservation in addition to the data provided by the Missouri Department of Natural Resources. The 2010 Missouri§ 303(d) List again proposed delisting of these water body/pollutant pairs. Missouri identified no additional data used in making their decision. By not providing additional data, the EPA was unable to determine whether conditions in these segments had changed to demonstrate good cause to delist these segments. As such, the EPA again added these segments to the state's § 303(d) list. For the 2012 Missouri§ 303(d) List, the state again proposes to delist these water body/pollutant pairs. The data Missouri appears to be assessing for these proposed delistings contains no new information. The EPA asks if additional information was used in the assessment for the 2012 Missouri§ 303(d) List.

Table Rock Lake (WBID 7313) the state proposes to remove the nutrients listing for this water body. Is this in response to the more specific listings for nitrogen and Chlorophyll?

- Waters proposed to be removed from the state's § 303(d) list because the water body was listed as impaired by error.

Dutro Carter Creek (WBID 3569) this water body is mentioned in these comments only to acknowledge that while part of the water body is proposed for removal from the state's list, the remainder is still proposed to be listed as impaired. For the purposes of the EPA's actions on the future submittal, water bodies are approved as listed or not based on the entire segment not portions thereof.

Lone Elm Hollow (WBID 3216U) this water body was proposed for delisting for concerns over quality control. The state should describe the concern with the data in its final submittal.

Truitt Creek (WBID 3715) this water body is being proposed for removal based on the removal of the whole body contact recreation use. In its August 16, 2011, action on Missouri's water quality standards, the EPA disapproved the state's removal of this use. In Missouri's November 10, 2011, response to the EPA's action it expressed a desire to address issues caused by the EPA's action itself. As the proposed delisting of Truitt Creek based on the removal of a designated use, reflects one of these issues, the EPA comments that it may be more appropriate to propose this delisting action once the designated use issue is resolved.

- General comment on the delisting of lakes and reservoirs based on the disapproval, by the EPA, of Missouri's proposed nutrient criteria (42 water body / pollutant combinations).

The EPA previously approved the listing of these lakes on the 2010 Missouri § 303(d) List based on the use of numeric translators for the state's narrative water quality standards. With the state's proposed delisting of these lakes based on the EPA's disapproval of the submitted criteria as water quality standards, has the state determined that these translators are no longer indicative of an excursion of the state's narrative criteria?

- Water bodies for which WBIDs or names have been assigned or changed

Baldwin Park Tributary (WBID 3963) is this water body previously identified as Tributary to Chat Creek (WBID 3168U-01)
Bee Fork (WBID 3966) is this the water body previously identified as 2760U-01?
Busch Lake #37 (WBID 7627) is this the water body previously identified as 7056U?
Chat Creek (WBID 3168) is this the water body previously identified as Douger Branch 3168?
Crooked Creek (WBID 3961) is this the water body previously identified as 1928U-01?
Douger Branch (WBID 3810) is this the water body previously identified as Douger Branch 3618?
Frisco Lake (WBID 7280) is this the water body previously identified as Schuman Park Lake 7280?
Lake of the Woods (WBID 7629) is this the water body previously identified as Lake of the Woods MO-U-01?
Little Medicine Creek (WBID 0623) is this the water body previously identified as West Fork Medicine Creek 0623?
Medicine Creek (WBID 0619) is this the water body previously identified as East Fork Medicine Creek 0619?
Perry Phillips Lake (WBID 7628) is this the water body previously identified as Phillips Lake 1003U-01?
Pole Cat Slough (WBID 3120) is this the water body previously identified as Ditch to Buffalo Ditch 3120?
Renfro Creek (WBID 0743) is this the water body previously identified as Trib to Cedar Creek 0743?
River des Peres (WBID 1710) is this the water body previously identified as River des Peres 1711?
Salt River (WNID 0103) is this the water body previously identified as Salt River 0091?
Strother Creek (WBID 3965) is this the water body previously identified as Strother Creek 2751U-01?
Sunset Lake (WBID 7399) is this the water body previously identified as McKay Park Lake (Sunset Lake) 7399?
Tributary to Flat River (WBID 3938) is this the water body previously identified as Flat River Creek, Trib. 2168-U01?
Tributary to Foster Branch (WBID 3943) is this the water body previously identified as Foster Branch 0747U-01?
Tributary to Flat River Creek (WBID 3938) is this the water body identified as 2168U-01 by the EPA when the water was added to Missouri's 2010 List?

- Water bodies listed in both the proposed delisting tab and the proposed listing tab of ***2012 Nov PN Working List.xlsx*** for the same pollutant. The EPA seeks clarification that these water bodies are still proposed to be listed on the 2012 Missouri § 303(d) List.

Cedar Creek (WBID 0737) delist unknown for TMDL and pollutant change to Aquatic Macroinvertebrate Bioassessments (w)
Middle Indian Creek (WBID 3262) delist unknown for TMDL and pollutant change to Aquatic Macroinvertebrate Bioassessments (w)
Middle Indian Creek (WBID 3263) delist unknown for TMDL and pollutant change to Aquatic Macroinvertebrate Bioassessments (w)
Tributary to Wolf Creek (WBID 3589) inadequate data, still listed for DO
West Fork Sni-a-Bar Creek (WBID 0400) delist for TMDL, still listed for DO

- Change in impairments, the EPA is commenting on these changes but not asking the state for further explanation.

All previous bacteria impairments now identified as E. coli.
Big Creek (WBID 2916) more specificity in metals contaminating sediment
Cedar Creek (WBID 0737) change from unknown impairment to aquatic macroinvertebrate assessment.
Cedar Creek (WBID 1344) change from unknown impairment to aquatic macroinvertebrate assessment.
Clear Creek (WBID 3239) change from nutrients to nutrients/eutrophication.
Courtois Creek (WBID 1943) more specificity in metal contaminating sediment
Horse Creek (WBID 1348) change from unknown impairment to aquatic macroinvertebrate assessment.
Little Beaver Creek (WBID 1529) change from inorganic sediment to sedimentation/siltation.
Little Medicine Creek (WBID 0623) change from unknown impairment to aquatic macroinvertebrate assessment. Name also changed from West Fork Medicine Creek.
Middle Indian Creek (WBID 3262) change from unknown impairment to aquatic macroinvertebrate assessment.
Middle Indian Creek (WBID 3263) change from unknown impairment to aquatic macroinvertebrate assessment.
Muddy Creek (WBID 0853) change from unknown impairment to aquatic macroinvertebrate assessment.
North Fork Cuivre River (WBID 0170) change from bacteria to fecal coliform.
North Fork Spring River (WBID 3188) change from ammonia to ammonia, total.
South Blackbird Creek (WBID 0655) change from ammonia to unionized ammonia.
Tributary to Foster Branch (WBID 3943) change from ammonia to unionized ammonia. Water body name and identification number also changed from the 2010 list.
Tributary to Old Mines (WBID 2114) change from sediment to sedimentation/siltation. Water body name also changed from Old Mines Creek, Tributary.

- Changes to impairment where the EPA is asking the state for further information.

Blackberry Creek (WBID 3184) change in pollutant from Sulfate+chloride to Total Dissolved Solids. Sulfate+chloride is a MO WQS TDS is not. This WB should be listed for the WQS.
Drywood Creek (WBID 1314) change in pollutant from Sulfate+chloride to Total Dissolved Solids. Sulfate+chloride is a MO WQS TDS is not. This WB should be listed for the WQS.

- Possible typographical errors

Knob Noster State Park Lake (WBID 7469) should the WBID for this water body 7169?
North Fork Cuivre River (WBID 0170) change from bacteria to fecal coliform, should this be E. coli?

- Complete set of data used by the state in its assessment.

Some data files for specific waters were not available with the public notice data sets. The state's final submittal should include a copy of all data used by the state in its assessment of waters for the 2012 Missouri § 303(d) List.

Comments on draft 2014 listing methodology

- Footnote 9 to Table 1.1 - Could lead to a condition where all aquatic life would be extirpated for a portion of the year, but would be okay on average, such a situation would not be considered impaired.
- Footnote 10 to Table 1.1 - With the state's proposed 2012 delisting of lakes based on the EPA's disapproval of the submitted criteria as water quality standards, has the state determined that these translators are no longer indicative of an excursion of the state's narrative criteria?
- Table 1.1 footnote 14 regarding PELs and PELQs is not consistent with Table B-1 and Appendix D.

Memo

To: Bruce Perkins, Region VII USEPA
From: John Ford, Missouri DNR, Water Protection Program
Subject: Responses to your Comments on Proposed 2012 303d List and 2014 Methodology Document.
Date: Feb.28, 2012

Bruce, as always, thanks for your careful review. With regard to your comments I offer the following.

-On tributary to Big Creek (Scroggins Br.) I do not believe re-noticing the Big Creek TMDL with implicit inclusion of the tributary would be a problem for us. We'll pursue that.
- With regard to our proposal to de-list Whetstone Creek for ammonia, while the first page of the the TMDL document that was approved by EPA states the pollutant is BOD, the approved TMDL document calculated water quality based loads for both BOD and ammonia.
-With regard to lead and zinc listings for WBID 1707.03, Mississippi River, we noted this error earlier and it has been corrected on our working copy of the list.
- We will list Clear Creek for Low DO as well as nutrients.
- On Clear Fork we will re-do the assessment and post the worksheet on our website.
- With regard to the proposed delisting of WBID 221 Dardenne Creek for sediment and unknown pollutants, we feel compelled to base our assessments on the listing methodology approved by the Missouri Clean Water Commission (sediment) and best professional judgement of interpretation of biological data (unknown pollutant).
- On Lone Elm Hollow, the original listing was based on three samples from a data generator for which we had no quality assurance data. This data should not have been used, as per our LMD, so we withdrew this listing. I am loath to add this stream to the list at this late date since we are nearing the end of the public notice period. I believe this stream does fail to meet acute zinc standards and does need to be listed. We are currently monitoring this stream about three times per year. If you like I can send you all our data when you begin looking at our list since there will probably be adequate data of known QC for listing, or we can wait until we develop our 2014 list. In either case, I would expect this stream to be on our proposed 2014 list.
-As with Dardenne Creek, the department feels compelled to abide by the LMD and best professional judgement when reviewing sediment deposition and biological data. Both these indicate Peruque Creek does not qualify as an impaired stream.
-Since the only numeric standards approved by EPA are for the White River arm, we've only listed this portion of the lake. Obviously however, this is a de facto listing of the entire lake since a TMDL for the White River arm would have to include loads to and from all tributary arms of the lake.
- Your comment on Dutro Carter is understood. In our assessment, we will continue to subsegment waterbodies where this better defines the nature and scope of the impairment, but understand that EPA will list whole WBIDs.
- With respect to Truitt Creek, the guidance I have received from within DNR for assessing waters with a standard that has been disapproved by EPA is to use the prior standard. In the case of Truitt Creek, there was no prior whole body contact standard and based upon the state's earlier action to remove all recreational uses, there must be good evidence these uses don't exist.

Thus, until new recreational use standards for this stream are promulgated, our preference is not to assume an arbitrary bacterial standard.

- With regard to your comment on our delisting of 42 lakes based on EPAs disapproval of numeric criteria. I can't comment on what the basis of EPAs approval of these lakes were on the 2010 list, but I can tell you that the department put them on the list because they exceeded numeric criteria promulgated in September 2009, not as translators of narrative criteria. Our removal of these from the 2012 list is due to the disapproval of the numeric criteria and the fact that our LMD does not have numeric translators for narrative criteria that address nutrient levels in lakes.
- Sorry about all the name changes. It has been a source of irritation and error for us as well but we are trying very hard to gain consistency with the USGS national database for names. In answer to your specific questions, you are correct on all counts except that Salt River WBID 103 and Salt River WBID 91 are different waterbodies and have not been altered for many years. 103 is the section of the river between Cannon dam and the re-reg dam, and 91 begins immediately downstream of 103. Some additional clarification is needed on two others on your list. What was previously listed as WBID 3168 Douger Branch has now been split into two WBIDs. The lower is WBID 3810 Douger Branch and the upstream portion is now 3168 Chat Creek (this was a change to get consistent with the USGS names). Also the entireties of what previously were WBID 1710 and 1711 River des Peres, have been combined and are now called WBID 1710 River des Peres.
- Cedar Creek, pollutant change from "unknown" to "aquatic bioassessment". As part of our new WQA data system, which downloads data directly to EPAs national assessment data base (at least in theory) we are now, of necessity, using EPA pollutant and source code words and phrases. Previously where we had evidence of biological impairment but no indication of the physical or chemical cause, we listed the pollutant as "unknown". Those have been switched to what we felt was the best match to the set of EPA codes, even though these codes are a mixture of pollutants and monitoring types (I'm pulling my hair out here). Same comment for Middle Indian Creek.
- Trib to Wolf Creek. Good catch. Since this water appears on the approved 2010 list and the small amount of data for this stream suggests a problem, it will remain on the 2012 list.
- We apparently caught and corrected the double listing for W. Fk. Sni-a-bar. It has been removed from the 2012 303(d) List and is proposed for de-listing based on an approved TMDL in 2006.
- The change in listing for Blackberry and Drywood Creeks is based on the need to import data to the EPA national assessment database using the correct codes. There is no code for "sulfate plus chloride" so we have used the closest code we could find, "TDS". I assume we could pursue having EPA add this code to their list, but we have not done so yet.
- Yes, the correct WBID for Knob Noster State Park Lakes is 7169. Thanks.
- Fecal coliform is the correct pollutant for N. Fork Cuivre River. The LMD says that if a waterbody is listed as impaired due to fecal coliform, it must remain on the list until there is sufficient E. coli data to determine the impairment status of the waterbody. To date, we have no E. coli data on N. Fk. Cuivre but are planning to begin monitoring this spring.

- Regarding your comment about footnote 9 in Table 1.1 of the LMD, I agree, but the same comment could be made for assessment periods as short as a month or even a week. Our WQ Standards are currently silent on this issue. Do you have any suggestions?
- Regarding your comment about footnote 10, the department has never used nor proposed to use the disapproved numeric lake nutrient criteria as translators for our narrative criteria. Footnote 10 clarifies this position.
- We have recently caught and corrected the discrepancies in Tables 1.1 and B.1 concerning the PEL and PELQ values. Thanks.

Biological Criteria for Stream Fish Communities of Missouri

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Acknowledgments

This research is a contribution of the Missouri Cooperative Fish and Wildlife Research Unit (U.S. Geological Survey, Missouri Department of Conservation, University of Missouri, and Wildlife Management Institute cooperating).

Executive Summary

The objective of this project was to develop a fish Index of Biological Integrity for wadeable streams in Missouri. Because the development of any biological "index" is fairly subjective we followed a stringent protocol documented here, ensuring that the final system was sensitive to human-induced changes, reproducible, with good sensitivity and low variability.

Step 1. Data collection, validation and usability
Fish collections (>450) used in this project were made using identical protocols (EPA – REMAP) between 1994 and 2005. Verified data were processed and analyzed by the Missouri Department of Conservation's Resource Assessment and Monitoring (RAM) coordinator using SAS programs developed by Environmental Monitoring and Assessment Program (EMAP) personnel (Kaufmann et al. 1999).

Step 2. Selection of reference sites
Data were reviewed by personnel from Missouri Department of Natural Resources, Missouri Department of Conservation and the University of Missouri to determine all preexisting MDNR reference sites and any others that would meet reference standards. Seventy-two candidate reference sites were retained. Additional GIS analysis of possible anthropogenic stressors resulted in a final list of 43 reference sites.

Step 3. Defining reference conditions for two major ecoregions
The two major ecoregions of Missouri (Plain and Ozark) are generally considered to harbor different fish communities and habitat conditions. We quantitatively evaluated these differences in several ways. First, ordination analysis of fish communities showed distinct separation of communities based on ecoregion. Statistical analyses indicated significant differences between the ecoregions in the overwhelming majority of watershed landscape and channel morphology variables. Fish communities (ordination site scores) of these reference streams from each ecoregion were not significantly associated with any human disturbance or land cover variables. Additionally, multiple habitat variables were determined to be statistically different between the two ecoregions. Finally a suite of fish metrics (n = 39) was compared between the 2 ecoregions and 62% were significantly different between ecoregions. The conclusion was to develop a unique IBI for each ecoregion.

Step 4. Metric evaluation and selection using reference sites
Forty-two candidate fish metrics were evaluated (Ozark n = 26, Plain n =17) following the process outlined by Hughes et al. (1998):

1) Criteria relating to the **range, normality and variability** with reference conditions resulted in elimination of 3 Plain metrics and 1 Ozark metric.
2) Responsiveness to **anthropogenic disturbance** was evaluated by statistically testing metric scores between reference and impaired sites. Thirteen metrics from the Ozark and 8 from the Plain ecoregions were deemed sufficiently sensitive. Sensitivity was scored on retained metrics using box plots on a score

from 0 - 3. Nine metrics using Ozark data showed good sensitivity. While 8 metrics showed good sensitivity in the Plain ecoregion, 4 metrics responded in the opposite direction of the prediction. Analysis of physical habitat for both ecoregions showed 23 variables that were significantly different between reference and impaired sites in the Ozark ecoregion, while only 9 variables were significantly different within the Plain ecoregion. The data support the conclusion that, for the Plain ecoregion, reference site conditions are scarcely better than those for the impaired sites. We concluded that the development of a useful IBI for the Plain ecoregion is not possible at this time. The following work focused exclusively on development of an IBI for the Ozark ecoregion.

3) **Metric precision** was analyzed by examining the ratio of among site variance (or signal) to within site variance from replicated sites (noise).
4) **Metric redundancy** was examined using correlation analysis. Based upon box plot sensitivity and precision, one of the pair was dropped.

Step 5. Final metric selection consisted of five metrics from the richness category: number of native darter species, number of native benthic species, number of native water column species, number of native minnow species, number of all native lithophilic species, two metrics from the balance/diversity/composition category: proportion of native sunfishes, and proportion of the 3 dominant species; one metric from the trophic and reproductive category: proportion of native insectivore cyprinid species, and one metric from the abundance category: number of native individuals.

Step 6. IBI Development
Metric values were converted into unitless scores of 1, 3, or 5 (poor to good). Out of a total possible score of 45, the mean for reference and impaired sites was 40.5 and 32.3 respectively (significantly different at $p = 0.0001$). Eight of the 9 metrics were positively related to the IBI score. Modeling indicated all metrics had roughly the same influence on the final IBI score.

A validation data set (n = 19) containing a wide range of habitat scores was assembled with sites different than those used in the calibration tests. Several statistical tests indicated a good ability for the IBI to distinguish the "good" from "poor" sites.

The calibration and verification data sets were then combined to develop quartiles for the final IBI scores. We suggest criteria for a three-level classification of stream condition of *no impairment*, *impaired* and *highly impaired*.

Conclusions and Recommendations

The development of a fish IBI for the Ozark ecoregion was successful and should serve as a useful indicator of the biological condition of wadeable streams in this area. Failure to achieve biocriteria for the Plain ecoregion may be due to fewer environmental differences in reference versus impaired streams, the lack of true reference streams, or the more tolerant nature of the current assemblage of fishes.

We suggest that future work on IBI development in Missouri, either for refinement of this IBI for the Ozark ecoregion or towards efforts to produce a viable IBI for the Plain ecoregion, be directed towards a more data-based approach to the screening process of the reference and impaired sites. Site selection could be improved and variance reduced if inclusion of sites was not based exclusively on Best Professional Judgment, but also included elimination criteria whereupon known "reference" or "impaired" sites could be dropped from use based on the associated physical habitat data or additional water quality data.

Introduction

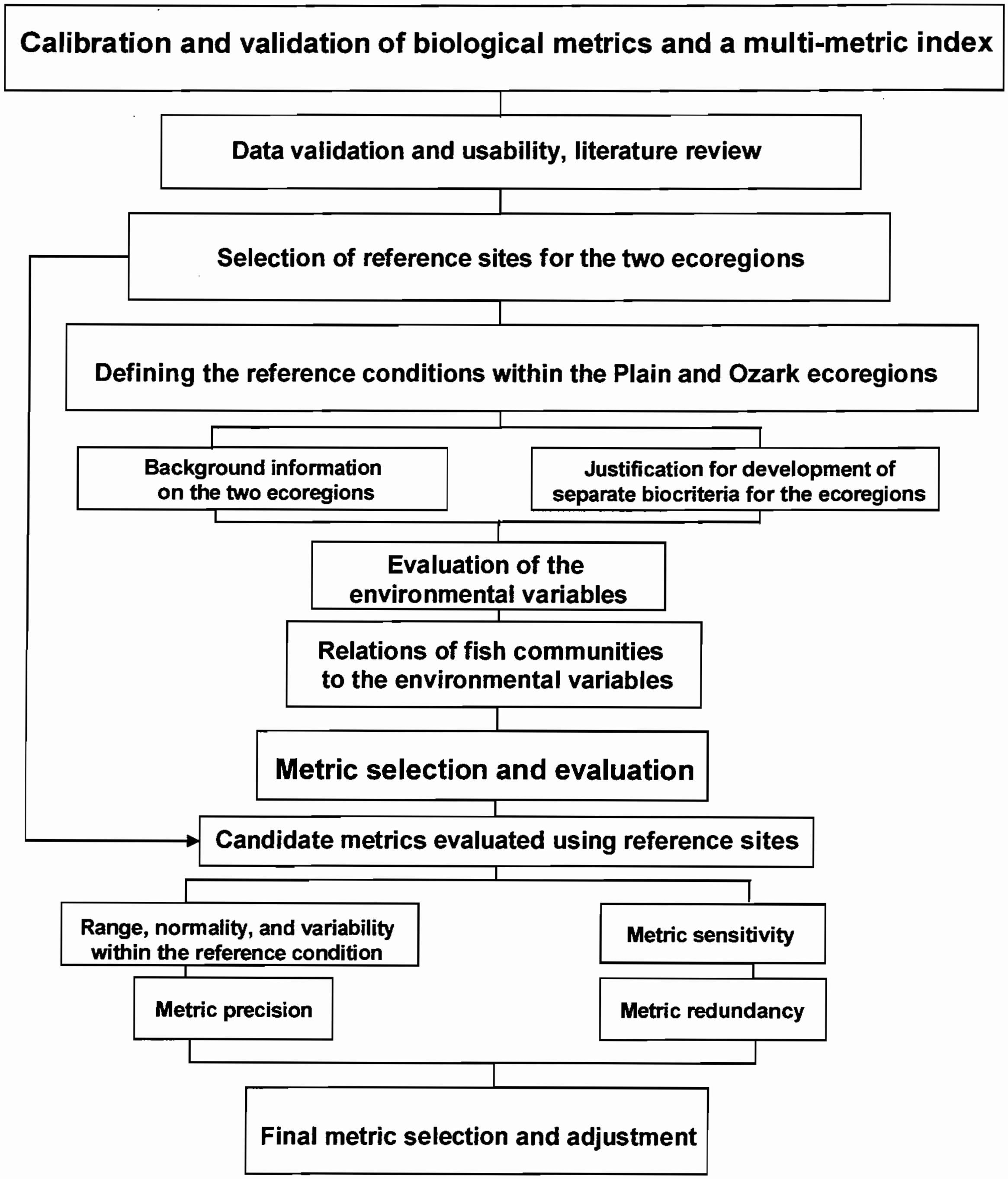
The concept of biological integrity was codified by the federal Clean Water Act Amendments of 1972, which mandated that the condition of the aquatic life existing in streams and rivers be an endpoint that could be measured. This has proven to be difficult because biological integrity is not definable in absolute terms. That is to say that while most people agree on exactly what represents a temperature of 20 degrees Celsius many people would disagree on a number representing biological integrity. The difference is that while temperature has the underpinnings of a physical law – motion of molecules – biological integrity is merely an idea. Nevertheless biologists have given the concept a definition – the most accepted one being the ability to support and maintain *"a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region"* (Karr and Dudley 1981). Biological integrity is equated with pristine conditions or those conditions with no or minimal disturbance, and it is used as the baseline for the IBI. While at the University of Illinois, Jim Karr (1981) produced the milestone system of using fish communities to evaluate stream health – The Index of Biological Integrity (IBI). This index has been widely used with considerable modification ever since. Karr's initial IBI used 12 metrics representing fish species composition and richness, and ecological factors most closely representing the concept of biological integrity.

The concept has been shown to be useful in a variety of aquatic systems and geographic areas. Along with usable indices there have been publications advocating particular protocols in the development of an IBI to insure scientifically sound results. This is particularly important, as the IBI is an index, one which could be developed in a number of different ways.

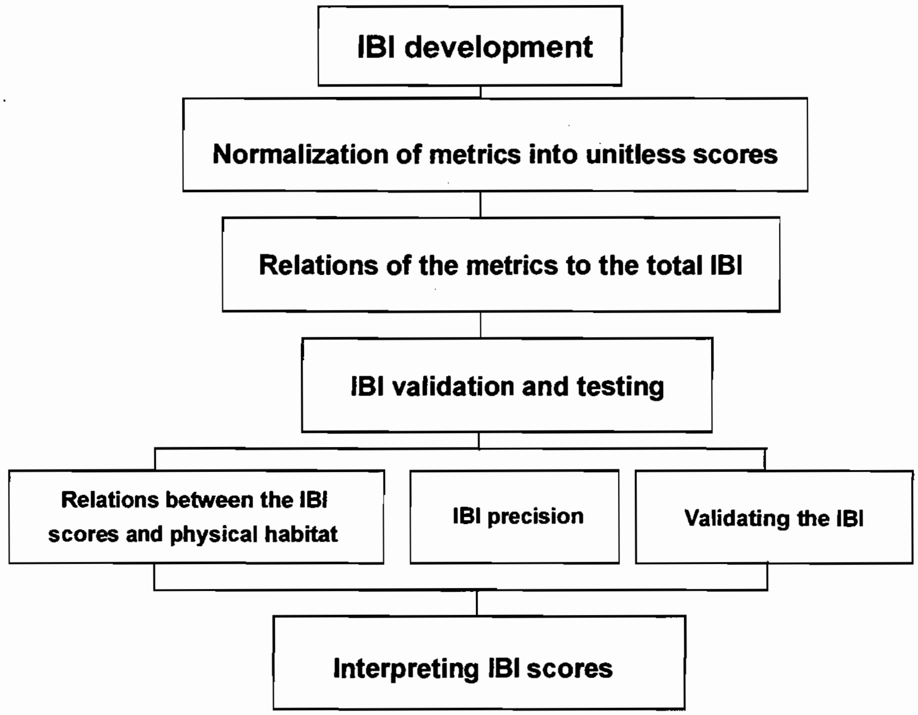
An Index of Biological Integrity should embody a number of attributes. Desirable attributes include the use of biological measures that can be interpreted at several trophic levels and are sensitive to the environmental conditions being monitored within a suitable range. These measures must be reproducible, with good precision and low variability (Simon 1999).

The objective of this project was to develop a fish Index of Biological Integrity for wadeable streams in Missouri. Because the development of any biological "index" is fairly subjective we followed a stringent protocol documented here.

Development of a fish IBI for Missouri



Development of a fish IBI for Missouri continued



Background

A wealth of fish community and associated water quality and physical habitat data have been collected by the Missouri Department of Conservation (MDC) Resources Assessment and Monitoring (RAM) program and the Department of Fisheries and Wildlife at the University of Missouri (UMC). All of these data have been accumulated using standardized procedures (developed by EMAP) for collecting community level data in a range of wadeable streams and rivers throughout Missouri (Strahler orders 2 – 5). Compatible data collections within both the Central Plain and Ozark ecoregions[1] (Figure 1) began in 1994 and 1995, and continued in 2000, 2001, 2002, 2004, and 2005. The sample sites were randomly selected using EMAP protocols, chosen due to their status as Missouri Department of Natural Resources (MDNR) reference sites, or handpicked to meet other research needs of MDC. Additional data for each sample site such as Strahler order, watershed size, and basic land use were determined using the perennial stream layers developed by the Missouri Resource Assessment Partnership (MoRAP).

Prior to this project, the RAM program could only provide a ranking of the fish community by stream size. Through informal discussions among Missouri members of the EPA Region 7 Biocriteria Workgroup [Dr. Charles Rabeni (UMC), Randy Sarver (MDNR) and Matt Combes (MDC)] it was agreed that in order to improve both MDNR and MDC abilities' to assess the biological integrity and/or impairment of Missouri's rivers and streams, the data must be developed into biological criteria for each of the major ecoregions of the state for use in monitoring sites of concern such as the growth areas of Branson and the Lake of the Ozarks thereby meeting the EPA's subobjective 2.2.1 of Goal 2, Improving water quality via watersheds, with the target activity of developing effective water quality standards (WQS) that protect existing high quality waters and achieve fishable and swimmable uses.

Although the development of a stream classification system for Missouri by the Missouri Resource Assessment Partnership (MoRAP) has greatly improved the ecological framework for biological criteria, there are still a number of steps that need to be taken to create biological criteria for fish communities. These basic steps include: 1) Better quantitative criteria for defining reference stream reaches, 2) Calibration and validation of biological metrics and a multi-metric index and 3) Development of criteria that establish the status of the community. The objective of this project was to accomplish steps 2 and 3.

[1] Biocriteria development for streams of the Mississippi Alluvial Basin was not addressed due to inadequate reference sites.

Calibration of biological metrics

Data validation and usability

An extensive literature review of criteria development for fish communities was performed prior to the start to ensure the incorporation of the latest techniques and results in the process. A compilation of pertinent publications and citations for this document can be found in Appendix A.

Verified data collected using the EMAP protocol were processed and analyzed by the RAM coordinator (Matt Combes, MDC) using SAS programs developed by EMAP personnel specifically for that protocol EPA/620/R-99/003 "Quantifying Physical Habitat in Wadeable Streams" by Kaufmann, Levine, Robison, Seeliger, and Peck (1999). The EMAP protocol and computer programs provide six general procedures for data verification. These include: data file structure, missing values, allowable ranges, unusual values, plausible channel morphology, and other evaluations of internal logic and consistency. These programs provide data summaries that are spatially representative estimates of the habitat characteristics measured.

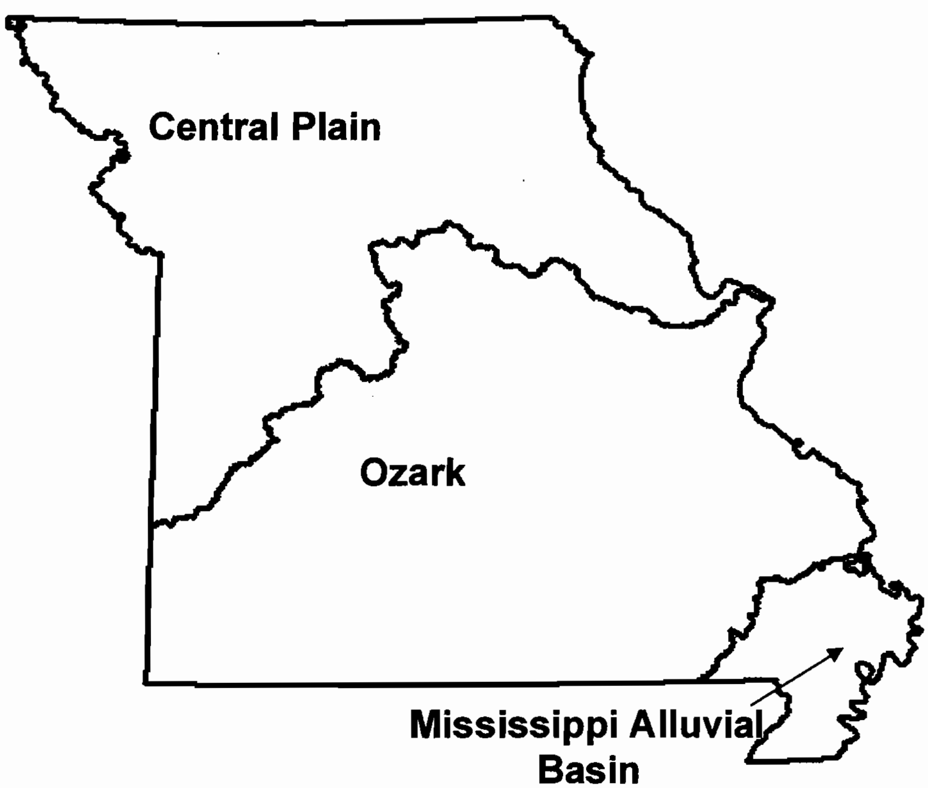


Figure 1. Missouri Aquatic Subregions (MoRAP 2004).

Selection of reference sites for the two ecoregions

The next step in biocriteria development was to identify a group of reference sites for each of the ecoregions. There are several methods of determining reference conditions. Reference sites may be selected from a group of streams that are minimally disturbed, or by using known disturbance gradients, historical and paleoecological information, and/or best professional judgment (Hughes and Oberdorff 1999). The committee agreed to use those reference sites previously determined by MDNR and the University of Missouri (Rabeni et al. 1997) to meet reference quality standards based on best professional judgment (BPJ) of the associated water quality, physical habitat, and the benthic invertebrate communities. The available RAM data (collections from over 450 streams) were reviewed to determine all the pre-existing MDNR reference sites that were assessed as a part of the RAM program and to determine other sites which fell within MDNR reference stream reaches. All data were again reviewed for obvious problems such as missing data, prior to entry into the candidate reference data set. Once entered, additional exploratory statistics were conducted using SAS to validate and verify the data prior to further analyses and to identify any outlying data that might indicate data entry errors. The remaining data were inspected so as to retain only those with complete fish, water quality, and physical habitat databases for use in biometric development.

As a result of these procedures 72 candidate reference sites were retained for possible use in either the calibration or validation data sets. After a review by the committee, nine of the candidate reference sites presented in Quarterly Report #1 (September 2006) were dropped for various reasons. An ArcView analysis of possible impacts was developed to aid in the evaluation of the remaining candidate reference sites, and to supplement those numbers. Each of the candidate sites was evaluated for mining, hazardous waste, NPDES, landfills, dams, 303d waters, losing stream sections, large springs, and connectivity to mainstem rivers, using GIS data layers that were downloaded from the University of Missouri's Missouri Spatial Data Information Service website. These layers included:

Ecological Sections and Subsections of State of Missouri	Projection Units: UTM

Geo-dataset delineating the ecological sections and subsections of Missouri.

Stream Valley Segment Classification of State of Missouri	Projection Units: UTM

This data was created as part of the Missouri Aquatic Gap Project. This coverage contains selected arcs from the 1:100,000 National Hydrography Dataset (NHD) that was developed by the USGS and EPA. The selected arcs represent the centerlines of wide streams.

Biological Reference Stream Segments of State of Missouri	Projection Units: UTM

Biological reference stream segments are segments of streams that represent the best stream conditions for support of aquatic life for a given area. The spatial framework for these areas is the Ecological Drainage Unit (EDU).

Missouri Dams of State of Missouri	Projection Units: UTM

This data set contains the locations of regulated and non-regulated dams in Missouri.

Inventory of Mines, Occurrences, and Prospects in Missouri of State of Missouri	Projection Units: UTM

This data set contains a partial inventory of mines, occurrences, and prospects for the State of Missouri.

Missouri Department of Natural Resources Hazardous Waste Program - Permits of State of Missouri	Projection Units: UTM

This data set contains sites permitted to treat, store or dispose of hazardous waste and facilities that are certified for resource recovery. Some of the permitted sites have known or suspected hazardous contamination.

Landfills of State of Missouri	Projection Units: UTM

This data set contains locations for all permitted active landfills in Missouri.

National Pollutant Discharge Elimination System (NPDES) Outfalls of State of Missouri	Projection Units: UTM

This is a point data set depicting outfall locations of wastewater facilities with Missouri NPDES Operating Permits. The permittee through permit application provided attribute information. Locational data was obtained using a variety of methods.

Missouri 2002 303(d) Listed Waters of State of Missouri	Projection Units: UTM

Line work representing streams, lakes and reservoirs were selected from the USGS 1:100,000 NHD files using the Missouri 2002 303(d) list. Only those features on the 303(d) list appear in this shapefile.

Department of Natural Resources - State Losing Streams - 2006 of State of Missouri	Projection Units: UTM

This data set contains stream segments classified by the Missouri Department of Natural Resources, Division of Geology and Land Survey (DGLS). Stream segments are classified as either losing or gaining.

Department of Natural Resources - State Known Spring Locations - 2006 of State of Missouri	Projection Units: UTM

Known spring locations.

As a result of these efforts, 43 reference sites were selected by the committee for use in the calibration data set (n = 26 from the Ozark ecoregion, n = 17 from the Plain ecoregion) to define the natural variation of the fish communities within the state (Appendix B, Figure 2).

Defining the reference conditions within the Plain and Ozark ecoregions

Background information on the two ecoregions

The Ozark ecoregion is characterized by limestone and dolomite bedrocks with upland elevations commonly above 1000 feet and local relief along major streams greater than 300 feet. Streams within this ecoregion usually occur in narrow, sinuous, entrenched valleys and may have high bluffs. Gradients are high and the channels follow a pattern of well-defined riffles and pools. Substrates are coarse and water clarity is high (Pflieger 1989; Nigh and Schroeder 2002).

The Plain ecoregion is characterized by shale and thin sandstone bedrock with limestone outcroppings along the big river areas. Loess and glacial till blanket this area varying from near absence to over 300 feet deep. Elevations away from large rivers exceed 1000 feet but local relief is typically less than 200 feet. Prior to settlement, streams in this area were meandering. Today, channels are straighter with high alluvial banks. Pools are longer than in the Ozarks, and riffles are generally lacking. Stream sediments are fine with silt and sand being the most common substrates (Pflieger 1989; Nigh and Schroeder 2002).

Justification for development of separate biocriteria for the ecoregions

Selection of the final reference sites for use in biocriteria development (the calibration data set) was finalized by the committee after consideration of the available GIS data, physical habitat data, and field knowledge of the proposed sites for which there was available fish community data. The committee agreed upon 17 reference sites from the Plain ecoregion and 26 sites from the Ozark ecoregion. Although Strahler order ranges from 2 – 4 for the Plain ecoregion, and 3 – 5 for the Ozark ecoregion, neither the mean watershed size or channel length sampled were significantly different between the reference sites from each ecoregion (172 km^2/268 m for the Plain and 173 km^2/276 m for the Ozark). Mean fish species richness was significantly higher in the Ozark ecoregion (22.0 v. 17.5, p = 0.002).

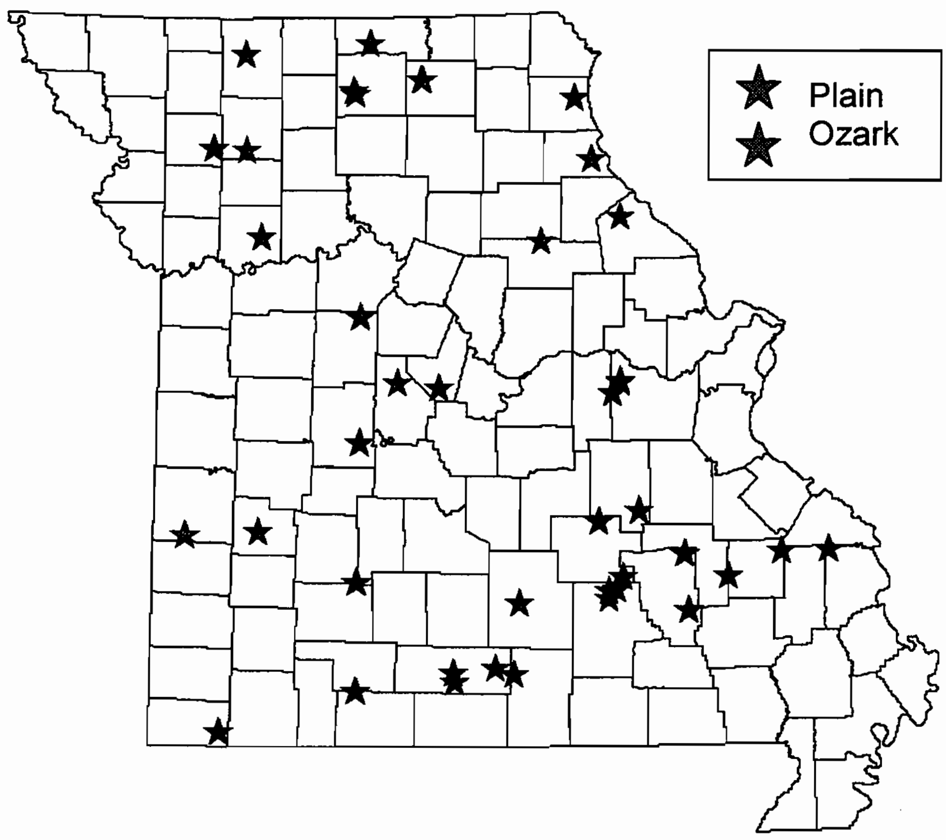


Figure 2. Final reference sites used in the calibration data set for the RAM biocriteria project.

The fish collection data for the reference sites from both ecoregions were evaluated using Detrended Correspondence Analyses (DCA) to confirm the need for separate biocriteria for the two ecoregions (Ozark and Plain). DCA was performed using PC-ORD (version 5.0, MjM software, Gleneden Beach, Oregon) with rare species downweighted. In DCA the sites are distributed along the axes based on their similarity in species composition, with equal distances in the ordination corresponding to equal differences in species composition, and with axis 2 derived independently of axis 1. DCA showed two distinct sites (Figure 3) with a slight mixing in the middle due to sites from EDU 26 (the Ozark border). This area has been shown with invertebrate data to be a transitional area between the two ecoregions (Rabeni and Doisy 2000) and is treated as part of the Ozark ecoregion in these analyses.

The fish community of the reference sites in the Plain ecoregion was represented by 52 species. The 17 sites were dominated by seven species: the red shiner, *Cyprinella lutrensis* (18%); the central stoneroller, *Campostoma anomalum* (16%); the bigmouth shiner, *Notropis dorsalis* (13%); the bluntnose minnow, *Pimephales notatus* (12%); the creek chub, *Semotilus atromaculatus* (6%); the sand shiner, *Notropis stramineus* (6%), and the green sunfish, *Lepomis cyanellus* (6%). The fish community of the reference sites in the Ozark ecoregion was represented by 75 species. The 26 sites were dominated by six species: the central stoneroller, *Campostoma anomalum* (18%); the bleeding shiner, *Luxilus zonatus* (11%); the largescale stoneroller, *Campostoma oligolepis* (9%); the Ozark minnow, *Notropis nubilus* (8%); the orangethroat darter, *Etheostoma specatabile* (5%); and the longear sunfish, *Lepomis megalotis* (5%).

Wilcoxon rank sum tests of the water quality and GIS data showed significant differences in the soil, water quality, and land use of two ecoregions (Table 1). These results, along with significantly higher species richness in the Ozark ecoregion and dominance by different species, support our development of separate biocriteria for the two ecoregions. This regionalization should help account for as much natural variation in the metrics as possible, enhancing the ability of the index to detect the effects of anthropogenic influences on the fish communities.

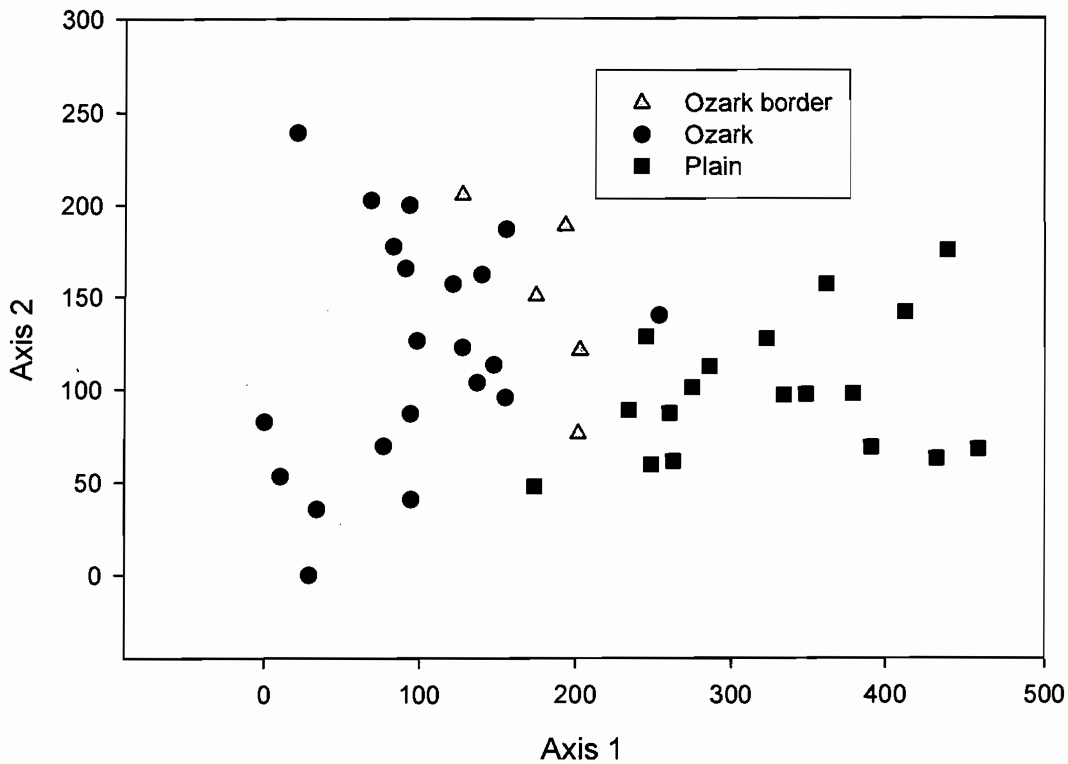


Figure 3. Detrended Correspondence Analysis of the Plain and Ozark (including the Ozark border) ecoregion reference sites.

Evaluation of the environmental variables

In addition to sampling the fish communities of all the selected streams, the EMAP protocol for quantifying the associated physical habitat was followed, allowing for detailed characterization of each stream with over 400 variables related to measures of the bank angle, bankfull, canopy, embeddedness, fish cover, habitat type, residual pools, sinuosity, slope, substrate, thalweg, woody debris, and human disturbance (Kaufmann et al. 1999). We retained 130 of these variables that were relevant to conditions found in Missouri. These variables, along with basic GIS landcover and water quality data, were analyzed with Spearman rank correlations to test for redundancy ($R_s \geq 0.80$). If two or more variables were redundant, the most ecologically relevant variable was retained. After removal of redundant variables, there were 73 remaining variables (Appendix C). Differences in the environmental variables of the reference conditions for the two ecoregions were determined using Wilcoxon rank sum tests (Table 1). Analyses of basic GIS data showed that mean slope of the local watershed, along with hydrologic soil group B and coarse soils are significantly higher in the Ozark ecoregion. Land cover analyses indicated that row crop cover is significantly higher in the watersheds of the reference sites of the Plain ecoregion, while forest cover is significantly higher in those within the Ozark ecoregion. However, the slope and sinuosity of the sampled reaches are not significantly different for the two ecoregions. Basic water quality[1] appears to vary only in conductivity and turbidity (turbidity was very low in both ecoregions).

The majority of the significant differences exist within the substrate data. The Ozark ecoregion has significantly higher percentages of rough bedrock and coarse and fine gravel, while the Plain ecoregion has higher sand, fine sediment and embeddedness. There are no significant differences in bank angle or thalweg between the two ecoregions. Bankfull width is greater in the Ozark ecoregion, while channel incision height is greater in the Plain ecoregion. Significantly higher percentages of reaches within the Ozark ecoregion were fast water habitat, while the Plain ecoregion contained higher percentages of pool habitat. However, residual pool measurements indicate no significant differences in number or volume between the two ecoregions. Measures of fish cover indicate no significant differences except for higher macrophyte cover in the Ozark ecoregion, while the Plain ecoregion has higher levels of canopy cover. There are no differences in available woody debris.

Relations of the fish communities of each ecoregion to the environmental variables

Detrended Correspondence Analyses (DCA) of the fish communities within the reference sites of the Plain and Ozark ecoregions were performed separately. Ordinations were followed with an independent assessment of the importance of the environmental variables by relating them to the coordinates (or scores) of the sites along the 2 dominant axes. Because data for many of the environmental variables could not be normalized, correlations between all variables including the ordination site scores were determined using Spearman's two-tailed rank correlation method. Alphas (0.05) for all correlations were adjusted using the Bonferroni multiple test procedure to minimize type I errors that might occur because of the high number of comparisons. There were no significant relations for the fish communities of the reference sites from the Plain or Ozark ecoregions with any of the land cover or human disturbance variables. The fish communities of the Ozark ecoregion were significantly related to the mean slope of the local watershed and the percent of the pool head length with fine sediment. The fish communities of the Plain ecoregion were significantly related to the percent of substrate < 2 mm in diameter and the number, volume and length of residual pools in the reach.

[1] These data are based on only one sample taken during collection of the phyhab data.

Table 1. Mean values and significance of Wilcoxon rank sum tests of the phyhab and other variables for the two ecoregions in the RAM biocriteria project.	PLAIN (n=17) mean	OZARK (n=26) mean	*p* - value
LANDCOV1 - percentage of urban land cover in watershed	0.13	0.08	NS
LANDCOV2 - percentage of row crop cover in watershed	32.1	2.7	<0.0001
LANDCOV3 - percentage of grassland in watershed	45.2	33.2	NS
LANDCOV4 - percentage of forest cover in watershed	17.0	62.6	<0.0001
LANDCOV6 - percentage of water cover in watershed	0.27	0.10	0.048
Water temperature – degrees centigrade	23.4	24.2	NS
Dissolved oxygen – mg/l	6.9	6.2	NS
Conductivity – umhoms/cm	430	338	0.002
pH – standard units	7.7	7.8	NS
Turbidity - NTU	16.0	0.8	0.0001
MNSLOPE - mean slope of local watershed	5.7	13.3	<0.0001
HGB_IP - percentage of local segmentshed in hydrologic soil group B	22.4	59.1	0.003
HGD_IP - percentage of local segmentshed in hydrologic soil group D	15.8	0.7	NS
COARS_SL - percentage of watershed in coarse soils	1.2	63.3	<0.0001
Sinuosity			
SINU = 'Channel Sinuosity (m/m)'	1.21	1.12	NS
Slope			
XSLOPE = 'Channel Slope -- reach mean (%)'	0.47	0.57	NS
Embeddedness export			
XCEMBED = 'Mean Embeddedness--Channel (%)'	67.6	24.4	0.0001
Substrate			
SUB_X = 'Substrate--Mean Size Class (1-6)'	2.7	3.3	0.036
PCT_RR = 'Substrate Rough Bedrock (%)'	0	3.6	0.014
PCT_RS = 'Substrate Smooth Bedrock (%)'	4.0	1.2	0.030
PCT_CB = 'Substrate Cobbles -- 64-250 mm (%)'	11.2	18.7	0.015
PCT_GC = 'Substrate Coarse Gravel -- 16-64 mm (%)'	16.8	41.4	0.0009
PCT_GF = 'Substrate Fine Gravel -- 2-16 mm (%)'	4.7	16.0	0.0005
PCT_SA = 'Substrate Sand -- .06-2 mm (%)'	35.8	4.4	0.0008
PCT_FN = 'Substrate Fines -- Silt/Clay/Muck (%)'	18.1	8.7	0.021
PCT_HP = 'Substrate Hardpan -- (%)'	4.1	0.6	0.026
PCT_SAFN = 'Substrate Sand & Fines -- <2 mm (%)'	53.9	13.1	<0.0001
PCT_BDRK = 'Substrate Bedrock (%)'	4.0	4.8	NS
Bank angle export			
XBKA = 'Bank Angle--mean (degrees)'	30.9	30.4	NS
XUN = 'Undercut Distance--Mean (m)'	0.01	0.02	NS
Bankfull export			
XINC_H = 'Channel Incision Ht.-Mean (m)'	3.2	1.9	<0.0001
XBKF_W = 'Bankfull Width--Mean (m)'	16.5	26.2	0.0002
XBKF_H = 'Bankfull Height-Mean (m)'	0.77	0.86	NS

Table 1 continued.

Thalweg			
WD_RAT = 'Mean Width/Depth Ratio (m/m)'	43.0	51.4	NS
Habitat type export			
PCT_PB = 'Backwater Pool (% of reach length)'	1.8	0.04	0.0019
PCT_FAST = 'Fast Wtr Hab (% riffle & faster)'	9.1	24.0	0.0004
PCT_POOL = 'Pools -- All Types (% of reach)'	56.3	30.9	0.014
Residual pool labels			
NRP = 'Number of residual pools in reach'	10.2	8.8	NS
PCTRCHRP = 'Resid. pool length percentage (%of rch)'	84.4	84.3	NS
RPGT50 = 'Resid Pools >50cm deep (number/reach)'	1.71	1.92	NS
RPGT75 = 'Resid Pools >75cm deep (number/reach)'	0.94	1.0	NS
RPMDEP = 'Maximum residual depth in reach (cm)'	97.9	98.3	NS
RPMLEN = 'Max. resid pool length in reach (m/pool)'	78.0	90.1	NS
RPMWID = 'Max resid width of any pool in reach (m)'	13.1	15.9	0.01
RPMVOL = 'Max volume of any pool in reach (m^3)'	169.9	195.9	NS
PCTUSED = '% of pool head length with sediment'	87.4	65.9	0.008
Fish cover export			
XFC_ALG = 'Fish Cvr-Filamentous Algae (Areal Prop)'	0.03	0.02	NS
XFC_AQM = 'Fish Cvr-Aq. Macrophytes (Areal Prop)'	0.02	0.11	0.0001
XFC_BRS = 'Fish Cvr-Brush&Small Debris (Areal Prop)'	0.07	0.07	NS
XFC_HUM = 'Fish Cvr-Artif. Structs. (Areal Prop)'	0.002	0.002	NS
XFC_LWD = 'Fish Cvr-Large Woody Debris (Areal Prop)'	0.05	0.07	NS
XFC_NAT = 'Fish Cvr-Natural Types (Sum Areal Prop)'	0.28	0.31	NS
XFC_OHV = 'Fish Cvr-Overhang Veg (Areal Prop)'	0.03	0.07	NS
XFC_RCK = 'Fish Cvr-Boulders (Areal Prop)'	0.08	0.07	NS
XFC_UCB = 'Fish Cvr-Undercut Banks (Areal Prop)'	0.04	0.02	NS
Canopy			
XPCAN = 'Rip Canopy Present (Fraction of reach)'	0.91	0.76	0.004
XPMID = 'Rip MidLayer Present (Fraction of reach)'	0.96	0.87	0.007
XPGVEG = 'Rip Ground Layer Present (Fract. reach)'	0.99	0.94	0.027
Canopy export			
XCDENBK = 'Mean Bank Canopy Density (%)'	85.0	76.0	NS
XCDENMID = 'Mean Mid-channel Canopy Density (%)'	63.6	46.0	0.007
Woody debris			
C1Wm100 = 'LWD in Bkf chnl (#/100m-all sizes)'	10.7	7.3	NS
V1Wm100 = 'LWD Vol in Bkf chnl (m3/100m-all sizes)'	11.4	6.1	NS

Metric selection and evaluation

Candidate metrics

The candidate metrics that were selected focused on native species because the wadeable streams of Missouri that were sampled contained less than 1% non-native species (Matt Combes, personal communication). Autecology of fish species was determined by a panel of regional experts put together by MDC. Candidate metrics calculated by the EMAP SAS programs (some of which have been modified by MDC to apply to MO fish communities) and their predicted responses to impairment are listed in Table 2. In addition to the 34 candidate metrics calculated by the EMAP program, eight additional metrics were calculated that represent variants of lithophilic species composition in an effort to include a measure of reproductive condition, and percentages of dominant species for a total of 42 candidate metrics. Each of these 42 metrics was calculated for each of the calibration reference sites for both ecoregions (n = 26 for the Ozark ecoregion, and n = 17 for the Plain ecoregion).

The candidate metrics were tested for significant differences using Wilcoxon rank sum tests of the reference sites for the two ecoregions to further justify the development of different biocriteria for the two ecoregions (Table 3). The Ozark ecoregion had significantly higher numbers of species, darter species, small benthic species, round bodies sucker species, benthic species, water column species, insectivore cyprinid species, long-lived species, insectivore and invertivores species, all types of lithophilic species, non-guarding lithophilic species, and water column specialist feeder species. The Ozark ecoregion also had higher percentages of darter individuals, small benthic individuals, round bodies sucker individuals, benthic individuals, omnivore and herbivore individuals, insectivore cyprinid individuals, insectivore and invertivores individuals, and carnivore individuals, while the Plain ecoregion had a higher number and percentage of simple lithophilic species, and percentages of tolerant and carnivore individuals.

Table 2. Candidate metrics for development of biocriteria for the fish communities of the Plain and Ozark ecoregions in Missouri and their predicted response to impairment.

Metric		Predicted response
numnativ	Number of native individuals	negative
numspec	Number of native species	negative
numnatfm	Number of native families	negative
nsnsen	Number of native sensitive species	negative
pnsen	Percentage of native sensitive individuals	negative
nsntole	Number of native tolerant species	positive
pntole	Percentage of native tolerant individuals	positive
nsndart	Number of native darter species	negative
pndart	Percentage of native darter individuals	negative
nsnsmben	Number of native small benthic species	negative
pnsmben	Percentage of native small benthic individuals	negative
nsnrbs	Number of native round bodies sucker species	negative
pnrbs	Percentage of native round bodies sucker individuals	negative
nsnbenth	Number of native benthic species	negative
pnbenth	Percentage of native benthic individuals	negative
nsnwcol	Number of native water column species	negative
pnwcol	Percentage of native water column individuals	negative
nsnlunk	Number of native long lived species	negative
pnlunk	Percentage of native long lived individuals	negative
nsnincyp	Number of native insectivore cyprinid species	negative
pnincyp	Percentage of native insectivore cyprinid individuals	negative
nsintro	Number of introduced species	positive
numintro	Number of introduced individuals	positive
pintro	Percentage of introduced individuals	positive
pnativ	Percentage of native individuals	negative
nsnsnfsh	Number of native sunfish species	negative
pnsnfsh	Percentage of native sunfish individuals	negative
nsnminn	Number of native minnow species	negative
pnminn	Percentage of native minnow individuals	negative
nsnomhb	Number of native omnivore and herbivore species	positive
pnomhb	Percentage of native omnivore and herbivore individuals	positive
nsnisiv	Number of native insectivore and invertivore species	negative
pninsiv	Percentage of native insectivore and invertivore individuals	negative
nsncarn	Number of native carnivore species	negative
pncarn	Percentage of native carnivore individuals	negative
persimp	Percentage of native simple lithophilous individuals	negative
pernong	Percentage of native non-guarding lithophilous individuals	negative
simprich	Number of native simple lithophilous species	negative
nongrich	Number of native non-guarding lithophilic species	negative
perall	Percentage of all native lithophilic individuals	negative
allrich	Number of all native lithophilic species	negative
nsnwcsp	Number of species of native water column specialists feeders	negative
pdom	Percentage of the top dominant species	positive
pdom3	Percentage of the three dominant species	positive

Table 3. Significant differences in the fish community metrics between the two ecoregions using Wilcoxon rank sum tests ($p < 0.05$ for significance).	Ozark n = 26	Plain n = 17	*p* value
Number of native individuals	669.4	641.6	NS
Number of native species	22.0	17.5	0.003
Number of native families	7.1	6.2	NS
Percentage of native tolerant individuals	0.04	0.32	<0.0001
Number of native tolerant species	1.80	3.90	<0.0001
Number of native sensitive species	0.23	0.00	NS
Percentage of native sensitive individuals	0.002	0.00	NS
Percentage of native darter individuals	0.11	0.04	0.0003
Number of native small benthic species	5.5	3.7	0.002
Percentage of native small benthic individuals	0.16	0.10	0.025
Number of native round bodies sucker species	1.80	0.60	0.001
Percentage of native round bodies sucker individuals	0.02	0.01	0.001
Number of native benthic species	7.3	4.2	<0.0001
Percentage of native benthic individuals	0.18	0.11	0.001
Number of native water column species	9.0	6.5	0.001
Percentage of native water column individuals	0.37	0.43	NS
Number of native long-lived species	12.2	9.3	0.004
Percentage of native long-lived individuals	0.30	0.38	NS
Number of native insectivore cyprinid species	2.8	1.9	0.026
Percentage of native insectivore cyprinid individuals	0.25	0.16	0.03
Number of native sunfish species	2.7	2.4	NS
Percentage of native sunfish individuals	0.1	0.1	NS
Number of native minnow species	7.7	8.1	NS
Percentage of native minnow individuals	0.68	0.70	NS
Number of native omnivore and herbivore species	5.4	5.5	NS
Percentage of native omnivore and herbivore individuals	0.44	0.35	NS
Number of native insectivore and invertivore species	7.1	4.2	0.0001
Percentage of native insectivore and invertivore individuals	0.18	0.11	0.003
Number of native carnivore species	2.7	2.1	0.012
Percentage of native carnivore individuals	0.03	0.12	0009
Percentage of native simple lithophilous individuals	0.08	0.17	0.022
Number of native simple lithophilous species	2.8	4.1	0.022
Percentage of native non-guarding lithophilous individuals	0.18	0.19	NS
Number of native non-guarding lithophilic species	6.3	4.9	0.04
Percentage of all native lithophilic individuals	0.66	0.79	0.0209
Number of all native lithophilic species	16.8	14.3	0.019
Number of native water column specialist feeders	7.1	5.5	0.022
Percentage of the top dominant species	0.30	0.34	NS
Percentage of the three dominant species	0.60	0.62	NS

Evaluating the candidate metrics using the reference sites

Each potential metric was evaluated based on the 4-step process developed by Hughes et al. (1998). First the candidate metrics are evaluated for range, normality, and variability within the reference condition. Retained metrics need to vary adequately across reference sites with a symmetrical distribution and no extreme outliers. In the second step metrics are evaluated for their responsiveness to anthropogenic disturbance. Metrics that respond the most strongly to human influence such as significantly different t-tests or box plots between reference and impaired sites, or significant relations with at least 3 measures—and no significant relations to other natural variables such as watershed size, gradient, sinuosity, or soil types—should be retained. The third step is to evaluate the precision of each metric. Metrics should discriminate among reaches but remain relatively constant at the same site. Finally, metrics need to be evaluated for redundancy. If two responsive metrics have a Spearman (R_s) greater than 0.75 the metric with the most significant correlations to human influence variables should be retained. For these data, candidate metrics were eliminated if they did not meet the assumptions of step 1. However, after those initial eliminations, no metrics were eliminated until steps 2, 3, and 4 were performed to allow for a comprehensive evaluation of the remaining metrics.

Range, normality, and variability within the reference condition

First, metrics were evaluated for their range within the reference condition. Candidate metrics with extreme outliers (> or < 2 standard deviations from the mean) and those composed of three or less species were eliminated. This resulted in the elimination of the number and percentage of native sensitive species for the Plain ecoregion, and the number and percentage of native or introduced species and individuals from both ecoregions. The candidate metrics were then evaluated for normality (Shapiro-Wilk test) and low variability [Coefficient of variation (CV) <100] using the reference site data for each ecoregion. The metrics that met these conditions were retained for that ecoregion, while those that were eliminated are indicated by hyphens in the columns under the *p* value and CV (Table 4). Following this process the candidate metrics for the reference site data were correlated with watershed size within each ecoregion separately using Pearson correlations to see if they would require adjustment as described by Emery et al. (2003). For the Ozark ecoregion (n = 26) two metrics were positively correlated with watershed size indicating they would need adjustment if used in the final IBI: number of non-guarding lithophilic species and number of native insectivore and invertivore species. For the Plain ecoregion (n = 17) the percentage of native tolerant individuals and percentage of native water column individuals were positively related to watershed size, while percentage of native omnivore and herbivore individuals and percentage of all lithophilic individuals were negatively correlated with watershed size.

Table 4. Normality (Shapiro – Wilk test) of each metric for the reference sites within each ecoregion (*p* values >0.05 indicate normally distributed data) followed by the Coefficient of Variation. Metrics that were close to normality were retained.	Ozark (n=26)		Plain (n=17)	
	normal	CV	normal	CV
Number of native individuals	0.07	55	0.33	59
Number of native species	0.63	19	0.82	23
Number of native families	-	-	0.68	32
Number of native sensitive species	-	-	-	-
Percentage of native sensitive individuals	-	-	-	-
Number of native tolerant species	-	-	-	-
Percentage of native tolerant individuals	-	-	0.86	56
Percentage of native darter individuals	0.71	54	0.07**	48
Number of native darter species	(0.04)	35	-	-
Number of native small benthic species	0.55	30	0.11	53
Percentage of native small benthic individuals	0.12	54	0.11	74
Number of native round bodies sucker species	-	-	-	-
Percentage of native round bodies sucker individuals	0.17**	67	-	-
Number of native benthic species	0.07	30	0.37*	34
Percentage of native benthic individuals	0.053	39	0.16	64
Number of native water column species	(0.037)	24	0.16*	16
Percentage of native water column individuals	0.31**	28	0.73	43
Number of native long-lived species	0.14	21	-	-
Percentage of native long-lived individuals	0.40	35	0.14**	41
Number of native insectivore cyprinid species	-	-	-	-
Percentage of native insectivore cyprinid individuals	0.12	59	0.38**	55
Number of introduced species	-	-	-	-
Number of introduced individuals	-	-	-	-
Percentage of introduced individuals	-	-	-	-
Number of native sunfish species	(0.03)	40	-	-
Percentage of native sunfish individuals	0.35**	54	0.40**	61
Number of native minnow species	0.09	24	0.10	24
Percentage of native minnow individuals	0.21	15	0.36	29
Number of native omnivore and herbivore species	0.053	24	-	-
Percentage of native omnivore and herbivore individuals	-	-	0.63	69
Number of native insectivore and invertivore species	0.15	30	0.37*	34
Percentage of native insectivore and invertivore individuals	0.05	42	0.16	64
Number of native carnivore species	-	-	-	-
Percentage of native carnivore individuals	0.52**	44	0.27**	60
Percentage of native simple lithophilous individuals	-	-	0.10**	60
Number of native simple lithophilous species	-	-	0.18*	33
Percentage of non-guarding lithophilous individuals	-	-	0.32**	49
Number of native non-guarding lithophilic species	0.14*	20	-	-
Percentage of all native lithophilic individuals	0.69	20	0.75**	20
Number of all native lithophilic species	0.30	19	0.41	24
Number of native water column specialists feeders	0.068	29	0.18*	22
Percentage of the top dominant species	-	-	0.34	38
Percentage of the three dominant species	0.05**	13	0.52	20

* Significant with a natural log transformation.
** Significant with an ARCSIN Square root transformation.

Responsiveness of metrics to anthropogenic disturbance

Unpaired t-tests.—The second step of metric evaluation is testing for responsiveness (or sensitivity) to anthropogenic disturbances for those metrics that were normally distributed and had low variation. First, unpaired t-tests were run using the calibration reference sites against groups of impaired sites that were suggested by MDNR and MDC personnel using best professional judgment. There were 18 impaired sites for the Ozark ecoregion and 11 impaired sites for the Plain ecoregion for which a full complement of physical habitat variables, land cover, and metrics were available. A portion of these sites was retained for each ecoregion for later use in validation testing of the IBI, leaving 12 impaired sites for calibration testing in the Ozark ecoregion, and 8 impaired sites for calibration testing in the Plain ecoregion. Results (Table 5) showed 13 metrics that were significantly different within the reference and impaired sites from the Ozark ecoregion, and 8 for the Plain ecoregion when the *p* value was increased to 0.10.

Table 5. Unpaired t-tests of the reference and impaired stream metrics that were retained for each ecoregion (p<0.10 for significance).	Ozark Ref = 26	Ozark Imp = 12	Ozark *p* value	Plain Ref = 17	Plain Imp = 8	Plain *p* value
Number of native individuals	669.4	506.8	NS	641.6	346.3	0.06
Number of native species	22.0	18.0	0.010	17.5	14.8	NS
Number of native families	-	-	-	6.2	6.0	NS
Percentage of native tolerant individuals	-	-	-	0.32	0.35	NS
Percentage of native darter individuals	0.11	0.11	NS	0.04	0.06	NS
Number of native darter species	3.6	2.2	0.003	-	-	-
Number of native small benthic species	5.5	3.9	0.006	3.7	3.3	NS
Percentage of native small benthic individuals	0.16	0.15	NS	0.10	0.20	0.005
Percentage of native round bodied sucker individuals	0.02	0.02	NS	-	-	-
Number of native benthic species	7.3	4.5	0.006	4.2	3.4	NS
Percentage of native benthic individuals	0.18	0.17	NS	0.10	0.20	0.005
Number of native water column species	9.0	6.7	0.005	6.5	5.6	NS
Percentage of native water column individuals	0.37	0.34	NS	0.43	0.43	NS
Number of native long-lived species	12.2	9.9	0.020	-	-	-
Percentage of native long-lived individuals	0.30	0.37	NS	0.38	0.34	NS
Percentage of native insectivore cyprinid individuals	0.25	0.15	0.059	0.16	0.07	0.06
Number of native sunfish species	2.7	2.3	NS	-	-	-
Percentage of native sunfish individuals	0.08	0.09	NS	0.14	0.10	NS
Number of native minnow species	7.7	6.4	0.032	8.1	5.9	0.018
Percentage of native minnow individuals	0.68	0.68	NS	0.70	0.64	NS
Number of native omnivore & herbivore species	5.4	4.8	NS	5.5	4.0	0.031
Percentage of native omnivore & herbivore individuals	-	-	-	0.35	0.30	NS
Number of native insectivore & invertivore species	7.1	5.0	0.009	4.3	3.7	NS
Percentage of insectivore & invertivore individuals	0.18	0.17	NS	0.11	0.20	0.005
Percentage of native carnivore individuals	0.03	0.05	NS	0.12	0.08	NS
Percentage of simple lithophilous individuals	-	-	-	0.18	0.17	NS
Number of native simple lithophilous species	-	-	-	4.0	3.4	NS

Table 5 continued.	Ozark Ref = 26	Ozark Imp = 12	Ozark *p* value	Plain Ref = 17	Plain Imp = 8	Plain *p* value
Percentage non-guarding lithophilous individuals	-	-	-	0.20	0.28	NS
Number of native non-guarding lithophilic species	6.3	4.5	0.011	-	-	-
Percentage of all native lithophilic individuals	0.66	0.74	NS	0.79	0.68	NS
Number of all native lithophilic species	16.8	13.3	0.003	14.3	11.6	0.051
Number of native water column specialist feeder	7.1	5.6	0.054	5.5	4.6	NS
Percentage of the top dominant species	-	-	-	0.34	0.32	NS
Percentage of the three dominant species	0.60	0.68	0.014	0.62	0.62	NS

Box plots.—After completion of the unpaired t-tests, box plots were made for the retained metrics from each ecoregion (Appendix D). The "box" in the box plots represents the interquartile range from the 25th percentile to the 75th percentile. The horizontal line within the box represents the median or 50th percentile, while the end points of the vertical lines that extend off either end of the box represent the 10th and 90th percentiles. Any points beyond the 10th and 90th percentile are outliers. The sensitivity of each metric was determined from the box plots based on the scoring system developed by Barbour et al. (1996). Metrics were determined to have a sensitivity of 3 if no overlap existed in the interquartile range (strong discriminatory power), a sensitivity of 2 if there was some overlap that did not extend to the medians, a sensitivity of 1 if there was a moderate overlap of interquartile ranges but at least one median was outside the range, and a sensitivity of 0 if interquartile overlap was considerable with weak discriminatory power between reference and impaired sites.

Results for the Ozark ecoregion showed that none of the metrics were highly sensitive (scoring a 3). The number of native water column species, percentage of native insectivore cyprinid individuals, and number of native lithophilic species scored a value of 2 for sensitivity; the number of native fishes, number of native species, number of native benthic species, number of native darter species, number of native minnow species, and number of insectivore and invertivores species scored a value of 1 for sensitivity; and the number and percentage of native small benthic individuals, percentage of native benthic individuals, number of native sunfish species, percentage of native minnow individuals, number of omnivore and herbivore species, number of long-lived species, percentage of long-lived individuals, percentage of native darter individuals, percentage of insectivore and invertivores individuals, percentage of all native lithophilic individuals, and number of water column specialist individuals all scored a value of 0, meaning weak discriminatory power. None of the metrics for the Plain ecoregion scored a 3; but the number of native fish, percentage of small benthic individuals, percentage of benthic individuals, number of native minnow species, and percentage of insectivore and invertivore individuals scored a 2; and the number of native omnivore and herbivore species, number of all lithophilic species, and percentage of insectivore cyprinid individuals all scored a value of 1.

Problems with the calibration data set for the Plain ecoregion.—However, inspection of the unpaired t-tests average values and the box plots indicate a serious problem regarding the development of biocriteria for the Plain ecoregion data. Of the 8 significant metrics, 4 reflect a response that is the opposite of the prediction (Table 2). The percentage of small benthic individuals, percentage of benthic individuals, and percentage of insectivore and invertivore individuals increased with impairment, while the number of omnivore and herbivore species decreased. One possible explanation was put forth by Matt Combes (MDC Resource Science Division, Resource Scientist),

> "Almost all metrics giving a correct response were based on "number of", but all metrics with incorrect responses were "percentage of". In short, the benthic species found at the impaired sites are the core species in the prairie region so are found at both reference and impaired sites in about equal amounts. However, communities at reference locations have the benthic species plus other species, so the percentage of benthic species is less than at impaired sites where the benthic species are all that's left. Sand shiner, bigmouth shiner, and johnny darters are found in almost all small prairie streams, and are small benthic species. If an impaired site has 10 species and a reference has 20, then the percentage of these common species is .30 and .15 respectively. All this just supports the idea that our prairie reference sites are barely better than our prairie impaired sites."

To further investigate this condition Wilcoxon rank sum tests were performed on all of the retained EMAP variables for the reference and impaired sites in both ecoregions (Table 6). Although the overall measures of physical habitat (the final habitat indices—QCPH, QPH, and QTPH) were significant (or close to significant <0.10) for both the Plain and Ozark ecoregions, the results of the individual environmental variables underscore the inadequate range of physical habitat conditions within the Plain ecoregion. For the Ozark ecoregion 23 variables were significantly different ($p<0.05$) between the reference and impaired streams (excluding the final habitat indices), but only 9 variables were significantly different between the reference and impaired sites for the Plain ecoregion: conductivity, % of backwater pools, mean slope, % cobble substrate, landfills on the bank, number of pieces of large woody debris in the bankfull channel, the % of residual pools in the reach, the amount of sediment in the head of the pools, and the % of hardpan substrate. However in contrast to expectations, the % of backwater pools was higher in the impaired streams of the Plain ecoregion, while the amount of fine sediment in the head of pools and the mean number of landfills on the bank were higher in the reference streams of the Plain ecoregion.

Table 6. Results of Wilcoxon rank sum tests for the reference and impaired streams of the Ozark and Plain ecoregions (p<0.05 for significance). See Appendix C for variable definitions.

	OZARK			PLAIN		
	REF = 26	IMP = 12	p value	REF = 17	IMP = 8	p value
MNSLOPE	13.3	7.2	0.0013	5.6	5.4	NS
HGB_IP	59.1	36.0	NS	21.2	16.6	NS
HGD_IP	0.7	9.3	0.016	20.4	30.5	NS
LANDCOV1	0.1	11.9	0.002	0.14	0.35	NS
LANDCOV2	2.7	9.0	0.011	33.2	24.8	NS
LANDCOV3	33.2	54.5	0.005	44.6	41.2	NS
LANDCOV4	62.6	24.1	<0.0001	16.8	15.5	NS
LANDCOV6	0.1	0.40	<0.0001	26.8	55.4	NS
TEMP	23.4	22.7	NS	24.2	23.7	NS
DO	6.9	6.8	NS	6.1	5.9	NS
CONDUCT	338.4	632.8	<0.0001	429.5	676.9	0.022
PH	7.7	7.7	NS	7.8	7.7	NS
NTU	0.8	7.9	0.009	15.3	24.3	NS
XBKA	30.4	38.6	0.044	31.5	36.0	NS
XUN	0.016	0.004	NS	0.01	0.002	NS
XBKF_W	26.2	20.0	0.023	16.8	18.0	NS
XBKF_H	0.86	0.88	NS	0.8	1.1	NS
XINC_H	1.9	2.8	0.022	3.2	3.6	NS
XCDENBK	76.3	80.9	NS	84.6	80.3	NS
XCDENMID	46.0	60.6	0.034	62.2	52.3	NS
XCEMBED	24.4	33.0	NS	67.0	76.9	NS
XFC_ALG	0.02	0.16	0.023	0.03	0.10	NS
XFC_AQM	0.11	0.04	NS	0.02	0.04	NS
XFC_LWD	0.07	0.02	NS	0.05	0.04	NS
XFC_BRS	0.07	0.04	NS	0.08	0.09	NS
XFC_OHV	0.07	0.03	NS	0.03	0.02	NS
XFC_UCB	0.02	0.04	NS	0.04	0.02	NS
XFC_RCK	0.07	0.06	NS	0.07	0.01	NS
XFC_HUM	0.0	0.03	NS	0.0	0.0	--
XFC_NAT	0.31	0.20	NS	0.27	0.18	NS
PCT_PB	0.04	0.42	NS	1.8	0.0	0.04
PCT_FAST	24.0	12.3	0.020	9.6	8.3	NS
PCT_POOL	30.9	27.3	NS	54.0	36.8	NS
NRP	8.8	8.3	NS	10.2	8.8	NS
RPGT50	1.9	1.4	NS	1.8	1.6	NS
RPGT75	1.0	0.8	NS	0.94	0.44	NS
RPMLEN	90.1	98.7	NS	80.7	94.7	NS
RPMDEP	98.3	73.9	NS	97.9	70.0	NS
RPMWID	15.9	11.4	0.032	13.2	11.2	NS

Table 6 continued.

	OZARK			PLAIN		
	REF = 26	IMP = 12	p value	REF = 17	IMP = 8	p value
RPMVOL	195.9	120.2	NS	185.1	182.6	NS
PCTRCHRP	84.3	62.0	0.010	84.3	85.3	0.014
PCTUSED	65.9	88.6	0.034	87.6	85.0	0.012
SINU	1.12	1.05	NS	1.2	1.1	NS
XSLOPE	0.57	0.23	0.034	0.47	0.14	0.017
SUB_X	3.3	3.2	NS	2.7	2.2	NS
PCT_CB	18.7	20.2	NS	11.2	5.3	0.019
PCT_FN	8.7	16.7	NS (0.053)	18.1	32.3	NS
PCT_GC	41.4	32.2	NS	17.8	16.0	NS
PCT_GF	16.0	10.3	NS	4.7	13.6	NS
PCT_SA	4.4	5.8	NS	33.8	28.4	NS
PCT_RS	1.9	6.2	NS	3.8	1.1	NS
PCT_RR	3.6	0.6	NS	0.0	0.4	NS
PCT_SAFN	13.1	22.6	NS	53.6	62.4	NS
PCT_BDRK	4.8	6.8	NS	3.8	1.6	NS
PCT_HP	0.63	0.0	NS	4.1	0.0	0.016
XWD_RAT	51.4	40.4	NS	42.9	54.6	NS
XPCAN	0.76	0.88	0.049	0.91	0.84	NS
XPMID	0.87	0.89	NS	0.96	0.94	NS
XPGVEG	0.94	0.97	NS	0.99	1.0	NS
C1WM100	7.3	1.7	0.043	10.7	1.9	0.016
V1WM100	6.1	2.9	NS	10.8	3.0	NS
BXPLDFL	0.05	0.00	NS	0.05	0.0	0.04
BXPPARK	0.0	0.0	NS	0.003	0.0	NS
BXPPSTR	0.01	0.0	NS	0.003	0.0	NS
BXPROAD	0.01	0.0	NS	0.005	0.0	NS
BXPMINE	0.02	0.0	NS	0.0	0.0	NS
CXPCROP	0.0	0.15	0.034	0.02	0.16	NS
CXPPSTR	0.06	0.14	NS	0.04	0.04	NS
CXPROAD	0.01	0.03	NS	0.005	0.02	NS
XB_HALL	0.11	0.02	NS	0.06	0.03	NS
XC_HALL	0.08	0.36	0.001	0.08	0.25	NS
XCB_HALL	0.19	0.39	NS	0.14	0.28	NS
X_HALL	0.58	0.81	NS	1.03	0.97	NS
QCPH1	0.73	0.65	0.040	0.63	0.52	NS (0.07)
QPH1	0.71	0.65	NS (0.06)	0.64	0.53	0.045
QTPH1	0.71	0.64	0.048	0.63	0.53	0.034
QCPH2	0.69	0.60	0.042	0.59	0.47	NS (0.06)
QPH2	0.68	0.61	NS (0.06)	0.61	0.49	0.033
QTPH2	0.68	0.61	NS (0.05)	0.61	0.50	0.018

The results for the Plain ecoregion of both the metric and environmental variable analyses indicate problems with either the available data or the methodology being used for development of biocriteria for that portion of the state. Several of the reference and impaired sites in both the Plain and Ozark ecoregion have final habitat indices that are much lower or higher than might be expected in reference or impaired sites. Further confirmation of possible problems with site selection are seen in the results of preliminary Spearman rank correlations run using only the reference and impaired sites for the Plain ecoregion. All the metrics had at least 3 significant correlations to physical habitat variables and 9 of the metrics were significantly correlated to at least 10 variables and/or significantly related to the final habitat index. To find such strong correlations between the metrics and physical habitat variables despite few findings of significant difference between the reference and impaired sites indicates that some of the selected sites may not be representative of the group to which they were attributed (based on BPJ). It was decided at this point to defer development of biocriteria for the Plain ecoregion until additional data and funding were available.

Spearman rank correlations for the Ozark ecoregion.—Spearman rank correlations between all the metrics (which met assumptions of normality) and the environmental variables were performed for the Ozark ecoregion using the calibration reference sites (n = 26), impaired sites (n = 12), and 13 randomly selected sites (Table 7). All the metrics were significantly correlated to at least 3 of the environmental parameters except for the number of water columnn specialist feeders, and 5 were significantly related to at least one of the measures of the final habitat quality: the percentage of darter individuals, the percentage of small benthic individuals, the percentage of benthic individuals, the percentage of insectivore cyprinid individuals, and the percentage of insectivore and invertivore individuals. Correlations between the metrics and the water quality indicators of turbidity (NTU) or ammonia could not be performed due to a lack of data for many of the sites. A summary of overall metric responsiveness is presented in Table 7. Metrics in italics were not found to be significantly different in the unpaired t-tests of the reference and impaired sites (Table 5).

After correlation analyses, all the retained metrics were evaluated using methodology proposed by Karr and Chu (1999) where scatter plots of each metric to the final habitat index were visually inspected for response patterns and thresholds (Appendix E). As indicated in Table 7, five of the metrics were significantly related to the final habitat index therefore indicating a broad response. No threshold responses were observed for any of the metrics with non-significant relations to the final habitat index. Those metrics were rated as having an uncertain response.

Table 7. Results of Spearman rank correlations between metrics and environmental variables using reference, impaired and random sites (*n* = 51) and box plot sensitivity rating.	Ozark ecoregion		
	Box plot sensitivity rating	Number of significant correlations	Significantly correlated to the final habitat index
Number of native individuals	1	6	
Number of native species	1	7	
Percentage of native darter individuals	0	4	Yes
Number of native darter species	1	5	
Number of native small benthic species	0	9	
Percentage of native small benthic individuals	0	9	Yes
Percentage of native round bodied sucker individuals	0	7	
Number of native benthic species	1	8	
Percentage of native benthic individuals	0	7	Yes
Number of native water column species	2	8	
Percentage of native water column individuals	0	3	
Number of native long-lived species	0	7	
Percentage of native long-lived individuals	0	6	
Percentage of native insectivore cyprinid individuals	2	13	Yes
Number of native sunfish species	0	3	
Percentage of native sunfish individuals	1	8	
Number of native minnow species	1	7	
Percentage of native minnow individuals	0	3	
Number of native omnivore and herbivore species	0	3	
Number of native insectivore and invertivore species	1	7	
Percentage of insectivore and invertivore individuals	0	7	Yes
Percentage of native carnivore individuals	0	6	
Number of native non-guarding lithophilic species	1	12	
Percentage of all native lithophilic individuals	0	4	
Number of all native lithophilic species	2	11	
Number of native water column specialist feeder	0	2	
Percentage of the three dominant species	1	6	

Metric precision

Metrics were evaluated for their precision because metrics that discriminate among reaches but remain relatively constant at the same site are desirable. Metric precision was calculated based on the methodology of Kaufmann et al. (1999) where they described the precision of stream habitat measurements by the ratio of among-site variance (signal) to within-site variance from replicated sites (noise). Nine of the sites from the calibration data set (representing reference, impaired and random conditions) had duplicate samples from the same season and year. These data were used to evaluate metric precision within a site in a single year, to compare to variance among the sites. The signal to noise variance ratio was calculated as the among-site variance divided by the within-site variance. A high signal to noise ratio is desirable. Precision results are shown in Table 8.

Metric redundancy

Metric redundancy was calculated using Pearson correlation analyses. Metrics that had correlation coefficients equal to or greater than 0.80 were considered redundant. Metrics that were redundant with one another are shown in Table 8.

Final metric selection and adjustment

A final summary of all the metric analyses is presented in Table 8. Box plot sensitivity ratings were the first selection criteria. All metrics with a box plot sensitivity rating of zero were dropped from further consideration. Other metrics that were dropped due to redundancy with a superior metric included the number of native species and the number of native non-guarding lithophilic species (compare with number of all native lithophilic species) and the number of native insectivore and invertivore species (compare with number of native benthic species). The remaining metrics with a high S/N ratio and a high number of significant correlations are highlighted in bold font. They include six metrics from the richness category: number of native darter species, number of native benthic species, number of native water column species, number of native minnow species, number of native insectivore and invertivore species, and number of all native lithophilic species; two metrics from the balance/diversity/composition category: percentage of native sunfish individuals, and percentage of the three dominant species; one metric from the trophic and reproductive category: percentage of native insectivore cyprinid individuals, and one metric from the fish abundance category: number of native individuals. Although some of these metrics did not achieve a significant t-test between the reference and impaired sites they were retained for IBI development due to a need for metrics in that category.

Spearman rank correlations of these metrics with the phyhab data showed several highly significant ($p<0.005$) relations with features of the environment associated with or impacted by anthropogenic activities. The number of native darter species and the number of native benthic species were negatively related to the percentage of urban land cover in the watershed; the number of native water column species was negatively related to the bank angle; the number of all native lithophilic species was positively related to the maximum residual pool width of the reach and the mean bankfull width; the percentage of native sunfish individuals was positively related to the percentage of water land cover in the watershed, and negatively related to the areal percentage of overhanging vegetation; the percentage of the three dominant species was negatively related to the percentage of rough bedrock; the percentage of native insectivore cypriniid individuals was positively related to the maximum volume of any pool in the reach and the areal percentage of brush and small debris, and negatively related to the percentage of water land cover in the watershed; while the number of native individuals was highly related to the percentage of pools in the reach.

Table 8. Summary of results of coefficient of variation, t-tests, box plot sensitivity, Spearman rank correlations, signal-noise variance ratios, and metric redundancy for final determination of metrics for the Ozark ecoregion. See Table 2 for definitions of abbreviations used in final column.

	CV	t-test *p* value	Box plot sensitivity rating	Number of significant correlations	Signal/ noise ratio	Metric redundancy
Number of native individuals	55	NS	1	6	0.4	none
Number of native species	19	0.010	1	7	12.7	nsnlunk, nongrich, allrich
Percentage of darter individuals	54	NS	0	4	1.1	none
Number of native darter species	35	0.003	1	5	4.6	none
Number of native small benthic species	30	0.006	0	9	4.1	nsnisiv, nsnbenth
Percentage of native small benthic individuals	54	NS	0	9	1.2	pninsiv, pnbenth
Percentage of native round bodied sucker individuals	67	NS	0	7	2.4	none
Number of native benthic species	30	0.006	1	8	8.5	nsnisiv, nongrich, nsnsmben
Percentage of native benthic individuals	39	NS	0	7	1.2	pninsiv, pnsmben
Number of native water column species	24	0.005	2	8	7.7	nsnwcsp
Percentage of native water column individuals	28	NS	0	3	1.1	pnincyp
Number of native long-lived species	21	0.020	0	7	10.6	numspec
Percentage of native long-lived individuals	35	NS	0	6	0.5	pnminn
Percentage of native insectivore cyprinid individuals	59	0.059	2	13	1.3	pnwcol
Number of native sunfish species	40	NS	0	3	4.8	none
Percentage of native sunfish individuals	54	NS	1	8	5.5	none
Number of native minnow species	24	0.032	1	7	0.8	none
Percentage of minnow individuals	15	NS	0	3	2.0	pnlunk
Number of native omnivore and herbivore species	24	NS	0	3	1.1	none
Number of native insectivore and invertivore individuals	30	0.009	1	7	8.1	nsnbenth, nsnsmben, nongrich
Percentage of native insectivore and invertivore individuals	42	NS	0	7	1.2	pnbenth, pnsmben
Percentage of native carnivore individuals	44	NS	0	6	4.2	none
Number of native non-guarding lithophilic species	20	0.011	1	12	0.3	allrich, nsnbenth, numspec, nsnisiv
Percentage of all native lithophilic individuals	20	NS	0	4	0.8	none
Number of all native lithophilic	19	0.003	2	11	6.2	numspec,

individuals						nongrich
Number of native water column specialist feeder	29	0.054	0	2	13.5	nsnwcol
Percentage of the three dominant species	13	0.014	1	6	4.3	none

In their study of IBI development in different regions of Virginia, Smogor and Angermeier (1999) found that the relations between taxonomic metrics and stream size varied from region to region (e.g. darters were related to stream size in one region, not in another) and were actually reversed in some regions (fewer species in larger streams). They also found that functional metrics were related to stream size in some regions. They reported that

> "Contrary to prior IBI emphases, our results showed that only a few taxonomic but several functional metrics varied with stream size and that most of these relations differed among as well as within IBI regions. Despite conceptual arguments and some prior evidence to the contrary, we found few generally applicable patterns in the way taxonomic or functional metrics varied with stream size...First IBI regions and relevant environmental gradients in each region should be explicitly defined and justified. Then for each region, metric criteria and their adjustments should be determined by examining empirical relations between each metric and each environmental gradient. Adjustments...should not be universally applied."

Adjustment based on stream size for each of the retained metric was evaluated as suggested above. Watershed size was correlated to the metrics using Pearson's correlation since the data for the retained metrics and watershed size were normally distributed. This analysis revealed that of the retained metrics only the number of native insectivore and invertivore species was significantly related to watershed size. Due to redundancy between this metric and the number of native benthic species, which performed comparably but was not related to watershed size, the latter was retained for IBI development. The remaining metrics were then correlated to the natural variables using Spearman rank correlations with the Bonferroni multiple test correction factor. Only one of the metrics was significantly related to any of the following natural variables: channel sinuosity, percentage of local segmentshed in hydrologic soil group B or hydrologic soil group D, percentage of the watershed in coarse soils, or channel slope of the reach. The number of all native lithophilic species was significantly correlated to the mean slope of the local watershed (calculated with GIS), but not significantly related to the mean slope of the reach (calculated with EMAP).

The following metrics were retained for use in IBI development. They include five metrics from the richness category: number of native darter species, number of native benthic species, number of native water column species, number of native minnow species, and number of all native lithophilic species; two metrics from the balance/diversity/composition category: percentage of native sunfish individuals, and percentage of the three dominant species; one metric from the trophic and reproductive category: percentage of native insectivore cyprinid species, and one metric from the fish abundance category: number of native individuals.

IBI development

Normalization of metrics into unitless scores

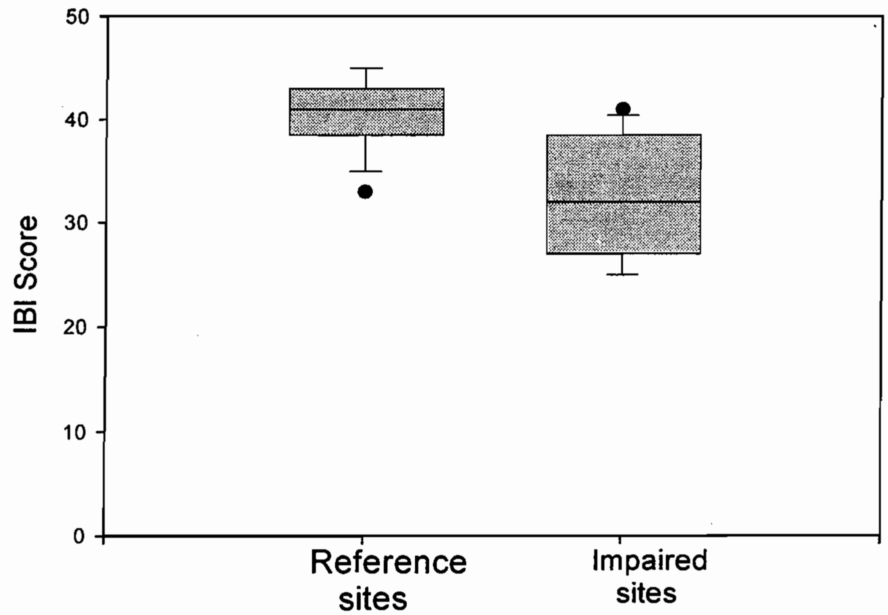
To convert the metrics into unitless scores, data values for each metric were scored with a 5, 3, or 1 following methods similar to those of Barbour et al. (1996) and Angermeier et al. (2000). For metrics that were positively related to stream quality, the lowest quartile (25^{th} percentile) of the distribution of the metric values from the reference quality sites was used as the minimum value for scoring a 5. The minimum metric value for scoring a 3 was set as ½ the value of the 25^{th} percentile and everything below that value was scored a 1. For the metric that was negatively related to stream quality (percentage of the three dominant species) the reverse procedure was followed using the 75^{th} percentile.

Table 9. Metric scoring criteria for calculating the index of biotic integrity (IBI) for the Ozark ecoregion.

	Metric score		
	1	3	5
Number of native individuals	< 216	216 - 431	≥ 432
Number of native darter species	< 2	2	≥ 3
Number of native benthic species	< 3	3 - 5	≥ 6
Number of native water column species	< 4	4 - 7	≥ 8
Number of native minnow species	< 3	3 - 5	≥ 6
Number of all native lithophilic species	< 7	7- 13	≥ 14
Percentage of native insectivore cyprinid individuals	< 0.067	0.067 – 0.134	≥ 0.135
Percentage of native sunfish individuals	< 0.013	0.013 – 0.026	≥ 0.027
Percentage of the three dominant species	> 0.815	0.64 – 0.815	≤ 0.63

All the metrics for the reference (n = 26) and impaired (n = 12) sites from the calibration data set were normalized into unitless scores. Out of a total possible score of 45, the mean (standard deviation) of the IBI scores for the reference and impaired sites were 40.5 (3.5) and 32.3 (5.8), respectively. An unpaired t-test of the IBI scores showed that the IBI scores for the reference sites were significantly higher (p <0.0001). A one-sided nonparametric median test was performed between the two types of sites (Mundahl and Simon 1999). This test calculated the median value of the IBI for the ranked reference and impaired sites combined. It then tested the predicted number of sites above this median for each type against the actual number of sites above the median for each type. For these data PR < Z = 0.0008 indicating that the IBI was able to distinguish between the reference and impaired sites. A box and whisker plot of the reference and impaired sites (Figure 4) revealed that the interquartile ranges of the reference and impaired sites did not overlap (1st quartile of reference sites = 39, 3rd quartile of the impaired sites = 38.5).

Figure 4. Box and whisker plot of IBI scores for the reference and impaired sites of the calibration data set -- Ozark ecoregion.



Relations of the metrics to the total IBI

Each metric was correlated with the total IBI scores for the reference and impaired sites (calibration data set) using Spearman rank correlations. Eight of the nine selected metrics were significantly related to the total IBI score (Appendix F). Only the percentage of native sunfishes was not significantly correlated to the total IBI scores ($R_s = 0.20$, $p = 0.24$). To assess whether any of the metrics had an excessive influence on the IBI, the IBI scores for the reference, impaired and random sites from the calibration data set were recalculated by dropping one metric at a time from the total IBI score and then correlating these new scores with the total IBI score. The results showed highly significant relations ($p < 0.0001$) for each recalculation indicating that each of the metrics had roughly the same influence on the total IBI score.

Scatter plots of raw metric values and the IBI scores (Appendix F) were made to allow visual assessment of the metrics to the total IBI scores with the range of total IBI scores across the metric values that changed most rapidly determined to be the range of primary sensitivity for that metric (Angermeier and Karr 1986). All appeared to have a broad range of sensitivity.

Additional IBI validation and testing

Relations between the IBI scores and the physical habitat

Spearman rank correlations (with a Bonferroni multiple test correction factor) were run with the IBI score for each of the reference, impaired and random sites against associated data for all the environmental variables and watershed area. There was only one significant relation ($p = 0.0002$), a negative correlation between the IBI scores and the percentage of urban land cover in the watershed. The IBI scores were not significantly related to any of the individual physical habitat variables or the syntheses of those variables, the final habitat indices (channel phyhab quality, channel plus riparian phyhab quality, channel plus riparian phyhab quality including human disturbance). This indicates that factors other than physical habitat may also be influencing these communities. This wasn't surprising since selection of the reference and impaired sites was based on best professional judgment rather than the physical habitat data collected through the EMAP protocol. Further analysis showed that while percentage of urban land cover was not related to the final habitat indices, it was positively related to the percentage of row crop land cover ($p = 0.0008$) for these sites. In contrast to urban land cover, row crop land cover was related (negatively) to two of the final habitat indices (channel phyhab quality, $p < 0.0001$, channel plus riparian phyhab quality, $p < 0.0001$).

IBI precision

Precision of the IBI was calculated in the same fashion as for the individual metrics based on the methodology of Kaufmann et al. (1999) where they described the precision of stream habitat measurements by the ratio of among-site variance (signal) to within-site variance from replicated sites (noise). Duplicate samples from the same season and year for nine reference, impaired and random sites of the calibration data set were used to evaluate metric precision within a site in a single year, to compare to variance among the sites. The signal to noise variance ratio was calculated as the among-site variance divided by the within-site variance. A high signal to noise ratio is desirable. Precision for the IBI scores was good at 5.9. It should be noted that variance within a year at the same site was higher among the impaired sites than the reference sites.

Validating the IBI

A validation data set was developed for use in testing the ability of the IBI to discern stream conditions. Nineteen additional sites were chosen from the RAM data set that had high and low ranges of the final habitat indices. None of these sites had been used in the calibration portion of this process. Seven "good" sites were chosen that had final habitat indices >0.8 (out of 1.0) and 5 "poor" sites were chosen that had final habitat indices <0.4. The rest of the 19 sites were chosen based on their occurrence within targeted watersheds listed by the EPA rather than physical habitat condition (see Appendix G). These random sites covered EPA targeted watersheds that were not all ready represented in earlier data sets presented here. All the metrics were calculated for each of these sites, normalized to unitless scores, and the final IBI for each was calculated for use in the validation data set. IBI scores for these sites were normally distributed.

The mean IBI scores for the sites ranked as "good" and "poor" were 40.4, and 24.6, respectively, and an unpaired t-test of these data was significant (p = 0.0006). Results of a one-sided nonparametric median test performed between the good and poor sites also indicated that the IBI was able to distinguish between the sites with good and poor habitat (PR < Z = 0.0025). A box and whisker plot of these data showed no overlap in the interquartile range (Figure 5).

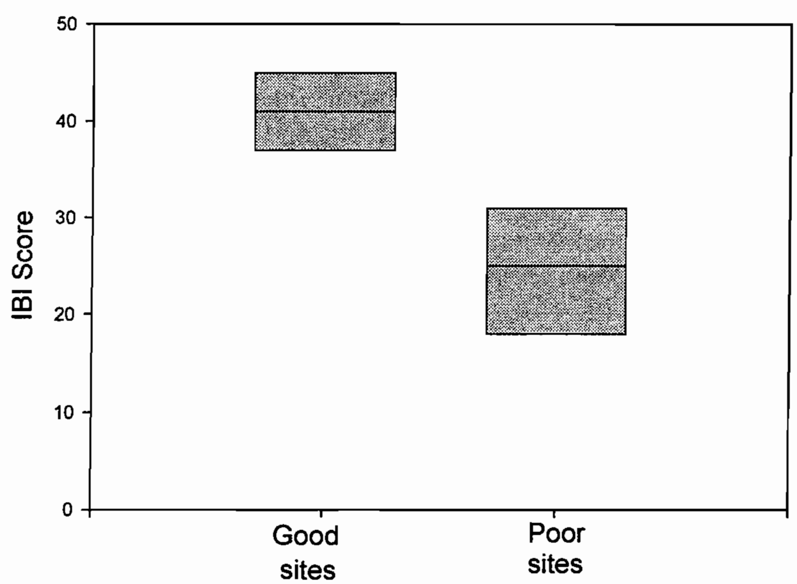


Figure 5. Box and whisker plot of the IBI validation data set – Ozark ecoregion.

Spearman rank correlations were run between the IBI scores for the validation sites with the land cover data and final habitat indices. Land cover data were only available for 17 of the 19 sites. Results of these analyses showed that rather than being negatively related to the percentage of urban land use like the original calibration data set, these validation sites (that were chosen based on EMAP final habitat indices instead of BPJ) were instead negatively related to the percentage of row crop cover (p <0.0001). The IBI scores for these validation data (n = 19) were also significantly positively related to the final habitat indices (channel plus riparian phyhab quality, p = 0.0016; channel phyhab quality, p = 0.0062; channel plus riparian phyhab quality including human disturbance impacts, p = 0.010). Final habitat indices for these data were also significantly negatively related to the percentage of row crop cover (channel plus riparian phyhab quality, p = 0.0059; channel phyhab quality, p = 0.0082; channel plus riparian phyhab quality including human impacts, p = 0.0125). As we saw with the original calibration data set, relations to the final habitat index that includes human disturbance impacts were not as strong as for the other habitat indices.

Interpreting the IBI scores

Due to the highly significant differences in IBI scores between the good and poor sites selected for the IBI validation data, IBI scores from those sites were added to the reference and impaired sites of the calibration data for calculations made to determine level classifications of the IBI scores. This resulted in a total of 33 reference sites and 17 impaired sites. Percentiles for these two groups were determined (Table 10).

Table 10. Quartiles for the IBI scores of the reference and impaired sites for the Ozark ecoregion.

	Impaired	Reference
25^{th} percentile	25	37
50^{th} percentile	29	41
75^{th} percentile	35	43

We suggest a three-level classification of stream condition of *no impairment, impaired*, and *highly impaired* based on the following criteria. Any streams with an IBI score greater than or equal to the 25^{th} percentile of the reference sites (37) would indicate *no impairment*. Streams with an IBI score higher than the median of the impaired streams (29) up to 36 would be deemed *impaired*, and anything less than 29 would be considered *highly impaired*. This establishes an IBI score of 36 as the threshold of impairment for any stream for which the IBI score is determined through this process.

Discussion and recommendations

Anyone who has frequented the state of Missouri inherently knows that development of biocriteria for the benthic invertebrates or fish requires the separation of the state into at least three different ecoregions: the Central Plain, Ozark, and Mississippi Alluvial Basin. Analyses of the fish community and physical habitat presented in this document clearly support the separation of the Central Plain and Ozark ecoregions (Figure 3, Tables 1 and 3).

The development of biocriteria for these two major ecoregions of the state was only successful for the Ozark ecoregion. Failure to achieve biocriteria for the Plain ecoregion may be the result of any or all of the following reasons. First, the current natural state of the streams in the Plain ecoregion in many ways—such as fine sediment deposition and water clarity—embodies qualities that science equates with water pollution and stream degradation. In addition, fishes of prairie streams are more tolerant of these conditions. Those facts, along with a history of extensive stream channel modification in the region, has led to the identification (and probably the existence) of an inadequate number of reference sites within the Plain ecoregion of Missouri. An additional source of variance may have been introduced in these data by the use of reference and impaired sites that were selected based on best professional judgment. Analyses of these BPJ sites for the Plain ecoregion (Table 6) highlight the lack of any basis for these stream condition assignments based on the land use, physical habitat or water quality. Still another source of critical information that needs improvement for both the Plain and Ozark ecoregions are water quality data. If funding is available, potential ways to address these problems might be the addition of data from a similar study in Iowa using reference sites from the Central Irregular Plains. Another possible approach might be the selection of both reference and impaired sites based solely on the physical habitat variables instead of including water quality concerns that are a part of selecting sites when using BPJ.

In contrast, conditions are still good within a large portion of the streams in the Ozark region. Current natural conditions of some of the streams in this ecoregion are comparable to the best found anywhere in the country. This allowed for a relatively wide selection of reference sites for biocriteria development. After metric screening that included tests of range, normality, variance, redundancy, responsiveness to human influences, and the ability to discern between reference and impaired conditions, nine metrics remained for IBI development. Data for these metrics from the calibration data set were developed into an IBI to which they all contributed approximately equally. The IBI was then assessed for variance, responsiveness to human influences and the overall ability to discern between reference and impaired conditions. Sites within the calibration data set were highly related to the percentage of urban land cover within the watershed, and although they were not related to the final habitat indices, the IBI was able to differentiate between reference and impaired conditions.

A final test of the IBI was performed using a validation data set that was developed based on the physical habitat (final habitat index scores) rather than best profession judgment[3]. These validation data showed that the IBI developed from the calibration data set was able to discriminate between reference and impaired conditions of other sites. These data also revealed that the primary relation to the physical habitat of Ozark streams was with the percentage of row crop land cover in the watershed, and the sites were (as expected) significantly related to the final habitat indices.

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[3] Reasons for this were two-fold—an inadequate number of impaired sites (based on BPJ) for both calibration and validation data sets, and earlier analyses of the calibration data set indicating no relation to the final habitat indices.

Although this index is able to easily discern between reference and impaired conditions, improvement of this index and development of an index for the Plain ecoregion, might be achieved in the future by a more careful data-based approach to the screening process of the reference and impaired sites. Several of the impaired sites (chosen by BPJ) that were used in the calibration data set had final habitat index scores that did not fit the expectation (e.g. impaired sites with very good physical habitat). Discussion of these sites with committee members who suggested them indicated that often sites were considered impaired based on repeated fish kills or suspected influences of urban development. These sites were retained for the process since development of biocriteria was meant to aid these agencies with assessing all types of stream perturbations. However, as the analyses progressed it became obvious to the analyst that many of these impaired sites with good physical habitat were introducing excessive variance into the process. The negative effect of this site selection method was corroborated when analyses of the validation sites (selected solely on the physical habitat data) revealed a stronger ability to discern between reference and impaired conditions (Figures 4 and 5).

We suggest the possibility of a two-pronged approach to stream monitoring in the state. Biocriteria development for the invertebrate communities of the state (Rabeni et al. 1997) showed that invertebrates were quite good at detecting water quality issues such as organic pollution but failed at the detection of habitat quality impairment. In contrast, studies of the development of biocriteria using fish communities have reported that physical habitat rather than water quality is the major influence (Wang et al. 1997, Bramblett et al. 2005). In the future, it might make sense for agencies to assess streams of concern within Missouri using invertebrate biocriteria for water quality issues and fish communities for physical habitat issues.

Appendix A. Literature review on development and use of biocriteria for fish communities of wadeable streams.

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Appendix B. List of sites used for IBI development in Missouri.

Stream name	Storet	Quality[1]	Ecoregion	Unique ID[2]	Segment ID[3]	EDU[4]	Watershed area (km^2)	rf3 order	UTM_X	UTM_Y	county
Gravois Creek	0001	Impaired	OZARK	00012-00	7140101 699	24	31	2	731699	4268438	29189
Hinkson Creek	0005	Impaired	OZARK	00051-00	10300102 1881	26	198	4	552192	4307272	29009
Flat River	0010	Impaired	OZARK	00101-00	7140104 6649	25	74	3	719587	4194107	29187
North Moreau Creek	0012	Impaired	OZARK	00121-00	10300102 4377	26	415	5	539395	4270434	29135
Buffalo Creek	0014	Impaired	OZARK	00141-00	11070208 4252	22	67	3	366714	4074038	29145
Indian Creek	0017	Impaired	OZARK	00171-00	11070208 4270	22	267	5	389174	4072773	29145
Bear Creek	0101	Impaired	OZARK	01011-01	10300102 1361	26	38	2	556096	4315467	29009
Wilson Creek	0103	Impaired	OZARK	01031-01	11010002 521	29	134	3	466303	4110171	29077
Hubble Creek	0113	Impaired	OZARK	01131-01	7140107 1078	28	50	3	793408	4138704	29031
Hinkson Creek	2080	Impaired	OZARK	20801-04	10300102 1747	26	134	3	558965	4309451	19
Straight Fork	2081	Impaired	OZARK	20811-04	10300102 4494	26	125	3	520839	4268711	135
Little Sac River	9674	Impaired	OZARK	96741-02	10290106 4949	27	488	4	458845	4144911	29167
Big Sugar Creek	2013	Reference	OZARK	20131-02	11070208 4872	22	223	4	397806	4049562	29119
Burris Fork	2014	Reference	OZARK	20141-03	10300102 4799	26	163	4	534719	4263052	29135
Boeuf Creek	2015	Reference	OZARK	20151-02	10300200 7515	26	174	4	647745	4266740	29071
Apple Creek	2016	Reference	OZARK	20161-02	7140105 3655	24	122	4	779940	4164309	29031
Meramac River	2017	Reference	OZARK	20171-02	7140102 4283	25	419	5	635969	4180819	29065
Cedar Creek	2018	Reference	OZARK	20181-02	10290106 4087	27	287	4	421239	4173472	29039
Deer Creek	2020	Reference	OZARK	20201-01	10290109 7203	27	161	4	484388	4228010	29015
Deer Creek	2020	Reference	OZARK	20201-02	10290109 7203	27	161	4	484388	4228010	29015
North Fork White River	2021	Reference	OZARK	20211-02	11010006 643	29	191	5	570948	4089057	29067
Sinking Creek	2022	Reference	OZARK	20221-02	11010007 5118	21	170	4	692861	4125785	29179
Sinking Creek	2023	Reference	OZARK	20231-02	11010008 718	21	302	4	642456	4132827	29203
Marble Creek	2024	Reference	OZARK	20241-02	8020202 1044	28	109	3	717796	4147674	29123
Boeuf Creek	2077	Reference	OZARK	20771-04	10300200 7675	26	78	3	643429	4260055	71
Boeuf Creek	2092	Reference	OZARK	20921-04	10300200 7408	26	255	5	648514	4267252	71
Barren Fork	561	Reference	OZARK	21071-04	11010008 561	21	124	4	642295	4137666	203
Shut in Creek	4139	Reference	OZARK	21181-04	110100074139	21	56	3	689721	4161159	179
Sinking Creek	529	Reference	OZARK	21271-04	11010008 529	21	117	4	647215	4139054	203
Spring Creek	845	Reference	OZARK	22201-05	11010006 845	29	42	3	582492	4085550	91
Rippee Creek	940	Reference	OZARK	22241-05	11010006 940	29	45	3	545895	4080107	67
Bull Creek	9548	Reference	OZARK	95481-01	11010003 6215	29	272	4	483897	4074766	29043

Appendix B continued.

Stream name	Storet	Quality[1]	Ecoregion	Unique ID[2]	Segment ID[3]	EDU[4]	Watershed area (km^2)	rf3 order	UTM_X	UTM_Y	county
Pomme De Terre River	9673	Reference	OZARK	96731-02	10290107 15553	27	237	4	483863	4143121	29167
Sinking Creek	9675	Reference	OZARK	96751-02	11010008 276	21	55	3	651273	4146797	29065
Castor River	9690	Reference	OZARK	96901-02	7140107 196	28	89	3	750450	4162752	29123
Huzzah Creek	9807	Reference	OZARK	98071-02	7140102 4048	25	290	3	660877	4187202	29055
West Piney River (creek)	05	Reference	OZARK	RES051-05	10290202 4819	23	219	4	585830	4129784	215
Hunter Creek	05	Reference	OZARK	RES131-05	11010006 749	29	137	4	544892	4085962	67
Big Berger Creek	2094	Random	OZARK	20941-04	10300200 7126	26	58	3	643130	4273837	71
Hillers Creek	2095	Random	OZARK	20951-04	10300102 3716	26	81	3	584545	4281782	27
Hungry Mother Creek	2098	Random	OZARK	20981-04	10300102 374	26	41	3	539057	4335240	89
Middle Fork Black River	4058	Random	OZARK	21081-04	11010007 4058	21	66	4	680343	4163800	93
Pine Creek	2145	Random	OZARK	21121-04	11010008 2145	21	52	3	598989	4101378	215
South Fork Buffalo Creek	3263	Random	OZARK	21141-04	11010008 3263	21	65	3	679297	4064627	181
Panther Creek	302	Random	OZARK	22151-05	11010002 302	29	106	3	497736	4116927	225
Indian Creek	658	Random	OZARK	22181-05	11010006 658	29	127	4	576568	4091933	67
Noblett Creek	733	Random	OZARK	22191-05	11010006 733	29	49	3	580881	4086421	91
Fox Creek	1098	Random	OZARK	22251-05	11010006 1098	29	64	4	554800	4076014	67
Pine Creek	1655	Random	OZARK	22291-05	11010006 1655	29	53	3	560820	4057824	153
S. Fk. Bratten Spring Creek	7611	Random	OZARK	22501-05	11010003 7611	29	43	3	537615	4045763	153
Pearson Creek	0107	Random	OZARK	01071-01	11010002 219	29	59	2	482645	4114093	29077
Deer Creek	2020	Duplicate	OZARK	20202-01	10290109 7203	27	161	4	484388	4228010	29015
Deer Creek	2020	Duplicate	OZARK	20202-02	10290109 7203	27	161	4	484388	4228010	29015
Bull Creek	9548	Duplicate	OZARK	95482-01	11010003 6215	29	272	4	483897	4074766	29043
Castor River	9690	Duplicate	OZARK	96902-02	7140107 196	28	89	3	750450	4162752	29123
Gravois Creek	0001	Duplicate	OZARK	00011-00	7140101 699	24	30.78	2	731699	4268438	29189
Hinkson Creek	0005	Duplicate	OZARK	00052-00	10300102 1881	26	198.23	4	552192	4307272	29009
North Moreau Creek	0012	Duplicate	OZARK	00122-00	10300102 4377	26	415.36	5	539395	4270434	29135
Bear Creek	0101	Duplicate	OZARK	01012-01	10300102 1361	26	38.46	2	556096	4315467	29009
Pine Creek	2145	Duplicate	OZARK	21122-04	11010008 2145	21	51.52	3	598989	4101378	215
Mill Creek	0006	Impaired	PLAIN	00061-00	7110008 669	16	43.32	3	668340	4332376	29113
West Fork Tebo Creek	0013	Impaired	PLAIN	00131-00	10290108 17557	15	46.2	2	443544	4252182	29083
Big Creek	0016	Impaired	PLAIN	00161-00	10290108 16114	15	316.7	4	398233	4286778	29037
Middle Fork Salt River	0102	Impaired	PLAIN	01021-01	7110006 14808	16	312.04	4	554611	4389916	29121

Appendix B continued.

Stream name	Storet	Quality[1]	Ecoregion	Unique ID[2]	Segment ID[3]	EDU[4]	Watershed area (km^2)	rf3 order	UTM_X	UTM_Y	county
Blue River	0111	Impaired	PLAIN	01111-01	10300101 7984	11	229.6	4	362246	4304048	29095
Spring Creek	0114	Impaired	PLAIN	01141-01	10280202 2018	12	206.89	4	520700	4455711	29001
Little Medicine Creek	0115	Impaired	PLAIN	01151-01	10280103 3897	12	174.42	3	467622	4463311	29129
Middle Fork Grand River	0117	Impaired	PLAIN	01171-01	10280101 3046	12	199.5	4	382526	4482746	29227
Middle Richland Creek	0110	Reference	PLAIN	01101-01	10300103 4130	11	55.8	3	507853	4265148	29141
Dog Creek	0116	Reference	PLAIN	01161-01	10280101 8074	12	55.98	3	412535	4410710	29061
Grindstone Creek	2006	Reference	PLAIN	20061-02	10280101 8030	12	153.4	4	392102	4411932	29063
Spring Creek	2008	Reference	PLAIN	20081-02	10280202 2032	12	216.2	4	521367	4454264	29001
Heaths Creek	2011	Reference	PLAIN	20111-02	10300103 2623	11	190.9	3	484140	4306586	29159
Heaths Creek	2011	Reference	PLAIN	20111-05	10300103 2623	11	190.9	3	484140	4306586	159
Little Dry Wood Creek	2012	Reference	PLAIN	20121-02	10290104 1701	15	159.5	4	376236	4172223	29217
East Fork Crooked River	5330	Reference	PLAIN	21631-05	10300101 5330	11	217.29	4	422334	4356113	177
West Fork of Big Creek	KKK3	Reference	PLAIN	21721-05	10280101 3788	12	332.38	4	411517	4470325	81
Spring Creek	KKK19	Reference	PLAIN	21831-05	10280202 2036	12	222.69	4	522810	4454091	1
Locust Creek	KKK34	Reference	PLAIN	21911-05	10280103 3444	12	234.88	4	489065	4476748	171
West Locust Creek	RWL6	Reference	PLAIN	22051-05	10280103 5521	12	198.01	3	480924	4445789	211
West Locust Creek	RWL5	Reference	PLAIN	22141-05	10280103 5349	12	188.28	3	480082	4447621	211
Sugar Creek	9532	Reference	PLAIN	95321-02	7110001 11866	16	117.2	3	617658	4443306	29111
South River	9663	Reference	PLAIN	96631-02	7110004 7335	16	99.1	2	628763	4405824	29127
Peno Creek	9801	Reference	PLAIN	98011-02	7110007 13132	16	86.7	4	647032	4369279	29163
Youngs Creek	9803	Reference	PLAIN	98031-00	7110006 15614	16	197.2	4	597771	4354618	29007

[1] Assigned condition of site. "Duplication" indicates additional reference sites used for validation purposes.
[2] Assigned by MDC--final two digits indicate the year of sampling 2000-2005.
[3] Stream segment identification number.
[4] Ecological drainage unit.

Appendix C. Definitions of the variables retained for use in the development of biocriteria for the fish communities in the wadeable streams of Missouri. The majority of these variables were derived from the EMAP protocol.

MNSLOPE – mean slope of local watershed
HGB_IP – percentage of local segmentshed in hydrologic soil group B
HGD_IP – percentage of local segmentshed in hydrologic soil group D

Bank angle export
XBKA = 'Bank Angle--mean (degrees)'
XUN = 'Undercut Distance--Mean (m)'

Bankfull export
XINC_H = 'Channel Incision Ht.-Mean (m)'
XBKF_W = 'Bankfull Width--Mean (m)'
XBKF_H = 'Bankfull Height-Mean (m)'

Canopy export
XCDENBK = 'Mean Bank Canopy Density (%)'
XCDENMID = 'Mean Mid-channel Canopy Density (%)'

Embeddedness export
XCEMBED = 'Mean Embeddedness--Channel only (%)'

Fish cover export
XFC_ALG = 'Fish Cvr-Filamentous Algae (Areal Prop)'
XFC_AQM = 'Fish Cvr-Aq. Macrophytes (Areal Prop)'
XFC_BRS = 'Fish Cvr-Brush&Small Debris (Areal Prop)'
XFC_HUM = 'Fish Cvr-Artif. Structs. (Areal Prop)'
XFC_LWD = 'Fish Cvr-Large Woody Debris (Areal Prop)'
XFC_NAT = 'Fish Cvr-Natural Types (Sum Areal Prop)'
XFC_OHV = 'Fish Cvr-Overhang Veg (Areal Prop)'
XFC_RCK = 'Fish Cvr-Boulders (Areal Prop)'
XFC_UCB = 'Fish Cvr-Undercut Banks (Areal Prop)'

Habitat type export
PCT_PB = 'Backwater Pool (% of reach length)'
PCT_FAST = 'Fast Wtr Hab (% riffle & faster)'
PCT_POOL = 'Pools -- All Types (% of reach)'

Residual pool labels
NRP = 'Number of residual pools in reach'
PCTRCHRP = 'Resid. pool length proportion (%of rch)'
RPGT50 = 'Resid Pools >50cm deep (number/reach)'
RPGT75 = 'Resid Pools >75cm deep (number/reach)'
RPMDEP = 'Maximum residual depth in reach (cm)'
RPMLEN = 'Max. resid pool length in reach (m/pool)'
RPMWID = 'Max resid width of any pool in reach (m)'
RPMVOL = 'Max volume of any pool in reach (m^3)'
PCTUSED = '% of pool head length with sediment'

Sinuosity
SINU = 'Channel Sinuosity (m/m)'

Slope
XSLOPE = 'Channel Slope -- reach mean (%)'

Substrate
SUB_X = 'Substrate--Mean Size Class (1-6)'
PCT_RR = 'Substrate Rough Bedrock (%)'
PCT_RS = 'Substrate Smooth Bedrock (%)'
PCT_CB = 'Substrate Cobbles – 64-250 mm (%)'
PCT_GC = 'Substrate Coarse Gravel -- 16-64 mm (%)'
PCT_GF = 'Substrate Fine Gravel -- 2-16 mm (%)'
PCT_SA = 'Substrate Sand -- .06-2 mm (%)'
PCT_FN = 'Substrate Fines -- Silt/Clay/Muck (%)'
PCT_HP = 'Substrate Hardpan – (%)'
PCT_SAFN = 'Substrate Sand & Fines -- <2 mm (%)'
PCT_BDRK = 'Substrate Bedrock (%)'

Thalweg
WD_RAT = 'Mean Width/Depth Ratio (m/m)'

Canopy
XPCAN = 'Rip Canopy Present (Fraction of reach)'
XPMID = 'Rip MidLayer Present (Fraction of reach)'
XPGVEG = 'Rip Ground Layer Present (Fract. reach)'

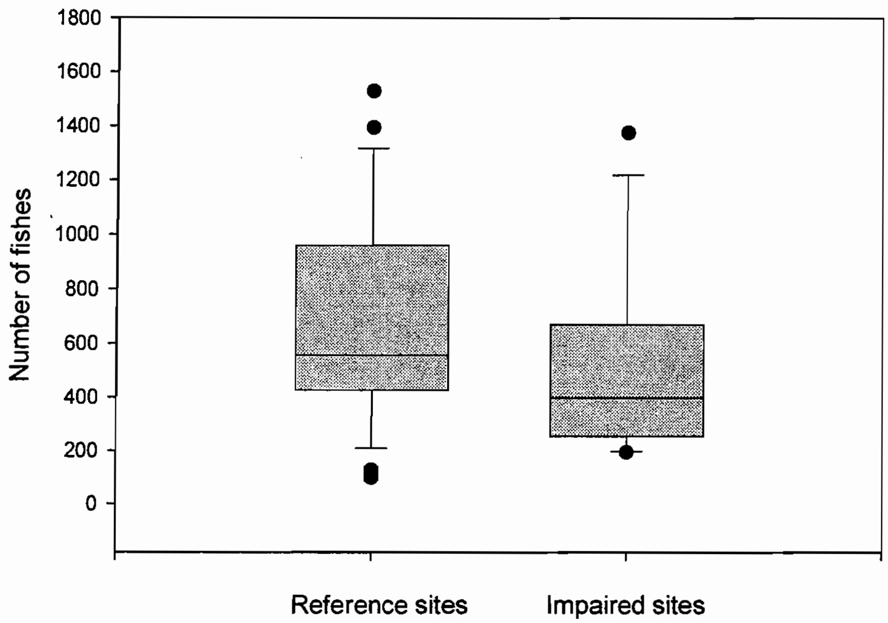
Woody debris
C1Wm100 = 'LWD in Bkf chnl (#/100m-all sizes)'
V1Wm100 = 'LWD Vol in Bkf chnl (m3/100m-all sizes)'

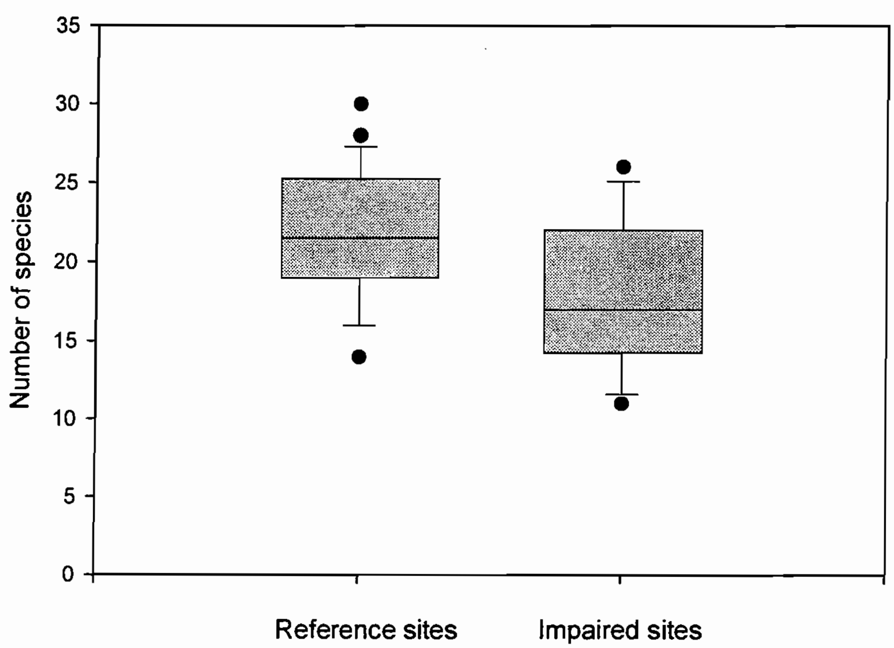
Human disturbance
LAND COVER 1 - percentage of urban land cover in watershed
LAND COVER 2 – percentage of row crop cover in watershed
LAND COVER 3 – percentage of grassland cover in the watershed
LAND COVER 4 – percentage of forest cover in the watershed
LAND COVER 6 – percentage of water cover in the watershed
Water temperature – (degrees centigrade) based on one measurement at time of field collections
Dissolved oxygen – (mg/l) based on one measurement at the time of field collections
Conductivity – (umhos/cm) based on one measurement at time of field collections
pH – (standard units) based on one measurement at time of field collections
Turbidity (NTU) - based on one measurement at time of field collections
BXPBLDG = 'The mean, BLDG, on Bank'
BXPMINE = 'The mean, MINE, on Bank'
BXPPARK = 'The mean, PARK/LAWN, on Bank'
BXPPSTR = 'The mean, PASTURE, on Bank'
BXPROAD = 'The mean, ROAD, on Bank'
BXPWALL = 'The mean, WALL, on Bank'
CXPCROP = 'The mean, CROP, in Riparian Plot'
CXPPSTR = 'The mean, PSTR, in ripar Plot'
CXPROAD = 'The mean, ROAD, in Ripar Plot'
XB_HALL = 'Rip Dist--Sum All Types instrm & on bank'
XCB_HALL = 'Rip Dist--Sum All Types instrm & in plot'
XC_HALL = 'Rip Dist--Sum All Types in Ripar Plots'
X_HALL = 'Rip Dist--Sum All Types str plt & beyond'

Final habitat indices
QCPH = Channel phyhab quality
QPH = Channel plus Riparian phyhab quality
QTPH = Channel plus Riparian phyhab quality including Riparian Human Disturbance
If followed by a '1' it indicates data not adjusted to watershed size, adjusted to watershed size if followed by a '2'.

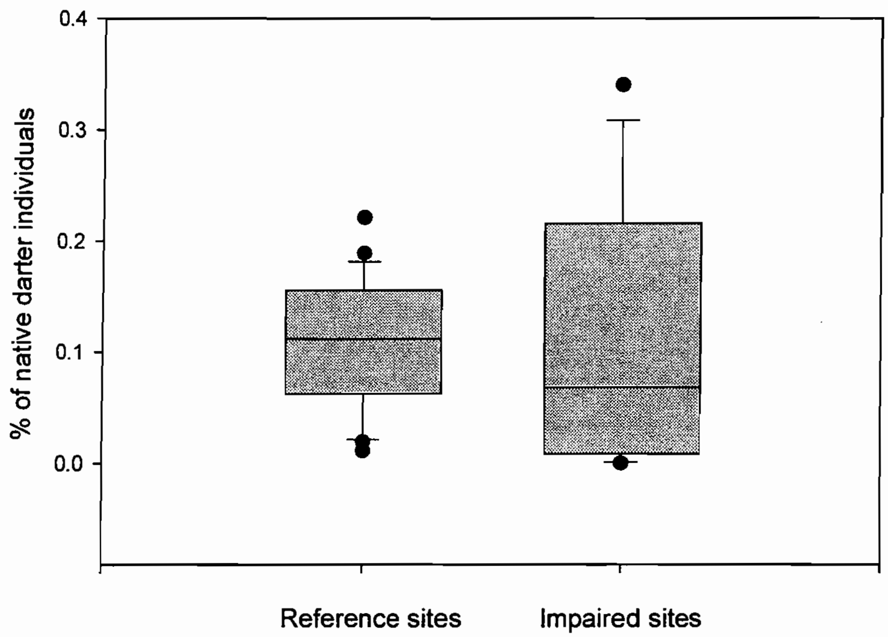
Appendix D. Metric comparisons for the Ozark and Plain ecoregions – reference versus impaired sites.

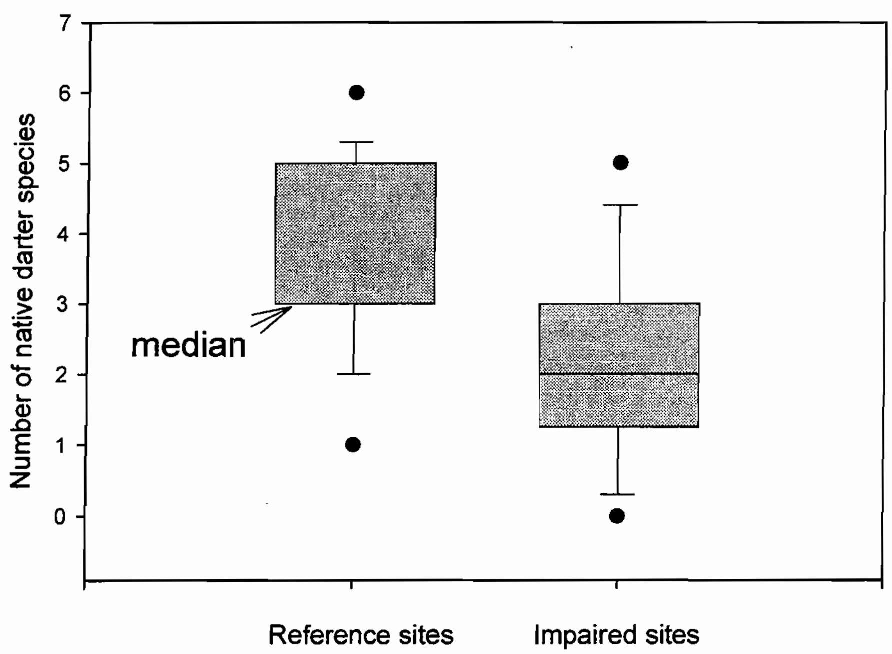
Ozark ecoregion metrics



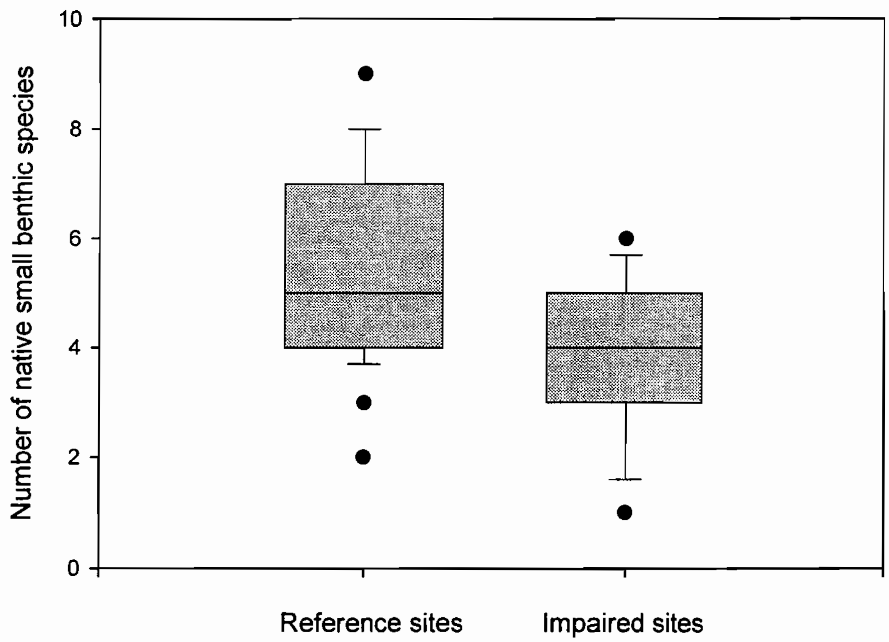


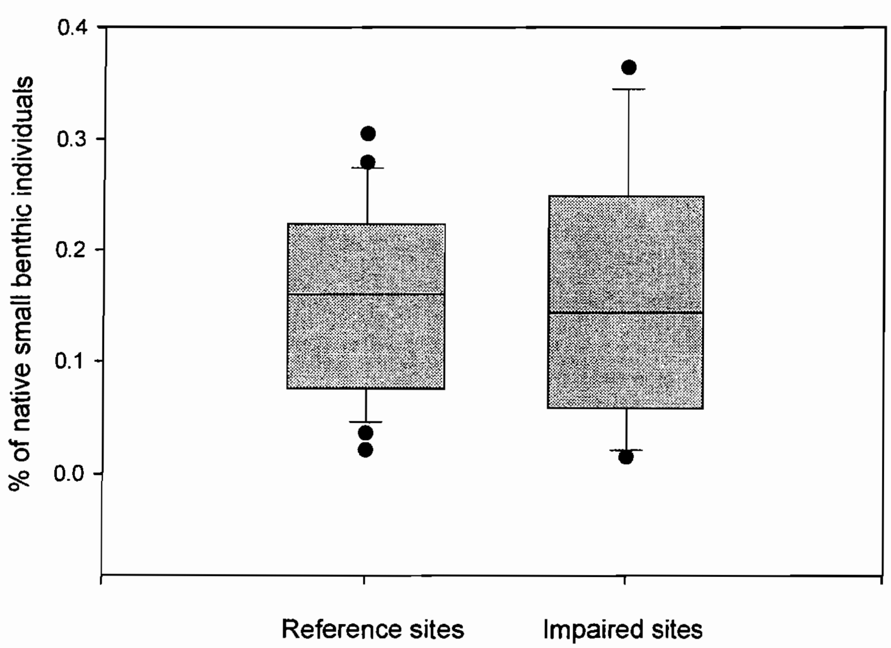
Ozark ecoregion metrics



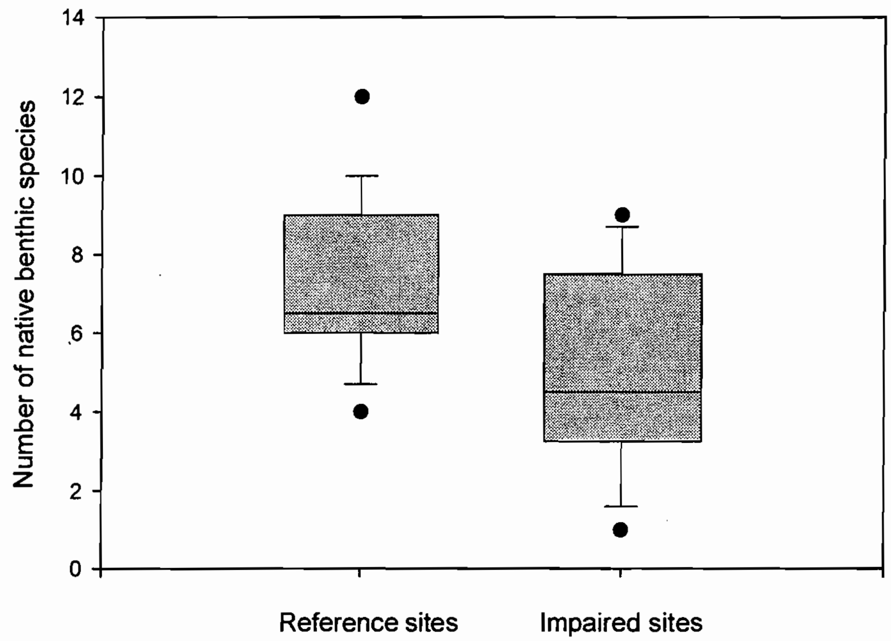


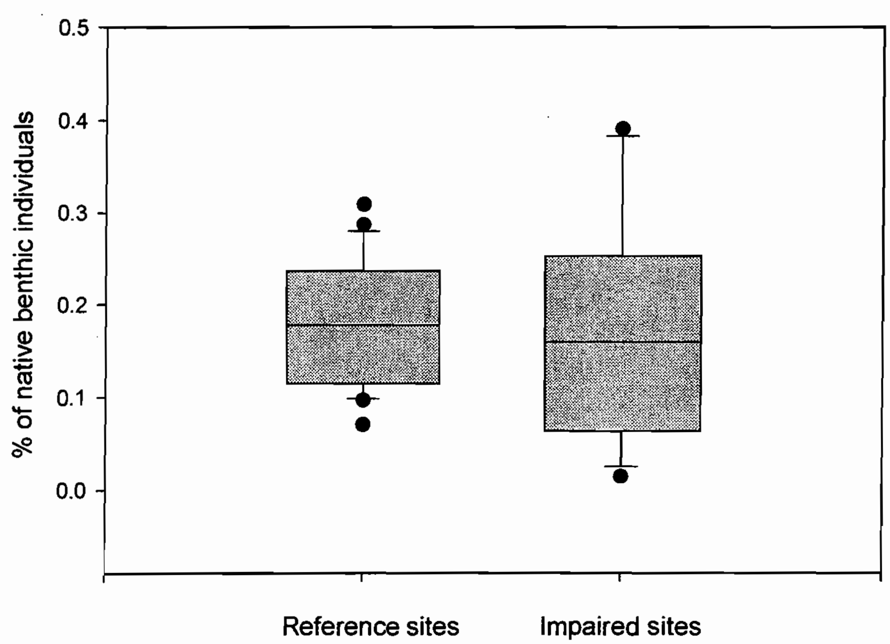
Ozark ecoregion metrics



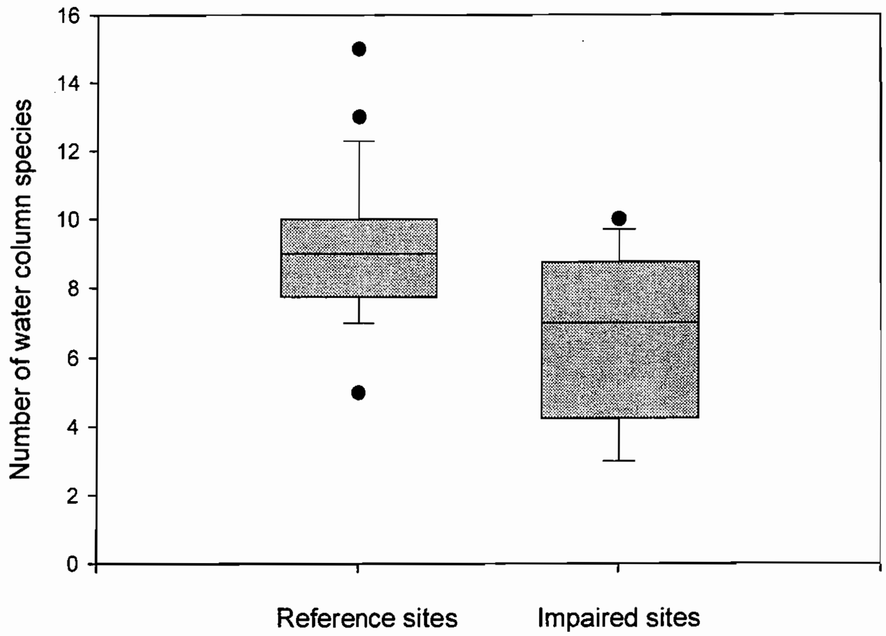


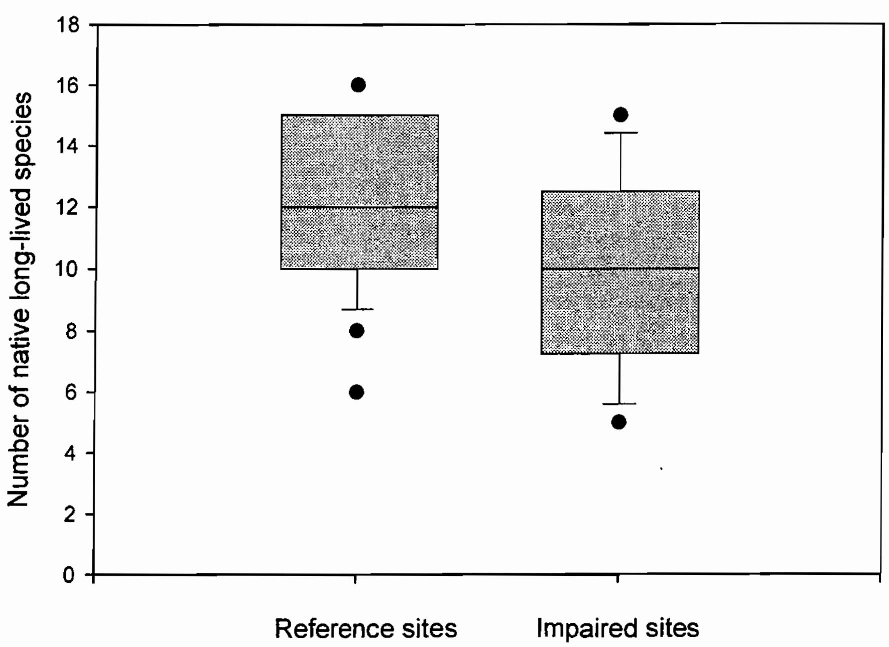
Ozark ecoregion metrics



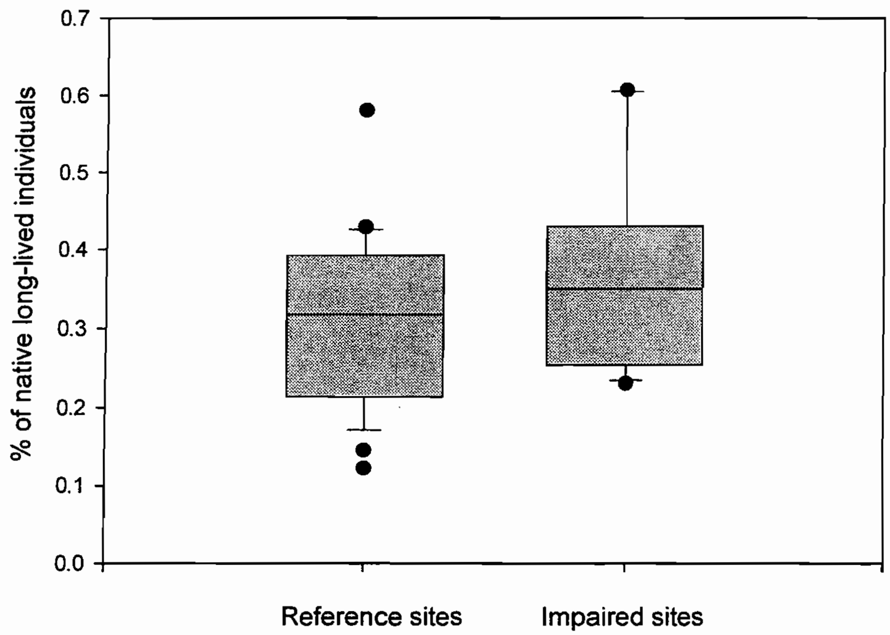


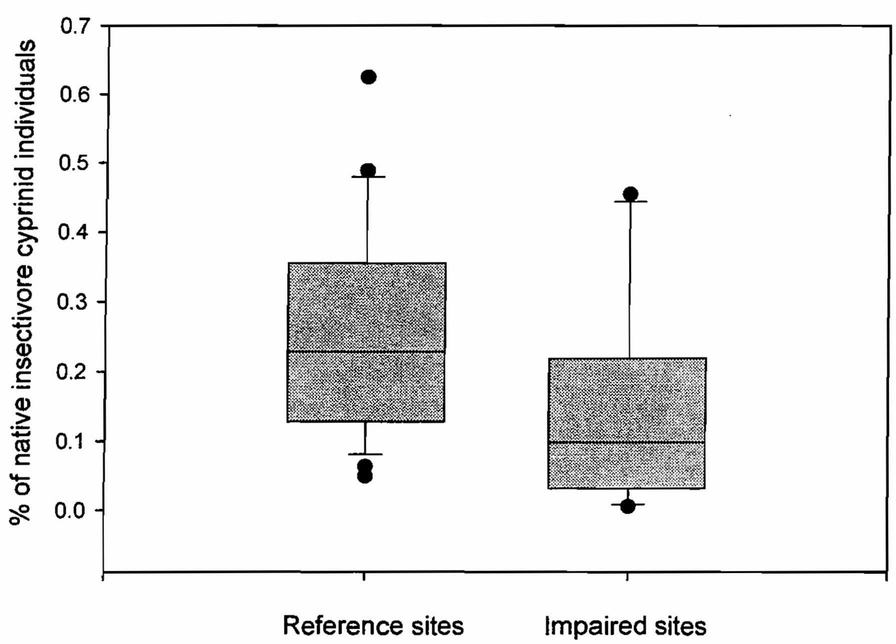
Ozark ecoregion metrics





Ozark ecoregion metrics





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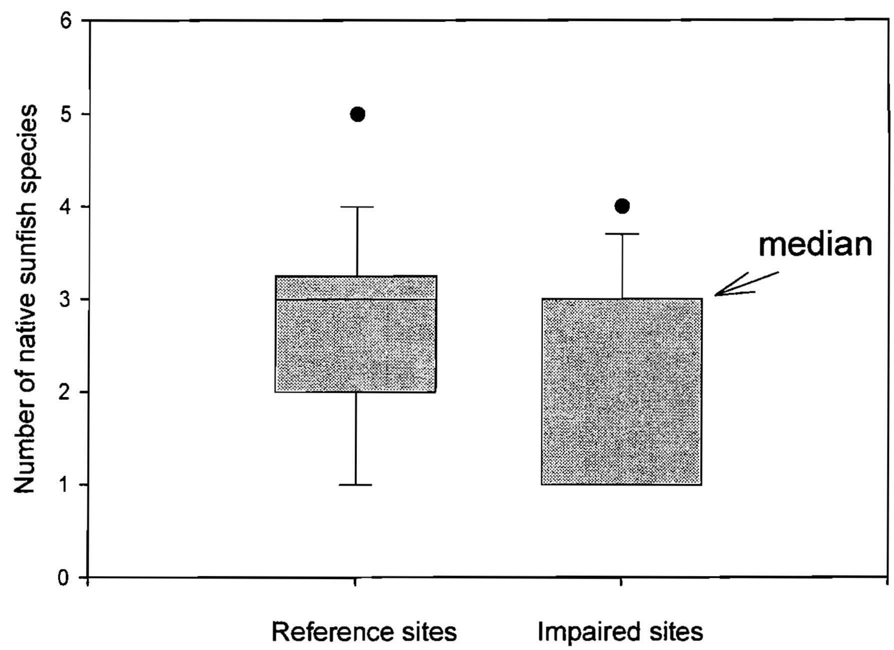
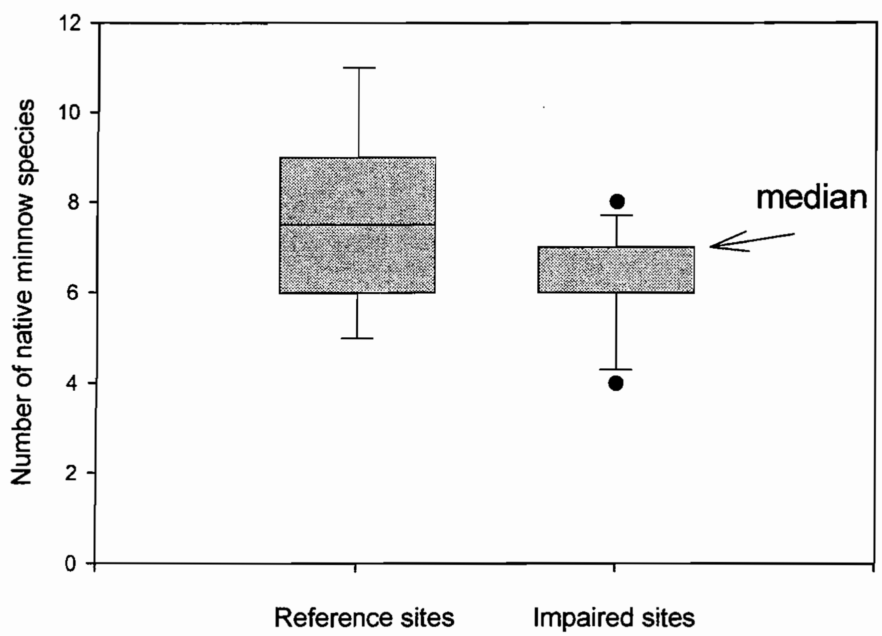
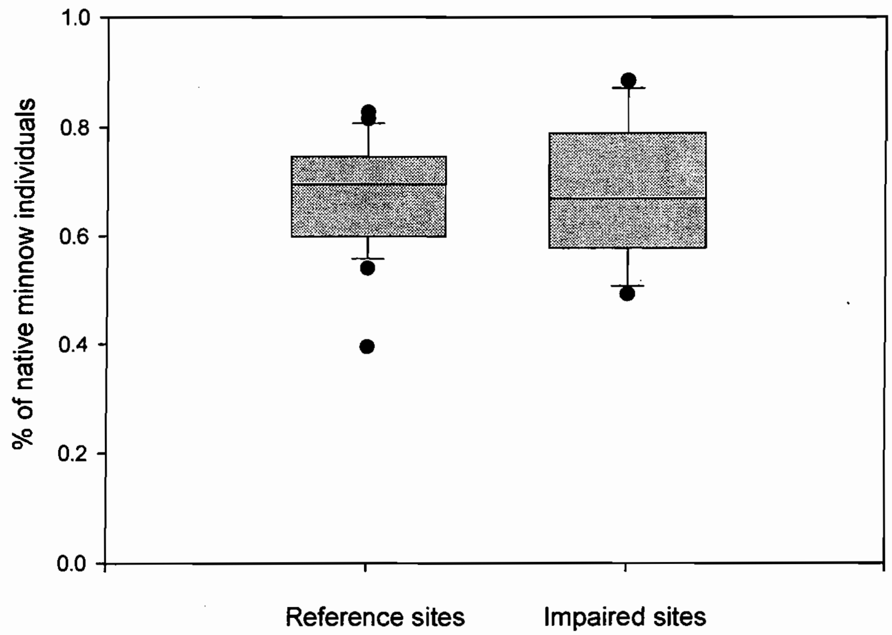
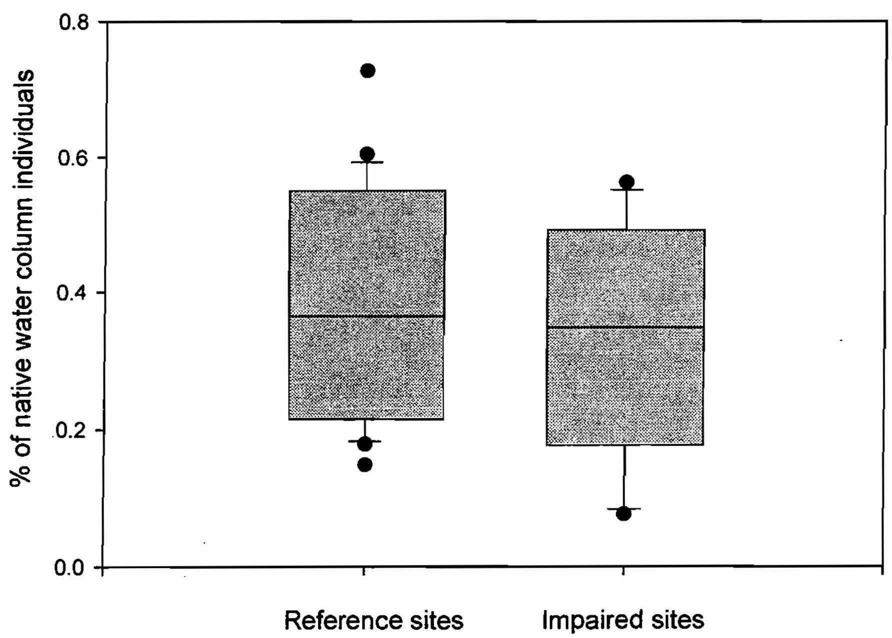


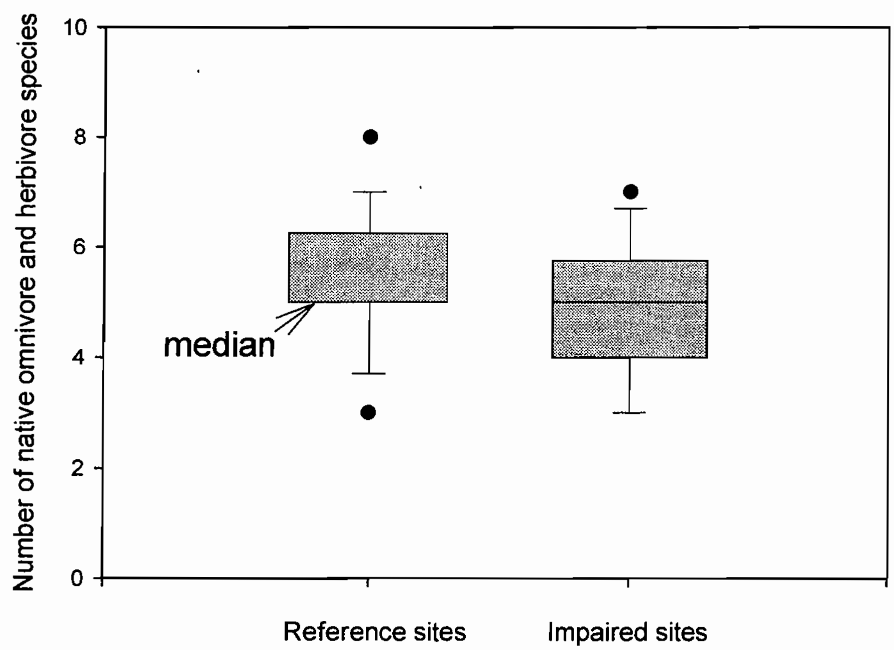


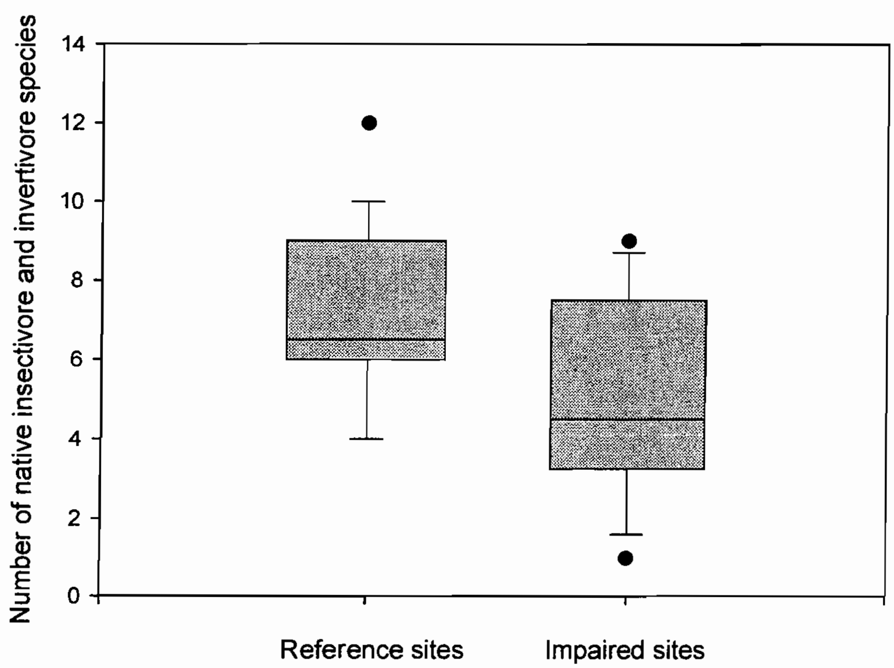
Ozark ecoregion metrics



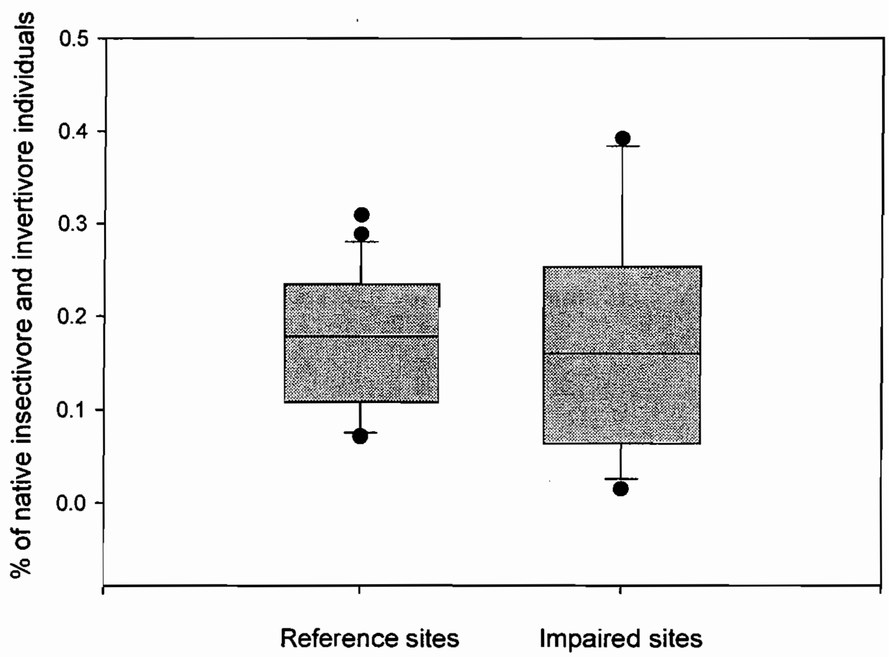


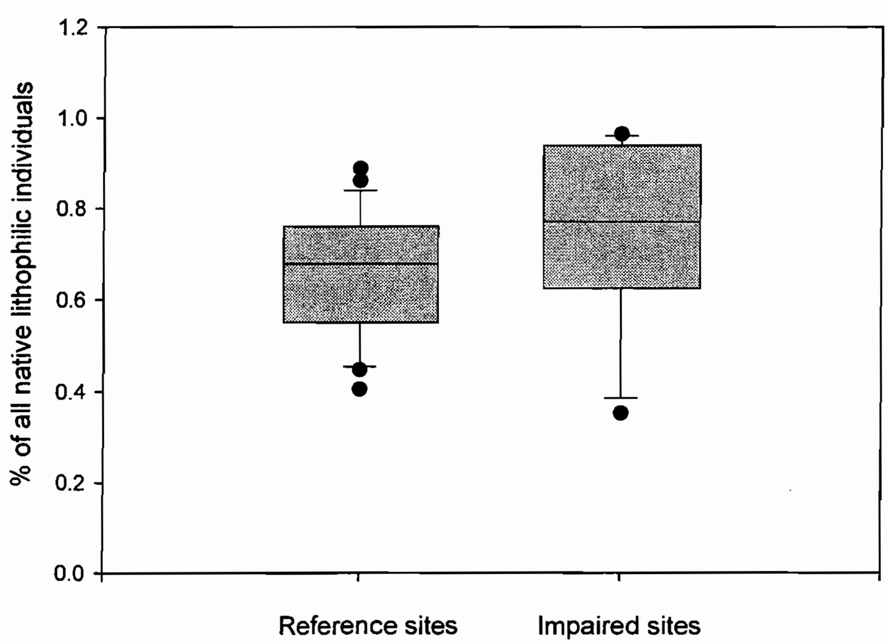
Ozark ecoregion metrics



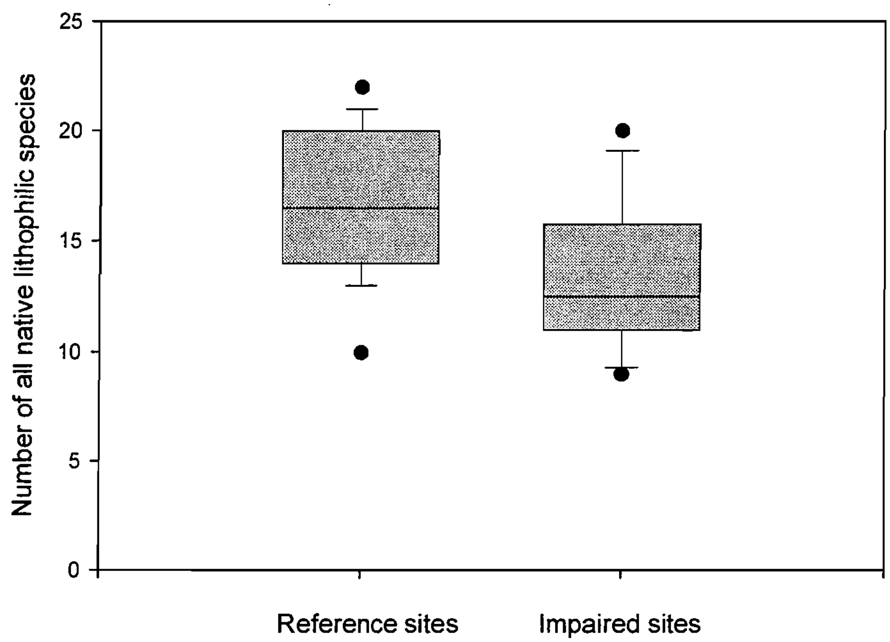


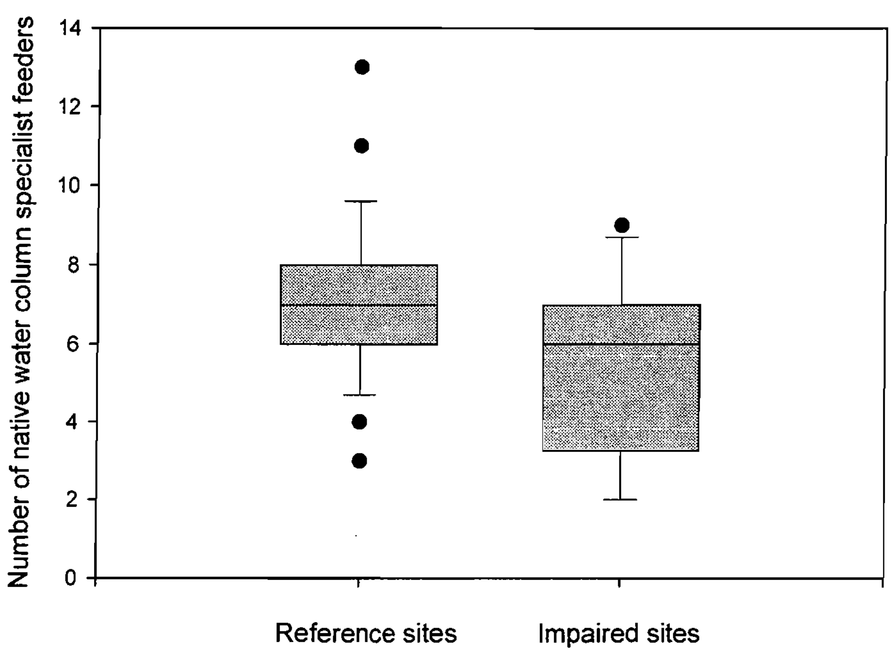
Ozark ecoregion metrics



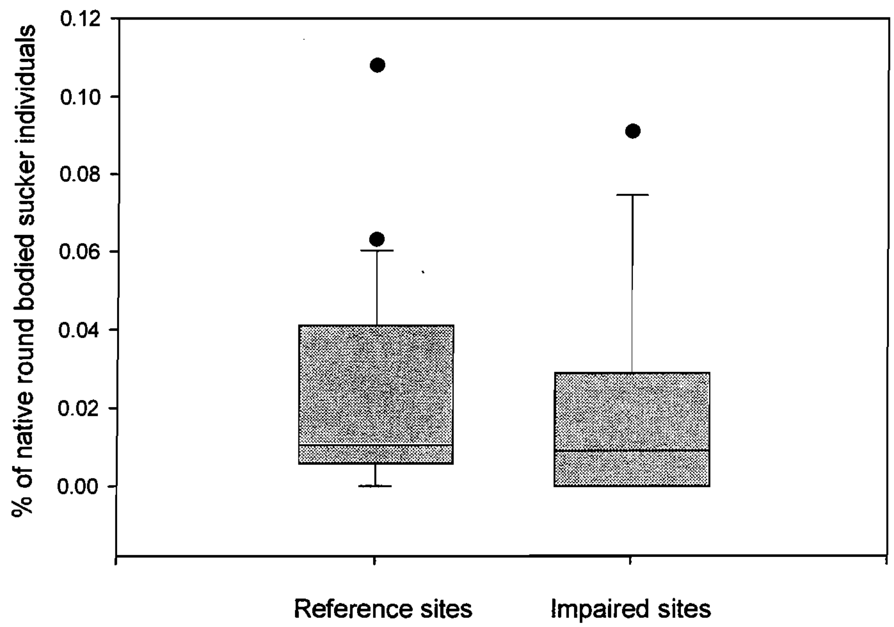


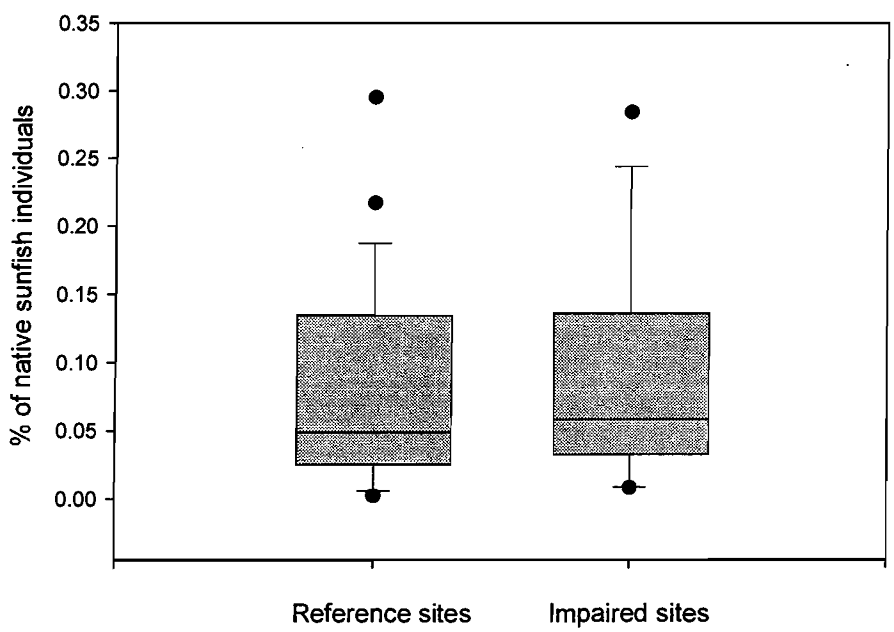
Ozark ecoregion metrics



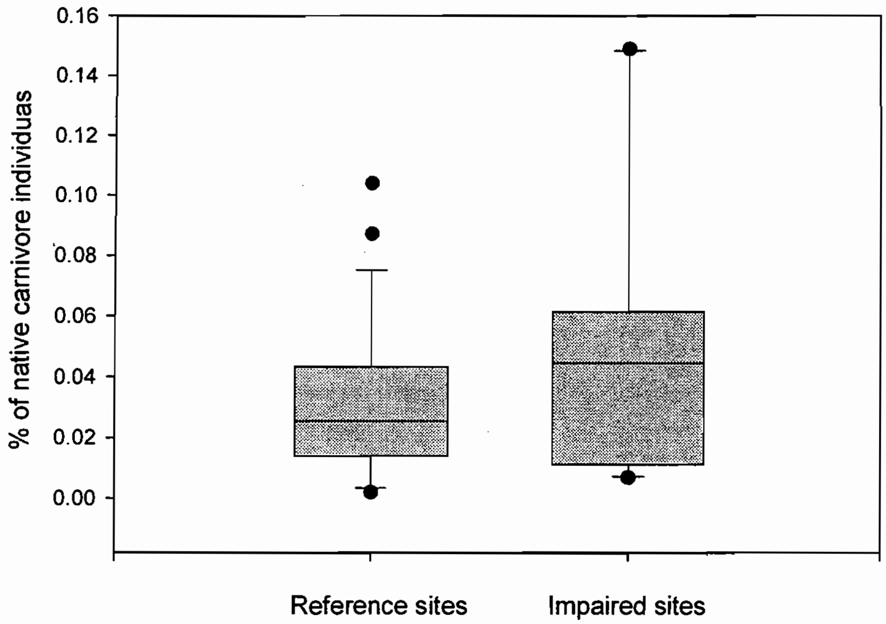


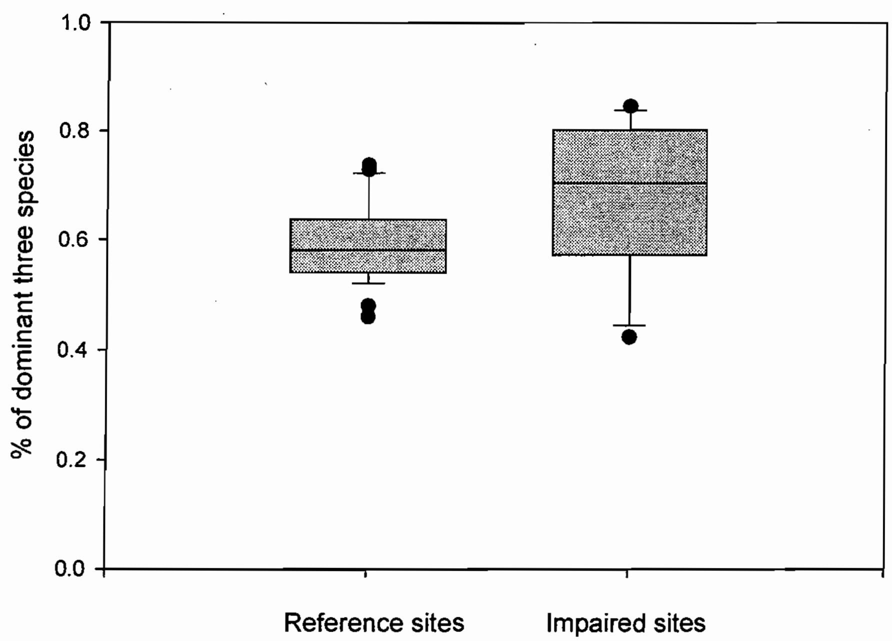
Ozark ecoregion metrics



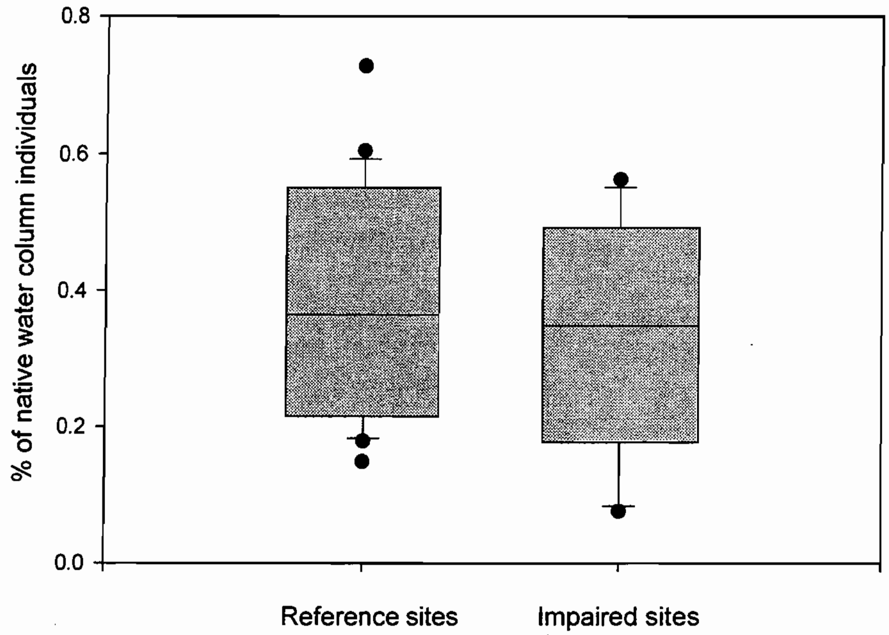


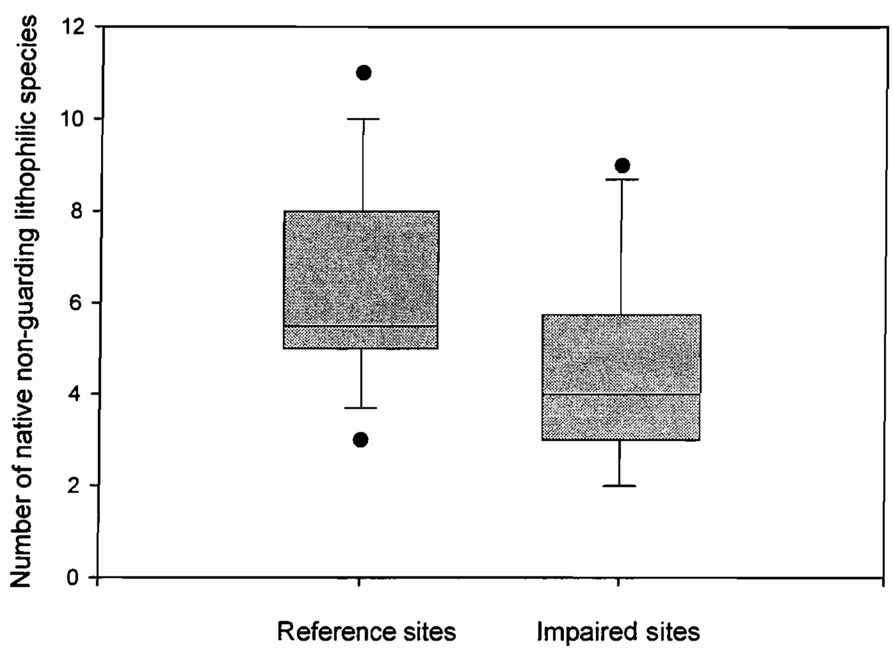
Ozark ecoregion metrics





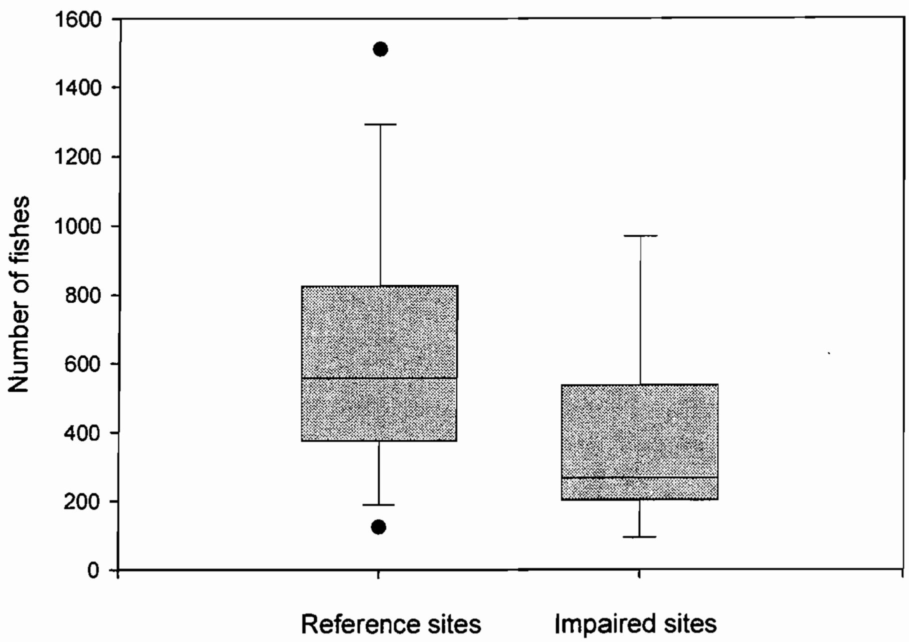
Ozark ecoregion metrics

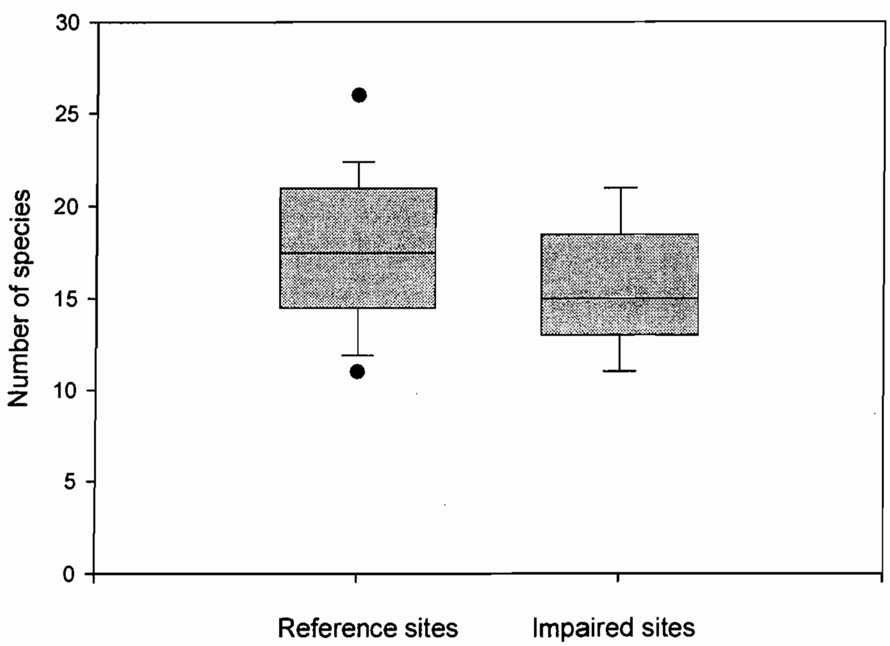




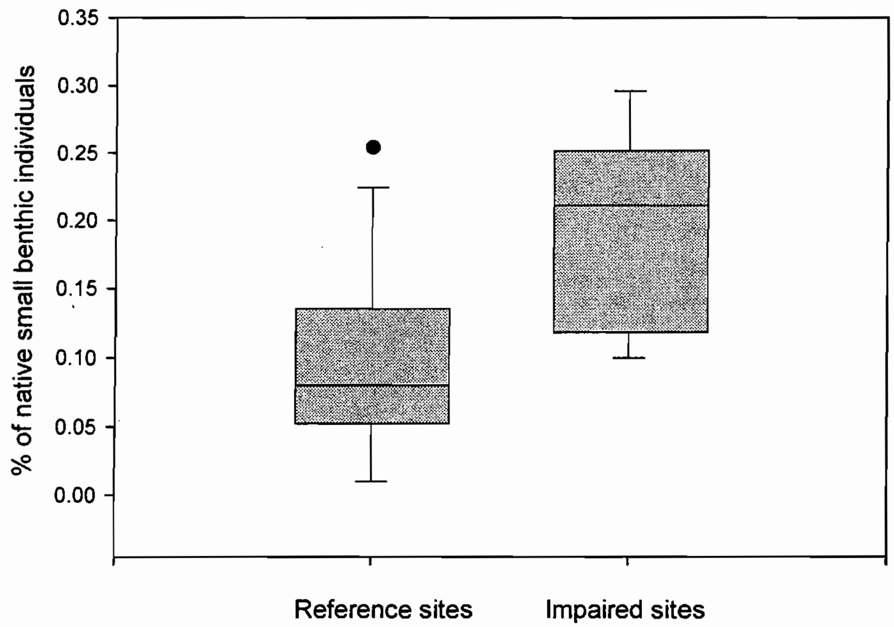
Metric comparisons for the Plain ecoregion – reference versus impaired sites

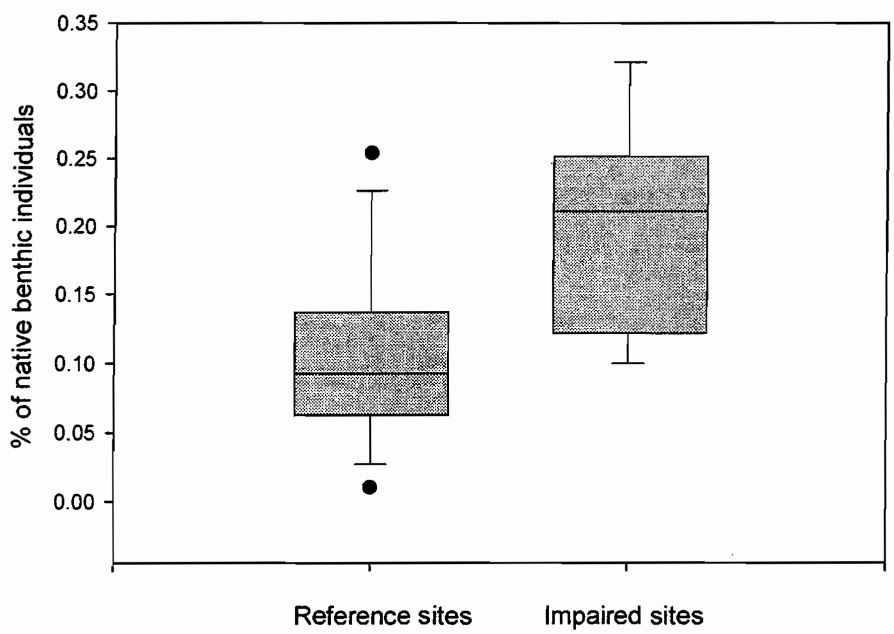
Plain ecoregion metrics



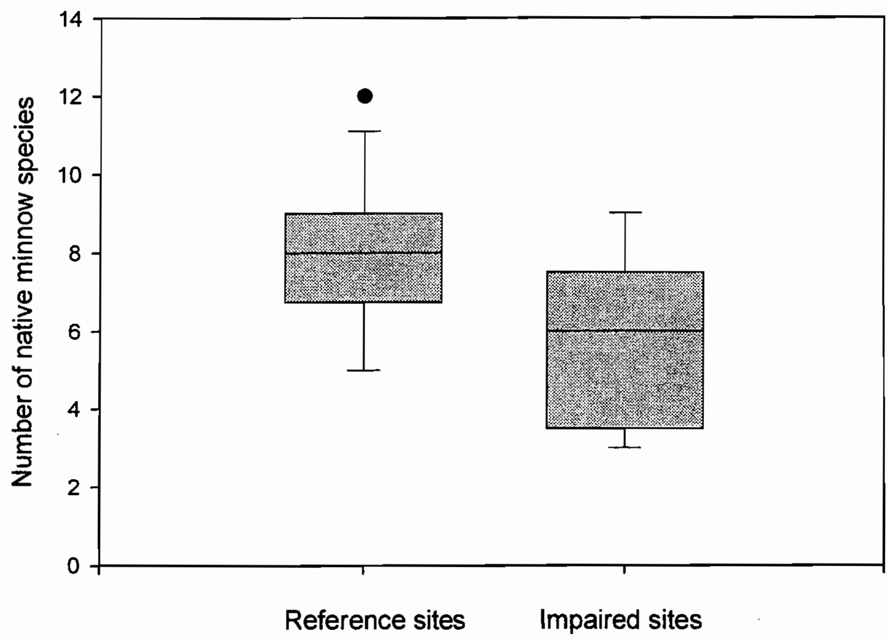


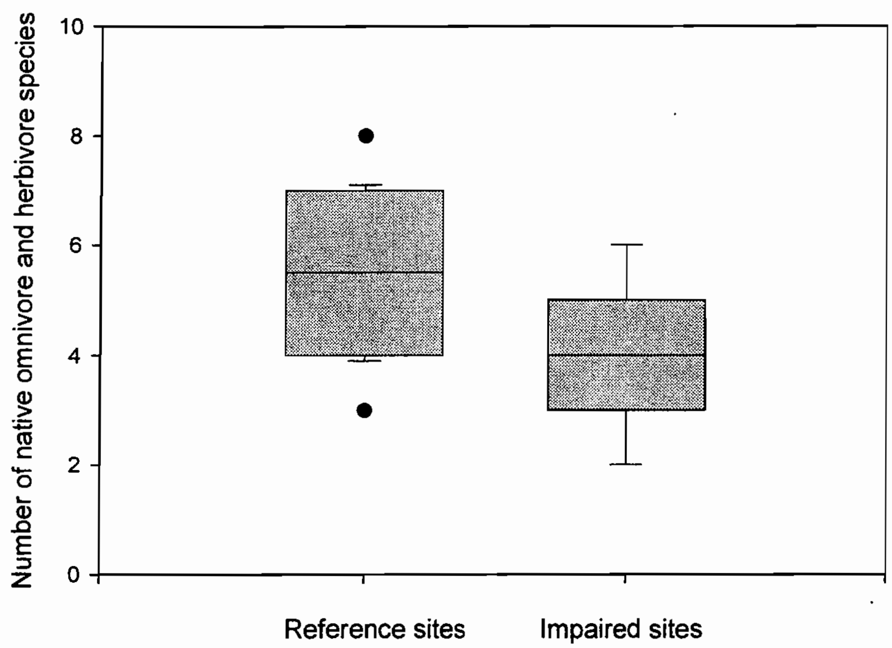
Plain ecoregion metrics



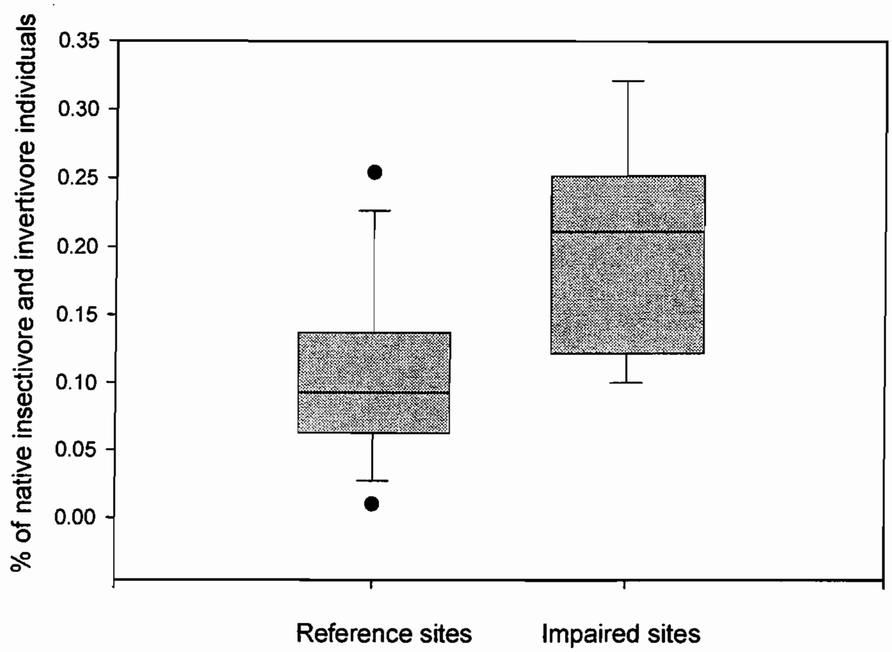


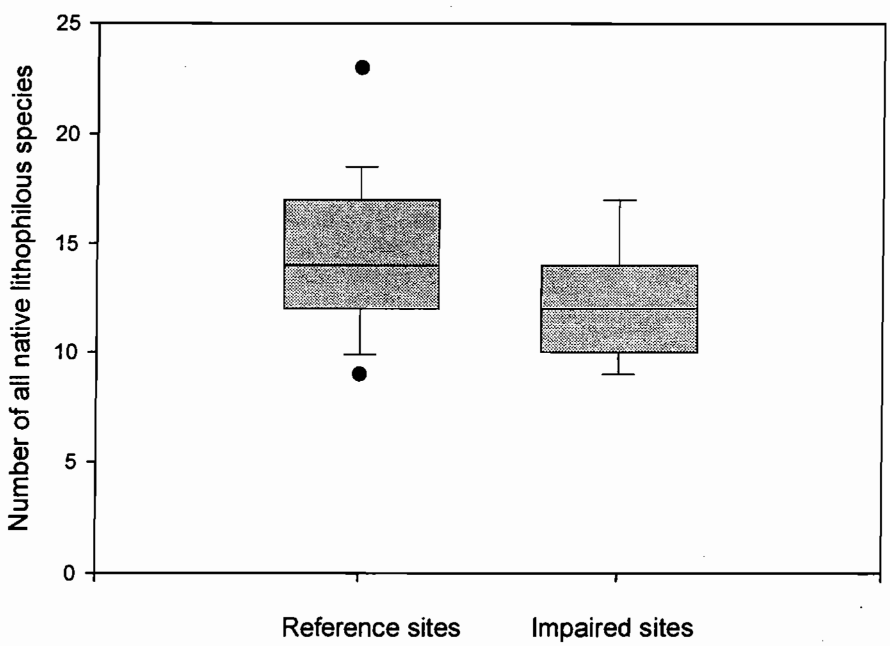
Plain ecoregion metrics



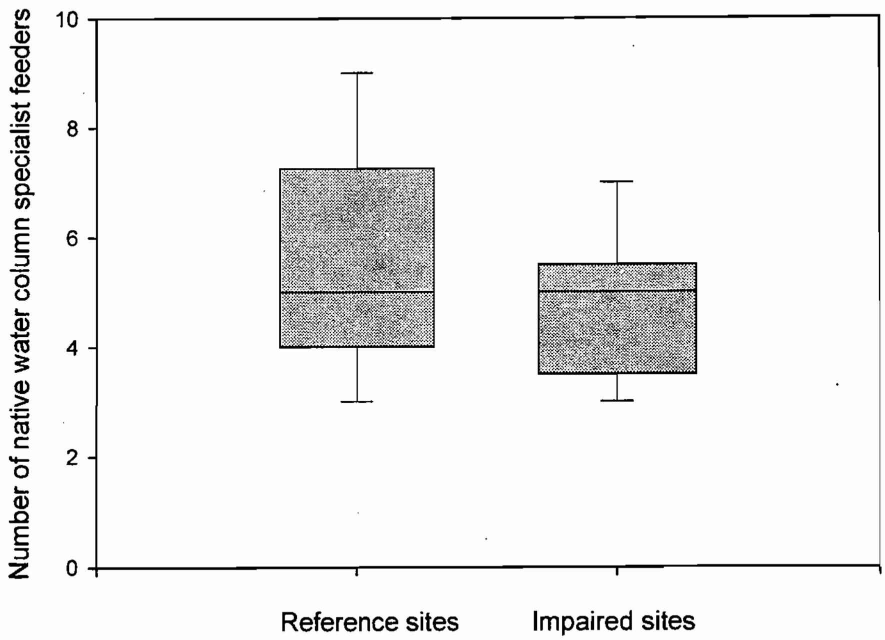


Plain ecoregion metrics



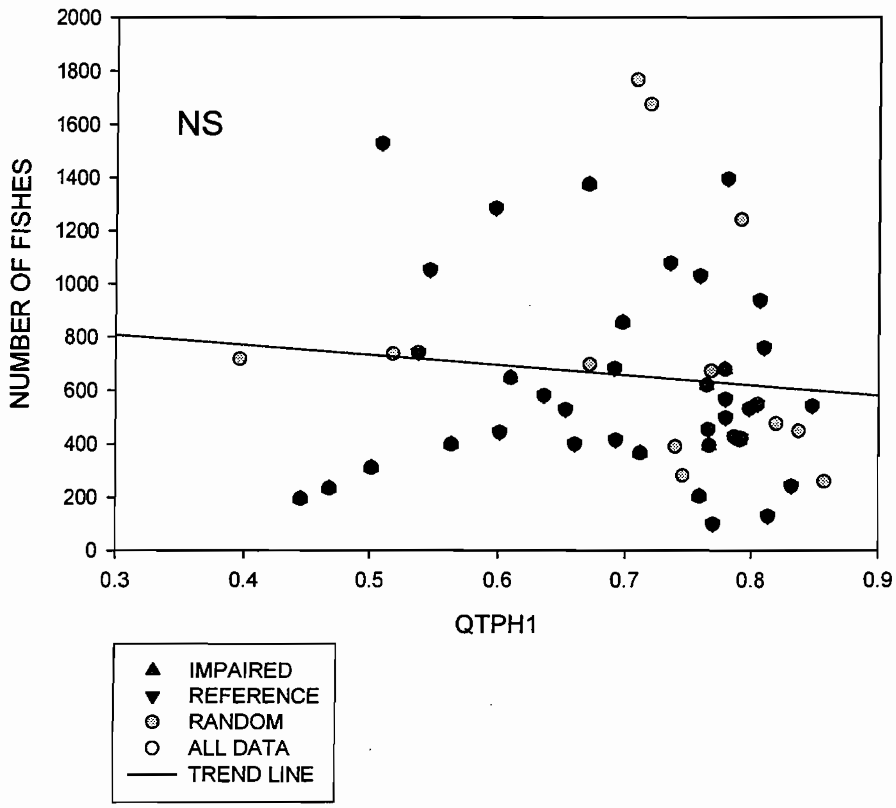


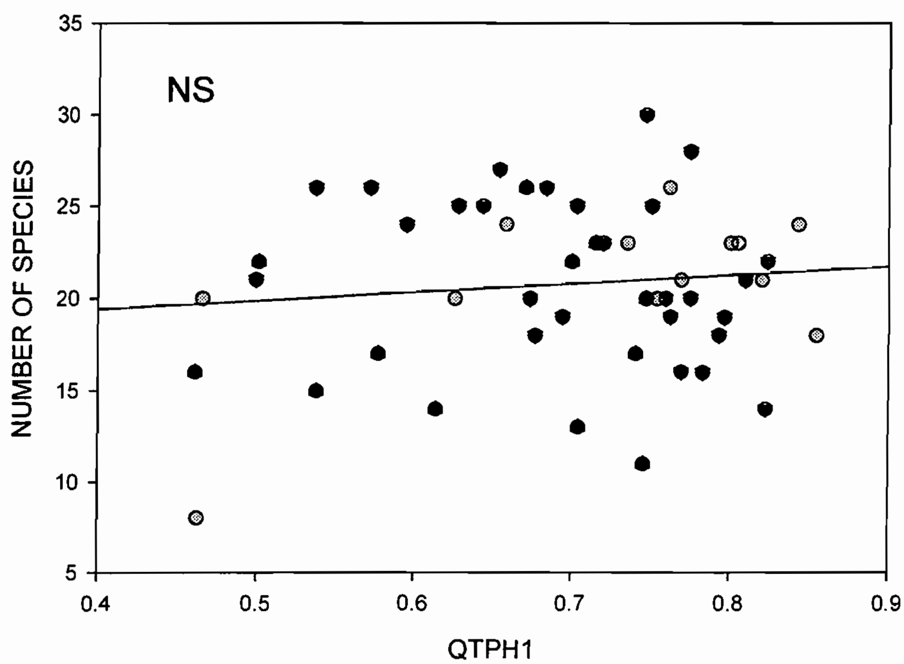
Plain ecoregion metrics



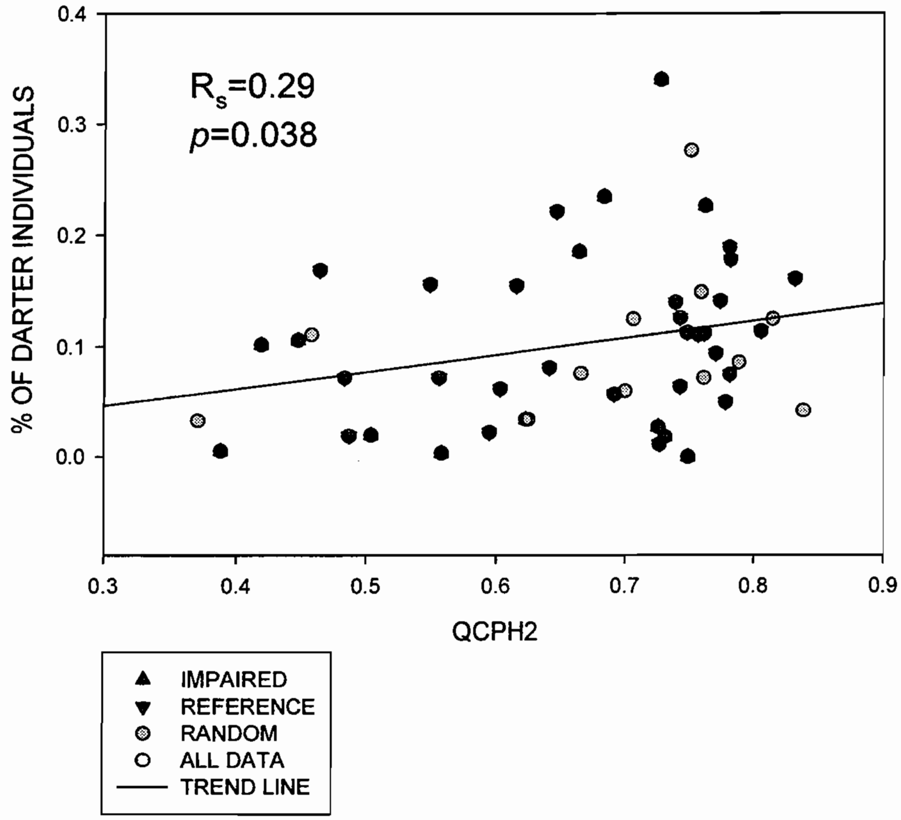
Appendix E. Spearman rank correlations of Ozark metrics with the final habitat index scores.

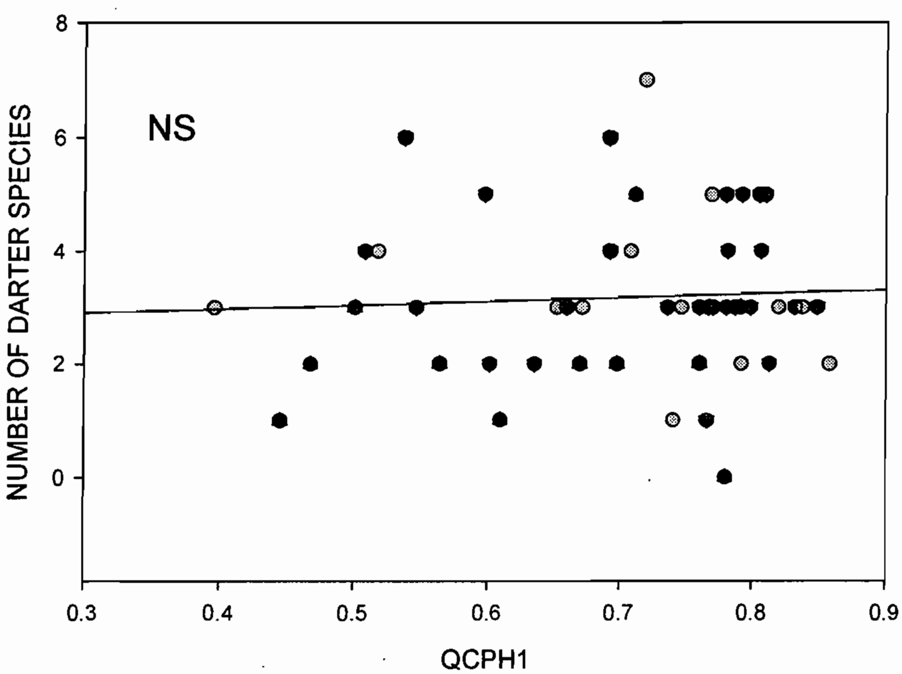
OZARK ECOREGION



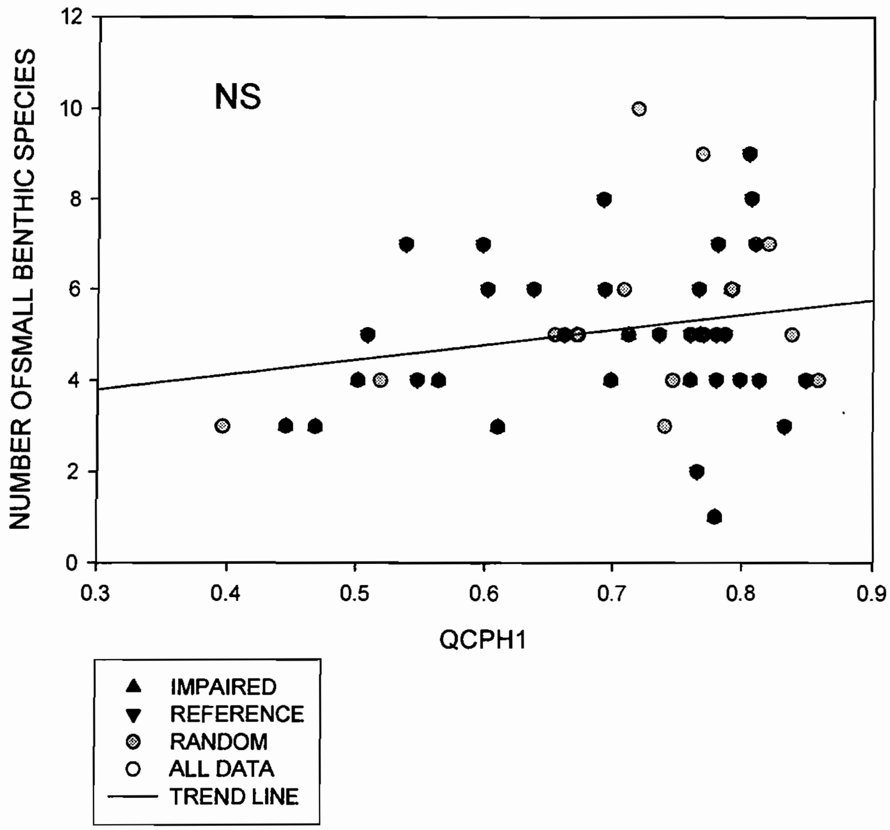


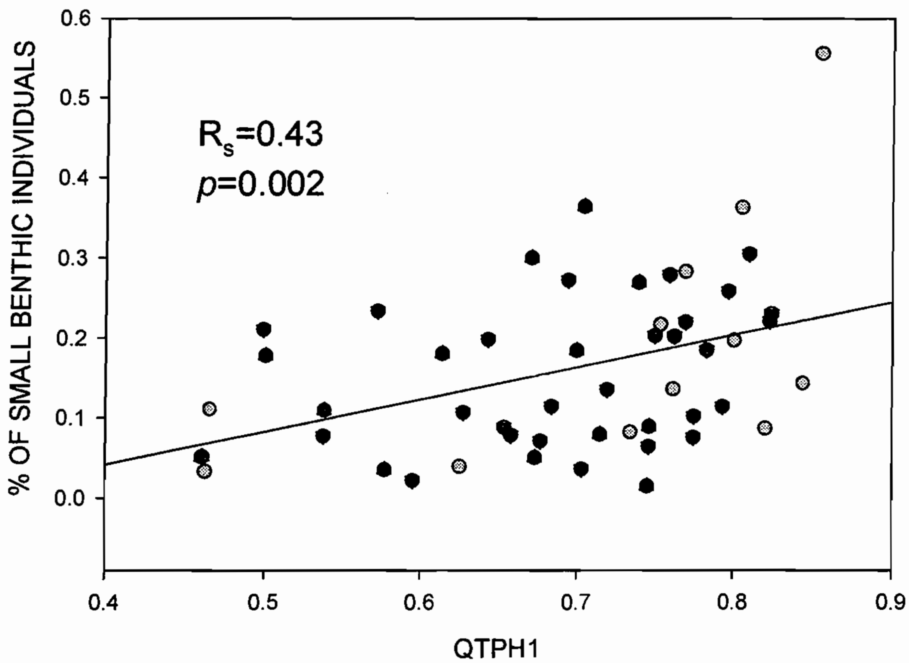
OZARK ECOREGION



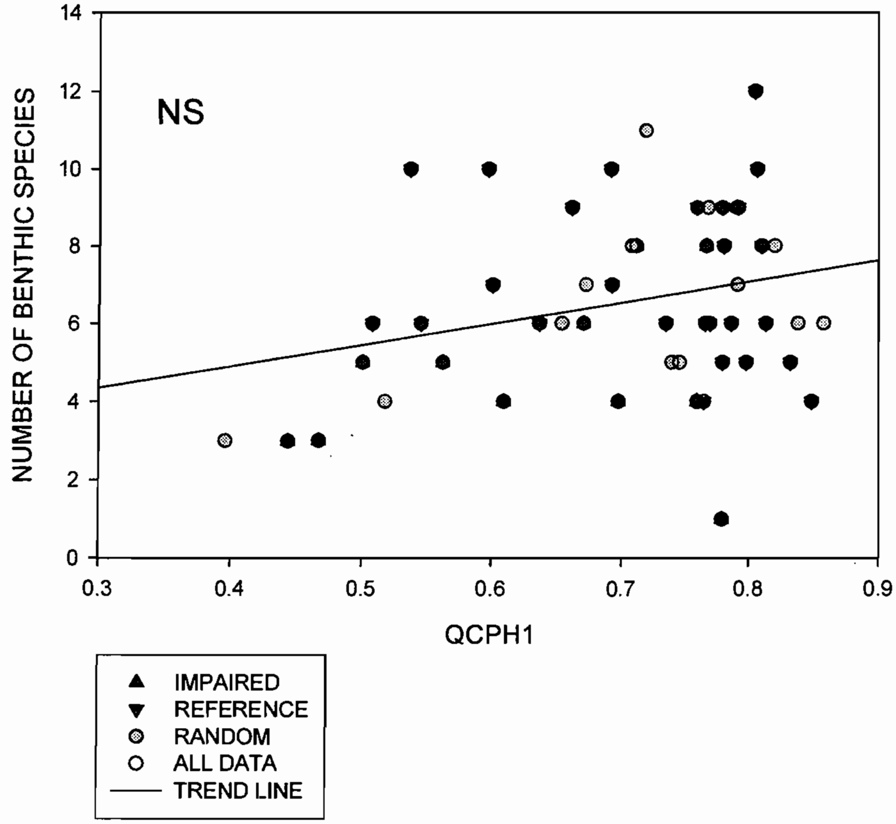


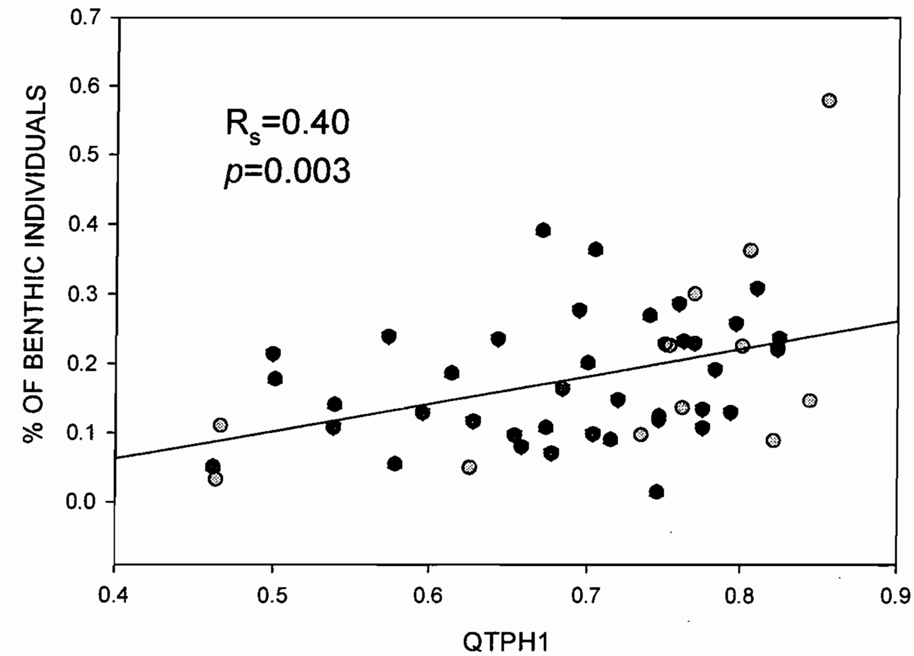
OZARK ECOREGION



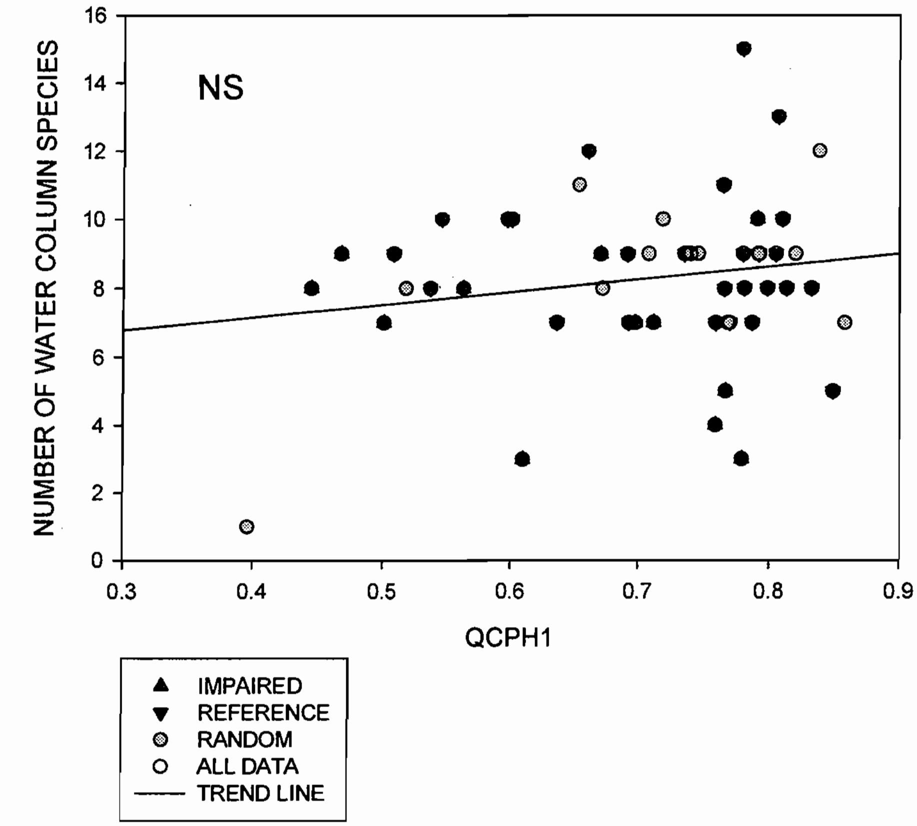


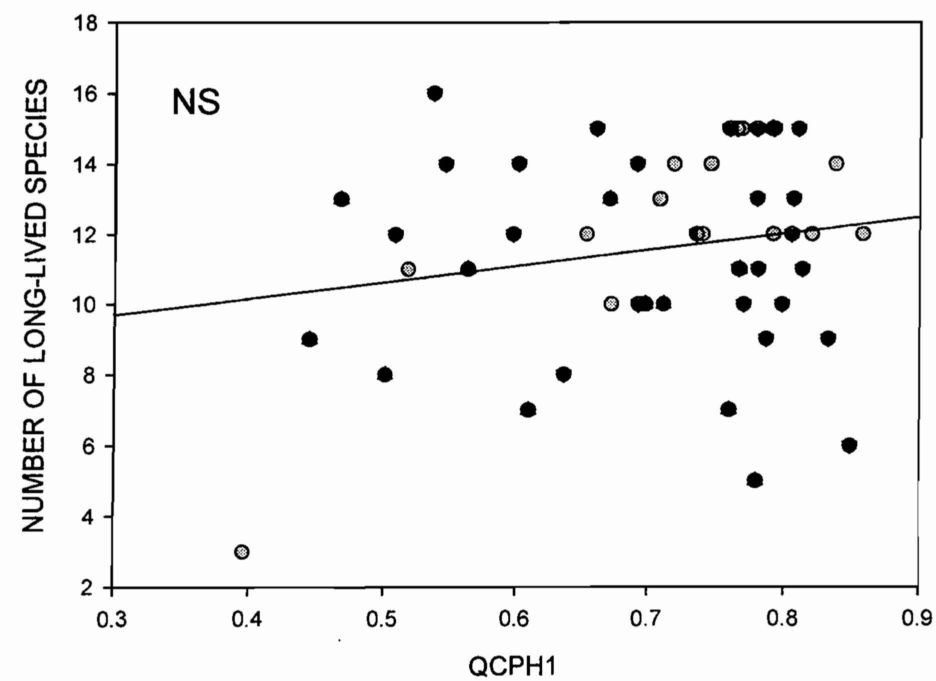
OZARK ECOREGION



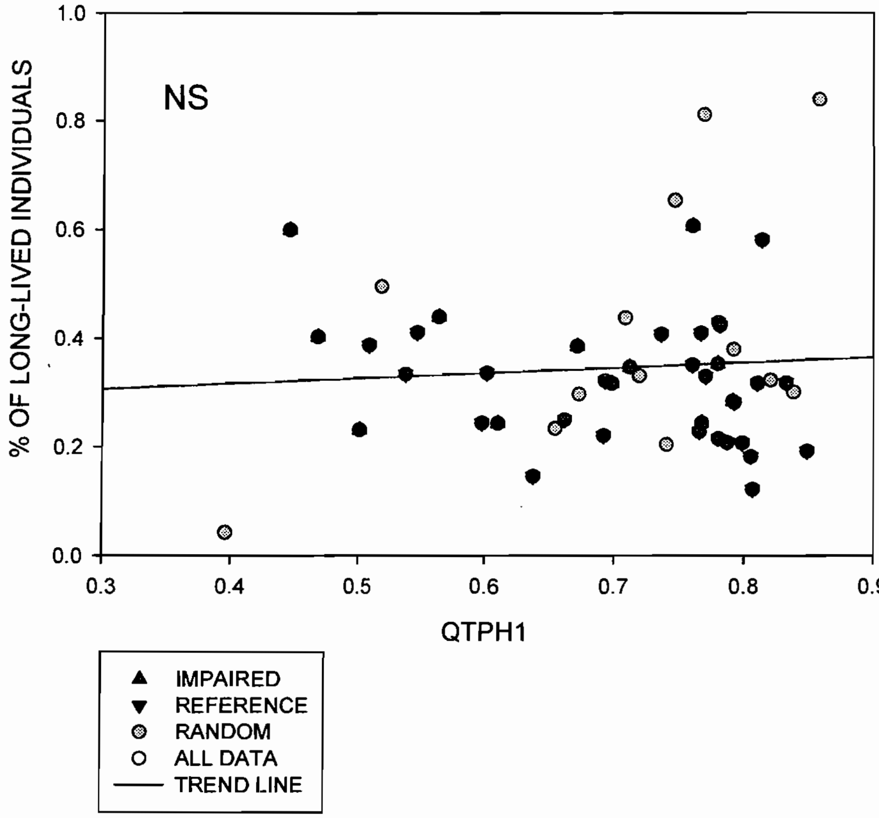


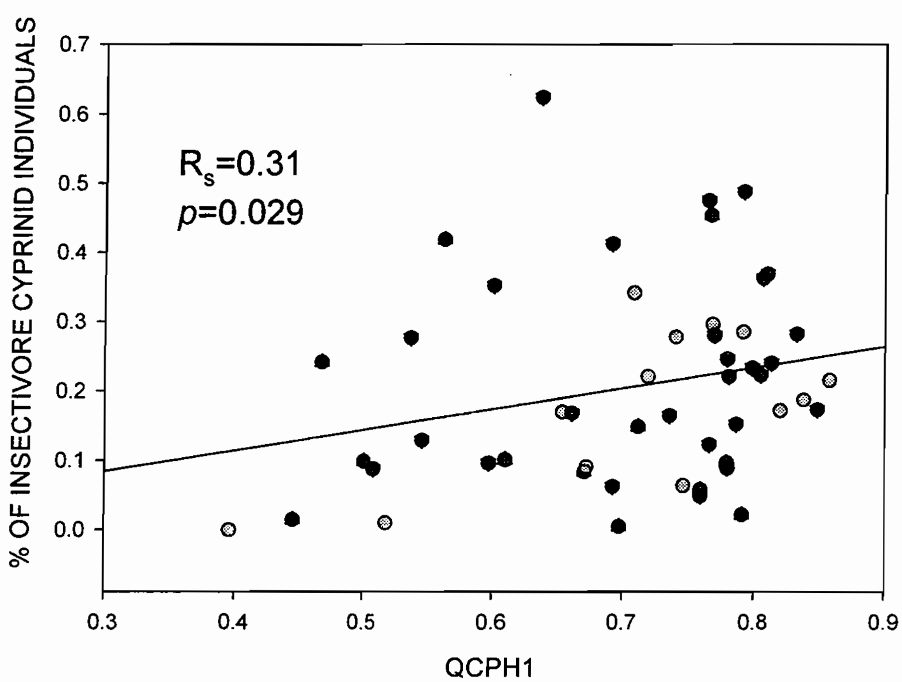
OZARK ECOREGION





OZARK ECOREGION





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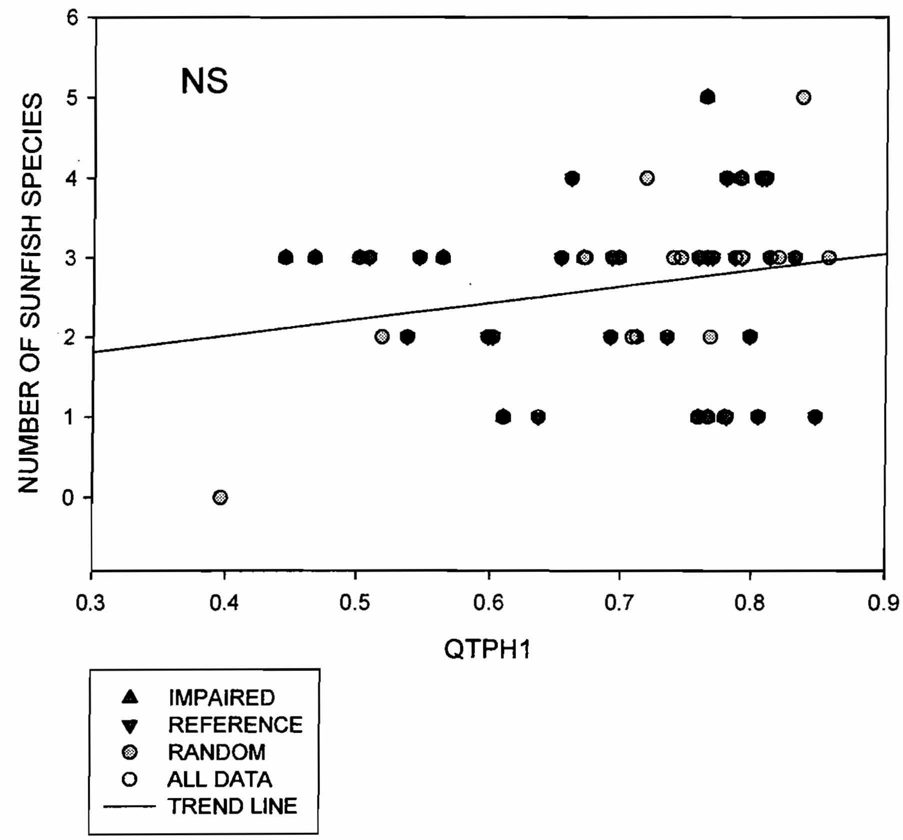

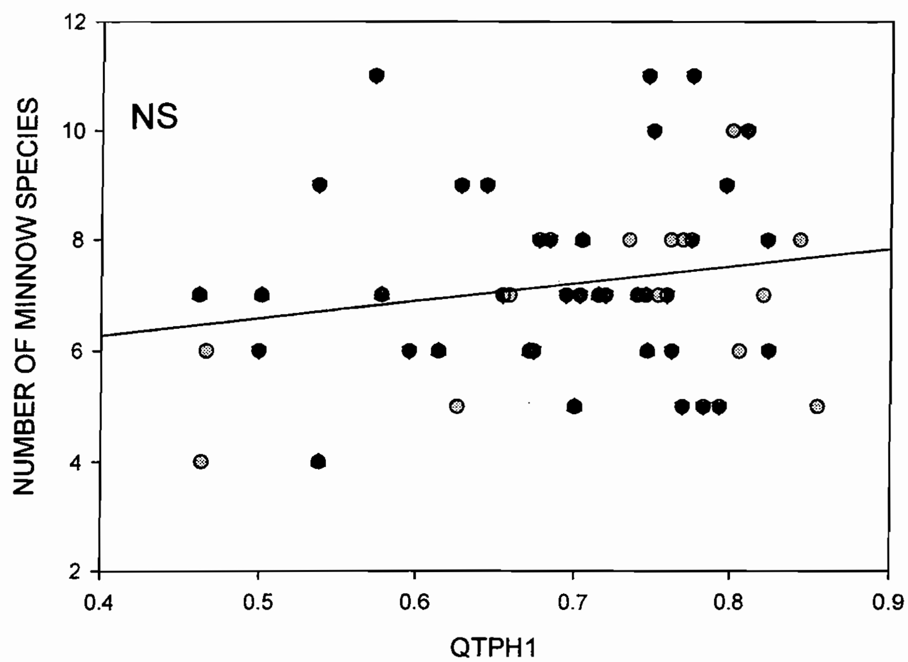

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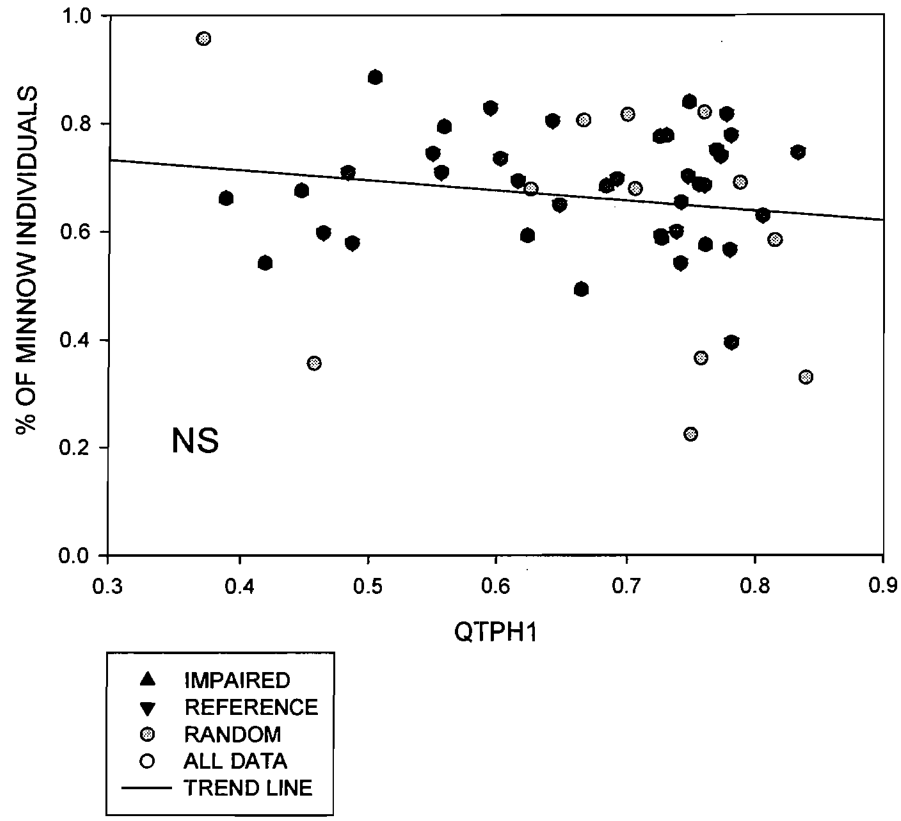

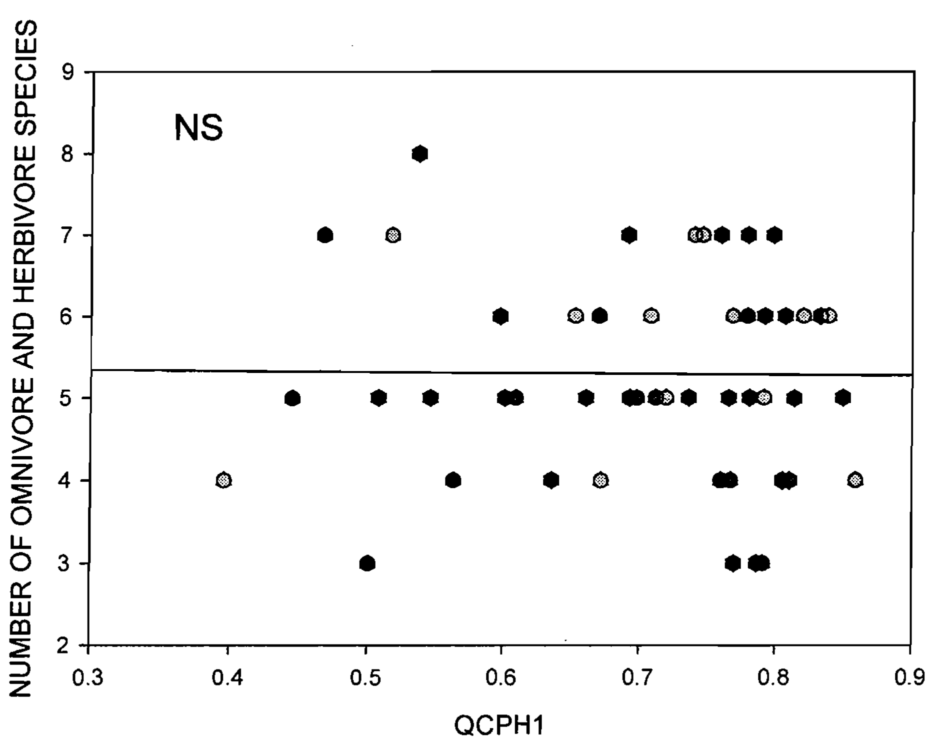

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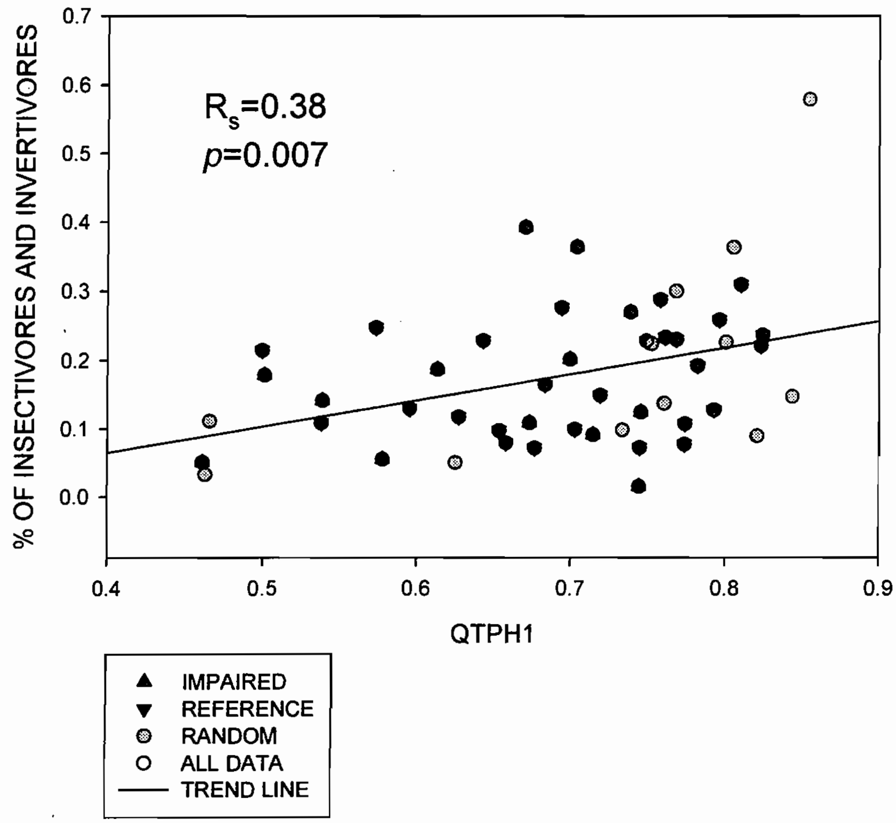
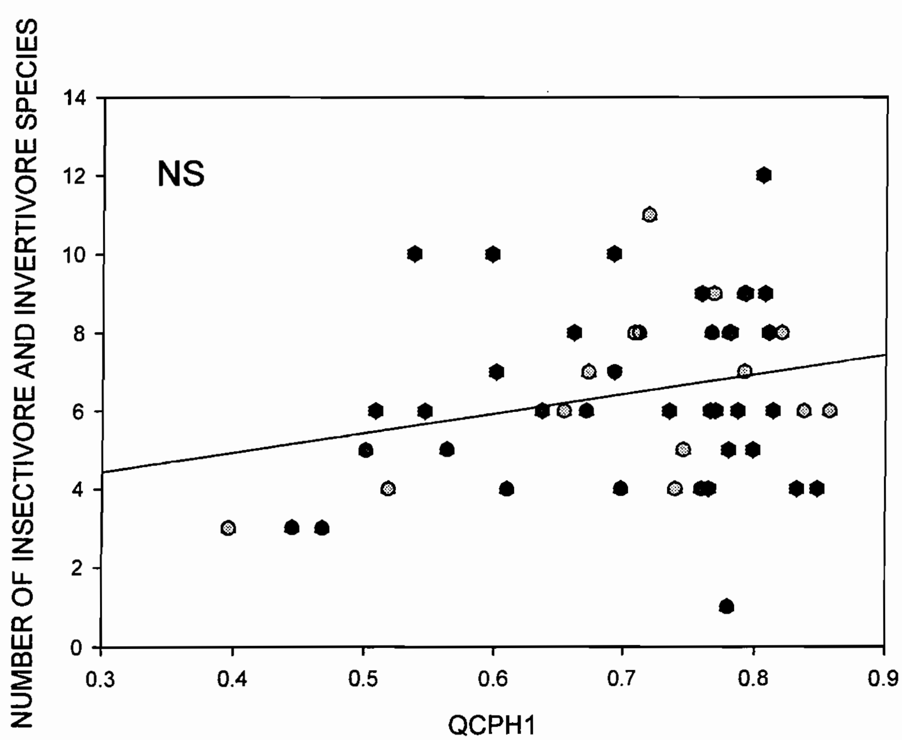
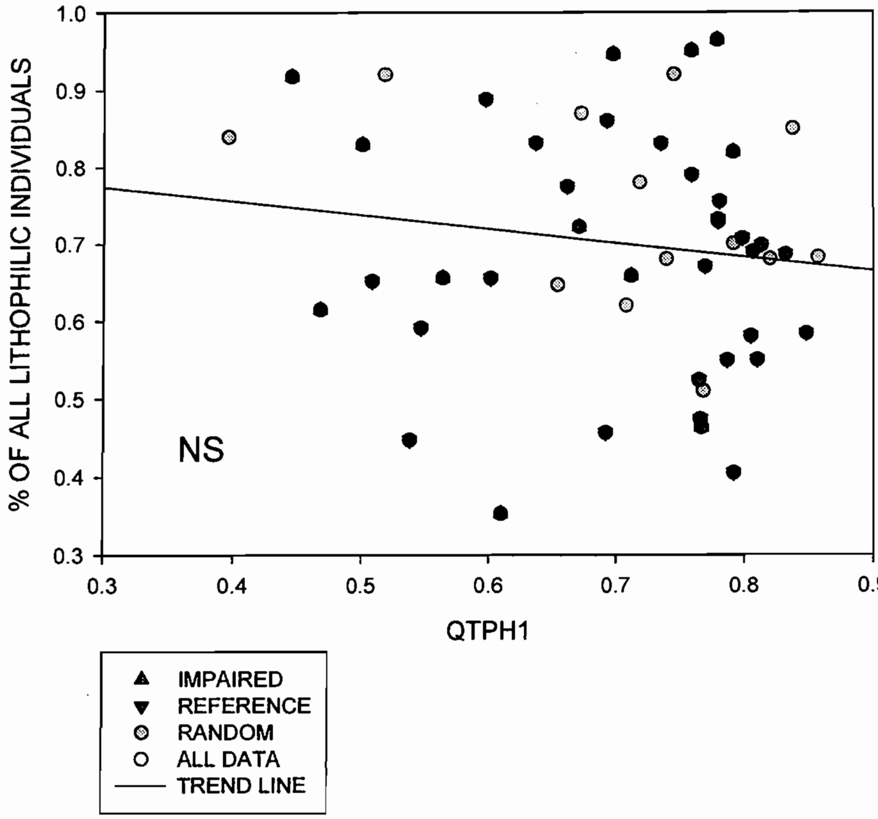
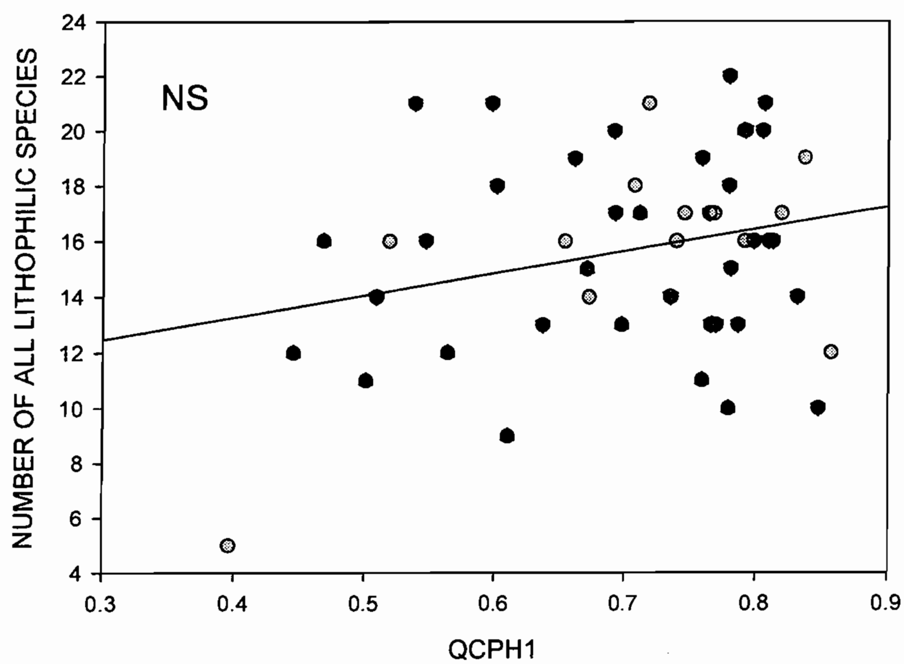
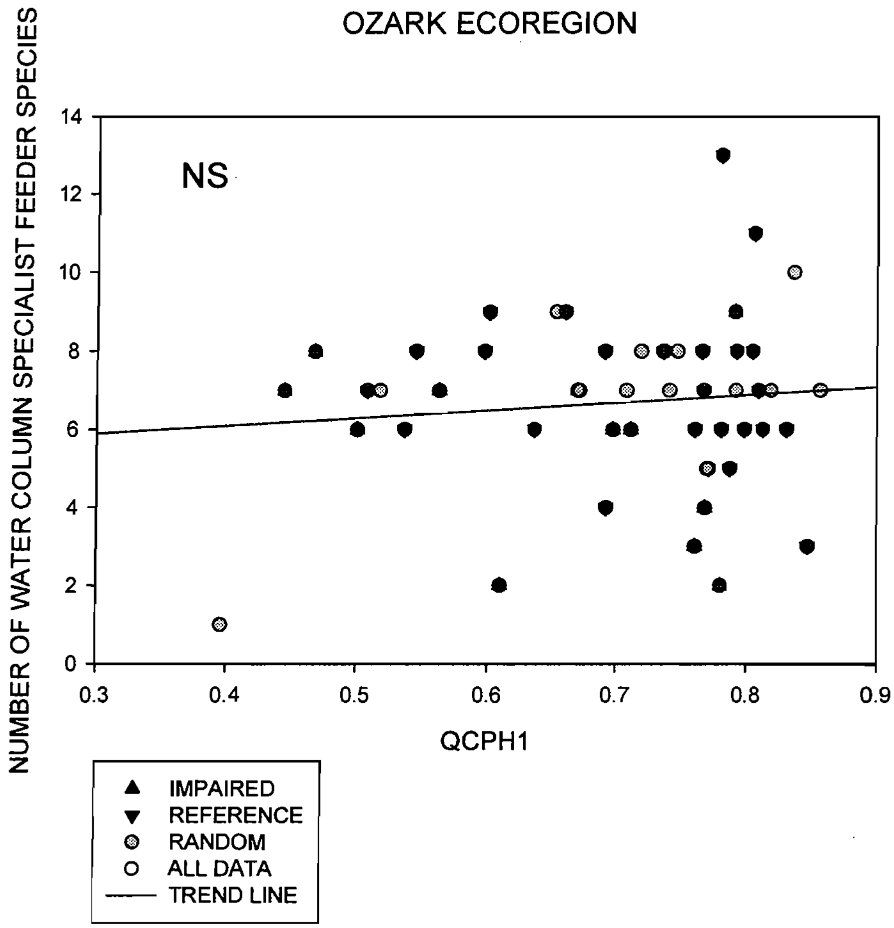




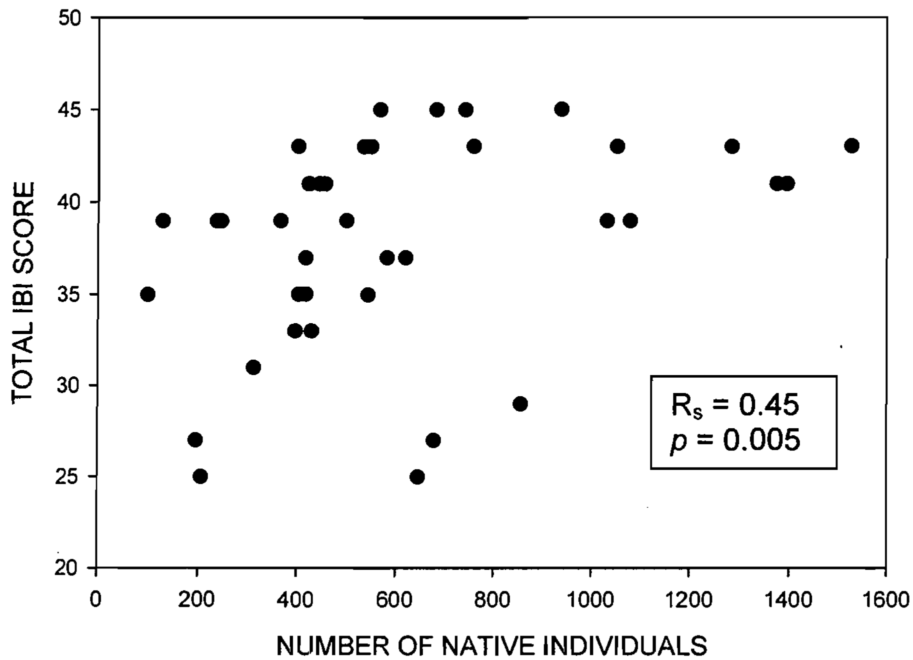
OZARK ECOREGION

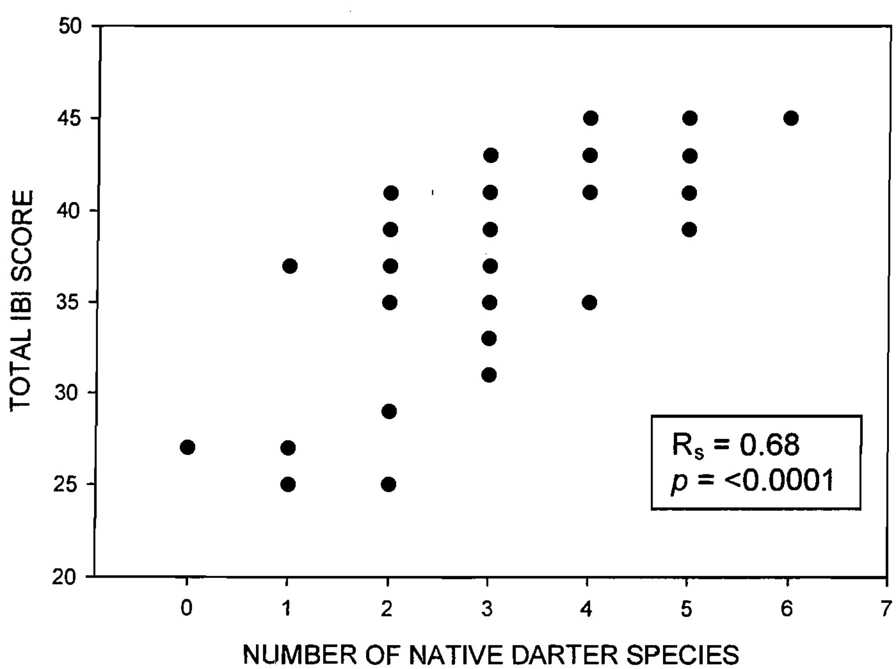


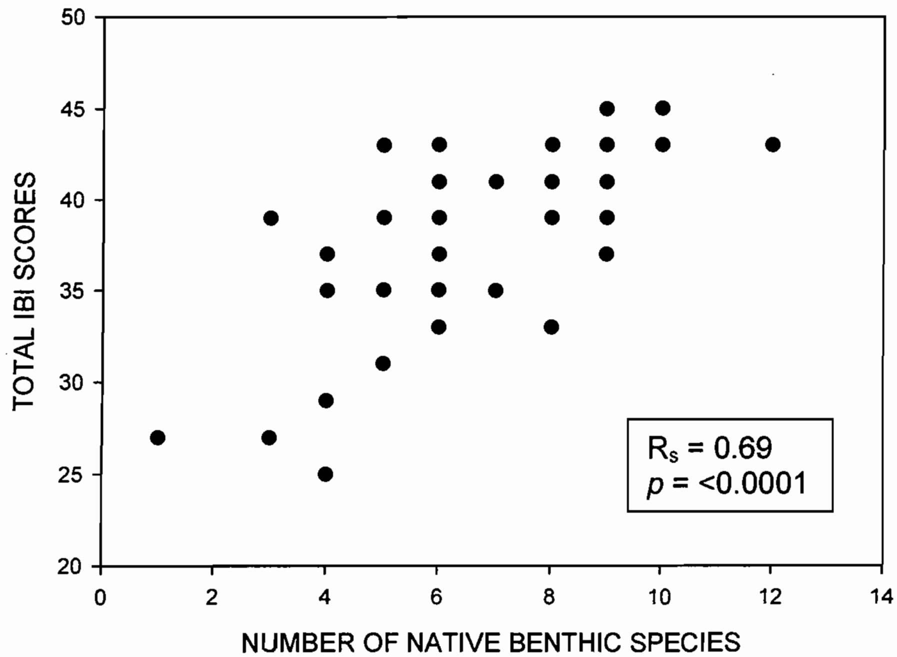


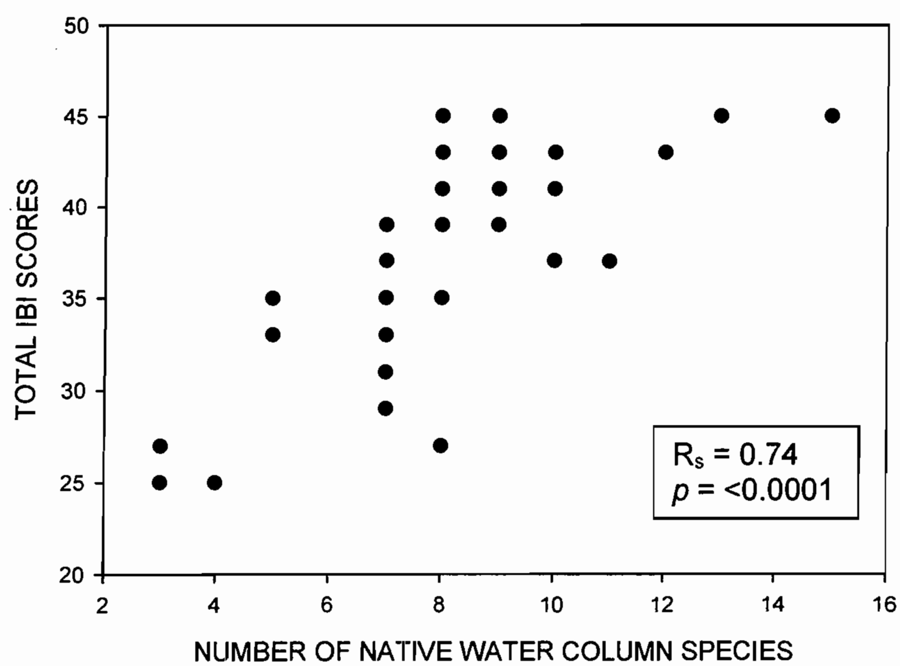

OZARK ECOREGION
NUMBER OF WATER COLUMN SPECIALIST FEEDER SPECIES
NS
14
12
10
8
6
4
2
0
0.3
0.4
0.5
0.6
0.7
0.8
0.9
QCPH1
IMPAIRED
REFERENCE
RANDOM
ALL DATA
TREND LINE

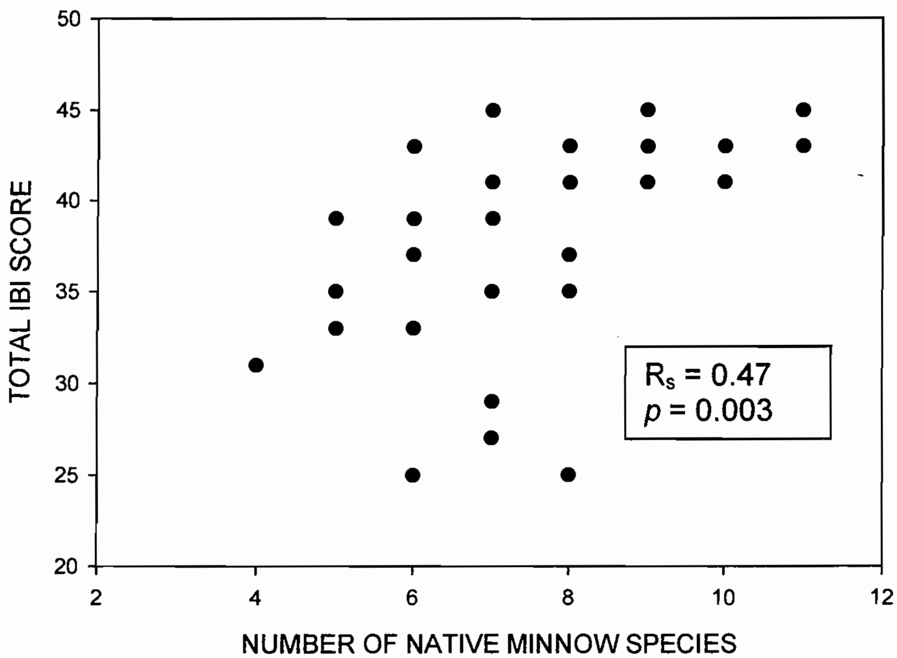
Appendix F. Scatter plots of the raw metric data to the total IBI scores for the Ozark ecoregion and the result of a Spearman rank correlation between the variables.

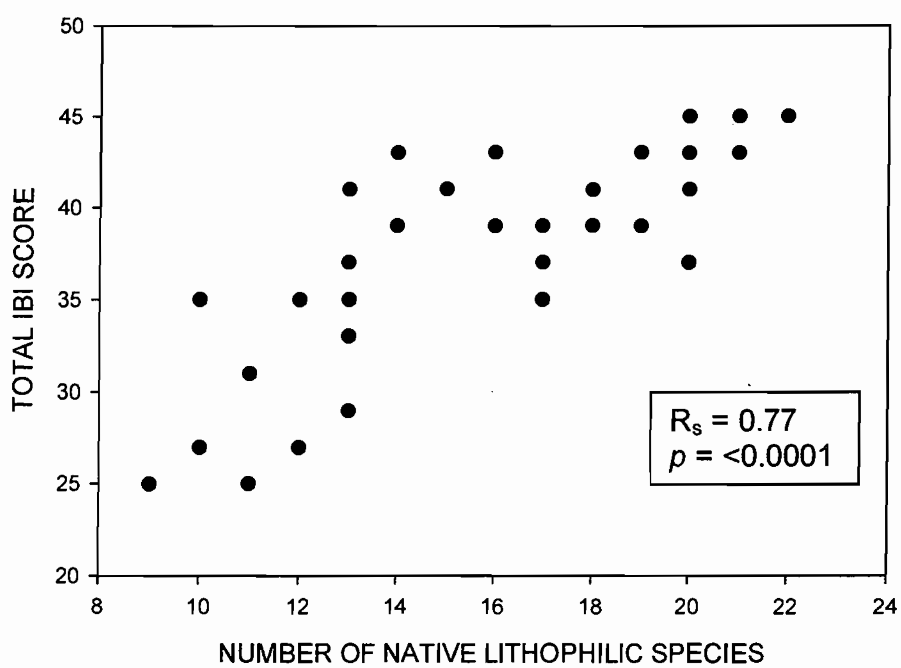


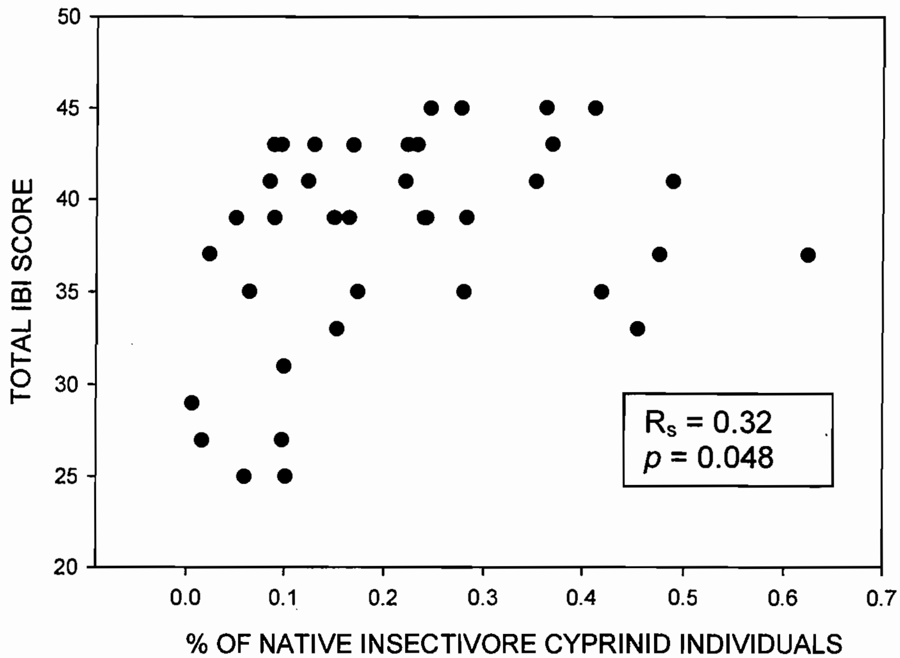



TOTAL IBI SCORES
NUMBER OF NATIVE BENTHIC SPECIES
R_s = 0.69
p = <0.0001

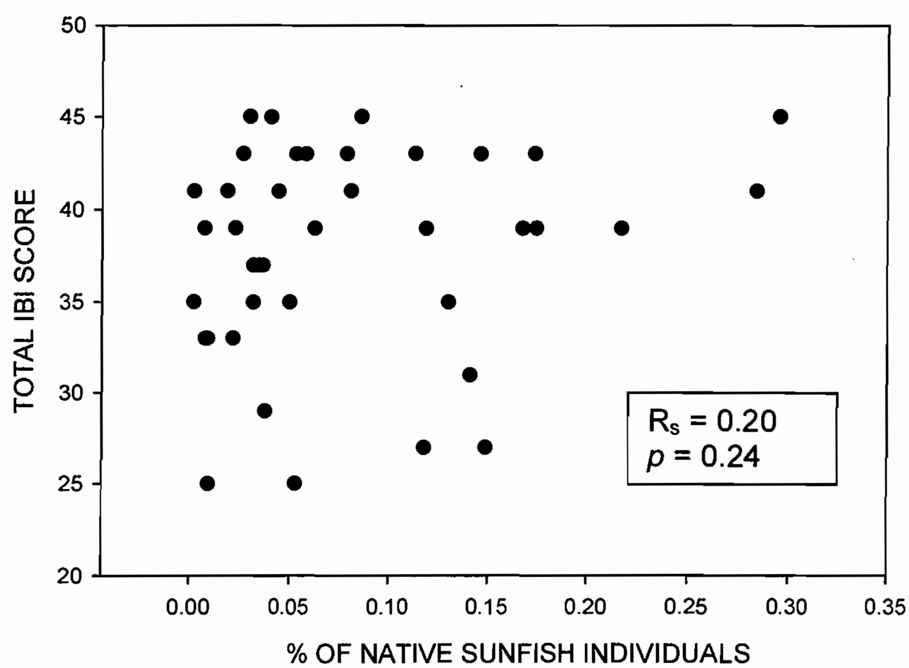

TOTAL IBI SCORES
NUMBER OF NATIVE WATER COLUMN SPECIES
R_s = 0.74
p = <0.0001


50
45
40
35
30
25
20
TOTAL IBI SCORE
2
4
6
8
10
12
NUMBER OF NATIVE MINNOW SPECIES
Rs = 0.47
p = 0.003

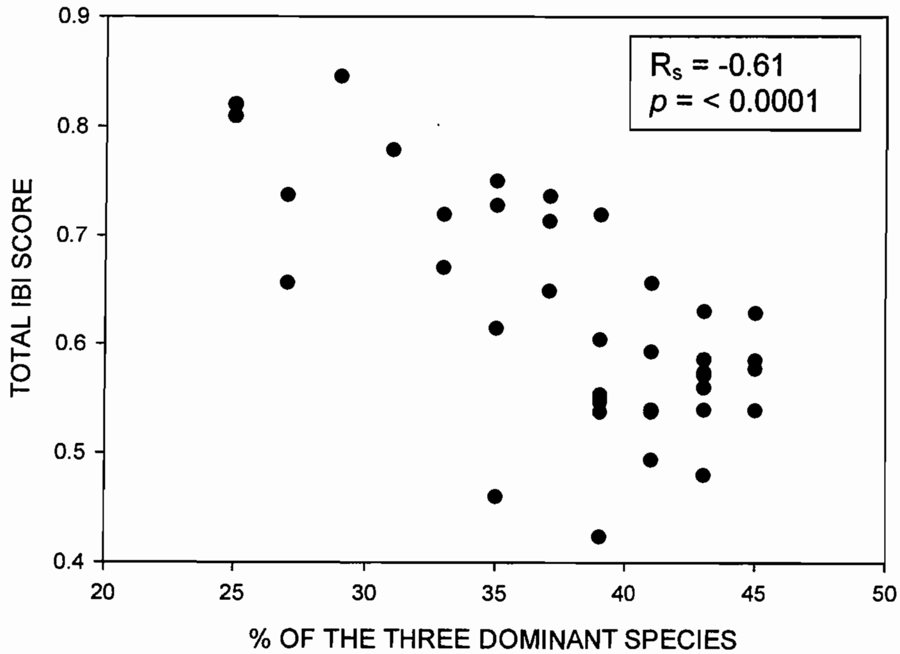

50
45
40
35
30
25
20
TOTAL IBI SCORE
8
10
12
14
16
18
20
22
24
NUMBER OF NATIVE LITHOPHILIC SPECIES
Rs = 0.77
p = <0.0001



50
45
40
35
30
25
20
TOTAL IBI SCORE
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
% OF NATIVE INSECTIVORE CYPRINID INDIVIDUALS
R_s = 0.32
p = 0.048



50
45
40
35
30
25
20
TOTAL IBI SCORE
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
% OF NATIVE SUNFISH INDIVIDUALS
R_s = 0.20
p = 0.24



R_s = -0.61
p = < 0.0001
TOTAL IBI SCORE
0.9
0.8
0.7
0.6
0.5
0.4
20
25
30
35
40
45
50
% OF THE THREE DOMINANT SPECIES

Appendix G. Streams and associated IBI scores for targeted watersheds (EPA-R7WWPD-05-005) taken from the RAM data sets.

Unique ID	Storet	Stream name	HUC	Watershed	IBI score[1]
95221-02	9522	Gallinipper Creek	10290105	Harry S Truman Reservoir	31
96741-02	9674	Little Sac River	10290106	Sac	39
20181-02	2018	Cedar Creek	10290106	Sac	45
96731-02	9673	Pomme De Terre R.	10290107	Pomme de Terre	45
20201-01	2020	Deer Creek	10290109	Lake of the Ozarks	39
20201-02	2020	Deer Creek	10290109	Lake of the Ozarks	35
RES061-05	030231-05	Roubidoux Creek	10290201	Upper Gasconade	41
95211-02	9521	Big Piney River	10290202	Big Piney	45
RES051-05	020221-05	West Piney River	10290202	Big Piney	43
96941-02	9694	Gourd Creek	10290203	Lower Gasconade	39
00051-00	0005	Hinkson Creek	10300102	Lower Missouri- Moreau	39
00121-00	0012	North Moreau Creek	10300102	Lower Missouri- Moreau	37
01011-01	0101	Bear Creek	10300102	Lower Missouri- Moreau	25
20141-03	2014	Burris Fork	10300102	Lower Missouri- Moreau	39
20801-04	2080	Hinkson Creek	10300102	Lower Missouri- Moreau	29
20811-04	2081	Straight Fork	10300102	Lower Missouri- Moreau	41
20951-04	2095	Hillers Creek	10300102	Lower Missouri- Moreau	39
20981-04	2098	Hungry Mother Creek	10300102	Lower Missouri- Moreau	21
20991-04	2099	Koch Creek	10300200	Lower Missouri	19
20151-02	2015	Boeuf Creek	10300200	Lower Missouri	41
20771-04	2077	Boeuf Creek	10300200	Lower Missouri	43
20921-04	2092	Boeuf Creek	10300200	Lower Missouri	43
20941-04	2094	Big Berger Creek	10300200	Lower Missouri	45
01031-01	0103	Wilson Creek	11010002	James	35
22151-05	302	Panther Creek	11010002	James	37
01071-01	0107	Pearson Creek	11010002	James	33
22411-05	5538	Beaver Creek	11010003	Bull Shoals Lake	37
22501-05	7611	S. Fk. Bratten Spring Ck.	11010003	Bull Shoals Lake	39
95481-01	9548	Bull Creek	11010003	Bull Shoals Lake	41
20211-02	2021	North Fork White River	11010006	North Fork of the White	43
22181-05	658	Indian Creek	11010006	North Fork of the White	41
22191-05	733	Noblett Creek	11010006	North Fork of the White	43
22201-05	845	Spring Creek	11010006	North Fork of the White	41
22241-05	940	Rippee Creek	11010006	North Fork of the White	41
22251-05	1098	Fox Creek	11010006	North Fork of the White	43
22291-05	1655	Pine Creek	11010006	North Fork of the White	43
RES131-05	040041-05	Hunter Creek	11010006	North Fork of the White	39

Appendix G continued.

Unique ID	Storet	Stream name	HUC	Watershed	IBI score[1]
20221-02	2022	Sinking Creek	11010007	Upper Black	45
21181-04	4139	Shut In Creek	11010007	Upper Black	43
21081-04	4058	Middle Fork Black River	11010007	Upper Black	37
20231-02	2023	Sinking Creek	11010008	Current	35
21071-04	561	Barren Fork	11010008	Current	35
21121-04	2145	Pine Creek	11010008	Current	45
21122-04	2145	Pine Creek	11010008	Current	45
21141-04	3263	South Fork Buffalo Creek	11010008	Current	45
21271-04	529	Sinking Creek	11010008	Current	37
21301-04	3200	Buffalo Creek	11010008	Current	45
96751-02	9675	Sinking Creek	11010008	Current	33
21201-04	7691	Hurricane Creek	11010011	Eleven Point	37
21251-04	8408	Mill Creek	11010011	Eleven Point	45
01081-01	0108	North Fork Spring River	11070207	Spring	33
00141-00	0014	Buffalo Creek	11070208	Elk	25
00171-00	0017	Indian Creek	11070208	Elk	33
20131-02	2013	Big Sugar Creek	11070208	Elk	37

[1] scores > 37 indicate *no impairment*, scores from 29 - 36 indicate *impaired* conditions, and scores < 29 indicate *highly impaired* conditions.