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TITLE: Measuring the status and trends of biological resources in Kansas using Environmental Monitoring and Assessment Program probability based sampling design (R-EMAP)

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FOREWORD:

The Regional Environmental Monitoring and Assessment Program is an ongoing study to collect baseline data for long term monitoring of streams and riparian areas. This report represents the completion of the second year of the first five year rotation of stream surveys in the state of Kansas. The EPA will present a final report with complete data analysis.

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INTRODUCTION

The U.S. Environmental Protection Agency (EPA) began the Environmental Monitoring and Assessment Program in 1989. It was designated to develop monitoring tools for determining the current status and trends in the condition of ecological resources on a regional, as well as national, scale. Some of these tools included indicators of ecological condition and statistical sampling designs. The data collected would give insight into whether or not ecological resources are responding positively, negatively or not at all to existing or future regulatory programs (Lazorchak, 1998).

In 1994, the U.S. EPA initiated the Regional Environmental Monitoring and Assessment Program (R-EMAP) in EPA Region VII. This study consisted of two years of stream surveys to be repeated every five years. The purpose of this study was to determine the current health and quality of the fisheries in Region VII and establish baseline data to be used in evaluating trends throughout the region. Kansas Department of Wildlife and Parks (KDWP) conducted the field work and presented the data from the 1994 and 1995 survey sites to the EPA (see Waters 1997a and 1997b for details).

The specific objectives of the 2000/2001 R-EMAP project were a) to collect data to measure the status of biological integrity and riparian habitat quality of the state's stream resources, b) to measure any changes in the biological integrity and habitat quality by comparing current data to data collected in Kansas during the 1994/1995 R-EMAP project, c) to determine whether differences exist between fish communities from the different ecoregions of Kansas, and d) to test, and if necessary, refine the Index of Biological Integrity (IBI) developed during the 1994/1995 project for fish communities in Kansas ecoregions.

KDWP collected data on the biological community (fish and macroinvertebrates), physical habitat (including riparian condition, substrate condition, and channel type) and water chemistry. In addition, we sent water, sediment, and fish tissue samples to the EPA for further chemical and nutrient analysis.

SITE SELECTION

In 1994, the EPA generated hundreds of random sites, from which 39 were deemed suitable based on presence of water and landowner permission. In addition to these random sites, KDWP selected five "discretionary sites" to be used to evaluate known or suspected water quality or habitat problems, to measure ecoregion reference sites, and/or provide additional random sites. Four more sites were designated as ecoregion reference sites to represent the best attainable habitat, water quality, and biological characteristics of an ecoregion (Waters, 1997a).

During the 2000 survey season, 34 of the 39 random sites were revisited. These consisted of sites which were greater than 70% wadeable and those not repeated during the 1994 survey season. In addition, 11 reference sites were surveyed during 2000. These included reference or discretionary sites surveyed in 1994 or 1995. Other reference sites were selected based on existing KDWP stream data, information from other agencies, and logistical accessability (Hase, 2001).

Thirty random sites were selected from a list of hundreds for 1995. Many sites were surveyed more than once during the 1995 season, and some 1994 sites were resurveyed in 1995. There were nine ecoregion reference sites and an additional ten Kansas Biological Criteria (KBC) sites surveyed in 1995. The KBC sites were used to provide examples of the best attainable biological characteristics of the ecoregion (Waters 1997b).

In 2001, 26 of the 30 random sites were re-surveyed. These also consisted of sites greater than 70% wadeable, those not repeated during the 1995 season, and those not surveyed in 2000. There were 20 reference sites surveyed in 2001. These included three ecoregion reference sites and three KBC sites surveyed in 1995. The additional 14 reference sites were selected from existing KDWP stream data, information from other agencies, and logistical accessability.

METHODS

Sampling protocols used during the 2000/2001 survey seasons were those established by the EPA for the R-EMAP project in 1994/1995 (USEPA, 1994). These protocols were developed for use in wadeable streams.

Survey crews consisted of five persons. There were different crew members and leaders each year. Sites were surveyed only once during the sampling season of May through September.

Site length was calculated to be forty times the average width with a minimum length of 150 meters and a maximum length of 300 meters. Eleven transects were evenly spaced from a central "x-site". The x-site was the generated latitude and longitude from the EPA in 1994 and 1995. In the case of the hand-picked reference sites, the x-site was the center transect. The x-site was located with a Garmin Survey II Global Positioning System (GPS) and geographic site data generated by the GPS was recorded. When possible, block nets were set up at

each end of the sample reach. Human disturbances adjacent to the sample site were also recorded.

Field water chemistry tests were conducted using a HACH kit. Measurements included dissolved oxygen (DO), turbidity, conductivity, total dissolved solids (TDS), chlorides, sulfates, phosphorus, nitrates, ammonia, alkalinity, pH, and temperature. Weather conditions and ambient temperature were also recorded at each site. In addition to the field water chemistry tests, water and sediment samples were collected and sent to the EPA Region VII Laboratory (EPAL) in Kansas City, Kansas, for pesticide, metal, and nutrient analysis.

Discharge was measured with a Pygmy-Gurley flow meter. Thirty measurements at 60% of the depth were taken across the width of the stream and summed for the total discharge measured in cubic feet per second (cfs).

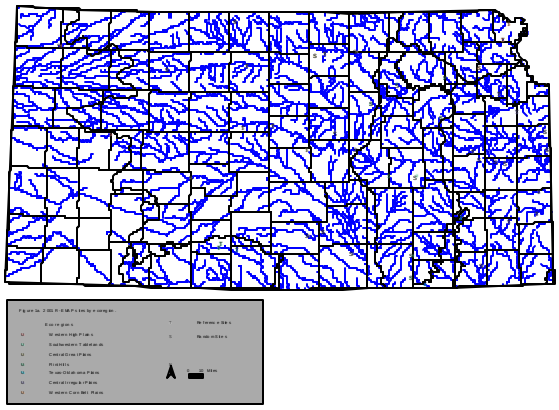
Fish sampling was conducted with a Smith-Root backpack electrofisher and seines of various sizes. The electrofishing was conducted first followed by seining. The number of seining attempts was determined by the complexity and size of the stream. Both methods were used to cover the biases the other has toward particular sizes and species of fish. Each method was timed and the quality of the sampling effort was recorded as a "yes" or "no" for best professional judgement (BPJ). Problems such as equipment malfunction, dry transects, or high water may have led to the site receiving a "no" for BPJ.

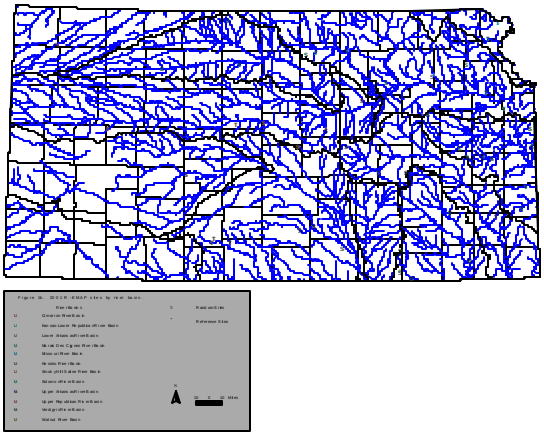
Large, easily identifiable fish were measured, inspected for anomalies, recorded, and released. The Gablehouse Sport Fish Index was used to categorize large sport fish. This index consists of five length categories: stock, quality, preferred, memorable, and trophy. Stock includes the smallest individuals, and trophy includes the largest individuals. Smaller fish were preserved for identification and voucher. All fish were identified as adult or juvenile. A fish specimen of at least 500 grams was sent to the EPAL for tissue analysis.

For each site, an Index of Biological Integrity (IBI) was calculated. This index was developed by the EPA for use during the 1994/1995 R-EMAP program. It consists of ten metrics using channel width as the regulating measure: Fish Family Richness, Fish Species Richness, Minnow Species Richness, Large Benthic Species Richness, Small Benthic Species Richness, Sunfish Species Richness, Percent Omnivores and Generalists, Percent Tolerants, Percent Invertivores, and Total Number of Fish. The EPA classified all fish species to be used in this IBI. The metrics are scaled to scoring of 10 for a total perfect IBI score of 100.

Macroinvertebrates, including aquatic insects and freshwater mussels, were collected at each site. Aquatic insects were sampled using a D-frame kick net at the inner nine transects using a zig-zag pattern. Pool and riffle samples were separated and sorted at the site. Three macrohabitat types were also sampled for ten minutes each. A Habitat Development Index (HDI) score was calculated for the macrohabitat collections. The HDI was developed by the Kansas Biological Survey to score the quality of habitat available to aquatic insects. All specimens collected were preserved at the site for later identification.

For each site, an Ephemeroptera-Plecoptera-Trichoptera (EPT) index was calculated using these three sensitive orders of aquatic macroinvertebrates to relate the stream condition. The numbers of families collected in each of these orders was divided by the total number of identified families collected at the site to give a percentage score.





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Live freshwater mussels and dead shells were collected during a one person hour search at each site. An attempt was made to collect all shell material present at each site or all species present. Live mussels were searched for by hand in shallow water. The live specimens were identified, photographed, or preserved for later verification and voucher. Shell material was identified and categorized as recent or weathered. KDWP considers "recent" shells as evidence of extant populations.

Physical habitat measurements were recorded at each transect. These measurements included wetted width, bankfull width, bankfull height, incised height, thalweg depth, cross-sectional depths, bank angles, canopy cover, substrate size and composition, and sinuosity. Visual assessment of the riparian vegetation, human disturbances, instream fish cover, large woody debris, and channel units was also recorded.

The streams were categorized according to their Strahler stream order, ecoregion, and river basin. Ecoregions in Kansas used in this study include: Western High Plains (WHP), Southwestern Tablelands (ST), Central Great Plains (CGP), Flint Hills (FH), Central Irregular Plains (CIP), Western Corn Belt Plains (WCBP), Texas-Oklahoma Plains (TOP), and Ozark Highlands (OH). River basins of the state include: Cimarron River Basin (CRB), Kansas-Lower Republican River Basin (KLR), Lower Arkansas River Basin (LARB), Marais des Cygnes River Basin (MDC), Missouri River Basin (MRB), Neosho River Basin (NRB), Smoky Hill-Saline River Basin (SHS), Solomon River Basin (SRB), Upper Arkansas River Basin (UARB), Upper Republican River Basin (URRB), Verdigris River Basin (VRB), and the Walnut River Basin (WRB).

RESULTS – 2001

General

There were a total of 46 sites surveyed throughout the state during the 2001 R-EMAP project. These included 26 random sites and 20 reference sites (Table 1). Sites were located in seven of the eight ecoregions: 6 in the Western High Plains, 3 in the Southwestern Tablelands, 12 in the Central Great Plains, 8 in the Flint Hills, 2 in the Texas-Oklahoma Plains, 12 in the Central Irregular Plains, and 3 in the Western Corn Belt Plains (Figure 1a). Sites were distributed through ten of the twelve river basins: 8 in the Kansas-Lower Republican, 7 in the

Table 1. KDWP R-EMAP 2001 stream survey geographic site data.

Site#	Date	Stream	Order	County	Ecoreg.	Basin	1/4	Sec.	Town.	Range	Latitude	Longitude
02101	20-May-01	Spring Creek	1	Cowley	28	Verdigris	SE	16	31S	8E	37-21-05	096-31-32
02105	11-Jun-01	Beaver Creek	4	Cheyenne	25	Upper Republican	SE & NE	24 & 25	5S	37W	39-35-56	101-25-05
02107	12-Jun-01	Sand Creek	3	Graham	27	Solomon	SE	8	8S	23W	39-21-58	099-54-32
02108	13-Jun-01	West Beaver Creek	3	Smith	27	Solomon	NE	1	2S	15W	39-54-40	098-57-41
02110	25-Jun-01	Parsons Creek	4	Washington	27	Kansas-Lower Republican	SE	25	5S	1E	39-34-55	097-15-52
02111	20-Aug-01	Kitten Creek	2	Riley	28	Kansas-Lower Republican	SE	36	9S	6E	39-13-13	096-42-21
02112	07-Jun-01	North Cottonwood River (tributary)	2	Marion	27	Neosho	NW	1	18S	1E	38-30-58	097-16-36
02113	04-Jun-01	East Branch Sharpes Creek	1	Chase	28	Neosho	NE	19	21S	9E	38-12-55	096-27-05
02114	21-Aug-01	Dragoon Creek	1	Wabaunsee	28	Marais Des Cygnes	NW	8	14S	12E	38-51-07	096-06-30
02115	26-Jul-01	Cross Creek	4	Pottawatomie	28	Kansas-Lower Republican	SW	12	9S	12E	39-17-17	096-02-06
02116	25-Jul-01	Delaware River (tributary)	1	Jefferson	47	Kansas-Lower Republican	SE	32	8S	17E	39-23-28	095-32-42
02117	21-Aug-01	Rock Creek (tributary)	1	Coffey	40	Marais Des Cygnes	NW	30	19S	17E	38-22-31	095-34-51
02118	08-Aug-01	Iantha Creek	3	Anderson	40	Marais Des Cygnes	NW	31	19S	19E	38-21-31	095-21-22
02119	18-Jun-01	North Wea Creek (tributary)	1	Miami	40	Marais Des Cygnes	SW	8	16S	25E	38-40-00	094-40-13
02120	09-Aug-01	Pottawatomie Creek (tributary)	2	Anderson	40	Marais Des Cygnes	NE	6	20S	20E	38-20-42	095-14-01
02121	07-Aug-01	Elm Creek	1	Miami	40	Marais Des Cygnes	NW	21	18S	25E	38-28-21	094-39-15
02122	12-Jul-01	Card Creek	1	Montgomery	40	Verdigris	SE	30	32S	14E	37-13-39	095-35-06
02123	29-May-01	North Cedar Creek (tributary)	1	Cowley	28	Verdigris	SW	4	34S	8E	37-06-59	096-32-21
02124	01-Aug-01	South Fork Ninnescah River	4	Kingman	27	Lower Arkansas	NW	25	28S	6W	37-35-13	097-55-59
02125	31-Jul-01	North Fork Ninnescah River	5	Sedgwick	27	Lower Arkansas	SE	10	28S	4W	37-37-28	097-44-16
02126	19-Jul-01	Pawnee River	6	Pawnee	27	Upper Arkansas	SW	29	21S	20W	38-11-42	099-32-37
02127	30-Jul-01	Smoky Hill River	5	Saline	27	Smoky Hill-Saline	SW	32	15S	2W	38-42-01	097-34-12
02128	28-Jun-01	Chapman Creek (tributary)	1	Dickinson	28	Smoky Hill-Saline	SE	14	12S	3E	39-00-59	097-03-31
02130	29-Aug-01	Ninnescah River (tributary)	2	Sumner	27	Lower Arkansas	NE	5	31S	1E	37-23-14	097-20-08
02133	02-Aug-01	Sandy Creek	4	Harper	27	Lower Arkansas	NE	5	35S	8W	37-02-01	098-12-26
02148	27-Jun-01	Whites Creek	3	Cloud	27	Kansas-Lower Republican	NW	14	6S	5W	39-32-21	097-50-40
KRS-012	06-Jun-01	Cedar Creek	5	Chase	28	Neosho	SW	13	21S	5E	38-13-36	096-50-07
KRS-013	26-Jun-01	Wolf Creek	4	Cloud	27	Kansas-Lower Republican	NW	12	6S	4W	39-33-15	097-42-58
KRS-014	02-Jul-01	Thompson Creek	3	Kiowa	26	Lower Arkansas	SW	25	29S	17W	37-29-20	099-07-56
KRS-015	03-Jul-01	Turkey Creek	3	Barber	26	Lower Arkansas	SW	13	30S	15W	37-25-43	098-55-09
KRS-016	09-Jul-01	Pawnee Creek	2	Bourbon	40	Marais Des Cygnes	SW	18	26S	24E	37-46-39	094-49-36
KRS-017	10-Jul-01	Canville Creek	3	Neosho	40	Neosho	SW	14	27S	20E	37-41-38	095-11-39
KRS-018	11-Jul-01	Sandy Creek	4	Woodson	29	Verdigris	NE	27	26S	14E	37-45-27	095-51-11
KRS-019	16-Jul-01	West Salt Creek	2	Lane	25	Smoky Hill-Saline	NE	18	16S	30W	38-40-01	100-40-21
KRS-020	17-Jul-01	Kill Creek	4	Osborne	27	Solomon	NW	28	7S	13W	39-25-12	098-47-12
KRS-021	17-Jul-01	Landon Creek	3	Russell	27	Smoky Hill-Saline	E/2	10	15S	14W	38-45-36	098-51-26
KRS-022	18-Jul-01	Spring Creek	3	Ellsworth	27	Smoky Hill-Saline	SE	4	15S	10W	38-46-35	098-26-15
KRS-023	06-Sep-01	Caney River	4	Chautauqua	29	Verdigris	SE	1	35S	9E	37-02-27	096-22-27
KRS-024	24-Jul-01	North Branch Independence Creek	3	Doniphan	47	Missouri	NW	30	4S	20E	39-40-45	095-13-10
KRS-025	27-Jul-01	Buck Creek	3	Jefferson	40	Kansas-Lower Republican	NW	22	11S	19E	39-05-09	095-17-24
KRS-026	06-Aug-01	Captain Creek	3	Johnson	40	Kansas-Lower Republican	SW	24	13S	21E	38-53-59	095-01-48
KRS-027	18-Jul-01	Wolf Creek	2	Rice	27	Smoky Hill-Saline	NW	2	18S	6W	38-30-55	097-57-22
KRS-028	23-Jul-01	Mosquito Creek	3	Doniphan	47	Missouri	NE	30	2S	21E	39-50-57	095-06-03
KRS-029	22-Aug-01	Long Creek	4	Osage	40	Marais Des Cygnes	NE	19	18S	16E	38-28-17	095-40-36
KRS-030	28-Aug-01	Medicine Lodge River	4	Kiowa	26	Lower Arkansas	SW	14	30S	17W	37-26-18	099-09-33
KRS-031	05-Sep-01	Little Osage River	4	Bourbon	40	Marais Des Cygnes	SW	28	23S	24E	38-00-50	094-47-00

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Lower Arkansas, 9 in the Marais Des Cygnes, 2 in the Missouri, 4 in the Neosho, 6 in the Smoky Hill-Saline, 3 in the Solomon, 1 in the Upper Arkansas, 1 in the Upper Republican, and 5 in the Verdigris River Basin (Figure 1b). Most streams (65%) surveyed were first through third order streams (Figure 7b).

Water Chemistry

Water samples were sent to the EPAL for a complete analysis. The field results collected by KDWP are presented in Appendix 1, but will not be discussed here.

Fish

KDWP collected 69 total fish species comprising 7 orders and 13 families (Appendix 2). We collected 1 polyodontid (paddlefishes), 2 lepisosteid (gars), 1 clupeid (herrings), 22 cyprinids (minnows), 8 catostomids (suckers), 8 ictalurids (catfishes), 2 fundulids (killifishes), 1 poecilid (livebearers), 1 atherinid (silversides), 2 moronids (temperate basses), 12 centrarchids (sunfishes) including 3 hybrids, 8 percids (perches), and 1 sciaenid (drums) (Appendix 3).

We collected 5 state-listed fish species, including the state-listed endangered peppered chub (*Macrohybopsis tetranema*), the state-listed threatened hornyhead chub (*Nocomis biguttatus*) and Arkansas darter (*Etheostoma cragini*), and two state-listed Species In Need of Conservation: the greenside darter (*Etheostoma blennioides*) and the spotted sucker (*Minytrema melanops*).

The central stoneroller (*Campostoma anomalum*), red shiner (*Cyprinella lutrensis*), and green sunfish (*Lepomis cyanellus*) were the most

Table 2. Number of sites and percent of sites for fish species collected during 2001 R-EMAP sampling season.

Common Name	Number of Sites	% of Sites	Common Name	Number of Sites	% of Sites
Arkansas darter**	3	6.52	longear sunfish hybrid	1	2.17
bigmouth buffalo	2	4.35	longnose gar	7	15.22
bigmouth shiner	1	2.17	orangespotted sunfish	14	30.43
black bullhead	13	28.26	orangespotted sunfish hybrid	1	2.17
black crappie	5	10.87	orangethroat darter	25	54.35
blackstripe topminnow	6	13.04	paddlefish	1	2.17
bluegill	24	52.17	peppered chub***	1	2.17
bluegill x green sunfish	1	2.17	plains killifish	6	13.04
bluntface shiner	2	4.35	quillback	4	8.70
bluntnose minnow	14	30.43	red shiner	33	71.74
brindled madtom	1	2.17	redear sunfish	1	2.17
brook silverside	7	15.22	redfin darter	1	2.17
bullhead minnow	5	10.87	redfin shiner	10	21.74
central stoneroller	34	73.91	river carpsucker	6	13.04
channel catfish	16	34.78	rosyface shiner	3	6.52
common carp	15	32.61	sand shiner	21	45.65
common shiner	1	2.17	shorthead redhorse	4	8.70
creek chub	15	32.61	shortnose gar	2	4.35
emerald shiner	4	8.70	silver chub	1	2.17
fantail darter	1	2.17	slender madtom	5	10.87
fathead minnow	19	41.30	slenderhead darter	5	10.87
flathead catfish	11	23.91	slim minnow	1	2.17
freckled madtom	2	4.35	smallmouth buffalo	8	17.39
freshwater drum	5	10.87	spotted bass	4	8.70
gizzard shad	11	23.91	spotted sucker*	1	2.17
golden redhorse	4	8.70	stonecat	3	6.52
golden shiner	5	10.87	striped bass	1	2.17
goldfish	1	2.17	suckermouth minnow	17	36.96
green sunfish	32	69.57	unidentified minnow	1	2.17
greenside darter*	1	2.17	western mosquitofish	11	23.91
hornyhead chub**	1	2.17	white bass	4	8.70
johnny darter	2	4.35	white crappie	8	17.39
largemouth bass	26	56.52	white sucker	5	10.87
logperch	9	19.57	yellow bullhead	14	30.43
longear sunfish	16	34.78			

* - State Listed Species In Need of Conservation

** - State Listed Threatened

*** - State Listed Endangered

Table 3. Number of individuals and relative abundance for fish species collected during 2001 REMAP sampling season.

Common Name	Number Collected	Relative Abundance (%)	Common Name	Number Collected	Relative Abundance (%)
Arkansas darter**	71	0.19	longear sunfish hybrid	6	0.02
bigmouth buffalo	5	0.01	longnose gar	8	0.02
bigmouth shiner	3	0.01	orangespotted sunfish	91	0.24
black bullhead	232	0.61	orangespotted sunfish hybrid	3	0.01
black crappie	7	0.02	orangethroat darter	838	2.21
blackstripe topminnow	62	0.16	paddlefish	1	0.00
bluegill	296	0.78	peppered chub***	2	0.01
bluegill x green sunfish	2	0.01	plains killifish	1186	3.13
bluntface shiner	606	1.60	quillback	4	0.01
bluntnose minnow	1216	3.21	red shiner	19557	51.63
brindled madtom	2	0.01	redear sunfish	1	0.00
brook silverside	748	1.97	redfin darter	2	0.01
bullhead minnow	135	0.36	redfin shiner	864	2.28
central stoneroller	4262	11.25	river carpsucker	94	0.25
channel catfish	204	0.54	rosyface shiner	19	0.05
common carp	315	0.83	sand shiner	1168	3.08
common shiner	33	0.09	shorthead redhorse	57	0.15
creek chub	991	2.62	shortnose gar	2	0.01
emerald shiner	152	0.40	silver chub	2	0.01
fantail darter	26	0.07	slender madtom	55	0.15
fathead minnow	1439	3.80	slenderhead darter	47	0.12
flathead catfish	40	0.11	slim minnow	76	0.20
freckled madtom	23	0.06	smallmouth buffalo	39	0.10
freshwater drum	28	0.07	spotted bass	34	0.09
gizzard shad	152	0.40	spotted sucker*	1	0.00
golden redhorse	35	0.09	stonecat	20	0.05
golden shiner	12	0.03	striped bass	1	0.00
goldfish	1	0.00	suckermouth minnow	590	1.56
green sunfish	766	2.02	unidentified minnow	1	0.00
greenside darter*	59	0.16	western mosquitofish	92	0.24
hornyhead chub**	2	0.01	white bass	204	0.54
johnny darter	21	0.06	white crappie	52	0.14
largemouth bass	243	0.64	white sucker	133	0.35
logperch	28	0.07	yellow bullhead	98	0.26
longear sunfish	316	0.83			

* - State Listed Species In Need of Conservation

** - State Listed Threatened

*** - State Listed Endangered

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commonly collected fish found at more than 30 sites. Twenty-four species were collected at less than 5% of the sites. Four of the five state-listed species were collected at only one site. The Arkansas darter was collected at 3 sites (Table 2).

The red shiner was the most numerous fish collected. It comprised 52% of the total number of fish collected in 2001. The central stoneroller was the second most abundant fish collected comprising 11% of the total number of fish collected. Fifty-six species (81%) comprised less than 1% of the total number of fish collected (Table 3).

Species richness ranged from 0 to 27 (Table 4). The highest species richness was found at Caney River, Chautauqua County (KRS-023). There were three sites where no fish were collected, two of which were dry (02117 and KRS-027). The average number of fish species collected at a site was 12. Species lists, number of individuals, relative abundances, and CPUE for each site are included in Appendix 4.

IBI scores using the unrevised metrics ranged from 11 to 97 (Table 4, IBI-1). The average IBI scores excluding the sites where no fish were collected was 71.5. The North Fork Ninnescah River, Sedgwick County (02125), Buck Creek, Jefferson County (KRS-025), Sandy Creek, Woodson County (KRS-018), Cross Creek, Pottawatomie County (02115), Medicine Lodge River, Kiowa County (KRS-020), Caney River, Chautauqua County (KRS-023), and Cedar Creek, Chase County (KRS-012) had the highest scores respectively using the old IBI metrics.

The highest scoring metric on average was the Percent Omnivore-Generalist with a score of 8.7 on a 10 point scale, indicating a low number of omnivores and generalists. The lowest scoring metric on average was the Percent Invertivores with a score of 5.5, indicating a low number of invertivores (Appendix 5).

The 1995 version of the IBI was designed to be used on a regional basis, not just in the state of Kansas. The metrics did not exclude introduced species and seemed to be weighted toward richness values (Mitchell, 2001). IBI scores were plotted against species richness values in Figure 2, and show a significant increase in IBI scores with an increase in species richness.

Table 4. 2001 fish and mussel community characteristics.

Site Number	Fish Community			Mussel Community	
	Species Richness	IBI-1 Score	IBI-2 Score	Species Richness	Number Live/Recent
02101	2	43	60	0	0
02105	0	0	0	0	0
02107	9	65	81	0	0
02108	1	11	19	0	0
02110	8	69	68	7	4
02111	15	88	94	0	0
02112	6	58	62	0	0
02113	1	30	41	0	0
02114	2	39	48	0	0
02115	22	92	79	15	8
02116	7	73	76	0	0
02117	0	0	0	1	0
02118	21	84	90	5	3
02119	5	52	65	0	0
02120	11	85	100	4	1
02121	13	82	92	1	1
02122	1	40	65	1	0
02123	2	40	59	4	1
02124	24	88	82	1	0
02125	24	97	94	3	2
02126	9	68	66	1	1
02127	10	63	61	6	3
02128	6	55	82	0	0
02130	10	65	72	0	0
02133	14	87	97	0	0
02148	6	46	51	2	2
KRS-012	21	90	84	18	14
KRS-013	9	69	65	3	3
KRS-014	14	82	91	0	0
KRS-015	12	78	83	0	0
KRS-016	15	69	78	5	4
KRS-017	20	78	78	2	0
KRS-018	22	94	82	11	2
KRS-019	9	56	48	0	0
KRS-020	10	68	81	1	1
KRS-021	13	85	78	1	1
KRS-022	9	82	86	1	0
KRS-023	27	90	109	18	11
KRS-024	16	85	66	1	0
KRS-025	20	95	92	3	0
KRS-026	15	81	95	2	0
KRS-027	0	0	0	0	0
KRS-028	22	89	78	0	0
KRS-029	21	85	75	12	6
KRS-030	14	91	94	3	2
KRS-031	26	88	75	17	8

With these concerns in mind, a new IBI was developed which addressed regional concerns and introduced species. New metrics were incorporated and weighted differently according to the region (Lowland, Plains, or Ozarks) where the stream was located (Waters, personal communication). The Lowlands region includes the Western Corn Belt Plains, Central Irregular Plains, Texas-Oklahoma Plains, and Flint Hills ecoregions. The Plains region includes the Western High Plains, Central Great Plains, and Southwestern Tablelands ecoregions. The Ozarks region includes only the Ozark Highlands ecoregion. There are 12 new metrics, each of which is scaled to 10 for a perfect IBI score of 120. The new metrics include Native Species Richness, Native Family Richness, Number of Individuals Collected, Sensitive Species Richness, Proportion of Tolerant Individuals, Number of Native Benthic Species, Number of Native Water Column Species, Number of Long-lived Species, Proportion of Introduced Species, Proportion of Carnivores, Proportion of Insectivores and Invertivores, and Proportion of

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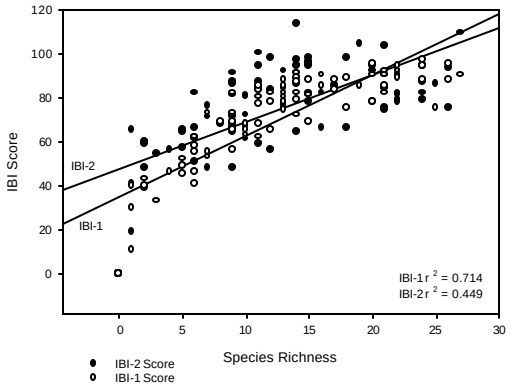
Omnivores and Herbivores.

Using the new metrics, IBI scores ranged from 19 to 109 (Table 4, IBI-2). The average score was 44.4. The Caney River, Chautauqua County (KRS-023), Pottawatomie Creek (tributary), Anderson County (02120), Sandy Creek, Harper County (02133), Captain Creek, Johnson County (KRS-026), Medicine Lodge River, Kiowa County (KRS-030), North Fork Ninnescah River, Sedgwick County (02125), and Kitten Creek, Riley County (02111) scored the highest respectively using the new IBI metrics.

The highest scoring metric on average was the Proportion of Introduced Individuals with a score of 9.1 on a 10 point scale, indicating a low number of introduced individuals. The lowest scoring metric on average was the Number of Native Water Column Species with a score of 2.2, indicating a low number of native water column species (Appendix 6).

There was a difference in scores for sites with a BPJ of "no" as compared to those sites with a

Figure 2. IBI scores vs. fish species richness values.



BPJ of "yes" using both IBI metrics. There were 14 sites with a BPJ of "no" with an average IBI score of 50.2 using the old metrics and 61.9 using the new metrics. The 32 sites with a BPJ of "yes" scored an average of 78.8 using the old metrics and 80.0 using the new metrics.

Most fish collected during 2001 were adults. 43% of the individuals collected were juveniles (Table 5). This is probably due to the biases from the equipment used and the time of year sampling occurs.

Table 5. Adult/Juvenile age class distribution for fishes collected during 2001 sampling season.

Common Name	Adult	Juvenile	Common Name	Adult	Juvenile
Arkansas darter**	58	13	longear sunfish hybrid	6	0
bigmouth buffalo	0	5	longnose gar	2	6
bigmouth shiner	3	0	orangespotted sunfish	82	9
black bullhead	56	176	orangespotted sunfish hybrid	3	0
black crappie	1	6	orangethroat darter	809	29
blackstripe topminnow	40	22	paddlefish	1	0
bluegill	8	288	peppered chub***	2	0
bluegill x green sunfish	0	2	plains killifish	489	697
bluntface shiner	170	436	quillback	1	3
bluntnose minnow	702	514	red shiner	11325	8232
brindled madtom	2	0	redear sunfish	1	0
brook silverside	43	705	redfin darter	2	0
bullhead minnow	135	0	redfin shiner	673	191
central stoneroller	2406	1856	river carpsucker	9	85
channel catfish	18	186	rosyface shiner	19	0
common carp	60	255	sand shiner	1121	47
common shiner	22	11	shorthead redhorse	0	57
creek chub	184	807	shortnose gar	1	1
emerald shiner	152	0	silver chub	2	0
fantail darter	26	0	slender madtom	40	15
fathead minnow	1368	71	slenderhead darter	38	9
flathead catfish	11	29	slim minnow	64	12
freckled madtom	16	7	smallmouth buffalo	34	5
freshwater drum	7	21	spotted bass	4	30
gizzard shad	11	141	spotted sucker*	1	0
golden redhorse	12	23	stonecat	10	10
golden shiner	12	0	striped bass	1	0
goldfish	1	0	suckermouth minnow	563	27
green sunfish	104	662	unidentified minnow	1	0
greenside darter*	1	58	western mosquitofish	92	0
hornyhead chub**	2	0	white bass	194	10
johnny darter	21	0	white crappie	14	38
largemouth bass	82	161	white sucker	0	133
logperch	23	5	yellow bullhead	42	56
longear sunfish	245	71			

* - State-listed Species In Need of Conservation
** - State-listed Threatened Species
*** - State-listed Endangered Species

We collected 20 sport fish species (Table 6). The most abundant sport fish collected was the green sunfish, followed by the common carp (*Cyprinus carpio*) and black bullhead (*Ameiurus melas*). The "stock" length using Gablehouse measurements was the most commonly collected size class. Past KDWP surveys show that most sport fish collected fall into the "stock" length category (Waters 1997a and 1997b, Mitchell 2001).

Mussels

We collected 29 species of mussels, including the exotic Asian clam (*Corbicula fluminea*) (Appendix 7). We collected 10 state-listed species including the endangered Neosho mucket (*Lampsilis rafinesqueana*) and the threatened Ouachita kidneyshell (*Ptychobranchus occidentalis*). Eight Species In Need of Conservation (SINC) were collected: the deertoe (*Truncilla truncata*), fatmucket (*Lampsilis siliquoidea*), fawnsfoot (*Truncilla donaciformis*), spike (*Elliptio dilatata*), creeper (*Strophitus undulatus*), Wabash pigtoe (*Fusconaia flava*), washboard (*Megalonaias nervosa*), and the yellow sandshell (*Lampsilis teres*). All SINC species were represented by live individuals or recently dead shells except the spike. All species were represented by weathered shells except the fawnsfoot, paper pondshell (*Utterbackia imbecillis*), and the threehorn wartyback (*Obliquaria reflexa*). Twenty-four species

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were represented by live or recently dead shells.

The most commonly collected mussel was the pondhorn (*Uniomerus tetralasmus*). Extant populations were found at 5 sites and weathered valves at an additional 7 sites. The Asian clam, fragile papershell (*Leptodea fragilis*), giant floater (*Pyganodon grandis*), and white heelsplitter (*Lasmigona complanata*) were represented by more live or recently weathered shells. Twenty-three species were collected at fewer than 10 sites (Table 7). It should be noted that live Asian clam specimens were not counted during the mussel search, only shells were collected.

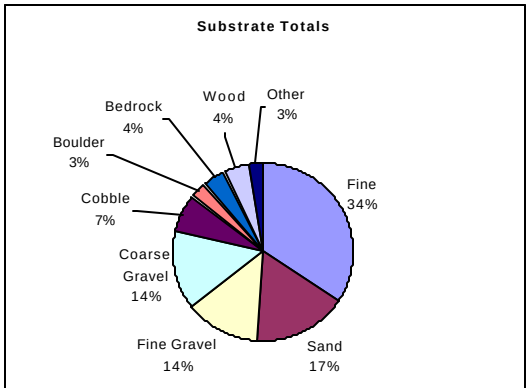

Figure 3. Substrate composition for 2001 R-EMAP sites.

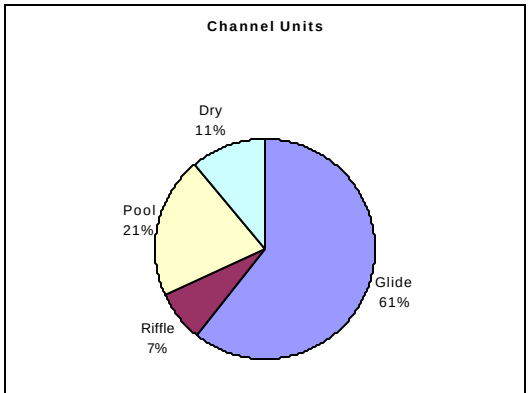

Figure 4. Channel unit distribution for 2001 R-EMAP stream sites.

Mussel species richness ranged from 0 to 18 (Table 4). No mussels were collected at 39% of the sites. Extant mussel species richness ranged from 0 to 14. No extant mussels were collected at 57% of the sites. On average, extant mussel species comprised 47.8% of the total number of mussel species collected per site.

Insects

Aquatic macroinvertebrates collected during the 2001 sampling season have not been identified at the time of this report. This data will be available at a later date.

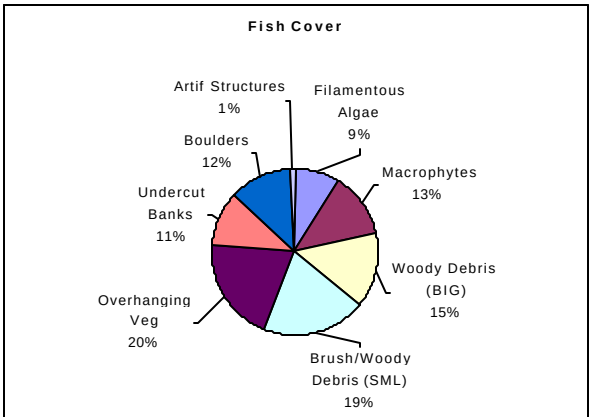

Figure 5. Fish cover percentages for 2001 R-EMAP stream sites.

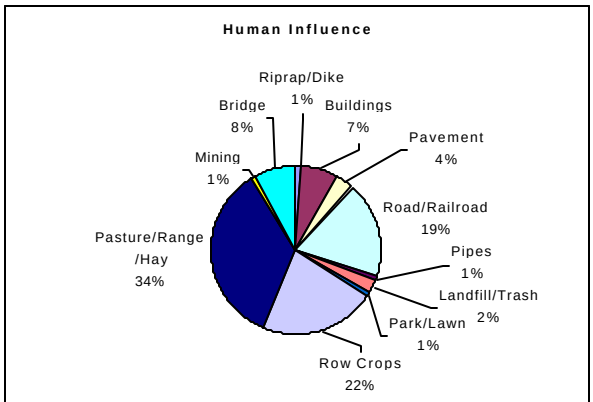

Figure 6. Human influence percentages for 2001 R-EMAP sites.

Physical Habitat

Fine substrate was encountered 30.9% of the time, followed by sand (15.7%), fine gravel (12.7%), and coarse gravel (12.7%) (Figure 3). The average

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embeddedness for the sites was 77.5%. Glides dominated the channel units at 60.6%, followed by pools (21%), dry channels (10.9%), and riffles (7.38%) (Figure 4).

The most abundant fish cover was overhanging vegetation, followed by small brush and woody debris, large woody debris, and macrophytes and boulders (Figure 5). Pasture and rangeland was the most encountered human influence (35.3%), followed by row crops (22.0%), and roads (18.6%) (Figure 6).

Further physical habitat measurements are presented in Appendix 9.

RESULTS – ALL

General

There were a total of 201 sites sampled for the R-EMAP project. 50 sites in 1994, 60 in 1995, 45 in 2000, and 46 in 2001. Of these, 58 were considered reference sites, 4 were lake sites, leaving 139 random sites (See Waters 1997a and 1997b, Hase 2001).

Sites were distributed throughout the state in every basin and ecoregion (Figure 7). Four sites in the Cimarron River Basin, 40 in the Kansas-Lower Republican River Basin, 29 in the Lower Arkansas River Basin, 21 in the Marais Des Cygnes River Basin, 8 in the Missouri River Basin, 19 in the Neosho River Basin, 32 in the Smoky Hill-Saline River Basin, 15 in the Solomon River Basin, 4 in the Upper Arkansas River Basin, 8 in the Upper Republican River Basin, 15 in the Verdigris River Basin, and 2 in the Walnut River Basin. Eighteen

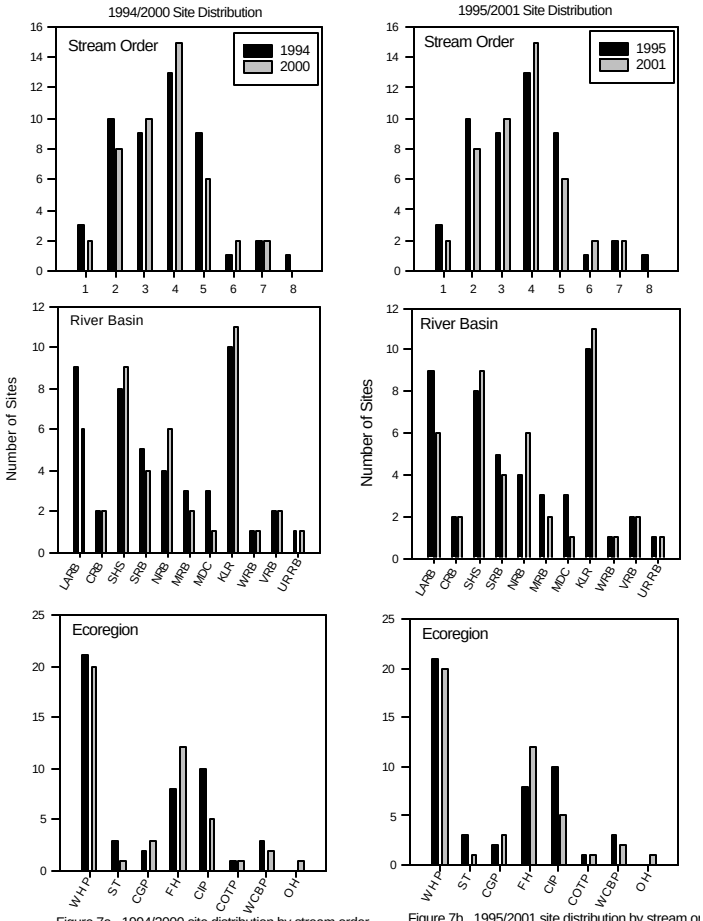

Figure 7a. 1994/2000 site distribution by stream order, river basin, and ecoregion. Includes both random and reference sites.

Figure 7b. 1995/2001 site distribution by stream or river basin, and ecoregion. Includes both random and reference sites.

sites were in the Western High Plains, 8 were in the Southwestern Tablelands, 76 were in the Central Great Plains, 42 were in the Flint Hills, 2 were in the Texas-Oklahoma Plains, 2 were in the Ozark Highlands, 38 were in the Central Irregular Plains, and 11 sites were in the Western Corn Belt Plains.

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Most sites (80%) were second to fifth order streams (Figure 7).

Fish

There were 86 total fish species collected in the four years of R-EMAP sampling. This does not include hybrids or unidentified fishes. There were 9 orders and 15 families represented by the fish collected. There were 1 polyodontid (paddlefishes), 2 lepisosteids (gars), 1 hiodontid (mooneyes), 1 clupeid (herrings), 34 cyprinids (minnows), 8 catostomids (suckers), 8 ictalurids (catfishes), 2 fundulids (killifishes), 1 poecilid (livebearers), 1 atherinid (silversides), 1 cottid (sculpins), 2 moronids (temperate basses), 11 centrarchids (sunfishes), 13 percids (perches), and 1 sciaenid (drums).

Several species were collected only during the 1994/1995 sampling season. The goldeye (*Hiodon alosoides*), blackside darter (*Percina maculata*), brassy minnow (*Hybognathus hankinsoni*), plains minnow (*Hybognathus placitus*), red river shiner (*Notropis bairdi*), ghost shiner (*Notropis bucanani*), Ozark minnow (*Notropis nubilus*), and walleye (*Stizostedion vitreum*) were not collected during the 2000/2001 sampling season. The quillback (*Carpiodes cyprinus*), an introduced species, was not collected during the 1994/1995 sampling season, and 375 individuals were collected at 7 sites during the 2000/2001 sampling season. Site species lists for repeated sites can be found in Appendix 4 and Hase, 2001.

The red shiner was the most abundant fish collected in all sites. It comprised 35.9% of the total

Table 8. Fish collected during the 1994/1995 and 2000/2001 R-EMAP sampling seasons.

	All Sites				Random Sites				Reference Sites			
Common Name	Number Collected	Relative Abundance (%)	Number of Sites	% of Sites	Number Collected	Relative Abundance (%)	Number of Sites	% of Sites	Number Collected	Relative Abundance (%)	Number of Sites	% of Sites
Arkansas darter**	328	0.23	10	5.08	132	0.15	5	3.62	196	0.35	5	8.47
banded darter*	17	0.01	2	1.02	0	0.00	0	0.00	17	0.03	2	3.39
banded sculpin*	15	0.01	2	1.02	0	0.00	0	0.00	15	0.03	2	3.39
bigeye shiner	41	0.03	3	1.52	0	0.00	0	0.00	41	0.07	3	5.08
bigmouth buffalo	36	0.03	5	2.54	30	0.03	3	2.17	6	0.01	2	3.39
bigmouth shiner	8	0.01	2	1.02	3	0.00	1	0.72	5	0.01	1	1.69
black bullhead	810	0.57	76	38.58	725	0.84	60	43.48	85	0.15	16	27.12
black crappie	21	0.01	10	5.08	15	0.02	6	4.35	6	0.01	4	6.78
blackside darter**	3	0.00	1	0.51	0	0.00	0	0.00	3	0.01	1	1.69
blackstripe topminnow	676	0.47	22	11.17	523	0.60	13	9.42	153	0.28	9	15.25
bluegill	1488	1.04	90	45.69	1202	1.39	57	41.30	286	0.51	33	55.93
bluegill x green sunfish	2	0.00	1	0.51	0	0.00	0	0.00	2	0.00	1	1.69
bluntface shiner	1419	0.99	8	4.06	0	0.00	0	0.00	1419	2.55	8	13.56
bluntnose minnow	4031	2.82	73	37.06	1832	2.11	45	32.61	2199	3.96	28	47.46
brassy minnow*	10	0.01	2	1.02	10	0.01	2	1.45	0	0.00	0	0.00
brindled madtom	2	0.00	1	0.51	0	0.00	0	0.00	2	0.00	1	1.69
brook silverside	2380	1.67	21	10.66	1484	1.71	8	5.80	896	1.61	13	22.03
buffalo (unidentified)	11	0.01	3	1.52	11	0.01	3	2.17	0	0.00	6	10.17
bullhead minnow	653	0.46	25	12.69	446	0.51	16	11.59	207	0.37	9	15.25
cardinal shiner	1125	0.79	3	1.52	0	0.00	0	0.00	1125	2.02	3	5.08
central stoneroller	15832	11.09	129	65.48	8359	9.65	87	63.04	7473	13.45	42	71.19
channel catfish	902	0.63	75	38.07	432	0.50	41	29.71	470	0.85	34	57.63
channel darter	7	0.00	4	2.03	0	0.00	0	0.00	7	0.01	4	6.78
common carp	1290	0.90	71	36.04	740	0.85	46	33.33	550	0.99	25	42.37
common shiner	1882	1.32	19	9.64	401	0.46	11	7.97	1481	2.67	8	13.56
creek chub	5774	4.05	83	42.13	4818	5.56	61	44.20	956	1.72	22	37.29
emerald shiner	1096	0.77	18	9.14	892	1.03	12	8.70	204	0.37	6	10.17
fantail darter	42	0.03	3	1.52	0	0.00	0	0.00	42	0.08	3	5.08
fathead minnow	9480	6.64	113	57.36	5626	6.49	84	60.87	3854	6.94	29	49.15
flathead catfish	185	0.13	39	19.80	71	0.08	20	14.49	114	0.21	19	32.20
freckled madtom	58	0.04	4	2.03	0	0.00	0	0.00	58	0.10	4	6.78
freshwater drum	116	0.08	23	11.68	85	0.10	16	11.59	31	0.06	7	11.86
ghost shiner	11	0.01	3	1.52	11	0.01	3	2.17	0	0.00	0	0.00
gizard shad	3050	2.14	44	22.34	2353	2.72	27	19.57	697	1.25	17	28.81
golden redhorse	176	0.12	17	8.63	109	0.13	7	5.07	67	0.12	10	16.95
golden shiner	80	0.06	22	11.17	73	0.08	18	13.04	7	0.01	4	6.78
goldeye	1	0.00	1	0.51	0	0.00	0	0.00	1	0.00	1	1.69
goldfish	37	0.03	3	1.52	13	0.02	1	0.72	24	0.04	2	3.39
gravel chub*	9	0.01	2	1.02	0	0.00	0	0.00	9	0.02	2	3.39
green sunfish	6299	4.41	161	81.73	5174	5.97	110	79.71	1125	2.02	51	86.44
green sunfish x bluegill	1	0.00	1	0.51	0	0.00	0	0.00	1	0.00	1	1.69
greenside darter*	75	0.05	4	2.03	0	0.00	0	0.00	75	0.13	4	6.78
hornyhead chub**	5	0.00	2	1.02	0	0.00	0	0.00	5	0.01	2	3.39
johnny darter	65	0.05	10	5.08	44	0.05	6	4.35	21	0.04	4	6.78
largemouth bass	994	0.70	106	53.81	723	0.83	71	51.45	271	0.49	35	59.32
logperch	196	0.14	38	19.29	80	0.09	19	13.77	116	0.21	19	32.20
longear sunfish	929	0.65	52	26.40	310	0.36	23	16.67	619	1.11	29	49.15
longear sunfish hybrid	6	0.00	1	0.51	6	0.01	1	0.72	0	0.00	0	0.00
longnose gar	47	0.03	18	9.14	35	0.04	13	9.42	12	0.02	5	8.47

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individuals collected and was found at 71.5% of the sites. It comprised 35.1% of the individuals collected at 66.6% of the random sites and 37.6% of the individuals collected at 83.1% of the reference sites. The green sunfish was collected at more sites (79.1% of random and 86.4% of reference), however it comprised only 5.98% and 2.02% respectively of the total individuals collected. The central stoneroller was the next most abundant fish comprising 11.1% of the total individuals collected at 65.5% of the sites. It was collected at 63.0% of the random sites comprising 9.7% of the total fish collected, and at 71.2% of the reference sites comprising 13.5% of the total fish collected. The fathead minnow (*Pimephales promelas*) followed being collected at 57.4% of the sites, and comprising 6.64% of the total individuals collected. It was collected at 60.9% of the random sites comprising 6.5% of the total individuals collected, and at 49.2% of the reference sites comprising 6.9% of the total individuals collected (Table 8).

Table 8. Fish collected during the 1994/1995 and 2000/2001 R-EMAP sampling seasons (cont).

	All Sites				Random Sites				Reference Sites			
Common Name	Number Collected	Relative Abundance (%)	Number of Sites	% of Sites	Number Collected	Relative Abundance (%)	Number of Sites	% of Sites	Number Collected	Relative Abundance (%)	Number of Sites	%
mimic shiner	120	0.08	3	1.52	10	0.01	1	0.72	110	0.20	2	
minnow (unidentified)	7	0.00	3	1.52	1	0.00	1	0.72	6	0.01	2	
orangespotted sunfish	1310	0.92	78	39.59	1083	1.25	53	38.41	227	0.41	25	
orangespotted sunfish hybrid	3	0.00	1	0.51	0	0.00	0	0.00	3	0.01	1	
orangethroat darter	4142	2.90	104	52.79	2881	3.32	62	48.55	1261	2.27	32	
Ozark minnow*	41	0.03	1	0.51	0	0.00	0	0.00	41	0.07	1	
paddlefish	2	0.00	2	1.02	2	0.00	2	1.45	0	0.00	0	
peppered chub***	7	0.00	3	1.52	7	0.01	3	2.17	0	0.00	0	
plains killifish	2784	1.95	35	17.77	2504	2.89	27	19.57	280	0.50	8	
plains minnow*	11	0.01	3	1.52	2	0.00	1	0.72	9	0.02	2	
quillback	375	0.26	7	3.55	368	0.42	6	4.35	7	0.01	1	
red river shiner	25	0.02	1	0.51	0	0.00	0	0.00	25	0.04	1	
red shiner	51309	35.95	141	71.57	30374	35.05	92	66.67	20935	37.68	49	
redear sunfish	1	0.00	1	0.51	0	0.00	0	0.00	1	0.00	1	
redfin darter	15	0.01	4	2.03	1	0.00	1	0.72	14	0.03	3	
redfin shiner	3869	2.71	45	22.84	2291	2.64	28	20.29	1578	2.84	17	
redhorse (unidentified)	45	0.03	3	1.52	3	0.00	2	1.45	42	0.08	1	
redspot chub**	8	0.01	2	1.02	0	0.00	0	0.00	8	0.01	2	
river carpsucker	523	0.37	34	17.26	326	0.38	20	14.49	197	0.35	14	
rock bass	18	0.01	2	1.02	0	0.00	0	0.00	18	0.03	2	
rosyface shiner	3154	2.21	16	8.12	1392	1.61	4	2.90	1762	3.17	12	
sand shiner	6161	4.32	94	47.72	4848	5.59	57	41.30	1313	2.36	37	
shorthead redhorse	178	0.12	20	10.15	23	0.03	5	3.62	155	0.28	15	
shortnose gar	9	0.01	6	3.05	5	0.01	2	1.45	4	0.01	4	
silver chub	4	0.00	2	1.02	4	0.00	2	1.45	0	0.00	0	
slender madtom	284	0.20	30	15.23	125	0.14	16	11.59	159	0.29	14	
slenderhead darter	403	0.28	24	12.18	140	0.16	14	10.14	263	0.47	10	
slim minnow	234	0.16	6	3.05	20	0.02	2	1.45	214	0.39	4	
smallmouth buffalo	68	0.05	23	11.68	20	0.02	11	7.97	48	0.09	12	
southern redbelly dace	654	0.46	4	2.03	169	0.20	2	1.45	485	0.87	2	
speckled darter*	5	0.00	2	1.02	0	0.00	0	0.00	5	0.01	2	
spotfin shiner*	43	0.03	2	1.02	0	0.00	0	0.00	43	0.08	2	
spotted bass	98	0.07	16	8.12	13	0.02	5	3.62	85	0.15	11	
spotted sucker*	21	0.01	4	2.03	18	0.02	2	1.45	3	0.01	2	
stonecat	191	0.13	22	11.17	89	0.10	11	7.97	102	0.18	11	
striped bass	1	0.00	1	0.51	1	0.00	1	0.72	0	0.00	0	
sucker (unidentified)	6	0.00	2	1.02	5	0.01	1	0.72	1	0.00	1	
suckermouth minnow	1837	1.29	74	37.56	842	0.97	46	33.33	995	1.79	28	
sunfish (unidentified)	155	0.11	11	5.58	114	0.13	9	6.52	41	0.07	2	
sunfish hybrid	14	0.01	3	1.52	14	0.02	3	2.17	0	0.00	0	
Topeka shiner**	295	0.21	7	3.55	275	0.32	5	3.62	20	0.04	2	
walleye	15	0.01	4	2.03	15	0.02	4	2.90	0	0.00	0	
warmouth	11	0.01	3	1.52	0	0.00	0	0.00	11	0.02	3	
western mosquitofish	980	0.69	56	28.43	659	0.76	39	28.26	321	0.58	17	
white bass	233	0.16	16	8.12	210	0.24	10	7.25	23	0.04	6	
white crappie	354	0.25	28	14.21	312	0.36	19	13.77	42	0.08	9	
white sucker	546	0.38	34	17.26	458	0.53	25	18.12	87	0.16	9	
yellow bullhead	417	0.29	61	30.96	268	0.31	36	26.09	149	0.27	25	

The peppered chub (*Macrohybopsis tetranema*) was the only endangered species collected during the four years of sampling. Five threatened species were collected: the Arkansas darter (*Etheostoma cragini*), blackside darter (*Percina maculata*), hornyhead chub (*Nocomis biguttatus*), redspot chub (*Nocomis asper*), and Topeka shiner (*Notropis topeka*). There were 10 SINC species collected: the banded darter (*Etheostoma zonale*), banded sculpin (*Cottus carolinae*), brassy minnow (*Hybognathus hankinsoni*), gravel chub (*Erimystax x-punctatus*), greenside darter (*Etheostoma blennioides*), Ozark minnow (*Notropis nubilus*), plains minnow (*Hybognathus placitus*), speckled darter (*Etheostoma stigmaeum*), spotfin shiner (*Cyprinella spiloptera*), and spotted sucker (*Minytrema melanops*).

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Species richness ranged from 0 to 30. There were 6 sites where no fish were collected. The highest species richness was found at Grouse Creek, Cowley County (09490) and Whetstone Creek, Shawnee County (09480). These were also the highest scoring random (09480) and reference sites (09490) for species richness. Site 09490 was not repeated during the 2000/ 2001 sampling season. The species richness for Whetstone Creek (02080) during the 2000 sampling season was 19 species. The average random site species richness was 11. The average reference species richness was 16. The Flint Hills and Central Irregular Plains had the highest species richness with 58 species, followed by the Central Great Plains with 49 species (Appendix 10). The Neosho River Basin had the highest species richness of the river basins with 61 species, followed by the Lower Arkansas River Basin and the Marais Des Cygnes River Basin with 51 species (Appendix 11).

IBI scores were only calculated for sites that were sampled and/or repeated during the 2000-2001 sampling season.

The average IBI score using the old metrics for the 1994/1995 sampling season was 67.3. The average score for the 2000/2001 sampling season was 71.4. IBI scores ranged from 11 at West Beaver Creek, Smith County (02108) to 97 at North Fork Ninnescah River, Sedgwick County (02125). The average IBI score excluding the sites where no fish were collected was 70.5. The Texas-Oklahoma Plains had the highest average IBI using the old metrics with a score of 86.6. The Lower Arkansas River Basin had the highest average basin score with an IBI of 82.5. The average random site score was 66.9, with the highest score of 97 at site 02125. The average reference site score was 81.0, with the highest score of 95 found at Otter Creek, Greenwood County (KRS-005) and Buck Creek, Jefferson County (KRS-025).

On average, the highest scoring metric was Percent Omnivores and Generalists with a score of 8.7, indicating a low number of omnivores and generalists. The lowest scoring metric was Percent Invertivores at 4.5, indicating a low number of invertivores.

Using the new IBI metrics, the average score for the 1994/1995 sites was 76.2 and the average score for the 2000/2001 sites was 77.6. The IBI scores ranged from 19 at West Beaver Creek, Smith County (02108) to 113 at Crooked Creek, Coffey County (02083). The average IBI score excluding the sites where no fish were collected was 76.9. The Texas Oklahoma Plains had the highest average score of 97.1. The Verdigris River Basin had the highest average basin score of 88.0. The average random site score was 75.4, with a high score of 113 found at site 02083. The average reference site score was 81.6, with a high score of 109 found at Caney River, Chautauqua County (KRS-023) (Table 9).

On average, the highest scoring metric was Proportion of Introduced Species with a score of 9.7, indicating a low number of introduced species. The lowest scoring metric was Number of Native Water Column Species with a score of 2.5, indicating a low number of native water column species. Ecoregion and basin IBI metric scores can be found in Appendix 12.

Table 9. IBI scores for all sites using both metric calculations. IBI-1 refers to 1995 metrics. IBI-2 refers to 2001 metrics.

Site Number	2000/2001		1994/1995	
	IBI-1	IBI-2	IBI-1	IBI-2
02051	90	82	71	84
02053	77	84	65	71
02054	80	87	59	74
02055	83	94	70	96
02056	62	61	48	58
02057	64	71	67	73
02058	49	64	41	61
02059	33	54	13	31
02060	67	80	66	77
02061	66	66	66	75
02062			68	82
02063	72	87	69	89
02065	41	66	62	77
02066	74	75	72	74
02067	53	71	57	73
02068	78	77	75	75
02069	83	85	61	68
02070	75	66	91	78
02071	73	91	72	84
02072	89	98	92	98
02073	46	56	68	72
02076	79	86	77	93
02080	85	104	89	102
02081	68	56	80	82
02082	82	98	81	99
02083	89	113	83	96
02084	82	74	92	88
02085	82	98	83	90
02086	45	57	17	59
02087	72	64	59	61
02088	68	83	67	78
02089	88	85	73	85
02092	80	76	47	65
02097	84	79	91	73
02101	43	60	51	81
02105			28	45
02107	65	81	84	87
02108	11	19	26	46
02110	69	68	69	68
02111	88	94	76	86
02112	58	62	64	71
02113	30	41	45	76
02114	39	48	13	28
02115	92	79	78	63
02116	73	76	63	95
02117				
02118	84	90	88	84

Site Number	2000/2001		1994/1995	
	IBI-1	IBI-2	IBI-1	IBI-2
02119	52	65	49	58
02120	85	100	79	96
02121	82	92	84	89
02122	40	65	56	64
02123	40	59		
02124	88	82	92	85
02125	97	94	92	90
02126	68	66	43	48
02127	63	61	64	61
02128	55	82	50	69
02130	65	72	78	84
02133	87	97	88	93
02148	46	51	55	69
KRS-001	55	48		
KRS-002	88	84		
KRS-003	62	59	92	70
KRS-004	81	96		
KRS-005	95	93	92	106
KRS-006	94	87	90	81
KRS-007	75	86	77	85
KRS-008	90	81		
KRS-009	92	90		
KRS-010	92	103		
KRS-011	90	94		
KRS-012	90	84		
KRS-013	69	65		
KRS-014	82	91		
KRS-015	78	83		
KRS-016	69	78	74	83
KRS-017	78	78	78	83
KRS-018	94	82		
KRS-019	56	48	43	58
KRS-020	68	81		
KRS-021	85	78		
KRS-022	82	86		
KRS-023	90	109	86	96
KRS-024	85	66	78	62
KRS-025	95	92		
KRS-026	81	95		
KRS-027			62	81
KRS-028	89	78		
KRS-029	85	75		
KRS-030	91	94		
KRS-031	88	75		

Mussels

Mussels were only collected during the 2000/2001 sampling seasons. There were 32 species collected during this two year sampling period,

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including the introduced Asian clam (*Corbicula fluminea*) (Appendix 8). There were 13 state-listed species collected. The endangered Neosho mucket (*Lampsilis rafinesqueana*), the threatened fluted shell (*Lasmigona costata*) and Ouachita kidneyshell (*Ptychobranchus occidentalis*), and 10 SINC species, including the creeper (*Strophitus undulatus*), cylindrical papershell (*Anodontoides ferussacianus*), deertoe (*Truncilla truncata*), fatmucket (*Lampsilis siliquoidea*), fawnsfoot (*Truncilla donaciformis*), round pigtoe (*Pleurobema sintoxia*), spike (*Elliptio dilatata*), Wabash pigtoe (*Fusconaia flava*), washboard (*Megalonaias nervosa*), and yellow sandshell (*Lampsilis teres*). All SINC species were represented by live or recently dead shells except the cylindrical papershell, round pigtoe, and spike (Table 10).

The most commonly collected mussels were the giant floater (*Pyganodon grandis*), pondhorn (*Uniomerus tetralasmus*), and pondmussel (*Ligumia subrostrata*) collected at 24 of the 91 sites sampled in 2000/2001. Eighteen species were collected at fewer than ten sites (Table 10).

Mussel species richness ranged from 0 to 18. The highest species richness was found at sites Cottonwood River, Marion County (02070), Otter Creek, Greenwood County (KRS-005), Cedar Creek, Chase County (KRS-012), and Caney River, Chautauqua County (KRS-023). Mussels were collected at 36 (60.0%) random sites and 22 (70.9%) reference sites. The Flint Hills had the highest species richness with 28 species collected. The Central Irregular Plains had a species richness of 23 and the Texas-Oklahoma Plains had a species richness of 21. The Verdigris River Basin had the highest species richness among the basins with 28 species. The Neosho River Basin, the Marais Des Cygnes River Basin, and the Kansas-Lower Republican River Basins followed with richness values of 23, 22, and 21 respectively. The Flint Hills also had the highest number of live mussel species with 11. The Central Irregular Plains and the Central Great Plains had 10 and 5 live mussel species respectively. No mussels were collected at 36.3% of the sites surveyed during the 2000/2001 sampling season. Mussel collections by ecoregion and basin are listed in Table 11a and 11b.

Table 10. Mussels collected during the 2000/2001 R-EMAP sampling season.

Common Name	# Sites	# Sites w/ Live	# Sites w/ Recent	# Sites w/ Weathered
Asian clam	19	–	16	6
black sandshell	2	0	0	2
bluefer	6	1	5	4
creeper*	8	0	3	7
cylindrical papershell*	1	0	0	1
deertoe*	2	0	2	1
fatmucket*	10	1	2	10
fawnsfoot*	2	0	1	1
fingernail clam	17	1	12	12
fluted shell**	3	0	0	3
fragile papershell	15	3	14	10
giant floater	24	3	15	22
lilliput	11	0	5	8
mapleleaf	15	5	10	12
Neosho mucket***	1	0	0	1
Ouachita kidneyshell**	1	0	0	1
paper pondshell	2	0	2	0
pimpleback	10	3	5	9
pink heelsplitter	4	1	2	3
pink papershell	9	0	8	4
pistolgrip	7	1	3	6
plain pocketbook	8	0	2	8
pondhorn	24	0	10	20
pondmussel	24	2	10	24
round pigtoe*	1	0	0	1
spike*	4	0	0	4
threehorn wartyback	2	0	2	0
threeridge	17	3	3	17
Wabash pigtoe*	13	1	2	13
washboard*	1	0	0	1
white heelsplitter	13	3	10	11
yellow sandshell*	13	1	5	11

* - State-listed Species In Need of Conservation
** - State-listed Threatened Species
*** - State-listed Endangered Species

Insects

Aquatic macroinvertebrates were collected for all four years of the R-EMAP project. However, the 2001 data are not complete as of the date of this report. Therefore, a full analysis cannot be done.

Table 11b. Live (L), recent (R), and weathered (W) mussels collected during 2000/2001 R-EMAP by ecoregion.

Common Name	WHP	ST	CGP	FH	TOP	OH	CIP	WCBP
Asian clam			R,W	R,W	R,W	R	R,W	
black sandshell				W			W	
bluefer				R,W	L,R,W			
creeper*				R,W	R,W		W	
cylindrical papershell*				W				
deertoe*					R		R,W	
fatmucket*			W	R,W	W		L,R,W	
fawnsfoot*			L,R,W	R,W				
fingernail clam	R,W	R		W	R,W		R,W	W
fluted shell**				W		W		
fragile papershell	R		R,W	L,R,W	L,R,W		L,R,W	
giant floater		R,W	L,R,W	R,W			R,W	W
lilliput		W	R,W	R,W	R,W		W	
mapleleaf			L,R,W	L,R,W	W		L,R,W	
Neosho mucket***					W			
Ouachita kidneyshell**					W			
paper pondshell				R			R	
pimpleback			R,W	L,R,W	W		W	
pink heelsplitter				L,R,W			R,W	
pink papershell			R,W	R,W				
pistolgrip				R,W	R,W		L,R,W	
plain pocketbook				R,W	R,W		W	
pondhorn	R,W		R,W	R,W			R,W	W
pondmussel			R,W	R,W	R,W		L,R,W	W
round pigtoe*				W				
spike*				W			W	
threehorn wartyback				R	R			
threeridge				L,R,W	W		L,R,W	W
Wabash pigtoe*			W	L,R,W	R,W		W	W
washboard*					W			
white heelsplitter			R,W	L,R,W	L,R,W		L,R,W	
yellow sandshell*			R,W	R,W	L,R,W		R,W	

* - State-listed Species In Need of Conservation
** - State-listed Threatened Species
*** - State-listed Endangered Species

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The 1994/2000 and 1995 data are summarized here. During the 1994/1995 sampling seasons, the HDI collection method was not used in conjunction with the transect collection method.

In the three years of sampling, there were a total of 19 orders, 8 classes, and 78 families of aquatic and semi-aquatic invertebrates collected (Appendix 13). In these 82 families, there were 204 genus represented by 19 033 individuals (10 158 collected in 2000).

The average family richness for the 1994/1995 sampling seasons was 8.7, and the average family richness for the 2000 sampling season was 16.9. This difference may be due to the incorporation of the HDI sampling method used during the 2000 sampling season. The average family richness for all sites was 12.3. The average random family richness was 10, the average reference family richness was 13. The highest reference family richness of 27 was found at Deep Creek, Riley County (KRS-006). The highest random site family richness was found at West Elkhorn Creek, Lincoln County (02063) and Mill Creek, Wabaunsee County (02097) with 25 species (Table 12a). The Ozark Highlands had the highest average family richness with 25 at one site. The Southwestern Tablelands had an average family richness of 17 between two sites. The Cimarron River Basin (three sites) had the highest average family richness of the river basins with 17 species. The Upper Republican River Basin (three sites) had an average family richness of 15 (Table 13).

The highest EPT score was 100% found at Smoky Hill River, Saline County (09627). East Creek, Morris County (09471) had an EPT score of 77.8%. The highest reference EPT score was 36.4% at Soldier Creek, Jackson County (KRS-008) (Table 13c). The Upper Republican River Basin (three sites) had the highest average EPT score of 61.1%. The Neosho River Basin had an average score of 35.0%. The Flint Hills had the highest average EPT score of the basins with a score of 33.0%. The Western High Plains had an average score of 30.4% (Table 13).

The highest HDI score achieved during the 2000 REMAP sampling season was 34 at Mill Creek, Wabaunsee County (02097). Shoal Creek, Cherokee County (KRS-007) had the highest reference site score of 33 (Table 12c). The average random site score was 18.6. The average reference site score was 22.5. The Ozark Highlands had one site with a score of 33, and the Southwestern Tablelands had one site with a score of 30. The Flint Hills had an average score of 22.3. The Cimarron River Basin (two sites) had the highest average HDI score of the river basins with a score of 29. The Upper Republican River Basin had one site with a score of 28. The Verdigris River Basin (two sites) and the Solomon River Basin (four sites) had average HDI scores of 22 (Table 13).

Table 12a. 1994/2000 invertebrate community characteristics.

Site Number	Total Family Richness	EPT Family Richness	EPT Score	Site Number	Total Family Richness	EPT Family Richness	EPT Score	HDI Score
09451	11	5	45.5	02051	17	6	35.3	15
09453	16	4	25.0	02053	18	5	27.8	30
09454	12	8	66.7	02054	18	10	55.6	28
09455	7	0	0.0	02055	11	2	18.2	10
09456	10	1	10.0	02056	15	1	6.7	10
09457	4	2	50.0	02057	17	7	41.2	21
09458	8	0	0.0	02058	19	3	15.8	27
09459	2	0	0.0	02059	13	2	15.4	10
09460	3	0	0.0	02060	13	2	15.4	24
09461	4	1	25.0	02061	16	3	18.8	24
09462	13	3	23.1	02062	16	3	18.8	19
09463	16	6	37.5	02063	25	6	24.0	19
09465	22	7	31.8	02065	18	3	16.7	27
09466	5	2	40.0	02066	21	7	33.3	25
09467	3	2	66.7	02067	12	3	25.0	26
09468	7	2	28.6	02068	21	7	33.3	9
09469	0	0	0.0	02069	12	1	8.3	14
09470	6	3	50.0	02070	21	8	38.1	27
09471	9	7	77.8	02071	17	5	29.4	28
09472	15	5	33.3	02072	19	2	10.5	9
09473	4	0	0.0	02073	9	0	0.0	29
09476	11	3	27.3	02076	17	1	5.9	21
09480	14	6	42.9	02080	11	0	0.0	7
09481	7	3	42.9	02081	10	2	20.0	18
09482	13	4	30.8	02082	12	2	16.7	18
09483	3	2	66.7	02083	12	0	0.0	7
09484	12	1	8.3	02084	23	7	30.4	10
09485	12	4	33.3	02085	15	3	20.0	8
09486	4	0	0.0	02086	16	3	18.8	11
09487	9	3	33.3	02087	12	2	16.7	15
09488	15	2	13.3	02088	11	1	9.1	7
09489	11	2	18.2	02089	11	2	18.2	23
09492	0	0	0.0	02092	16	4	25.0	25
09497	19	8	42.1	02097	25	5	20.0	34

Physical Habitat

The most commonly encountered substrate was sand (30%). Fines, fine gravel, and coarse gravel

Table 13. Aquatic macroinvertebrate scores by basin and ecoregion for all R-EMAP data.

Basin	Total Family Richness	EPT Score	HDI Score
CRB	17	21.51	29
KLR	13	23.36	18
LARB	14	30.45	16
MDC	11	32.06	21
MRB	8	4.69	20
NRB	14	34.99	22
SHS	11	30.41	18
SRB	12	15.55	22
UARB	3	0.00	
URRB	15	61.11	28
VRB	13	27.82	22
WRB	9	31.43	18

Ecoregion	Total Family Richness	EPT Score	HDI Score
WHP	13	30.43	22
ST	17	26.39	30
CGP	12	25.35	18
FH	14	33.01	22
TOP	13	23.72	18
OH	25	28.00	33
CIP	10	24.91	15
WCBP	11	19.27	18

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were also highly abundant. Reference sites had 33.2% fine, 25.6% sand, 13.7% coarse gravel, and 9.1% fine gravel and cobble. Random sites had a higher sand composition (34.3%), with 30.8% fine, 12.6% fine gravel, and 12.4% coarse gravel. Cobble comprised only 4.5% of the random site substrate. The Cimarron River Basin had the highest percentage of sandy substrate (81.4%), while the Upper Arkansas River Basin had the highest percentage of fine substrates (90.5%). The Western Corn Belt Plains had the highest amount of fine substrate (43.7%) and the Southwestern Tablelands had the highest amount of sandy substrates (73.4%). In general, both sand and fine substrates decreased from west to east across the state, and substrate diversity increased from west to east (Figure 8).

Channel units were very similar throughout the state, with glides being the most common (67.9%). Pools and riffles combined comprised only half as much of the channel units as glides (16.9% and 10.4% respectively). Dry channels were encountered as well (4.4%) (Figure 9). Reference and random sites were also very similar in their channel unit composition. They had 68.9% and 68.6% of the channel in glide, respectively.

The most commonly encountered human influence was pasture/range/hay. Road/railroad and row crops followed respectively. The high amount of road/railroad influence could be due to accessability to the stream. It should also be noted that bridges were not observed during the 1994/1995 sampling season (Figure 10).

Overhanging vegetation, brush and small woody debris were the most abundant fish cover types. Macrophytes and filamentous algae were encountered frequently as well (Figure 11).

Figure 8. Substrate composition by basin and ecoregion for all R-EMAP data.

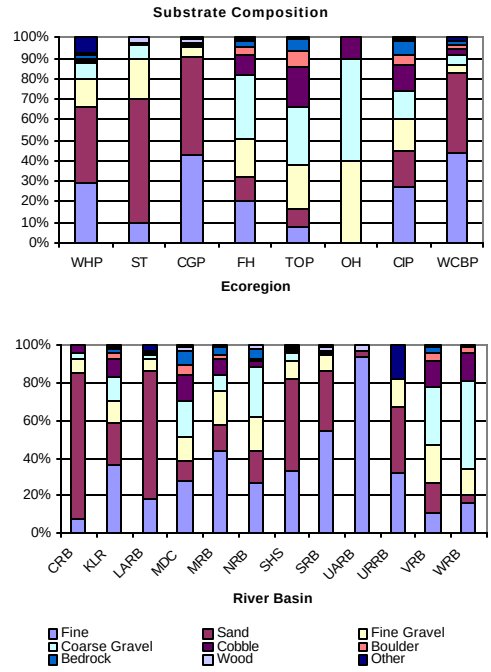
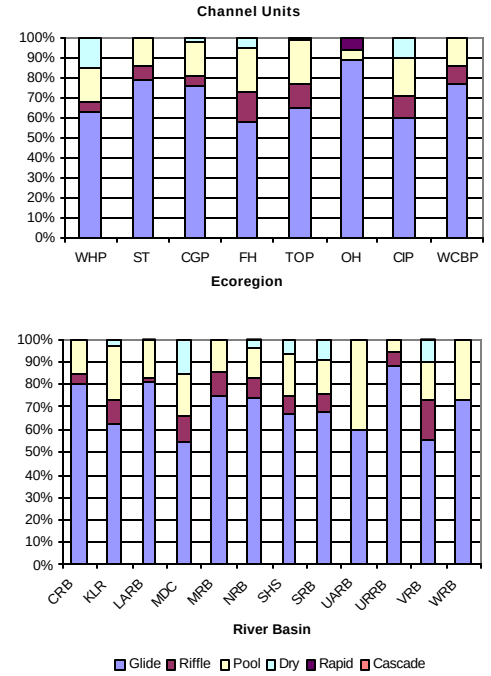


Figure 9. Channel units by basin and ecoregion for all R-EMAP data.



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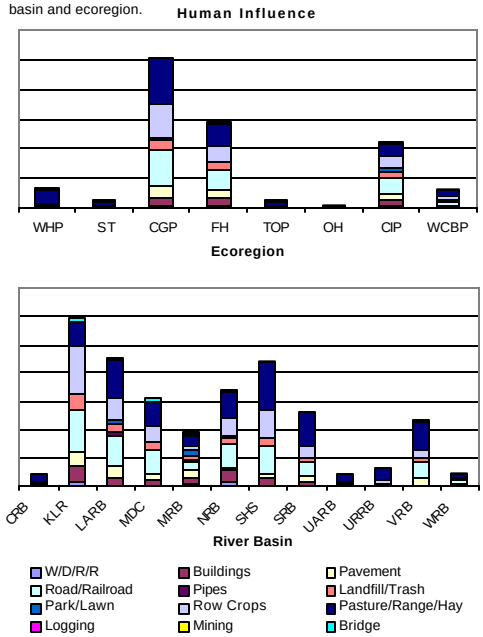
DISCUSSION

In 1994 the EPA initiated R-EMAP in the state of Kansas. KDWP collected biological and physical habitat measurements for the EPA. During 2000/2001 these sites were revisited and reference sites were established. KDWP compiled all the data collected during these four years and summarized it in this report. It is difficult to detect trends with only two years of data. However, regional assessments were made and random sites were compared to reference sites to assess the validity of hand picking reference sites. IBI metrics were also reviewed and new ones implemented.

On average, reference sites were higher than random sites in most biological categories, i.e. fish species richness, IBI scores, mussel species richness, invertebrate family richness, and HDI scores. When separating the sites by ecoregions, we find a similar situation. Reference sites have higher fish species richness, on average, than random sites. Using the old IBI metrics, reference sites scored higher than random sites. However, using the new IBI metrics, only two ecoregions (Flint Hills and Southwestern Tablelands) had reference IBI scores higher than random scores. Mussel species richness was variable between random and reference sites in ecoregions. The Southwestern Tablelands, Flint Hills, Texas-Oklahoma Plains, and Central Irregular Plains all had higher reference site mussel species richness (Table 14).

Figure 10. Human influences encountered during R-EMAP project by basin and ecoregion.



It should be noted the varying number of random and reference sites located in each ecoregion (Figure 7). More representative comparisons could be done with more data and more sites.

CONCLUSION

Random sites seem to represent the current condition of streams in the ecoregions. However, with low numbers of sites in some ecoregions, those ecoregions may be misrepresented. Hand-picked

Table 14. Biological data by ecoregion for random and reference sites.

	Fish Species Richness		IBI-1 Scores		IBI-2 Scores		Mussel Spe Richness	
Ecoregion	Random	Reference	Random	Reference	Random	Reference	Random	Ref
WHP	8	7	64	64.8	79.2	66.5	2	
ST	11	12	71	83.7	77.5	89.3	0	
CGP	11	12	65.1	77.5	71.6	74.8	13	
FH	11	23	66.7	90.8	73.3	91.7	23	
TOP	15	25	81.5	90	98.5	95.7	3	
OH	0	26	0	76	0	85.5	0	
CIP	14	19	74.8	81	86.1	82.4	11	
WCBP	6	17	54.2	84	71.3	68.7	6	

reference sites on the whole seem to represent the

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best attainable habitat for streams on a statewide basis, However, due to varying site numbers in different ecoregions, a valid assessment is difficult.

A new IBI has been developed for the state which includes native and introduced species, items not addressed in the old IBI. On average, IBI scores were higher using the new metrics, but there was also a higher attainable score (100 vs. 120). The new IBI seems to better represent the species composition within the state of Kansas.

KDWP has completed the second rotation of the R-EMAP project in the state of Kansas. This data has been summarized and presented in this report. The EPA will produce a final report presenting further analysis of data collected for this project.

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