



## Evaluating Progress of Biological Condition in Streams of the Minnesota River Basin

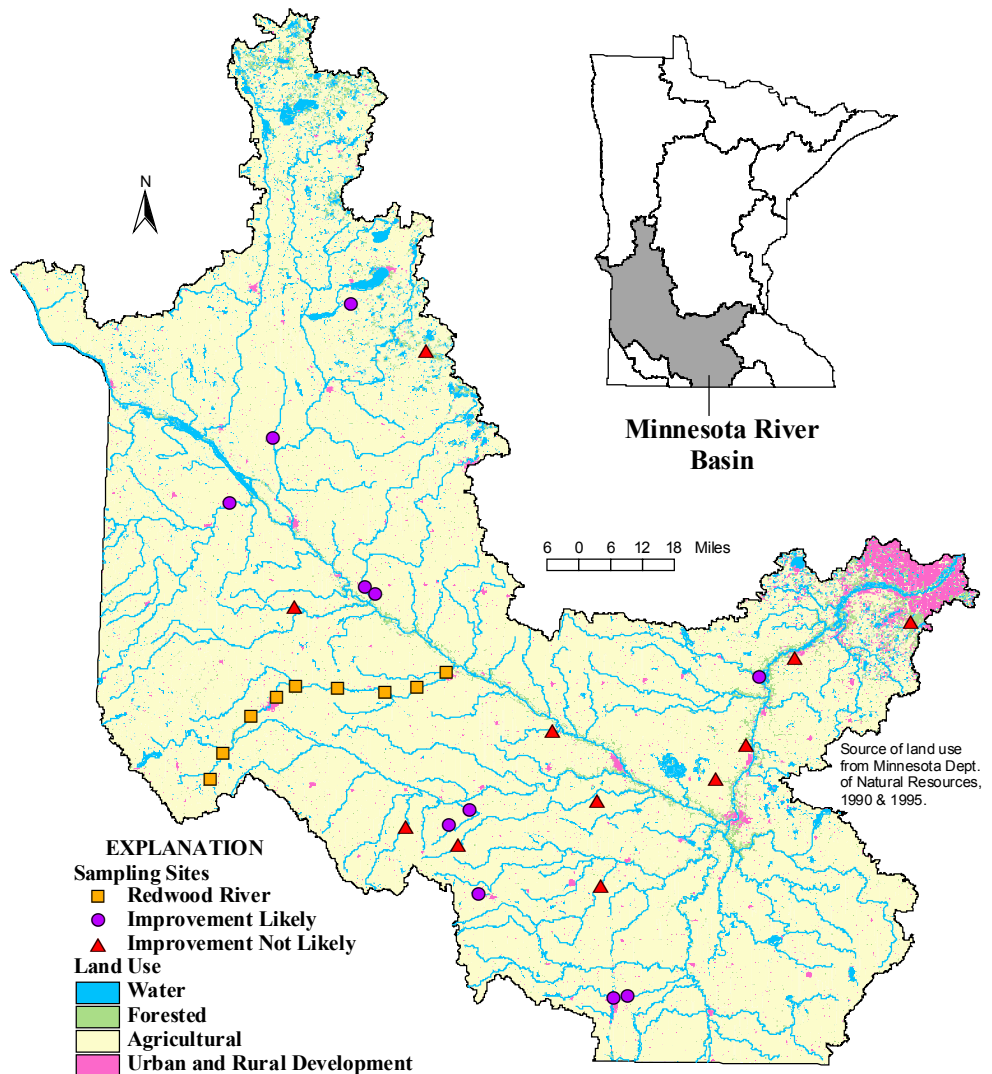
Over the last decade, the Minnesota River Basin has been the recipient of a comprehensive effort intended to restore water quality. Many government agencies and private citizens have collaborated in an effort to improve water quality through land conservation easements, best management practices, and other management activities. In the summer of 2001, fish communities at 31 stream sites that were originally sampled from 1990-1992 as part of the Minnesota River Assessment Project (MRAP) were re-sampled to evaluate change in stream biological condition. The index of biological integrity (IBI) was used to evaluate change in stream biological condition between the two periods. A comparison of mean IBI scores indicated that there was not a significant change in stream biological condition between sampling periods. Given the pervasiveness of land use modifications in the basin, the existing level and elapsed time of restoration activities in selected watersheds may not have been sufficient to improve stream biological condition.

### Introduction

The degradation of Minnesota's rivers and streams can be traced to a multitude of sources including: chemical pollutants from municipal and industrial point source discharges; agricultural runoff of sediment, nutrients, and pesticides; hydrologic alteration from stream channelization, dams, and artificial drainage; and habitat alteration from agricultural, urban, and residential encroachment. In Minnesota, perhaps no river basin has experienced more landscape level changes than the Minnesota River Basin, where agricultural land use exceeds 80% (fig. 1).

The recognition of a distinct loss in resource quality led to intensive research into the pollutant sources, transport mechanisms, and associated impacts on the river. In 1992, then Governor Arne Carlson issued a proclamation to clean up the Minnesota River within ten years. To determine the feasibility of improving water quality in the basin, the Minnesota River Assessment Project (MRAP) was completed over a four-year period from 1989 to 1993. Led by the MPCA and involving more than 30 federal, state, and local government agencies, MRAP established a comprehensive monitoring network in the basin to assess the chemical, physical, and biological condition of surface waters and developed recommendations for improving water quality (MPCA 1994).

As part of MRAP, fish community assessments were conducted at 116 sites on rivers and streams throughout the basin to evaluate biological condition. Data collected from least impacted (reference) sites and historical information were used to develop an Index of Biological Integrity (IBI: Karr



**Figure 1. -- Location of sampling sites, sample groups, and land use within the Minnesota River Basin of Minnesota.**

1981) for fish communities of the Minnesota River Basin (Bailey et al. 1993). The IBI used 12 attributes (termed metrics) of the fish community related to species richness and composition, trophic structure and reproductive function, and fish abundance and condition. Ratings of 5,

3, and 1 were assigned to each metric according to whether its value approximated, deviated somewhat from, or deviated strongly from the value expected at the reference sites. When the metrics are summed together the resulting index score characterizes the underlying biological integrity or

“health” of a site (Karr et al. 1986). Narrative descriptions are used to rate the integrity of a site as: Excellent, 50-60; Good, 40-49; Fair, 30-39; Poor, 20-29; Very Poor, 12-20; and No Fish. Biological assessments are used by the MPCA to determine impairment for 305b (aquatic life use) and 303d (TMDL) listing.

The increased focus on the Minnesota River Basin has resulted in a number of success stories. Numerous government agencies, organizations, and citizens have worked cooperatively to begin the restoration of water resources within the basin. Programs such as the Conservation Reserve Program (CRP), Reinvest in Minnesota (RIM), and the Conservation Reserve Enhancement Program (CREP) have been successful in taking thousands of acres of environmentally sensitive land out of agricultural production. The implementation of best management practices (BMP’s) such as conservation tillage, grass waterways, and buffer strips have resulted in reductions of sediment and phosphorus loading into the Minnesota River and its tributaries (MPCA 1997).

The purpose of this study was to determine if biological condition has changed in select streams of the Minnesota River Basin since MRAP was conducted. A sub-set of MRAP sites was re-sampled to evaluate if management activities have thus far resulted in an improvement of water quality as measured by the fish IBI.

### Site Selection

Interviews were conducted with Soil and Water Conservation District (SWCD) staff to evaluate the likelihood of water quality improvements. SWCD staff were asked to rate the MRAP sites in their region based on their knowledge of management activities (CRP and RIM enrollment, BMP implementation, etc.) that have since occurred in the watersheds of MRAP sites. A group of sites identified as the most likely and the least likely to have exhibited a change in stream condition was selected for re-sampling. Nine sites on the Redwood River were also selected because this watershed has progressed furthest in the Clean Water Partnership (CWP) program and has experienced considerable implementation of management

activities designed to improve water quality. A total of 31 MRAP sites (20 likely to improve and 11 where change was not likely) were re-sampled during the months of July and August 2001. The drainage areas of watersheds ranged from 2 mi<sup>2</sup> to 898 mi<sup>2</sup>. The percent of agricultural land use within each watershed ranged from 28% to 96% (table 1).

### Fish Sampling

Fish communities were sampled by electrofishing (pulsed DC) during base-flow conditions. The length of the reach needed to collect a representative sample of fish followed guidance provided by Lyons (1992). One pass was made in an upstream direction at each site. All available habitat types were sampled in the proportion that they occurred. All fish were identified to species and counted. A length range and batch species weight was recorded.

Any apparent external anomalies were also noted.

### Analysis

IBI scores were calculated for each site using the IBI developed by Bailey et al. (1993) with only one exception; metric classifications for fish species were updated following Niemela and Feist (2000). Sites were grouped based on their likelihood of improvement (table 1). The Redwood River sites were grouped separately to evaluate change in biological condition within this system. Differences in mean IBI scores between sampling periods for each group were compared utilizing a two-tailed paired t-test.

The Local Government Annual Reporting System (LARS) database, established to track and quantify BMP installation, was used to determine the extent of BMP implementation within the watershed of each site. Activities

	Stream Name	MPCA Site #	Drainage Area (sq. mi.)	% Agriculture	% Rangeland	% Urban	% Forest	% Wetland	% Water	# BMP's	# BMP/sq.mi.	MRAP IBI score	2001 IBI score	Change in IBI
Improvement Likely	Mountain Lake Inlet	91mn098	2	88	2	2	0	7	0	0.00	17	19	2	
	Signalness Creek	90mn008	11	51	34	1	7	4	3	0	0.00	31	26	-5
	Minnesota River trib	91mn050	12	84	8	3	2	3	0	1	0.08	17	22	5
	Mound Creek trib	91mn065	13	87	10	1	1	0	0	0	0.00	29	22	-7
	Buffalo Creek	90mn111	28	89	3	2	6	0	0	0	0.00	38	46	8
	Mound Creek	91mn067	45	87	11	1	1	0	0	13	0.29	43	36	-7
	Center Creek	92mn083	92	80	5	6	3	1	5	5	0.05	19	24	5
	Center Creek	92mn084	99	79	6	6	3	0	5	6	0.06	24	36	12
	Cottonwood Creek	90mn011	100	94	3	1	1	0	0	16	0.16	32	28	-4
	Hawk Creek	90mn017	501	88	4	3	3	1	2	54	0.11	40	44	4
Improvement Not Likely	Lac qui Parle River	90mn004	898	82	12	2	3	1	1	133	0.15	28	34	6
	Little Cottonwood River trib	91mn057	7	96	2	2	1	0	0	0	0.00	34	34	0
	Robert Creek	91mn112	10	71	9	6	9	5	0	1	0.10	26	31	5
	County Ditch 46A	91mn059	12	83	5	2	3	7	0	1	0.08	22	17	-5
	Little Cottonwood River	91mn056	22	93	3	2	1	0	0	2	0.09	34	36	2
	Credit River	90mn117	24	28	18	16	26	8	3	0	0.00	36	26	-10
	Mud Creek	90mn009	26	48	19	1	13	4	15	0	0.00	46	46	0
	Rogers Creek	91mn061	27	88	4	2	5	1	0	6	0.22	17	22	5
	Spring Creek	91mn055	37	94	2	2	2	0	0	1	0.03	41	41	0
	Highwater Creek	90mn063	93	87	7	2	2	1	2	23	0.25	43	43	0
Improvement Likely	Spring Creek	91mn014	121	92	4	1	2	1	0	29	0.24	20	44	24
	S.F. Watonwan River	90mn099	190	90	4	2	3	0	1	43	0.23	26	30	4
	Redwood River	92mn022	56	81	12	2	1	1	3	17	0.30	38	46	8
	Redwood River	92mn025	131	83	11	2	2	1	1	35	0.27	40	32	-8
	Redwood River	92mn030	256	78	13	2	3	1	3	59	0.23	36	36	0
	Redwood River	92mn031	266	78	12	3	3	1	3	62	0.23	40	36	-4
	Redwood River	92mn033	308	79	11	4	3	1	3	65	0.21	28	28	0
	Redwood River	92mn038	473	82	10	3	3	1	2	98	0.21	24	28	4
	Redwood River	92mn041	517	83	9	3	3	1	2	104	0.20	36	32	-4
	Redwood River	92mn044	611	85	8	2	2	1	2	111	0.18	36	30	-6
Redwood River	92mn049	703	86	7	2	2	0	1	126	0.18	46	46	0	

Table 1. -- Site characteristics by sample group

reported in LARS as protective of only groundwater were excluded. A Pearson Correlation Coefficient was calculated to determine if there was a relationship between the change in IBI score and the number of BMP's per watershed square mile. Six sites were sampled twice in 2001 to examine the within year variability in IBI score.

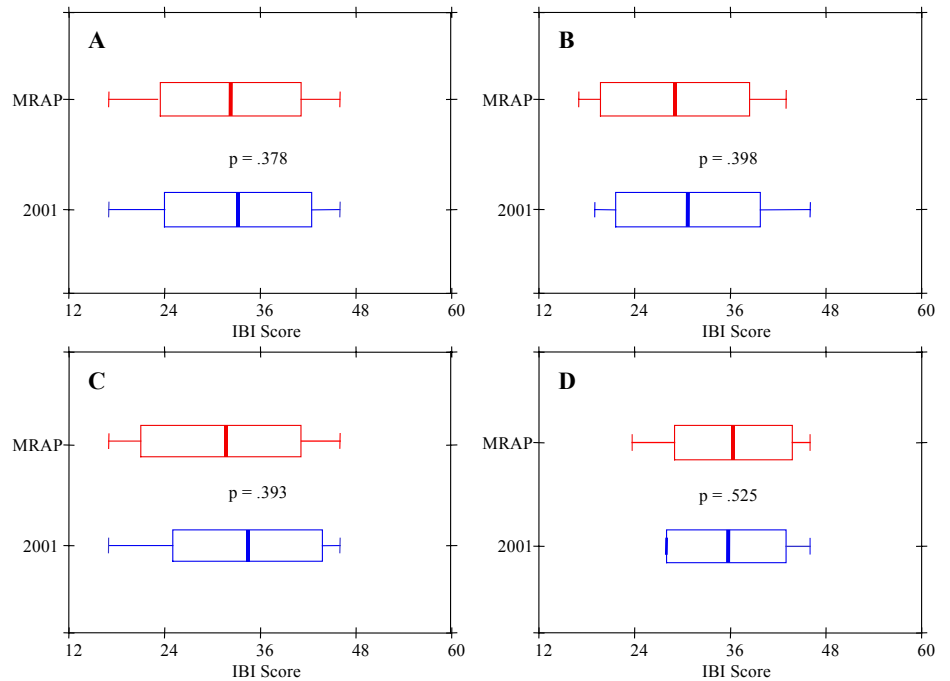
## Results

There was no significant difference in mean IBI scores between sampling periods when all of the data from each site was combined, or when the data was divided into groups based on the likelihood of improvement (fig. 2). In fact, most IBI scores were remarkably similar between the two periods. Twenty-one sites differed in IBI score by 5 or fewer IBI points, including 7 sites that had identical IBI scores. Only 2 sites had IBI scores that differed by more than 10 IBI points. There was also no significant difference in IBI scores between sampling years for sites on the Redwood River. However, there was a general trend of lower IBI scores progressing downstream before improving near the confluence with the Minnesota River (fig. 3). There was no correlation between the number of BMP's per watershed square mile and the change in IBI score between sampling years (Pearson  $r=.07$ ,  $p>.5$ ) (fig. 4). The mean ( $\pm$  SE) difference in IBI scores for the 6 within year repeat sites was  $2.67\pm 1.02$ . A difference of  $\pm 4.2$  IBI points represents a 95% confidence limit in IBI score.

## Conclusions

The biological condition at a select group of streams in the Minnesota River Basin has not changed since MRAP as indicated by the analysis of mean IBI scores between sampling periods. Over the last decade, it appears changes in land use and the implementation of BMP's have not yet resulted in an improvement of stream biological condition at select sites.

As figure 4 illustrates, there is no relationship between BMP density and change in IBI score. The maximum density of watershed BMP's for sampling sites is only 0.30 per square mile (mean=0.13). With agricultural land use in these same watersheds averaging 81%, it may be



**Figure 2. -- Box and whisker graphs depicting the observed range (whisker boundaries) and the mean IBI score  $\pm$  one standard deviation (center bar and box boundaries) for each sample group. A) all sites collectively, B) sites likely to improve, C) sites not likely to improve, and D) Redwood River sites. [p-value indicates significance level of paired t-test between sample means]**

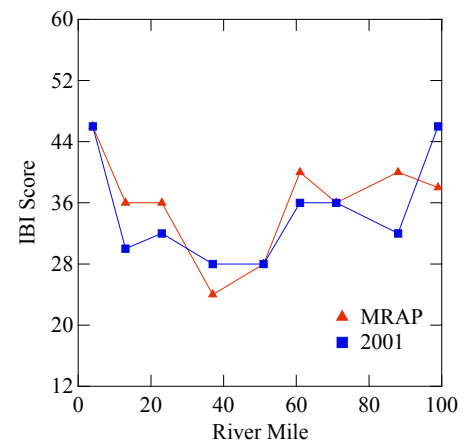
understandable why biological condition has not yet improved given the current level of BMP implementation. Greater BMP densities may be necessary before a positive change in biological condition is achieved.

Of interest however, is a change in biological condition at small ( $<100\text{mi}^2$ ), unchannelized sites that contain some BMP implementation. The 7 sampling sites that met these criteria had a mean difference in IBI score of 5.29 and were significantly different (paired t-test,  $p=.012$ ) between periods, suggesting biological condition may be responding to restoration activities within small watersheds where streams are not channelized.

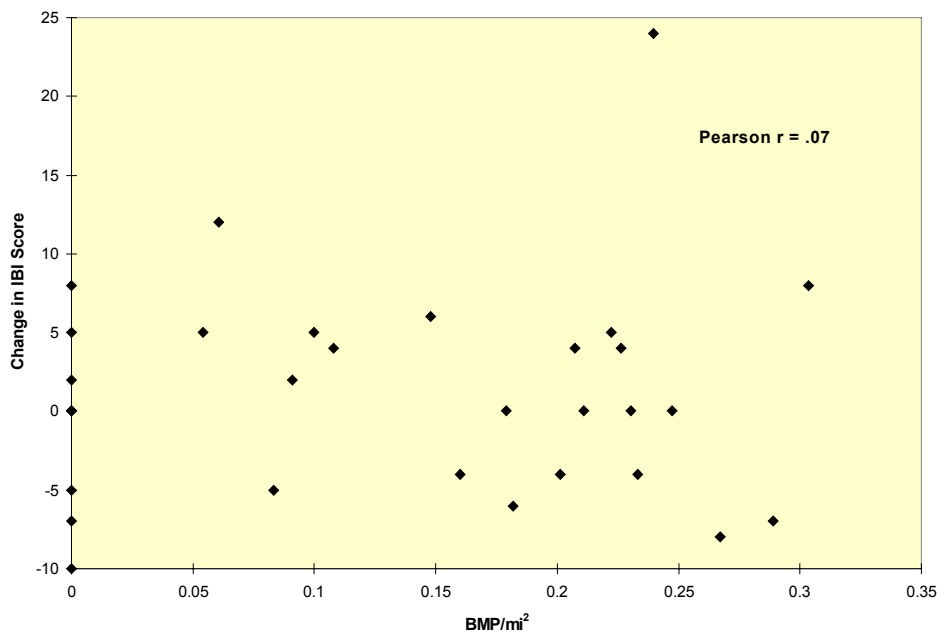
While BMP implementation has been most pronounced in the Redwood River watershed (table 1), thus far biological condition has not improved. The large size of this watershed may be obscuring improvements that are occurring at a smaller scale as a result of restoration activities.

The median change in IBI scores between sampling years for all sites was 0 and ranged from  $-10$  to  $24$  (mean = 1.10). Spring Creek (site# = 91mn014), which was not expected to

improve, demonstrated a 24 point (from 20 to 44) improvement in IBI score between sampling years. A possible explanation is that Spring Creek originally scored lower than it should have because it was sampled outside (Oct. 3, 1991) the normal index period of mid-June to mid-September. As water temperature and flow decrease in the fall, fish community structure changes, many species will migrate downstream to larger rivers to over-winter in deeper water. A transient impact event prior



**Figure 3. -- Redwood River IBI scores between sampling periods.**



**Figure 4. -- The change in IBI score between sampling periods vs. the number of BMP's implemented per mi.<sup>2</sup> of watershed as reported in LARS.**

to sampling in 1991 is also a plausible explanation.

The Credit River (site# =90mn117) elicited the greatest decline in IBI score, a 10 point decrease (from 36 to 26). The watershed is located primarily within the developing communities of Savage and Prior Lake and may be experiencing the effects associated with urban development. It is well documented that urbanization and the corresponding increase in impervious surface area can cause degradation to the stream environment through modifications to the hydrology, habitat structure, water chemistry, and biological condition of aquatic systems (Schueler 1994; Wang et al. 1997; Talmage et al. 1999).

Because sampling sites were restricted to former MRAP sites, areas with more intensive management may have been missed. In other words, management activities within the basin were not specifically implemented with the intent of improving MRAP sites. It is possible that watersheds exist within the basin that have greater densities of BMP's and conservation easements.

Most of the management activities in the basin intended to improve water quality have occurred more recently (i.e., the last several years). Many CWP projects in the basin have only recently entered the implementation phase; and the Conservation Reserve Enhancement Program (CREP), with a goal of setting aside 100,000 acres

permanently, just received full funding in the 2001 legislative session.

Moreover, due to the extent of impacts in the basin, a decade simply may not be enough time to restore the biological integrity of surface waters. Perhaps as BMP's, conservation easements, and other management activities become more established we will begin to see an overall improvement in stream biological condition.

Diligent accounting of BMP's (both number and extent) will be essential to track watershed improvements. Efforts should also be made to evaluate which BMP's are most effective in improving stream biological condition. Given the proliferation of artificial tile drainage and the extensive ditching that has occurred in the basin, mitigation of their effects to the stream environment will need to be addressed in many watersheds if improvements in biological condition are to be realized. Furthermore, a focus on smaller watershed projects may yield timelier results.

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