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Changes in the Diversity of Native Fishes in Seven Basins in Illinois, USA

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Abstract.—A study of the fish faunas in all or parts of seven Illinois river basins revealed an average loss of 8.4 species per basin over approximately the last 100 y. In contrast, between the 1980s and 1990s, five basins showed an increase in the species richness (number of species) and two showed a statistically significant increase (paired *t*-test) in the species richness per sample site. Only the Kaskaskia River basin had a significant decline (paired *t*-test) in the species richness per sample site between the 1980s and 1990s. Minnows (Cyprinidae) had the largest number of species showing declines over the last 100 y and was followed in decreasing order by darters and perches (Percidae), catfishes (Ictaluridae), suckers (Catostomidae), topminnows (Fundulidae) and sunfishes (Centrarchidae). Changes in the overall fauna since the 1980s show an increase in species occurrence, but minnows and catfishes showed little net change and suckers, sunfishes and darters showed a positive increase in occurrence.

Introduction

Across North America, fish faunas have been highly altered over the past 100–200 y. Many changes have been noted and summarized in various books that address regional or state faunas (*see* Forbes and Richardson, 1909; Minckley, 1973; Wydoski and Whitney, 1979; Trautman, 1981). Such texts generally discuss declines across much of the native fauna and list a number of factors considered to be responsible for the decline. Much of the information is based on general observations and often on data that are not quantitative or comparative in nature. However, long-term studies that are comparative and well quantified will provide a greater knowledge of large-scale faunal changes over long time periods. Comparative studies of fishes of this type are fairly rare (Anderson *et al.*, 1995).

A number of studies have been published on the stability of fish populations in small streams over 3 to 12 y periods (*see* Grossman *et al.*, 1990 and Matthews, 1998 for reviews of these works). These studies concentrate on short-term fluctuations and not long-term trends over larger areas.

Three recent studies have examined changes in species distributions over large areas and over longer time periods (approximately 30 or 100 y). Patton *et al.* (1997) resampled sites first visited in the 1960s. These sites covered a large portion of Wyoming. In 1986 Anderson *et al.* (1995) resampled 129 sites located throughout most of Texas. Their sites were first sampled in 1953. Both studies calibrated their methods to account for differences in methods and amount of sampling effort. The third study by Koel and Peterka (1998) encompassed the Red River of the North in the Minnesota, North Dakota and South Dakota. This study relied on published and unpublished records including museum specimen records and on personal communications. Although some of the records are unpublished or unsupported by vouchered specimens, they were able to extend the time period to 100 y.

In Illinois, the results of two statewide surveys of fishes have been published by Forbes and Richardson (1909) and Smith (1979). The former study was based on 1500 collections from 600 localities. The latter was based on 3000 collections from 2400 localities. Since the study of Smith (1979), efforts have been made to resurvey the state by biologists of the Illinois Department of Natural Resources (IDNR) and Illinois Natural History Survey (INHS; INHS is now an autonomous entity of IDNR). The early records and recent sampling efforts provide an excellent opportunity to study changes in fish distributions over a large geographic area. Hence, the goal of this study is to determine if there have been any changes in the species richness (the number of species) of native fishes within all or parts of seven river basins in Illinois between 1876–1905 and 1960–1998 (long time period) and between 1982–1986 and 1997–1998 (short time period). Individual species and overall pattern changes in the fauna also is discussed.

METHODS

This study used fish collection data from surveys in all or parts of seven river basins in Illinois: Des Plaines River, upper Kaskaskia River, Kishwaukee River, Pecatonica River, upper Rock River, Salt Creek (of the Sangamon River system) and Vermilion River (of the Wabash River system) (Fig. 1).

The data used were collected during four time periods: 1876–1905, 1960–1970, 1982–1986 and 1997–1998. The 1876–1905 data primarily are based on the study of Forbes and Richardson (1909) and a few additional samples obtained by other collectors (Smith, 1979). The locations of these samples were published in Smith (1979) and were used herein to develop a list of species for each of the basins studied for this time period. These early collections were made using seines and other kinds of nets and were not standardized (*i.e.*, no attempt to quantify the catch per unit effort). Generally, collections were made on the larger tributaries of the drainage basins.

Data from 1960–1970 are from Smith's (1979) survey of Illinois. Although Smith himself sampled most locations, his data also included samples made by IDNR stream crews and other field biologists. Most of Smith's material was not gathered using standardized methods (usually by seine but no record of catch per unit effort). Generally, collections were made throughout the drainage basins.

Data from 1982–1986 mostly were from unpublished reports on basin surveys written by IDNR fisheries personnel. Data for the Pecatonica drainage basin was from Staff Report (1988). During 1982–1986 IDNR stream crews generally used rotenone over a measured distance to quantitatively sample fish populations at shallow sites. At deeper sample sites a boat mounted electroshocker was used for 30 to 60 min. Shocking from boat was effective in collecting large nonbenthic species, but less so in collecting small benthic species. Supplemental seining along the shore was done to capture species that shocking from boat may have missed. Shocking from boat underestimates numbers of minnows, darters and catfishes (Bailey and Dowling, 1990). One exception was that all shallow sites ($N = 4$) in the Des Plaines basin were sampled with a combination of backpack electroshocker and seine instead of rotenone.

Data from 1997–1998 were obtained directly from the field notes and specimens deposited in the INHS fish collection. During 1997–1998 IDNR stream crews used two basic techniques to collect specimens. As in the earlier time period, a boatmounted electroshocker was used for 30 to 60 min in areas too deep to wade and was supplemented by seining. The second method was the use of an electric seine, which was pulled upstream over a measured distance (typically 100 m or more). Electric seining is considered to be highly effective when used in shallow wadable depths (Bayley and Dowling, 1990).

During 1982–1986 and 1997–1998 the samples were taken as part of an effort to monitor fish populations and water quality of each basin. An effort was made to sample both large and small streams. Typically, 20–30% of samples were made on the main-stem of a drainage basin and the balance on smaller tributaries.

While deep water sites were sampled by shocking from boat during both time periods, most of the 1982–1986 IDNR shallow sites in all basins except in the Des Plaines were based

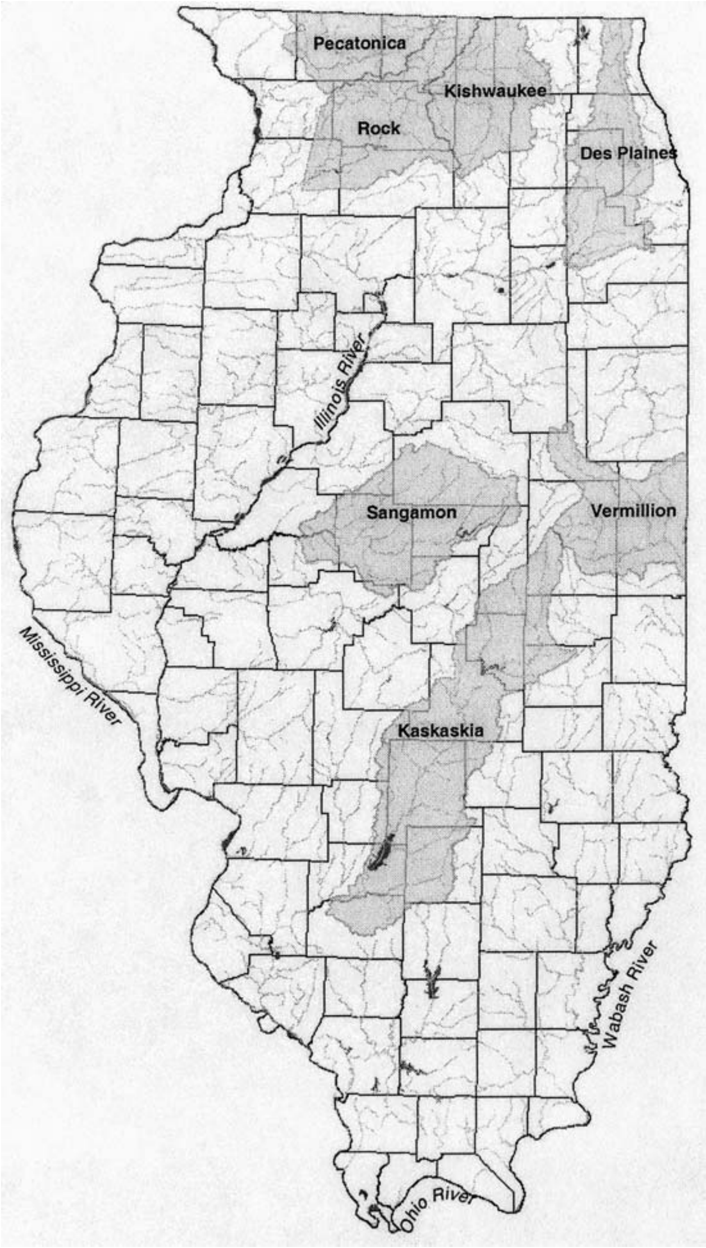

FIG 1.—Map showing the locations of seven study basins in Illinois

on rotenone collections, and 1997–1998 data collections were based on electric seine methods. Because of the differences in efficiency of rotenone and electric seine, an effort was made to equilibrate these methods. Comparisons of these methods or others have been done in Illinois streams and permit equal or near equal comparisons of samples (Larimore, 1961; Bayley *et al.*, 1989; Bayley and Dowling, 1990). Bayley and Dowling (1990) found the electric seine to be about 85% of the efficiency of rotenone in the capture of species. While rotenone was used in early studies, later studies generally used the electric seine over a larger area. The distance sampled using rotenone typically was 91.5 m, whereas most electric seine sites were 91.5 to 183 m. Because a greater sample area will compensate for the less efficiency of the electric seine, both methods were considered to be equivalent if electric seine sites were greater than 91.5. It is possible that very long electric seine sites (>150 m) may have yielded more species than a rotenone sample. However, at these sample lengths, few additional species would be added, based on the results of Lyons (1992) in southern Wisconsin streams. At these lengths, the number of species captured will approach or reach an asymptote. This situation only applied to the Kaskaskia River basin where electric seine sites sometimes exceeded 200 m in length. This possible bias is further discussed in results. Finally, four sites in older Des Plaines study were sampled using an electric backpack shocker or seine. These methods are less efficient than the electric seine (Bayley *et al.*, 1989) and this bias is further discussed in results.

To examine changes in species richness for the long time period (1876–1905 to 1960–1998), I estimated the extirpation of native species in each of the river basins. Species were considered native if they were indigenous to Illinois at the time of Forbes and Richardson (1909). A few of these species have had their distributions altered by stocking and at least one species (*Cyprinella lutrensis*) has expanded naturally its range within Illinois, and these special cases are discussed. Although I would have preferred to test if there had been a net gain or loss in species richness, differences in sampling methods and the larger number of sample sites visited during the later time period would over estimate the number of species appearing in a basin for the first time in that time period. However, the greater effort and number of samples from later period insured that an extirpation of a species likely did occur. For most basins, the early number of sampled sites varied from 8 to 14 although the Kaskaskia and Vermilion drainage basins had 32 and 40 sample sites, respectively. The number of sites sampled 1960–1998 ranged approximately from 50 to 100 per drainage basin. The loss of species was determined by differences in species lists for each of the periods. The 1960–1998 list included all of the species collected during the 1960–1970, 1982–1986 and 1997–1998 periods.

Dividing the long time period along these lines is rather awkward in that even within the 1960–1998 time period, many changes to the fauna may have occurred. Ideally, the 1876–1905 data would be compared with the 1997–1998 data. Unfortunately, the quality and quantity of data makes this comparison difficult at best. Not enough samples were made during 1876–1905 and 1997–1998 to reveal the overall faunal changes in drainage basins that may have occurred. This low number of samples would greatly under estimate the species richness in each the basins at each time period. Indeed, pooling the 1960–1998 data insures a much more robust list of species that existed in the basins and reduces the likelihood of overestimating the number of species lost since the early time period. Also same site comparisons between the two time periods would not be possible as the early collection methods are unknown, and it is likely that few collections were made at the same geographic locations. These two factors would introduce unacceptable bias into the analysis.

For the short time period (1982–1986 to 1997–1998), I examined changes in species richness using two statistics: (1) changes in the species richness per sample site for each drainage basin and (2) net change in the total species richness of each drainage basin. The first statistic, changes in species richness per sample site, was tested using a paired *t*-test. The *t*-test was used to compare means of species richness obtained from sites resampled in two different years. These resampled sites had equivalent collecting methods and sampling effort to limit bias in the analysis. Differences in means were considered to be significant at the 0.05 level.

The second statistic, the net change in species richness of each drainage basin, was based on the sum of the number of species gained and lost between the two time periods across each drainage basin. The gain or loss of species was determined from the lists of species developed for each basin from the IDNR collections. The Vermilion, Salt and Kaskaskia drainage basins used the data from the same-paired sites used for the first statistic. The other basins also used the paired site data but also used data from additional non-paired sample sites. Samples sizes for the earlier and later time periods, respectively, are for the Des Plaines N = 15, 19 sample sites, Kishwaukee N = 15, 19, Pecatonica N = 19, 10 and Rock N = 21, 15. Using this additional data increased the number of species to better represent the total fauna of each basin. However, sample sizes were not equal for these basins, possibly creating bias in the analysis. To estimate sampling bias, species accumulation curves were created based on the addition of new species with the addition of sample sites. Curves for these basins reached asymptotes before the additional site data was added, meaning that extra sites did not add additional species to the list. The unequal number of sites did not introduce sampling bias.

To examine changes in the fauna for the long time period, lists of species for 1876–1905 and 1960–1998 were created for each basin. Species that showed at least one extirpation from one of the basins between 1876–1905 and 1960–1998 were summarized for further discussion of faunal changes (Table 1).

To assess the change in status of species over the short time period, a tabulation of species showing at least one change in occurrence was constructed (Table 2). (Herein I define change of status as the gain or loss of a species in a basin). A species not recorded in a basin during the 1980s, but recorded in the 1990s, was assigned a +1, an occurrence gain. A species recorded in a basin during the 1980s, but not recorded in the 1990s, was assigned a –1, an occurrence loss. A score of net occurrences for each species was summed across all seven basins. This score then reflects the total number of occurrence gains and losses for a species over all seven basins. In turn, all species scores were summed to produce an overall index that reflects net number of new gains or losses. A positive score indicated a positive trend, negative score a negative trend and 0 no net trend in species occurrences across all basins. Significance of overall species occurrence gains and losses between the two time periods was tested using a Wilcoxon signed ranks test of matched pairs (*i.e.*, a pair being the number of occurrence gains and losses for a species between the two time periods). A probability of 0.05 or less was considered significant.

RESULTS

Species richness changes.—All of the drainage basins lost species during the long time period (Table 1). The Vermilion River had the lowest number of extirpated species (4) and the Des Plaines River had the highest loss (16). As a percent of the original native fauna, the Des Plaines and Kishwaukee lost substantial portions of their faunas (28% and 20%, respectively), and the Vermilion had the lowest percent loss (8%). Basins lost a mean of 8.4 species.

During the short time period, there was a general trend of increased species richness within most basins, but only the Des Plaines and Pecatonica drainage basins had significant increases in species richness per sample site (Table 3). The Kaskaskia River had a significant decrease in species richness per sample site. Indeed, this number is likely to be conservative since the higher sample distances of the electric seine method may have yielded a slightly higher number of species than the previous rotenone samples. Although that yield would only be slightly higher because of asymptotic limits on the number of new species that can be discovered (Lyons, 1992).

TABLE 1.—List of species extirpated from all or parts of one or more of seven Illinois basins since 1876–1905

Species	Des Plaines R.	Kaskaskia R.	Kishwaukee R.	Pecatonica R.	Rock R.	Salt Cr.	Vermillon R.	Total number of extirpations.
Lepisosteus osseus	—	k	u	u	k	k	k	1
Amia calva	k	k	u	—	u	k	u	1
Umbra limi	k	u	k	k	—	u	u	1
Campostoma oligolepis	—	—	k	k	k	k	u	2
Erimystax x-punctatus	u	u	k	k	k	—	k	1
Hybopsis amblops SE	u	—	u	u	u	u	k	1
Hybognathus nuchalis	—	k	k	k	—	k	u	2
Notropis anogenus SE	—	u	u	u	u	u	u	1
Notropis chalybeus ST	—	u	u	u	u	u	u	1
Notropis heterolepis SE	—	u	k	—	—	u	—	4
Notropis hudsonius	k	u	—	k	u	—	u	2
Notropis nubilis	u	u	—	k	k	u	u	1
Notropis texanus SE	u	u	—	k	—	u	u	2
Opsopoeodus emiliae	u	—	u	u	u	u	u	1
Erimyzon oblongus	k	k	—	—	u	k	k	2
Erimyzon sucetta	u	u	k	—	u	u	k	1
Moxostoma carinatum ST	u	—	u	u	—	u	k	2
Moxostoma valenciennesi SE	—	u	u	u	u	u	u	1
Ameiurus nebulosus	u	k	u	u	u	—	k	1
Noturus flavus	k	—	k	k	k	k	k	1
Noturus gyrinus	k	k	k	—	k	k	k	1
Noturus miurus	u	—	u	u	u	u	k	1
Noturus nocturnus	—	k	u	u	u	k	u	1
Fundulus diaphanus ST	—	u	—	u	u	—	u	3
Fundulus dispar	—	u	—	k	u	u	u	2
Aphredoderus sayanus	k	k	u	u	u	—	u	1
Labidesthes sicculus	k	k	—	k	k	u	—	2
Percopsis omiscomaycus	—	u	u	u	u	—	u	2
Morone chrysops	—	k	k	u	k	k	k	1
Lepomis humilis	k	k	k	k	k	k	—	1
Lepomis megalotis	k	k	—	u	u	k	k	1
Ammocrypta clara SE	u	k	—	k	—	k	u	2
Etheostoma asprigene	k	k	u	—	u	—	—	3
Etheostoma chlorosomum	u	k	u	u	u	—	u	1
Etheostoma exile SE	—	u	k	k	u	u	k	1
Etheostoma flabellare	k	—	k	k	k	k	k	1
Etheostoma microperca	—	u	k	u	k	u	u	1
Etheostoma zonale	—	u	k	k	k	k	u	1
Percina shumardi	u	—	u	u	u	u	u	1
Stizostedion canadense	u	—	k	k	k	k	k	1
Stizostedion vitreum	k	—	k	k	k	k	k	1
Cottus bairdi	—	u	u	k	k	u	u	1
Total[1] (% loss of native species)	16 (28)	10 (17)	9 (20)	6 (16)	6 (11)	8 (15)	4 (8)	

[1] Total refers to the total number of species extirpated from a drainage since pre-1908
% extirpated is the percent of the species that is extirpated from a basin
SE = state endangered; ST = state threatened u = never known from basin; k = presently known from basin; – = extirpated from basin

TABLE 2.—Changes in native fish species presence/absence for seven Illinois basins between the 1980s and 1990s[1]

Species	Rock R.	Kishwaukee R.	Vermillion R.	Salt Cr.	Des Plaines R.	Pecatonica R.	Upper Kaskaskia R.	Totals[2]
Lepisosteus osseus							+	+1
Lepisosteus platostomus	+						–	0
Amia calva				–	+			0
Anguilla rostrata	+							+1
Dorosoma cepedianum	+					+		+2
Esox americanus					–			−1
Esox lucius					+			+1
Esox masquinongy	+					+		+2
Umbra limi					–			−1
Cyprinella lutrensis	–				–			−2
Cyprinella spiloptera							–	−1
Cyprinella whipplei							–	−1
Erimystax x-punctatus	+					+		+2
Hybopsis amblops			+					+1
Hybognathus hankinsoni	+					–		0
Hybognathus nuchalis		+	+			+		+3
Lythurus fumeus							–	−1
Macrhybopsis aestivalis		–	–					−2
Notemigonus crysoleucas	+		+	–				+1
Notropis atherinoides		–			+			0
Notropis blennius	–							−1
Notropis boops			+					+1
Notropis dorsalis						–		−1
Notropis hudsonius					–	–		−2
Notropis rubellus					+	+		+2
Notropis shumardi							–	−1
Phenacobius mirabilis					+			+1
Phoxinus erythrogaster							+	+1
Pimephales promelas			–					−1
Pimephales vigilax				+				+1
Carpiodes carpio						+		+1
Carpiodes velifer						+		+1
Erimyzon oblongus				+	+			+2
Ictiobus bubalus					+			+1
Ictiobus cyprinellus		+	+					+2
Hypentilium nigricans							–	−1
Ictiobus niger			+					+1
Minytrema melanops				+	+			+2
Moxostoma anisurum					+			+1
Moxostoma carinatum			+					+1
Moxostoma duquesnei	+		+	+				+3
Ameiurus melas	+		–				–	−1
Ameiurus natalis	–					–		−2
Ictalurus punctatus					+			+1
Noturus exilis	+	–				–		−1
Noturus flavus					+			+1
Noturus gyrinus	–	–		–	+			−2

TABLE 2.—Continued

Species	Rock R.	Kishwaukee R.	Vermillion R.	Salt Cr.	Des Plaines R.	Pecatonica R.	Upper Kaskaskia R.	Totals[2]
Noturus miurus			+					+1
Fundulus dispar						+		+1
Fundulus notatus				+	+			+2
Labidesthes sicculus	−				+	−		−1
Culaea inconstans		−				−		−2
Morone chrysops		−	−					−2
Morone mississippiensis	+			+	+		+	+4
Ambloplites rupestris					+			+1
Lepomis gibbosus	+	−				+		+1
Lepomis gulosus			+					+1
Lepomis humilis					+			+1
Lepomis megalotis				+	+			+2
Micropterus punctulatus							+	+1
Pomoxis annularis		+		−	−			−1
Pomoxis nigromaculatus			−	+				0
Ammocrypta clara				−				−1
Etheostoma chlorosomum							+	+1
Etheostoma gracile							−	−1
Etheostoma exile						−		−1
Etheostoma flabellare					+			+1
Etheostoma nigrum					+			+1
Etheostoma spectabile	−				+			0
Etheostoma zonale	+					−		0
Percina caprodes	+					+		+2
Percina maculata	−		+		+			+1
Percina phoxocephala	+		−		+	+		+2
Perca flavescens					−			−1
Sander canadense	+	+				+		+3
Sander vitreum		+	+	+	+			+4
Aplodinotus grunniens			+		+	+		+3
Net change in species richness	+9	−2	+7	+4	+19	+4	−3	Total +38

1 Based on IDNR samples from early to mid 1980s and 1997–98

2 A single "–" is equal to a minus one, "+" is equal to a positive one; total is the sum of the row of positive and negative integers

Species richness in the Des Plaines drainage basin could be artificially high due to the use of the more efficient electric seine at four sites in the later time period rather than the backpack shocker and seine used earlier. Bayley *et al.* (1989) showed the relative efficiencies of the electric seine, backpack shocker and seine. However, the difference in efficiencies are unlikely to account for the entire difference in species richness between the time periods, especially when these sites only comprised a minor portion of the entire sample (4 of 15 sites). Also, at just boat electroshock sites, the average number of species collected per site in the earlier study was 12.81 vs. 18.81 in the later samples. This difference suggests that the increase in species richness found at a site has significantly increased.

The largest net increases in the species richness found across a basin were in the Des Plaines and Rock drainage basins, 19 and 9, species, respectively. The Kaskaskia drainage basin had the highest net loss of three species (Table 2).

TABLE 3.—Mean species richness of sample sites for seven drainage basins. Probability of significant differences (P) between means of the 1980s and 1990s calculated from paired *t*-tests. N = number of sample sites

Drainage basin	1982–86	1997–98	N	P
Des Plaines River	21.64	30.69	15	0.001
Kaskaskia River	25.64	22.29	14	0.02
Kishwaukee River	23.50	23.50	12	—
Pecatonica River	16.20	20.20	10	0.05
Rock River	19.44	21.22	9	0.28
Salt Creek	22.42	23.33	12	0.58
Vermilion River	23.22	22.78	9	0.87

Faunal changes.—For the long time period, a total of 42 species showed at least one extirpation from one or more of the basins (Table 1). This total amounts to 31% of the original number of species found among the seven basins. Of the 42 species, most showed extirpations from one or two basins. Three species, *Notropis heterolepis, Fundulus diaphanus* and *Etheostoma asprigene*, showed extirpations from three or four basins. No species had extirpations from more than four basins.

For the short time period, 77 species showed a change in status in at least one basin (Table 2). Of these, 45 showed net occurrence gains, 25 showed net occurrence losses and 7 showed no net changes. An overall index for all species across all basins is +38, a highly positive score. A Wilcoxon signed ranks test of matched pairs test of significance of the net occurrence gains and losses of each species was highly significant, ($Z = 2.621$, $P = 0.009$). Six species showed new occurrences in three or four of the seven basins: *Hybognathus nuchalis, Moxostoma duquesnei, Morone mississippiensis, Sander canadense, S. vitreum* and *Aplodinotus grunniens.* No species had net new occurrence gains in more than four basins. Four species had net occurrence losses from two basins: *Macrhybopsis aestivalis, Notropis hudsonius, N. gyrinus, Culaea inconstans* and *Morone chrysops.* No species had net occurrence losses from three or more basins during the short time period.

DISCUSSION

Species richness.—During the long time period, all seven drainage basins lost four or more species of fishes (Table 1). While it is difficult to estimate the loss of species in an unaltered system over this period, the results provide a relative measure of losses induced by human activities. The Vermilion River had the lowest number of extirpated species, four, and is the least altered of the seven basins (Page *et al.*, 1992). At the other end of the spectrum, is the highly disturbed Des Plaines River, which flows through the Chicago region of Illinois, that has lost the highest number of species, 16 (Table 1). Because of efforts to improve water quality in the Chicago in the last 30 y, the loss of the native fauna probably was higher; recently, the fauna partially has recovered (*see* below). The other drainages are primarily agricultural, and their loss of native fauna, while less than that of the Des Plaines River, still ranged from 8 to 20%.

Koel and Peterka (1998) found that in the Red River (in North and South Dakota and Minnesota) over a similar time period (1892–1994), only one species was extirpated and eight species showed moderate declines out of a total of 84 native and non-native species. This modest decline in species relative to Illinois populations likely is due to two reasons. First, the larger geographic scale of the Red River will mask a greater number of extirpations at smaller scales, an observation also noted by Anderson *et al.* (1995). Second, land-use pressures likely are less in the Red River drainage. This area has a lower population density (U.S. Census Bureau, 2000) and less row-crop methods of agriculture than in Illinois (Schwab and Schleusener, 2003).

During the short time period, all seven drainage basins showed evidence of changing species richness (Tables 2, 3). Except for the upper Kaskaskia and Kishwaukee drainage basins, all of the basins showed an increase in the total number of species found within a basin. However, only the Des Plaines, upper Kaskaskia and Pecatonica rivers showed significant changes in mean number of species per site and a change in total number of native species per basin, suggesting that they have had the greatest changes in species richness.

The basin showing the most significant positive change was the Des Plaines River (Tables 2, 3). Widely perceived to be severely degraded by urban influences (Smith, 1971), this area has benefited greatly from the treatment of sewage and other wastes. Improvements in the fish community were noted as early as the early 1990s (Lerczak *et al.*, 1992). However, as recently as 1995, the basin has been rated a stream of limited resource (The Biological Streams Characterization Work Group, 1996), which indicates that considerable improvement remains to be seen.

The upper Kaskaskia River showed evidence of decreased species richness (Tables 2, 3). The basin was significantly less rich in 1997 and the gain of five native species was little more than half that of the loss of eight native species. Like the other basins (except the Des Plaines River) the Kaskaskia River is located in an area intensively used for agriculture and has a number of small towns and cities on the landscape. Unlike the other basins, two large reservoirs (Lakes Carlyle and Shelbyville) have been created on the mainstem since 1960 (Larimore and Fritz, 1993). Isolation of the sub-basins and actual destruction of much of the mainstem riverine habitats have probably negatively impacted the fauna (Larimore and Fritz, 1993). In fact, Smith (1971) predicted this decline. As extirpation of species from tributaries occurs, re-colonization from extant populations will be inhibited by the reservoirs. Examining individual tributaries to the reservoirs could further test this hypothesis. Direct tributaries to the reservoirs should be less diverse than indirect tributaries of similar size. Larimore and Fritz (1993) thought that the fish community currently is stable in the entire basin. However, this new information suggests otherwise for the upper Kaskaskia River.

The Rock, Salt and Vermilion drainage basins showed net gains in species richness (Table 2). However, none of these drainage basins showed significant increases in species richness per sample site.

The Pecatonica River, a tributary of the Rock River, also increased in species richness since 1984 (Tables 2, 3). Past reports rated the river as fair for diversity (Smith, 1971) and as a moderate aquatic resource (Staff Report, 1988), but the information herein suggests an improvement in the aquatic community.

In Champaign County, Illinois, four fish surveys have been completed with the first being made by Forbes and Richardson (1909). A recent study of Champaign County based on these surveys by Larimore and Bayley (1996) showed trends similar to most of the basins in this study. Their study also included small portions of the upper Kaskaskia and Vermilion rivers. They found a significant decline in species richness after the second survey in 1928. However, species richness has increased since the 1959–1960 survey. They concluded that improved water quality since that time period was largely responsible for the higher species richness.

In contrast, two other studies have indicated recent declines in distributions at time and spatial scales similar to this study. In Wyoming between the 1960s and 1990s, fish assemblages showed mostly declines. Patton *et al.* (1997) attributed the declines to decreased silt loads in the large rivers and increased silt loads and water temperatures in smaller streams. The large river traditionally had fish guilds adapted to high silt loads, whereas smaller streams had guilds adapted to cool temperatures and clear water. Anderson *et al.* (1995) found declines between 1953 and 1986 at resampled sites in Texas. They associated the declines with the introduction of non-native species, eutrophication of water and changes in instream flow. Direct comparisons of these two studies and the study herein are not simple. First, this study begins after the start of the effort to control point source pollution. The other studies begin before pollution control, and they still show overall declines although one would expect some improvements since the 1970s, when point source pollution began to be addressed (Critical Trends Assessment Project, 1994). However, it could be that in the case of Wyoming, a low population state, point source pollution would not have been a major problem anyway, and indeed, the silt loads and temperature changes that Patton *et al.* (1997) cite likely are due to non-point sources. Unless these problems also have been dealt with, it is likely that the assemblages are still in decline in Wyoming.

The problems in Texas are likely to be more similar to those in Illinois given its large population size. Why Anderson *et al.* (1995) failed to show any improvement after the effort to improve water began is unknown. One possibility is that not enough time had passed for water quality improvements to take effect. If so, Texas likely will have improvements in species richness in the 1990s.

Will the positive trends continue for these basins and possibly others in Illinois? If the movement to increase water treatment and reduce soil erosion continues, then stream assemblages should continue to recover. However, many species that require high water and habitat quality have been isolated into small areas and it is not known if these restricted populations are sustainable or if they will be able to recolonize other areas. Restoration and conservation of the species in decline is one of the most important issues to be considered in the recovery of midwestern streams.

Faunal changes.—The number of species showing extirpation from at least one basin over the long term period is a substantial proportion of the original fauna of the seven basins. Beyond just considering the number of species, an examination of the list (Table 1) of species gives insight into the taxonomic and ecological groups most affected over the last 100 y. Not surprisingly, 10 of the 42 species that showed declines are on the Illinois list of endangered and threatened species.

Although most fish families are represented by at least one species, the family of minnows (Cyprinidae) has the largest number of species (11) on the list followed in decreasing order by darters and perches (Percidae), catfishes (Ictaluridae), suckers (Catostomidae), topminnows (Fundulidae) and sunfishes (Centrarchidae) (Table 1). These numbers do not mean necessarily that minnows or darters are more vulnerable to extirpation. However, the numbers simply may reflect the proportion of those families in fish assemblages. Species of minnows and darters dominate fish assemblages of midwestern streams (Pfleiger, 1975; Smith, 1979).

An examination of the fish species in Table 1 indicates that two groups can be distinguished on the basis of their ecologies and life histories. One group of species typically is found in streams of very high water quality, clear water and clean riffles. *Campostoma oligolepis*, *Hybopsis amblops*, *Moxostoma carinatum* and *Ammocrypta clara* are representatives of this group. Water pollution, sedimentation and turbidity are the primary reasons for their decline (Smith, 1979). The second group typically is found in glacial lakes, floodplain lakes and slow moving streams, often with clear water and aquatic vegetation. In Illinois, many of these habitats have been destroyed by drainage and channelization. *Umbra limi*, *Notropis chalybeus*, *Erimyzon sucetta*, *Ameiurus nebulosus*, *Fundulus dispar* and *Etheostoma exile* are examples of this group.

The future of these two groups is likely to be different. While water treatment and erosion abatement is likely to help maintain or increase species adapted to clear and clean streams, the group typically found in lakes, back water lakes and slow moving streams, is likely to decline further as drainage and destruction of habitats continue. Only a significant creation or restoration of these habitats will have a positive impact on these species.

In the Red River basin, the declining groups are similar to those in Illinois and the species generally are the same (Koel and Peterman, 1998). The families with the largest declines in distributions are (in decreasing number of species) minnows, darters and perches, sunfishes, suckers and catfishes. These families also have the largest number of species in the Red River and Illinois. Again, cyprinids, percids, etc., might not necessarily be more vulnerable to decline because of their biology but simply because there are more species of them. Of five minnows species showing declines, three species are also in decline in Illinois: *Hybognathus hankinsoni*, *Notropis anogenous* and *N. heterolepis*. This observation suggests that these species are declining at a larger scale, perhaps across their entire ranges.

Short-term changes show a less grim picture for fishes of the basins in Illinois. Overall, the results indicate more positive species occurrences. A wide variety of taxa show positive changes (Table 2), but within families, the changes are mixed. The minnows showed a strongly negative trend over the long time period, and one would expect the family to have a positive short-term trend. However, nine species had a positive trend vs. ten species that had negative trends. Four of the declining species (*Notropis blennius*, *N. hudsonius*, *N. shumardi* and *Macrhybopsis aestivalis*) generally occur in large rivers and their occurrence in these basins would be considered to be not typical (Smith, 1979). No clear explanation exists for their declines although perhaps changes in flow could account for changes in their distributions. Greater periods of low water might induce them to leave these basins for larger streams. Examination of flow records could be examined to test this hypothesis. Conversely, three species (*Hybognathus nuchalis*, *Erimystax x-punctatus* and *Pimephales vigilax*) are medium-sized stream inhabitants that have increased in occurrence. This observation would be consistent with lower water flows and improved water and habitat quality.

Cyprinella lutrensis has been a species noted for increasing its abundance in the state at the expense of its congeners *C. spiloptera* and *C. whipplei* (Page and Smith, 1970). *Cyprinella lutrensis* prefers habitats that are turbid; the congeners prefer clear water. With increased turbidity in midwestern streams, *C. lutrensis* had increased in abundance. Its decline in occurrence in two basins (Table 2) does suggest that efforts to control erosion may be reversing this trend. The continued decline by *C. spiloptera* and *C. whipplei* does not support this possibility although recovery of these species may be more complex than what we would expect.

All of the species of suckers showed increased occurrences except *Hypentilium nigicans*. In general, these relatively large-bodied species are large stream inhabitants. They probably have benefited from improved water quality in the larger streams since the construction of water treatment facilities around urban areas. *Moxostoma duquesnei* appears to have increased in occurrence more than the other suckers. Forbes and Richardson (1909) found the species to be rare in the state, but Smith's (1979) and more recent records in the collection of fishes at INHS indicate that the species is increasing in abundance across the state.

Most of the species of sunfishes show a positive increase in occurrence. *Lepomis megalotis* probably has benefited from the continued creation of ditches, an environment in which they commonly occur (pers. obs.). However, several of the other species are thought to be fairly sensitive to environmental changes: *Ambloplites rupestris*, *Lepomis gibbosus*, *L. gulosus* and *L. humilis* (Smith, 1979). Their increased occurrences suggest better environmental conditions.

The darters showed a positive trend overall. *Ammocrypta clara* and *Etheostoma exile* showed declines while the species of *Percina* showed increased occurrences. The large perches, *Sander canadense* and *S. vitreum*, showed strong positive trends although these species are likely to be stocked in local reservoirs and large rivers, thereby skewing these results (D. Carney, Illinois Department of Natural Resources, pers. comm.). Interestingly, another large-bodied nonpercid species, *Aplodinotus grunniens*, showed new occurrences in three basins. Presumably, this species is continuing to respond to the increased water quality in the basins.

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