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A report for a cooperative agreement on

FACTORS CONTROLLING THE RECOVERY OF AQUATIC
SYSTEMS FROM DISTURBANCE

by

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Foreword

The enclosed report represents a summary of a two year effort to develop an approach for assessing the recovery of aquatic systems from disturbance. The report is divided into three sections: (1) a general overview of the results of an extensive search of the scientific literature for case studies on recovery of aquatic systems, (2) an extensive compilation of the raw data for case studies in which some aspect of the recovery of an aquatic system has been documented, and (3) a list of references for each of the case studies on recovery. Hence, this report summarizes case studies of recovery and what will be the necessary steps to develop a comprehensive useable approach to predicting recovery rates of organisms within aquatic systems. Last year's report considers in more detail the quantitative aspects of understanding recovery (resilience), resistance, and disturbance of aquatic systems.

The progress made under this cooperative agreement generally has been consistent with the objectives originally proposed for this study. More progress was made than originally projected in the identification of sites for case studies on recovery. For example, we proposed to identify 25 to 35 sites for recovery studies, yet we identified more than 150 sites. Hence, more time was spent compiling and focusing on recovery rather than on quantifying the physical, chemical, and biological parameters of aquatic systems; this had been proposed as an alternative if these were limited on recovery case studies.

Part I.

Overview of case studies on recovery of aquatic systems from
disturbance

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Abstract

An extensive review of the published literature identified more than 150 case studies in which some aspect of resilience in freshwater systems was reported. Approximately 79% of systems studied were lotic and the remainder lentic. Most of the stressor types were chemical with DDT ($n = 29$) and rotenone ($n = 15$) the most common. The most common non-chemical stressors were logging activity ($n = 16$), flooding ($n = 8$), dredging ($n = 3$), and drought ($n = 7$).

The variety of endpoints to which recovery could be measured ranged from sparse data for phytoplankton ($n = 13$), periphyton ($n = 6$), macrophytes ($n = 8$), and water quality ($n = 80$) to relatively more data for fish ($n = 412$) and macroinvertebrates ($n = 664$).

Unfortunately the same characteristics were rarely measured consistently among sites. For example, with respect to fish, more than 30 different species have been studied and recovery has been measured in many ways; most commonly on the basis of (1) first reappearance of the species, (2) return time of pre-disturbance densities, and (3) return time of pre-disturbance average individual size. Based on these criteria, all systems seem to be resilient to most disturbances with most recovery times being less than 3 years. Exceptions included when (1) the disturbance resulted in physical alteration of the existing habitat, (2) residual pollutants remained in the system, or (3) the system was isolated and recolonization was suppressed.

This data base provides a framework for examining the extent that specific hypotheses on resilience can be tested using historical data. These data also illustrate that much of our knowledge on recovery of aquatic systems is fragmented and uncoordinated. This data base can

serve as a focal point for further research because limitations in knowledge and in the range of systems studied have been identified with respect to resilience.

INTRODUCTION

The inherent capacity of an aquatic system to naturally recover from a stressor has been a neglected consideration in environmental assessments (Cairns 1978, 1980). Primary reasons for this neglect are a lack of appreciation for the importance of recovery of an aquatic system following exposure to a stressor, and the lack of pre-disturbance data to properly assess whether a system has recovered. Most ecological research has focused on understanding how various stressors alter the chemical, physical, and biological function and structure of aquatic ecosystems. Once the effects are documented, funding generally has not been available to continue long term studies of these systems (Likens 1983). Long term studies of natural ecosystems are likely the only vehicle by which the recovery phase of a system can be understood.

The lack of an appreciation for understanding the recovery process following a disturbance is puzzling. For instance, consider two aquatic systems (A and B) that are subject to two different stressors (Figure 1). In system A the effect of the stressor is substantial, while in B the effect is relatively minor. In contrast, the recovery of system A is relatively fast, while in B it is slow or non-existent. A short term study limited to understanding the effects would conclude that the stressor in system A is more detrimental than the stressor in system B. Yet, in the long term the overall effects may be more detrimental in system B because of the slow or non-existent recovery relative to system A. This is especially true if the variables being considered such as populations of fish and shellfish have substantial ecological and economic importance.

recorded at the highest taxonomic level at which all individuals were within the same functional group, but were never lumped above the familial level.

The majority of sites for which macroinvertebrate recovery information was available were low (1-3) order streams. Organisms resident in these systems are adapted to unpredictable flooding events, highly variable organic inputs, and, in the northern latitudes, seasonal disturbances in the form of ice cover and concomitant reduced habitat areas. Considering the adaptations necessary for species survival in such systems, rapid recovery following pulse disturbances might be expected. In fact, 85% of all macroinvertebrate recovery endpoints (density or first appearance) after pulse disturbances occurred in less than 18 months (Tables 11 and 12).

Studies examining the resilience of reduced or impacted populations have identified a variety of factors which contribute to the rate of recovery. These include 1) presence of refugia, 2) distance to source for recolonization (and, for streams, upstream or downstream direction), 3) time of year in which disturbance occurs, 4) life history of the organism, including generation time, emergence time, and propensity to disperse (drift), and 5) persistence of the impact, including changes in system productivity, habitat integrity, and persistence of the stressor. Because of the large number of biological, chemical, and physical interactions impacting recovery rates, a particular organism may exhibit a range of recovery times. It is the purpose of this review to present these ranges as they have occurred in the literature. Rather than discuss all of the studies,

Ignoring recovery in the environmental assessment process should not be construed as a lack of interest in recovery by ecologists. During the past 20 years there has been both considerable research in the theoretical understanding on how ecological systems should recover from stressors and field studies to test many of the purported theories (e.g. see Yount and Niemi 1989). However, most work has been limited in the types of systems studied in the field or considered in theoretical developments. The primary purpose of this report is to summarize a comprehensive review of the published literature on field studies that have examined some aspect of the recovery of an aquatic system from a stressor or in some instances multiple stressors. This review will then form the basis for the current status and understanding of the recovery of aquatic systems. In addition, a report is in preparation which will identify what data needs to be gathered to test specific hypotheses on the recovery for different aquatic systems subjected to different stressors. Once the appropriate hypotheses are tested, then a prediction model can be formulated.

Definition of terms

Niemi et al. (1987) reviewed definitions and provided a quantitative basis for defining the terms commonly used in the literature for disturbance, resistance, and resilience in ecological studies. We will use the definitions developed in that paper here, except for one clarification. Generally, we will refer to the specific cause in the disturbance scenario (Gerritson and Patten 1985) as a stressor (e.g., chemical, nutrient, siltation, or acid precipitation). As modified from Gerritson and Patten (1985), a

disturbance is reserved for the situation when the stressor or stressors result in a change in the state of the system that is different from normal behavior. In some instances, such as a toxic chemical spill, the stressor and disturbance are equivalent. When multiple stressors are involved, such as in mining activity, the term disturbance generally refers to the entire activity. Mining activity may initiate several specific stressors including increased particulates and sedimentation from erosion, and increased metal toxicity from leaching. In addition, we will use the terms pulse and press in reference to disturbances as developed by Bender et al. (1984). A pulse disturbance has been defined as a disturbance of limited and easily definable duration. Pulse disturbances have little effect on the surrounding watershed. Most chemical stressors are examples of pulse-type disturbances. Press disturbances are longer in duration and often involve changes in the watershed or stream channel. Timber harvesting and channelization are examples of press-type disturbances.

Recovery time to the various endpoints was estimated from the time of initiation for most pulse stressors. (An endpoint refers to any biological or chemical variable commonly measured with respect to the structure or function of an aquatic system that was determined to have recovered following exposure to a stressor.) Recovery from most press disturbances was estimated from the time that the physical activity which initiated the stressor was ended. Commonly press disturbances such as habitat and watershed alterations lasted many years.

We used the following criteria to determine whether a system had recovered from a stressor with respect to a specific endpoint. (1)

Adequate pre-stressor data existed so that post-stressor data could be compared with the pre-stressor data. (2) A suitable reference area (e.g., upstream sample point or control lake) existed to compare with post-stressor data for a system of interest. (3) The investigator of a peer-reviewed study stated that a particular variable had recovered from the stressor. (4) If no pre-stressor data were available, return to a stable, reproducing population was considered evidence of recovery. The latter was often necessary when monitoring was not initiated until after a catastrophic event (e.g., spill or flood) had severely impacted the biota. Criterion 1 is certainly the most desirable and criterion 3 and 4 the least desirable. However, being any more restrictive with these data would greatly reduce the number of endpoints and case studies that could be considered in this review. In addition, the proper context to interpret these results is to view these data in an exploratory fashion such that testable hypotheses can be formulated and subsequently tested under more rigorous experimental procedures.

In our initial review of the case studies of recovery, we searched for data that included both structural and functional variables describing the aquatic systems. However, little data, such as productivity estimates or nutrient cycling rates, were available for functional characteristics of these systems. Therefore, we primarily focused our efforts on an organismic-based approach and grouped the data into the following categories: (1) water quality, (2) phytoplankton, (3) periphyton, (4) zooplankton, (5) benthic macroinvertebrates, (6) fish, (7) amphibians, (8) microorganisms, and (9) aquatic macrophytes. Within each of these categories, a variety

of endpoints have been presented in the literature ranging from concentration measurements for specific compounds such as calcium to first reappearance of a species in a system in which it was eliminated by a stressor. The vast majority of endpoints were identified for benthic macroinvertebrates and fish. However, for both groups there were relatively few consistent endpoints for specific species. Therefore, for benthic macroinvertebrates we chose to group species and genera into functional groups such as collectors, shredders, grazers, and predators. Data were thus recorded at the most general taxonomic group at which all individuals were within the same functional group, but never lumped more generally than the familial level. In addition, fish and macroinvertebrate information was presented as: (1) recovery to average size, (2) recovery to previous density, (3) recovery of species or genera richness (at least 80% of original number of taxa), (4) recovery of total biomass, (5) first reappearance, or (6) return to a relatively stable population level as determined from a seasonal population curve which was judged to be similar to pre-stressor levels. The latter was encountered when monitoring was initiated after a catastrophic disturbance.

The AQUIRE (Russo and Pilli 1984) species list was used to assign identification numbers to organisms. When a species not included in AQUIRE was found in the recovery literature, it was placed on a supplemental list and verified in a recognized reference for its division. A list of verification references is available in Appendix A. For data analysis, fish, amphibians, and macrophytes were grouped by species, phytoplankton and periphyton by division, zooplankton by genus, and macroinvertebrates by family, unless a family included

significant representation in more than one functional group (Merriam and Cummins 1984) as described above.

Quality assurance

All studies have been reviewed by at least two individuals to insure reasonable interpretation of data not always intended to yield "time to recovery" information. In cases where studies of the recovery process were not initiated soon after the disturbance, recovery endpoints were recorded as "less than" values. In cases where recovery had not occurred by the end of the study, endpoints were recorded as "greater than" values. Data entries were proofread twice by database personnel and appropriate corrections were made after reviewing the original paper.

Site selection

Systems with at least one achieved endpoint were included in the study. Sites were eliminated if data did not meet the following three criteria:

- 1) Availability of predisturbance data, reference system data, investigators' assurance of recovery, or data indicating return to a relatively stable population density, species richness, or biomass,
- 2) Documented post-disturbance sampling that allowed quantitative statements of recovery time, typically repeated sampling initiated immediately after the disturbance and continuing until predisturbance, reference system, or relatively stable conditions were reached,

- 3) Ability to pinpoint a time when the physical activity which initiated the stressor ended (e.g., channelization or logging completed). Studies of eutrophication were not included due to the inability to identify neither when nutrients were initially added to a system nor when they ceased to have an impact. Some mining cases also were omitted for this reason.

No case studies were included when any form of artificial restoration was performed, with the exceptions of two sites where in-stream structures were used to mitigate the effects of channelization. These were the St. Regis Rivers, MT (Lund 1976, case 127 in Part III) and the Olentangy River, OH (Edwards et al. 1984, case 184).

Site characteristics

An attempt was made to characterize a number of site parameters which we felt might be important in determining and understanding the range of recovery rates (Table 1). Values were derived from the original publications, United States Geological Survey records, topographic maps, and specific inquiries to either the investigator or to the state agency in which the system was located. Many of these values were unavailable due to the length of time since the study was conducted or the lack of any such measurements.

Data searches

We conducted several automated literature searches including Biological Abstracts (1970-1986), Dissertation Abstracts, BRS Information Technologies (1970-1985), Aquatic Science Abstracts (1978-1985), and Water Resources Abstracts (1968-1986). The following

keywords were used for these searches: ecosystems, communities, stress, perturbations, damage, wind, volcano, storms, disturbance, pollution, mining, logging, flood, recovery, restoration, and resilience.

These searches identified many citations from which we subsequently conducted systematic searches of the Literature Cited or Reference sections for titles that were pertinent to studies of recovery. Approximately one person year (about 6 individuals over a two-year period) was spent on these systematic searches. In addition, Hynes (1986) provided a list of 10,000 citations in his personal bibliography of lotic systems. Citations were identified from source codes supplied by Hynes. These codes included the following key phrases: (1) effects of man, (2) control of (undesirable) stream organisms, (3) pollution of running water, and (4) experimental streams and rearings. A total of 800 references were identified and obtained from the Hynes' bibliography.

Limitations

Even though we located a relatively large number of systems that had some information on recovery, few were designed specifically to examine recovery. Because of this most of the information reported concerning recovery was based on subjective judgements using upstream or downstream areas, suitable reference areas, or statements in the papers made by the authors on the extent of recovery.

The systems included in this review cannot be construed in any fashion to represent a random sample of aquatic systems within the United States. In fact, there are definite biases in the aquatic systems included here and most (> 70 %) are represented by small lotic

aquatic systems. Few studies have been published on lentic systems or on lotic systems beyond 6th order. The reasons appear to be: 1) small lotic systems are much easier to study than larger lotic or lentic systems, 2) suitable data were available prior to exposure to stressors and it is likely that the systems actually recovered from the stressors within a reasonable period to enable detection, and 3) small systems are likely exposed to discrete stressors rather than multiple, cumulative, or press-type stressors.

These latter types of stressors confound our abilities to evaluate recovery in larger aquatic systems. For instance, we suspect that large aquatic systems are being stressed from several different sources; each of which alters the physical, chemical, and biological composition of an aquatic system over time. If these different interacting stressors also vary with respect to their intensity, duration, and frequency over time, then deciphering the overall effects or recovery from these stressors is extremely difficult. In addition, once the natural variability of aquatic systems is considered, then partitioning the contribution from the various stressors becomes nearly impossible. Hence, our focus on relatively discrete stressors within relatively small aquatic systems appears to be one of the only alternatives available for evaluating the recovery of natural systems from disturbance.

One of the next steps in consideration of studies on recovery will be the study of stressors and systems associated with incomplete recovery such as recovery to an alternate state or lack of recovery. Because our review was based on cases in which a judgment could be made that recovery had occurred, other forms of "recovery" were

neglected. It will be especially important to identify stressors and aquatic systems that have shown a lack of recovery.

RESULTS AND DISCUSSION

A total of 166 aquatic systems were identified with at least one endpoint measured in respect to recovery. The aquatic systems studied were predominantly lotic systems (79 %), while studies of lakes (15 %) and ponds (6 %) were less common. In general the distribution of systems were widespread across the United States with some localized clumping in the northeast (DDT forest spraying) and in the southeast (primarily studies at Coweeta) (Figure 2). The distribution of a total of 1269 endpoints measured in respect to these 171 systems (Table 2) showed that the vast majority of data were available for macroinvertebrates (30 %) and fish (21 %) studied in lotic systems of less than 4th order. In general, data were very sparse for phytoplankton (n = 13), periphyton (n = 6), amphibians (n = 1), microorganisms (n = 4), and aquatic macrophytes (n = 8). The data available for these groups are shown in Table 3. Phytoplankton and microorganisms are mentioned briefly below, while data for periphyton, macrophytes, and amphibians are not considered further in this report. In addition, data were very limited for large lakes and large lotic systems (total n = 7) and, hence, they also will not be considered further. Relatively limited data were available for water quality and for zooplankton.

The most common forms of disturbances associated with these studies were DDT insecticide applications in forest sprayings, logging activity, dredging/channelization of lotic ecosystems, or rotenone applications to lake and pond systems (Table 4). The most common

category of disturbance for both lentic and lotic systems was general chemical disturbances. In this category were a variety of individual chemical types of stressors with few replicates among the aquatic systems studied (refer to Table 7, Part III for complete list).

Phytoplankton and microorganisms

Given the paucity of data on phytoplankton ($n = 13$) and microorganisms ($n = 4$) few conclusions can be drawn. In most cases recovery of density, biomass, or productivity occurred within four to thirty days. The one case of nutrient addition into a lake was an exception. In Crecy Lake, NB (Smith 1969, case 31) recovery required up to two years, but it involved a decrease in nuisance algae to predisturbance densities. This lentic nutrient addition was also the only press disturbance to include phytoplankton or microorganism.

Water quality

Cases documenting water quality included 80 recovery endpoints (Table 5) representing 28 different parameters (Table 6). Eleven endpoints were indistinct (e.g., time < 3 yr or time > 0.5 yr) and are not considered in this analysis. The remaining 69 endpoints resulted from 17 pulse and 20 press disturbances. Thirty-nine recovery endpoints were reached in one year or less. These typically resulted from pulse stressors : chemicals, moderate flooding, or increased suspended solids after heavy rain. Ten water quality properties recovered in three to five years (Table 6). These intermediate recovery times followed one pulse and six press disturbances. The only pulse disturbance with a water quality parameter recovery time of greater than 3 years involved persistently lower organic seston concentrations following methoxychlor treatment of a first-order

stream in Coweeta Hydrologic Laboratory (Cuffney et al. 1984, Wallace et al. 1986, case 144). The authors felt that the most likely explanation was the slow recovery of the macroinvertebrates which in turn reduced the production of invertebrate drift and insect-shredded vegetation. Ten disturbances yielded 17 parameters with recovery times greater than five years (Table 6). All of these were press disturbances with timber harvesting ($n = 8$) the most common.

Analysis of these data was complicated by the variety and lack of replication of water quality parameters. Properties disturbed by press stressors and having recovery times greater than five years were directly related to watershed changes. Examples are decreased coarse particulate organic matter (CPOM), increased runoff, and increased temperature associated with timber harvesting. Given the low number of lakes ($n = 5$) and ponds ($n = 1$) with water quality recovery data and the diversity of parameters (Table 2), it is impossible to draw conclusions on differences between lotic and lentic systems.

Zooplankton

Most zooplankton recovery endpoints (75 of 81) were derived from studies monitoring the incidental impacts of non-persistent insecticides or piscicides. Mean recovery times of the major zooplankton groups subjected to these pulse stressors were 0.35, 0.28 and 0.88 years for rotifers, cladocerans, and copepods, respectively. Recovery endpoints for the major groups are summarized in Tables 7 and 8 and presented in detail in Part III.

Only three studies which we examined might be considered press disturbances. These provide the only cases where recovery time exceeded three years. Although studies involving recovery from

eutrophication were generally avoided in this review, nutrient impacts on Crecy Lake, B.C. (Smith 1969) and Haley Pond, ME (Bailey et al. 1979) were included because of the intermittent experimental nature of the former and the abrupt initiation and termination of nutrient addition in the latter. In Crecy Lake, zooplankton biomass did not return (decrease) to pre-fertilization levels for approximately 3.5 years. In Haley Pond, calanoid copepods had not regained their former levels of abundance three years after initiation of tertiary treatment, even though water retention time was only 0.13 years. Both of these studies demonstrate a comparatively long recovery time for zooplankton when existing nutrient budgets and primary production pathways were disrupted. The only other press disturbance examined was habitat associated. The macrophyte-associated cladoceran Eurycercus had not recovered to pre-stressor densities 1.5 years after paraquat had been used to eliminate macrophytes from Barry Reservoir, England (Brooker and Edwards, 1974).

The importance of generation time to recovery rate can be demonstrated through an examination of zooplankton recovery rate versus latitude (Figures 3 and 4). Many species of zooplankton are capable of producing multiple generations within one growing season, the number of generations varying with water temperature (e.g. latitude and elevation in this review). The only cladoceran recovery times which exceeded 0.5 years were in three sites at 52 and 57 degrees N latitude. The only copepod or total zooplankton density recovery times which approached those exhibited in the press disturbances were within these same systems.

The importance of refugia and competition was well documented in reviewed studies. We were reluctant to label a species as "non-persistent" in a system, even though investigators failed to collect individuals for some months following the treatment. The rates of recovery in practically all instances indicate that some individuals survived in atypical habitats. This was indicated by the invasion of the limnetic zone by zooplankton species which were typically restricted to littoral habitat (Anderson 1970, case 11; Kiser et al. 1963, case 12). As the limnetic species became reestablished, littoral species populations retreated to the near-shore zone habitats. The near-shore zones also were the areas which provided refugia for the small numbers of limnetic zooplankters which eventually reestablished their open-water populations.

Further evidence of the effect of competition (or lack thereof) on population recovery was the proliferation of small cladocerans (e.g. Bosmina sp) shortly after disturbances (Morrison and Struthers 1975, case 200; Anderson 1970, case 11). Hrbacek et al (1961) and Brooks and Dodson (1965) demonstrated that selective fish predation on larger zooplankton results in the dominance of smaller zooplankton whose populations are competitively restrained when planktivorous fish are absent. Pulse disturbances often result in populations of the smaller zooplankton far in excess of normal levels until reduced by competition from the larger zooplankton which have a lower fecundity and longer generation time (Anderson 1970). Slower recovery of the predaceous zooplankton also contributes to the proliferation of small zooplankton (Anderson 1970, Hurlbert et al. 1972, cases 48, 49).

Recovery of initial population densities and species composition after pulse disturbances generally occurs within one year in latitudes

within the continental United States. Populations in small mountain lakes (1200 m elevation) in a more northern latitude required approximately three years to recover. Rate of recovery of individual species within these periods is related to fecundity, time of reproduction relative to stress, and the presence of resistant stages (Anderson 1970). Generation time, presence of refugia, and competition-predation interactions among resident species also impact recovery times.

Press disturbances which alter habitat, nutrient pathways, or reduce predators or competitors result in much longer recovery times which may never be achieved if 'recovery' is considered to be a return to pre-stressor species composition and relative density.

Macroinvertebrates

Studies documenting recovery endpoints for macroinvertebrates included a wide variety of natural and anthropogenic disturbance events. Man-induced pulse disturbances were primarily chemical in nature, with more than 20 chemical species represented (the majority of cases involved DDT and rotenone). The cases examining natural pulse disturbances were primarily flooding and drought. Press disturbances were the result of timber harvest, mining, and channelization.

A total of 664 recovery endpoints were recorded for macroinvertebrates. These were derived from 106 systems and included 37 estimates of recovery time for genera richness, 32 for total biomass, 54 for total density, 391 for pre-stressor densities for individual taxa, and 129 records of first appearance (Tables 9 and 10). Endpoints represented 22 macroinvertebrate orders. Data were

we will present expected ranges, explore reasons for outliers in the data, and offer a few studies which present insight into the processes determining recovery rate. All of the data are presented in Part III of this report for the reader to examine in more detail.

Press disturbances offer the most outstanding examples of impacts with consistently long recovery times (Table 13). A primary difficulty in examining impacts from disturbances such as mining activity, channelization, and watershed disturbances such as timber harvest is that the time scales for recovery are too long to document endpoints. Twenty-three recovery endpoints exceeded 18 years (Table 13). An additional 44 endpoints do not appear in the table as they were recorded as "greater than" 5-15 years, depending on the time after impact that the study was conducted. One group of endpoints resulted from residual metal toxicity after a mining operation in Montana. While some dipterans had recovered in 8 years, most organisms had not recovered in 10 (Chadwick et al. 1986, case 84). The primary impact of all other press disturbances with recovery times exceeding 5 years (one case of mining, two of timber harvest, and three of channelization) was habitat degradation or simplification. Physical diversity in substrate composition, channel form and sinuosity, discharge, and velocity maximizes the heterogeneity of the instream community by reducing flushing rates of allochthonous and autochthonous organics and providing varied habitats and refugia. Watershed events which increase sediment loading and overload stream transport capacity (e.g. timber harvest) or in-stream disturbances such as channelization or snag removal serve to simplify habitat. Recovery to pre-stressor species richness and relative species density generally will not occur until the fluvial dynamics of the system

return the stream bed to approximately original conditions. As can be noted from the recovery rates of organisms after pulse disturbances, the biota adjust quickly relative to the slowly adjusting physical conditions.

The press disturbances reviewed here best reflect rates of physical adjustment in fluvial systems. Recovery after pulse disturbances represent the abilities of the organisms to repopulate after catastrophic events. The range of recovery endpoints for total density after such events was 0.02-3.0 years, with only one of these endpoints exceeding two years (Table 11). The latter recovery scenario followed DDT spraying of an entire watershed (Ide 1967, case 85). Total density often recovered more rapidly than most individual taxa as elimination of predators and competitors allowed a proliferation of organisms (usually dipterans such as chironomids and simuliids) with short generation times (e.g. Cook and Moore 1969, case 21; Cuffney et al. 1984, case 144). It might be expected that total biomass or at least genera richness would recover more slowly, but a comparison of recovery endpoints from studies which included at least two of these measurements demonstrated no consistent differences (Table 14).

At the ordinal level, rates of recovery for the major lotic groups rank Diptera > Ephemeroptera > Plecoptera > Trichoptera (Table 11). Coleoptera is not represented by a large number of endpoints, but is an important group and appears to recover similarly or more slowly than Trichoptera. Recovery rate is apparently related to the propensity of organisms to enter the drift and their generation time. Ephemeroptera and Diptera have the highest drift rates relative to

benthic standing crop (e.g. Townsend and Hildrew 1976). Dipterans and Ephemeropterans also contain more species whose reproductive cycles are not closely synchronized with the autumn input of organic matter. Reproductive adults or non-sensitive aestivating stages are thus more likely to be present after unpredictably timed disturbance events. Recovery time is slower for Trichopterans as they are often cased, which reduces their presence in the drift, and they may have a generation time of more than one year.

Timing of the disturbance event can impact recovery rates for individual species or for total population endpoints. In systems such as Sonoran desert streams which have unpredictable year-round disturbance events (spates and droughts), unstable substrates which offer minimal refugia, and temperatures which allow growth and reproduction throughout the year, species survival strategies include short multivoltine life cycles and aestivating stages (Gray and Fisher 1981). The timing of disturbance events consequently has little impact on recovery rate. In more temperate climates, univoltine life cycles are common. Disturbance events can have greater impacts on recovery patterns if they occur during critical life stages or if they occur in autumn when lower winter drift rates and lack of winter reproduction delay recovery until the following spring. DDT applications in June to control blackflies or spruce budworms ($n = 7$) resulted in an average recovery time for blackflies of 1.1 years (range 1-1.5). Disturbances which severely reduced or eliminated blackfly larvae in other months ($n = 7$) resulted in an average recovery time of 0.3 years (range 0.014 - 0.80).

Several studies demonstrated the importance of distance from an undisturbed source for recolonization (refugia). Elimination of

macroinvertebrates in a first order stream in Coweeta Hydrologic Laboratory using multiple applications of methoxychlor resulted in a large number of macroinvertebrates which had not recovered after 2 years (Cuffney et al. 1984, Wallace et al. 1986; case 144). In this instance, complete treatment of an isolated 1st order stream eliminated recolonization by drift and minimized recolonization by aerial adults. Small non-insect macroinvertebrates and insects with very short generation times recovered during the two year duration of the study.

The massive fish rehabilitation effort on the Green and New Fork Rivers, Wyoming (Binns 1967, cases 14-17) presented an example of a large stream with treated areas isolated from undisturbed sources for recolonization by distances of up to 250 km. Time to recovery of total density was related to distance from source, but recovery of genera richness (at least 80% of pretreatment taxa) and biomass was not (Table 14). Some genera had not yet reappeared when monitoring was terminated after 2 years.

An intentional point source introduction of DDT into a Montana stream (Schoenthal 1963, case 186) provides an excellent example of recolonization mechanisms. Eight sites spanning 7.2 km downstream from the DDT introduction were monitored for 1.5 years. Recolonization was found to be closely related to the drift behavior and rates of endemic organisms. Mayflies and dipterans recolonized rapidly, with mayflies achieving pretreatment densities for a distance of 0.9 km in 6 months. Recolonization was not complete over the 7.2 km study area at 12 months, but by 17 months both total density and species composition had recovered. The November sample in which

recovery was first evident coincided with the expected fall reproductive pulse. This study provided evidence that drift rates are the primary recolonization mechanism during the first year for reaches close to an unperturbed site, but natural reproduction from aerial adults or rapidly drifting individuals may become the primary mechanism in more distant reaches.

In summary, recovery times following pulse disturbances are affected by the presence of refugia, distance from refugia, time of year of disturbance, and life cycle characteristics. Downstream drift is the primary recolonization mechanism in lotic environments. If the disturbed area is far from refugia, life-table characteristics (e.g. generation time and fecundity) assume more importance in dictating recovery rate. In general, however, population recovery is rapid, usually less than 2 years, if the physical diversity of the habitat is unchanged. Press disturbances which impact the physical characteristics of the habitat do not allow recovery of macroinvertebrate density or biomass until fluvial processes slowly readjust the system. The response of the biota is rapid relative to the recovery of the physical habitat.

Fish

Recovery endpoints for fish have been reported following a wide range of natural (flooding, drought) and anthropogenic stressors. Anthropogenic stressors include pulse chemical inputs (e.g. DDT, rotenone), habitat manipulation (instream habitat development, lake drawdown, nonchemical organism removal) and watershed-level disturbances (mining, logging activity, channelization).

A total of 406 endpoints were recorded for fish recovery, the majority of which represent recovery times for individual taxa: recovery of fish populations to pre-disturbance densities (48%), time to first appearance (34%), or recovery of average size (6%). Data were reported for 15 different families, although most endpoints (87%) represented fish species within five common families: Catostomidae, Centrarchidae, Cyprinidae, Salmonidae, and Percidae. Fewer data are available on recovery of community-level parameters (total fish biomass, density, productivity, or species richness), i.e. 27 case studies representing only 12% of all endpoints.

Recovery times to all endpoints ranged from .01 to >52 years (Table 15). The longest recovery times are associated with press stressors leading to long-term alterations in physical habitat (Table 16); the recovery process involves an adjustment to a new steady state determined by a change in carrying capacity. Channelization produces the most radical change in stream environment; fish populations in the channelized sections of the Luxapalila River, Mississippi, did not recover within 52 years (Arner et al. 1976, case 58). Habitat modification designed to mitigate channelization effects can shorten recovery times, but its effectiveness varies with time since channelization has occurred and with the particular habitat requirements of individual species. The Olentangy River had been channelized 25 years before the mitigation process was begun, allowing time for extensive (> 1 m depth) silt build-up in channelized stretches. Following mitigation, smallmouth bass (Micropterus dolomieu) and largemouth bass (Micropterus salmoides) recovered in less than 5 years (Edwards et al. 1984, case 132). Both of these species require the deep pools created during habitat enhancement, and

their growth rate improved in response to increased levels of macroinvertebrate drift. The bottom dwelling detritus feeders (Carpiodes cyprinus, Hypentelium nigricans, Moxostoma anisurum, M. duquesnei, and Carassius auratus) required more than 5 years to recover, possibly because sediment characteristics and macroinvertebrate populations had not returned to their predisturbance state. In sections of the St. Regis River in Montana, in which different levels of mitigation were tested, the availability of pool habitats (pool/riffle ratio) was related to the degree of recovery of trout populations (Lund 1976, case 127).

The effect of system characteristics (e.g. stream gradient, latitude, watershed area) on recovery from press disturbances is difficult to determine due to the limited range of sites (15) and of site characteristics associated with press-type stressors. In addition, these systems could not be followed long enough to determine final recovery times so the lower limit of recovery times reported cannot be compared (e.g. > 5 years vs. > 52 years) (See Figure 5). Therefore, although system variables such as stream gradient could determine how fast the physical stream habitat (and thus the biota) can return to normal following increased siltation during a press-type disturbance, the data available from the literature are not adequate to determine whether this is the case.

In contrast to recovery from press-type disturbances, recovery times associated with single or multiple natural or pulse anthropogenic stressors were all less than 5 years, with the exception of recovery times of 5-6 years for Atlantic salmon (Salmo salar) following watershed-scale sprayings of DDT (Elson 1967, cases 54-57).

The long recovery time for adult Atlantic salmon compared to recovery of < 1.1 to > 2.25 years for salmonids in other systems (cutthroat trout [Salmo clarki], brown trout [Salmo trutta], and brook trout [Salvelinus fontinalis]) is related to differences in life history. Atlantic salmon spend the first two to three years of life within streams before migrating to the ocean, then return to those same streams at 4+ years of age to spawn. Thus both the effect of the stressor and recovery of adult populations returning to spawn is delayed by the time period required for maturation to the age of first reproduction. In contrast, cutthroat, brown trout, and brook trout populations generally recovered from DDT sprayings in 1-2 years (Warner and Fenderson 1962, cases 87-92; Schoenthal 1963, case 186), because immigration can occur from residual populations upstream or downstream of affected areas. When recolonization sources are limited, however, impacts to and recovery of salmonids from DDT sprayings will be prolonged due to the bioaccumulation of DDT by the fish, and remobilization of DDT at the onset of colder temperatures when fat reserves are metabolized. A number of investigators reported a second peak in DDT toxicity to fish in the fall (Schoenthal 1963, case 186; Graham 1959, cases 174, 175).

None of the intrinsic site characteristics considered (latitude, longitude, elevation, mean discharge, watershed area, stream gradient, and stream order) were good predictors of recovery time of fish presence or density following pulse disturbances. However, in specific case studies, adjoining headwater streams were a significant source of immigrant fish species (Binns 1967, cases 14-17; Olmsted and Cloutman 1974, case 38). Minnows from headwater regions may be well adapted to colonize variable environments under stressful conditions.

Matthews and Styron (1980) found that cyprinids and darters from headwater streams were better adapted to low and variable dissolved oxygen and pH levels than those from mainstem streams.

Several stressor-specific factors affected recovery rates from pulse disturbances. To compare recovery rates for different disturbances as a function of species persistence or the presence of upstream or downstream refugia, median recovery times were calculated for each case study (Tables 17 and 18). This approach prevented the numerous endpoints for a few studies from biasing the results, and allowed us to use data reported as "less than" or "greater than" values which could not be averaged.

Persistence of a species following a disturbance did not guarantee that recovery would occur within one year. Only one-quarter of cases with persistent species had recovery times for population densities of ≤ 1 year, as compared to half of the cases with nonpersistent species (Table 17). However, in the case of extensive rotenone treatment of the Green River, in which recovery times were constrained by distance to the recolonizing source, species persistence did produce interspecific differences in recovery rates (Binns 1967, case 186). Carp (Cyprinus carpio) recovered to pretreatment densities in less than one year because of the presence of refugia within the system. At the time of rotenone application, carp were present in backwater breeding areas.

The presence of undisturbed stretches upstream or downstream of a stressed system did appear to affect recovery times for fish densities. Over one-third of those systems with recolonization sources upstream or downstream from a site had median recovery times

of ≤ 1 year (Table 18). In contrast, only one site without known recolonization sources upstream or downstream had a median recovery time of ≤ 1 year, and species within this system had persisted throughout the disturbance period.

Within specific systems, the presence of barriers to fish movement affected recovery time. For example, in Seas Branch, Wisconsin, a fish barrier was installed in the middle of the study section prior to antimycin A treatment (Avery 1978, cases 124, 187). Above the fish barrier, only 8 of 13 original species had reappeared within 3.5 years of treatment, and of these the smaller species (brook stickleback [Culaea inconstans] and fathead minnow [Pimephales promelas]) with shorter generation times were most abundant. Below the barrier all species present before treatment reappeared within one year.

In those systems with no refugia or persistent populations following a disturbance, distance of a site from an unperturbed population affected recovery rates. Binns (1967) reported net downstream migration rates of 60-100 miles/yr and 75 miles/yr for whitefish (Prosopium williamsoni) and brown trout (Salmo trutta), respectively. Recovery times for overall species richness were 1, 2, or > 2 years for sites 13-16, 80, or 244 km from an unperturbed upstream site. In addition, different species of fish have different degrees of vagility. The smaller cyprinid minnows, chubs, and darters and the younger age classes of larger fish species tended to be more mobile and their net rates of migration downstream into disturbed regions were more rapid than those of larger fish (Binns 1967, Avery 1978, Olmsted and Cloutman 1974).

The timing of a stressor relative to spawning season may determine whether species recover within one year or whether a full year or more is required for a successful spawn to occur. Median recovery times for pulse-type disturbances were 0.04-0.08 years and 0.13 years, respectively, for first appearance and recovery of densities of nonsalmonids for systems perturbed in April or May, before the spawning season of warmwater fishes (Table 19). In contrast, median recovery times for disturbances ending in June through December were 0.33-0.5 years for time to first reappearance and 0.50-2.0 years for time to recover density.

For case studies of pulse disturbances, many authors identified migration and recolonization rather than increase of the resident population as the main mechanism for recovery. Thus, the presence and distance of refugia or unperturbed stretches relative to a stressed site and the timing of a stressor relative to spawning season influenced recovery times. Generation time and species or year-class-specific migratory tendencies affected recovery rate in sites isolated by large disturbances or barriers. While recovery times were less than five years for all but two cases of pulse disturbances, recovery times following all but one press disturbance ranged from 5 to > 52 years. Press disturbances required long recovery times because they produced instream habitat alterations (e.g., changes in pool/riffle ratios) that lowered the carrying capacity for individual species, or because they severely impacted the vegetated buffer zone surrounding streams. Intrinsic site characteristics probably have a greater influence on recovery from these press-type disturbances, but too few data exist for these cases to identify trends, and often these data

cannot be compared because endpoints are not discrete (i.e. > x years).

CONCLUSIONS

A major impetus for this study was to examine whether the current U.S. EPA water quality criteria which allow exceedance of water quality standards once every three years were reasonable in the light of recovery processes and rates (U.S. EPA 1985). For instance, if water quality criteria were exceeded, then it is assumed that some mortality would occur within an aquatic system. The major question is whether those aquatic systems could recover within a reasonable period of time. If not, what aquatic systems and what disturbance scenarios lead to long recovery times?

Approximately 1,270 chemical and biological endpoints of recovery were examined here with respect to a variety of disturbance scenarios. Stressors that largely required long recovery times after abatement were:

- 1) channelization of rivers which led to long recovery times in fish and macroinvertebrate communities in widespread areas such as the Chariton River, Missouri; the Luxapalila River, Mississippi; Rush Creek, California; and the St. Regis River, Montana (mode of action--habitat alteration);
- 2) DDT forest spraying in several rivers of New Brunswick which led to long recovery times in fish and macroinvertebrates (modes of action--isolation from refugia and impact on species with long generation time);

- 3) mining activity in lotic systems in Tennessee (mode of action--habitat alteration) and Montana (mode of action--residual toxicity) which led to long recovery times in fish, macroinvertebrates, and water quality; and
- 4) timber activity in lotic system watersheds of North Carolina, Arkansas, and Oregon with primary effects on water quality (mode of action--habitat alteration, watershed alteration).

Factors affecting the recovery rate of the biota in studies reviewed here can be considered as independent or dependent on the specific organisms found within the system. The dependent factors identified as important to recovery included generation time, fecundity, presence of aestivating or resistant stages, propensity to disperse, and predation-competition interactions. Factors independent of the organisms which impacted recovery rates were changes in habitat, changes in system productivity, residual toxicity, time of impact, and presence or distance of refugia. In general, the dependent factors regulated recovery time within a relatively narrow range. That is, the biota were resilient to disturbance if a residual population persisted or refugia were available.

Of the independent factors, the timing of impact generally changed recovery time by less than one year (adjustments occurred within one reproductive cycle). Refugia were of obvious importance, both in terms of distance and presence. Long term effects were observed if a species was eliminated and if barriers to recolonization were present. Changes in system productivity as a result of nutrient

enrichment changed food and habitat resources and resulted in prolonged recovery times. Although we did not deal broadly with this type of impact due to the difficulty in establishing recovery endpoints, the existing literature on eutrophication and its control documents the lengthy and complex adjustments which occur as nutrients continue to recycle. Disturbances that resulted in habitat alterations were the most common impact associated with long recovery times.

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Table 1. Site characteristics summarized for lotic and lentic systems considered in the recovery data base.

Lotic	Lentic
Size of watershed	Size of watershed
Latitude and longitude	Latitude and longitude
Elevation	Elevation
Stream order	Retention time
Mean discharge	Hydrologic class
Annual range in discharge	Mean and maximum depth
Stream gradient	Mean secchi depth (growing season)
Pool:riffle ratio	Conductivity or total dissolved solids
Avg. total phosphorus (growing season)	Avg. total phosphorus (growing season)
Watershed vegetation and land-use characteristics	Watershed vegetation and land-use characteristics

Table 2. Distribution of endpoints in different types of aquatic systems with respect to five major chemical and biological groupings.

Aquatic system	No. of Water quality endpoints	No. of Phyto- plankton endpoints	No. of Zoo- plankton endpoints	No. of Macro- invert. endpoints	No. of fish endpoints
Lake - small (< 50 ha)	5	5	49	18	
- medium (50 - 300 ha)			15	21	
- large (> 300 ha)	1	3		2	
Lotic - small (< 3rd Order)	46			381	262
- medium (4 - 6 Order)	26	1	3	224	148
- large (> 6th Order)					
Pond -	3	4	16	21	1

Table 3. Summary of time to recovery following disturbance for phytoplankton, periphyton, amphibians, microorganisms, and aquatic macrophytes (see part II for complete listing).

Recovery type	System Type	Parameter	n	Minimum (yrs)	Maximum (yrs)
AMPHIBIANS					
First appears		<u>Rana pipiens</u>	1	.12	.12
AQUATIC MACROPHYTES					
Density	Lake	<u>Myriophyllum spicatum</u>	1	4.00	4.00
Density	Lake	Species richness	1	>4.00	>4.00
Density	Pond	Density	1	.25	.25
Density	River	Biomass	2	>1.00	>52.00
Density	River	Density	1	>52.00	>52.00
Density	River	<u>Elodea canadensis</u>	1	.80	.80
Density	River	Species richness	1	.25	.25
		Total	8		
MICROORGANISMS					
Density	Lake	Density	2	.01	.02
Density	Pond	Density	1	.07	.07
Density	River	Density	1	.03	.03
		Total	4		
PERIPHYTON					
Density		Biomass/biovolume	3	.02	.42
Density		Genera richness	1	.02	.02
Density		Productivity	1	.30	.30
Density		sum bl-gr alg density	1	.42	.42
		Total	6		
PHYTOPLANKTON					
Density		Biomass/biovolume	1	.02	.02
Density		<u>Ceratium</u> sp.	1	> .17	> .17
Density		Chlorophyll a	3	.01	.04
Density		<u>Microcystis</u> sp.	1	.06	.06
Density		Productivity	3	.02	.04
Density		Total density	2	> .01	.09
Density		fall bl-gr predominance	1	1.25	1.25
Density		sum bl-gr predominance	1	2.00	2.00
		Total	13		

Table 4. Frequency of stressor types associated with recovery for lotic and lentic systems.

System type	Stressor type	n
Lentic	Rotenone	6
	Dredging	3
	Chemical, metals	2
	Chemical, other	22
	Nutrient addition	1
	Oxygen stress	1
	Flooding	1
Lotic	DDT	29
	Logging activity	16
	Dredging/channelization	11
	Rotenone	9
	Organism removal	8
	Flooding	8
	Drought	7
	Suspended solids	7
	TFM lampricides	4
	Miscellaneous	36

Table 5. Summary of water quality recovery times in years.

Parameter	n	Minimum (yrs)	Maximum (yrs)
Alkalinity	2	.01	>25.00
Aluminum	1	.01	.01
Ammonia	1	.02	.02
CPOM	3	>15.00	>135.00
Calcium	3	.01	4.00
Carbon dioxide	1	2.20	>2.20
Copper	3	.01	.36
Dissolved Org. C	1	>2.00	>2.00
Dissolved oxygen	1	>2.20	>2.20
Fine Sediment	8	.67	>5.00
Inorganic P (SRP)	2	.01	.11
Iron	2	.02	18.00
Lead	3	.01	.38
Magnesium	1	.01	.01
Manganese	1	.01	.01
Nitrate	8	.06	20.00
Stressor	7	<.01	1.20
Phosphorus	6	.01	3.50
Potassium	4	.01	>2.00
Seston	3	3.75	>23.00
Sulfate	1	25.00	25.00
Temperature	2	>8.00	>15.00
Tot. susp. solids	1	.04	.04
Transparency(secchi)	1	1.00	1.00
Turbidity	4	.01	>1.00
Water yield, runoff	6	>3.00	>22.00
Zinc	2	.01	.38
pH	2	.08	20.00
Total	80		

Table 6. Distribution of recovery endpoints for water quality parameters.

Parameter	No. of 0-1 yr endpoints	No. of 1-3 yr endpoints	No. of 3-5 yr endpoints	No. of >5 yr endpoints
Alkalinity	1			1
Aluminum	1			
Ammonia	1			
CPOM				3
Calcium	1	1	1	
Copper	3			
Fine Sediment	4		2	1
Inorganic P (SRP)	2			
Iron	1			1
Lead	3			
Magnesium	1			
Manganese	1			
Nitrate	1	3	1	2
Stressor	6	1		
Phosphorus	4		1	
Potassium	2	1		
Seston			1	2
Sulfate				1
Temperature				2
Tot. susp. solids	1			
Transparency(sec- chi)	1			
Turbidity	2			
Water yield, runoff		1		3
Zinc	2			
pH	1			1

Table 7. Summary of recovery times in years for zooplankton groups.

Group	Recovery type	n	Minimum (yrs)	Maximum (yrs)
Cladocera	Density	42	.04	> 1.50
Eucopepoda	Density	19	.03	> 3.00
Diptera	Density	1	.90	.90
Rotifera	Density	5	.06	.75
	Total	67		

Table 8. Distribution of recovery endpoints (pre-disturbance densities) for major zooplankton groups.

Group	No. of 0-3 months endpoints	No. of 3-6 months endpoints	No. of 6-12 months endpoints	No. of 12-15 months endpoints	No. of >15 months endpoints
Cladocera	24	3	6	0	1
Eucopepoda	9	1	1	2	5
Rotifera	3	0	2	0	0

Table 9. Summary of recovery times in years for macroinvertebrate groups.

System	Recovery Type	Group	n	Minimum (yrs)	Maximum (yrs)
Lake	Density	Amphipoda	4	> .17	> .31
Lake	Density	Coleoptera	1	> 1.50	> 1.50
Lake	Density	Diptera	8	.02	4.30
Lake	Density	Ephemeroptera	3	.10	> 1.70
Lake	Density	Gastropoda	2	> 1.00	< 2.00
Lake	Density	Hirudinea	2	> 1.00	< 2.00
Lake	Density	Lepidoptera	1	> 1.50	> 1.50
Lake	Density	Neuroptera	1	.16	.16
Lake	Density	Oligochaeta	3	.03	> .07
Lake	Density	Ostracoda	1	> 1.50	> 1.50
Lake	First appears	Amphipoda	2	.06	> .67
Lake	First appears	Coleoptera	1	> 1.50	> 1.50
Lake	First appears	Lepidoptera	1	> 1.50	> 1.50
Pond	Density	Amphipoda	1	> 2.40	> 2.40
Pond	Density	Coleoptera	4	> .10	> .10
Pond	Density	Diptera	3	.15	2.00
Pond	Density	Ephemeroptera	2	> .10	> .10
Pond	Density	Hemiptera	6	.08	> .10
Pond	Density	Odonata	3	.08	> 2.40
River	Density	Amphipoda	9	> .01	1.80
River	Density	Arachnida	1	> .50	> .50
River	Density	Coleoptera	9	.25	>25.00
River	Density	Collembola	1	> 2.00	> 2.00
River	Density	Decapoda	2	.33	> 1.00
River	Density	Diptera	82	.01	>20.00
River	Density	Ephemeroptera	83	.01	>25.00
River	Density	Gastropoda	5	.58	> 1.80
River	Density	Hemiptera	3	.33	< 1.00
River	Density	Isopoda	1	> 1.00	> 1.00
River	Density	Megaloptera	1	> 1.00	> 1.00
River	Density	Nematodes	2	.02	> .50
River	Density	Odonata	5	.08	.33
River	Density	Oligochaeta	7	.02	8.00
River	Density	Ostracoda	1	.21	.21
River	Density	Pelecypoda	3	< .25	1.25
River	Density	Plecoptera	56	.10	>20.00
River	Density	Trichoptera	65	.12	>25.00
River	First appears	Arachnida	1	1.00	1.00
River	First appears	Coleoptera	9	.02	2.20
River	First appears	Decapoda	1	> .33	> .33
River	First appears	Diptera	16	.02	2.00
River	First appears	Ephemeroptera	35	.01	2.00
River	First appears	Gastropoda	9	.02	>10.00
River	First appears	Hirudinea	1	1.00	1.00
River	First appears	Nematodes	1	1.00	1.00
River	First appears	Odonata	4	.04	2.20
River	First appears	Oligochaeta	6	.17	1.30
River	First appears	Plecoptera	11	.91	1.00
River	First appears	Trichoptera	25	.01	> 4.00
River	First appears	Turbellaria	1	1.40	1.40
Total			502		

Table 10. Summary of recovery times in years for macroinvertebrates by functional group.

System	Functional Group	Recovery type	n	Minimum (yrs)	Maximum (yrs)
Lake	Collectors	Density	8	.03	> 1.70
Lake	Grazers	Density	1	< 2.00	< 2.00
Lake	Predators	Density	1	.16	.16
Lake	Shredders	Density	2	> 1.50	> 1.50
Lake	Shredders	First appears	2	> 1.50	> 1.50
Pond	Collectors	Density	5	> .10	> 2.40
Pond	Predators	Density	11	.08	> 2.40
River	Collectors	Density	133	< .01	>25.00
River	Collectors	First appears	55	.01	> 4.00
River	Grazers	Density	17	.20	>10.00
River	Grazers	First appears	15	.02	>10.00
River	Predators	Density	36	.08	>20.00
River	Predators	First appears	15	.05	2.20
River	Shredders	Density	25	.10	>20.00
River	Shredders	First appears	4	1.00	1.00
Total			330		

Table 11. Distribution of macroinvertebrate recovery endpoints for pulse disturbances¹. Endpoints for specific taxa are pre-disturbance densities.

Parameter	No. of endpoints by time interval (years)							
	0- .25	.25- .50	.50- .75	.75- 1.00	1.00- 1.25	1.25- 1.50	1.5- 2.0	>2.0
Biomass	6		1	9	2			1
Density	17	5	3	9	1	2		2
Genera richness	5	2	1	11	4			1
Species composition	4			2	1	1		4
Amphipoda	3	2	1	1	1		1	
Coleoptera	2			1		1		1
Collembola								1
Decapoda		1						
Diptera	34	9	3	9	1	4	1	6
Ephemeroptera	15	7	4	17	1	5	5	6
Gastropoda			1				1	
Hemiptera	2	1		1				
Hirudinea							1	
Nematodes	1							
Neuroptera	1							
Odonata	5	1						
Oligochaeta	4			1				
Ostracoda	1							
Pelecypoda	1			1	1			
Plecoptera	8	5	2	6	1	1	1	12
Trichoptera	5	8	6	7	2	4	2	8
Other	3	2		1	1		1	1
Total	117	43	22	76	16	18	13	43

1 - includes all disturbance classes except mining, timber harvest, nutrient addition, and channelization

Table 12. Distribution of macroinvertebrate first appearance recovery endpoints for pulse disturbances¹.

Parameter	No. of endpoints by time interval (years)							
	0- .25	.25- .50	.50- .75	.75- 1.00	1.00- 1.25	1.25- 1.50	1.5- 2.0	>2.0
Amphipoda	1							
Arachnids				1				
Coleoptera	1			3	1	1	1	2
Diptera	7	1	1	1		1	2	1
Ephemeroptera	13	2	3	16			1	
Gastropoda	4	3		1				
Hirudinea				1				
Nematodes				1				
Odonata	2						1	1
Oligochaeta	2		1	1	1	1		
Plecoptera				11				
Trichoptera	2	4	1	6	2		6	2
Turbellarians						1		
Other				3				1
Total	32	10	6	45	4	4	11	7

1 - includes all disturbance classes except mining, timber harvest, nutrient addition, and channelization

Table 13. Distribution of macroinvertebrate recovery endpoints¹ for press disturbances².

Parameter	No. of endpoints by time interval (years)					
	0-3	3-6	6-12	12-15	15-18	>18
Biomass		1				2
Density		1				3
Genera richness						3
Species composition						1
Coleoptera						1
Diptera			6			2
Ephemeroptera					1	2
Oligochaeta			1			
Plecoptera			1			3
Trichoptera			2			3
Other						3
Total		2	10		1	23

1 - includes both first appearance and density endpoints

2 - includes mining, timber harvest, nutrient addition, and channelization

Table 14. Recovery time for macroinvertebrate biomass, total density, and genera richness in systems for which at least two of those measures are available.

Case number	Stressor	Biomass	Density	Richness
58	Channelization	>52.00	>52.00	>52.00
132	"	>25.00	>25.00	>25.00
133	"	> 5.00	> 5.00	
85	DDT	0.08	3.00	3.00
97	"	0.13		1.00
98	"	1.20		1.10
99	"	1.00		1.00
101	"	1.00		1.00
174	"	> 1.20	> 1.20	
185	"	> 1.25	1.08	
40	"	> 1.00	> 1.00	> 1.00
108	"		< 0.25	> 0.25
109	"		< 0.50	1.00
119	"		0.33	0.17
122	"		0.30	1.25
185	"	> 1.25	1.08	
144	"	2.25	0.30	
44	Drought	< 1.00	< 1.00	1.00
22	"		0.21	0.27
137	"		1.00	1.20
33	Dredging		0.02	0.02
34	"		0.03	0.03
35	"		0.03	> 0.07
96	"	1.10	0.80	
110	"		1.00	1.00
25	Flood	0.17		0.17
95	"	> 0.33	> 0.33	> 0.33
125	"	1.00	1.00	1.00
84	Mining	>10.00	>10.00	>10.00
69	"		22.00	22.00
151	Multiple	0.58	0.58	
31	Nutrient addition	4.30	4.30	
14	Rotenone	1.00	0.17	1.20
14	"	1.00	0.67	1.20
15	"	0.90	0.90	1.00
16	"	0.90	1.00	1.00
17	"	0.08	0.17	1.00
70	Timber	> 5.00	> 5.00	< 5.00
40	Other	> 1.00	> 1.00	> 1.00
108	"		< 0.25	> 0.25
109	"		< 0.50	1.00
144	"	2.25	2.25	
189	"		> 0.50	> 0.50

Table 15. Summary of recovery times in years for fish families.

Recovery type	Family	n	Minimum (yrs)	Maximum (yrs)
Average size	Catostomidae	4	.13	2.00
Average size	Centrarchidae	10	.13	>52.00
Average size	Cyprinidae	2	.13	.13
Average size	Salmonidae	9	1.00	> 5.00
Density	Anguillidae	1	> .83	> .83
Density	Aphredoderidae	1	>52.00	>52.00
Density	Atherinidae	1	.17	.17
Density	Catostomidae	30	.13	>52.00
Density	Centrarchidae	25	.10	>52.00
Density	Clupeidae	1	< 1.00	< 1.00
Density	Cottidae	9	< 1.00	7.00
Density	Cyprinidae	60	.08	>52.00
Density	Cyprinodontidae	2	.16	>52.00
Density	Esocidae	2	> 1.00	>52.00
Density	Gasterosteidae	2	1.00	1.00
Density	Ictaluridae	10	< 1.00	>52.00
Density	Percidae	15	.13	>52.00
Density	Salmonidae	35	.10	>50.00
First appears	Atherinidae	1	.08	.08
First appears	Catostomidae	23	.04	> 4.00
First appears	Centrarchidae	12	.04	1.50
First appears	Cottidae	6	.42	> 2.20
First appears	Cyprinidae	61	.01	3.50
First appears	Cyprinodontidae	1	.01	.01
First appears	Gasterosteidae	2	.50	.50
First appears	Ictaluridae	9	.15	> 4.00
First appears	Percidae	14	.04	> 2.00
First appears	Salmonidae	9	.10	> 2.00
Total		357		

Table 16. Distribution of fish recovery endpoints.

Stressor	No. of endpoints by time interval (years)							
	1	2	3	4	5	5-10	11-20	>20
Channeli- zation								33
Chemical, DDT	1	3	3		3	1		
Chemical, other	52	7		1				
Chemical, Rotenone	57	46		1				
Drought	3							
Flooding	1	1	1	1				
Habitat Development	1				4			
Lake drawdown	2							
Mining activity						1		
Multiple disturb.	53	1						
Organism removal	11							
Timber activity						1		

Table 17. Distribution of median recovery times for fish population densities from case studies with persistent and locally exterminated species.

Persistence	No. of ≤1 yr endpoints	No. of >1 yr endpoints	No. of >2 yr endpoints
Persistent species	5	10	6
Locally exterminated species	9	8	2

Table 18. Distribution of median recovery times for density of fish populations from case studies with and without known recolonization sources.

Unstressed source population for recolonization	No. of ≤1 yr endpoints	No. of >1 yr endpoints	No. of >2 yr endpoints
Upstream source	8	9	3
Downstream source, no upstream source	4	4	2
No known upstream or downstream source	1	5	3

Table 19. Median recovery time for first appearance or density of warmwater fish species (nonsalmonids) by pulse stressor type and timing of onset of recovery.

Stressor type	Median recovery time by season (yrs)		Median recovery time by season (yrs)	
	April-May	June-Dec	April-May	June-Dec
Chemical, other	0.08	0.50	0.13	2.00
Chemical, rotenone		0.33		1.00
Drought				1.00
Flooding				0.75
Lake drawdown				0.50
Organism removal				1.00
Multiple	0.04		0.13	

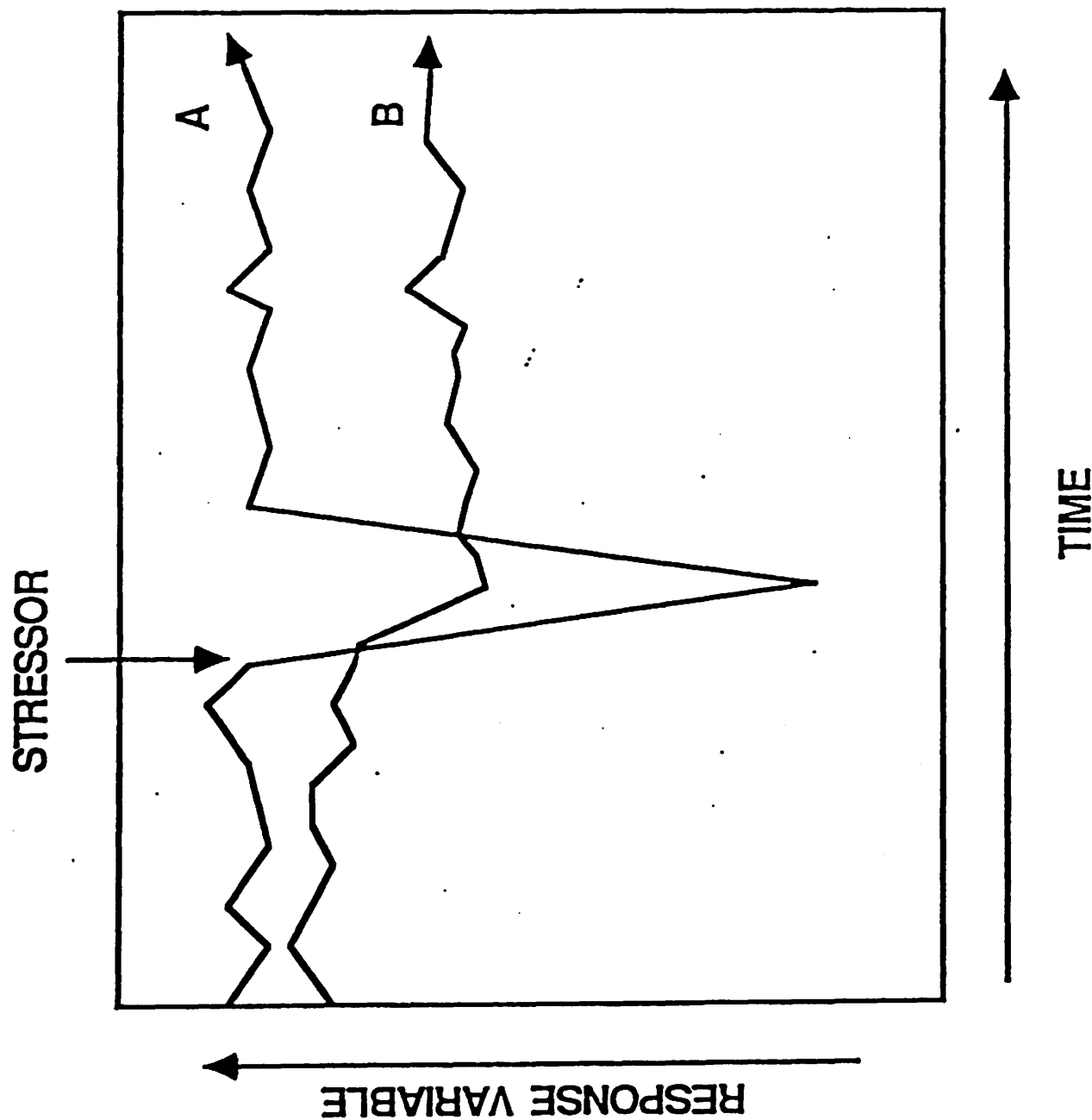


FIG. 1 - Hypothetical contrast between two systems exposed to the same stressor. System A illustrates a large effect, but fast recovery. System B illustrates small effect, but no recovery.

RECOVERY SITES

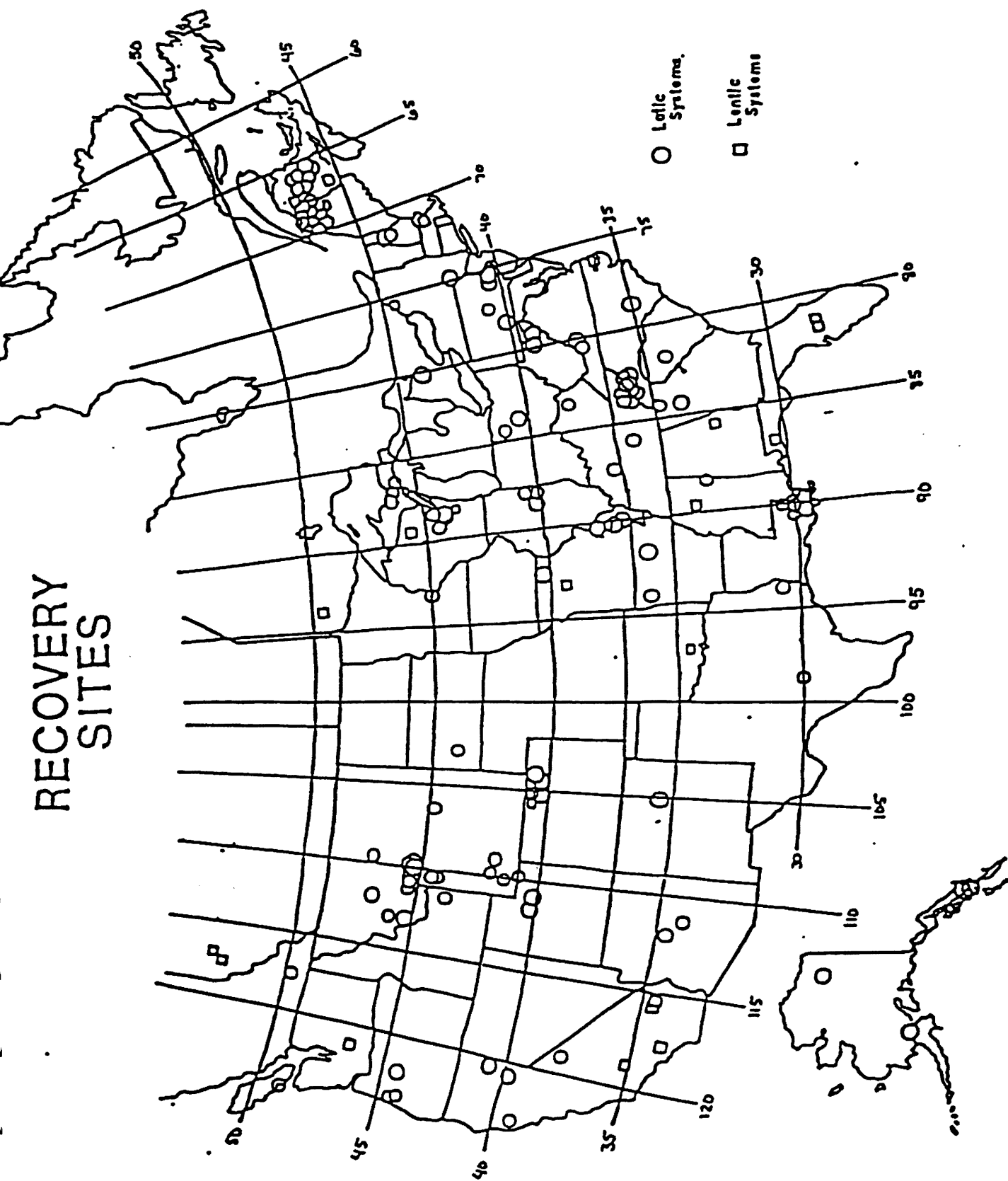


FIG. 2 - DISTRIBUTION OF CASE STUDIES ON RECOVERY ACROSS NORTH AMERICA.

Fig. 3 — Mean time required for cladocerans to attain pre-disturbance densities following pulse disturbances in lakes at various latitudes in North America.

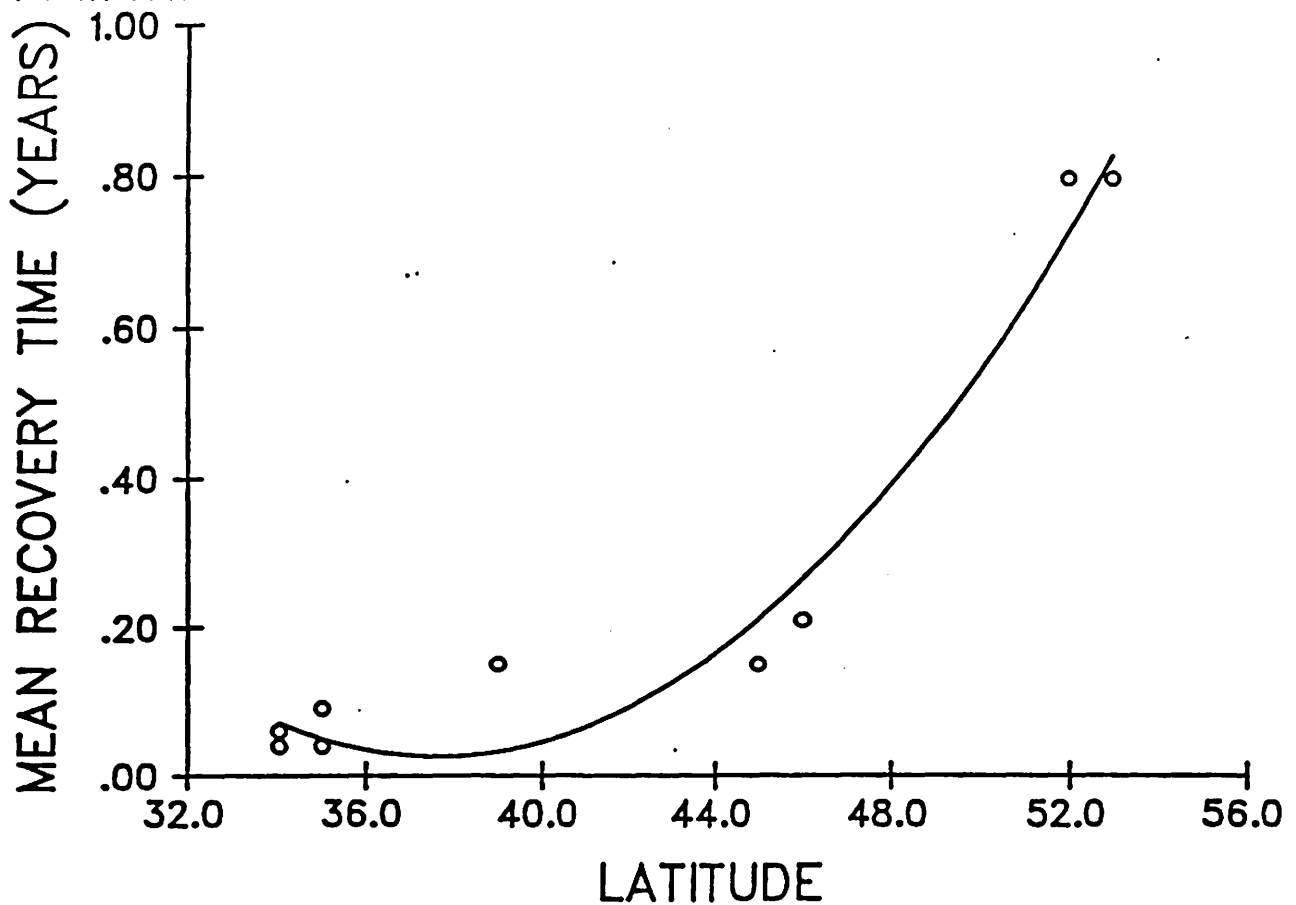
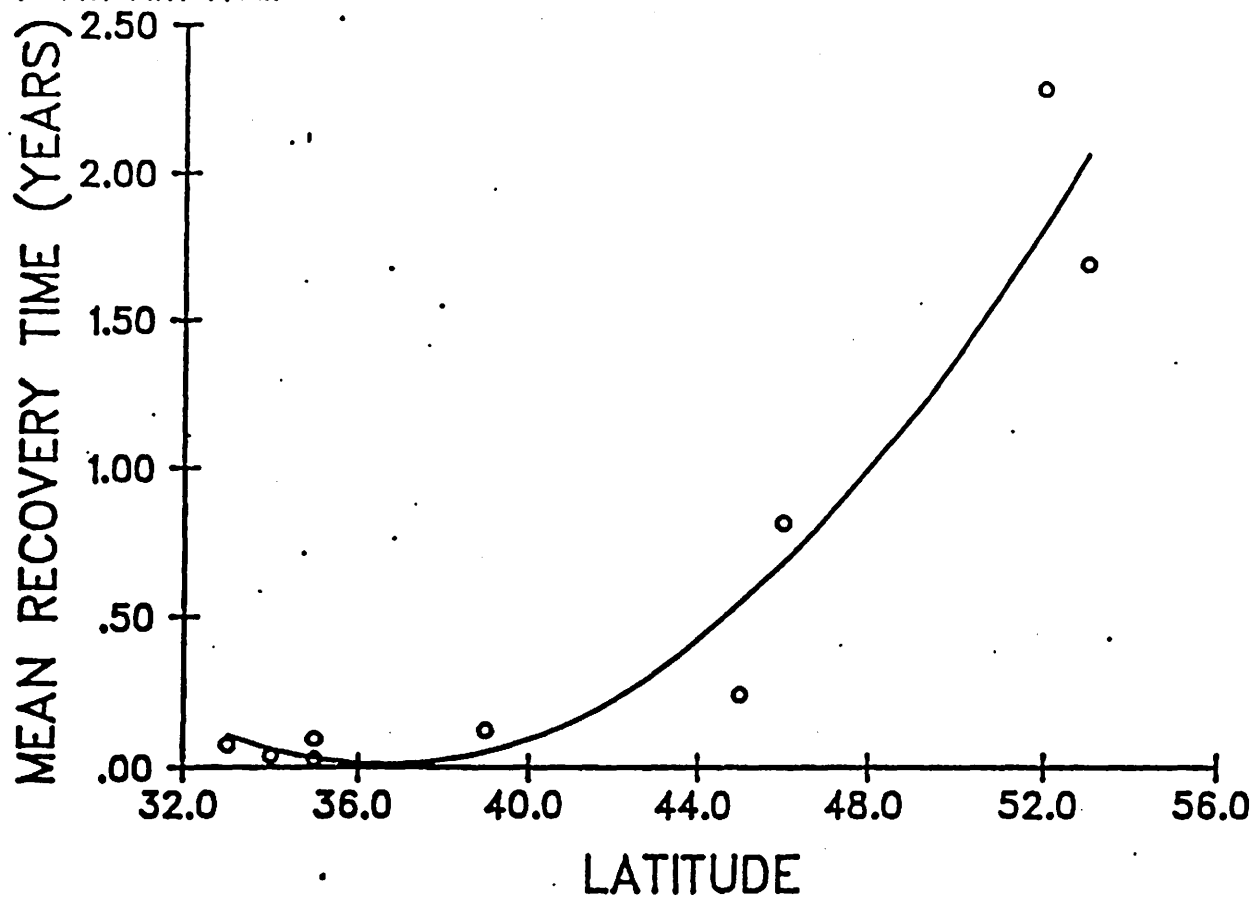


Fig. 4 - Mean time required for copepods to attain pre-disturbance densities following pulse disturbances in lakes at various latitudes in North America.



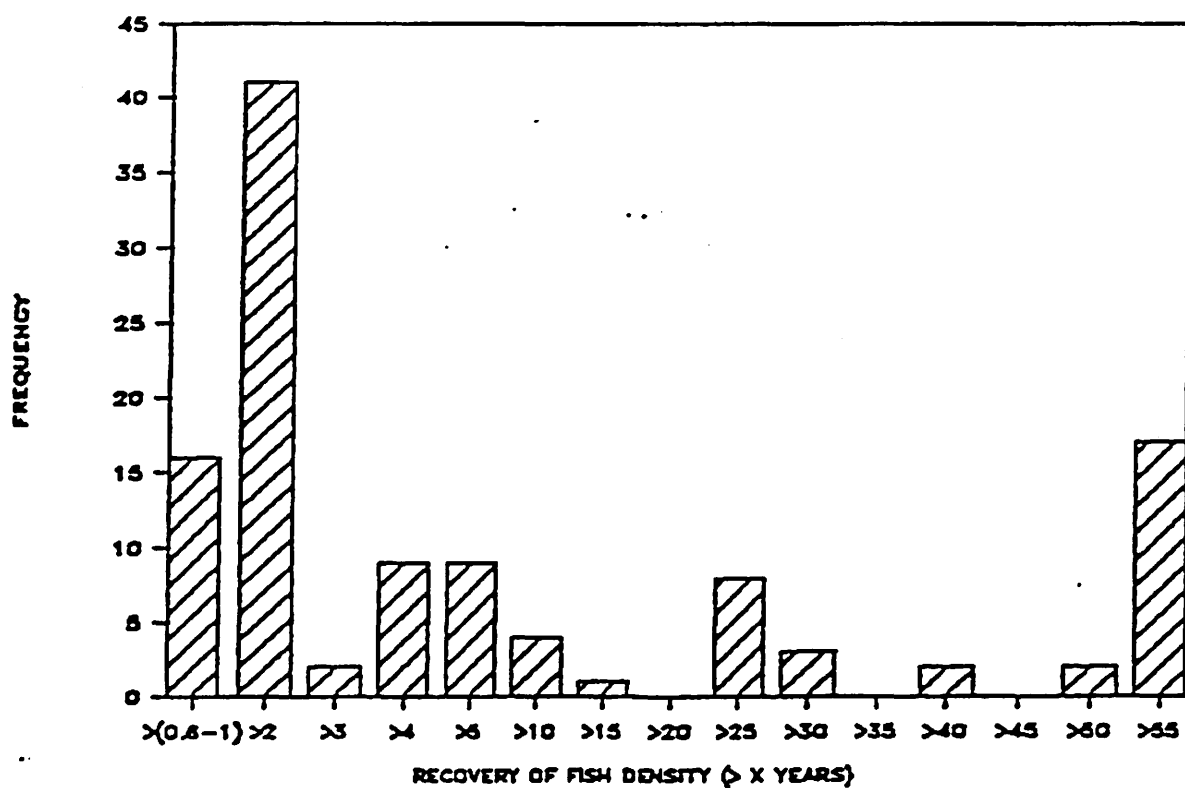
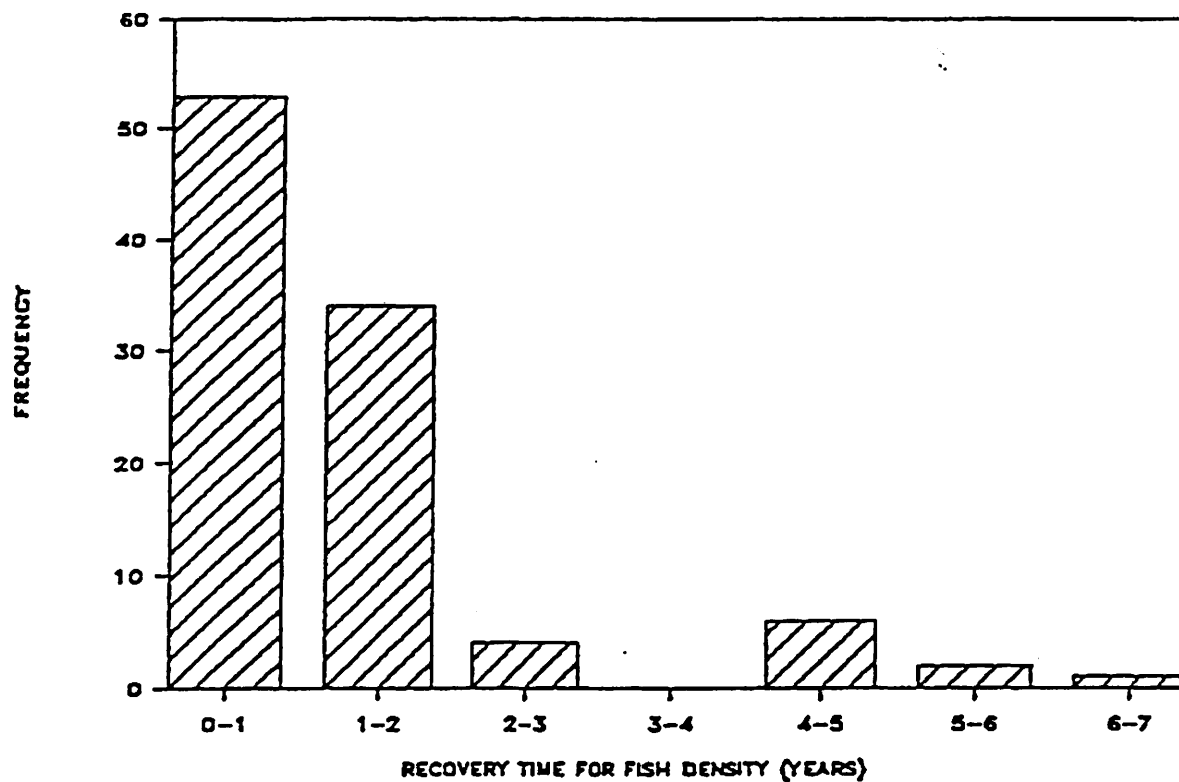


Figure 5. Frequency distribution of fish density for a) discrete recovery endpoints and b) recovery endpoints reported as "greater than" values.

Part II. Factors controlling the recovery of aquatic systems from
disturbance

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Abstract

The major hypotheses explaining the recovery of aquatic systems following disturbance were reviewed and interpreted in light of an exhaustive literature review on case studies examining recovery. The literature revealed that most studies have been performed on small lotic systems and that these studies have focused on an organismic-based approach to assessments of recovery. Although many hypotheses to explain recovery have focused on the functional aspects of ecosystems, a paucity of information is available for functional endpoints (e.g., nutrient cycling rates or productivity).

In consideration of these limitations, the most important factors associated with predicting recovery appear to be assessments of the following: (1) the habitat conditions following the disturbance (substantial habitat changes result in long recovery times or in lack of recovery); (2) determination of the availability of appropriately distributed refugia to supply recolonizing populations; (3) whether there is residual toxicity; (4) timing of the impact; (5) changes in system productivity (e.g., reduced or increased); and (6)

identification of whether any life history characteristics (e.g., low fecundity, long generation time, lack of aestivating or resistant stages, or poor dispersal capabilities) would prohibit or impede recolonization or repopulation of the affected area. Disturbances that resulted in habitat changes (e.g., mining, timber harvesting, channelization, and dredging) were clearly associated with the most prolonged recovery periods.

Introduction

In Part 1 above we describe a comprehensive review of published case studies which document some aspect of the recovery of aquatic systems from disturbance. However, an ecologically important question is whether the recovery rate of chemical and biological aspects of an aquatic system can be predicted with respect to particular stressors (Westman 1986). Here it is our intention to summarize hypotheses that have been presented to explain and possibly predict recovery in aquatic systems. We present these hypotheses in two forms. The first form includes those hypotheses that are dependent on the aquatic system itself and the second those that are independent of the system. The latter are those primarily related to characteristics of the organisms found within those systems. Finally, we present a summary of those hypotheses which seem most reasonable with respect to the case studies reviewed in Part I. This summary, therefore, will provide a framework for determination of the factors needed to predict recovery rates of aquatic systems exposed to a variety of stressors.

Recovery hypotheses - dependent on aquatic system

Productivity

A variety of researchers have suggested that productivity (e.g., Odum and Pinkerton 1955, O'Neill 1976) or other related factors such as nutrient cycling (Jordan et al. 1970, Webster et al 1975, DeAngelis 1980, and DeAngelis et al. 1988) are related with resilience in ecological systems. The basic concept as suggested by O'Neill (1976, pg. 1247) revolves around power capacity (Odum and Pinkerton 1955) as the quantity of energy processed per unit time per unit living tissue. "Greater power capacity would result in greater capability of a system

to counteract change" or, in terms of resilience, a shorter time to recover from a stressor. As suggested by DeAngelis et al. (1988), "this is an intuitively reasonable conclusion, since a faster rate of nutrient input per unit of biomass should increase the nutrient turnover rate and thus increase the rate at which a system can recover."

Recently, Waide (1987) expanded on these basic ideas and provided a conceptual model for understanding the relative stability of different ecosystems. His conceptual framework recognizes ecosystems as a dual hierarchy including both functional processes and comprised of species populations. Waide (1987) defines three macroscopic variables that characterize ecosystems: (1) productive capacity which is estimated by gross autotrophic productivity, (2) frequency structure of the environment which is measured by the biomass turnover rate, and (3) potential total ecosystem structure which is quantified as the sum of autotrophic biomass and total non-living organic matter. Highly resilient systems (short recovery times) are those with small, short-lived autotrophs with high biomass turnover rates, and relatively low autotrophic biomass and non-living organic matter. Increases in the size and generation time of autotrophs, decreases in biomass turnover rates, and increases in the sum total of autotrophic biomass and non-living organic matter of a system result in longer recovery times or less resilient systems.

Food web structure

Pimm and Lawton (1977), Pimm (1982), and recently DeAngelis et al. (1988) in conjunction with nutrient cycling have argued that food chain length is related with the stability of an ecological system.

Stability here referring to the rate at which an ecological system returns to a steady state following exposure to a stressor. Hence, ecological systems with longer, more complicated food webs would exhibit greater relative stability or faster recovery times as a result of exposure to a stressor.

Retention time/flushing rate

The residence time of a potential stressor within an aquatic system has an obvious correlation with the ability of a system to recover because of dose/response relationships, especially for chemical stressors (Cairns 1977). Increased residence times should be associated with increased recovery times because the system and organisms within the system receive longer exposure to the stressor.

Refugia for recolonization

The structure of the watershed in which an exposed and affected aquatic system exists is related to the ability of the system to recover from the stressor (Cairns 1977). Available refugia in lotic systems would include areas of suitable and unaffected habitats upstream, downstream, or within the hyporheic zone, depending on organisms affected. In lentic systems available refugia may be reflected in shoreline complexity or basin shape. Larger and more accessible refugia would be related with shorter recovery times. The essence of many of these factors have already been well documented in the context of classic island biogeographic theory (MacArthur and Wilson 1967). In this case, the size and distance of refugia to the affected area (or island) play major roles in the immigration and extinction rates of colonizing species.

Disturbance history of ecosystem

A number of researchers have hypothesized that systems exposed to greater and more frequent stressors will be both more resilient and resistant to these exposures as compared with systems less exposed to stressors (Fisher 1977; Boesch and Rosenberg 1981). The basic tenet of this hypothesis is that the system and the organisms found within stressed environments will have evolved mechanisms to deal with frequent exposures to these stressors. Common examples are hostile environments like desert streams that are constantly exposed to both flooding and drought conditions. In fact, in many of these systems the presence of stressors is essential to maintain the structure and function of the system.

Size of aquatic system

The area and volume of an aquatic system and its watershed should be related with its ability to recover or be affected by a stressor. One obvious reason for the importance of size is related with the ability to dilute the potential effects of a stressor through dose/response relationships. This assumes similar doses per unit volume and similar recycling rates among the systems being compared (e.g., recycling of nutrients). In addition, available refugia should increase with the size of the system, while flushing rates would likely decrease with increasing size of the system. Hence, the net effect of size is difficult to judge, except the dilution factor and availability of refugia would likely dwarf the influence of decreased flushing rates in most systems.

Disturbance types

All stressors do not produce the same effects because the observed effects are dependent on the intensity, duration, and frequency of the stressor (Boesch and Rosenberg 1981, Pimm 1984, Harwell et al. 1987). According to classic dose/response relationships, longer recovery times would be a complex function of greater intensities, longer durations, and increased frequencies of the stressor.

Recovery hypotheses - independent of aquatic system

Species life history characteristics

Species have limitations in their abilities to recover from a stressor over time. These limitations include several life history characteristics that can impact recovery rate (Boesch and Rosenberg 1981). The major characteristics are those described below.

- (1) Generation time of the organism - if there are no recolonization areas available from which an organism may repopulate a system, then repopulation can arise from adults, eggs, larvae, or pupae remaining in the system. Increase in recovery time is proportional with longer generation times.
- (2) Fecundity - as for generation time, repopulation can arise from adults or eggs remaining in the system. Increase in recovery time is inversely proportional with fecundity, more fecund species would be expected to have shorter recovery times because of the ability to produce more young. Both generation time and fecundity are related with feedback loops of population

growth that Harrison (1979) has suggested are important in the resilience of communities.

- (3) Dispersal - species or age-specific migratory or dispersal tendencies affect recolonization rates. Better dispersal capabilities lead to shorter recovery periods.
- (4) Habitat specificity - the speed of recovery of an organism can be related with the habitat specificity. For example, a stenoecious species would be expected to have a longer recovery time than a euryecious species that can tolerate a wide variety of environmental conditions. There are at least two premises that support this hypothesis: (a) a euryecious species is more likely to pass through habitat or environmental barriers upon dispersal, and (b) if the habitat of an impacted area is slightly changed from its previous condition, then a euryecious species is more likely to tolerate these changes.
- (5) Aestivating or resistant stages -the ability of a species to metamorphose into a dormant or less vulnerable life stage (e.g. egg or pupa) will enhance its ability to recover from a disturbance. In general, the quicker the ability to change a life stage and the more resistant that life stage, the greater the resilience of that organism.

Interrelationships among hypotheses

Most of the hypotheses presented above are not mutually exclusive and, therefore, one hypothesis may be closely related with another. A clear example was presented with respect to the size of the system or watershed, flushing rates, and availability of refugia.

Considerations for predicting recovery rates

Interpretation of the major hypotheses to explain recovery rates in light of the exhaustive literature review on case studies presented in Part I revealed that it was not possible to test most of these hypotheses because of a lack of suitable data. In general, estimates of productivity, data on food web structure, flushing rates, availability of refugia, or details of the disturbance scenario were not reported. Hence, it is difficult to examine whether any of these potential explanatory variables can predict recover rates in a quantitative fashion. An alternative is to summarize the purported reasons for the recovery of the various case studies, bearing in mind that most systems that have been studied are small lotic systems and these studies have focused on an organismic-based approach to assessments of recovery.

In consideration of these limitations, the most important factors associated with predicting recovery appear to be assessments of the following:

- (1) the habitat conditions following the disturbance
(substantial habitat changes result in long recovery times or lack in recovery);
- (2) determination of the availability of appropriately distributed refugia to supply recolonizing populations;

- (3) whether there is residual toxicity;
- (4) timing of the impact;
- (5) changes in system productivity (e.g., reduced or increased); and
- (6) identification of whether any life history characteristics (e.g., low fecundity, long generation time, lack of aestivating or resistant stages, or poor dispersal capabilities) would prohibit recolonization or repopulation of the affected area.

Disturbances that resulted in habitat changes (e.g., mining, timber harvesting, channelization, and dredging) were clearly associated with the most prolonged recovery periods.

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Part III. Summary of case studies on the recovery of aquatic systems organized by (a) state (b) disturbance type, and (c) taxa.

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Table 1. Characteristics of lentic systems by state, province or country.
(foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed area (ha)		Retention time (hrs)	Hydrol. class.	Mean depth (m)		Conduc- tivity (µmhos/cm)	Ave tot phosph. (ppm)	Land use characteristics		
					(ha)	(ha)			(m)	(m)			Ag.	Forest	Grass
ALABAMA															
52	Auburn Ponds, AL	32,30N	85,35W	216	0	5.88	9999.0	1	1.5			100	0	0	0
CALIFORNIA															
6	North Silver Lake, CA	34,20N	117,15W	828		75.00		1	5.0			0	0	0	100
7	South Silver Lake, CA	34,20N	117,15W	828		55.00		1	5.0			0	0	0	100
8	Village Grove Lake, CA	33,50N	117,50W	250		4.00		1	1.3			0	0	0	100
9	Village Grove Lake, CA	33,50N	117,50W	250		4.00		1	1.3			0	0	0	100
48	Bakersfield Ponds, CA	35,05N	119,00W	116		.01	9999.0	1	.2		800.0				
49	Bakersfield Ponds, CA	35,05N	119,00W	116		.01	9999.0	1	.2		800.0				
166	South Silver Lake, CA	34,20N	117,15W	828		55.00		1	5.0			0	0	0	100
167	South Silver Lake, CA	34,20N	117,15W	828		55.00		1	5.0			0	0	0	100
168	South Silver Lake, CA	34,20N	117,15W	828		55.00		1	5.0			0	0	0	100
169	South Silver Lake, CA	34,20N	117,15W	828		55.00		1	5.0			0	0	0	100
COLORADO															
4	Reservoir #4, CO	40,40N	105,00W	1594		24.30		5	14.0	3.1					
FLORIDA															
30	Florida Ponds, FL	30,20N	87,09W	2	100	.15		1	.4	1.0	.9	0	0	0	0
33	Lake Thonotosassa, FL	28,00N	82,10W	13	15500	300.00	.2	3	3.5	4.9		.69	157.5	100	0
34	Lake Thonotosassa, FL	28,00N	82,10W	13	15500	300.00	.2	3	3.5	4.9		.69	157.5	100	0
35	Lake Thonotosassa, FL	28,00N	82,10W	13	15500	300.00	.2	3	3.5	4.9		.69	157.5	100	0
47	Florida Mesocosms	28,00N	81,55W	37		.00		1	.9	.9					
51	Florida Mesocosms	28,00N	81,55W	37		.00		1	.9	.9					

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
2 - Average total phosphorus
3 - Total dissolved solids

(continued) Table 1. Characteristics of lentic systems by state, province or country.
(Porelga sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)		Retention time (yrs)	1 Mean depth (m)	2 Max. depth (m)	Mean Secchi depth (m)	Conduc- tivity (µmhos/cm)	2 Ave tot phosph. (ppm)		3 Land use characteristics		
					(ha)	(ha)								YDS	Agr.	Forest
								class.	(a)	(a)		mg P/L	(ppm)	X	X	X
MAINE																
191	Kale Pond, ME	45.0N	70.50W	465	2560	68.80	.1	3	2.4	7.0	3.0	74.0	.01	0	98	0
205	Kaline Ponds, ME	46.00N	70.00W	330	1.50						60.0			0	100	0
MASSACHUSETTS																
32	Hill Pond Reservoir, MA	42.30N	71.10W					5								
MISSISSIPPI																
29	Grenada Reservoir, MS	33.48N	89.46W	64	341900	12073.00		5	14.7	20.9						
MISSOURI																
111	Experimental Ponds, MO	39.00N	92.30W	231	0	.08	9999.0	1	1.0	2.0						
NEW YORK																
3	Catenovia Lake, NY	42.50N	75.50W	185	35500	466.20		3				.01		57	11	8
NORTH CAROLINA																
46	Kitty Hawk Bay, NC	36.10N	75.40W	0	40000.00			3	1.6	2.5	.8	.03		0	0	20
OKLAHOMA																
173	Franklin Pond, OK	34.10N	97.10W	240	.85			1								
WASHINGTON																
12	Fern Lake, WA	45.00N	121.00W		8.59			3	7.6			26.0				
WISCONSIN																
13	Spruce Lake, WI	46.05N	89.35W	507	39	6.07		2	4.9	2.6	16.0	.05		1	99	0
188	Bartlaub Lake, WI	44.0N	87.40W	210	259	15.20	2.0	4	6.7	18.0	344.0			50	50	0
ALBERTA																

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
2 - Average total phosphorus
3 - Total dissolved solids

(continued) Table 1. Characteristics of lentic systems by state, province or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed area		Retention time (yrs)	1 Mean Max. depth (m)		Mean Secchi depth (m)	Conductivity (µmhos/cm)	Ave tot phosph. (ppm)	3 Land use characteristics			
					(ha)	(ha)		Hydrol. class.	(m)				(m)	agr.	Forest	Urban
ALBERTA																
10	Patricia Lake, Alberta	52.54N	118.05W	1180	235	69.00	3	13.0	42.0	601.0	.01					
11	Celestine Lake, Alberta	53.11N	118.02W	1220		69.00	1	4.0	12.0	5.5		.00	137.8	0	100	0
NEW BRUNSWICK																
5	Potter's Lake, N.B.	47.30N	69.00W				4									
31	Cree Lake, N.B.	45.14N	67.01W		160		3				.01					
SCOTLAND																
200	Loch Kinardochy, Scotland	57.00N	5.00W	360		16.60	1	2.7	9.2							
USSR																
50	Iler Ponds, USSR	50.40N	31.00E	0		.15	1									
WALES																
2	Barry Reservoir, Wales	51.40N	3.50W		10		20.0	1								

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
2 - Average total phosphorus
3 - Total dissolved solids

Table 2. Characteristics of lentic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Surface area (ha)	Retention time (yrs)	1		Mean Secchi depth (m)	Conductivity (µmhos/cm)	Ave tot phosph. (ppm)	2			3		
								Hydro. class.	depth (m)				Land use	agr.	forest	grass	urban	
Chemical, metals																		
52	Auburn Ponds, AL	32.30N	85.35W	216	0	5.80	9999.0	1	1.5				100	0	0	0		
3	Cazenovia Lake, NY	42.50N	75.50W	185	35500	466.20		3				.01	57	11	8	24		
32	Hill Pond Reservoir, MA	42.30N	71.10W					5										
Chemical, other																		
48	Bakersfield Ponds, CA	35.05N	119.00W	116		.01	9999.0	1	.2	.2	800.0							
49	Bakersfield Ponds, CA	35.05N	119.00W	116		.01	9999.0	1	.2	.2	800.0							
2	Barry Reservoir, Wales	51.40N	3.50W		10		20.0	1										
111	Experimental Ponds, MO	39.00N	92.30W	231	0	.08	9999.0	1	1.0	2.0								
47	Florida Mesocosms	28.00N	81.55W	37		.00		1	.9	.9								
51	Florida Mesocosms	28.00N	81.55W	37		.00		1	.9	.9								
30	Florida Ponds, FL	30.20N	87.09W	2	100	.15		1	.4	1.0	.9		0	0	0	0		
188	Hartlaub Lake, WI	44.0N	87.40W	210	259	15.20	2.0	4	6.7	18.0	344.0		50	50	0	0		
50	Kier Ponds, USSR	50.40N	31.00E	0		.15		1										
46	Kitty Hawk Bay, NC	36.10N	75.40W	0	40000.00			3	1.6	2.5	.8	.03	0	0	20	80		
205	Maine Ponds, ME	46.00N	70.00W	330		1.50					60.0		0	100	0	0		
6	North Silver Lake, CA	34.20N	117.15W	828		75.00		1	5.0				0	0	0	100		
4	Reservoir #4, CO	40.40N	105.00W	1594		24.30		5		14.0	3.1		0	0	0	100		
7	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0				0	0	0	100		
166	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0				0	0	0	100		
167	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0				0	0	0	100		
168	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0				0	0	0	100		
169	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0				0	0	0	100		
13	Spruce Lake, WI	46.05N	89.35W	507	39	6.07		2		4.9	2.6	.05	1	99	0	0		
8	Village Grove Lake, CA	33.50N	117.50W	250		4.00		1	1.3				0	0	0	100		
9	Village Grove Lake, CA	33.50N	117.50W	250		4.00		1	1.3				0	0	0	100		

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments

2 - Average total phosphorus

3 - Total dissolved solids

(continued) Table 2. Characteristics of lentic systems by stressor.

Case no.	System	Latitude	Longitude	Size of Surface		Retention time (yrs)	Hydrol. class.	1 Mean Max. depth (m)	2 Mean Secchi depth (m)	Conduc- tivity (µmhos/cm)	Ave tot phosph. (ppm)	3 Land use characteristics		
				Elevation (m)	Watershed area (ha)							TDS	Agr.	Forest
												X	X	X
Chemical, rotenone														
11	Celestine Lake, Alberta	53.11N	118.02W	1220	69.00		1	4.0	12.0	5.5	.00	137.8	0	100
12	Pera Lake, WA	45.00N	121.00W		8.59		3		7.6			26.0		
173	Frashila Pond, OK	34.10N	97.10W	240	.85		1							
200	Loch Kinardochy, Scotland	57.00N	5.00W	360	16.60		1	2.7	9.2					
10	Patricia Lake, Alberta	52.54N	118.05W	1180	59.00		3	13.0	42.0	601.0	.01			
5	Potter's Lake, N.B.	47.30N	69.00W				4							
Dredging														
33	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9	.69	157.5	100	0
34	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9	.69	157.5	100	0
35	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9	.69	157.5	100	0
Multiple disturbances														
191	Bailey Pond, ME	45.0N	70.50W	465	2560	68.80	.1	3	2.4	7.0	3.0	74.0	0	98
Nutrient addition														
31	Creecy Lake, N.B.	45.14N	67.01W	160			3				.01			
Oxygen stress														
29	Grenada Reservoir, MS	33.48N	89.46W	64	341900	12073.00		5	14.7	20.9				

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
 2 - Average total phosphorus
 3 - Total dissolved solids

Table 3. Characteristics of leatic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed		Retention time (yrs)	Hydrocl. class.	1 Mean depth (m)	2 Max. depth (m)	Mean Secchi depth (m)	Conduc- tivity (µmhos/cm)	Are tot phosph. P/L (ppm)			Land use characteristics		
					(ha)	(ha)							Y	X	Y	Y	X	X
2	Barry Reservoir, Wales	51.40N	3.50W	185	10	466.20	20.0	1										
3	Cazenovia Lake, NY	42.50N	75.50W	1594	35500	24.30		3					.01		57	11	8	24
4	Reservoir #4, CO	40.40N	105.00W					5	14.0	3.1								
5	Potter's Lake, N.B.	47.30N	69.00W					4										
6	North Silver Lake, CA	34.20N	117.15W	828		75.00		1	5.0						0	0	0	100
7	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0						0	0	0	100
8	Village Grove Lake, CA	33.50N	117.50W	250		4.00		1	1.3						0	0	0	100
9	Village Grove Lake, CA	33.50N	117.50W	250		4.00		1	1.3						0	0	0	100
10	Patricia Lake, Alberta	52.54N	118.05W	1180	235	69.00		3	13.0	42.0	601.0		.01					
11	Celestine Lake, Alberta	53.11N	118.02W	1220		69.00		1	4.0	12.0	5.5		.00	137.8	0	100	0	0
12	Fern Lake, WA	45.00N	121.00W			8.59		3		7.6				26.0				
13	Spruce Lake, WI	46.05N	89.35W	507	39	6.07		2		4.9	2.6	16.0	.05		1	99	0	0
29	Grenada Reservoir, MS	33.48N	89.46W	64	341900	12073.00		5	14.7	20.9								
30	Florida Ponds, FL	30.20N	87.09W	2	100	.15		1	.4	1.0	1.0	.9			0	0	0	0
31	Cree Lake, N.B.	45.14N	67.01W		160			3					.01					
32	Hill Pond Reservoir, MA	42.30N	71.10W					5										
33	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9			.69	157.5	100	0	0	0
34	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9			.69	157.5	100	0	0	0
35	Lake Thonotosassa, FL	28.00N	82.10W	13	15500	300.00	.2	3	3.5	4.9			.69	157.5	100	0	0	0
46	Litty Bank Bay, NC	36.10N	75.40W	0		40000.00		3	1.6	2.5	.8		.03		0	0	20	80
47	Florida Mesocosms	28.00N	81.55W	37		.00		1	.9	.9								
48	Battersfield Ponds, CA	35.05N	119.00W	116		.01	9999.0	1	.2	.2	800.0							
49	Battersfield Ponds, CA	35.05N	119.00W	116		.01	9999.0	1	.2	.2	800.0							
50	Kiev Ponds, USSR	50.40N	31.00E	0		.15		1										
51	Florida Mesocosms	28.00N	81.55W	37		.00		1	.9	.9								
52	Auburn Ponds, AL	32.30N	85.35W	216	0	5.80	9999.0	1	1.5						100	0	0	0
111	Experimental Ponds, MO	39.00N	92.30W	231	0	.08	9999.0	1	1.0	2.0								
166	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0						0	0	0	100
167	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0						0	0	0	100
168	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0						0	0	0	100
169	South Silver Lake, CA	34.20N	117.15W	828		55.00		1	5.0						0	0	0	100
173	Franklin Pond, OK	34.10N	97.10W	240		.85		1										
188	Hartlaub Lake, WI	44.0N	87.40W	210	259	15.20	2.0	4	6.7	18.0	344.0				50	50	0	0

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
 2 - Average total phosphorus
 3 - Total dissolved solids

(continued) Table 3. Characteristics of lentic systems by case number.

Case no.	System	Latitude	Longitude	Size of watershed		Retention time (yrs)	1 Mean		Mean Secchi depth (m)	Conductivity (µmhos/cm)	Ave total phosph. (mg P/L)		3 Land use characteristics			
				(ha)	(ha)		Hydrol. class.	(m)			(m)	TDS (ppm)	Agr.	Forest	Grass	Urban
191	Haley Pond, ME	45,0N	70,50W	465	2560	.1	3	2.4	7.0	3.0	74.0	.01	0	98	0	2
200	Loch Kinnadochy, Scotland	57,00N	5,00W	360	16.60		1	2.7	9.2							
205	Maine Ponds, ME	46,00N	70,00W	330	1.50						60.0		0	100	0	0

1 - 1. No permanent inlets or outlets 2. Intermittent outlet only 3. Permanent inlet and outlet 4. Permanent outlet and no inlet 5. Impoundments
 2 - Average total phosphorus
 3 - Total dissolved solids

Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/ P/L			Land use characteristics		
											mg/ P/L	%	%	Agri.	Forest	Grass
ALASKA																
40	Big Kitoi Creek, AK	58,10N	153,00W	8		1	1,340	.40 -	4.30	2.30	.25		0	100	0	0
64	Harris River, AK	55,30N	132,30W	4	8300	4	25,160	.62 -	51.00	.30	.67		0	100	0	0
65	Twelve Mile Creek, AK	55,30N	132,30W	4	3600	3	8,300	.34 -	17.00	.12	.67		0	100	0	0
189	Happy Valley Creek, AK	69,09N	148,50W	290	8940	3	.300	0.00 -	39.00	.73		.100	0	20	75	5
ARIZONA																
19	Tule Creek, AZ	34,21N	112,16W	913	2900	1		-		3.64						
25	Sycamore Creek, AZ	33,45N	111,30W	1295	50500	3	.300	1.00 -	7.00	3.66						
ARKANSAS																
38	Mud Creek, AR	36,00N	94,10W	360	650	3		-		1.55						
199	Piney Creek, AR	36,10N	92,03W	190	45000	6		-		.35						
CALIFORNIA																
21	Robinson Creek, CA	39,05N	123,15W	2134	3000	3	1,560	0.00 -	12.60	3.60			50	50	0	0
133	Rush Creek, CA	41,30N	120,30W	1652	9046	2	2,970	.20 -		4.31			95	5	0	0
162	Convict Creek, CA	37,30N	118,50W	2227	5000	2		-		5.50						
198	Butte Creek, CA	40,20N	121,10W	1950	15900	2		.07 -	12.00	1.50	2.50		0	100	0	0
COLORADO																
195	Joe Wright Creek, CO	40,40N	105,50W	2883	9580	2	.800	.08 -	1.40	3.00			0	73	27	0
GEORGIA																
105	Grant Mem. For., MS 14, GA	33,20N	83,30W		33	1		-								
119	Brasstown Bald Stream, GA	34,53N	83,57W	2300	136	1	8,520	-		22.70			0	80	20	0

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave lot phosph. mg/ P/L	Land use characteristics			
												Agri.	Forest	Grass	Urban
												%	%	%	%
IDAHO															
137	Teton River, ID	43,50N	112,00W	1193		5		-				.15			
ILLINOIS															
43	Smiths Branch, IL	40,00N	88,00W	195	5200	3		-				.12			
128	Whitley Creek, IL	39,30N	88,30W	183	13750	3		-				.03			
180	Sugar Creek, IL	40,40N	87,50W	195	10000	3	9.600	.18 - 152.00				.09			
KENTUCKY															
41	Whippoorwill Creek, KY	36,40N	87,15W	163		3		-				.03			5
42	North Fork River, KY	38,30N	83,40W	253		3	153.900	-				.11			
LOUISIANA															
37	Talisheet Creek, LA	30,30N	89,55W	18	4356	3	.173	-				.01			
176	Lawrence Creek, LA	30,50N	90,10W	245		5	.405	-				.65			
177	Bayou Laconbe I, LA	30,30N	90,05W	10		2	.178	-				.06			
178	Bayou Laconbe II, LA	30,15N	89,50W	2		3	.252	-				.02			
179	Warner Creek, LA	30,40N	90,10W	57	2533	4	.040	-				.36			
MAINE															
87	Saleon Brook, ME	46,48N	68,10W	198	5900	4		-				.85			
88	Gardner Brook, ME	46,48N	68,17W	197	3782	3		-				.83			
89	Armstrong Brook, ME	47,05N	68,11W	232	2725	3		-				1.04			
90	Little Armstrong Brook, ME	47,05N	68,08W	197	1200	1		-				.69			
91	Mud Brook, ME	47,07N	68,07W	206	3472	2		-				.57			
92	Alexander Brook, ME	46,55N	68,15W	220	2710	2		-				.91			
97	Alexander Brook Tributary, ME	46,55N	68,15W	230	830	1		-				1.24			
98	Halfway Brook, ME	47,03N	68,04W	215	8400	4		-				.69			
99	Little Goodard Brook, ME	46,58N	68,21W	203	4017	2		-				.37			

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle %	Pool: ratio	1					
											Ave tot phosph. mg/ P/L	Land use characteristics	Agri.	Forest	Grass	Urban
MAINE																
100	Caniba Brook, ME	47,09N	68,03W	218	1500	2	-	-	2.00							
101	Picard Brook, ME	47,02N	68,02W	238	1430	2	-	-	1.24							
206	Northern Maine Streams, ME	46,30N	69,00W	350		2	-	-				0	100	0	0	0
207	Northern Maine Streams, ME	46,40N	68,40W	350	770	3	-	-				0	100	0	0	0
208	Northern Maine Streams, ME	46,40N	68,40W	350	690	3	-	-				0	100	0	0	0
209	Northern Maine Streams, ME	46,40N	68,40W	350	690	3	-	-				0	100	0	0	0
MICHIGAN																
61	Iron River, MI	46,40N	87,30W	186	6700	3	2.100	1.70 - 3.70	.17			0	85	5	10	
62	Gongeau Creek, MI	46,20N	86,40W	220	1150	2	-	-	1.05							
63	Sturgeon River, MI	46,00N	86,50W	197	189000	4	5.700	1.30 - 32.80	.35			0	90	10	0	
MINNESOTA																
68	Valley Creek, MN	44,55N	92,50W	226	2660	3	.140	-	.59							
74	Valley Creek, MN	44,55N	92,50W	226	2660	3	.140	-	.59							
75	Valley Creek, MN	44,55N	92,50W	226	2660	3	.140	-	.59							
MISSISSIPPI																
58	Luxapallila River, MS	33,37N	88,00W	105	207717	4	5.100	.65 - 280.00	.08							
MISSOURI																
117	Saline Creek, MO	37,34N	90,15W	195	3600	3	-	-	.66					0	100	0
118	Logan Creek, MO	37,12N	90,54W	317	7512	4	-	-	.28					47	5	47
197	Chariton River, MO	40,15N	92,45W	240	47140	3	.420	.28 - 710.00	.04					15	45	39
201	Big River, MO	38,00N	90,30W	153	186000	5	19.300	7.40 - 989.00	.09	6.00	.160					
203	Hill Creek, MO	38,00N	90,30W	274		2	< .100	0.00 - 3.00	.51	2.00	.030	10	60	30	0	

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle ratio	Ave tot phosph. Agri. Forest Grass Urban				
										mg P/L	mg P/L	mg P/L	mg P/L	
MONTANA														
80	Hellroaring Creek, MT	45,05N	110,45W	2239	41700	2		-	2.55					
81	Tower Creek, MT	45,05N	110,45W			2		-						
84	Silver Bow Creek, MT	46,00N	112,45W	1770		4	.950	.51 - 1.67	.50					
126	St. Regis River, MT	47,20N	115,30W	1256	78500	4	15,900	-	1.43	.850	95	0	0	5
127	St. Regis River, MT	47,20N	115,30W	1256	78500	4	15,900	-	1.43					
174	Sheep Creek, MT	44,46N	110,49W	1780	14100	4	1,100	.19 - 7.90						
175	Mussellshell River, MT	44,45N	110,30W					-		.280				
181	Trapper Creek, MT	45,20N	113,30W	2190	11160	4	.420	.14 - 1.13	4.70					
182	Canyon Creek, MT	45,20N	113,30W	2127	12800	4	.710	.17 - 2.26	3.56					
185	Ruby River, MT	45,20N	112,05W	2180	139300	5	4,500	.19 - 34.80	1.45					
186	Trail Creek, MT	45,30N	110,30W	1600	18500	3	.850	.17 - 20.10	.60					
NEW HAMPSHIRE														
78	Wht. Mt. Nat'l For. Streams, NH	44,00N	71,30W	450	20	2		-	4.00		0	100	0	0
79	Wht. Mt. Nat'l For. Streams, NH	44,00N	71,30W	450	50	2		-	4.00		0	100	0	0
194	Hubbard Brook Watershed #2, NH	43,50N	71,40W	450	16	1		0.00 -	.10 25.00	.010	0	100	0	0
NEW MEXICO														
125	Tesuque Creek, NM	36,20N	105,10W	2990	4256	2	.039	-	21.10		0	100	0	0
NEW YORK														
190	Ten Mile River, NY	41,30N	75,00W	290	11700	4	1,770	.12 - 23.00	.74					
NORTH CAROLINA														
66	Coveeta Watersheds, NC	35,03N	83,25W		30	1		-		.002				
67	Coveeta Watershed 7, NC	35,03N	83,25W	909	59	2	.018	.02 - 1.92		.002				
70	Coveeta Watershed 10, NC	35,03N	83,25W	940	760	4		.02 - 2.32	4.24	.002				
144	Coveeta Watershed 53, NC	35,03N	83,25W	829	5	1		-	27.00					

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. ag/P/L	Land use characteristics			
												Agri.	Forest	Grass	Urban
												%	%	%	%
NORTH CAROLINA															
148	Coveeta Watershed 28, NC	35,03N	83,25W	1200	144	1		.02 - 4.47	52.00						
149	Coveeta Watershed 37, NC	35,03N	83,25W	1314	44	1		.01 - 12.70	71.00						
150	Coveeta Watershed 13, NC	35,03N	83,25W	819	16	1	.005	.01 - 2.49	49.00						
172	North Carolina Stream, NC	35,30N	77, 0W	0				0.00 - 1.40							
193	Coveeta Watershed 6	35,03N	83,25W	800	9	2	3,340	.90 - 67.80	.24			0			0
OHIO															
44	Little Auglaize River, OH	41,00N	84,20W	235	105700	3	2,040	.10 - 4.54	.04		.110	100	0	0	0
132	Olentangy River, OH	40,10N	83,00W	280	139000	4	13,000	.72 - 31.93	.10		.200	30	7	7	55
184	Olentangy River, OH	40,10N	83,00W	280	139000	4	13,000	.72 - 31.93	.10						
OREGON															
26	Deer Creek, OR	44,30N	124,00W	204	303	3	1,440	.17 - 5.77	1.80			0	100	0	0
27	Needle Branch, OR	44,30N	124,00W	174	71	2	.368	.05 - 1.27	1.40						
204	H.J.Andrews Exp For Streams,OR	44,08N	122,20W	560	600	2		.02 - .	5.00			0	100	0	0
PENNSYLVANIA															
95	Burns Run, PA	41,00N	77,15W	431	2088	2	.150	.03 - .22	5.40	.67			100		
122	Choke Creek, PA	41,10N	75,45W	512	1930	2		-	.90			0	90	0	10
152	Roaring Run, PA	40,28N	78,40W	580		2		-	1.68						
160	Bear Creek, PA	41,10N	75,40W	510	12600	3	.500	-	.80						
170	New Stream (Ridley Creek), PA	40,00N	75,10W	110	21260	3		-	.37		.018				
SOUTH CAROLINA															
171	Broad River, SC	35,00N	81,40W	165	400000	4	70,000	90.00 - 252.00	.10						

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient riffle %	Pool: ratio	Ave tot phosph. mg/ P/L			Land use characteristics		
											Agri.	Forest	Grass	Urban	Agri.	Forest
SOUTH DAKOTA																
109	Grace Coolidge Creek, SD	43,45N	103,10W	1217	12300	4	.053	0.00 - 1.30	1.52							
TENNESSEE																
69	New River Drainage, TN	36,30N	83,55W	333	98900		18.000	.23 - 450.00	14.00			0	95	0	5	
93	Pine Creek, TN	35,55N	85,45W	280	7290	2		.18 - .50	.61							
TEXAS																
39	San Marcos River, TX	30,00N	98,30W	107	150	1	4.840	-	.93							
83	Oil Creek, TX	30,34N	94,20W	32	300	2	1.000	0.00 - 5.00	.08		.140	0	100	0	0	0
UTAH																
151	Weber River, UT	40,45N	111,10W	2465	113000	4	6.500	1.50 - 30.00	2.19							
192	South Willow Creek, UT	40,25N	112,30W	1827	5200	2	.085	.07 - .74	4.70	.06	.080	0	100	0	0	0
VIRGINIA																
24	Hill Creek, VA	37,16N	80,22W	637	1017	3		-	3.60							
107	Experimental streams, VA	37,25N	80,50W			1	.001	-								
WEST VIRGINIA																
120	Back Creek, WV	39,25N	78,00W	198		4	.590	-	.04							
196	Fenrow Exp Forest WS NJ, WV	39,00N	79,40W	504	34	1		-	25.00		.050	0	100	0	0	0
WISCONSIN																
60	Three Mile Creek, WI	44,35N	87,30W	186	1084	2		-	.13			70	30	0	0	0
124	Seas Branch Creek, WI sec. 2	43,30N	90,40W	244	3603	3	.200	-	.95		.330	79	21	0	0	0
139	Lawrence Creek, WI	43,40N	89,30W	282	1660	2	.450	-	.28			30	70	0	0	0
187	Seas Branch Creek, WI sec. 1	43,30N	90,40W	244	3603	3	.170	-	.95		.330	79	21	0	0	0

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient %	Pool: riffle ratio	Land use characteristics				
											Ave lot phosph. mg/P/L	Agri.	Forest	Grass Urban	
WYOMING															
14	Green R., Section 2, WY	42,40N	109,58W	2105	520000	3		2.00 - 87.70	.24						
15	Green R., Section 3, WY	42,07N	110,11W	1990	1200000	4	39,700	5.36 - 223.60	.16						
16	Green R., Section 4, WY	41,31N	109,27W	1810	3910000	5	7,800	5.36 - 263.20	.09						
17	New Fort River, WY	42,34N	109,56W		319000	4		.85 - 141.50	.15						
18	Mushroom Spring, WY	44,20N	111,00W	2500	0	1		-							
22	Tongue River, WY	45,00N	107,00W	1122	380000	5	15,000	2.30 - 115.00	.19						
104	Serendipity Springs, WY	44,30N	110,45W		0	1		-						.170	
BRITISH COLUMBIA															
110	Archibald Creek, B.C.	49,11N	117,26W	2320	3271	3		-							
ENGLAND															
96	East Stote Mill Stream, Engl.	50,45N	2,10W					-						.123	
134	River Cray, England	51,30N	0,00					-							
202	River Hull, England	54,00N	2,00W	40		4	5,000	1.00 - 11.00	.20				85	0	15
FRANCE															
135	Rhone River, France	46,00N	5,30E					-							
JAPAN															
115	Nachikoshi River, Japan	35,00N	139,00E					-							
NEW BRUNSWICK															
54	Miranichi River, N.B.	47,00N	66,00W			4		-							
55	Restigouche River, N.B.	47,30N	67,40W			4		-							
56	Tobique River, N.B.	47,00N	67,20W			4		-							
57	Jacquet River, N.B.	47,45N	66,00W			4		-							
85	Trout Brook, N.B.	47,00N	66,00W			2		-							

1 - Average total phosphorus

(continued) Table 4. Characteristics of lotic systems by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/P/L		Land use characteristics			
											Agri.	Forest	Grass	Urban		
NEW BRUNSWICK																
86	Miramichi River, N.B.	47,00N	66,00W			3		-								
114	Middle Brook, N.B.	46,22N	66,53W			2		-								
NEW ZEALAND																
1116	Makotuku River, New Zealand	39,15S	175,00E			2		-								
NIGERIA																
108	Ikpoba River, Nigeria	6,30N	5,50E			4		-								
ONTARIO																
106	Ransom Lake subbasins, Ontario	49,40N	93,44W		170	2		-								
154	Mud Creek, ON	43,08N	80,54W			3		-								
SCOTLAND																
102	Loch ard Forest, Scotland	56,00N	4,00W		56	2		-								
WALES																
136	Afon Hirnant, North Wales	53,00N	3,30W			2		-								
ZIMBABWE																
82	Munwaku Stream, Zimbabwe	17,32S	31,09E			1		-								
155	Elpidha Stream, Zimbabwe	17,00S	31,00E	1364		3		-								
156	Munwaku Stream, Zimbabwe	17,32S	31,09E	1434		1		-								
157	Avilin Fara Stream, Zimbabwe	17,30S	31,25E			1		-								

1 - Average total phosphorus

Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle ratio	Pool: Ave tot phosph. mg/ P/L	Land use characteristics			
											Agri.	Forest	Grass	Urban
											%	%	%	%
Channelization														
133	Rush Creek, CA	41,30N	120,30W	1652	9046	2	2.970	.20 -	4.31		95	5	0	0
58	Luxapalila River, MS	33,37N	88,00W	105	207717	4	5.100	.65 - 280.00	.08					
197	Chariton River, MO	40,15N	92,45W	240	47140	3	.420	.28 - 710.00	.04	.160	47	5	47	1
126	St. Regis River, NT	47,20N	115,30W	1256	78500	4	15.900	-	1.43					
172	North Carolina Stream, NC	35,30N	77, 0W	0				0.00 - 1.40						
132	Oientangy River, OH	40,10N	83,00W	280	139000	4	13.000	.72 - 31.93	.10	.200	30	7	7	55
154	Mud Creek, ON	43,08N	80,54W			3	-	-						
Chemical, DDT														
119	Brasstown Bald Stream, GA	34,53N	83,57W	2300	136	1	8.520	-	22.70		0	80	20	0
87	Salmon Brook, ME	46,48N	68,10W	198	5900	4		-	.85					
88	Gardner Brook, ME	46,48N	68,17W	197	3782	3		-	.83					
89	Armstrong Brook, ME	47,05N	68,11W	232	2725	3		-	1.04					
90	Little Armstrong Brook, ME	47,05N	68,08W	197	1200	1		-	.69					
91	Mud Brook, ME	47,07N	68,07W	206	3472	2		-	.57		0	100	0	0
92	Alexander Brook, ME	46,55N	68,15W	220	2710	2		-	.91					
97	Alexander Brook Tributary, ME	46,55N	68,15W	230	830	1		-	1.24					
98	Halfway Brook, ME	47,03N	68,04W	215	8400	4		-	.69					
99	Little Goodard Brook, ME	46,58N	68,21W	203	4017	2		-	.37					
100	Caniba Brook, ME	47,09N	68,03W	218	1500	2		-	2.00					
101	Picard Brook, ME	47,02N	68,02W	238	1430	2		-	1.24					
80	Hellroaring Creek, NT	45,05N	110,45W	2239	41700	2		-	2.55					
81	Tower Creek, NT	45,05N	110,45W			2		-						
174	Sheep Creek, NT	44,46N	110,49W	1780	14100	4	1.100	.19 - 7.90		.280				
175	Mussellsheil River, NT	44,45N	110,30W					-						
181	Trapper Creek, NT	45,20N	113,30W	2190	11160	4	.420	.14 - 1.13	4.70					
182	Canyon Creek, NT	45,20N	113,30W	2127	12800	4	.710	.17 - 2.26	3.56					

1 - Average total phosphorus

(continued) Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle %	Pool: ratio	Ave tot phosph. Agri. Forest Grass Urban				
											mg/ P/L	%	%	%	
Chemical, DDT															
185	Ruby River, MT	45,20N	112,05W	2180	139300	5	4.500	.19 -	34.80	1.45					
186	Trail Creek, MT	45,30N	110,30W	1600	18500	3	.850	.17 -	20.10	.60					
54	Miramichi River, N.B.	47,00N	66,00W			4		-							
55	Restigouche River, N.B.	47,30N	67,40W			4		-							
56	Tobique River, N.B.	47,00N	67,20W			4		-							
57	Jacquet River, N.B.	47,45N	66,00W			4		-							
85	Trout Brook, N.B.	47,00N	66,00W			2		-							
86	Miramichi River, N.B.	47,00N	66,00W			3		-							
122	Choke Creek, PA	41,10N	75,45W	512	1930	2		-		.90		0	90	0	10
160	Bear Creek, PA	41,10N	75,40W	510	12600	3	.500	-		.80					
120	Back Creek, WV	39,25N	78,00W	198		4	.590	-		.04					
Chemical, acid															
24	Mill Creek, VA	37,16N	80,22W	637	1017	3		-		3.60					
Chemical, alkaline															
134	River Cray, England	51,30N	0,00					-							
Chemical, metals															
107	Experimental streams, VA	37,25N	80,50W			1	.001	-							
Chemical, other															
40	Big Kitoi Creek, AK	58,10N	153,00W	8		1	1.340	.40 -	4.30	2.30	.25	0	100	0	0
189	Happy Valley Creek, AK	69,09N	148,50W	290	8940	3	.300	0.00 -	39.00	.73	.100	0	20	75	5
38	Mud Creek, AR	36,00N	94,10W	360	650	3		-		1.55					
180	Sugar Creek, IL	40,40N	87,50W	195	10000	3	9.600	.18 -	152.00	.09					
206	Northern Maine Streams, ME	46,30N	69,00W	350		2		-				0	100	0	0
207	Northern Maine Streams, ME	46,40N	68,40W	350	770	3		-				0	100	0	0

1 - Average total phosphorus

(continued) Table 3. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/ P/L	Land use characteristics			
												Agri.	Forest	Grass	Urban
												%	%	%	%
Chemical, other															
208	Northern Maine Streams, ME	46,40N	68,40W	350	690	3	-	-	-	-	-	0	100	0	0
209	Northern Maine Streams, ME	46,40N	68,40W	350	690	3	-	-	-	-	-	0	100	0	0
61	Iron River, MI	46,40N	87,30W	186	6700	3	2.100	1.70 - 3.70	.17	-	-	0	85	5	10
62	Gongau Creek, MI	46,20N	86,40W	220	1150	2	-	-	1.05	-	-	-	-	-	-
63	Sturgeon River, MI	46,00N	86,50W	197	189000	4	5.700	1.30 - 32.80	.35	-	-	0	90	10	0
114	Middle Brook, N.B.	46,22N	66,53W	-	-	2	-	-	-	-	-	-	-	-	-
116	Makotuku River, New Zealand	39,15S	175,00E	-	-	2	-	-	-	-	-	-	-	-	-
108	Ikpoba River, Nigeria	6,30N	5,50E	-	-	4	-	-	-	-	-	-	-	-	-
144	Coweeta Watershed S3, NC	35,03N	83,25W	829	5	1	-	-	27.00	-	-	-	-	-	-
152	Roaring Run, PA	40,28N	78,40W	580	-	2	-	-	1.68	-	-	-	-	-	-
109	Grace Coolidge Creek, SD	43,45N	103,10W	1217	12300	4	.053	0.00 - 1.30	1.52	-	-	-	-	-	-
83	Oil Creek, TX	30,34N	94,20W	32	300	2	1.000	0.00 - 5.00	.08	-	.140	0	100	0	0
60	Three Mile Creek, WI	44,35N	87,30W	186	1084	2	-	-	.13	-	-	70	30	0	0
124	Seas Branch Creek, WI sec. 2	43,30N	90,40W	244	3603	3	.200	-	.95	-	.330	79	21	0	0
187	Seas Branch Creek, WI sec. 1	43,30N	90,40W	244	3603	3	.170	-	.95	-	.330	79	21	0	0
155	Elpidha Stream, Zimbabwe	17,00S	31,00E	1364	-	3	-	-	-	-	-	-	-	-	-
156	Munwahuku Stream, Zimbabwe	17,32S	31,09E	1434	-	1	-	-	-	-	-	-	-	-	-
157	Avilin Fara Stream, Zimbabwe	17,30S	31,25E	-	-	1	-	-	-	-	-	-	-	-	-
Chemical, rotenone															
21	Robinson Creek, CA	39,05N	123,15W	2134	3000	3	1.560	0.00 - 12.60	3.60	-	-	50	50	0	0
41	Whippoorwill Creek, KY	36,40N	87,15W	163	-	3	-	-	.03	-	-	-	-	-	5
42	North Fork River, KY	38,30N	83,40W	253	-	3	153.900	-	.11	-	-	-	-	-	-
190	Ten Mile River, NY	41,30N	75,00W	290	11700	4	1.770	.12 - 23.00	.74	-	-	-	-	-	-
93	Pine Creek, TN	35,55N	85,45W	280	7290	2	-	.18 - .50	.61	-	-	-	-	-	-
14	Green R., Section 2, NY	42,40N	109,58W	2105	520000	3	-	2.00 - 87.70	.24	-	-	-	-	-	-
15	Green R., Section 3, NY	42,07N	110,11W	1990	1200000	4	39.700	5.36 - 223.60	.16	-	-	-	-	-	-
16	Green R., Section 4, NY	41,31N	109,27W	1810	3910000	5	7.800	5.36 - 263.20	.09	-	-	-	-	-	-

1 - Average total phosphorus

(continued) Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. Agri. Forest				Land use characteristics			
											mg/ P/L	%	%	%	%	%	%	%
Chemical, rotenone																		
17	New Fork River, NY	42,34N	109,56W		319000	4		.85 - 141.50	.15									
Dredging																		
110	Archibald Creek, B.C.	49,11N	117,26W	2320	3271	3		-			.123							
96	East Stoke Mill Stream, Engl.	50,45N	2,10W					-										
202	River Hull, England	54,00N	2,00W	40		4	5.000	1.00 - 11.00	.20									
39	San Marcos River, TX	30,00N	98,30W	107	150	1	4.840	-	.93								15	
Drought																		
162	Convict Creek, CA	37,30N	118,50W	2227	5000	2		-		5.50								
137	Teton River, ID	43,50N	112,00W	1193		5		-		.15								
44	Little Auglaize River, OH	41,00N	84,20W	235	105700	3	2.040	.10 - 4.54	.04		.110	100	0	0	0	0	0	
170	New Stream (Ridley Creek), PA	40,00N	75,10W	110	21260	3		-		.37	.018							
136	Afon Hirnant, North Wales	53,00N	3,30W			2		-										
22	Tonque River, NY	45,00N	107,00W	1122	380000	5	15.000	2.30 - 115.00	.19									
82	Munwahuku Stream, Zimbabwe	17,32S	31,09E			1		-										
Flooding																		
19	Tule Creek, AZ	34,21N	112,16W	913	2900	1		-		3.64								
25	Sycamore Creek, AZ	33,45N	111,30W	1295	50500	3	.300	1.00 - 7.00	3.66									
199	Piney Creek, AR	36,10N	92,03W	190	45000	6		-	.35									
68	Valley Creek, MN	44,55N	92,50W	226	2660	3	.140	-	.59									
125	Tesuque Creek, NM	36,20N	105,10W	2990	4256	2	.039	-	21.10									
95	Burns Run, PA	41,00N	77,15W	431	2088	2	.150	.03 - .22	5.40	.67		0	100	0	0	0	0	
171	Broad River, SC	35,00N	81,40W	165	400000	4	70.000	90.00 - 252.00	.10									
192	South Willow Creek, UT	40,25N	112,30W	1827	5200	2	.085	.07 - .74	4.70	.06	.080	0	100	0	100	0	0	

1 - Average total phosphorus

(continued) Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/ P/L				Land use characteristics			
											%	%	%	%	%	%	%	%
Forest fire																		
106	Rawson Lake subbasins, Ontario	49,40N	93,44W		170	2		-										
204	H.J.Andrews Exp For Streams,OR	44,08N	122,20W	560	600	2		.02 -	5.00		0	100	0	0	0			
Habitat development																		
127	St. Regis River, MT	47,20N	115,30W	1256	78500	4	15.900	-	1.43									
184	Oientangy River, OH	40,10N	83,00W	280	139000	4	13.000	.72 - 31.93	.10									
139	Lawrence Creek, WI	43,40N	89,30W	282	1660	2	.450	-	.53		30	70	0	0	0			
Hailstorm																		
18	Mushroom Spring, WY	44,20N	111,00N	2500	0	1		-										
Lake drawdown																		
128	Whitley Creek, IL	39,30N	88,30W	183	13750	3		-	.03									
Mining activity																		
84	Silver Bow Creek, MT	46,00N	112,45W	1770		4	.950	.51 - 1.67	.50		.850	95	0	0	5			
69	New River Drainage, TN	36,30N	83,55W	333	98900		18.000	.23 - 450.00	14.00		0	95	0	0	5			
Multiple disturbances																		
43	Smiths Branch, IL	40,00N	88,00W	195	5200	3		-	.12									
115	Mochikoshi River, Japan	35,00N	139,00E					-										
151	Weber River, UT	40,45N	111,10W	2465	113000	4	6.500	1.50 - 30.00	2.19									
Nutrient addition																		
102	Loch ard Forest, Scotland	56,00N	4,00W		56	2		-										
Organism removal (non chem)																		
37	Talisheet Creek, LA	30,30N	89,55W	18	4356	3	.173	-	.01									

1 - Average total phosphorus

(continued) Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/ P/L				Land use characteristics			
											Agri.	Forest	Grass	Urban	Agri.	Forest	Grass	Urban
Organism removal (non chem)																		
176	Laurence Creek, LA	30.50N	90.10W	245		5	.405	-	.65									
177	Bayou Laconbe I, LA	30.30N	90.05W	10		2	.178	-	.06									
178	Bayou Laconbe II, LA	30.15N	89.50W	2		3	.252	-	.02									
179	Warner Creek, LA	30.40N	90.10W	57	2533	4	.040	-	.36									
74	Valley Creek, NH	44.55N	92.50W	226	2660	3	.140	-	.59									
75	Valley Creek, NH	44.55N	92.50W	226	2660	3	.140	-	.59									
104	Serendipity Springs, WI	44.30N	110.45W		0	1		-				.170						
Suspended solids																		
198	Butte Creek, CA	40.20N	121.10W	1950	15900	2		.07 -	12.00	1.50	2.50		0	100	0			
195	Joe Wright Creek, CO	40.40N	105.50W	2883	9580	2	.800	.08 -	1.40	3.00			0	73	27			
135	Bhone River, France	46.00N	5.30E					-										
117	Saline Creek, MO	37.34N	90.15W	195	3600	3		-	.66				0	100	0			
118	Logan Creek, MO	37.12N	90.54W	317	7512	4		-	.28					45	39			
201	Big River, MO	38.00N	90.30W	153	186000	5	19.300	7.40 -	989.00	.09	6.00	.030	15	60	30			
203	Hill Creek, MO	38.00N	90.30W	274		2	< .100	0.00 -	3.00	.51	2.00		10					
Timber activity																		
64	Harris River, AK	55.30N	132.30W	4	8300	4	25.160	.62 -	51.00	.30	.67		0	100	0			
65	Twelve Mile Creek, AK	55.30N	132.30W	4	3600	3	8.300	.34 -	17.00	.12	.67		0	100	0			
105	Grant Mtn. For., MS 14, GA	33.20N	83.30W		33	1		-										
78	Wht. Mt. Nat'l For. Streams, NH	44.00N	71.30W	450	20	2		-	4.00				0	100	0			
79	Wht. Mt. Nat'l For. Streams, NH	44.00N	71.30W	450	< 50	2		-	4.00				0	100	0			
194	Hubbard Brook Watershed 12, NH	43.50N	71.40W	450	16	1		0.00 -	.10	25.00		.010	0	100	0			
66	Coveeta Watersheds, NC	35.03N	83.25W		30	1		-				.002						
67	Coveeta Watershed 7, NC	35.03N	83.25W	909	59	2	.018	.02 -	1.92			.002						
70	Coveeta Watershed 10, NC	35.03N	83.25W	940	760	4		.02 -	2.32	4.24		.002						
148	Coveeta Watershed 28, NC	35.03N	83.25W	1200	144	1		.02 -	4.47	52.00								

1 - Average total phosphorus

(continued) Table 5. Characteristics of lotic systems by stressor.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle %	Pool:		Ave tot phosph. mg/ P/L	Land use characteristics			
										ratio	rifle		Agri.	Forest	Grass	Urban
Flabber activity																
149	Coveeta Watershed 37, NC	35,03N	83,25W	1314	44	1		.01 -	12.70	71.00						
150	Coveeta Watershed 13, NC	35,03N	83,25W	819	16	1	.005	.01 -	2.49	49.00						
193	Coveeta Watershed 6	35,03N	83,25W	800	9	2	3.540	.90 -	67.80	.24		0				0
26	Deer Creek, OR	44,30N	124,00W	204	303	3	1.640	.17 -	5.77	1.80		0	100	0	0	0
27	Needle Branch, OR	44,30N	124,00W	174	71	2	.368	.05 -	1.27	1.40						
196	Fenron Exp Forest WS #3, WY	39,00N	79,40W	504	34	1		-		25.00	.050	0	100	0	0	0

1 - Average total phosphorus

Table 6. Characteristics of lotic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle %	Pool: riffle ratio	1 Ave tot phosph. mg/ P/L				Land use characteristics			
											Agri.	Forest	Grass	Urban				
14	Green R., Section 2, NY	42,40N	109,50W	2105	520000	3		2.00 - 87.70	.24									
15	Green R., Section 3, NY	42,07N	110,11W	1990	1200000	4	39.700	5.36 - 223.60	.16									
16	Green R., Section 4, NY	41,31N	109,27W	1810	3910000	5	7.800	5.36 - 263.20	.09									
17	New Fork River, NY	42,34N	109,56W		319000	4		.85 - 141.50	.15									
18	Mushroom Spring, NY	44,20N	111,00W	2500	0	1		-										
19	Tule Creek, AZ	34,21N	112,16W	913	2900	1		-	3.84									
21	Robinson Creek, CA	39,05N	123,15W	2134	3000	3	1.560	0.00 - 12.60	3.60			50	50	0	0			
22	Tongue River, NY	45,00N	107,00W	1122	380000	5	15.000	2.30 - 115.00	.19									
24	Mill Creek, VA	37,16N	80,22W	637	1017	3		-	3.60									
25	Sycamore Creek, AZ	33,45N	111,30W	1295	50500	3	.300	1.00 - 7.00	3.66									
26	Deer Creek, OR	44,30N	124,00W	204	303	3	1.640	.17 - 5.77	1.80			0	100	0	0			
27	Needle Branch, OR	44,30N	124,00W	174	71	2	.368	.05 - 1.27	1.40									
37	Talisheet Creek, LA	30,30N	89,55W	18	4356	3	.173	-	.01									
38	Mud Creek, AR	36,00N	94,10W	360	650	3		-	1.55									
39	San Marcos River, TX	30,00N	98,30W	107	150	1	4.840	-	.93									
40	Big Kitoi Creek, AK	58,10N	153,00W	8		1	1.340	.40 - 4.30	2.30	.25		0	100	0	0			
41	Whippoorwill Creek, KY	36,40N	87,15W	163		3		-	.03									5
42	North Fork River, KY	38,30N	83,40W	253		3	153.900	-	.11									
43	Saiths Branch, IL	40,00N	88,00W	195	5200	3		-	.12									
44	Little Auglaize River, OH	41,00N	84,20W	235	105700	3	2.040	.10 - 4.54	.04		.110	100	0	0	0			
54	Miranichi River, N.B.	47,00N	66,00W			4		-										
55	Restigouche River, N.B.	47,30N	67,40W			4		-										
56	Tobique River, N.B.	47,00N	67,20W			4		-										
57	Jacquet River, N.B.	47,45N	66,00W			4		-										
58	Luxapallia River, MS	33,37N	88,00W	105	207717	4	5.100	.65 - 280.00	.08									
60	Three Mile Creek, MI	44,35N	87,30W	186	1084	2		-	.13		70	30	0	0				
61	Iron River, MI	46,40N	87,30W	186	6700	3	2.100	1.70 - 3.70	.17		0	85	5	10				
62	Gongau Creek, MI	46,20N	86,40W	220	1150	2		-	1.05									
63	Sturgeon River, MI	46,00N	86,50W	197	189000	4	5.700	1.30 - 32.80	.35			0	90	10	0			
64	Harris River, AK	55,30N	132,30W	4	8300	4	25.160	.62 - 51.00	.30	.67		0	100	0	0			

1 - Average total phosphorus

(continued) Table 6. Characteristics of lotic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. mg/P/L				Land use characteristics			
65	Twelve Mile Creek, AK	55.30N	132.30W	4	3600	3	8.300	.34 - 17.00	.12	.67			0	100	0	0		
66	Coneata Watersheds, NC	35.03N	83.25W		30	1					.002							
67	Coneata Watershed 7, NC	35.03N	83.25W	909	59	2	.018	.02 - 1.92			.002							
68	Valley Creek, NH	44.55N	92.50W	226	2660	3	.140		.59									
69	New River Drainage, TN	36.30N	83.55W	333	98900		18.000	.23 - 450.00	14.00				0	95	0	5		
70	Coneata Watershed 10, NC	35.03N	83.25W	940	760	4		.02 - 2.32	4.24		.002							
74	Valley Creek, NH	44.55N	92.50W	226	2660	3	.140		.59									
75	Valley Creek, NH	44.55N	92.50W	226	2660	3	.140		.59									
78	Mt. Mt. Nat'l For. Streams, NH	44.00N	71.30W	450	20	2			4.00				0	100	0	0		
79	Mt. Mt. Nat'l For. Streams, NH	44.00N	71.30W	450	50	2			4.00				0	100	0	0		
80	Hellroaring Creek, NY	45.05N	110.45W	2239	41700	2			2.55									
81	Toner Creek, NY	45.05N	110.45W			2												
82	Munabuku Stream, Zimbabwe	17.32S	31.09E			1												
83	Oil Creek, TX	30.34N	94.20W	32	300	2	1.000	0.00 - 5.00	.08		.140		0	100	0	0		
84	Silver Box Creek, NY	46.00N	112.45W	1770		4	.950	.51 - 1.67	.50		.850		95	0	0	5		
85	Trout Brook, N.B.	47.00N	66.00W			2												
86	Miranichi River, N.B.	47.00N	66.00W			3												
87	Salmon Brook, ME	46.48N	68.10W	198	5900	4			.85									
88	Gardner Brook, ME	46.48N	68.17W	197	3782	3			.83									
89	Arastrong Brook, ME	47.05N	68.11W	232	2725	3			1.04									
90	Little Arastrong Brook, ME	47.05N	68.08W	197	1200	1			.69									
91	Mud Brook, ME	47.07N	68.07W	206	3472	2			.57				0	100	0	0		
92	Alexander Brook, ME	46.55N	68.15W	220	2710	2			.91									
93	Pine Creek, TN	35.55N	85.45W	280	7290	2		.18 - .50	.61									
95	Burns Run, PA	41.00N	77.15W	431	2088	2	.150	.03 - .22	5.40	.67						100		
96	East Stote Hill Stream, Engl.	50.45N	2.10W								.123							
97	Alexander Brook Tributary, ME	46.55N	68.15W	230	830	1			1.24									
98	Halfway Brook, ME	47.03N	68.04W	215	8400	4			.69									
99	Little Goodard Brook, ME	46.58N	68.21W	203	4017	2			.37									
100	Caniba Brook, ME	47.09N	68.03W	218	1500	2			2.00									
101	Picard Brook, ME	47.02N	68.02W	238	1430	2			1.24									

1 - Average total phosphorus

(continued) Table 6. Characteristics of lotic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m3/sec)	Annual range in discharge (m3/sec)	Gradient riffle %	Pool: ratio	Ave tot phosph. ¹		Land use characteristics			
											mg/ P/L	Agri.	Forest	Grass	Urban	
102	Loch ard Forest, Scotland	56,00N	4,00W		56	2		-								
104	Serendipity Springs, NY	44,30N	110,45W		0	1		-		.170						
105	Grant Res. For., MS 14, GA	33,20N	83,30W		33	1		-								
106	Rauson Lake subbasins, Ontario	49,40N	93,44W		170	2		-								
107	Experimental streams, VA	37,25N	80,50W			1	.001	-								
108	Ikpoba River, Nigeria	6,30N	5,50E			4		-								
109	Grace Coolidge Creek, SD	43,45N	103,10W	1217	12300	4	.053	0.00	1.30	1.52						
110	Archibald Creek, B.C.	49,11N	117,26W	2320	3271	3		-								
114	Middle Brook, N.B.	46,22N	66,53W			2		-								
115	Nochikoshi River, Japan	35,00N	139,00E					-								
116	Natotuku River, New Zealand	39,15S	175,00E			2		-		.66						
117	Saline Creek, MO	37,34N	90,15W	195	3600	3		-					0	100	0	0
118	Logan Creek, MO	37,12N	90,54W	317	7512	4		-		.28			0	80	20	0
119	Brasstown Bald Stream, GA	34,53N	83,57W	2300	136	1	8.520	-		22.70						
120	Back Creek, WY	39,25N	78,00W	198		4	.590	-		.04						
122	Chote Creek, PA	41,10N	75,45W	512	1930	2		-		.90			0	90	0	10
124	Seas Branch Creek, WI sec. 2	43,30N	90,40W	244	3603	3	.200	-		.95	.330	79	21	0	0	0
125	Tesque Creek, MN	36,20N	105,10W	2990	4256	2	.039	-		21.10						
126	St. Regis River, NY	47,20N	115,30W	1256	78500	4	15.900	-		1.43						
127	St. Regis River, NY	47,20N	115,30W	1256	78500	4	15.900	-		1.43						
128	Whitley Creek, IL	39,30N	88,30W	183	13750	3		-		.03						
132	Olentangy River, OH	40,10N	83,00W	280	139000	4	13.000	.72	31.93	.10	.200	30	7	7	55	
133	Rush Creek, CA	41,30N	120,30W	1652	9046	2	2.970	.20		4.31		95	5	0	0	
134	River Gray, England	51,30N	0,00					-								
135	Rhone River, France	46,00N	5,30E					-								
136	Afon Hirnant, North Wales	53,00N	3,30W			2		-								
137	Teton River, ID	43,50N	112,00W	1193		5		-		.15						
139	Lawrence Creek, WI	43,40N	89,30W	282	1660	2	.450	-	.53	.28		30	70	0	0	0
144	Coveeta Watershed 53, NC	35,03N	83,25W	829	5	1		-		27.00						
148	Coveeta Watershed 28, NC	35,03N	83,25W	1200	144	1		.02	4.47	52.00						
149	Coveeta Watershed 37, NC	35,03N	83,25W	1314	44	1		.01	12.70	71.00						

¹ - Average total phosphorus

(continued) Table 6. Characteristics of lotic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient %	Pool: riffle ratio	Ave tot phosph. Agri. Forest Grass Urban			
											mg/ P/L	X	X	X
150	Coveeta Watershed 13, NC	35,03N	83,25W	819	16	1	.005	.01 - 2.49	49.00					
151	Weber River, UT	40,45N	111,10W	2465	113000	4	6.500	1.50 - 30.00	2.19					
152	Roaring Run, PA	40,28N	78,40W	580		2			1.68					
154	Mad Creek, OH	43,08N	80,54W			3								
155	Alpida Stream, Zimbabwe	17,00S	31,00E	1364		3								
156	Munabuku Stream, Zimbabwe	17,32S	31,09E	1434		1								
157	Avilin Farm Stream, Zimbabwe	17,30S	31,25E			1								
160	Bear Creek, PA	41,10N	75,40W	510	12600	3	.500		.80					
162	Convict Creek, CA	37,30N	118,50W	2227	5000	2			5.50					
170	New Stream (Hidley Creek), PA	40,00N	75,10W	110	21260	3			.37		.018			
171	Broad River, SC	35,00N	81,40W	165	400000	4	70.000	90.00 - 252.00	.10					
172	North Carolina Stream, NC	35,30N	77, 0W					0.00 - 1.40						
174	Sheep Creek, NY	44,46N	110,49W	1780	14100	4	1.100	.19 - 7.90						
175	Mussellsell River, NY	44,45N	110,30W								.280			
176	Lawrence Creek, LA	30,50N	90,10W	245		5	.405		.65					
177	Bayou Laconbe I, LA	30,30N	90,05W	10		2	.178		.06					
178	Bayou Laconbe II, LA	30,15N	89,50W	2		3	.252		.02					
179	Warner Creek, LA	30,40N	90,10W	57	2533	4	.040		.36					
180	Sugar Creek, IL	40,40N	87,50W	195	10000	3	9.600	.18 - 152.00	.09					
181	Trapper Creek, NY	45,20N	113,30W	2190	11160	4	.420	.14 - 1.13	4.70					
182	Canyon Creek, NY	45,20N	113,30W	2127	12800	4	.710	.17 - 2.26	3.56					
184	Olentangy River, OH	40,10N	83,00W	280	139000	4	13.000	.72 - 31.93	.10					
185	Ruby River, NY	45,20N	112,05W	2180	139300	5	4.500	.19 - 34.80	1.45					
186	Trail Creek, NY	45,30N	110,30W	1600	18500	3	.850	.17 - 20.10	.60					
187	Seas Branch Creek, WI sec. 1	43,30N	90,40W	244	3603	3	.170		.95		.330	79	21	0
189	Happy Valley Creek, AK	69,09N	148,50W	290	8940	3	.300	0.00 - 39.00	.73		.100	0	20	75
190	Ten Mile River, NY	41,30N	75,00W	290	11700	4	1.770	.12 - 23.00	.74					
192	South Willow Creek, UT	40,25N	112,30W	1827	5200	2	.085	.07 - .74	4.70	.06	.080	0	100	0
193	Coveeta Watershed 6	35,03N	83,25W	800	9	2	3.540	.90 - 67.80	.24			0		0
194	Hubbard Brook Watershed 12, NH	43,50N	71,40W	450	16	1		0.00 - .10	25.00		.010	0	100	0
195	Joe Wright Creek, CO	40,40N	105,50W	2883	9580	2	.800	.08 - 1.40	3.00			0	73	27

1 - Average total phosphorus

(continued) Table 6. Characteristics of lotic systems by case number.

Case no.	System	Latitude	Longitude	Elevation (m)	Size of watershed (ha)	Stream order	Mean discharge (m ³ /sec)	Annual range in discharge (m ³ /sec)	Gradient riffle ratio	Pool: ratio	Ave tot phosph. Agri. Forest Grass Urban				
											mg/ P/L	x	x	x	x
196	Fearon Exp Forest WS #3, WV	39,00N	79,40W	504	34	1		-	25.00		.050	0	100	0	0
197	Charlton River, MO	40,15N	92,45W	240	47140	3	.420	.28 - 710.00	.04		.160	47	5	47	1
198	Butte Creek, CA	40,20N	121,10W	1950	15900	2		.07 - 12.00	1.50	2.50		0	100	0	0
199	Piney Creek, AR	36,10N	92,03W	190	45000	6		-	.35						
201	Big River, MO	38,00N	90,30W	153	186000	5	19.300	7.40 - 989.00	.09	6.00	.030	15	45	39	1
202	River Hull, England	54,00N	2,00W	40		4	5.000	1.00 - 11.00	.20			85	0	0	15
203	Mill Creek, MO	38,00N	90,30W	274		2	.100	0.00 - 3.00	.51	2.00		10	60	30	0
204	H.J.Andreus Exp For Streams,OR	44,08N	122,20W	560	600	2		.02 -	5.00			0	100	0	0
206	Northern Maine Streams, ME	46,30N	69,00W	350		2		-				0	100	0	0
207	Northern Maine Streams, ME	46,40N	68,40W	350	770	3		-				0	100	0	0
208	Northern Maine Streams, ME	46,40N	68,40W	350	690	3		-				0	100	0	0
209	Northern Maine Streams, ME	46,40N	68,40W	350	690	3		-				0	100	0	0

1 - Average total phosphorus

Table 7. Description of stressors.

Case no.	System	Strength of stressor	Event duration(yrs)	1 No. yrs.	2 No./yr.	3 Month	4
CHANNELIZATION							
58	Luxapalila River, MS	channelized in segments up to 52 years before					
126	St. Regis River, MT	channelization, no mitigation					
132	Olentangy River, OH	channeliz. 25 yrs ago, 800 m stream, no mitigation					
133	Rush Creek, CA						
154	Mud Creek, ON						
172	North Carolina Stream, NC	examination of 23 channelized streams					
197	Chariton River, MO						
CHEMICAL, ACID							
24	Mill Creek, VA	pH < 4.0	<.001	1	1	8	
CHEMICAL, ALKALINE							
134	River Cray, England	caustic soda	.003	1	1	4	
CHEMICAL, DDT							
54	Miranichi River, N.B.	0.28-0.56 kg/ha in watershed	.003	5	1	6	
55	Restigouche River, N.B.	0.28-0.56 kg/ha in watershed	.003	6	1	6	
56	Tobique River, N.B.	0.28-0.56 kg/ha in watershed	.003	6	1	6	
57	Jacquet River, N.B.	0.28-0.56 kg/ha in watershed	.003	3	1	6	
80	Hellroaring Creek, NY	1.1 kg/ha in oil, sprayed watershed	.003	1	1	7	
81	Tower Creek, NY	1.1 kg/ha in oil, sprayed watershed	.003	1	1	7	
85	Trout Brook, N.B.	0.28-0.56 kg/ha in watershed	.003	1	1	6	
86	Miranichi River, N.B.	0.28-0.56 kg/ha in watershed	.003	1	1	6	
87	Salmon Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
88	Gardner Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
89	Armstrong Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
90	Little Armstrong Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
91	Mud Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
92	Alexander Brook, ME	1.1 kg/ha(11b/acre) oil solvent sprayed from plane	.003	1	1	6	
97	Alexander Brook Tributary, ME	1.1 kg/ha, sprayed most of watershed	.003	1	1	6	
98	Halfway Brook, ME	1.1 kg/ha, sprayed most of watershed	.003	1	1	6	
99	Little Goodard Brook, ME	1.1 kg/ha, sprayed most of watershed	.003	1	1	6	
100	Caniba Brook, ME	1.1 kg/ha, sprayed most of watershed	.003	1	1	6	
101	Picard Brook, ME	1.1 kg/ha, sprayed most of watershed	.003	1	1	6	
119	Brasstown Bald Stream, GA	0.56 kg/ha, in oil solution, sprayed from plane	<.001	2	1	5	
120	Back Creek, NY	1.1 kg/ha, sprayed in water suspension	.003	1	1	7	
122	Choke Creek, PA	1.1 kg/ha, sprayed from plane	.003	1	1	6	
160	Bear Creek, PA	1.1 kg/ha	.012	1	1	6	
174	Sheep Creek, NY	1.1 kg/ha	.003		1	5	
175	Mussellshell River, NY	1.1 kg/ha	.003		1	5	
181	Trapper Creek, NY	1.1 kg/ha	.003	1	1	7	
182	Canyon Creek, NY	1.1 kg/ha	.003	1	1	7	
185	Ruby River, NY	1.1 kg/ha	.003	1	1	7	
186	Trail Creek, NY	1.1 kg/ha, 0.4 mg/L in water	.003	1	1	8	

1 - Length of time stressor was applied or discharged into water during a single event.

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3 - Number of disturbance events per year.

4 - Month of disturbance (last disturbance in the case of multiple events) after which recovery was initiated.

(continued) Table 7. Description of stressors.

Case no.	System	Strength of stressor	Event duration(yrs)	1 No. yrs.	2 No. yr.	3 No. yr.	4 Month
CHEMICAL, METALS							
3	Cazenovia Lake, NY	CuSO ₄ treatment for algae control	.003			3	9
32	Mill Pond Reservoir, MA	CuSO ₄ 76 ug/L	.003	1		1	8
52	Auburn Ponds, AL	CuSO ₄ 0.06 mg/L	.003	1		3	8
107	Experimental streams, VA	Cu 0.06 mg/L	<.003	1		1	8
CHEMICAL, OTHER							
2	Barry Reservoir, Wales	Paraquat (herbicide) 0.8 mg/L	.003			2	6
4	Reservoir #4, CO	Toxaphene treatment 0.1 mg/L	.003	1		1	10
6	North Silver Lake, CA	Chlorpyrifos 0.007 mg/L	<.003	1		1	8
7	South Silver Lake, CA	Diiflubenzuron, 0.0037 mg/L, treated arms of lake	<.003	1		1	6
8	Village Grove Lake, CA	Diiflubenzuron, 25% formulation at 0.012 mg/L	<.003	1		2	8
9	Village Grove Lake, CA	Diiflubenzuron 25%, 0.012 mg/L, growth inhibitor	<.003	1		2	4
13	Spruce Lake, WI	Antimycin (3.8 ug/L) + rotenone (0.05 mg/L)	.003	1		2	5
30	Florida Ponds, FL	Dichlobenil (herbicide) 1 mg/L	.003	1		1	4
38	Mud Creek, AR	Cattle tick pesticide, 100% fish mortality	.003	1		1	5
40	Big Kitoi Creek, AK	Toxaphene 1.5 mg/L	.050	1		1	7
46	Kitty Hawk Bay, NC	2-4 D BEE 112 kg ac/ha	.003	1		1	7
47	Florida Mesocosms	Baytex 0.025 mg/L technical	<.003	1		1	11
48	Bakersfield Ponds, CA	Dursban 7.2 ug/L	.003	1		3	7
49	Bakersfield Ponds, CA	Dursban (insecticide) 72 ug/L	<.003	1		3	7
50	Kiev Ponds, USSR	2-4-D, Na salt 3.6 mg/L	.003	1		1	5
51	Florida Mesocosms	Baytex 0.025 mg/L technical	<.003	1		1	1
60	Three Mile Creek, WI	TFN lampricide 5.2 mg/L	.003	1		1	4
61	Iron River, MI	TFN lampricide 3.8 mg/L	.002	1		1	7
62	Gongeau Creek, MI	TFN lampricide 5.6 mg/L	.003	1		1	4
63	Sturgeon River, MI	TFN lampricide 6 mg/L	.002	1		1	5
83	Oil Creek, TX	Oil spill, 25440 liter	<.003	1		1	12
108	Ikpoba River, Nigeria	Lindane and dewatering	.040	1		1	1
109	Grace Coolidge Creek, SD	Gasoline spill, 18.9 cubic meters	<.003	1		1	11
111	Experimental Ponds, MO	Polynuclear Fluorene- 10 mg/L	.003	1		1	7
114	Middle Brook, N.B.	Fenitrothion, 23 ug/L, point source	.003	1		2	6
116	Makotuku River, New Zealand	Oil spill	.003	1		1	12
124	Seas Branch Creek, WI sec. 2	Antimycin, 17-60 micrograms/L Antimycin A	.003	1		1	10
144	Coveeta Watershed 53, NC	Methoxychlor, 24% emuls. conc., 10% nominal conc.	.001	1		4	11
152	Roaring Run, PA	Kerosene, clean-up began promptly	.010	1		1	10
155	Elpidha Stream, Zimbabwe	Bayluscide	.006	1		1	5
156	Munwahuku Stream, Zimbabwe	Bayluscide	.003	1		1	4
157	Avilin Farm Stream, Zimbabwe	Bayluscide	.003	2		8	10
166	South Silver Lake, CA	Diiflubenzuron, .0074 mg/L, treated arms of lake	<.003	1		1	8
167	South Silver Lake, CA	Chlorpyrifos, .0074 mg/L, two arms treated	<.003	1		1	6
168	South Silver Lake, CA	Temephos, .0042 mg/L, treated main lake	<.003	1		1	8
169	South Silver Lake, CA	Temephos, .0092 mg/L, treated two arms of lake	<.003	1		1	6
180	Sugar Creek, IL	Aldrin 2.2 kg/ha	.003	1		1	11
187	Seas Branch Creek, WI sec. 1	Antimycin A 60 ug/L	.003	1		1	10
188	Hartlaub Lake, WI	Toxaphene	<.003	1		1	7
189	Happy Valley Creek, AK	Oil leaks, 15 no. intermittant		2			2

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(continued) Table 7. Description of stressors.

Case no.	System	Strength of stressor	Event duration(yrs)	1 No. yrs.	2 No./yr.	3 No./yr.	4 Month
CHEMICAL, OTHER							
205	Maine Ponds, ME	Carbaryl, 840 g A.I./ha	<.003	1	1	1	6
206	Northern Maine Streams, ME	Carbaryl, 1.13 kg A.I./ha	<.003	1	1	1	6
207	Northern Maine Streams, ME	Carbaryl, 1120 g AI/ha, treated 89% of watershed	<.003	1	1	1	6
208	Northern Maine Streams, ME	Carbaryl, 840 g AI/ha, treated 68% of watershed	<.003	1	1	1	6
209	Northern Maine Streams, ME	Carbaryl, 1120 and 840 g AI/ha, treated 88% watsrd	<.003	2	1	1	6
CHEMICAL, ROTENONE							
5	Potter's Lake, N.B.	0.025 mg/L nominal concentrate in lake	<.003	1	1	1	7
10	Patricia Lake, Alberta	0.038 mg/L active ingredient	<.003	1	1	1	9
11	Celestine Lake, Alberta	0.038 mg/L active ingredient	<.003	1	1	1	9
12	Fern Lake, WA	0.025 mg/L active ingredient	.003	1	1	1	6
14	Green R., Section 2, NY	0.025 mg/L active ingredient(nominal conc)	.001	1	1	1	9
15	Green R., Section 3, NY	0.025 mg/L active ingredient(nominal conc)	.001	1	1	1	9
16	Green R., Section 4, NY	0.025 mg/L active ingredient(nominal conc)	.001	1	1	1	9
17	New Fork River, NY	0.025 mg/L active ingredient(nominal conc)	.001	1	1	1	9
21	Robinson Creek, CA	0.05 mg/L active ingredient	.001	1	1	1	9
41	Whippoorwill Creek, KY	0.05 mg/L active ingredient, total eradication	<.003	1	1	1	7
42	North Fork River, KY	0.05 mg/L active ingredient, total eradication	<.003	1	1	1	7
93	Pine Creek, TN	5 mg/L conc. in stream 1st hr, 1 mg/L for hrs 2-6	.001	1	1	1	10
173	Franklin Pond, OK	0.05 mg/L active ingredient	.003	1	1	1	6
190	Ten Mile River, NY	1 mg/L, 5% emulsifiable, 640m treated	<.003	1	1	1	10
200	Loch Kinardochy, Scotland	.042 mg/L	.003	1	1	1	6
DREDGING							
33	Lake Thonotosassa, FL	sediment disturbance to simulate fish nest const.	.003	1	1	1	8
34	Lake Thonotosassa, FL	disturbance simulating nest construction	.003	1	1	1	5
35	Lake Thonotosassa, FL	disturbance simulating nest construction	.003	1	1	1	2
39	San Marcos River, TX	dredging near headwaters of spring-fed stream	2.000	2	1	1	3
96	East Stoke Mill Stream, Engl.	Entire 100m study reach dredged April-Sept. 1964	.270	1	1	1	9
110	Archibald Creek, B.C.	excavation & refilling for submersed oil pipeline	.005	1	1	1	9
202	River Hull, England	dredging		1	1	1	12
DROUGHT							
22	Tongue River, WY	river diverted to newly dredged channel		1	1	1	8
44	Little Auglaize River, OH	complete drying of entire channelized section	.170	1	1	1	8
82	Munwahuku Stream, Zimbabwe	complete drying, pools+runs dry, incl all headwaters	.250		1	1	11
136	Afon Hirnant, North Wales	dry 10 weeks, stream not normally intermittent	.190	1	1	1	11
137	Teton River, ID	total drying of streambed, preceded by flash flood	.330	1	1	1	12
162	Convict Creek, CA	flooding of channel previously dry		1			7
170	New Stream (Ridley Creek), PA	new channel created and flooded		1	1	1	8
FLOODING							
19	Tule Creek, AZ	100 year flood	.200	1	1	1	3
25	Sycamore Creek, AZ	3 floods peak discharges 28X, 12X and 8X normal	.005	1	3	1	8
68	Valley Creek, MN	severe flooding in March, June 1965, and Feb. 1966		2	2	1	2
95	Burns Run, PA	300-400 yr flood, flow>100x norm, from hurricane		1	1	1	6

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(continued) Table 7. Description of stressors.

Case no.	System	Strength of stressor	Event duration(yrs)	1 No. yrs.	2 No./yr.	3 No./yr.	4 Month
FLOODING							
125	Tesuque Creek, NM	eroded 1 m of streambed, flashflood	<.003	1	1	1	8
171	Broad River, SC	moderate intensity and duration, 2.8 X normal flow	.014	1	1	1	5
192	South Willow Creek, UT	first large flood in 50 yrs, restructured channel	.003	1	1	1	8
199	Piney Creek, AR	100 yr flood		1	1	1	12
FOREST FIRE							
106	Rawson Lake subbasins, Ontario	whole basin, severe wind storm 1 year before	.003	1	1	1	6
204	H.J.Andrews Exp For Streams,OR						
HABITAT DEVELOPMENT							
127	St. Regis River, MT	channelization, mitigation, jetties,riprap					
139	Lawrence Creek, WI	86 paired bankcovers, current deflectors		1	1	1	10
184	Olentangy River, OH	channelization with mitigation					
HAILSTORM							
18	Mushroom Spring, WY	15 cm hail	<.001	1	1	1	8
LAKE DRAWDOWN							
128	Whitley Creek, IL	fluctuation in res. level changes lentic to lotic	.500	1	1	1	10
MINING ACTIVITY							
69	New River Drainage, TN	siltation (not acidity)	40.000	40	365		
84	Silver Bow Creek, MT	acid mine drainage, Fe, Cu, Zn	1.000	100	365		
MULTIPLE DISTURBANCES							
43	Smiths Branch, IL	100 yr drought, Rotenone	2.700	3	1	1	4
115	Nochikoshi River, Japan	earthquake caused flood of slag and cyanide	.003	1	1	1	1
151	Weber River, UT	channelization and 'habitat improvement'	.170	1	1	1	11
191	Haley Pond, ME	5 year P addition prior to tertiary trmt.					
NUTRIENT ADDITION							
31	Crecy Lake, N.B.	exp. fertilization .390mg/L P, .21mg/L N,.27mg/L K	.003	3	1	1	6
102	Loch ard Forest, Scotland	K,P04,N03 fertilizer, 47 kg/ha		2	2	2	12
ORGANISM REMOVAL (NON CHEM)							
37	Talisheek Creek, LA	fish removed by electrofishing	.006	2	1	1	6
74	Valley Creek, MN	macroinvert. experimentally denuded from riffle	<.003	1	1	1	12
75	Valley Creek, MN	macroinvert. experimentally denuded from riffle	<.003	1	1	1	10
104	Serendipity Springs, WY	algal colonization rate of denuded boards	.003	1	1	1	8
176	Lawrence Creek, LA	fish removed by electrofishing	.009	1	1	1	9
177	Bayou Lacombe I, LA	fish removed by electrofishing	.009	1	3	3	6
178	Bayou Lacombe II, LA	fish removed by electrofishing	.009	1	1	1	8
179	Warner Creek, LA	fish removed by electrofishing	.009	1	1	1	7

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4 - Month of disturbance (last disturbance in the case of multiple events) after which recovery was initiated.

(continued) Table 7. Description of stressors.

Case no.	System	Strength of stressor	Event duration (yrs)	1 No. yrs.	2 No./yr.	3 Month	4
OXYGEN STRESS							
29	Grenada Reservoir, MS	deoxygenation of hypolimnion nearly 0 mg/L	.330	2	1	8	
SUSPENDED SOLIDS							
117	Saline Creek, MO	Pb mining tailings discharged after heavy rains		1	1	3	
118	Logan Creek, MO	Pb mining tailings discharged after heavy rains		1	2	4	
135	Rhone River, France	sediment and oxygen stress due to dam flushing	.010	1	1	7	
195	Joe Wright Creek, CO	road construction					
198	Butte Creek, CA	gold suction dredging with resultant sedimentation	.250	1	1	8	
201	Big River, MO	broken dam from 37 ha barite tailings pond	<.003	1	1	8	
203	Mill Creek, MO	broken dam from 37 ha barite tailings pond	.003	1	1	8	
TIMBER ACTIVITY							
26	Deer Creek, OR	25% clear-cut, harvesting done in three patches	.670	1	1	11	
27	Needle Branch, OR	entire watershed clear-cut and slash burned	.670	1	1	11	
64	Harris River, AK	22% of watershed logged, 37 km of loggers road		5			
65	Twelve Mile Creek, AK	29% of watershed logged, 20 km of logged road		5			
66	Coweeta Watersheds, NC	multiple watersheds					
67	Coweeta Watershed 7, NC	clear-cut, cable logged	.500	1	1	6	
70	Coweeta Watershed 10, NC	logging ended 5 years prior to study; erosion					
78	Wht. Mt. Nat'l For. Streams, NH	100% clear-cutting of 9 watersheds		1	1		
79	Wht. Mt. Nat'l For. Streams, NH	35% clear-cutting of 2 watersheds		1	1	3	
105	Grant Mem. For., WS 14, GA	100% clear-cut & planting	1.000	2			
148	Coweeta Watershed 28, NC	partial clear-cut		1	1		
149	Coweeta Watershed 37, NC	clear-cut		1	1		
150	Coweeta Watershed 13, NC	clear-cut		1	1		
193	Coweeta Watershed 6	timber harvested 30 yrs ago, field treated 1958-68					
194	Hubbard Brook Watershed #2, NH	clear cutting	.120	1	1	12	
196	Fenrow Exp Forest WS #3, NV	100% clearcut, buffer strip, careful rd cons&skid	.630	1	1	3	

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Table 8. Recovery times for amphibians, aquatic macrophytes, microorganisms, periphyton, and phytoplankton by state, province or country. (Foreign sites follow U.S. states)

Case no.	State, province or country	Stressor	Parameter	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
AMPHIBIANS								
19	Arizona	Flooding	Ranidae(Leopard frog) density	.120		yes	-	-
AQUATIC MACROPHYTES								
30	Florida	Chemical, other	Density	.250		yes	-	-
58	Mississippi	Channelization	Biomass	> 52.000	39.000	-	yes	yes
58	Mississippi	Channelization	Density	> 52.000	39.000	-	yes	yes
46	North Carolina	Chemical, other	Myriophyllum spicatum density	4.000	1.400	no	-	-
46	North Carolina	Chemical, other	Species richness	> 4.000	1.400	yes	-	-
39	Texas	Dredging	Biomass	> 1.000	.280	no	yes	yes
39	Texas	Dredging	Species richness	.250	.280	no	yes	yes
96	England	Dredging	Elodea canadensis density	.800	.050	no	yes	yes
MICROORGANISMS								
3	New York	Chemical, metals	Density	.016		yes	-	-
170	Pennsylvania	Drought	Density	.030	.010	no	-	-
50	USSR	Chemical, other	Density	.066		yes	-	-
2	Wales	Chemical, other	Density	.010		yes	-	-
PERIPHYTON								
39	Texas	Dredging	Productivity	.300	.280	no	yes	yes
107	Virginia	Chemical, metals	Biomass/biovolume	.020	.010	yes	-	-
107	Virginia	Chemical, metals	Genera richness	.020	.010	yes	-	-
18	Wyoming	Hailstorm	Biomass/biovolume	.420	.019	yes	yes	yes
18	Wyoming	Hailstorm	Summer bl-gr density	.420	.019	yes	yes	yes
104	Wyoming	Organism removal (non chem)	Biomass/biovolume	.100		yes	-	-

(continued) Table 8. Recovery times for amphibians, aquatic macrophytes, microorganisms, periphyton, and phytoplankton by state, province, or country. (Foreign sites follow U.S. states)

Case no.	State, province or country	Stressor	Parameter	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	Upstream	Downstream
PHYTOPLANKTON									
48	California	Chemical, other	Total density	.090	.020	-	-	-	-
49	California	Chemical, other	Total density	> .010	.020	-	-	-	-
32	Massachusetts	Chemical, metals	Ceratium sp. density	> .170		-	-	-	yes
32	Massachusetts	Chemical, metals	Chlorophyll a	.030		-	-	-	yes
32	Massachusetts	Chemical, metals	Productivity	.030		-	-	-	yes
111	Missouri	Chemical, other	Productivity	.040		-	-	-	-
3	New York	Chemical, metals	Biomass/biovolume	.015		yes	-	-	-
3	New York	Chemical, metals	Chlorophyll a	.038		yes	-	-	-
3	New York	Chemical, metals	Productivity	.015		yes	-	-	-
171	South Carolina	Flooding	Chlorophyll a	.014		yes	yes	-	-
31	New Brunswick	Nutrient addition	Fall bl-gr predominance	1.250		-	-	-	-
31	New Brunswick	Nutrient addition	Summer bl-gr predominance	2.000		-	-	-	-

Table 9. Recovery times for amphibians, aquatic macrophytes, microorganisms, periphyton, and phytoplankton by stressor.

Case no.	Stressor	Parameter	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	Upstream	Downstream
AMPHIBIANS								
19	Flooding	Ranidae (Leopard frog) density	.120		yes	-	-	-
AQUATIC MACROPHYTES								
58	Channelization	Biomass	> 52.000	39.000	-	yes	yes	yes
58	Channelization	Density	> 52.000	39.000	-	yes	yes	yes
30	Chemical, other	Density	.250		yes	-	-	-
46	Chemical, other	Myriophyllum spicatum density	4.000	1.400	no	-	-	-
46	Chemical, other	Species richness	> 4.000	1.400	yes	-	-	-
39	Dredging	Biomass	> 1.000	.280	no	yes	yes	yes
96	Dredging	Elodea canadensis density	.800	.050	no	yes	yes	yes
39	Dredging	Species richness	.250	.280	no	yes	yes	yes
MICROORGANISMS								
3	Chemical, metals	Density	.016		yes	-	-	-
50	Chemical, other	Density	.066		yes	-	-	-
2	Chemical, other	Density	.010		yes	-	-	-
170	Drought	Density	.030	.010	no	-	-	-
PERIPHYTON								
107	Chemical, metals	Biomass/biovolume	.020	.010	yes	-	-	-
107	Chemical, metals	Genera richness	.020	.010	yes	-	-	-
39	Dredging	Productivity	.300	.280	no	yes	yes	yes
18	Hailstorm	Biomass/biovolume	.420	.019	yes	yes	yes	yes
18	Hailstorm	Summer bl-gr density	.420	.019	yes	yes	yes	yes
104	Organism removal (non chem)	Biomass/biovolume	.100		yes	-	-	-
PHYTOPLANKTON								
3	Chemical, metals	Biomass/biovolume	.015		yes	-	-	-
32	Chemical, metals	Ceratium sp. density	> .170		-	-	yes	-
32	Chemical, metals	Chlorophyll a	.030		-	-	yes	-
3	Chemical, metals	Chlorophyll a	.038		yes	-	-	-
32	Chemical, metals	Productivity	.030		-	-	yes	-
3	Chemical, metals	Productivity	.015		yes	-	-	-
111	Chemical, other	Productivity	.040		-	-	-	-
48	Chemical, other	Total density	.090	.020	-	-	-	-
49	Chemical, other	Total density	> .010	.020	-	-	-	-
171	Flooding	Chlorophyll a	.014		yes	yes	-	-
31	Nutrient addition	Fall bl-gr predominance	1.250		-	-	-	-
31	Nutrient addition	Summer bl-gr predominance	2.000		-	-	-	-

Table 10. Recovery times for amphibians, aquatic macrophytes, microorganisms, periphyton, and phytoplankton by taxa.

Case no.	Parameter	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	Upstream	Downstream
AMPHIBIANS								
19	Ranidae(Leopard frog) density	Flooding	.120		yes	-	-	
AQUATIC MACROPHYTES								
58	Biomass	Channelization	> 52.000	39.000	-	yes	yes	yes
39	Biomass	Dredging	> 1.000	.280	no	yes	yes	yes
58	Density	Channelization	> 52.000	39.000	-	yes	yes	yes
30	Density	Chemical, other	.250		yes	-	-	
96	Elodea canadensis density	Dredging	.800	.050	no	yes	yes	
46	Myriophyllum spicatum density	Chemical, other	4.000	1.400	no	-	-	
46	Species richness	Chemical, other	> 4.000	1.400	yes	-	-	
39	Species richness	Dredging	.250	.280	no	yes	yes	
MICROORGANISMS								
3	Density	Chemical, metals	.016		yes	-	-	
50	Density	Chemical, other	.066		yes	-	-	
2	Density	Chemical, other	.010		yes	-	-	
170	Density	Drought	.030	.010	no	-	-	
PERIPHYTON								
107	Biomass/biovolume	Chemical, metals	.020	.010	yes	-	-	
18	Biomass/biovolume	Hailstorm	.420	.019	yes	yes	yes	
104	Biomass/biovolume	Organism removal (non chem)	.100		yes	-	-	
107	Genera richness	Chemical, metals	.020	.010	yes	-	-	
39	Productivity	Dredging	.300	.280	no	yes	yes	
18	Summer bl-gr density	Hailstorm	.420	.019	yes	yes	yes	
PHYTOPLANKTON								
3	Biomass/biovolume	Chemical, metals	.015		yes	-	-	
32	Ceratium sp. density	Chemical, metals	> .170		-	-	yes	
32	Chlorophyll a	Chemical, metals	.030		-	-	yes	
3	Chlorophyll a	Chemical, metals	.038		yes	-	-	
171	Chlorophyll a	Flooding	.014		yes	yes	-	
31	Fall bl-gr predominance	Nutrient addition	1.250		-	-	-	
32	Productivity	Chemical, metals	.030		-	-	yes	
3	Productivity	Chemical, metals	.015		yes	-	-	
111	Productivity	Chemical, other	.040		-	-	-	
31	Summer bl-gr predominance	Nutrient addition	2.000		-	-	-	
48	Total density	Chemical, other	.090	.020	-	-	-	
49	Total density	Chemical, other	> .010	.020	-	-	-	

Table 11. Recovery times for water quality by state, country, or province.
(Foreign sites follow U.S. states)

Case no.	Stressor	Parameter	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
ALASKA								
40	Chemical, other	Stressor	River	.060	.50	-	-	-
64	Timber activity	Fine sediment	River	5.000		-	-	-
65	Timber activity	Fine sediment	River	5.000		-	-	-
ARIZONA								
25	Flooding	Nitrate	River	.057		yes	no	no
COLORADO								
195	Suspended solids	Tot. susp. solids	River	.040		-	-	-
195	Suspended solids	Fine sediment	River	1.000		-	-	-
GEORGIA								
105	Timber activity	Water yield, runoff	River	> 3.000		-	-	-
MAINE								
191	Multiple disturbances	Phosphorus	Pond	1.000		-	-	-
191	Multiple disturbances	Transparency(secchi)	Pond	1.000		-	-	-
205	Chemical, other	Stressor	Pond	1.200		-	-	-
MASSACHUSETTS								
32	Chemical, metals	Stressor	Lake	.170		-	-	-
MISSOURI								
117	Suspended solids	Turbidity	River	.011	1.30	-	-	-
117	Suspended solids	Copper	River	.140	1.30	-	-	-
117	Suspended solids	Lead	River	.160	1.30	-	-	-
117	Suspended solids	Zinc	River	.380	1.30	-	-	-
117	Suspended solids	Fine sediment	River	.670	1.30	-	-	-
118	Suspended solids	Turbidity	River	.011	7.40	-	-	-
118	Suspended solids	Copper	River	.360	7.40	-	-	-
118	Suspended solids	Lead	River	.380	7.40	-	-	-
118	Suspended solids	Fine sediment	River	.670	7.40	-	-	-
201	Suspended solids	Turbidity	River	> 1.000	12.90	-	-	-
203	Suspended solids	Turbidity	River	> 1.000	4.80	yes	yes	yes
MONTANA								
185	Chemical, DDT	Stressor	River	.004		-	-	-
NEW HAMPSHIRE								
78	Timber activity	Calcium	River	4.000		-	no	-
78	Timber activity	Nitrate	River	4.000		-	no	-
79	Timber activity	Calcium	River	3.000		-	no	-
79	Timber activity	Nitrate	River	3.000		-	no	-
194	Timber activity	Water yield, runoff	River	> 3.000		-	-	-

(continued) Table 11. Recovery times for water quality by state, country, or province.
(Foreign sites follow U.S. states)

Case no.	Stressor	Parameter	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
NEW YORK								
3	Chemical, metals	Stressor	Lake	.010		-	-	-
NORTH CAROLINA								
66	Timber activity	Nitrate	River	20.000		-	-	-
67	Timber activity	Dissolved Org. C	River	> 2.000		-	-	-
67	Timber activity	Seston	River	> 8.000		-	-	-
70	Timber activity	Fine sediment	River	> 5.000	.10	-	-	-
NORTH CAROLINA								
144	Chemical, other	Seston	River	3.750	.07	-	-	-
148	Timber activity	Water yield, runoff	River	12.000		-	-	-
149	Timber activity	Water yield, runoff	River	12.000		-	-	-
150	Timber activity	Water yield, runoff	River	> 22.000		-	-	-
150	Timber activity	CPOM	River	> 23.000		-	-	-
150	Timber activity	Seston	River	> 23.000		-	-	-
193	Timber activity	CPOM	River	> 15.000		-	-	-
193	Timber activity	Temperature	River	> 15.000		-	-	-
OREGON								
26	Timber activity	Fine sediment	River	1.000		-	-	-
27	Timber activity	Potassium	River	.160		-	-	-
27	Timber activity	Nitrate	River	6.000		-	-	-
27	Timber activity	Fine sediment	River	> 3.000		-	-	-
27	Timber activity	Temperature	River	> 8.000		-	-	-
204	Forest fire	CPOM	River	> 135.000		-	-	-
PENNSYLVANIA								
152	Chemical, other	Stressor	River	.250		-	-	-
SOUTH CAROLINA								
171	Flooding	Alkalinity	River	.011		-	-	-
171	Flooding	Aluminum	River	.011		-	-	-
171	Flooding	Calcium	River	.011		-	-	-
171	Flooding	Copper	River	.011		-	-	-
171	Flooding	Lead	River	.011		-	-	-
171	Flooding	Magnesium	River	.011		-	-	-
171	Flooding	Manganese	River	.011		-	-	-
171	Flooding	Potassium	River	.011		-	-	-
171	Flooding	Zinc	River	.011		-	-	-
171	Flooding	Inorganic P (SRP)	River	.014		-	-	-
171	Flooding	Phosphorus	River	.014		-	-	-
171	Flooding	Iron	River	.015		-	-	-
171	Flooding	Ammonia	River	.016		-	-	-

(continued) Table 11. Recovery times for water quality by state, country, or province.
(Foreign sites follow U.S. states)

Case no.	Stressor	Parameter	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
TENNESSEE								
69	Mining activity	Iron	River	18.000		-	-	-
69	Mining activity	pH	River	20.000		-	-	-
69	Mining activity	Sulfate	River	25.000		-	-	-
69	Mining activity	Alkalinity	River	> 25.000		-	-	-
TEXAS								
83	Chemical, other	Carbon dioxide	River	> 2.200		-	-	-
83	Chemical, other	Dissolved oxygen	River	> 2.200		-	-	-
WEST VIRGINIA								
196	Timber activity	Phosphorus	River	.700		-	-	-
196	Timber activity	Nitrate	River	1.300		-	-	-
NEW BRUNSWICK								
31	Nutrient addition	Inorganic P (SRP)	Lake	.110		-	-	-
31	Nutrient addition	Phosphorus	Lake	1.000		-	-	-
ONTARIO								
106	Forest fire	Water yield, runoff	River	3.000		-	-	-
106	Forest fire	Nitrate	River	> 2.000		-	-	-
106	Forest fire	Phosphorus	River	> 2.000		-	-	-
106	Forest fire	Potassium	River	> 2.000		-	-	-
SCOTLAND								
102	Nutrient addition	Potassium	River	2.000		-	-	-
102	Nutrient addition	Nitrate	River	3.000		-	-	-
102	Nutrient addition	Phosphorus	River	3.500		-	-	-
WALES								
2	Chemical, other	Stressor	Lake	.038		-	-	-
2	Chemical, other	pH	Lake	.080		-	-	-

Table 12. Recovery times for water quality by stressor.

Case no.	Stressor	Parameter	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
185	Chemical, DDT	Stressor	River	.004		-	-	-
3	Chemical, metals	Stressor	Lake	.010		-	-	-
32	Chemical, metals	Stressor	Lake	.170		-	-	-
83	Chemical, other	Carbon dioxide	River	2.200		-	-	-
83	Chemical, other	Dissolved oxygen	River	2.200		-	-	-
144	Chemical, other	Seston	River	3.750	.07	-	-	-
2	Chemical, other	Stressor	Lake	.038		-	-	-
40	Chemical, other	Stressor	River	.060	.50	-	-	-
152	Chemical, other	Stressor	River	.250		-	-	-
205	Chemical, other	Stressor	Pond	1.200		-	-	-
2	Chemical, other	pH	Lake	.080		-	-	-
171	Flooding	Alkalinity	River	.011		-	-	-
171	Flooding	Aluminum	River	.011		-	-	-
171	Flooding	Ammonia	River	.016		-	-	-
171	Flooding	Calcium	River	.011		-	-	-
171	Flooding	Copper	River	.011		-	-	-
171	Flooding	Inorganic P (SRP)	River	.014		-	-	-
171	Flooding	Iron	River	.015		-	-	-
171	Flooding	Lead	River	.011		-	-	-
171	Flooding	Magnesium	River	.011		-	-	-
171	Flooding	Manganese	River	.011		-	-	-
25	Flooding	Nitrate	River	.057		yes	no	no
171	Flooding	Phosphorus	River	.014		-	-	-
171	Flooding	Potassium	River	.011		-	-	-
171	Flooding	Zinc	River	.011		-	-	-
204	Forest fire	CPOM	River	>135.000		-	-	-
106	Forest fire	Nitrate	River	> 2.000		-	-	-
106	Forest fire	Phosphorus	River	> 2.000		-	-	-
106	Forest fire	Potassium	River	> 2.000		-	-	-
106	Forest fire	Water yield, runoff	River	3.000		-	-	-
69	Mining activity	Alkalinity	River	> 25.000		-	-	-
69	Mining activity	Iron	River	18.000		-	-	-
69	Mining activity	Sulfate	River	25.000		-	-	-
69	Mining activity	pH	River	20.000		-	-	-
191	Multiple disturbances	Phosphorus	Pond	1.000		-	-	-
191	Multiple disturbances	Transparency(secchi)	Pond	1.000		-	-	-
31	Nutrient addition	Inorganic P (SRP)	Lake	.110		-	-	-
102	Nutrient addition	Nitrate	River	3.000		-	-	-
31	Nutrient addition	Phosphorus	Lake	1.000		-	-	-

(continued) Table 12. Recovery times for water quality by stressor.

Case no.	Stressor	Parameter	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
102	Nutrient addition	Phosphorus	River	3.500		-	-	-
102	Nutrient addition	Potassium	River	2.000		-	-	-
117	Suspended solids	Copper	River	.140	1.30	-	-	-
118	Suspended solids	Copper	River	.360	7.40	-	-	-
117	Suspended solids	Fine sediment	River	.670	1.30	-	-	-
118	Suspended solids	Fine sediment	River	.670	7.40	-	-	-
195	Suspended solids	Fine sediment	River	1.000		-	-	-
117	Suspended solids	Lead	River	.160	1.30	-	-	-
118	Suspended solids	Lead	River	.380	7.40	-	-	-
195	Suspended solids	Tot. susp. solids	River	.040		-	-	-
117	Suspended solids	Turbidity	River	.011	1.30	-	-	-
118	Suspended solids	Turbidity	River	.011	7.40	-	-	-
201	Suspended solids	Turbidity	River	> 1.000	12.90	-	-	-
203	Suspended solids	Turbidity	River	> 1.000	4.80	yes	yes	yes
117	Suspended solids	Zinc	River	.380	1.30	-	-	-
150	Timber activity	CPOM	River	> 23.000		-	-	-
193	Timber activity	CPOM	River	> 15.000		-	-	-
78	Timber activity	Calcium	River	4.000		-	no	-
79	Timber activity	Calcium	River	3.000		-	no	-
67	Timber activity	Dissolved Org. C	River	> 2.000		-	-	-
26	Timber activity	Fine sediment	River	1.000		-	-	-
27	Timber activity	Fine sediment	River	> 3.000		-	-	-
64	Timber activity	Fine sediment	River	5.000		-	-	-
65	Timber activity	Fine sediment	River	5.000		-	-	-
70	Timber activity	Fine sediment	River	> 5.000	.10	-	-	-
27	Timber activity	Nitrate	River	6.000		-	-	-
66	Timber activity	Nitrate	River	20.000		-	-	-
78	Timber activity	Nitrate	River	4.000		-	no	-
79	Timber activity	Nitrate	River	3.000		-	no	-
196	Timber activity	Nitrate	River	1.300		-	-	-
196	Timber activity	Phosphorus	River	.700		-	-	-
27	Timber activity	Potassium	River	.160		-	-	-
87	Timber activity	Seston	River	> 8.000		-	-	-
150	Timber activity	Seston	River	> 23.000		-	-	-
27	Timber activity	Temperature	River	> 8.000		-	-	-
193	Timber activity	Temperature	River	> 15.000		-	-	-
105	Timber activity	Water yield, runoff	River	> 3.000		-	-	-
148	Timber activity	Water yield, runoff	River	12.000		-	-	-
149	Timber activity	Water yield, runoff	River	12.000		-	-	-
150	Timber activity	Water yield, runoff	River	> 22.000		-	-	-
194	Timber activity	Water yield, runoff	River	> 3.000		-	-	-

Table 13. Recovery times for water quality by parameter.

Case no.	Parameter	Disturbance	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
171	Alkalinity	Flooding	River	.011		-	-	-
69	Alkalinity	Mining activity	River	> 25.000		-	-	-
171	Aluminum	Flooding	River	.011		-	-	-
171	Ammonia	Flooding	River	.016		-	-	-
204	CPON	Forest fire	River	>135.000		-	-	-
150	CPON	Timber activity	River	> 23.000		-	-	-
193	CPON	Timber activity	River	> 15.000		-	-	-
171	Calcium	Flooding	River	.011		-	-	-
78	Calcium	Timber activity	River	4.000		-	no	-
79	Calcium	Timber activity	River	3.000		-	no	-
83	Carbon dioxide	Chemical, other	River	> 2.200		-	-	-
171	Copper	Flooding	River	.011		-	-	-
117	Copper	Suspended solids	River	.140	1.30	-	-	-
118	Copper	Suspended solids	River	.360	7.40	-	-	-
67	Dissolved Org. C	Timber activity	River	> 2.000		-	-	-
83	Dissolved oxygen	Chemical, other	River	> 2.200		-	-	-
117	Fine sediment	Suspended solids	River	.670	1.30	-	-	-
118	Fine sediment	Suspended solids	River	.670	7.40	-	-	-
195	Fine sediment	Suspended solids	River	1.000		-	-	-
26	Fine sediment	Timber activity	River	1.000		-	-	-
27	Fine sediment	Timber activity	River	> 3.000		-	-	-
64	Fine sediment	Timber activity	River	5.000		-	-	-
65	Fine sediment	Timber activity	River	5.000		-	-	-
70	Fine sediment	Timber activity	River	> 5.000	.10	-	-	-
171	Inorganic P (SRP)	Flooding	River	.014		-	-	-
31	Inorganic P (SRP)	Nutrient addition	Lake	.110		-	-	-
171	Iron	Flooding	River	.015		-	-	-
69	Iron	Mining activity	River	18.000		-	-	-
171	Lead	Flooding	River	.011		-	-	-
117	Lead	Suspended solids	River	.160	1.30	-	-	-
118	Lead	Suspended solids	River	.380	7.40	-	-	-
171	Magnesium	Flooding	River	.011		-	-	-

(continued) Table 13. Recovery times for water quality by parameter.

Case no.	Parameter	Disturbance	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
171	Manganese	Flooding	River	.011		-	-	-
25	Nitrate	Flooding	River	.057		yes	no	no
106	Nitrate	Forest fire	River	> 2.000		-	-	-
102	Nitrate	Nutrient addition	River	3.000		-	-	-
27	Nitrate	Timber activity	River	6.000		-	-	-
66	Nitrate	Timber activity	River	20.000		-	-	-
78	Nitrate	Timber activity	River	4.000		-	no	-
79	Nitrate	Timber activity	River	3.000		-	no	-
196	Nitrate	Timber activity	River	1.300		-	-	-
171	Phosphorus	Flooding	River	.014		-	-	-
106	Phosphorus	Forest fire	River	> 2.000		-	-	-
191	Phosphorus	Multiple disturbance	Pond	1.000		-	-	-
31	Phosphorus	Nutrient addition	Lake	1.000		-	-	-
102	Phosphorus	Nutrient addition	River	3.500		-	-	-
196	Phosphorus	Timber activity	River	.700		-	-	-
171	Potassium	Flooding	River	.011		-	-	-
106	Potassium	Forest fire	River	> 2.000		-	-	-
102	Potassium	Nutrient addition	River	2.000		-	-	-
27	Potassium	Timber activity	River	.160		-	-	-
144	Seston	Chemical, other	River	3.750	.07	-	-	-
67	Seston	Timber activity	River	> 8.000		-	-	-
150	Seston	Timber activity	River	> 23.000		-	-	-
185	Stressor	Chemical, DDT	River	.004		-	-	-
3	Stressor	Chemical, metals	Lake	.010		-	-	-
32	Stressor	Chemical, metals	Lake	.170		-	-	-
2	Stressor	Chemical, other	Lake	.038		-	-	-
40	Stressor	Chemical, other	River	.060	.50	-	-	-
152	Stressor	Chemical, other	River	.250		-	-	-
205	Stressor	Chemical, other	Pond	1.200		-	-	-
69	Sulfate	Mining activity	River	25.000		-	-	-
27	Temperature	Timber activity	River	> 8.000		-	-	-
193	Temperature	Timber activity	River	> 15.000		-	-	-
195	Tot. susp. solids	Suspended solids	River	.040		-	-	-
191	Transparency(secchi)	Multiple disturbance	Pond	1.000		-	-	-

(continued) Table 13. Recovery times for water quality by parameter.

Case no.	Parameter	Disturbance	System type	Time to recover (yrs)	Distance to refugia (km)	Persistence of species in system	Unperturbed source for recolonization	
							Upstream	Downstream
201	Turbidity	Suspended solids	River	> 1.000	12.90	-	-	-
203	Turbidity	Suspended solids	River	> 1.000	4.80	yes	yes	yes
201	Turbidity	Suspended solids	River	> 1.000	12.90	-	-	-
203	Turbidity	Suspended solids	River	> 1.000	4.80	yes	yes	yes
106	Water yield, runoff	Forest fire	River	3.000		-	-	-
105	Water yield, runoff	Timber activity	River	> 3.000		-	-	-
148	Water yield, runoff	Timber activity	River	12.000		-	-	-
149	Water yield, runoff	Timber activity	River	12.000		-	-	-
150	Water yield, runoff	Timber activity	River	> 22.000		-	-	-
194	Water yield, runoff	Timber activity	River	> 3.000		-	-	-
171	Zinc	Flooding	River	.011		-	-	-
117	Zinc	Suspended solids	River	.380	1.30	-	-	-
2	pH	Chemical, other	Lake	.080		-	-	-
69	pH	Mining activity	River	20.000		-	-	-

Table 14. Recovery times to pre-disturbance densities for zooplankton by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Group	Scientific name	Common name	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization Upstream	Downstream
CALIFORNIA									
7	Cladocera	Daphnia sp.	Water flea	Chemical, other	.04	.80	yes	-	-
8	Cladocera	Bosmina sp.	Water flea	Chemical, other	.17		yes	-	-
8	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.08		yes	-	-
8	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	.08		yes	-	-
9	Cladocera	Bosmina sp.	Water flea	Chemical, other	.27		yes	-	-
9	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, other	> .31		yes	-	-
9	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .31		yes	-	-
9	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.12		yes	-	-
9	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	> .31		yes	-	-
48			Community compos.	Chemical, other	> .10	.02	yes	-	-
48	Cladocera	Moina sp.	Water flea	Chemical, other	.04	.02	yes	-	-
48	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.03	.02	yes	-	-
48	Rotifera	Rotifera	Rotifer phylum	Chemical, other	.10	.02	yes	-	-
49			Community compos.	Chemical, other	> .10	.02	yes	-	-
49	Cladocera	Moina sp.	Water flea	Chemical, other	.09	.02	yes	-	-
49	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.10	.02	yes	-	-
49	Rotifera	Rotifera	Rotifer phylum	Chemical, other	.10	.02	yes	-	-
166	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .42	.80	no	-	-
166	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	.04	.80	no	-	-
167	Cladocera	Daphnia sp.	Water flea	Chemical, other	.06	.80	yes	-	-
168	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .42		no	-	-
169	Cladocera	Daphnia sp.	Water flea	Chemical, other	.04	.80	yes	-	-
FLORIDA									
47	Cladocera	Cladocera	Water flea order	Chemical, other	.42		yes	-	-
51	Cladocera	Cladocera	Water flea order	Chemical, other	.15		yes	-	-
MAINE									
191	Eucopepoda	Calanoida	Copepod suborder	Multiple disturbances	> 3.00		yes	-	-
MASSACHUSETTS									
32	Cladocera	Daphnia sp.	Water flea	Chemical, metals	.75		-	-	yes
32	Rotifera	Keratella sp.	Rotifer	Chemical, metals	.06		-	-	yes
MISSOURI									
111			Crust/rot sp. rich	Chemical, other	.08		yes	-	-
111			Total den, rotifers	Chemical, other	.04		yes	-	-
111	Cladocera	Cladocera	Water flea order	Chemical, other	.15		yes	-	-
111	Eucopepoda	Copepoda	Copepod subclass	Chemical, other	.13		yes	-	-

(continued) Table 14. Recovery times to pre-disturbance densities for zooplankton by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Group	Scientific name	Common name	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persis. in system	Unperturbed Source for recolonization Upstream	Downstream
SOUTH CAROLINA									
171			Community compos.	Flooding	.01		yes	yes	-
171			Total den, crust/rot	Flooding	.01		yes	yes	-
WASHINGTON									
12			Biomass/biovolume	Chemical, rotenone	.28		-	-	-
12			Crust species rich	Chemical, rotenone	.31		-	-	-
12	Cladocera	Acroporus sp.	Water flea	Chemical, rotenone	.17		-	-	yes
12	Cladocera	Alona sp.	Water flea	Chemical, rotenone	.13		-	-	yes
12	Cladocera	Alonella sp.	Cladoceran	Chemical, rotenone	.06		-	-	yes
12	Cladocera	Camptocercus sp.	Water flea	Chemical, rotenone	.25		-	-	yes
12	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.31		-	-	yes
12	Cladocera	Chydorus sp.	Water flea	Chemical, rotenone	.19		-	-	yes
12	Cladocera	Diaphanosoma sp.	Water flea	Chemical, rotenone	.13		-	-	yes
12	Cladocera	Holopedium sp.	Water flea	Chemical, rotenone	.16		-	-	yes
12	Cladocera	Ilyocryptus sp.	Water flea	Chemical, rotenone	.10		-	-	yes
12	Cladocera	Pleuroxus sp.	Water flea	Chemical, rotenone	.06		-	-	yes
12	Cladocera	Scapholeberis sp.	Water flea	Chemical, rotenone	.15		-	-	yes
12	Cladocera	Sida sp.	Water flea	Chemical, rotenone	.15		-	-	yes
12	Cladocera	Simocephalus sp.	Water flea	Chemical, rotenone	.10		-	-	yes
12	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	.37		-	-	yes
12	Eucopepoda	Epischura sp.	Calanoid copepod	Chemical, rotenone	.13		-	-	yes
WISCONSIN									
13			Total den, crust	Chemical, other	.15		yes	-	-
13	Cladocera	Daphnia sp.	Water flea	Chemical, other	.12		yes	-	-
13	Cladocera	Eubosmina sp.	Water flea	Chemical, other	.25		yes	-	-
13	Cladocera	Holopedium sp.	Water flea	Chemical, other	.25		yes	-	-
13	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.25		yes	-	-
13	Eucopepoda	Leptodiaptomus sp.	Calanoid copepod	Chemical, other	1.10		yes	-	-
13	Eucopepoda	Skistodiaptomus sp.	Calanoid copepod	Chemical, other	1.10		yes	-	-
ALBERTA									
10			Total den, crust/rot	Chemical, rotenone	2.70		yes	-	-
10			Total den, rotifers	Chemical, rotenone	.75		yes	-	-
10	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
10	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
10	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.70		yes	-	-
10	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	2.50		yes	-	-
10	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	2.70		yes	-	-
10	Rotifera	Kellicottia sp.	Rotifer	Chemical, rotenone	.75		yes	-	-
10	Rotifera	Keratella sp.	Rotifer	Chemical, rotenone	.75		yes	-	-
11			Total den, crust/rot	Chemical, rotenone	2.70		yes	-	-
11			Total den, rotifers	Chemical, rotenone	.75		yes	-	-
11	Cladocera	Bosmina sp.	Water flea	Chemical, rotenone	.70		yes	-	-
11	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
11	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	.90		yes	-	-
11	Diptera	Chaoboridae	Phantom midge family	Chemical, rotenone	.90		yes	-	-
11	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.70		yes	-	-

(continued) Table 14. Recovery times to pre-disturbance densities for zooplankton by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Group	Scientific name	Common name	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization Upstream	Downstream
NEW BRUNSWICK									
5	Cladocera	Cladocera	Water flea order	Chemical, rotenone	< 1.00		yes	-	-
5	Eucopepoda	Copepoda	Copepod subclass	Chemical, rotenone	< 1.00		yes	-	-
31			Biomass/biovolume	Nutrient addition	3.58		-	-	-
SCOTLAND									
200	Cladocera	Bosmina sp.	Water flea	Chemical, rotenone	.25		yes	-	-
200	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	1.00		yes	-	-
200	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.00		yes	-	-
200	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	2.00		yes	-	-
WALLES									
2	Cladocera	Eurycerus sp.	Water flea	Chemical, other	> 1.50		yes	-	-

Table 15. Recovery times to pre-disturbance densities for zooplankton by stressor.

Case no.	Stressor	Group	Scientific name	Common name	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization Upstream	Downstream
32	Chemical, metals	Cladocera	Daphnia sp.	Water flea	.75		-	-	yes
32	Chemical, metals	Rotifera	Keratella sp.	Rotifer	.06		-	-	yes
48	Chemical, other			Community compos.	.10	.02	yes	-	-
49	Chemical, other			Community compos.	.10	.02	yes	-	-
111	Chemical, other			Crust/rot sp. rich	.08		yes	-	-
13	Chemical, other			Total den, crust	.15		yes	-	-
111	Chemical, other			Total den, rotifers	.04		yes	-	-
8	Chemical, other	Cladocera	Bosmina sp.	Water flea	.17		yes	-	-
9	Chemical, other	Cladocera	Bosmina sp.	Water flea	.27		yes	-	-
9	Chemical, other	Cladocera	Ceriodaphnia sp.	Water flea	.31		yes	-	-
47	Chemical, other	Cladocera	Cladocera	Water flea order	.42		yes	-	-
51	Chemical, other	Cladocera	Cladocera	Water flea order	.15		yes	-	-
111	Chemical, other	Cladocera	Cladocera	Water flea order	.15		yes	-	-
7	Chemical, other	Cladocera	Daphnia sp.	Water flea	.04	.80	yes	-	-
9	Chemical, other	Cladocera	Daphnia sp.	Water flea	.31		yes	-	-
13	Chemical, other	Cladocera	Daphnia sp.	Water flea	.12		yes	-	-
166	Chemical, other	Cladocera	Daphnia sp.	Water flea	.42	.80	no	-	-
167	Chemical, other	Cladocera	Daphnia sp.	Water flea	.06	.80	yes	-	-
168	Chemical, other	Cladocera	Daphnia sp.	Water flea	.42		no	-	-
169	Chemical, other	Cladocera	Daphnia sp.	Water flea	.04	.80	yes	-	-
13	Chemical, other	Cladocera	Eubosmina sp.	Water flea	.25		yes	-	-
2	Chemical, other	Cladocera	Eurycerus sp.	Water flea	1.50		yes	-	-
13	Chemical, other	Cladocera	Holopedium sp.	Water flea	.25		yes	-	-
48	Chemical, other	Cladocera	Moina sp.	Water flea	.04	.02	yes	-	-
49	Chemical, other	Cladocera	Moina sp.	Water flea	.09	.02	yes	-	-
111	Chemical, other	Eucopepoda	Copepoda	Copepod subclacs	.13		yes	-	-
8	Chemical, other	Eucopepoda	Cyclops sp.	Cyclopoid copepod	.08		yes	-	-
9	Chemical, other	Eucopepoda	Cyclops sp.	Cyclopoid copepod	.12		yes	-	-
13	Chemical, other	Eucopepoda	Cyclops sp.	Cyclopoid copepod	.25		yes	-	-
48	Chemical, other	Eucopepoda	Cyclops sp.	Cyclopoid copepod	.03	.02	yes	-	-
49	Chemical, other	Eucopepoda	Cyclops sp.	Cyclopoid copepod	.10	.02	yes	-	-
8	Chemical, other	Eucopepoda	Diaptomus sp.	Calanoid copepod	.08		yes	-	-
9	Chemical, other	Eucopepoda	Diaptomus sp.	Calanoid copepod	.31		yes	-	-
166	Chemical, other	Eucopepoda	Diaptomus sp.	Calanoid copepod	.04	.80	no	-	-
13	Chemical, other	Eucopepoda	Leptodiaptomus sp.	Calanoid copepod	1.10		yes	-	-
13	Chemical, other	Eucopepoda	Skistodiaptomus sp.	Calanoid copepod	1.10		yes	-	-
48	Chemical, other	Rotifera	Rotifera	Rotifer phylum	.10	.02	yes	-	-
49	Chemical, other	Rotifera	Rotifera	Rotifer phylum	.10	.02	yes	-	-
12	Chemical, rotenone			Biomass/biovolume	.28		-	-	-
12	Chemical, rotenone			Crust species rich	.31		-	-	-
10	Chemical, rotenone			Total den, crust/rot	2.70		yes	-	-
11	Chemical, rotenone			Total den, crust/rot	2.70		yes	-	-
10	Chemical, rotenone			Total den, rotifers	.75		yes	-	-
11	Chemical, rotenone			Total den, rotifers	.75		yes	-	-
12	Chemical, rotenone	Cladocera	Acroporus sp.	Water flea	.17		-	-	yes

(continued) Table 15. Recovery times to pre-disturbance densities for zooplankton by stressor.

Case no.	Stressor	Group	Scientific name	Common name	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization Upstream	Downstream
12	Chemical, rotenone	Cladocera	Alona sp.	Water flea	.13		-	-	yes
12	Chemical, rotenone	Cladocera	Alonella sp.	Cladoceran	.06		-	-	yes
11	Chemical, rotenone	Cladocera	Bosmina sp.	Water flea	.70		yes	-	-
200	Chemical, rotenone	Cladocera	Bosmina sp.	Water flea	.25		yes	-	-
12	Chemical, rotenone	Cladocera	Camptocercus sp.	Water flea	.25		-	-	yes
10	Chemical, rotenone	Cladocera	Ceriodaphnia sp.	Water flea	.80		yes	-	-
11	Chemical, rotenone	Cladocera	Ceriodaphnia sp.	Water flea	.80		yes	-	-
12	Chemical, rotenone	Cladocera	Ceriodaphnia sp.	Water flea	.31		-	-	yes
12	Chemical, rotenone	Cladocera	Chydorus sp.	Water flea	.19		-	-	yes
5	Chemical, rotenone	Cladocera	Cladocera	Water flea order	< 1.00		yes	-	-
10	Chemical, rotenone	Cladocera	Daphnia sp.	Water flea	.80		yes	-	-
11	Chemical, rotenone	Cladocera	Daphnia sp.	Water flea	.90		yes	-	-
200	Chemical, rotenone	Cladocera	Daphnia sp.	Water flea	1.00		yes	-	-
12	Chemical, rotenone	Cladocera	Diaphanosoma sp.	Water flea	.13		-	-	yes
12	Chemical, rotenone	Cladocera	Holopedium sp.	Water flea	.16		-	-	yes
12	Chemical, rotenone	Cladocera	Ilyocryptus sp.	Water flea	.10		-	-	yes
12	Chemical, rotenone	Cladocera	Plenroxus sp.	Water flea	.06		-	-	yes
12	Chemical, rotenone	Cladocera	Scapholeberis sp.	Water flea	.15		-	-	yes
12	Chemical, rotenone	Cladocera	Sida sp.	Water flea	.15		-	-	yes
12	Chemical, rotenone	Cladocera	Simocephalus sp.	Water flea	.10		-	-	yes
11	Chemical, rotenone	Diptera	Chaoboridae	Phantom midge family	.90		yes	-	-
5	Chemical, rotenone	Eucopepoda	Copepoda	Copepod subclass	< 1.00		yes	-	-
10	Chemical, rotenone	Eucopepoda	Cyclops sp.	Cyclopoid copepod	1.70		yes	-	-
10	Chemical, rotenone	Eucopepoda	Cyclops sp.	Cyclopoid copepod	2.50		yes	-	-
11	Chemical, rotenone	Eucopepoda	Cyclops sp.	Cyclopoid copepod	1.70		yes	-	-
200	Chemical, rotenone	Eucopepoda	Cyclops sp.	Cyclopoid copepod	1.00		yes	-	-
10	Chemical, rotenone	Eucopepoda	Diaptomus sp.	Calanoid copepod	2.70		yes	-	-
12	Chemical, rotenone	Eucopepoda	Diaptomus sp.	Calanoid copepod	.37		-	-	yes
200	Chemical, rotenone	Eucopepoda	Diaptomus sp.	Calanoid copepod	2.00		yes	-	-
12	Chemical, rotenone	Eucopepoda	Epicrura sp.	Calanoid copepod	.13		-	-	yes
10	Chemical, rotenone	Rotifera	Kellicottia sp.	Rotifer	.75		yes	-	-
10	Chemical, rotenone	Rotifera	Keratella sp.	Rotifer	.75		yes	-	-
171	Flooding			Community compos.	.01		yes	yes	-
171	Flooding			Total den, crust/rot	.01		yes	yes	-
191	Multiple disturbances	Eucopepoda	Calanoida	Copepod suborder	> 3.00		yes	-	-
31	Nutrient addition			Biomass/biovolume	3.50		-	-	-

Table 16. Recovery times to pre-disturbance densities for zooplankton by taxa.

Case no.	Group	Scientific name	Common name	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization	
								Upstream	Downstream
12			Biomass/biovolume	Chemical, rotenone	.28		-	-	-
31			Biomass/biovolume	Nutrient addition	3.50		-	-	-
48			Community compos.	Chemical, other	> .10	.02	yes	-	-
49			Community compos.	Chemical, other	> .10	.02	yes	-	-
171			Community compos.	Flooding	.01		yes	yes	-
12			Crust species rich	Chemical, rotenone	.31		-	-	-
111			Crust/rot sp. rich	Chemical, other	.08		yes	-	-
13			Total den, crust	Chemical, other	.15		yes	-	-
10			Total den, crust/rot	Chemical, rotenone	2.70		yes	-	-
11			Total den, crust/rot	Chemical, rotenone	2.70		yes	-	-
171			Total den, crust/rot	Flooding	.01		yes	yes	-
111			Total den, rotifers	Chemical, other	.04		yes	-	-
10			Total den, rotifers	Chemical, rotenone	.75		yes	-	-
11			Total den, rotifers	Chemical, rotenone	.75		yes	-	-
12	Cladocera	Acroporus sp.	Water flea	Chemical, rotenone	.17		-	-	yes
12	Cladocera	Alona sp.	Water flea	Chemical, rotenone	.13		-	-	yes
12	Cladocera	Alonella sp.	Cladoceran	Chemical, rotenone	.06		-	-	yes
8	Cladocera	Bosmina sp.	Water flea	Chemical, other	.17		yes	-	-
9	Cladocera	Bosmina sp.	Water flea	Chemical, other	.27		yes	-	-
11	Cladocera	Bosmina sp.	Water flea	Chemical, rotenone	.70		yes	-	-
200	Cladocera	Bosmina sp.	Water flea	Chemical, rotenone	.25		yes	-	-
12	Cladocera	Camptocercus sp.	Water flea	Chemical, rotenone	.25		-	-	yes
9	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, other	> .31		yes	-	-
10	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
11	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
12	Cladocera	Ceriodaphnia sp.	Water flea	Chemical, rotenone	.31		-	-	yes
12	Cladocera	Chydorus sp.	Water flea	Chemical, rotenone	.19		-	-	yes
47	Cladocera	Cladocera	Water flea order	Chemical, other	.42		yes	-	-
51	Cladocera	Cladocera	Water flea order	Chemical, other	.15		yes	-	-
111	Cladocera	Cladocera	Water flea order	Chemical, other	.15		yes	-	-
5	Cladocera	Cladocera	Water flea order	Chemical, rotenone	< 1.00		yes	-	-
32	Cladocera	Daphnia sp.	Water flea	Chemical, metals	.75		-	-	yes
7	Cladocera	Daphnia sp.	Water flea	Chemical, other	.04	.80	yes	-	-
9	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .31		yes	-	-
13	Cladocera	Daphnia sp.	Water flea	Chemical, other	.12		yes	-	-
166	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .42	.80	no	-	-
167	Cladocera	Daphnia sp.	Water flea	Chemical, other	.06	.80	yes	-	-
168	Cladocera	Daphnia sp.	Water flea	Chemical, other	> .42		no	-	-
169	Cladocera	Daphnia sp.	Water flea	Chemical, other	.04	.80	yes	-	-
10	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	.80		yes	-	-
11	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	.90		yes	-	-
200	Cladocera	Daphnia sp.	Water flea	Chemical, rotenone	1.00		yes	-	-
12	Cladocera	Diaphanosoma sp.	Water flea	Chemical, rotenone	.13		-	-	yes
13	Cladocera	Eubosmina sp.	Water flea	Chemical, other	.25		yes	-	-
2	Cladocera	Eurycerus sp.	Water flea	Chemical, other	> 1.50		yes	-	-
13	Cladocera	Holopedium sp.	Water flea	Chemical, other	.25		yes	-	-
12	Cladocera	Holopedium sp.	Water flea	Chemical, rotenone	.16		-	-	yes
12	Cladocera	Ilyocryptus sp.	Water flea	Chemical, rotenone	.10		-	-	yes
48	Cladocera	Moina sp.	Water flea	Chemical, other	.04	.02	yes	-	-
49	Cladocera	Moina sp.	Water flea	Chemical, other	.09	.02	yes	-	-
12	Cladocera	Pleuroxus sp.	Water flea	Chemical, rotenone	.06		-	-	yes

(continued) Table 16. Recovery times to pre-disturbance densities for zooplankton by taxa.

Case no.	Group	Scientific name	Common name	Stressor	Time to recover (yrs)	Distance to refugia (km)	Persis. of species in system	Unperturbed Source for recolonization Upstream	Downstream
12	Cladocera	Scapholeberis sp.	Water flea	Chemical, rotenone	.15		-	-	yes
12	Cladocera	Sida sp.	Water flea	Chemical, rotenone	.15		-	-	yes
12	Cladocera	Simocephalus sp.	Water flea	Chemical, rotenone	.10		-	-	yes
11	Diptera	Chaoboridae	Phantom midge family	Chemical, rotenone	.90		yes	-	-
191	Eucopepoda	Calanoida	Copepod suborder	Multiple disturbances	> 3.00		yes	-	-
111	Eucopepoda	Copepoda	Copepod subclass	Chemical, other	.13		yes	-	-
5	Eucopepoda	Copepoda	Copepod subclass	Chemical, rotenone	< 1.00		yes	-	-
8	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.08		yes	-	-
9	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.12		yes	-	-
13	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.25		yes	-	-
48	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.03	.02	yes	-	-
49	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, other	.10	.02	yes	-	-
10	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.70		yes	-	-
10	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	2.50		yes	-	-
11	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.70		yes	-	-
200	Eucopepoda	Cyclops sp.	Cyclopoid copepod	Chemical, rotenone	1.00		yes	-	-
8	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	.08		yes	-	-
9	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	> .31		yes	-	-
166	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, other	.04	.80	no	-	-
10	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	2.70		yes	-	-
12	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	.37		-	-	yes
200	Eucopepoda	Diaptomus sp.	Calanoid copepod	Chemical, rotenone	2.00		yes	-	-
12	Eucopepoda	Epischura sp.	Calanoid copepod	Chemical, rotenone	.13		-	-	yes
13	Eucopepoda	Leptodiaptomus sp.	Calanoid copepod	Chemical, other	1.10		yes	-	-
13	Eucopepoda	Skistodiaptomus sp.	Calanoid copepod	Chemical, other	1.10		yes	-	-
10	Rotifera	Kellicottia sp.	Rotifer	Chemical, rotenone	.75		yes	-	-
32	Rotifera	Leraticella sp.	Rotifer	Chemical, metals	.06		-	-	yes
10	Rotifera	Leraticella sp.	Rotifer	Chemical, rotenone	.75		yes	-	-
48	Rotifera	Rotifera	Rotifer phylum	Chemical, other	.10	.02	yes	-	-
49	Rotifera	Rotifera	Rotifer phylum	Chemical, other	.10	.02	yes	-	-

Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Forelga sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Perturb source	Unperturbed source
ALASKA										
CHEMICAL, OTHER										
40			Biomass		River	Biomass	> 1.000	.500	-	yes
40			Density		River	Density	> 1.000	.500	-	yes
40			Genera richness		River	Genera richness	> 1.000	.500	-	yes
189			Density		River	Density	> .500	.060	yes	yes
189			Genera richness		River	Genera richness	> .500	.060	yes	yes
189	Arachnids	Hydracarina	Water mite	Predators	River	Density	> .500	.060	yes	yes
189	Diptera	Chironomidae	Ridge family		River	Density	> .500	.060	yes	yes
189	Diptera	Tabanidae	Horsefly family		River	Density	> .500	.060	yes	yes
189	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	Density	> .500	.060	yes	yes
189	Renatodes	Renatode phylum			River	Density	> .500	.060	yes	yes
189	Oligochaeta	Annelid worm class		Collectors	River	Density	> .500	.060	yes	yes
189	Plecoptera	Stonely order			River	Density	> .500	.060	yes	yes
189	Trichoptera	Caddisfly order			River	Density	> .500	.060	yes	yes
ARIZONA										
FLOODING										
25			Biomass		River	Biomass	.170		yes	no
25			Genera richness		River	Genera richness	.170		yes	no
25			Species composition		River	Species composition	.170		-	-
CALIFORNIA										
CANALIZATION										
133			Biomass		River	Biomass	> 5.000	1.000	yes	yes
133			Density		River	Density	> 5.000		-	-
133	Diptera	Siaulidae	Blackfly family	Collectors	River	Density	> 5.000	1.000	yes	yes
133	Spheceroptera	Sphecerellidae	Mayfly family	Collectors	River	Density	> 5.000	1.000	yes	yes
133	Spheceroptera	Heptageniidae	Mayfly family	Collectors	River	Density	> 5.000	1.000	yes	yes
133	Oligochaeta	Annelid worm class		Collectors	River	Density	> 5.000	1.000	yes	yes
133	Plecoptera	Isoperla sp.	Stonely	Predators	River	Density	> 5.000	1.000	yes	yes
133	Plecoptera	Perlidae	Stonely family	Predators	River	Density	> 5.000	1.000	yes	yes
133	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	> 5.000	1.000	yes	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	System		Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source for recolonization
				Function	type					

CALIFORNIA										
CHEMICAL, OTHER										
6	Amphipoda	Talitridae	Scud family	Grazers	Lake	First appears	> .670		no	-
6	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.170		yes	-
7	Amphipoda	Talitridae	Scud family	Grazers	Lake	Density	> .170	.800	yes	-
8	Ephemeroptera	Caenidae	Mayfly family	Collectors	Lake	Density	.100		yes	-
9	Amphipoda	Talitridae	Scud family	Grazers	Lake	Density	> .310		yes	-
9	Ephemeroptera	Caenidae	Mayfly family	Collectors	Lake	Density	.130		-	-
48	Coleoptera	Dytiscidae	Diving beetle family	Predators	Pond	Density	> .100	.020	yes	-
48	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	Pond	Density	> .100	.020	yes	-
48	Ephemeroptera	Baetidae	Mayfly family	Collectors	Pond	Density	> .100	.020	no	-
48	Neoptera	Belostomatidae	Water bug family	Predators	Pond	Density	> .100	.020	yes	-
48	Neoptera	Corixidae	Water boatman family	Predators	Pond	Density	.080	.020	yes	-
48	Neoptera	Notonectidae	Backswimmer family	Predators	Pond	Density	> .100	.020	yes	-
48	Odonata	Coenagrionidae	Damselfly family	Predators	Pond	Density	.080	.020	no	-
49	Coleoptera	Dytiscidae	Diving beetle family	Predators	Pond	Density	> .100	.020	yes	-
49	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	Pond	Density	> .100	.020	yes	-
49	Ephemeroptera	Baetidae	Mayfly family	Collectors	Pond	Density	> .100	.020	no	-
49	Neoptera	Belostomatidae	Water bug family	Predators	Pond	Density	> .100	.020	yes	-
49	Neoptera	Corixidae	Water boatman family	Predators	Pond	Density	> .100	.020	yes	-
49	Neoptera	Notonectidae	Backswimmer family	Predators	Pond	Density	> .100	.020	yes	-
49	Odonata	Coenagrionidae	Damselfly family	Predators	Pond	Density	.100	.020	no	-
166	Amphipoda	Talitridae	Scud family	Grazers	Lake	Density	> .190	.800	no	-
166	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.040	.800	yes	-
167	Amphipoda	Talitridae	Scud family	Grazers	Lake	Density	> .170	.800	no	-
167	Amphipoda	Talitridae	Scud family	Grazers	Lake	First appears	.060	.800	no	-
167	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.120	.800	yes	-

CALIFORNIA										
CHEMICAL, ROTENONE										
21			Density	River		Density	.080	4.400	yes	yes
21	Diptera	Chironomidae	Midge family	River		First appears	.120	4.400	yes	yes
21	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.038	4.400	yes	yes
21	Ephemeroptera	Ephemeroptera	Mayfly order	River		First appears	.080	4.400	yes	yes
21	Plecoptera	Plecoptera	Stonefly order	River		Density	.500	4.400	yes	yes
21	Trichoptera	Trichoptera	Caddisfly order	River		First appears	.038	4.400	yes	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source for recolonization
CALIFORNIA										
DROUGHT										
162			Density		River	Density	< .250	0.000	no	yes
162			Species composition		River	Species composition	< .250	0.000	no	yes
162	Diptera	Diptera	Fly, mosquito, midge order		River	Density	< .250	.250	no	yes
162	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	< .250	.250	no	yes
162	Pelecypoda	Mollusca	Mollusk phylum	Grazers	River	Density	< .250	.250	no	yes
162	Plecoptera	Plecoptera	Stonefly order		River	Density	< .250	.250	no	yes
162	Trichoptera	Trichoptera	Caddisfly order		River	Density	< .250	.250	no	yes
CALIFORNIA										
SUSPENDED SOLIDS										
198			Density		River	Density	.120	1.000	yes	yes
COLORADO										
CHEMICAL, OTHER										
4	Diptera	Chironomidae	Midge family		Lake	Density	.750		yes	-
FLORIDA										
CHEMICAL, OTHER										
47	Diptera	Chironomidae	Midge family		Pond	Density	.330		yes	-
51	Diptera	Chironomidae	Midge family		Pond	Density	.150		yes	-
FLORIDA										
DREDGING										
33			Density		Lake	Density	.016		-	-
33			Genera richness		Lake	Genera richness	.016		-	-
33	Diptera	Chironomidae	Midge family		Lake	Density	.016	.001	-	yes
33	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	Lake	Density	.033	.001	-	yes
34			Density		Lake	Density	.033	.001	-	-
34			Genera richness		Lake	Genera richness	.033		-	-
34	Diptera	Chironomidae	Midge family		Lake	Density	.033	.001	-	yes
34	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	Lake	Density	.041	.001	-	yes
35			Density		Lake	Density	.025		-	-
35			Genera richness		Lake	Genera richness	.074		-	-
35	Diptera	Chironomidae	Midge family		Lake	Density	.056	.001	-	yes
35	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	Lake	Density	.074	.001	-	yes
GEORGIA										
CHEMICAL, DDT										
119			Density		River	Density	.330	.600	yes	no
119			Genera richness		River	Genera richness	.170	.600	-	-
119	Decapoda	Cambaridae	Crayfish family	Grazers	River	Density	.330	.600	yes	yes
119	Diptera	Chironomidae	Midge family		River	Density	.330	.600	no	no

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Forelga sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source for recolonization
GEORGIA										
CHEMICAL, DDT										
119	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.330	.600	yes	no
119	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.330	.600	yes	no
119	Ephemeroptera	Isonychia sp.	Mayfly	Collectors	River	Density	.330	.600	yes	no
119	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	.330	.600	yes	no
119	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	.290	.600	yes	no
119	Odonata	Aeshnidae	Damselfly family	Predators	River	Density	.330	.600	yes	no
119	Plecoptera	Alloperla sp.	Stonefly	Collectors	River	Density	.330	.600	yes	no
119	Plecoptera	Peltoperlidae	Stonefly family	Shredders	River	Density	.310	.600	yes	no
119	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	.330	.600	yes	no
119	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.330	.600	yes	no
119	Trichoptera	Limnephilidae	Caddisfly family	Shredders	River	Density	.330	.600	yes	no
IDARO										
DROUGHT										
137			Density	River	Density		1.000	15.000	no	yes
137			Functional grp prop	River	Functional grp prop		3.500	15.000	no	yes
137			Genera richness	River	Genera richness		1.200	15.000	no	yes
ILLINOIS										
CHEMICAL, OTHER										
180	Diptera	Chironomidae	Midge family	River	Density		.500	4.800	yes	yes
180	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		1.600		-	yes
180	Trichoptera	Trichoptera	Caddisfly order	River	Density		.700	4.800	yes	yes
ILLINOIS										
MULTIPLE DISTURBANCES										
43	Diptera	Chironomidae	Midge family	River	Density		.130		yes	yes
43	Gastropoda	Lymnaeidae	Pond snail family	Grassers	River	First appears	.500	5.100	yes	-
43	Gastropoda	Physidae	Pouch snail family	Grassers	River	First appears	.500	5.100	yes	-
MAINE										
CHEMICAL, DDT										
90			Density	River	Density		1.250	7.800	yes	no
90	Diptera	Chironomidae	Midge family	River	Density		.080	7.800	yes	no
90	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	7.800	no	no
90	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		1.000	7.800	yes	no
90	Plecoptera	Plecoptera	Stonefly order	River	Density		1.200	7.800	yes	no
90	Trichoptera	Trichoptera	Caddisfly order	River	Density		1.200	7.800	yes	no
97			Biomass	River	Biomass		.130		-	-
97			Genera richness	River	Genera richness		1.000		-	-
97	Diptera	Chironomidae	Midge family	River	Density		.130		yes	no

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance Persis. (km)	Unperturbed source for recolonization in sys. Upstream	Downstream
MAINE										
CHEMICAL, DDT										
97	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
97	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
97	Plecoptera	Plecoptera	Stonefly order		River	Density	1.000	no	no	yes
97	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.200	no	no	yes
98			Bionass		River	Bionass	1.200	-	-	-
98			Genera richness		River	Genera richness	1.100	-	-	-
98	Diptera	Chironomidae	Hidge family		River	Density	1.000	yes	no	yes
98	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
98	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	no	no	yes
98	Ephemeroptera	Ephemeroptera	Mayfly order		River	First appears	.130	no	no	yes
98	Plecoptera	Plecoptera	Stonefly order		River	Density	> 1.200	no	no	yes
98	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.200	no	no	yes
98	Trichoptera	Trichoptera	Caddisfly order		River	First appears	1.100	no	no	yes
99			Bionass		River	Bionass	1.000	-	-	-
99			Genera richness		River	Genera richness	1.000	-	-	-
99	Diptera	Chironomidae	Hidge family		River	Density	.130	yes	no	yes
99	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
99	Plecoptera	Plecoptera	Stonefly order		River	Density	1.200	yes	no	yes
99	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.200	yes	no	yes
100	Diptera	Chironomidae	Hidge family		River	Density	.020	yes	no	yes
100	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	no	no	yes
100	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
100	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.000	yes	no	yes
101			Bionass		River	Bionass	1.000	-	-	-
101			Genera richness		River	Genera richness	1.000	-	-	-
101	Diptera	Chironomidae	Hidge family		River	Density	.130	yes	no	yes
101	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	no	no	yes
101	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
101	Plecoptera	Plecoptera	Stonefly order		River	Density	1.000	no	no	yes
101	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.200	no	no	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source for recolonization
									Upstream	Downstream
MAINE										
CHEMICAL, OTHER										
205			Density		Pond	Density	2.300	-	-	-
205	Aphlopoda	Gammaridae	Scud family	Collectors	Pond	Density	> 2.400	-	-	-
205	Odonata		Dragonfly and damselfly order	Predators	Pond	Density	> 2.400	-	-	-
206	Plecoptera	Leuctridae	Stonelfy family	Shredders	River	Density	> 4.000	yes	no	-
206	Plecoptera	Leuctridae	Stonelfy family	Shredders	River	Density	> 4.000	yes	yes	-
206	Plecoptera	Mesouridae	Stonelfy family	Shredders	River	Density	> 4.000	yes	no	-
206	Plecoptera	Mesouridae	Stonelfy family	Shredders	River	Density	> 4.000	yes	yes	-
206	Plecoptera		Stonelfy order		River	Density	> 4.000	yes	no	-
206	Plecoptera		Stonelfy order		River	Density	> 4.000	yes	yes	-
207	Ephemeroptera		Mayfly order		River	Density	< 1.000	yes	-	-
208			Density		River	Density	1.000	yes	-	-
208			Genera richness		River	Genera richness	1.000	yes	-	-
208	Diptera		Fly, mosquito, midge order		River	Density	< 1.000	yes	-	-
208	Diptera	Microtendipes	Nidge		River	Density	.160	yes	-	-
208	Ephemeroptera		Mayfly order		River	Density	< 1.000	yes	-	-
208	Trichoptera		Caddisfly order		River	Density	.500	yes	-	-
209	Diptera	Microtendipes	Nidge		River	Density	.160	yes	-	-
MAINE.										
MULTIPLE DISTURBANCES										
191	Diptera	Chaoboridae	Phantom midge family	Predators	Pond	Density	2.800	yes	-	-
MICHIGAN										
CHEMICAL, OTHER										
61	Gastropoda	Ballotia sp.	Black abalone	Grazers	River	Density	> 1.000	2.400	yes	no
61	Trichoptera	Phryganeidae	Caddisfly family		River	Density	> 1.000	2.400	yes	no
61	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	> 1.000	2.400	yes	no
62			Density		River	Density	.120	1.600	yes	no
62	Diptera	Chironomidae	Nidge family		River	Density	.120	1.600	yes	no
63			Density		River	Density	.120	31.000	yes	no
63	Coleoptera	Elmidae	Riffle beetle family	Collectors	River	Density	1.000	31.000	yes	no
MINNESOTA										
FLOODING										
68	Aphlopoda	Gammaridae	Scud family	Collectors	River	Density	.500	3.000	yes	no

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source for recolonization	Downstream
MINNESOTA											
ORGANISM REMOVAL (NON CHEM)											
74	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.011	.000	yes	yes	yes
74	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.027	.000	yes	yes	yes
75	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.003	.000	yes	yes	yes
75	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.011	.000	yes	yes	yes
MISSISSIPPI											
CHANNELIZATION											
58			Biomass	River	Biomass		> 52.000	39.000	-	yes	yes
58			Density	River	Density		> 52.000	39.000	-	yes	yes
58			Genera richness	River	Genera richness		> 52.000	39.000	-	yes	yes
MISSISSIPPI											
OXYGEN STRESS											
29			Species composition	Lake	Species composition		> 1.700	-	-	yes	yes
29	Ephemeroptera	Ephemeridae	Mayfly family	Collectors	Lake	Density	> 1.700	-	-	yes	yes
MISSOURI											
SUSPENDED SOLIDS											
117			Density	River	Density		> 1.000	1.300	yes	yes	yes
117			Genera richness	River	Genera richness		> 1.000	1.300	yes	yes	yes
117			Species composition	River	Species composition		> 1.000	1.300	yes	yes	yes
118			Density	River	Density		> .900	7.400	yes	yes	yes
118			Genera richness	River	Genera richness		> .900	7.400	yes	yes	yes
118			Species composition	River	Species composition		> .900	7.400	yes	yes	yes
201			Density	River	Density		.300	1.600	yes	yes	yes
201			Species composition	River	Species composition		.100	1.600	yes	yes	yes
203			Species composition	River	Species composition		.900	4.800	yes	yes	yes
203	Decapoda	Cambaridae	Crayfish family	Grazers	River	Density	> 1.000	4.800	yes	yes	yes
203	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
203	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
203	Ephemeroptera	Isoneurinae sp.	Mayfly	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
203	Ephemeroptera	Stenocranus sp.	Mayfly	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
203	Ephemeroptera	Stenocranus sp.	Mayfly	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
203	Megaloptera	Corydalidae	Dobsonfly family	Predators	River	Density	> 1.000	4.800	yes	yes	yes
203	Rotifera	Rotifera	Rotifer phylum	Grazers	River	Density	> 1.000	4.800	yes	yes	yes
203	Trichoptera	Philopotamidae	Caddisfly family	Collectors	River	Density	> 1.000	4.800	yes	yes	yes
MONTANA											
CHEMICAL, DDY											
80			Species composition	River	Species composition		> 4.000	yes	yes	no	-
80	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		3.000	yes	yes	no	-

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	(yrs)	(km)	in sys.	Upstream	Downstream

MONTANA											
CHEMICAL, DOY											
80	Plecoptera	Plecoptera	Stonefly order	Collectors	River	Density	3.000	yes	no	-	-
80	Trichoptera	Leptoceridae	Caddisfly family		River	First appears	> 4.000	no	no	-	-
80	Trichoptera	Trichoptera	Caddisfly order		River	Density	2.000	yes	no	-	-
81			Species composition		River	Species composition	> 4.000	yes	no	-	-
81	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density	2.000	yes	yes	no	-	-
81	Plecoptera	Plecoptera	Stonefly order	River	Density	1.000	yes	yes	no	-	-
81	Trichoptera	Trichoptera	Caddisfly order	River	Density	3.000	yes	yes	no	-	-
174			Biomass	River	Biomass	> 1.200	-	-	-	-	-
174			Density	River	Density	> 1.250	-	-	-	-	-
181			Biomass	River	Biomass	1.000	6.400	yes	yes	yes	yes
181			Species composition	River	Species composition	1.170	6.400	yes	yes	yes	yes
182			Biomass	River	Biomass	> 1.200	6.400	yes	yes	yes	yes
185			Biomass	River	Biomass	> 1.250	-	-	-	-	-
185			Density	River	Density	1.080	-	-	-	-	-
185	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density	1.000	-	-	-	-	-
185	Trichoptera	Trichoptera	Caddisfly order	River	Density	> 1.250	-	-	-	-	-
186			Density	River	Density	.400	.080	no	yes	yes	yes
186			Density	River	Density	1.400	.400	no	yes	yes	yes
186			Species composition	River	Species composition	1.500	3.200	no	yes	yes	yes
186	Coleoptera	Coleoptera	Beetle order	River	Density	1.400	.080	no	yes	yes	yes
186	Coleoptera	Coleoptera	Beetle order	River	First appears	1.000	1.600	no	yes	yes	yes
186	Coleoptera	Coleoptera	Beetle order	River	First appears	1.330	3.200	no	yes	yes	yes
186	Diptera	Diptera	Fly, mosquito, sidge order	River	Density	.080	4.800	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density	.410	.400	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density	< 1.000	1.200	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	First appears	.040	.010	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	First appears	.080	.080	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	First appears	.250	.400	no	yes	yes	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	First appears	.410	4.800	no	yes	yes	yes
186	Plecoptera	Plecoptera	Stonefly order	River	Density	1.000	.080	no	yes	yes	yes
186	Plecoptera	Plecoptera	Stonefly order	River	First appears	.910	4.800	no	yes	yes	yes
186	Trichoptera	Trichoptera	Caddisfly order	River	Density	1.400	.080	no	yes	yes	yes
186	Trichoptera	Trichoptera	Caddisfly order	River	First appears	.910	4.800	no	yes	yes	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persists in sys.	Unperturbed source for recolonization
MONTANA										
Mining Activity										
84			Biomass	River	Biomass		> 10,000	1,500	no	yes
84			Density	River	Density		> 10,000	1,500	no	yes
84			Genera richness	River	Genera richness		> 10,000	1,500	no	yes
84			Productivity	River	Productivity		> 10,000	1,500	no	yes
84			Species composition	River	Species composition		> 10,000	1,500	no	yes
84	Coleoptera		Beetle order	River	Density		> 10,000	1,500	no	yes
84	Coleoptera	Elmidae	Rifle beetle family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Diptera	Anocha sp.	Cranefly	Collectors	River	Density	> 10,000	1,500	no	yes
84	Diptera	Cricotopus sp.	Hedge	Shredders	River	Density	8,000	1,500	no	yes
84	Diptera	Damesinae	Hedge subfamily	Collectors	River	Density	8,000	1,500	no	yes
84	Diptera	Diptera	Fly, mosquito, aldrige order	River	Density		8,000	1,500	no	yes
84	Diptera	Epididae	Dancefly family	Predators	River	Density	8,000	1,500	no	yes
84	Diptera	Epididae	Dancefly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Diptera	Hexatoma sp.	Cranefly	Predators	River	Density	> 10,000	1,500	no	yes
84	Diptera	Microspectra sp.	Hedge	Collectors	River	Density	> 10,000	1,500	no	yes
84	Diptera	Orthocladus sp.	Hedge	Collectors	River	Density	8,000	1,500	no	yes
84	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Diptera	Thienemannimyia	Hedge	Predators	River	Density	8,000	1,500	no	yes
84	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Claytonia sp.	Mayfly	Grazers	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Ephemeroptera	Mayfly order	Collectors	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Rhythrogena sp.	Mayfly	Collectors	River	Density	> 10,000	1,500	no	yes
84	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	> 10,000	1,500	no	yes
84	Oligochaeta	Tubificidae	Oligochaete family	Collectors	River	Density	8,000	1,500	no	yes
84	Plecoptera	Capniidae	Stonefly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Chloroperlidae	Stonefly family	River	Density		> 10,000	1,500	no	yes
84	Plecoptera	Hexuridae	Stonefly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Plecoptera	Stonefly order	Predators	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Plecoptera	Stonefly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	Density	8,000	1,500	no	yes
84	Trichoptera	Glossosomatidae	Caddisfly family	Grazers	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	8,000	1,500	no	yes
84	Trichoptera	Hydropsychidae	Caddisfly family	Grazers	River	Density	> 10,000	1,500	no	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Perturb source in sys.	Upstream	Downstream
MONTANA											
MINING ACTIVITY											
84	Trichoptera	Lepidostomatidae	Caddisfly family	Shredders	River	Density	> 10,000	1,500	no	no	yes
84	Trichoptera	Rhyacophilidae	Caddisfly family	Predators	River	Density	> 10,000	1,500	no	no	yes
84	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 10,000	1,500	no	no	yes
NEW MEXICO											
FLOODING											
125			Biomass		River	Biomass	1,000	.250	yes	yes	yes
125			Density		River	Density	1,000	.250	yes	yes	yes
125			Genera richness		River	Genera richness	1,000	.250	yes	yes	yes
125	Coleoptera		Beetle order		River	Density	> 2,000	.250	yes	yes	yes
125	Diptera		Fly, mosquito, midge order		River	Density	.170	.250	yes	yes	yes
125	Ephemeroptera		Mayfly order		River	Density	.850	.250	yes	yes	yes
125	Plecoptera		Stonefly order		River	Density	.850	.250	yes	yes	yes
125	Trichoptera		Caddisfly order		River	Density	1,000	.250	yes	yes	yes
NORTH CAROLINA											
CHEMICAL, OTHER											
144			Biomass		River	Biomass	2,250	.068	yes	no	yes
144			Density		River	Density	.320	.068	yes	no	yes
144			Functional grp prop		River	Functional grp prop	2,000	.068	yes	no	yes
144			Species composition		River	Species composition	> 2,000	.068	yes	no	yes
144	Collembola		Springtail	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Diptera		Dixa midge family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Diptera		Cranefly	Predators	River	Density	> 2,000	.068	-	no	yes
144	Diptera		Blackfly family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Ephemeroptera		Mayfly family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Ephemeroptera		Mayfly family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Ephemeroptera		Mayfly family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Plecoptera		Mayfly family	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Plecoptera		Stonemason sp.	Collectors	River	Density	> 2,000	.068	-	no	yes
144	Plecoptera		Leuctridae	Shredders	River	Density	> 2,000	.068	-	no	yes
144	Plecoptera		Perlidae	Predators	River	Density	> 2,000	.068	-	no	yes
144	Trichoptera		Blanchellidae	Shredders	River	Density	> 2,000	.068	-	no	yes
144	Trichoptera		Rhyacophilidae	Predators	River	Density	> 2,000	.068	-	no	yes
144	Trichoptera		Caddisfly family	Shredders	River	Density	> 2,000	.068	-	no	yes
144	Trichoptera		Caddisfly family	Shredders	River	Density	> 2,000	.068	-	no	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Upstream	Unperturbed source for recolonization
NORTH CAROLINA											
TIMBER ACTIVITIES											
70			Bionass		River	Bionass	> 5.000	.100	yes	yes	yes
70			Density		River	Density	> 5.000	.100	yes	yes	yes
70			Genera richness		River	Genera richness	< 5.000	.100	yes	yes	yes
193			Bionass		River	Bionass	> 15.000		yes	no	yes
193			Productivity		River	Productivity	> 15.000		yes	no	yes
193					River	First appears	> 25.000		no	no	yes
193			Biting ridge family		River	Density	> 20.000		yes	no	yes
193	Diptera	Ceratopogonidae	Fly	Predators	River	Density	> 20.000		yes	no	yes
193	Diptera	Dicranota sp.	Cranefly	Predators	River	Density	> 20.000		yes	no	yes
193	Diptera	Hexatoma sp.	Mayfly family	Collectors	River	Density	> 20.000		yes	no	yes
193	Ephemeroptera	Leptophlebiidae	Stonelfy	Collectors	River	Density	> 20.000		yes	no	yes
193	Plecoptera	Alloperla sp.	Stonelfy family	Shredders	River	Density	> 20.000		yes	no	yes
193	Plecoptera	Leuctridae	Stonelfy family	Shredders	River	Density	> 20.000		yes	no	yes
193	Plecoptera	Peltoperlidae	Stonelfy family	Shredders	River	Density	> 20.000		yes	no	yes
193	Plecoptera	Philopotanidae	Caddisfly family	Collectors	River	Density	> 20.000		yes	no	yes
193	Trichoptera	Rhyacophilidae	Caddisfly family	Predators	River	Density	> 20.000		yes	no	yes
OHIO											
CHANNELIZATION											
132			Bionass		River	Bionass	> 25.000		yes	yes	yes
132			Density		River	Density	> 25.000		yes	yes	yes
132			Genera richness		River	Genera richness	> 25.000		yes	yes	yes
132			Rifle beetle family		Collectors	River	> 25.000		yes	yes	yes
132	Coleoptera	Elmidae	Beetle family		River	Density	> 25.000		yes	yes	yes
132	Coleoptera	Peptenidae	Mayfly family		Collectors	River	> 25.000		yes	yes	yes
132	Coleoptera	Heptageniidae	Caddisfly family		Collectors	River	> 25.000		yes	yes	yes
132	Ephemeroptera				Collectors	River	> 25.000		yes	yes	yes
132	Trichoptera	Hydropsychidae			Collectors	River	> 25.000		yes	yes	yes
DROUGHT											
OHIO											
44			Bionass		River	Bionass	< 1.000	31.000	-	no	yes
44			Density		River	Density	< 1.000	31.000	-	no	yes
44			Genera richness		River	Genera richness	1.000	31.000	-	no	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. in sys.	Unperturbed source
										Upstream
										Downstream
OHIO										
HABITAT DEVELOPMENT										
184			Biomass	River	Biomass		< 5,000	1,000	-	yes
184			Density	River	Density		< 5,000	1,000	-	yes
184			Genera richness	River	Genera richness		< 5,000	1,000	-	yes
PENNSYLVANIA										
CHEMICAL, DDT										
122			Density	River	Density		.300	3,200	yes	no
122			Genera richness	River	Genera richness		1,250	3,200	yes	no
122	Coleoptera	Elmidae	Riffle beetle family	Collectors	River	Density	1,330	3,200	-	no
122	Diptera	Chaoboridae	Phantom midge family	Predators	River	Density	1,330	3,200	-	no
122	Diptera	Chironomidae	Hidge family	River	Density		.210	3,200	-	no
122	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1,330	3,200	-	no
122	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1,330	3,200	-	no
122	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	Density	1,330	3,200	-	no
122	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.330	3,200	-	no
122	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	1,330	3,200	-	no
122	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	1,330	3,200	-	no
122	Plecoptera	Nesuridae	Stonefly family	Shredders	River	Density	1,000	3,200	-	no
122	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	1,330	3,200	-	no
122	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1,330	3,200	-	no
122	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	First appears	1,330	3,200	no	no
122	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	1,330	3,200	-	no
122	Trichoptera	Hyacophillidae	Caddisfly family	Predators	River	Density	1,330	3,200	-	no
160			Density	River	Density		1,000		yes	yes
160	Diptera	Chironomidae	Hidge family	River	Density		.300		yes	yes
160	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1,300		no	yes
160	Diptera	Tipulidae	Cranefly family	River	Density		1,300		yes	yes
160	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1,300		yes	yes
160	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	Density	1,000		yes	yes
160	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.300		yes	yes
160	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	1,300		yes	yes
160	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	1,300		no	yes
160	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1,300		yes	yes
160	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	First appears	1,300		no	yes
160	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	1,300		yes	yes
160	Trichoptera	Hyacophillidae	Caddisfly family	Predators	River	Density	.300		yes	yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance to refugia (km)	Persis. in sys.	Unperturbed source for recolonization
PENNSYLVANIA										
DROUGHT										
170	Diptera	Chironomidae	Ridge family		River	First appears	.030	.010	no	-
170	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.014	.010	no	-
170	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.014	.010	no	-
170	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	First appears	.093	.010	no	-
170	Trichoptera	Trichoptera	Caddisfly order		River	First appears	.014	.010	no	-
PENNSYLVANIA										
FLOODING										
95			Biomass		River	Biomass	.330	-	-	-
95			Density		River	Density	.330		yes	no
95			Genera richness		River	Genera richness	.330		yes	no
95	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.330		yes	no
95	Decapoda	Asellidae	Crayfish family	Collectors	River	First appears	.330		no	no
95	Diptera	Chironomidae	Ridge family	Collectors	River	Density	.330		yes	no
95	Diptera	Simuliidae	Blackfly family	Collectors	River	First appears	.330		no	no
95	Diptera	Tabanidae	Horsefly family	Collectors	River	First appears	.330		no	no
95	Diptera	Tipulidae	Cranefly family		River	First appears	.330		no	no
95	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.120		yes	no
95	Ephemeroptera	Speorus sp.	Mayfly	Collectors	River	Density	.330		yes	no
95	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.330		yes	no
95	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	Density	.330		yes	no
95	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	.330		yes	no
95	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	.120		yes	no
95	Plecoptera	Hexuridae	Stoneworm family	Shredders	River	Density	.120		yes	no
95	Plecoptera	Perlidae	Stoneworm family	Predators	River	Density	.120		yes	no
95	Plecoptera	Pteronarcidae	Stoneworm family	Shredders	River	Density	.330		yes	no
95	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.330		yes	no
95	Trichoptera	Phlebotanidae	Caddisfly family	Collectors	River	Density	.330		yes	no
95	Trichoptera	Rhyacophilidae	Caddisfly family	Predators	River	Density	.330		yes	no
SOUTH DAKOTA										
CHEMICAL, OTHER										
109			Density		River	Density	.500		-	-
109			Genera richness		River	Genera richness	1.000		-	-
109			Species composition		River	Species composition	1.000	1.000	yes	no
109	Diptera	Orthocladus sp.	Ridge	Collectors	River	Density	.500	1.000	yes	no
109	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	1.000	yes	no
109	Plecoptera	Plecoptera	Stoneworm order		River	Density	2.500	1.000	yes	no
109	Trichoptera	Helicopsychidae	Caddisfly family	Grazers	River	First appears	.500	.500	yes	no

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance to refugia species (km)	Perturbed source
SOUTH DAKOTA									
CHEMICAL, OTHER									
109	Trichoptera	Oecetis sp.	Caddisfly	Predators	River	First appears	.500	.500	yes
109	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.000	1.000	yes
TENNESSEE									
CHEMICAL, ROTENONE									
93			Density		River	Density	< 1.000		yes
93	Diptera	Diptera	Fly, mosquito, midge order		River	Density	< 1.000		yes
93	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	< 1.000		yes
93	Emiptera	Emiptera	Waterbug order	Predators	River	Density	< 1.000		yes
93	Isopoda	Isopoda	Sorbug order	Collectors	River	Density	> 1.000		yes
93	Neuroptera	Neuroptera	Spongillafly order	Predators	River	Density	< 1.000		yes
93	Trichoptera	Trichoptera	Caddisfly order		River	Density	< 1.000		yes
TENNESSEE									
MINING ACTIVITY									
69			Density		River	Density	22.000		yes
69			Genera richness		River	Genera richness	22.000		yes
69			Species composition		River	Species composition	> 20.000		yes
69	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	18.000		yes
69	Plecoptera	Plecoptera	Stonefly order		River	Density	8.000		yes
TEXAS									
CHEMICAL, OTHER									
83			Species composition		River	Species composition	> 2.200		yes
83	Coleoptera	Dytiscidae	Diving beetle family	Predators	River	First appears	2.200		no
83	Diptera	Chironomidae	Midge family		River	Density	2.200		no
83	Diptera	Tribelos sp.	Midge	Grazers	River	First appears	1.300		no
83	Odonata	Coenagrionidae	Danselfly family	Predators	River	First appears	2.200		no
83	Oligochaeta	Malldae	Oligochaete family		River	First appears	1.300		no
83	Pelecypoda	Sphaeriidae	Clam family	Collectors	River	First appears	2.200		no
UTAH									
FLOODING									
192			Density		River	Density	.250		yes
192	Diptera	Chironomidae	Midge family		River	Density	.250		yes
192	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.250		yes

(continued) Table 17. Recovery times for acroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Disturbance	Upstream	Downstream
UTAH											
MULTIPLE DISTURBANCES											
151			Bionass		River	Bionass	.580	-	-	-	-
151			Density		River	Density	.580	yes	yes	yes	yes
151	Diptera		Fly, mosquito, aldrge order		River	Density	.580	yes	yes	yes	yes
151	Spheceroptera		Mayfly order		River	Density	.580	yes	yes	yes	yes
151	Plecoptera		Stonelfy order		River	Density	.580	yes	yes	yes	yes
151	Trichoptera		Caddisfly order		River	Density	.580	yes	yes	yes	yes
VIRGINIA											
CHEMICAL, ACID											
24			Density		River	Density	.080	.010	yes	yes	yes
WEST VIRGINIA											
CHEMICAL, DDT											
120	Trichoptera		Caddisfly family		Collectors	River Density	1.000	.720	yes	yes	yes
WISCONSIN											
CHEMICAL, OTHER											
60			Density		River	Density	.020	1.200	yes	yes	no
60	Trichoptera		Caddisfly family		Collectors	River Density	.120	1.200	yes	yes	no
124			Bionass		River	Bionass	.170	2.900	yes	no	yes
124	Aphipoda		Scud family		Collectors	River Density	.150	2.900	yes	no	yes
124	Diptera		Cranfly		Collectors	River Density	2.000	2.900	yes	no	yes
124	Diptera		Nidge faatly		Collectors	River Density	.170	2.900	yes	no	yes
124	Diptera		Blackfly family		Collectors	River Density	.250	2.900	yes	no	yes
124	Spheceroptera		Mayfly family		Collectors	River Density	.442	2.900	yes	no	yes
124	Trichoptera		Caddisfly family		Collectors	River Density	2.000	2.900	yes	no	yes
124	Trichoptera		Caddisfly family		Collectors	River Density	1.000	2.900	yes	no	yes
187			Density		River	Density	.600	1.100	yes	no	yes
187	Aphipoda		Scud family		Collectors	River Density	1.800	1.100	yes	no	yes
187	Diptera		Cranfly		Collectors	River Density	.900	1.100	yes	no	yes
187	Spheceroptera		Mayfly family		Collectors	River Density	.700	1.100	yes	no	yes
187	Spheceroptera		Mayfly		Collectors	River Density	.600	1.100	yes	no	yes
187	Plecoptera		Stonelfy family		Predators	River Density	.750	1.100	no	no	yes
187	Trichoptera		Caddisfly family		Collectors	River Density	2.100	1.100	yes	no	yes
187	Trichoptera		Caddisfly family		Grassers	River Density	.600	1.100	yes	no	yes
187	Trichoptera		Caddisfly family		Grassers	River Density	.600	1.100	yes	no	yes
187	Trichoptera		Caddisfly family		Collectors	River Density	.830	1.100	yes	no	yes
187	Trichoptera		Caddisfly family		Grassers	River Density	.600	1.100	yes	no	yes
188	Diptera		Phantom aldrge family		Predators	Lake Density	4.300	.400	no	-	-

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs) (km)	Persia. Unperturbed source in sys. Upstream Downstream
NYONG								
CHEMICAL, POTENTI								
15	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors River	River	First appears	1.000 92.000	yes no
15	Ephemeroptera	Baithrogena sp.	Mayfly	Collectors River	River	First appears	1.000 92.000	yes no
15	Ephemeroptera	Tricorythidae	Mayfly family	Collectors River	River	Density	1.200 92.000	yes no
15	Ephemeroptera	Tricorythidae	Mayfly family	Collectors River	River	First appears	1.000 92.000	yes no
15	Gastropoda	Gastropoda	Snails, limpets class	Grazers River	River	First appears	.040 92.000	yes no
15	Gastropoda	Lymnaeidae	Pond snail family	Grazers River	River	First appears	.040 92.000	yes no
15	Birudinea	Birudinea	Leech class	River	River	First appears	1.000 92.000	yes no
15	Renatodes	Renatodes	Renatode phylum	River	River	First appears	1.000 92.000	yes no
15	Odonata	Gomphidae	Dragonfly family	Predators River	River	First appears	.040 92.000	yes no
15	Oligochaeta	Oligochaeta	Annelid worm class	Collectors River	River	First appears	1.000 92.000	yes no
15	Oligochaeta	Tubificidae	Oligochaete family	Collectors River	River	First appears	.170 92.000	yes no
15	Plecoptera	Perlidae	Stonefly family	Predators River	River	First appears	1.000 92.000	yes no
15	Plecoptera	Pteronarcidae	Stonefly family	Predators River	River	First appears	1.000 92.000	yes no
15	Plecoptera	Brachycentridae	Stonefly family	Predators River	River	First appears	1.000 92.000	yes no
15	Trichoptera	Glossosomatidae	Caddisfly family	Shredders River	River	First appears	1.000 92.000	yes no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors River	River	First appears	1.000 92.000	yes no
15	Trichoptera	Hydropsychidae	Caddisfly family	Grazers River	River	First appears	1.000 92.000	yes no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors River	River	Density	2.000 92.000	yes no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors River	River	First appears	1.700 92.000	yes no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors River	River	First appears	2.000 92.000	yes no
15	Trichoptera	Leptoceridae	Caddisfly family	Collectors River	River	First appears	1.000 92.000	yes no
16			Bioness	River	Bioness		.900 180.000	yes no
16			Density	River	Density		1.000 185.000	yes no
16			Genera richness	River	Genera richness		1.000 185.000	yes no
16				River	First appears		2.000 180.000	yes no
16	Colleptera	Pallaganiidae	Water scavenger beetle family	Collectors River	River	First appears	1.700 185.000	yes no
16	Diptera	Chironomidae	Wedge family	River	River	First appears	.170 180.000	yes no
16	Ephemeroptera	Baithidae	Mayfly family	Collectors River	River	First appears	.670 210.000	yes no
16	Ephemeroptera	Caenidae	Mayfly family	Collectors River	River	First appears	1.000 185.000	yes no
16	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors River	River	First appears	1.000 185.000	yes no
16	Ephemeroptera	Ephemeridae	Mayfly family	Collectors River	River	First appears	2.000 210.000	yes no
16	Ephemeroptera	Leptagala sp.	Mayfly	Grazers River	River	Density	1.000 185.000	yes no
16	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors River	River	Density	2.000 185.000	yes no
16	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors River	River	First appears	1.000 185.000	yes no
16	Ephemeroptera	Polytaenidae	Mayfly family	Collectors River	River	Density	1.700 210.000	yes no
16	Ephemeroptera	Polytaenidae	Mayfly family	Collectors River	River	First appears	1.000 210.000	yes no
16	Ephemeroptera	Baithrogena sp.	Mayfly	Collectors River	River	First appears	1.000 185.000	yes no
16	Ephemeroptera	Tricorythidae	Mayfly family	Collectors River	River	Density	1.000 185.000	yes no

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. (km)	Unperturbed source for recolonization in sys. Downstream
WYOMING									
CHEMICAL, ROTENONE									
16	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	185.000	yes
16	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	.040	180.000	yes
16	Oligochaeta	Tubificidae	Oligochaete family	Collectors	River	First appears	.170	180.000	yes
16	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	185.000	yes
16	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	185.000	yes
16	Trichoptera	Glossosomatidae	Caddisfly family	Grazers	River	First appears	2.000	180.000	yes
16	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	210.000	yes
16	Trichoptera	Leptoceridae	Caddisfly family	Collectors	River	First appears	1.250	185.000	yes
17			Blonass	River	Blonass		.080	18.000	-
17			Density	River	Density		.170		yes
17			Genera richness	River	Genera richness		1.000		yes
17	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	River	First appears	1.000	16.000	no
17	Diptera	Danellidae	Dancefly family	Predators	River	First appears	2.000	16.000	yes
17	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.800	16.000	no
17	Diptera	Tipulidae	Cranefly family	River	First appears		1.000	16.000	yes
17	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.250	16.000	-
17	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.070	16.000	-
17	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	First appears	.070	16.000	yes
17	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	First appears	1.000	16.000	no
17	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	16.000	no
17	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	First appears	1.250	16.000	yes
17	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	16.000	no
17	Plecoptera	Pteronarcidae	Stonefly family	Shredders	River	First appears	1.000	16.000	yes
17	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	First appears	1.700	16.000	yes
17	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	16.000	yes
17	Trichoptera	Leptostomatidae	Caddisfly family	Shredders	River	First appears	1.000	16.000	yes
DROUGHT									
22			Density	River	Density		.210	.300	yes
22			Genera richness	River	Genera richness		.270	.300	yes
22			Functional group	Collectors	River	Density	.380	.300	yes
22	collectors-gatherers	filters	Functional group	Collectors	River	Density	.380	.300	yes
22			Functional group	Predators	River	Density	1.100	.300	yes
22			Functional group	Grazers	River	Density	.820	.300	yes
22			Widge family	River	Density		.040	.300	yes
22	Diptera	Chironomidae	Blackfly family	Collectors	River	Density	.120	.300	yes
22	Diptera	Simuliidae	Mayfly family	Collectors	River	Density	.080	.300	yes
22	Ephemeroptera	Baetidae		Collectors	River	Density			yes

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Perils in sys.	Unperturbed source
WYOMING										
DROUGHT										
22	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.120	.300	no	yes
22	Ephemeroptera	Nittitropena sp.	Mayfly	Collectors	River	Density	.190	.300	no	yes
22	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	.120	.300	no	yes
22	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	Density	.350	.300	no	yes
22	Plecoptera	Alloperla sp.	Stonefly	Collectors	River	Density	.120	.300	no	yes
22	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	.120	.300	no	yes
22	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.120	.300	no	yes
ALBERTA										
CHEMICAL, ROTENONE										
10	Nirudinea	Nirudinea	Leech class	Late	Density		< 2,000		yes	-
11	Gastropoda	Gastropoda	Snails, limpets class	Late	Density		< 2,000		yes	-
BRITISH COLUMBIA										
DREDGING										
110			Density	River	Density		1,000	.010	yes	yes
110			Genera richness	River	Genera richness		1,000	.010	yes	yes
110	Ephemeroptera	Betidae	Mayfly family	Collectors	River	Density	2,000	.010	yes	yes
110	Ephemeroptera	Cinygula sp.	Mayfly	Grazers	River	Density	.800	.010	yes	yes
110	Ephemeroptera	Isonema sp.	Mayfly	Collectors	River	Density	.800	.010	yes	yes
110	Plecoptera	Alloperla sp.	Stonefly	Collectors	River	Density	2,200	.010	yes	yes
110	Plecoptera	Capniidae	Stonefly family	Shredders	River	Density	.100	.010	yes	yes
110	Trichoptera	Rhyacophyllidae	Caddisfly family	Predators	River	Density	.800	.010	yes	yes
ENGLAND										
CHEMICAL, ALLIUMINE										
134			Density	River	Density		1,400		-	-
134	Anphipoda	Gammaridae	Scud family	Collectors	River	Density	1,250	2,000	yes	no
134	Coleoptera	Coleoptera	Beetle order	Predators	River	First appears	1,250	2,000	yes	no
134	Odonata	Coenagrionidae	Damselfly family	Predators	River	First appears	1,800	2,000	yes	no
134	Rotifera	Rotifera	Rotifer phylum	Grazers	River	Density	1,250	2,000	yes	no
134	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.420	2,000	yes	no
134	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	.500	2,000	yes	no
134	Trichoptera	Leptoceridae	Caddisfly family	Collectors	River	First appears	.500	2,000	yes	no
134	Turbellarians	Platyhelminthes	Flatworm division	River	First appears		1,400	2,000	yes	no

Time to Distance Persia. Unperturbed source
recover to refugia species for recolonization
(yrs) (km) in yrs. Upstream Downstream

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	(yrs)	(km)	in yrs.	Upstream	Downstream
ENGLAND											
DROFCING											
96			Bioness		River	Bioness	1.100	.050	no	yes	yes
96			Density		River	Density	.800	.050	no	yes	yes
96	Gastropoda		Snails, limpets class		River	Density	1.000	.050	no	yes	yes
96	Oligochaeta		Anellid worm class		Collectors	Density	1.000	.050	no	yes	yes
202			Genera richness		River	Genera richness	.500	.200	yes	yes	yes
202		Silo algricorals			River	Density	.400	.200	yes	yes	yes
202	Asphipoda	Gammaridae	Scud family		Collectors	Density	.010	.200	yes	yes	yes
202	Gastropoda	Potamopyrgus sp.	Snail		Grassers	Density	.400	.200	yes	yes	yes
202	Oligochaeta		Anellid worm class		Collectors	Density	.400	.200	yes	yes	yes
FRANCE											
SUSPENDED SOLIDS											
135	Asphipoda	Gammaridae	Scud family		Collectors	River Density	1.000	-	yes	yes	.yes
JAPAN											
MULTIPLE DISTURBANCES											
115			Genera richness		River	Genera richness	.600	1.600	-	-	-
115	Diptera	Chironomidae	Ridge family		River	First appears	.330	1.600	yes	yes	yes
115	Ephemeroptera	Baetidae	Mayfly family		Collectors	River First appears	.330	1.600	yes	yes	yes
115	Ephemeroptera	Isonychia sp.	Mayfly		Collectors	River First appears	.600	1.600	yes	yes	yes
115	Ephemeroptera	Ephemerellidae	Mayfly family		Collectors	River First appears	1.000	1.600	yes	yes	yes
115	Trichoptera	Hydropsychidae	Caddisfly family		Collectors	River First appears	.600	1.600	yes	yes	yes
NEW BRUNSWICK											
CHEMICAL, DDT											
85			Bioness		River	Bioness	.080	-	-	-	-
85			Density		River	Density	3.000	-	-	-	-
85			Genera richness		River	Genera richness	3.000	-	-	-	-
85	Diptera	Chironomidae	Ridge family		River	Density	.080	-	no	no	no
85	Diptera	Simuliidae	Blackfly family		Collectors	River Density	1.500	-	no	no	no
85	Ephemeroptera	Ephemerellidae	Mayfly order		River	Density	3.000	-	no	no	no
85	Plecoptera	Plecoptera	Stonefly order		River	Density	2.000	-	no	no	no
85	Trichoptera	Trichoptera	Caddisfly order		River	Density	3.000	-	no	no	no
85	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	3.000	-	no	no	no
85	Plecoptera	Plecoptera	Stonefly order		River	Density	4.000	-	no	no	no
85	Trichoptera	Trichoptera	Caddisfly order		River	Density	5.000	-	no	no	no
CHINA											
True bug suborder											
82	Ephemeroptera	Ephemeroptera	Predators		River	Density	.330	.675	no	no	yes
82	Beetle	Beetle									

(continued) Table 17. Recovery times for macroinvertebrates by state, country, or province and by stressor.
(Foreign sites follow U.S. states)

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover (yrs)	Distance (km)	Persists in sys.	Upstream	Downstream
ZIMBABWE											
DROUGHT											
82	Neuroptera	Neuroptera	Neuroptera phylum		River	Density	.020	.675	yes	no	yes
82	Odonata	Calopterygidae	Damselfly family	Predators	River	Density	.250	.675	no	no	yes
82	Odonata	Libellulidae	Dragonfly family	Predators	River	Density	.080	.675	no	no	yes
82	Odonata	Libellulidae	Dragonfly family	Predators	River	First appears	.050	.675	no	no	yes
82	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	Density	.020	.675	yes	no	yes
82	Ostracoda	Ostracoda	Ostracod, seed shrimp subclass	Collectors	River	Density	.210	.675	no	no	yes
82	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.250	.675	no	no	yes
82	Trichoptera	Hydropsychidae	Caddisfly family	Grazers	River	Density	.200	.675	no	no	yes
82	Trichoptera	Oecetis sp.	Caddisfly	Predators	River	Density	.200	.675	no	no	yes
82	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	Density	.330	.675	no	no	yes

Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
CHANNELIZATION									
133			Bioness		River	Bioness	> 5.000	1.000	yes yes
58			Bioness		River	Bioness	> 52.000	39.000	- yes
132			Bioness		River	Bioness	> 25.000		yes yes
133			Density		River	Density	> 5.000		- yes
58			Density		River	Density	> 52.000	39.000	- yes
132			Density		River	Density	> 25.000		yes yes
58			Genera richness		River	Genera richness	> 52.000	39.000	- yes
132			Genera richness		River	Genera richness	> 25.000		yes yes
132			Riffle beetle family	Collectors	River	Density	> 25.000		yes yes
132			Beetle family	Collectors	River	Density	> 25.000		yes yes
133			Blackfly family	Collectors	River	Density	> 5.000	1.000	yes yes
133			Mayfly family	Collectors	River	Density	> 5.000	1.000	yes yes
133			Mayfly family	Collectors	River	Density	> 5.000	1.000	yes yes
132			Mayfly family	Collectors	River	Density	> 25.000		yes yes
133			Annelid worm class	Collectors	River	Density	> 5.000	1.000	yes yes
133			Stonefly	Predators	River	Density	> 5.000	1.000	yes yes
133			Stonefly family	Predators	River	Density	> 5.000	1.000	yes yes
133			Caddisfly family	Collectors	River	Density	> 5.000	1.000	yes yes
132			Caddisfly family	Collectors	River	Density	> 25.000		yes yes
CHEMICAL, ACID									
24			Density		River	Density	.080	.010	yes yes
CHEMICAL, ALKALINE									
134			Density		River	Density	1.400		- yes
134			Scud family	Collectors	River	Density	1.250	2.000	yes no
134			Beetle order	Predators	River	First appears	1.250	2.000	yes no
134			Danselily family	Grazers	River	First appears	1.800	2.000	yes no
134			Rotifer phylum	Collectors	River	Density	1.250	2.000	yes no
134			Caddisfly family	Collectors	River	First appears	.420	2.000	yes no
134			Caddisfly family	Collectors	River	First appears	.500	2.000	yes no
134			Caddisfly family	Collectors	River	First appears	.500	2.000	yes no
134			Flatworm division	Collectors	River	First appears	1.400	2.000	yes no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. (km)	Unperturbed source for recolonization in sys. Upstream Downstream
CHEMICAL, DDT									
97		Bionass	Bionass		River	Bionass	.130	-	-
98		Bionass	Bionass		River	Bionass	1.200	-	-
99		Bionass	Bionass		River	Bionass	1.000	-	-
101		Bionass	Bionass		River	Bionass	1.000	-	-
174		Bionass	Bionass		River	Bionass	> 1.200	-	-
181		Bionass	Bionass		River	Bionass	1.000	6.400	yes
182		Bionass	Bionass		River	Bionass	> 1.200	6.400	yes
185		Bionass	Bionass		River	Bionass	> 1.250	-	-
85		Bionass	Bionass		River	Bionass	.080	-	-
119		Density	Density		River	Density	.330	.600	yes
90		Density	Density		River	Density	> 1.250	7.800	yes
174		Density	Density		River	Density	> 1.250	-	-
185		Density	Density		River	Density	1.080	-	-
186		Density	Density		River	Density	.400	.080	yes
186		Density	Density		River	Density	1.400	.400	yes
85		Density	Density		River	Density	3.000	-	-
122		Density	Density		River	Density	.300	3.200	yes
160		Density	Density		River	Density	1.000	yes	yes
119		Genera richness	Genera richness		River	Genera richness	.170	.600	-
97		Genera richness	Genera richness		River	Genera richness	1.000	-	-
98		Genera richness	Genera richness		River	Genera richness	1.100	-	-
99		Genera richness	Genera richness		River	Genera richness	1.000	-	-
101		Genera richness	Genera richness		River	Genera richness	1.000	-	-
85		Genera richness	Genera richness		River	Genera richness	3.000	-	-
122		Genera richness	Genera richness		River	Genera richness	1.250	3.200	yes
80		Species composition	Species composition		River	Species composition	> 4.000	yes	no
81		Species composition	Species composition		River	Species composition	> 4.000	yes	no
181		Species composition	Species composition		River	Species composition	1.170	6.400	yes
186		Species composition	Species composition		River	Species composition	1.500	3.200	yes
	Coleoptera	Beetle order	Beetle order		River	Density	1.400	.080	yes
186	Coleoptera	Beetle order	Beetle order		River	First appears	1.000	1.600	yes
186	Coleoptera	Beetle order	Beetle order		River	First appears	1.330	3.200	yes
122	Coleoptera	Riffle beetle family	Riffle beetle family	Collectors	River	Density	> 1.330	3.200	-
119	Decapoda	Crayfish family	Crayfish family	Grazers	River	Density	.330	.600	yes
122	Diptera	Phantom midge family	Phantom midge family	Predators	River	Density	1.330	3.200	-
119	Diptera	Midge family	Midge family		River	Density	.330	.600	no
90	Diptera	Midge family	Midge family		River	Density	.080	7.800	yes
97	Diptera	Midge family	Midge family		River	Density	.130	yes	no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. (km)	Unperturbed source for recolonization Upstream	Downstream
CHEMICAL, DDT										
98	Diptera	Chironomidae	Hidge family		River	Density	1.000	yes	no	yes
99	Diptera	Chironomidae	Hidge family		River	Density	.130	yes	no	yes
100	Diptera	Chironomidae	Hidge family		River	Density	.020	yes	no	yes
101	Diptera	Chironomidae	Hidge family		River	Density	.130	yes	no	yes
85	Diptera	Chironomidae	Hidge family		River	Density	.080	-	no	no
122	Diptera	Chironomidae	Hidge family		River	Density	.210	3.200	-	yes
160	Diptera	Chironomidae	Hidge family		River	Density	.300	4.800	yes	yes
186	Diptera	Diptera	Fly, mosquito, hidge order		River	Density	.080	.600	yes	yes
119	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.330	7.800	no	no
90	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
97	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
98	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
100	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
101	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.000	yes	no	yes
85	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.500	-	no	no
122	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.330	3.200	-	yes
160	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	1.300	no	yes	yes
160	Diptera	Tipulidae	Cranefly family		River	Density	1.300	yes	yes	yes
119	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.330	.600	yes	yes
122	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1.330	3.200	-	yes
160	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1.300	yes	yes	yes
122	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	Density	1.330	3.200	-	yes
160	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	Density	1.000	yes	yes	yes
122	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.330	3.200	-	yes
160	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.300	yes	yes	yes
90	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	7.800	yes	no
97	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
98	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
99	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
100	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
101	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	yes	no	yes
98	Ephemeroptera	Ephemeroptera	Mayfly order		River	First appears	.130	no	no	yes
80	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	3.000	yes	no	-
81	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	2.000	yes	no	-
185	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	-	-	-
186	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	.410	.400	no	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	1.200	no	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order		River	First appears	.040	.010	no	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	(yrs)	(km)	Time to Distance	Persis. Unperturbed source
recover to refugia species for recolonisation										
la syc. Upstream Downstream										
CHEMICAL, DDT										
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	River	First appears	.080	.080	no	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	River	First appears	.250	.400	no	yes
186	Ephemeroptera	Ephemeroptera	Mayfly order	River	River	First appears	.410	4.800	no	yes
85	Ephemeroptera	Ephemeroptera	Mayfly order	River	River	Density	3.000	-	no	no
86	Ephemeroptera	Ephemeroptera	Mayfly order	River	River	Density	3.000	-	no	no
119	Ephemeroptera	Isocyba sp.	Mayfly	Collectors	River	Density	.330	.600	yes	yes
119	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	.330	.600	yes	yes
119	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	.290	.600	yes	yes
122	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	1.330	3.200	-	yes
160	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	1.300	-	no	yes
119	Odonata	Aeshnidae	Damselfly family	Predators	River	Density	.330	.600	yes	yes
119	Plecoptera	Alloperla sp.	Stonefly	Collectors	River	Density	.330	.600	yes	yes
122	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	1.330	3.200	-	yes
160	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	1.300	-	yes	yes
122	Plecoptera	Meconuridae	Stonefly family	Shredders	River	Density	1.000	3.200	-	yes
119	Plecoptera	Peltoperlidae	Stonefly family	Shredders	River	Density	.310	.600	yes	yes
119	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	.330	.600	yes	yes
122	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	1.330	3.200	-	yes
90	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.200	7.800	yes	no
97	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.000	-	no	yes
98	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.200	-	no	yes
99	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.200	yes	yes	yes
101	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.000	yes	yes	yes
80	Plecoptera	Plecoptera	Stonefly order	River	River	Density	3.000	yes	no	yes
81	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.000	yes	yes	-
186	Plecoptera	Plecoptera	Stonefly order	River	River	Density	1.000	.080	yes	-
186	Plecoptera	Plecoptera	Stonefly order	River	River	First appears	.910	4.800	no	yes
85	Plecoptera	Plecoptera	Stonefly order	River	River	Density	2.000	-	no	yes
86	Plecoptera	Plecoptera	Stonefly order	River	River	Density	4.000	-	no	no
119	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.330	.600	yes	yes
122	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1.330	3.200	-	yes
160	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1.300	-	yes	yes
120	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1.000	.720	yes	yes
80	Trichoptera	Leptoceridae	Caddisfly family	Collectors	River	First appears	4.000	yes	no	-
119	Trichoptera	Limnephilidae	Caddisfly family	Shredders	River	Density	.330	.600	yes	yes
122	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	First appears	1.330	3.200	no	yes
160	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	First appears	1.300	-	no	yes
122	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	1.330	3.200	-	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia (yrs)	Perils. species in sys. (ha)	Unperturbed source for recolonization
CHEMICAL, DDT									
160	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	1.300	yes	yes
122	Trichoptera	Hydropsychidae	Caddisfly family	Predators	River	Density	> 1.330	3.200	no yes
160	Trichoptera	Hydropsychidae	Caddisfly family	Predators	River	Density	.300	yes	yes
90	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.200	7.800	no no
97	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.200	no	yes
98	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.200	no	yes
99	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.200	yes	yes
100	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.000	yes	yes
101	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.200	no	yes
98	Trichoptera	Trichoptera	Caddisfly order		River	First appears	1.100	no	yes
80	Trichoptera	Trichoptera	Caddisfly order		River	Density	2.000	yes	no
81	Trichoptera	Trichoptera	Caddisfly order		River	Density	3.000	yes	no
185	Trichoptera	Trichoptera	Caddisfly order		River	Density	> 1.250	-	-
186	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.400	.080	yes
186	Trichoptera	Trichoptera	Caddisfly order		River	First appears	.910	4.800	yes
85	Trichoptera	Trichoptera	Caddisfly order		River	Density	3.000	-	no no
86	Trichoptera	Trichoptera	Caddisfly order		River	Density	5.000	-	no no
CHEMICAL, OTHER									
40			Bioness		River	Bioness	> 1.000	.500	no
114			Bioness		River	Bioness	.030	yes	-
144			Bioness		River	Bioness	2.250	.068	no yes
124			Bioness		River	Bioness	.178	2.900	yes
40			Density		River	Density	> 1.000	.500	no
189			Density		River	Density	> .500	.060	yes
285			Density		Pond	Density	2.300	-	-
208			Density		River	Density	1.000	yes	-
62			Density		River	Density	.120	1.600	no
63			Density		River	Density	.120	31.000	yes
116			Density		River	Density	.250	yes	yes
108			Density		River	Density	< .250	yes	-
144			Density		River	Density	.320	.068	yes
109			Density		River	Density	< .500	-	-
60			Density		River	Density	.020	1.200	yes
187			Density		River	Density	.600	1.100	no
144			Functional grp prop		River	Functional grp prop	2.000	.068	yes
40			Genera richness		River	Genera richness	> 1.000	.500	no
189			Genera richness		River	Genera richness	> .500	.060	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia (yrs)	Persis. (km)	Unperturbed source for recolonization in sys. Upstream
CHEMICAL, OTHER									
208			Genera richness	River	Genera richness	1.000	yes	-	-
108			Genera richness	River	Genera richness	.250	yes	-	-
109			Genera richness	River	Genera richness	1.000	-	-	-
144			Species composition	River	Species composition	2.000	.068	yes	no
109			Species composition	River	Species composition	1.000	1.000	yes	no
83			Species composition	River	Species composition	2.200	-	no	yes
205	Aphipoda	Gammaridae	Scud family	Collectors	Pond	Density	2.400	-	-
124	Aphipoda	Gammaridae	Scud family	Collectors	River	Density	.750	yes	no
187	Aphipoda	Gammaridae	Scud family	Collectors	River	Density	1.800	1.100	yes
7	Aphipoda	Talitridae	Scud family	Grazers	Lake	Density	.170	.800	yes
9	Aphipoda	Talitridae	Scud family	Grazers	Lake	Density	.310	yes	-
166	Aphipoda	Talitridae	Scud family	Grazers	Lake	Density	.190	.800	no
167	Aphipoda	Talitridae	Scud family	Grazers	Lake	Density	.170	.800	no
6	Aphipoda	Talitridae	Scud family	Grazers	Lake	First appears	.670	no	-
167	Aphipoda	Talitridae	Scud family	Grazers	Lake	First appears	.060	.800	no
189	Arachnids	Hydracarina	Water mite	Predators	River	Density	.500	.060	yes
108	Coleoptera	Coleoptera	Beetle order	River	Density	<	.250	no	-
2	Coleoptera	Curculionidae	Weevil family	Shredders	Lake	Density	1.500	no	-
2	Coleoptera	Curculionidae	Weevil family	Shredders	Lake	First appears	1.500	no	-
48	Coleoptera	Dytiscidae	Diving beetle family	Predators	Pond	Density	.100	.020	yes
49	Coleoptera	Dytiscidae	Diving beetle family	Predators	Pond	Density	.100	.020	yes
83	Coleoptera	Dytiscidae	Diving beetle family	Predators	River	First appears	2.200	no	no
63	Coleoptera	Elaeidae	Riffle beetle family	Collectors	River	Density	1.000	31.000	yes
48	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	Pond	Density	.100	.020	yes
49	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	Pond	Density	.100	.020	yes
144	Collembola	Collembola	Springtail	Collectors	River	Density	2.000	.068	-
124	Diptera	Antocha sp.	Cranefly	Collectors	River	Density	.900	1.100	yes
187	Diptera	Antocha sp.	Cranefly	Collectors	River	Density	.250	yes	no
108	Diptera	Chaoboridae	Phantom midge family	Predators	River	Density	4.300	.400	yes
188	Diptera	Chaoboridae	Phantom midge family	Predators	Lake	Density	.500	.060	yes
189	Diptera	Chironomidae	Nidge family	River	Density	>	.750	yes	-
4	Diptera	Chironomidae	Nidge family	Pond	Density	>	.330	yes	-
47	Diptera	Chironomidae	Nidge family	Pond	Density	>	.150	yes	-
51	Diptera	Chironomidae	Nidge family	River	Density	>	.500	4.800	yes
180	Diptera	Chironomidae	Nidge family	River	Density	>	.120	1.600	yes
62	Diptera	Chironomidae	Nidge family	River	Density	>	.250	yes	no
108	Diptera	Chironomidae	Nidge family	River	Density	>	2.200	no	yes
83	Diptera	Chironomidae	Nidge family	River	Density	>	2.200	no	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	(yrs)	(km)	in sys.	Upstream	Downstream
Time to Distance Persists. Unperturbed source recover to refugia species for recolonization											
CHEMICAL, OTHER											
124	Diptera	Chironomidae	Midge family		River	Density	.170	2.900	yes	no	yes
208	Diptera	Diptera	Flv. mosquito, midge order		River	Density	< 1.000		yes	-	-
144	Diptera	Dixidae	Dixa midge family	Collectors	River	Density	> 2.000	.068	-	no	yes
144	Diptera	Hexatoma sp.	Cranefly	Predators	River	Density	> 2.000	.068	-	no	yes
208	Diptera	Microtendipes	Midge		River	Density	.160		yes	-	-
209	Diptera	Microtendipes	Midge		River	Density	.160		yes	-	-
2	Diptera	Orthocladiinae	Midge subfamily		Lake	Density	.160		yes	-	-
109	Diptera	Orthocladius sp.	Midge	Collectors	River	Density	< .500	1.000	yes	yes	no
2	Diptera	Psectrocladius sp.	Midge	Collectors	Lake	Density	.160		yes	-	-
144	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	> 2.000	.068	-	no	yes
124	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.250	2.900	yes	no	yes
189	Diptera	Tabanidae	Housefly family		River	Density	> .500	.060	yes	yes	yes
108	Diptera	Tanyderidae	Primitive crane fly faml	Shredders	River	Density	> .250		no	-	-
83	Diptera	Tribelos sp.	Midge	Grazers	River	First appears	1.300		no	no	yes
48	Ephemeroptera	Baetidae	Mayfly family	Collectors	Pond	Density	.100	.020	no	-	-
49	Ephemeroptera	Baetidae	Mayfly family	Collectors	Pond	Density	> .100	.020	no	-	-
108	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> .250		no	-	-
124	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.442	2.900	yes	no	yes
187	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.700	1.100	yes	no	yes
8	Ephemeroptera	Caenidae	Mayfly family	Collectors	Lake	Density	.100		yes	-	-
9	Ephemeroptera	Caenidae	Mayfly family	Collectors	Lake	Density	.130		-	-	-
144	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	> 2.000	.068	-	no	yes
180	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	> 1.600		-	yes	yes
207	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	< 1.000		yes	-	-
208	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	< 1.000		yes	-	-
109	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	1.000	1.000	yes	yes	no
116	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	.830		yes	yes	yes
144	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	> 2.000	.068	-	no	yes
144	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	> 2.000	.068	-	no	yes
187	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	.600	1.100	yes	no	yes
189	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	Density	.500	.060	yes	yes	yes
155	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	Density	> 1.800		-	-	-
157	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	Density	.580		-	-	-
157	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	.330		-	-	-
156	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	.830		-	-	-
61	Gastropoda	Hydrobia sp.	Black abalone	Grazers	River	Density	> 1.000	2.400	yes	yes	no
48	Hemiptera	Belostomatidae	Water bug family	Predators	Pond	Density	> .100	.020	yes	-	-
49	Hemiptera	Belostomatidae	Water bug family	Predators	Pond	Density	> .100	.020	yes	-	-

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. in sys. (km)	Unperturbed source for recolonization
CHEMICAL, OTHER									
48	Heimptera	Corixidae	Water boatman family	Predators	Pond	Density	.080	yes	-
49	Heimptera	Corixidae	Water boatman family	Predators	Pond	Density	> .100	yes	-
108	Heimptera	Heimptera	Waterbug order	Predators	River	Density	> .250	no	-
48	Heimptera	Kotonectidae	Backswimmer family	Predators	Pond	Density	.100	yes	-
49	Heimptera	Kotonectidae	Backswimmer family	Predators	Pond	Density	> .100	yes	-
2	Lepidoptera	Pyraustidae	Aquatic caterpillar fam.	Shredders	Lake	Density	> 1.500	no	-
2	Lepidoptera	Pyraustidae	Aquatic caterpillar fam.	Shredders	Lake	First appears	> 1.500	no	-
189	Heimatodes	Heimatodes	Heimatode phylum	Predators	River	Density	> .500	yes	yes
108	Odonata	Anisoptera	Dragonfly suborder	Predators	River	Density	< .250	yes	-
48	Odonata	Coenagrionidae	Damselfly family	Predators	Pond	Density	.080	no	-
49	Odonata	Coenagrionidae	Damselfly family	Predators	Pond	Density	.100	no	-
83	Odonata	Coenagrionidae	Damselfly family	Predators	River	First appears	2.200	no	yes
205	Odonata	Odonata	Dragonfly and damselfly order	Predators	Pond	Density	> 2.400	-	-
108	Odonata	Zygoptera	Damselfly suborder	Predators	River	Density	> .250	yes	-
83	Oligochaeta	Naididae	Oligochaete family	Collectors	River	First appears	1.300	no	yes
189	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	Density	> .500	yes	yes
108	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	Lake	Density	.040	yes	-
6	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.170	yes	-
166	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.040	yes	-
167	Ostracoda	Cypridae	Seed shrimp family	Collectors	Lake	Density	.800	yes	-
2	Ostracoda	Ostracoda	Ostracod, seed shrimp subclass	Collectors	Lake	Density	.120	yes	-
83	Pelecypoda	Sphaeriidae	Clam family	Collectors	Lake	Density	1.500	yes	-
206	Plecoptera	Leuctridae	Stonefly family	Shredders	River	First appears	2.200	no	yes
206	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 4.000	yes	-
114	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 4.000	yes	yes
144	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	.140	yes	no
206	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 2.000	yes	yes
206	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 4.000	yes	-
206	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 4.000	yes	-
144	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	> 2.000	yes	yes
187	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	.750	no	yes
189	Plecoptera	Plecoptera	Stonefly order	Predators	River	Density	> .500	yes	yes
206	Plecoptera	Plecoptera	Stonefly order	Predators	River	Density	> 4.000	yes	yes
206	Plecoptera	Plecoptera	Stonefly order	Predators	River	Density	> 4.000	yes	-
109	Plecoptera	Plecoptera	Stonefly order	Predators	River	Density	> 4.000	yes	-
124	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	Density	< 2.500	yes	yes
187	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	Density	2.000	yes	no
187	Trichoptera	Glossosomatidae	Caddisfly family	Grazers	River	Density	> 2.100	yes	yes
109	Trichoptera	Bellocopsychidae	Caddisfly family	Grazers	River	First appears	.600	yes	yes
							< .500	yes	no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. (km)	Unperturbed source for recolonization in sys. Upstream
CHEMICAL, OTHER									
187	Trichoptera	Helicopsychidae	Caddisfly family	Grazers	River	Density	.600	1.100	yes no yes
124	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	1.000	2.900	yes no yes
187	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.830	1.100	yes no yes
187	Trichoptera	Hydropsychidae	Caddisfly family	Grazers	River	Density	.600	1.100	yes no yes
144	Trichoptera	Limnephilidae	Caddisfly family	Shredders	River	Density	> 2.000	.068	- no yes
109	Trichoptera	Oecetis sp.	Caddisfly	Predators	River	First appears	< .500	.500	yes no yes
61	Trichoptera	Phryganeidae	Caddisfly family	River	Density		> 1.000	2.400	yes no no
61	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	> 1.000	2.400	yes no no
60	Trichoptera	Psychomyiidae	Caddisfly family	Collectors	River	Density	> .120	1.200	yes no no
144	Trichoptera	Rhyacophilidae	Caddisfly family	Predators	River	Density	> 2.000	.068	- no yes
144	Trichoptera	Sericostomatidae	Caddisfly family	Shredders	River	Density	> 2.000	.068	- no yes
189	Trichoptera	Trichoptera	Caddisfly order	River	Density		> .500	.060	yes yes yes
180	Trichoptera	Trichoptera	Caddisfly order	River	Density		.700	4.800	yes yes yes
208	Trichoptera	Trichoptera	Caddisfly order	River	Density		.500		yes - -
109	Trichoptera	Trichoptera	Caddisfly order	River	Density		1.000	1.000	yes no no
CHEMICAL, POTENTIAL									
14			Bionass	River	Bionass		1.000	1.000	- - -
14			Bionass	River	Bionass		1.000	24.000	- - -
16			Bionass	River	Bionass		.900	180.000	- yes no
17			Bionass	River	Bionass		.080	18.000	- - -
15			Bionass	River	Density		.900	92.000	- yes no
21			Density	River	Density		.080	4.400	yes yes yes
93			Density	River	Density		< 1.000		yes no no
14			Density	River	Density		.170	1.000	- - -
14			Density	River	Density		.670	24.000	- yes no
15			Density	River	Density		.900	92.000	- yes no
16			Density	River	Density		1.000	185.000	- yes no
17			Density	River	Density		.170		- yes no
14			Genera richness	River	Genera richness		1.200	24.000	- yes no
15			Genera richness	River	Genera richness		1.000	92.000	- yes no
16			Genera richness	River	Genera richness		1.000	185.000	- yes no
17			Genera richness	River	Genera richness		1.000		- yes no
16		Palingeniidae	Water mite	Predators	River	First appears	> 2.000	180.000	no no no
15	Arachnids	Hydracarina		Collectors	River	First appears	1.000	92.000	no no no
14	Coleoptera	Elmidae	Rifle beetle family	Collectors	River	First appears	.020	8.000	yes no no
15	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	River	First appears	1.000	92.000	no no no
16	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	River	First appears	1.700	185.000	no no no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	System		Recovery type	Time to Distance		Unperturbed source		
				Function	type		(yrs)	(km)		recover to refugia species for recolonization	in sys. Upstream Downstream
CHEMICAL, BOTENONE											
17	Coleoptera	Hydrophilidae	Water scavenger beetle family	Collectors	River	First appears	1.000	16.000	no	yes	no
5	Diptera	Chaoboridae	Phantom midge family	Predators	Lake	Density	> 1.000		yes	-	-
21	Diptera	Chironomidae	Midge family		River	First appears	.120	4.400	yes	yes	yes
14	Diptera	Chironomidae	Midge family		River	Density	.670	24.000	no	yes	no
15	Diptera	Chironomidae	Midge family		River	Density	1.200	92.000	no	yes	no
14	Diptera	Chironomidae	Midge family		River	First appears	.038	8.000	no	yes	no
15	Diptera	Chironomidae	Midge family		River	First appears	.170	92.000	no	yes	no
16	Diptera	Chironomidae	Midge family		River	First appears	.170	180.000	yes	yes	no
93	Diptera	Diptera	Fly, mosquito, midge order		River	Density	< 1.000		yes	no	no
14	Diptera	Epididae	Dancefly family	Predators	River	First appears	1.700	24.000	no	yes	no
17	Diptera	Epididae	Dancefly family	Predators	River	First appears	2.000	16.000	no	yes	no
21	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.038	4.400	yes	yes	yes
17	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.800	16.000	-	yes	no
15	Diptera	Simuliidae	Blackfly family	Collectors	River	First appears	.670	92.000	no	yes	no
15	Diptera	Tipulidae	Cranefly family	Collectors	River	First appears	> 2.000	92.000	no	yes	no
17	Diptera	Tipulidae	Cranefly family		River	First appears	1.000	16.000	no	yes	no
14	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.670	16.000	no	yes	no
15	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1.700	92.000	no	yes	no
17	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.250	16.000	-	yes	no
14	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.170	1.600	no	yes	no
15	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.670	92.000	no	yes	no
16	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.670	210.000	no	yes	no
17	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.020	16.000	-	yes	no
16	Ephemeroptera	Caenidae	Mayfly family	Collectors	River	First appears	1.000	185.000	no	yes	no
14	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	First appears	1.000	24.000	no	yes	no
15	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	First appears	1.000	92.000	no	yes	no
16	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	First appears	1.000	185.000	no	yes	no
17	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	First appears	.020	16.000	no	yes	no
16	Ephemeroptera	Ephemeridae	Mayfly family	Collectors	River	First appears	2.000	210.000	no	yes	no
21	Ephemeroptera	Ephemeroptera	Mayfly order		River	First appears	.080	4.400	yes	yes	yes
93	Ephemeroptera	Ephemeroptera	Mayfly order		River	Density	< 1.000		yes	no	no
16	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	Density	1.000	185.000	no	yes	no
14	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	First appears	1.000	24.000	no	yes	no
15	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	First appears	1.000	92.000	no	yes	no
17	Ephemeroptera	Heptagenia sp.	Mayfly	Grazers	River	First appears	1.000	16.000	no	yes	no
16	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	2.000	185.000	no	yes	no
14	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	First appears	1.000	24.000	no	yes	no
15	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	First appears	1.000	92.000	no	yes	no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	System		Recovery type	Time to Distance recover to refugia species for recolonization in sys. Upstream Downstream			
				Function	type		(yrs)	(km)		
CHEMICAL, ROTENONE										
16	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	First appears	1.000	185.000	no	yes
16	Ephemeroptera	Polynitarcidae	Mayfly family	Collectors	River	Density	1.700	210.000	no	yes
16	Ephemeroptera	Polynitarcidae	Mayfly family	Collectors	River	First appears	1.000	210.000	no	yes
14	Ephemeroptera	Rhithrogena sp.	Mayfly	Collectors	River	First appears	1.000	24.000	no	yes
15	Ephemeroptera	Rhithrogena sp.	Mayfly	Collectors	River	First appears	1.000	92.000	no	yes
16	Ephemeroptera	Rhithrogena sp.	Mayfly	Collectors	River	First appears	1.000	185.000	no	yes
15	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	Density	1.200	92.000	no	yes
16	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	Density	1.000	185.000	no	yes
14	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	.040	8.000	no	yes
14	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	24.000	no	yes
15	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	92.000	no	yes
16	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	185.000	no	yes
17	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	First appears	1.000	16.000	no	yes
11	Gastropoda	Gastropoda	Snails, limpets class	Grazers	Lake	Density	< 2.000		yes	-
15	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	.040	92.000	-	yes
16	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	.040	180.000	-	yes
14	Gastropoda	Lynnaeidae	Pond snail family	Grazers	River	First appears	.019	24.000	yes	yes
15	Gastropoda	Lynnaeidae	Pond snail family	Grazers	River	First appears	.040	92.000	yes	yes
5	Gastropoda	Viviparidae	Snail family	Grazers	Lake	Density	> 1.000		no	-
93	Neoptera	Neoptera	Waterbug order	Predators	River	Density	< 1.000		yes	no
10	Hirudinea	Hirudinea	Leech class		Lake	Density	< 2.000		yes	-
5	Hirudinea	Hirudinea	Leech class		Lake	Density	> 1.000		no	-
15	Hirudinea	Hirudinea	Leech class		River	First appears	1.000	92.000	no	yes
93	Isopoda	Isopoda	Sowbug order	Collectors	River	Density	> 1.000		yes	no
15	Neatodes	Neatoda	Nematode phylum	Predators	River	First appears	1.000	92.000	no	yes
93	Neuroptera	Neuroptera	Spongillafly order	Predators	River	Density	< 1.000		yes	no
15	Odonata	Gomphidae	Dragonfly family	Predators	River	First appears	.040	92.000	-	yes
14	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	First appears	.570	24.000	no	yes
15	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	First appears	1.000	92.000	no	yes
17	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	First appears	1.250	16.000	no	yes
15	Oligochaeta	Tubificidae	Oligochaete family	Collectors	River	First appears	.170	92.000	-	yes
16	Oligochaeta	Tubificidae	Oligochaete family	Collectors	River	First appears	.170	180.000	yes	yes
14	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	24.000	no	yes
15	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	92.000	no	yes
16	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	185.000	no	yes
17	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	16.000	no	yes
14	Plecoptera	Perlodidae	Stonefly family	Predators	River	First appears	1.000	24.000	no	yes
15	Plecoptera	Perlodidae	Stonefly family	Predators	River	First appears	1.000	92.000	no	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	(yrs)	(km)	in sys.	Upstream	Downstream
CHEMICAL, ROTENONE											
16	Plecoptera	Perlidae	Stonefly family	Predators	River	First appears	1.000	185.000	no	yes	no
21	Plecoptera	Plecoptera	Stonefly order		River	Density	.500	4.400	yes	yes	yes
14	Plecoptera	Pteronarcidae	Stonefly family	Shredders	River	First appears	1.000	24.000	no	yes	no
15	Plecoptera	Pteronarcidae	Stonefly family	Shredders	River	First appears	1.000	92.000	no	yes	no
17	Plecoptera	Pteronarcidae	Stonefly family	Shredders	River	First appears	1.000	16.000	no	yes	no
14	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	First appears	1.000	24.000	no	yes	no
15	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	First appears	1.000	92.000	no	yes	no
17	Trichoptera	Brachycentridae	Caddisfly family	Collectors	River	First appears	1.700	16.000	no	yes	no
15	Trichoptera	Glossosomatidae	Caddisfly family	Grazers	River	First appears	1.000	92.000	no	yes	no
16	Trichoptera	Glossosomatidae	Caddisfly family	Grazers	River	First appears	2.000	180.000	no	yes	no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	2.000	92.000	no	yes	no
14	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	24.000	no	yes	no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	92.000	no	yes	no
15	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	2.000	92.000	no	yes	no
16	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	210.000	no	yes	no
17	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	1.700	16.000	no	yes	no
17	Trichoptera	Lepidostomatidae	Caddisfly family	Shredders	River	First appears	1.000	16.000	no	yes	no
15	Trichoptera	Leptoceridae	Caddisfly family	Collectors	River	First appears	1.000	92.000	no	yes	no
16	Trichoptera	Leptoceridae	Caddisfly family	Collectors	River	First appears	1.250	185.000	no	yes	no
21	Trichoptera	Trichoptera	Caddisfly order	Collectors	River	First appears	.038	4.400	yes	yes	yes
93	Trichoptera	Trichoptera	Caddisfly order		River	Density	1.000		yes	no	no
BREEDING											
96			Biomass	River	Biomass		1.100	.050	no	yes	yes
110			Density	River	Density		1.000	.010	yes	yes	yes
96			Density	River	Density		.800	.050	no	yes	yes
33			Density	Lake	Density		.016		-	-	-
34			Density	Lake	Density		.033	.001	-	-	-
35			Density	Lake	Density		.025		-	-	-
110			Genera richness	River	Genera richness		1.000	.010	yes	yes	yes
202			Genera richness	River	Genera richness		.500	.200	yes	yes	yes
33			Genera richness	Lake	Genera richness		.016		-	-	-
34			Genera richness	Lake	Genera richness		.033		-	-	-
35			Genera richness	Lake	Genera richness		.074		-	-	-
202		Silo nigricornis		River	Density		.400	.200	yes	yes	yes
202	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.010	.200	yes	yes	yes
33	Diptera	Chironomidae	Nidge family	Lake	Density		.016	.001	-	-	yes
34	Diptera	Chironomidae	Nidge family	Lake	Density		.033	.001	-	-	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. species (km)	Unperturbed source for recolonization in sys.
DREDGING									
35	Diptera	Chironomidae	Nidge family	Lake	Density		.056	.001	-
110	Ephemeroptera	Baetidae	Mayfly family	Collectors River	Density		2.000	.010	yes
110	Ephemeroptera	Claygula sp.	Mayfly	Grazers River	Density		.800	.010	yes
110	Ephemeroptera	Epeorus sp.	Mayfly	Collectors River	Density		.800	.010	yes
96	Gastropoda	Gastropoda	Snails, limpets class	Grazers River	Density		1.000	.050	no
202	Gastropoda	Potanoprgus sp.	Snail	Grazers River	Density		.400	.200	yes
96	Oligochaeta	Oligochaeta	Annelid worm class	Collectors River	Density		1.000	.050	no
202	Oligochaeta	Oligochaeta	Annelid worm class	Collectors River	Density		.400	.200	yes
33	Oligochaeta	Oligochaeta	Annelid worm class	Collectors Lake	Density		.033	.001	-
34	Oligochaeta	Oligochaeta	Annelid worm class	Collectors Lake	Density		.041	.001	-
35	Oligochaeta	Oligochaeta	Annelid worm class	Collectors Lake	Density		.074	.001	-
110	Plecoptera	Alloperla sp.	Stonefly	Collectors River	Density		2.200	.010	yes
110	Plecoptera	Capniidae	Stonefly family	Shredders River	Density		.100	.010	yes
110	Trichoptera	Rhyacophillidae	Caddisfly family	Predators River	Density		.800	.010	yes
DROUGHT									
44		Biomass	River	Biomass			< 1.000	31.000	-
162		Density	River	Density			< .250	0.000	no
137		Density	River	Density			1.000	15.000	no
44		Density	River	Density			< 1.000	31.000	-
22		Density	River	Density			.210	.300	no
137		Functional grp prop	River	Functional grp prop			3.500	15.000	no
137		Genera richness	River	Genera richness			1.200	15.000	no
44		Genera richness	River	Genera richness			1.000	31.000	-
22		Genera richness	River	Genera richness			.270	.300	no
82		Genera richness	River	Genera richness			.100	.680	-
162		Species composition	River	Species composition			.250	0.000	no
82		Species composition	River	Species composition			.200	.675	-
22		Functional group	Collectors River	Density			.380	.300	no
22		Functional group	Collectors River	Density			.380	.300	no
22		Functional group	Predators River	Density			1.100	.300	no
22		Functional group	Grazers River	Density			.820	.300	no
82	Coleoptera	Diving beetle family	Predators River	Density			.250	.675	no
82	Diptera	Biting midge family	River	Density			.080	.675	no
82	Diptera	Biting midge subfamily	Predators River	Density			.330	.675	no
170	Diptera	Nidge family	River	First appears			.030	.010	no
22	Diptera	Nidge family	River	Density			.040	.300	no
82	Diptera	Nidge	Collectors River	First appears			.030	.675	no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	(km)	Persis. Unperturbed source recover to refugia species for recolonization in yrs.	Upstream Donstream
DROUGHT										
162	Diptera	Diptera	Fly, mosquito, midge order	River	Density	Density	< .250	.250	no	yes
82	Diptera	Orthocladinae	Kidge subfamily	River	Density	Density	> .020	.675	no	yes
82	Diptera	Orthocladinae	Kidge subfamily	River	Density	Density	> .420	.675	no	yes
170	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	> .014	.010	no	-
22	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	> .120	.300	no	yes
82	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	> .060	.675	no	yes
82	Diptera	Simuliidae	Blackfly family	Collectors	River	First appears	> .020	.675	no	yes
82	Diptera	Tanyptodinae	Kidge subfamily	Predators	River	Density	> .080	.675	no	yes
82	Diptera	Tanyptodinae	Kidge subfamily	Collectors	River	Density	> .170	.675	no	yes
82	Diptera	Tipulidae	Cranefly family	River	Density	Density	> .420	.675	no	yes
170	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	> .014	.010	no	-
136	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> .130	1.000	yes	yes
136	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	> .080	1.000	yes	yes
22	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> .080	.300	no	yes
82	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> .190	.675	no	yes
82	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	> .050	.675	no	yes
82	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	> .190	.675	no	yes
22	Ephemeroptera	Caenidae	Mayfly family	Collectors	River	Density	> .120	.300	no	yes
162	Ephemeroptera	Ephemerellidae	Mayfly order	Collectors	River	Density	> .250	.250	no	yes
22	Ephemeroptera	Rhythrogena sp.	Mayfly	Collectors	River	Density	> .190	.300	no	yes
170	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	First appears	> .093	.010	no	-
22	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	> .120	.300	no	yes
22	Ephemeroptera	Tricorythidae	Mayfly family	Collectors	River	Density	> .350	.300	no	yes
82	Emiptera	Heteroptera	True bug suborder	Predators	River	Density	> .330	.675	no	yes
82	Neatodes	Neatoda	Neatode phylum	River	Density	Density	> .020	.675	yes	yes
82	Odonata	Calopterygidae	Damselfly family	Predators	River	Density	> .250	.675	no	yes
82	Odonata	Libellulidae	Dragonfly family	Predators	River	Density	> .080	.675	no	yes
82	Odonata	Libellulidae	Dragonfly family	Predators	River	First appears	> .050	.675	no	yes
82	Oligochaeta	Oligochaeta	Annelid worm class	Collectors	River	Density	> .020	.675	yes	yes
82	Ostracoda	Ostracoda	Ostracod, seed shrimp subclass	Collectors	River	Density	> .210	.675	no	yes
162	Pelecypoda	Mollusca	Mollusk phylum	Grazers	River	Density	> .250	.250	no	yes
22	Plecocoptera	Alloperla sp.	Stonefly	Collectors	River	Density	> .120	.300	no	yes
136	Plecocoptera	Leuctridae	Stonefly family	Shredders	River	Density	> .500	1.000	yes	yes
136	Plecocoptera	Nemouridae	Stonefly family	Shredders	River	Density	> .500	1.000	yes	yes
136	Plecocoptera	Perlidae	Stonefly family	Predators	River	Density	> .130	1.000	yes	yes
22	Plecocoptera	Plecoptera	Stonefly family	Predators	River	Density	> .120	.300	no	yes
162	Plecocoptera	Plecoptera	Stonefly order	River	Density	Density	> .250	.250	no	yes
22	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	> .120	.300	no	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia (yrs)	Persis. (km)	Unperturbed source for recolonization in sys. Upstream	Downstream
DROUGHT										
82	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	Density	.250	.675	no	yes
82	Trichoptera	Hydroptilidae	Caddisfly family	Grazers	River	Density	.200	.675	no	yes
82	Trichoptera	Oecetis sp.	Caddisfly	Predators	River	Density	.200	.675	no	yes
82	Trichoptera	Philopotanidae	Caddisfly family	Collectors	River	Density	.330	.675	no	yes
162	Trichoptera	Trichoptera	Caddisfly order	River	Density	<	.250	.250	no	yes
170	Trichoptera	Trichoptera	Caddisfly order	River	First appears		.014	.010	no	-
FLOODING										
25			Biomass	River	Biomass		.170		yes	no
125			Biomass	River	Biomass		1.000	.250	yes	yes
95			Biomass	River	Biomass	>	.330		-	-
125			Density	River	Density		1.000	.250	yes	yes
95			Density	River	Density	>	.330		yes	no
192			Density	River	Density		.250		yes	no
25			Genera richness	River	Genera richness		.170		yes	no
125			Genera richness	River	Genera richness		1.000	.250	yes	yes
95			Genera richness	River	Genera richness	>	.330		yes	no
25			Species composition	River	Species composition		.170		-	-
68	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.500	3.000	yes	no
95	Amphipoda	Gammaridae	Scud family	Collectors	River	Density	.330		yes	no
125	Coleoptera	Coleoptera	Beetle order	River	Density		2.000	.250	yes	yes
95	Decapoda	Astacidae	Crayfish family	Collectors	River	First appears	>	.330	no	no
95	Diptera	Chironomidae	Midge family	River	Density		.330		yes	no
192	Diptera	Chironomidae	Midge family	River	Density		.250		yes	no
125	Diptera	Diptera	Fly, mosquito, midge order	River	Density		.170	.250	yes	yes
95	Diptera	Simuliidae	Blackfly family	Collectors	River	First appears	>	.330	no	no
192	Diptera	Simuliidae	Blackfly family	Collectors	River	Density	.250		yes	no
95	Diptera	Tabanidae	Horsefly family	River	First appears	>	.330		no	no
95	Diptera	Tipulidae	Cranefly family	River	Density		.330		yes	no
95	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.120		yes	no
95	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	Density	.330		yes	no
95	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	.330		yes	no
125	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		.850	.250	yes	yes
95	Ephemeroptera	Ephemeroptera	Mayfly	Grazers	River	Density	.330		yes	no
95	Ephemeroptera	Heptagenia sp.	Mayfly family	Collectors	River	Density	.330		yes	no
95	Ephemeroptera	Leptophlebiidae	Mayfly	Collectors	River	Density	.120		yes	no
95	Ephemeroptera	Stenonema sp.	Stonefly family	Shredders	River	Density	.120		yes	no
95	Plecoptera	Heururidae	Stonefly family	Predators	River	Density	.120		yes	no
95	Plecoptera	Perlodidae	Stonefly family	Predators	River	Density	.120		yes	no

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	System	Function	Recovery type	Time to Distance recover to refugia (yrs)	Persis. (km)	Disturbed source
FLOODING									
125	Plecoptera	Plecoptera	Stonefly order	River	Density		.850	.250	yes
95	Plecoptera	Pteronarcidae	Stonefly family	Shredders	River Density		.330	yes	no
95	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River Density		.330	yes	no
95	Trichoptera	Phlebotanidae	Caddisfly family	Collectors	River Density		.330	yes	no
95	Trichoptera	Mayacophillidae	Caddisfly family	Predators	River Density		.330	yes	no
125	Trichoptera	Trichoptera	Caddisfly order	River	Density		1.000	.250	yes
HABITAT DEVELOPMENT									
184			Biomass	River	Biomass		< 5.000	1.000	yes
184			Density	River	Density		< 5.000	1.000	yes
184			Genera richness	River	Genera richness		< 5.000	1.000	yes
MINING ACTIVITY									
84			Biomass	River	Biomass		> 10.000	1.500	yes
84			Density	River	Density		> 10.000	1.500	yes
69			Density	River	Density		22.000		-
84			Genera richness	River	Genera richness		> 10.000	1.500	yes
69			Genera richness	River	Genera richness		22.000		-
84			Productivity	River	Productivity		> 10.000	1.500	yes
84			Species composition	River	Species composition		> 10.000	1.500	yes
69			Species composition	River	Species composition		> 20.000		-
84	Coleoptera		Beetle order	River	Density		> 10.000	1.500	yes
84	Coleoptera	Elmidae	Riffle beetle family	Collectors	River Density		> 10.000	1.500	yes
84	Diptera	Antocha sp.	Cranefly	Collectors	River Density		> 10.000	1.500	yes
84	Diptera	Cricotopus sp.	Nidge	Shredders	River Density		8.000	1.500	yes
84	Diptera	Dianesinae	Nidge subfamily	Collectors	River Density		8.000	1.500	yes
84	Diptera		Fly, mosquito, nidge order	River	Density		8.000	1.500	yes
84	Diptera	Epididae	Dancefly family	Predators	River Density		8.000	1.500	yes
84	Diptera	Epididae	Dancefly family	Predators	River Density		> 10.000	1.500	yes
84	Diptera	Hexatoma sp.	Cranefly	Predators	River Density		> 10.000	1.500	yes
84	Diptera	Microspectra sp.	Nidge	Collectors	River Density		> 10.000	1.500	yes
84	Diptera	Orthocladus sp.	Nidge	Collectors	River Density		8.000	1.500	yes
84	Diptera	Simuliidae	Blackfly family	Collectors	River Density		> 10.000	1.500	yes
84	Diptera	Thienemannimyia	Nidge	Collectors	River Density		> 10.000	1.500	yes
84	Ephemeroptera	Baetidae	Mayfly family	Predators	River Density		8.000	1.500	yes
84	Ephemeroptera	Cinygula sp.	Mayfly	Collectors	River Density		> 10.000	1.500	yes
84	Ephemeroptera	Ephemerellidae	Mayfly family	Grassers	River Density		> 10.000	1.500	yes
84	Ephemeroptera	Ephemeroptera	Mayfly order	Collectors	River Density		> 10.000	1.500	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to recover to refugia (yrs)	Distance to species (km)	Persis. for recolonization in sys.	Unperturbed source
MINING ACTIVITY										
69	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		18,000		yes	no
84	Ephemeroptera	Leptophlebiidae	Mayfly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Ephemeroptera	Rhythrogena sp.	Mayfly	Collectors	River	Density	> 10,000	1,500	no	yes
84	Gastropoda	Gastropoda	Snails, limpets class	Grazers	River	First appears	> 10,000	1,500	no	yes
84	Oligochaeta	Tubificidae	Oligochaete family	Collectors	River	Density	8,000	1,500	no	yes
84	Plecoptera	Capniidae	Stonefly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Chloroperlidae	Stonefly family	River	Density		> 10,000	1,500	no	yes
84	Plecoptera	Menouridae	Stonefly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Perlidae	Stonefly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Plecoptera	Plecoptera	Stonefly family	Predators	River	Density	> 10,000	1,500	no	yes
69	Plecoptera	Plecoptera	Stonefly order	River	Density		> 10,000	1,500	no	yes
84	Plecoptera	Pteronarcidae	Stonefly order	Shredders	River	Density	8,000		yes	no
84	Trichoptera	Brachycentridae	Stonefly family	Collectors	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Glossosomatidae	Caddisfly family	Collectors	River	Density	8,000	1,500	no	yes
84	Trichoptera	Hydropsychidae	Caddisfly family	Grazers	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Hydropsychidae	Caddisfly family	Grazers	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Lepidostomatidae	Caddisfly family	Shredders	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Rhyacophilidae	Caddisfly family	Predators	River	Density	> 10,000	1,500	no	yes
84	Trichoptera	Trichoptera	Caddisfly order	River	Density		> 10,000	1,500	no	yes
MULTIPLE DISTURBANCES										
151			Biomass	River	Biomass		.580		-	-
151			Density	River	Density		.580		yes	yes
115			Genera richness	River	Genera richness		.600	1,600	-	-
191	Diptera	Chaoboridae	Phantom midge family	Predators	Pond	Density	2,000		yes	-
43	Diptera	Chironomidae	Midge family	River	Density		.130		yes	yes
115	Diptera	Chironomidae	Midge family	River	First appears		.330	1,600	yes	yes
151	Diptera	Diptera	Fly, mosquito, midge order	River	Density		.580		yes	yes
115	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	First appears	.330	1,600	yes	yes
115	Ephemeroptera	Epeorus sp.	Mayfly	Collectors	River	First appears	.600	1,600	yes	yes
115	Ephemeroptera	Ephemereleididae	Mayfly family	Collectors	River	First appears	1,000	1,600	yes	yes
151	Ephemeroptera	Ephemeroptera	Mayfly order	River	Density		.580		yes	yes
43	Gastropoda	Lymnaeidae	Pond snail family	Grazers	River	First appears	.500	5,100	yes	-
43	Gastropoda	Physidae	Pouch snail family	Grazers	River	First appears	.500	5,100	yes	-
151	Plecoptera	Plecoptera	Stonefly order	River	Density		.580		yes	yes
115	Trichoptera	Hydropsychidae	Caddisfly family	Collectors	River	First appears	.600	1,600	yes	yes
151	Trichoptera	Trichoptera	Caddisfly order	River	Density		.580		yes	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	Persis. (km)	Unperturbed source
NUTRIENT ADDITION									
31			Biomass		Lake	Biomass	4.300	-	-
31			Density		Lake	Density	4.300	-	-
ORGANISM REMOVAL (NON CHEM)									
74	Annelipoda	Gammaridae	Scud family	Collectors	River	Density	.011	.000	yes
75	Annelipoda	Gammaridae	Scud family	Collectors	River	Density	.003	.000	yes
74	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.027	.000	yes
75	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	.011	.000	yes
OXYGEN STRESS									
29			Species composition		Lake	Species composition	1.700	-	yes
29	Ephemeroptera	Ephemeridae	Mayfly family	Collectors	Lake	Density	1.700	-	yes
SUSPENDED SOLIDS									
198			Density		River	Density	.120	1.000	yes
117			Density		River	Density	1.000	1.300	yes
118			Density		River	Density	.900	7.400	yes
201			Density		River	Density	.300	1.600	yes
117			Genera richness		River	Genera richness	1.000	1.300	yes
118			Genera richness		River	Genera richness	.900	7.400	yes
117			Species composition		River	Species composition	1.000	1.300	yes
118			Species composition		River	Species composition	.900	7.400	yes
201			Species composition		River	Species composition	.100	1.600	yes
203			Species composition		River	Species composition	.900	4.800	yes
135	Annelipoda	Gammaridae	Scud family	Collectors	River	Density	1.000	yes	yes
203	Decapoda	Caenidae	Crayfish family	Grazers	River	Density	1.000	4.800	yes
203	Ephemeroptera	Baetidae	Mayfly family	Collectors	River	Density	1.000	4.800	yes
203	Ephemeroptera	Ephemerellidae	Mayfly family	Collectors	River	Density	1.000	4.800	yes
203	Ephemeroptera	Isonychia sp.	Mayfly	Collectors	River	Density	1.000	4.800	yes
203	Ephemeroptera	Stenacron sp.	Mayfly	Collectors	River	Density	1.000	4.800	yes
203	Ephemeroptera	Stenonema sp.	Mayfly	Collectors	River	Density	1.000	4.800	yes
203	Megaloptera	Corydalidae	Dobsonfly family	Predators	River	Density	1.000	4.800	yes
203	Rotifera	Rotifera	Rotifer phylum	Grazers	River	Density	1.000	4.800	yes
203	Trichoptera	Philoctanidae	Caddisfly family	Collectors	River	Density	1.000	4.800	yes

(continued) Table 18. Recovery times for macroinvertebrates by stressor.

Case no.	Order	Scientific name	Common name	Function	System type	Recovery type	Time to Distance recover to refugia species (yrs)	Persis. (km) in sys.	Unperturbed source
									Downstream
TINBER ACTIVITY									
70			Bionass		River	Bionass	> 5.000	yes	yes
193			Bionass		River	Bionass	> 15.000	yes	yes
70			Density		River	Density	> 5.000	yes	yes
70			Genera richness		River	Genera richness	< 5.000	yes	yes
193			Productivity		River	Productivity	> 15.000	yes	yes
193					River	First appears	> 25.000	no	yes
193			Biting midge family		River	Density	> 20.000	yes	yes
193	Diptera	Ceratopogonidae	Fly	Predators	River	Density	> 20.000	yes	yes
193	Diptera	Dicranota sp.	Cranefly	Predators	River	Density	> 20.000	yes	yes
193	Diptera	Hexatoma sp.	Mayfly family	Collectors	River	Density	> 20.000	yes	yes
193	Ephemeroptera	Leptophlebiidae	Stonefly	Collectors	River	Density	> 20.000	yes	yes
193	Plecoptera	Alloperla sp.	Stonefly family	Shredders	River	Density	> 20.000	yes	yes
193	Plecoptera	Leuctridae	Stonefly family	Shredders	River	Density	> 20.000	yes	yes
193	Plecoptera	Peltoperilidae	Stonefly family	Shredders	River	Density	> 20.000	yes	yes
193	Trichoptera	Philopotamidae	Caddisfly family	Collectors	River	Density	> 20.000	yes	yes
193	Trichoptera	Rhyacophillidae	Caddisfly family	Predators	River	Density	> 20.000	yes	yes

Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
133	Biomass			Channelization	River	Biomass	> 5.000	1.000	yes yes yes
58	Biomass			Channelization	River	Biomass	> 52.000	39.000	- yes yes
132	Biomass			Channelization	River	Biomass	> 25.000		yes yes yes
97	Biomass			Chemical, DDT	River	Biomass	.130		- - -
98	Biomass			Chemical, DDT	River	Biomass	1.200		- - -
99	Biomass			Chemical, DDT	River	Biomass	1.000		- - -
101	Biomass			Chemical, DDT	River	Biomass	1.000		- - -
174	Biomass			Chemical, DDT	River	Biomass	> 1.200		- - -
181	Biomass			Chemical, DDT	River	Biomass	1.000	6.400	yes yes yes
182	Biomass			Chemical, DDT	River	Biomass	> 1.200	6.400	yes yes yes
185	Biomass			Chemical, DDT	River	Biomass	> 1.250		- - -
85	Biomass			Chemical, DDT	River	Biomass	.080		- - -
40	Biomass			Chemical, other	River	Biomass	> 1.000	.500	- yes no
114	Biomass			Chemical, other	River	Biomass	.030		yes - -
144	Biomass			Chemical, other	River	Biomass	2.250	.068	yes no yes
124	Biomass			Chemical, other	River	Biomass	.170	2.900	yes no yes
14	Biomass			Chemical, rotenone	River	Biomass	1.000	1.000	- - -
14	Biomass			Chemical, rotenone	River	Biomass	1.000	24.000	- - -
16	Biomass			Chemical, rotenone	River	Biomass	.900	180.000	- yes no
17	Biomass			Chemical, rotenone	River	Biomass	.080	18.000	- - -
15	Biomass			Chemical, rotenone	River	Density	.900	92.000	- yes no
96	Biomass			Chemical, rotenone	River	Biomass	1.100	.050	no yes yes
44	Biomass			Dredging	River	Biomass	< 1.000	31.000	- no yes
25	Biomass			Drought	River	Biomass	.170		yes no no
125	Biomass			Flooding	River	Biomass	1.000	.250	yes yes yes
95	Biomass			Flooding	River	Biomass	> .330		- - -
184	Biomass			Habitat development	River	Biomass	< 5.000	1.000	- yes yes
84	Biomass			Mining activity	River	Biomass	> 10.000	1.500	no no yes
151	Biomass			Multiple disturbances	River	Biomass	.580		- - -
31	Biomass			Nutrient addition	Lake	Biomass	4.300		- - -
70	Biomass			Timber activity	River	Biomass	> 5.000	.100	yes yes yes
193	Biomass			Timber activity	River	Biomass	> 15.000		yes no yes
133	Density			Channelization	River	Density	> 5.000		- - -
58	Density			Channelization	River	Density	> 52.000	39.000	- yes yes
132	Density			Channelization	River	Density	> 25.000		yes yes yes
119	Density			Chemical, DDT	River	Density	.330	.600	yes no yes
90	Density			Chemical, DDT	River	Density	> 1.250	7.800	yes no yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
174	Density			Chemical, DDT	River	Density	> 1.250	-	-
185	Density			Chemical, DDT	River	Density	1.080	-	-
186	Density			Chemical, DDT	River	Density	.400	.080	no yes
186	Density			Chemical, DDT	River	Density	1.400	.400	no yes
85	Density			Chemical, DDT	River	Density	3.000	-	-
122	Density			Chemical, DDT	River	Density	.300	3.200	yes no yes
160	Density			Chemical, DDT	River	Density	1.000	yes	yes yes
24	Density			Chemical, acid	River	Density	.080	.010	yes yes
134	Density			Chemical, alkaline	River	Density	1.400	-	-
40	Density			Chemical, other	River	Density	> 1.000	.500	- yes no
189	Density			Chemical, other	River	Density	> .500	.060	yes yes
205	Density			Chemical, other	Pond	Density	2.300	-	-
208	Density			Chemical, other	River	Density	1.000	yes	-
62	Density			Chemical, other	River	Density	.120	1.600	yes no
63	Density			Chemical, other	River	Density	.120	31.000	yes no
116	Density			Chemical, other	River	Density	1.250	yes	yes yes
108	Density			Chemical, other	River	Density	< .250	yes	-
144	Density			Chemical, other	River	Density	.320	.068	yes no yes
109	Density			Chemical, other	River	Density	< .500	-	-
60	Density			Chemical, other	River	Density	.020	1.200	yes no
187	Density			Chemical, other	River	Density	.600	1.100	yes no yes
21	Density			Chemical, rotenone	River	Density	.080	4.400	yes yes
93	Density			Chemical, rotenone	River	Density	< 1.000	yes	no no
14	Density			Chemical, rotenone	River	Density	.170	1.000	-
14	Density			Chemical, rotenone	River	Density	.670	24.000	- yes no
15	Density			Chemical, rotenone	River	Density	.900	92.000	- yes no
16	Density			Chemical, rotenone	River	Density	1.000	185.000	- yes no
17	Density			Chemical, rotenone	River	Density	.170	-	- yes no
110	Density			Dredging	River	Density	1.000	.010	yes yes
96	Density			Dredging	River	Density	.800	.050	no yes
33	Density			Dredging	Lake	Density	.016	-	-
34	Density			Dredging	Lake	Density	.033	.001	-
35	Density			Dredging	Lake	Density	.025	-	-
162	Density			Drought	River	Density	< .250	0.000	no yes
137	Density			Drought	River	Density	1.000	15.000	no yes
44	Density			Drought	River	Density	< 1.000	31.000	- no yes
22	Density			Drought	River	Density	.210	.300	no yes
125	Density			Flooding	River	Density	1.000	.250	yes yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
95	Density			Flooding	River	Density	> .330		yes no
192	Density			Flooding	River	Density	.250		yes no
184	Density			Habitat development	River	Density	< 5.000	1.000	yes yes
84	Density			Mining activity	River	Density	> 10.000	1.500	no no yes
69	Density			Mining activity	River	Density	22.000		yes no -
151	Density			Multiple disturbances	River	Density	.580		yes yes
31	Density			Nutrient addition	Lake	Density	4.300		- -
198	Density			Suspended solids	River	Density	.120	1.000	yes yes
117	Density			Suspended solids	River	Density	> 1.000	1.300	yes yes
118	Density			Suspended solids	River	Density	> .900	7.400	yes yes
201	Density			Suspended solids	River	Density	.300	1.600	yes yes
70	Density			Timber activity	River	Density	> 5.000	.100	yes yes
144	Functional grp prop			Chemical, other	River	Functional grp prop	2.000	.068	yes no yes
137	Functional grp prop			Drought	River	Functional grp prop	> 3.500	15.000	no yes yes
58	Genera richness			Channelization	River	Genera richness	> 52.000	39.000	- yes yes
132	Genera richness			Channelization	River	Genera richness	> 25.000		yes yes yes
119	Genera richness			Chemical, DDT	River	Genera richness	.170	.600	- -
97	Genera richness			Chemical, DDT	River	Genera richness	1.000		- -
98	Genera richness			Chemical, DDT	River	Genera richness	1.100		- -
99	Genera richness			Chemical, DDT	River	Genera richness	1.000		- -
101	Genera richness			Chemical, DDT	River	Genera richness	1.000		- -
85	Genera richness			Chemical, DDT	River	Genera richness	3.000		- -
122	Genera richness			Chemical, DDT	River	Genera richness	1.250	3.200	yes no yes
40	Genera richness			Chemical, other	River	Genera richness	> 1.000	.500	- yes no
189	Genera richness			Chemical, other	River	Genera richness	> .500	.060	yes yes yes
208	Genera richness			Chemical, other	River	Genera richness	1.000		yes - -
108	Genera richness			Chemical, other	River	Genera richness	> .250		yes - -
109	Genera richness			Chemical, other	River	Genera richness	1.000		- -
14	Genera richness			Chemical, rotenone	River	Genera richness	1.200	24.000	- yes no
15	Genera richness			Chemical, rotenone	River	Genera richness	1.000	92.000	- yes no
16	Genera richness			Chemical, rotenone	River	Genera richness	1.000	185.000	- yes no
17	Genera richness			Chemical, rotenone	River	Genera richness	1.000		- yes no
110	Genera richness			Dredging	River	Genera richness	1.000	.010	yes yes yes
202	Genera richness			Dredging	River	Genera richness	.500	.200	yes yes yes
33	Genera richness			Dredging	Lake	Genera richness	.016		- -
34	Genera richness			Dredging	Lake	Genera richness	.033		- -
35	Genera richness			Dredging	Lake	Genera richness	> .074		- -
137	Genera richness			Drought	River	Genera richness	1.200	15.000	no yes yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	Time to Distance recover to refugia species for recolonization (ks)	Persis. Unperturbed source in eye. Upstream Donnstrea
44		Genera richness		Drought	River	Genera richness	1.000	31.000	-
22		Genera richness		Drought	River	Genera richness	.270	.300	no
82		Genera richness		Drought	River	Genera richness	.100	.680	-
25		Genera richness		Flooding	River	Genera richness	.170		yes
125		Genera richness		Flooding	River	Genera richness	1.000	.250	yes
95		Genera richness		Flooding	River	Genera richness	.330		yes
184		Genera richness		Habitat development	River	Genera richness	< 5.000	1.000	-
84		Genera richness		Mining activity	River	Genera richness	> 10.000	1.500	no
69		Genera richness		Mining activity	River	Genera richness	22.000		yes
115		Genera richness		Multiple disturbances	River	Genera richness	.600	1.600	-
117		Genera richness		Suspended solids	River	Genera richness	> 1.000	1.300	yes
118		Genera richness		Suspended solids	River	Genera richness	> .900	7.400	yes
70		Genera richness		Timber activity	River	Genera richness	< 5.000	.100	yes
84		Productivity		Mining activity	River	Productivity	> 10.000	1.500	no
193		Productivity		Timber activity	River	Productivity	> 15.000		yes
80		Species composition		Chemical, DDT	River	Species composition	> 4.000		yes
81		Species composition		Chemical, DDT	River	Species composition	> 4.000		yes
181		Species composition		Chemical, DDT	River	Species composition	1.170	6.400	yes
186		Species composition		Chemical, DDT	River	Species composition	1.500	3.200	no
144		Species composition		Chemical, other	River	Species composition	> 2.000	.068	yes
109		Species composition		Chemical, other	River	Species composition	1.000	1.000	yes
33		Species composition		Chemical, other	River	Species composition	> 2.200		no
182		Species composition		Drought	River	Species composition	< .250	0.000	no
82		Species composition		Drought	River	Species composition	.200	.675	-
25		Species composition		Flooding	River	Species composition	.170		-
84		Species composition		Mining activity	River	Species composition	> 10.000	1.500	no
69		Species composition		Mining activity	River	Species composition	> 20.000		yes
29		Species composition		Oxygen stress	Lake	Species composition	> 1.700		-
117		Species composition		Suspended solids	River	Species composition	> 1.000	1.300	yes
118		Species composition		Suspended solids	River	Species composition	> .900	7.400	yes
201		Species composition		Suspended solids	River	Species composition	.100	1.600	yes
203		Species composition		Suspended solids	River	Species composition	.900	4.800	yes
193	Nyphomyiidae			Timber activity	River	Species composition	> 25.000		no
16	Paltingeniidae			Chemical, rotenone	River	First appears	> 2.000	180.000	no
202	Silo nigricornis			Dredging	River	Density	> .400	.200	yes
22	collectors-gatherers	Functional group	Collectors	Drought	River	Density	.380	.300	yes
22	filterers	Functional group	Collectors	Drought	River	Density	.380	.300	yes
22	predators	Functional group	Predators	Drought	River	Density	1.100	.300	yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance		Permits. Unperturbed source	
							(yrs)	(km)	in sys.	Downstream
22	scrapers	Functional group	Grazers	Drought	River	Density	.820	.300	no	yes
ANPHIPODA										
134	Gammaridae	Scud family	Collectors	Chemical, alkaline	River	Density	1.250	2.000	yes	no
205	Gammaridae	Scud family	Collectors	Chemical, other	Pond	Density	> 2.400		-	-
124	Gammaridae	Scud family	Collectors	Chemical, other	River	Density	.750	2.900	yes	no
187	Gammaridae	Scud family	Collectors	Chemical, other	River	Density	1.800	1.100	yes	yes
202	Gammaridae	Scud family	Collectors	Dredging	River	Density	.010	.200	yes	yes
68	Gammaridae	Scud family	Collectors	Flooding	River	Density	.500	3.000	yes	no
95	Gammaridae	Scud family	Collectors	Flooding	River	Density	.330		yes	no
74	Gammaridae	Scud family	Collectors	Organism removal (non ch)	River	Density	.011	.000	yes	yes
75	Gammaridae	Scud family	Collectors	Organism removal (non ch)	River	Density	.003	.000	yes	yes
135	Gammaridae	Scud family	Collectors	Suspended solids	River	Density	1.000		yes	yes
7	Talitridae	Scud family	Grazers	Chemical, other	Lake	Density	> .170	.800	yes	-
9	Talitridae	Scud family	Grazers	Chemical, other	Lake	Density	> .310		yes	-
166	Talitridae	Scud family	Grazers	Chemical, other	Lake	Density	> .190	.800	no	-
167	Talitridae	Scud family	Grazers	Chemical, other	Lake	Density	> .170	.800	no	-
6	Talitridae	Scud family	Grazers	Chemical, other	Lake	First appears	> .670		no	-
167	Talitridae	Scud family	Grazers	Chemical, other	Lake	First appears	.060	.800	no	-
ARACHNIDS										
189	Hydracarina	Water mite	Predators	Chemical, other	River	Density	> .500	.060	yes	yes
15	Hydracarina	Water mite	Predators	Chemical, rotenone	River	First appears	1.000	92.000	no	yes
COLEOPTERA										
186	Coleoptera	Beetle order		Chemical, DDT	River	Density	1.400	.080	no	yes
186	Coleoptera	Beetle order		Chemical, DDT	River	First appears	1.000	1.600	no	yes
186	Coleoptera	Beetle order		Chemical, DDT	River	First appears	1.330	3.200	no	yes
134	Coleoptera	Beetle order		Chemical, alkaline	River	First appears	1.250	2.000	yes	no
108	Coleoptera	Beetle order		Chemical, other	River	Density	< .250		no	-
125	Coleoptera	Beetle order		Flooding	River	Density	> 2.000	.250	yes	yes
84	Coleoptera	Beetle order		Mining activity	River	Density	> 10.000	1.500	no	yes
2	Curculionidae	Weevil family	Shredders	Chemical, other	Lake	Density	> 1.500		no	-
2	Curculionidae	Weevil family	Shredders	Chemical, other	Lake	First appears	> 1.500		no	-
48	Dytiscidae	Diving beetle family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-
49	Dytiscidae	Diving beetle family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-
83	Dytiscidae	Diving beetle family	Predators	Chemical, other	River	First appears	2.200		no	yes
82	Dytiscidae	Diving beetle family	Predators	Drought	River	Density	.250	.675	no	yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	Perils. Unperturbed source in sys. Upstream Downstream
COLEOPTERA								
132	Elmidae	Riffle beetle family	Collectors	Channelization	River	Density	> 25,000	yes yes
122	Elmidae	Riffle beetle family	Collectors	Chemical, DDT	River	Density	> 1,330	3,200 - no yes
63	Elmidae	Riffle beetle family	Collectors	Chemical, other	River	Density	1,000	31,000 yes yes no
14	Elmidae	Riffle beetle family	Collectors	Chemical, rotenone	River	First appears	.020	8,000 yes yes no
84	Elmidae	Riffle beetle family	Collectors	Mining activity	River	Density	> 10,000	1,500 no no yes
48	Hydrophilidae	Water scavenger beetle family	Collectors	Chemical, other	Pond	Density	> .100	.020 yes - -
49	Hydrophilidae	Water scavenger beetle family	Collectors	Chemical, other	Pond	Density	> .100	.020 yes - -
15	Hydrophilidae	Water scavenger beetle family	Collectors	Chemical, rotenone	River	First appears	1,000	92,000 no yes no
16	Hydrophilidae	Water scavenger beetle family	Collectors	Chemical, rotenone	River	First appears	1,700	185,000 no yes no
17	Hydrophilidae	Water scavenger beetle family	Collectors	Chemical, rotenone	River	First appears	1,000	16,000 no yes no
132	Psephenidae	Beetle family	Channelization		River	Density	> 25,000	yes yes yes
COLLEMBOLA								
144	Collembola	Springtail	Collectors	Chemical, other	River	Density	> 2,000	.068 - no yes
DECAPODA								
95	Astacidae	Crayfish family	Collectors	Flooding	River	First appears	> .330	no no no
119	Cambaridae	Crayfish family	Grazers	Chemical, DDT	River	Density	.330	.600 yes no yes
203	Cambaridae	Crayfish family	Grazers	Suspended solids	River	Density	> 1,000	4,800 yes yes yes
DIPTERA								
124	Anatocla sp.	Cranefly	Collectors	Chemical, other	River	Density	> 2,000	2,900 yes no yes
187	Anatocla sp.	Cranefly	Collectors	Chemical, other	River	Density	.900	1,100 yes no yes
84	Anatocla sp.	Cranefly	Collectors	Mining activity	River	Density	> 10,000	1,500 no no yes
82	Ceratopogonidae	Biting midge family	Drought		River	Density	.080	.675 no no yes
193	Ceratopogonidae	Biting midge family	Flaiber activity		River	Density	> 20,000	yes no yes
82	Ceratopogonidae	Biting midge subfamily	Predators	Drought	River	Density	.330	.675 no no yes
122	Chaoboridae	Phantom midge family	Predators	Chemical, DDT	River	Density	1,330	3,200 - no yes
108	Chaoboridae	Phantom midge family	Predators	Chemical, other	River	Density	> .250	yes - -
188	Chaoboridae	Phantom midge family	Predators	Chemical, other	Lake	Density	4,300	.400 no - -
5	Chaoboridae	Phantom midge family	Predators	Chemical, rotenone	Lake	Density	> 1,000	yes - -
191	Chaoboridae	Phantom midge family	Predators	Multiple disturbances	Pond	Density	2,000	yes - -
119	Chironomidae	Midge family	Chemical, DDT		River	Density	.330	.600 no no yes
90	Chironomidae	Midge family	Chemical, DDT		River	Density	.080	7,800 yes no no
97	Chironomidae	Midge family	Chemical, DDT		River	Density	.130	yes no yes
98	Chironomidae	Midge family	Chemical, DDT		River	Density	1,000	yes no yes
99	Chironomidae	Midge family	Chemical, DDT		River	Density	.130	yes no yes
100	Chironomidae	Midge family	Chemical, DDT		River	Density	.020	yes no yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
DIPTERA									
101	Chironomidae	Hidge family		Chemical, DDT	River	Density	.130		yes no yes
85	Chironomidae	Hidge family		Chemical, DDT	River	Density	.080		- no no
122	Chironomidae	Hidge family		Chemical, DDT	River	Density	.210	3.200	- no yes
160	Chironomidae	Hidge family		Chemical, DDT	River	Density	.300		yes yes yes
189	Chironomidae	Hidge family		Chemical, other	River	Density	.500	.060	yes yes yes
4	Chironomidae	Hidge family		Chemical, other	Lake	Density	.750		yes - -
47	Chironomidae	Hidge family		Chemical, other	Pond	Density	.330		yes - -
51	Chironomidae	Hidge family		Chemical, other	Pond	Density	.150		yes - -
180	Chironomidae	Hidge family		Chemical, other	River	Density	.500	4.800	yes yes yes
62	Chironomidae	Hidge family		Chemical, other	River	Density	.120	1.600	yes yes no
108	Chironomidae	Hidge family		Chemical, other	River	Density	.250		yes - -
83	Chironomidae	Hidge family		Chemical, other	River	Density	2.200		no no yes
124	Chironomidae	Hidge family		Chemical, other	River	Density	.170	2.900	yes no yes
21	Chironomidae	Hidge family		Chemical, rotenone	River	First appears	.120	4.400	yes yes yes
14	Chironomidae	Hidge family		Chemical, rotenone	River	Density	.670	24.000	no yes no
15	Chironomidae	Hidge family		Chemical, rotenone	River	Density	1.200	92.000	no yes no
14	Chironomidae	Hidge family		Chemical, rotenone	River	First appears	.038	8.000	no yes no
15	Chironomidae	Hidge family		Chemical, rotenone	River	First appears	.170	92.000	no yes no
16	Chironomidae	Hidge family		Chemical, rotenone	River	First appears	.170	180.000	yes yes no
33	Chironomidae	Hidge family		Dredging	Lake	Density	.016	.001	- - yes
34	Chironomidae	Hidge family		Dredging	Lake	Density	.033	.001	- - yes
35	Chironomidae	Hidge family		Dredging	Lake	Density	.056	.001	- - yes
170	Chironomidae	Hidge family		Drought	River	First appears	.030	.010	no - -
22	Chironomidae	Hidge family		Drought	River	Density	.040	.300	no yes yes
95	Chironomidae	Hidge family		Flooding	River	Density	.330		yes no no
192	Chironomidae	Hidge family		Flooding	River	Density	.250		yes yes no
43	Chironomidae	Hidge family		Multiple disturbances	River	Density	.130		yes yes yes
115	Chironomidae	Hidge family		Multiple disturbances	River	First appears	.330	1.600	yes yes yes
82	Chironomus sp.	Hidge	Collectors	Drought	River	First appears	.030	.675	no no yes
84	Cricotopus sp.	Hidge	Shredders	Mining activity	River	Density	8.000	1.500	no no yes
84	Diamasinae	Hidge subfamily	Collectors	Mining activity	River	Density	8.000	1.500	no no yes
193	Dicranota sp.	Fly	Predators	Timber activity	River	Density	20.000		yes no yes
186	Diptera	Fly, mosquito, midge order		Chemical, DDT	River	Density	.080	4.800	no yes yes
208	Diptera	Fly, mosquito, midge order		Chemical, other	River	Density	1.000		yes - -
93	Diptera	Fly, mosquito, midge order		Chemical, rotenone	River	Density	1.000		yes no no
162	Diptera	Fly, mosquito, midge order		Drought	River	Density	.250	.250	no yes yes
125	Diptera	Fly, mosquito, midge order		Flooding	River	Density	.170	.250	yes yes yes
84	Diptera	Fly, mosquito, midge order		Mining activity	River	Density	8.000	1.500	no no yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to recover to refugia species for recolonization (yrs)	Distance (km)	Unperturbed source in sys. Upstream Downstream	
DIPTERA										
151	Diptera	Fly, mosquito, midge order		Multiple disturbances	River	Density	.580		yes	yes
144	Dixidae	Dixa midge family	Collectors	Chemical, other	River	Density	> 2,000	.068	-	no
14	Epididae	Dancefly family	Predators	Chemical, rotenone	River	First appears	1,700	24,000	no	yes
17	Epididae	Dancefly family	Predators	Chemical, rotenone	River	First appears	2,000	16,000	no	yes
84	Epididae	Dancefly family	Predators	Mining activity	River	Density	8,000	1,500	no	yes
84	Epididae	Dancefly family	Predators	Mining activity	River	Density	> 10,000	1,500	no	yes
144	Hexatona sp.	Cranefly	Predators	Chemical, other	River	Density	> 2,000	.068	-	no
84	Hexatona sp.	Cranefly	Predators	Mining activity	River	Density	> 10,000	1,500	no	yes
193	Hexatona sp.	Cranefly	Predators	Timber activity	River	Density	> 20,000		yes	yes
84	Microspectra sp.	Midge	Collectors	Mining activity	River	Density	> 10,000	1,500	no	yes
208	Microtendipes	Midge		Chemical, other	River	Density	.160		yes	-
209	Microtendipes	Midge		Chemical, other	River	Density	.160		yes	-
2	Orthocladinae	Midge subfamily		Chemical, other	Lake	Density	.160		yes	-
82	Orthocladinae	Midge subfamily		Drought	River	Density	.020	.675	no	yes
82	Orthocladinae	Midge subfamily		Drought	River	Density	> .420	.675	no	yes
109	Orthocladus sp.	Midge	Collectors	Chemical, other	River	Density	< .500	1,000	yes	yes
84	Orthocladus sp.	Midge	Collectors	Mining activity	River	Density	8,000	1,500	no	yes
2	Psectrocladius sp.	Midge	Collectors	Chemical, other	Lake	Density	.160		yes	-
133	Simuliidae	Blackfly family	Collectors	Channelization	River	Density	> 5,000	1,000	yes	yes
119	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	.330	.600	yes	yes
90	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000	7,800	no	no
97	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000		yes	yes
98	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000		yes	yes
100	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000		no	yes
101	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000		no	yes
85	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,000		no	yes
122	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	1,500		-	no
160	Simuliidae	Blackfly family	Collectors	Chemical, DDT	River	Density	> 1,330	3,200	-	yes
144	Simuliidae	Blackfly family	Collectors	Chemical, other	River	Density	1,300	.068	no	yes
124	Simuliidae	Blackfly family	Collectors	Chemical, other	River	Density	> 2,000		-	yes
21	Simuliidae	Blackfly family	Collectors	Chemical, rotenone	River	Density	.250	2,900	yes	yes
17	Simuliidae	Blackfly family	Collectors	Chemical, rotenone	River	Density	.038	4,400	yes	yes
15	Simuliidae	Blackfly family	Collectors	Chemical, rotenone	River	Density	.800	16,000	-	yes
170	Simuliidae	Blackfly family	Collectors	Chemical, rotenone	River	First appears	.670	92,000	no	yes
22	Simuliidae	Blackfly family	Collectors	Drought	River	Density	.014	.010	no	-
82	Simuliidae	Blackfly family	Collectors	Drought	River	Density	.120	.300	no	yes
82	Simuliidae	Blackfly family	Collectors	Drought	River	Density	.060	.675	no	yes
82	Simuliidae	Blackfly family	Collectors	Drought	River	First appears	.020	.675	no	yes
95	Simuliidae	Blackfly family	Collectors	Flooding	River	First appears	> .330		no	no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	(km)	Persis. Unperturbed source in sys. Upstream Downstream
DIPTERA									
192	Simuliidae	Blackfly family	Collectors	Flooding	River	Density	.250		yes
84	Simuliidae	Blackfly family	Collectors	Mining activity	River	Density	> 10.000	1.500	no
189	Tabanidae	Horsefly family		Chemical, other	River	Density	> .500	.060	yes
95	Tabanidae	Horsefly family		Flooding	River	First appears	> .330		no
108	Tanyderidae	Primitive crane fly family	Shredders	Chemical, other	River	Density	> .250		no
82	Tanytopodinae	Hidge subfamily	Predators	Drought	River	Density	.080	.675	no
82	Tanytopodinae	Hidge subfamily	Collectors	Drought	River	Density	.170	.675	no
84	Tanytopodinae	Hidge	Predators	Mining activity	River	Density	8.000	1.500	no
160	Tipulidae	Cranefly family		Chemical, DDT	River	Density	1.300		yes
15	Tipulidae	Cranefly family		Chemical, rotenone	River	First appears	> 2.000	92.000	no
17	Tipulidae	Cranefly family		Chemical, rotenone	River	First appears	1.000	16.000	yes
82	Tipulidae	Cranefly family		Drought	River	Density	> .420	.675	no
95	Tipulidae	Cranefly family		Flooding	River	Density	.330		yes
83	Tribelios sp.	Hidge	Grazers	Chemical, other	River	First appears	1.300		no
EPHEMEROPTERA									
119	Baetidae	Mayfly family	Collectors	Chemical, DDT	River	Density	.330	.600	yes
122	Baetidae	Mayfly family	Collectors	Chemical, DDT	River	Density	1.330	3.200	no
160	Baetidae	Mayfly family	Collectors	Chemical, DDT	River	Density	1.300		yes
48	Baetidae	Mayfly family	Collectors	Chemical, other	Pond	Density	> .100	.020	no
49	Baetidae	Mayfly family	Collectors	Chemical, other	Pond	Density	> .100	.020	no
108	Baetidae	Mayfly family	Collectors	Chemical, other	River	Density	> .250		no
124	Baetidae	Mayfly family	Collectors	Chemical, other	River	Density	.442	2.900	yes
187	Baetidae	Mayfly family	Collectors	Chemical, other	River	Density	.700	1.100	yes
14	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	.670	16.000	no
15	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	1.700	92.000	yes
17	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	.250	16.000	no
14	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	.170	1.600	yes
15	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	.670	92.000	no
15	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	.670	210.000	no
16	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	.020	16.000	yes
17	Baetidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	2.000	.010	yes
110	Baetidae	Mayfly family	Collectors	Dredging	River	Density	.014	.010	no
170	Baetidae	Mayfly family	Collectors	Drought	River	First appears	.130	1.000	yes
136	Baetidae	Mayfly family	Collectors	Drought	River	Density	.080	1.000	yes
22	Baetidae	Mayfly family	Collectors	Drought	River	Density	.080	.300	yes
82	Baetidae	Mayfly family	Collectors	Drought	River	Density	.190	.675	no
82	Baetidae	Mayfly family	Collectors	Drought	River	First appears	.050	.675	no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	Time to Distance recover to refugia species for recolonization (km)	Persis. Unperturbed source in sys. Upstream Downstream
EPHEMEROPTERA									
95	Beetidae	Mayfly family	Collectors Flooding	Collectors Flooding	River	Density	.120	yes	no
84	Baetidae	Mayfly family	Collectors Mining activity	Collectors Mining activity	River	Density	> 10.000	1.500	no
115	Baetidae	Mayfly family	Collectors Multiple disturbances	Collectors Multiple disturbances	River	First appears	.330	1.600	yes
74	Baetidae	Mayfly family	Collectors Organism removal (non ch)	Collectors Organism removal (non ch)	River	Density	.027	.000	yes
75	Baetidae	Mayfly family	Collectors Organism removal (non ch)	Collectors Organism removal (non ch)	River	Density	.011	.000	yes
203	Baetidae	Mayfly family	Collectors Suspended solids	Collectors Suspended solids	River	Density	> 1.000	4.800	yes
8	Caenidae	Mayfly family	Collectors Chemical, other	Collectors Chemical, other	Lake	Density	.100		yes
9	Caenidae	Mayfly family	Collectors Chemical, other	Collectors Chemical, other	Lake	Density	.130		-
16	Caenidae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	1.000	185.000	no
82	Caenidae	Mayfly family	Collectors Drought	Collectors Drought	River	Density	.190	.675	no
110	Cinygmula sp.	Mayfly	Grazers Dredging	Grazers Dredging	River	Density	.800	.010	yes
84	Cinygmula sp.	Mayfly	Grazers Mining activity	Grazers Mining activity	River	Density	> 10.000	1.500	no
122	Epeorus sp.	Mayfly	Collectors Chemical, DDT	Collectors Chemical, DDT	River	Density	.1330	3.200	-
160	Epeorus sp.	Mayfly	Collectors Chemical, DDT	Collectors Chemical, DDT	River	Density	1.000		yes
110	Epeorus sp.	Mayfly	Collectors Dredging	Collectors Dredging	River	Density	.800	.010	yes
95	Epeorus sp.	Mayfly	Collectors Flooding	Collectors Flooding	River	Density	> .330		yes
115	Epeorus sp.	Mayfly	Collectors Multiple disturbances	Collectors Multiple disturbances	River	First appears	.600	1.600	yes
133	Ephemerellidae	Mayfly family	Collectors Channelization	Collectors Channelization	River	Density	> 5.000	1.000	yes
122	Ephemerellidae	Mayfly family	Collectors Chemical, DDT	Collectors Chemical, DDT	River	Density	.330	3.200	-
160	Ephemerellidae	Mayfly family	Collectors Chemical, DDT	Collectors Chemical, DDT	River	Density	.300		yes
144	Ephemerellidae	Mayfly family	Collectors Chemical, other	Collectors Chemical, other	River	Density	> 2.000	.068	-
14	Ephemerellidae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	1.000	24.000	no
15	Ephemerellidae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	1.000	92.000	no
16	Ephemerellidae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	1.000	185.000	no
17	Ephemerellidae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	.020	16.000	no
22	Ephemerellidae	Mayfly family	Collectors Drought	Collectors Drought	River	Density	.120	.300	yes
95	Ephemerellidae	Mayfly family	Collectors Flooding	Collectors Flooding	River	Density	> .330		yes
84	Ephemerellidae	Mayfly family	Collectors Mining activity	Collectors Mining activity	River	Density	> 10.000	1.500	no
115	Ephemerellidae	Mayfly family	Collectors Multiple disturbances	Collectors Multiple disturbances	River	First appears	1.000	1.600	yes
203	Ephemerellidae	Mayfly family	Collectors Suspended solids	Collectors Suspended solids	River	Density	> 1.000	4.800	yes
16	Ephemeridae	Mayfly family	Collectors Chemical, rotenone	Collectors Chemical, rotenone	River	First appears	2.000	210.000	no
29	Ephemeridae	Mayfly family	Collectors Oxygen stress	Collectors Oxygen stress	Lake	Density	> 1.700		-
90	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000	7.800	yes
97	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000		no
98	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000		yes
99	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000		no
100	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000		yes
101	Ephemeroptera	Mayfly order	Chemical, DDT	Chemical, DDT	River	Density	1.000		no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia species for recolonization (yrs)	Perils. Unperturbed source in sys. Upstream Downstream
EPTHEMEROPTERA								
98	Ephemeroptera	Mayfly order		Chemical, DDT	River	First appears	.130	no no yes
80	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	3.000	yes no -
81	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	2.000	yes no -
185	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	1.000	- - -
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	.410	no yes yes
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	< 1.000	no yes yes
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	First appears	.040	no yes yes
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	First appears	.080	no yes yes
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	First appears	.250	no yes yes
186	Ephemeroptera	Mayfly order		Chemical, DDT	River	First appears	.410	no yes yes
85	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	3.000	- no no
86	Ephemeroptera	Mayfly order		Chemical, DDT	River	Density	3.000	- no no
180	Ephemeroptera	Mayfly order		Chemical, other	River	Density	> 1.600	- yes yes
207	Ephemeroptera	Mayfly order		Chemical, other	River	Density	< 1.000	yes - -
208	Ephemeroptera	Mayfly order		Chemical, other	River	Density	< 1.000	yes - -
109	Ephemeroptera	Mayfly order		Chemical, other	River	Density	1.000	yes yes no
21	Ephemeroptera	Mayfly order		Chemical, rotenone	River	First appears	.080	yes yes yes
93	Ephemeroptera	Mayfly order		Chemical, rotenone	River	Density	< 1.000	yes no no
162	Ephemeroptera	Mayfly order		Drought	River	Density	< .250	no yes yes
125	Ephemeroptera	Mayfly order		Flooding	River	Density	.850	yes yes yes
84	Ephemeroptera	Mayfly order		Mining activity	River	Density	> 10.000	no no yes
69	Ephemeroptera	Mayfly order		Mining activity	River	Density	18.000	yes no no
151	Ephemeroptera	Mayfly order		Multiple disturbances	River	Density	.560	yes yes yes
16	Reptagenia sp.	Mayfly	Grazers	Chemical, rotenone	River	Density	1.000	185.000 no yes no
14	Reptagenia sp.	Mayfly	Grazers	Chemical, rotenone	River	First appears	1.000	24.000 no yes no
15	Reptagenia sp.	Mayfly	Grazers	Chemical, rotenone	River	First appears	1.000	92.000 no yes no
17	Reptagenia sp.	Mayfly	Grazers	Chemical, rotenone	River	First appears	1.000	16.000 no yes no
95	Reptagenia sp.	Mayfly	Grazers	Flooding	River	Density	.330	yes no no
133	Reptageniidae	Mayfly family	Collectors	Channelization	River	Density	> 5.000	1.000 yes yes yes
132	Reptageniidae	Mayfly family	Collectors	Channelization	River	Density	> 25.000	yes yes yes
119	Isonychia sp.	Mayfly	Collectors	Chemical, DDT	River	Density	> .330	.600 yes no yes
203	Isonychia sp.	Mayfly	Collectors	Suspended solids	River	Density	> .330	4.800 yes no yes
119	Leptophlebiidae	Mayfly family	Collectors	Chemical, DDT	River	Density	.830	yes yes yes
116	Leptophlebiidae	Mayfly family	Collectors	Chemical, other	River	Density	> 2.000	.068 - no yes
144	Leptophlebiidae	Mayfly family	Collectors	Chemical, other	River	Density	2.000	185.000 no yes no
16	Leptophlebiidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	1.000	24.000 no yes no
14	Leptophlebiidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	92.000 no yes no
15	Leptophlebiidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	92.000 no yes no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to recover to refugia species (yrs)	Distance (km)	Persis. Unperturbed source in sys. Upstream	Donstream
EPHEMEROPTERA										
16	Leptophlebiidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	185.000	no	yes
95	Leptophlebiidae	Mayfly family	Collectors	Flooding	River	Density	> .330		yes	no
84	Leptophlebiidae	Mayfly family	Collectors	Mining activity	River	Density	> 10.000	1.500	no	no
193	Leptophlebiidae	Mayfly family	Collectors	Timber activity	River	Density	> 20.000		yes	yes
16	Polysitarcidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	1.700	210.000	no	yes
16	Polysitarcidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	210.000	no	yes
14	Rhithrogena sp.	Mayfly	Collectors	Chemical, rotenone	River	First appears	1.000	24.000	no	yes
15	Rhithrogena sp.	Mayfly	Collectors	Chemical, rotenone	River	First appears	1.000	92.000	no	yes
16	Rhithrogena sp.	Mayfly	Collectors	Chemical, rotenone	River	First appears	1.000	185.000	no	yes
22	Rhithrogena sp.	Mayfly	Collectors	Drought	River	Density	.190	.300	no	yes
84	Rhithrogena sp.	Mayfly	Collectors	Mining activity	River	Density	> 10.000	1.500	no	yes
203	Stenonema sp.	Mayfly	Collectors	Suspended solids	River	Density	> 1.000	4.800	yes	yes
119	Stenonema sp.	Mayfly	Collectors	Chemical, DDT	River	Density	.290	.600	yes	yes
122	Stenonema sp.	Mayfly	Collectors	Chemical, DDT	River	Density	1.330	3.200	-	no
160	Stenonema sp.	Mayfly	Collectors	Chemical, DDT	River	Density	1.300		no	yes
144	Stenonema sp.	Mayfly	Collectors	Chemical, other	River	Density	> 2.000	.068	-	yes
187	Stenonema sp.	Mayfly	Collectors	Chemical, other	River	Density	.600	1.100	yes	yes
170	Stenonema sp.	Mayfly	Collectors	Drought	River	First appears	.093	.010	no	-
22	Stenonema sp.	Mayfly	Collectors	Drought	River	Density	.120	.300	no	yes
95	Stenonema sp.	Mayfly	Collectors	Flooding	River	Density	.120		yes	no
203	Stenonema sp.	Mayfly	Collectors	Suspended solids	River	Density	> 1.000	4.800	yes	yes
15	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	1.200	92.000	no	yes
16	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	Density	1.000	185.000	no	yes
14	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	.040	8.000	no	yes
14	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	24.000	no	yes
15	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	92.000	no	yes
16	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	185.000	no	yes
17	Tricorythidae	Mayfly family	Collectors	Chemical, rotenone	River	First appears	1.000	16.000	no	yes
22	Tricorythidae	Mayfly family	Collectors	Drought	River	Density	> .350	.300	no	yes

Table 19. Recovery times for macroinvertebrates by taxa. (continued)

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	(yrs)	(km)	In sys.	Upstream	Downstream
GASTROPODA											
189	Gastropoda	Snails, limpets class	Grazers	Chemical, other	River	Density	> .500	.060	yes	yes	yes
155	Gastropoda	Snails, limpets class	Grazers	Chemical, other	River	Density	> 1.800	-	-	-	-
157	Gastropoda	Snails, limpets class	Grazers	Chemical, other	River	Density	.580	-	-	-	-
157	Gastropoda	Snails, limpets class	Grazers	Chemical, other	River	First appears	.330	-	-	-	-
156	Gastropoda	Snails, limpets class	Grazers	Chemical, other	River	First appears	.830	-	-	-	-
11	Gastropoda	Snails, limpets class	Grazers	Chemical, rotenone	Lake	Density	< 2.000	-	yes	-	-
15	Gastropoda	Snails, limpets class	Grazers	Chemical, rotenone	River	First appears	.040	92.000	-	yes	no
16	Gastropoda	Snails, limpets class	Grazers	Chemical, rotenone	River	First appears	.040	180.000	-	yes	no
96	Gastropoda	Snails, limpets class	Grazers	Dredging	River	Density	1.000	.030	no	yes	yes
84	Gastropoda	Snails, limpets class	Grazers	Mining activity	River	First appears	> 10.000	1.500	no	no	yes
61	Heliotis sp.	Black abalone	Grazers	Chemical, other	River	Density	> 1.000	2.400	yes	yes	no
14	Lymnaeidae	Pond snail family	Grazers	Chemical, rotenone	River	First appears	.019	24.000	yes	yes	no
15	Lymnaeidae	Pond snail family	Grazers	Chemical, rotenone	River	First appears	.040	92.000	yes	yes	no
43	Lymnaeidae	Pond snail family	Grazers	Multiple disturbances	River	First appears	.500	5.100	yes	-	-
43	Physidae	Pouch snail family	Grazers	Multiple disturbances	River	First appears	.500	5.100	yes	-	-
202	Potamopyrgus sp.	Snail	Grazers	Dredging	River	Density	> .400	.200	yes	yes	yes
5	Viviparidae	Snail family	Grazers	Chemical, rotenone	Lake	Density	> 1.000	-	no	-	-
HEMIPTERA											
48	Belostomatidae	Water bug family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-	-
49	Belostomatidae	Water bug family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-	-
48	Corixidae	Water boatman family	Predators	Chemical, other	Pond	Density	.080	.020	yes	-	-
49	Corixidae	Water boatman family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-	-
108	Hemiptera	Waterbug order	Predators	Chemical, other	River	Density	> .250	-	no	-	-
93	Hemiptera	Waterbug order	Predators	Chemical, rotenone	River	Density	< 1.000	-	yes	no	no
82	Heteroptera	True bug suborder	Predators	Drought	River	Density	.330	.675	no	no	yes
48	Molonecridae	Backsweeper family	Predators	Chemical, other	Pond	Density	.100	.020	yes	-	-
49	Molonecridae	Backsweeper family	Predators	Chemical, other	Pond	Density	> .100	.020	yes	-	-

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia (yrs)	Distance (km)	Persis. Unperturbed source species for recolonization in sys. Upstream Downstream
HIRUDINEA									
10	Hirudinea	Leech class		Chemical, rotenone	Lake	Density	< 2.000		yes
5	Hirudinea	Leech class		Chemical, rotenone	Lake	Density	> 1.000		no
15	Hirudinea	Leech class		Chemical, rotenone	River	First appears	1.000	92.000	yes no
ISOPODA									
93	Isopoda	Soubug order	Collectors	Chemical, rotenone	River	Density	> 1.000		yes no no
LEPIDOPTERA									
2	Praustidae	Aquatic caterpillar fan.	Shredders	Chemical, other	Lake	Density	> 1.500		no
2	Praustidae	Aquatic caterpillar fan.	Shredders	Chemical, other	Lake	First appears	> 1.500		no
MEGALOPTERA									
203	Corydalidae	Dobsonfly family	Predators	Suspended solids	River	Density	> 1.000	4.800	yes yes yes
HEMATODES									
189	Nematoda	Nematode phylum		Chemical, other	River	Density	> .500	.060	yes yes yes
15	Nematoda	Nematode phylum		Chemical, rotenone	River	First appears	1.000	92.000	no yes no
82	Nematoda	Nematode phylum		Drought	River	Density	.020	.675	yes no yes
NEUROPTERA									
93	Neuroptera	Spongillafly order	Predators	Chemical, rotenone	River	Density	< 1.000		yes no no
ODONATA									
119	Aeshnidae	Danselfly family	Predators	Chemical, DDT	River	Density	.330	.600	yes no yes
108	Anisoptera	Dragonfly suborder	Predators	Chemical, other	River	Density	< .250		yes
82	Calopterygidae	Danselfly family	Predators	Drought	River	Density	.250	.675	no no yes
134	Coenagrionidae	Danselfly family	Predators	Chemical, alkaline	River	First appears	1.800	2.000	yes yes no
48	Coenagrionidae	Danselfly family	Predators	Chemical, other	Pond	Density	.080	.020	no
49	Coenagrionidae	Danselfly family	Predators	Chemical, other	Pond	Density	.100	.020	no
83	Coenagrionidae	Danselfly family	Predators	Chemical, other	River	First appears	2.200		no no yes
15	Gomphidae	Dragonfly family	Predators	Chemical, rotenone	River	First appears	.040	92.000	yes no
82	Libellulidae	Dragonfly family	Predators	Drought	River	Density	.080	.675	no no yes
82	Libellulidae	Dragonfly family	Predators	Drought	River	First appears	.050	.675	no no yes
205	Odonata	Dragonfly and danselfly order	Predators	Chemical, other	Pond	Density	> 2.400		no
108	Zygoptera	Danselfly suborder	Predators	Chemical, other	River	Density	> .250		yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to recover to refugia species for recolonization (yrs)	Distance (km)	Persis. Unperturbed source in sys. Upstream Downstream
OLIGOCHAETA									
83	Naididae	Oligochaete family	Collectors	Chemical, other	River	First appears	1.300	no	yes
133	Oligochaeta	Annelid worm class	Collectors	Channelization	River	Density	> 5.000	1.000	yes
189	Oligochaeta	Annelid worm class	Collectors	Chemical, other	River	Density	> .500	.050	yes
108	Oligochaeta	Annelid worm class	Collectors	Chemical, other	River	Density	.040	yes	-
14	Oligochaeta	Annelid worm class	Collectors	Chemical, rotenone	River	First appears	.670	24.000	no
15	Oligochaeta	Annelid worm class	Collectors	Chemical, rotenone	River	First appears	1.000	92.000	no
17	Oligochaeta	Annelid worm class	Collectors	Chemical, rotenone	River	First appears	1.250	16.000	no
96	Oligochaeta	Annelid worm class	Collectors	Dredging	River	Density	1.000	.050	yes
202	Oligochaeta	Annelid worm class	Collectors	Dredging	River	Density	> .400	.200	yes
33	Oligochaeta	Annelid worm class	Collectors	Dredging	Lake	Density	.033	.001	-
34	Oligochaeta	Annelid worm class	Collectors	Dredging	Lake	Density	.041	.001	-
35	Oligochaeta	Annelid worm class	Collectors	Dredging	Lake	Density	> .074	.001	-
82	Oligochaeta	Annelid worm class	Collectors	Drought	River	Density	.020	.675	yes
15	Tubificidae	Oligochaete family	Collectors	Chemical, rotenone	River	First appears	.170	92.000	-
16	Tubificidae	Oligochaete family	Collectors	Chemical, rotenone	River	First appears	.170	180.000	yes
84	Tubificidae	Oligochaete family	Collectors	Mining activity	River	Density	8.000	1.500	no
OSTRACODA									
6	Cypridae	Seed shrimp family	Collectors	Chemical, other	Lake	Density	.170	yes	-
166	Cypridae	Seed shrimp family	Collectors	Chemical, other	Lake	Density	.040	.800	-
167	Cypridae	Seed shrimp family	Collectors	Chemical, other	Lake	Density	.120	.800	-
2	Ostracoda	Ostracod, seed shrimp subclass	Collectors	Chemical, other	Lake	Density	> 1.500	yes	-
82	Ostracoda	Ostracod, seed shrimp subclass	Collectors	Drought	River	Density	.210	.675	yes
PELECYPODA									
162	Mollusca	Mollusk phylum	Grazers	Drought	River	Density	< .250	.250	yes
83	Sphaeriidae	Clam family	Collectors	Chemical, other	River	First appears	2.200	no	yes
PLECOPTERA									
119	Alloperla sp.	Stonefly	Collectors	Chemical, DDT	River	Density	.330	.600	yes
110	Alloperla sp.	Stonefly	Collectors	Dredging	River	Density	> 2.200	.010	yes
22	Alloperla sp.	Stonefly	Collectors	Drought	River	Density	.120	.300	yes
193	Alloperla sp.	Stonefly	Collectors	Flaber activity	River	Density	> 20.000	yes	yes
110	Capniidae	Stonefly family	Shredders	Dredging	River	Density	.100	.010	yes
84	Capniidae	Stonefly family	Shredders	Mining activity	River	Density	> 10.000	1.500	no
84	Chloroperlidae	Stonefly family	Mining activity		River	Density	> 10.000	1.500	no
133	Isoneria sp.	Stonefly	Predators	Channelization	River	Density	> 5.000	1.000	yes
122	Leuctridae	Stonefly family	Shredders	Chemical, DDT	River	Density	> 1.330	3.200	no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case No.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia (yrs)	Distance (km)	Persis. Unperturbed source species for recolonization in sys. Upstream Donngrean
PLASCOPTERA									
160	Leuctridae	Stonefly family	Shredders	Chemical, DDT	River	Density	> 1.300		yes
206	Leuctridae	Stonefly family	Shredders	Chemical, other	River	Density	> 4.000		yes
206	Leuctridae	Stonefly family	Shredders	Chemical, other	River	Density	> 4.000		yes
114	Leuctridae	Stonefly family	Shredders	Chemical, other	River	Density	.140	.300	yes
144	Leuctridae	Stonefly family	Shredders	Chemical, other	River	Density	> 2.000	.068	no
136	Leuctridae	Stonefly family	Shredders	Drought	River	Density	> .500	1.000	yes
193	Leuctridae	Stonefly family	Shredders	Timber activity	River	Density	> 20.000		yes
122	Neouridae	Stonefly family	Shredders	Chemical, DDT	River	Density	1.000	3.200	yes
206	Neouridae	Stonefly family	Shredders	Chemical, other	River	Density	> 4.000		yes
206	Neouridae	Stonefly family	Shredders	Chemical, other	River	Density	> 4.000		yes
136	Neouridae	Stonefly family	Shredders	Drought	River	Density	> .500	1.000	yes
95	Neouridae	Stonefly family	Shredders	Flooding	River	Density	.120		yes
84	Neouridae	Stonefly family	Shredders	Mining activity	River	Density	> 10.000	1.500	no
119	Peltoperlidae	Stonefly family	Shredders	Chemical, DDT	River	Density	.310	.600	yes
193	Peltoperlidae	Stonefly family	Shredders	Timber activity	River	Density	> 20.000		yes
133	Perlidae	Stonefly family	Predators	Channelization	River	Density	> 5.000	1.000	yes
119	Perlidae	Stonefly family	Predators	Chemical, DDT	River	Density	.330	.600	yes
144	Perlidae	Stonefly family	Predators	Chemical, other	River	Density	> 2.000	.068	no
14	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	24.000	yes
15	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	92.000	yes
16	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	185.000	yes
17	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	16.000	yes
84	Perlidae	Stonefly family	Predators	Mining activity	River	Density	> 10.000	1.500	no
122	Perlidae	Stonefly family	Predators	Chemical, DDT	River	Density	1.330	3.200	yes
187	Perlidae	Stonefly family	Predators	Chemical, other	River	Density	.750	1.100	yes
14	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	24.000	yes
15	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	92.000	yes
16	Perlidae	Stonefly family	Predators	Chemical, rotenone	River	First appears	1.000	185.000	yes
136	Perlidae	Stonefly family	Predators	Drought	River	Density	.130	1.000	yes
22	Perlidae	Stonefly family	Predators	Drought	River	Density	.120	.300	yes
95	Perlidae	Stonefly family	Predators	Flooding	River	Density	.120		yes
84	Perlidae	Stonefly family	Predators	Mining activity	River	Density	> 10.000	1.500	yes
90	Plecoptera	Stonefly order	Predators	Chemical, DDT	River	Density	> 1.200	7.800	yes
97	Plecoptera	Stonefly order		Chemical, DDT	River	Density	1.000		yes
98	Plecoptera	Stonefly order		Chemical, DDT	River	Density	> 1.200		yes
99	Plecoptera	Stonefly order		Chemical, DDT	River	Density	1.200		yes
101	Plecoptera	Stonefly order		Chemical, DDT	River	Density	1.000		yes
80	Plecoptera	Stonefly order		Chemical, DDT	River	Density	3.000		yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia (yrs)	(km)	Persis. Unperturbed source species for recolonization in sys. Upstream Downstream
PLECOPTERA									
81	Plecoptera	Stonefly order		Chemical, DDT	River Density	Density	1.000		yes no
186	Plecoptera	Stonefly order		Chemical, DDT	River Density	Density	1.000	.080	no yes
186	Plecoptera	Stonefly order		Chemical, DDT	River First appears	First appears	.910	4.800	no yes
85	Plecoptera	Stonefly order		Chemical, DDT	River Density	Density	2.000		- no no
86	Plecoptera	Stonefly order		Chemical, DDT	River Density	Density	4.000		- no no
189	Plecoptera	Stonefly order		Chemical, other	River Density	Density	> .500	.060	yes yes
206	Plecoptera	Stonefly order		Chemical, other	River Density	Density	> 4.000		yes no
206	Plecoptera	Stonefly order		Chemical, other	River Density	Density	> 4.000		- -
109	Plecoptera	Stonefly order		Chemical, other	River Density	Density	< 2.500	1.000	yes no
21	Plecoptera	Stonefly order		Chemical, rotenone	River Density	Density	.500	4.400	yes yes
162	Plecoptera	Stonefly order		Drought	River Density	Density	< .250	.250	no yes
125	Plecoptera	Stonefly order		Flooding	River Density	Density	.850	.250	yes yes
84	Plecoptera	Stonefly order		Mining activity	River Density	Density	> 10.000	1.500	no no
69	Plecoptera	Stonefly order		Mining activity	River Density	Density	8.000		yes no
151	Plecoptera	Stonefly order		Multiple disturbances	River Density	Density	.580		yes yes
14	Pteronarcidae	Stonefly family	Shredders	Chemical, rotenone	River First appears	First appears	1.000	24.000	no yes
15	Pteronarcidae	Stonefly family	Shredders	Chemical, rotenone	River First appears	First appears	1.000	92.000	no yes
17	Pteronarcidae	Stonefly family	Shredders	Chemical, rotenone	River First appears	First appears	1.000	16.000	no yes
95	Pteronarcidae	Stonefly family	Shredders	Flooding	River Density	Density	.330		yes no
84	Pteronarcidae	Stonefly family	Shredders	Mining activity	River Density	Density	> 10.000	1.500	no no
ROTIFERA									
134	Rotifera	Rotifer phylum	Grazers	Chemical, alkaline	River Density	Density	1.250	2.000	yes no
203	Rotifera	Rotifer phylum	Grazers	Suspended solids	River Density	Density	> 1.000	4.800	yes yes
TRICHOPTERA									
124	Brachycentridae	Caddisfly family	Collectors	Chemical, other	River Density	Density	2.000	2.900	yes no
187	Brachycentridae	Caddisfly family	Collectors	Chemical, other	River Density	Density	> 2.100	1.100	yes no
14	Brachycentridae	Caddisfly family	Collectors	Chemical, rotenone	River First appears	First appears	1.000	24.000	no yes
15	Brachycentridae	Caddisfly family	Collectors	Chemical, rotenone	River First appears	First appears	1.000	92.000	no yes
17	Brachycentridae	Caddisfly family	Collectors	Chemical, rotenone	River First appears	First appears	1.700	16.000	no yes
84	Brachycentridae	Caddisfly family	Collectors	Mining activity	River Density	Density	8.000	1.500	no no
187	Glossosomatidae	Caddisfly family	Grazers	Chemical, other	River Density	Density	.600	1.100	yes yes
15	Glossosomatidae	Caddisfly family	Grazers	Chemical, rotenone	River First appears	First appears	1.000	92.000	no yes
16	Glossosomatidae	Caddisfly family	Grazers	Chemical, rotenone	River First appears	First appears	> 2.000	180.000	no yes
84	Glossosomatidae	Caddisfly family	Grazers	Mining activity	River Density	Density	> 10.000	1.500	no no
109	Helicopsyphidae	Caddisfly family	Grazers	Chemical, other	River First appears	First appears	< .500	.500	yes yes
187	Helicopsyphidae	Caddisfly family	Grazers	Chemical, other	River Density	Density	.600	1.100	yes no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to recover to refugia species for recolonization (yrs)	Distance (km)	Persis. Unperturbed source in sys. Upstream Downstream
TRICHOPTERA									
133	Hydropsychidae	Caddisfly family	Collectors	Channelization	River	Density	> 5,000	1,000	yes yes
132	Hydropsychidae	Caddisfly family	Collectors	Channelization	River	Density	> 25,000		yes yes
119	Hydropsychidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	.330	.600	yes no
122	Hydropsychidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	> 1,330	3,200	- no yes
160	Hydropsychidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	1,300		yes yes
120	Hydropsychidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	> 1,000	.720	yes yes
134	Hydropsychidae	Caddisfly family	Collectors	Chemical, alkaline	River	Density	.420	2,000	yes no
134	Hydropsychidae	Caddisfly family	Collectors	Chemical, alkaline	River	First appears	.500	2,000	yes no
124	Hydropsychidae	Caddisfly family	Collectors	Chemical, other	River	Density	1,000	2,900	yes no
187	Hydropsychidae	Caddisfly family	Collectors	Chemical, other	River	Density	.830	1,100	yes no
15	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	Density	> 2,000	92,000	no yes
14	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,700	24,000	no yes
15	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,700	92,000	no yes
15	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	2,000	92,000	no yes
16	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,700	210,000	no yes
17	Hydropsychidae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,700	16,000	no yes
22	Hydropsychidae	Caddisfly family	Collectors	Drought	River	Density	.120	.300	no yes
82	Hydropsychidae	Caddisfly family	Collectors	Drought	River	Density	.250	.675	no yes
95	Hydropsychidae	Caddisfly family	Collectors	Flooding	River	Density	.330		no no
84	Hydropsychidae	Caddisfly family	Collectors	Mining activity	River	Density	8,000	1,500	no yes
115	Hydropsychidae	Caddisfly family	Collectors	Multiple disturbances	River	First appears	.600	1,600	yes yes
187	Hydroptilidae	Caddisfly family	Grazers	Chemical, other	River	Density	.600	1,100	yes no
82	Hydroptilidae	Caddisfly family	Grazers	Drought	River	Density	.200	.675	no yes
84	Hydroptilidae	Caddisfly family	Grazers	Mining activity	River	Density	> 10,000	1,500	no yes
17	Lepidostomatidae	Caddisfly family	Shredders	Chemical, rotenone	River	First appears	1,000	16,000	no yes
84	Lepidostomatidae	Caddisfly family	Shredders	Mining activity	River	Density	> 10,000	1,500	no no
80	Leptoceridae	Caddisfly family	Collectors	Chemical, DDT	River	First appears	> 4,000		no -
134	Leptoceridae	Caddisfly family	Collectors	Chemical, alkaline	River	First appears	.500	2,000	yes no
15	Leptoceridae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,000	92,000	no yes
16	Leptoceridae	Caddisfly family	Collectors	Chemical, rotenone	River	First appears	1,250	185,000	no yes
119	Limnephilidae	Caddisfly family	Shredders	Chemical, DDT	River	Density	.330	.600	yes no
144	Limnephilidae	Caddisfly family	Shredders	Chemical, other	River	Density	> 2,000	.068	- no yes
109	Oecetis sp.	Caddisfly	Predators	Chemical, other	River	First appears	< .500	.500	yes no
82	Oecetis sp.	Caddisfly	Predators	Drought	River	Density	.200	.675	no no
122	Philopotanidae	Caddisfly family	Collectors	Chemical, DDT	River	First appears	> 1,330	3,200	no yes
160	Philopotanidae	Caddisfly family	Collectors	Chemical, DDT	River	First appears	> 1,300		no yes
82	Philopotanidae	Caddisfly family	Collectors	Drought	River	Density	.330	.675	no no
95	Philopotanidae	Caddisfly family	Collectors	Flooding	River	Density	.330		yes no

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia (yrs)	Persis. (km)	Unperturbed source species for recolonization in sys. Upstream Downstream
TRICHOPTERA									
203	Philoptanidae	Caddisfly family	Collectors	Suspended solids	River	Density	> 1,000	4,800	yes
193	Philoptanidae	Caddisfly family	Collectors	Timber activity	River	Density	> 20,000		yes
61	Phryganeidae	Caddisfly family		Chemical, other	River	Density	> 1,000	2,400	yes
122	Psychomyiidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	1,330	3,200	-
160	Psychomyiidae	Caddisfly family	Collectors	Chemical, DDT	River	Density	1,300		yes
61	Psychomyiidae	Caddisfly family	Collectors	Chemical, other	River	Density	> 1,000	2,400	yes
60	Psychomyiidae	Caddisfly family	Collectors	Chemical, other	River	Density	> .120	1,200	yes
122	Rhyacophilidae	Caddisfly family	Predators	Chemical, DDT	River	Density	> 1,330	3,200	-
160	Rhyacophilidae	Caddisfly family	Predators	Chemical, DDT	River	Density	.300		yes
144	Rhyacophilidae	Caddisfly family	Predators	Chemical, other	River	Density	> 2,000	.068	-
110	Rhyacophilidae	Caddisfly family	Predators	Dredging	River	Density	.800	.010	yes
95	Rhyacophilidae	Caddisfly family	Predators	Flooding	River	Density	.330		yes
84	Rhyacophilidae	Caddisfly family	Predators	Mining activity	River	Density	> 10,000	1,500	no
193	Rhyacophilidae	Caddisfly family	Predators	Timber activity	River	Density	> 20,000		yes
144	Sericostomatidae	Caddisfly family	Shredders	Chemical, other	River	Density	> 2,000	.068	-
90	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	> 1,200	7,800	yes
97	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	1,200		no
98	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	> 1,200		yes
99	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	1,200		yes
100	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	1,000		yes
101	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	> 1,200		yes
98	Trichoptera	Caddisfly order		Chemical, DDT	River	First appears	1,100		yes
80	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	2,000		-
81	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	3,000		-
185	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	> 1,250		-
186	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	1,400	.080	no
186	Trichoptera	Caddisfly order		Chemical, DDT	River	First appears	.910	4,800	yes
85	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	3,000		no
86	Trichoptera	Caddisfly order		Chemical, DDT	River	Density	5,000		no
189	Trichoptera	Caddisfly order		Chemical, other	River	Density	> .500	.060	yes
180	Trichoptera	Caddisfly order		Chemical, other	River	Density	.700	4,800	yes
208	Trichoptera	Caddisfly order		Chemical, other	River	Density	.500		-
109	Trichoptera	Caddisfly order		Chemical, other	River	Density	1,000	1,000	yes
21	Trichoptera	Caddisfly order		Chemical, rotenone	River	First appears	.038	4,400	yes
93	Trichoptera	Caddisfly order		Chemical, rotenone	River	Density	< 1,000		yes
162	Trichoptera	Caddisfly order		Drought	River	Density	< .250	.250	yes
170	Trichoptera	Caddisfly order		Drought	River	First appears	.014	.010	-
125	Trichoptera	Caddisfly order		Flooding	River	Density	1,000	.250	yes

(continued) Table 19. Recovery times for macroinvertebrates by taxa.

Case no.	Scientific name	Common name	Function	Stressor	System type	Recovery type	Time to Distance recover to refugia (yrs)	(km)	Persis. Unperturbed source species for recolonization in sys. Upstream Downstream
TRICHOPTERA									
84	Trichoptera	Caddisfly order		Mining activity	River	Density	> 10,000	1,500	no no yes
151	Trichoptera	Caddisfly order		Multiple disturbances	River	Density	.580		yes yes yes
TURBELLARIANS									
134	Platyhelminthes	Flatworm division		Chemical, alkaline	River	First appears	1,400	2,000	yes yes no

Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Persis.	Unperturbed Source
						Recover to refugia of spec.	in sys.		
						(yrs) pop (km)			
ALASKA									
40	Chemical, other	Cottidae	Cottus aleuticus	Coastrange sculpin	Density	> 1.00	.50	no	yes
ARKANSAS									
38	Chemical, other	Atherinidae	Labidesthes sicculus	Species richness	Species richness	.10	.10	no	yes
38	Chemical, other	Atherinidae	Labidesthes sicculus	Brook silverside	Density	.17	.60	no	yes
38	Chemical, other	Atherinidae	Labidesthes sicculus	Brook silverside	First appears	.08	.60	no	yes
38	Chemical, other	Catostomidae	Moxostoma melanops	Spotted sucker	Density	> 1.00	.10	no	yes
38	Chemical, other	Catostomidae	Moxostoma duquesnei	Black redborse	Density	> 1.00	.10	no	yes
38	Chemical, other	Catostomidae	Moxostoma duquesnei	Black redborse	First appears	.15	.10	no	yes
38	Chemical, other	Catostomidae	Moxostoma melanops	Spotted sucker	First appears	.21	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis cyaneellus	Green sunfish	Average size	> 1.00	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis macrochirus	Bluegill	Average size	> 1.00	.10	no	yes
38	Chemical, other	Centrarchidae	Micropterus salmoides	Largemouth bass	Average size	> 1.00	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis segalotis	Longear sunfish	Density	.10	.10	no	yes
38	Chemical, other	Centrarchidae	Micropterus salmoides	Largemouth bass	Density	.10	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis cyaneellus	Green sunfish	Density	.12	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis macrochirus	Bluegill	Density	.50	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis segalotis	Longear sunfish	First appears	.04	.10	no	yes
38	Chemical, other	Centrarchidae	Micropterus salmoides	Largemouth bass	First appears	.04	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis cyaneellus	Green sunfish	First appears	.08	.10	no	yes
38	Chemical, other	Centrarchidae	Leponis macrochirus	Bluegill	First appears	.13	.10	no	yes
38	Chemical, other	Cyprinidae	Notropis boops	Bigeye shiner	Density	.08	.10	no	yes
38	Chemical, other	Cyprinidae	Caspostoma anomalum	Central stoneroller	Density	.13	.10	no	yes
38	Chemical, other	Cyprinidae	Pimephales notatus	Bluntnose minnow	Density	.29	.10	no	yes
38	Chemical, other	Cyprinidae	Dionda nubila	Ozark minnow	Density	> 1.00	.10	no	yes
38	Chemical, other	Cyprinidae	Notropis pilsbryi	Duskystripe shiner	Density	> 1.00	.60	no	yes
38	Chemical, other	Cyprinidae	Notropis boops	Bigeye shiner	First appears	.01	.10	no	yes
38	Chemical, other	Cyprinidae	Pimephales notatus	Bluntnose minnow	First appears	.04	.10	no	yes
38	Chemical, other	Cyprinidae	Caspostoma anomalum	Central stoneroller	First appears	.06	.10	no	yes
38	Chemical, other	Cyprinidae	Notropis pilsbryi	Duskystripe shiner	First appears	.19	.60	no	yes
38	Chemical, other	Cyprinidae	Dionda nubila	Ozark minnow	First appears	.65	.10	no	yes
38	Chemical, other	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	Density	.16	.10	no	yes

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec. (yrs)	pop (km) in sys.	

ARKANSAS								
38	Chemical, other	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	First appears	.01	.10	yes
38	Chemical, other	Ictaluridae	Ictalurus melas	Black bullhead	Density	1.00	.10	yes
38	Chemical, other	Ictaluridae	Ictalurus natalis	Yellow bullhead	Density	> 1.00	.10	yes
38	Chemical, other	Ictaluridae	Ictalurus melas	Black bullhead	First appears	.15	.10	yes
38	Chemical, other	Ictaluridae	Ictalurus natalis	Yellow bullhead	First appears	.19	.10	yes
38	Chemical, other	Percidae	Etheostoma spectabile	Orangethroat darter	First appears	.04	.10	yes
199	Flooding			Species richness	Species richness	.75	yes	no

CALIFORNIA								
133	Channelization			Biomass	Biomass	> 5.00	1.00	yes
133	Channelization	Catostomidae	Catostomus microps	Modoc sucker	Density	> 5.00	1.00	yes
133	Channelization	Salmonidae	Salmo gairdneri	Rainbow trout	Average size	> 5.00	1.00	yes
133	Channelization	Salmonidae	Salmo trutta	Brown trout	Average size	> 5.00	1.00	yes
133	Channelization	Salmonidae	Salmo gairdneri	Rainbow trout	Density	> 5.00	1.00	yes

ILLINOIS								
43	Multiple disturbances			Density	Density	.20	3.20	no
43	Multiple disturbances			Species richness	Species richness	.20	3.20	no
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	Average size	.13	3.20	no
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	Density	.13	3.20	no
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	First appears	.04	6.60	no
43	Multiple disturbances	Catostomidae	Catostomus commersoni	White sucker	First appears	.04	10.10	no
43	Multiple disturbances	Catostomidae	Moxostoma erythrum	Golden redborse	First appears	.04	4.30	no
43	Multiple disturbances	Catostomidae	Cariodes cyprinus	Quillback	First appears	.13	5.10	no
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	Average size	.13	3.20	no
43	Multiple disturbances	Centrarchidae	Ambloplites rupestris	Rock bass	Density	.13	3.20	no
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	.13	3.20	no
43	Multiple disturbances	Centrarchidae	Micropterus dolomieu	Smallmouth bass	First appears	.04	2.10	no
43	Multiple disturbances	Centrarchidae	Ambloplites rupestris	Rock bass	First appears	.04	3.20	no
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	First appears	.04	4.30	no
43	Multiple disturbances	Centrarchidae	Lepomis megalotis	Longear sunfish	First appears	1.50	4.80	no
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	Average size	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Semotilus atromaculatus	Creek chub	Average size	.13	3.20	no

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

1

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs) pop (km)	Persis. in sys.	Unperturbed Source for recolonization Upstream Downstream
ILLINOIS								
43	Multiple disturbances	Cyprinidae	Camptostoma anomalum	Central stoneroller	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Hypentelium sp.	Hog sucker	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Notropis sp.	Shiner	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Semotilus atromaculatus	Creek chub	Density	.13	3.20	no
43	Multiple disturbances	Cyprinidae	Ericymba buccata	Silverjaw minnow	First appears	.04	10.10	no
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	First appears	.04	10.10	no
43	Multiple disturbances	Cyprinidae	Semotilus atromaculatus	Creek chub	First appears	.04	10.10	no
43	Multiple disturbances	Cyprinidae	Phenacobius mirabilis	Suckermouth minnow	First appears	.04	2.10	no
43	Multiple disturbances	Cyprinidae	Notropis sp.	Shiner	First appears	.04	3.20	no
43	Multiple disturbances	Cyprinidae	Camptostoma anomalum	Central stoneroller	First appears	.04	4.30	no
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	First appears	.04	6.60	no
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	First appears	.04	6.60	no
43	Multiple disturbances	Cyprinidae	Hypentelium sp.	Hog sucker	First appears	.04	9.10	no
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	First appears	.04	9.10	no
43	Multiple disturbances	Cyprinidae	Camptostoma anomalum	Central stoneroller	First appears	.06	.24	no
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	First appears	.06	.24	no
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	First appears	.06	.24	no
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	First appears	.06	.24	no
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	First appears	.06	.24	no
43	Multiple disturbances	Cyprinidae	Notemigonus crysoleucas	Golden shiner	First appears	.13	5.10	no
43	Multiple disturbances	Ictaluridae	Ictalurus melas	Black bullhead	First appears	.33	5.10	no
43	Multiple disturbances	Ictaluridae	Ictalurus natalis	Yellow bullhead	First appears	.33	5.10	no
43	Multiple disturbances	Percidae	Etheostoma blennioides	Greenside darter	Density	.13	3.20	no
43	Multiple disturbances	Percidae	Etheostoma caeruleum	Rainbow darter	Density	.13	3.20	no
43	Multiple disturbances	Percidae	Etheostoma flabellare	Fantail darter	Density	.13	3.20	no
43	Multiple disturbances	Percidae	Etheostoma spectabile	Orangethroat darter	Density	.13	3.20	no
43	Multiple disturbances	Percidae	Percina nacula	Blackside darter	Density	.13	3.20	no
43	Multiple disturbances	Percidae	Etheostoma flabellare	Fantail darter	First appears	.04	.50	no
43	Multiple disturbances	Percidae	Percina nacula	Blackside darter	First appears	.04	9.10	no

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source	
						Recover to refugia of spec. (yrs)	pop (km) in sys.		Upstream Downstream
ILLINOIS									
43	Multiple disturbances	Percidae	Etheostoma blennioides	Greenside darter	First appears	.04	no	no	yes
43	Multiple disturbances	Percidae	Etheostoma caeruleum	Bainbow darter	First appears	.04	no	no	yes
43	Multiple disturbances	Percidae	Etheostoma spectabile	Orangethroat darter	First appears	.04	no	no	yes
43	Multiple disturbances	Percidae	Etheostoma nigrum	Johnny darter	First appears	.33	no	no	yes
128	Lake drawdown			Density	Density	< .50	yes	yes	yes
128	Lake drawdown			Species richness	Species richness	< .50	yes	yes	yes
KENTUCKY									
41	Chemical, rotenone			Biomass	Biomass	2.00	no	yes	yes
41	Chemical, rotenone			Density	Density	< 1.00	no	yes	yes
41	Chemical, rotenone			Species richness	Species richness	< 1.00	no	yes	yes
41	Chemical, rotenone	Catostomidae	Moxostoma sp.	Redhorse, sucker	Density	< 1.00	no	yes	yes
41	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	< 1.00	no	yes	yes
41	Chemical, rotenone	Cottidae	sculpin (unspecified)	Sculpin (unspecified)	Density	< 1.00	no	yes	yes
41	Chemical, rotenone	Cyprinidae	Cyprinidae	Minnow, carp family	Density	< 1.00	no	yes	yes
41	Chemical, rotenone	Cyprinidae	Hypentelium sp.	Hog sucker	Density	< 1.00	no	yes	yes
42	Chemical, rotenone			Biomass	Biomass	> 4.00	no	yes	yes
42	Chemical, rotenone			Density	Density	< 2.00	no	-	-
42	Chemical, rotenone			Species richness	Species richness	4.00	no	-	-
42	Chemical, rotenone	Catostomidae	Catostomus commersoni	White sucker	Density	< 1.00	no	no	yes
42	Chemical, rotenone	Catostomidae	Moxostoma sp.	Redhorse, sucker	Density	> 4.00	no	no	yes
42	Chemical, rotenone	Catostomidae	Minytrema melanops	Spotted sucker	First appears	2.00	no	no	yes
42	Chemical, rotenone	Catostomidae	Ictiobus cyprinellus	Bigmouth buffalo	First appears	> 4.00	no	no	yes
42	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	< 1.00	no	no	yes
42	Chemical, rotenone	Centrarchidae	Lepomis gulosus	Warbouth	Density	> 4.00	no	no	yes
42	Chemical, rotenone	Centrarchidae	Micropterus notius	Savannee bass	Density	> 4.00	no	no	yes
42	Chemical, rotenone	Clupeidae	Dorosoma cepedianum	Gizzard shad	Density	< 1.00	no	no	yes
42	Chemical, rotenone	Cyprinidae	Cyprinidae	Minnow, carp family	Density	< 1.00	no	yes	yes
42	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Carp	Density	< 1.00	no	no	yes
42	Chemical, rotenone	Cyprinidae	Semotilus atrovaculatus	Creech chub	Density	< 1.00	no	yes	yes
42	Chemical, rotenone	Ictaluridae	Ictalurus natalis	Yellow bullhead	Density	2.00	no	no	yes
42	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	Density	< 1.00	no	no	yes
42	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	First appears	> 4.00	no	no	yes

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

1

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs)	Percis. pop (km)	Unperturbed Source for recolonization in sys.

KENTUCKY								
42	Chemical, rotenone	Ictaluridae	<i>Pylodictis olivaris</i>	Flathead catfish	First appears	> 4.00	37.00	no
42	Chemical, rotenone	Percidae	<i>Etheostoma</i> sp.	Darter	Density	< 1.00	37.00	yes

LOUISIANA								
37	Organism removal (non ch Catostomidae)		<i>Erimyzon tenuis</i>	Sharpfin chubsucker	Average size	1.00	.03	yes
37	Organism removal (non ch Catostomidae)		<i>Erimyzon tenuis</i>	Sharpfin chubsucker	Density	1.00	.03	yes
37	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Average size	1.00	.03	no
37	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Density	1.00	.03	no
176	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Average size	1.00	.04	yes
176	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Density	1.00	.04	yes
177	Organism removal (non ch Catostomidae)		<i>Erimyzon tenuis</i>	Sharpfin chubsucker	Density	1.00	.04	yes
177	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Average size	1.00	.04	yes
177	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Density	> 1.20	.04	yes
177	Organism removal (non ch Centrarchidae)		<i>Esox americanus americanus</i>	Redfin pickerel	Density	> 1.00	.04	yes
178	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Average size	1.00	.30	yes
178	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Density	1.00	.30	yes
179	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Average size	> 2.00	.04	yes
179	Organism removal (non ch Centrarchidae)		<i>Lepomis macrochirus</i>	Bluegill	Density	1.00	.04	yes
179	Organism removal (non ch Centrarchidae)		<i>Lepomis gulosus</i>	Warmouth	Density	> 2.00	.04	yes
179	Organism removal (non ch Centrarchidae)		<i>Lepomis megalotis</i>	Longear sunfish	Density	> 2.00	.04	yes

MAINE								
87	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	6.00	yes
88	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 2.25	6.00	no
89	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	8.50	yes
90	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	7.80	no
91	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 1.25	4.60	yes
92	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 1.25	32.00	yes

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec.	Recover to refugia of spec. for recolonization	
						(yrs) pop (ha)	in sys. Upstream Downstream	
MINNESOTA								
68	Flooding	Salmonidae	Salvelinus fontinalis	Brook trout	Productivity	2.00	yes	no
68	Flooding	Salmonidae	Salvelinus fontinalis	Brook trout	Average size	4.00	yes	no
68	Flooding	Salmonidae	Salvelinus fontinalis	Brook trout	Density	3.00	yes	no
MISSISSIPPI								
58	Channelization	Aphredoderidae	Aphredoderus sayanus	Biomass	Biomass	> 52.00	>	yes
58	Channelization	Catostomidae	Moxostoma valenciennesi	Density	Density	> 52.00	>	yes
58	Channelization	Centrarchidae	Micropterus salmoides	Species richness	Species richness	> 52.00	>	yes
58	Channelization	Centrarchidae	Micropterus salmoides	Pirate perch	Density	> 52.00	>	yes
58	Channelization	Centrarchidae	Micropterus salmoides	Spotted sucker	Density	> 52.00	>	yes
58	Channelization	Centrarchidae	Micropterus salmoides	Largemouth bass	Average size	> 52.00	>	yes
58	Channelization	Centrarchidae	Micropterus salmoides	Bluegill	Density	> 52.00	>	yes
58	Channelization	Cyprinidae	Hybognathus haysi	Cypress minnow	Density	> 52.00	>	yes
58	Channelization	Cyprinidae	Notropis stilbius	Silverstripe shiner	Density	> 52.00	>	yes
58	Channelization	Cyprinidae	Pimephales notatus	Bluntnose minnow	Density	> 52.00	>	yes
58	Channelization	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	Density	> 52.00	>	yes
58	Channelization	Esocidae	Esox niger	Chain pickerel	Density	> 52.00	>	yes
58	Channelization	Ictaluridae	Ictalurus punctatus	Channel catfish	Density	> 52.00	>	yes
58	Channelization	Ictaluridae	Pylodictis olivaris	Flathead catfish	Density	> 52.00	>	yes
58	Channelization	Percidae	Ambloplites rupestris	Crystall darter	Density	> 52.00	>	yes
58	Channelization	Percidae	Etheostoma caeruleum	Cypress darter	Density	> 52.00	>	yes
58	Channelization	Percidae	Percina caprodes	Logperch	Density	> 52.00	>	yes
58	Channelization	Percidae	Percina sciera	Dusky darter	Density	> 52.00	>	yes
MISSOURI								
197	Channelization			Biomass	Biomass	> 30.00	>	yes
197	Channelization			Density	Density	> 30.00	>	yes
197	Channelization			Species richness	Species richness	> 30.00	>	yes

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance			Unperturbed Source
						Recover to refugia of spec.	(yrs)	pop (km)	
MONTANA									
126	Channelization	Salmonidae	Salmo clarki	Cutthroat trout	Density	> 50.00	1.50	yes	yes
126	Channelization	Salmonidae	Salvelinus fontinalis	Brook trout	Density	> 50.00	1.50	yes	yes
127	Habitat development	Salmonidae	Salmo clarki	Cutthroat trout	Density	1.00	1.00	yes	yes
174	Chemical, DDT			Density	Density	> 2.20	-	-	-
174	Chemical, DDT	Cottidae	Cottus sp.	Sculpin	Density	> 2.20	no	-	yes
174	Chemical, DDT	Cottidae	Cottus sp.	Sculpin	First appears	> 2.20	no	-	yes
174	Chemical, DDT	Salmonidae	Prosopium williamsoni	Mountain whitefish	Average size	> 2.00	yes	-	yes
174	Chemical, DDT	Salmonidae	Salvelinus fontinalis	Brook trout	Average size	> 2.00	yes	-	yes
174	Chemical, DDT	Salmonidae	Prosopium williamsoni	Mountain whitefish	Density	2.00	yes	-	yes
174	Chemical, DDT	Salmonidae	Salmo trutta	Brown trout	Density	2.00	yes	-	yes
174	Chemical, DDT	Salmonidae	Salmo clarki	Cutthroat trout	Density	> 1.20	yes	-	yes
174	Chemical, DDT	Salmonidae	Salmo gairdneri	Rainbow trout	Density	> 1.20	yes	-	yes
175	Chemical, DDT	Salmonidae	Salvelinus fontinalis	Brook trout	Average size	> 2.00	yes	-	yes
175	Chemical, DDT	Salmonidae	Salvelinus fontinalis	Brook trout	Density	2.00	yes	-	yes
186	Chemical, DDT	Salmonidae	Salmo clarki	Cutthroat trout	Density	< 1.00	.80	yes	yes
186	Chemical, DDT	Salmonidae	Salmo clarki	Cutthroat trout	Density	> 1.10	2.40	yes	yes
186	Chemical, DDT	Salmonidae	Salmo trutta	Brown trout	Density	> 1.10	2.40	yes	yes
NEW YORK									
190	Chemical, rotenone			Bionass	Bionass	> .83	.60	yes	yes
190	Chemical, rotenone			Density	Density	> .83	.60	yes	yes
190	Chemical, rotenone	Anguillidae	Anguilla rostrata	American eel	Density	> .83	.60	yes	yes
190	Chemical, rotenone	Catostomidae	Catostomus commersoni	White sucker	Average size	> .83	.60	yes	yes
190	Chemical, rotenone	Catostomidae	Catostomus commersoni	White sucker	Density	< .83	.60	yes	yes
190	Chemical, rotenone	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Density	< .83	.60	yes	yes
190	Chemical, rotenone	Cyprinidae	Notropis cornutus	Common shiner	Density	> .83	.60	yes	yes
190	Chemical, rotenone	Cyprinidae	Rhinichthys cataractae	Longnose dace	Density	> .83	.60	yes	yes
190	Chemical, rotenone	Percidae	Percina maculata	Blackside darter	Density	> .83	.60	yes	yes
190	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> .83	.60	yes	yes

(continued) Table 20. Recovery times for fish by state, province, or country.
(foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec. (yrs)	Pop (km) in sys.	
NORTH CAROLINA								
172	Channelization			Biomass	> 40.00	-	-	-
172	Channelization			Density	> 40.00	-	-	-
OHIO								
44	Drought			Density	< 1.00	31.00	no	yes
44	Drought			Species richness	< 1.00	31.00	no	yes
44	Drought			Species richness	> 1.00	41.00	no	no
132	Channelization	Catostomidae	<i>Hypentelium nigricans</i>	Northern hog sucker	Density	> 25.00	yes	yes
132	Channelization	Catostomidae	<i>Moxostoma duquesnei</i>	Black redborse	Density	> 25.00	yes	yes
132	Channelization	Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	Density	> 25.00	yes	yes
132	Channelization	Centrarchidae	<i>Lepomis megalotis</i>	Longear sunfish	Density	> 25.00	yes	yes
132	Channelization	Centrarchidae	<i>Micropterus dolomieu</i>	Smallmouth bass	Density	> 25.00	yes	yes
132	Channelization	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Density	> 25.00	yes	yes
132	Channelization	Ictaluridae	<i>Ictalurus natalis</i>	Yellow bullhead	Density	> 25.00	yes	yes
132	Channelization	Percidae	<i>Perca caprodes</i>	Log perch	Density	> 25.00	yes	yes
184	Habitat development			Species richness	< 5.00	1.00	-	yes
184	Habitat development	Catostomidae	<i>Carpiondes cyprinus</i>	Quillback	Density	> 5.00	1.00	yes
184	Habitat development	Catostomidae	<i>Hypentelium nigricans</i>	Northern hog sucker	Density	> 5.00	1.00	yes
184	Habitat development	Catostomidae	<i>Moxostoma anisurum</i>	Silver redborse	Density	> 5.00	1.00	yes
184	Habitat development	Catostomidae	<i>Moxostoma duquesnei</i>	Black redborse	Density	> 5.00	1.00	yes
184	Habitat development	Centrarchidae	<i>Micropterus dolomieu</i>	Smallmouth bass	Density	< 5.00	1.00	yes
184	Habitat development	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Density	< 5.00	1.00	yes
184	Habitat development	Centrarchidae	<i>Pomoxis annularis</i>	White crapple	Density	> 5.00	1.00	yes
184	Habitat development	Cyprinidae	<i>Carassius auratus</i>	Goldfish	Density	> 5.00	1.00	yes
OKLAHOMA								
173	Chemical, rotenone			Biomass	2.00	-	-	-

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

1

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs)	Unperturbed Source pop (km) in sys. Upstream Downstream	
OREGON								
27	Timber activity	Cottidae	Cottus perplexus	Reticulate sculpin	Density	7.00	- no yes	
27	Timber activity	Salmonidae	Salmo clarki	Cutthroat trout	Density	> 8.00	- no yes	
TENNESSEE								
69	Mining activity			Species richness	Species richness	6.00	- no yes	
69	Mining activity			Species richness	Species richness	> 12.00	- no no	
93	Chemical, rotenone			Biomass	Biomass	> 1.33	.50 no no	
93	Chemical, rotenone			Density	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Species richness	Species richness	> 1.33	.50 no no	
93	Chemical, rotenone			Spring cavefish	First appears	> 1.33	.50 no no	
93	Chemical, rotenone			Northern hog sucker	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Northern hog sucker	First appears	1.33	.50 no no	
93	Chemical, rotenone			Green sunfish	Density	1.33	.50 no no	
93	Chemical, rotenone			Green sunfish	First appears	.33	.50 no no	
93	Chemical, rotenone			Bluegill	First appears	.33	.50 no no	
93	Chemical, rotenone			Rock bass	First appears	> 1.33	.50 no no	
93	Chemical, rotenone			Largemouth bass	First appears	> 1.33	.50 no no	
93	Chemical, rotenone			Banded sculpin	Density	1.33	.50 no no	
93	Chemical, rotenone			Banded sculpin	First appears	.42	.50 no no	
93	Chemical, rotenone			Central stoneroller	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Hosyside dace	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Southern redbelly dace	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Blacknose dace	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Creek chub	Density	> 1.33	.50 no no	
93	Chemical, rotenone			Hosyside dace	First appears	.33	.50 no no	
93	Chemical, rotenone			Central stoneroller	First appears	.42	.50 no no	
93	Chemical, rotenone			Creek chub	First appears	.42	.50 no no	
93	Chemical, rotenone			Southern redbelly dace	First appears	.50	.50 no no	
93	Chemical, rotenone			Blacknose dace	First appears	1.33	.50 no no	
93	Chemical, rotenone			Goldfish	First appears	> 1.33	.50 no no	
93	Chemical, rotenone			Black bullhead	Density	> 1.33	.50 - no no	
93	Chemical, rotenone			Black bullhead	First appears	.33	.50 no no	
93	Chemical, rotenone			Tenn snubnose darter	Density	> 1.33	.50 no no	

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec. (yrs)	pop (km)	
TENNESSEE								
93	Chemical, rotenone	Percidae	Etheostoma caeruleum	Tenn snubnose darter	First appears	1.33	.50	no
93	Chemical, rotenone	Percidae	Etheostoma blennioides	Greenside darter	First appears	> 1.33	.50	no
93	Chemical, rotenone	Salmonidae	Salvelinus fontinalis	Brook trout	Density	> 1.33	.50	no
UTAH								
192	Flooding			Density	Density	> .60	no	yes
WISCONSIN								
124	Chemical, other			Biomass	Biomass	> 3.50	no	no
124	Chemical, other			Density	Density	> 3.50	no	no
124	Chemical, other			Species richness	Species richness	> 3.50	no	no
124	Chemical, other			White sucker	Density	> 2.00	no	no
124	Chemical, other	Catostomidae	Catostomus commersoni	White sucker	First appears	.50	no	no
124	Chemical, other	Catostomidae	Catostomus commersoni	Northern hog sucker	First appears	> 2.00	no	no
124	Chemical, other	Catostomidae	Hypentelium nigricans	Slimy sculpin	Density	> 3.50	no	no
124	Chemical, other	Cottidae	Cottus cognatus	Slimy sculpin	First appears	.50	no	no
124	Chemical, other	Cottidae	Cottus cognatus	Fathead minnow	Density	> 2.00	no	no
124	Chemical, other	Cyprinidae	Pimephales promelas	Blacknose dace	Density	> 2.00	no	no
124	Chemical, other	Cyprinidae	Rhinichthys atratulus	Central stoneroller	Density	> 3.50	no	no
124	Chemical, other	Cyprinidae	Caspiostoma anomalum	Creek chub	Density	> 3.50	no	no
124	Chemical, other	Cyprinidae	Semotilus atromaculatus	Fathead minnow	First appears	.50	no	no
124	Chemical, other	Cyprinidae	Pimephales promelas	Central stoneroller	First appears	2.00	no	no
124	Chemical, other	Cyprinidae	Caspiostoma anomalum	Blacknose dace	First appears	2.00	no	no
124	Chemical, other	Cyprinidae	Rhinichthys atratulus	Creek chub	First appears	2.00	no	no
124	Chemical, other	Cyprinidae	Semotilus atromaculatus	Bluntnose minnow	First appears	3.50	no	no
124	Chemical, other	Cyprinidae	Pimephales notatus	Hornhead chub	First appears	> 2.00	no	no
124	Chemical, other	Cyprinidae	Rocotis biguttatus	Southern redbelly dace	First appears	> 2.00	no	no
124	Chemical, other	Cyprinidae	Phoxinus erythrogaster	Longnose dace	First appears	> 2.00	no	no
124	Chemical, other	Cyprinidae	Rhinichthys catarractae	Brook stickleback	Density	1.00	no	no
124	Chemical, other	Gasterosteidae	Culaea inconstans	Brook stickleback	First appears	.50	no	no
124	Chemical, other	Gasterosteidae	Culaea inconstans	Fantail darter	First appears	> 2.00	no	no
124	Chemical, other	Percidae	Etheostoma flabellare	Johnny darter	First appears	> 2.00	no	no
124	Chemical, other	Percidae	Etheostoma nigrum	Biomass	Biomass	5.00	.35	yes
139	Habitat development							yes

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs) pop (km)	Persis. Unperturbed Source for recolonization in sys. Upstream Downstream	
WISCONSIN								
139	Habitat development	Salmonidae	Salvelinus fontinalis	Productivity	Productivity	5.00	.35	yes
139	Habitat development			Brook trout	Average size	5.00	.35	yes
139	Habitat development			Brook trout	Density	5.00	.35	yes
187	Chemical, other	Salmonidae	Salvelinus fontinalis	Biomass	Biomass	2.00	1.10	no
187	Chemical, other			Density	Density	1.00	1.10	no
187	Chemical, other			Species richness	Species richness	1.00	1.10	no
187	Chemical, other	Catostomidae	Catostomus commersoni	White sucker	Density	2.00	1.10	no
187	Chemical, other			White sucker	First appears	.50	1.10	no
187	Chemical, other			Central stoneroller	Density	.50	1.10	no
187	Chemical, other	Cyprinidae	Kocosis biguttatus	Hornhead chub	Density	1.00	1.10	no
187	Chemical, other			Blacknose dace	Density	1.00	1.10	no
187	Chemical, other			Longnose dace	Density	1.00	1.10	no
187	Chemical, other	Cyprinidae	Rhinichthys atratulus	Creek chub	Density	1.00	1.10	no
187	Chemical, other			Southern redbelly dace	Density	2.00	1.10	no
187	Chemical, other			Bluntnose minnow	Density	> 2.00	1.10	no
187	Chemical, other	Cyprinidae	Pimephales promelas	Fathead minnow	Density	> 2.00	1.10	no
187	Chemical, other			Central stoneroller	First appears	.50	1.10	no
187	Chemical, other			Hornhead chub	First appears	.50	1.10	no
187	Chemical, other	Cyprinidae	Kocosis biguttatus	Bluntnose minnow	First appears	.50	1.10	no
187	Chemical, other			Fathead minnow	First appears	.50	1.10	no
187	Chemical, other			Blacknose dace	First appears	.50	1.10	no
187	Chemical, other	Cyprinidae	Rhinichthys atratulus	Longnose dace	First appears	.50	1.10	no
187	Chemical, other			Creek chub	First appears	.50	1.10	no
187	Chemical, other			Southern redbelly dace	First appears	1.00	1.10	no
187	Chemical, other	Cyprinidae	Pimephales notatus	Brook stickleback	Density	1.00	1.10	no
187	Chemical, other			Brook stickleback	First appears	.50	1.10	no
187	Chemical, other			Johnny darter	Density	2.00	1.10	no
187	Chemical, other	Percidae	Etheostoma nigrum	Fantail darter	Density	> 2.00	1.10	no
187	Chemical, other			Fantail darter	First appears	.50	1.10	no
187	Chemical, other			Johnny darter	First appears	1.00	1.10	no

(continued) Table 28. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

1

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs) pop (km) in sys.	Persis. for recolonization Upstream Downstream
WYOMING							
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Species richness	Species richness	1.00	13.00
14	Chemical, rotenone	Catostomidae	Catostomus sp.	Flannemouth sucker	Average size	2.00	13.00
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Sucker	Density	1.00	13.00
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	2.00	13.00
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	.75	13.00
14	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	1.00	13.00
14	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	Density	2.00	13.00
14	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	First appears	2.00	13.00
14	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	13.00
14	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	2.00	13.00
14	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	.17	13.00
14	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	.17	13.00
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Average size	1.00	13.00
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	.10	13.00
14	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	2.00	13.00
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.10	13.00
14	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.75	13.00
15	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Species richness	Species richness	2.00	80.00
15	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	1.00	80.00
15	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	1.00	80.00
15	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	2.00	80.00
15	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	Density	2.00	80.00
15	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	First appears	2.00	80.00
15	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	1.00	80.00
15	Chemical, rotenone	Cyprinidae	Pimephales promelas	Fathead minnow	Density	2.00	80.00
15	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	80.00
15	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Cosson, mirror carp	Density	> 2.00	80.00
15	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	Density	> 2.00	80.00
15	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Cosson, mirror carp	First appears	1.00	80.00
15	Chemical, rotenone	Cyprinidae	Pimephales promelas	Fathead minnow	First appears	1.00	80.00
15	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	1.00	80.00
15	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	1.00	80.00
15	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	First appears	2.00	80.00

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source	
						Recover to refugia of spec. (yrs)	pop (km) in sys.		for recolonization
WYOMING									
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Average size	2.00	80.00	no	yes
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	2.00	80.00	no	yes
15	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> 2.00	80.00	no	yes
15	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.10	80.00	-	yes
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.75	80.00	no	yes
16	Chemical, rotenone			Species richness	Species richness	> 2.00	150.00	-	yes
16	Chemical, rotenone			Species richness	Species richness	> 2.00	244.00	no	yes
16	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Density	1.70	244.00	no	yes
16	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	Density	2.00	150.00	no	yes
16	Chemical, rotenone	Catostomidae	Xyrauchen texanus	Razorback sucker	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	First appears	1.00	150.00	no	yes
16	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	2.00	244.00	no	yes
16	Chemical, rotenone	Catostomidae	Xyrauchen texanus	Razorback sucker	First appears	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cottidae	Cottus sp.	Sculpin	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cottidae	Cottus sp.	Sculpin	First appears	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Common, mirror carp	Density	1.70	210.00	no	yes
16	Chemical, rotenone	Cyprinidae	Pimephales promelas	Fathead minnow	Density	2.00	150.00	no	yes
16	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	150.00	no	yes
16	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila atraria	Utah chub	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila cypha	Humpback chub	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila elegans	Bontail chub	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Ptychocheilus lucius	Colorado squawfish	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Common, mirror carp	First appears	1.70	150.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila elegans	Bontail chub	First appears	2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Pimephales promelas	Fathead minnow	First appears	2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila atraria	Utah chub	First appears	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Gila cypha	Humpback chub	First appears	> 2.00	244.00	no	yes
16	Chemical, rotenone	Cyprinidae	Ptychocheilus lucius	Colorado squawfish	First appears	> 2.00	244.00	no	yes
16	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	Density	> 2.00	244.00	no	yes
16	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	Density	> 2.00	244.00	no	yes

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. (yrs) pop (km)	Persis. in sys.	Unperturbed Source for recolonization Upstream Downstream
NYONING								
16	Chemical, rotenone	Ictaluridae	Ictalurus nebulosus	Black bullhead	First appears	> 2.00	244.00	no
16	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	First appears	> 2.00	244.00	no
16	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> 2.00	150.00	no
16	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	> 2.00	244.00	no
16	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	1.00	150.00	no
16	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	> 2.00	244.00	no
17	Chemical, rotenone	Salmonidae	Salmo trutta	Species richness	Species richness	1.00	21.00	-
17	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Density	2.00	21.00	no
17	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	Density	2.00	21.00	no
17	Chemical, rotenone	Catostomidae	sucker(unspecified)	Sucker(unspecified)	Density	2.00	21.00	no
17	Chemical, rotenone	Catostomidae	Catostomus ardens	Utah sucker	Density	> 2.00	21.00	no
17	Chemical, rotenone	Catostomidae	sucker(unspecified)	Sucker(unspecified)	First appears	.17	21.00	yes
17	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	.70	21.00	no
17	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	First appears	1.00	21.00	no
17	Chemical, rotenone	Catostomidae	Catostomus ardens	Utah sucker	First appears	2.00	21.00	no
17	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	.70	21.00	-
17	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Common, mirror carp	Density	2.00	21.00	no
17	Chemical, rotenone	Cyprinidae	Platypharodon promelas	Fathead minnow	Density	2.00	21.00	no
17	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	21.00	no
17	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Common, mirror carp	First appears	.10	21.00	no
17	Chemical, rotenone	Cyprinidae	Platypharodon promelas	Fathead minnow	First appears	.10	21.00	no
17	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	.10	21.00	no
17	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	.10	21.00	no
17	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	1.70	21.00	no
17	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	2.00	21.00	no
17	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.17	7.00	no
17	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.17	7.00	no
NEW BRUNSWICK								
54	Chemical, DDT	Salmonidae	Salmo salar	Atlantic salmon	Density	5.00	50.00	yes
55	Chemical, DDT	Salmonidae	Salmo salar	Atlantic salmon	Density	5.00	45.00	yes
56	Chemical, DDT	Salmonidae	Salmo salar	Atlantic salmon	Density	5.00	70.00	yes
57	Chemical, DDT	Salmonidae	Salmo salar	Atlantic salmon	Density	6.00	25.00	yes

1 - persistence of species in system

(continued) Table 20. Recovery times for fish by state, province, or country.
(Foreign sites follow U.S. states)

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec.	Persis. in sys.	
						(yrs)	pop (km)	Upstream Downstream
ONTARIO								
154	Channelization			Biomass	Biomass	> 6.00	3.00	yes
154	Channelization			Density	Density	> 6.00	3.00	yes
154	Channelization			Productivity	Productivity	> 6.00	3.00	yes
MALES								
136	Drought	Salmonidae	Salmo trutta	Brown trout	First appears	.17	1.00	yes no

Table 21. Recovery times for fish by stressor.

Case	1				Time to Distance Persists. Unperturbed Source		Recover to refugia of spec. for recolonization	
	no.	Stressor	Family	Scientific name	Common name	Recovery type	(yrs) pop (kn) in sys.	Upstream Downstream
133 Channelization	58	Channelization	Aphredoderidae	Aphredoderus sayanus	Bionass	Bionass	> 5.00	1.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Catostomus microps	Bionass	Bionass	> 52.00	39.00 - yes
133 Channelization	197	Channelization	Catostomidae	Hypentelium nigricans	Bionass	Bionass	> 30.00	20.00 yes yes
133 Channelization	172	Channelization	Catostomidae	Moxostoma valenciennesi	Bionass	Bionass	> 40.00	- -
133 Channelization	154	Channelization	Catostomidae	Leponis macrochirus	Bionass	Bionass	> 6.00	3.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Density	Density	> 52.00	39.00 - yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Density	Density	> 30.00	20.00 yes yes
133 Channelization	172	Channelization	Catostomidae	Leponis macrochirus	Density	Density	> 40.00	- -
133 Channelization	154	Channelization	Catostomidae	Leponis macrochirus	Density	Density	> 6.00	3.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Productivity	Productivity	> 6.00	3.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Species richness	Species richness	> 52.00	39.00 - yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Species richness	Species richness	> 30.00	20.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Pirate perch	Density	> 52.00	39.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Modoc sucker	Density	> 5.00	1.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Northern hog sucker	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Spotted sucker	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Black rehorse	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Bluegill	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Bluegill	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Longear sunfish	Density	> 25.00	yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Smallmouth bass	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Largemouth bass	Average size	> 52.00	39.00 - yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Largemouth bass	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Cypress minnow	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Silverstripe shiner	Density	> 52.00	39.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Bluntnose minnow	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Blackspotted topminnow	Density	> 52.00	39.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Chain pickerel	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Yellow bullhead	Density	> 25.00	yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Channel catfish	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Flathead catfish	Density	> 52.00	39.00 yes yes
133 Channelization	58	Channelization	Catostomidae	Leponis macrochirus	Crystal darter	Density	> 52.00	39.00 yes yes
133 Channelization	197	Channelization	Catostomidae	Leponis macrochirus	Cypress darter	Density	> 52.00	39.00 yes yes

(continued) Table 21. Recovery times for fish by stressor.

Case	no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization		
							(yrs)	pop (ha)	in sys. Upstream Downstream
132	Channelization	Percidae	<i>Perca caprodes</i>	Log perch	Density	> 25.00	yes	yes	yes
58	Channelization	Percidae	<i>Percina caprodes</i>	Logperch	Density	> 52.00	39.00	yes	yes
58	Channelization	Percidae	<i>Percina sciera</i>	Dusky darter	Density	> 52.00	39.00	yes	yes
126	Channelization	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Density	> 50.00	1.50	yes	yes
133	Channelization	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Average size	> 5.00	1.00	yes	yes
133	Channelization	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Density	> 5.00	1.00	yes	yes
133	Channelization	Salmonidae	<i>Salmo trutta</i>	Brown trout	Average size	> 5.00	1.00	yes	yes
126	Channelization	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 50.00	1.50	yes	yes
174	Chemical, DDT	Cottidae	<i>Cottus sp.</i>	Density	Density	> 2.20	-	-	-
174	Chemical, DDT	Cottidae	<i>Cottus sp.</i>	Sculpin	Density	> 2.20	no	no	yes
174	Chemical, DDT	Cottidae	<i>Cottus sp.</i>	Sculpin	First appears	> 2.20	no	no	yes
174	Chemical, DDT	Salmonidae	<i>Prosopium williamsoni</i>	Mountain whitefish	Average size	> 2.00	yes	yes	yes
174	Chemical, DDT	Salmonidae	<i>Prosopium williamsoni</i>	Mountain whitefish	Density	2.00	yes	yes	yes
174	Chemical, DDT	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Density	> 1.20	yes	yes	yes
186	Chemical, DDT	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Density	< 1.00	.80	yes	yes
186	Chemical, DDT	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Density	> 1.10	2.40	yes	yes
174	Chemical, DDT	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Density	> 1.20	yes	yes	yes
54	Chemical, DDT	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Density	5.00	50.00	yes	yes
55	Chemical, DDT	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Density	5.00	45.00	yes	yes
56	Chemical, DDT	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Density	5.00	70.00	yes	yes
57	Chemical, DDT	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Density	6.00	25.00	yes	yes
174	Chemical, DDT	Salmonidae	<i>Salmo trutta</i>	Brown trout	Density	2.00	yes	yes	yes
186	Chemical, DDT	Salmonidae	<i>Salmo trutta</i>	Brown trout	Density	> 1.10	2.40	yes	yes
174	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Average size	> 2.00	yes	yes	yes
175	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Average size	> 2.00	yes	yes	yes
87	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	6.00	yes	yes
88	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	6.00	yes	yes
89	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	8.50	yes	yes
90	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.25	7.80	yes	no
91	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 1.25	4.60	yes	no
92	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	> 1.25	32.00	yes	yes
175	Chemical, DDT	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Density	2.00	yes	yes	yes

1 - persistence of species in system

1
Time to Distance Persis. Unperturbed Source
Recover to refugia of spec. for recolonization

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

1

Case

Time to Distance
Recover to refugia of spec.

Persis. Unperturbed Source
for recolonization

no.	Stressor	Family	Scientific name	Common name	Recovery type	(yrs)	pop (km)	in sys.	Upstream	Downstream
187	Chemical, other	Cyprinidae	Capostoma anomalus	Central stoneroller	Density	.50	1.10	no	no	yes
38	Chemical, other	Cyprinidae	Capostoma anomalus	Central stoneroller	First appears	.06	.10	no	yes	yes
124	Chemical, other	Cyprinidae	Capostoma anomalus	Central stoneroller	First appears	2.00		no	no	no
187	Chemical, other	Cyprinidae	Capostoma anomalus	Central stoneroller	First appears	.50	1.10	no	no	yes
38	Chemical, other	Cyprinidae	Dionda nubila	Ozark minnow	Density	> 1.00	.10	no	yes	yes
38	Chemical, other	Cyprinidae	Dionda nubila	Ozark minnow	First appears	.65	.10	no	yes	yes
187	Chemical, other	Cyprinidae	Koconis biguttatus	Hornyhead chub	Density	1.00	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Koconis biguttatus	Hornyhead chub	First appears	> 2.00		no	no	no
187	Chemical, other	Cyprinidae	Koconis biguttatus	Hornyhead chub	First appears	.50	1.10	no	no	yes
38	Chemical, other	Cyprinidae	Notropis boops	Bigeye shiner	Density	.08	.10	no	yes	yes
38	Chemical, other	Cyprinidae	Notropis boops	Bigeye shiner	First appears	.01	.10	no	yes	yes
38	Chemical, other	Cyprinidae	Notropis pilbryi	Dusystripe shiner	Density	> 1.00	.60	no	yes	yes
38	Chemical, other	Cyprinidae	Notropis pilbryi	Dusystripe shiner	First appears	.19	.60	no	yes	yes
187	Chemical, other	Cyprinidae	Phoxinus erythrogaster	Southern redbelly dace	Density	2.00	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Phoxinus erythrogaster	Southern redbelly dace	First appears	> 2.00		no	no	no
187	Chemical, other	Cyprinidae	Phoxinus erythrogaster	Southern redbelly dace	First appears	1.00	1.10	no	no	yes
38	Chemical, other	Cyprinidae	Pisephales notatus	Bluntnose minnow	Density	.29	.10	no	yes	yes
187	Chemical, other	Cyprinidae	Pisephales notatus	Bluntnose minnow	Density	> 2.00	1.10	no	no	yes
38	Chemical, other	Cyprinidae	Pisephales notatus	Bluntnose minnow	First appears	.04	.10	no	yes	yes
124	Chemical, other	Cyprinidae	Pisephales notatus	Bluntnose minnow	First appears	3.50		no	no	no
187	Chemical, other	Cyprinidae	Pisephales notatus	Bluntnose minnow	First appears	.50	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Pisephales promelas	Fathead minnow	Density	> 2.00		no	no	no
187	Chemical, other	Cyprinidae	Pisephales promelas	Fathead minnow	Density	> 2.00	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Pisephales promelas	Fathead minnow	First appears	.50		no	no	no
187	Chemical, other	Cyprinidae	Pisephales promelas	Fathead minnow	First appears	.50	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Density	> 2.00		no	no	no
187	Chemical, other	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Density	1.00	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Rhinichthys atratulus	Blacknose dace	First appears	2.00		no	no	no
187	Chemical, other	Cyprinidae	Rhinichthys atratulus	Blacknose dace	First appears	.50	1.10	no	no	yes
187	Chemical, other	Cyprinidae	Rhinichthys cataractae	Longnose dace	Density	1.00	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Rhinichthys cataractae	Longnose dace	First appears	> 2.00		no	no	no
187	Chemical, other	Cyprinidae	Rhinichthys cataractae	Longnose dace	First appears	.50	1.10	no	no	yes
124	Chemical, other	Cyprinidae	Senotilus atronaculatus	Creek chub	Density	> 3.50		no	no	no
187	Chemical, other	Cyprinidae	Senotilus atronaculatus	Creek chub	Density	1.00	1.10	no	no	yes

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case	Stressor	Family	Scientific name	Common name	Recovery type	1		
						Time to Distance Recover to refugia of spec.	Persis. in sys.	Unperturbed Source for recolonization Downstream
no.						(yrs)	pop (km)	
124	Chemical, other	Cyprinidae	<i>Senotilus atronauculatus</i>	Creek chub	First appears	2.00	no	no
187	Chemical, other	Cyprinidae	<i>Senotilus atronauculatus</i>	Creek chub	First appears	.50	1.10	no
38	Chemical, other	Cyprinodontidae	<i>Fundulus olivaceus</i>	Blackspotted topminnow	Density	.16	.10	no
38	Chemical, other	Cyprinodontidae	<i>Fundulus olivaceus</i>	Blackspotted topminnow	First appears	.01	.10	yes
124	Chemical, other	Gasterosteidae	<i>Culaea inconstans</i>	Brook stickleback	Density	1.00	no	yes
187	Chemical, other	Gasterosteidae	<i>Culaea inconstans</i>	Brook stickleback	Density	1.00	1.10	no
124	Chemical, other	Gasterosteidae	<i>Culaea inconstans</i>	Brook stickleback	First appears	.50	no	yes
187	Chemical, other	Gasterosteidae	<i>Culaea inconstans</i>	Brook stickleback	First appears	.50	1.10	no
38	Chemical, other	Ictaluridae	<i>Ictalurus melas</i>	Black bullhead	Density	1.00	.10	no
38	Chemical, other	Ictaluridae	<i>Ictalurus melas</i>	Black bullhead	First appears	.15	.10	yes
38	Chemical, other	Ictaluridae	<i>Ictalurus natalis</i>	Yellow bullhead	Density	1.00	.10	no
38	Chemical, other	Ictaluridae	<i>Ictalurus natalis</i>	Yellow bullhead	First appears	.19	.10	yes
187	Chemical, other	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Density	2.00	1.10	no
124	Chemical, other	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	First appears	2.00	no	yes
187	Chemical, other	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	First appears	.50	1.10	no
187	Chemical, other	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	Density	2.00	1.10	no
124	Chemical, other	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	First appears	2.00	no	yes
187	Chemical, other	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	First appears	1.00	1.10	no
38	Chemical, other	Percidae	<i>Rtheostoma spectabile</i>	Orangethroat darter	First appears	.04	.10	yes
41	Chemical, rotenone			Bionass	Bionass	2.00	9.70	no
42	Chemical, rotenone			Bionass	Bionass	4.00	37.00	no
190	Chemical, rotenone			Bionass	Bionass	.83	.60	yes
173	Chemical, rotenone			Bionass	Bionass	2.00	-	-
93	Chemical, rotenone			Bionass	Bionass	1.33	.50	no
41	Chemical, rotenone			Density	Density	1.00	9.70	no
42	Chemical, rotenone			Density	Density	2.00	37.00	no
190	Chemical, rotenone			Density	Density	.83	.60	yes
93	Chemical, rotenone			Density	Density	1.33	.50	no
41	Chemical, rotenone			Species richness	Species richness	1.00	9.70	no
42	Chemical, rotenone			Species richness	Species richness	4.00	37.00	no
93	Chemical, rotenone			Species richness	Species richness	1.33	.50	no
14	Chemical, rotenone			Species richness	Species richness	1.00	13.00	-
15	Chemical, rotenone			Species richness	Species richness	2.00	80.00	-

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case no.	Stressor	Family	Scientific name	Common name	Time to Distance		Recovery type	(yrs)	pop (km)	Persis. Unperturbed Source	
					Recover to refugia of spec.	for recolonization					
16	Chemical, rotenone	Amblyopsidae	Chologaster agassizi	Species richness	Species richness	>	2.00	150.00	-	yes	no
16	Chemical, rotenone		Anguilla rostrata	Species richness	Species richness	>	2.00	244.00	no	yes	no
17	Chemical, rotenone		Catostomus ardens	Species richness	Species richness	>	1.00	21.00	-	yes	no
93	Chemical, rotenone		Catostomus ardens	Spring carefish	First appears	>	1.33	.50	-	no	no
190	Chemical, rotenone		Catostomus commersoni	American eel	Density	>	.83	.60	yes	yes	yes
17	Chemical, rotenone		Catostomus commersoni	Utah sucker	Density	>	2.00	21.00	no	yes	no
17	Chemical, rotenone		Catostomus commersoni	Utah sucker	First appears	>	2.00	21.00	no	yes	no
190	Chemical, rotenone		Catostomus commersoni	White sucker	Average size	>	.83	.60	yes	yes	yes
42	Chemical, rotenone		Catostomus commersoni	White sucker	Density	<	1.00	37.00	no	no	yes
190	Chemical, rotenone		Catostomus commersoni	White sucker	Density	<	.83	.60	yes	yes	yes
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Average size	>	2.00	13.00	no	yes	no
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	>	2.00	13.00	-	yes	no
15	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	>	1.00	80.00	no	yes	no
16	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	>	1.70	244.00	no	yes	no
17	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	Density	>	2.00	21.00	no	yes	no
14	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	>	.75	13.00	-	yes	no
15	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	>	1.00	80.00	no	yes	no
16	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	>	1.00	150.00	no	yes	no
17	Chemical, rotenone	Catostomidae	Catostomus latipinnis	Flannemouth sucker	First appears	>	1.00	21.00	no	yes	no
14	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	Density	>	1.00	13.00	no	yes	no
16	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	Density	>	2.00	150.00	no	yes	no
17	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	Density	>	2.00	21.00	no	yes	no
14	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	>	1.00	13.00	no	yes	no
15	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	>	2.00	80.00	no	yes	no
16	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	>	2.00	244.00	no	yes	no
17	Chemical, rotenone	Catostomidae	Catostomus sp.	Sucker	First appears	>	.70	21.00	no	yes	no
93	Chemical, rotenone	Catostomidae	Hypentelium nigricans	Northern hog sucker	Density	>	1.33	.50	no	no	no
93	Chemical, rotenone	Catostomidae	Hypentelium nigricans	Northern hog sucker	First appears	>	1.33	.50	no	no	no
42	Chemical, rotenone	Catostomidae	Ictiobus cyprinellus	Bigmouth buffalo	First appears	>	4.00	37.00	no	no	yes
42	Chemical, rotenone	Catostomidae	Moxostoma melanops	Spotted sucker	First appears	>	2.00	37.00	no	no	yes
41	Chemical, rotenone	Catostomidae	Moxostoma sp.	Redhorse, sucker	Density	<	1.00	9.70	no	yes	yes
42	Chemical, rotenone	Catostomidae	Moxostoma sp.	Redhorse, sucker	Density	>	4.00	37.00	no	no	yes
16	Chemical, rotenone	Catostomidae	Iyrauchen texanus	Razorback sucker	Density	>	2.00	244.00	no	yes	no
16	Chemical, rotenone	Catostomidae	Iyrauchen texanus	Razorback sucker	First appears	>	2.00	244.00	no	yes	no

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization		
						(yrs)	pop (km)	in sys. Upstream Downstream
17	Chemical, rotenone	Catostomidae	sucker(unspecified)	Sucker(unspecified)	Density	2.00	21.00	no yes
17	Chemical, rotenone	Catostomidae	sucker(unspecified)	Sucker(unspecified)	First appears	.17	21.00	yes
93	Chemical, rotenone	Centrarchidae	Ambloplites rupestris	Rock bass	First appears	1.33	.50	no no
41	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	1.00	9.70	no yes
42	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	1.00	37.00	no yes
93	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	1.33	.50	no no
93	Chemical, rotenone	Centrarchidae	Lepomis cyanellus	Green sunfish	First appears	.33	.50	no no
42	Chemical, rotenone	Centrarchidae	Lepomis gulosus	Warmouth	Density	4.00	37.00	no yes
93	Chemical, rotenone	Centrarchidae	Lepomis macrochirus	Bluegill	First appears	.33	.50	no no
42	Chemical, rotenone	Centrarchidae	Micropterus notius	Sunshine bass	Density	4.00	37.00	no yes
93	Chemical, rotenone	Centrarchidae	Micropterus salmoides	Largemouth bass	First appears	1.33	.50	no no
42	Chemical, rotenone	Clupeidae	Dorosoma cepedianum	Gizzard shad	Density	1.00	37.00	no yes
14	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	Density	2.00	13.00	no yes
15	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	Density	2.00	80.00	no yes
14	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	First appears	2.00	13.00	no yes
15	Chemical, rotenone	Cottidae	Cottidae	Sculpin family	First appears	2.00	80.00	no yes
93	Chemical, rotenone	Cottidae	Cottus caroliniae	Banded sculpin	Density	1.33	.50	no no
93	Chemical, rotenone	Cottidae	Cottus caroliniae	Banded sculpin	First appears	.42	.50	no no
16	Chemical, rotenone	Cottidae	Cottus sp.	Sculpin	Density	2.00	244.00	no yes
16	Chemical, rotenone	Cottidae	Cottus sp.	Sculpin	First appears	2.00	244.00	no yes
41	Chemical, rotenone	Cottidae	sculpin (unspecified)	Sculpin (unspecified)	Density	1.00	9.70	no yes
93	Chemical, rotenone	Cyprinidae	Carpiostoma anomalum	Central stoneroller	Density	1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Carpiostoma anomalum	Central stoneroller	First appears	.42	.50	no no
93	Chemical, rotenone	Cyprinidae	Carassius auratus	Goldfish	First appears	1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Clinostomus funduloides	Posyside dace	Density	1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Clinostomus funduloides	Posyside dace	First appears	.33	.50	no no
41	Chemical, rotenone	Cyprinidae	Cyprinidae	Minnow, carp family	Density	1.00	9.70	no yes
42	Chemical, rotenone	Cyprinidae	Cyprinidae	Minnow, carp family	Density	1.00	37.00	no yes
42	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Carp	Density	1.00	37.00	no yes
15	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Coszon, mirror carp	Density	2.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Coszon, mirror carp	Density	1.70	210.00	no yes
17	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Coszon, mirror carp	Density	2.00	21.00	no no
15	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Coszon, mirror carp	First appears	1.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Coszon, mirror carp	First appears	1.70	150.00	no yes

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization		
						(yrs)	pop (ka)	in sys. Upstream Downstream
17	Chemical, rotenone	Cyprinidae	Cyprinus carpio	Common, mirror carp	First appears	.10	21.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila atraria	Utah chub	Density	> 2.00	244.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila atraria	Utah chub	First appears	> 2.00	244.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila cypha	Humpback chub	Density	> 2.00	244.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila cypha	Humpback chub	First appears	> 2.00	244.00	no yes
15	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	Density	> 2.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	Density	> 2.00	244.00	no yes
15	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	First appears	2.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Gila elegans	Bonytail chub	First appears	2.00	244.00	no yes
41	Chemical, rotenone	Cyprinidae	Hypentelium sp.	Bog sucker	Density	< 1.00	9.70	no yes
190	Chemical, rotenone	Cyprinidae	Motropis cornutus	Common shiner	Density	> .83	.60	yes yes
93	Chemical, rotenone	Cyprinidae	Phoxinus erythrogaster	Southern redbelly dace	Density	> 1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Phoxinus erythrogaster	Southern redbelly dace	First appears	.50	.50	no no
15	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	Density	2.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	Density	2.00	150.00	no yes
17	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	Density	2.00	21.00	no yes
15	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	First appears	1.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	First appears	2.00	244.00	no yes
17	Chemical, rotenone	Cyprinidae	Pisephales pronelas	Fathead minnow	First appears	.10	21.00	no yes
16	Chemical, rotenone	Cyprinidae	Ptychocheilus lucius	Colorado squawfish	Density	> 2.00	244.00	no yes
16	Chemical, rotenone	Cyprinidae	Ptychocheilus lucius	Colorado squawfish	First appears	> 2.00	244.00	no yes
190	Chemical, rotenone	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Density	< .83	.60	yes yes
93	Chemical, rotenone	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Density	> 1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Rhinichthys atratulus	Blacknose dace	First appears	1.33	.50	no no
190	Chemical, rotenone	Cyprinidae	Rhinichthys cataractae	Longnose dace	Density	> .83	.60	yes yes
14	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	13.00	- yes
15	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	150.00	no yes
17	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	Density	2.00	21.00	no yes
14	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	.17	13.00	- yes
15	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	1.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	2.00	244.00	no yes
17	Chemical, rotenone	Cyprinidae	Rhinichthys osculus	Speckled dace	First appears	.10	21.00	no yes
14	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	2.00	13.00	- yes

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization		
						(yrs)	pop (ka)	Upstream Downstream
15	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	1.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	2.00	244.00	no yes
17	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	Density	.70	21.00	-
14	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	.17	13.00	- yes
15	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	1.00	80.00	no yes
16	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	2.00	244.00	no yes
17	Chemical, rotenone	Cyprinidae	Richardsonius balteatus	Redside shiner	First appears	.10	21.00	no yes
42	Chemical, rotenone	Cyprinidae	Semotilus atromaculatus	Creek chub	Density	< 1.00	37.00	no yes
93	Chemical, rotenone	Cyprinidae	Semotilus atromaculatus	Creek chub	Density	> 1.33	.50	no no
93	Chemical, rotenone	Cyprinidae	Semotilus atromaculatus	Creek chub	First appears	.42	.50	no no
42	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	Density	< 1.00	37.00	no no
93	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	Density	> 1.33	.50	no no
16	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	Density	> 2.00	244.00	no yes
93	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	First appears	.33	.50	no no
16	Chemical, rotenone	Ictaluridae	Ictalurus melas	Black bullhead	First appears	> 2.00	244.00	no yes
42	Chemical, rotenone	Ictaluridae	Ictalurus natalis	Yellow bullhead	Density	2.00	37.00	no no
16	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	Density	> 2.00	244.00	no yes
42	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	First appears	> 4.00	37.00	no no
16	Chemical, rotenone	Ictaluridae	Ictalurus punctatus	Channel catfish	First appears	> 2.00	244.00	no yes
42	Chemical, rotenone	Ictaluridae	Pygidictis olivaris	Flathead catfish	First appears	> 4.00	37.00	no no
93	Chemical, rotenone	Percidae	Etheostoma blennioides	Greenside darter	First appears	> 1.33	.50	no no
93	Chemical, rotenone	Percidae	Etheostoma sinoternum	Tenn snubnose darter	Density	> 1.33	.50	no no
93	Chemical, rotenone	Percidae	Etheostoma sinoternum	Tenn snubnose darter	First appears	1.33	.50	no no
42	Chemical, rotenone	Percidae	Etheostoma sp.	Darter	Density	< 1.00	37.00	no yes
190	Chemical, rotenone	Percidae	Percina maculata	Blackside darter	Density	> .83	.60	yes yes
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Average size	1.00	13.00	no yes
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Average size	2.00	80.00	no yes
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	.10	13.00	no yes
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	2.00	80.00	no yes
16	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	> 2.00	244.00	no no
17	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	Density	2.00	21.00	no yes
14	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.10	13.00	no yes
15	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.75	80.00	no yes
16	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	1.00	150.00	no yes

(continued) Table 21. Recovery times for fish by stressor.

Time to Distance
Recover to refugia of spec. for recolonization

Case	Stressor	Family	Scientific name	Common name	Recovery type	(yrs)	pop (kn)	in sys.	Upstream	Downstream
17	Chemical, rotenone	Salmonidae	Coregonus sp.	Cisco, whitefish	First appears	.17	7.00	no	yes	no
190	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> .83	.60	yes	yes	yes
14	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	2.00	13.00	no	yes	no
15	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> 2.00	20.00	no	yes	no
16	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	> 2.00	150.00	no	yes	no
17	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	Density	1.70	21.00	no	yes	no
14	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.75	13.00	no	yes	no
15	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.10	80.00	-	yes	no
16	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	> 2.00	244.00	no	yes	no
17	Chemical, rotenone	Salmonidae	Salmo trutta	Brown trout	First appears	.17	7.00	no	yes	no
93	Chemical, rotenone	Salmonidae	Salvelinus fontinalis	Brook trout	Density	> 1.33	.50	-	no	no
44	Drought			Density	Density	< 1.00	31.00	no	no	yes
44	Drought			Species richness	Species richness	< 1.00	31.00	no	no	yes
44	Drought			Species richness	Species richness	> 1.00	41.00	no	no	no
136	Drought	Salmonidae	Salmo trutta	Brown trout	First appears	.17	1.00	yes	no	yes
192	Flooding			Density	Density	> .60		no	yes	no
68	Flooding			Productivity	Productivity	2.00		yes	no	no
199	Flooding			Species richness	Species richness	.75		yes	no	no
68	Flooding	Salmonidae	Salvelinus fontinalis	Brook trout	Average size	4.00		yes	no	no
68	Flooding	Salmonidae	Salvelinus fontinalis	Brook trout	Density	3.00		yes	no	no
139	Habitat development			Biomass	Biomass	5.00	.35	yes	yes	yes
139	Habitat development			Productivity	Productivity	5.00	.35	yes	yes	yes
184	Habitat development			Species richness	Species richness	< 5.00	1.00	-	yes	yes
184	Habitat development	Catostomidae	Carpiodes cyprinus	Quillback	Density	> 5.00	1.00	-	yes	yes
184	Habitat development	Catostomidae	Hypentelium nigricans	Northern hog sucker	Density	> 5.00	1.00	-	yes	yes
184	Habitat development	Catostomidae	Moxostoma valenciennesi	Silver redbhorse	Density	> 5.00	1.00	-	yes	yes
184	Habitat development	Catostomidae	Moxostoma valenciennesi	Black redbhorse	Density	> 5.00	1.00	-	yes	yes
184	Habitat development	Centrarchidae	Micropterus dolomieu	Smallmouth bass	Density	< 5.00	1.00	-	yes	yes
184	Habitat development	Centrarchidae	Micropterus salmoides	Largemouth bass	Density	< 5.00	1.00	-	yes	yes
184	Habitat development	Centrarchidae	Pomoxis annularis	White crappie	Density	> 5.00	1.00	-	yes	yes
184	Habitat development	Cyprinidae	Carassius auratus	Goldfish	Density	> 5.00	1.00	-	yes	yes

(continued) Table 21. Recovery times for fish by stressor.

Time to Distance Persis. Unperturbed Source
Recover to refugia of spec. for recolonization

Case	Stressor	Family	Scientific name	Common name	Recovery type	(yrs)	pop (km)	in sys.	Upstream	Downstream
127	Habitat development	Salmonidae	Salmo clarki	Cutthroat trout	Density	1.00	1.00	yes	yes	yes
139	Habitat development	Salmonidae	Salvelinus fontinalis	Brook trout	Average size	5.00	.35	yes	yes	yes
139	Habitat development	Salmonidae	Salvelinus fontinalis	Brook trout	Density	5.00	.35	yes	yes	yes
128	Lake drawdown			Density	Density	.50	1.00	yes	yes	yes
128	Lake drawdown			Species richness	Species richness	.50	1.00	yes	yes	yes
69	Mining activity			Species richness	Species richness	6.00	-	-	no	yes
69	Mining activity			Species richness	Species richness	12.00	-	-	no	no
43	Multiple disturbances			Density	Density	.20	3.20	no	no	yes
43	Multiple disturbances			Species richness	Species richness	.20	3.20	no	no	yes
43	Multiple disturbances	Catostomidae	Cariodes cyprinus	Quillback	First appears	.13	5.10	no	no	yes
43	Multiple disturbances	Catostomidae	Catostomus commersoni	White sucker	First appears	.04	10.10	no	no	yes
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	Average size	.13	3.20	no	no	yes
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Catostomidae	Erimyzon oblongus	Creek chubsucker	First appears	.04	6.60	no	no	yes
43	Multiple disturbances	Catostomidae	Moxostoma erythrum	Golden redbreast	First appears	.04	4.30	no	no	yes
43	Multiple disturbances	Centrarchidae	Ambloplites rupestris	Rock bass	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Centrarchidae	Ambloplites rupestris	Rock bass	First appears	.04	3.20	no	no	yes
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	Average size	.13	3.20	no	no	yes
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Centrarchidae	Lepomis cyanellus	Green sunfish	First appears	.04	4.30	no	no	yes
43	Multiple disturbances	Centrarchidae	Lepomis megalotis	Longear sunfish	First appears	1.50	4.80	no	no	yes
43	Multiple disturbances	Centrarchidae	Micropterus dolomieu	Smallmouth bass	First appears	.04	2.10	no	no	yes
43	Multiple disturbances	Cyprinidae	Caupostoma anomalum	Central stoneroller	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Cyprinidae	Caupostoma anomalum	Central stoneroller	First appears	.04	4.30	no	no	yes
43	Multiple disturbances	Cyprinidae	Caupostoma anomalum	Central stoneroller	First appears	.06	.24	no	no	yes
43	Multiple disturbances	Cyprinidae	Ericymba buccata	Silverjaw minnow	First appears	.04	10.10	no	no	yes
43	Multiple disturbances	Cyprinidae	Hypentelium sp.	Bog sucker	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Cyprinidae	Hypentelium sp.	Bog sucker	First appears	.04	9.10	no	no	yes
43	Multiple disturbances	Cyprinidae	Notemigonus crysoleucas	Golden shiner	First appears	.13	5.10	no	no	yes
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	Density	.13	3.20	no	no	yes
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	First appears	.04	6.60	no	no	yes

1 - persistence of species in system

(continued) Table 21. Recovery times for fish by stressor.

Case no.	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance		Persis.	Unperturbed Source
						Recover to refugia of spec.	for recolonization		
						(yrs)	pop (km)	in sv.	Upstream Downstream
43	Multiple disturbances	Cyprinidae	Notropis cornutus	Common shiner	First appears	.06	1.24	no	yes
43	Multiple disturbances	Cyprinidae	Notropis sp.	Shiner	Density	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Notropis sp.	Shiner	First appears	.04	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	Density	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	First appears	.04	6.60	no	yes
43	Multiple disturbances	Cyprinidae	Notropis spilopterus	Spotfin shiner	First appears	.06	.24	no	yes
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	Average size	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	Density	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	First appears	.04	9.10	no	yes
43	Multiple disturbances	Cyprinidae	Notropis umbratilis	Redfin shiner	First appears	.06	.24	no	yes
43	Multiple disturbances	Cyprinidae	Phenacobius mirabilis	Suckermouth minnow	First appears	.04	2.10	no	yes
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	Density	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	First appears	.04	10.10	no	yes
43	Multiple disturbances	Cyprinidae	Pimephales notatus	Bluntnose minnow	First appears	.06	.24	no	yes
43	Multiple disturbances	Cyprinidae	Senotilus atronaculatus	Creek chub	Average size	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Senotilus atronaculatus	Creek chub	Density	.13	3.20	no	yes
43	Multiple disturbances	Cyprinidae	Senotilus atronaculatus	Creek chub	First appears	.04	10.10	no	yes
43	Multiple disturbances	Ictaluridae	Ictalurus melas	Black bullhead	First appears	.33	5.10	no	yes
43	Multiple disturbances	Ictaluridae	Ictalurus natalis	Yellow bullhead	First appears	.33	5.10	no	yes
43	Multiple disturbances	Percidae	Etheostoma blennioides	Greenside darter	Density	.13	3.20	no	yes
43	Multiple disturbances	Percidae	Etheostoma blennioides	Greenside darter	First appears	.04	.50	no	yes
43	Multiple disturbances	Percidae	Etheostoma caeruleum	Rainbow darter	Density	.13	3.20	no	yes
43	Multiple disturbances	Percidae	Etheostoma caeruleum	Rainbow darter	First appears	.04	3.20	no	yes
43	Multiple disturbances	Percidae	Etheostoma flabellare	Fantail darter	Density	.13	3.20	no	yes
43	Multiple disturbances	Percidae	Etheostoma flabellare	Fantail darter	First appears	.04	.50	no	yes
43	Multiple disturbances	Percidae	Etheostoma nigrum	Johnny darter	First appears	.33	5.10	no	yes
43	Multiple disturbances	Percidae	Etheostoma spectabile	Orangethroat darter	Density	.13	3.20	no	yes
43	Multiple disturbances	Percidae	Etheostoma spectabile	Orangethroat darter	First appears	.04	9.10	no	yes
43	Multiple disturbances	Percidae	Percina maculata	Blackside darter	Density	.13	3.20	no	yes
43	Multiple disturbances	Percidae	Percina maculata	Blackside darter	First appears	.04	9.10	no	yes

(continued) Table 21. Recovery times for fish by stressor.

Case	Stressor	Family	Scientific name	Common name	Recovery type	Time to Distance Recover to refugia of spec. for recolonization		
						(yrs)	pop (ha)	in sys. Upstream Downstream
37	Organism removal (non ch Catostomidae)		Erimyzon tenuis	Sharpfin chubnucker	Average size	1.00	.03	yes yes
37	Organism removal (non ch Catostomidae)		Erimyzon tenuis	Sharpfin chubnucker	Density	1.00	.03	yes yes
177	Organism removal (non ch Catostomidae)		Erimyzon tenuis	Sharpfin chubnucker	Density	1.00	.04	yes yes
179	Organism removal (non ch Centrarchidae)		Leponis gulosus	Warmouth	Density	> 2.00	.04	yes yes
179	Organism removal (non ch Centrarchidae)		Leponis macrochirus	Bluegill	Density	1.00	.04	yes yes
37	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Average size	1.00	.03	no yes
176	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Average size	1.00	.04	yes yes
177	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Average size	1.00	.04	yes yes
178	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Average size	1.00	.30	yes yes
179	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Average size	> 2.00	.04	yes yes
37	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Density	1.00	.03	no yes
176	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Density	1.00	.04	yes yes
177	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Density	> 1.20	.04	yes yes
178	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Density	1.00	.30	yes yes
179	Organism removal (non ch Centrarchidae)		Leponis negalotis	Longear sunfish	Density	> 2.00	.04	yes yes
177	Organism removal (non ch Esocidae)		Esox americanus americanus	Redfin pickerel	Density	> 1.00	.04	yes yes
27	Timber activity	Cottidae	Cottus perplexus	Reticulate sculpin	Density	7.00	-	- no
27	Timber activity	Salmonidae	Salmo clarki	Cutthroat trout	Density	> 8.00	-	- no

Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance		Persis.		Unperturbed Source
						Recover to refugia of spec. (yrs) pop (km) in sys.		for recolonization Upstream Downstream		
133			Bionass	Channelization	Bionass	> 5.00	1.00	yes	yes	yes
41			Bionass	Chemical, rotenone	Bionass	2.00	9.70	no	yes	yes
42			Bionass	Chemical, rotenone	Bionass	> 4.00	37.00	no	-	-
58			Bionass	Channelization	Bionass	> 52.00	39.00	-	yes	yes
197			Bionass	Channelization	Bionass	> 30.00	20.00	yes	yes	yes
190			Bionass	Chemical, rotenone	Bionass	> .83	.60	yes	yes	yes
172			Bionass	Channelization	Bionass	> 40.00		-	-	-
173			Bionass	Chemical, rotenone	Bionass	2.00		-	-	-
154			Bionass	Channelization	Bionass	> 6.00	3.00	yes	yes	yes
93			Bionass	Chemical, rotenone	Bionass	> 1.33	.50	no	no	no
124			Bionass	Chemical, other	Bionass	> 3.50		no	no	no
139			Bionass	Habitat development	Bionass	5.00	.35	yes	yes	yes
187			Bionass	Chemical, other	Bionass	2.00	1.10	no	no	yes
43			Density	Multiple disturbances	Density	.20	3.20	no	no	yes
128			Density	Lake drawdown	Density	< .50	1.00	yes	yes	yes
41			Density	Chemical, rotenone	Density	< 1.00	9.70	no	yes	yes
42			Density	Chemical, rotenone	Density	< 2.00	37.00	no	-	-
58			Density	Channelization	Density	> 52.00	39.00	-	yes	yes
197			Density	Channelization	Density	> 30.00	20.00	yes	yes	yes
174			Density	Chemical, DDT	Density	> 2.20		-	-	-
190			Density	Chemical, rotenone	Density	> .83	.60	yes	yes	yes
172			Density	Channelization	Density	> 40.00		-	-	-
44			Density	Drought	Density	< 1.00	31.00	no	no	yes
154			Density	Channelization	Density	> 6.00	3.00	yes	yes	yes
93			Density	Chemical, rotenone	Density	> 1.33	.50	no	no	no
192			Density	Flooding	Density	> .60		no	yes	no
124			Density	Chemical, other	Density	> 3.50		no	no	no
187			Density	Chemical, other	Density	1.00	1.10	no	no	yes
68			Productivity	Flooding	Productivity	2.00		yes	no	no
154			Productivity	Channelization	Productivity	> 6.00	3.00	yes	yes	yes
139			Productivity	Habitat development	Productivity	5.00	.35	yes	yes	yes
38			Species richness	Chemical, other	Species richness	.10	.10	no	yes	yes
199			Species richness	Flooding	Species richness	.75		yes	no	no
43			Species richness	Multiple disturbances	Species richness	.20	3.20	no	no	yes

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance		Unperturbed Source		
						Recover to refugia of spec. (yrs)	Recover to refugia of spec. in avg. (km)			
128			Species richness	Lake drawdown	Species richness <	.50	1.00	yes	yes	yes
41			Species richness	Chemical, rotenone	Species richness <	1.00	9.70	no	yes	yes
42			Species richness	Chemical, rotenone	Species richness	4.00	37.00	no	-	-
58			Species richness	Channelization	Species richness >	52.00	39.00	-	yes	yes
197			Species richness	Channelization	Species richness >	30.00	20.00	yes	yes	yes
44			Species richness	Drought	Species richness <	1.00	31.00	no	no	yes
44			Species richness	Drought	Species richness >	1.00	41.00	no	no	no
184			Species richness	Habitat development	Species richness <	5.00	1.00	-	yes	yes
69			Species richness	Mining activity	Species richness	6.00	-	-	no	yes
69			Species richness	Mining activity	Species richness >	12.00	-	-	no	no
93			Species richness	Chemical, rotenone	Species richness >	1.33	.50	no	no	no
124			Species richness	Chemical, other	Species richness >	3.50	-	no	no	no
187			Species richness	Chemical, other	Species richness	1.00	1.10	no	no	yes
14			Species richness	Chemical, rotenone	Species richness	1.00	13.00	-	yes	no
15			Species richness	Chemical, rotenone	Species richness	2.00	80.00	-	yes	no
16			Species richness	Chemical, rotenone	Species richness >	2.00	150.00	-	yes	no
16			Species richness	Chemical, rotenone	Species richness >	2.00	244.00	no	yes	no
17			Species richness	Chemical, rotenone	Species richness	1.00	21.00	-	yes	no
93	Ablypsidae	Chologaster agassizi	Spring cavefish	Chemical, rotenone	First appears	1.33	.50	-	no	no
190	Anguillidae	Anguilla rostrata	American eel	Chemical, rotenone	Density	.83	.60	yes	yes	yes
58	Aphredoderidae	Aphredoderus sayanus	Pirate perch	Channelization	Density	52.00	39.00	yes	yes	yes
38	Atherinidae	Labidesthes sicculus	Brook silverside	Chemical, other	Density	.17	.60	no	yes	yes
38	Atherinidae	Labidesthes sicculus	Brook silverside	Chemical, other	First appears	.08	.60	no	yes	yes
43	Catostomidae	Carpiodes cyprinus	Quillback	Multiple disturbances	First appears	.13	5.10	no	no	yes
184	Catostomidae	Carpiodes cyprinus	Quillback	Habitat development	Density	5.00	1.00	-	yes	yes
17	Catostomidae	Catostomus ardens	Utah sucker	Chemical, rotenone	Density	2.00	21.00	no	yes	no
17	Catostomidae	Catostomus ardens	Utah sucker	Chemical, rotenone	First appears	2.00	21.00	no	yes	no
43	Catostomidae	Catostomus commersoni	White sucker	Multiple disturbances	First appears	.04	10.10	no	no	yes
42	Catostomidae	Catostomus commersoni	White sucker	Chemical, rotenone	Density	1.00	37.00	no	no	yes
190	Catostomidae	Catostomus commersoni	White sucker	Chemical, rotenone	Average size	.83	.60	yes	yes	yes

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization (yrs) pop (km) in sys. Upstream Downstream		
						<	>	>
190	Catostomidae	Catostomus commersoni	White sucker	Chemical, rotenone	Density	.83	.50	yes
124	Catostomidae	Catostomus commersoni	White sucker	Chemical, other	Density	2.00	no	no
187	Catostomidae	Catostomus commersoni	White sucker	Chemical, other	Density	2.00	1.10	no
124	Catostomidae	Catostomus commersoni	White sucker	Chemical, other	First appears	.50	no	no
187	Catostomidae	Catostomus commersoni	White sucker	Chemical, other	First appears	.50	1.10	no
14	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	Average size	2.00	13.00	no
14	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	Density	2.00	13.00	-
15	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	Density	1.00	80.00	no
16	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	Density	1.70	244.00	no
17	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	Density	2.00	21.00	no
14	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	First appears	.75	13.00	-
15	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	First appears	1.00	80.00	no
16	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	First appears	1.00	150.00	no
17	Catostomidae	Catostomus latipinnis	Flannelmouth sucker	Chemical, rotenone	First appears	1.00	21.00	no
133	Catostomidae	Catostomus microps	Kodoc sucker	Chemical, rotenone	First appears	1.00	21.00	no
14	Catostomidae	Catostomus sp.	Sucker	Channelization	Density	5.00	1.80	yes
16	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	Density	1.00	13.00	no
17	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	Density	2.00	150.00	no
14	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	Density	2.00	21.00	no
15	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	First appears	1.00	13.00	no
16	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	First appears	2.00	80.00	no
17	Catostomidae	Catostomus sp.	Sucker	Chemical, rotenone	First appears	2.00	244.00	no
43	Catostomidae	Erimyzon oblongus	Creek chubsucker	Chemical, rotenone	First appears	.70	21.00	no
43	Catostomidae	Erimyzon oblongus	Creek chubsucker	Multiple disturbances	Average size	.13	3.20	no
43	Catostomidae	Erimyzon oblongus	Creek chubsucker	Multiple disturbances	Density	.13	3.20	no
37	Catostomidae	Erimyzon tenuis	Sharpfin chubsucker	Multiple disturbances	First appears	.04	6.50	no
37	Catostomidae	Erimyzon tenuis	Sharpfin chubsucker	Organism removal (non ch	Average size	1.00	.03	yes
177	Catostomidae	Erimyzon tenuis	Sharpfin chubsucker	Organism removal (non ch	Density	1.00	.03	yes
132	Catostomidae	Erimyzon tenuis	Sharpfin chubsucker	Organism removal (non ch	Density	1.00	.04	yes
184	Catostomidae	Erimyzon tenuis	Northern hog sucker	Channelization	Density	25.00	yes	yes
93	Catostomidae	Erimyzon tenuis	Northern hog sucker	Habitat development	Density	5.00	1.00	-
93	Catostomidae	Erimyzon tenuis	Northern hog sucker	Chemical, rotenone	Density	1.33	.50	no
124	Catostomidae	Erimyzon tenuis	Northern hog sucker	Chemical, rotenone	First appears	1.33	.50	no
42	Catostomidae	Erimyzon tenuis	Northern hog sucker	Chemical, other	First appears	2.00	no	no
38	Catostomidae	Erimyzon tenuis	Bigmouth buffalo	Chemical, rotenone	First appears	4.00	37.00	no
			Spotted sucker	Chemical, other	Density	1.00	.10	yes

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization (yrs) pop (km) in sys. Upstream Downstream		
38	Catostomidae	<i>Moxostoma melanops</i>	Spotted sucker	Chemical, other	First appears	.21	.10	yes
42	Catostomidae	<i>Moxostoma melanops</i>	Spotted sucker	Chemical, rotenone	First appears	2.00	37.00	no
58	Catostomidae	<i>Moxostoma melanops</i>	Spotted sucker	Channelization	Density	> 52.00	39.00	yes
184	Catostomidae	<i>Moxostoma anisurum</i>	Silver redhorse	Habitat development	Density	> 5.00	1.00	-
38	Catostomidae	<i>Moxostoma duquesnei</i>	Black redhorse	Chemical, other	Density	> 1.00	.10	no
38	Catostomidae	<i>Moxostoma duquesnei</i>	Black redhorse	Chemical, other	First appears	.15	.10	no
132	Catostomidae	<i>Moxostoma duquesnei</i>	Black redhorse	Channelization	Density	> 25.00	.10	yes
184	Catostomidae	<i>Moxostoma duquesnei</i>	Black redhorse	Habitat development	Density	> 5.00	1.00	yes
43	Catostomidae	<i>Moxostoma erythrum</i>	Golden redhorse	Multiple disturbances	First appears	.04	4.30	no
41	Catostomidae	<i>Moxostoma sp.</i>	Redhorse, sucker	Chemical, rotenone	Density	< 1.00	9.70	no
42	Catostomidae	<i>Moxostoma sp.</i>	Redhorse, sucker	Chemical, rotenone	Density	> 4.00	37.00	no
16	Catostomidae	<i>Xyrauchen texanus</i>	Razorback sucker	Chemical, rotenone	Density	> 2.00	244.00	no
16	Catostomidae	<i>Xyrauchen texanus</i>	Razorback sucker	Chemical, rotenone	First appears	> 2.00	244.00	no
17	Catostomidae	sucker(unspecified)	Sucker(unspecified)	Chemical, rotenone	Density	2.00	21.00	no
17	Catostomidae	sucker(unspecified)	Sucker(unspecified)	Chemical, rotenone	First appears	.17	21.00	yes
43	Centrarchidae	<i>Abloplites rupestris</i>	Rock bass	Multiple disturbances	Density	.13	3.20	no
43	Centrarchidae	<i>Abloplites rupestris</i>	Rock bass	Multiple disturbances	First appears	.04	3.20	no
93	Centrarchidae	<i>Abloplites rupestris</i>	Rock bass	Chemical, rotenone	First appears	> 1.33	.50	no
38	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, other	Average size	> 1.00	.10	no
38	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, other	Density	.12	.10	yes
38	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, other	First appears	.08	.10	yes
43	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Multiple disturbances	Average size	.13	3.20	no
43	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Multiple disturbances	Density	.13	3.20	no
43	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Multiple disturbances	First appears	.04	4.30	no
41	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, rotenone	Density	< 1.00	9.70	no
42	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, rotenone	Density	< 1.00	37.00	no
93	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, rotenone	Density	1.33	.50	no
93	Centrarchidae	<i>Lepomis cyanellus</i>	Green sunfish	Chemical, rotenone	First appears	.33	.50	no
42	Centrarchidae	<i>Lepomis gulosus</i>	Warmouth	Chemical, rotenone	Density	> 4.00	37.00	no
179	Centrarchidae	<i>Lepomis gulosus</i>	Warmouth	Organism removal (non ch)	Density	> 2.00	.04	yes
38	Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	Chemical, other	Average size	> 1.00	.10	no
38	Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	Chemical, other	Density	.50	.10	no
38	Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	Chemical, other	First appears	.13	.10	no
179	Centrarchidae	<i>Lepomis macrochirus</i>	Bluegill	Organism removal (non ch)	Density	1.00	.04	yes

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source		
						Recover to refugia of spec. for recolonization	(yrs) pop (ka) in sys.	Upstream Downstream
58	Centrarchidae	<i>Leponis macrochirus</i>	Bluegill	Channelization	Density	> 52.00	39.00	yes
132	Centrarchidae	<i>Leponis macrochirus</i>	Bluegill	Channelization	Density	> 25.00		yes
93	Centrarchidae	<i>Leponis macrochirus</i>	Bluegill	Chemical, rotenone	First appears	.33	.50	no
38	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Chemical, other	Density	.10	.10	yes
38	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Chemical, other	First appears	.04	.10	yes
43	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Multiple disturbances	First appears	1.50	4.80	no
37	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Average size	1.00	.03	no
176	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Average size	1.00	.04	yes
177	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Average size	1.00	.04	yes
178	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Average size	1.00	.30	yes
179	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Average size	> 2.00	.04	yes
37	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Density	1.00	.03	no
176	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Density	1.00	.04	yes
177	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Density	> 1.20	.04	yes
178	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Density	1.00	.30	yes
179	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Organism removal (non ch)	Density	> 2.00	.04	yes
132	Centrarchidae	<i>Leponis megalotis</i>	Longear sunfish	Channelization	Density	> 25.00		yes
43	Centrarchidae	<i>Micropterus dolomieu</i>	Shallmouth bass	Multiple disturbances	First appears	.04	2.10	no
132	Centrarchidae	<i>Micropterus dolomieu</i>	Shallmouth bass	Channelization	Density	> 25.00		yes
184	Centrarchidae	<i>Micropterus dolomieu</i>	Shallmouth bass	Habitat development	Density	< 5.00	1.00	-
42	Centrarchidae	<i>Micropterus notius</i>	Savannee bass	Chemical, rotenone	Density	> 4.00	37.00	no
38	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Chemical, other	Average size	> 1.00	.10	yes
38	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Chemical, other	Density	.10	.10	yes
38	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Chemical, other	First appears	.04	.10	yes
58	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Channelization	Average size	> 52.00	39.00	-
132	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Channelization	Density	> 25.00		yes
184	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Habitat development	Density	< 5.00	1.00	-
93	Centrarchidae	<i>Micropterus salmoides</i>	Largemouth bass	Chemical, rotenone	First appears	> 1.33	.50	no
184	Centrarchidae	<i>Pomoxis annularis</i>	White crappie	Habitat development	Density	> 5.00	1.00	-
42	Clupeidae	<i>Dorosoma cepedianum</i>	Gizzard shad	Chemical, rotenone	Density	< 1.00	37.00	no
14	Cottidae	Cottidae	Sculpin family	Chemical, rotenone	Density	2.00	13.00	no
15	Cottidae	Cottidae	Sculpin family	Chemical, rotenone	Density	2.00	80.00	no
14	Cottidae	Cottidae	Sculpin family	Chemical, rotenone	First appears	2.00	13.00	no

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source		
						Recover to refugia of spec. for recolonization (yrs)	pop (ha) in sys.	Upstream Downstream
15	Cottidae	Cottidae	Sculpin family	Chemical, rotenone	First appears	2.00	80.00	no
40	Cottidae	Cottus aleuticus	Coastrange sculpin	Chemical, other	Density	> 1.00	.50	yes
93	Cottidae	Cottus caroliniae	Banded sculpin	Chemical, rotenone	Density	1.33	.50	no
93	Cottidae	Cottus caroliniae	Banded sculpin	Chemical, rotenone	First appears	.42	.50	no
124	Cottidae	Cottus cognatus	Slimy sculpin	Chemical, other	Density	> 3.50	no	no
124	Cottidae	Cottus cognatus	Slimy sculpin	Chemical, other	First appears	.50	no	no
27	Cottidae	Cottus perplexus	Reticulate sculpin	Fiber activity	Density	7.00	-	no
174	Cottidae	Cottus sp.	Sculpin	Chemical, DDT	Density	> 2.20	no	yes
174	Cottidae	Cottus sp.	Sculpin	Chemical, DDT	First appears	> 2.20	no	yes
16	Cottidae	Cottus sp.	Sculpin	Chemical, rotenone	Density	> 2.00	244.00	yes
16	Cottidae	Cottus sp.	Sculpin	Chemical, rotenone	First appears	> 2.00	244.00	no
41	Cottidae	sculpin (unspecified)	Sculpin (unspecified)	Chemical, rotenone	Density	< 1.00	9.70	yes
38	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	Density	.13	.10	yes
38	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	First appears	.06	.10	yes
43	Cyprinidae	Camptostoma anomalus	Central stoneroller	Multiple disturbances	Density	.13	3.20	no
43	Cyprinidae	Camptostoma anomalus	Central stoneroller	Multiple disturbances	First appears	.04	4.30	no
43	Cyprinidae	Camptostoma anomalus	Central stoneroller	Multiple disturbances	First appears	.06	.24	no
93	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, rotenone	Density	> 1.33	.50	no
93	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, rotenone	First appears	.42	.50	no
124	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	Density	> 3.50	no	no
187	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	Density	.50	1.10	no
124	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	First appears	2.00	no	yes
187	Cyprinidae	Camptostoma anomalus	Central stoneroller	Chemical, other	First appears	.50	1.10	no
184	Cyprinidae	Carassius auratus	Goldfish	Habitat development	Density	> 5.00	1.00	yes
93	Cyprinidae	Carassius auratus	Goldfish	Chemical, rotenone	First appears	> 1.33	.50	no
93	Cyprinidae	Clinostomus funduloides	Rosyside dace	Chemical, rotenone	Density	> 1.33	.50	no
93	Cyprinidae	Clinostomus funduloides	Rosyside dace	Chemical, rotenone	First appears	.33	.50	no
41	Cyprinidae	Cyprinidae	Minnow, carp family	Chemical, rotenone	Density	< 1.00	9.70	yes
42	Cyprinidae	Cyprinidae	Minnow, carp family	Chemical, rotenone	Density	< 1.00	37.00	yes
42	Cyprinidae	Cyprinus carpio	Carp	Chemical, rotenone	Density	< 1.00	37.00	yes
15	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	Density	> 2.00	80.00	no
16	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	Density	1.70	210.00	no
17	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	Density	2.00	21.00	no
15	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	First appears	1.00	80.00	yes

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance		Persis.	Uperturbed Source
						Recover to refugia of spec.	in sys.		
						(yrs) pop (km)			
16	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	First appears	1.70	150.00	no	yes
17	Cyprinidae	Cyprinus carpio	Common, mirror carp	Chemical, rotenone	First appears	.10	21.00	no	yes
38	Cyprinidae	Dionda nubila	Ozark minnow	Chemical, other	Density	> 1.00	.10	no	yes
38	Cyprinidae	Dionda nubila	Ozark minnow	Chemical, other	First appears	.65	.10	no	yes
43	Cyprinidae	Epiplatys buccata	Silverjaw minnow	Multiple disturbances	First appears	.04	10.10	no	yes
16	Cyprinidae	Gila atraria	Utah chub	Chemical, rotenone	Density	> 2.00	244.00	no	yes
16	Cyprinidae	Gila atraria	Utah chub	Chemical, rotenone	First appears	> 2.00	244.00	no	yes
16	Cyprinidae	Gila cypha	Humback chub	Chemical, rotenone	Density	> 2.00	244.00	no	yes
16	Cyprinidae	Gila cypha	Humback chub	Chemical, rotenone	First appears	> 2.00	244.00	no	yes
15	Cyprinidae	Gila elegans	Bonytail chub	Chemical, rotenone	Density	> 2.00	80.00	no	yes
16	Cyprinidae	Gila elegans	Bonytail chub	Chemical, rotenone	Density	> 2.00	244.00	no	yes
15	Cyprinidae	Gila elegans	Bonytail chub	Chemical, rotenone	First appears	2.00	80.00	no	yes
16	Cyprinidae	Gila elegans	Bonytail chub	Chemical, rotenone	First appears	2.00	244.00	no	yes
58	Cyprinidae	Hybognathus haysi	Cypress minnow	Channelization	Density	> 52.00	39.00	yes	yes
43	Cyprinidae	Hypentelium sp.	Hog sucker	Multiple disturbances	Density	.13	3.20	no	yes
43	Cyprinidae	Hypentelium sp.	Hog sucker	Multiple disturbances	First appears	.04	9.10	no	yes
41	Cyprinidae	Hypentelium sp.	Hog sucker	Chemical, rotenone	Density	< 1.00	9.70	no	yes
187	Cyprinidae	Moconis biguttatus	Hornhead chub	Chemical, other	Density	1.00	1.10	no	yes
124	Cyprinidae	Moconis biguttatus	Hornhead chub	Chemical, other	First appears	> 2.00	no	no	no
187	Cyprinidae	Moconis biguttatus	Hornhead chub	Chemical, other	First appears	.50	1.10	no	yes
43	Cyprinidae	Notemigonus crysoleucas	Golden shiner	Multiple disturbances	First appears	.13	5.10	no	yes
38	Cyprinidae	Notropis boops	Bigeye shiner	Chemical, other	Density	.08	.10	no	yes
38	Cyprinidae	Notropis boops	Bigeye shiner	Chemical, other	First appears	.01	.10	no	yes
43	Cyprinidae	Notropis cornutus	Cozon shiner	Multiple disturbances	Density	.13	3.20	no	yes
43	Cyprinidae	Notropis cornutus	Cozon shiner	Multiple disturbances	First appears	.04	6.60	no	yes
43	Cyprinidae	Notropis cornutus	Cozon shiner	Multiple disturbances	First appears	.06	.24	no	yes
190	Cyprinidae	Notropis cornutus	Cozon shiner	Multiple disturbances	Density	> .83	.60	yes	yes
38	Cyprinidae	Notropis pileabryi	Duckstripe shiner	Chemical, rotenone	Density	> 1.00	.60	no	yes
38	Cyprinidae	Notropis pileabryi	Duckstripe shiner	Chemical, other	First appears	.19	.60	no	yes
43	Cyprinidae	Notropis sp.	Shiner	Multiple disturbances	Density	.13	3.20	no	yes
43	Cyprinidae	Notropis sp.	Shiner	Multiple disturbances	First appears	.04	3.20	no	yes
43	Cyprinidae	Notropis spilopterus	Spotfin shiner	Multiple disturbances	Density	.13	3.20	no	yes
43	Cyprinidae	Notropis spilopterus	Spotfin shiner	Multiple disturbances	First appears	.04	6.60	no	yes
43	Cyprinidae	Notropis spilopterus	Spotfin shiner	Multiple disturbances	First appears	.06	.24	no	yes
58	Cyprinidae	Notropis stilbus	Silverstripe shiner	Channelization	Density	> 52.00	39.00	yes	yes

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source Recover to refugia of spec. for recolonization (yrs) pop (km) in sys. Upstream Downstream		
43	Cyprinidae	<i>Motropis unbratilis</i>	Redfin chiner	Multiple disturbances	Average size	.13	3.20	no
43	Cyprinidae	<i>Motropis unbratilis</i>	Redfin chiner	Multiple disturbances	Density	.13	3.20	no
43	Cyprinidae	<i>Motropis unbratilis</i>	Redfin chiner	Multiple disturbances	First appears	.04	9.10	no
43	Cyprinidae	<i>Motropis unbratilis</i>	Redfin chiner	Multiple disturbances	First appears	.06	.24	no
43	Cyprinidae	<i>Phenacobius mirabilis</i>	Suckermouth minnow	Multiple disturbances	First appears	.04	2.10	no
93	Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace	Chemical, rotenone	Density	> 1.33	.50	no
93	Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace	Chemical, rotenone	First appears	.50	.50	no
187	Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace	Chemical, other	Density	2.00	1.10	no
124	Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace	Chemical, other	First appears	> 2.00		no
187	Cyprinidae	<i>Phoxinus erythrogaster</i>	Southern redbelly dace	Chemical, other	First appears	1.00	1.10	no
38	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Chemical, other	Density	.29	.10	yes
38	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Chemical, other	First appears	.04	.10	yes
43	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Multiple disturbances	Density	.13	3.20	no
43	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Multiple disturbances	First appears	.04	10.10	no
43	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Multiple disturbances	First appears	.06	.24	no
58	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Channelization	Density	> 52.00	39.00	yes
187	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Chemical, other	Density	> 2.00	1.10	no
124	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Chemical, other	First appears	3.50		no
187	Cyprinidae	<i>Pimephales notatus</i>	Bluntnose minnow	Chemical, other	First appears	.50	1.10	no
124	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, other	Density	> 2.00		no
187	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, other	Density	> 2.00	1.10	no
124	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, other	First appears	.50		no
187	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, other	First appears	.50	1.10	no
15	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	Density	2.00	80.00	no
16	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	Density	2.00	150.00	no
17	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	Density	2.00	21.00	no
15	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	First appears	1.00	80.00	no
16	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	First appears	2.00	244.00	no
17	Cyprinidae	<i>Pimephales promelas</i>	Fathead minnow	Chemical, rotenone	First appears	.10	21.00	no
16	Cyprinidae	<i>Ptychocheilus lucius</i>	Colorado squawfish	Chemical, rotenone	Density	> 2.00	244.00	no
16	Cyprinidae	<i>Ptychocheilus lucius</i>	Colorado squawfish	Chemical, rotenone	First appears	> 2.00	244.00	no
190	Cyprinidae	<i>Rhinichthys atratulus</i>	Blacknose dace	Chemical, rotenone	Density	< .83	.60	yes
93	Cyprinidae	<i>Rhinichthys atratulus</i>	Blacknose dace	Chemical, rotenone	Density	> 1.33	.50	no
93	Cyprinidae	<i>Rhinichthys atratulus</i>	Blacknose dace	Chemical, rotenone	First appears	1.33	.50	no
124	Cyprinidae	<i>Rhinichthys atratulus</i>	Blacknose dace	Chemical, other	Density	> 2.00		no

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. Unperturbed Source		
						Recover to refugia of spec. for recolonization (yrs)	pop (ha) in sys.	Upstream Downstream
187	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Chemical, other	Density	1.00	1.10	no
124	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Chemical, other	First appears	2.00	no	no
187	Cyprinidae	Rhinichthys atratulus	Blacknose dace	Chemical, other	First appears	.50	1.10	no
190	Cyprinidae	Rhinichthys cataractae	Longnose dace	Chemical, rotenone	Density	> .83	.60	yes
187	Cyprinidae	Rhinichthys cataractae	Longnose dace	Chemical, other	Density	1.00	1.10	no
124	Cyprinidae	Rhinichthys cataractae	Longnose dace	Chemical, other	First appears	> 2.00	no	no
187	Cyprinidae	Rhinichthys cataractae	Longnose dace	Chemical, other	First appears	.50	1.10	no
14	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	Density	2.00	13.00	-
15	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	Density	2.00	80.00	no
16	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	Density	2.00	150.00	no
17	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	Density	2.00	21.00	no
14	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	First appears	.17	13.00	-
15	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	First appears	1.00	80.00	no
16	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	First appears	2.00	244.00	no
17	Cyprinidae	Rhinichthys osculus	Speckled dace	Chemical, rotenone	First appears	.10	21.00	no
14	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	Density	2.00	13.00	-
15	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	Density	1.00	80.00	no
16	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	Density	2.00	244.00	no
17	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	Density	.70	21.00	-
14	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	First appears	.17	13.00	-
15	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	First appears	1.00	80.00	no
16	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	First appears	2.00	244.00	no
17	Cyprinidae	Richardsonius balteatus	Bedside shiner	Chemical, rotenone	First appears	.10	21.00	no
43	Cyprinidae	Seotilus atronaculatus	Creek chub	Multiple disturbances	Average size	.13	3.20	no
43	Cyprinidae	Seotilus atronaculatus	Creek chub	Multiple disturbances	Density	.13	3.20	no
43	Cyprinidae	Seotilus atronaculatus	Creek chub	Multiple disturbances	First appears	.04	10.10	no
42	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, rotenone	Density	< 1.00	37.00	no
93	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, rotenone	Density	> 1.33	.50	no
93	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, rotenone	First appears	.42	.50	no
124	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, other	Density	> 3.50	no	no
187	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, other	Density	1.00	1.10	no
124	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, other	First appears	2.60	no	no
187	Cyprinidae	Seotilus atronaculatus	Creek chub	Chemical, other	First appears	.50	1.10	no

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance		Unperturbed Source
						Recover to refugia of spec. (yrs)	pop (ha) in sys.	
38	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	Chemical, other	Density	.16	.10	yes
38	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	Chemical, other	First appears	.01	.10	yes
58	Cyprinodontidae	Fundulus olivaceus	Blackspotted topminnow	Channelization	Density	> 52.00	39.00	yes
177	Isocidae	Isosx americanus americanus	Redfin pickerel	Organism removal (non ch)	Density	> 1.00	.04	yes
58	Isocidae	Isosx niger	Chain pickerel	Channelization	Density	> 52.00	39.00	yes
124	Gasterosteidae	Calaea inconstans	Brook stickleback	Chemical, other	Density	1.00	no	no
187	Gasterosteidae	Calaea inconstans	Brook stickleback	Chemical, other	Density	1.00	1.10	no
124	Gasterosteidae	Calaea inconstans	Brook stickleback	Chemical, other	First appears	.50	no	no
187	Gasterosteidae	Calaea inconstans	Brook stickleback	Chemical, other	First appears	.50	1.10	no
38	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, other	Density	1.00	.10	yes
38	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, other	First appears	.15	.10	yes
43	Ictaluridae	Ictalurus nebulosus	Black bullhead	Multiple disturbances	First appears	.33	5.10	no
42	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, rotenone	Density	< 1.00	37.00	no
93	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, rotenone	Density	> 1.33	.50	no
93	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, rotenone	First appears	.33	.50	no
16	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, rotenone	Density	> 2.00	244.00	no
16	Ictaluridae	Ictalurus nebulosus	Black bullhead	Chemical, rotenone	First appears	> 2.00	244.00	yes
38	Ictaluridae	Ictalurus natalis	Yellow bullhead	Chemical, other	Density	> 1.00	.10	yes
38	Ictaluridae	Ictalurus natalis	Yellow bullhead	Chemical, other	First appears	.19	.10	yes
43	Ictaluridae	Ictalurus natalis	Yellow bullhead	Multiple disturbances	First appears	.33	5.10	no
42	Ictaluridae	Ictalurus natalis	Yellow bullhead	Chemical, rotenone	Density	2.00	37.00	no
132	Ictaluridae	Ictalurus natalis	Yellow bullhead	Channelization	Density	> 25.00	yes	yes
42	Ictaluridae	Ictalurus punctatus	Channel catfish	Chemical, rotenone	First appears	> 4.00	37.00	no
58	Ictaluridae	Ictalurus punctatus	Channel catfish	Channelization	Density	> 52.00	39.00	yes
16	Ictaluridae	Ictalurus punctatus	Channel catfish	Chemical, rotenone	Density	> 2.00	244.00	no
16	Ictaluridae	Ictalurus punctatus	Channel catfish	Chemical, rotenone	First appears	> 2.00	244.00	no
42	Ictaluridae	Pylodictis olivaris	Flathead catfish	Chemical, rotenone	First appears	> 4.00	37.00	no
58	Ictaluridae	Pylodictis olivaris	Flathead catfish	Channelization	Density	> 52.00	39.00	yes
58	Percidae	Anacrypta asprella	Crystal darter	Channelization	Density	> 52.00	39.00	yes
43	Percidae	Etheostoma blennioides	Greenside darter	Multiple disturbances	Density	.13	3.20	no
43	Percidae	Etheostoma blennioides	Greenside darter	Multiple disturbances	First appears	.04	.50	no

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance		Persis. Unperturbed Source	
						(yrs)	pop (km)	Recover to refugia of spec. for recolonization	in sys. Upstream Downstream
93	Percidae	<i>Rtheostoma blennioides</i>	Greenside darter	Chemical, rotenone	First appears	> 1.33	.50	no	no
43	Percidae	<i>Rtheostoma caeruleum</i>	Rainbow darter	Multiple disturbances	Density	.13	3.20	no	no
43	Percidae	<i>Rtheostoma caeruleum</i>	Rainbow darter	Multiple disturbances	First appears	.04	3.20	no	no
43	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Multiple disturbances	Density	.13	3.20	no	no
43	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Multiple disturbances	First appears	.04	.50	no	no
187	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Chemical, other	Density	> 2.00	1.10	no	no
124	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Chemical, other	First appears	> 2.00	no	no	no
187	Percidae	<i>Rtheostoma flabellare</i>	Fantail darter	Chemical, other	First appears	.50	1.10	no	no
43	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	Multiple disturbances	First appears	.33	5.10	no	no
187	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	Chemical, other	Density	2.00	1.10	no	no
124	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	Chemical, other	First appears	> 2.00	no	no	no
187	Percidae	<i>Rtheostoma nigrum</i>	Johnny darter	Chemical, other	First appears	1.00	1.10	no	no
58	Percidae	<i>Rtheostoma proliare</i>	Cypress darter	Channelization	Density	> 52.00	39.00	yes	yes
93	Percidae	<i>Rtheostoma sinoterum</i>	Tenn snubnose darter	Chemical, rotenone	Density	> 1.33	.50	no	no
93	Percidae	<i>Rtheostoma sinoterum</i>	Tenn snubnose darter	Chemical, rotenone	First appears	1.33	.50	no	no
42	Percidae	<i>Rtheostoma sp.</i>	Darter	Chemical, rotenone	Density	< 1.00	37.00	no	yes
38	Percidae	<i>Rtheostoma spectabile</i>	Orangethroat darter	Chemical, other	First appears	.04	.10	no	yes
43	Percidae	<i>Rtheostoma spectabile</i>	Orangethroat darter	Multiple disturbances	Density	.13	3.20	no	yes
43	Percidae	<i>Rtheostoma spectabile</i>	Orangethroat darter	Multiple disturbances	First appears	.04	9.10	no	yes
132	Percidae	<i>Percina caprodes</i>	Log perch	Channelization	Density	> 25.00	39.00	yes	yes
58	Percidae	<i>Percina caprodes</i>	Logperch	Channelization	Density	> 52.00	39.00	yes	yes
43	Percidae	<i>Percina maculata</i>	Blackside darter	Multiple disturbances	Density	.13	3.20	no	yes
43	Percidae	<i>Percina maculata</i>	Blackside darter	Multiple disturbances	First appears	.04	9.10	no	yes
190	Percidae	<i>Percina maculata</i>	Blackside darter	Chemical, rotenone	Density	> .83	.60	yes	yes
58	Percidae	<i>Percina sciera</i>	Dusky darter	Channelization	Density	> 52.00	39.00	yes	yes
14	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Average size	1.00	13.00	no	yes
15	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Average size	2.00	80.00	no	yes
14	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Density	.10	13.00	no	no
15	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Density	2.00	80.00	no	no
16	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Density	> 2.00	244.00	no	no
17	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	Density	2.00	21.00	no	no
14	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	First appears	.10	13.00	no	no
15	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	First appears	.75	80.00	no	yes
16	Salmonidae	<i>Coregonus sp.</i>	Cisco, whitefish	Chemical, rotenone	First appears	1.00	150.00	no	no

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance Persis. 1 Recover to refugia of spec. for recolonization (yrs) pop (ka) in sys. Upstream Downstream		
17	Salmonidae	<i>Coregonus</i> sp.	Cisco, whitefish	Chemical, rotenone	First appears	.17	7.00	no
174	Salmonidae	<i>Prosopium williamsi</i>	Mountain whitefish	Chemical, DDT	Average size	> 2.00		yes
174	Salmonidae	<i>Prosopium williamsi</i>	Mountain whitefish	Chemical, DDT	Density	2.00		yes
126	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Channelization	Density	> 50.00	1.50	yes
127	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Habitat development	Density	1.00	1.00	yes
174	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Chemical, DDT	Density	> 1.20		yes
186	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Chemical, DDT	Density	< 1.00	.80	yes
186	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Chemical, DDT	Density	> 1.10	2.40	yes
27	Salmonidae	<i>Salmo clarki</i>	Cutthroat trout	Fiber activity	Density	> 8.00		no
133	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Channelization	Average size	> 5.00	1.00	yes
133	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Channelization	Density	> 5.00	1.00	yes
174	Salmonidae	<i>Salmo gairdneri</i>	Rainbow trout	Chemical, DDT	Density	> 1.20		yes
54	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Chemical, DDT	Density	5.00	50.00	yes
55	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Chemical, DDT	Density	5.00	45.00	yes
56	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Chemical, DDT	Density	5.00	70.00	yes
57	Salmonidae	<i>Salmo salar</i>	Atlantic salmon	Chemical, DDT	Density	6.00	25.00	yes
133	Salmonidae	<i>Salmo trutta</i>	Brown trout	Channelization	Average size	> 5.00	1.00	yes
174	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, DDT	Density	2.00		yes
186	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, DDT	Density	> 1.10	2.40	yes
190	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	Density	> .83	.60	yes
136	Salmonidae	<i>Salmo trutta</i>	Brown trout	Drought	First appears	.17	1.00	yes
14	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	Density	2.00	13.00	no
15	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	Density	> 2.00	80.00	no
16	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	Density	> 2.00	150.00	no
17	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	Density	1.70	21.00	no
14	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	First appears	.75	13.00	no
15	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	First appears	.10	80.00	no
16	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	First appears	> 2.00	244.00	no
17	Salmonidae	<i>Salmo trutta</i>	Brown trout	Chemical, rotenone	First appears	.17	7.00	no
87	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	2.25	6.00	yes
88	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	> 2.25	6.00	no
89	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	2.25	8.50	yes
90	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	2.25	7.80	no
91	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	> 1.25	4.60	yes
92	Salmonidae	<i>Salvelinus fontinalis</i>	Brook trout	Chemical, DDT	Density	> 1.25	32.00	yes

1 - persistence of species in system

(continued) Table 22. Recovery times for fish by taxa.

Case no.	Family	Scientific name	Common name	Stressor	Recovery type	Time to Distance			Unperturbed Source	
						Recover to refugia of spec.	Recover to refugia of spec.	Recover to refugia of spec.	Recover to refugia of spec.	Recover to refugia of spec.
						(yrs)	pop (km)	in sys.	Upstream	Downstream
68	Salmonidae	Salvelinus fontinalis	Brook trout	Flooding	Average size	4.00		yes	no	no
68	Salmonidae	Salvelinus fontinalis	Brook trout	Flooding	Density	3.00		yes	no	no
174	Salmonidae	Salvelinus fontinalis	Brook trout	Chemical, DDT	Average size	> 2.00		yes	-	yes
175	Salmonidae	Salvelinus fontinalis	Brook trout	Chemical, DDT	Average size	> 2.00		yes	-	yes
126	Salmonidae	Salvelinus fontinalis	Brook trout	Channelization	Density	> 50.00	1.50	yes	yes	yes
175	Salmonidae	Salvelinus fontinalis	Brook trout	Chemical, DDT	Density	2.00		yes	-	yes
93	Salmonidae	Salvelinus fontinalis	Brook trout	Chemical, rotenone	Density	> 1.33	.50	-	no	no
139	Salmonidae	Salvelinus fontinalis	Brook trout	Habitat development	Average size	5.00	.35	yes	yes	yes
139	Salmonidae	Salvelinus fontinalis	Brook trout	Habitat development	Density	5.00	.35	yes	yes	yes

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