Evaluating alternative macroinvertebrate sampling methodologies in wetlands: Influence of sieve mesh size on relationships between environmental and assemblage variables

by

Ryan Charles Baldwin

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Program of Study Committee:
Timothy W. Stewart, Co-Major Professor
Michael J. Weber, Co-Major Professor
Richard C. Schultz

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ABSTRACT

By definition, a macroinvertebrate is any invertebrate that is large enough to be retained on a 500-µm mesh sieve. Although macroinvertebrates (hereafter invertebrates) are important in food webs and sensitive to environmental conditions, they are often omitted from wetland condition monitoring programs because use of this fine-mesh sieve makes sample collection and processing time consuming and expensive. The objective of this study was to identify a more cost-effective approach for obtaining invertebrate-based data that can be used to evaluate wetland condition. In 2014 and 2015, invertebrates and associated particulate matter (PM; living and dead plants, sediment) were collected from 27 wetlands in the Iowa Prairie Pothole Region using a stovepipe sampler. Sample material retained on a 500-µm mesh sieve was preserved. In the laboratory, samples were washed through a series of sieves that separated invertebrates and particulate matter into four size fractions. The 6-mm fraction included material retained on the 6-mm sieve, the 4-mm fraction included material retained on both 4- and 6-mm sieves, the 2-mm size fraction included material retained on 2-, 4-, and 6-mm sieves, and the 500-µm fraction was the sum total of material retained on 2-, 4-, 6-, and 500-µm sieves (i.e., the entire sample). Volume of each sample size fraction and time required to separate invertebrates from PM were recorded. Invertebrates were identified to family (mollusks, insects, isopods), order (amphipods, decapods), or class (annelids), and numbers of individuals were recorded. Subsequently, invertebrates were again washed through the sieve column in the absence of PM, and organisms in each size fraction were identified and counted. Values for invertebrate numerical density and taxon richness variables were quantified for each of the four invertebrate size fractions and when PM was present (+ PM) and absent (- PM). Invertebrate assemblage variables were related to environmental variables indicative of wetland condition (e.g., turbidity, chloride concentration, fish biomass, tiger salamander abundance, plant cover). Relationship strengths were affected by sieve mesh size, invertebrate variable measured, and presence or absence of PM in samples. Across the entire gradient of sieve mesh sizes and PM abundance, invertebrate taxon richness variables were more consistently and strongly related to environmental variables than invertebrate density variables. Regardless of sieve mesh size and PM presence, invertebrate taxon richness exclusive of four taxa recorded in every wetland (planorbid snails, oligochaetes, leeches, chironomid midges; TTR-PEOC) was positively correlated with plant cover and negatively correlated with turbidity and fish biomass. Use of a 2-mm, 4-mm, or 6-mm mesh sieve reduced sample volume by 19-35% and time required to separate invertebrates from PM by 36-54%, relative to use of a 500-μm mesh sieve. Results presented here indicate that use of an invertebrate taxon richness metric in which ubiquitous taxa are eliminated from analysis, and using a sieve mesh size of 6 mm, will generate cost savings in wetland monitoring while still producing data that accurately reflect wetland condition.

INTRODUCTION

Wetlands provide many valuable ecosystem services (Mitsch and Gosselink 2000). These ecosystems maintain groundwater and reduce downstream flooding by absorbing surface water (Zedler and Kercher 2005; Min et al. 2010). By reducing surface water runoff, wetlands preserve topsoil and reduce inputs of sediment, nutrients, and synthetic contaminants to streams (Zedler and Kercher 2005; Kovacic et al. 2006). Many contaminants entering wetlands are sequestered and transformed by plants and microorganisms, or degraded through physical mechanisms (Schulz and Peall 2001; Blackwell et al. 2002). Additionally, wetlands provide critical habitat for many species and can support high biological production and taxonomic diversity that contribute to opportunities for hunting, fishing, and viewing wildlife (Woodward and Wui 2001).

A diverse group that plays important roles in wetlands are macroinvertebrates, including mollusks, worms, insects and crustaceans. Through diverse functional feeding groups (e.g., scrapers, shredders, collector-gatherers), macroinvertebrates incorporate energy and nutrients from plants, algae, and decomposing organic matter into animal biomass (Merritt et al. 2008). In turn, macroinvertebrates are essential prey for wetland vertebrates, including fishes, amphibians, and birds (Benoy et al. 2002; Euliss et al. 2004; Benoy 2008). For example, many species of waterfowl and songbirds depend on wetland macroinvertebrate prey to obtain sufficient energy and nutrients for successful reproduction and migration (Cox et al. 1998 Anteau et al. 2008; MacDade et al. 2011). Thus, understanding macroinvertebrates is important due to their essential role in the food web.

Several studies have demonstrated the value of macroinvertebrate assemblage features, including measures of taxonomic diversity and population densities, for assessing wetland condition (Hentges and Stewart 2010; Maurer et al. 2014; Meyer et al. 2015). Macroinvertebrates are useful in this capacity because many taxa complete most or all of their life cycle in wetlands, where they are exposed to episodic and cumulative effects of environmental change (Fore et al. 1996; Kashian and Burton 2000; USEPA 2002). Additionally, macroinvertebrate taxa vary in habitat requirements and sensitivity to stressors, resulting in different assemblage structures based off the wetland condition (Batzer 2013).

Changes in land use that affect and reflect wetland condition also influences the macroinvertebrate assemblage structure (Euliss and Mushet 1999; Gleason et al. 2003; Riens et al. 2013). Disturbance of the surrounding landscape (e.g., crop fields, roads) influences habitat available to wetland-dependent invertebrates with terrestrial life stages (Euliss and Mushet 1999; Meyer et al. 2015; Scharold et al. 2015). Through these changes, the addition of nutrients and synthetic chemicals at high concentrations in the sediment or water column negatively affect macroinvertebrates at certain thresholds (Relyea 2005; Petranka and Francis 2013; Riens et al. 2013). High herbicide use in the watershed has been linked to reduced wetland macroinvertebrate abundance and taxon richness, and shifts from diverse aquatic insect-based assemblages to those dominated by oligochaetes (Euliss and Mushet 1999; Relyea 2005; Davis and Bidwell 2008). Furthermore, the toxicity of high chloride concentration increases macroinvertebrate mortality, reducing densities and diversity (Benbow and Merritt 2004; Petranka and Francis 2013).

Alterations in the biological composition of wetlands also influences the macroinvertebrate assemblage structure (Hentges and Stewart 2010; Maurer et al. 2014; Meyer et al. 2015). Artificial drainage systems connect historically isolated wetlands from other water bodies and provide migration corridors that enable colonization by fishes (Hanson et al. 2005;

Miller et al. 2012). Furthermore, fish population persistence is promoted by enhanced water inputs that increase wetland depth (Euliss and Mushet 1996; Miller et al. 2012). Consequently, introduced fishes can reduce macroinvertebrate abundance directly through predation (Mittelbach 1988; Beresford and Jones 2010). Additionally, large-bodied benthivorous fishes, including common carp (*Cyprinus carpio*) and black bullhead (*Ameiurus melas*), can indirectly affect macroinvertebrates by physically re-suspending sediment or excreting nutrients (Potthoff et al. 2008; Weber and Brown 2009; Maurer et al. 2014). This sediment may cover macroinvertebrate gills and eggs, and elevated turbidity from sediment and nutrient-generated phytoplankton blooms prevents light from penetrating the water column, subsequently causing declines in wetland plant abundance (Gleason et al. 2003; Riens et al. 2013; Maurer et al. 2014). Additionally, wetland plant abundance and diversity have been found to decline as water column concentration of chloride and herbicides increase, due to toxicity of these contaminants (Haller et al. 1974; Lacoul and Freedman 2006; Duman et al. 2014). Strong positive relationships between plant and macroinvertebrate abundance and diversity have been observed in wetlands (Hentges and Stewart 2010; Maurer et al. 2014; Meyer et al. 2015). Therefore, reduced plant abundance through mechanisms described above can lead to reduced abundance and diversity of macroinvertebrates that depend on plants for food and habitat (Zimmer et al. 2003; Zimmer et al. 2006; Maurer et al. 2014).

Development of wetland condition assessment protocols enables objective ecosystem evaluation, thereby guiding management actions that enhance social and ecological values of wetlands. Many protocols used to monitor wetland condition include metrics representing a range of physical and biological attributes (USEPA 2002; GLCWC 2008). Despite their acknowledged value in reflecting wetland condition, macroinvertebrate metrics are often omitted from assessment programs because collecting data using traditional approaches is expensive (Barba et al. 2010; USEPA 2011; Pinna et al. 2013). By convention, a “macroinvertebrate” is defined as an invertebrate that is retained by a sieve with a mesh size of 500-600 µm (APHA et al. 2005). When this fine-mesh sieve is used to collect wetland samples, abundant small-bodied organisms and particulate matter are retained, resulting in extensive time to process samples (Turner and Trexler 1997; Bartsch et al. 1998; Pinna et al. 2013). Consequently, a macroinvertebrate-based assessment protocol is not presently included in the United States Environmental Protection Agency (USEPA) National Wetland Condition Assessment plan (USEPA 2011). Identifying methods that increase data collection efficiency and also produce metric values that accurately reflect ecosystem condition is needed for macroinvertebrate assemblages to become useful wetland assessment tools.

Most attempts to identify cost-effective methods of obtaining wetland macroinvertebrate data have focused on evaluating alternative sampling gear, including long-handled sweep nets (with or without a drop frame), stovepipe samplers, and activity traps (e.g., funnel traps; Turner and Trexler 1997; USEPA 2002; Meyer et al. 2011). Of these methods, activity traps generally produce samples requiring the least amount of time to process, due to minimal particulate matter in samples (Turner and Trexler 1997; USEPA 2002; Jurado et al. 2008). However, this method severely underestimates macroinvertebrate abundance and diversity due to predation that occurs as animals remain for long periods in the trap, and because few sedentary or sediment-dwelling taxa are captured (Turner and Trexler 1997; USEPA 2002; Jurado et al. 2008). Use of long-handled nets to sweep the water column for macroinvertebrates generally results in higher abundance and diversity values than those obtained from activity traps (Turner and Trexler 1997). However, this method is difficult to standardize and still tends to underestimate macroinvertebrate abundance and diversity values (Turner and Trexler 1997; USEPA 2002; Meyer et al. 2011). Although, incorporating a drop frame with the sweep net can standardized the sampling effort but exhaustive sampling of macroinvertebrates using this technique results in large samples that time-consuming to process (Meyer et al. 2011).

A stovepipe sampler functions similarly to a drop frame, but encloses a smaller area. Once placed on the wetland bed, the stovepipe traverses the water column and extends above the water surface. Organisms are trapped within the cylinder, and can be removed using a hand-held net. This method offers advantages of accounting for macroinvertebrates inhabiting sediment and the water column, along with standardizing for sampling area. Additionally, the relatively small area enclosed by the stovepipe can be exhaustively sampled and generate more accurate estimates of abundance and taxonomic diversity than other sampling methods (Turner and Trexler 1997; USEPA 2002; Meyer et al. 2011). Previous studies employing stovepipe sampling demonstrated that macroinvertebrate taxonomic richness and numerical densities in Iowa Prairie Pothole wetlands were highly correlated with other indicators of wetland condition, including fish biomass, turbidity, and areal cover by plants (Hentges and Stewart 2010; Maurer et al. 2014; Sundberg 2016). Although stovepipe sampling can produce relatively accurate values for wetland macroinvertebrate metrics, time required to process samples retained by the standard 500-µm mesh sieve is still too extensive for this method to be widely used in wetland monitoring (Turner and Trexler 1997; Meyer at al. 2011; Maurer et al. 2014).

Attempts to reduce time required to collect macroinvertebrate data have also focused on sample processing approaches in the laboratory. Subsampling, using both fixed counts and fixed area approaches, may reduce sample processing time but does so at the risk of reducing accuracy of abundance and taxonomic diversity estimates (Doberstein et al. 2000; King and Richardson

2002; USEPA 2002). Elutriation, which involves use of supersaturated solutes to separate organisms from other material, appears to have limited effectiveness in wetlands because both invertebrates and plant material tend to float in this medium (Brinkman and Duffy 1996; USEPA 2002; Foth et al. 2012).

An additional approach with potential for reducing macroinvertebrate data collection time involves obtaining samples using a sieve with mesh size larger than 500 µm. Studies conducted in marine and lotic ecosystems have compared effectiveness of macroinvertebrate sampling using mesh sizes ranging from 500 µm to 2 mm, and results suggest that adherence to the conventional 500-µm sieve may be unnecessary and even suboptimal in ecosystem condition assessment (Barba et al. 2010; Couto et al. 2010; Pinna et al. 2013). For example, Pinna et al. (2013) found that macroinvertebrate metric values were similarly effective in ecosystem condition assessment for a Mediterranean lagoon regardless of whether a mesh size of 500 µm, 1 mm, or 2 mm was used to collect samples. Results from other studies conducted in lotic and marine ecosystems revealed a general tendency for large-bodied macroinvertebrate taxa (i.e., those retained by coarse mesh) to be more sensitive to environmental degradation than small-bodied taxa, perhaps due to their relatively long generation time, lower reproductive potential, or greater vulnerability to visually-oriented vertebrate predators (Lampadariou et al. 2005; Barba et al. 2010; Pinna et al. 2013).

These observations, in combination with reduced time required to process samples collected using coarse-mesh sieves, indicate the potential of identifying a more cost-effective macroinvertebrate-based wetland assessment procedure. In a recent review of refereed literature, there was no evidence of a previous study conducted in freshwater wetlands in which macroinvertebrate data collected using different sieve mesh sizes were evaluated and compared.

However, potential for these relationships exists. Examination of results from previous studies conducted in wetlands revealed that abundance and taxonomic richness of several macroinvertebrate taxa with relatively large body sizes (e.g., Gastropoda, Odonata, Hemiptera, Trichoptera, Coleoptera) were strongly related to non-invertebrate wetland condition indicators, including plant cover, fish biomass, and turbidity (Hentges and Stewart 2010; Reins et al. 2013; Maurer et al. 2014). Conversely, small-bodied taxa (e.g., Oligochaeta, Chironomidae) whose numbers dominate most wetland macroinvertebrate assemblages and that contribute substantially to data collection time, were weakly related to non-invertebrate wetland condition indicators (Mittelbach 1988; Hentges and Stewart 2010; Maurer et al. 2014).

The broad objective of this thesis research was to contribute to the development of a macroinvertebrate assessment protocol for Iowa's prairie pothole region (PPR). The specific objective was to evaluate relationships between macroinvertebrate-based variables obtained from samples collected using four sieve mesh sizes (6 mm, 4 mm, 2 mm, and 500 µm) with and without particulate matter and nine additional physical and biological variables that reflect wetland condition in the Iowa PPR. Relationships between macroinvertebrate variables, environmental variables, and sample volume and processing time were used to evaluate efficacy of each sieve for collecting data, and identify the most informative macroinvertebrate-based wetland condition assessment metrics. I hypothesized that relationships between macroinvertebrate assemblage and environmental variables would either be similar across a gradient of increasing mesh size, or be strongest when a mesh size larger than 500 µm was used. Either finding, in combination with reduced sample processing time that inevitably occurs when using a sieve with coarse mesh, would facilitate incorporation of macroinvertebrate assemblages into wetland assessment protocols.

METHODS

Study sites

Macroinvertebrate assemblages and nine additional environmental variables (percent crop land and developed land in watershed, wetland surface area, water column concentrations of chloride and herbicides, turbidity, fish biomass, plant cover, tiger salamander numerical abundance) were collected from 18 wetlands in 2014 and nine wetlands in 2015 (n = 27 wetlands). Study sites were located in the PPR of north-central Iowa, U.S.A., in Cerro Gordo, Hancock, Worth, and Winnebago counties (range of geographic coordinates = N 42° 56' 32" to 43° 29' 39", W 93° 08' 07" to 93° 46' 48"; Appendix A). All wetlands occurred in the Shell Rock, Winnebago, West Fork Cedar, and Upper Iowa watersheds (HUC 8-digit watersheds). Wetlands with similar hydrological characteristics were selected to enable detection of strong relationships among variables of interest. Specifically, all wetlands retained water for the duration of the study period (from May to August in 2014 and 2015) and were classified as permanently or semi-permanently flooded palustrine wetlands (Cowardin et al. 1979). No wetlands were directly connected to streams, although some became temporarily connected to other aquatic ecosystems during flood events. Data from previous studies (Hentges and Stewart 2010; Maurer et al. 2014), site visits, and visual assessment of orthophotos from the Iowa Geographic Map Server (ortho.gis.iastate.edu) were used to select wetlands included in this study. Specifically, sites were selected to collectively produce a strong gradient in wetland condition based primarily on turbidity and plant abundance.

Of the 27 study sites, 25 were located on land managed by the Iowa Department of Natural Resources (IDNR; 14 sites), Cerro Gordo, Hancock, Worth, or Winnebago County Conservation Boards (10 sites), or the Nature Conservancy (1 site). The remaining two sites were located on privately owned land. Crop land was the predominant land use throughout the study region. However, many wetlands were bordered by grassland, while forest (i.e., trees, shrubs) and developed (i.e., impervious surfaces) land cover also occurred in the vicinity of some wetlands. Most wetlands included in this study had been restored or hydrologically modified at some point in their history. However, at least four years separated this study from the most recent management event.

Macroinvertebrate Data Collection

Macroinvertebrates (hereafter invertebrates) were sampled on one date in each wetland between June 10 and July 11. A 36-cm diameter stovepipe sampler was used to sample invertebrates at five evenly-spaced locations at a depth of 40-60 cm in each wetland. Sampling depths corresponded to the open-water zone, which supported floating-leaved and submerged plants in wetlands that had populations of these plants (Richardson and Vymazal 2001). The sampler penetrated the sediment, traversed the water column, and extended above the water surface. Plants, plant fragments, and pieces of organic matter ≥ 5 cm long that were trapped within the cylinder were harvested by hand along with the top 2.5 cm of sediment, using a fine-mesh (250 µm) net (hereafter collectively referred to as particulate matter; PM). Then the fine-mesh net was used to sweep through the water column until 10 consecutive sweeps produced no visible invertebrates. Collected material retained by a 500-µm mesh sieve was preserved in a jar with 5% buffered formalin and Rose Bengal dye for at least 48 h that was then replaced with 95% ethanol. All five invertebrate samples from a wetland were composited into one sample representative of the entire wetland.

In the laboratory, invertebrates and associated PM in each sample were first divided into four size classes by washing material through a stacked column of four sieves with progressively smaller mesh sizes (6 mm, 4 mm, 2 mm, and 500 µm). Invertebrates were separated from PM while scanning sieve contents under intense light, and were then identified under 10x magnification. Mollusks, insects, and isopods were identified to family, while other taxa (leeches, oligochaetes, amphipods, decapods) were identified to class or order. Abundance of taxa that are typically classified as “microfauna” (nematodes, mites, springtails, ostracods, cladocerans, copepods) was not recorded because many of these invertebrates are too small to be retained by a 500-µm mesh sieve. Counts of each invertebrate taxon and time required to separate invertebrates from PM were recorded for each sieve. Volume of material retained by each sieve was recorded after transferring contents to a graduated cylinder.

The presence of PM could have substantial effects on invertebrate values and on their relationships with environmental variables due to the occlusion of mesh openings preventing the passage of invertebrates. As a result, after processing samples as described above, invertebrates in the absence of PM were washed through the sieve column again, and individuals retained on each sieve were again identified and counted. By reporting invertebrate data obtained before and after removal of PM from samples, the effects of both sieve mesh size and PM on results could be assessed.

Values for invertebrate abundance and taxonomic diversity were calculated for each of four invertebrate body size classes, in the presence and absence of PM, based on organisms retained by 6-mm, 4-mm, 2-mm, and 500-µm mesh sieves. Invertebrates within the 6-mm body size class included all individuals retained by the 6-mm mesh sieve. Invertebrates within the 4-mm body size class included all individuals retained by both 6-mm and 4-mm mesh sieves.

Invertebrates within the 2-mm body size class included all individuals retained by 6-mm, 4-mm, and 2-mm mesh sieves. Invertebrates within the 500-µm size class included all individuals retained by 6-mm, 4-mm, 2-mm, and 500-µm mesh sieves. Values for the 500-µm size class were assumed to be the same in both presence and absence of PM because they were based on sum totals across all four body size classes. For each body size class, invertebrate densities were quantified as number of individuals/m^3, and taxon richness was equivalent to the number of taxa collected from the entire volume of water that was sampled in each of the 27 wetlands (range of water volume sampled = 0.22-0.29 m^3).

Sample processing time (i.e., time required to separate invertebrates from PM) and sample volume (PM) were also determined for each sieve mesh size. Methods for measuring sample processing time and volume were similar to those used to obtain data for invertebrate body size classes. For example, sample processing time for the 6-mm mesh sieve was equivalent to amount of time required to separate invertebrates and PM that were retained on a 6-mm mesh sieve. Sample processing time for the 500-µm mesh sieve was equivalent to the total amount of time required to separate invertebrates and PM that were retained on 6-mm, 4-mm, 2-mm, and 500-µm mesh sieves. Sample volume obtained using a 6-mm mesh sieve was equivalent to the volume of invertebrates and PM retained on a 6-mm mesh sieve. Sample volume obtained using a 500-µm mesh sieve was equivalent to the total volume of invertebrates and PM retained on 6-mm, 4-mm, 2-mm, and 500-µm mesh sieves.

Environmental Variable Data Collection

In a recent study of wetlands in the Iowa PPR, Sundberg (2016) measured a large number of variables representing multiple environmental attributes. Attributes included land use within the watershed, wetland water volume, chloride and herbicide abundance in the wetland water column, and wetland biological characteristics including the fish and plant assemblage, and tiger salamander (*Ambystoma tigrinum*) abundance. Based on strength of relationships among variables, and costs of measuring each variable, Sundberg (2016) identified nine variables as effective wetland condition indicators in the Iowa PPR. These variables (crop land and developed land cover in the watershed, wetland surface area, chloride concentration, herbicide concentration, turbidity, fish biomass, plant cover, tiger salamander numerical abundance) were evaluated for potential relationships with invertebrate assemblage variables in this study.

Land use was quantified as percent of watershed classified as crop land or developed land. Land use data for each wetland watershed were obtained from the U.S. Department of Agriculture National Statistics Service (NASS; USDA 2014). Data were downloaded from NASS and percent cover of different land use types were calculated for a watershed. Land use types in this study were based on aggregations of Cropland Data Layer (CDL) land cover categories (Boryan et al. 2011; USDA 2014). Crop land cover was based on aerial cover by USDA agriculture land cover categories, including alfalfa, clover/wildflowers, corn, hay, oats, other crops, other hay/non-alfalfa, peas, rye, sorghum, soybeans, and winter wheat (USDA 2015). Developed land cover was quantified from percent of total land area covered by developed land of low, medium and high intensity, developed/open space, and barren land. Open space, low, medium, and high intensity development categories were defined as areas where vegetation cover was dominated by lawns and impervious surfaces accounted for <20%, 20-49%, 50-79%, and 80-100% of land area, respectively (USGS 2015). Barren land was defined as unpaved yet disturbed land where vegetation occurred on <15% of total area (USGS 2015).

Watershed area and surface area of each wetland were calculated in ArcMap (ArcGIS versions 10.0 and 10.1; ESRI 2012). A National Elevation Dataset (NED) raster (USGS NED n43w094 1/3 arc-second 2013 1 x 1 degree ArcGrid) downloaded from the U.S. Geological Survey National Map Viewer (USGS 2013) was used to delineate the watershed of each wetland. Wetland area (ha) was quantified as basin area under bank full conditions, including emergent and open water plant zones. Wetland area was calculated from digitizations of wetland orthophotos (1 m pixel) that were downloaded from the Iowa Geographic Map Server (ISU GIS Facility 2015).

Turbidity was measured from the water column of each wetland on three dates between May 9 and August 7. On each sampling date, water samples were collected from just below the water surface at five evenly spaced locations within the open water zone (i.e., beyond the emergent plant zone; van der Valk et al. 1978), and a HACH 2100Q or 2100P turbidimeter was used to measure turbidity in each sample. At least 14 days separated each sampling event. Turbidity values were averaged across all dates and sampling locations to obtain a single turbidity value for each wetland.

Water samples for measuring herbicides and chloride were collected from just below the water surface in the open water zone of each wetland on two dates, between June 17 and July 31 (USEPA methods 300.0, 547, 8270). On each date, one 60-mL water sample was analyzed for chloride concentration, one 60-mL sample was analyzed for glyphosate and its breakdown product aminomethylphosphonic acid (AMPA), and one 500-mL water sample was analyzed for remaining herbicides (see Table 1 for complete list of herbicides whose concentrations were measured). Samples were stored in a cooler at 4˚C and transported to the State Hygienic Laboratory (SHL) in Ankeny, Iowa within 30 h of collection for analysis. Similar to turbidity, water column concentrations of chloride and herbicides in each wetland were based on average values from the two sampling dates.

Abundance of free-floating, floating-leaved, emergent, and submerged nonvascular and vascular macroscopic plants was quantified as total area covered by plants (plant cover; Goldsmith and Harrison 1976; Richardson and Vymazal 2001; Maurer et al. 2014; Sundberg 2016). Plant surveys occurred on one date in each wetland between June 30 and July 23. Five parallel transects were established at equally spaced locations, with each transect extending from shoreline to shoreline (defined by uninterrupted presence of standing water). Each transect was divided into five sections of equal length, and a 1.0-m^2 sampling plot was randomly selected from each section. In each plot, visual observations and a plant rake were used to estimate plant cover (Goldsmith and Harrison 1976; Maurer et al. 2014). Plant cover values reported in results and used in statistical analysis were means based on percent cover values across all 25 plots.

Fish and tiger salamanders were sampled on one date from each wetland between May 8 and June 26 using unbaited fyke nets. Three standard nets (15.24 m lead, 1.9 cm mesh, 0.61 x 1.22 m frame) and three mini fyke nets (3.70 m lead, 0.5 cm mesh, 0.61 x 1.22 m frame) were oriented perpendicular to the shoreline and deployed in the open water zone at evenly spaced locations. Nets were retrieved after 24 h and number of individuals and biomass of captured individuals quantified. Data were used to quantify numerical abundance of tiger salamanders and fish biomass, measured as number of individuals and weight collected on a catch per unit effort (CPUE) basis.

Data Summary and Analysis

Each wetland was treated as an independent sampling unit in statistical analyses. To meet assumptions of parametric statistical methods, data for variables that were quantified as percentages (land cover, plant cover) were transformed using arcsine-square root(X). Remaining data were transformed using $\log_{10}(X)$, or $\log_{10}(X+1)$ if one or more “zero” counts occurred for the variable. Relationships were considered statistically significant at $p \leq 0.05$.

Relationships between invertebrate assemblage variables and environmental variables were first assessed using nonmetric multidimensional scaling that was conducted using data for the 500-µm invertebrate body size class (NMDS; Bray-Curtis distance measure, varimax rotation; McCune and Grace 2002). Two NMDS analyses were conducted. In the first analysis, relationships between environmental variables and numerical densities of invertebrate taxa were evaluated. In the second analysis, relationships between environmental variables and presence or absence of invertebrate taxa in wetlands were evaluated. Inclusion of taxa with abundant “0” values in a data set can reduce reliability of NMDS results (McCune and Grace 2002). Thus, to detect meaningful relationships, taxa that were recorded in < 5 wetlands were omitted from NMDS. Nonmetric multidimensional scaling was performed using PCORD version 5 (MJM Software Design 2006). Results based on the NMDS in this study and pervious research in the study area (Hentges and Stewart 2010; Maurer et al. 2014) were used to create additional invertebrate density and taxon richness variables. The new density variable was created by excluding taxa that were consistently weakly related to environmental variables and most abundant in wetlands of relatively poor condition (leeches, oligochaetes, corixid bugs, tabanid flies; EOCT). Additionally, the new taxon richness variable was created by removing ubiquitous taxa (planorbid snails, leeches, oligochaetes, chironomid midges; PEOC). Exclusion of these taxa could lead to cost savings in wetland assessment, in addition to generating invertebrate metrics that are most reflective of ecosystem condition.

Relationships between environmental variables and invertebrate variables with potential value in wetland condition assessment were subsequently quantified using correlation analysis (PROC CORR in SAS 9.4; SAS Institute 2013). Invertebrate variables assessed were total density (TD) and total taxon richness (TTR) based on their usefulness in previous studies (Hentges and Stewart 2010; Maurer et al. 2014) and then modified variables TD-EOCT and TTR-PEOC. Relationships were quantified for each of the four invertebrate body size classes, and for samples with and without PM. Invertebrate variables having the highest potential value in wetland condition assessment were identified based on relative strength of correlative relationships between environmental variables and invertebrate density and taxon richness variables.

RESULTS

Environmental Variables

Values for environmental variables exhibited large differences across wetlands (Table 2). Crop land and developed land occurred in 74% and 63% of wetland watersheds, with maximum values of 78% and 41% cover. The largest wetland had a surface area 17 times greater than the smallest wetland. The wetland with the highest water transparency had a mean turbidity 16 times lower than at the most turbid site. Chloride was detected in 19 of 27 (70%) wetlands, and the maximum average in a wetland was 25.5 mg/L. Herbicides were detected in all 27 wetlands, with mean concentrations in wetlands ranging from 0.2-9.9 µg/L. Atrazine was the most frequently detected herbicide, and was recorded on 42 of 54 sampling events. Average atrazine concentrations ranged from 0.1-9.0 µg/L, with an overall mean concentration of 0.6 µg/L.

Biological variables also indicated a substantial environmental gradient across wetlands (Table 2). Although some wetlands had low plant abundance, others were densely populated by a combination of emergent, floating, floating-leaved, and submerged taxa. Dominant plant taxa in the study area included coontail (*Ceratophyllum demersum*), lesser duckweed (*Lemna minor*), and leafy pondweed (*Potamogeton foliosus*). Fish occurred in 37% of wetlands and were generally very abundant where they did occur, with black bullhead (*Ameiurus melas*) and fathead minnow (*Pimephales promelas*) constituting 78% of total fish biomass. Tiger salamander larvae and adults were detected in 81% of wetlands, with as many as 435 individuals recorded at a site.

Sampling Effort

The use of a 500-µm mesh sieve with a stovepipe sample resulted in a large sampling effort. On average, time required separating PM and invertebrates was 38.7 ± 3.9 h (± 1 standard error; SE), and mean sample volume was 2,375 ± 208 ml (Fig. 1). Compared to the 500-µm mesh sieve, the 2-mm mesh sieve reduced sample processing time and volume by 36% and 19%, the 4-mm sieve reduced sample processing time and volume by 50% and 31%, and a 6-mm mesh sieve reduced sample processing time and volume by 54% and 35% (Fig. 1).

When using a 500-µm mesh sieve, total invertebrate density averaged 15,980 ± 2,358 individuals/m^3 (± 1 SE), and total taxon richness averaged 23 ± 1 taxa per wetland (Fig. 2). In the presence of PM, total numbers of invertebrates retained by 2-mm, 4-mm, and 6-mm mesh sieves were reduced by 35%, 53%, and 56%, relative to the 500-µm mesh sieve. When PM was absent in samples, numbers of invertebrates retained by a 2-mm mesh sieve was reduced by 91%, and by more than 99% in 4-mm and 6-mm mesh sieves, relative to the 500-µm mesh sieve. By removing PM from samples, the number of invertebrates retained by 2-mm, 4-mm, and 6-mm sieves were reduced by 87%, 98%, and 99% (Fig. 2). In the presence of PM, numbers of taxa retained by 2-mm, 4-mm, and 6-mm mesh sieves was 4%, 9%, and 13% lower than in the 500-µm mesh sieve. Compared to the 500-µm mesh sieve, total taxon richness was reduced by 30%, 70%, and 83% in 2-mm, 4-mm, and 6-mm mesh sieves when PM was absent in samples. Additionally, the removal of PM reduced the number of taxa retained on the 2-mm, 4-mm, and 6-mm sieves by 27%, 67%, and 80% (Fig. 2).

Invertebrate variables TD-EOCT and TTR-PEOC also resulted in fewer individuals and taxa to process. By using TD-EOCT, the average invertebrate density was reduced by 33% in samples collected with a 500-µm mesh, and by 16-23% and 14-15% in the presence and absence of PM when samples were collected using coarser mesh sieves, compared to TD (Fig. 2). Additionally, using TTR-PEOC resulted in a reduction of 17-20% and 12-25% of the taxa in samples with and without PM compared to TTR (Fig. 2).

Despite the effect of sieve mesh size on invertebrate assemblage values, use of sieve mesh sizes 2-6 mm were typically correlated with values retained on a 500-µm sieve mesh size. Regardless of the invertebrate variable, samples sieved with mesh sizes 2-6 mm with PM were significantly correlated with the 500-µm sieve (Tables 3-6). However, in the absence of PM, only TD retained on the 2-mm sieve was significantly correlated with the 500-µm sieve (Table 3) but TD-EOCT retained on the 2-mm and 4-mm sieves were significantly correlated with the 500-µm sieve (Table 4). Conversely, both TTR (Table 5) and TTR-PEOC (Table 6) retained on the sieve mesh sizes 2-6 mm in the absence of PM were significantly correlated with the 500-µm sieve.

Relationships Between Environmental and Invertebrate Assemblage Variables

Results from NMDS indicated that densities and likelihood of occurrence of most invertebrate taxa were greatest in wetlands with high plant cover and low turbidity and fish biomass (Figs. 3-4). Additionally, wetlands with high turbidity and fish abundance were generally larger wetlands and were located in watersheds with high crop land cover (Fig. 3). NMDS analysis based on invertebrate taxon densities (stress = 11.6, three-dimensional solution) revealed a tendency for density of gastropods (Lymnaeidae, Physidae), odonates (Aeshnidae, Lestidae), hemipterans (Belostomatidae, Mesoveliidae, Notonectidae, Pleidae), coleopterans (Chrysomelidae, Dytiscidae) dipterans (Chaoboridae, Ephydridae, Stratiomyidae), and crustaceans (Amphipoda, Asellidae, Decapoda) to increase with plant cover and tiger salamander abundance (Fig. 3). Comparatively few taxa, including leeches (Euhirudinea), caenid mayflies (Caenidae), corixid bugs (Corixidae), haliplid beetles (Haliplidae), and tabanid flies (Tabanidae), were most abundant in relatively degraded wetlands with high turbidity and high fish biomass (Fig. 3).

NMDS analysis based on presence/absence of invertebrate taxa (stress = 17.3, three-dimensional solution) again indicated that haliplid beetles and tabanid flies were positively associated with high fish biomass and low plant cover, but that most taxa were more likely to occur in wetlands with low fish biomass and high plant cover (Fig. 4). Planorbid snails (Planorbidae), leeches (Euhirudinea), oligochaetes (Oligochaeta), and chironomid midges (Chironomidae) were recorded in all 27 wetlands, and these four taxa were represented by a point on the NMDS plot where environmental vectors intersect (Fig. 4).

When PM occurred in samples, relationships between total invertebrate density (TD) and four environmental variables were statistically significant when samples were collected using 4-mm and 6-mm mesh sieves (Table 7). In these cases, TD was negatively correlated with water column chloride concentration and fish biomass, and positively correlated with plant cover and tiger salamander abundance (Table 7). Relationships between TD and environmental variables were weak when 500-µm or 2-mm mesh sieves were used to sample invertebrates in the presence of PM, or when invertebrates were collected using any mesh size in the absence of PM. In the presence of PM, only plant cover was significantly correlated with TD when a 2-mm mesh sieve was used to collect samples, and no significant relationships occurred between environmental variables and invertebrates retained by a 500-µm mesh sieve (Table 7). Of 36 correlation analyses involving TD in the absence of PM, the only statistically significant relationship occurred between water column herbicide concentration and invertebrates retained on a 2-mm mesh sieve (Table 7).

The number of significant relationships between environmental variables and invertebrate density was greater when oligochaetes, leeches, corixid bugs, and tabanid flies were excluded (TD-OECT; Table 8). After excluding those four taxa, invertebrate density using the 500-µm sieve, was significantly and positively related to plant cover and tiger salamander numerical abundance, and negatively related to turbidity, chloride, and fish biomass (Table 8). Relationships between environmental variables and TD-EOCT remained strong when 2-mm, 4-mm, and 6-mm mesh sieves were used when PM occurred in samples (Table 8). However, removal of the four taxa still produced relationships with environmental variables that were weak when PM was absent in samples and sieves with mesh sizes of 2-6 mm were used to collect organisms (Tables 8).

Relationships between environmental variables and total taxon richness (TTR) produced several significant responses (Tables 9). Regardless of whether or not PM was present in samples, TTR was negatively correlated with turbidity and fish biomass and positively correlated with plant cover when either a 500-µm or 2-mm mesh sieve was used to obtain samples. However, in the absence of PM, TTR was not significantly correlated with environmental variables when invertebrates were collected using sieve mesh sizes of 4 mm or 6 mm (Table 9). Additionally, the 6-mm mesh sieve with PM had more and stronger relationships with environmental variables than when the 500-µm mesh sieve was used to collect samples. Under these conditions, total taxon richness was negatively correlated with turbidity, chloride concentration, and fish biomass and positively correlated with plant cover and tiger salamander numerical abundance.

The number of significant relationships between environmental variables and taxon richness was greater when planorbid snails, oligochaetes, leeches, and chironomid midges were excluded (TTR-PEOC; Table 10). Regardless of whether or not PM was present in samples, TTR was negatively correlated with turbidity and fish biomass and positively correlated with plant cover when either a 500-μm or 2-mm mesh sieve was used to obtain samples (Tables 10). Conversely, TTR-PEOC estimates with 4-mm and 6-mm mesh sieves were more strongly related with environmental variables. In particular, invertebrate taxon richness exclusive of these four taxa was significantly and positively correlated with plant cover and tiger salamander abundance, and negatively correlated with turbidity and fish biomass, when PM was absent in samples (Table 10).

DISCUSION

This study provides insight into procedures that enhance cost-effectiveness of incorporating invertebrate assemblage metrics into wetland condition assessment protocols. Results indicated that use of a sieve with mesh size larger than 500 µm to sample invertebrates can yield strong relationships between assemblage variables and other biophysical indicators of wetland condition. Statistically significant relationships between invertebrate density and taxonomic richness variables and turbidity, water column chloride concentration, plant cover, fish biomass, and tiger salamander abundance were found when invertebrates were collected with sieves having mesh sizes ranging from 500 µm to 6 mm. Relationship strengths were affected by sieve mesh size, the invertebrate variable measured, and abundance of PM in samples. Across the entire range of sieve mesh sizes and PM abundance evaluated in this study, invertebrate taxon richness variables were more consistently and strongly related to environmental variables than invertebrate density variables. Regardless of sieve mesh size and PM presence in samples, invertebrate taxon richness exclusive of four taxa recorded in every wetland (planorbid snails, oligochaetes, leeches, chironomid midges; TTR-PEOC) was positively correlated with plant cover, and negatively correlated with turbidity and fish biomass. Use of an invertebrate taxon richness metric in which ubiquitous taxa are eliminated from analysis, and organisms are collected using a sieve with mesh size of 6 mm, can enable greater incorporation of macroinvertebrate assemblages into wetland monitoring and assessment programs. Applying these methods in wetland condition assessments would be beneficial due to the robust relationships observed between the proposed invertebrate metric and environmental variables, reduced processing time due to smaller sample volume, and the need to only record presence/absence of invertebrate taxa.

Previous studies conducted in marine, estuarine, and lotic ecosystems also evaluated the influence of sieve mesh size on macroinvertebrate abundance and taxonomic richness values, relationships between assemblage and environmental variables, and costs of collecting data (Barba et al. 2010; Pinna et al. 2013; Souza and Barros 2015). Sieve mesh size consistently influenced invertebrate assemblage values due to differences in retention of small-bodied invertebrates, and consequently, potentially useful ecological information was lost when using coarse-mesh sieves (Couto et al. 2010; Aarnio et al. 2011; Hartwell and Fukuyama 2015). However, studies often revealed that invertebrate metric values generated using coarse-mesh sieves were adequate for assessing ecosystem condition, and also reduced economic costs by reducing sample processing time (Barba et al. 2010; Pinna et al. 2013; Souza and Barros 2015). Similarly, in this study, increasing sieve mesh size decreased invertebrate assemblage values but the coarser sieves were still adequate for assessing ecosystem condition while providing lower processing times.

In estuarine and marine ecosystems, Couto et al. (2010) and Aarnio et al. (2011) concluded that certain invertebrate metric values predicted habitat condition slightly better if data were collected using a 500-um mesh sieve than if a 1-mm mesh sieve was used. However, other investigators found that metric values obtained using sieve mesh sizes ranging from 500 µm to 2 mm were either similarly effective in ecosystem condition assessment, or that coarser mesh sizes better reflected extent of human impacts on the ecosystem (Hammerstrom et al. 2010; Pinna et al. 2013, 2014). Thompson et al. (2003) and Ferraro et al. (2006) concluded that assessments using estuarine and marine benthic invertebrates should be conducted using a 1-mm mesh sieve because metric values obtained using 1-mm and 500-um mesh sieves were highly correlated, and use of the sieve with coarser mesh significantly reduced data collection time. Similarly, in a study conducted in streams, Barba et al. (2010) found that values for invertebrate metrics obtained using a 500-um and 1-mm mesh sieve were different, yet these differences were consistent and proportional across an environmental gradient. Consequently, Barba et al. (2010) concluded that a 1-mm mesh sieve was adequate for describing macroinvertebrate assemblage characteristics and their relationships to environmental variables. This investigation included sieves with mesh sizes that were coarser (4 mm and 6 mm) than those typically used in most comparative studies. It was observed that invertebrate taxon richness data obtained using sieve mesh sizes of 2-6 mm was sufficient to assess condition of semipermanent and permanent wetlands in the Iowa PPR. Samples obtained using these course-mesh sieves produced significant relationships between environmental variables (fish biomass, turbidity, plant cover, tiger salamander abundance) and TTR-PEOC.

As a result of occupancy and abundance of invertebrate taxa in wetlands generally being influenced by plant abundance, turbidity, and fish predation, results from this study are likely transferable to a variety of wetland types outside the Iowa PPR. In the absence of PM, invertebrate taxa retained by the 6-mm mesh sieve, in addition to the ubiquitous planorbid gastropods, leeches, oligochaetes, and chironomid midges, included gastropods (Lymnaeidae, Physidae), bivalves (Pisidiidae), odonates (Aeshnidae, Libellulidae, Coenagrionidae, Lestidae), hemipterans (Belostomatidae, Corixidae, Nepidae, Notonectidae), trichopterans (Phryganeidae), dipterans (Stratiomyidae, Tabanidae), and decapods (Decapoda). Many of these large bodied taxa are more strongly affected by turbidity and abundance of plants and fish than smaller organisms (Mittelbach 1988; Tolonen et al. 2003; Beresford and Jones 2010). There is evidence that abundance of gastropods, odonates, belostomatid and notonectid bugs, and stratiomyid flies decline as turbidity increases, in part because particulate matter in the water column interferes with respiration and feeding, and eggs are smothered by settling particles (Gleason et al. 2003; Reins et al. 2013; Maurer et al. 2014). Indirectly, high turbidity reduces invertebrate abundance and taxon richness by reducing plant abundance (Olson et al. 1995; Hentges and Stewart 2010; Maurer et al. 2014). Plants are a critically important resource for many wetland invertebrates, and reduce large bodied taxa, including gastropods, odonates, hemipterans and trichopterans, because they provide refuges from predators, food, attachment sites, mergence substrate, and oviposition sites (Tolonen et al. 2003; Foote and Hornung 2005; Beresford and Jones 2010). Experiments demonstrated that optimal foraging behavior by insectivorous fish can cause declines in abundance of large bodied taxa, including gastropods, odonates and trichopterans, while abundance of small-bodied oligochaetes and chironomids tend to increase or remain unaffected by predation (Mittelbach 1988; Beresford and Jones 2010). Furthermore, benthivorous fishes reduce invertebrate abundance by increasing turbidity through excretion and physically re-suspending sediment, and consequently reducing plant abundance (Zimmer et al. 2006; Potthoff et al. 2008; Maurer et al. 2014). Consequently, a focus on large-bodied taxa should lead to improved wetland condition assessment.

Results from this study also provided quantitative evidence that values for invertebrate density and taxon richness were inflated by occurrence of PM in samples, especially when sieves with larger mesh sizes are used. In this study, the effect was substantial despite samples being thoroughly rinsed with running water as they were washed through sieves. As in this study, investigations conducted in streams revealed that particulate matter restricted passage of invertebrates through sieves by occluding mesh openings and entangling organisms, leading to potentially misleading results (Morin et al. 2004; Gruenert et al. 2007). Because plants and decomposing organic matter tends to be very abundant in wetlands, its effect on invertebrate abundance and taxon richness values is likely to be especially strong in these ecosystems.

In this study, PM also influenced relationships between environmental and invertebrate assemblage variables, with this effect varying as a function of sieve mesh size and the measured assemblage variable, which has not been studied. Total invertebrate density and TD-EOCT variables were strongly related to several environmental variables when PM was abundant in samples, but these relationships were weak when PM was absent and invertebrates were sampled using sieves with 2-6 mm mesh. However, regardless of sieve mesh size and PM presence or absence in samples, relationships between TTR-PEOC were negatively related to turbidity and fish biomass and positively related to plant cover and tiger salamander numerical abundance.

By using TTR-PEOC as a wetland condition metric, and collecting data using a coarse-mesh sieve (e.g., 6 mm mesh), investigators are likely to effectively assess wetland condition, while directing less effort to obtaining invertebrate data relative to other metrics and finer sieve mesh sizes. In this study, volume of sample retained on a 6-mm mesh sieve was reduced by 35% relative to sample volume retained on a 500-µm mesh sieve, and time required to separate PM and invertebrates in samples obtained using a 6-mm mesh sieve was reduced by 54% compared to a 500-um mesh sieve. Use of the TTR-PEOC metric, or an equivalent metric that excludes ubiquitous taxa from taxon richness metric, will further contribute to time and cost savings. Although effects of the measured invertebrate variables on sample processing time were not quantified, use of taxon richness metrics instead of density would save considerable time by eliminating the need to count individual organisms. Use of a 6-mm mesh sieve instead of a 500-um mesh sieve reduced the number of retained invertebrate individuals in this study by 54% and 99% in samples where particulate matter was present and absent, respectively. Relative to total taxon richness measured using a 500-um sieve, use the TR-PEOC metric and a 6-mm mesh sieve reduced the number of taxa in samples by 30% and 87% when particulate matter was present and absent in samples, respectively.

In conclusion, conventional approaches to obtaining invertebrate data can be revised to increase cost-effectiveness of including invertebrates in wetland condition assessment. Based on results from Iowa PPR wetland study sites, measurement of invertebrate taxon richness from samples collected using a sieve with a 6-mm mesh reflected wetland condition better than invertebrate density variables, and as well as taxon richness measured using finer-mesh sieves. Strength of relationships with environmental variables, and consistency of relationships across a large particulate matter gradient, can be increased if taxa occupying all or nearly all wetland sites are eliminated from taxon richness measurement. Implementing this approach of using coarser-mesh sieves and taxon richness metrics in wetland condition assessment will result in considerably reduced data collection time due to smaller sample volume, and because counts of individual organisms do not need to be conducted.

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Table 1. Chemical family, formula (Wood 2015), and application time for herbicides measured in this study (Iowa State University Extension 2005).

Herbicide	Chemical family	Formula	Timing of application for corn and soybean
acetochlor	ambide herbicides	$C_{14}H_{20}ClNO_2$	pre-emergent
alachlor	ambide herbicides	$C_{14}H_{20}ClNO_2$	pre-emergent
butachlor	ambide herbicides	$C_{17}H_{26}ClNO_2$	pre-emergent
dimethenamid	ambide herbicides	$C_{12}H_{18}ClNO_2S$	pre-emergent
metolachlor	ambide herbicides	$C_{15}H_{22}ClNO_2$	pre-emergent
propachlor	ambide herbicides	$C_{11}H_{14}ClNO$	pre-emergent
trifluralin	dinitroaniline herbicides	$C_{13}H_{16}F_3N_3O_4$	pre-emergent
glyphosate	organophosphorus herbicides	$C_3H_8NO_5P$	pre and post-emergent
butylate	thiocarbamate herbicides	$C_{11}H_{23}NOS$	pre-emergent
EPTC	thiocarbamate herbicides	$C_9H_{19}NOS$	pre and post-emergent
ametryn	triazine herbicides	$C_9H_{17}N_5S$	pre-emergent
atrazine	triazine herbicides	$C_8H_{14}ClN_5$	pre and post-emergent
cyanazine	triazine herbicides	$C_9H_{13}ClN_6$	pre-emergent
prometon	triazine herbicides	$C_{10}H_{19}N_5O$	pre and post-emergent
propazine	triazine herbicides	$C_9H_{16}ClN_5$	pre and post-emergent
simazine	triazine herbicides	$C_7H_{12}ClN_5$	pre and post-emergent
metribuzin	triazinone herbicides	$C_8H_{14}N_4OS$	pre-emergent

Table 2. Mean, standard error (± 1 SE), and range of values for environmental variables measured in Iowa PPR wetlands (n = 27).

Variable	Mean	SE	Range
Crop land cover (% of watershed)	21.9	0.05	0-78
Developed land cover (% of watershed)	5.4	0.02	0-41
Wetland surface area (ha)	2.2	0.4	0.5-8.4
Turbidity (NTU)	5.3	1.1	1.8-28.1
Chloride concentration (mg/L)	5.5	1.3	0-25.5
Herbicide concentration (µg/L)	2.4	0.7	0.2-9.9
Plant cover (%)	78.1	4.2	15-100
Fish biomass (g/CPUE)	2,564	1,007	0-18,904
Tiger salamander abundance (individuals/CPUE)	72	21	0-435

Table 3. Pearson correlation coefficients (r) of invertebrate total density (TD) retained on four sieve mesh sizes and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,**,*** = $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively.

		TD (+PM)				TD (-PM)			
		500 µm	2 mm	4 mm	6 mm	500 µm	2 mm	4 mm	6 mm
TD (+PM)	500 µm	1	–	–	–	–	–	–	–
	2 mm	**0.98*** **	1	–	–	–	–	–	–
	4 mm	**0.88*****	**0.94*****	1	–	–	–	–	–
	6 mm	**0.85*****	**0.90*****	**0.99*****	1	–	–	–	–
TD (-PM)	500 µm	**1.00*****	**0.98*****	**0.88*****	**0.85*****	1	–	–	–
	2 mm	**0.73*****	**0.74*****	**0.73*****	**0.71*****	**0.73*****	1	–	–
	4 mm	0.37	**0.41***	**0.49****	**0.48***	0.37	**0.70*****	1	–
	6 mm	-0.03	0.03	0.12	0.12	-0.03	0.18	**0.66*****	1

Table 4. Pearson correlation coefficients (r) of invertebrate total density (TD) minus Euhirudinea, Oligochaeta, Corixidae, Tabanidae (TD - EOCT) retained on four sieve mesh sizes and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,**,*** = $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively.

		TD-EOCT (+PM)				TD-EOCT (-PM)			
		500 µm	2 mm	4 mm	6 mm	500 µm	2 mm	4 mm	6 mm
TD-EOCT (+PM)	500 µm	1	–	–	–	–	–	–	–
	2 mm	**0.98*****	1	–	–	–	–	–	–
	4 mm	**0.96*****	**0.99*****	1	–	–	–	–	–
	6 mm	**0.96*****	**0.97*****	**0.99*****	1	–	–	–	–
TD-EOCT (-PM)	500 µm	**1.00*****	**0.98*****	**0.96*****	**0.96*****	1	–	–	–
	2 mm	**0.81*****	**0.84*****	**0.81*****	**0.77*****	**0.81*****	1	–	–
	4 mm	**0.58****	**0.62*****	**0.64*****	**0.61*****	**0.58****	**0.74*****	1	–
	6 mm	0.30	0.34	**0.39***	0.37	0.30	0.27	**0.68*****	1

Table 5. Pearson correlation coefficients (r) of invertebrate total taxon richness (TTR) retained on four sieve mesh sizes and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,**,*** = $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively.

		TTR (+PM)				TTR (-PM)			
		500 µm	2 mm	4 mm	6 mm	500 µm	2 mm	4 mm	6 mm
TTR (+PM)	500 µm	1	–	–	–	–	–	–	–
	2 mm	**0.98*** **	1	–	–	–	–	–	–
	4 mm	**0.95*** **	**0.97*** **	1	–	–	–	–	–
	6 mm	**0.91*** **	**0.92*** **	**0.96*** **	1	–	–	–	–
TTR (-PM)	500 µm	**1.00*** **	**0.98*** **	**0.95*** **	**0.91*** **	1	–	–	–
	2 mm	**0.87*** **	**0.88*** **	**0.85*** **	**0.84*** **	**0.87*** **	1	–	–
	4 mm	**0.72*** **	**0.77*** **	**0.76*** **	**0.76*** **	**0.72*** **	**0.64*** **	1	–
	6 mm	**0.54** **	**0.56** **	**0.53** **	**0.51** **	**0.54** **	**0.46* **	**0.70*** **	1

Table 6. Pearson correlation coefficients (r) of invertebrate total taxon richness (TTR) minus Planorbidae, Euhirudinea, Oligochaeta, Chironomidae (TTR - PEOC) retained on four sieve mesh sizes and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,**,*** = $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively.

		TTR-PEOC (+PM)				TTR-PEOC (-PM)			
		500 µm	2 mm	4 mm	6 mm	500 µm	2 mm	4 mm	6 mm
TTR-PEOC (+PM)	500 µm	1	–	–	–	–	–	–	–
	2 mm	**0.98*** **	1	–	–	–	–	–	–
	4 mm	**0.96*** **	**0.97*** **	1	–	–	–	–	–
	6 mm	**0.91*** **	**0.93*** **	**0.97*** **	1	–	–	–	–
TTR-PEOC (-PM)	500 µm	**1.00*** **	**0.98*** **	**0.96*** **	**0.91*** **	1	–	–	–
	2 mm	**0.87*** **	**0.88*** **	**0.85*** **	**0.83*** **	**0.87*** **	1	–	–
	4 mm	**0.78*** **	**0.81*** **	**0.83*** **	**0.86*** **	**0.78*** **	**0.71*** **	1	–
	6 mm	**0.61*** **	**0.61*** **	**0.64*** **	**0.66*** **	**0.61*** **	**0.44* **	**0.74*** **	1

Table 7. Pearson correlation coefficients (r) for associations between total invertebrate density (TD) and environmental variables. Relationships are provided for analyses based on invertebrates collected using sieves with four mesh sizes, and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,** = p ≤ 0.05 and p ≤ 0.01, respectively.

	500 µm	2 mm		4 mm		6 mm	
		+ POM	- POM	+ POM	- POM	+ POM	- POM
Crop land	-0.02	-0.01	0.29	-0.1	0.37	-0.1	0.22
Developed land	-0.01	-0.02	<-0.01	-0.1	0.11	-0.1	0.19
Wetland area	0.19	0.19	0.38	0.10	0.26	0.09	0.18
Turbidity	-0.36	-0.37	-0.17	-0.4	0.03	-0.4	-0.03
Chloride concentration	-0.31	-0.35	-0.16	**-0.42***	0.06	**-0.43***	0.21
Herbicide concentration	0.04	0.05	**0.45***	0.12	0.25	0.15	0.05
Plant cover	0.37	**0.39***	0.08	**0.40***	0.2	**0.38***	0.16
Fish biomass	-0.22	-0.24	-0.01	**-0.39***	0.03	**-0.41***	-0.01
Salamander abundance	0.28	-0.27	0.09	**0.38***	0.04	**0.41***	-0.05

Table 8. Pearson correlation coefficients (r) for associations between total invertebrate density (minus Euhirudinea, Oligochaeta, Corixidae, Tabanidae; TD - EOCT) and environmental variables. Relationships are provided for analyses based on invertebrates collected using sieves with four mesh sizes, and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,** = p ≤ 0.05 and p ≤ 0.01, respectively.

	500 µm	2 mm		4 mm		6 mm	
		+ POM	- POM	+ POM	- POM	+ POM	- POM
Crop land	-0.24	-0.20	0.15	-0.2	0.12	-0.26	-0.18
Developed land	-0.06	-0.06	-0.02	-0.1	0.10	-0.13	0.11
Wetland area	0.07	0.11	0.29	0.07	0.12	0.05	-0.07
Turbidity	**-0.46***	**-0.40***	-0.25	-0.4	-0.08	**-0.40***	-0.29
Chloride concentration	**-0.51****	**-0.47***	-0.25	**-0.46 ***	-0.01	**-0.49****	0.01
Herbicide concentration	0.18	0.23	**0.48***	0.25	0.28	0.23	0.04
Plant cover	**0.41***	0.37	0.17	0.37	0.30	**0.39***	**0.41***
Fish biomass	**-0.54****	**-0.47***	-0.17	**-0.51 *****	-0.15	**-0.55****	-0.32
Salamander abundance	**0.51***	**0.44***	0.21	**0.46 ***	0.22	**0.51****	0.34

Table 9. Pearson correlation coefficients (r) for associations between total taxon richness (TTR) and environmental variables. Relationships are provided for analyses based on invertebrates collected using sieves with four mesh sizes, and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,** = p ≤ 0.05 and p ≤ 0.01, respectively.

	500 µm	2 mm		4 mm		6 mm	
		+ POM	- POM	+ POM	- POM	+ POM	- POM
Crop land	-0.25	-0.24	<0.01	-0.24	-0.03	-0.23	-0.15
Developed land	0.09	0.03	0.04	0.03	-0.03	-0.06	0.03
Wetland area	0.03	0.05	0.20	0.06	0.23	0.06	0.06
Turbidity	**-0.53****	**-0.52****	**-0.51****	**-0.51****	-0.28	**-0.53****	-0.37
Chloride concentration	-0.28	-0.34	-0.33	-0.35	-0.18	**-0.42***	-0.11
Herbicide concentration	-0.01	-0.03	0.01	-0.02	0.21	0.08	0.19
Plant cover	**0.47***	**0.50****	**0.40***	**0.56****	0.35	**0.53****	0.35
Fish biomass	**-0.45***	**-0.45***	**-0.42***	**-0.45***	-0.26	**-0.49****	-0.27
Salamander abundance	0.32	0.30	0.21	0.33	0.28	**0.40***	0.25

Table 10. Pearson correlation coefficients (r) for associations between invertebrate taxon richness (minus Planorbidae, Euhirudinea, Oligochaeta, Chironomidae; TTR - PEOC) and environmental variables. Relationships are provided for analyses based on invertebrates collected using sieves with four mesh sizes, and in samples with (+) and without (-) particulate matter (PM). Bold represents statistically significant relationships and *,** = p ≤ 0.05 and p ≤ 0.01, respectively.

	500-µm	2 mm		4 mm		6 mm	
		+ POM	- POM	+ POM	- POM	+ POM	- POM
Cropland	-0.26	-0.25	0.01	-0.25	-0.14	-0.25	-0.36
Developed land	0.09	0.04	0.05	0.03	-0.07	-0.05	-0.07
Wetland area	0.03	0.05	0.20	0.05	0.11	0.06	-0.05
Turbidity	**-0.52****	**-0.52****	**-0.50****	**-0.51****	**-0.48***	**-0.52****	**-0.50***
Chloride concentration	-0.28	-0.34	-0.32	-0.35	-0.31	**-0.42***	-0.26
Herbicide concentration	<0.01	-0.02	<0.01	-0.01	0.19	0.10	0.18
Plant cover	**0.47***	**0.50****	**0.40***	**0.56****	**0.46***	**0.53****	**0.49****
Fish biomass	**-0.45***	**-0.45***	**-0.42***	**-0.46***	**-0.48***	**-0.49****	**-0.44***
Salamander abundance	0.32	0.31	0.20	0.34	**0.43***	**0.41***	**0.42***

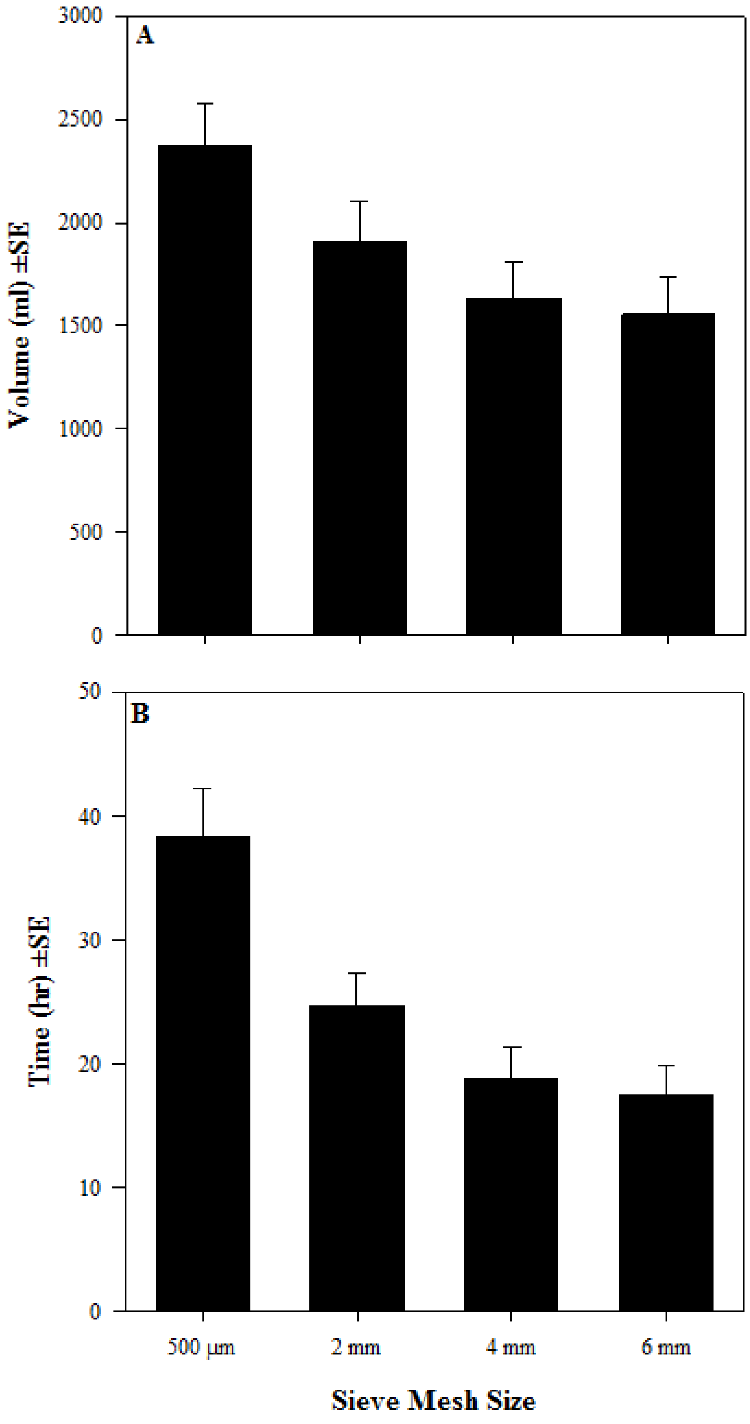

Figure 1. Mean (± 1 standard error) invertebrate sample volume (A) and processing time (B; n = 27 samples).

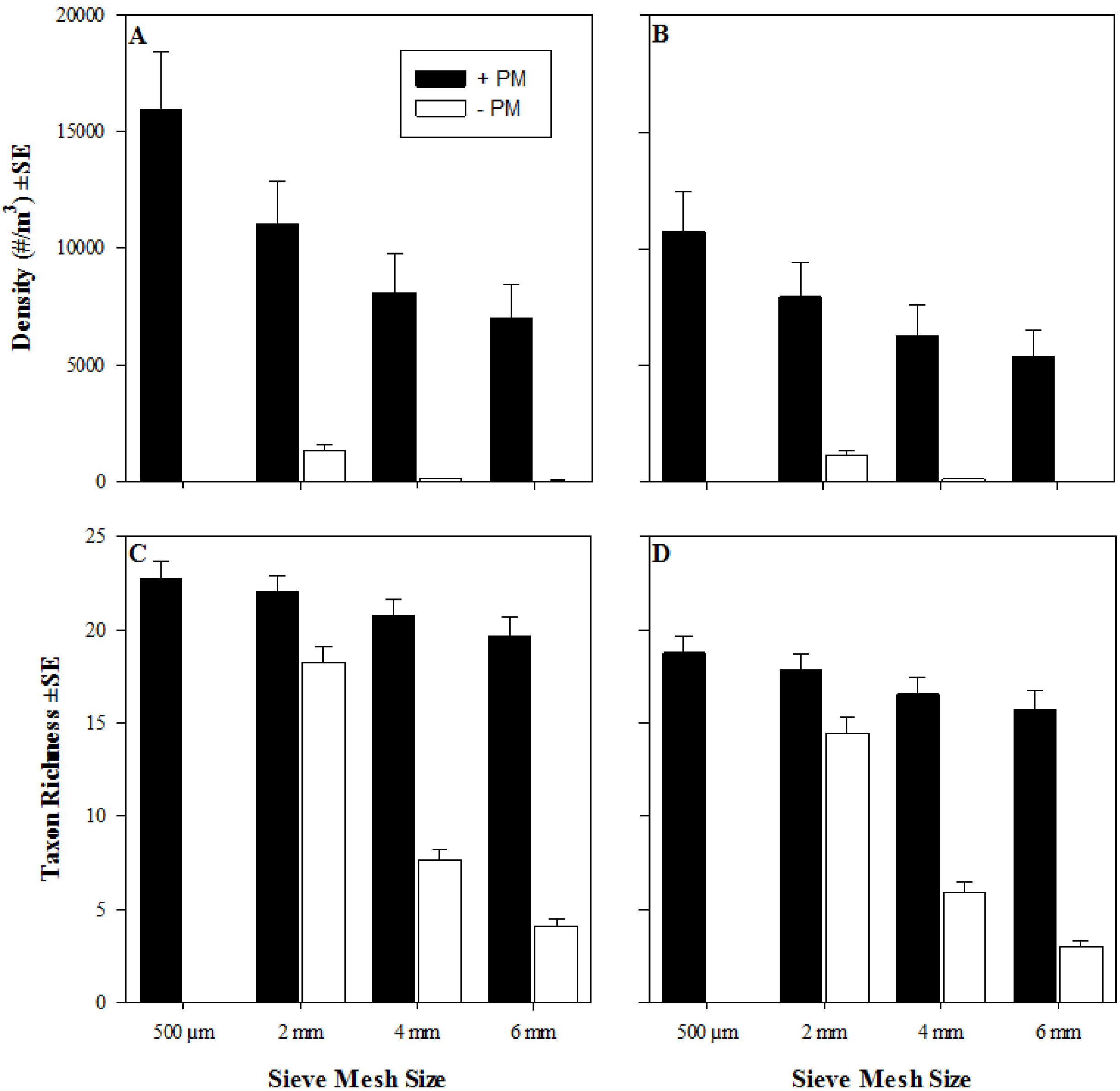

Figure 2. Mean (± 1 standard error) values for total invertebrate density (A), total density after excluding Euhirudinea, Oligochaeta, Corixidae and Tabanidae (B), total taxon richness (C), and total taxon richness after excluding Planorbidae, Euhirudinea, Oligochaeta and Chironomidae (D). Results are based on invertebrates retained on four different sieve mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and samples sieved with (+) and without (-) particulate matter (PM).

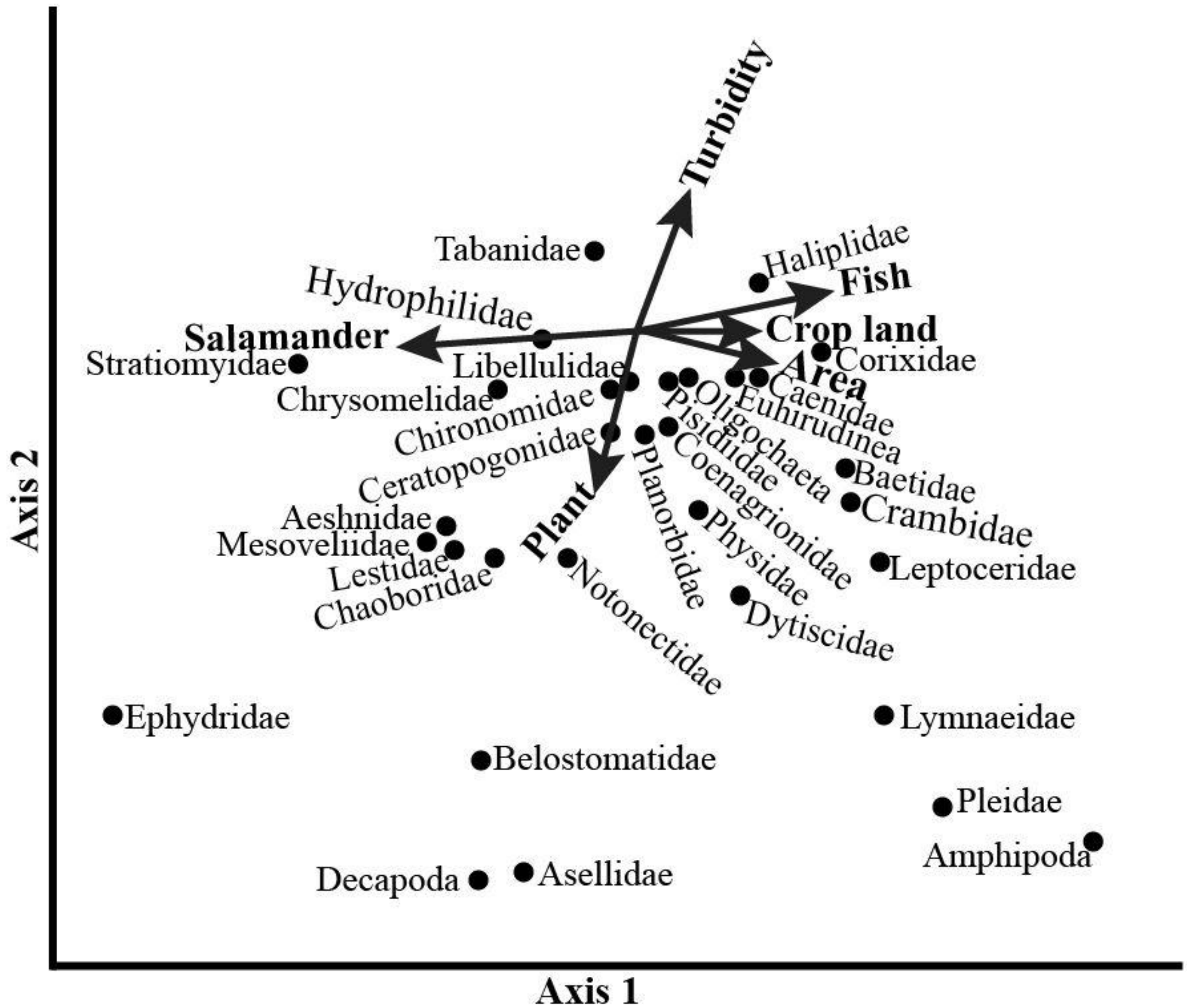

Figure 3. Nonmetric multidimensional scaling (NMDS) plot of associations among environmental variables and densities of wetland invertebrates, based on data collected using a 500-µm mesh sieve. Vectors are included for environmental variables that were significantly related to invertebrate densities (joint plot $R^2 \geq 0.15$, $p \leq 0.05$). Cropland = percent cropland in the watershed, Area = wetland area, Turbidity = turbidity, Fish = fish biomass, Plant = plant cover, Salamander = tiger salamander numerical abundance.

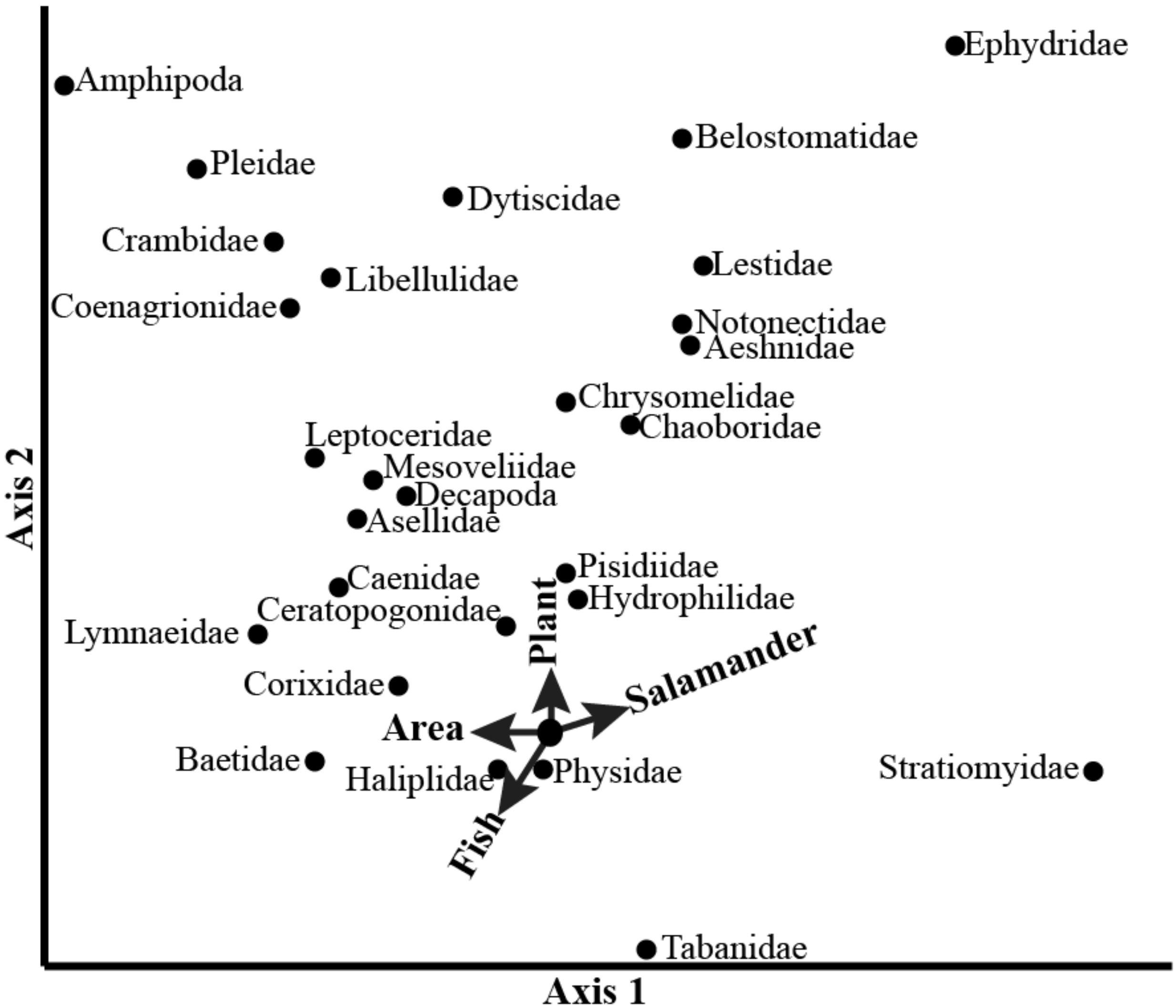

Figure 4. Nonmetric multidimensional scaling (NMDS) plot of associations among environmental variables and occurrence of wetland invertebrate taxa (i.e., presence/absence), based on invertebrate data collected using a 500-μm mesh sieve. Vectors are included for environmental variables that were significantly related to invertebrate densities (joint plot $R^2 \geq 0.15$, $p \leq 0.05$). Area = wetland area, Fish = fish biomass, Plant = plant cover, Salamander = tiger salamander numerical abundance. Taxa represented by the unlabeled point at vector origins (Planorbidae, Euhirudinea, Oligochaeta, Chironomidae) were recorded at all 27 wetland sites.

APPENDICES

APPENDIX A

STUDY SITE INFORMATION

Names, year of sampling, and locations of wetlands included in this study (n = 27).

Wetland	Year	Latitude	Longitude	County
Bailey Creek	2014	42°57’10”N	93°26’39”W	Cerro Gordo
CA Block	2014	43°22’01”N	93°37’31”W	Winnebago
Christianson Taylor	2014	43°29’11”N	93°19’09”W	Worth
Eagle Flatts	2014	43°09’41”N	93°43’59”W	Hancock
Gabrielson	2015	43°14’22”N	93°33’39”W	Hancock
Gladfelter 1	2014	43°12’05”N	93°46’35”W	Hancock
Gladfelter 2	2014	43°12’07”N	93°46’48”W	Hancock
Gladfelter 3	2014	43°12’31”N	93°46’27”W	Hancock
Hanlontown	2014	43°20’19”N	93°23’27”W	Worth
Harmon 3	2015	43°27’46”N	93°42’39”W	Winnebago
Hoffman Prairie	2014	43°08’03”N	93°27’23”W	Cerro Gordo
Korleski 1	2014	42°59’15”N	93°29’01”W	Cerro Gordo
Mallard Marsh	2014	43°14’27”N	93°28’10”W	Cerro Gordo
Northern Prairie	2015	43°29’39”N	93°27’36”W	Worth
Osmundson	2014	43°19’18”N	93°44’20”W	Winnebago
Paul Willis 1	2014	42°57’48”N	93°27’13”W	Cerro Gordo
Pilot Knob	2014	43°15’39”N	93°33’12”W	Winnebago
Prairie Pothole 2	2015	43°14’57”N	93°29’35”W	Cerro Gordo
Sandpiper	2014	43°14’24”N	93°28’56”W	Cerro Gordo
Silver Lake	2015	43°29’15”N	93°25’15”W	Worth
Teal Basin	2014	43°13’04”N	93°26’41”W	Cerro Gordo
Union Hills 1	2014	43°0.0’44”N	93°25’43”W	Cerro Gordo
Union Hills 2	2014	43°01’11”N	93°25’32”W	Cerro Gordo
Union Hills 4	2015	43°01’15”N	93°25’59”W	Cerro Gordo
Upper Grove	2015	42°56’32”N	93°34’40”W	Hancock
Worth 1	2015	43°28’29”N	93°25’47”W	Worth
Worth 2	2015	43°28’45”N	93°18’48”W	Worth

APPENDIX B

INVERTEBRATE TAXON RICHNESS

Invertebrate taxon richness (number of taxa per wetland) for organisms retained on sieves with different sieve mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	15	15	10	15	5	15	2
CA Block	15	14	7	13	5	10	3
Christianson Taylor	23	22	20	20	6	19	1
Eagle Flatts	20	19	17	19	6	19	4
Gabrielson	27	26	22	24	8	24	5
Gladfelter 1	26	25	21	24	10	24	8
Gladfelter 2	23	23	22	23	7	23	2
Gladfelter 3	31	30	23	28	9	28	3
Hanlontown	25	25	22	25	13	25	6
Harmon 3	29	29	24	28	10	27	4
Hoffman Prairie	29	24	18	23	6	22	4
Korleski 1	25	23	23	21	15	21	5
Mallard Marsh	22	21	18	18	9	18	7
Northern Prairie	25	27	20	27	11	21	6
Osmundson	20	19	18	19	7	19	5
Paul Willis 1	24	24	17	23	10	23	3
Pilot Knob	24	24	20	22	10	21	5
Prairie Pothole 2	21	20	16	16	5	13	4
Sandpiper	20	19	13	19	7	18	3
Silver Lake	25	25	20	24	8	24	6
Teal Basin	23	21	16	18	7	18	4
Union Hills 1	23	22	20	21	7	21	5
Union Hills 2	25	23	23	23	5	22	3
Union Hills 4	27	27	23	26	10	26	7
Upper Grove	23	23	18	20	6	14	4
Worth 1	12	12	10	10	4	8	2
Worth 2	13	12	12	11	2	9	1

APPENDIX C

TOTAL INVERTERBATE DENSITIES

Invertebrate numerical densities (number of individuals/m^3) for organisms retained on sieves with different sieve mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	11,041	8,453	748	7,246	28	7,205	10
CA Block	4,790	1,940	312	744	62	707	36
Christianson Taylor	21,420	10,962	2,839	5,577	188	5,011	13
Eagle Flatts	41,384	31,675	1,903	28,938	246	28,630	100
Gabrielson	20,863	15,784	825	12,896	230	12,706	134
Gladfelter 1	14,860	7,878	1,506	6,596	129	6,348	48
Gladfelter 2	16,768	13,348	1,087	12,416	87	11,956	20
Gladfelter 3	53,180	36,639	2,097	30,793	190	29,668	10
Hanlontown	12,422	10,708	2,698	8,862	368	8,243	174
Harmon 3	18,878	12,322	1,026	6,779	206	5,289	88
Hoffman Prairie	12,526	8,019	522	6,119	31	5,562	21
Korleski 1	18,210	10,675	4,294	7,833	389	7,650	38
Mallard Marsh	9,171	6,835	1,833	4,387	160	4,015	49
Northern Prairie	26,807	15,773	5,304	11,674	395	11,398	53
Osmundson	6,476	3,794	906	3,048	288	2,824	112
Paul Willis 1	12,705	7,849	799	6,178	112	6,139	22
Pilot Knob	28,669	17,704	1,192	14,714	184	14,371	45
Prairie Pothole 2	3,868	2,319	415	1,071	43	810	27
Sandpiper	2,709	1,747	193	1,416	65	1347	22
Silver Lake	10,582	6,419	1,268	2,404	105	1,705	29
Teal Basin	7,307	4,697	829	3,042	68	2,756	21
Union Hills 1	3,080	1,486	363	1,101	53	1,063	38
Union Hills 2	8,496	4,305	646	2,457	39	2,001	12
Union Hills 4	18,295	14,165	1,042	8,985	90	7,998	42
Upper Grove	10,742	6,141	773	2,240	199	1,073	55
Worth 1	642	542	218	348	71	271	44
Worth 2	37,988	17,885	814	2,932	24	2,083	12

APPENDIX D

INVERTEBRATE TAXA DENSITIES

Mean (± 1 standard error) values for invertebrate densities (individuals/m^3) in 27 wetlands. Results are provided for four body size classes (500 µm, 2 mm, 4 mm, 6 mm) in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Taxa		+ PM	- PM	+ PM	- PM	+ PM	- PM
Mollusca (mollusks)							
Gastropoda (snails)							
Lymnaeidae	21 (12)	21 (11)	5 (3)	20 (11)	4 (2)	19 (11)	3 (1)
Physidae	351 (91)	226 (90)	29 (11)	112 (50)	3 (1)	92 (45)	1 (<1)
Planorbidae	814 (103)	479 (146)	46 (16)	319 (100)	4 (1)	295 (95)	1 (<1)
Bivalvia (clams)							
Pisidiidae	76 (40)	45 (17)	8 (3)	34 (16)	5 (2)	24 (14)	1 (<1)
Annelida (annelids)							
Euhirudinea (leeches)	364 (50)	195 (79)	13 (4)	105 (42)	3 (1)	88 (35)	2 (<1)
Oligochaeta (oligochaetes)	4,829 (1,642)	2,722 (811)	28 (7)	1,591 (524)	1 (<1)	1,461 (510)	<1 (<1)
Arthropoda (arthropods)							
Insecta (insects)							
Ephemeroptera (mayflies)							
Baetidae	167 (126)	105 (60)	10 (6)	45 (23)	<1 (<1)	38 (22)	0
Caenidae	1,260 (367)	857 (228)	20 (7)	652 (198)	<1 (<1)	609 (192)	0
Ephemeridae	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	0	0	0
Odonata (dragonflies, damselflies)							
Aeshnidae	22 (3)	19 (3)	3 (1)	15 (3)	1 (<1)	14 (2)	1 (<1)
Coenagrionidae	101 (25)	66 (14)	5 (1)	55 (12)	1 (<1)	51 (12)	<1 (<1)
Lestidae	30 (4)	30 (10)	7 (2)	28 (9)	3 (1)	25 (8)	1 (<1)

APPENDIX D continued.

Taxa	500 µm	2 mm		4 mm		6 mm	
		+ PM	- PM	+ PM	- PM	+ PM	- PM
Libellulidae	18 (5)	14 (4)	2 (1)	12 (4)	2 (1)	11 (4)	2 (1)
Hemiptera (true bugs)							
Belostomatidae	4 (1)	4 (1)	1 (<1)	3 (1)	<1 (<1)	2 (1)	<1 (<1)
Corixidae	41 (12)	33 (8)	6 (1)	21 (6)	1 (<1)	16 (4)	<1 (<1)
Mesoveliidae	2 (1)	1 (<1)	0	1 (<1)	0	1 (<1)	0
Nepidae	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)
Notonectidae	25 (14)	20 (8)	2 (1)	13 (6)	<1 (<1)	10 (5)	<1 (<1)
Pleidae	5 (3)	3 (2)	0	2 (1)	0	2 (1)	0
Veliidae	1 (<1)	1 (<1)	<1 (<1)	<1 (<1)	0	<1 (<1)	0
Trichoptera (caddisflies)							
Hydroptilidae	3 (2)	2 (2)	<1 (<1)	2 (2)	0	2 (2)	0
Leptoceridae	118 (5)	109 (93)	11 (9)	87 (75)	1 (<1)	79 (70)	0
Phryganeidae	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)
Lepidoptera (moths)							
Crambidae	43 (12)	30 (15)	1 (<1)	20 (10)	0	19 (10)	0
Neuroptera (lacewings)							
Sisyridae	<1 (<1)	1 (<1)	0	<1 (<1)	0	<1 (<1)	0
Coleoptera (beetles)							
Chrysomelidae	318 (104)	238 (98)	7 (4)	200 (84)	<1 (<1)	196 (82)	0
Curculioniade	<1 (<1)	<1 (<1)	0	0	0	0	0
Dytiscidae	34 (9)	27 (8)	2 (1)	19 (6)	<1 (<1)	17 (5)	0
Gyrinidae	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	0	<1 (<1)	0
Haliplidae	37 (7)	32 (8)	5 (2)	22 (6)	0	20 (6)	0
Hydrophilidae	31 (11)	29 (11)	5 (2)	22 (8)	<1 (<1)	21 (8)	0
Diptera (flies)							
Ceratopogonidae	296 (65)	199 (44)	16 (4)	149 (36)	1 (<1)	140 (35)	0
Chaoboridae	69 (24)	59 (19)	5 (2)	39 (13)	<1 (<1)	36 (13)	0

APPENDIX D continued.

Taxa	500 µm	2 mm		4 mm		6 mm	
		+ PM	- PM	+ PM	- PM	+ PM	- PM
Chironomidae	6,037 (1,637)	4,257 (1,142)	97 (33)	3,514 (1,037)	6 (3)	3,408 (1,026)	<1 (<1)
Ephydridae	9 (5)	7 (4)	<1 (<1)	6 (3)	0	6 (3)	0
Sciomyzidae	<1 (<1)	<1 (<1)	0	<1 (<1)	0	<1 (<1)	0
Stratiomyidae	8 (2)	8 (2)	1 (<1)	6 (2)	<1 (<1)	6 (2)	<1 (<1)
Tabanidae	4 (1)	3 (<1)	<1 (<1)	2 (1)	<1 (<1)	2 (1)	<1 (<1)
Tipulidae	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	0	<1 (<1)	0
Malacostraca (malacostracans)							
Amphipoda (amphipods)	271 (103)	163 (83)	13 (8)	85 (42)	<1 (<1)	74 (36)	0
Isopoda (isopods)							
Asellidae	550 (324)	351 (190)	3 (1)	217 (111)	0	192 (95)	0
Decapoda (crayfish)	17 (1)	16 (12)	4 (3)	16 (12)	3 (2)	15 (11)	2 (1)

APPENDIX E

LYMNAEIDAE DENSITIES

Values for Lymnaeidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 14). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
CA Block	7	7	7	4	0	0	0
Gabrielson	237	262	230	262	172	262	110
Gladfelter 3	7	3	3	0	0	0	0
Hanlontown	62	62	50	62	50	58	47
Harmon 3	158	164	147	164	140	156	70
Korleski 1	11	0	0	0	0	0	0
Northern Prairie	4	4	4	4	4	4	0
Osmundson	9	9	9	9	9	9	4
Prairie Pothole 2	8	7	8	4	4	4	4
Silver Lake	4	4	4	4	4	4	4
Union Hills 1	4	4	4	4	4	4	4
Union Hills 4	31	32	10	20	3	20	3
Upper Grove	16	10	12	7	0	0	0
Worth 2	12	7	8	3	0	0	0

APPENDIX F

PHYSIDAE DENSITIES

Values for Physidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 26). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	7	7	7	3	0	3	0
CA Block	22	22	22	15	11	7	4
Christianson Taylor	562	397	219	143	67	58	0
Eagle Flatts	10	3	3	3	0	3	0
Gabrielson	3	0	0	0	0	0	0
Gladfelter 1	52	22	15	18	7	11	0
Gladfelter 2	35	35	0	35	0	35	0
Gladfelter 3	606	540	256	235	3	208	0
Hanlontown	163	139	62	104	16	70	12
Harmon 3	599	230	81	90	0	66	0
Hoffman Prairie	73	42	3	14	0	14	0
Korleski 1	729	408	313	213	53	171	4
Mallard Marsh	2,954	2,205	958	1,256	30	1,085	8
Northern Prairie	2,221	1,142	586	623	23	594	15
Osmundson	240	64	43	34	9	30	0
Paul Willis 1	29	22	11	14	7	11	4
Pilot Knob	56	34	26	4	4	0	0
Prairie Pothole 2	43	33	23	7	0	0	0
Sandpiper	18	18	18	11	7	0	0
Silver Lake	870	466	126	103	4	75	4
Teal Basin	104	71	32	21	14	14	7
Union Hills 2	31	24	24	8	0	8	0
Union Hills 4	66	59	38	12	0	12	0
Upper Grove	125	97	82	49	12	10	0
Worth 1	4	4	4	4	4	0	0
Worth 2	47	17	8	3	4	0	0

APPENDIX G

PLANORBIDAE DENSITIES

Values for Planorbidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 27). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	162	138	45	69	0	69	0
CA Block	196	181	112	94	14	83	0
Christianson Taylor	411	379	286	111	31	80	0
Eagle Flatts	263	97	24	93	0	93	0
Gabrielson	72	49	17	30	0	30	0
Gladfelter 1	1,616	1,327	624	1,075	74	1,024	15
Gladfelter 2	717	708	35	704	4	692	0
Gladfelter 3	1,578	751	173	440	17	398	3
Hanlontown	74	70	12	66	0	62	0
Harmon 3	596	211	37	62	0	55	0
Hoffman Prairie	59	17	3	14	3	10	3
Korleski 1	5,702	2,774	1,508	1,573	11	1,520	8
Mallard Marsh	3,829	2,991	548	2,156	65	1,996	0
Northern Prairie	1,213	807	243	699	15	699	4
Osmundson	777	176	77	129	0	103	0
Paul Willis 1	288	259	65	220	7	216	0
Pilot Knob	1,440	275	154	169	79	124	26
Prairie Pothole 2	484	376	209	136	19	77	12
Sandpiper	76	22	15	18	7	7	0
Silver Lake	946	316	100	118	4	91	4
Teal Basin	11	11	4	7	0	7	0
Union Hills 1	153	76	76	53	15	42	15
Union Hills 2	142	55	39	39	0	12	0
Union Hills 4	878	614	135	444	31	400	10
Upper Grove	246	115	86	56	39	45	35
Worth 1	8	8	8	4	4	4	4
Worth 2	150	124	130	34	0	31	0

APPENDIX H

PISIDIIDAE DENSITIES

Values for Pisidiidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 19). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	41	28	17	24	7	21	7
Christianson Taylor	174	58	18	4	0	0	0
Eagle Flatts	969	426	228	419	204	374	80
Gabrielson	72	49	38	38	21	30	0
Gladfelter 1	4	4	0	0	0	0	0
Gladfelter 2	16	16	16	12	8	8	0
Gladfelter 3	3	3	0	0	0	0	0
Hanlontown	31	31	31	15	0	12	0
Harmon 3	176	179	143	66	7	39	0
Hoffman Prairie	111	35	10	28	7	10	0
Northern Prairie	42	38	34	33	27	29	15
Osmundson	4	4	4	4	0	4	0
Paul Willis 1	7	7	0	4	0	4	0
Prairie Pothole 2	4	0	0	0	0	0	0
Sandpiper	109	98	44	95	323	80	11
Union Hills 2	12	8	8	8	4	4	0
Union Hills 4	56	28	14	16	7	12	7
Upper Grove	180	156	172	146	113	31	12
Worth 1	48	46	48	15	8	0	0

APPENDIX I

EUHIRUDINEA DENSITIES

Values for Euhirudinea densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 27). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	31	31	14	14	0	14	0
CA Block	4	4	4	4	4	4	0
Christianson Taylor	3,714	2,037	397	972	31	843	13
Eagle Flatts	55	38	3	31	0	31	0
Gabrielson	31	19	7	11	0	11	0
Gladfelter 1	288	181	33	144	15	140	11
Gladfelter 2	98	79	39	67	35	43	16
Gladfelter 3	131	80	3	66	0	59	0
Hanlontown	1,523	929	105	700	47	552	23
Harmon 3	434	168	33	94	0	82	0
Hoffman Prairie	90	48	14	21	0	17	0
Korleski 1	271	168	61	118	8	114	8
Mallard Marsh	232	178	49	83	11	76	8
Northern Prairie	197	96	65	29	15	25	8
Osmundson	34	34	4	34	4	34	4
Paul Willis 1	11	11	0	11	0	11	0
Pilot Knob	808	211	79	98	11	72	4
Prairie Pothole 2	62	33	16	7	8	7	4
Sandpiper	105	62	15	40	7	40	7
Silver Lake	310	174	79	95	33	59	8
Teal Basin	7	4	4	4	4	4	0
Union Hills 1	31	11	4	11	0	11	0
Union Hills 2	138	55	4	24	0	20	0
Union Hills 4	28	24	7	8	0	4	0
Upper Grove	152	80	20	35	4	10	4
Worth 1	79	77	79	70	56	66	40
Worth 2	976	447	253	55	20	38	12

APPENDIX J

OLIGOCHAETA DENSITIES

Values for Oligochaeta densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 27). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	1,293	955	10	776	0	769	0
CA Block	4,268	1,563	112	537	4	530	4
Christianson Taylor	8,277	3,339	348	1,819	27	1,685	0
Eagle Flatts	5,111	4,094	253	3,689	3	3,665	0
Gabrielson	9,691	7,165	89	6,338	0	6,292	0
Gladfelter 1	1,838	565	0	418	0	381	0
Gladfelter 2	1,083	704	20	598	0	519	0
Gladfelter 3	22,592	15,613	48	13,287	0	12,851	0
Hanlontown	3,988	3,510	492	2,988	62	2,852	0
Harmon 3	2,342	1,517	0	729	0	542	0
Hoffman Prairie	772	471	28	322	0	291	0
Korleski 1	3,115	1,741	408	1,455	61	1,448	0
Mallard Marsh	567	342	49	186	0	182	0
Northern Prairie	5,868	1,276	137	519	0	494	0
Osmundson	1,176	554	13	382	0	335	0
Paul Willis 1	730	569	18	410	0	410	0
Pilot Knob	3,782	1,322	8	1,081	0	1,024	0
Prairie Pothole 2	368	177	8	52	0	44	0
Sandpiper	364	237	11	204	0	200	0
Silver Lake	3,025	1,701	155	671	0	446	0
Teal Basin	371	225	4	64	0	46	0
Union Hills 1	687	274	65	118	0	114	0
Union Hills 2	1,591	967	177	452	0	358	0
Union Hills 4	4,309	3,401	56	1,629	0	1,272	0
Upper Grove	7,809	4,227	113	1,358	0	674	0
Worth 1	365	279	16	193	0	147	0
Worth 2	35,538	16,700	257	2,684	0	1,887	0

APPENDIX K

BAETIDAE DENSITIES

Values for Baetidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 22). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
CA Block	4	0	0	0	0	0	0
Christianson Taylor	67	53	13	31	0	27	0
Eagle Flatts	10	7	7	7	0	7	0
Gabrielson	27	19	3	8	0	8	0
Gladfelter 1	77	59	30	33	0	33	0
Gladfelter 2	150	126	43	90	0	59	0
Gladfelter 3	118	52	7	38	0	35	0
Harmon 3	151	133	4	70	0	43	0
Hoffman Prairie	3	0	0	0	0	0	0
Korleski 1	15	8	4	8	4	4	0
Mallard Marsh	15	11	11	8	0	8	0
Northern Prairie	3,304	1,535	608	586	0	569	0
Pilot Knob	4	4	4	0	0	0	0
Prairie Pothole 2	39	26	4	7	0	7	0
Sandpiper	4	4	0	4	0	4	0
Silver Lake	75	67	33	32	0	24	0
Union Hills 1	27	19	19	11	0	11	0
Union Hills 2	20	16	12	4	0	4	0
Union Hills 4	667	662	163	258	3	186	0
Upper Grove	12	7	4	3	0	0	0
Worth 1	28	23	16	8	0	4	0
Worth 2	12	7	4	0	0	0	0

APPENDIX L

CAENIDAE DENSITIES

Values for Caenidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 23). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	125	120	63	62	0	49	0
Eagle Flatts	145	125	0	114	0	111	0
Gladfelter 1	3,731	1,626	44	1,412	0	1,360	0
Gladfelter 2	6,118	4,691	35	4,447	0	4,356	0
Gladfelter 3	6,003	3,703	7	2,987	0	2,821	0
Hanlontown	1,756	1,660	326	1,412	8	1,351	0
Harmon 3	1,449	1,268	125	729	0	558	0
Hoffman Prairie	1,647	1,215	73	831	0	730	0
Korleski 1	1,927	1,250	80	1,154	11	1,147	0
Mallard Marsh	15	11	0	8	0	8	0
Northern Prairie	715	673	441	502	0	494	0
Paul Willis 1	29	22	0	14	0	14	0
Pilot Knob	56	38	0	38	0	38	0
Prairie Pothole 2	314	232	16	110	0	103	0
Sandpiper	367	288	0	218	0	211	0
Silver Lake	2,724	2,084	510	600	0	399	0
Teal Basin	518	318	0	182	0	161	0
Union Hills 1	836	450	11	419	0	415	0
Union Hills 2	2,906	1,356	4	873	0	755	0
Union Hills 4	2,531	1,895	250	1,459	0	1,324	0
Upper Grove	86	59	39	24	0	14	0
Worth 1	8	8	8	8	0	8	0
Worth 2	79	45	16	10	0	10	0

APPENDIX M

EPHEMERIDAE DENSITIES

Values for Ephemeridae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 1). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

Wetland	500 µm	2 mm		4 mm		6 mm	
		+ PM	- PM	+ PM	- PM	+ PM	- PM
Upper Grove	4	4	4	4	0	0	0

APPENDIX N

AESHNIDAE DENSITIES

Values for Aeshnidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 20). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	10	10	10	10	3	10	3
Christianson Taylor	9	9	0	0	0	0	0
Eagle Flatts	14	14	7	14	7	14	3
Gabrielson	7	8	7	8	7	8	7
Gladfelter 1	30	15	7	15	0	15	0
Gladfelter 2	28	28	24	28	4	24	0
Gladfelter 3	45	38	14	31	3	31	0
Hanlontown	12	8	0	8	0	8	0
Harmon 3	26	23	7	20	0	8	0
Hoffman Prairie	21	21	17	17	3	17	3
Korleski 1	19	19	11	15	0	15	0
Mallard Marsh	42	30	23	23	4	23	4
Osmundson	30	30	30	30	13	30	9
Paul Willis 1	72	65	40	50	4	47	4
Pilot Knob	30	30	15	23	4	23	4
Silver Lake	21	20	13	8	0	8	0
Teal Basin	54	43	39	32	14	32	4
Union Hills 1	27	27	23	27	11	27	8
Union Hills 2	31	28	20	20	0	20	0
Union Hills 4	56	52	21	28	3	28	3

APPENDIX O

COENAGRIONIDAE DENSITIES

Values for Coenagrionidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 20). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	18	13	13	13	4	13	0
Eagle Flatts	31	24	0	21	0	21	0
Gladfelter 1	395	181	33	148	7	144	4
Gladfelter 2	366	279	63	252	20	244	4
Gladfelter 3	284	180	3	145	0	138	0
Hanlontown	93	93	93	85	8	85	0
Harmon 3	70	74	70	70	11	62	0
Hoffman Prairie	246	163	24	128	0	111	0
Korleski 1	107	65	11	61	4	61	0
Northern Prairie	29	29	23	29	19	29	0
Paul Willis 1	79	40	0	29	0	29	0
Pilot Knob	147	105	8	105	0	102	0
Prairie Pothole 2	35	33	35	22	4	15	0
Sandpiper	15	15	0	11	0	11	0
Silver Lake	63	59	63	55	25	51	0
Teal Basin	211	100	7	57	0	43	0
Union Hills 1	176	88	8	61	0	61	0
Union Hills 2	87	59	16	51	0	43	0
Union Hills 4	243	186	66	143	14	119	3
Upper Grove	27	3	0	0	0	0	0

APPENDIX P

LESTIDAE DENSITIES

Values for Lestidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 19). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	55	55	28	52	10	52	0
Gabrielson	24	23	21	19	7	19	0
Gladfelter 1	7	7	7	4	4	7	4
Gladfelter 3	10	10	3	10	3	10	0
Hanlontown	12	12	8	12	0	12	0
Harmon 3	15	15	11	15	7	15	4
Hoffman Prairie	7	7	7	7	3	7	0
Korleski 1	38	38	38	38	23	34	0
Mallard Marsh	46	46	46	46	23	38	15
Northern Prairie	35	25	23	25	23	21	0
Osmundson	245	245	210	240	56	215	13
Paul Willis 1	126	126	115	115	54	104	14
Sandpiper	7	7	7	7	4	7	0
Silver Lake	46	43	42	36	21	28	0
Teal Basin	32	32	32	32	18	32	7
Union Hills 1	15	15	15	11	4	8	0
Union Hills 2	31	31	31	28	24	24	4
Union Hills 4	21	12	7	12	3	12	0
Upper Grove	55	49	49	45	23	24	4

APPENDIX Q

LIBELLULIDAE DENSITIES

Values for Libellulidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 18). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Eagle Flatts	3	3	3	3	3	3	3
Gabrielson	3	3	3	3	3	3	0
Gladfelter 1	4	4	4	4	4	4	4
Gladfelter 2	51	31	4	31	4	31	0
Gladfelter 3	14	7	0	7	0	7	0
Hanlontown	93	93	93	93	89	93	85
Harmon 3	4	4	4	4	4	4	4
Hoffman Prairie	28	17	14	14	3	10	3
Korleski 1	27	23	19	19	11	19	11
Mallard Marsh	15	15	15	11	8	11	8
Northern Prairie	4	4	4	4	4	4	4
Pilot Knob	8	8	8	8	8	8	8
Prairie Pothole 2	7	7	7	7	7	7	7
Sandpiper	7	7	7	7	4	7	4
Teal Basin	64	36	7	25	4	21	4
Union Hills 1	34	15	0	11	0	11	0
Union Hills 2	114	71	20	51	4	51	4
Union Hills 4	17	17	17	16	14	12	7

APPENDIX R

BELOSTOMATIDAE DENSITIES

Values for Belostomatidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 13). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gabrielson	7	8	7	4	3	4	3
Gladfelter 1	7	7	7	7	4	7	4
Gladfelter 3	14	14	14	10	3	7	3
Harmon 3	4	4	4	4	0	4	0
Hoffman Prairie	3	3	3	3	0	0	0
Korleski 1	4	4	4	0	0	0	0
Mallard Marsh	8	8	8	8	4	8	0
Osmundson	4	4	4	4	0	4	0
Paul Willis 1	11	11	11	4	4	4	0
Pilot Knob	4	4	4	4	4	4	0
Silver Lake	13	12	13	8	8	8	4
Union Hills 2	4	4	4	4	4	0	0
Upper Grove	16	16	16	14	0	7	0

APPENDIX S

CORIXIDAE DENSITIES

Values for Corixidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 25). Values of “0” were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
CA Block	33	25	25	15	0	15	0
Christianson Taylor	40	36	9	22	0	18	0
Eagle Flatts	14	7	7	7	0	3	0
Gabrielson	3	4	3	4	0	4	0
Gladfelter 1	66	59	55	44	7	33	4
Gladfelter 2	8	8	4	4	0	4	0
Gladfelter 3	24	17	17	17	3	7	0
Hanlontown	8	8	8	8	0	4	0
Harmon 3	125	125	107	129	4	66	0
Hoffman Prairie	3	3	0	3	0	3	0
Korleski 1	11	8	4	8	4	8	0
Mallard Marsh	4	4	4	4	0	4	0
Northern Prairie	268	146	49	63	0	63	0
Osmundson	26	26	17	21	0	21	0
Paul Willis 1	65	61	61	43	4	43	0
Pilot Knob	94	75	75	75	64	49	0
Prairie Pothole 2	8	7	8	7	0	0	0
Sandpiper	7	7	7	4	0	4	0
Silver Lake	42	32	17	20	0	4	0
Teal Basin	18	18	18	14	11	11	0
Union Hills 1	8	8	4	4	0	4	0
Union Hills 4	42	44	24	12	0	12	0
Upper Grove	4	3	0	3	0	3	0
Worth 1	44	43	32	19	0	15	0
Worth 2	178	117	59	21	0	21	0

APPENDIX T

MESOVELIIDAE DENSITIES

Values for Mesoveliidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 8). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Eagle Flatts	10	0	0	0	0	0	0
Gladfelter 1	4	0	0	0	0	0	0
Gladfelter 3	14	10	0	10	0	10	0
Harmon 3	4	4	0	4	0	4	0
Hoffman Prairie	14	10	0	3	0	3	0
Pilot Knob	11	8	0	8	0	8	0
Sandpiper	4	0	0	0	0	0	0
Silver Lake	4	4	0	4	0	4	0

APPENDIX U

NEPIDAE DENSITIES

Values for Nepidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 1). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Pilot Knob	4	4	4	4	4	4	4

APPENDIX V

NOTONECTIDAE DENSITIES

Values for Notonectidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 20). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	3	3	3	3	3	3	0
Gabrielson	10	10	10	11	7	11	3
Gladfelter 1	26	26	22	22	0	18	0
Gladfelter 2	307	208	47	153	12	134	0
Gladfelter 3	17	10	7	7	3	3	0
Harmon 3	15	15	4	12	0	0	0
Hoffman Prairie	7	7	3	3	0	3	0
Korleski 1	8	8	8	8	4	8	0
Mallard Marsh	4	4	4	0	0	0	0
Northern Prairie	13	8	4	0	0	0	0
Osmundson	4	4	4	4	0	4	0
Paul Willis 1	18	18	14	11	4	11	0
Pilot Knob	120	60	8	30	0	30	0
Prairie Pothole 2	8	7	4	4	0	0	0
Sandpiper	4	4	4	4	4	4	0
Silver Lake	13	12	8	4	0	4	0
Teal Basin	4	4	0	4	0	4	0
Union Hills 1	4	4	4	4	4	4	0
Union Hills 4	94	94	63	55	3	24	0
Upper Grove	12	12	12	7	0	7	0

APPENDIX W

PLEIDAE DENSITIES

Values for Pleidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 5). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Hanlontown	27	27	0	23	0	23	0
Harmon 3	81	59	0	27	0	16	0
Hoffman Prairie	7	0	0	0	0	0	0
Northern Prairie	4	4	0	4	0	4	0
Union Hills 2	4	0	0	0	0	0	0

APPENDIX X

VELIIDAE DENSITIES

Values for Veliidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 3). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gladfelter 3	3	3	0	3	0	3	0
Hoffman Prairie	3	3	0	0	0	0	0
Pilot Knob	19	15	4	8	0	8	0

APPENDIX Y

HYDROPTILIDAE DENSITIES

Values for Hydroptilidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 4). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gladfelter 2	59	47	4	43	0	43	0
Northern Prairie	4	0	0	0	0	0	0
Prairie Pothole 2	4	4	0	4	0	4	0
Union Hills 4	7	4	0	4	0	4	0

APPENDIX Z

LEPTOCERIDAE DENSITIES

Values for Leptoceridae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 17). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	134	58	18	17	0	17	0
Gabrielson	17	17	7	11	0	8	0
Gladfelter 1	70	52	18	37	0	37	0
Gladfelter 2	35	28	8	28	0	28	0
Gladfelter 3	45	42	28	31	0	28	0
Hanlontown	2,601	2,535	919	2,043	50.3876	1,888	0
Harmon 3	81	81	51	66	11.02941	51	0
Hoffman Prairie	7	3	0	3	0	3	0
Korleski 1	8	8	8	8	0	8	0
Mallard Marsh	4	4	0	0	0	0	0
Paul Willis 1	25	25	14	25	7.194245	25	0
Prairie Pothole 2	39	29	12	11	0	4	0
Silver Lake	63	24	0	16	0	8	0
Teal Basin	4	4	0	0	0	0	0
Union Hills 2	4	0	0	0	0	0	0
Union Hills 4	28	24	17	20	0	16	0
Worth 2	24	21	12	17	0	10	0

APPENDIX AA

PHRYGANEIDAE DENSITIES

Values for Phryganeidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 1). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Hanlontown	4	4	4	4	4	4	4

APPENDIX AB

CRAMBIDAE DENSITIES

Values for Crambidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 17). Values of “0” were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	554	361	40	259	0	250	0
Gabrielson	3	3	0	0	0	0	0
Gladfelter 1	48	44	30	30	0	26	0
Gladfelter 2	47	47	4	47	0	47	0
Gladfelter 3	21	21	3	17	0	17	0
Hanlontown	12	12	8	4	0	4	0
Korleski 1	46	38	11	27	0	27	0
Northern Prairie	25	17	0	4	0	4	0
Paul Willis 1	32	32	0	22	0	22	0
Prairie Pothole 2	4	4	0	0	0	0	0
Sandpiper	4	4	0	4	0	4	0
Silver Lake	276	186	13	99	0	91	0
Teal Basin	4	0	0	0	0	0	0
Union Hills 1	8	8	4	0	0	0	0
Union Hills 2	24	8	4	8	0	8	0
Union Hills 4	35	12	3	12	0	12	0
Upper Grove	16	7	0	0	0	0	0

APPENDIX AC

SISYRIDAE DENSITIES

Values for Sisyridae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 2). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Harmon 3	4	4	0	0	0	0	0
Silver Lake	13	12	0	12	0	12	0

APPENDIX AD

CHRYSOMELIDAE DENSITIES

Values for Chrysomelidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 20). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	107	62	13	49	0	45	0
Eagle Flatts	107	80	3	66	0	66	0
Gabrielson	10	11	0	11	0	11	0
Gladfelter 1	1,325	1,027	151	839	0	820	0
Gladfelter 2	539	491	98	464	0	448	0
Gladfelter 3	405	260	3	183	0	180	0
Hanlontown	8	8	0	8	0	8	0
Harmon 3	26	16	4	12	0	8	0
Hoffman Prairie	443	322	21	235	0	222	0
Korleski 1	19	19	19	19	11	15	0
Mallard Marsh	4	0	0	0	0	0	0
Osmundson	4	4	4	4	0	4	0
Paul Willis 1	2,716	1,836	32	1,552	0	1,548	0
Pilot Knob	45	34	0	8	0	8	0
Sandpiper	44	25	0	22	0	22	0
Teal Basin	2,175	1,834	343	1,583	0	1,533	0
Union Hills 1	88	76	11	72	0	72	0
Union Hills 2	461	283	20	256	0	248	0
Union Hills 4	66	28	0	28	0	28	0
Worth 1	4	4	4	0	0	0	0

APPENDIX AE

CURCULIONIDAE DENSITIES

Values for Curculionidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 2). Values of “0” were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Korleski 1	4	0	0	0	0	0	0
Teal Basin	7	7	0	0	0	0	0

APPENDIX AF

DYTISCIDAE DENSITIES

Values for Dytiscidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 21). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	192	169	67	85	0	76	0
Gabrielson	7	7	0	4	0	4	0
Gladfelter 1	148	115	52	67	0	59	0
Gladfelter 2	165	126	28	114	0	98	0
Gladfelter 3	7	7	0	7	0	7	0
Hanlontown	54	31	4	31	0	31	0
Harmon 3	15	15	7	15	4	15	0
Hoffman Prairie	3	0	0	0	0	0	0
Korleski 1	46	38	27	27	19	27	0
Mallard Marsh	68	65	0	49	0	49	0
Northern Prairie	79	63	27	46	4	46	0
Osmundson	4	0	0	0	0	0	0
Paul Willis 1	7	4	4	0	0	0	0
Pilot Knob	15	8	0	8	0	4	0
Prairie Pothole 2	4	4	0	0	0	0	0
Silver Lake	21	16	0	8	0	4	0
Teal Basin	4	0	0	0	0	0	0
Union Hills 1	23	19	0	11	0	11	0
Union Hills 2	43	28	16	20	0	20	0
Union Hills 4	7	7	4	4	0	4	0
Upper Grove	12	10	4	7	0	7	0

APPENDIX AG

GYRINIDAE DENSITIES

Values for Gyrinidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 3). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	4	0	0	0	0	0	0
Northern Prairie	4	4	4	4	0	0	0
Paul Willis 1	4	4	4	4	0	4	0

APPENDIX AH

HALIPLIDAE DENSITIES

Values for Haliplidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 26). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	7	3	0	3	0	3	0
CA Block	7	7	0	4	0	0	0
Christianson Taylor	13	4	0	0	0	0	0
Eagle Flatts	31	31	21	28	0	28	0
Gabrielson	3	3	3	0	0	0	0
Gladfelter 1	26	18	0	11	0	11	0
Gladfelter 2	130	122	59	110	0	110	0
Gladfelter 3	80	62	0	62	0	62	0
Hanlontown	16	15	8	12	0	12	0
Harmon 3	7	4	0	4	0	4	0
Hoffman Prairie	3	0	0	0	0	0	0
Korleski 1	164	160	134	122	0	122	0
Mallard Marsh	8	8	4	0	0	0	0
Northern Prairie	29	29	8	29	0	29	0
Paul Willis 1	18	11	0	11	0	11	0
Pilot Knob	11	4	4	0	0	0	0
Prairie Pothole 2	50	48	39	33	0	22	0
Sandpiper	33	29	18	25	0	25	0
Silver Lake	42	36	33	12	0	8	0
Teal Basin	7	7	0	0	0	0	0
Union Hills 1	23	19	11	19	0	19	0
Union Hills 2	28	24	8	20	0	16	0
Union Hills 4	42	40	28	12	0	12	0
Upper Grove	121	108	90	45	0	21	0
Worth 1	8	8	4	0	0	0	0
Worth 2	103	72	51	38	0	31	0

APPENDIX AI

HYDROPHILIDAE DENSITIES

Values for Hydrophilidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 18). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	14	10	0	10	0	10	0
CA Block	4	4	0	4	0	4	0
Christianson Taylor	138	129	76	71	0	53	0
Eagle Flatts	17	10	10	10	0	10	0
Gabrielson	4	4	0	4	0	4	0
Gladfelter 1	55	55	18	48	0	48	0
Gladfelter 2	67	67	39	63	0	63	0
Gladfelter 3	48	45	14	38	0	38	0
Hanlontown	8	8	8	8	0	8	0
Korleski 1	130	122	84	107	0	107	0
Mallard Marsh	8	8	8	4	0	4	0
Northern Prairie	4	0	0	0	0	0	0
Paul Willis 1	22	11	4	7	0	7	0
Pilot Knob	248	241	180	177	4	169	0
Sandpiper	4	4	0	4	0	4	0
Teal Basin	25	18	7	11	0	11	0
Union Hills 1	23	19	19	8	0	4	0
Union Hills 2	28	28	12	24	0	20	0

APPENDIX AJ

CERATOPOGONIDAE DENSITIES

Values for Ceratopogonidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 26). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	17	13	0	10	0	10	0
CA Block	11	7	0	4	0	4	0
Christianson Taylor	406	374	165	308	27	294	0
Eagle Flatts	391	201	76	190	0	190	0
Gabrielson	182	83	14	57	0	57	0
Gladfelter 1	410	277	92	225	4	218	0
Gladfelter 2	555	464	177	432	0	421	0
Gladfelter 3	903	733	118	658	0	644	0
Hanlontown	372	368	233	317	23	306	0
Harmon 3	37	39	7	20	0	20	0
Hoffman Prairie	1,014	765	97	606	0	585	0
Korleski 1	718	518	218	331	8	331	0
Mallard Marsh	46	27	8	15	0	11	0
Northern Prairie	54	33	4	17	0	17	0
Osmundson	39	26	0	21	0	21	0
Paul Willis 1	169	68	18	58	0	58	0
Pilot Knob	462	245	102	121	0	117	0
Prairie Pothole 2	39	37	19	26	0	18	0
Sandpiper	175	80	7	69	0	62	0
Silver Lake	33	32	4	12	0	8	0
Teal Basin	996	465	161	175	0	122	0
Union Hills 1	80	27	4	15	0	11	0
Union Hills 2	587	236	75	138	0	71	0
Union Hills 4	198	190	14	178	0	174	0
Upper Grove	16	4	0	0	0	0	0
Worth 2	83	58	4	10	0	7	0

APPENDIX AK

CHAOBORIDAE DENSITIES

Values for Chaoboridae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 21). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	7	3	0	3	0	3	0
Christianson Taylor	18	9	4	7	0	9	0
Eagle Flatts	277	225	35	190	0	190	0
Gabrielson	344	344	86	235	0	228	0
Gladfelter 1	380	307	173	207	0	196	0
Gladfelter 2	63	35	4	24	0	24	0
Gladfelter 3	52	42	0	28	0	17	0
Harmon 3	44	39	18	27	0	23	0
Hoffman Prairie	131	111	38	69	0	52	0
Mallard Marsh	19	15	4	8	0	8	0
Northern Prairie	17	17	0	8	0	8	0
Osmundson	26	17	13	17	0	17	0
Paul Willis 1	29	29	22	14	0	14	0
Pilot Knob	11	8	4	8	0	8	0
Prairie Pothole 2	16	7	4	0	0	0	0
Sandpiper	18	15	11	11	0	11	0
Silver Lake	33	20	13	16	0	4	0
Teal Basin	39	32	14	21	4	18	0
Union Hills 1	23	19	19	4	0	4	0
Union Hills 2	12	8	4	4	0	4	0
Union Hills 4	309	289	66	155	0	135	0

APPENDIX AL

CHIRONOMIDAE DENSITIES

Values for Chironomidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 27). Values of “0” were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	9,362	7,184	610	6,256	0	6,225	0
CA Block	98	33	0	11	0	11	0
Christianson Taylor	3,527	1,632	143	753	0	722	0
Eagle Flatts	33,536	26,006	1,197	23,833	14	23,604	0
Gabrielson	5,986	5,226	199	4,346	0	4,243	0
Gladfelter 1	4,247	1,892	85	1,781	0	1,752	0
Gladfelter 2	5,630	4,636	126	4,407	0	4,282	0
Gladfelter 3	20,066	14,322	1,353	12,411	149	12,027	0
Hanlontown	903	685	105	580	4	553	0
Harmon 3	3.206	1,942	51	1,197	0	1,014	0
Hoffman Prairie	7,443	4,472	152	3,586	0	3,288	0
Korleski 1	5,084	3,254	1,317	2,518	156	2,461	8
Mallard Marsh	1,209	801	76	474	8	459	4
Northern Prairie	11,732	9,465	2,890	8,261	255	8,081	0
Osmundson	614	309	4	223	0	210	0
Paul Willis 1	8,151	4,558	335	3,507	18	3,492	0
Pilot Knob	21,192	14,883	485	12,680	0	12,518	0
Prairie Pothole 2	2,329	1,244	4	633	0	497	0
Sandpiper	1,345	823	29	659	0	644	0
Silver Lake	1,879	1,054	33	450	0	347	0
Teal Basin	2,643	1,462	150	801	0	690	0
Union Hills 1	786	286	38	213	0	206	0
Union Hills 2	2,087	940	134	362	0	256	0
Union Hills 4	8,513	6,409	28	4,443	0	4,162	0
Upper Grove	1,691	1,101	31	392	0	201	0
Worth 1	44	39	0	23	0	23	0
Worth 2	775	272	12	55	0	48	0

APPENDIX AM

EPHYDRIDAE DENSITIES

Values for Ephydridae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 5). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gladfelter 3	3	0	0	0	0	0	0
Hoffman Prairie	59	52	0	38	0	38	0
Osmundson	86	73	9	73	0	73	0
Union Hills 1	4	0	0	0	0	0	0
Union Hills 2	94	59	4	51	0	47	0

APPENDIX AN

SCIOMYZIDAE DENSITIES

Values for Sciomyzidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 1). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gladfelter 1	4	4	0	4	0	4	0

APPENDIX AO

STRATIOMYIDAE DENSITIES

Values for Stratiomyidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 14). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	14	10	3	7	3	7	0
CA Block	4	4	0	4	0	0	0
Gabrielson	27	30	17	19	0	19	0
Gladfelter 3	14	14	10	14	0	14	0
Hoffman Prairie	3	0	0	0	0	0	0
Korleski 1	4	4	4	4	0	4	0
Osmundson	21	21	13	13	4	13	0
Paul Willis 1	61	54	32	47	4	47	0
Pilot Knob	15	15	11	8	4	8	0
Teal Basin	4	4	4	4	0	4	0
Union Hills 1	15	15	15	15	11	15	8
Union Hills 2	12	12	8	8	0	8	0
Upper Grove	27	24	27	24	8	17	0
Worth 1	4	4	0	4	0	4	0

APPENDIX AP

TABANIDAE DENSITIES

Values for Tabanidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 14). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Bailey Creek	17	3	0	3	0	3	0
CA Block	11	7	0	0	0	0	0
Christianson Taylor	4	4	4	4	0	4	0
Gladfelter 1	4	4	4	4	4	4	4
Hanlontown	8	8	8	8	4	4	4
Harmon 3	4	4	4	4	4	4	0
Hoffman Prairie	10	7	0	7	0	7	0
Paul Willis 1	7	7	0	7	0	7	0
Silver Lake	4	4	4	0	0	0	0
Teal Basin	7	4	4	4	0	4	0
Union Hills 1	8	8	8	8	4	8	4
Union Hills 2	8	8	4	8	4	8	4
Union Hills 4	7	8	3	8	0	4	0
Worth 2	12	0	0	0	0	0	0

APPENDIX AQ

TIPULIDAE DENSITIES

Values for Tipulidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 1). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Gabrielson	3	3	3	3	0	3	0

APPENDIX AR

AMPHIPODA DENSITIES

Values for Amphipoda densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 10). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
Christianson Taylor	2,853	1,658	906	802	0	734	0
Gabrielson	69	30	7	11	0	11	0
Gladfelter 2	500	374	209	263	0	244	0
Gladfelter 3	3	3	3	3	0	3	0
Hanlontown	585	383	116	259	4	232	0
Harmon 3	2,338	1,568	63	772	0	597	0
Korleski 1	4	4	4	0	0	0	0
Northern Prairie	933	343	141	171	0	171	0
Union Hills 4	35	12	0	4	0	4	0
Upper Grove	78	35	4	14	0	0	0

APPENDIX AS

ASELLIDAE DENSITIES

Values for Asellidae densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 15). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
CA Block	94	47	0	22	0	22	0
Christianson Taylor	71	58	36	31	0	31	0
Eagle Flatts	374	270	10	204	0	201	0
Gabrielson	4,007	2,376	41	1,427	0	1,423	0
Gladfelter 3	66	48	3	42	0	38	0
Hanlontown	12	12	8	12	0	12	0
Harmon 3	6,857	4,392	29	2,356	0	1,818	0
Hoffman Prairie	304	215	3	156	0	128	0
Mallard Marsh	68	57	11	42	0	42	0
Osmundson	2,807	,1867	124	1,489	0	1,408	0
Pilot Knob	86	75	11	53	0	49	0
Prairie Pothole 2	4	4	0	0	0	0	0
Silver Lake	59	39	0	20	0	16	0
Union Hills 4	3	4	0	0	0	0	0
Upper Grove	35	14	0	3	0	0	0

APPENDIX AT

DECAPODA DENSITIES

Values for Decapoda densities (number of individuals/m^3) in all wetlands that were occupied by this taxon (n = 12). Values of "0" were obtained for all wetland sites not listed here. Density values were calculated based on organisms retained on sieves with different mesh sizes (500 µm, 2 mm, 4 mm, 6 mm) and in samples with (+) and without (-) particulate matter (PM).

	500 µm	2 mm		4 mm		6 mm	
Wetland		+ PM	- PM	+ PM	- PM	+ PM	- PM
CA Block	29	29	29	29	29	29	29
Eagle Flatts	14	14	14	14	14	14	14
Gabrielson	10	10	10	10	10	10	10
Gladfelter 3	3	3	3	3	3	3	3
Harmon 3	15	15	15	15	15	15	11
Hoffman Prairie	10	10	10	10	10	10	10
Mallard Marsh	8	8	8	8	8	4	4
Northern Prairie	17	13	11	13	8	13	8
Osmundson	326	326	322	313	193	288	82
Silver Lake	4	4	4	4	4	4	4
Union Hills 4	7	7	7	7	7	7	7
Upper Grove	4	4	4	4	0	0	0

APPENDIX AU

PROCESSING TIME

Processing time (hr) for sample retained on sieves with different sieve mesh sizes (500 µm, 2 mm, 4 mm, 6 mm).

Wetland	500 µm	2 mm	4 mm	6 mm
Bailey Creek	44.0	37.5	33.6	33.2
CA Block	25.4	14.8	10.8	10.3
Christianson Taylor	44.0	20.6	11.8	11.0
Eagle Flatts	53.6	41.3	37.9	37.2
Gabrielson	49.8	35.2	28.7	28.2
Gladfelter 1	32.9	16.7	13.8	12.9
Gladfelter 2	44.0	24.0	22.0	20.3
Gladfelter 3	100.8	68.0	55.7	53.3
Hanlontown	26.2	22.6	20.6	19.6
Harmon 3	67.0	43.7	30.2	24.9
Hoffman Prairie	62.1	36.6	28.5	22.2
Korleski 1	40.4	23.8	21.5	21.3
Mallard Marsh	28.8	21.5	15.6	15.1
Northern Prairie	32.7	15.8	11.6	11.3
Osmundson	13.9	8.5	7.3	7.0
Paul Willis 1	27.5	18.7	15.1	14.8
Pilot Knob	71.8	50.3	44.8	43.6
Prairie Pothole 2	22.0	14.5	6.6	5.4
Sandpiper	21.9	15.6	12.4	12.1
Silver Lake	33.3	22.7	13.2	10.5
Teal Basin	28.4	18.9	13.3	12.6
Union Hills 1	22.4	15.6	11.9	10.4
Union Hills 2	24.1	12.9	9.7	8.6
Union Hills 4	39.9	24.5	16.3	12.9
Upper Grove	28.8	17.6	6.8	4.2
Worth 1	4.1	3.5	2.5	2.3
Worth 2	45.3	21.3	6.9	5.5

APPENDIX AV

SAMPLE VOLUME

Sample volume (ml) for particulate organic matter retained on sieves with different sieve mesh sizes (500 µm, 2 mm, 4 mm, 6 mm).

Wetland	500 µm	2 mm	4 mm	6 mm
Bailey Creek	3,960	3,770	3,615	3,600
CA Block	2,395	1,925	1,745	1,725
Christianson Taylor	1,645	850	685	650
Eagle Flatts	1,540	1,340	1,170	1,140
Gabrielson	3,030	2,835	2,690	2,650
Gladfelter 1	1,630	1,020	870	780
Gladfelter 2	1,690	1,145	950	850
Gladfelter 3	2,482	2,112	1,887	1,812
Hanlontown	3,025	2,660	2,375	2,300
Harmon 3	5,950	4,850	3,850	3,690
Hoffman Prairie	2,655	1,845	1,435	1,175
Korleski 1	1,832	1,587	1,462	1,450
Mallard Marsh	1,935	1,570	1,470	1,465
Northern Prairie	3,085	2,190	1,690	1,600
Osmundson	1,265	760	600	585
Paul Willis 1	2,560	2,010	1,835	1,770
Pilot Knob	4,045	3,770	3,640	3,605
Prairie Pothole 2	1,810	1,305	1,070	900
Sandpiper	2,405	2,020	1,720	1,690
Silver Lake	3,180	2,535	1,685	1,485
Teal Basin	2,850	2,515	2,345	2,285
Union Hills 1	1,740	1,215	1,065	1,055
Union Hills 2	1,770	1,220	1,020	960
Union Hills 4	1,620	1,372	1,127	1,050
Upper Grove	2,195	1,700	880	600
Worth 1	1,070	970	850	830
Worth 2	750	525	310	300