DESCRIPTIVE ANALYSIS OF AQUATIC INVERTEBRATE COMMUNITIES IN WADEABLE AND NON-WADEABLE STREAMS OF THE NORTHERN GREAT PLAINS NETWORK

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ABSTRACT

The National Park Service has initiated the Inventory & Monitoring Program to identify and monitor vital signs of park conditions throughout the United States. Initial assessments and inventories are required to facilitate this monitoring program. This effort provided preliminary and methodologically consistent descriptions for wadeable and non-wadeable streams of the Northern Great Plains Network (NGPN). Sweepnet samples were collected from 41 reaches of 7 non-wadeable streams and 23 wadeable streams during the summers of 2004 and 2005 using modified U.S. EPA EMAP protocols. Wadeable stream samples contained 219 taxa (77 families, 188 genera), comprised primarily of insects (86%). Non-wadeable samples contained 179 taxa (62 families, 148 genera), also mostly insects (85%). Diptera and Coleoptera contributed the greatest number of genera and species to wadeable and non-wadeable stream communities. However, Ephemeroptera and Diptera were most numerically abundant from both habitats and the cumulative percent contribution of Ephemeroptera, Plecoptera and Trichoptera averaged 33.9% and 37.3% in wadeable and non-wadeable streams, respectively. Wadeable stream Shannon-Weiner H' (SW) averaged 1.71 while non-wadeable SW averaged 1.51. Hilsenhoff Biotic Index values in wadeable sites ranged from 3.1 to 9.6 while non-wadeable site values ranged from 0.9 to 9.0. Swimming and clinging taxa, shredding large or gathering fine organic detritus were most abundant. Feeding and habit guild diversity was roughly similar between wadeable and non-wadeable stream classes. Results of this effort provide some of the first inventories and descriptions of aquatic invertebrates allowing comparisons among all 13 parks. These data provide a baseline for future monitoring of wadeable and non-wadeable streams within the network.

Keywords

National Park Service, invertebrates, invertebrate metrics, streams, vital signs

INTRODUCTION

The National Park Service (NPS) is known for its conservation efforts towards maintaining and managing minimally impacted ecological systems. Many parks are subjected to negative human impacts such as urban encroachment, air and water pollution, and excessive visitation. These impacts can threaten the quality or existence of many natural resources and ecosystems in the parks. To help prevent the loss or impairment of natural resources, Congress appropriated funds for the National Park Service to establish the Natural Resource Inventory and Monitoring (I&M) Program (NPS 1996). One of the main goals of the NPS I&M Program is to develop inventories of park resources and ecosystems and to determine their status. Baseline data will be used to monitor park resources into the future.

Park monitoring will focus on changes in "vital signs" established for each park. Vital signs serve as measurable signals that indicate changes that may impair the long-term health of natural resources or ecosystems. Aquatic macroinvertebrate community structure has been rated high by park staff and collaborators for monitoring park conditions.

Baseline descriptions are essential for monitoring future resource changes, whether those changes stem from management decisions, natural fluctuations, or anthropogenic disturbance. The objectives of this effort were to provide initial assessments of non-wadeable and wadeable streams within the Northern Great Plains Network (NGPN) and provide descriptions of macroinvertebrate communities within aquatic habitat of the NGPN.

STUDY AREA

All sampling sites were located within wadeable and non-wadeable streams of the Northern Great Plains Network (NGPN) of the NPS (Figure 1, Table 1). Parks comprising the NGPN are located in South Dakota, North Dakota, Wyoming, and Nebraska, falling within six different ecoregions (Table 2). Consequently, natural differences in habitat, physical, chemical parameters and invertebrate communities were expected. Each site was divided into different system types (wadeable and non-wadeable streams) and had one to three reaches.

METHODS

Habitat and biological assessments were conducted at all reach lengths within each study site and were adapted from EPA's Environmental Monitoring and Assessment Program (EMAP). Modifications were made to several sampling

Figure 1. Map depicting the NGPN of the National Park Service and the respective parks (NPS 2003).

procedures as constraints in money and time prevented us from fully adopting the methodology (Rust 2006). Reach lengths were 40 times the wetted width of the channel (Lazorchak et al. 2000; Peck et al. 2006) with 10 transects at each reach. A hand held Global Positioning System (GPS) was used to determine latitude and longitude of all transects within a sampled reach.

Invertebrate samples were taken from five randomly chosen transects within a reach. A D-frame net (350 um mesh) was used for invertebrate sampling at wadeable and non-wadeable sites. The base of the net was positioned against the substrate and the stream bottom was sufficiently disturbed to dislodge stream organisms for three minutes while the organisms were carried by the current into the net. Five sweepnets were combined to generate one composite sample. The sample was placed into a labeled container and preserved with 70% ethanol.

Invertebrate samples were subsampled and sorted in the laboratory (Barbour et al. 1999). Samples were rinsed thoroughly in a 250 um mesh sieve to remove

Table 1. Parks, their alpha codes, sites within the parks and classification of sites as either wadeable or non-wadeable streams for the NGPN.

PARK	PARK ALPHA CODE	SITES	SITE CLASSIFICATION
Agate Fossil Beds	AGFO	Niobrara River	Stream
Badlands	BADL	Sage Creek	Stream
Devils Tower	DETO	Belle Fourche River	River
Fort Laramie	FOLA	North Platte River Laramie River Deer Creek	River River Stream
Fort Union Trading Post	FOUS	Missouri River	River
Knife River Indian Villages	KNRI	Missouri River Knife River	River River
Missouri National Recreation River	MNRR	Missouri	River
Mount Rushmore	MORU	Beaver Dam Creek Lafferty Gulch Grizzly Creek	Stream Stream Stream
Niobrara National Scenic River	NIOB	Niobrara River Berry Falls Fort Falls Smith Falls	River Stream Stream Stream
Scott's Bluff	SCBL	North Platte River	River
Theodore Roosevelt	THRO	Little Missouri River Beaver Creek	River Stream
Wind Cave	WICA	Cold Spring Creek Highland Creek	Stream Stream

ethanol and fine sediment. Large organic material (i.e. leaves, twigs, macrophytic mats) were visually inspected for invertebrates and discarded. After washing, the sample was spread evenly in a gridded pan and re-suspended in water. Four random grid cells were selected. The four grid cells were extracted from the whole sample and placed in another gridded pan. If more than 300 organisms (+/- 20%) were found within this sample, then subsampling was complete. If the invertebrate density of the four rings had many more than 300 organisms, randomly selected rings were extracted from that subsample and placed in another gridded pan for sorting until 300 (+/- 20%) organisms were found. If, in the original gridded pan, 300 organisms (+/- 20%) could not be found within the four rings, another ring was chosen until 300 organisms (+/- 20%) are found or the entire pan was sorted. After invertebrate sorting, the tray was scanned for large, rare, and voucher specimens. Ten percent of the samples were randomly recounted for quality control during the first year of invertebrate sorting.

Major taxa were separated into separate vials to be identified to the lowest possible taxonomic level (genus, species) using several identification keys (e.g.

Table 2. The ecoregions of the NGPN, average summer temperature and average rainfall.

ECOREGION	SUMMER TEMPERATURE (MIN/MAX ºC)	ANNUAL AVERAGE RAINFALL (CM)	PARKS WITHIN REGION
Northwestern Great Plains	13/29	38	BADL, FOUS, KNRI, THRO
Northwestern Glaciated Plains	16/32	53.3	MNRR, NIOB
Middle Rockies	13/28	43.2	DETO, JECA, MORU, WICA
Northern Glaciated Plains	16/31	48.3	MNRR, NIOB
Nebraska Sand Hills	14/33	41.9	NIOB
Western High Plains	14/33	41.9	AGFO, FOLA, NIOB, SCBL
Western Corn Belt Plains	17/31	61.0	MNRR

Merritt and Cummins 1996, Thorp and Covich 1991, Wiggins 1997, Weiderholm 1983). Invertebrate identifications were randomly checked by capable staff for quality control. Voucher specimens of each taxa were also kept for future reference.

RESULTS

Insects composed 86% of the 219 invertebrate taxa collected from wadeable streams. Overall, familial and generic diversity was high with 77 families and 188

Table 3. Class Insecta familial and generic richness from wadeable streams of the NGPN.

ORDER	FAMILIES	GENERA
Diptera	12	68
Coleoptera	13	33
Trichoptera	9	16
Ephemeroptera	6	10
Hemiptera	8	15
Odonata	6	12
Plecoptera	5	8
Collembola	1	1
Lepidoptera	0	0
Megaloptera	1	1

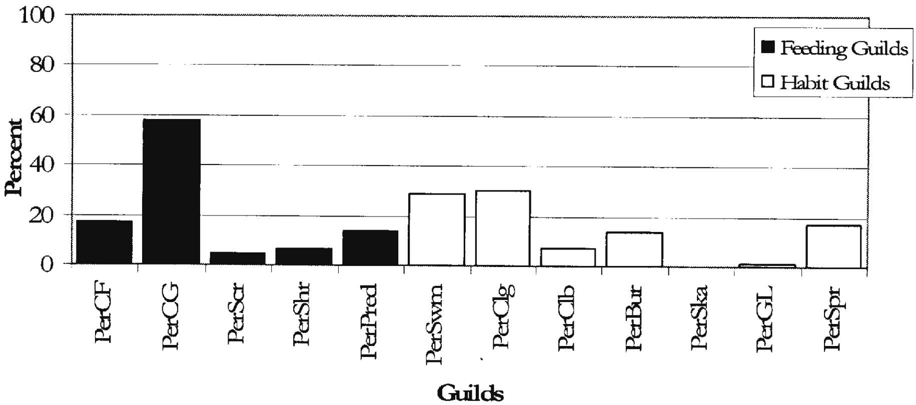

Figure 2. Functional feeding guilds and habit guilds of wadeable streams in the NGPN. PerCF=Percent Collector-Filterers, PerCG=Percent Collector-Gatherers, PerScr=Percent Scrapers, PerShr=Percent Shredders, PerPred=Percent Predators, PerSwm=Percent Swimmers, PerClg=Percent Clingers, PerClb=Percent Climbers, PerBur=Percent Burrowers, PerSka=Percent Skaters, PerGL=Percent Gliders, PerSpr=Percent Sprawlers.

genera. Diptera and Coleoptera contributed the greatest number of families and genera for wadeable streams (Table 3). Fifty different taxa were unique to wadeable stream habitats within the NGPN. Most of the unique taxa were insects.

Feeding guilds consisted primarily of collector-gatherers (58%), collector-filterers (17%), and predators (14%). Clingers (30%) and swimmers (29%) were the most common invertebrate habit guilds. Sprawlers (17%) and burrowers (14%) were moderately abundant (Figure 2).

Wadeable systems within the Black Hills and the Niobrara basin all exhibited similar invertebrate metric characteristics. Systems within the Nebraska panhandle and eastern Wyoming (i.e. FOLA's Deer Creek) displayed higher HBI values. Wind Cave wadeable streams also had higher HBI values (Figure 3). Those areas with fewer intolerant organisms were generally more accessible to livestock or bison (i.e. BADL, WICA, FOLA).

Black Hills and Niobrara sites had the highest Shannon-Wiener Diversity (H'), while Sage Creek (BADL) displayed the lowest H' of all sites (Figure 4). Percent non-insect abundance was lowest at Grizzly Creek (MORU), Fort Falls (NIOB), Highland Creek (WICA), and Sage Creek (range=0%-66.5%). Highest percentages of invertebrates other than insects were found from the Niobrara River (AGFO). The Ephemeroptera, Plecoptera, Trichoptera (EPT): EPT + Chironomidae ratio averaged about 1.00 in Berry Falls (NIOB), Highland Creek (WICA), and Smith Falls (NIOB). Percent EPT richness was also over 40% at Fort Falls (NIOB), Smith Falls (NIOB), Berry Falls (NIOB), and Grizzly Creek (MORU).

A total of 179 different invertebrate genera and species were found in non-wadeable streams of the NGPN (19 orders, 62 families, and 148 genera). Most of these were insects (85%). Coleoptera contributed the highest familial richness, while Diptera contributed the largest number of genera (Table 4). Thirty-three invertebrate genera collected were only found in non-wadeable streams.

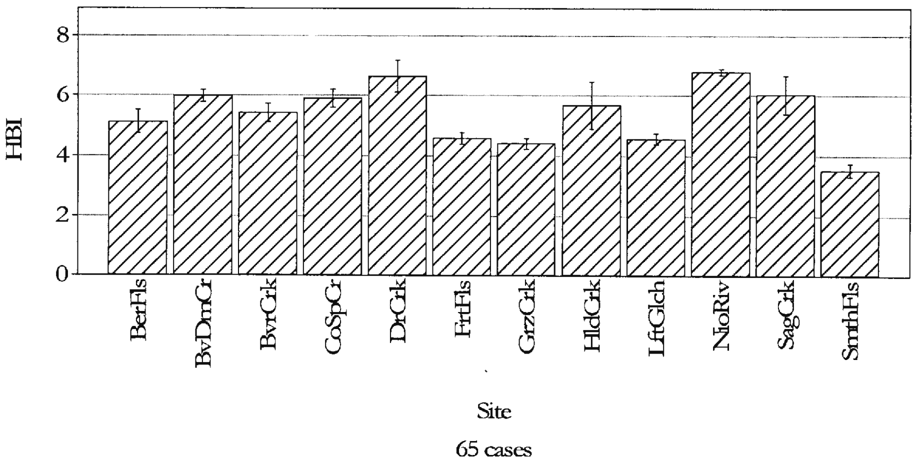

Figure 3. Mean (+/- 1 SE) intolerant taxa richness for wadeable streams for the NGPN. Site abbreviations: BerFls=Berry Falls, BvDmCr=Beaver Dam Creek, CoSpCr=Cold Spring Creek, DrCrk=Deer Creek, FrtFls=Fort Falls, GrzCrk=Grizzly Creek, HldCrk=Highland Creek, LftGlch=Lafferty Gulch, NioRiv=Niobrara River, SagCrk=Sage Creek, SmthFls=Smith Falls.

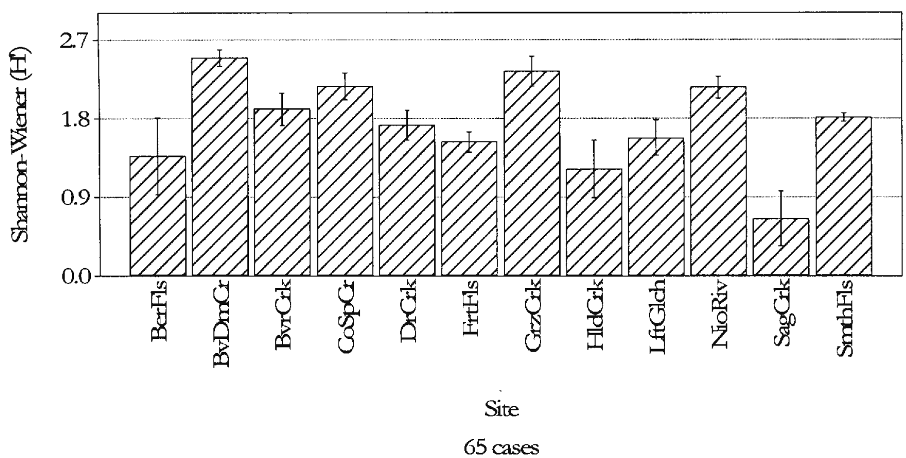

Figure 4. Mean (+/- 1 SE) Shannon-Wiener Diversity (H') for all wadeable streams within the NGPN. Site abbreviations: BerFls=Berry Falls, BvDmCr=Beaver Dam Creek, CoSpCr=Cold Spring Creek, DrCrk=Deer Creek, FrtFls=Fort Falls, GrzCrk=Grizzly Creek, HldCrk=Highland Creek, LftGlch=Lafferty Gulch, NioRiv=Niobrara River, SagCrk=Sage Creek, SmthFls=Smith Falls.

Ephemeroptera contributed the most to the unique taxa (9 genera), while Diptera contributed 8 genera.

Feeding guilds primarily consisted of collector-gatherers (45%, Figure 5). Collector-filterers and predators were also well represented (18% and 19%). Habit guilds were dominated by clingers (33%) and swimmers (31%), with burrowers and sprawlers contributing moderately (15% and 13%) to guild structure. Overall, functional feeding guild (FFG) diversity equaled 0.82 while the Niobrara River (NIOB) and the Laramie River (FOLA) had the highest FFG

Table 4. Class Insecta familial and generic richness from non-wadeable streams of the NGPN.

ORDER	FAMILIES	GENERA
Diptera	7	43
Coleoptera	12	29
Trichoptera	5	9
Ephemeroptera	8	20
Hemiptera	5	9
Odonata	3	7
Plecoptera	4	5
Collembola	2	2
Lepidoptera	1	1
Megaloptera	1	1

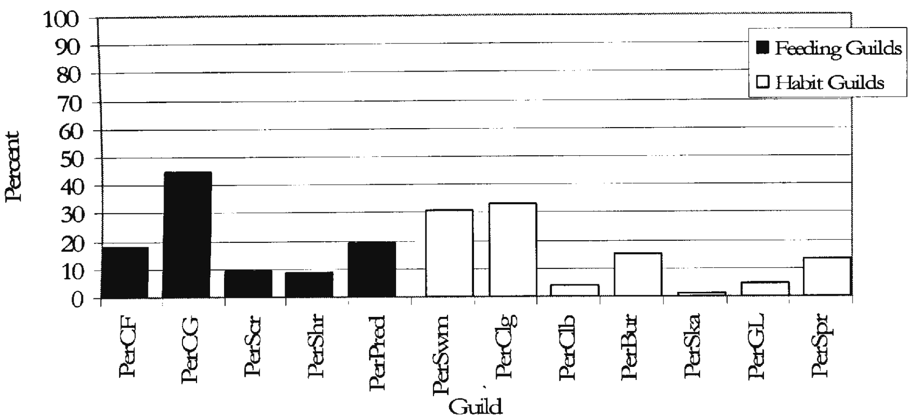

Figure 5. Functional feeding guilds and habit guilds of non-wadeable streams in the NGPN. PerCF=Percent Collector-Filterers, PerCG=Percent Collector-Gatherers, PerScr=Percent Scrapers, PerShr=Percent Shredders, PerPred=Percent Predators, PerSwm=Percent Swimmers, PerClg=Percent Clingers, PerClb=Percent Climbers, PerBur=Percent Burrowers, PerSka=Percent Skaters, PerGL=Percent Gliders, PerSpr=Percent Sprawlers.

diversity (both with H'=1.02). The Missouri River (KNRI) had the highest FFG evenness (0.77), while overall FFG evenness was 0.66. Habit guild diversity was highest at the Niobrara River (H'=1.18) and overall habit diversity was 1.02. Habit evenness was highest within the Missouri River (KNRI, 1.00), while overall habit evenness reached 0.73.

Percent EPT varied considerably among non-wadeable sites (Figure 6). The Central and Gering irrigation canals (SCBL) displayed the highest percentage of EPT while Knife River and the Missouri River (KNRI) had the lowest numbers of these three insect orders. The North Platte River (FOLA) had the highest percentage of Chironomidae and total richness was greatest at the Niobrara River (NIOB), followed by the Laramie River (FOLA). Non-Insecta taxa were

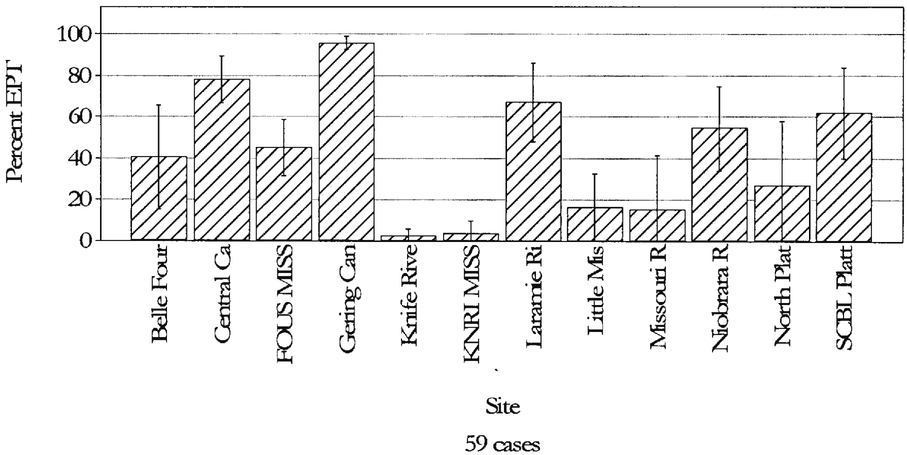

Figure 6.. Mean (+/- 1 SE) percent EPT for all non-wadeable sites within the NGPN. Site abbreviations: BelFrc=Belle Fourche River at DETO. FlPlt=North Platte River at FOLA, FuMis=Missouri River at FOUS, KniRiv=Knife River at KNRI, KrMis=Missouri River at KNRI, LarRiv=Laramie River at FOLA, LitMis=Little Missouri River at THRO, MisRiv=Missouri River at MNRR, NioRiv=Niobrara River at NIOB, and SbPlt=North Platte River at SCBL.

also most abundant from the Laramie River. HBI averaged approximately 5.0, but HBI values over 6.0 were found from the Knife River and Missouri River (KNRI, Figure 7).

DISCUSSION

The insect orders Ephemeroptera, Plecoptera and Trichoptera were commonly observed among NGPN wadeable and non-wadeable sites. Taxonomic richness of these orders and their contribution to total abundance have been selected as metrics for use in other lotic systems (Hannaford and Resh 1995, Maxted et al. 2000, Zweig and Rabeni 2001). EPT metrics do well for monitoring programs because these insect groups are sensitive to water quality changes related to dissolved oxygen. Mayflies, stoneflies and caddisflies all have gills that allow them to absorb oxygen from the water (Resh and Rosenberg 1984). If oxygen is depleted from organic pollution or temperature increases, numbers of EPT taxa and relative abundance decrease. Mayflies are also generally intolerant of low pH (Mackie 2004). Plecoptera reside in cool, well-oxygenated waters and have lower diversities in eutrophic streams (Resh and Rosenberg 1984, Mackie 2004). Caddisflies (Trichoptera) display a large diversity of habitat and functional feeding behavior (Mackie 2004, Mandaville 1999). They inhabit cool, running waters and their presence reflects good water quality (Mackie 2004).

The order Diptera contributed a large percentage of total abundance and number of genera from sampled wadeable and non-wadeable stream sites. While generally not noted as good water quality indicators, members of the order Diptera are a very diverse group of insects and they respond differently to anthropogenic and natural disturbances (Lenat 1993, Gronke 2004, Foley 1997, Yoder and Rankin 1994). The Chironomidae, in particular, may be both very

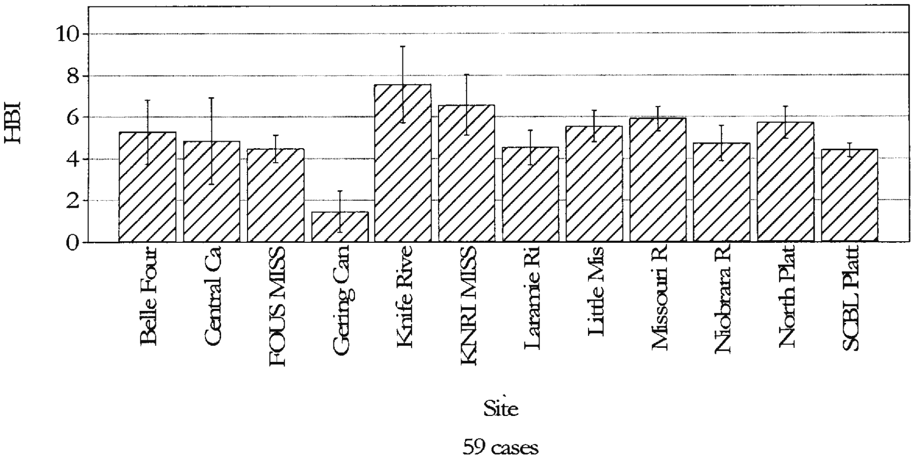

Figure 7. Mean (+/- 1 SE) HBI for all non-wadeable sites within the NGPN. Site abbreviations: BelFrc=Belle Fourche River at DETO. FlPlt=North Platte River at FOLA, FuMis=Missouri River at FOUS, KniRiv=Knife River at KNRI, KrMis=Missouri River at KNRI, LarRiv=Laramie River at FOLA, LitMis=Little Missouri River at THRO, MisRiv=Missouri River at MNRR, NioRiv=Niobrara River at NIOB, and SbPlt=North Platte River at SCBL.

abundant and also very diverse (taxonomically and functionally) within prairie stream systems. Because members of this group may inhabit systems over a wide range of physical and chemical conditions (Mackie 2004), identification and enumeration of this group may facilitate discrimination among prairie stream sites.

Functional guilds are examined to evaluate how organisms utilize their environment. Guilds are defined based on evolved morphological and behavioral adaptations (Rosenberg and Resh 1996). Functional guilds are known to vary depending on system type, land-use, and landscape attributes. For example, invertebrate clingers and climbers were most prevalent in wadeable and non-wadeable stream sites with good water and habitat quality (Grizzly Creek, Smith Falls, Laramie River). These same habit guilds are often depressed when habitat becomes impaired (Maxted et al. 2000, Merritt et al. 2002, Mackie 2004).

Glider abundance was especially high at the Niobrara River at AGFO. The community of this sampled reach included four gastropod genera and one bivalve genus, together contributing up to 16% of the total abundance. The high abundance of gliding gastropods is probably associated with periphyton and detrital materials on and below macrophyte beds within the stream (Thorp and Covich 1991).

Wadeable stream invertebrate metrics varied in association with geomorphic landscape features. Invertebrate diversity was greatest from Black Hills streams, but some prairie streams also displayed high diversity. For example, Shannon-Wiener diversity was high from the Niobrara River (AGFO) and Deer Creek (FOLA) relative to Black Hills streams. Both of these systems flow through prairie landscapes upstream from sampled reaches. However, while diversity was high in most of the sampled plains streams, these communities tended to have higher abundances of Diptera and Mollusca (e.g. Niobrara River at AGFO, and

Deer Creek at FOLA), while most Black Hills streams and NIOB streams had higher numbers of EPT taxa. Plains streams have been shown to display smaller numbers of genera and families than mountain streams (Tate and Heiny 1995), but have also been shown to have higher production than forested streams during times of stable flow (Stagliano and Whiles 2002).

Wadeable streams with higher numbers of tolerant organisms were found primarily in plains areas, particularly those with bison or livestock using the stream upstream or within sampled reaches. Plains streams sampled within this study were primarily used for livestock grazing upstream from sampled reaches. WICA streams were utilized by bison, and Beaver Dam Creek (MORU) had a heavily used horse trail along a portion of the stream. Livestock (or bison) grazing along the riparian area can also influence the structure of aquatic invertebrate communities by physically altering the habitat through trampling or foraging or by adding nutrients (through manure). These changes in habitat may lead to species replacement and a shift to greater numbers of tolerant taxa (Zomora-Munez and Alba Tercedor 1996; Del Rosario et al. 2002).

The Missouri River communities in North Dakota had slightly fewer total taxa than the lower reaches in South Dakota, but had 10% more intolerant taxa, greater EPT abundance and more EPT taxa. The Missouri River in MNRR had higher percentages of collector-gatherers and clingers, but smaller percentages of swimmers. HBI was nearly equal for all Missouri River sites. Plecoptera was not collected from MNRR sites, but added over 6% to the total abundance for North Dakota Missouri River sites. Higher numbers of intolerant taxa may in part, be due to lower average temperature, higher dissolved oxygen, lower conductivity and dissolved solids from North Dakota sites (Weiel et al. 2003). An ideal temperature range for maximum growth of stoneflies falls between 5°C and 22°C (Brinck 1949; Heiman and Knight 1975). Summer temperatures of MNRR approached upper limits of that range while those from North Dakota sites were at the low end of the range.

Data collected from this effort characterize invertebrate communities of NGPN streams using consistent methodology. These data may be used to identify optimal invertebrate metrics for the development of an index of biotic integrity and serve to facilitate future biological monitoring with NGPN streams. Limited invertebrate data are available within many of the parks sampled during this study. Thus, we recommend additional invertebrate inventories and more comprehensive sampling efforts to further describe and inventory these unique and diverse biotic communities.

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