ASSESSING ECOSYSTEM INTEGRITY THROUGH ENERGY FLOW IN WETLANDS OF GRAND TETON AND YELLOWSTONE NATIONAL PARKS

WALTER G. DUFFY ✦ SOUTH DAKOTA COOPERATIVE RESEARCH UNIT
SOUTH DAKOTA STATE UNIVERSITY ✦ BROOKINGS

✦ INTRODUCTION

Ecosystems that possess physical, chemical and biological elements interacting in ways necessary for sustainability are said to have integrity. While conceptually appealing, measuring the condition of ecosystems has proven difficult. Ecosystems are thought to respond to stressors (e.g. detrimental or disorganizing influences) through changes in functional attributes such as energy flow and nutrient cycling and through changes in community structure as well as general system-level changes (Margalef 1981; Odum 1985; Kay and Schneider 1993). Attempts to assess ecosystem condition have rarely considered energy flow and focused instead on either community structure or nutrient cycling (Karr 1993).

Although energy flow has not been widely used as a tool in assessing and monitoring ecosystems, its importance to ecosystem integrity is recognized (Ricklefs 1979). All systems require energy and altering the nature (quantity, flow, flux) of that energy supply alters the quality of the ecosystem. In spite of this knowledge few, if any, agency programs devote attention to balancing energy sources (Karr 1993). Recent research suggests that positive relationships between biodiversity and energy flow within ecosystems may exist (Tillman 1996).

✦ OBJECTIVES

The goal of this research is to evaluate energy flow and flux through wetland aquatic invertebrate communities as a metric for assessing ecosystem integrity. Objectives being addressed as part of this goal are to: 1) develop pc-based bioenergetics models for common aquatic invertebrate species, 2) determine the variability (among years, among wetlands) associated with aquatic invertebrate secondary production estimates, 3) compare aquatic invertebrate secondary production estimates and P/B ratios from wetlands in stressed and non-stressed ecosystems and 4) compare aquatic invertebrate secondary production estimates with biological diversity of wetlands.

STUDY-AREA

This research is being conducted in Grand Teton and Yellowstone National Parks and the Prairie Pothole Region of South Dakota. Basin wetlands of various sizes occur throughout Grand Teton National Park and in the Lamar River Valley of Yellowstone National Park. Many thousands of basin wetlands occur in the Prairie Pothole Region of South Dakota.

Many of the wetlands in the Greater Yellowstone Ecosystem (GYE) should exist in a "relatively" natural setting and should exhibit energy flow functions (secondary production) typical of functional ecosystems. That is, rates of secondary production and P/B ratios should not be excessively high. In contrast, hundreds of thousands of wetlands in the Prairie Pothole region have been human influenced, often by agricultural activities. If hypotheses about the response of ecosystems to energy subsidies (Odum 1985) are correct, prairie wetlands should support greater amounts of aquatic invertebrate secondary production than GYE wetlands.

Eight wetlands within the GYE were selected for study and sampled during 1995. Four of these wetlands were located within Grand Teton National Park and four were located in the Lamar River Valley of Yellowstone National Park. Eight wetlands were again sampled in 1996, including six of the original wetlands selected in 1995. Sampling of these eight wetlands will continue for another three years.

✦ METHODS

Sampling for aquatic invertebrates as well as ancillary biological, physical and chemical data was conducted monthly from late May or early June through September of both years. Recording thermistors were placed in two wetlands during 1995 and six wetlands in 1996. Thermistors were programmed to record water temperature at 4 hr intervals. Water samples were collected for nutrient (nitrate-N, total-N, dissolved-P, total-P) concentration analysis in the lab each time biological samples were collected. Dissolved oxygen concentration, dissolved solids and pH were measured in the field. Beginning in 1996, chlorophyll a samples were collected as a measure of primary productivity and will be sampled each time aquatic invertebrates are collected.

Aquatic invertebrates were sampled using a 7.6 cm dia. x 1.5 m long core designed to sample the upper 10 cm of sediment and overlying water (Duffy and LaBar 1994). Immediately after collecting samples, they were rinsed through a 149 um sieve and preserved in 90% ethanol for later processing. Later processing of samples includes enumerating organisms in samples to obtain data on community composition and population change, and size measurements to assess organismal growth rates.

Production of the macroinvertebrate community will be modeled using a bioenergetics approach. Physiological data exists for a number of aquatic macroinvertebrates and mathematical models have been developed for some organisms (Kooijman 1993). However, I will develop bioenergetics models for aquatic invertebrate taxa common in wetlands of the GYE using an approach developed by Hewett and Johnson (1992). Modeling has not yet been initiated, but will be reported on in the future.

PRELIMINARY RESULTS AND DISCUSSION

Analyses of samples for ancillary physical and chemical data have been completed for both years. However, analysis of aquatic invertebrate samples is more laborious and have not been completed. Data presented here are intended to be representative, but not complete.

Wetlands sampled in the GYE may be classified by hydrologic regime into semi-permanent, seasonal or temporary (Table 1). Semi-permanent wetlands are those that contain water during all seasons in most years, seasonal wetlands contain surface water during much of the growing season, and temporary wetlands usually contain surface water for < 1 month each year. Wetlands in the GYE also may be characterized by buffering capacity, as indicated by alkalinity and specific conductance (Table 1). Wetlands in the northern range of Yellowstone National Park are well buffered, as are others having large drainage area:wetland surface area ratios. However, wetlands that have a relatively small drainage basin, relative to wetland surface area, such as the Signal Mountain site in Grand Teton National Park, are not well buffered (Table 1). Hydrogen ion concentration (pH) was typically neutral or basic in most wetlands during most months. However, slightly acidic conditions were occasionally encountered in those wetlands having the least buffering capacity.

Table 1. Maximum and minimum values of physical and chemical parameters measured in wetlands of the Greater Yellowstone Ecosystem.

Wetland	Hydrologic regime	Depth (cm)	Dissolved oxygen (mg/l)	pH (s.u.)	Specific conduct. (uS/cm)	Total alkalinity (meq/l)
Grand Teton NP						
Hedrick	S	0 - 105	1.6 - 5.8	7.2 - 8.5	220 - 580	1.7 - 4.9
Lozier	S	14 - 110	1.3 - 6.9	6.7 - 7.8	10 - 40	0.1 - 1.4
Moose	T	30	–	9.2	930	–
Plantain	S	50	–	7.4	270	–
Res. Station	SP	50 - 175	1.7 - 4.0	6.3 - 8.1	20 - 30	0.2 - 0.5
Signal Mt.	SP	85 - 166	1.2 - 5.7	6.3 - 8.2	10 - 20	0.1 - 0.6
Snake	SP	60 - 115	2.4 - 8.8	7.5 - 8.9	160 - 300	1.7 - 2.8
Yellowstone NP						
Bison	S	0 - 160	2.6 - 4.5	7.1 - 8.1	250 - 1150	4.4 - 6.2
Cont. Divide	S	60	8.1	–	<10	–
Coot	S	0 - 55	2.2 - 2.9	7.9 - 8.7	760	8.2 - 8.6
Lamar	S	80 - 120	2.4 - 8.0	7.7 - 9.7	180 - 212	1.8 - 2.0
Slough	SP	20 - 91	1.8 - 6.4	7.5 - 9.2	270 - 760	2.9 - 11.4
Wave	SP	33 - 103	2.0 - 5.8	7.9 - 10.1	270 - 550	3.7 - 7.2
Bridg.-Teton NF						
Temp. #1	T	30	–	7.5	50	–
Temp. #2	T	20	–	7.9	60	–
Semi-p. #1	SP	75	–	8.5	130	–
Semi-p. #2	SP	100	–	7.9	60	–

Water temperature in GYE wetlands exhibit considerable temporal variation. During 1996, water temperature increased to a maximum of > 21 °C in early July at most sites. Water temperature of wetlands on grasslands (Figure 1) appeared to remain warm longer than did the temperature of wetlands located in forested habitats (Figure 2). However, differences in seasonal temperature patterns are influenced by water depth and volume, as well as solar radiation.

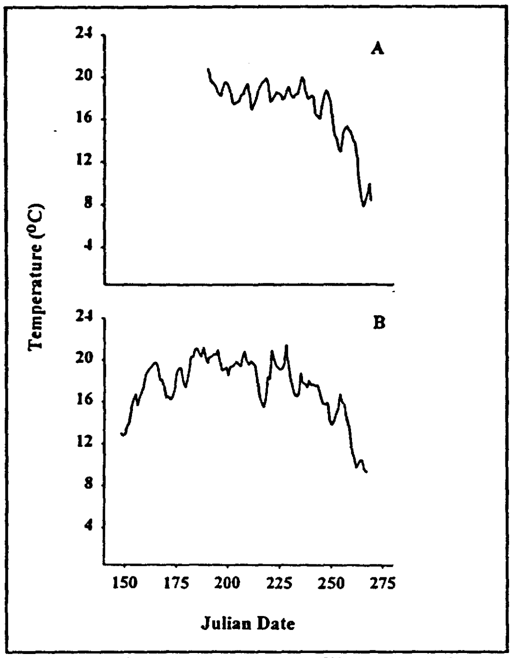

Figure 1. Mean daily water temperature at Wave wetland, Yellowstone National Park during (A) 1995 and (B) 1996.

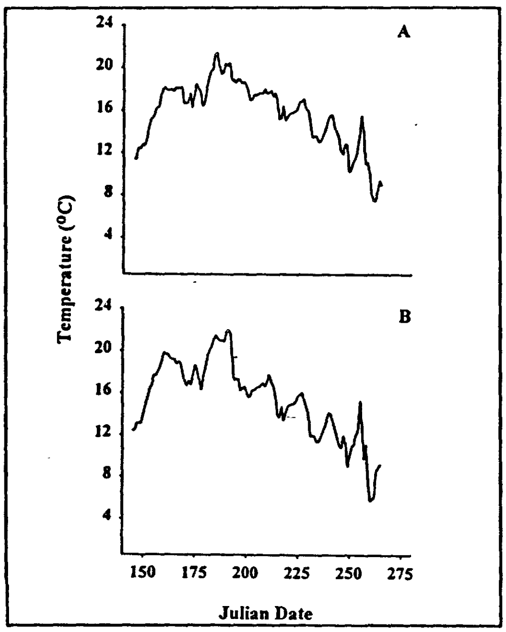

Figure 2. Mean daily water temperature at (A) Hedrick and (B) Lozier Wetlands, Grand Teton National Park, during 1996.

Nutrient concentrations in wetlands are often greater than concentrations found in lakes. In wetlands of the GYE, typical concentrations of total phosphorus are < 0.25 mg/l while total nitrogen concentrations most often ranged from 0.5 - 1.5 mg/l. Nutrient concentrations in the wetlands sampled tended to be greater in the northern range of Yellowstone National Park (Figure 3) than in Grand Teton National Park (Figure 4).

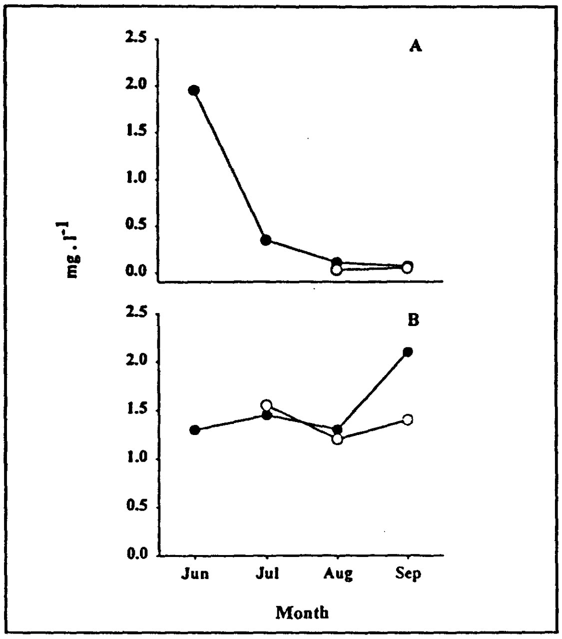

Figure 3. Concentration of (A) total phosphorus and (B) total nitrogen at Wave Wetland, Yellowstone National Park. Open circles are 1995 data and closed circles are 1996 data.

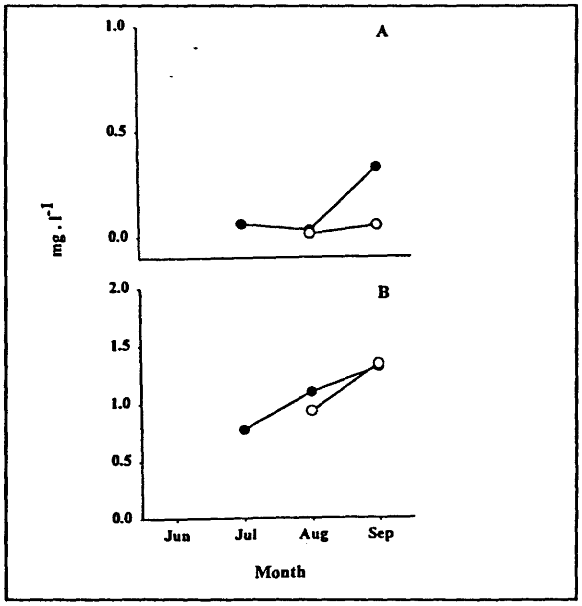

Figure 4. Concentration of (A) total phosphorus and (B) total nitrogen at Signal Mountain Wetland, Grand Teton National Park. Open circles are 1995 data and closed circles are 1996 data.

Wetlands of the GYE tend to support a diverse community of aquatic invertebrates. A total of 133 taxa have been identified from the 1995 samples that have been processed (Table 2). Perhaps more importantly, 80 (60.1%) of these taxa are taxa that have not been previously recorded in either Grand Teton or Yellowstone National Parks. This high proportion of new distributional records is the result of a paucity of wetland sampling in the parks and not due to rarity of taxa. None of the 133 taxa identified could be classified as rare.

Aquatic invertebrate communities in GYE wetlands are often abundant, as well as diverse. Seasonal abundance tended to increase from spring through autumn at most wetlands sampled (Figure 5). Abundance of aquatic invertebrates at more productive sites, such as the Wave site in Yellowstone National Park, often approached or exceeded 200,000 individuals . m^{-2} (Figure 5). More typically, seasonal abundance increased from around 10,000 . m^{-2} in spring to between 20,000 and 40,000 . m^{-2} by autumn (Figure 5).

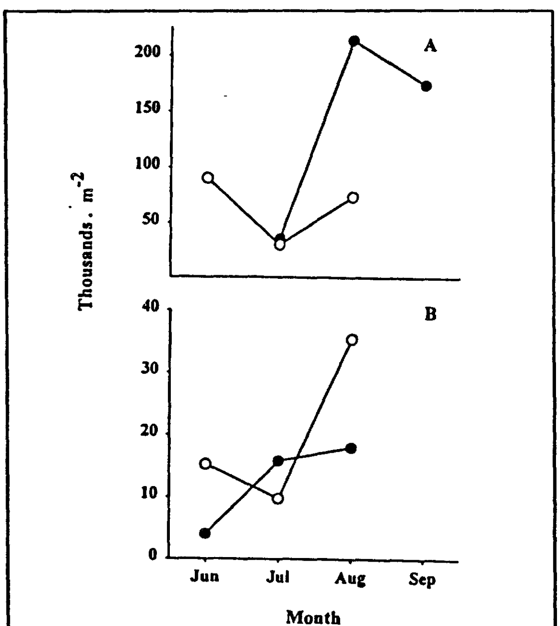

Figure 5. Total aquatic invertebrates. m^{-2} at four GYE wetlands. (A) closed circle = Wave Wetland, YNP, (A) open circle = Hedrick Wetland, GTNP, (B) closed circle = Snake Wetland, GTNP, and (B) open circle = Signal Mountain Wetland, GTNP.

The preliminary nature of these data prevent extensive analyses or conclusions. However, several observations can be made. First, wetlands of the GYE obviously do support a very diverse aquatic invertebrate community and one that has received scant attention in the past. Second, individuals in these aquatic invertebrate communities can reach exceptional densities. Analyses of relationships between wetland habitat conditions, aquatic invertebrate community composition and production should provide valuable information on how these wetlands function within the GYE.

Table 2. Aquatic invertebrate taxa collected from wetlands in the Greater Yellowstone Ecosystem.

Order	Family	*Genus species*
Turbellaria		
		Phagocata sp.
Nematoda		
		Mesodorylaimus sp.
Hydroida		
		Hydra americana
Rhynchobdellidae		
	Glossiphoniidae	
		Helobdella fusca
		Helobdella stagnalis
		Placobdella ornata
Oligochaeta		
	Naididae	
		Chaetogaster diaphanus
		Pristina idrensis
		Paranais literalis
	Tubificidae	
		Limnodrilus udekemianus
Cladocera		
	Daphnidae	
		Ceriodaphnia reticulata
		Daphnia pulex
		Daphnia rosea
		Daphnia schodleri
		Scapholeberis mucronata
		Simocephalus serrulatus
		Simocephalus vetulus
	Chydoridae	
		Acroperus harpae
		Alona guttata
		Biapture affinis
		Chydorus sphaericus
		Graptoleberis testudinaria
		Leydigia leydigia
		Pleuroxus aduncus
		Pleuroxus procurvatus
	Macrothricidae	
		Eurycercus lamellatus
		Lathonura rectirostris
		Macrothrix montana
	Sididae	
		Diaphanosoma brachyurum
		Sida crystallina
Copepoda		
	Cyclopoida	
		Acanthocyclops vernalis
		Eucyclops agilis
		Aedes fitchii
		Anopheles earlei
		Culiseta alaskaensis
		Culiseta inornata
	Dixidae	
		Dixella sp.
	Ephidridae	
		Hydrellia sp.
		Parydra sp.
	Tipulidae	
		Prionocera cf. primoveris
		Tipula sp.
Collembola		
		Podura aquatica
Ephemeroptera		
	Caenidae	
		Caenis youngi
	Baetidae	
		Callibaetis ferrugineus
Coleoptera		
	Carabidae	
	Chrysomelidae	
		Donacia subtilus
		Donacia tubercalifrons
	Dytiscidae	
		Cybister sp.
		Coptotomus cf. longulus
		Eretes sp.
		Graphoderus sp.
		Hydaticus modestus
		Laccophytes sp.
		Rhantus zimmermanni
	Gyrinidae	
		Gyrinus affinis
		Gyrinus latilimbus
	Haliplidae	
		Haliplus immaculicollis
		Haliplus longulus
		Haliplus subguttatus
	Helophoridae	
		Helophorus lineatus
	Hydrophilidae	
		Tropisternus sp.
	Staphylinidae	
		Stenus sp.
Hemiptera		
	Corixidae	
		Callicorixa audeni
		Cenocorixa sp.
		Hesperocorixa atopodonta
		Sigara alternata
	Gerridae	
		Gerris buenoi
		Macrocyclops albidus
		Tropocyclops prasinus
	Harpacticoida	
	Calanoida	
		Aglaodiaptomus leptopus
		Hesperodiaptomus shoshone
		Leptodiaptomus coloradensis
Anostraca		
		Brachinecta coloradensis
		Streptocephalus dorothea
Conchostraca		
		Lynceus brachyurus
Amphipoda		
		Hyalella azteca
Ostracoda		
		Candona sp.
		Candona decora
		Cypridopsis aculeata
		Cypris pubera
		Eucypris rava
		Eucypris hystrix
		Limnocythere reticulata
Hyrdracarina		
		Arrenurus sp.
		Hydrachna sp.
Diptera		
	Ceratopogonidae	
		Bezzia/Probezzia sp.
		Palpomyia sp.
		Stilobezzia sp.
	Chironomidae	
		Ablabesmyia sp.
		Procladius sp.
		Chironomus sp
		Cladopelma sp.
		Cryptochironomus sp.
		Paratanytarsus sp.
		Psectrocladius sp.
		Derotanypus sp.
		Rheocricotopus sp.
		Corynoneura sp.
		Thienemanniella sp.
		Tvetenia sp.
	Chaoboridae	
		Chaoborus americanus
	Culicidae	
		Aedes cataphylla
		Gerris mutabilis
		Gerris remigis
	Notonectidae	
		Notonecta irrorata
		Notonecta undulata
Odonata		
		Coenagrion resolutum
		Enallagma carunculatum
		Enallagma civile
		Lestes congener
		Lestes unguiculatus
		Aeshna sp.
		Pachydiplax sp.
		Sympetrum sp.
Trichoptera		
		Ecclisomyia spp.
		Grammotaulis sp.
		Limnephilus sp.
		Philarctus quaeris
Mecoptera		
	Bittacidae	
		Bittacus sp.
Gastropoda		
		Armiger crista
		Gyraulus circumstriatus
		Stagnicola elodes
		Lymnaea stagnalis jugularis
		Helisoma cf. anceps anceps
		Helisoma trivolvis subcrenatum
		Planorbula campestris
		Promenetus exacuous exacuous
		Valvata sincera
Pelecypoda		
		Pisidium milium
		Sphaerium lacustre
		Spaerium nitidum
		Sphaerium occidentale

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