Nebraska and Kansas Turner Properties Stream Inventory

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Annual Progress Report to:
Turner Properties, Inc.,
Bozeman, Montana

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Overview

Stream fish and habitat sampling was conducted from May to October of 2005 on Turner Property ranches in Nebraska and Kansas to determine the presence and distribution of stream fishes. Sampling sites on all 10 streams (Bear Creek, Blue Creek, Big Sandy Creek, Deer Creek, Horseshoe Drainage Ditch, Mud Creek, Niobrara River, North Loup River, Salt Fork Arkansas River, and Snake River) were selected based on the total stream length available within ranch property boundaries prior to sampling. Approximately 173 rkm were predetermined to be sampled using GIS stream data, topographic maps, and aerial photos. A systematic design was used to assign sampling sites every 3 rkm for each stream resulting in 49 sites. An attempt was made to locate the most downstream sampling site 1 rkm upstream from the property boundary. At least 3 sites were sampled on every stream except the Niobrara River. Due to limited access and low flows only 2 sites were sampled in 2005. The Niobrara will however be extensively sampled in the summer of 2006.

Field sampling of all 49 sites was conducted using a modification of the established Environmental Protection Agency's (EPA) standardized protocol for sampling fish, physiochemical instream habitat and adjacent terrestrial characteristics (Lazorchak et al. 1998). Site length was calculated to be 40 times the mean stream width (MSW) with a minimum length of 150 m and a maximum length of 300 m.

Fish sampling was conducted using a Smith-Root LR-24 backpack or Smith-Root Tote Barge electrofisher using pulsed DC current. All sampling was conducted using a single pass upstream run. Sampling was supplemented by a single downstream seine at each site. A total of 19,091 fish consisting of 35 species and one hybrid were collected in 2005. (Table 1 and Appendices A & B) All fish have been identified and measured. Catch per unit effort (CPUE)

was determined for each species as the number of fish per minute of electrofishing or seining by site. A voucher collection has been created for each state to be stored and documented at the each state's respective natural history museums.

Physical habitat (i.e. depth, width, instream fish cover, etc.) was measured at six evenly spaced transects at each site. Prior to fish sampling and physical habitat measurements, discharge and *in-situ* water chemistry (i.e. water temperature, conductivity, turbidity, alkalinity, etc.) were measured (Appendix C). Data not included in Appendix C but currently in preparation are riparian vegetation structure, riparian human influence impacts, large woody debris abundance, channel classifications, canopy cover, and substrate composition.

All fish and physical habitat data have been entered into a database designed specifically for the fish inventory. This database was created to be integrated into both Nebraska and Kansas stream monitoring program databases for comparison and inclusion of both fish and physical habitat data.

Preliminary analysis

Turner properties data was supplemented by existing stream monitoring data from the Nebraska Game and Parks Commission (NGPC) and Kansas Department of Wildlife and Parks (KDWP) in a preliminary analysis to determine the influence of instream physical habitat on the structuring of streams throughout the region.

Kansas

The 11 sites sampled on Turner properties in Kansas were grouped with 105 KDWP sites in the Kansas Redhills. Forty eight total species were collected at the 116 sites. Of these 48 species the Arkansas darter *Etheostoma cragini*, a state threatened species, occurred at 65 sites

(none collected on Turner Property) and plains minnow *Hybognathus placitus*, a Kansas Species In Need of Conservation (SINC) species, occurred at 31 sites (7 sites on Turner Property).

Fish habitat in this analysis was defined by 15 environmental variables including five instream fish cover variables (percent cover of filamentous algae, macrophytes, woody debris, overhanging vegetation, and undercut banks), two measures of stream size (mean depth and mean width), and eight physiochemical parameters (water temperature, dissolved, oxygen, conductivity, turbidity, alkalinity, chlorides, nitrates, ammonia, and phosphorus) (Appendix C).

Nebraska

The 38 sites located within Turner properties were analyzed in conjunction with 23 NGPC sites for a total of 61 sites in the Nebraska Sandhills. Forty six species total species were collected at the 61 sites. Of these 46 species the northern redbelly dace *Phoxinus eos*, Tier 1 at risk and state threatened species, occurred at 11 sites (all Turner property sites) and plains topminnow *Fundulus sciadicus*, Nebraska Tier 1 at risk species, occurred at 38 sites (29 sites on Turner Properties). The brook stickleback *Culea inconstans* and orangethroat darter *Etheostoma spectabile* are listed as Tier II at risk species and occurred at 22 and 10 sites on Turner Properties, respectively.

Fish habitat in this analysis was defined 11 environmental variables including five instream fish cover variables (percent cover filamentous algae, macrophytes, woody debris, overhanging vegetation, and undercut banks), two measures of stream size (mean depth and mean width), and four physiochemical parameters (water temperature, dissolved, oxygen, conductivity, and turbidity) (Appendix C). Since the NGPC sites data did not include similar water chemistry data as in the Redhills' analysis, these variables were omitted from the Turner Properties data in the analysis.

Analysis

A principal component analysis (PCA) was used on all of the before mentioned environmental variables for each region to identify the primary environmental gradients that influence the sites within the regions.

Results

The PCA for both regions (Figures 1 and 2) found that nearly all of the same environmental variables (percent cover of filamentous algae, macrophytes, woody debris, mean width, and conductivity) were most important in structuring sites throughout their respective regions, indicating consistency in the structuring of stream types based on instream fish cover.

Future directions

We will continue to analyze the additional habitat variables collected (i.e. canopy cover, substrate, adjacent terrestrial landuse, etc.) to determine the factors that influence fish distributions in the Great Plains. To better understand the factors influencing these communities various spatial scales of environmental influences will be evaluated; 1) instream cover and physiochemical influences, 2) adjacent terrestrial landuse and vegetation, 3) upstream adjacent stream landcover, 4) upstream basin-wide landcover. Beyond environmental influences, community composition structure will also be evaluated throughout each region. This will primarily focus on but not be limited to the status of native species throughout each of the regions.

Additionally, a separate analysis of the status of the plains topminnow, a species of special conservation concern in the Nebraska, is currently underway. This species was found throughout all ranches owned by Turner Properties in the Nebraska Sandhills. Declines of the plains topminnow have been attributed to a number of causes (i.e. competition, predation, and

habitat loss) (Rahel and Thel 2004). However, there is great need for information regarding the causes that have been proposed as influencing the species. The objectives of this study are to 1) determine if historical changes in community structure are correlated with declines of the plains topminnow and 2) determine what potential environmental influence/physical habitat changes have occurred which have potentially resulted in the decline of the species.

In the summer of 2006 four streams, Salt Fork of the Arkansas, Blue Creek, North Loup, and the Niobrara will be extensively sampled to evaluate the established sampling protocols for wadeable streams (Lazorchak et al. 1998). The same protocol for fish sampling as 2005 will be used to determine species richness and CPUE for sites. Power analysis will be used to determine how many sites per stream and site length are needed to detect 25% and 10% difference in CPUE for each species, similar to methods described by Allen et al. (1999). The number of sites needed to reach the asymptotic species richness will correlated against stream habitat metrics (e.g. mean depth, turbidity, conductivity, flow, etc.) to determine if the number of sites needed is related to stream habitat. Similarly, the number of samples needed to achieve the desired level of precision (10 or 25%) for the power analysis will be correlated with the same habitat metrics. These analyses will provide insight on the effects of habitat on precision of CPUE and species richness and to better refine sampling protocols for stream fishes.

References

Allen, M. S., M. M. Hale, and W. E. Pine III. 1999. Comparison of trap nets and otter trawls for sampling black crappie in two Florida lakes. North American Journal of Fisheries Management 19:977-983.

Lazorchak, J. M., D. J. Klemm, D. V. Peck (editors). 1998. Environmental monitoring and assessment program – surface waters: field operations and methods for measuring ecological condition of wadable streams. EPA/620/R-94/004F. USEPA. Washington, D.C.

Rahel, F. J. amd L. A. Thel. (2004, September 13). Plains topminnow (*Funduls sciadicus*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/plainstopminnow.pdf [March, 30 2006].

Table. 1 Occurrence of all species by stream

	Bear Creek	Blue Creek	Big Sandy Creek	Deer Creek	Horseshoe Drainage Ditch	Mud Creek	Niobrara River	North Loup River	Salt Fork Arkansas River	Snake river
Bigmouth shiner		X		X		X	X	X		
Black bullhead						X				
Bluegill									X	
Bluntnose minnow									X	
Brassy minnow	X					X		X		
Brook stickleback[a]	X			X		X	X	X		X
Central stoneroller			X				X		X	
Channel catfish									X	
Creek chub		X		X		X	X	X		X
Common carp								X		
Emerald shiner									X	
Fathead minnow		X		X		X	X	X	X	X
Green sunfish			X		X			X	X	
Green x longear sunfish			X							
Iowa darter							X	X		
Largemouth bass							X		X	
Longear sunfish			X						X	
Longnose dace		X		X		X	X	X		X
Northern redbelly dace[b]						X		X		
Orangethroat darter[a]		X	X			X				
Plains killifish									X	
Plains minnow[c]									X	
Plains topminnow[b]		X		X		X	X	X		X
Pumpkinseed					X					
Red shiner			X				X	X	X	
River shiner						X		X		
Rock bass							X			
Sand shiner			X				X		X	X
Shorthead redhorse							X			
Stonecat		X		X			X	X		
Suckermouth minnow	X								X	
Western mosquitofish			X						X	
White sucker		X		X			X	X		
Yellow bullhead									X	
Yellow perch							X			

[a] Nebraska Tier II At-risk species

[b]Nebraska Tier 1 At-risk species

[c]Kansas Species In Need of Conservation (SINC)

Figure 1. PCA ordiantion of 116 Kansas Redhill stream sites

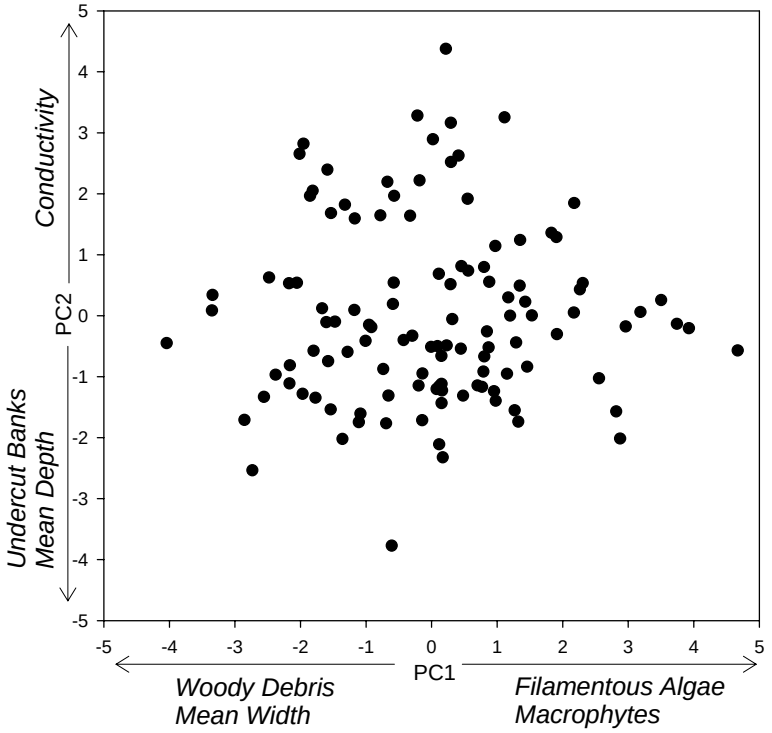
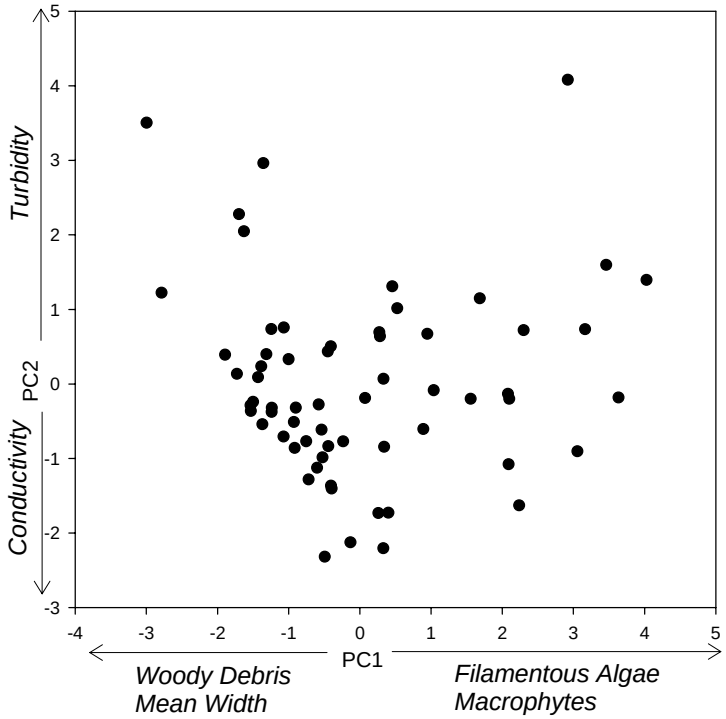


Figure 2. PCA ordination of 61 Nebraska Sandhill stream sites



Appendix A. Catch per unit effort (fish/min of **electrofishing**) by species sampled from streams within Turner Properties for May through October 2005. Number in parenthesis represents standard error. N = number of sites.

				Species													
Ranch-Stream	N	Mean time electrofished (min)		Bigmouth shiner		Black bullhead		Bluegill		Bluntnose minnow		Brassy minnow		Brook stickleback	
Blue Creek Ranch																	
Blue Creek	8	45.1	(3.8)	0.01	(0.01)	0	(0)	0	(0)	0	(0)	0	(0)	0.64	(0.81)		
Deer Creek Ranch																	
Deer Creek	5	24.9	(2.1)	0.60	(0.78)	0	(0)	0	(0)	0	(0)	0	(0)	0.02	(0.05)		
Niobrara River	2	46.7	(18.8)	1.46	(1.4)	0	(0)	0	(0)	0	(0)	0	(0)	0.06	(0.04)		
Snake River	3	16.8	(1.8)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.09	(0.15)		
McGinley Ranch																	
Bear Creek	3	15.7	(1.4)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.19	(0.12)		
Horseshoe Drainage Ditch[a]	3	20.0	(0.2)	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])		
Spikebox Ranch																	
North Loup River	10	41.4	(12.3)	0.37	(0.63)	0.04	(0.07)	0	(0)	0	(0)	0.53	(1.09)	0.04	(0.08)		
Mud Creek	4	27.1	(3.1)	0.05	(0.07)	0.03	(0.04)	0	(0)	0	(0)	0	(0)	0.16	(0.26)		
Z-Bar Ranch																	
Big Sandy Creek	1[b]	13.8	([b])	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])		
Salt Fork Arkansas River	7	29.5	(7.6)	0	(0)	0	(0)	0.20	(0.14)	0.04	(0.1)	0	(0)	0	(0)		

[a] No fish collected.

[b] Only one site electrofished due to high conductivity

Appendix A. Continued (see page 10 for heading)

Ranch-Stream	Species											
	Central stoneroller		Channel catfish		Common carp		Creek chub		Emerald shiner		Fathead minnow		Green sunfish	
Blue Creek Ranch														
Blue Creek	0	(0)	0	(0)	0	(0)	14.85	(5.88)	0	(0)	0.05	(0.11)	0.01	(0.01)
Deer Creek Ranch														
Deer Creek	0	(0)	0	(0)	0	(0)	0.26	(0.23)	0	(0)	0.40	(0.52)	0	(0)
Niobrara River	0.02	(0.02)	0	(0)	0	(0)	1.11	(0.93)	0	(0)	0.70	(0.57)	0	(0)
Snake River	0	(0)	0	(0)	0	(0)	0.55	(0.95)	0	(0)	1.34	(1.3)	0	(0)
McGinley Ranch														
Bear Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.61	(0.94)	0	(0)
Horseshoe Drainage Ditch[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Spikebox Ranch														
North Loup River	0	(0)	0	(0)	0.01	(0.01)	0.71	(1.33)	0	(0)	0.09	(0.27)	0.01	(0.02)
Mud Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.69	(1.26)	0	(0)
Z-Bar Ranch														
Big Sandy Creek	0.80	([b])	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])	0.29	([b])
Salt Fork Arkansas River	0.20	(0.31)	0.03	(0.041)	0	(0)	0	(0)	0.21	(0.14)	0.01	(0.03)	0.23	(0.15)

Appendix A. Continued (see page 10 for heading)

Ranch-Stream	Species													
	Iowa darter		Largemouth bass		Longear sunfish		Longnose dace		Northern redbelly dace		Orangethroat darter		Plains killifish	
Blue Creek Ranch														
Blue Creek	0	(0)	0	(0)	0	(0)	0.10	(0.12)	0	(0)	5.10	(1.34)	0	(0)
Deer Creek Ranch														
Deer Creek	0	(0)	0	(0)	0	(0)	9.50	(10.5)	0	(0)	0	(0)	0	(0)
Niobrara River	0.01	(0.02)	0.01	(0.012)	0	(0)	0.20	(0.16)	0	(0)	0	(0)	0	(0)
Snake River	0	(0)	0	(0)	0	(0)	0	(0)	0.84	(0.73)	0	(0)	0	(0)
McGinley Ranch														
Bear Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Horseshoe Drainage Ditch[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Spikebox Ranch														
North Loup River	0.01	(0.02)	0	(0)	0	(0)	2.66	(3.15)	0.78	(1.75)	0	(0)	0	(0)
Mud Creek	0	(0)	0	(0)	0	(0)	0.92	(1.07)	0.13	(0.13)	0.08	(0.11)	0	(0)
Z-Bar Ranch														
Big Sandy Creek	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])	1.59	([b])
Salt Fork Arkansas River	0	(0)	0.09	(0.06)	0.08	(0.07)	0	(0)	0	(0)	0	(0)	2.08	(1.15)

Appendix A. Continued (see page 10 for heading)

Ranch-Stream	Species											
	Plains minnow		Plains topminnow		Red shiner		Shorthead redhorse		Stonecat		Suckermouth minnow		Western mosquitofish	
Blue Creek Ranch														
Blue Creek	0	(0)	0.50	(0.36)	0	(0)	0	(0)	0.06	(0.07)	0	(0)	0	(0)
Deer Creek Ranch														
Deer Creek	0	(0)	0.05	(0.1)	0	(0)	0	(0)	0.11	(0.09)	0	(0)	0	(0)
Niobrara River	0	(0)	0.69	(0.34)	0.99	(1.14)	0.47	(0.1)	0.06	(0.)	0	(0)	0	(0)
Snake River	0	(0)	1.10	(0.71)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
McGinley Ranch														
Bear Creek	0	(0)	0.02	(0.03)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Horseshoe Drainage Ditch[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Spikebox Ranch														
North Loup River	0	(0)	0.43	(0.46)	0	(0)	0	(0)	0.06	(0.09)	0	(0)	0	(0)
Mud Creek	0	(0)	0.24	(0.39)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Z-Bar Ranch														
Big Sandy Creek	0	([b])	0	([b])	0.51	([b])	0	([b])	0	([b])	0	([b])	0	([b])
Salt Fork Arkansas River	3.65	(1.49)	0	(0)	0.84	(0.38)	0	(0)	0	(0)	0.03	(0.03)	0.16	(0.05)

Appendix A. Continued (see page 10 for heading)

Ranch-Stream	Species											
	White sucker		Yellow bullhead		Yellow perch		River shiner		Rock bass		Sand shiner	
Blue Creek Ranch												
Blue Creek	0.55	(0.34)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Deer Creek Ranch												
Deer Creek	0.07	(0.1)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Niobrara River	2.11	(1.)	0	(0)	0.36	(0.04)	0	(0)	0.01	(0.01)	5.80	(5.88)
Snake River	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.02	(0.04)
McGinley Ranch												
Bear Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Horseshoe Drainage Ditch[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Spikebox Ranch												
North Loup River	0.29	(0.16)	0	(0)	0	(0)	0.02	(0.07)	0	(0)	0.02	(0.05)
Mud Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Z-Bar Ranch												
Big Sandy Creek	0	([b])	0	([b])	0	([b])	0	([b])	0	([b])	1.59	([b])
Salt Fork Arkansas River	0	(0)	0.02	(0.02)	0	(0)	0	(0)	0	(0)	6.14	(5.12)

Appendix B. Catch per unit effort (fish/min of **seining**) by species sampled from streams within Turner Properties for May through October 2005. Number in parenthesis represents standard error. N = number of sites.

				Species												
Ranch-Stream	N	Mean time seined (min)		Bigmouth shiner		Black bullhead		Bluegill		Brassy minnow		Brook stickleback		Central stoneroller	
Blue Creek Ranch																
Blue Creek	8	7.38	(0.55)	0.03	(0.09)	0	(0)	0	(0)	0	(0)	0.02	(0.05)	0	(0)
Deer Creek Ranch																
Deer Creek	3[b]	5.66	(0.8)	11.14	(8.78)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Niobrara River	2	5.04	(0.48)	10.89	(2.46)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Snake River	2[b]	4.79	(1.54)	0	(0)	0	(0)	0	(0)	0	(0)	0.22	(0.07)	0	(0)
McGinley Ranch																
Bear Creek[a]	0[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Horseshoe Drainage Ditch	3	8.57	(3.37)	0	(0)	0.07	(0.06)	0.09	(0.09)	0	(0)	0	(0)	0	(0)
Spikebox Ranch																
North Loup River	4[b]	5.88	(2.19)	6.09	(4.09)	0	(0)	0	(0)	0.20	(0.41)	0	(0)	0	(0)
Mud Creek	3[b]	4.70	(0.17)	9.90	(10.96)	0	(0)	0	(0)	0.22	(0.22)	0	(0)	0	(0)
Z-Bar Ranch																
Big Sandy Creek	4	5.30	(0.37)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	22.97	(16.38)
Salt Fork Arkansas River	7	6.81	(1.08)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.05	(0.08)

[a] No collected.

[b] Due to extensive instream cover not all sites were seinable. See appendix A for number of sites electrofished

Appendix B. Continued (see page 15 for heading)

Ranch-Stream	Species											
	Creek chub		Emerald shiner		Fathead minnow		Grass pickerel		Green sunfish		Largemouth bass		Longear sunfish	
Blue Creek Ranch												
Blue Creek	0.71	(0.65)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Deer Creek Ranch												
Deer Creek	0.07	(0.12)	0	(0)	0.18	(0.17)	0	(0)	0	(0)	0	(0)	0	(0)
Niobrara River	0	(0)	0	(0)	0.11	(0.15)	0	(0)	0	(0)	0	(0)	0	(0)
Snake River	0.36	(0.26)	0	(0)	3.12	(3.27)	0	(0)	0	(0)	0	(0)	0	(0)
McGinley Ranch												
Bear Creek[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Horseshoe Drainage Ditch	0	(0)	0	(0)	0	(0)	0.08	(0.15)	0.07	(0.06)	0	(0)	0	(0)
Spikebox Ranch												
North Loup River	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Mud Creek	0.42	(0.72)	0	(0)	0.91	(1.57)	0	(0)	0	(0)	0	(0)	0	(0)
Z-Bar Ranch												
Big Sandy Creek	0	(0)	0	(0)	0	(0)	0	(0)	2.56	(3.26)	0.14	(0.19)	2.13	(3.22)
Salt Fork Arkansas River	0	(0)	1.02	(0.99)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)

Appendix B. Continued (see page 15 for heading)

Ranch-Stream	Species													
	Longnose dace		Northern pike		Orangethroat darter		Plains killifish		Plains minnow		Plains topminnow		Pumpkinseed	
Blue Creek Ranch														
Blue Creek	0.46	(0.63)	0	(0)	0.05	(0.07)	0	(0)	0	(0)	0	(0)	0	(0)
Deer Creek Ranch														
Deer Creek	19.36	(7.76)	0	(0)	0	(0)	0	(0)	0	(0)	0.13	(0.11)	0	(0)
Niobrara River	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.11	(0.15)	0	(0)
Snake River	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.58	(0.33)	0	(0)
McGinley Ranch														
Bear Creek[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Horseshoe Drainage Ditch	0	(0)	0.03	(0.05)	0	(0)	0	(0)	0	(0)	0	(0)	0.08	(0.15)
Spikebox Ranch														
North Loup River	2.91	(2.97)	0	(0)	0	(0)	0	(0)	0	(0)	0.14	(0.27)	0	(0)
Mud Creek	12.78	(11.95)	0	(0)	0.07	(0.12)	0	(0)	0	(0)	0	(0)	0	(0)
Z-Bar Ranch														
Big Sandy Creek	0	(0)	0	(0)	0.38	(0.54)	19.81	(22.65)	0	(0)	0	(0)	0	(0)
Salt Fork Arkansas River	0	(0)	0	(0)	0	(0)	26.79	(8.98)	3.17	(5.18)	0	(0)	0	(0)

Appendix B. Continued (see page 15 for heading)

Ranch-Stream	Species													
	Red shiner		River shiner		Sand shiner		Stonecat		Longear x Green Sunfish		Western mosquitofish		White sucker	
Blue Creek Ranch														
Blue Creek	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.07	(0.1)
Deer Creek Ranch														
Deer Creek	0	(0)	0	(0)	0	(0)	0.12	(0.11)	0	(0)	0	(0)	0	(0)
Niobrara River	2.47	(1.92)	0	(0)	6.99	(5.16)	0	(0)	0	(0)	0	(0)	0	(0)
Snake River	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
McGinley Ranch														
Bear Creek[a]	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])	0	([a])
Horseshoe Drainage Ditch	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Spikebox Ranch														
North Loup River	1.48	(2.96)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0.10	(0.12)
Mud Creek	0	(0)	0.22	(0.22)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
Z-Bar Ranch														
Big Sandy Creek	2.76	(1.65)	0	(0)	20.48	(23.12)	0	(0)	0.05	(0.097)	1.10	(1.26)	0	(0)
Salt Fork Arkansas River	3.05	(2.63)	0	(0)	27.06	(11.17)	0	(0)	0	(0)	0.08	(0.1)	0	(0)

Appendix C. Mean **physical habitat** and **cover** characteristics for streams within Turner Properties sampled during May through October 2005. Number in parenthesis represents standard error. N = number of sites

		Physiochemical variables													
Ranch-Stream	N	Mean depth (cm)		Mean width (m)		Discharge (m3/s)		Filamentous algae (%)		Macrophytes (%)		Large woody debris (%)		Brush/small woody debris (%)	
Blue Creek Ranch															
Blue Creek	8	44.7	(4.5)	9.8	(1.9)	2.01	(0.17)	18.1	(21.4)	50.0	(0)	0	(0)	1.0	(2.3)
Deer Creek Ranch															
Deer Creek	5	18.2	(5.4)	2.6	(0.9)	0.15	(0.1)	0.0	(0)	36.7	(22.8)	1.3	(3.)	6.0	(13.4)
Niobrara River	2	14.8	(3.4)	29.8	(13.7)	2.33	(0.45)	45.0	(0)	17.5	(10.6)	3.3	(2.4)	5.0	(4.7)
Snake River	3	14.0	(5.9)	1.7	(0.5)	0.04	(0.01)	0.0	(0)	28.3	(20.2)	0	0	2.2	(1.9)
McGinley Ranch															
Bear Creek	3	20.3	(2.4)	1.4	(0.2)	0.02	(0.01)	14.4	(13.6)	36.1	(42.8)	0	(0)	0	(0)
Horseshoe Drainage Ditch	3	34.2	(4.)	3.9	(2.4)	0.23	(0.07)	41.7	(38.2)	46.7	(39.4)	0	(0)	0	(0)
Spikebox Ranch															
North Loup River	10	30.5	(7.5)	8.2	(4.8)	1.23	(0.75)	3.8	(3.9)	40.0	(13.1)	0	(0)	5.3	(9.6)
Mud Creek	4	32.9	(8.8)	3.2	(0.4)	0.32	(0.15)	34.2	(35.2)	43.5	(20.2)	0	(0)	18.8	(23.9)
Z-Bar Ranch															
Big Sandy Creek	4	15.9	(9.3)	3.0	(1.1)	0.02	(0.01)	42.1	(15.8)	32.1	(30.9)	0.8	(1.)	5.0	(2.7)
Salt Fork Arkansas River	7	5.3	(0.8)	20.0	(5.7)	0.32	(0.03)	0.0	(0)	0	(0)	0.2	(1.7)	1.0	(7.9)

Appendix C. Continued (see page 19 for heading)

Ranch-Stream	Physiochemical variables													
	Overhanging vegitation (%)		Undercut banks (%)		Boulders (%)		Temperature (C^o)		Dissolved oxygen (mg/l)		Specific conductance (umhos/cm)		Turbidity (NTUs)	
Blue Creek Ranch														
Blue Creek	12.5	(7.1)	1.9	(1.4)	0	(0)	20.35	(2.7)	6.3	(0.7)	157.9	(4.0)	11.7	(2.3)
Deer Creek Ranch														
Deer Creek	27.0	(17.9)	8.0	(1.8)	0	(0)	20.52	(3.5)	6.6	(0.5)	119.5	(1.5)	13.7	(6.2)
Niobrara River	10.0	(0)	0	(0)	0.8	(1.2)	16.60	(7.2)	3.6	(0.5)	262.1	(11.9)	6.2	(2.2)
Snake River	25.0	(13.23)	1.7	(2.9)	0	(0)	24.83	(4.1)	4.2	(1.9)	287.8	(28.8)	6.9	(2.4)
McGinley Ranch														
Bear Creek	47.8	(14.4)	0.0	(0)	0	(0)	19.10	(5.7)	6.0	(0.9)	125.0	(2.6)	3.3	(0.95)
Horseshoe Drainage Ditch	23.9	(24.1)	11.7	(16.1)	0	(0)	17.00	(2.9)	6.0	(3.04)	403.3	(23.4)	4.6	(1.5)
Spikebox Ranch														
North Loup River	14.7	(8.4)	2.0	(2.3)	5.8	(7.7)	21.54	(2.8)	3.2	(1.5)	173.0	(6.3)	4.9	(1.4)
Mud Creek	38.3	(27.3)	1.3	(2.5)	0	(0)	24.78	(1.9)	4.3	(1.9)	238.5	(2.4)	9.1	(4.6)
Z-Bar Ranch														
Big Sandy Creek	14.2	(10.7)	8.8	(14.2)	0	(0)	23.48	(4.7)	2.7	(2.3)	2610.8	(349.8)	1.9	(0.4)
Salt Fork Arkansas River	1.1	(14.3)	0.1	(1.3)	0	(0)	28.39	(4.8)	3.5	(1.6)	3328.9	(224.0)	14.4	(3.7)

Appendix C. Continued (see page 19 for heading)

Ranch-Stream	Physiochemical variables									
	Alkalinity (mg/l CaCO3)		Chloride (mg/L)		Nitrate (mg/L)		Ammonia (mg/L)		Phosphate (mg/L)	
Blue Creek Ranch										
Blue Creek	72.0	(3.1)	0.7	(0.3)	1.2	(0.2)	0.01	(0.02)	0.7	(0.05)
Deer Creek Ranch										
Deer Creek	55.2	(1.9)	0.3	(0.2)	0.6	(0.3)	0.1	(0.03)	1.3	(0.3)
Niobrara River	122.5	(2.1)	1.4	(0.8)	1.0	(0.1)	0.1	(0.05)	0.7	(0.3)
Snake River	145.7	(13.3)	1.9	(0.4)	0.5	(0.2)	0.3	(0.1)	1.0	(0.5)
McGinley Ranch										
Bear Creek	67.1	(2.4)	0.4	(0.1)	0.5	(0.3)	0.2	(0.1)	1.2	(0.3)
Horseshoe Drainage Ditch	190.3	(22.3)	1.2	(0.9)	1.4	(0.4)	0.3	(0.1)	0.6	(0.2)
Spikebox Ranch										
North Loup River	79.7	(5.1)	0.7	(0.3)	0.6	(0.3)	0.1	(0.03)	0.8	(0.1)
Mud Creek	108.9	(3.7)	1.2	(0.2)	0.8	(0.3)	0.2	(0.05)	1.2	(0.3)
Z-Bar Ranch										
Big Sandy Creek	171.5	(24.6)	5.0	(1.3)	0.5	(0.4)	2.7	(0.03)	0.2	(0.03)
Salt Fork Arkansas River	136.1	(6.4)	24.5	(0)	0.6	(0.3)	0.05	(0.04)	0.3	(0.2)