Recovery of Channel Morphology and Benthic Macroinvertebrate Assemblages after Livestock Exclusion

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Abstract

Many streams in Virginia are experiencing severe bank degradation, habitat destruction, and loss of vegetation due to livestock access (DCR, 2006). The USDA-NRCS administers the Conservation Reserve Enhancement Program (CREP) to promote bank stability and habitat diversity, while helping farmers control their livestock. CREP is Virginia's most funded conservation program (DCR, 2006); however, its effectiveness in enhancing channel morphology and aquatic habitat has not been monitored extensively, and no attempt has been made to evaluate how long the recovery process takes. The main goals of this research are to determine the improvements to channel morphology and benthic macroinvertebrate assemblages due to livestock exclusion and to evaluate the time required for significant aquatic and geomorphic stream improvements to occur along stream reaches with CREP or CREP-like livestock exclusion practices.

Objectives

1. Assess the effectiveness of existing livestock exclusion projects in southwest Virginia for improving:
   - A) Stream morphology
   - B) Streambank and riparian characteristics
   - C) Instream habitat and water chemistry
   - D) Benthic macroinvertebrate assemblages
2. Determine the gradient of improvement over time since livestock exclusion.

Study Sites

Five study sites in southwest Virginia consisting of paired, contiguous livestock exclusion and grazed stream reaches have been identified for use in this study (Fig 1). The study sites are located on the North Fork of the Roanoke River, Tom's Creek, Johns Creek, and Sinking Creek.

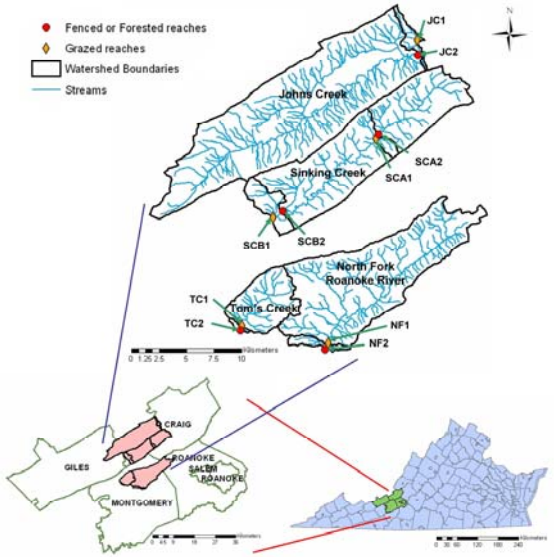

Figure 1. Location of paired-reach study sites.

Methods

Geomorphology: Longitudinal and cross-section surveys were conducted with a total station for a minimum reach length of 20 times bankfull width for each study reach in summer 2006 (Fig 2 & 3). Cross sections were surveyed at two riffle and two pool sections within each reach. Reach-averaged grain-size distribution was determined using a modification of the Wolman (1954) pebble count (400 samples per reach). Average width, depth, width to depth ratio, and Reach Condition Index (RCI) for each reach, as well as their drainage area, reach slope, and site description are summarized in Table 1.

Figure 2. Surveying and pebble count in summer 2006.

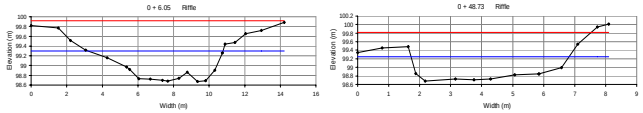

Figure 3. Cross-section profiles for grazed and livestock exclusion reaches on Sinking Creek (SCA1 and SCA2).

Riparian Vegetation and Soils: Riparian vegetation (groundcover, shrubs, and trees) was evaluated using three nested quadrats 1, 25, and 100 m^2 in size at two random locations on each streambank (Hession et al., 2000). Streambank soils were characterized for each distinct horizon at the quadrat locations in terms of bulk density, particle size, and soil type (Fig 4).

Figure 4. Ground Cover and Bulk density sampling in fall 2006.

Benthic Macroinvertebrates: The EPA Rapid Bioassessment Protocol (RBP) was utilized to evaluate reach-scale habitat quality with a rapid habitat assessment and collection of benthic macroinvertebrate (Barbour et al., 1999; Fig 5). Identification of macroinvertebrates was completed in Feb 2007.

Figure 5. Benthic macroinvertebrate collection in summer 2006.

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Results

Table 1. Drainage area, water surface slope, average width, average depth, width to depth (W/D) ratio, and Reach Condition Index (RCI) score for each site.

Site	Site Description	Drainage Area (km^2)	Slope (%)	Width (m)	Depth (m)	W/D Ratio	RCI score
TC1	Grazed	25.69	0.15	8.5	0.6	13.2	2.1
TC2	Livestock exclusion 2 years	26.38	0.27	4.0	0.8	7.0	3.4
SCA1	Grazed	40.46	0.15	9.1	0.4	21.8	2.9
SCA2	CREP 2.5 years	38.23	0.20	5.7	0.5	12.2	4.2
SCB1	Grazed	107.20	0.32	15.2	0.6	25.0	2.9
SCB2	CREP 4 years	97.44	0.24	13.4	0.6	23.5	4.2
NF1	Grazed	105.78	0.34	12.2	0.7	19.7	1.3
NF2	CREP 14 years	109.78	0.33	13.4	0.8	19.4	4.2
JC1	Grazed	170.95	0.24	12.4	0.9	16.9	2.1
JC2	Forested	166.53	0.18	17.1	1.1	16.5	5.8

Geomorphic Assessment: The RCI was used to evaluate the geomorphic condition of each reach (USEPA and VDEQ, 2006). The RCI assigns a value from 0 (degraded) to 7 (excellent) to a reach based on its geomorphic condition (Table 1). Figure 3 displays cross-section profiles that were created for a riffle in a grazed (left) and livestock exclusion reach (right). The grazed reaches have a greater width to depth ratio and a lower RCI score than the livestock exclusion reaches; there were no significant differences for the remaining geomorphic parameters.

Benthic Macroinvertebrates: The Virginia Multimetric Stream Conditions Index (SCI) was used to evaluate the benthic macroinvertebrates collected at each reach (USEPA and VDEQ, 2003). The SCI assigns a habitat score ranging from 1 (severe stress) to 100 (excellent) to each reach based on the benthic assemblages identified (Table 2). No significant differences were found between the benthic assemblages at the grazed and livestock exclusion reaches (Fig 6).

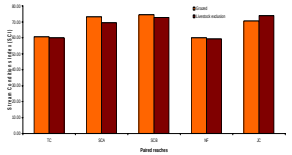


Figure 6. SCI scores.

Table 2. Virginia SCI scores and aquatic life use (ALU) tiers (USEPA and VDEQ, 2003).

SCI Score	ALU tiers
<42	Severe Stress
42-55	Moderate Stress
55-63	Fair (Gray Zone)
63-73	Good
>73	Excellent

Time Gradient: To determine a gradient of improvement over time since livestock exclusion, 1:1 plots were used to detect if the studied parameters followed a time gradient. Only one of the parameters, RCI, displayed a time gradient (Fig 7). None of the other parameters, including SCI, showed a time gradient (Fig 8).

Figure 7.
RCI 1:1 plot

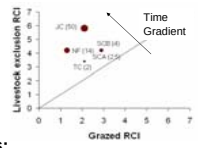
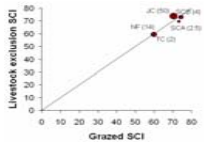


Figure 8.
SCI 1:1 Plot



Conclusions:

1. Stream morphology, bank soils, and vegetation were significantly different between paired grazed and livestock exclusion reaches.
2. BMV assemblages were not significantly different.
3. RCI increased with time since livestock exclusion. All other parameters did not show a clear temporal response.
4. Short sections of livestock exclusion may not result in improved biological integrity. Rather, a watershed-wide initiative to reduce negative impacts from streams must be taken for improvements to occur.