United States
Department
of Agriculture

Forest Service

**Intermountain
Research Station**

General Technical
Report INT-GTR-311

July 1994

Northern/Intermountain Regions' Fish Habitat Inventory: Grazed, Rested, and Ungrazed Reference Stream Reaches, Silver King Creek, California

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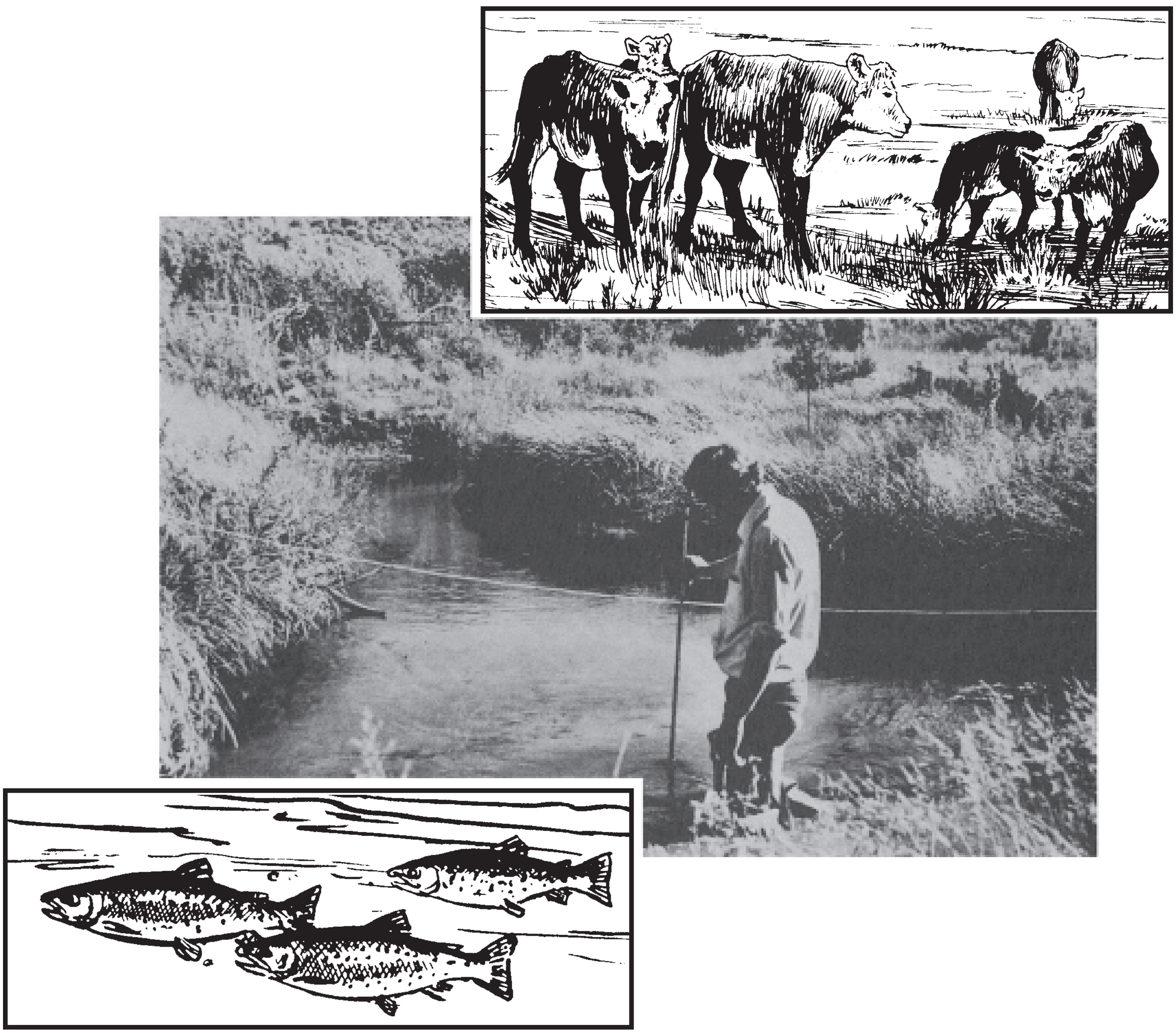

The Authors

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Research Summary

In September 1991, data describing fish habitat (descriptors) were collected for Silver King Creek and one of its major tributaries, Coyote Valley Creek, using the Forest Service's R1/R4 [Northern/Intermountain Region] fish habitat inventory procedures. The purpose was to describe fish habitat conditions of channels traversing stream sections grazed by livestock and sections being rested from grazing, in reference to sections that had no known livestock grazing. The objectives were: (1) to determine if there are differences between grazed and rested sections along Silver King Creek and Coyote Valley Creek; (2) to assess habitat condition of grazed and rested sections of Silver King Creek by calculating the percent deviation from natural potential using habitat variables from ungrazed reference streams; and (3) to recommend monitoring methods to measure progress toward the desired condition (natural potential).

Rested management sections appeared to have better bank conditions (stable banks and more bank undercuts) than grazed management sections in both streams. The rested sections in Coyote Valley Creek had deeper and narrower channels than the grazed sections. Ungrazed reference streams similar in parent geology, precipitation, channel type, habitat types, drainage area, and stream width had higher bank stability values and lower width-to-depth ratios than both grazed and rested management sections of Silver King Creek. Banks in the rested sections of Silver King Creek appear to be recovering, as bank stability values were approaching those of the ungrazed reference streams. Power curve analysis indicates that the chance of detecting true differences between grazed and rested sections is very low because the individual stream sections were so short. Habitat descriptors and sample sizes required to measure recovery are suggested from results of the power curve analysis.

Acknowledgments

This study was funded by the Forest Service's Intermountain Region Fish and Wildlife staff, the Toiyabe National Forest, and the Intermountain Research Station. Jane Schmidt, range conservationist, Carson Ranger District, Toiyabe National Forest, and Brian Sanborn, fishery biologist, Deerlodge National Forest, contributed in the development of the study and this manuscript. Data collection, entry, and proofing were completed by Intermountain Research Station fishery technicians. Robyn Armstrong, Kelly Duncan, and Shari Whitwell compiled data summaries.

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Northern/Intermountain Regions' Fish Habitat Inventory: Grazed, Rested, and Ungrazed Reference Stream Reaches, Silver King Creek, California

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Introduction

Livestock grazing has contributed to the deterioration of western riparian areas and fish habitat (Armour and others 1991; Behnke 1980; Chaney and others 1991; Kovalchik and Elmore 1992; Minshall and others 1989). Changes in grazing management are being advocated by natural resource specialists and managers due to growing public interest in improving riparian conditions, in maintaining and enhancing water quality, in enhancing recreation opportunities, and in protecting fish and wildlife habitat (USDA FS 1992).

Studies have demonstrated that livestock grazing within riparian areas eliminates or reduces streamside vegetation, destabilizes stream banks, causes channel sedimentation and aggradation, widens channels, increases stream temperature extremes, lowers the water table, reduces bank undercut, and reduces pool frequency and depth (Armour and others 1991; Chaney and others 1991; Kauffman and Krueger 1984; Kovalchik and Elmore 1992; Meehan 1991; Platts 1991). These changes in channel morphology can be detrimental to salmonid populations by damaging spawning and rearing habitat. Some land managers are revamping grazing allotment management plans (grazing strategies) to restore desirable riparian conditions, narrow and deepen stream channels, and improve fish habitat.

Efforts to identify and measure grazing's direct impacts are confounded by other changes and natural variability (Platts 1991). To develop effective management strategies, the land manager needs assessment tools to determine the current and the potential condition of streams and to monitor progress in reducing the differences between the two. Existing stream channel conditions on a grazed stream reach can be compared to those on a similar stream reach unaffected by grazing that represents the potential natural condition.

Fishery biologists at the Intermountain Research Station, in collaboration with biologists of the Northern and Intermountain Regions of the Forest Service, U.S. Department of Agriculture, selected stream characteristics they believed to be altered by land management activities and that they believed had ecological significance to fish. We used these characteristics to describe and compare reaches of Silver King Creek and Coyote Valley Creek in grazed and rested management sections. Our objectives were: (1) to determine what differences, if any, exist between grazed and rested sections along Silver King Creek and Coyote Valley Creek; (2) to assess the habitat condition of grazed and rested sections of Silver King Creek by calculating the percent deviation from natural potential using habitat variables from ungrazed reference streams; and (3) to recommend monitoring methods to measure progress toward stream recovery (desired condition or natural potential).

Study Site Description

The Silver King Creek drainage lies entirely within the Carson-Iceberg Wilderness (Toiyabe National Forest) of east-central California (fig. 1). The basin was logged in the 1860's, pastured sheep in the early 1900's through the late 1930's, and has pastured cattle since the 1940's. Today, cattle are grazed on a deferred grazing system throughout much of the Silver King Creek drainage. The main proper use criteria for judging the level of grazing is 55 percent use of key forage plants by livestock (Jane Schmidt, range conservationist, Carson Ranger District).

Silver King Creek is a fourth-order tributary to the East Fork of the Carson River. The elevation at the confluence is 1,950 m; and the elevation at its headwaters is 2,895 m. Discharge at the time of survey (September 14 to 20, 1991) was estimated at 0.5 m^3/second in the mainstem of Silver King Creek.

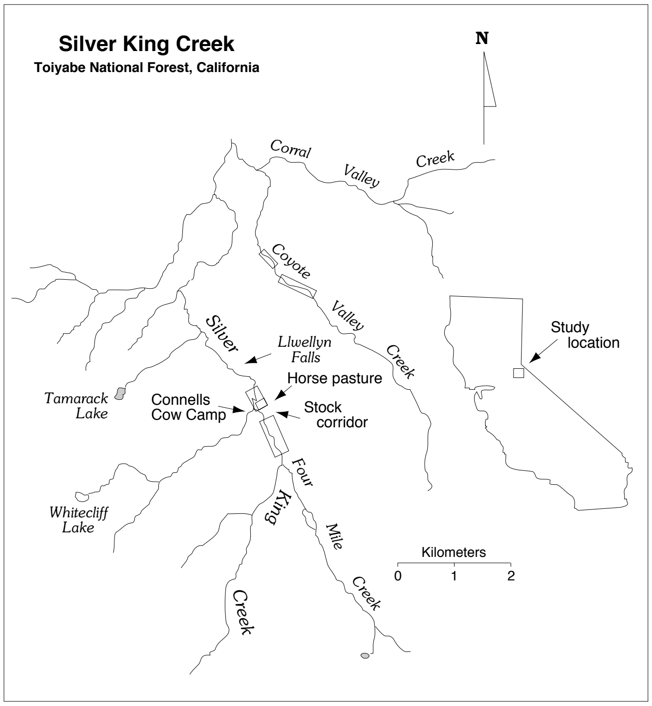

Figure 1—Location of study sites for Silver King Creek and Coyote Valley Creek.

The Silver King Creek drainage has predominantly granitic geology. Riparian vegetation ranges from sedge/rush and grass/forbs/sagebrush at streamside to coniferous forest in the uplands. Meadow portions are dominated by Nebraska sedge (*Carex nebraskensis*) and silver sagebrush (*Artemisia cana*) plant communities.

We surveyed the mainstem of Silver King Creek for 4.9 km immediately upstream from Llewellyn Falls (fig. 1). The survey area included 3.3 km of stream that was accessible to cattle and 1.6 km of stream that was not. Cattle have been excluded from the 1.6-km section by a solar-powered electric fence. The exclosure was built to improve Paiute cutthroat trout habitat (USDA FS 1993). A small area (including 0.18 km of stream) was enclosed for horses to graze.

The study reaches were classified as "C" channel type (Rosgen 1985). The gradient varied; the upper exclosure, stock corridor, and lower grazed sections were estimated to have a gradient between 1 and 2 percent, with the horse pasture and the lower rested exclosure having a gradient less than 1 percent. The drainage area above Llewellyn Falls was estimated to be 3,494 ha. Table 1 provides a general description of the Silver King Creek study reaches.

Coyote Valley Creek is a first-order tributary that flows into Silver King Creek about 5 km downstream from Llewellyn Falls (fig. 1). The study reaches on Coyote Valley Creek, totaling about 2.1 km, were classified as "C" channel type. The study sections included two rested sections, totaling 1.1 km of stream. The drainage area to the downstream end of the study sections was estimated at 1,153 ha (table 1).

Reaches of Fishhook Creek and Hell Roaring Creek were used as the ungrazed reference. Both streams are part of the Region 4 (Intermountain Region) Desired Future Condition (DFC) database maintained at the Boise Forestry Sciences Laboratory. They are located in central Idaho in the Stanley Basin. The creeks are similar to the Silver King Creek study sites in geology, elevation, precipitation, and drainage area (table 1).

Methods

The Forest Service's proposed R1/R4 [Northern Region/Intermountain Region] fish habitat inventory procedures (basin-level habitat typing, appendix A) were used to describe the physical habitat of the streams in September 1991. Different reaches of Silver King Creek and Coyote Valley Creek were selected for study based on management activities: grazed by cattle, horse pasture, and rested from grazing (fig. 1).

Fish habitat within each reach was classified into discrete channel units using a hierarchical habitat typing scheme based on flow patterns and channel morphological shape (Hawkins and others 1993). We visually estimated length, average width, and average and maximum depth at each fast-water habitat type (riffles, runs, and glides). We measured every fifth fast-water habitat type to develop a correction factor for the visual estimates using a methodology similar to Hankin and Reeves (1988).

At each slow-water habitat type, pools were separated by position of scour and formative feature (such as a log, meander, or bend). Pool habitat type dimensions (length, width, and depth) were determined as above. Maximum depth and pool crest maximum depth were measured for all pools (table 2).

Percent stream channel surface fines (particles less than 2 mm) were visually estimated for low gradient riffle and pool habitat types. Estimates were taken only in pool tails (narrow band upstream from pool tail crest) for the slow-water habitat types.

The length of stable bank was estimated for all habitat types with a correction factor determined from a 20 percent subsample of measured habitat types. The correction factor was applied to the estimates to create a calibrated data set. Stable banks had no sign of mechanical damage, cracking, or eroding.

The gradient was measured over one or more stream meander cycles using an abney hand level and stadia rod. Measurements were recorded at the

Table 1—General descriptors of Silver King Creek and Coyote Valley Creek study reaches and ungrazed stream reaches that represent natural potential habitat conditions. All reaches had a granitic parent geology

Stream and management treatment	Mean width	Length	Elevation	Precipitation	Drainage area
	- - - - - - - - - - - -	*Meters*	- - - - - - - - - - - - -	*cm*	*ha*
Silver King Creek	4.0	4,901.2		[1]84.50	[2]3,494
Upper grazed	3.2	2,650.7			
Upper rested	3.8	991.0			
Stock corridor	4.4	220.0			
Horse pasture	4.7	179.0			
Lower rested	5.9	443.0			
Lower grazed	7.4	417.0	2,438		
Coyote Valley Creek	0.8	2,085.5			[3]1,153
Upper grazed	1.0	565.0			
Rested	0.6	594.0			
Grazed	1.0	339.0			
Rested	0.6	493.5			
Lower grazed	0.7	94.0	2,475		
(Ungrazed stream reaches)					
Fishhook Creek	7.2	3,295.0	2,066	[4]80.26	[3]3,098
Hell Roaring Creek	7.8	3,032.0	2,170		[3]3,051

[1]Average (1981-1990 reference years) based on Mountain Data from U.S. Department of Agriculture, Soil Conservation Service, SNOTEL site at Poison Flat.
[2]Approximate drainage area above Llewellyn Falls.
[3]Approximate drainage area at downstream end of survey reach.
[4]Average (1961-1990 reference years) based on Mountain Data from U.S. Department of Agriculture, Soil Conservation Service, SNOTEL site at Galena Summit.

start of the survey, at management section breaks, and at the survey's end.

The floodplain/riparian vegetation complex was categorized each time the complex changed. We estimated the percentage of each vegetation type to characterize the dominant and subdominant floodplain and riparian vegetation. Categories included: sagebrush, grass or forb, riparian shrub, upland shrub, riparian tree, and upland tree.

The drainage area above Llewellyn Falls for Silver King Creek and to the downstream end of the surveyed portion of Coyote Valley Creek was calculated by digitizing watershed area from a 3⁄8-inch-scale general map of the Carson-Iceberg Wilderness. The drainage area for the downstream end of the survey reaches of Fishhook and Hell Roaring Creeks was calculated by digitizing the watershed area from 1:24,000 U.S. Geological Survey topographic maps.

Table 2—Habitat variables that were measured, estimated, or calculated for each habitat type

Estimated/measured variable	Calculated variable
All habitat types	Width/depth ratio
Length	Width/maximum-depth ratio
Width	Residual maximum depth[1]
Depth	Residual pool volume[1]
Maximum depth	
Surface fines[2]	
Percent stable banks	
Percent undercut banks	

[1]Pools only.
[2]Pool tails and low-gradient riffles only.

Data Analysis

Summary statistics were completed for physical habitat measures and descriptors (table 3). An analysis of variance was used to determine if differences occurred between management types. Silver King Creek was broken into six management classes beginning from the lower end of the survey: lower grazed, lower rested, horse pasture, stock corridor, upper rested, and upper grazed (table 1). Because the sample size was low, Coyote Valley Creek study reaches were combined into only two classes, grazed and rested, for statistical purposes. Tukey's HSD was used for multiple comparisons of those variables that were found to differ significantly. All analyses were performed using SAS statistical software (SAS Institute Inc. 1988). Power curves were used to evaluate the adequacy of detecting differences for those variables that did not show significance (Parkinson and others 1988; Peterman 1990).

Table 3—Sample size, mean, and standard deviations (SD) for variables from the differently managed sections of Silver King Creek

Habitat	Lower grazed			Lower rested			Horse pasture			Stock corridor			Upper rested			Upper grazed		
variable	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)
All habitats																		
Mean width (m)	15	7.5	(0.9)	10	5.8	(0.8)	8	4.7	(0.6)	6	4.3	(0.8)	19	3.8	(0.4)	51	3.6	(1.0)
Mean depth (m)	15	0.3	(0.1)	10	0.3	(0.1)	8	0.2	(0.1)	6	0.3	(0.1)	19	0.3	(0.4)	51	0.3	(0.1)
Maximum-depth (m)	15	0.6	(0.2)	10	0.6	(0.2)	8	0.3	(0.2)	6	0.7	(0.2)	19	0.6	(0.2)	51	0.6	(0.2)
Width/depth	15	27.7	(11.6)	10	21.4	(6.4)	8	20.2	(8.0)	6	18.7	(6.8)	19	15.4	(6.2)	51	16.4	(8.4)
Width/maximum-depth	15	16.6	(0.4)	10	10.1	(3.9)	8	10.8	(6.5)	6	6.8	(2.1)	19	6.8	(3.5)	51	7.0	(4.2)
Stable banks (percent)	15	60.0	(23.0)	10	82.4	(13.5)	8	54.7	(21.3)	6	48.4	(11.1)	19	63.7	(25.5)	50	60.2	(24.2)
Pools only																		
Mean width (m)	5	7.5	(0.9)	5	5.7	(0.8)	4	4.5	(0.7)	3	4.4	(1.2)	10	3.9	(0.5)	23	3.7	(1.0)
Mean depth (m)	5	0.5	(0.0)	5	0.3	(0.0)	4	0.3	(0.0)	3	0.3	(0.0)	10	0.3	(0.0)	23	0.3	(0.0)
Maximum-depth (m)	5	0.9	(0.1)	5	0.8	(0.2)	4	0.7	(0.1)	3	0.8	(0.1)	10	0.8	(0.0)	23	0.7	(0.1)
Residual depth (m)	5	0.7	(0.0)	5	0.6	(0.2)	4	0.6	(0.1)	3	0.7	(0.1)	10	0.7	(0.1)	23	0.6	(0.1)
Residual volume (m^3)	5	86.3	(27.9)	5	51.3	(28.2)	4	41.9	(19.3)	3	40.0	(27.3)	10	40.7	(15.0)	23	21.7	(11.7)
Surface fines (percent)	5	20.0	(10.0)	5	17.0	(2.7)	4	18.2	(4.7)	3	14.3	(5.8)	10	19.5	(4.4)	23	22.0	(7.4)
Riffles only																		
Mean width (m)	5	7.5	(1.1)	2	5.8	(0.6)	3	5.1	(0.1)	3	4.3	(0.3)	9	3.8	(0.3)	23	3.7	(1.0)
Width/depth	5	37.6	(7.7)	2	27.8	(4.6)	3	29.3	(1.4)	3	24.1	(7.3)	9	19.2	(7.3)	23	22.6	(8.8)
Surface fines (percent)	5	13.0	(4.5)	2	16.5	(2.1)	3	15.0	(0.0)	3	15.0	(1.8)	9	15.9	(1.8)	23	17.1	(4.7)
Stable banks (percent)	5	52.9	(30.2)	2	96.2	(5.3)	3	54.5	(7.8)	3	53.5	(10.9)	9	55.4	(10.9)	22	51.9	(22.4)
Undercut banks (percent)	5	6.2	(14.0)	2	42.9	(22.7)	3	22.3	(3.0)	3	14.0	(12.7)	9	19.9	(12.7)	22	17.9	(11.7)

Two ungrazed stream reaches from the Region 4 (Intermountain Region) Desired Future Condition database for Idaho were selected for reference to the natural potential or desired condition. These two streams are similar to Silver King Creek in parent geology, channel type (gradient and confinement), precipitation, and drainage area. Only Silver King Creek's lower grazed and lower rested sections were directly compared; these sections were similar to each other in length and similar to the reference stream in width (table 1). Overall means of selected habitat variables were calculated from the reference streams (table 4). No appropriate examples of ungrazed stream reaches are currently available for comparison to Coyote Valley Creek, which is smaller than the reference streams.

To assess the condition of fish habitat within the lower grazed and lower rested sections of Silver King Creek, we used percent deviation of selected habitat variables as a comparative index:

$$\text{Percent deviation} = \frac{\bar{R} - \bar{M}}{\bar{R}} \times 100$$

where ($\bar{R}$) is the combined ungrazed reference habitat variable mean, and ($\bar{M}$) is the managed section habitat variable mean. Habitat variables were selected based on their being representative of channel descriptors that would respond to changes in sediment levels, water yield, and bank erosion.

Results

We compared the habitat descriptors of the Silver King Creek grazed sections to the rested sections. We then compared the Silver King Creek managed sections (grazed and rested) to the ungrazed sections of the reference streams. Coyote Valley Creek's grazed sections were compared to the rested sections. Coyote Valley Creek's five managed sections (table 1) were combined into two study sections, grazed and rested, for statistical comparison.

Silver King Creek Grazed Versus Rested Sections

We found little observable difference in means of habitat descriptors for the different sections (table 3). Bank stability was higher for rested sections (63.7 to 82.4 percent) than for grazed sections (48.4 to 60.2 percent) for all habitat types, and for rested sections (55.4 to 96.2 percent) than for grazed sections (51.9 to 54.5 percent) in riffles only (table 3). Bank undercut also was greater for rested (19.9 to 42.9 percent) than for grazed sections (6.2 to 22.3 percent) in riffles only (table 3). Surface fines ranged from 13 to 17 percent for riffles only, and from 14 to 22 percent for pools only, with no apparent relationship between management sections (table 3). Other habitat variables appeared to increase downstream, as would be expected as drainage area increases.

Table 4—Sample size, mean, and standard deviations (SD) for variables from ungrazed stream reaches with similar gross geologies and drainage areas as Silver King Creek. Hell Roaring Creek did not have any riffle habitat

Habitat variable	Fishhook Creek			Hell Roaring Creek			Overall		
	N	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)
All habitats									
Mean width (m)	46	7.2	(1.7)	40	7.8	(1.8)	86	7.5	(1.7)
Mean depth (m)	45	0.5	(0.1)	40	0.7	(0.3)	85	0.6	(0.2)
Maximum-depth (m)	46	1.0	(0.2)	40	1.1	(0.3)	86	1.0	(0.3)
Width/depth	45	15.3	(6.3)	40	14.6	(8.2)	85	15.0	(7.2)
Width/maximum-depth	46	7.9	(2.8)	40	7.8	(3.7)	86	7.8	(13.1)
Stable banks (percent)	46	91.5	(20.7)	40	100.0	(0.0)	86	95.4	(15.7)
Pools only									
Mean width (m)	19	7.2	(1.9)	20	7.0	(1.5)	39	7.1	(1.7)
Mean depth (m)	18	0.6	(0.1)	20	0.9	(0.2)	38	0.7	(0.2)
Maximum-depth (m)	19	1.1	(0.2)	20	1.2	(0.3)	39	1.2	(0.3)
Residual depth (m)	15	0.7	(0.3)	20	0.8	(0.3)	35	0.8	(0.3)
Residual volume (m^3)	15	127.7	(91.0)	20	121.2	(81.0)	35	124.0	(84.2)
Surface fines (percent)	14	22.8	(18.8)	19	17.9	(8.9)	33	20.0	(13.9)
Riffles only									
Mean width (m)	8	7.4	(1.9)						
Width/depth	8	21.1	(11.4)						
Surface fines (percent)	7	12.4	(7.8)						
Stable banks (percent)	8	100.0	(0.0)						
Undercut banks (percent)	8	33.5	(0.2)						

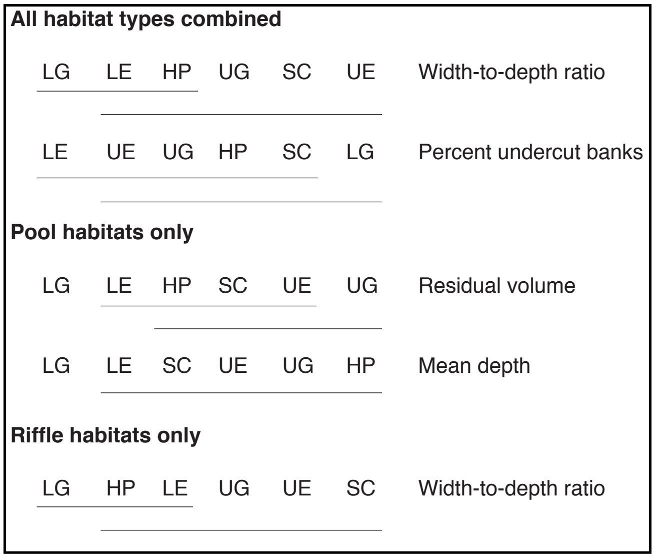

Figure 2—Results of Tukey's HSD for those variables found to be significant at $\alpha = 0.05$. Managed sections that are not connected by an underline are significantly different. The acronyms are: LG = lower grazed; LE = lower rested; HP = horse pasture; SC = stock corridor; UE = upper rested; UG = upper grazed.

Statistical comparisons of management types revealed few significant differences; those that were significant did not show a distinct break between the grazed and rested sections of Silver King Creek (fig. 2). Combining all habitat types showed a significant difference in width-to-maximum-depth ratio and mean percent undercut banks. Pool habitats only showed a significant difference in residual volume and mean depth, while riffle habitats only showed a significant difference in width-to-depth ratio. All significant levels were at $\alpha = 0.05$.

Silver King Creek Managed Versus Reference Sections

The ungrazed reference streams had greater mean depth (0.6 versus 0.3 m) and maximum depth (1.0 versus 0.6 m) for all habitat types, and had lower width-to-depth ratios (15.0 versus 27.7), width-to-maximum-depth ratios (7.8 versus 16.6), and greater bank stability (95.4 versus 60 percent) than the lower grazed section of Silver King Creek (table 5). In comparison with the lower rested sections, the ungrazed reference streams were deeper (mean depth 0.6 versus 0.3 m; maximum depth 1.0 versus 0.6 m), had lower width-to-depth ratios (15.0 versus 21.4), width-to-maximum-depth ratios (7.8 versus 10.1), and greater bank stability (95.4 versus 82.4 percent) (table 5).

In comparing Silver King Creek with the ungrazed reference stream sections, the lower grazed portion deviated markedly in width-to-depth ratio (–84 percent) and width-to-maximum-depth ratio (–113 percent) for all habitats, in width-to-depth ratio (78 percent) and percent undercut banks (82 percent) for riffles only (table 5). Other variables deviated 50 percent

Table 5—Percent deviation in selected habitat variables at Silver King Creek from the combined reference stream means

Habitat variable	Reference Mean (SD)[1]	Lower grazed	Percent deviation	Lower rested	Percent deviation
All habitats					
Mean depth (m)	0.6 (0.2)	0.3 (0.1)	50	0.3 (0.1)	50
Maximum-depth (m)	1.0 (0.3)	0.6 (0.2)	40	0.6 (0.2)	40
Width/depth	15.0 (7.2)	27.7 (11.6)	–84	21.4 (6.4)	–43
Width/maximum-depth	7.8 (3.2)	16.6 (0.4)	–113	10.1 (3.9)	–30
Stable banks (percent)	95.4 (15.7)	60.0 (23.0)	37	82.4 (13.5)	14
Pools only					
Mean depth (m)	0.7 (0.2)	0.5 (0.0)	29	0.3 (0.0)	57
Maximum-depth (m)	1.2 (0.3)	0.9 (0.1)	25	0.8 (0.2)	33
Residual depth (m)	0.8 (0.3)	0.7 (0.0)	13	0.6 (0.2)	25
Residual volume (m^3)	124.0 (84.2)	86.3 (27.9)	30	51.3 (28.2)	59
Surface fines (percent)	20.0 (13.9)	20.0 (10.0)	0	17.0 (2.7)	15
Riffles only					
Width/depth	21.1 (11.4)	37.6 (7.7)	78	27.8 (4.6)	–32
Surface fines (percent)	12.4 (7.8)	13.0 (4.5)	–5	16.5 (2.1)	–33
Stable banks (percent)	100.0 (0.0)	52.9 (30.2)	47	96.2 (5.3)	4
Bank undercuts (percent)	33.5 (0.2)	6.2 (14.0)	82	42.9 (22.7)	–28

[1]Standard deviation.

or less. The lower rested area deviated less markedly, with the majority of the variables between 4 and 50 percent; the exceptions were in pools, where mean depth (57 percent) and residual volume (59 percent) had the largest deviations.

Coyote Valley Creek Grazed Versus Rested Sections

In Coyote Valley Creek, observed mean width (0.6 m), width-to-depth (3.0 and 3.5), and width-to-maximum depth (1.7) ratios in rested sections were less than in grazed sections for all habitat types (table 6). Percent stable banks (92.8 and 98.9) and percent undercut banks (90.8 and 91.5) were greater in rested than in grazed sections. The percent surface fines (43.5 and 68.5) in the rested sections were greater than in the grazed sections (26.7 to 54.7), with the lowest percentage in the upper grazed section.

In comparisons involving pools only, rested sections were narrower (0.6 and 0.7 m) than grazed sections (1.1 to 1.3 m), the upper rested section was 0.1 m deeper (mean depth) than all other sections, and 0.1 m deeper (mean maximum depth) than all the grazed sections, except the upper grazed section that was just as deep (table 6). The percent surface fines in pool tails ranged widely, from 22.0 percent in the upper grazed section to 76.3 percent in the lower rested section.

In riffles only, the mean width for rested sections (0.4 and 0.5 m) was less than for grazed sections (0.8 to 1.1 m), and width-to-depth ratios were lower for rested sections (3.1 and 3.6) than for grazed sections (5.3 to 9.1) (table 6).

Significant differences in all the variables of interest for Coyote Valley Creek were found when habitat types were combined. Pool habitats only showed significant differences in maximum depth, mean depth, and mean width between grazed and rested sections. The riffle habitats showed significant differences in percent undercut bank, percent stable bank, percent surface fines, and width-to-depth ratio.

Power Curves

To understand the relationship between sample size variance and statistical power, power curves can be used. Figures 3 through 5 describe the relationship between sample size and the power of detecting differences between selected habitat variables that were not significantly different for all habitat types (fig. 3), for pools only (fig. 4), and for riffles only (fig. 5).

Discussion

Improper livestock grazing degrades water quality and fish habitat of many western streams. Managers of public lands want to develop and implement grazing management strategies that will protect and restore stream values. A stream's current conditions and the potential conditions must be described when developing

Table 6—Sample size, mean, and standard deviations (SD) for variables from the differently managed areas within Coyote Valley Creek

Habitat variable	Lower grazed			Lower rested			Middle grazed			Upper rested			Upper grazed		
	N	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)	*N*	Mean	(SD)
All habitats															
Mean width (m)	5	1.1	(0.6)	7	0.6	(0.3)	6	1.0	(0.2)	6	0.6	(0.2)	3	1.1	(0.1)
Mean depth (m)	5	0.2	(0.0)	7	0.2	(0.1)	6	0.1	(0.0)	6	0.2	(0.1)	3	0.1	(0.1)
Maximum-depth (m)	5	0.3	(0.0)	7	0.4	(0.1)	6	0.3	(0.0)	6	0.3	(0.1)	3	0.3	(0.1)
Width/depth	5	6.8	(3.8)	7	3.5	(1.0)	6	7.4	(2.6)	6	3.0	(0.9)	3	7.6	(2.6)
Width/maximum-depth	5	3.4	(1.9)	7	1.7	(0.5)	6	3.6	(1.2)	6	1.7	(0.5)	3	3.4	(1.2)
Stable banks (percent)	5	62.2	(29.0)	7	92.8	(18.9)	6	45.6	(24.0)	6	98.9	(1.8)	3	42.5	(3.6)
Surface fines (percent)	4	54.7	(33.3)	4	68.5	(18.5)	5	43.8	(20.6)	6	43.5	(16.5)	3	26.7	(4.5)
Undercut banks (percent)	5	51.1	(19.6)	7	90.8	(12.5)	6	17.4	(19.9)	6	91.5	(12.0)	3	19.7	(9.6)
Pools only															
Mean width (m)	3	1.3	(0.6)	3	0.7	(0.4)	2	1.1	(0.3)	3	0.6	(0.2)	1	1.1	(—)
Mean depth (m)	3	0.2	(0.0)	3	0.2	(0.1)	2	0.2	(0.0)	3	0.3	(0.0)	1	0.2	(—)
Maximum-depth (m)	3	0.3	(0.0)	3	0.4	(0.1)	2	0.3	(0.0)	3	0.4	(0.0)	1	0.4	(—)
Residual depth (m)	3	0.2	(0.0)	3	0.3	(0.1)	2	0.3	(0.0)	3	0.3	(0.1)	1	0.4	(—)
Residual volume (m^3)	3	1.2	(0.3)	3	0.9	(0.6)	2	2.1	(0.2)	3	1.5	(0.9)	1	6.4	(—)
Surface fines (percent)	3	65.7	(30.8)	3	76.3	(12.1)	2	65.0	(9.9)	3	45.0	(23.8)	1	22.0	(—)
Riffles only															
Mean width (m)	1	0.8	(—)	1	0.5	(—)	3	1.1	(0.3)	1	0.4	(—)	2	1.0	(0.2)
Width/depth	1	5.3	(—)	1	3.6	(—)	3	8.7	(2.8)	1	3.1	(—)	2	9.1	(9.1)
Surface fines (percent)	1	22.0	(—)	1	45.0	(—)	3	29.7	(7.1)	1	36.0	(—)	2	29.0	(2.8)
Stable banks (percent)	1	27.8	(—)	1	100.0	(—)	3	38.7	(9.9)	1	95.9	(—)	2	40.4	(0.6)
Undercut banks (percent)	1	77.8	(—)	1	68.7	(—)	3	29.3	(21.8)	1	92.6	(—)	2	14.6	(5.1)

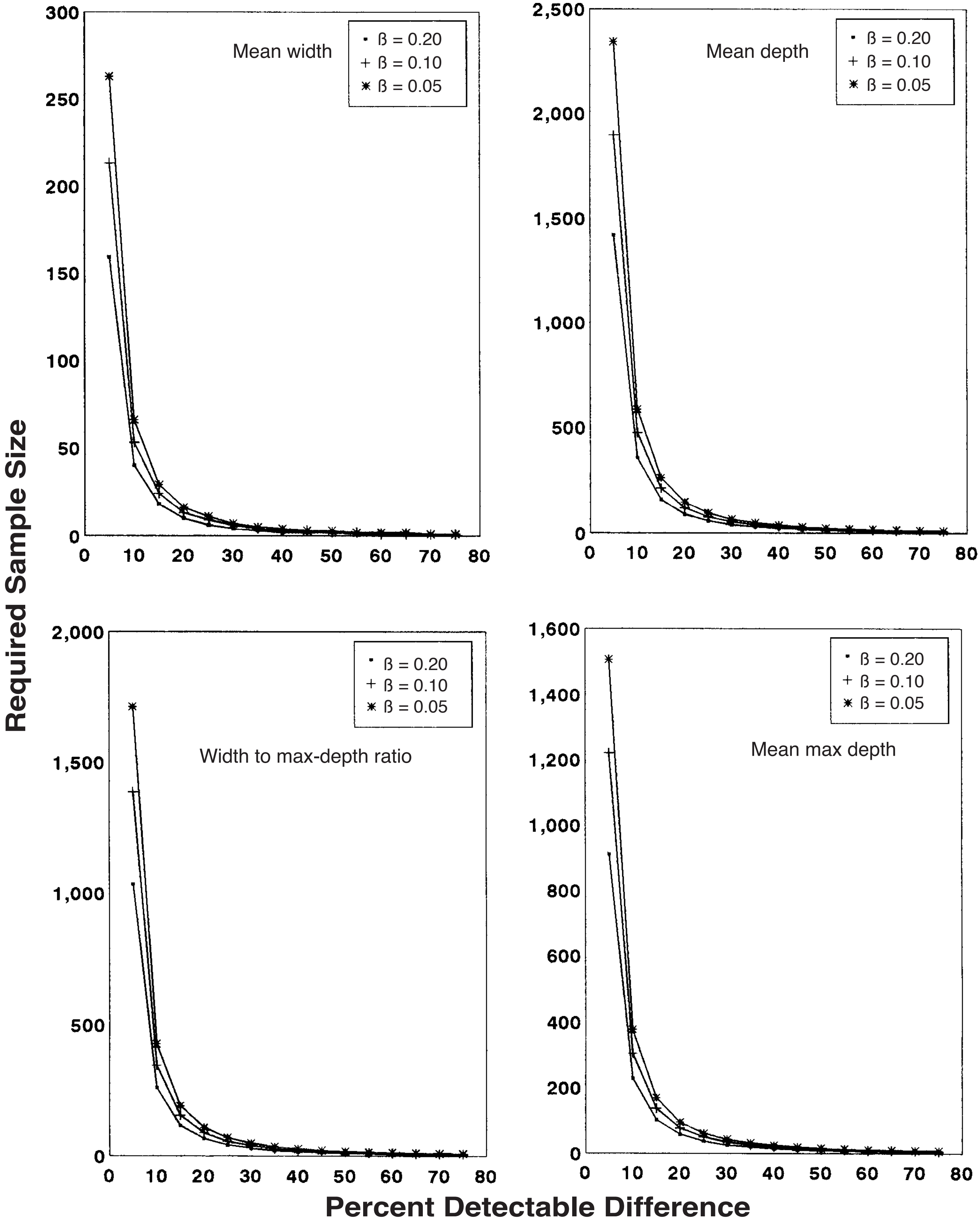

Figure 3—Sample sizes required to detect differences for various levels of ß in all habitat types combined.

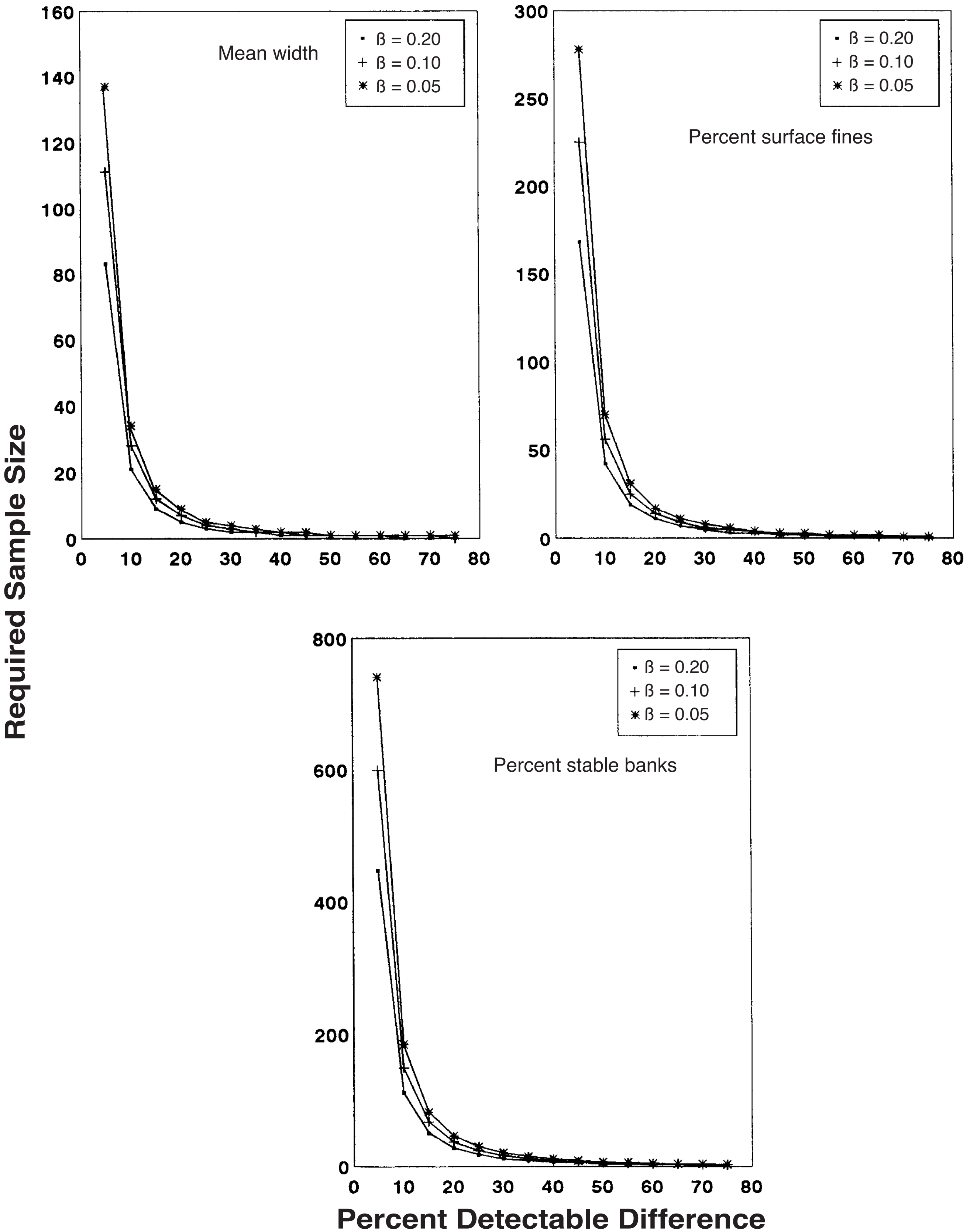

Figure 4—Sample sizes required to detect differences for various levels of ß in riffle habitats only.

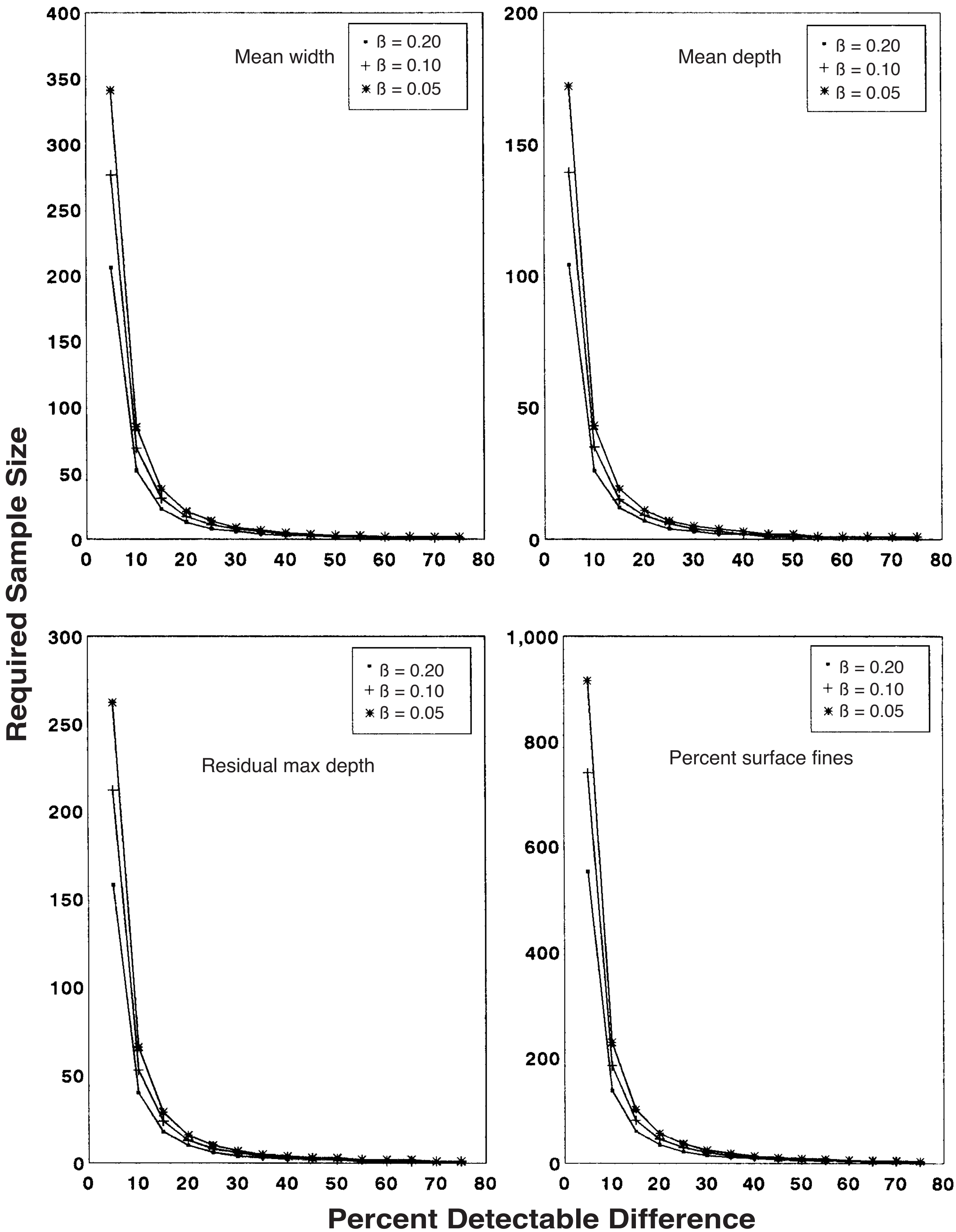

Figure 5—Sample sizes required to detect differences for various levels of ß in pool habitat types only.

management strategies to achieve the desired condition. This study used the Forest Service's R1/R4 [Northern Region/Intermountain Region] inventory procedures to ascertain the current condition of a selected stream reach. This required field observations that would detect differences between management activities.

The rested areas in Silver King and Coyote Valley Creeks had greater bank stability and bank undercut, primarily due to the increased bank vegetation and decreased bank sloughing. Removing livestock from western riparian areas increases bank cover (Duff 1983). Overall, channels in the rested areas were deeper and narrower with lower width-to-depth ratios than channels in grazed areas. These differences reflect the expected progression as bank vegetation develops a root mass that protects bank soils from scour erosion and filters out sediments, forming banks. Well-sodded banks gradually erode beneath the roots, creating undercuts—important hiding places for salmonids (Platts 1991). When streamside vegetation is depleted by grazing, bank erosion accelerates (Platts 1981b), especially during floods (Platts and others 1985). Water surface area increased and water depth decreased in areas that were grazed (Gunderson 1968). Stream width normally decreases when livestock are removed from the streamside areas (Gunderson 1968; Platts 1981b; Platts and Nelson 1985). Stream width has been reduced from 10 to 400 percent when livestock have been removed (Platts 1991). Water has been deeper (10 to 500 percent) in ungrazed areas than in grazed areas (Gunderson 1968; Platts 1981a).

If the differences between rested and grazed sections in Silver King Creek are a result of fencing of livestock, they have occurred over five growing seasons. The rested sections were fenced in 1986, and the data for this study were collected in 1991. Channels' widths and depths have not changed dramatically, although they show a trend toward becoming deeper and narrower in the rested sections. These changes require bank building and channel bed scouring that depend on relatively high flows, bank-stabilizing vegetation, and sedimentation.

Channels in the rested sections of Coyote Valley Creek are narrower and deeper than channels in grazed sections. The width-to-depth and width-to-maximum-depth ratios were half those of the grazed sections (table 6). We conclude that these differences are related to the effects of livestock grazing on the condition of the banks. This conclusion must be considered tentative, however, because sample sizes were small. Surface fines levels ranged widely—22 to 45 percent for riffles only and 22 to 76 percent for pools only—with no apparent pattern; values alternated back and forth irrespective of management section. This was probably due to the alternating positions of the management sections along the stream, small sample sizes, and local gradient shifts.

Comparison to Ungrazed Reference Streams

Comparisons to ungrazed reference streams are one way of judging current stream condition and help establish the natural potential or desired condition. We believe the two Idaho reference stream reaches and the lower Silver King Creek management sections are suitable for comparison for some habitat descriptors. They are within watersheds similar in parent geology and precipitation, have similar valley morphologies (unconfined alluvial channels with developed flood plains), reach types (pool-riffle sequence), channel slope, and drainage area. One difference is the presence of large woody debris in the two Idaho stream reaches. Silver King Creek has a free-formed pool-riffle sequence, where pools are formed as a result of cross-channel oscillating flow that scours alternating banks of the channel. The two reference streams have a forced pool-riffle sequence, where pools are anchored by large woody debris, as well as free-formed pools (Lisle 1986; Montgomery and Buffington 1993). This difference should not affect bank characteristics (stability and undercut), but would be expected to influence channel dimensions and pool frequencies.

We recommend bank stability and width-to-depth ratios as the indicators for assessing habitat conditions in Silver King Creek. Banks can be affected by local bank disturbances as well as disturbances upstream and upslope. The stability of stream banks depends on bank material and vegetation type and density (Platts 1984); stability can be an important indicator of watershed condition. Bank instability can be initiated by natural events or human disturbances that change discharge, sediment load, and channel stability (MacDonald and others 1991). Ungrazed banks for stream reaches within granitic geologies from Idaho "C" channel types had a combined mean of 90 percent stable (average of means from 13 stream reaches). An interim Desired Future Condition (DFC) of greater than 80 percent stable was recommended for "C" channel types for Idaho streams (Overton 1991). The two reference stream reaches had values of 91.5 and 100 percent stable (table 4). Based on this information, we estimate that stream banks within grazed Silver King Creek management areas are 20 to 30 percentage points below the interim DFC value and 40 to 60 percentage points below the maximum obtainable values. Rested areas approach the interim DFC value, but are still below maximum obtainable values.

Width-to-depth ratios provide a dimensionless index of channel morphology (Clifton 1989; MacDonald and others 1991). Width-to-depth ratios will often increase as a result of increased sediment, water yield, peak flows, or bank erosion. The width-to-depth ratios for the ungrazed reference stream reaches were almost half those of the lower grazed section of Silver King Creek for all habitat types (15.0 versus 27.7) and for riffles only (21.1 versus 37.6). The interim DFC width-to-depth ratio for "C" channel types in Idaho streams is recommended to be lower than 23 (Overton 1991). Granitic "C" channel types in Idaho streams have a combined mean width-to-depth ratio of 7.9 based on an average of means from 13 streams (Overton 1991). The width-to-maximum-depth ratio for all habitat types in the lower grazed section of Silver King Creek was 16.6, compared to 10.1 in the lower rested section. Based on this information, we speculate that the lower grazed section was about 50 percent below optimum values and the lower rested section was about 30 percent below optimum values. Bank stability and width-to-depth ratios appear to be correlated (table 5).

Surface fines in Silver King Creek showed small variations between management sections—13 to 17 percent for riffles only and 14 to 22 percent for pools only—and no logical pattern. The reasons why surface fines show no logical pattern are probably the same for Silver King Creek as for Coyote Creek.

Recovery and Monitoring Strategy

Stable banks (greater than 90 percent), deeper pools, and narrower wetted width would be the desired condition of a recovery strategy for Silver King and Coyote Creeks. Achieving this depends on: reducing lateral bank erosion, entraining suspended sediment in bank-holding vegetation, and decreasing inchannel sedimentation. These actions should increase bed scour, carving a deeper channel and undercutting the banks. Establishing vegetation to stabilize the banks is the first step in the recovery process.

Assuming that differences between management sections reflect healing from grazing impacts over the past five growing seasons, banks should stabilize over a 5- to 10-year period. Elmore and Beschta (1987) found that riparian areas improved in 8 to 16 years; Clary and Webster (1989) suggested that 1 to 15 years of rest, or longer, would be required to improve degraded riparian areas; Schulz and Leininger (1990) found that riparian areas degraded by heavy livestock use improved quickly when livestock were removed. Changes in channel shape (width-to-depth ratio) will probably occur more slowly. Smaller stream channels will change more quickly (as indicated by the changes in Coyote Valley Creek). Channel recovery will also depend on a healthy watershed upslope. If large volumes of sediment are produced by upslope erosion or by concentrated overland flows due to trailing of livestock or similar disturbances, the erosion sources will have to be reduced to obtain the desired changes in channel shape. Channel morphology adjusts to increases in sediment supply, especially in low-gradient channels. Channel morphology reflects local, watershed, and integrated processes that influence sediment supply and transport capacity (Leopold and others 1964; Montgomery and Buffington 1993). It is doubtful that instream structural work will speed up recovery until a predictable pattern of channel recovery has been established. Inchannel structures could slow recovery by interfering with scour and deposition processes as the channel seeks equilibrium between sediment delivery, storage, and transport. Watershed and riparian restoration are generally more effective than instream structures (Frissell 1992). Channel recovery depends on establishing bank integrity and reducing sedimentation and deposition.

Analysis for this study was difficult because we ventured into the field without a rigorous experimental design. The inventory data provided information on the frequency, distribution, and description of the habitat. These data can be used to design a rigorous monitoring strategy. The recovery strategy should include an effective monitoring scheme to evaluate the predicted recovery of bank stability and channel morphology. Based on the inventory data, habitat variables to be monitored would include percent bank stability and bank undercut, width-to-depth ratios, and pool frequencies and dimensions. These habitat variables need to be sampled and compared either by grouped riffles and pools (randomly selected), or by grouped low-gradient riffles and meander-formed lateral scour pools (randomly selected), the dominant habitat types found within a "C" channel type. This approach would provide a representative sample scheme and would group streams with channels of similar shapes and similar channel-forming processes, reducing hydrologic variability to increase comparability.

To provide some guidance in identifying sample sizes, we examined plots of the power curves as described earlier. Based on this analysis, detection of differences within 10 percent and $\beta = 0.20$ would require sample sizes of 50 to 200 if all habitat types are grouped (fig. 3), depending on the variable of interest (width, depth, maximum depth) (figs. 3, 4, 5). The required sample size of pools only or riffles only would range from 20 to 150 (figs. 4, 5). We recommend the following variables, sample sizes, and detection levels: for bank stability in riffles only (fig. 5), a sample size of 30 to detect a 20 percent difference; for pool habitat type dimensions and width-to-depth ratios, sample sizes of 50 would appear to detect 10 percent changes (sample sizes of 30 would detect 20 percent changes). Management areas would have to be long enough to allow random selection of enough habitat types to satisfy the sample requirements for the desired detection levels.

In combination with the monitoring scheme, photopoints recorded with video tape or 35-mm slides should be established to visually display changes over time of bank vegetation, bank stability, and channel shape. These photopoints should be sampled at the same habitat type and at the same times the physical measurements are taken.

Many time-trend monitoring projects fail when personnel change. The technology now exists to link photo-point images and tabulated habitat statistics with Global Positioning System (GPS) geodetic positions (point locations; longitude and latitude) into a Geographic Information System (GIS). Such systems help monitor results through time.

Conclusions

Cutthroat populations have declined markedly throughout the Western States due to the degradation of habitat (Marnell 1988; Rieman and Apperson 1989). Many streams are currently in a degraded condition because of a variety of impacts over the past century (Platts 1991). Behnke (1977) concludes that the best opportunity for increasing fish populations in the Western States is to improve riparian conditions that have been adversely modified by livestock grazing.

We conclude that differences between grazed and rested areas are likely to have been caused by grazing; the differences we observed are consistent with results of studies done elsewhere. Bank stability, bank undercut, and channel morphology differed between sections. Areas protected from grazing had more stable banks and bank undercuts and were deeper and narrower. The data collected will help managers gauge the condition of a stream and help them determine if a stream reach is moving toward a more desired condition for salmonids. Recovery depends on establishing vegetation to hold the banks. Changes in bank conditions should be observable within 2 to 4 years; however, favorable changes in channel morphology will be slower since they depend on upstream watershed conditions as well as the integrity of stream banks in the area. Monitoring the success of a recovery strategy requires sample sizes large enough to detect differences in the habitat variables selected.

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Appendix A: R1/R4 [Northern/Intermountain Region] Inventory Parameters and Procedures Used for the 1991 Survey of Silver King Creek and Coyote Valley Creek

Standard Stream Inventory

Field Parameters and Measurement Procedures

Objective: To provide a standard set of stream inventory parameters to link management and research objectives.

Fish Habitat Data: Field Data

Channel Reach: The channel reach will be described using gradient and confinement. Below is a table listing the criteria for classifying the channel reach (based on Rosgen Channel Classification Scheme).

Stream Form Code	Gradient	Confinement
A	>4.0%	Confined Colluvial
B	1.5 to 4.0%	Confined Alluvial
C	<1.5%	Unconfined Alluvial
D (Braided)	Variable	Unconfined Alluvial

Confinement: Channel confinement is defined as the ratio of floodplain width to bankfull width. Confined Colluvial is less than 1.5; Mod-confined Alluvial is 1.2 to 2.5; and Unconfined Alluvial is greater than 2.5.

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 ___        ___          \___          ___/         \            /
    \______/                  \________/              \________/
 Unconfined - “C”         Mod-confined - “B”          Confined - “A”
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Habitat Unit Number: Habitat Types are numbered sequentially beginning with #1 from the downstream end of the stream. Side channels, adjacent habitat types, and backwater pools will be separated by using a two-digit decimal code (.10) behind the main channel habitat unit number. The number of side channels will be identified by the first digit of the decimal code (.20) and habitat types within the side channels will be numbered using the second digit of the decimal code (.21). For example, a habitat type with the habitat unit number of 24.21 refers to the first habitat type of the second side channel that drains into the 24th habitat type. For complex side channel numbering, draw a diagram on the back of the field form and label it to ensure the analyzer understands what is actually on the ground. Place a note in the comments section referring to a drawing and the habitat unit number. For Measured Habitat Types place an “M” behind the habitat unit number.

Aquatic Habitat Types: A habitat type is a fluvial geomorphic descriptor of the channel that will be used to quantify fish habitat. Record only those habitat types that are longer than the wetted channel width unless they are a significant single habitat type. Habitat types are primarily recognized by channel shape and scour pattern. Main channel habitat types will be entered on the form in the habitat type row; side channels, adjacent habitat types, and backwater pools will be entered on the form in the side channel row. Habitat Type Codes are listed on the last page. Habitat types at a minimum will be classified as fast water habitat types and slow water pool habitat types broken down by position (midchannel, lateral or off-channel), type (dam or scour), and formative feature (such as beaver, bedrock, boulder, culvert, large wood, root system, meander, other).

Fast Water Habitat Types:

Riffle: A portion of the stream where water flows swiftly over completely or partially submerged obstructions, producing surface agitation. Optional—Riffles can be further broken down into Low Gradient (≤4 percent), and High Gradient (>4 percent) riffles.

Cascade (Rapids): The steepest riffle habitat, consisting of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders.

Glide: A portion of the stream that is wide and shallow, flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Do not confuse glides with tails of pools. Pool tails will be measured as part of the pool, upstream from the pool tail crest.

Runs: Swiftly flowing reaches with some surface agitation and no major flow obstructions. Runs often appear to be flooded riffles. Typical substrates are gravel, cobble, and boulders.

Slow Water Pool Habitat Types: A portion of the stream with reduced current velocity (generally less than 1 foot per second), often with water deeper than surrounding areas. Pools can be described as follows.

Pool types are identified by position (midchannel, lateral or off-channel), type (dam or scour), and formative feature (beaver, bedrock, boulder, culvert, large wood, root system, meander, other). The pool type codes are listed on the last page.

Pocket Pools: Pocket pools are created behind obstructions as inclusions in glides, runs, and riffle habitat types. These are small, subunit pools that do not meet the habitat type definition (longer than the wetted channel width) and are larger than 1 square meter. Count the pocket pools in glides, runs, and riffles. The field form has separate columns for pocket pool numbers and average pocket pool depth, which can be determined from a subsample of pocket pools.

Step Pools: Step pools are a series of small pools and riffles that are shorter than the wetted channel width. If the pools and riffles are uniform, treat them as one habitat type. Count the number of pools and determine average depth. Enter this data in the pocket pool columns.

Off-Channel Pools: Pool habitat types (such as backwater and eddy pools) separated from the main channel by a sand or gravel bar, or other feature (logs, rootwads) should be considered as a separate habitat type if larger than 1 square meter. Treat as a separate habitat type. Code as a side channel or adjacent habitat type in the habitat number column. Enter the habitat type in the side channel column.

Side Channels: A side channel is not a separate habitat type. It may contain any of the above habitat types. Habitat types will be identified in ascending order beginning at the downstream end. Side channel habitat types will be coded by a two-digit decimal as described in Habitat Unit Number: the habitat type will be entered in the side channel column. **Dry Side Channels** or **Insignificant Side Channels** (<10 percent flow) will not be typed; Place "DRY" or "INS" code in the side channel column.

Habitat Type Dimensions: Visually estimated dimensions are calibrated using measurements of the same dimensions at a stratified random subset of habitat types (Hankin and Reeves 1988). "N" equals the sample interval at which the various aquatic habitat types are measured. Measurements should be taken frequently enough so that at least 10 habitat types of each type are measured per stream. If habitat types are relatively large, a higher proportion of total types will need to be measured to meet this criteria (for instance, sample one of every three to five types). If habitat types are relatively small, which is often the case in small streams with abundant structure, a smaller proportion of the total types will need to be measured to meet this criteria (for instance, sample 1 of every 20 types). The first habitat unit to be measured (for each type) is determined randomly by the throw of a die. Channel shape and scour patterns are key parameters for determining the boundaries of the habitat type. The starting and ending points of a habitat type are primarily recognized by identifying the breaks in slope (highest point) along the thalweg of the channel bottom. The minimum set of habitat measurements follows.

Dimensions For All Habitat Types:

Average habitat type length—Thalweg length.

Average habitat type width—Estimate the wetted width at a specific point in the habitat type you believe represents the average width. Measured average width—Determined by measuring and summing wetted widths at points ¼, ½, and ¾ along the length of the habitat type, and dividing by 3.

Average water depth—Measured depth is calculated from nine measurements taken across the three wetted-width cross sections described above. Measurements are taken at points ¼, ½, and ¾ along each cross section, summed, and divided by 12 to compensate for "0" depth at the banks.

Habitat type shore depths—At measured habitat types only, measure right and left bank shore depths on each measured width.

For all pool types use a graduated rod to quickly measure:

Maximum pool depth (wherever it occurs in the habitat type).

Maximum pool tail crest depth.

Surface Fines: Surface fines (<0.6 cm) will be estimated at all pool tails (within a 2-foot band upstream from the pool tail crest) and for all low gradient riffles (≤4 percent). To verify measurements, measure surface fines at every "N"th riffle (≤4 percent) and pool tail. Data will be entered on Form 1A. Surface fines are measured using a 49-intersection grid at a stratified random subset of habitat types. "N" equals the sample interval at which surface fines are measured. At least three grid counts are taken at each measured habitat type.

Pool Complexity: For each pool habitat type, pool complexity will be determined from the following categories estimated to the nearest 10 percent:

Large substrate (that will provide rearing).

Overhead cover (includes terrestrial vegetation within 0.3 meters of the surface and surface turbulence).

Submerged cover (large and small wood, root wads).

Undercut banks.

Wetted Channel Shape: Determine wetted channel shape for every habitat type using the following codes and shapes.

T = Triangle \ /   R = |Rectangular|

Z = /Trapezoidal\   I = \Inverse trapezoidal/

The form contains left and right bank columns for bank shape. Look upstream when determining left and right bank.

Substrate Composition: Substrate composition is estimated at each habitat type and measured on a subset of habitat types using a “pebble counting” technique. In pools, estimate or measure the substrate at the pool tails only, not throughout the entire pool. Substrate is to be tallied by six classes:

Sand/silt	<0.2 cm (<0.10 inches)
Gravel	0.2 to 7.5 cm (0.10 to 3.0 inches)
Rubble	7.5 to 15 cm (3.0 to 6.0 inches)
Cobble	15 to 30 cm (6.0 to 12.0 inches)
Boulder	>30 cm (>12.0 inches)
Bedrock	

Substrate Estimate Verification—Measure substrate at every “N”th Habitat Type (pool tails versus the entire pool) using a pebble counting technique; “N” equals the sample interval at which substrate composition is measured. Pebble counts will be recorded on Form 4A.

Pebble counts are typically made over the width of the bankfull channel (wetted or dry). Pebble count transects are typically located perpendicular to stream flow or randomly along an axis parallel to stream flow (except for pools, use pool tails). For the purposes of this survey, transects may be located at the ¼, ½, and ¾ points of the length of the habitat type. If the channel is too narrow to secure 100 pebbles along the three transects, locate transects at the ⅕, ⅖, ⅗, and ⅘ points of the length of the habitat type, or some other suitable frequency.

Stability Class by Bank Length: Length of bank that is stable or unstable is visually estimated at all habitat types and measured at a subset of habitat types. In making this evaluation, view the bank as if it were composed of 1-foot-long or 1-meter-long pieces, then estimate the length of streambank that is stable and the length that is unstable. Determine for both left and right banks.

A “stable” streambank (as viewed at the steepest sloped portion of the channel between the bankfull and existing water level) shows no evidence of active erosion, breakdown, tension cracking, shearing, or slumping. An “unstable” streambank shows evidences of active erosion or sloughing. Undercut banks are considered “stable” until tension fractures show on the ground surface at the back of the undercut.

Bank Shape Class by Length: Length of bank by shape class is visually estimated at all habitat types and measured at a subset of habitat types. In making this estimate, view the bank as if it were composed of 1-foot-long or 1-meter-long pieces. Determine for both left and right banks.

Bank shape classes include:

Undrct = Undercut (<90 degree angle from water surface)
Gntslp = Gently Sloping (135 degree angle from water surface)
Stpslp = Steeply Sloping (90 to 135 degree angle from water surface)

Bankfull Channel Dimensions: Local bankfull channel dimensions are measured for every measured riffle or run habitat type (straight and uniform channel section) at a cross section with a wetted width that approximates the average wetted width of the habitat type. Dimensions consist of:

Bankfull channel width
Maximum bankfull depth
Bankfull shore depths

Bankfull Channel Shape: Bankfull channel shape will be determined for all habitat types using the following codes:

“R” = Rectangular
“T” = Triangular
“Z” = Trapezoidal
“I” = Inverse Trapezoidal

The form contains left and right bank columns for bank shape differences. Look upstream when determining left and right bank.

Large Woody Debris (LWD): Record on Form 2A. The LWD data will be used to develop a measure of the large woody debris present in the survey section. Large woody debris is defined as pieces of wood that are at least 3 meters long or two-thirds the channel width and 0.1 meter in diameter one-third up from the base. Estimate the length of the single pieces; measure at least 10 single pieces per day to develop a correction factor. Estimate the number of pieces and the volume (LXWXD) of LWD aggregates. The three categories for woody debris are:

R = rootwad(s)
S = a single piece
A = aggregate (estimate the number of pieces and the volume)

The LWD will be estimated only for those pieces located within the bankfull active channel. For every habitat type, record the number for each category on Form 2A.

Water Temperature: Water and air temperature and time of day will be taken at reference points throughout the survey. Ensure that morning, noon, and afternoon water and air temperatures are taken and recorded on the field form.

Habitat Type Tally: Keep track of habitat type frequencies for identifying measured (nth) habitat types.

Comments: Record any other characteristics of each habitat type. This will include: any significant landmarks, tributaries (bank from which it enters), bridges, wide open flat areas, road and railroad grades, landslides, management activities (grazing, timber sales, mining), irrigation dams, etc. Place a check in the field form and enter comments on Form 5A.

Photo Points: Photos looking upstream and downstream of tributary reach breaks, and photos of unique features (landslides, management activities, unusual habitat types, and representative habitat types). Photos are to be recorded on Form 4A referenced to the habitat number.

Supplemental Data Forms

FORM 1A: Location and General Information, Percent Surface Fines, and Fish Species

Stream: Spell out the stream name as it appears on the topographic map.

Forest: Use two-digit numerical code and spell out the Forest name.

District: Use two-digit numerical or alpha-numerical code for Ranger District, and spell out the District name.

Reference Reach: A reference reach will be designated between tributary stream breaks that appear on 7½-minute quads (Regional standard). The EPA Reach Number System will be used to identify the tributary breaks. Enter the EPA Stream Catalog number from the EPA River Reach File for Idaho, July 1989.

Other Reference Data: Other reference data that can be added: township, range, section, longitude and latitude, geologic type, ecoregion by section, GPS locations, elevation, etc.

Survey Date(s): Identify the date or dates the inventory was conducted. Dates are to be entered as Month/Day-Day/Year.

Unit of Measure: Indicate if the units of measure are reported in feet (ft) or meters (m). CAUTION: Be sure you know what unit you are working with.

Estimator: List the name of the person on the inventory team making visual estimates of dimensions.

Recorder: List the name of the person taking and recording measurements of dimensions on a subset of habitat units.

Gradient: Channel gradient is measured to the nearest 0.5 percent over one or more stream meander cycles using a hand level and rod. Gradient and reach delineation should be predetermined from contour maps and field checked.

Discharge: Discharge, to the nearest cubic meter per second (cms) or cubic foot per second (cfs) calculated at channel reach breaks or at beginning and ending of stream inventory.

FORM 2A: Large Woody Debris

Follow form instructions.

FORM 3A: Riparian Complex

Woody Species Regeneration: Woody species regeneration will be determined for each vegetation type. Woody species regeneration can be made along the same green line as shrubby species regeneration (USDA FS 1992). The sampler uses a 2-meter pole that has the center already marked. Shrub measurements are made by walking 100 meters on each side of the stream with the center of the pole held directly over the green line. Using the green line as the center of the belt measurement helps to assure that the sampling is done in a setting where regeneration is most likely. All shrub species rooted within the tips of the pole (1 meter either side of the green line) are tallied based on the following age class categories:

Number stems = 1	Sprout
Number stems = 2 to 10	Young

Number stems > 10, > half the stems living	Mature
Number stems > 10, < half the stems living	Decadent
No living stems	Dead

For smaller willow species, such as *Salix wolfii* and *Salix planifolia*, five stems (with more than half the stems living) indicate a mature willow.

A tally of shrubs by age class provides a preliminary indication of shrub regeneration. A high proportion of plants recorded in the sprout, young, and early mature categories would indicate the shrub component is in good health. Conversely, low numbers of plants in the sprout and young categories would indicate they may not be receiving proper management. Some riparian areas are not well suited to grow woody species. This appears to be especially true where the stream has a low gradient and a limited amount of natural stream channel movement. In these settings, understory sedges and rushes are able to buffer the forces of water without woody species. A comparison of settings where the complex is as close to potential natural vegetation as possible may be used as a standard to evaluate overall shrub status. Subsequent measurements on the same area will provide a measurement of shrub regeneration trend.

Most of the woody riparian species in the Intermountain Region regenerate best on settings where there is minimum competition from herbaceous species (Winward 1986).

Floodplain/Riparian Vegetation: At major vegetation complex breaks, the percent of each vegetation type listed below will be determined from a tally of types by category from the *woody regeneration data sheet*:

Sedge/rush
Grass/forbs
Riparian shrub
Upland shrub
Riparian tree
Upland tree

FORM 4A: Wolman Pebble Counts Data and Photographs

Follow form instructions.

FORM 5A: Comments

Follow form instructions.

Field Data Form

Stream ________________ Reach No. ______________ Form No. ________________

Forest ________________ District ______________ Page _____ of _____

Channel reach type ______ Gradient _____ Discharge _________ Date __________

Habitat number											
Habitat type											
Side channel											
GPS start time											
No. pocket pools											
Pocket pool average depth											
Habitat length											
Habitat average width											
Habitat average depth											
Habitat maximum depth											
Max pool crest depth											
Surface fines percent											
Pool complex large substrate											
Overhead cover											
Substory cover											
Uncovered bank											
Wetted channel shape	L										
Wetted channel shape	R										
Substrate <0.2 cm	SS										
0.2 cm - 7.5 cm	GR										
7.5 cm - 15 cm	RB										
15 cm - 30 cm	CB										
>30 cm	BL										
Bedrock	BR										
Bank length stable	L										
Bank length stable	R										
Unstable	L										
Unstable	R										
Bank length undercut	L										
Bank length undercut	R										
Gently sloping	L										
Gently sloping	R										
Steeply sloping	L										
Steeply sloping	R										

Measured units only

Shore depth	L										
Shore depth	R										
Bank-full width											
Max bank-full depth											
Bank-full shore depth	L										
Bank-full shore depth	R										
Bank-full channel depth	L										
Bank-full channel depth	R										
Temperature	H_2O										
Temperature	Air										
Temperature	Time										
Habitat type tally											
Comments											

Habitat Typing Field Codes

These three-digit codes will be used to describe the habitat types:

DRY - Dry channel
LGR - Low gradient riffle
HGR - High gradient riffle
CAS - Cascade
GLD - Glide
RUN - Run
EGW - Edgewater
POW - Pocketwater
BRS - Bedrock sheet
SRN - Step run
INS - Insignificant side channel
(<10% flow of main channel)

Pool Formative Feature Codes

These codes will be used to describe pools. The asterisk will be replaced with the appropriate number to describe the formative feature:

BW* - Backwater pool
LS* - Lateral scour pool
SC* - Secondary channel pool
TR* - Trench/chute
PL* - Plunge pool
DP* - Dammed pool
MC* - Midchannel pool
CC* - Channel confluence pool
ST* - Step pool
OC* - Off-channel pool

1 - Artificial (specify type in comments, for example, habitat improvement, structure, dam, and so forth)
2 - Beaver dam
3 - Bedrock
4 - Boulder
5 - Culvert
6 - Log
7 - Meander
8 - Rootwad

Form 1A—Location and General Information, Percent Surface Fines, and Fish Species

Page_____of______

Stream__________ Forest__________ District__________ Reach__________
Stream code__________ Forest code__________ Ecoregion__________ Bailey__________ Omernik__________ Geologic type__________
Watershed code__________ EPA reach No.__________ Range__________ Township__________ Section__________
Quad name__________ Survey date__________ Estimator__________ Recorder__________
Units of measure__________(m or ft) Elevation__________ Map gradient__________ Field gradient__________ Rosgen type__________
Discharge__________(cms) Confinement__________ Weather__________

Measure dimensions at every *n*th__________ Riffle__________ Glide__________ Pool__________ Side channel__________

Percent Surface Fines (PSF) (at least three grid measurements per sample site)

Habitat number	Mean PSF	1	2	3	4	5	6	7	8	9	10

Habitat number	Mean PSF	1	2	3	4	5	6	7	8	9	10

Fish Species

Habitat number	Fish species	No. of fry	No. of fingerlings	No. of adults	No. of redds	Information collected by: visual observation, snorkel, shocking, other

Form 2A—Large Woody Debris (LWD)

Stream________________________ Forest________________________ District________________________ Reach_____________ Page____of____

Instructions: Estimate (est) length (len) and diameter (dia) for single pieces (range for other categories) and measure (meas) a random subset to develop correction factor.
For aggregates, estimate the total number of pieces and the volume of the aggregate (LXWXD).

	Single pieces			Single pieces			Aggregate LXWXD			Rootwad		
Habitat number	N	Est len x dia	Meas len x dia	N	Est len x dia	Meas len x dia	N	Est No. of pieces	Est volume	N	Est len x dia	Meas len x dia

Form 3A—Riparian Complex

Stream____________________ Forest____________________ District_____________________ Reach______________ Page____of____
Unit numbers___________________

Community type	Seedling/sprout		Young/sapling		Mature		Decadent		Dead	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Riparian shrub										
Willows										
Riparian trees										
Cottonwoods										
Upland trees										
Totals										
	Left					Right				
Sedge/rush CT										
Grass/forb CT										

Unit numbers___________________

Riparian shrub										
Willows										
Riparian trees										
Cottonwoods										
Upland trees										
Totals										
	Left					Right				
Sedge/rush CT										
Grass/forb CT										

Form 4A—Wolman Pebble Counts and Photographs

Stream__________________________ Forest__________________________ District__________________________ Reach_________________ Page_____of_____

Wolman Pebble Counts

Habitat number	Sand/silt <0.2 cm	Gravel 0.2–7.5 cm	Rubble 7.5–15 cm	Cobble 15–30 cm	Boulder >30 cm	Bedrock

Habitat number	Sand/silt <0.2 cm	Gravel 0.2–7.5 cm	Rubble 7.5–15 cm	Cobble 15–30 cm	Boulder >30 cm	Bedrock

Photographs (E = Exposure)

Roll #__________ Begin E #__________ End E #__________
Roll #__________ Begin E #__________ End E #__________

Habitat number		Habitat number		Habitat number	
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#
	E#		E#		E#

Form 5A—Comments

Stream______________________ Forest______________________ District______________________ Reach____________ Page____of____

Habitat number	

Overton, C. Kerry; Chandler, Gwynne L.; Pisano, Janice A. 1994. Northern/Intermountain Regions' fish habitat inventory: grazed, rested, and ungrazed reference stream reaches, Silver King Creek, California. Gen. Tech. Rep. INT-GTR-311. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 27 p.

Stream reaches that have been rested from livestock grazing appear to have stable banks and more bank undercuts than grazed stream sections. Ungrazed reference streams that are similar in parent geology, precipitation, channel type, habitat types, drainage area, and stream width had greater bank stability values and lower width-to-depth ratios than those of grazed and rested management sections of Silver King Creek. Power curve analysis was used to suggest the sample sizes required to monitor progress toward the desired condition.

Keywords: grazing effects, stream inventory, monitoring, fish habitat, sample sizes, desired conditions

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

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