AN ECOLOGICAL CHARACTERIZATION AND FUNCTIONAL ANALYSIS OF RIVERINE WETLANDS IN BOULDER MOUNTAIN PARKS, BOULDER, COLORADO

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Submitted to:

City of Boulder Mountain Parks
and
Boulder Open Space

April 1, 1999

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PROJECT SUMMARY

The City of Boulder Mountain Parks (BMP) has both ecological and societal values. To balance the goals of retaining the natural features and processes of the park and allowing public access requires a clear understanding of its biological systems. A key component of this understanding should be knowledge of the types and functions of wetland systems which affect and are affected by BMP.

The goals of this project were to (1) continue the wetland survey begun in 1997 (D'Amico et al. 1998), and (2) establish a series of permanent sampling stations along BMP streams and began to characterize the hydrology, water characteristics, and vegetation at these stations.

The vegetation survey portion of this study was designed to extend work begun in 1997. We selected 14 wetland sites in two drainages (Bear Claw Canyon and Greenman Spring Canyon) and characterized their vegetation and ecological conditions. An average of 35 plant species were found at each site and canyons showed no differences in species richness. Vegetation at the sites grouped into six community types relating to the elevation and hydrology. The total of sites surveyed in this and the initial study (D'Amico et al. 1998) includes 54 wetland areas with a total of 232 plant species.

Vegetation sampling and hydrology monitoring was performed at permanent transects in three canyons: Shadow, Bear, and Gregory-Long. Data collected suggests that the three streams monitored are highly precipitation driven and flow varies significantly over short periods of time, and that a number of surface water characteristics varied due to canyon, sample date, and elevation. Vegetation at transect sites varied over small spatial scales as a result of interactions between aspect, topography, soils, and hydrology across the riparian zone.

INTRODUCTION

The City of Boulder Mountain Parks (BMP) is a biologically diverse landscape with enormous ecological and societal values. It provides much needed refugia for native flora and fauna, some of which is uncommon or rare. The park also provides a recreational amenity for the citizens of the Front Range in this increasingly urban area. The goal of preserving the natural features and processes of the park while allowing public access requires a detailed, scientific understanding of its biological systems. Without such knowledge, management decisions are relegated to judgement calls which may be suspect and subject to legitimate scrutiny by various user groups.

The diverse physiography of BMP supports a rich vegetation. It harbors more than 40 percent of the species documented in Boulder County while comprising less than two percent of the land area (Hogan 1993, Weber 1995). The park lies mostly in the montane zone (Marr 1961) and exhibits ponderosa pine *(Pinus ponderosa)*, douglas-fir *(Pseudotsuga menziesii)* and mixed ponderosa pine/douglas-fir forest types as well as three grassland associations and plains, foothills and mountain riparian vegetation types (Cooper 1984, Hogan 1993).

Many plant species which are locally common in BMP are otherwise uncommon in Colorado. Several of these are eastern North American disjuncts and/or relictual species that have persisted in the cool, moist mountain refugia following post-Pleistocene warming (Weber 1965, Hogan 1993). In addition, many plants of special concern are found in riparian and wetland habitats of BMP including broad-lipped twayblade *(Listera convallarioides)*, white adder's mouth *(Malaxis monophyllos)*, rattlesnake fern *(Botrypus virginianus)* and others (Hogan 1989, 1993; CNHP 1995).

Wetland resources within BMP have received little attention. Because of this paucity of research, initial studies are necessarily coarse grained, but are exceedingly important since they lay the foundation for future studies and highlight the most pressing management concerns. Fundamental to understanding BMP's natural resources is knowing the types of wetland systems found within the park boundaries and the environmental functions which they perform.

D'Amico et al.(1998) initiated a survey of wetland communities and performed a qualitative functional analysis of surveyed wetlands. The current project had two major portions and objectives. First, for streams and areas not previously surveyed, the present study was designed to duplicate the wetland sampling, delineation of wetland communities, and ecological characterization initiated by D'Amico et al. (1998). In a separate portion of the study, our objectives were to establish series of permanent sampling transects and begin to characterize stream hydrology, water characteristics, and vegetation at these transect sites.

METHODS

Study area

The study was conducted primarily in the City of Boulder Mountain Park. The Boulder Mountain Park (40° 00' N, 105° 20' W) encompasses approximately 2400 hectares (6000 acres) along the Front Range of Colorado. The park stretches approximately 10 km north to south (from Boulder Creek on the north to South Boulder Creek on the south) and approximately 3 km from east to west (Fig. 1). Portions of the study were also conducted in adjacent lands managed by City of Boulder Open Space and Federal land. City Open Space land borders the southeast portion of the Park, and federal land surrounding the National Center for Atmospheric Research (NCAR) borders the park on the east, north of Open Space land (U.S.G.S Eldorado Springs Quadrangle).

Boulder Creek Granite and Fountain Sandstone underlie much of the park. (Chronic and Chronic 1972, Lovering and Goddard 1950). Four soil complexes are mapped within the park: Juget-Rock Outcrop, Fern Cliff-Allens Park Rock Outcrop, Goldvale-Rock Outcrop, Baller Stony Sandy Loam (U.S.D.A. 1975). These complexes are composed primarily of Ustolls, Cyroboralfs, and Lithic Orthents with alluvial soils in riparian areas.

Mean annual precipitation in Boulder is 45 cm, most of which occurs in April and May. In 1998, precipitation through the end of the sampling season (October) was above average. Temperatures are warmest in July (23°C/74° F) and coldest in January (0° C/32° F), with an annual mean of 10.5° C (51° F) and approximately 150 frost-free days.

The vegetation and flora of the park have been described by Cooper (1984), Jones (1990) and Hogan (1993). The park's vegetation has been classified into ponderosa pine forest, Douglas-fir forest, mixed ponderosa pine and Douglas-fir forest, grassland, riparian, and cliffs/rock faces. Making up these vegetation classes are 639 species of vascular plants, 172 lichens, 57 mosses, and 8 hepatics (Hogan 1993).

Site descriptions and sampling design

Releves - Vegetation Survey

The vegetation survey portion of this study was designed to extend work begun in 1997 (D'Amico et al. 1998). They characterized the vegetation and ecological conditions at 40 sites within the Park. To select the remaining sites for this portion of the study, we consulted with Ann Armstrong (Boulder Mountain Parks) and D'Amico (Boulder Open Space) who developed a priority list of drainages to be surveyed.

In August 1998, we selected sites in the two highest priority drainages: Greenman Spring Canyon and Bear Claw Canyon. Greenman Spring Canyon runs north from the north slope of Green Mountain to Gregory Canyon. The 8 sites we placed in this canyon (T 1 S, R 71 W, S 1) were all along the main stream channel, beginning at Greenman Springs (elevation 7040') and ending along the cliff face (elevation 6350') above the confluence with the Gregory stream (Fig.

2). Bear Claw Canyon runs west from the western slope of Bear Peak to the west boundary of the park (T 1 S, R 71 W, S 13-14). Five of the six sites in this canyon were along the main stream channel and the remaining site was in a small side drainage near the headwaters (Fig. 3). The elevation at these sites ranged from approximately 7400' to 7180'. Individual site location within both drainages was semi-stratified based on elevation and further refined based on changes in vegetation, topography, and hydrology.

Transects - Functional analysis

In May and early June of 1998, we located and established long-term monitoring transects. We increased the proposed number of these sites from 12 located in 2 canyons to 19 transects which we located along the drainages of 3 major canyons: Gregory - Long Canyons, Bear Canyon, and Shadow Canyon. We placed 6 transects in both Bear and Shadow Canyons and 7 in the Gregory-Long Canyons (Figs. 2-4). Within each canyon the basis of our sampling design was a series of transects oriented perpendicular to the length of the channel. After surveying the length of each canyon to find the headwaters, we determined the elevational range of the streams and stratified our preliminary transect locations based on elevation. Once narrowed, exact transect location was based on local vegetation, topography, and hydrology.

All transects in Gregory-Long Canyon were located within the park boundaries and stretch from just upstream of Flagstaff Road (elevation 5760') to a point in Long Canyon upstream of Panther Canyon (elev. 7040'). The Bear Canyon transects begin on NCAR land (elev. 5760') and proceed across the park, ending just east of the western Park boundary (elev. 7160'). In Shadow Canyon, we established five of the six transects in Boulder Open Space land with the lowest transect at approximately 5690'. The highest transect in Shadows is located at the headwaters just inside the Park boundary at 6610' (Figs. 2-4).

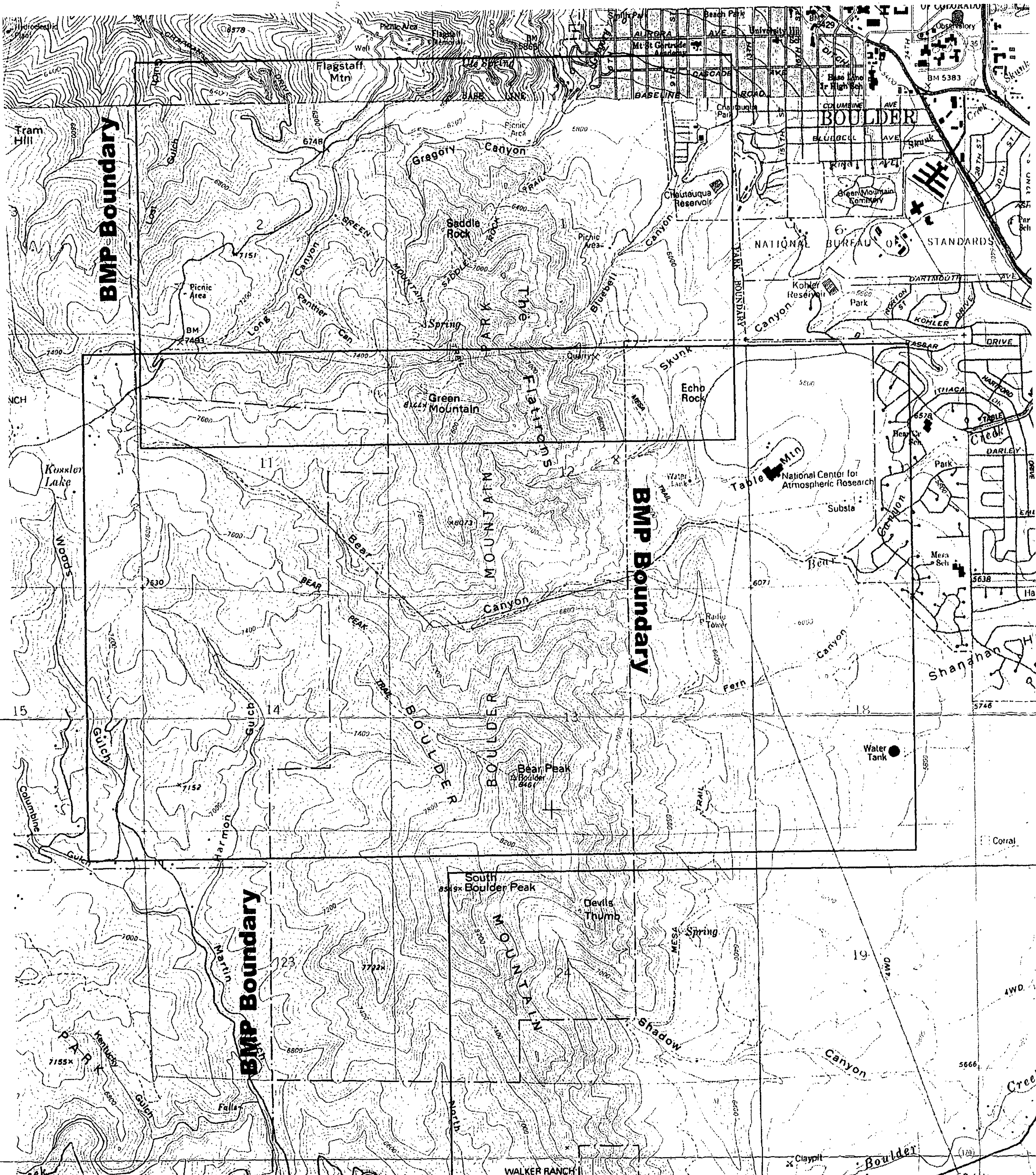
To maintain continuity in sample numbering, the transect series begun in Gregory Canyon continuing into Long Canyon is designated as GC 1 - 7 (Fig. 2). Within Gregory Canyon, to differentiate transect sites from releve sites, the designation of releve sites is GSC 1-8, or "Greenman Spring Canyon" which was the start of the releve series.

Field Methods

Releves - vegetation sampling

Because this portion of the study was a continuation of work begun in 1997 (D'Amico 1998), our methods for this part of the study mirrored their's as closely as possible. The goal of the sampling at these releve sites was to characterize the vegetation and general ecological conditions. The sampling design and data collected were based on a modified WET evaluation (Amadus et al. 1987). All sampling at these sites was done on August 10, 11, except for water pH which was sampled on August 17, 1998.

At each site we constructed a sample plot (releve) of approximately 100 m^2, oriented with the long axis parallel to the stream channel. Releve width varied with the width of the riparian vegetation, but was generally 3-8 meters. At two sites it was not possible to construct a releve of



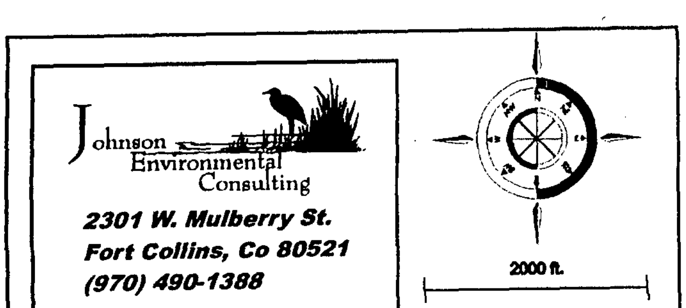


Figure 1. Assembled USGS quadrangle maps showing study area. Bold faced rectangles show the extents of detail map contained in the Figures 2-4.

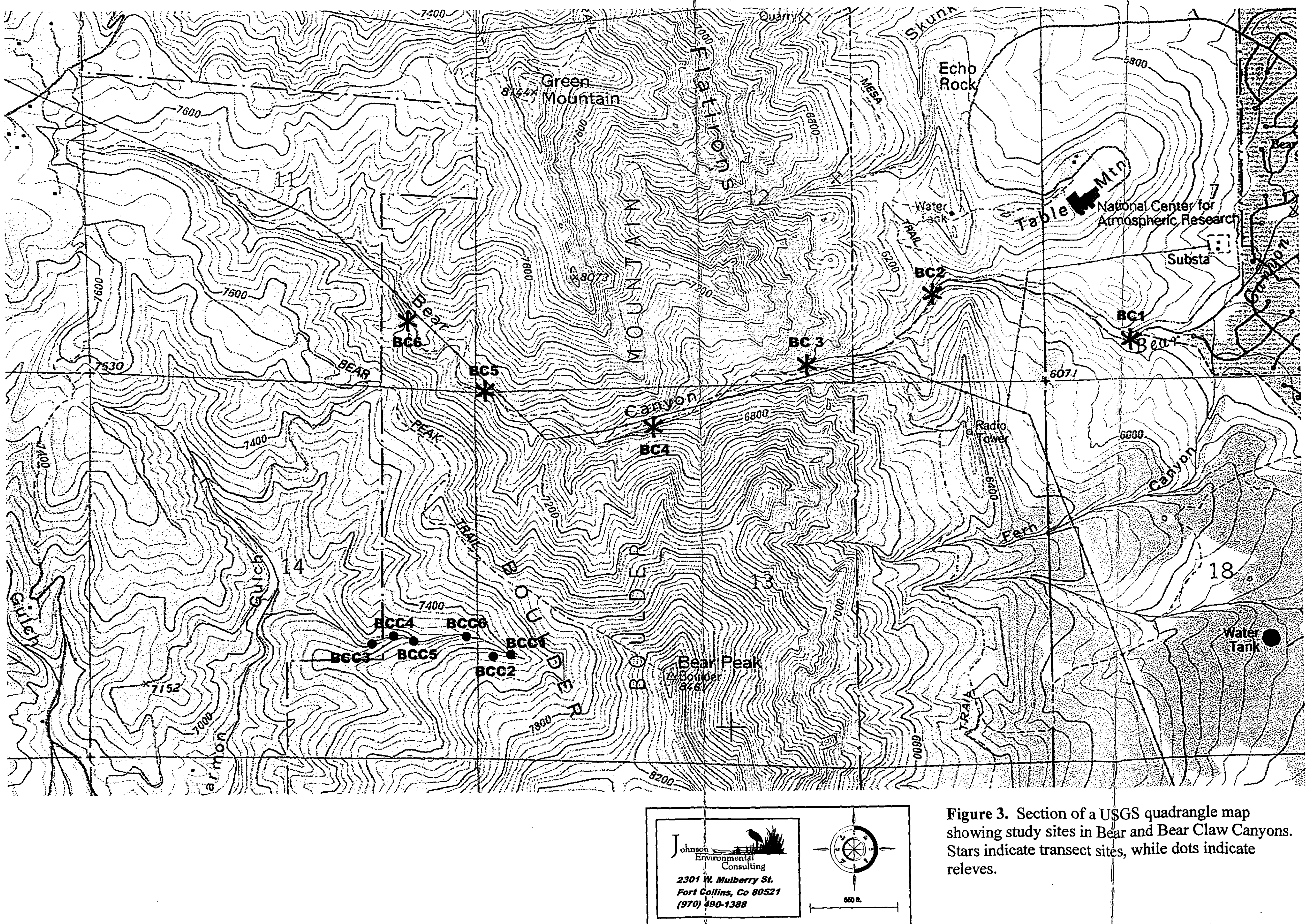
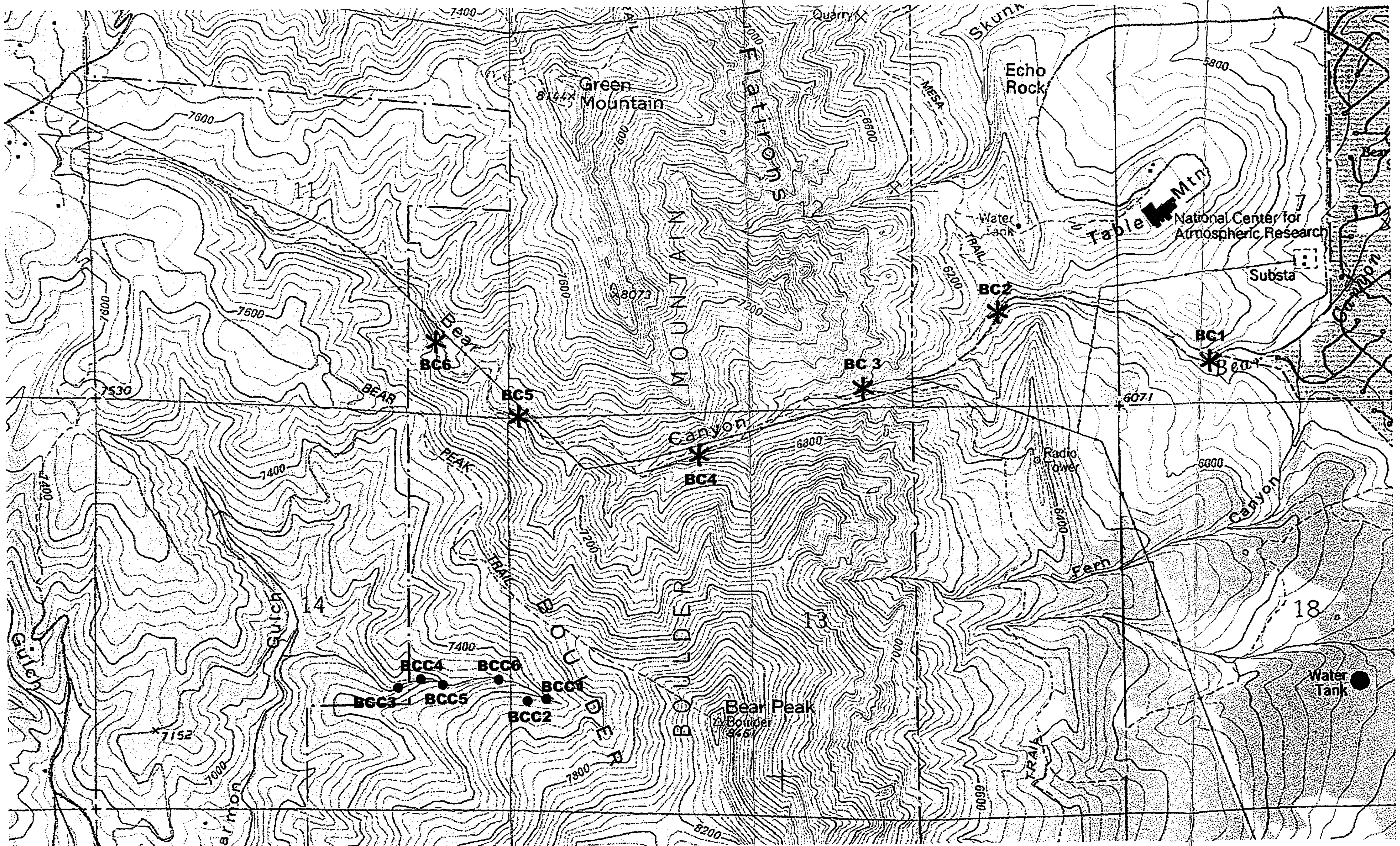


Figure 3. Section of a USGS quadrangle map showing study sites in Bear and Bear Claw Canyons. Stars indicate transect sites, while dots indicate releves.



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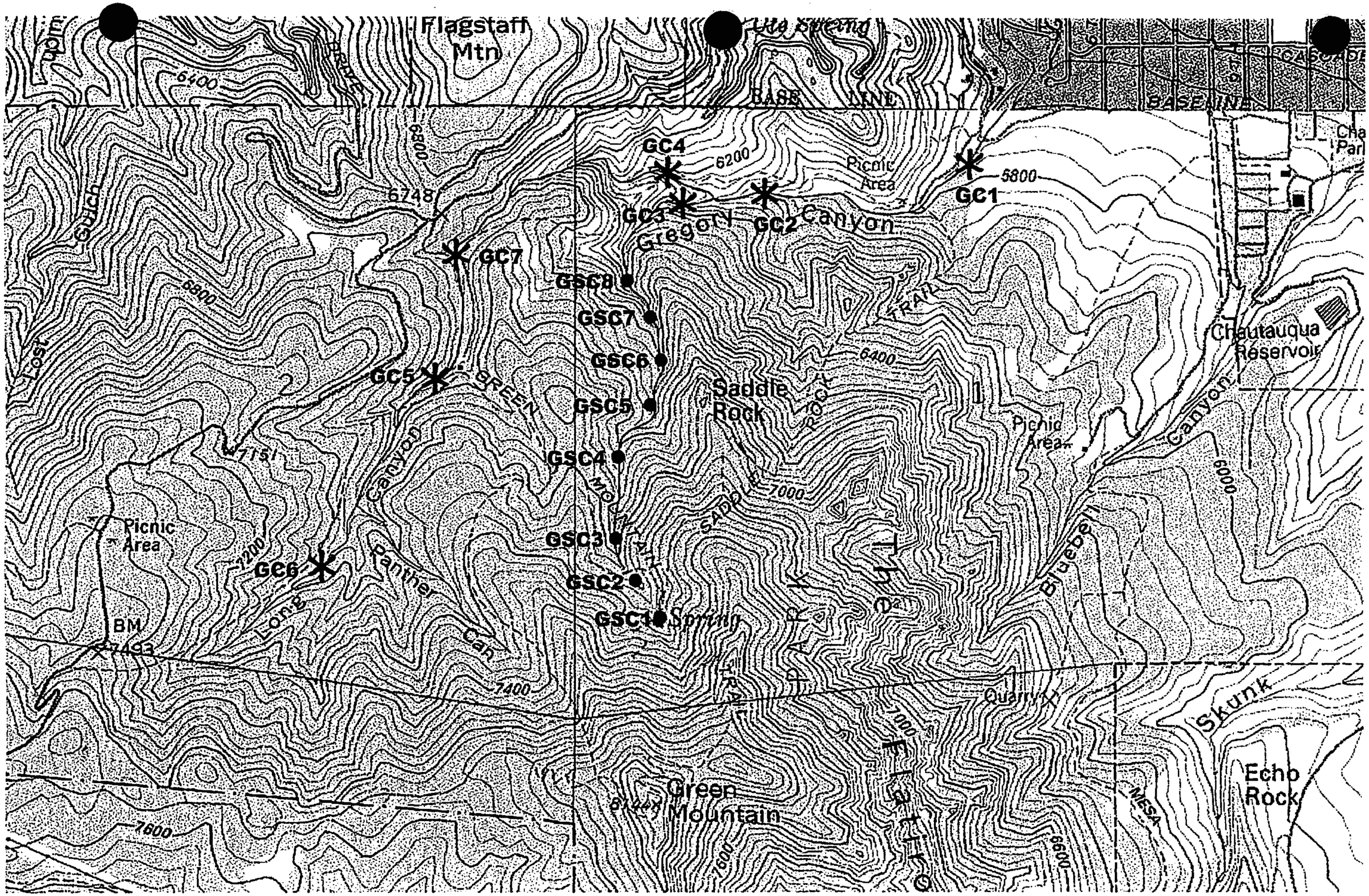

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Figure 2. Section of a USGS quadrangle map showing study sites in Gregory and Long Canyons. Stars indicate transect sites, while dots indicate releves. The transect series originating in Gregory Canyon continues into Long Canyon as well. Releve sites within Gregory Canyon are indicate as by GSC, or Greenman Spring Canyon, the location at which the series was started.

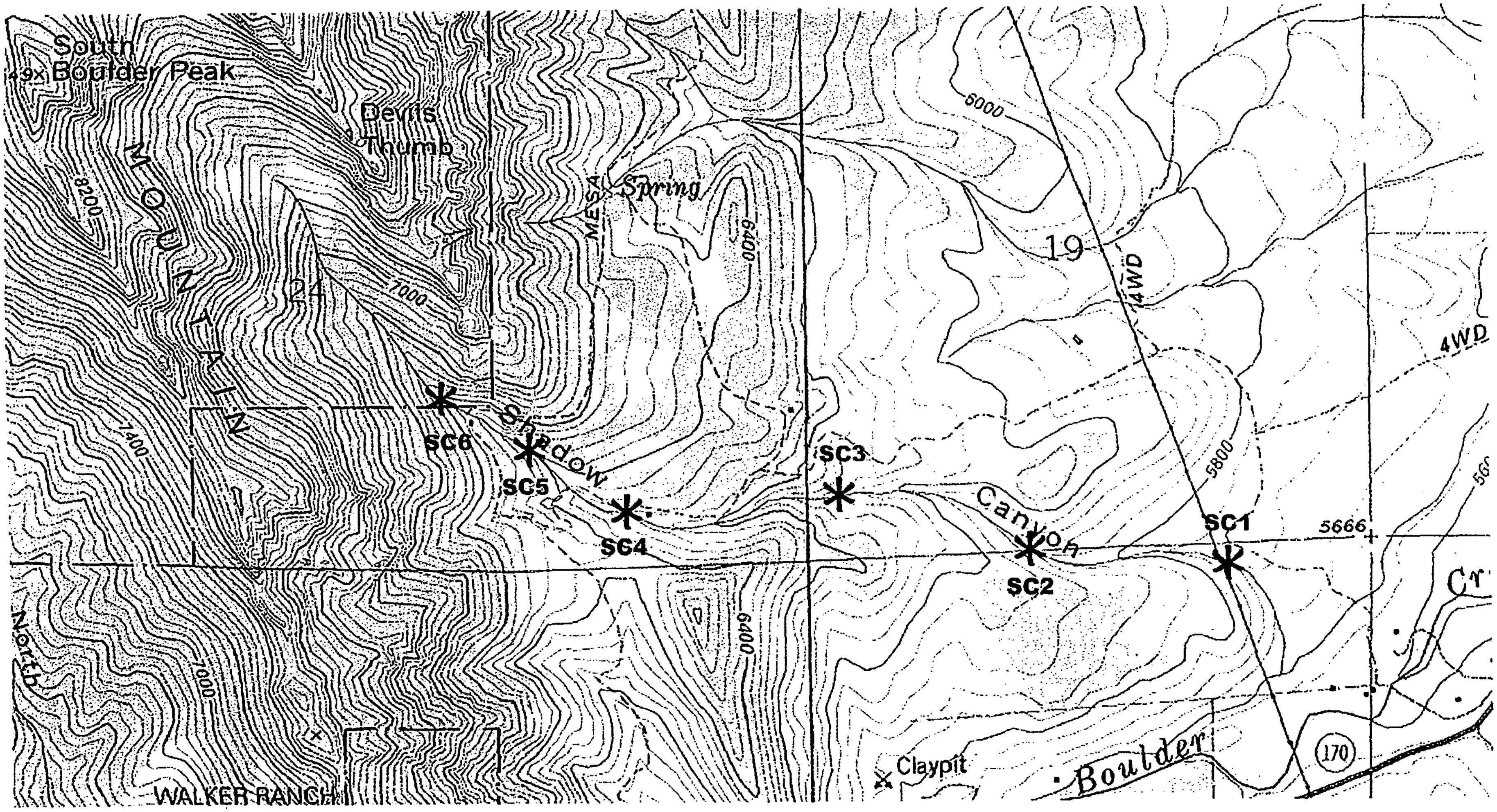


Figure 4. Section of a USGS quadrangle map showing study sites in Shadow Canyon. Stars indicate transect sites. Note that the stream is indicated by the map to continue above SC6, but SC6 is actually located at the headwater spring.

100 m^2 because of abrupt changes in the vegetation. At these sites we made releves as close to 100m^2 as possible. In order to permanently mark releves for future monitoring studies, we placed small monuments on concrete reenforcing bars at one corner. Releves can be reconstructed by locating the monument and using the dimensions recorded in Appendix A.

Within releves, we recorded each plant species and visually estimated the percent of canopy coverage. Special attention was devoted to searching for rare species since their presence may have important influences on management decisions.

Releves - abiotic sampling and ecological characterization

In conjunction with the vegetation data, we collected data on topography, soils and hydrology. We determined local channel direction and gradient within each releve. Soil cores were taken with a 2.5 cm diameter gouge auger to the depth of lithic contact. Cores were taken approximately 1 m from the stream channel in areas where vegetation was present. Soil texture and color were estimated from the B-horizon. Following USDA methods (1996), we identified hydric soils by looking for indicators such as mottles and concretions in the B-horizon; when present, we estimated percent mottles and determined mottle color. At sites where water was present in the channel, we determined water conductivity, temperature, and pH (YSI Model 30), and measured water depth and channel width in a representative location within the releve. At all sites, we estimated depth to water table approximately 1 m from the channel edge (see Appendix B for releve abiotic data).

Ecological characterization of the sites was done by evaluating each plot using a modification of the WET evaluation (Adamus et al. 1987). This technique characterizes riparian and wetland areas by ranking the site on a series of functions. Each function receives a score from 1 (lowest) to 5 (highest) and each score receives a rating from A to C based on the confidence with which the score can be made. We scored each site for 12 functions.

Transects - vegetation sampling

We sampled vegetation along 12 transects: six in Bear Canyon and six in Gregory-Longs Canyons (Figs. 2 and 3). The goal of the vegetation sampling at these transects was to intensively characterize the vegetation as a function of distance to the stream channel. At each site we established a permanent transect across the riparian vegetation and marked the endpoints with rebar. Transect length depended on the width of the riparian vegetation corridor, ranging from 10 to 17 m. We arranged contiguous, square 1 m^2 subplots along the transect and estimated cover of each plant species in each subplot. To more fully characterize the canopy cover, plants were divided into two height classes: lower than 1.5 m and taller than 1.5 m. Thus, some species could receive two cover estimates within a single subplot if individuals of different heights were present. Vegetation sampling at these transects was done between July 10 and July 29, 1998.

The cross-section of each channel and riparian area was made by surveying the transect. We attached PVC pipes to the rebar markers of each transect end and hung a level line along the transect. A transit and surveyor's staff were used to measure the distance from the line to the ground surface at 0.5 m intervals along the transect.

Transects - hydrology and water analysis sampling

To facilitate hydrograph construction, we established a permanent staff gauge and hydrology transect at all 19 transect sites (Bear, Shadow, and Gregory-Long Canyons; Figs. 2-4). The hydrologic stations were established between May 27 and June 1, 1998. At all transects except for two, we created a staff gauge mark by etching a 5 cm long line in a large, partially submerged boulder. We chose to install as many staff marks as possible on rocks to minimize the impact of the stations on the environment and aesthetics of the area. Each week, BMP personnel visited these stations to read the staff gauges, measure volumetric flow, and measure surface water dissolved oxygen, pH, temperature, and conductivity. Our goal in installing these stations was to develop a stage-discharge relationship across all three streams and evaluate patterns in hydrological regimes.

Two additional sampling designs were used to investigate surface water characteristics. Sampling and laboratory analyses of all water samples were coordinated by Amy Struthers. We anticipate that details of the sampling and analyses can be found in her report (Struthers in prep.). Water samples were collected by BMP personnel at all transect sites during August 5-12. Concentrations were determined for 18 metals (Appendix C). Although dissolved concentrations were determined for the lowest elevation site in each canyon, we used only the total concentrations (measured at all sites) in our analyses. In addition to the metal sampling, water samples were collected three times at the lowest elevation sites in each canyon (June 22 - 24, August 3 - 5, and 11 - 12). Replicate samples were made at some sites on some dates (see Appendix D). We used the measurements provided on 19 water quality variables in our analyses.

Statistical Analyses

We used PC-ORD v. 3.04 (McCune and Mefford 1997) to perform ordinations and used Systat v. 7.0 (SPSS, Inc. 1997) for all other statistical analyses.

Releves

Vegetation data from releves measured in 1998 was analyzed with TWINSPAN and detrended correspondence analysis (DCA) (Hill and Gauch 1980). TWINSPAN classifies both species and samples in one dimension based on a reciprocal averaging ordination space (McCune and Mefford 1997). For our purposes, the relevant output is a grouping of releve sites based on species abundance and composition. The aim of DCA is to construct multiple axes based on species composition data in which releve sites that are similar in species composition are represented by points that are close together. For TWINSPAN, we based our analysis on D'Amico et al. (1998) as closely as feasible. We created classes and transformed cover data into Daubenmire classes (Daubenmire 1959). Limitations on the analysis included: five indicators per division, a maximum of 5 divisions, and a minium group size of 5 to be considered for further division. We used DCA to separate releves along two axes. Percent cover data were log $(x + 1)$ transformed before analysis to decrease the influence of species with very high cover. We used the default DCA settings in PC-ORD (rare species not downweighted, rescale axes, rescaling threshold = 0, number of segments = 26).

In addition, we combined the releve data from this study with that of D'Amico et al. (1998), resulting in a total of 54 releve sites, and used DCA to separate and group sites from both sampling years. PC-ORD default settings were used. Spearman rank correlations were used to correlate DCA scores with environmental variables in order to determine whether measured environmental data related to separations based on vegetation data. Significance of correlations were determined from statistical tables (Zar 1984). Because not all environmental variables were available from all releve sites, sample sizes for correlations were not equal.

Transects - vegetation

Vegetation data from transect sites was analyzed in two different, but complementary, analyses. In the first analysis, our goal was to assess whether species composition within each subplot could be related to canyon, elevation, aspect, and height above or distance from the channel. In other words, we wanted to see if factors at a variety of spatial scales were important in influencing species composition. We used TWINSPAN to separate and group subplots based on presence/absence data. We pooled data from all subplots (2 canyons, 6 sites/canyon) for a total sample size of 160. Limitations on the analysis included: five indicators per division, a maximum of 4 divisions, and a minium group size of 5 to be considered for further division.

In the second analysis of transect vegetation data, we wanted to test for patterns in species abundance at smaller spatial (within transects). We analyzed data from each transect separately using DCA to determine how subplots along the transect grouped or separated. Plant cover (0-100 %) was standardized with a log (x + 1) transformation before analysis to decrease the influence of very abundant species. We used the default DCA settings in PC-ORD (rare species not downweighted, rescale axes, rescaling threshold = 0, number of segments = 26).

Transects - hydrology and water analyses

Regressions and analysis of variance were done on weekly flow measurements using the MGLH procedure. For each canyon, we used factorial analysis of variance to test for differences in flow due to site and date. Significant differences due to site were further analyzed by using Tukey tests to compare all site pairs within a canyon. This analysis was designed to detect losing or gaining reaches along the three streams. We also wanted to test for a linear trend in flow due to elevation. However, elevation and site were completely confounded, so we also used a linear regression to test for the effect of elevation on flow.

We used two principal components analyses (PCA) with a correlations cross-products matrix to analyze water quality data: one for metal concentrations and one for water quality data collected at the lowest elevation transects in each canyon. Although analyses were run for 18 metals, the concentrations of 12 metals showed no variation among transects. Data included in the metal concentration PCA were concentrations of six metals (Al, Ba, Fe, Mn, Sb, Zn) at each transect. In the second PCA, we analyzed water quality data from the lowest elevation sites in each canyon collected in June and twice in August. Some sites and dates included replicate samples and lab analyses; where these were available, we included replicate samples in the analyses (total of 14 samples). Data from each sample included 19 variables but some of these were missing for certain samples (see Appendix D).

Measurements of four of the variables included above (temperature, pH, DO%, conductivity) were sampled weekly during flow sampling. We used a general linear model to test for the main effects of canyon (Bear, Gregory, Shadow), date, and elevation on each of these variables with the MGLH procedure of Systat 7.0. Sample sizes varied for each variable: conductivity (n = 254), dissolved oxygen (n = 103), pH (n = 254), temperature (n = 257).

RESULTS

Releves - vegetation - 1998 sites

We located fourteen releves in two canyons and found a total of 121 species. Species richness per releve ranged from 22 to 51 with a mean of 35 species. We found no difference in species richness between the two canyons: the six releves in Bear Claw Canyon had an average of 38 species per releve and the eight releves in Greenman Springs Canyon had an average of 32 species. Of the 121 species, 45 occurred at only one releve site, an additional eleven were found in only two releves, while 22 species were found in more than half of the fourteen releves (see Appendix E for species tables).

TWINSPAN separated the fourteen releves into six groups. The first group separated contained 3 releves and was based on the presence *Bromus pubescens*. The three releves in the *Bromus* group were at relatively low elevations (between approx. 2160 - 2145 m) in Bear Claw Canyon (BCC3-5, Fig. 5). The *Bromus* group is characterized by *Pinus ponderosa*, *Prunus virginianus*, *Ribes inerme*, and *Rosa woodsii*; two of these releves also contained *Juniperus scopulorum*. The herbaceous layer in the *Bromus* group is characterized by the presence of *Bromus pubescens*, *Cerastium fontanum*, and *Carex deweyana* (Fig. 6).

The second group separated was based on the presence of *Juniperus communis*. The *Juniperus* group is made up of two releves in Greenman Springs Canyon (Fig. 5). Releves GSC4 and GSC8 are both open sites: GSC4 is located in a wide, open riparian area at 2090 m, and GSC8 is located on a cliff face at 1980 m (Fig. 7). These two releves were the only two where *J. communis* occurred and the only two where *Salix bebbiana* had a canopy coverage greater than 1%. Although the two releves do show similarities, two dominant species at the GSC4 releve are not dominants at the cliff releve (GSC8). At releve GSC4, coverage of *Cornus sericea* (30 %) and *Pteridium aquilinum* (35 %) is much higher than at GSC8 (4 % and 0 %, respectively). The herbaceous species that best characterize the *Juniperus* group are *Agrostis gigantea*, *Achillea millefolium*, *Agrostis scabra*, and *Rudbeckia ampla*.

TWINSPAN separated a third group using *Jamesia americana* and *Circaea alpina* as indicators. The *Jamesia* group contains three releves in Greenman Springs Canyon (GSC 5 - 7, Fig. 5), two of which have *Jamesia* coverage of over 10 % (the third has coverage of 2 %). Other species which characterize these releves include *Corylus cornuta* (cover > 10 %) and *Prunus vulgarus*. Although not serving to truly differentiate the group, all three releves in the *Jamesia* group contain *Aralia nudicaulis*, *Arnica cordifolia*, and *Circaea alpina* (the sister group had a higher cover of *Circaea*), as well as relatively high cover of *Pseudotsuga menziesii* and *Betula fontinalis*.

A single releve (GSC1) was separated from the remaining 6 releves as a fourth TWINSPAN group based on the presence of an unidentifiable *Carex*. The releve is located at the Greenman Spring and is characterized by the presence of *Oxalis dillenii*, *Parthenocissus inserta*, *Rubus parviflorus*, *Smilax lasioneuron*, and a high cover of *Acer glabrum*.

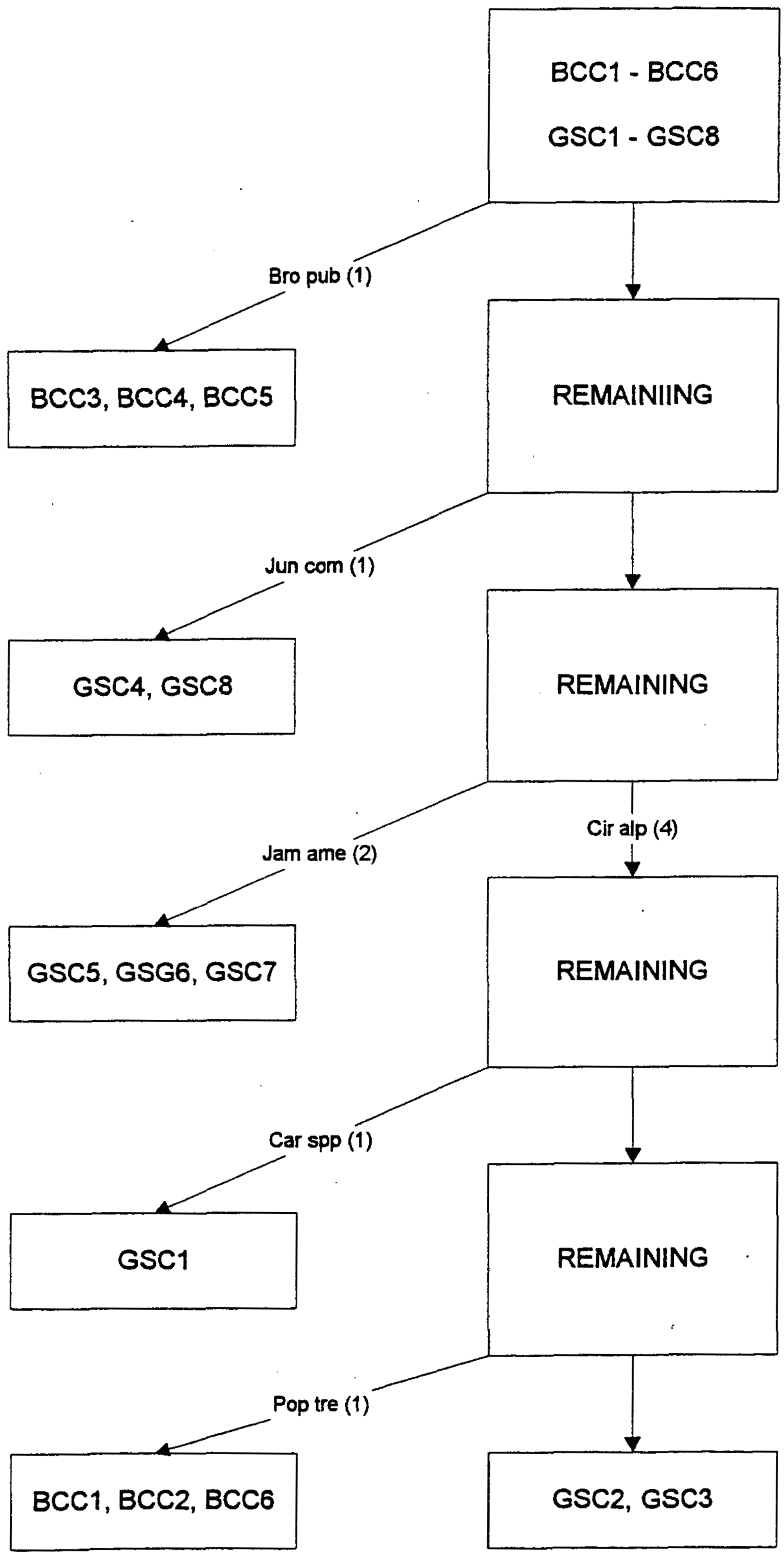


Fig. 5. Diagram of TWINSPAN analysis. Data is from 14 releves: 6 in Bear Claw Canyon (BCC) and 8 in Greenman Spring Canyon (GSC). TWINSPAN was performed on percent cover data (0-100) with cutlevels set at 0, 2, 5, 10, and 20 percent. The species and cut level separating groups are indicated.

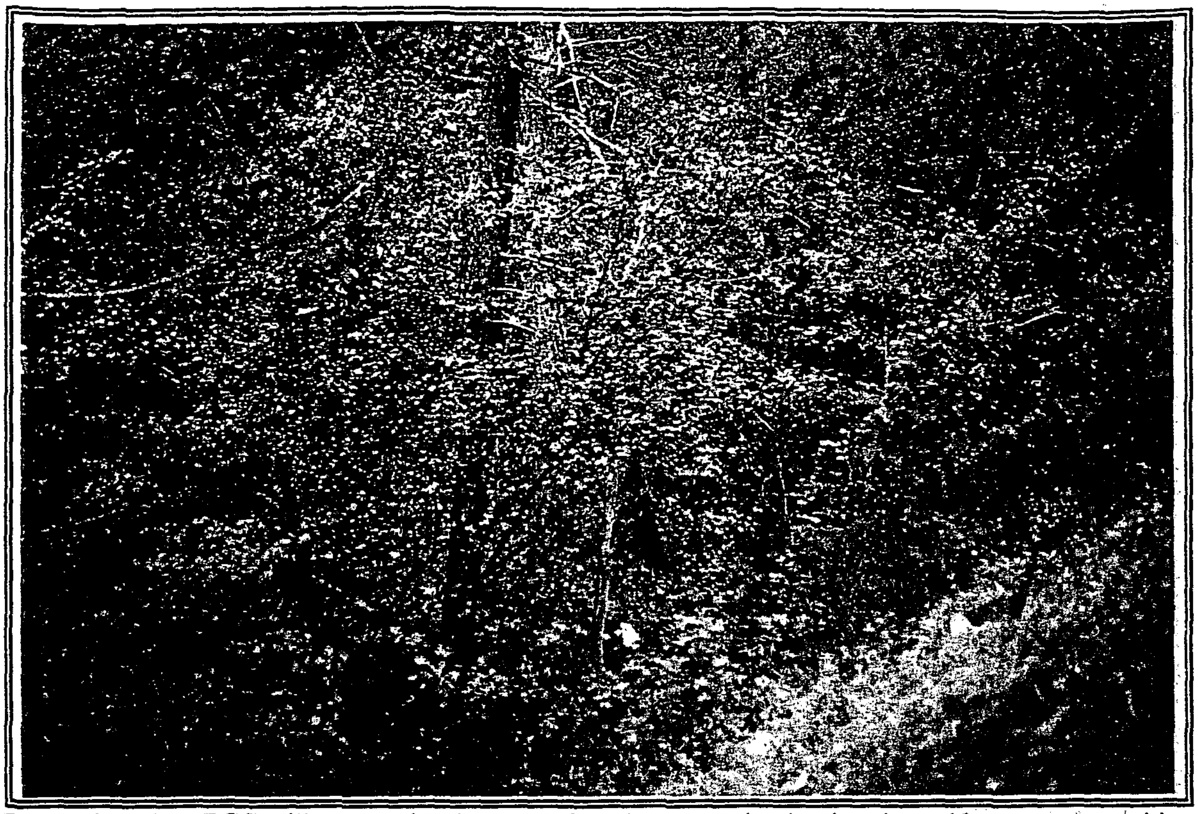


Figure 6. Releve BCC 4 illustrates the character of semi-open, moist riparian channel bottom communities, bordered by ponderosa pine forest on south slopes and Douglas-fir on the north.

Figure 7. Releve GSC 4 showing the character of open riparian communities bounded by coniferous forest.

The remaining five releves were separated by TWINSPAN into two groups using *Populus tremuloides* as an indicator (Fig. 5). The *Populus* group contained three releves in Bear Claw Canyon (BCC 1, 2, 6) all at basically the same elevation (2240 - 2250 m; Fig. 8). The group can also be characterized by the presence of *Ribes inerme*, *Athyrium filix-femlina*, and *Ligusticum porteri*. Although not distinguishing, the three releves also contain *Pseudotsuga menziesii* and *Betula fontinalis* in the overstory, and *Cystopteris fragilis*, *Galium triflorum*, *Lonicera involucrata*, *Osmorhiza depauperata*, and *Viola rydbergii* in the understory.

The remaining group contains two releves in Greenman Springs Canyon (GSC 2, 3) and is best distinguished from the *Populus* group by the absence of *Populus* and the presence of *Prunus virginiana* and greater than trace amounts of *Pteridium aquilinum*. Similar to the *Populus* group, both releves in the *Prunus-Pteridium* group, *Pseudotsuga menziesii* and *Betula fontinalis* in the overstory, and *Cystopteris fragilis*, *Galium triflorum*, *Lonicera involucrata*, *Osmorhiza depauperata*, and *Viola rydbergii* in the understory (Fig. 9).

DCA ordination separated the releves along two axes (Axis 1 eigenvalue = 0.38; Axis 2 eigenvalue = 0.21). The location of releves in the DCA ordination does not show a clear separation of all TWINSPAN groups but some separations are apparent (Fig. 10). The three releves from the *Bromus* group (•)of TWINSPAN all score high on Axis 1 but are separated along Axis 2. The *Jamesia* group (⊙), the *Populus* group (✱), the *Prunus-Pteridium* group (+), and the *Carex* group (^) all congregate towards the lower left portion of the plot, low on both axes (Fig. 10). Finally, the two releves in the *Juniperus* group are similar on axis 1, but are strongly separated from each other along axis 2.

Correlations of the DCA scores with environmental variables show some significant patterns. Scores on axis 1 scores are significantly positively correlated with depth to water table ($r = 0.75$, $P < 0.05$) and with surface water temperature ($r= 0.52$, $P < 0.10$). In other words, releves with higher scores on axis 1 tended to be in areas with warmer channel water and a deeper water table. Scores on axis 1 are moderately related to channel gradient and bearing, but these negative correlations with axis 1 were not significant (channel gradient, $r = -0.43$; channel bearing $r = -0.35$). Scores on axis 2 were significantly and negatively related to elevation ($r= -0.58$, $P < 0.05$), indicating that releves scoring high on axis 2 tended to be lower elevation sites.

Releves - 1998 - ecological characterization

Following the protocol used in the first year of the wetland and riparian study (D'Amico et al. 1997), we evaluated each site in Bear Claw and Greenman Springs Canyon using a modification of WET (Adamus and Stockwell 1983, Adamus et al. 1987). The WET approach considers wetland functions to be physical, chemical, and biological characteristics and assigns values to characteristics that are valuable to society. In performing the WET evaluation we subjectively assigned a probability rating of "high," "moderate," or "low" to each of the evaluated functions This rating is essentially an estimate of the "likelihood" that a wetland will perform a function but does not estimate the degree to which a function is performed. In addition, we estimated the degree to which these functions may be performed by the local wetland/riparian site and subjectively ranked each function from 1-5

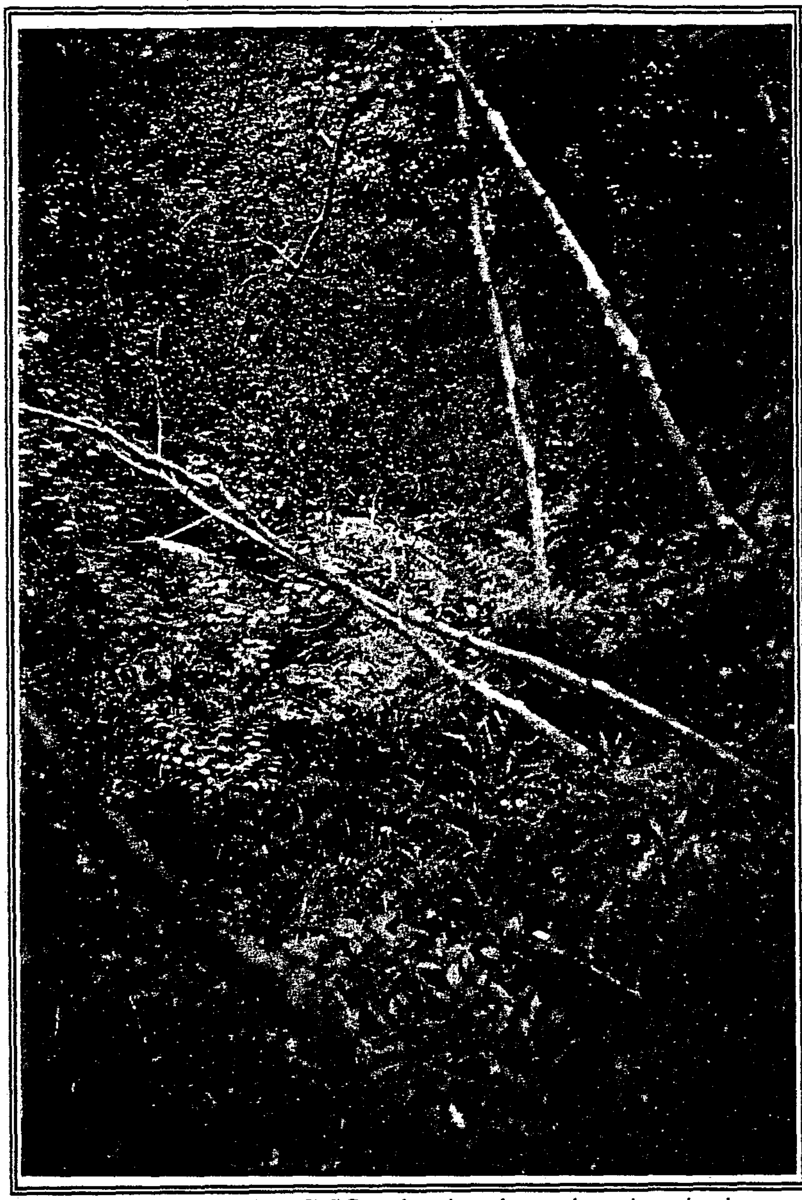


Figure 8. Photo of releve BCC 2 showing the cool, moist mixed aspen-Douglas-fir canopied channel. These sites possessed a rich understory of fern and other herbaceous species.

Figure 9. Photograph of releve GSC2 showing a detail of the moist. species rich channel bottom communities. These sites were typically fringed by shrubs, in this case *Betula fontinalis*.

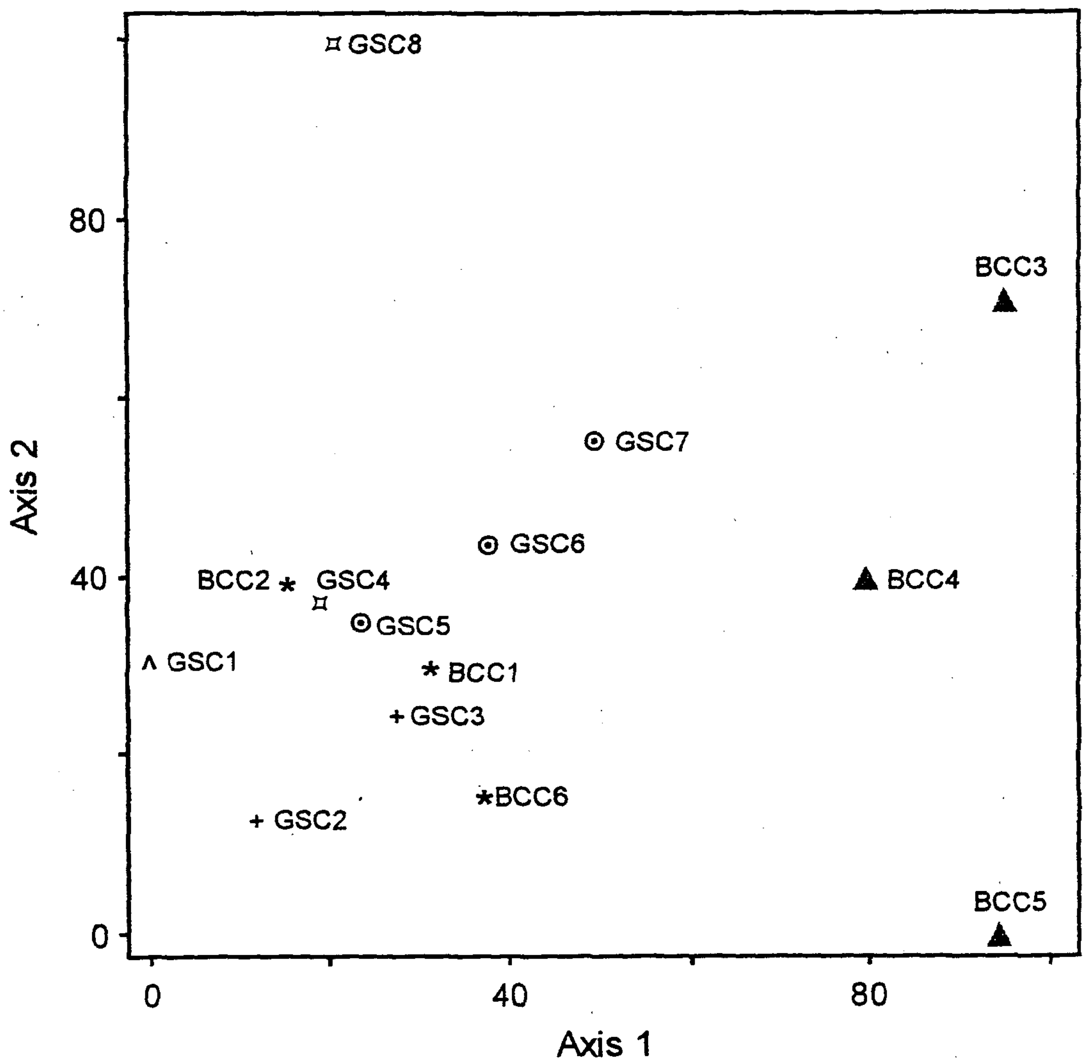


Fig. 10. Plot of releve sites along DCA axes. Releves were located in Bear Claw and Greenman Spring Canyons (BCC and GSC). Releves separated as a group together by TWINSPAN share the same plot symbols. For axis 1, eigenvalue = 0.38; for axis 2 eigenvalue = 0.21.

Because the data gathered during WET evaluation is subjective, analysis of the data collected was not performed (Appendix F). However, a consideration of the data may still be informative. Several sites in both Greenman Springs and Bear Claw Canyon ranked high for ground water discharge. In Greenman Springs Canyon, the highest elevation site (GSC1) is located at the headwater spring, and the lowest elevation site (GSC8) is located on a cliff and waterfall where surface and groundwater from surrounding soil runs over bare rock. In Bear Claw Canyon, both of the highest elevation releve sites (BCC1 and 2) are located at or near small seeps. Because channels are not as well developed at the spring and seep, the area immediately surrounding these sites also functions as groundwater recharge sites. Nutrient retention rankings were related to the channel profile and estimates of surface water flow. Releve sites with slower flow and wider, shallower channels with vegetation growing up to or in the channels ranked relatively high for nutrient retention. Sediment retention scores were relatively low at most releves, again related to flow, channel profile, channel gradient, and to their position on the stream longitudinally (Table 1). Although most releve sites scored high for food web support and wildlife habitat, all scored low for fish habitat, primarily because we estimated that water and flow were insufficient through most of the year, and because we observed no fish.

Table 1 Count of WET scores for each function evaluated. Scores ranged from 1-5 and the average score is noted in the final column. Numbers in each table cell are the number of sites receiving a given score.

	1	2	3	4	5	Avg.
GW recharge	1	5	4	3	1	2.9
GW discharge	0	1	7	5	1	3.4
Flood retention	1	10	3	0	0	2.1
Shoreline anchoring	1	4	8	1	0	2.6
Sediment trapping	0	9	5	0	0	2.4
Short-term nutrient retention	0	3	8	3	0	3.0
Long-term nutrient retention	0	7	5	2	0	2.6
Within foodweb support	0	1	0	9	4	4.1
Downstream foodweb support	0	2	6	5	1	3.4
Fish habitat	14	0	0	0	0	1.0
Wildlife habitat	0	0	1	2	11	4.7
Recreation/heritage	0	3	7	2	2	3.2

Releves - vegetation - 1997 and 1998

Combined data from 1997 and 1998 releves includes 54 releve sites located in at least five canyons (the canyon locations of ten 1997 releves were not available). A total of 232 plant species were found. Species richness ranged from 14 species at releve D26 to a high of 51 at releve BCC3, and average richness was 33 species. Sixty-six species were found in only one releve, and an additional 31 species were found in only two releves.

The plot of releves in the DCA ordination shows that all 14 of the releves measured in 1998 are located along the lower half of axis 1 (eigenvalue = 0.49) and tend to cluster together at about the midpoint of axis 2 (eigenvalue = 0.36, Fig. 11). Releves from Gregory Canyon (D1 - D6) scored high on both axes, releves from Long Canyon (D7 - D13) cluster near the center of the ordination, and releves from Bear Canyon (D14 - D29) score near the center of axis 1 but spread out along axis 2. Canyon locations for the remaining 1997 releves could not be obtained (D30 - D39).

Without the locations of the 1997 releves, it is not possible to further interpret differences in releves with respect to canyon, aspect, or bearing. However, correlations of DCA scores with six abiotic variables were possible for most releves even though environmental data was not available for all releves (variables for which sufficient data were available: channel width, depth to water table, elevation, gradient, riparian width, surface water depth). Axis 1 scores were positively correlated with channel width ($r= 0.59$, $P< 0.05$) and depth to water table ($r= 0.39$, $P< 0.05$), and negatively correlated with elevation ($r= -0.53$, $P< 0.05$). Thus, releves scoring high on axis 1 tended to be lower elevation sites with wider channels and a deeper water table. Axis 2 scores were positively correlated with depth to water table ($r= 0.38$, $P< 0.05$) and surface water depth ($r=0.41$, $P< 0.05$), and negatively correlated with elevation ($r= -0.68$). In other words, releves scoring high on axis 2 tended to be lower elevation sites with relatively deep channel water and a relatively deep water table.

Transects - riparian zone topography

Transects were surveyed and a cross section of riparian zone topography was made at each transect (Figs. 12 and 13). Cross sections have been diagramed to allow the best comparison between topography and vegetation subplots. For each transect, horizontal distance in cross section topography is set to zero for the beginning of the transect (at subplot 1). Because topography was determined from a level line above the transect, the length of the cross section does not always match the length of the vegetation transects, which were placed along the ground surface. However, lengths are never different by more than 0.5 m. In other words, to a first approximation, subplot vegetation (Appendixix F) can be visually projected into riparian zone topography by starting subplot 1 for each transect at 0 m horizontal distance (Figs. 12 and 13).

Transects - vegetation - TWINSPAN

We pooled the data from all transects in Bear and Gregory Canyons and used TWINSPAN to separate and group individual subplots (n = 160). The first division created one group of 44 plots based on the presence of *Populus angustifolium, Prunus virginianus*, or *Hydrophyllum fendleri* (Fig. 14). The *Populus-Prunus* group was separated based on the

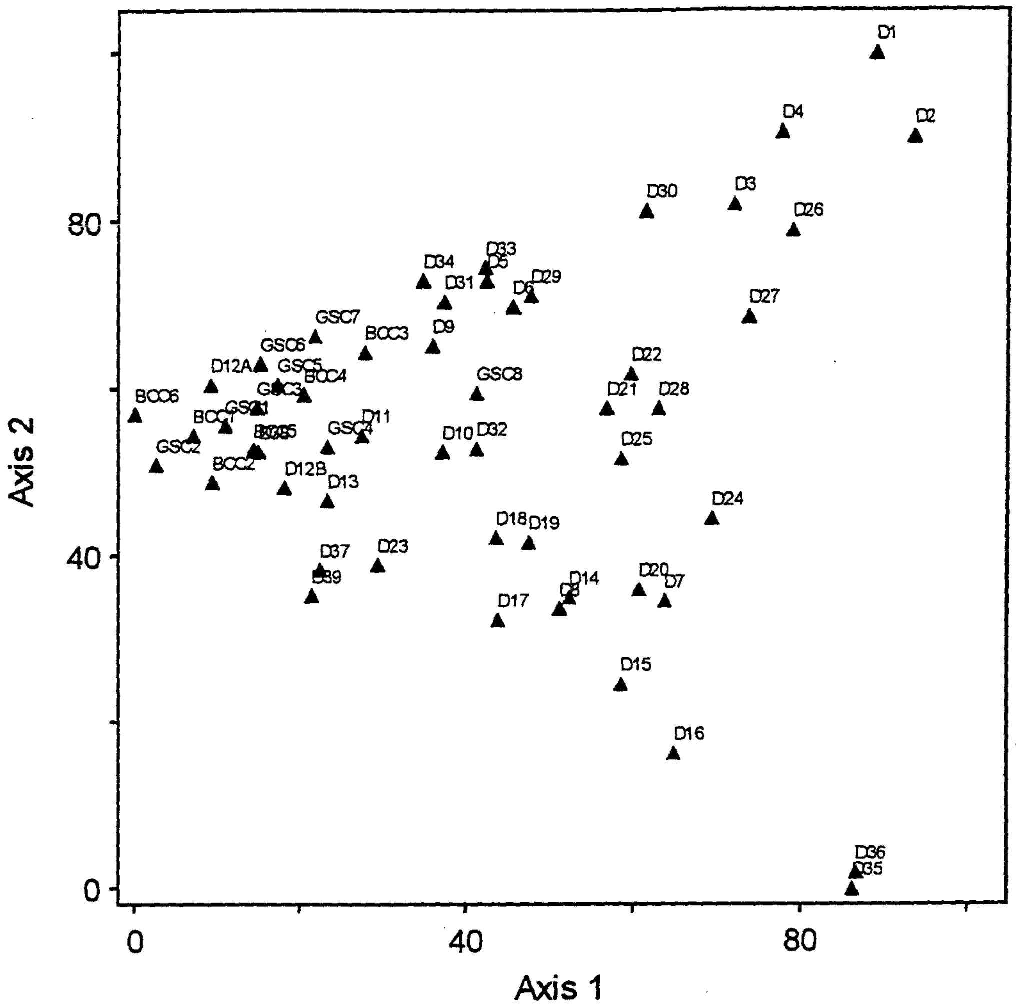


Fig. 11. DCA ordination of all releves. Eigenvalue for axis 1 = 0.49; eigenvalue axis 2 = 0.36. Releves in Bear Claw (BCC) and Greenman Springs Canyons (GSC) were sampled in 1998; those in other canyons (D) were sampled in 1997.

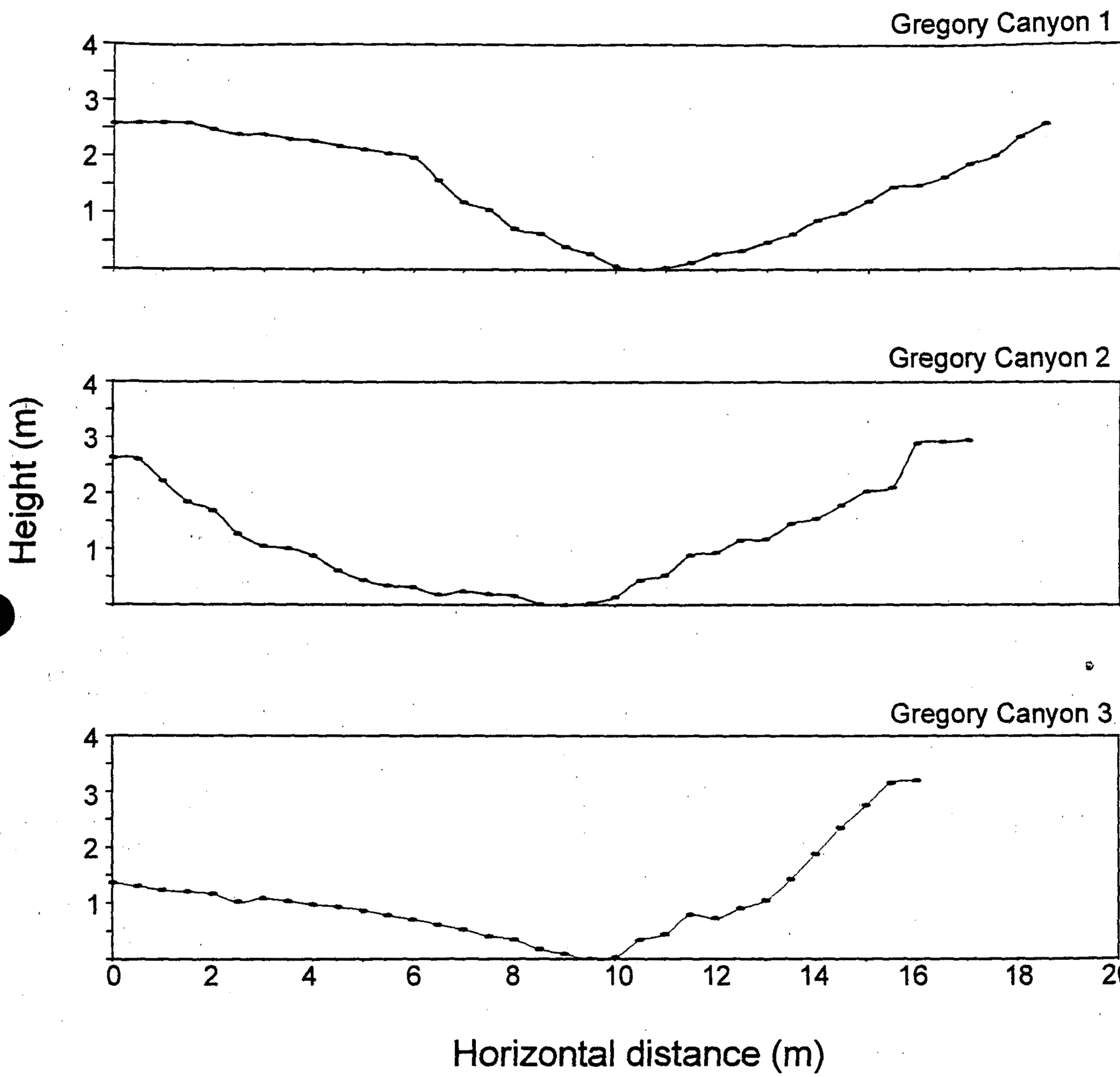


Fig. 12a. Cross-sections of channels at three transect sites in Gregory Canyon. At each site, view is from downstream, facing upstream. Measurements were made to ground surface at 0.5 m intervals on a level line above the transect. The reference for 0 m height at each transect was the lowest point measured in the channel.

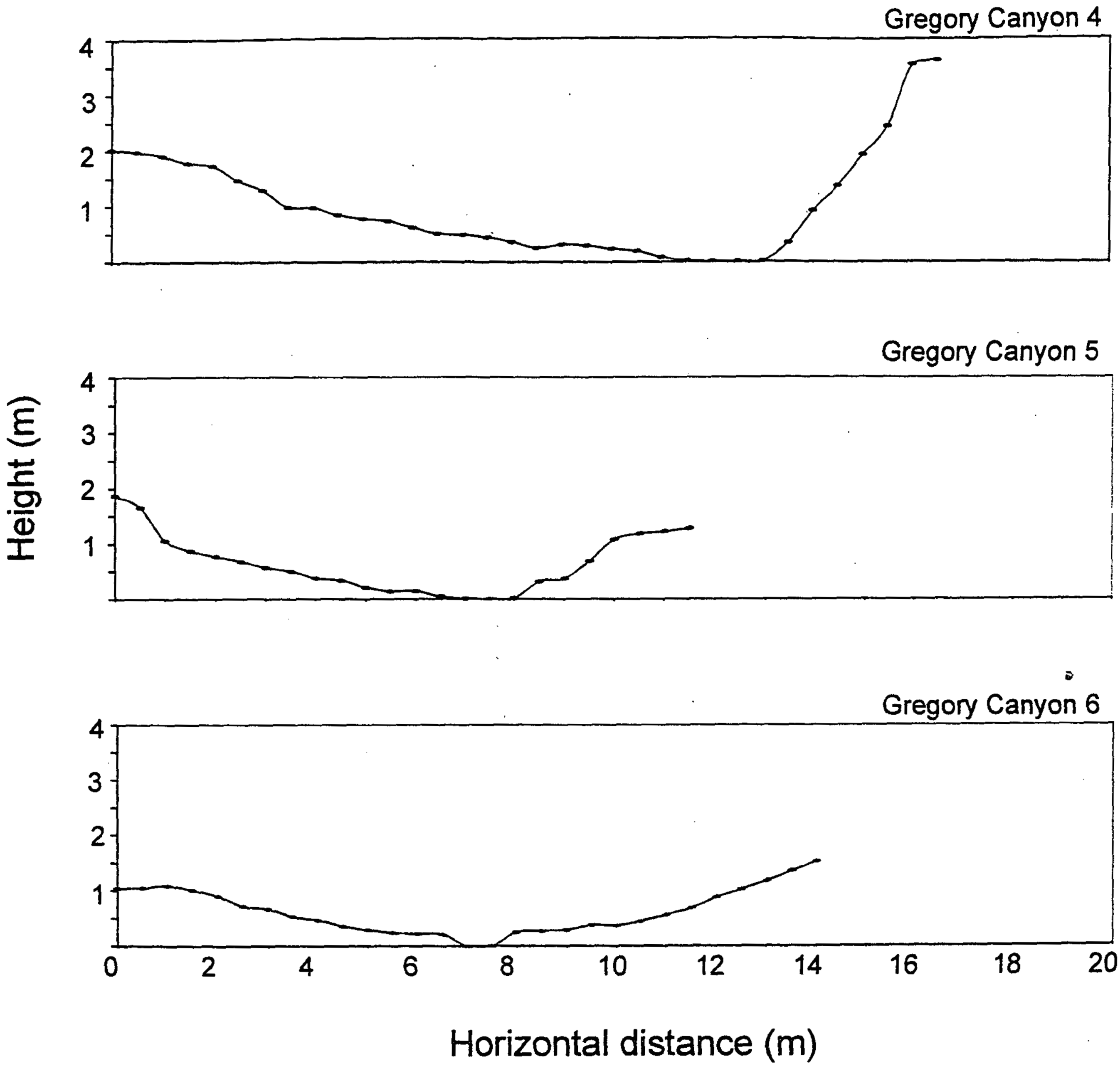


Fig. 12b. Cross-sections of channels at three transect sites in Gregory Canyon. At each site, view is from downstream, facing upstream. Measurements were made to ground surface at 0.5 m intervals on a level line above the transect. The reference for 0 m height at each transect was the lowest point measured in the channel.

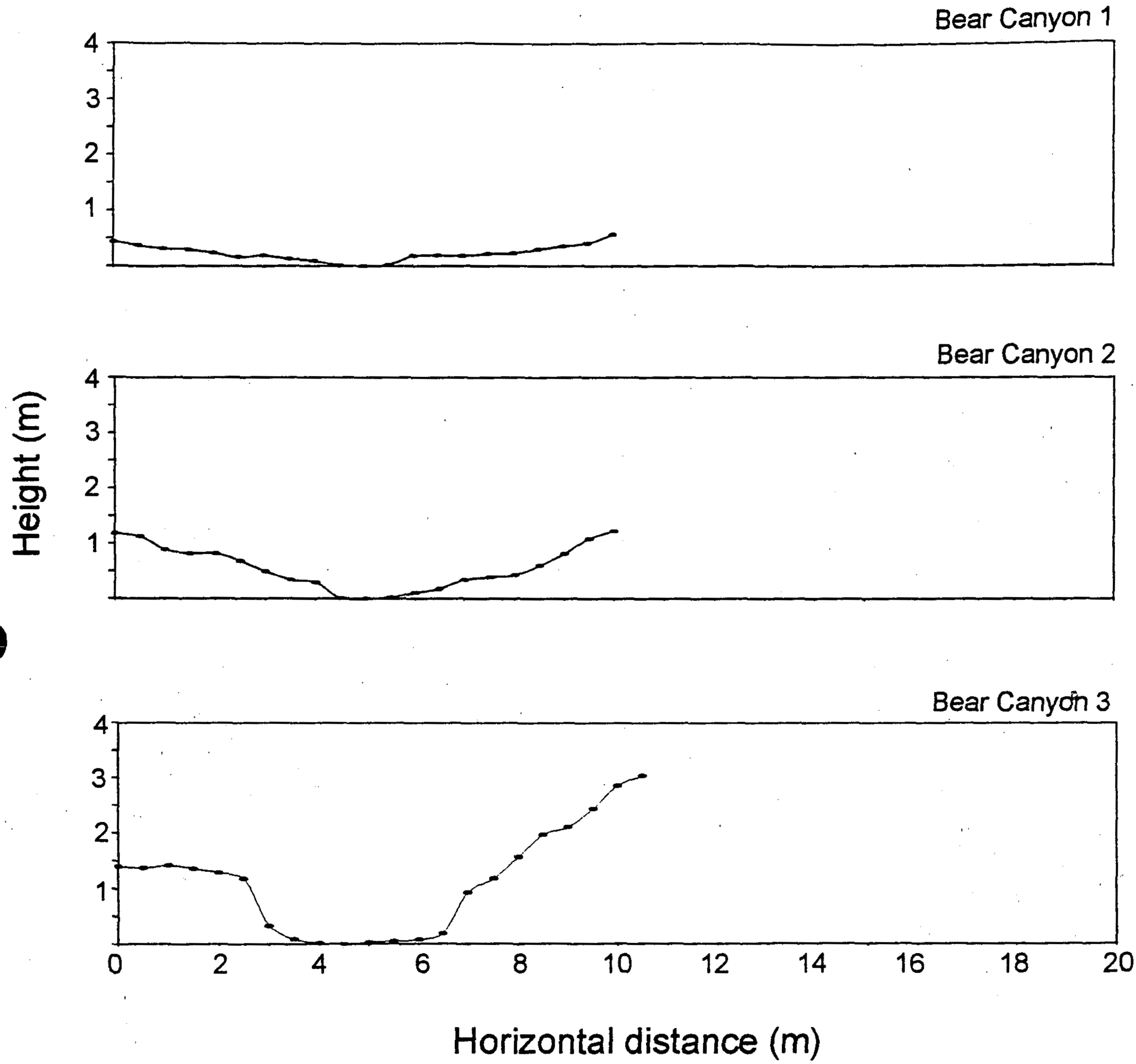


Fig. 13a. Cross-sections of channels at three transect sites in Bear Canyon. At each site, view is from downstream, facing upstream. Measurements were made to ground surface at 0.5 m intervals on a level line above the transect. The reference for 0 m height at each transect was the lowest point measured in the channel.

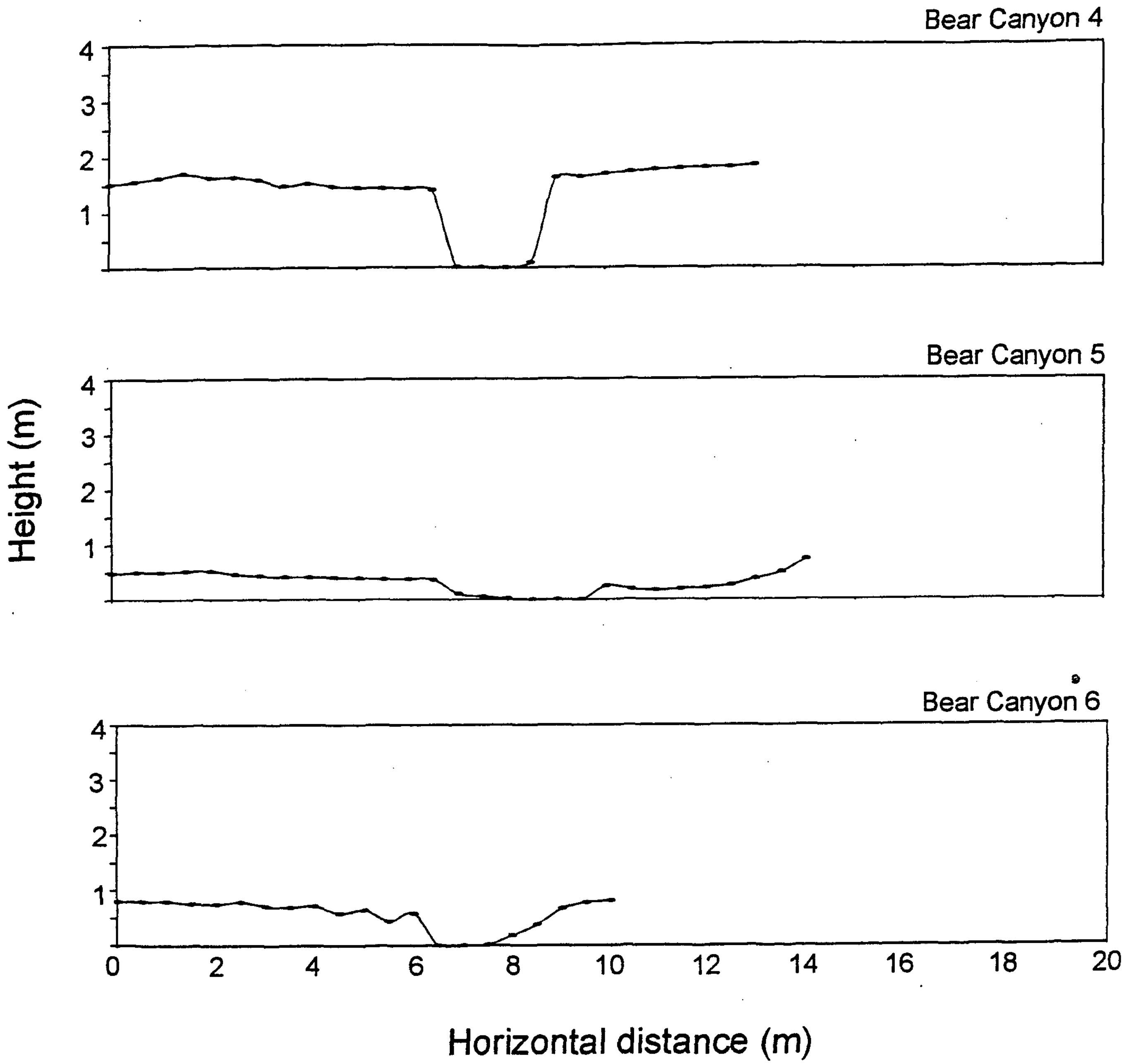


Fig. 13b. Cross-sections of channels at three transect sites in Bear Canyon. At each site, view is from downstream, facing upstream. Measurements were made to ground surface at 0.5 m intervals on a level line above the transect. The reference for 0 m height at each transect was the lowest point measured in the channel.

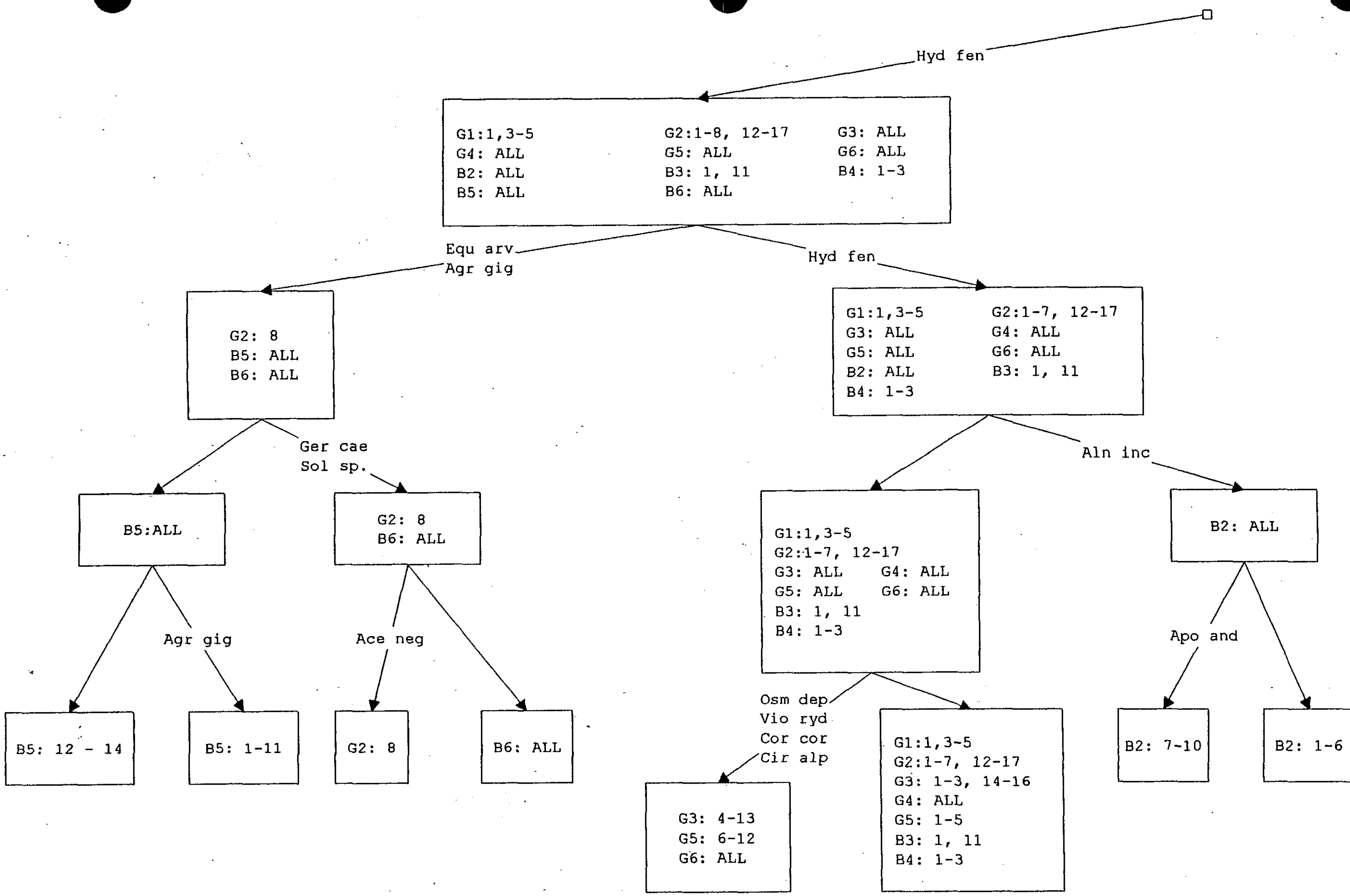


Fig. 14a. Diagram of TWINSPAN results. Data is from 160 $1m^2$ subplots located along transects at six sites in Bear Canyon (B1 - B6) and six sites in Gregory Canyon (G1 - G6). All 116 subplots in this diagram have already been separated from the remaining subplots by the first TWINSPAN division. Numbers following the transect designation indicate the subplot number. For example, G2: 1-5 indicates the first five subplots at transect G2. TWINSPAN was performed on presence/absence data plant species. Indicator species for each division are indicated.

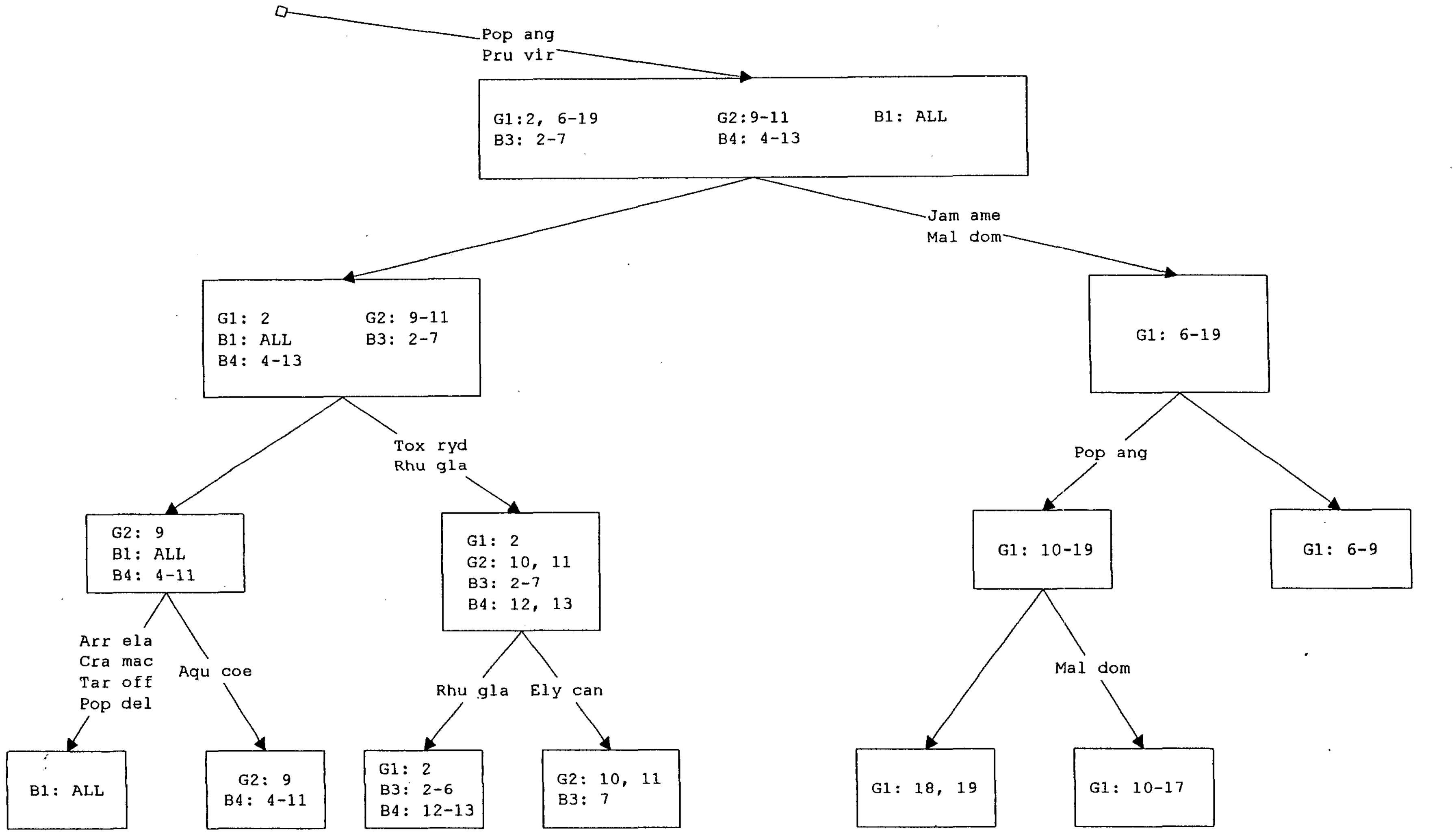


Fig. 14b. Diagram of TWINSPAN results. Data is from 160 1m^2 subplots located along transects at six sites in Bear Canyon (B1 - B6) and six sites in Gregory Canyon (G1 - G6). All 44 subplots in this diagram have already been separated from the remaining subplots (Fig. 14a) by the first TWINSPAN division. Numbers following the transect designation indicate the subplot number. For example, G2: 1-5 indicates the first five subplots at transect G2. TWINSPAN was performed on presence/absence data plant species. Indicator species for each division are indicated.

presence of *Malus domestica* and *Jamesia americana*. The *Malus-Jamesia* group contained subplots on the north bank (and extending slightly across the channel) of transect 1 in Gregory Canyon. This *Malus-Jamesia* group was further separated based on *Populus angustifolia*. This division separated sites on the north side of the bank from those adjacent to the channel. The other portion of the *Populus-Prunus* group contained plots from five different transects in both canyons, all located below 2050 m. This group was split based on the presence of *Toxicodendron* and *Rhus glabra*. The *Toxicodendron-Rhus* group contained subplots from four transects located in both canyons and spanning the range of elevations and aspects in the parent group. The subplots in the *Toxicodendron-Rhus* group were separated based on the presence of *Elymus canadensis* and *Rhus*, but this division did not separate canyons or transects The level 3 sister group to the *Toxicodendron-Rhus* group contained all of the subplots from the lowest elevation transect in Bear canyon and subplots from two other transects. This group was split into the Bear transect 1 group, based on the presence of four species, and a separate group containing eight adjacent subplots from Bear Canyon transect 4 and a single subplot from Gregory Canyon transect 2. A common link between the Bear 4 subplots is that they are not at either end of the transect, instead being closer to either channel bank.

The other group from the first division contained 116 subplots, approximately half of these subplots (54) containing the indicator species *Hydrophyllum fendleri* (*Hydrophyllum* group). This group was split, again using *Hydrophyllum fendleri*. The subplots positive for *Hydrophyllum* contained most of the subplots in Gregory Canyon, and all of the subplots (except those immediately adjacent to the channel) in Gregory above 1800 m (Gregory-*Hydrophyllum* group). The entire Bear Canyon transect 2 was split off of the Gregory-*Hydrophyllum* group based on the presence of *Alnus incana* (*Alnus*-Bear 2 group), and this *Alnus*-Bear 2 group was split into subplots on the right (southern) and left (northern) banks based on the presence of *Apocynum androsaemifolium* on the north bank. The remainder of the Gregory-*Hydrophyllum* group contained subplots from eight different transects, including all of the subplots from the four highest elevation sites in Gregory (G3-6). This group was separated based on the presence of four indicator species: *Osmorhiza depauperata*, *Viola rydbergii*, *Corylus cornuta*, *Circaea alpina* (*Osmorhiza - Viola* group). The *Osmorhiza-Viola* group contains all the subplots from the highest elevation transect in Gregory, and subplots from two other Gregory transects: the middle of the transect at Gregory 3 and the left of the transect (SE aspect) at Gregory 5. Subplots not in the Gregory-*Hydrophyllum* group were grouped together based on *Equisetum arvense* and *Agrostis gigantea*. The *Equisetum-Agrostis* group contained all the subplots from the two highest elevation transects in Bear Canyon, and a lone subplot from Gregory Canyon. The highest elevation transect in Bear Canyon (B6) was grouped with the lone subplot from Gregory based on the presence of *Geranium caespitosum* and a *Solidago* species (*Geranium* group); the lone subplot from Gregory was split off based on the presence of *Acer negundo*, leaving all of the subplots from Bear transect 6 in one group (Bear 6 group). The portion of the *Equisetum-Agropyron* group not included in the *Geranium* group contained all the subplots from the second highest elevation transect in Bear Canyon (Bear 5 group). Subplots from the end of the transect on the northeast bank of the channel were separated out of the Bear 5 group based on the absence of *Agrostis gigantea*.

Transect - within transect patterns - DCA

We looked at trends in vegetation composition within transects by performing DCAs on the subplots for each transect separately. We hypothesized that two factors, distance from (or height above) the channel and aspect, might produce shifts in species composition along each transect. In general, we found that these two factors appear to influence composition but the importance of and interactions between the factors differ between sites.

The plots of DCA scores at several transects show a "C" shape when followed from subplot 1 to the opposite end of the transect (Figs. 15, 16). Transects 2 and 3 in Gregory Canyon and transects 1, 2, 3, and 5 in Bear Canyon exhibit this "C" shape although subplots in Bear Canyon transect 2 show more of a linear decrease along Axis 1 and 2 with one central subplot (and therefore a subplot in or very near the channel) creating the "C" shape. The shape of the subplots across species space suggests that aspect, changing from subplot 1 to the last subplot, and distance from the channel, decreasing from subplot 1 to the mid-point and then increasing to the last subplot, are combining to influence the vegetation at these small scales. Note that the species composition at each of these transects is not identical (Appendix G), but that the changes in relative abundance of the species at that transects and the gain or loss of particular species along the transect result in a similar distribution of points in the biplots.

Plots of transects 4 and 6 in Bear Canyon and transects 1, 4, and 6 in Gregory Canyon all show a similar shape, somewhat like a "lollipop." This suggests a different interaction between distance from the channel and aspect, or possibly the influence of additional factors. Differences in the channel and riparian area profiles (Fig. 12 and 13) or the bearing of the steam could both create differences in the interaction with distance from the channel to create the "C" versus "lollipop" shapes. The only site which does not fit into one of these shapes is transect 5 in Gregory Canyon. The subplots here are spread out along Axis 1 but seem to have several repeating shifts down the second DCA axis.

Transects - water - volumetric flow

Within each canyon mean volumetric flow differed significantly among transects (Bear $P = 0.009$; Shadow $P = 0.025$; Gregory $P = 0.0218$; Fig. 17). To determine whether sections of streams between transects were gaining or losing reaches, we used post-hoc comparisons to compare sites in pairs. In Bear and Gregory Canyons, no pair-tests showed significant differences (Tukey $P > 0.05$) and we can not conclude that any of the stretches between the transects monitored are either gaining or losing stretches. In other words, although differences in average flow could be detected when all transects within a canyon were analyzed, the lower sample sizes involved in making pairwise comparisons do not show that any one transect differs significantly from any other. In Shadow Canyon, significant differences were found in pairwise comparisons. The highest elevation transect (SC6) had a significantly lower mean flow than the four lowest elevation transects (SC1-4) indicating that the stream gains water between SC6 and these downstream transects. No other pairs of transects in Shadow had significantly different flows.

Although we did not statistically detect gaining and losing reaches in Bear and Gregory Canyons, such stretches of stream may exist in the canyons. We noticed, while sampling

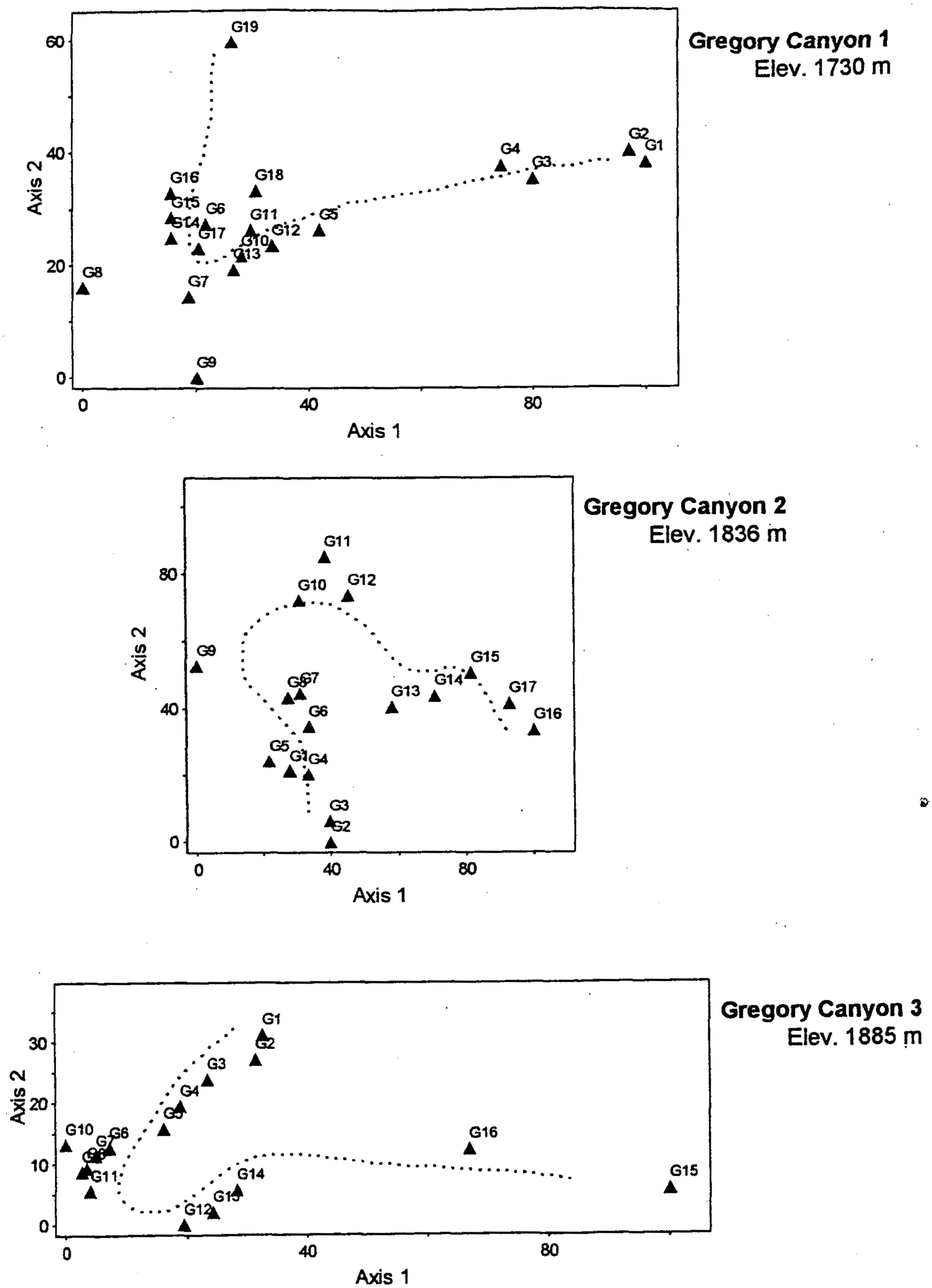
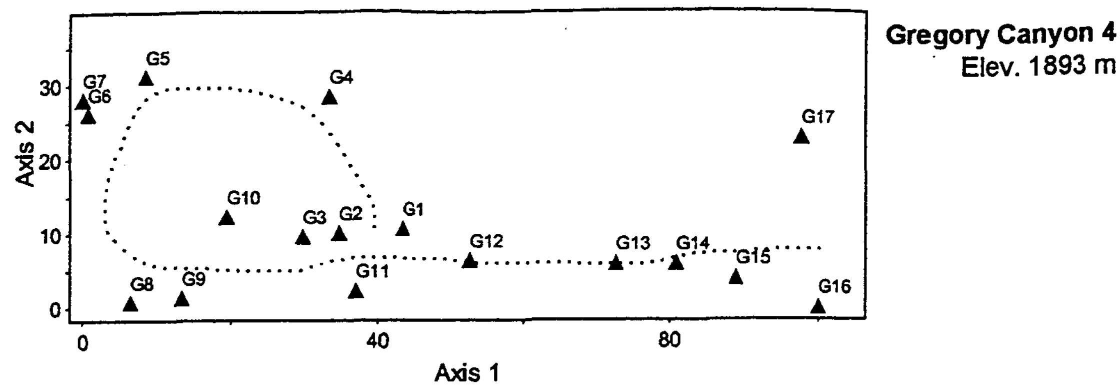
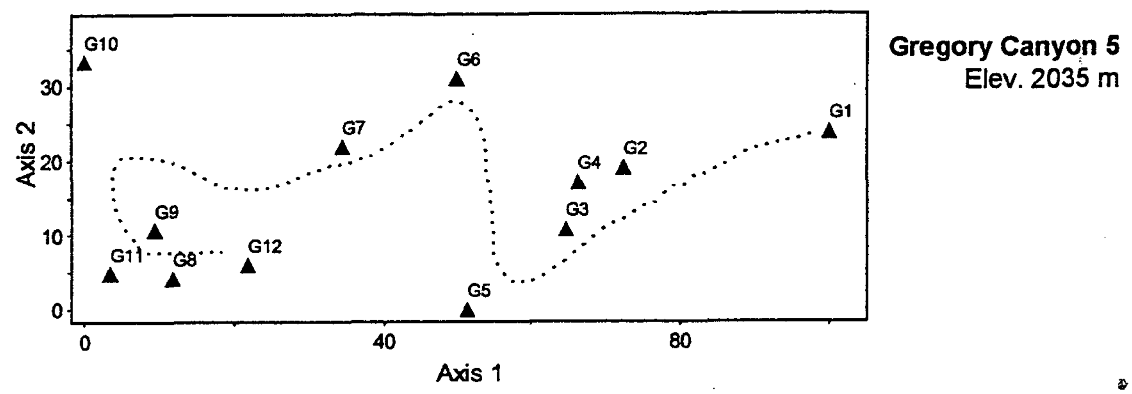


Fig. 15a. Plots of DCA scores of 1m² subplots at transect sites 1, 2, and 3 in Gregory Canyon. Within each transect, subplot numbering starts on the right-hand side of the channel facing downstream. The dotted line has been added to highlight the transitions along each transect





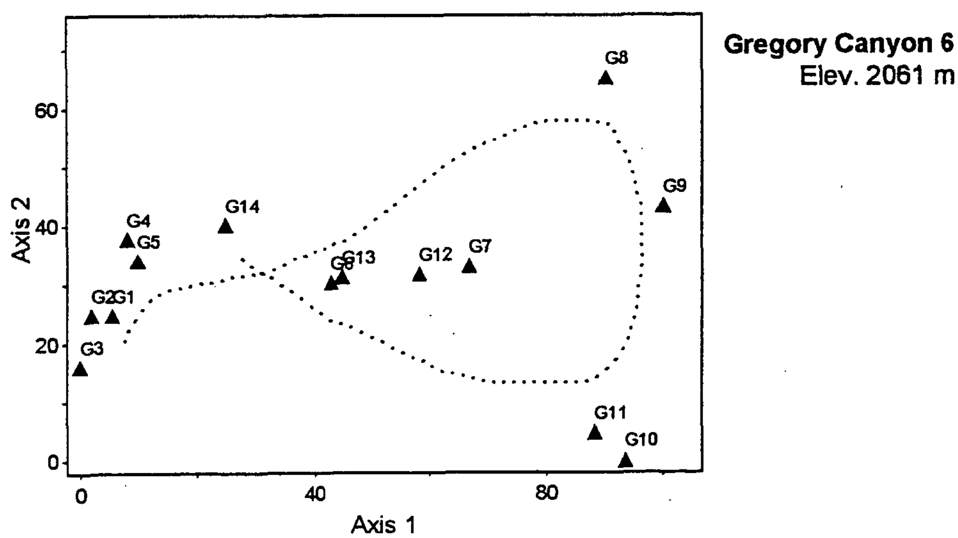


Fig. 15b. Plots of DCA scores of 1 m^2 subplots at transect sites 4, 5, and 6 in Gregory Canyon. Within each transect, subplot numbering starts on the right-hand side of the channel facing downstream. The dotted line has been added to highlight the transitions along each transect

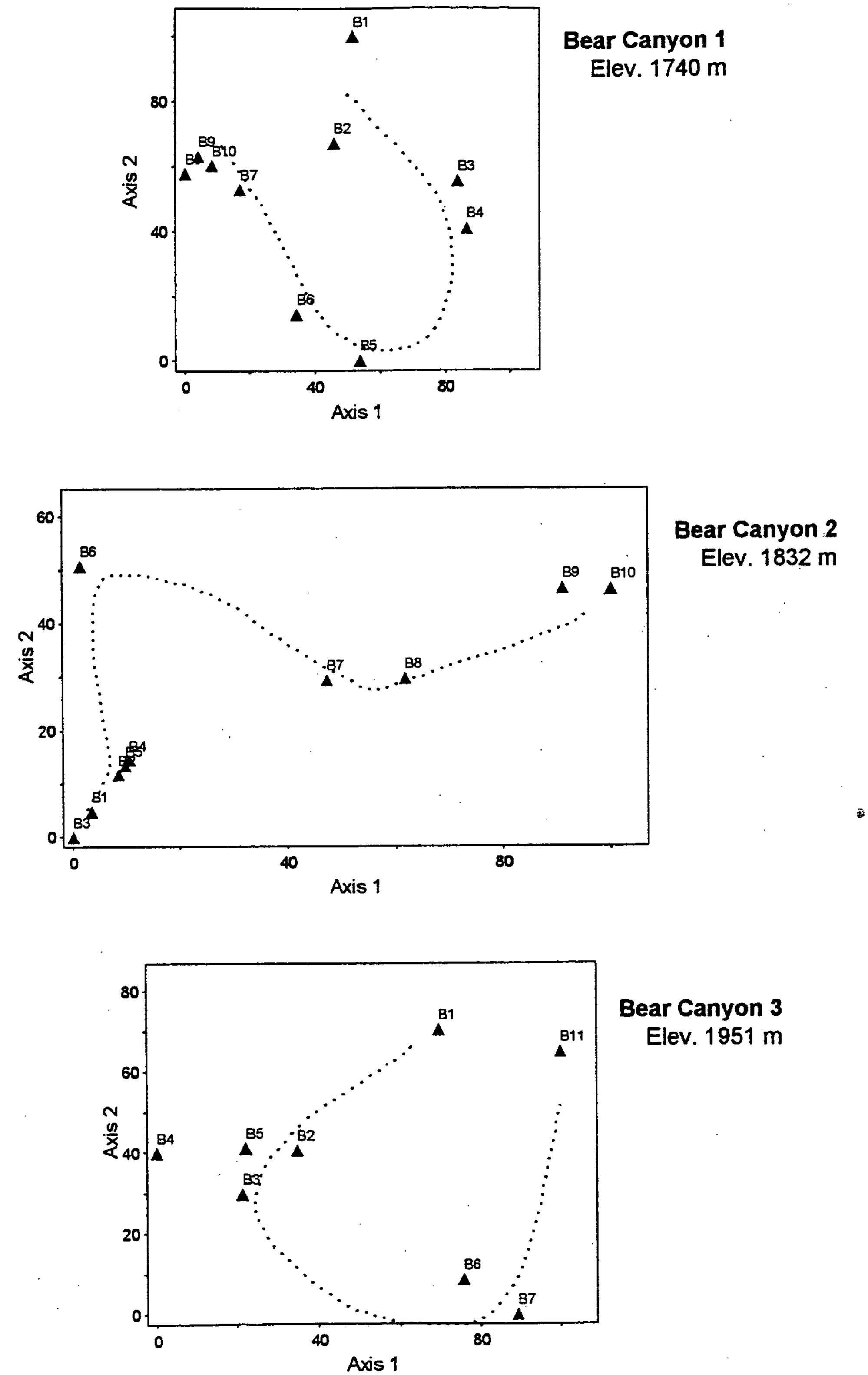
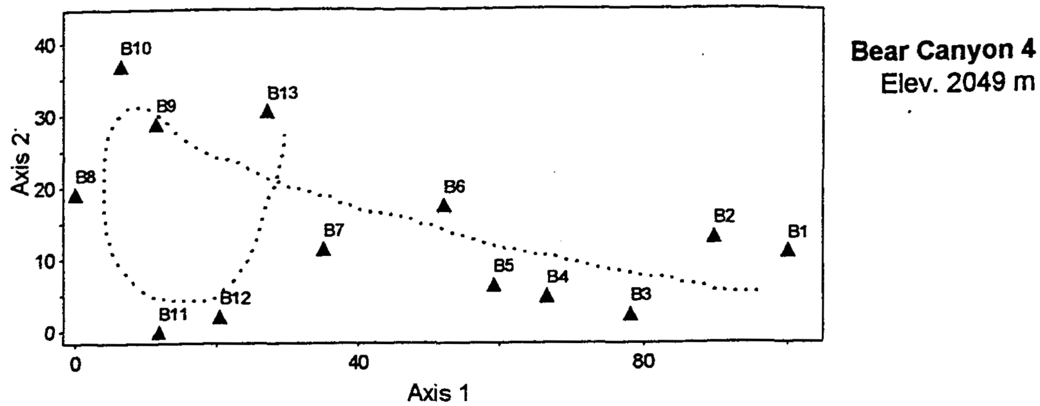
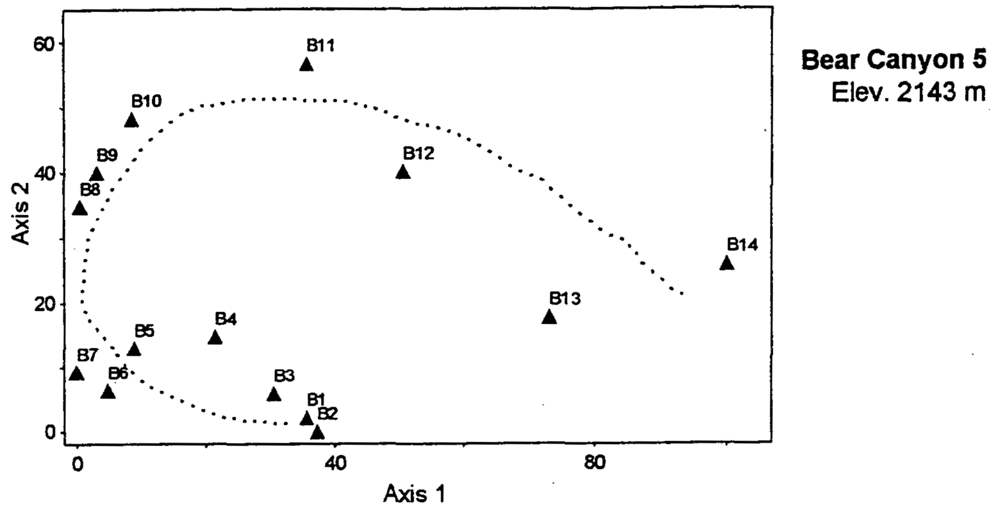


Fig. 16a. Plots of DCA scores of 1m² subplots at transect sites 1, 2, and 3 in Bear Canyon. Within each transect, subplot numbering starts on the right-hand side of the channel facing downstream. The dotted line has been added to highlight the transitions along each transect





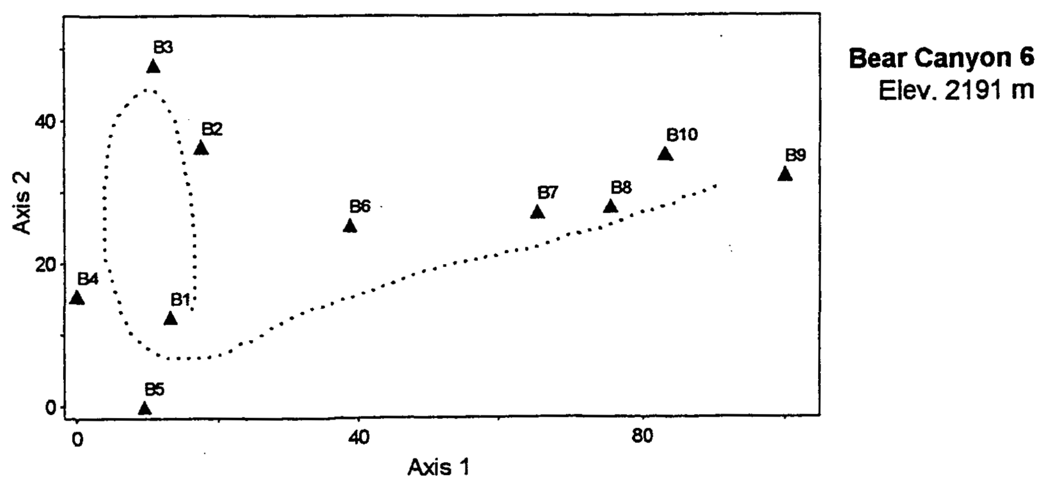


Fig. 16b. Plots of DCA scores of $1m^2$ subplots at transect sites 4, 5, and 6 in Bear Canyon. Within each transect, subplot numbering starts on the right-hand side of the channel facing downstream. The dotted line has been added to highlight the transitions along each transect

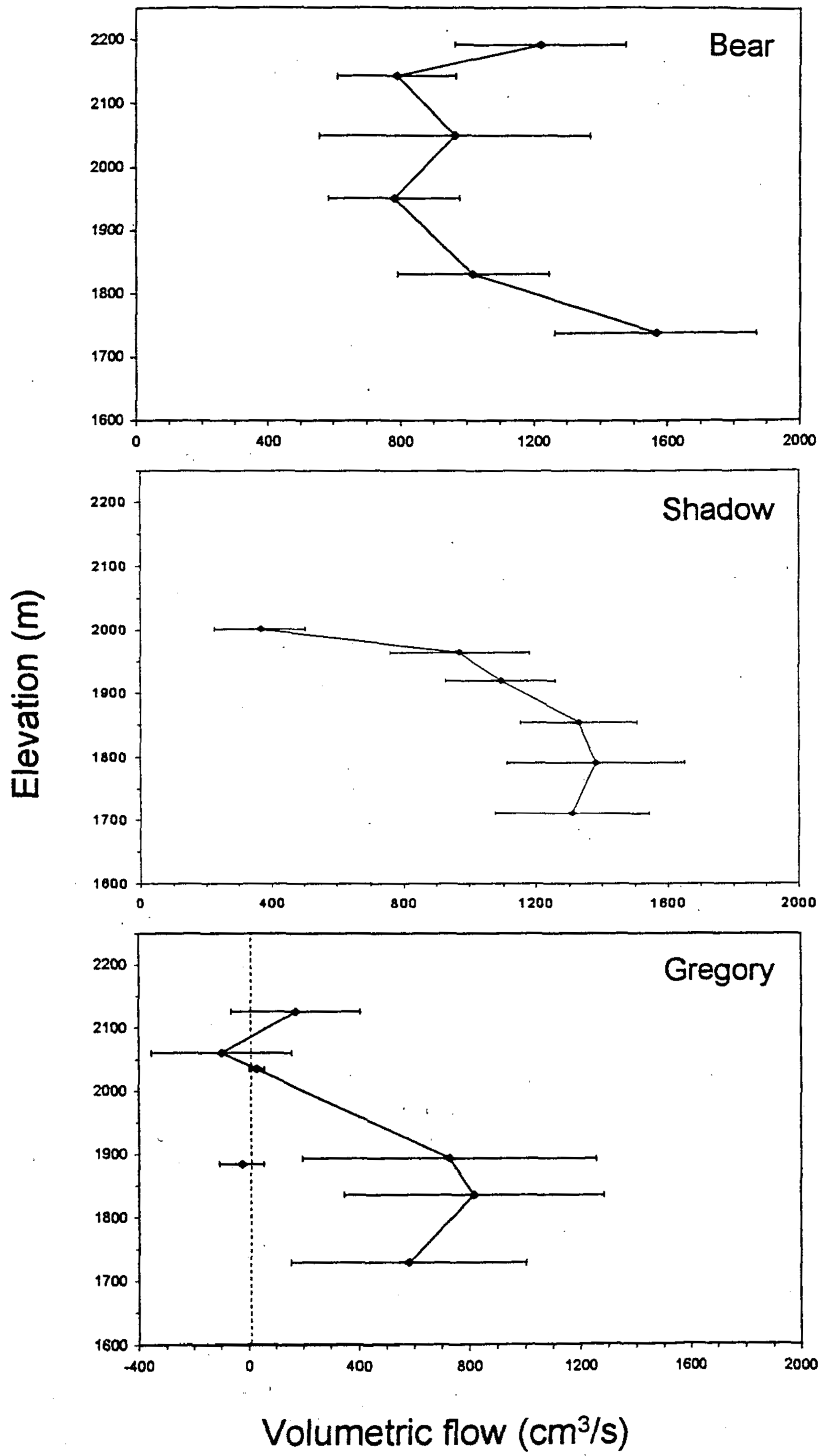


Fig. 17 Mean flow for transect stations in Bear, Shadow, and Gregory Canyons plotted against elevation. Error bars are S.E. of the means and sample sizes varied according to collected data. The unconnected point in Gregory Canyon is located in the Gregory side canyon channel just above the Gregory/Long fork; sites at higher elevations in Gregory are all in the Long fork of the canyon.

vegetation, that water volume changed along several stretches of stream, especially in Gregory Canyon. Springs, sinkholes, and changes in geology along stream channels can create gaining and losing reaches by altering the connections between surface flow and groundwater. Additional measurements of flow at the installed transects will increase the accuracy with which mean flow can be determined and may reveal additional gaining or losing reaches

In addition to making comparisons among transects, we also tested for a linear effect of elevation on mean flow within each canyon. Only Shadow Canyon showed a significant effect of elevation ($P = 0.001$; Fig. 17). Note the test of elevation is different than the test for the effect of transect since flow could differ among transects without showing a trend due to elevation. In other words, if mean flow does not change monotonically as elevation changes, location along the stream (i.e. transect) could effect flow without an effect of elevation. This could happen, for example, if the stream contained both gaining and losing stretches reaches.

In addition to the main effects of transect and date on flow, the interaction between transect and date was significant for all canyons (Bear $P = 0.009$; Shadow $P = 0.025$; Gregory $P = 0.021$). This indicates that the change of flow across dates was not the same at all sites. It is evident from the hydrographs of each site that changes in flow between dates varied more at some transects than others, and sometimes in opposite directions (Figs. 18-20). For example, transect 1 in Shadow Canyon had a lower flow than transects 2 and 3 early in the sampling season, but a higher flow than both sites from late August to early October

The hydrographs show that flow at most transects did not change smoothly over the sampling season, suggesting that flow in these streams may be influenced strongly by short-term precipitation To make a rough comparison between precipitation and channel flow, we obtained total precipitation data from Boulder (Station I.D. = 50848) for 1998 up until the last flow sampling period (Fig. 21). Total precipitation was above the long-term average (years: 1931-1997) for 1998 up through the final sampling date. We did not compare precipitation data with flow data statistically for each site, however, it appears from comparing the precipitation plot with the hydrographs that the effect of precipitation on flow differed between transects and canyons. For example, flow at the lower elevation transects in Gregory Canyon (GC1-4) showed a relatively strong increase after the heavy precipitation in the first week of August; other sites showed varying responses (Figs. 18-20). Some of this variation in response is probably due to patchy rainfall, however, some of the variation may also be due to the relative contributions of groundwater and precipitation to channel flow at different sites and in different canyons. The lower sites in Gregory Canyon showed a positive flow only during this period of precipitation and were essentially dry for the remainder of the season. Although the higher elevation sites in Gregory showed a small response to the early August rain, the most noticeable effect of precipitation at these sites is at the highest elevation site (GC6) in late September.

In addition to these statistical comparisons, we also observed rapid changes in flow and water volume at transects. During return trips to some transects, we noticed that flow decreased noticeably as the time since the last rainfall increased. Water depth at transect 1 (GC1) in Gregory Canyon decreased from approximately 5 inches to an essentially dry channel in less than four days. In addition, water depth in a pool at transect 4 in Gregory Canyon decreased from approximately 8 inches to 0 as we were sampling vegetation.

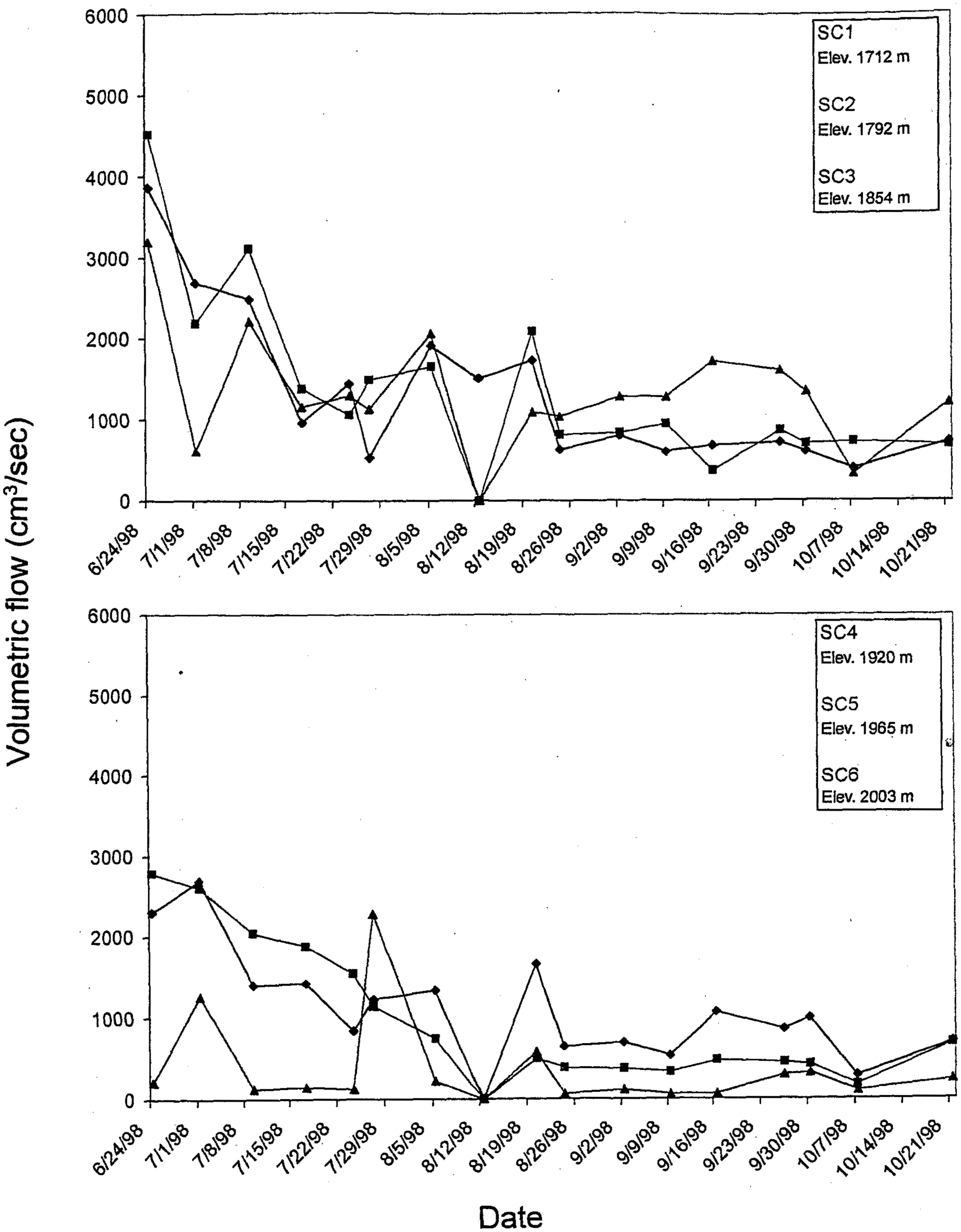


Fig. 18 Volumetric flow measured weekly for six sites in Shadow Canyon.

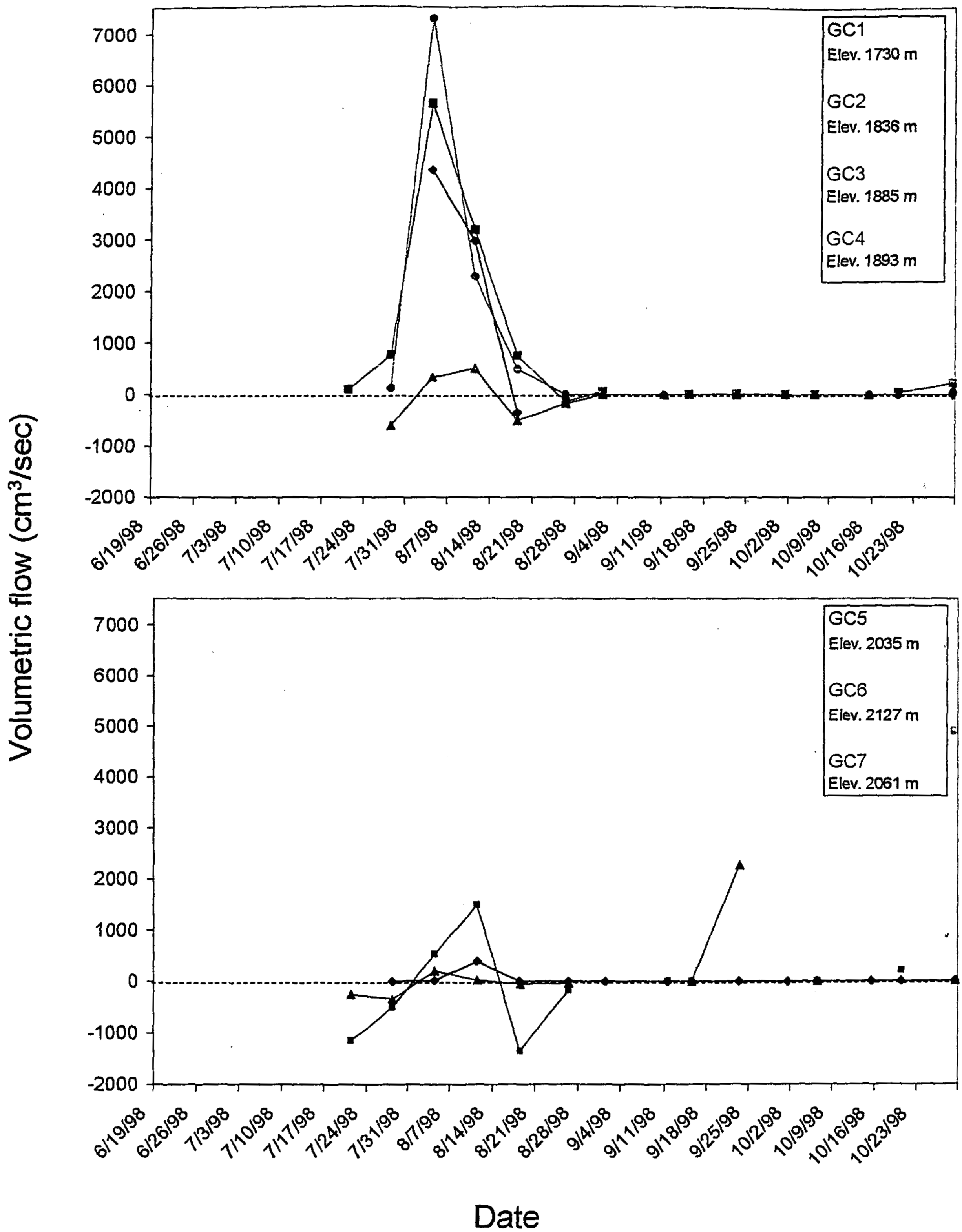


Fig. 19 Volumetric flow measured weekly for six sites in Gregory Canyon. Note that the Y-axis has both negative and positive values, and that GC7 is at a lower elevation than GC6.

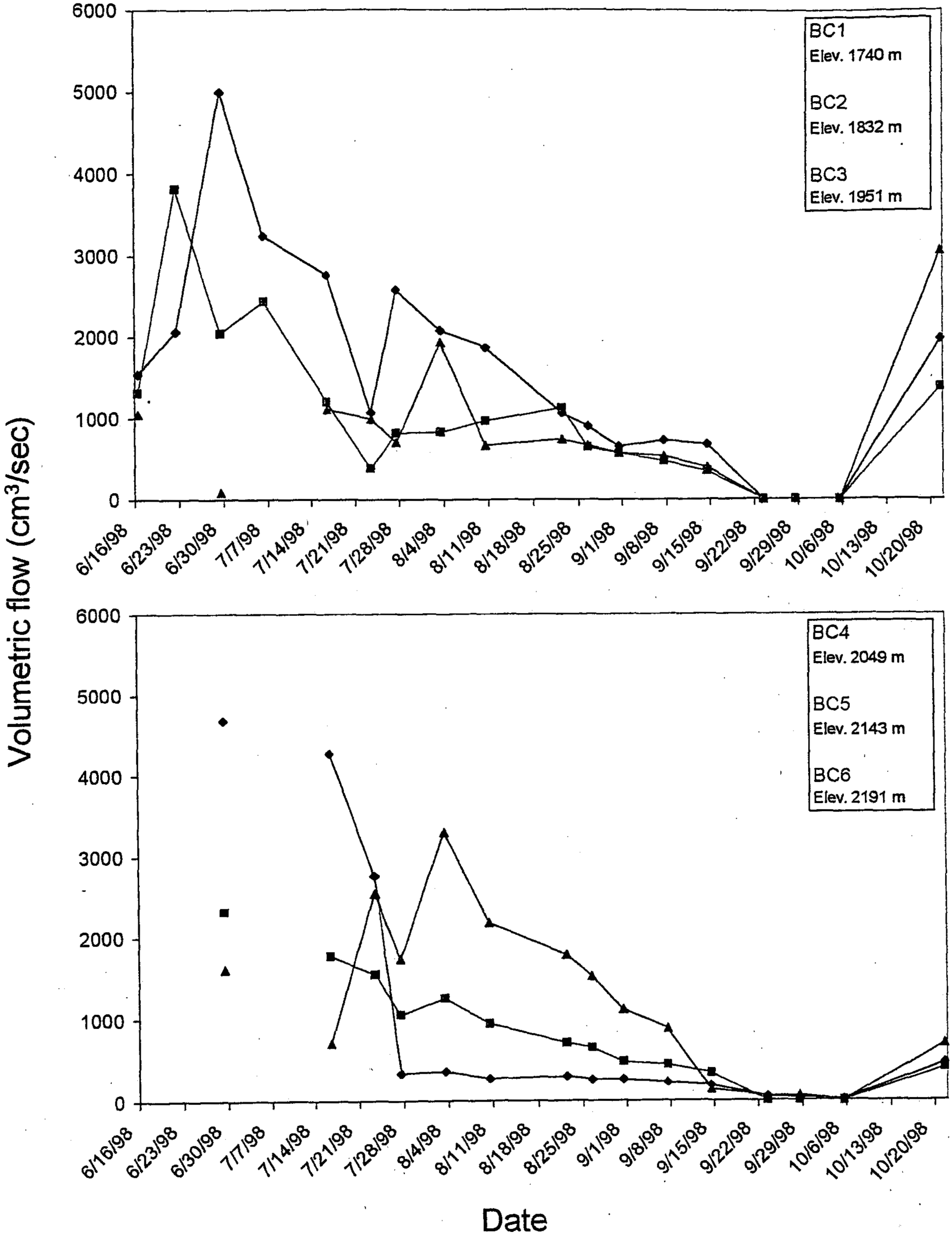


Fig. 20 Volumetric flow measured weekly for six sites in Bear Canyon.

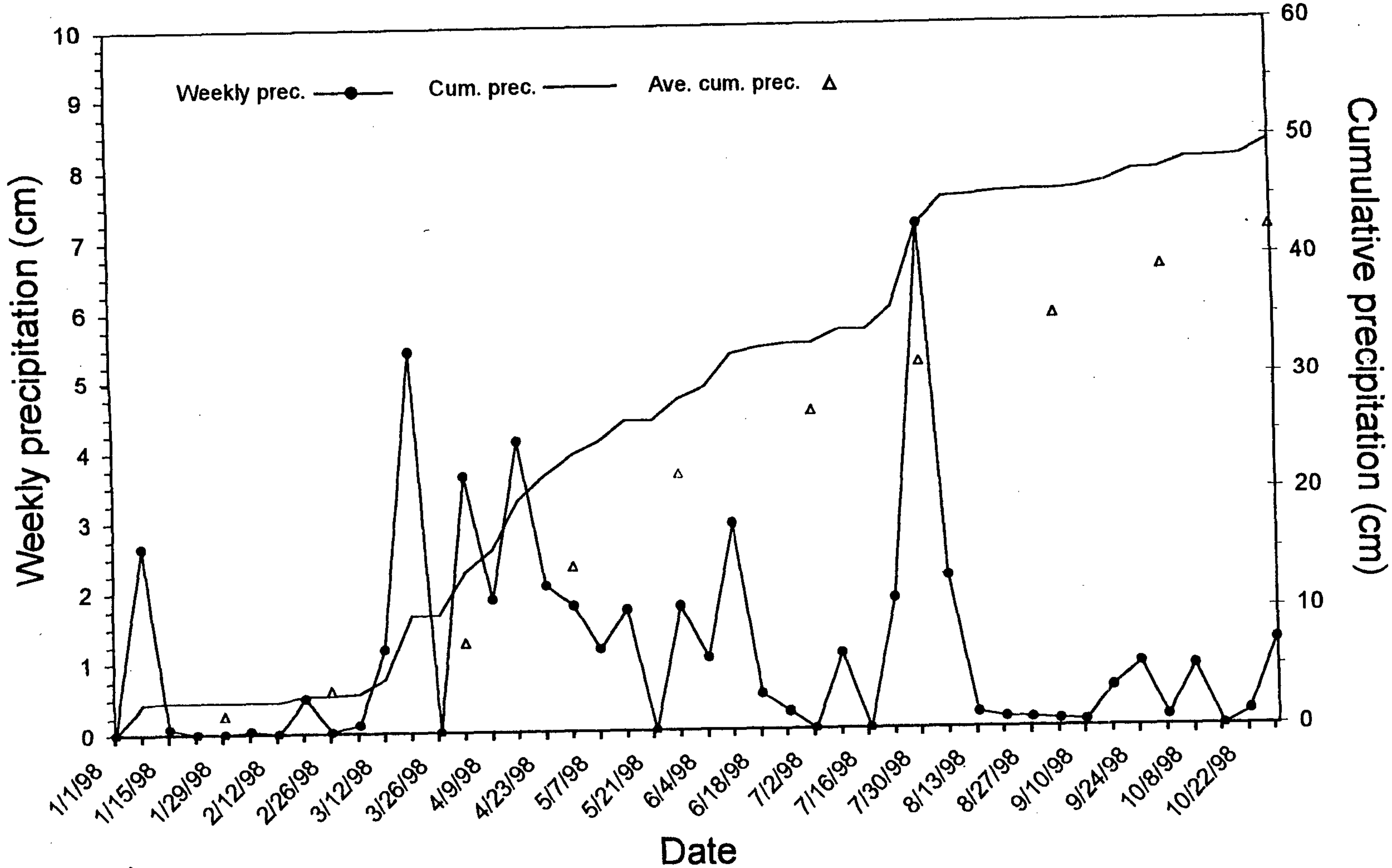


Fig. 21 Precipitation data. Data were obtained from the Colorado Climate Center for Boulder (Station id = 50848). Total precipitation for each week, the cumulative precipitation for the year 1998, and the long-term (1931-1997) average cumulative precipitation are plotted for dates up through the last flow sampling period.

Transects - water - metal concentration

Analyses were run for 18 metals, but the concentrations of 12 of these were below detection limits at all sites. Metals with below-detection limit concentrations included: silver (Ag), arsenic (As), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), thallium (Tl). Therefore, only six metals could be used in analyses: aluminum (Al), barium (Ba), iron (Fe), manganese (Mn), antimony (Sb), and zinc (Zn).

Principal components analysis (PCA) separated the 19 transects along two axes that explain 61 % of the total variance (Fig. 22). Axis 1 (eigenvalue = 2.358) explained 39% of the variance and was strongly influenced by the concentrations of aluminum and iron, both of which were negatively related to the axis. Sites which scored low on Axis 1 have higher concentrations of these metals than sites scoring higher. Axis 2 (eigenvalue = 1.290) explained an additional 22 % of the variance and was influenced primarily by three metals: manganese and antimony loaded positively on the axis, and zinc loaded negatively. Barium concentrations loaded negatively but moderately on both Axis 1 and Axis 2

In order to help interpret the PCA results, we analyzed the effect of canyon and elevation on metal concentrations. The concentrations of both aluminum ($P = 0.033$) and barium ($P < 0.001$) differed significantly between canyons. The concentration of aluminum was more than twice as high in Shadow Canyon as it was in Gregory Canyon (Bonferonni $P = 0.0313$), but did not differ between other pairs of canyons. This is evident in the plots of PCA scores: Shadow canyon transects grouped towards the lower end of Axis 1, representing higher concentrations of aluminum (Fig. 22). Barium concentrations were significantly lower in Bear Canyon than in either Gregory ($P < 0.001$) or Shadow ($P < 0.001$), but the concentrations in Gregory and Shadow were not significantly different. Five of the Bear canyon transects tend to cluster toward the upper ends of both Axes 1 and 2, indicating higher barium concentrations, (Fig. 22), but the separation between these transects and those from other canyons is not complete because the PCA scores were influenced by variables other than barium concentration. In addition to relations with PCA scores, we also found through regression analyses that, pooled across all canyons, barium concentrations decreased significantly with elevation ($P < 0.001$). In other words, these trend of decreasing barium concentrations as elevation increased was consistent across all three canyons. Iron also decreased with elevation, but this trend was significant only for Shadow Canyon ($P = 0.018$).

Transects - water - weekly water quality

Four characteristics (dissolved oxygen, temperature, pH, and conductivity) of the channel water were measured at each transect site while flow data was being collected. We analyzed this data to test for differences due to the main effects of canyon (Bear, Gregory, Shadow), date, and elevation (Table 2). Averaged across canyons and dates, elevation had a significant effect on all water characteristics. Averaged across other factors, canyon and date had significant effects on three of the four characteristics (Table 2).

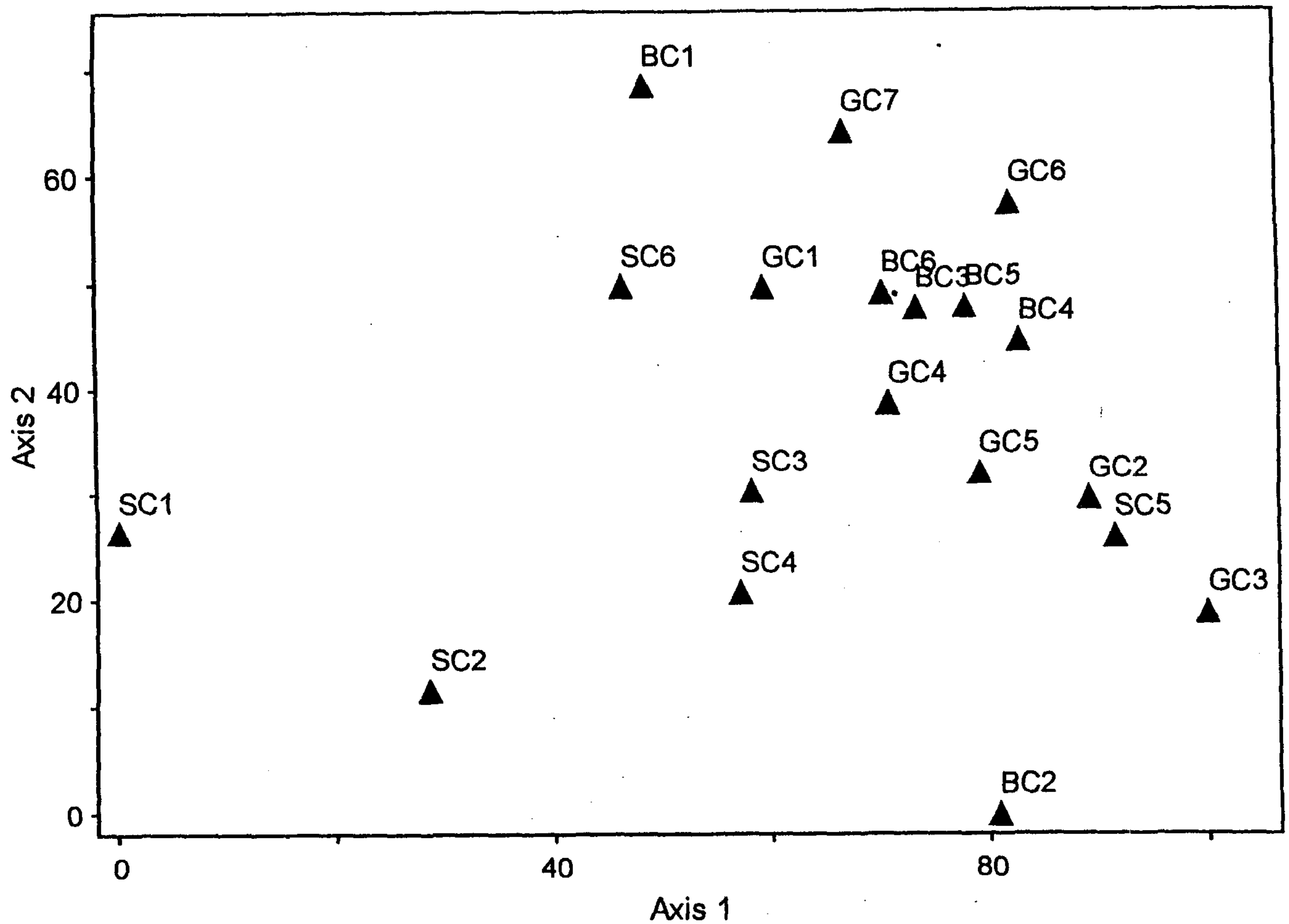


Fig. 22 Plot of transect sites according to PCA scores for metal analysis. Sites were located in three canyons: Bear Canyon (BC), Gregory Canyon (GC), and Shadow Canyon (SC). Samples were collected during the first two weeks of August 1998. Data included the total concentration of six metals: Al, Ba, Fe, Mn, Sb, Zn.

Table 2 Influence of three factors on channel water characteristics at transect sites

	N	Canyon	Date	Elevation
Conductivity	254	< 0.0001	< 0.0001	0.0353
Dissolved oxygen	103	NS	0.0052	< 0.0001
pH	254	< 0.0001	NS	< 0.0001
Temperature	257	0.0001	< 0.0001	0.0015

Sample size (N) and P-values are listed for the effects of canyon, date, and elevation on four water characteristics. Effects were considered significant when $P < 0.05$. NS indicates that the effects were not significant.

Transects - water - additional water quality

At the lowest elevation sites in each of the three canyons, additional water quality data was collected once during June and twice during August. PCA separated these date-transects along two axes explaining 66 % of the variance (Fig. 23) Axis 1 (eigenvalue = 7.64) explained 40% of the variance in samples and had seven variables loading about equally. Total alkalinity and total hardness loaded positively; turbidity, orthophosphate, total phosphate, and the two water color measurements loaded negatively (absolute values of all seven ranged from 0.3016 - 0.3377) Axis 2 (eigenvalue = 4.96) explained 26 % of the total variance and had five variables that loaded relatively high. Temperature (-0.352), dissolved oxygen (-0.413), and pH (-0.357) loaded negatively on Axis 2, and total organic carbon (0.306) and ammonia (0.322) loaded positively.

At all sampling dates, the Shadow Canyon transect is clearly separated from the remaining two transects along Axis 1 while the transects in Bear and Gregory Canyon are congregated toward the higher end of Axis 1 (Fig. 23). Compared to the other two canyons, the Shadow Canyon sites all have lower turbidity and color values, and lower phosphate levels, but higher measurements for alkalinity and hardness. Two other groups are evident and are separated by Axis 2. The sites in Bear and Gregory Canyons from the June sampling date cluster together and all the August samples from Bear and Gregory except for BCA-1 cluster together. Interpreting the clustering and lack of clustering among the Bear and Gregory Canyon sites is hindered by missing data. Data for four of the water qualities (temperature, dissolved oxygen, pH, ammonia) that load high on Axis 2 are missing for at least some of the samples. For replicated samples, both replicates scored close together on PCA scores.

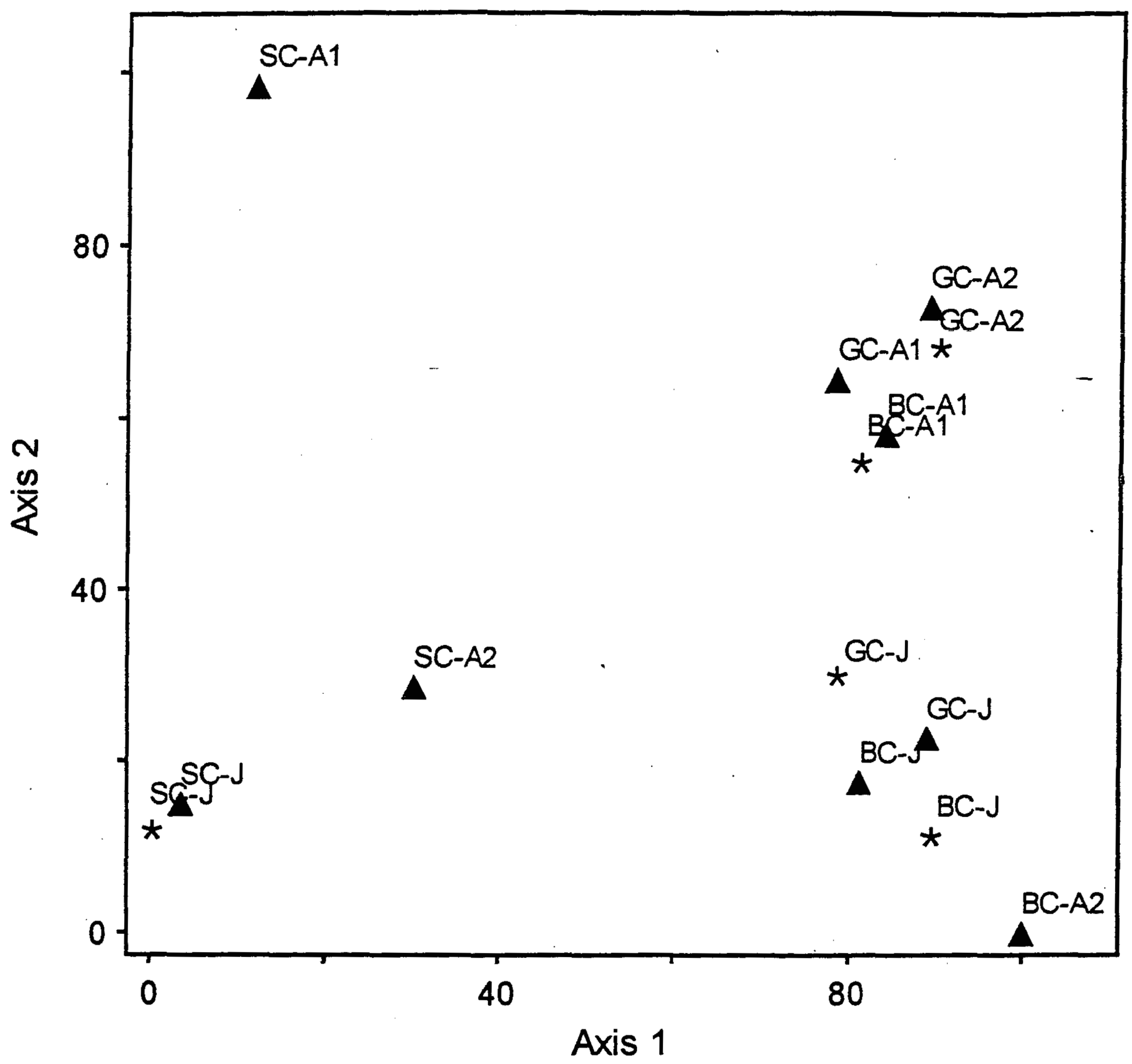


Fig. 23 Plot of lowest elevation transects along PCA axes. Transects analyzed were the lowest elevation transects in each canyon: Bear Canyon (BC), Gregory Canyon (GC), and Shadow Canyon (SC). Water samples were collected three times, once in June (J), and twice in August (A1 and A2). Replicate samples were collected and analyzed for some transects and dates; these are marked with different plot symbols (*). Nineteen water quality measurements were used in the PCA.

DISCUSSION

Vegetation types at releve sites

Vegetation and community types varied both within and between canyons. TWINSPAN defined six vegetation types based on the species composition of releves in Bear Claw and Greenman Springs Canyon. Within Bear Claw Canyon, releves at similar elevations grouped together (Fig. 5). The three lowest elevation sites in Bear Claw Canyon made up the *Bromus* group while the three higher elevation releves made up the *Populus* group. In addition to their lower elevation, compared to the *Populus* group, releves in the *Bromus* group are located in areas where the channel bearing is more westerly than northwesterly and where the water table is deeper. The DCA ordination also separated these Bear Claw Canyon releves into two groups (Fig. 10), with the *Populus* group releves and the *Bromus* group releves separatting primarily along Axis 1, and then releves within each group separating along Axis 2.

The tendency for releves at similar elevations to be similar in species composition was also evident in Greenman Springs Canyon, however, the elevational separations were not as strong or sharp. Starting at the top of the canyon, the headwater site at the Greenman Spring was put by TWINSPAN into its own group, and the next two relves were in another group (*Prunus-Pteridium* group, Fig. 5). Although they are relatively distant, two open and exposed riparian areas (releves GSC4 and GSC8) grouped together based on the presence *Juniperus communis*. It appears that in this case exposure had a relatively stronger influence than elevation, however, the total species composition at the sites did differ noticeably, reflecting the importance of elevation and soil differences between the releve sites (Fig. 10). The remaining sites in the canyon grouped together and species composition appears to change smoothly along this stretch of the canyon, as evident in the DCA ordination (Fig. 10). .

The range of vegetation types surveyed is greatly expanded when releves from 1997 and 1998 are considered. There is a tendency for releves in the same canyon to cluster together in ordination space, however, as mentioned above, environmental and vegetation gradients are also clear within canyons (Fig. 11). Both between and across canyons, geographic, topographic, and hydrologic factors affected vegetation. Of the environmental factors we could relate to the ordination scores, elevation, channel width, depth to the water table, and channel water depth all had significant correlations. In other words, changes in vegetation followed changes in these factors. Correlations of vegetation with environmental and spatial data could be expanded when data from 1997 releves become available, and the importance of additional abiotic factors may become apparent.

Changes in Vegetation Along Transects

Vegetational composition can change markedly in only small distances along channel cross-sections. These gradients were quantified in a series of DCA ordinations (Fig. 15 and 16). Based on these ordinations, the majority of vegetational change can be attributed to a small number of environmental factors: exposure, distance from channel, cross-sectional slope, and substrate. The first three of these factors are significant because of how strongly they influence soil moisture, and the fourth can affect soil moisture as well. So most simply, one may state that at a given site vegetational composition is mainly dictated by local soil moisture conditions. In semi-arid regions such as Colorado, soil moisture is most often *the* critical ecological factor, so this is not unexpected. But substrate characteristics can also alter species composition in ways unrelated to soil moisture. Surface growing conditions can sometimes be drastically modified, such as when the substrate is a talus pile or broken rock slab. All the above factors are related in how they affect vegetational composition, and separating them into discrete causative factors is somewhat artificial. It is a convenient heuristic device, however, and each will be individually discussed below.

Exposure can play a primary role in influencing species composition, or it can have little effect depending on the surrounding topography and the orientation of the stream channel. Exposure mainly affects site conditions by influencing heat load, and therefore soil water content. A strong effect of exposure is manifested in the ordinations, by elongation of the transect of sites and suppression of the "C" shape described in the Results section.

The effects of distance from channel likewise affect soil moisture. Vegetation further from the channel receives less over-bank flooding. It is also generally more removed from the alluvial water table due to steep topography. This factor is largely responsible for the "C" in the ordinations, with the arm length of the "C" being controlled by the distance to the channel. The width of the throat of the "C" is due to secondary factors, such as exposure or others explained below. Essentially, the wider the throat, the more influential are factors other than distance from channel.

Topographical steepness affects vegetation through a variety of mechanisms, all of them relevant to the control of soil moisture. Topographical slope tends to increase the amount of solar radiation received by a surface; this is especially pronounced on south facing slopes. On steep slopes hydrological gradients are steep as well. This causes a relatively rapid draining of moisture from the soil profile after precipitation events. The role of topographical steepness is most important when combined with other factors such as exposure and soil texture. Topographical steepness, like exposure, tends to widen the throat of the "C" in the ordinations, or suppress its appearance.

Substrate actually includes two separate factors – soil factors and lithic factors. Soil character can change along transects in response to fluvial activities such as sediment deposition, biological activities such as organic matter deposition, or lithic factors such differences in parent material. All of these factors can alter both soil nutrient levels and texture. Like the above factors, soil texture influences soil moisture, since finely textured soils can hold moisture longer than those more coarsely textured. In certain situations soil texture can mask the effects of other factors such as slope and exposure. For example, south facing slopes with finely textured soils may have soil moisture regimes similar to coarsely textured, north facing soils. It can, however, magnify such effects as well.

Lithic factors, as they are called here, act in more overt ways. The lithic contact in Boulder Mountain Park soils is very shallow, and commonly masses of bedrock, boulders, or talus piles are at the surface. In areas with broken rock slabs, forbs and small shrubs such as boulder raspberry (*Oreobatus deliciosus*) grow in soil filled cracks. Vegetation tends to be sparse and is limited by viable growing sites. In the cool, moist channel bottoms, moss coverage greatly increases as the amount of exposed rock increases (Fig. 24). Talus piles tend to be vegetated by spindly shrubs such as dog bane (*Apocynum* spp.) and smooth sumac (*Rhus glabra*), and twining species like poison ivy (*Toxicodendron rydbergii*) and Virginia creeper (*Parthenocissus inserta*) that can grow up through opening between boulders.

All of the aforementioned factors act synergistically to control site vegetation (Figs. 25-27). Superimposed on these within-transect effects are larger scale, between-transect influences such as elevation and local geology. On relatively cool, north facing exposures at low elevation, dense thickets of choke cherry (*Prunus virginiana*) with little understory form. In the channel bottoms, cottonwood form the canopy, under which riparian shrubs such as *Salix irrorata* dominate (Fig. 28). The south facing slopes in these sites are frequently dominated by shrubs and small trees such as wax flower (*Jamesia americana*), choke cherry or hawthorn (*Crataegus macracantha*). At higher elevations, douglas-fir forests inhabit cool north facing slopes, while ponderosa pine woodlands grow opposite, on the drier south facing slopes. In the sheltered channel bottoms, riparian shrubs such as hazelnut (*Corylus cornuta*) and/or alder (*Alnus incana*) frequently form a closed canopy (Fig. 30). Where there is southern exposure or high light, mountain maple (*Acer glabrum*) is commonly also a dominant canopy species. In the field layer a rich flora is often present. It is under these conditions that species of interest such as rattle snake fern (*Botrypus virginianus*), broad-lipped twayblade (*Listera convallarioides*) and white adders mouth (*Malaxis monophyllos*). More common understory species are tall coneflower (*Rudbeckia ampla*), enchanter's nightshade (*Circaea alpina*), violet (*Viola* spp.), cow parsnip (*Heracleum sphondylium*), sweet cicely (*Osmorhiza* spp.), male fern (*Dryopteris filix-mas*), female fern (*Athyrium filix-femina*) and brittle fern (*Cystopteris fragilis*).

When channel banks are exceedingly steep or rocky, more xerophilic vegetation is present (Fig. 29). This is especially true on south facing slopes. Trees are generally not present under such conditions. Common species on these steep, dry slopes are boulder raspberry, holly grape (*Mahonia repens*), geranium (*Geranium* spp.), wild lettuce (*Lactuca* spp.), prairie sage (*Artemisia ludoviciana*), mullein (*Verbascum thapsus*) and blue wild rye (*Elymus glaucus*).

Analysis of transect vegetation has yielded valuable insights into the factors controlling species composition within Boulder Mountain Parks. Examination of within site vegetational changes has facilitated the control of potentially confounding large scale landscape factors such as elevation and geology. As the result of the permanent nature of these transects, future analyses can be performed to detect the effects of management practices, user impacts, or climatic changes.

Figure 24. Moisture. substrate and exposure combine to create the vegetation assemblage found on the steepest of the sites examined. GSC 8, shown here, can be seen to possess a high coverage of mosses. Herbaceous vegetation is dense when present but sporadic due to lack of rooting area.

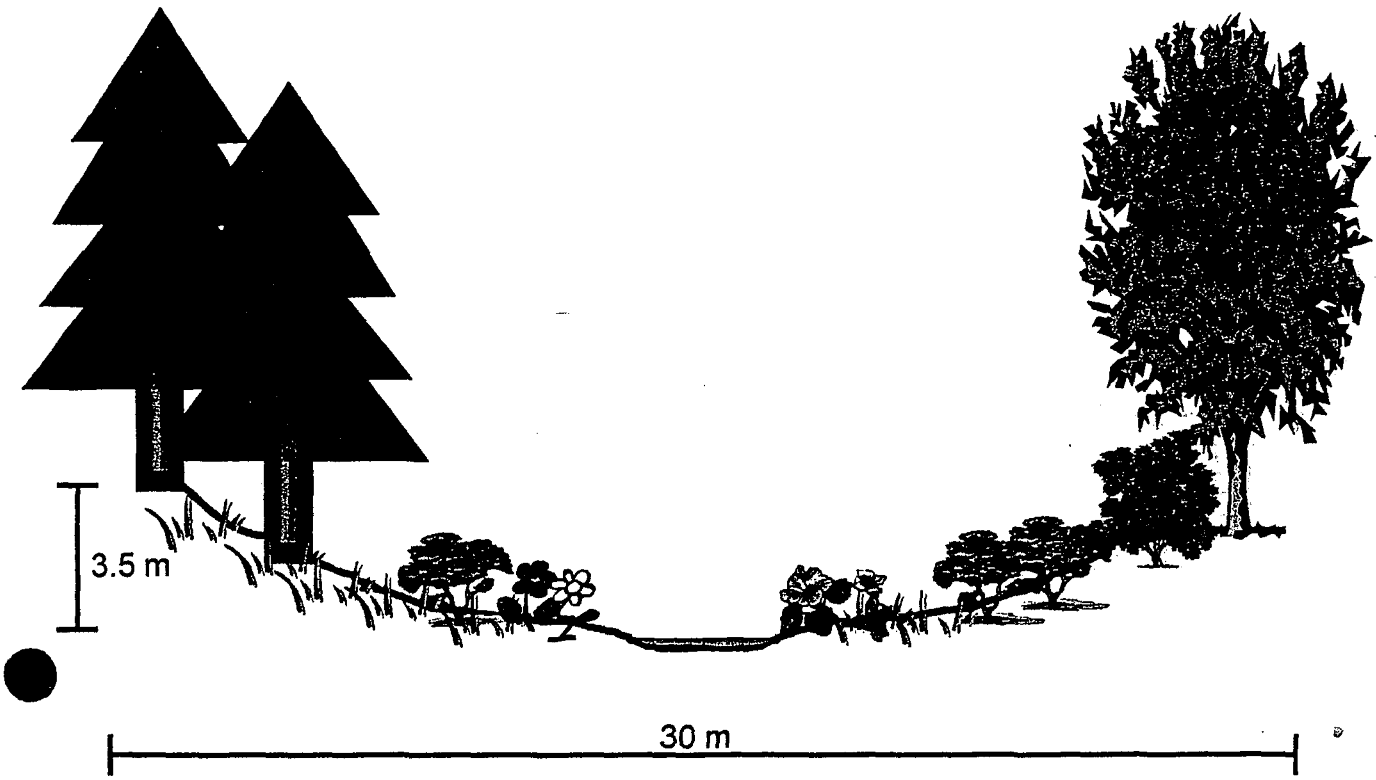


Fig. 25 Schematic representation of channel and vegetation profile. Although this profile does not match any one actual transect, the horizontal and vertical scales of the channel profile are representative of those found at transect sites in Bear and Gregory Canyon. The scale of the vegetation distribution (distance away from and above the channel) matches that of the channel profile, however the scale of each individual plant has been adjusted for the diagram. At sites like the one diagrammed above, the channel is wide and the near-channel riparian zone is wide with a gentle slope. Vegetation near the channel tends to be affected primarily by distance from the channel. Further from the channel, both distance and exposure have effects on vegetation. While the right bank in flattens out approximately 10 meters from the channel, the left bank steepens and continues upwards, increasing solar insolation and, resulting in a drier habitat than would be expected based on distance to the channel.

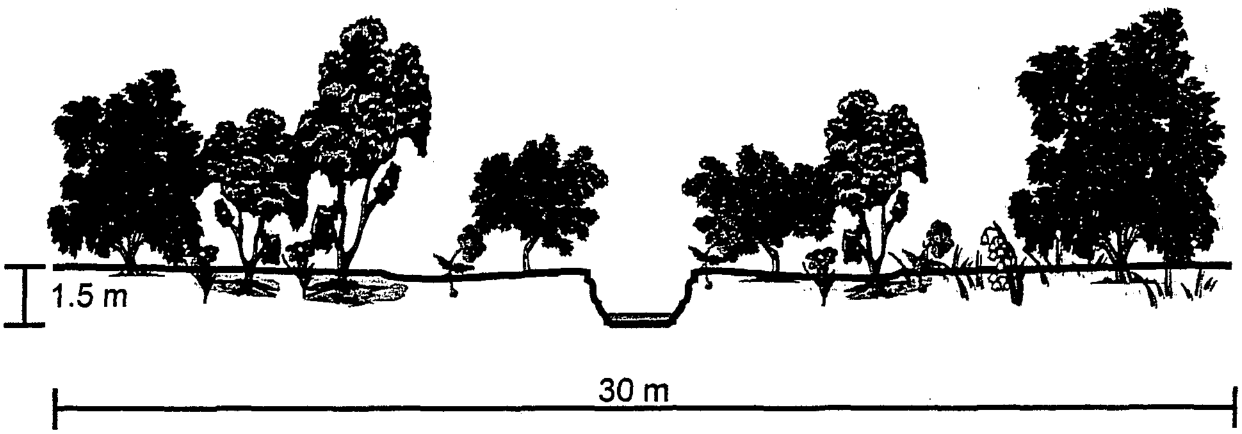


Fig. 26 Schematic representation of channel and vegetation profile. Although this profile does not match any one actual transect, the horizontal and vertical scales of the channel profile are representative of those found at transect sites in Bear and Gregory Canyon. The scale of the vegetation distribution (distance away from and above the channel) matches that of the channel profile, however the scale of each individual plant has been adjusted for the diagram. At sites like the one diagrammed above, the channel is deep and the surounding riparian zone is essentially flat. Vegetation on either side of the channel is affected primarily by distance from the channel and the related effects on soil mositure. Differences in understory vegetation start to appear further from the channel as lithic factors and local surrounding topography begin to influence the vegetation.

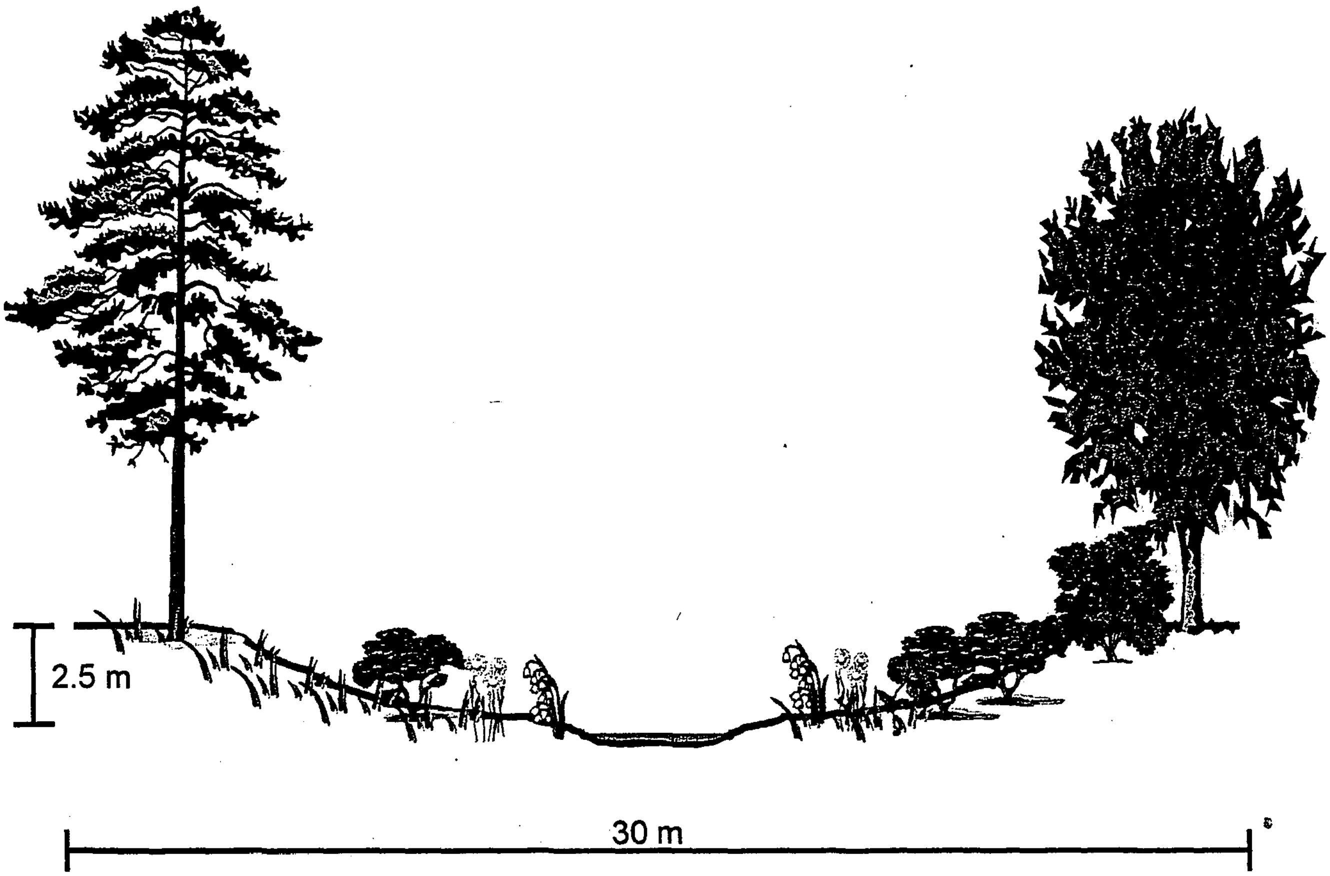


Fig. 27 Schematic representation of channel and vegetation profile. Although this profile does not match any one actual transect, the horizontal and vertical scales of the channel profile are representative of those found at transect sites in Bear and Gregory Canyon. The scale of the vegetation distribution (distance away from and above the channel) matches that of the channel profile, however the scale of each individual plant has been adjusted for the diagram. At sites like the one diagrammed above, topography in the riparian zone is fairly symmetrical with respect to the channel. On either side of the channel, the riparian zone is flat and only slightly higher than the channel, then begins to steepen and finally plateaus 7-12 meters from the stream. Close to the channel, vegetation is affected primarily by distance from the stream. In this case, stream bearing influences the effects of aspect, topography, and distance from the stream. In the diagram above, the left bank has a southern exposure and the right bank faces north. Because of this orientation, the left bank is drier even though topographic affects on exposure are not extreme at this site (for comparison, see Fig. 25).

Figure 28. Relatively open, mid-elevation forests such as this one at transect GC 1, have an incomplete canopy of cottonwoods with ponderosa pine and a shrubby understory populated by *Salix irrorata* and graminoids.

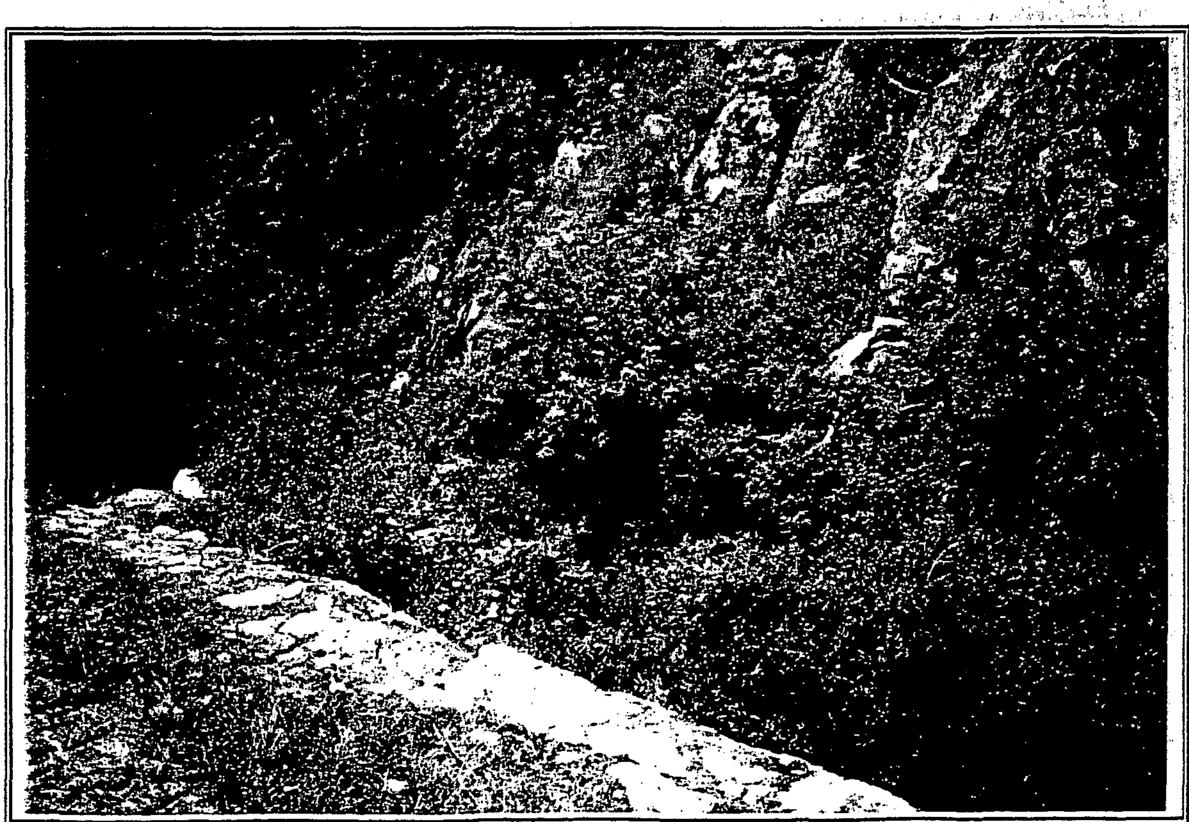


Figure 29. The combined effect of slope and exposure can be seen at transect GC 2. The south facing slope at the lower left has sparse xerophilic vegetation, while the more mesic, steep north facing possesses denser vegetation populated with scattered, low shrubs, forbs and grasses. The open channel bottom is dominated by willow, box elder, and wax flower.

Figure 30. Mid to high elevation channels frequently have a closed canopy of tall shrubs, such as hazel nut and mountain maple shown here at releve GSC 3. The understory consists of shade tolerant herbs such as cow parsnip, violets and others.

Hydrology Boulder Mountain Park Streams

The hydrology of streams in BMP is considerably more complicated than cursory examination might suggest. Because of the short data record (less than one complete season) and problems with data from Gregory Canyon, we only have an incomplete picture of the behavior of these streams. We can, however, make several assertions based on the information gathered during this study.

These streams are heavily precipitation driven. Channel reaches often remained dry for much of the summer, only having flow for a brief period after storms. This characteristic produces an erratic hydrograph with sudden sharp peaks and long periods when flow is only subsurface. Interestingly, the streams are not consistently gaining or losing along their lengths. For instance in Bear Canyon (Fig. 17), between the first four stations, flow either decreased or remained constant, even though lateral input of water from springs and tributaries was prevalent. This runs counter to typical riverine conditions where such inputs are reflected by increasing stream flow. Of the three channels studied, only Shadow Canyon appears to possess a "typical" hydrologic profile.

A high rate of ground water recharge presumably causes the hydrograph behavior displayed by Bear and Gregory Canyons. However, recharge rate is highly variable along stream reaches probably due to heterogeneities and fractures in the underlying bedrock. Streams were often seen flowing at one location, then less then 50 meters away they would have completely submerged, only to reemerge a short way further downstream. Recharge is also rapid after storm events. During one sampling trip, after a hard storm the prior night, the channel water level dropped 18 inches within two and a half hours, and the channel was dry by the time we left.

These characteristics muddle straightforward interpretation of stream hydrology. This underscores the need for reliable long-term hydrological monitoring of streams within Boulder Mountain Parks. This study has laid the groundwork for such a program. Should long-term data be collected, BMP managers and scientists would be able to gauge the effects of water management practices and determine whether mitigative steps are necessary to insure the maintenance of native community types.

Water quality

Although a detailed examination of water quality and its effects on the vegetation was not a part of this project, several observations on water quality measurements can be made. The total concentrations of most of the metals was consistently below detection limits across canyons and dates: only six of the eighteen metals showed variation. Ordination of this data partially separated canyons, with water in Shadow Canyon, especially the two sites at the lowest elevations, being the most dissimilar from water at the remaining transect sites (Fig. 22). Ordination of a different suite of water quality measurements, collected at the lowest elevation transect sites in each canyon, also differentiated Shadow Canyon from Bear and Gregory-Long Canyons. Here Shadow was separated from the other canyons based on a combination of seven water quality characteristics. Water from Bear and Gregory-Long Canyons was similar and mainly showed variation between sampling dates (Fig. 23).

The canyon in which streams were located affected both aluminum and barium concentrations. Aluminum concentrations of the surface water were high in Shadow canyon and barium concentrations were relatively low in Bear Canyon. In addition, canyon differences were evident in weekly measurements of conductivity, pH, and temperature (Table 2). Pooled across canyons, both elevation and date also influenced water quality characteristics.

Species and habitats of special concern

Only one state-listed species of special concern was present at the 12 transect sites. We sampled a paper birch stand on the northwest side of the channel at the highest elevation site in Gregory-Long Canyon. At the 14 releve sites, we found four state-listed species of special concern (Table 3). Within each canyon, species of concern were found at relatively high elevations. All four of the species were found in Greenman Springs Canyon, and two releves in Greenman Springs Canyon (GSC2 and GSC3) each had two species of special concern. This area has been identified by Hogan (1989) as a part of the park where rare species are found. The releve containing the newly identified population of *Botrypus* and a population of *Listera convallarioides* is only several meters upstream of sites where *Malaxis monophyllos* populations have been identified (Ann Armstrong, pers. comm.). Only one rare species (*Listera convallarioides*) was found in Bear Claw Canyon, and the two sites at which it was found (BCC2 and BCC6) are relatively close together at an elevation of approximately 2240 m (7350 ft.).

Table 3 Species of concern found in 1998 at transect stations and at releve sites

Species	Common name	Sites
Betula papyrifera	Paper birch	GC7
Botrypus virginianus	Rattlesnake fern	GSC2 * [new population]
Listera convallarioides	Broad-lipped twayblade	BCC2, BCC6, GSC2, GSC3
Polypodium amorphum	Polypody	GSC3
Smilax lasioneuron	Carrion flower	GSC1

Hogan (1989) reports that the northern slopes of Green Mountain are characterized by cool, mesic habitats, a rare habitat in the BMP, and that the species found in these habitats have eastern woodland affinities. Species typical of this habitat include *Aralia nudicaulis*, *Sanicula marilandica*, and *Sorbus scopulina* (Hogan 1989). Some of the survey sites in the Greenman Springs Canyon and Bear Claw Canyon seem to match with the descriptions given by Hogan (1989). For example, we found *Aralia nudicaulis* at six of the eight sites located in Greenman Springs Canyon and at four of six sites in Bear Claw Canyon. We found *Sanicula marilandica* at three sites in Greenman Springs Canyon and two sites in Bear Claw Canyon. Of the 28 species listed by Hogan as "relictual, woodland species" in this area of the park, 12 of them are present in at least one of the 14 survey sites (see Appendix E; Appendix II in Hogan 1989).

Management Concerns

Boulder Mountain Parks is known for its outstanding natural beauty and unique flora and fauna. In general, user impacts in the park decrease exponentially as one leaves the trail. Therefore, trail maintenance and placement are truly critical issues. A poorly placed trail can focus impacts in an ecologically sensitive area. Several of the sites we surveyed are more likely to be impacted by park visitors due to established trail placement. The three upper elevation sites in Greenman Springs Canyon are located along or close to established trails. At the spring site (GSC1), the trail crosses through the lower part of the spring, and downstream at another sites (GSC3), the trail again crosses the channel (Fig. 2). Of the 14 sites surveyed, these sites are by far the most likely to be impacted by trail use because the trail crosses through the channel at these points. Additional concern may be warranted because four species of special concern (Table 3) are found at sites GSC1 - GSC3. Although the trail does not cross the channel at GSC2, any impacts from the crossing at GSC1 could affect the site immediately downstream. Because the trail crosses through the spring (GSC1) and because the area immediately downstream supports several rare species. A similar situation exists in Bear Canyon where the trail crosses the stream in numerous places. If an new trail alignment were feasible in this canyon, it would be desirable to distance the trail from the stream. From a recreational point of view this is not desirable, however, since people are naturally drawn to water courses and it is aesthetically pleasing to walk near them.

Boulder Mountain Parks management has the challenging task of trying to balance maintenance of the park's ecological integrity with user activities and legal rights. In the majority of cases this challenge seems to have been met quite well; however, park usage will continue to grow as the Front Range cites expand and balance will become more and more difficult. Making a wise management decision is making an informed management decision. Studies like this one increase our knowledge of how the ecosystems within the park function, thereby making such informed decisions possible. Boulder Mountain Parks has taken large steps towards understanding the ecological character of the park by facilitating numerous ecological studies. Their continued pursuit of such understanding will greatly aid in balancing the sometimes conflicting needs of park users and the native species.

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Appendix A. Releve statistics. Monument location is given facing downhill unless otherwise specified. Plots span stream channels and continue in the direction specified.

Plot I.D.	Plot Width (m)	Plot Length (m)	Monument Location	Direction of Plot From Monument	Notes
BCC 1	5	15	Right	Downstream	Plot bends with channel
BCC 2	7	14	Right	Downstream	
BCC 3	4	255	Right	Upstream	Plot Bends with channel
BCC 4	7	14	Right	Downstream	
BCC 5	4	23	Right	Upstream	
BCC 6	5	20	Right	Downstream	Monument near large rock and big blue spruce
GSC 1	8	12	Left (facing up hill)	Uphill	
GSC 2	3	30	Right	Downstream	
GSC 3	4	25	Left (facing up hill/upstream)	Upstream	Monument just off trail, base of boulder
GSC 4	6	18.5	Right	Downstream	
GSC 5	7	14	Right	Downstream	
GSC 6	5	20	Right	Downstream	Plot bends with channel
GSC 7	8	12.5	Right	Downstream	
GSC 8	3	30	Right	Downstream	

Appendix B - Abiotic data for releve sites

ID	Date	Canyon	Elevation (m)	Channel bearing downstream	Channel gradient (%)	Channel width (cm)	Riparian width (m)	Surface water CND	Surface water temp	Depth to water table (cm)	Depth of surface water (cm)
BCC1-98	8/10/98	Bear Claw	2251	325	18	0	4.8	55.8	15.6	0-30	0
BCC2-98	8/10/98	Bear Claw	2244	287	25	48	7-8	65.4	11.9	0-40	1.2
BCC3-98	8/10/98	Bear Claw	2143	288	16	48	4-5			50	0
BCC4-98	8/10/98	Bear Claw	2161	234	11	68	7-8	77.7	13.7	40	1.8
BCC5-98	8/10/98	Bear Claw	2162	254	19	51	4-6	79.1	13.6	30	3
BCC6-98	8/10/98	Bear Claw	2240	295	17	75	7	64.5	11.4	15-30	0.9
GSC1-98	8/11/98	Greenman Spring		331	36	91 and 10	8-10	48.4	9.4	0+	4 and 0.2-1.1
GSC2-98	8/11/98	Greenman Spring	2171	304	38	52	3-5	130.3	11.5	20	1.2
GSC3-98	8/11/98	Greenman Spring	2134	326	17	56	4-5	163	12	20-30	4.6
GSC4-98	8/11/98	Greenman Spring	2090	0	8	84	4-6	193.8	13.6	25	3.5
GSC5-98	8/11/98	Greenman Spring		336	10	51	7-9	196.5	13.6	30-40	0.8
GSC6-98	8/11/98	Greenman Spring	2040	50 and 95	17	44	5	192	14.4	35	2.4
GSC7-98	8/11/98	Greenman Spring	2006	335	14	89	12-13	173.5	14.6	50	dry to 2.3
GSC8-98	8/11/98	Greenman Spring	1980	342	112	40	2.4	164.4	13	0	thin to 3

ID	Location of surface water	Water source	Hydroperiod	Soil depth (cm)	Soil matrix color	Soil mottle color	Mottle %	Soil texture
BCC1-98	none	spring	Int.	28	5YR 2.5/1		0	coarse sandy loam
BCC2-98	channel and springs	GW + runoff	Int.	29	7.5YR 2.5/1		0	coarse sandy loam
BCC3-98	none	GW + runoff	Int.	44	2.5YR 2.5/1		0	coarse sandy loam
BCC4-98	channel	GW + runoff	Int.	82+	10YR 2/1		0	coarse sandy loam
BCC5-98	channel	GW + runoff	Int.	20	2.5YR 2.5/1		0	sandy loam
BCC6-98	channel	GW + runoff	Int.	12	2.5YR 2.5/1		0	sandy loam - loam
GSC1-98	spring pools	spring	perm?	11 and 32	10YR 2/1	7.5YR 3/2, 5YR 2.5/1, 5YR 5/3	18	coarse sandy loam
GSC2-98	channel	GW + runoff + side seep	perm?	12	10YR 3/2		0	loamy sand
GSC3-98	channel	GW + runoff	Int. - perm	14	10YR 2/1		0	sandy loam - loamy sand
GSC4-98	channel	GW + runoff	Int.	13-17	7.5YR 3/3		0	loamy sand to coarse snady loam
GSC5-98	channel	GW + runoff	Int.	12	5YR 2.5/1		0	coarse sandy loam
GSC6-98	channel	GW + runoff	Int.	24	2.5YR 2.5/1	10YR 5/8	3	light sandy loam
GSC7-98	channel	GW + runoff	Int.	17	5YR 2.5/1	2.5YR 4/3	1	sandy loam
GSC8-98	rock face, channel	GW + runoff	Int.	0	rock face, channel		0	rock

* All sites were located in Bear Claw Canyon (BCC) and Greenman Springs Canyons (GSC).

Appendix C - *Surface water metal concentrations*

Sample	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Tl	Zn
SC1	0.5	405.5	3.5	61.2	0.2	0.5	1.2	1.3	3.7	584	7.7	3.2	1.6	1.9	0.9	4.5	18.6	6.9
SC2	0.5	225.3	3.5	60.3	0.2	0.5	1.2	1.3	3.7	359	9.7	3.2	1.6	1.9	0.9	4.5	18.6	25.5
SC3	0.5	173.6	3.5	55.4	0.2	0.5	1.2	1.3	3.7	227	5.4	3.2	1.6	1.9	0.9	4.8	18.6	1.9
SC4	0.5	156.8	3.5	48.1	0.2	0.5	1.2	1.3	3.7	197	7.5	3.2	1.6	1.9	0.9	4.5	18.6	17.3
SC5	0.5	50.7	3.5	50.3	0.2	0.5	1.2	1.3	3.7	53	1.9	3.2	1.6	1.9	0.9	4.5	18.6	1.9
SC6	0.5	195.7	3.5	48.3	0.2	0.5	1.2	1.3	3.7	206	13.8	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC1	0.5	65.5	3.5	53.5	0.2	0.5	1.2	1.3	3.7	183	14.3	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC2	0.5	50.5	3.5	47.2	0.2	0.5	1.2	1.3	3.7	73	3.1	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC3	0.5	3.8	3.5	59.4	0.2	0.5	1.2	1.3	3.7	10	-0.1	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC4	0.5	117.2	3.5	41.0	0.2	0.5	1.2	1.3	3.7	174	6.6	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC5	0.5	87.9	3.5	48.3	0.2	0.5	1.2	1.3	3.7	116	4.6	3.2	1.6	1.9	0.9	4.5	18.6	1.9
GC7	0.5	117.9	3.5	44.1	0.2	0.5	1.2	1.3	3.7	150	8.8	3.2	1.6	1.9	1.6	4.5	18.6	1.9
GC6	0.5	44.1	3.5	48.7	0.2	0.5	1.2	1.3	3.7	71	7.0	3.2	1.6	1.9	1.6	4.5	18.6	1.9
BC1	0.5	199.8	3.5	44.7	0.2	0.5	1.2	1.3	3.7	287	8.2	3.2	1.6	1.9	1.8	4.5	18.6	1.9
BC2	0.5	73.0	3.5	36.3	0.2	0.5	1.2	1.3	3.7	88	3.2	3.2	1.6	1.9	0.9	4.5	18.6	33.4
BC3	0.5	96.4	3.5	27.0	0.2	0.5	1.2	1.3	3.7	192	8.3	3.2	1.6	1.9	0.9	4.5	18.6	1.9
BC4	0.5	66.9	3.5	25.7	0.2	0.5	1.2	1.3	3.7	154	6.4	3.2	1.6	1.9	0.9	4.5	18.6	1.9
BC5	0.5	86.3	3.5	23.6	0.2	0.5	1.2	1.3	3.7	173	7.7	3.2	1.6	1.9	0.9	4.5	18.6	1.9
BC6	0.5	96.0	3.5	21.9	0.2	0.5	1.2	1.3	3.7	239	8.8	3.2	1.6	1.9	0.9	4.5	18.6	3.6
Detection limit	0.5	5	3.6	0.2	0.2	0.5	1.2	1.3	3.7	5	0.6	3.2	1.6	1.9	0.9	4.8	18.6	1.9

Water samples were collected by Boulder personnel August 5 and 12, 1998 and analyzed by the City of Boulder Wastewater / Environmental Laboratory. Concentrations reported are for total metal concentration and units for all metals are ug/L.

Appendix D - Water quality of lowest elevation sites in Bear (BC), Gregory (GC) and Shadow Canyons (SC)

Site	Date	Sampler	Weather	Time	Temperature (°C)	DO (%)	pH (su)	Turbidity (ntu)	T Alkalinity (mg/L)	T Hardness (mg/L)	Ortho P (ug/L)	TP (ug/L)	TSS (mg/L)	Specific Conductance
BC1	06/22/98	MK,CS	sunny,calm,clear	9:15	11.7	102	7.5	10.10	78.0	112.90	14.44	29.7490	9.2	300
BC1 rep	06/22/98	MK,CS	sunny,calm,clear	9:15	11.7	102	7.5	10.20	77.4	112.90	13.70	30.7440	9.2	300
GC1	06/23/98	MK,MRM,CM	sunny,calm,clear	9:30	13.0	93	7.4	4.62	84.3	91.80	17.41	29.7490	6.2	300
GC1 rep	06/23/98	MK,MRM,CM	sunny,calm,clear	9:30	13.0	93	7.4	4.38	84.3	92.70	17.04	30.4130	6.0	300
SC1	06/24/98	MK,CS	sunny,calm,clear	9:25	13.1	95	7.0	25.00	42.7	63.00	23.36	57.9580	27.2	200
SC1 rep	06/24/98	MK,CS	sunny,calm,clear	9:25	13.1	95	7.0	25.20	43.0	61.90	22.24	56.9620	27.6	200
BC1	08/03/98	MK,CS	partly cloudy,calm	10:10				10.50	75.1	103.30	13.70	27.6969	5.2	233
BC1 rep	08/03/98	MK,CS	partly cloudy,calm	10:10				9.93	74.3	103.50	14.81	28.8356	4.4	236
GC1	08/04/98	MK,MRM,CM	overcast,rainy	9:15	13.8		8.14	3.01	88.3	95.40	14.44	26.0313	4.0	228
SC1	08/05/98	MK,CS	partly cloudy	9:45				16.90	43.2	59.20	23.36	41.5917	5.0	137
GC1	08/11/98	MK,CM,BD	partly cloudy,calm	9:10				1.60	92.4	97.70	16.30	27.3632	1.2	232
GC1 rep	08/11/98	MK,CM,BD	partly cloudy,calm	9:10				1.70	91.5	97.30	16.30	16.0504	2.0	234
SC1	08/12/98	MK,BD	sunny,calm,clear	10:40	17.0	110	8.18	10.90	37.6	48.10	24.84	42.1671	5.0	111.7
BC1	08/12/98	MK,BD	sunny,calm,clear	9:40	14.7	116	8.34	9.00	85.2	125.40	14.81	31.5377	10.2	282

Site	True Color (Abs)	True Color (PtCo)	Nitrite/Nitrate	F Coli (no/100mL)	TOC	Ammonia	TKN-O (mg/L)	TKN-N (mg/L)	UV-254 (Abs)
BC1	0.0021	8.4007	0.08	28	2.84	0.00	0.27	0.27	0.0655
BC1 rep	0.0021	8.4007	0.08		2.85				0.0655
GC1	0.0024	9.5338	0.02	42	3.13	0.00	0.28	0.28	0.0767
GC1 rep	0.0023	9.1561	0.02		3.11				0.0768
SC1	0.0048	18.5980	0.21	38	2.62	0.00	0.35	0.35	0.0811
SC1 rep	0.0045	17.4650	0.32		2.66	0.00	0.40	0.40	0.0792
BC1	0.0023	9.1561	0.02	113	2.58	0.07	0.20	0.27	0.0663
BC1 rep	0.0023	9.1561	0.02		2.50	0.05	0.18	0.24	0.0668
GC1	0.0033	12.9330	0.01	119	3.79	0.05	0.27	0.32	0.1040
SC1	0.0081	31.0620	0.01	22	3.68	0.10	0.27	0.36	0.0889
GC1	0.0029	11.4220	0.01	73	3.35	0.00	0.13	0.13	0.0945
GC1 rep	0.0029	11.4220	0.00		3.36	0.00	0.22	0.22	0.0946
SC1	0.0052	20.1090	0.00	40	2.50				0.0892
BC1	0.0020	8.0230	0.00	232	2.36				0.0583

Appendix B - Species table for 1998 releve sites

Releves were 100 m² and located in two canyons: Bear Claw Canyon and Greenman Spring Canyon. Numbers given are percent cover estimated on August 10 or August 11, 1998. A "t" indicates a trace presence.

	BCC1	BCC2	BCC3	BCC4	BCC5	BCC6	GSC1	GSC2	GSC3	GSC4	GSC5	GSC6	GSC7	GSC8
Acer glabrum	3	3	45	8	2	0	10	3	0	1	0	35	20	10
Achillea millefolium	0	t	t	t	t	0	0	t	0	t	0	0	0	t
Aconitum columbianum	0	t	0	0	0	0	0	0	0	0	0	0	0	0
Actaea rubra	t	0	t	0	0	1	1	t	0	1	t	0	0	0
Agrostis exerata	0	0	0	1	1	0	0	0	t	0	0	0	0	0
Agrostis gigantea	t	12	0	t	0	0	0	0	0	t	0	0	0	1
Agrostis scabra	0	t	2	0	0	0	0	0	0	t	0	0	0	1
Aletes acaulis	0	0	0	0	0	0	0	0	0	0	0	0	0	t
Anaphalis marg	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Antenaria spp.	0	0	0	0	0	t	0	0	0	0	t	0	t	0
Antennaria rosea	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Apocynum spp.	0	1	0	0	0	0	0	0	0	0	2	0	0	0
Aquilegia coerulea	0	0	0	0	0	0	1	t	0	t	0	t	0	t
Aralia nudicaulis	0	t	1	0	t	5	0	t	t	t	t	t	1	0
Arnica cordifolia	t	t	0	0	0	0	0	t	t	0	t	t	t	0
Artemisia ludoviciana	0	0	0	0	0	0	0	0	0	0	0	0	0	t
Aster laevis	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Athyium filix-femina	3	3	0	0	0	3	4	15	0	0	5	0	0	0
Betula fontinalis	8	20	0	45	30	35	15	65	55	10	75	60	7	0
Botrypus virginianus	0	0	0	0	0	0	0	t	0	0	0	0	0	0
Bromopsis lanatipes	0	0	0	0	0	0	0	0	0	0	t	0	t	t
Bromopsis pubescens	0	0	1	2	2	0	0	0	0	0	0	0	0	0
Calamagrostis canadensis	0	t	0	0	0	0	0	0	0	0	0	0	0	0
Campanula rotundifolia	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Carex deweyana	t	0	7	5	5	t	0	t	t	1	t	0	5	t
Carex disperma	0	0	0	t	2	1	0	0	0	0	0	0	0	0
Carex geyeri	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Carex hasseyi	0	0	0	0	t	0	0	0	0	0	0	0	0	0
Carex microptera	0	t	0	1	1	0	0	0	0	0	0	0	0	0
Carex spp.	0	0	0	0	0	0	t	0	0	t	0	0	0	0
Cerastium fontanum	0	t	t	1	1	0	0	0	0	0	0	0	0	0
Chamerion angustifolium	0	t	0	0	0	1	0	0	0	0	0	0	0	0
Circaea alpina	12	0	1	1	25	40	15	20	10	5	5	7	3	t

Appendix E (cont.)

	BCC1	BCC2	BCC3	BCC4	BCC5	BCC6	GSC1	GSC2	GSC3	GSC4	GSC5	GSC6	GSC7	GSC8
Cirsium arvense	1	t	0	0	t	0	0	t	t	0	t	0	0	0
Cirsium sp.	0	0	0	t	0	0	0	0	0	0	0	0	0	0
Cornus sericea	0	0	0	0	0	0	0	0	8	30	3	0	0	4
Cornus stolonifera	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Corylus cornuta	5	2	7	0	2	0	0	0	15	0	35	10	27	0
Crunocallis chamissoi	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Cryptogramma acrostichoides	0	0	0	0	0	0	0	0	0	0	0	0	0	t
Cynoglossum officinale	0	0	0	0	0	0	0	0	0	0	0	t	0	0
Cystopteris fragilis	t	t	t	t	t	t	t	t	t	t	t	t	0	t
Danthonia spicata	0	t	0	0	0	0	0	0	0	0	0	0	0	0
Dodecatheon pulchellum	0	1	t	1	1	1	0	t	t	t	0	0	0	t
Dryopteris felix-mas	0	0	0	0	0	0	t	0	t	0	0	0	0	0
Elymus canadensis	0	0	t	1	0	0	0	0	t	0	0	t	t	t
Elymus glaucous	0	0	0	0	t	0	0	0	0	0	0	0	0	0
Epilobium lactiflorum	0	t	t	0	t	t	0	t	t	t	t	0	0	t
Equisetum arvense	0	2	0	0	1	0	0	0	t	1	t	0	0	0
Equisetum hyemale	0	0	0	0	0	0	0	0	0	0	7	0	0	0
Equisetum laevigatum	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Erigeron speciosous	0	0	0	t	0	0	0	t	0	0	t	0	0	0
Erigeron spp.	0	0	0	0	0	0	0	0	0	0	t	0	0	t
Eupatorium maculatum	0	0	0	0	0	0	0	t	0	0	0	0	0	0
Fragaria spp.	0	0	t	t	t	t	0	t	t	t	0	0	t	0
Galium septentrionale	0	0	t	t	0	0	0	0	0	0	0	0	0	0
Galium trflorum	2	t	t	t	t	t	t	t	t	0	0	t	t	0
Geranium caespitosum	0	t	0	1	0	0	1	1	1	1	1	0	0	1
Geum macrophyllum	0	0	t	t	0	0	0	0	0	t	0	0	0	0
Glyceria striata	0	0	0	2	7	2	0	1	1	4	1	t	t	0
Goodyera oblongifolia	0	0	0	0	0	t	0	0	0	0	0	0	0	0
Heracleum sphondylium	1	t	t	2	1	0	2	0	12	7	0	3	1	0
Heuchera bracteata	0	0	0	0	0	0	0	0	0	0	0	0	0	t
Hydrophyllum fendleri	0	0	0	0	0	0	0	0	0	0	0	0	t	0
Jamesia americana	0	1	3	0	0	t	0	t	2	3	25	2	10	4
Juniperus communis	0	0	0	0	t	0	0	0	0	1	0	0	0	1
Juniperus scopulrum	0	1	3	4	0	0	0	0	0	0	0	0	8	0
Lactuca canadensis	0	0	0	0	0	0	0	0	0	0	0	0	t	0
Lactuca serriola	0	0	t	0	t	0	0	0	0	0	0	0	0	0
Ligusticum porteri	t	t	2	1	1	t	0	0	1	0	t	1	1	0
Listera convallarioides	0	t	0	0	0	1	0	2	1	0	0	0	0	0

Appendix E (cont.)

	BCC1	BCC2	BCC3	BCC4	BCC5	BCC6	GSC1	GSC2	GSC3	GSC4	GSC5	GSC6	GSC7	GSC8
Lonicera involucrata	5	1	1	4	7	2	0	1	2	5	1	t	0	1
Lymnorchis hyperborea	0	0	0	0	0	0	0	0	0	t	0	0	0	0
Mahonia repens	0	0	t	t	0	0	0	0	0	0	t	0	1	0
Maianthemum amplexicaule	0	0	1	0	t	t	0	0	0	0	0	t	0	0
Maianthemum stellatum	t	0	0	1	0	t	0	t	t	t	t	0	t	0
Mentha arvensis	0	0	0	0	0	0	t	t	0	0	0	0	0	0
Monarda fistulosa	0	0	1	2	0	0	0	0	0	0	0	0	t	0
Moss	4	12	0	0	1	25	40	45	0	0	20	5	20	25
Muhlenbergia racemosa	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Osmorhiza depauperata	1	t	1	0	t	t	t	t	1	0	0	1	0	0
Oxalis dillenii	0	0	t	0	0	0	t	0	0	0	0	0	0	0
Parthenocissus inserta	0	0	0	0	0	0	t	0	0	0	0	0	0	0
Physocarpus monogynus	0	0	0	0	0	0	0	0	0	4	7	0	3	2
Picea pungens	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Pinus contorta	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Pinus ponderosa	0	0	30	18	20	4	0	0	2	0	1	0	4	0
Plantago major	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Poa compressa	0	0	1	4	0	0	0	0	0	0	0	0	0	1
Polypodium amorphum	0	0	0	0	0	0	0	0	t	0	0	0	0	0
Populus tremuloides	35	20	2	7	0	45	15	0	0	0	2	0	0	0
Prunella vulgaris	0	0	1	1	2	0	0	t	t	t	t	t	t	0
Prunus virginiana	0	0	1	1	1	0	0	0	0	1	0	t	0	0
Psedotsuga menziesii	t	5	0	5	0	3	2	5	t	0	4	30	15	2
Pseudocymopterus montanus	0	0	0	0	0	t	0	0	0	0	0	0	0	0
Pteridium aquilinum	0	1	0	0	0	0	6	5	4	35	0	0	5	0
Pyrola chlorantha	0	0	0	0	0	0	0	0	t	0	0	0	0	0
Pyrola rotundifolia	0	0	0	0	0	t	0	0	0	0	0	0	0	0
Ranunculus maconii	0	0	t	0	t	0	0	0	0	0	0	0	0	0
Ribes inerme	t	t	1	t	2	t	0	0	0	0	0	0	0	0
Rosa woodsii	0	0	3	2	2	0	0	0	0	0	t	0	0	0
Rubus delicious	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Rubus idaeus	0	0	0	t	0	t	1	0	0	0	0	t	1	0
Rubus parviflorus	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Rubus pubescens	0	t	0	0	0	0	t	0	t	0	0	0	0	0
Rudbeckia ampla	0	0	3	0	7	0	0	0	0	3	5	0	2	1
Salix bebbiana	0	1	0	0	0	0	0	0	0	6	0	0	0	8
Sambucus canadensis	0	0	0	0	0	0	0	t	0	0	0	0	0	0
Sanicula marilandica	0	0	0	t	0	t	0	0	0	t	t	t	0	0
sedum lanceolatum	0	0	0	0	0	0	0	0	0	0	0	0	0	t

Appendix E (cont.)

	BCC1	BCC2	BCC3	BCC4	BCC5	BCC6	GSC1	GSC2	GSC3	GSC4	GSC5	GSC6	GSC7	GSC8
Smilax lasioneuron	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Solidago canadensis	0	0	0	0	0	0	0	0	t	t	0	0	0	0
Sorbus scopulina	0	0	2	0	10	0	0	0	0	0	0	0	0	0
Streptopus amplexiflorus	0	3	0	0	0	0	0	2	2	1	0	0	0	0
Symphoricarpos albus	t	0	1	t	0	t	0	0	0	0	1	0	2	1
Taraxacum officinale	0	t	0	0	0	0	0	0	0	0	0	t	t	t
Thlaspi spp.	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Trifolium spp.	0	0	0	0	t	0	0	0	0	0	0	0	0	0
Urtica gracilis	0	0	0	0	t	0	0	0	0	0	0	0	0	0
Veronica americana	0	0	0	t	0	0	0	0	0	0	0	0	0	0
Viola rydbergii	1	1	1	2	1	7	3	1	1	2	1	15	3	0
Viola scopoulorum	0	0	0	0	0	0	0	0	0	0	0	t	0	0

Appendix F *WET function scores for releves*

ID	GW recharge	GW discharge	Flood retention	Shoreline anchoring	Sediment trapping	Short-term nutrient retention	Long-term nutrient retention	Within food web suport	Downstream food web support	Fish habitat	Wildlife habitat	Passive rec/her
BCC1-98	4b	4c	2c	1c	2c	4c	4c	5c	2b	1c	5c	3c
BCC2-98	4b	4c	3b	3b	3c	4b	4b	5c	3b	1c	5c	3c
BCC3-98	3b	2b	2b	2b	3c	3b	3b	4c	2c	1c	4c	3c
BCC4-98	3c	4b	2c	3b	2c	3b	2c	4c	3b	1c	5c	3c
BCC5-98	4b	3b	2c	3b	2c	4b	2b	5c	3c	1c	5c	3c
BCC6-98	3b	3b	2c	2c	2c	3c	2b	4b	3b	1c	5c	3c
GSC1-98	2b	5c	2b	2c	2c	3b	3b	4c	4c	1c	5c	5c
GSC2-98	2c	4c	2c	4b	2b	2b	2b	4b	4b	1c	4b	4c
GSC3-98	2b	3b	2c	3c	3b	2b	2b	4b	4c	1c	5c	5c
GSC4-98	3b	3b	3b	3b	3c	3c	3b	5b	4b	1c	5c	3b
GSC5-98	2b	3b	2c	3b	2b	3b	3b	4b	3c	1c	5c	2b
GSC6-98	2b	3c	2c	3b	3b	3b	3b	4b	4b	1c	5c	2b
GSC7-98	5c	3b	3b	3b	2b	3b	2b	4c	3c	1c	5c	2c
GSC8-98	1c	4c	1c	2c	2c	2c	2c	2c	5c	1c	3c	4c

Site identification is noted in the first column and wetland fucntions scores are reported in the remainder of the table. Functions were subjectively evaluated on August 10 and 11, 1998. Each function received a rank from 1(low) - 5 (high) estimating the degree to which the function was performed at the site and the immediately surrounding area. Each function received a score from a (low) - c (high) estimating the probability that the function was performed at that site.

Appendix G Species tables for transect sites in Bear Canyon and Gregory-Long Canyon. Numbers are estimated percent cover for each subplot in the transect. A "t" indicates a trace presence. Some species abbreviations are followed by a "S" or "T" with "S" indicating that the plants were < 1.5 m in height, and "T" indicating plants that were > 1.5 m in height. Species that are not marked with S or T were not classified into height classes.

Bear Canyon 1

	1	2	3	4	5	6	7	8	9	10
Arrela	t	2	0	0	0	20	20	6	15	30
CleligS	2	2	9	0	0	0	0	0	0	0
CleligT	0	8	0	0	0	0	0	0	0	0
CramacS	30	30	t	0	0	0	30	3	80	60
CramacT	0	0	0	0	0	0	8	35	12	0
Dacglo	4	0	15	3	0	0	0	0	0	0
Elycan	0	0	0	0	0	0	0	t	0	t
Equarv	0	0	0	0	0	0	2	0	0	0
Erispp	t	0	0	0	0	0	0	t	0	0
Hydfen	t	t	0	0	0	0	0	0	0	0
Osmlon	3	0	0	0	0	0	0	0	0	0
Poacom	t	0	0	0	0	t	0	0	0	0
PopangT	0	0	0	0	70	100	100	75	30	100
PopdelT	0	10	50	10	40	8	20	0	0	0
PruvirS	20	50	80	30	0	0	0	45	18	45
PruvirT	40	30	60	15	0	0	35	0	0	0
Ribine	0	t	t	0	0	0	0	0	0	0
SalirrS	0	0	35	40	0	0	0	0	0	0
SalirrT	0	0	30	45	100	40	0	0	0	0
Symalb	3	t	0	0	0	0	0	4	3	2
Taroff	0	t	0	0	0	0	t	t	t	2

Appendix G (cont.)

Bear Canyon 2

	1	2	3	4	5	6	7	8	9	10
AcenegS	0	0	0	0	0	2	1	t	0	0
AcenegT	0	0	0	0	0	2	0	0	0	0
AlnincT	20	70	10	100	75	90	30	60	100	80
Apoand	0	0	0	0	0	0	5	7	4	9
Cardew	0	0	0	0	0	0	3	5	4	0
CorcorS	0	0	0	0	0	0	0	0	2	40
CorcorT	100	100	100	80	75	30	100	85	0	0
Mahrep	0	0	0	0	0	0	1	10	29	7
PinponT	0	0	0	0	0	0	15	95	100	100
PsemenS	0	0	0	0	0	0	t	0	0	0
Taroff	0	0	0	0	0	0	1	0	0	0

Bear Canyon 3

	1	2	3	4	5	6	7	8	9	10	11
AceglaS	0	0	0	0	0	0	0	0	0	0	20
AceglaT	0	0	0	0	0	0	0	0	0	0	90
Apocan	5	8	0	0	0	0	0	0	0	0	0
Aqucoe	0	9	0	0	0	0	0	0	0	0	0
Astfal	0	0	0	0	0	0	0	0	0	0	3
Elycan	2	1	0	0	0	0	0.1	0	0	0	2
Epicil	0	0	0	0.1	1	0	0	0	0	0	0
Impcap	0	0	1	0	0	0	0	0	0	0	0
Mahrep	3	0	0	0	0	0	0	0	0	0	0
Menarv	0	0	0	2	35	0	0	0	0	0	0
Passmi	0	0	0	0	0	20	0	0	0	0	0
Poacom	0	0	10	0	3	3	0	0	0	0	0
Poapra	0	2	1	0	0.1	0	0	0	0	0	0
Poleng	0	0	0	0.1	0	0	0	0	0	0	0
PopangS	0	3	25	30	10	0	0	0	0	0	0
PopangT	0	5	40	60	5	0	0	0	0	0	0
PruvirS	0	0	0	0	0	30	30	0	0	0	0
PsemenT	3	0	0	0	0	0	0	0	0	0	0
RhuglaS	30	1	30	3	30	35	0	0	0	0	35
RubdelS	0	20	0	0	0	0	0	0	0	0	0
Setvir	0	0	0	0	0	0	0.1	0	0	0	0
Toxryd	20	45	8	0	15	40	65	0	0	0	30

Appendix G (cont.)

Bear Canyon 4

	1	2	3	4	5	6	7	8	9	10	11	12	13
AceglaS	5	5	0	0	0	0	0	0	5	0	0	0	0
Agrsca	0	0	0	0	0	0	0	1	0	0	0	0	0
Aqucoe	0	0	0	0	2	8	0	3	4	2	3	9	30
Aranud	t	0	0	0	0	0	0	0	0	0	0	0	0
Cargey	0	0	t	0	0	0	0	0	0	0	0	0	0
Cirarv	0	0	0	0	0	0	2	0	0	0	0	0	0
CorcorS	25	95	0	3	40	80	30	0	0	0	0	0	0
CorcorT	0	0	100	100	75	0	0	0	0	0	0	0	0
Elygla	0	0	0	0	0	0	0	0	0	0	0	1	2
JamameS	0	0	10	7	0	0	0	0	0	0	0	0	0
Maiste	t	0	0	0	0	0	0	0	0	0	0	0	0
PinponT	0	0	5	10	5	15	0	0	0	0	55	95	100
Poapra	0	0	0	0	0	0	0	0	0	0	0	0	1
PopangT	0	0	0	0	0	0	30	70	85	80.	15	10	1
PruvirS	0	0	0	1	3	7	0	0	0	5	0	0	2
PruvirT	0	0	0	0	0	0	0	0	0	0	40	60	0
PsemenS	0	0	0	0	0	0	0	0	0	0	0	0	t
PsemenT	100	60	10	0	0	0	0	0	0	0	0	0	0
RhuglaS	0	0	0	0	0	0	0	0	0	0	0	15	35
RoswooS	0	0	0	t	4	0	0	0	0	0	6	7	0
SalirrS	0	0	0	0	0	0	2	9	4	0	20	0	0
SalirrT	0	0	0	0	0	0	0	15	65	75	35	0	0
Symalb	0	0	1	0	3	3	0	0	0	0	0	0	0

Appendix G (cont.)

Bear Canyon 5

	1	2	3	4	5	6	7	8	9	1	11	12	13	14
AceglaS	0	7	0	0	0	0	0	0	0	0	0	0	0	0
AceglaT	0	0	90	90	0	0	0	0	0	0	0	0	0	0
Acevul	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Agrgig	8	t	1	20	3	3	t	T	1	20	35	0	0	0
AlnincS	0	0	0	0	0	0	0	30	0	0	0	0	0	0
AlnincT	0	0	0	5	100	100	50	95	80	35	0	0	0	0
Angamp	0	0	0	0	3	9	35	35	60	20	0	0	0	0
Barort	0	0	0	0	2	4	0	t	0	0	0	0.1	0	0
Carlan	0	0	0	0	0	0	0	0	0	0	10	20	1	1
Cirarv	0	4	0	0	0	t	t	0	0	0	1	1	0	0
Danspi	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dodpul	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Elyely	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Epicil	0	0	0	0	t	0	0	1	0	0	t	0	0	0
Equarv	20	75	30	10	10	30	7	4	0	0	0	20	15	t
Equlae	0	0	0	0	0	0	0	0	0	0	t	1	t	0
Fraspp	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Gerric	0	0	0	0	0	0	0	0	0	0	0	0	1	2
JamameS	0	0	0	0	t	1	8	3	0	0	0	0	0	0
Juncom	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Laccan	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Maiste	0	3	4	2	1	0	0	0	0	0	0	0	0	0
Phlalp	5	1	t	0	t	0	0	0	t	0	0	t	1	0
PinponT	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Poacom	0	0	0	0	t	0	0	0	0	0	0	0	0	0
Poapra	0	0	0	0	0	0	0	0	0	0	0	3	0	t
PsemenT	80	65	85	2	0	0	0	0	0	0	0	0	0	0
Ribine	0	0	0	0	0	0	0	3	2	0	0	0	0	0
Rubida	15	15	20	7	12	7	3	5	7	0	0	0	0	0
Rumcri	0	0	0	0	0	0	0	0	0	0	t	0	0	0
Salbeb	0	0	0	0	0	75	80	0	0	0	0	0	0	0
SalexiS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SalexiT	0	0	0	0	0	0	0	0	0	0	0	0	20	3
SalfraT	0	0	0	0	0	0	0	10	25	75	75	40	0	0
Scrlan	0	0	30	35	95	80	15	0	0	0	0	0	0	0
Thlarv	0	0	2	0	0	0	0	0	0	0	0	0	0	3

Appendix G (cont.)

Bear Canyon 6

	1	2	3	4	5	6	7	8	9	10
Agrgig	8	5	15	1	t	0	0	0	0	0
Anecyl	0	0	1	1	0	0	0	0	0	0
Aqucoe	0	5	4	0	0	2	0	0	0	1
Cardew	2	0	0	t	2	0	0	0	0	t
Corcor	85	25	0	0	0	0	0	0	0	0
Elygla	1	0	0	0	0	0	0	0	0	0
Equarv	25	40	20	4	15	4	t	3	0	10
Equlae	0	0	0	0	0	0	t	0	0	0
Fraspp	0	0	5	4	1	1	0	0	0	0
Galsep	0	0	0	0	0	0	0	0	0	t
Gercae	40	25	10	7	45	10	t	5	t	t
Geumac	0	0	0	2	2	0	0	0	0	0
Glystr	0	0	0	0	0	20	7	8	0	t
Maiste	0	0	1	1	0	0	0	0	0	0
Phlalp	0	t	t	0	0	0	0	0	0	0
Picpun	0	0	0	0	0	0	0	50	100	65
Pinpon	0	0	0	0	0	0	0	40	100	100
Poapra	0	0	3	0	0	0	0	0	0	0
Poptre	0	45	30	0	0	0	0	0	0	0
Rubida	2	0	6	10	12	1	0	0	0	0
Scrlan	0	0	0	2	2	0	0	0	0	0
Solsp.	5	7	1	0	0	0	0	3	0.1	0
Symalb	0	0	1	0	0	0	0	0	0	7
Taroff	0	0	0	0	0	t	t	0	0	0

Appendix G (cont.)

Gregory Canyon 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Broine	20	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CorcorT	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0
CramacS	0	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galsep	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydfen	0	0	2	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JamameS	0	0	0	2	100	100	90	80	3	20	20	0	3	4	70	80	55	90	30
JamameT	0	0	0	0	0	0	0	0	0	t	10	2	0	10	35	55	0	0	25
Mahrep	1	t	5	1	1	0	0	0	0	0	15	10	0	0	0	0	0	0	0
Maiste	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MaldomT	0	0	0	0	0	0	10	90	100	100	100	100	100	75	80	20	5	0	0
Parqui	0	0	0	0	0	0	0	t	0	0	0	0	0	0	0	0	0	0	0
PinponT	30	80	40	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poapra	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PopangT	0	0	0	0	0	0	0	0	0	70	70	100	100	100	100	80	100	100	95
PruvirS	30	55	95	70	t	0	0	0	0	25	30	50	10	0	0	0	0	10	20
PruvirT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
RoswooS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
SalexiS	10	15	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toxryd	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VitripS	0	0	3	1	2	0	0	t	1	0	0	0	0	0	0	0	0	0	0

Appendix G (cont.)

Gregory Canyon 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AceglaS	0	0	0	0	0	0	0	0	0	0	0	0	0	10	50	80	4
AcenegT	0	0	t	85	100	100	100	100	100	20	0	0	0	0	0	0	0
Achmil	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Agrexa	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
Agrgig	0	0	0	0	0	0	20	40	0	0	0	0	0	0	0	0	0
Artlud	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Astlae	20	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Brobri	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Broine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Cargeo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Ciralp	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Circan	0	t	0	t	10	4	3	2	0	0	1	0	0	4	0	0	0
CorserS	0	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0	0
Dacglo	0	0	4	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryfis	1	20	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Elycan	0	0	0	0	0	0	0	0	0	3	25	5	0	0	0	0	0
Elygla	1	1	t	t	4	0	0	0	0	0	0	0	5	0	0	0	0
Epicil	0	0	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gercae	7	1	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0
Hydfen	0	0	10	10	1	15	0	0	0	0	0	0	8	18	0	5	0
Lacser	0	0	t	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepvir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Ligpor	0	0	0	0	0	0	0	0	0	8	0	10	0	0	0	0	0
Mahrep	10	7	10	0	0	0	0	0	0	0	0	0	9	0	0	0	0
Mercil	0	0	0	0	0	0	0	0	0	t	0	0	0	0	0	0	0
Monfis	0	0	0	0	0	0	0	0	0	3	1	t	7	0	0	0	0
Nepcat	0	0	0	0	0	0	0	0	0	0	1	t	0	0	0	0	0
Opufra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Osmdep	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Parins	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	0
Parqui	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	8
Phlmul	0	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PhysmonS	15	0	0	0	0	0	0	0	0	30	30	9	0	0	0	0	0
PhysmonT	0	0	0	0	0	0	0	0	30	3	0	0	0	0	0	0	0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PinponS	0	0	0	0	0	0	0	0	0	0	0	t	0	0	0	0	0
Poapra	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
PruvirS	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
RhuglaS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
RoswooS	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0
RubdelS	10	10	30	7	40	0	0	0	0	0	0	0	0	0	0	0	0
Rubpar	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Rudamp	0	0	0	0	20	30	0	0	0	0	0	0	0	0	0	0	0
SalirrS	0	0	0	0	0	0	0	0	0	15	40	0	0	0	0	0	0
SalirrT	0	0	0	0	0	0	0	0	15	15	0	0	0	0	0	0	0
Solsp.	0	0	0	0	0	3	15	10	0	0	0	3	0	0	0	0	0
Symalb	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taroff	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Toxryd	0	0	0	4	0	10	30	5	0	20	12	15	12	25	20	0	35
Tradub	0	0	0	0	0	0	0	0	0	0	t	0	0	0	0	0	0
Vertha	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Viosco	0	0	0	t	0	0	0	0	0	0	0	0	0	0	0	0	0
VitripS	0	0	0	0	0	0	0	0	0	0	0	4	25	7	10	0	0

Appendix G (cont.)

Gregory Canyon 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AceglaS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
AceglaT	0	0	30	90	90	90	80	10	25	7	100	100	100	75	0	0
Arncor	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Brotec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	t
Camrot	0	0	0	0	0	0	0	0	0	0	0	0	0	t	0	0
Cardew	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Cernut	0	0	0	0	0	0	0	0	0	0	0	0	0	0	t	t
Ciralp	0	0	0	0	0	0	0	2	1	2	1	20	2	0	0	0
CorcorT	0	0	0	0	2	70	90	100	100	100	10	0	0	0	0	0
Cysfra	2	1	2	2	0	0	1	t	0	1	t	0	t	t	0	0
Eriumb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
Hersph	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Hydfen	12	25	25	9	5	t	2	2	3	3	0	40	10	7	0	0
Ligpor	0	0	0	0	0	0	0	0	0	0	0	11	10	0	0	0
Mahrep	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercil	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Monfis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
Nepcat	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	7
Osmdep	1	3	10	1	3	2	2	3	t	1	0	4	20	0	0	0
PsemenT	100	100	100	85	70	10	0	0	0	0	0	0	25	25	0	0
Ribcer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
RoswooS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RubdelS	20	20	3	0	0	0	0	0	0	0	0	0	0	0	0	6
Rudamp	0	0	0	0	0	0	0	0	0	0	0	3	2	3	0	0
Solsp.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Symalb	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Taroff	0	0	0	0	0	0	0	0	0	0	0	0	t	0	0	0
Toxryd	0	0	0	0	0	0	0	0	0	0	0	0	7	2	0	0
Traocc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Viosco	2	2	1	t	0	0	0	0	0	t	0	1	2	4	0	2

Appendix G (cont.)

Gregory Canyon 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AceglaS	0	0	0	t	2	65	45	0	0	0	0	0	0	0	0	0	0
AceglaT	40	1	0	0	0	0	0	0	0	0	0	85	100	35	15	0	0
AcenegS	8	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cardew	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Cargey	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	20
Ciralp	0	0	0	0	0	0	0	10	t	t	0	0	0	0	0	0	0
CorserS	80	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CorcorS	0	0	0	0	18	10	1	30	50	50	2	0	0	0	0	0	0
CorcorT	0	0	0	0	0	0	0	0	0	0	40	70	2	0	0	0	0
Cynoff	0	0	0	3	11	0	0	0	0	0	0	0	0	0	0	0	0
Dacglo	0	0	0	0	t	0	0	0	0	0	0	0	0	0	0	0	0
Elycan	0	0	0	t	t	0	0	2	3	0	0	0	0	0	0	0	0
Hersph	0	0	0	0	15	5	20	30	0	0	0	0	0	0	0	0	0
Hydfen	1	5	5	8	5	8	25	25	20	3	3	1	0	0	0	0	0
JunscoT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
Mahrep	0	0	0	t	0	t	0	0	0	0	0	0	0	0	0	0	3
Maiste	0	0	0	t	t	0	0	1	t	2	0	0	0	0	0	0	0
Osmdep	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Parins	7	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0
PinponT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	95	100
PopangT	90	70	40	5	0	0	0	10	30	25	90	35	1	0	0	0	0
PruvirS	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
PsemenT	0	0	0	0	0	0	0	0	0	0	0	0	30	100	95	100	20
Ribine	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
RoswooT	0	0	0	0	0	0	0	40	20	0	0	0	0	0	0	0	0
Symalb	0	0	0	0	t	0	0	0	0	0	0	0	0	0	0	0	0
VitripS	2	15	20	50	35	4	5	20	25	30	0	0	0	0	0	0	0
VitripT	5	0	0	0	0	0	0	0	0	35	10	0	0	0	0	0	0

Appendix G (cont.)

Gregory Canyon 5

	1	2	3	4	5	6	7	8	9	10	11	12
AceglaS	t	10	90	100	0	0	2	1	0	0	0	0
AceglaT	0	0	20	0	100	30	0	0	0	0	0	0
Achmil	0	0	0	0	0	t	0	2	t	t	0	1
Agrsca	t	0	0	0	0	0	0	0	t	0	0	0
Antros	t	0	0	0	0	0	0	0	t	0	0	0
Arncor	t	1	t	3	t	0	0	0	0	0	0	0
Brolan	0	0	0	0	0	0	0	0	0	t	0	t
Camrot	t	0	0	0	0	0	0	0	0	0	0	0
Cardew	0	0	0	0	0	0	0	0	0	7	0	0
Cargey	15	25	8	1	4	4	0	0	0	0	0	0
Carspp	0	0	0	0	0	0	0	0	1	0	0	0
Cerfon	0	0	0	0	0	0	0	1	0	0	0	t
Cirarv	0	0	0	0	0	0	0	4	4	7	35	15
CorcorS	0	0	0	0	35	0	10	20	0	0	0	0
CorcorT	0	0	0	0	0	100	20	0	0	0	0	0
Cynoff	0	0	0	0	0	0	0	1	0	0	0	0
Epilac	0	0	0	0	0	0	0	0	0	0	t	0
Erispp	1	0	0	0	0	0	0	0	0	0	0	0
Fraspp	0	0	0	0	0	0	0	3	5	5	5	0
Galsep	1	t	0	0	0	0	0	0	0	0	0	0
Galtri	0	0	0	0	0	0	0	0	t	0	0	0
Glystr	0	0	0	0	0	0	1	15	10	0	0	0
Glylep	0	0	0	0	0	0	0	0	0	4	12	0
Hersph	0	0	0	0	0	0	0	20	3	0	0	0
Hydfen	0	t	1	0	3	0	0	2	1	0	2	9
Mahrep	3	1	4	1	t	0	0	0	0	0	0	t
Maiste	0	0	0	t	0	0	0	0	0	0	0	0
Mercil	0	0	0	0	0	0	1	0	0	0	0	0
Monfis	0	0	0	0	0	0	0	6	6	2	10	10
Osmdep	0	10	t	4	3	10	0	0	5	0	1	0
PinponT	75	10	0	0	0	0	0	0	0	0	0	0

	1	2	3	4	5	6	7	8	9	10	11	12
Poacom	0	0	0	0	0	0	0	1	5	10	8	8
Poapra	0	0	0	0	0	0	0	3	7	0	4	5
PruvirS	0	0	0	0	0	0	0	0	0	0	0	12
PsemenS	20	0	0	0	0	0	0	0	0	0	0	0
PsemenT	0	50	75	65	10	0	0	0	0	0	0	70
Psejam	t	0	0	0	0	0	0	0	0	0	0	0
Ribine	0	0	1	t	0	0	0	8	2	0	8	2
Rubida	0	0	0	0	0	0	9	0	0	0	0	0
Rubpar	0	0	0	0	0	0	0	0	0	1	0	0
Rudamp	0	0	0	0	0	20	0	0	0	2	0	0
Taroff	t	0	0	0	0	1	1	0	1	1	0	0
Turgla	0	0	0	0	0	0	0	0	0	0	t	T
Vioryd	0	0	0	0	0	0	3	4	1	4	0	0
Viosco	t	1	0	t	0	0	0	0	0	0	0	1
Viospp	0	0	0	0	0	0	0	0	3	0	0	0

Appendix G (cont.)

Gregory Canyon 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Achmil	0	0	0	0	0	0	0	0	t	0	0	0	0	0
Anamar	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Aranud	12	7	8	0	0	0	0	0	0	0	0	0	0	0
Arncor	1	5	7	6	1	t	5	1	0	0	0	t	2	15
BetpapT	60	90	55	55	40	0	0	0	0	0	0	0	0	0
Cardew	0	0	0	0	0	0	0	1	10	9	4	0	t	0
Cargey	4	0	0	0	2	0	0	0	0	0	0	0	0	9
Carmic	0	0	0	0	0	0	3	0	2	0	0	0	0	0
Ciralp	0	0	0	0	10	20	15	2	12	15	8	5	10	5
CorcorS	30	0	2	0	15	0	0	0	0	0	0	7	5	0
CorcorT	0	0	0	40	20	75	35	5	0	0	0	40	100	100
Dodpul	0	0	0	0	0	0	3	0	0	4	2	0	0	0
Elycan	0	0	0	0	0	0	0	t	0	0	0	1	0	0
Equarv	0	0	0	0	0	2	3	2	0	1	1	3	1	0
Fraspp	0	0	t	0	0	0	0	0	0	0	0	0	0	0
Galsep	t	0	0	0	0	0	0	0	0	0	0	0	0	0
Galtri	t	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Gercae	0	0	0	0	0	0	0	0	0	8	15	1	1	0
Geumac	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0
Glystr	0	0	t	0	0	t	4	2	7	4	2	0	0	0
Hersph	10	0	0	0	0	0	5	35	0	20	26	20	4	0
Hydfen	1	3	2	5	2	7	4	0	6	2	7	8	4	0
Mahrep	t	0	0	2	3	0	0	0	0	0	0	0	3	8
Maiste	0	0	0	0	0	0	0	0	0	0	0	1	0	t
Mercil	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Monfis	t	0	2	0	0	0	0	0	t	2	1	0	0	0
Osmdep	3	3	4	5	2	3	6	0	0	0	4	3	4	2
Phlpra	0	0	0	0	0	0	0	0	3	2	4	0	0	0
PsemenT	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Pteaqu	0	15	8	0	0	45	40	1	t	3	35	65	8	0
Ribine	0	0	0	0	0	0	0	0	2	0	0	4	0	0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rubida	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Rubpub	1	0	0	0	0	0	0	0	0	2	0	0	0	1
Rudamp	0	0	0	0	0	0	1	28	30	0	0	0	0	0
SorscoS	0	0	0	0	0	0	0	0	0	0	3	0	0	0
SorscoT	35	25	40	50	70	30	0	0	0	0	0	0	0	0
Strfas	0	0	0	0	0	20	5	0	0	0	0	0	0	0
Symalb	0	2	4	0	0	0	0	0	0	0	0	0	2	0
Taroff	0	0	0	0	0	0	2	0	1	4	0	0	0	0
Vioryd	35	25	25	8	8	10	3	0	3	3	0	4	0	4