P1.1 INVESTIGATING VEGETATION CHANGES IN RELATION TO ALTITUDE AND ENVIRONMENTAL FACTORS ALONG OLIVER AND CLEAR CREEKS IN THE CLOUD PEAK WILDERNESS AREA OF THE BIGHORN MOUNTAINS

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1. INTRODUCTION

In July of 2002, a joint consortium of high school students from Knox Academy and Dunbar Grammar School in Scotland and State College Area High School in Pennsylvania conducted research in the Cloud Peak Wilderness Area in the Big Horn Mountains in Wyoming. The vegetation of the area was studied at five different sites ranging in altitude from less than 7000 feet to more than 9000 feet all within the Oliver Creek/Clear Creek watershed. Data involving vegetation profiles, soil chemistry, atmospheric factors, and benthic macroinvertebrates were collected at each of the sites. Additional data on the impact of cows on meadow vegetation was gathered at three sites within the Big Horn Mountains.

2. STUDY METHODS

Vegetation: For each altitude study site, a N-S transect was constructed across a riparian area or across one moraine crest. The transect consisted of five 1 meter square quadrats on each side, spaced out from the riverbank at 10 meter intervals and marked with flags. A random sample of the vegetation inside each quadrat was taken using the point-intercept method (Fig. 1) to determine the percent of types of ground cover by recording the knitting needle contacts on a meter-squared frame (Elziga (1998)). Vegetative species were identified using guides by Jensen (1987), Girard (1997), and Craighead (1991). Also at each quadrat, readings were taken of percent cover, slope angle, the girths of the 5 nearest trees, and, for each site as a whole, stand characteristics. Site characteristics often limited the exact implementation of this method, so modifications were made on-site. For sites involving cow impact, two sites were randomly selected within the chosen meadow and the same attributes were measured at each quadrat.

Soil: At each quadrat, a Kelway soil meter was used to determine soil pH and an IR thermometer was used to determine soil temperature. A soil sample was taken from each quadrat; all the obtained samples are currently being analyzed at the Pennsylvania State University Department of Agriculture Laboratory for macro and micronutrients as well as conductivity.

Macroinvertebrates: At each riparian environment, the water quality was determined by examining the benthic macroinvertebrate population (Fig. 2). A random sampling of the rocks was taken in the streams and the observed organisms were recorded so that a PTI could be calculated. Each selected rock's diameter was then measured to determine the general substrate size of the environment.

Figure 1. Establishing a quadrat for the vegetation study.

Figure 2. Identifying benthic macroinvertebrates.

3. VEGETATION RESULTS

The total list of species observed and the altitude sites in which they were counted are presented in Table 1, giving an indication of the species progression from lower to higher altitude and from farther from the stream source to closer. Graphs of the type of coverage measured at each altitude site are presented in Figures 3 – 6, so that the dominators of ground cover are clear.

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TABLE 1. Type and Location of Vegetation
Presence of plant denoted by X.

Plant	Mosier Gulch	Middle Fork	Central	W. L. Outflow	W. L. Moraine
Taraxacum officinale	X	X	X	X	X
Antennaria microphylla	X	X	X		
Antennaria alpina				X	X
Dodecatheon conjugens	X	X	X		
Smilacina racemosa	X	X	X		
Stipa sp.	X	X	X		
Juniperus communis	X	X		X	X
Vaccinium globulosa	X	X			
Rosa woodsii	X	X			
Trifolium hybridum	X	X			
Aquilegia caerulea	X		X		
Holodiscus discolor	X				
Bryophyta 1	X				
Ribes viscosissimum	X				
Agropyron spicatum	X				
Pinus ponderosa	X				
Populus balsamifera	X				
Epilobium angustifolium		X	X	X	X
Vaccinium scoparium		X	X	X	X
Arnica cordifolia		X	X		X
Achillea millefolium		X		X	X
Salix sp.		X	X	X	
Fragaria virginiana		X	X		
Thalictrum venulosum		X	X		
Viola adunca		X			
Viola vallicola			X		
Ribes montigenum		X	X		
Calamagrostis canadensis		X	X		
Carex sp.		X	X		
Equisetum arvense		X	X		
Climacium dendroides		X	X		
Astragulus americanus		X			
Linnaea borealis		X			
Polemonium pulcherrimum		X			
Galium boreale		X			
Populus tremuloides		X			
Potentilla gracilis			X		
Potentilla fruticosa			X		
Potentilla concinna				X	X
Pedicularis groenlandica			X	X	
Abies lasiocarpa			X	X	
Allium schoenoprasm			X		
Mertensia ciliata			X		
Sedum rhodanthum			X		
Habenaria obtusata			X		
Picea englemanii			X		
Juncus sp.				X	X
Bryophyta 2				X	X
Senecio fremontii				X	X
Polytrichum juniperinum				X	X
Cirsium sp.				X	
Solidago spathulata				X	
Penstemon procerus				X	
Erigeron compositus					X
Frasera speciosa					X
Lupinus argenteus					X
Arenaria nuttallii					X
Bryum sp.					X
Sedum lanceolatum					X

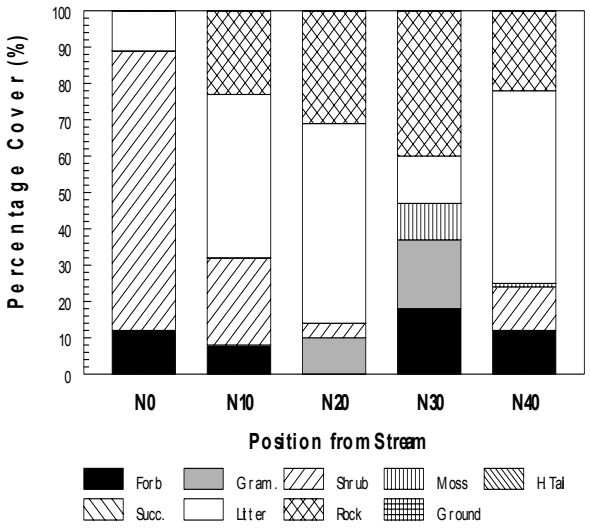

Figure 3. Quadrat Percent Coverages at Mosier Gulch Site. These quadrats, spaced 10 m apart, are located on the north side of Clear Creek. N0 denotes the quadrat location immediately adjacent to stream.

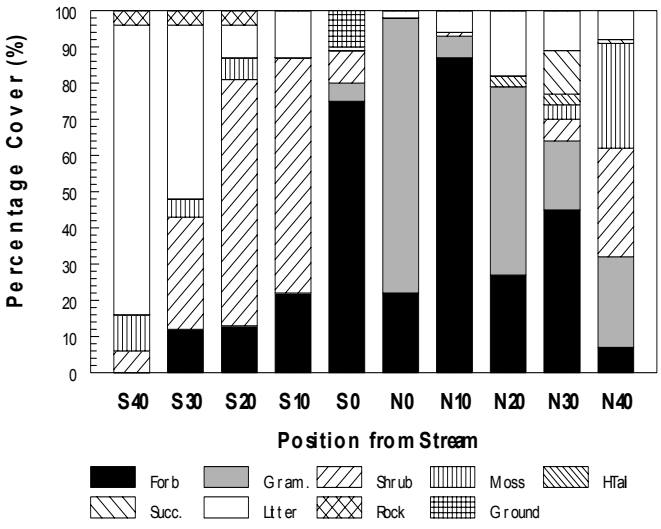

Figure 5. Quadrat Percent Coverages at Central Site. These quadrats, spaced 10 m apart, are located on the south and north sides of Oliver Creek. S0 and N0 denote the quadrats immediately adjacent to stream on the south and north sides, respectively.

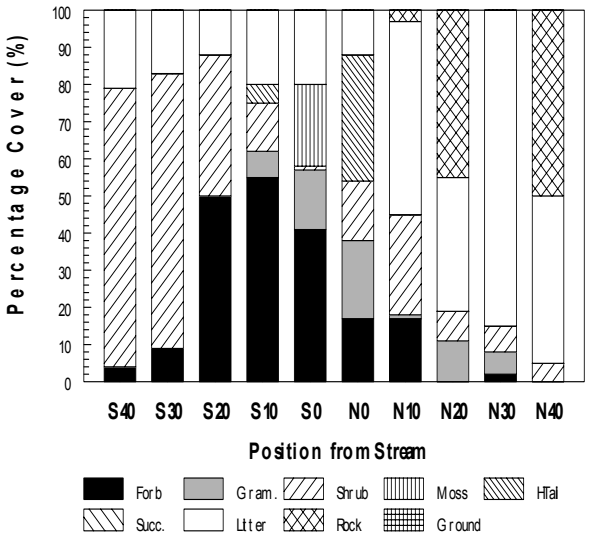

Figure 4. Quadrat Percent Coverages at Middle Fork Site. These quadrats, spaced 10 m apart, are located on the south and north sides of Clear Creek. S0 and N0 denote the quadrats immediately adjacent to stream on the south and north sides, respectively.

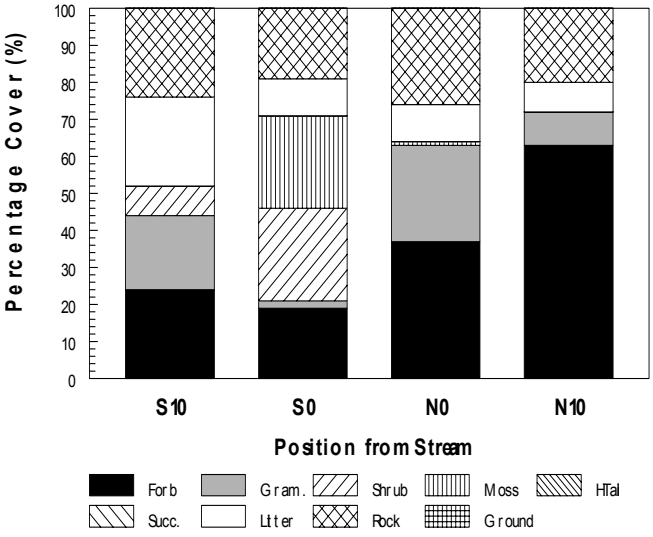

Figure 6. Quadrat Percent Coverages at Willow Lake Outflow Site. These quadrats, spaced 10 m apart, are located on the south and north sides of Oliver Creek. S0 and N0 denote quadrats immediately adjacent to the outflow on the south and north sides, respectively.

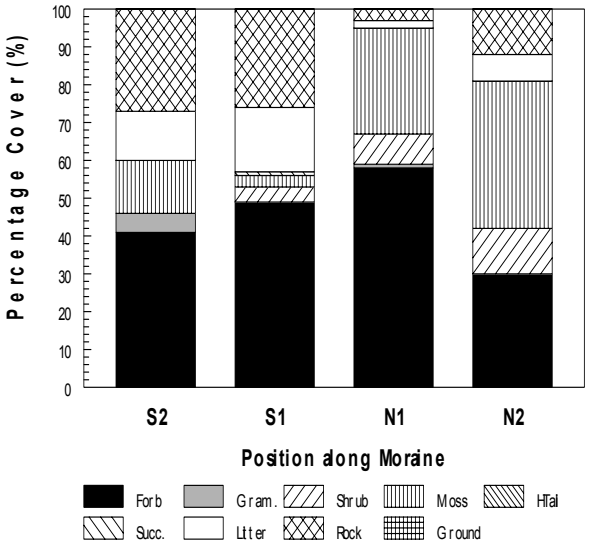

Figure 7. Quadrat Percent Coverages at Willow Lake Moraine. These quadrats, spaced 5 m apart, are located on the south side of Oliver Creek. S1 and S2 denote quadrat locations 5 m and 10m south of the moraine's crest, and N1 and N2 denote quadrats 5 m and 10 m north of the moraine's crest.

The auxiliary data gathered at each site led to assessments of site characteristics that allowed for a better understanding of each altitude site.

Mosier Gulch: This site was located at 44.33° N and 106.81° W and at an elevation of about 6900 ft. Only the north side was studied because the south side was inaccessible. The stand was mainly comprised of *Populus balsamifera (*Balsam Poplar), *Populus deltoides* (Plains Cottonwood), *Acer glabrum Torr* (Rocky Mountain Maple), and *Pinus ponderosa* (Ponderosa Pine) species; the overhead cover was, on average, approximately 50% over the entire area. The slope across the riparian area was less than 10°. This community was more arid than the other sites studied and can be considered a sagebrush community.

Middle Fork: This study site was located at the coordinates 44.30° N and 106.97° W and at an elevation of close to 7600 ft. It was located within a uniform stand of mainly *Pinus contorta* (Lodgepole Pine) and *Picea engelmannii* (Engelmann Spruce) with some *Populus tremuloides* (Quaking Aspen) present. The overhead cover was about 50% and the slope was less than 5° throughout the stand. The community was a floodplain below rocky slopes and was extremely moist and richly vegetated.

Central: The Central study site was located at a latitude of 44.27° N, a longitude of 107.02° W, and an elevation of 8800 ft. The stand was composed of mainly Engelmann Spruce, Lodgepole Pine, and *Abies lasiocarpa (*Sub-Alpine Fir). Overhead cover was less than 25% and the slope was 0° on the north side and around 20° on the south side. The site was extremely moist and had high levels of litter on the south side.

Willow Lake Outflow: This site was located at the outflow point of Willow Lake at coordinates 44.28° N and 107.05° W and at an elevation of 9300 ft. The north side had almost 0% overhead cover, while the south side had around 50% overhead cover. The slope angle was around 10° on average and the stand was composed entirely of Sub-Alpine Fir. The site can be described as consisting of open rocky banks amidst boulder fields.

Willow Lake Moraine: This site was the only one of the altitude series not located in a riparian area, but up on a moraine instead. This site was selected to provide information from a higher elevation and to gain a more representative sample of vegetation above 9000 ft. The latitude was 44.27° N, the longitude was 107.05° W, and the elevation was 9600 ft. The site was extremely open with 0% overhead cover, and the slope was highly variable, ranging from 5° to 50°. The open slope was rocky with scattered Lodgepole Pine and Sub-Alpine Fir.

4. MACROINVERTEBRATE RESULTS

The benthic macroinvertebrates of the Oliver Creek/Clear Creek system were analyzed at each of our riparian altitude sites to assess the water quality of the stream running through each site. The macroinvertebrates recorded are listed in Table 2, along with the corresponding Pollution Tolerance Index (PTI) value of each site. In the PTI, each benthic macroinvertebrate is assigned an index value corresponding to its degree of pollution tolerance and the index values for all the observed organisms are totaled to result in a PTI value for the sample site. The total PTI value is then assigned an assessment value: below 10 - poor, from 11 to 16 - fair, from 17 to 22 - good, and above 23 - excellent (Mitchell (2000)).

Rock diameters were measured at each site to ascertain the substrate characteristics of the stream at that location. Both Mosier Gulch and the Willow Lake Outflow points had average rock lengths within the boulder range (>256 mm), while both the Middle Fork and Central sites had average rock lengths within the cobble range (64-256 mm), as specified by the Udden-Wentworth scale.

TABLE 2. Benthic Macroinvertebrate Data.
The study sites are designated as follows: MG – Mosier Gulch, MF – Middle Fork, C – Central, WLO – Willow Lake Outflow

Aquatic Organism	MG	MF	C	WLO
Mayfly nymph	X	X	X	X
Stonefly nymph	X	X	X	
Caddisfly larva	X	X	X	X
Midge larva	X	X	X	X
Blackfly larva	X	X	X	
Planaria	X	X	X	X
Water Mite	X	X	X	
PTI				
Cumulative Index Value	20	20	20	12
Assessment	Good	Good	Good	Fair
Rock Size of Substrate				
Boulder	X			X
Cobble		X	X	

5. DISCUSSION

Mosier Gulch exhibited low forb percent coverage, with an average around 10%. Shrub percentages were higher closer to the stream and tapered off with increasing distance. Rock percentages were large throughout but became greater at increasing distances from the stream and litter percentages were also reasonably high; these values are results of the harsh, semi-arid climate and the high degree of overhead cover which limits understory growth. The species richness of Mosier Gulch was 16 species, the lowest of any of the studied sites.

The Middle Fork site followed the expected trend of decreasing forb cover with greater distance from stream, due to drier soils. On the south side, as forb cover decreased, the shrub cover increased, while on the north side, litter and rock became more prominent as forb cover diminished. The prevalence of litter and rock on the north side was likely due to the reasonably steep slope at farther distances from the stream and the greater degree of shading from a rock face. The species richness here was 27 species, the highest value observed.

At the Central site, the forb ground cover percentages decreased with increasing distance from the stream again as expected. Shrub cover and litter dominated the south side at farther distances from the creek; as shrub percentages decreased, litter percentages increased. There was a high degree of graminoid cover on the north side and low percentages of litter. The low slope angle on the north side allows for moister soils farther from the river and for greater growth of graminoids; the greater slope on the south side makes vegetative growth more difficult due to erosional forces and does not allow for moist floodplain soils, resulting in higher shrub and litter percentages. The species richness here was 27 species, tied with Middle Fork for the highest observed.

Both the Willow Lake Outflow and the Willow Lake Moraine sites had relatively constant distributions of ground cover; this constancy likely resulted from the homogeny of the quadrats within a site as they were spaced relatively close together. Both sites exhibited high forb cover (close to 50% on average) and devoted large percentages of ground cover to boulders in the soil. Many graminoids were observed at the Willow Lake Outflow, likely due to the moist soil, and the Willow Lake moraine had high moss coverage. The outflow had a species richness of 17 while the moraine had richness of 18, both relatively low values.

The greatest species richness was observed at the Middle Fork and Central sites; this is likely due to the transitional nature of the sites so that they can support species from both higher and lower altitudes. *Taraxacum officinale* (Common Dandelion) was found at all altitudes; a species of *Antennaria* (Pussytoes) was found at all altitudes as well, with the rose variety (species *microphylla*) at lower altitudes and the alpine variety (species *alpina*) at higher elevations. *Epilobium angustifolium* (Fireweed) and *Vaccinium scoparium* (Low Huckleberry) were both found at each of the upper four sites.

The forb percentages were extremely low at Mosier Gulch, with an average of 10% forb cover, especially in comparison to the Willow Lake Moraine, where the average approached 50%. This was likely due to the semi-arid, harsher conditions observed at Mosier Gulch. Forb percentages were highly variable at the Middle Fork and Central sites and higher and constant at the Willow Lake Outflow.

As indicated by Table 1, there is a clear progression of species from the 6900 ft. Mosier Gulch site to the 9600 ft. Willow Lake Moraine site. The species observed at the Moraine are almost completely distinct from the species at Mosier Gulch, with the exception of three plant types. Many species are restricted to one site, such as *Frasera speciosa* (Green Gentian) on the Moraine or *Holodiscus discolor* (Ocean Spray) at Mosier Gulch. While some of the distinctions between sites may be tied into site-specific variables, the progression of species is certainly in part tied into altitude changes.

The macroinvertebrate results indicate that the Oliver Creek/Clear Creek system is of good to fair quality throughout the studied area and, thus, that the degree of water quality is not influencing the vegetation distribution. Sampling restrictions may have limited the diversity of organisms sampled, but the presence of highly pollution-intolerant organisms at each sample site indicates definitively the high quality of the water system. The substrate size was determined to be within the boulder range in the Willow Lake and Mosier Gulch sites and in the cobble range in the Central and Middle Fork sites; this information further characterizes the waterway of the riparian area.

Soil results are not available at this time as they are still being analyzed in the Agriculture lab, but the results will be incorporated into the analysis and discussion for the poster presentation. Additionally, a side

investigation on the impact of cow-grazing on meadow vegetation was conducted, but has not been included at this time.

6. REFERENCES

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