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**Vegatational and Water Quality Differences**
**in**
**Constructed versus Natural Wetlands**

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### *ABSTRACT*

Vegetational and water quality differences were observed in constructed (Dry Creek) and natural (Sombrero Marsh) wetland sites in Boulder, Colorado. Data were collected on vegetational and inundation composition as well as on water quality at both sites during the month of December 1995. Results indicate that there was a significant difference in vegetational composition between constructed and nonconstructed wetlands. Dominance of a species of cattails (*Typha*) was evident at the constructed wetland; whereas, the vegetational composition at the natural site was more diverse but was dominated by reeds (*Phragmites*). Water quality tests between each site showed little variance, yet a slight increase in the dissolved oxygen content at the natural wetland may be a relative factor in the increase of species' composition at this site. Previous studies have indicated that a relationship may exist involving pollution uptake by particular macrophytic species and their usefulness in water quality management in constructed watersheds. This study has examined the differences exhibited between constructed and natural wetlands with regard to vegetational and water chemistry composition.

## INTRODUCTION

Section 404 of the Clean Water Act defines wetlands as 'those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions' (Kent 1994). This vegetation that is "typically adapted for life in saturated soil conditions," is identified in the Clean Water Act because it functions as a key water quality regulator.

Wetlands, and the plants that exist there, are an important stage of the hydrologic cycle in both natural and developed watersheds. Wetlands interaction with biological, physical and chemical factors of this cycle make wetlands an important part of system health. Wetlands provide biologically important habitat for many animals, and are physically important in flood attenuation, groundwater recharge and sediment entrapment. The chemical functions of wetlands are nutrient removal and toxic decontamination (Kent, 1994). Because wetlands serve so many beneficial functions, many studies have been done on natural wetlands in order to provide information for wetland maintenance and construction.

In developed watersheds where anthropogenic introduction of organic nutrients and toxic substances into the hydrologic system is high, wetlands are a crucial biological regulator of water quality. Recently it has been recognized that the construction of an artificial wetland can be a helpful form of water treatment in areas of water quality concern. Our study is designed to contribute information on the differences between a natural and a constructed wetland.

Defining the characteristics and processes present in a wetlands habitat will help show how and why wetlands are such a beneficial part of the hydrologic cycle. The three parameters that identify wetlands are: the presence of wetlands hydrology (surficial or groundwater), a prevalence of wetlands vegetation (hydrophytes) which have specialized morphological and physiological adaptations to tolerate saturated or inundated conditions, and wetland or "hydric soils" (Kent 1994). Wetlands can accumulate organic matter and other pollutants through high primary productivity, by decreased decomposition under anaerobic conditions or by lack of export (Larson et al, 1989). High primary productivity absorbs and modifies nutrients and other pollutants by incorporating them into plant biomass. This absorption differs among plant species and is a function of plant density and diversity. Wetland soils that are saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions, leaving oxygen unavailable to plants are called "hydric soils" (Kent, 1994). Wetland plant have adapted to these hydric soils with extensive lacunae or aerenchyma which are air spaces that allow diffusion of atmospheric gases from the aerial portions of the plant into the roots. This is important because the oxygen transported to the roots of wetlands plants can leak out and oxidize potentially hazardous substances and modify nutrients in the surrounding substrate (Hammer, 1992). Lack of export simply involves the settling of pollutants out of the water and is mostly a function of velocity.

The purpose of our study is to examine how these characteristics and processes differ between a constructed and a natural wetland. We will use plant community structure and water chemistry to highlight the differences in natural and constructed wetlands. Macrophytes are used in ecological surveys of water quality due to their ability to accumulate chemicals, and to the fact that they comprise the largest biomass in wetlands and are immobile (Lewis 1994). Another study showed that measurement of plant species diversity may indicate the quality of a wetlands habitat (Kent 1994). We will use the physical and chemical parameters of water that affect the survival and growth of wetland plant species including; water clarity, pH, dissolved nutrients and oxygen, salinity, flow, and velocity.

Identification of the above biological, chemical and physical parameters will help this study address questions regarding species diversity and water quality in natural and constructed wetlands. More specifically, is there a relationship between vegetative species diversity and density and pollution absorption in natural versus constructed wetlands? If there is a difference in water quality between the two sites is there a corresponding vegetative difference? If there is no difference in water quality, is there more abundance of pollution absorbing vegetation in the constructed wetland as opposed to the natural wetland? Furthermore, can certain indicator species be identified to characterize pollution absorption ability? We have operated under the null hypothesis that there will be no significant difference in vegetation diversity/abundance or water chemistry between constructed and natural wetland sites.

## METHODS

**Study sites:**

The constructed wetland site chosen for this study was the Dry Creek inlet wetland, which was constructed some years ago just above Boulder Reservoir. The Dry Creek wetland receives nutrient loading from an upstream urban development that has its own private sewage treatment, and receives waters from Lefthand Creek which is infamous for high loads of heavy metals and other related pollutants caused by past mining activity. In order to protect water quality in Boulder Reservoir, which is part of Boulder's drinking supply, it was recognized that this would be a good area to construct a wetland.

The nonconstructed or natural wetland chosen for this study was the Sombrero Marsh which is located adjacent to a housing development, south of Arapahoe on 63rd street in Boulder. This is our "natural" wetland because this wetland has been in existence since before European settlement of Colorado.

**Field Techniques:**

Data were collected based on two distinct categories including; vegetative density and diversity (biological features), and chemical water testing (physical/chemical features). Vegetation data were collected by running transects perpendicular to the floodplain direction, extending to the edge of the floodplain on either side. At every two meters along the transects drawn out by a tape measure, a plot of 2m by 2m was analyzed. This analysis was assessed by observing vegetation and inundation which was then scored in percentage of abundance. Vegetation identified and measured consisted of; shrubs, grasses, sedges, cattails, reeds, inundated. Percent inundation was included as the percentage of water in comparison to all other ground cover vegetation in the plot.

Physical/chemical parameters were also measured by sampling and testing water in each transect. These parameters included: pH, dissolved oxygen, nitrates and phosphates. To perform these water quality tests, a mediocre chemical testing kit was utilized with specific chemicals and directions contained within this kit for each test.

**Statistical Analyses:**

The first objective in analyzing this data was to compile all raw percentages of vegetative composition from the two transects at each site and calculating the average. The average for each site was then graphed on bar graphs for both the constructed and nonconstructed sites in order to exhibit species composition and diversity in these wetlands. This data was also utilized in calculating a percent similarity between the two sites. A chi-square value was also calculated in order to determine whether or not a significant difference occurred in vegetation and inundation between the constructed and nonconstructed wetlands. A diversity index was also calculated for each site. Water chemistry data were compiled and arranged in a data table, but no statistical analyses were made due to the simplicity of the data.

## RESULTS

The results of this study indicate that there are differences in both vegetation and water chemistry between the constructed and nonconstructed sites. Chart 1 describes the percent composition of vegetation at the Dry Creek wetland. Results show that this site was composed of; 16% grasses, 15% sedges, 47% cattails (*Typha*), 23% inundation, and 0% shrubs and reeds (*Phragmites*). Chart 2 shows the percent vegetative composition at Sombrero Marsh wetland. Results indicated that this site is composed of; 4% shrubs, 8% grasses, 6% sedges, 7% cattails, 26% reeds, and 49% inundation. Table 1 describes the percent similarity between the two sites to be 44%. Table 2 shows the calculated chi-square results of percent composition to be 65.27, which greatly exceeds the p-value at 11.1 indicating that there is less than a 5% chance that the samples were taken from the same population and are significantly different. Table 3 is the results of the diversity index comparison, H= .55 for the constructed wetland and H= .60 for the natural wetland. Table 4 describes the results of chemical water quality tests for each site. Dissolved oxygen was 9.0 ppm at the constructed area and 9.7 ppm at the natural. pH was 8 at the constructed and 9 at the natural wetland.

## DISCUSSION

The results of our study indicate that although there is only a small difference in water chemistry between the constructed and nonconstructed wetland sites, there is a significant difference in vegetational composition. More specifically, there is higher vegetational diversity and richness in the natural wetland while the constructed wetland is composed of fewer macrophytic species with the dominance by a single species common in both areas.

The first notable trend in the data pertains to species richness and diversity. Differences in species richness are small, the constructed area has three major macrophyte species and the natural area has five. The diversity index also shows a small difference in diversity, the natural wetland was slightly more diverse. Studies comparing plant communities in disturbed and undisturbed wetland sites have found that taxa richness differed little between sites, however, the types of species present differed relatively (Hammer 1992). This is represented in the results of our study by the change in a the dominating species, cattails (*Typha*) in the constructed wetland and reeds (*Phragmites*) in the natural wetland, without high differences in diversity and richness.

The next notable difference between the two sites are differing dominating plant species at each site. The natural wetland is dominated by reeds (*Phragmites*) and there is an abundance of cattails (*Typha*) in the constructed wetland. Past studies have found that the effects of organic pollution may result in a decrease in overall species richness, and an increase in any species favored by pollution (Haslam,1987). Furthermore, it has been found that cattails tolerate a wide range of water chemistries including waters with very poor quality, and are commonly used in North America in wetland management (Hammer1992). Another study showed that a typical response to wastewater discharge (increased nitrogen and phosphorus) yielded a species shift to cattail (*Typha latifola*) (Kadlec,1989). These studies help explain the abundance of cattails in the constructed wetland we studied.

Due to the overuse and undercare of the water quality testing equipment we had access to, the chemistry results we obtained are somewhat suspect. The tests for nitrogen and phosphorous concentrations yielded a largely useless data set. Fortunately there are some important differences in the water quality chemistry data we collected that can be discussed. Both wetlands contained slightly basic water, the constructed area had pH of 8 and the natural area a pH of 9. Dissolved oxygen concentration in wetland water can represent the relative productivity of that wetland. Wetland plants produce large amounts of oxygen through their biomass production process. This increases the dissolved oxygen content of the water and also of the soil, which increases the capacity for supporting a wider range of oxygen using emergents (Hammer 1992). This corresponds to the result obtained in our study. The DO was higher in the natural wetland where richness was also higher. Diversity and DO were both lower in the constructed wetland.

## CONCLUSION

The results of our study show that there is a significant difference in species richness, species diversity, percent inundation and chemistry between the two sites we examined. The constructed wetland has lower species richness and diversity, lower pH, and lower inundation and lower dissolved oxygen. The constructed wetlands is dominated by cattails, an indicator species of poor water quality. The natural wetland had higher species richness and diversity, higher pH, and higher inundation and higher DO. This wetland area was dominated by reeds. Research indicates that these are typical differences found when comparing constructed and natural wetlands.

| Percent Similarity | | | | |
|---|---|---|---|---|
| | % at Dry Creek | % at Sombero | Minimun % | |
| Shrub | 0 | 0.04 | 0 | |
| Grass | 0.16 | 0.08 | 0.08 | |
| Sedge | 0.15 | 0.06 | 0.06 | |
| Catail | 0.47 | 0.07 | 0.07 | |
| Reed | 0 | 0.26 | 0 | |
| Inundation | 0.23 | 0.49 | 0.23 | |
| | | | % Similar= | 44% |

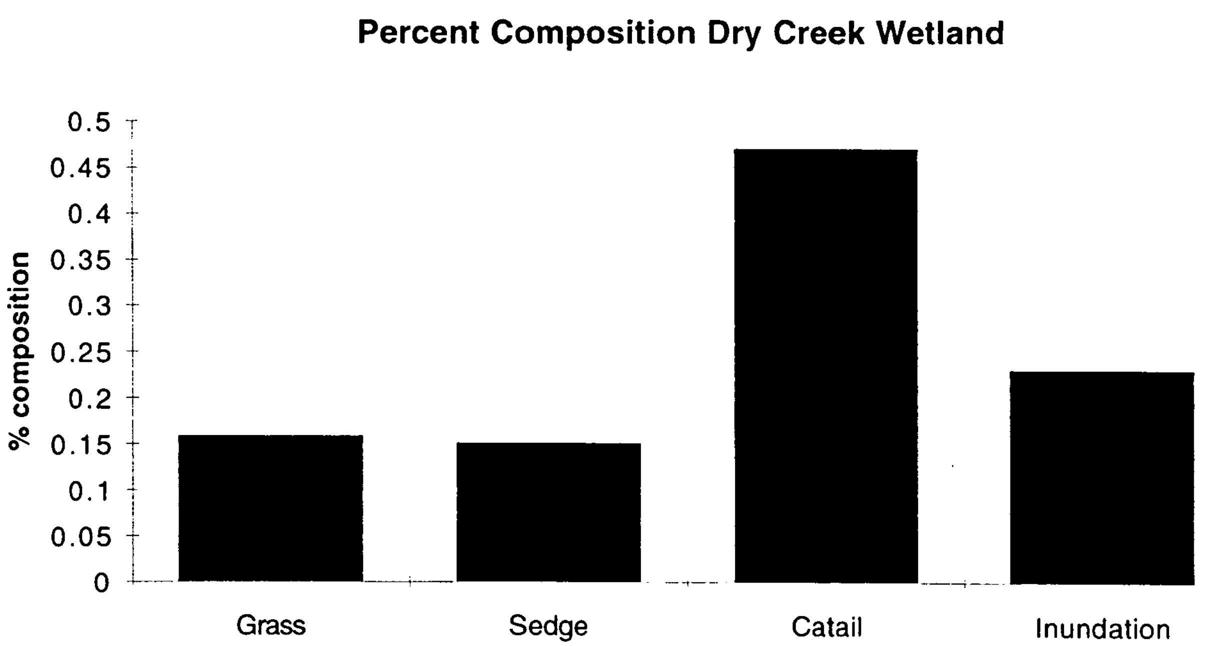
Chisquare Wetlands

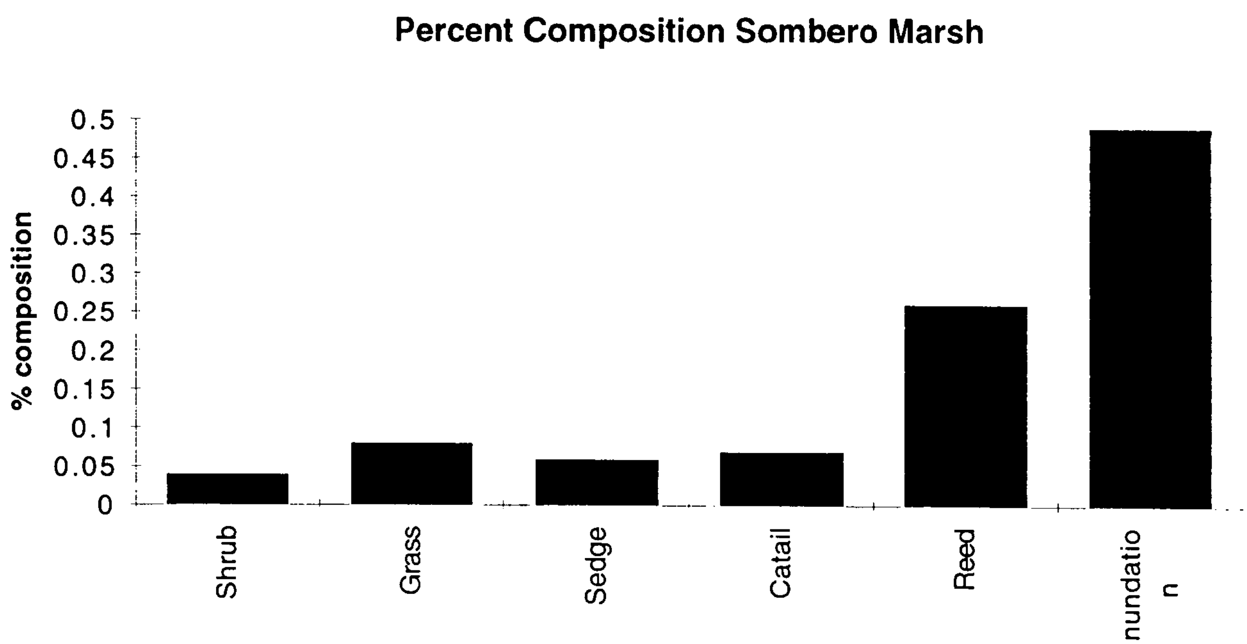
| Chisquare | | | | | |
|---|---|---|---|---|---|
| Plant Type | Dry Creek | Sombrero | Row Totals | E(Dry Creek) | E(Sombrero) |
| Shrub | 0 | 3 | 3 | 2 | 1 |
| Grass | 14 | 6 | 20 | 11 | 9 |
| Sedge | 13 | 5 | 18 | 10 | 8 |
| Catail | 41 | 5 | 46 | 25 | 21 |
| Reed | 0 | 20 | 20 | 11 | 9 |
| Inundation | 20 | 37 | 57 | 31 | 26 |
| | | | | | |
| Colomn Totals | 88 | 76 | 164 | | |
| | | | | X2 (Dry Creek) | X2 (Sombrero) |
| | | | | 2 | 4 |
| | | | | 0.82 | 1 |
| | | | | 0.9 | 1.13 |
| | | | | 10.24 | 12.19 |
| | | | | 11 | 13.44 |
| | Degrees of Freedom = 5 | | | 3.9 | 4.65 |
| | P < 0.05 at X2 = 11.1 | | | Chisquare = | 65.27 |

| Diversity Index | | | |
|---|---|---|---|
| p(Dry Creek) | p(Sombrero) | p(D)[log p(D)] | p(S)[log p(S)] |
| 0 | 0.04 | 0 | -0.0559176 |
| 0.16 | 0.08 | -0.1273408 | -0.0877528 |
| 0.15 | 0.06 | -0.12358631 | -0.07331092 |
| 0.47 | 0.07 | -0.15411401 | -0.08084314 |
| 0 | 0.26 | 0 | -0.15210693 |
| 0.23 | 0.49 | -0.1468026 | -0.15180392 |
| | H= | 0.55184372 | 0.60173531 |

Chemistry Wetlands

| Water Quality Chemistry | | | | |
|---|---|---|---|---|
| Test | Dry Creek 1 | Dry Creek 2 | Sombrero 1 | Sombero 2 |
| pH | 8 | 8 | 9 | 9 |
| DO | 9.2 | 8.8 | 10 | 9.4 |
| N | 0 | 0 | 0 | 0 |
| P | 0.8 | 0 | 0 | 0 |


Percent Composition Dry Creek Wetland
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
% composition
Grass
Sedge
Catail
Inundation


Percent Composition Sombero Marsh
% composition
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Shrub
Grass
Sedge
Catail
Reed
Inundation

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