Technical Memorandum

Brindle Creek

40 England Woods Drive
Weaverville, NC 28787
(970) 232-4058

Prepared for: City of Casper

Project Title: North Platte River Riparian Soils and Vegetation Research Project

Technical Memorandum No. 1

Subject: Preliminary Research Results

Date: December 19, 2022

To: Jolene Martinez

From: Randy Walsh, Brindle Creek LLC; Rachel Ridenour, Ridenour Research Ltd.; and Paul Swartzinski, Bluestem Consulting LLC

Executive Summary

This Technical Memorandum 1 (Tech Memo 1) describes the preliminary results of vegetation sampling and analytical soils testing in riparian areas associated with the City of Casper's North Platte River Restoration Projects.

Section 1: Introduction

1.1 Scope of Work

Brindle Creek, Ridenour Research, and Bluestem Consulting (*hereafter:* Ecology Team) were contracted by the City of Casper (City) to quantitatively assess the riparian vegetation and soils associated with four(4) Study Areas. The Study Areas identified for work included three (3) previously constructed river restoration project reaches: the contiguous river reaches at *Morad Park* (~2500 LF; constructed in 2016), *Wyoming Boulevard and Water Treatment Plant* (~5000 LF total; constructed in 2017), and the downtown reach centered at *1st Street* (~3000 LF; constructed in 2020). A fourth Study Area – *North Platte Park* – has been identified as a potential restoration reach but was used as a reference site for soils and vegetation for this research study. Existing conditions data for vegetation and soils were collected through field sampling efforts in the four Study Areas in October 2022.

1.2 Research Objectives

Healthy and robust riparian zones protect riverbanks from erosion, provide floodplain stability, create shading and thermal refugia, enhance riverine aesthetics, and create diverse habitat for a host of lifeforms, among other benefits. Healthy native vegetation is thus a fundamental element of river restoration success. As such, the City broadly seeks to:

1. Determine if revegetation efforts at previously constructed river restoration sites have been suboptimal (based on previous qualitative observations), and if so, identify potential causes.
2. Determine methods, tools, and techniques that can be employed to enhance the establishment and survivability of planted native vegetation such that the sites will, over time, develop floristic communities with adaptive capacity and structural complexity.

The purpose of Tech Memo 1 is to partially address the first objective, above, by providing preliminary information and data analyses stemming from the vegetation and soils sampling efforts. The primary aim of the field surveys was to inventory the current vegetative communities and soils, and in doing so, identify locations within the Study Areas where revegetation efforts are meeting successes criteria and locations where they are deficient. Quantifying and analyzing the corresponding soils and vegetation communities at these sites will better inform management approaches that might be used to improve revegetation success at both current and future river restoration project locations on the North Platte River in Natrona County. A Final Report, currently in development by the Ecology Team, will more fully-address the research objectives.

1.3 Methods

Field surveys included vegetative cover sampling, woody plant density measurements, riparian corridor width measurements, site photographs, and composited soil sampling. Soil sampling methods are discussed in more detail in Section 2.2.2. Soils samples were analyzed for soil and microbiome health metrics (Soil Health Assessment, PLFA testing) by Ward Laboratories in Kearney, Nebraska.

Study Areas were stratified into Sample Units by bank (left bank and right bank) and sampled independently (Table 1). The Study Areas were restored at various times and with various methods and are subject to differing levels of recreational use depending on geographic location and bank position (river-left and river-right). Due to the extensive recent reconstruction of the 1St Street Study Area, the prior urban impacts to this reach, and the lack (to-date) of woody plantings, the 1St Street Study Area was further stratified by planform position (upstream and downstream). The right bank of North Platte Park was sampled as a reference area for both vegetation and soils and was employed in this research as a "non-restored" site for comparison. The left bank of North Platte Park was not sampled for vegetation due to access limitations.

Table 1 Study Areas and Corresponding Sample Units

Study Area	Sample Location[1]	Sample Unit Code
Morad Park	Left Bank	MOR-LB
	Right Bank	MOR-RB
WY Blvd/WTP	Left Bank	WYB-LB
	Right Bank	WYB-RB
1st Street	Left Bank - Upper	FST-LBU
	Left Bank – Lower	FST-LBL
	Right Bank – Upper	FST-RBU
	Right Bank – Lower	FST-RBL
North Platte Park (Reference Area)	~~Left Bank~~ [2]	~~NPP-LB~~
	Right Bank	NPP-RB

[1] The 1st Street Study Area is further stratified into "upper" and "lower" reaches. The 1st Street bridge is the dividing line between upper and lower Sample Units.

[2] The North Platte Left Bank Sample Unit was only sampled for soils.

Section 2: Preliminary Results

2.1 Vegetation

2.1.1 Overview

Most reaches exhibited a mosaic of vegetative communities characterized by a diverse species assemblage. Figure 1, below, depicts the contributions to total vegetative cover (%) by eight cover types in the understory stratum (depicted on the y-axis as 0-100 Percent Average Cover) and one cover type (trees and shrubs >1.5m) in the overstory stratum (depicted on the y-axis as >100 Percent Average Cover). Vegetation cover was determined by point-line intercept. Vibrant willow stands and multilayer cottonwood galleries exist in several Study Areas. However, most Sample Units also contain areas characterized by poor vegetation performance and/or areas of bare ground. These poorly vegetated areas are likely due to one or a combination of causes that may include low quality planting stock or seed, physical barriers to establishment and growth (*e.g.,* multi-layer coir fiber matting), species selection, competition, herbivory and seed predation, water/hydrology issues, and other potential microsite and microbiome issues, among others.

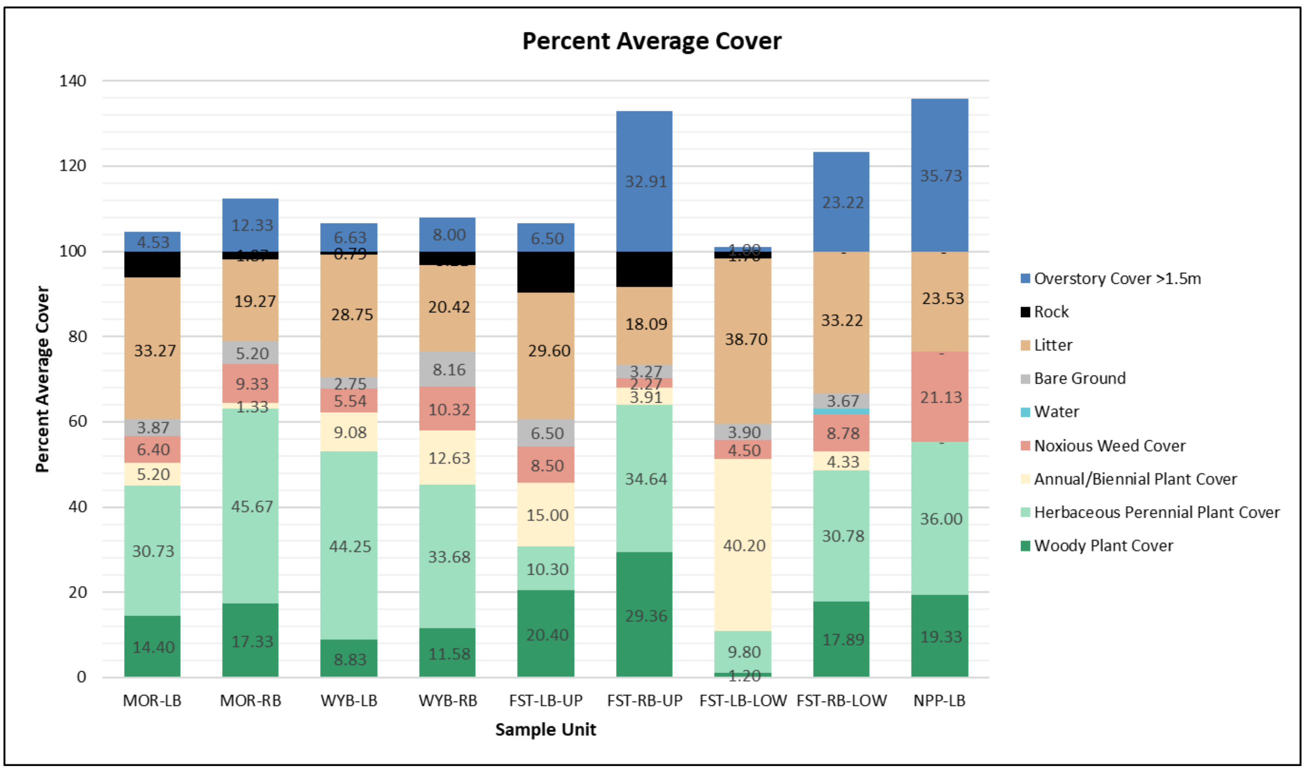

Figure 1 Understory and Overstory Cover (%) by Cover Type Across all Sample Units

Overall, there has been significant success in reestablishing native riparian plant communities within each of the Study Areas, but there are also numerous locations where the density and cover of native plant species is below expectations. While trends cannot be inferred from these initial baseline data, we suspect that all but one Sample Unit are on a positive successional trajectory. Regardless, active management strategies could be employed to accelerate successional development and correct factors that are inhibiting robust vegetative performance. While growth and development are generally good, there is considerable opportunity for improving plant establishment and growth, accelerating vegetative community development, reducing the extent and density of noxious and invasive plant species, reducing areas devoid of vegetation, and increasing woody and/or herbaceous plant cover where appropriate.

2.1.2 Noxious/Invasive Plant Species

Noxious and invasive plant species documented within the Study Areas are typical for mesic and riparian ecosystems in the Western U.S. (Table 2). It is evident that extermination and control measures for noxious species are being implemented in most sample units. The results of recent herbicide spraying, mowing, and Russian olive removal were observed during field surveys. Noxious weed cover ranged from 2-20% across sites. Noxious weeds were encountered on 50-100% of the transects sampled and varied by Sample Unit. The total number of vegetative species detected during in each Sample Unit, organized their nativity status, is presented in Figure 2.

Table 2 Noxious and Invasive Plant Species Documented in Study Areas

Lifeform	Duration	Weed Class	Common Name(s)	Scientific Name	Species Code
Grass/grasslike	A	County	Field Brome	*Bromus arvensis*	BRAR5
Grass/grasslike	A	County	Downy Brome (Cheatgrass)	*Bromus tectorum*	BRTE
Grass/grasslike	P	State	Quackgrass (Common Couch)	*Elymus repens*	ELRE4
Forb	P	State	Russian Knapweed (Hardheads)	*Acroptilon repens*	ACRE3
Forb	A	State	Musk Thistle (Nodding Plumeless Thistle)	*Carduus nutans*	CANU4
Forb	P	State	Spotted Knapweed	*Centaurea stoebe*	CEST8
Forb	P	State	Canada Thistle (Creeping Thistle)	*Cirsium arvense*	CIAR4
Forb	A	State	Bull Thistle	*Cirsium vulgare*	CIVU
Forb	A	State	Poison Hemlock	*Conium maculatum*	COMA2
Forb	P	State	Field Bindweed	*Convolvulus arvensis*	COAR4
Forb	A	State	Houndstongue	*Cynoglossum officinale*	CYOF
Forb	A	State	Redstem Filaree (Redstem Stork's Bill)	*Erodium cicutarium*	ERCI6
Forb	P	State	Perennial Pepperweed (Broadleaved Pepperweed)	*Lepidium latifolium*	LELA2
Forb	P	State	Dalmatian Toadflax	*Linaria dalmatica*	LIDA
Forb	A	State	Scotch Thistle	*Onopordum acanthium*	ONAC
Forb	P	County	Curly Dock	*Rumex crispus*	RUCR
Forb	A	County	Yellow Salsify (Goat's Beard)	*Tragopogon dubius*	TRDU
Forb	A	County	Puncture Vine (Goat's Heads)	*Tribulus terrestris*	TRTE
Woody plant	P	State	Russian Olive	*Elaeagnus angustifolia*	ELAN
Woody plant	P	State	Tamarisk (Saltcedar)	*Tamarix ramosissima*	TARA
P - Perennial, A - Annual or Biennial					

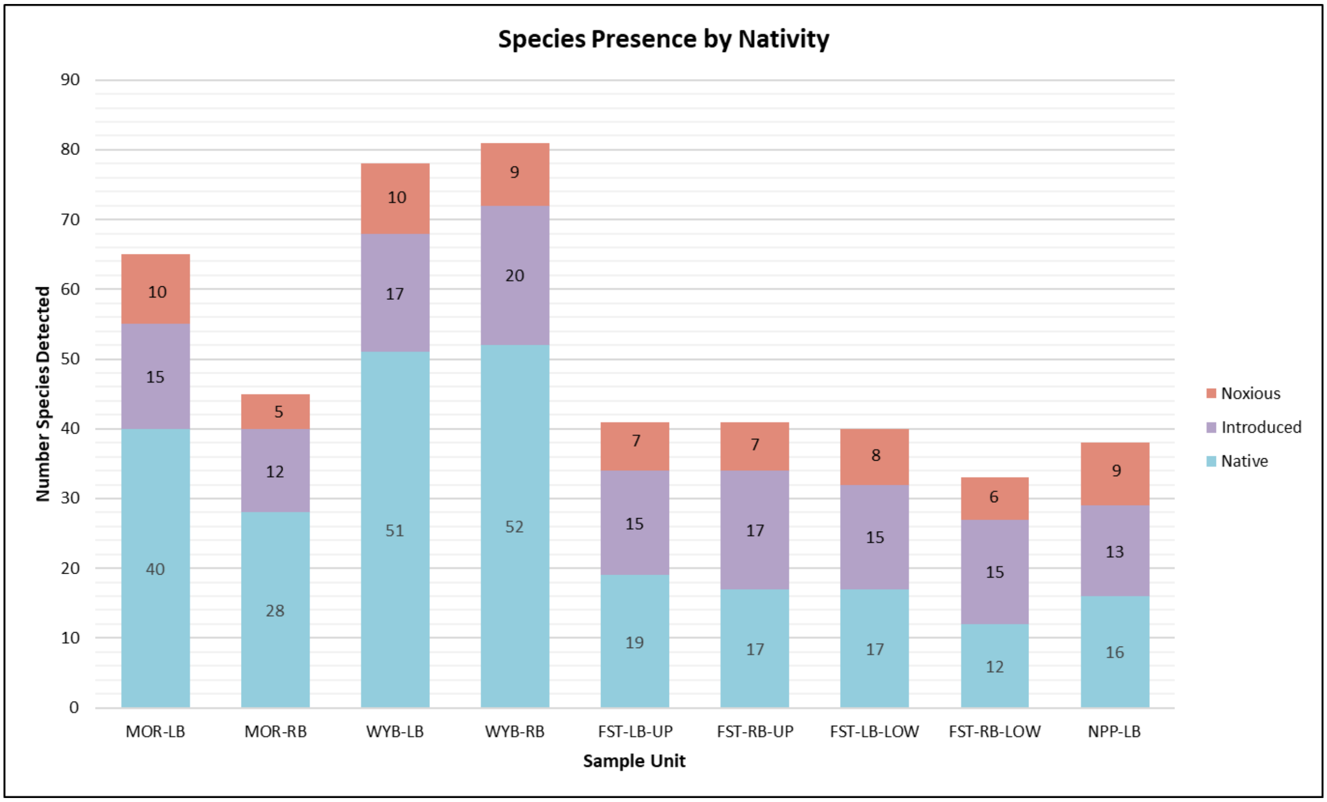

Figure 2 Number of Plant Species Stratified by Nativity Status

2.1.3 Reach-Specific Results

2.1.3.1 Morad Park

Left Bank Morad Park (MOR-LB) exhibits a variety of vegetative cover types ranging from dense willow stands, open meadows, constructed backwater inlets, and barren patches. This Sample Unit does not currently support an abundance of mature trees (only 3 per acre) but is supporting an abundance of sapling trees (>1300 per acre), primarily cottonwood. Due to a lack public access on river left, there is a high probability that at least a fraction of these saplings will successfully mature into large trees if left undisturbed. There are isolated areas within the Sample Unit that lack sufficient desirable plant cover, exhibit bare patches of gravel, and have areas of noxious weed infestation. Lack of success in these locations are likely due to poor seed and planting stock establishment or aggressive weed infestations leading to competitive exclusion. It was noted that areas of noxious weeds have been actively treated.

Right Bank Morad Park (MOR-RB) exhibits a variety of vegetative cover types ranging from mature tree galleries, dense willow stands, complex shrub mosaics, meadows, wetland pockets, and barren patches. This area is quite diverse in terms of vegetative structure and encompasses a wide riparian area of over 200 meters in some places along the reach. Barren patches are primarily due to intense recreational use of the area. Introduced perennial grasses dominate in some areas, resulting in reduced native forb diversity.

2.1.3.2 Wyoming Boulevard/Water Treatment Plant

Left Bank Wyoming Boulevard (WYB-LB) exhibits a variety of vegetative cover types ranging from mature cottonwood galleries, dense willow stands, open meadows, constructed backwater inlets, and barren patches. This unit currently supports a low density of mature trees (12 per acre) but significant numbers of sapling trees (~ 2000 per acre). There is a high probability that at least a fraction of these saplings will mature into large mature trees. There are isolated areas that lack sufficient desirable plant cover, bare patches of gravel, and areas of noxious weed infestation. Lack of success in these areas are likely due to poor seed take, planting stock issues, or aggressive weed infestations and treatment. Areas of noxious weeds are evidently undergoing active treatment. Monarch butterfly caterpillars were observed feeding on milkweed in this Sample Unit.

Right Bank Wyoming Boulevard exhibits a variety of vegetative cover types ranging from dense willow stands, grassy swaths, shrub patches, wetland pockets, and barren patches. This Sample Unit currently supports scattered mature trees (23 per acre) but significant numbers of sapling trees (1295 per acre). There is a high probability that at least a fraction of these saplings will mature into larger mature trees. There are isolated areas that lack sufficient desirable plant cover, bare patches of gravel, and areas of noxious weed infestation. Lack of success in these areas are likely due to poor seed take, loss of ground water connection, or aggressive weed infestations. A stand of mature Russian olives is present on the north end of this Sample Unit. Areas adjacent to the wastewater treatment plant exhibit less vegetative success and elevated noxious weed cover as compared to the area to the south. It is unclear if the reduced vegetation in these areas is due to hydrology, poor seed take, or a variance in management regimes. A mature beaver was observed on the bank in this unit.

2.1.3.3 1st Street - Upper (Upstream of 1st Street Bridge)

Left Bank 1st Street Upper (FST-LBU) exhibits steep, rocky slopes within a narrow riparian corridor. The vegetation is a mosaic of dense willows, shrub patches, mesic herbaceous swaths, and scattered mature trees. The area supports a dense, diverse native shrub community. A total of 62 sapling trees were observed, and some of these trees may grow to maturity over time. The herbaceous layer is characterized by low cover and a dominance by annual species. The patches of annuals are scattered and may reflect ease of public access to the area.

Right Bank 1st Street Upper (FST-RBU) exhibits steep rocky slopes within a narrow riparian corridor. The vegetation is a mosaic of dense willows, shrub patches, mesic herbaceous swaths, annual plant patches, and scattered mature trees. The unit supports quite a significant density of native shrubs. Introduced shrub species are also present. A total of 52 sapling trees were observed, which may gain size and maturity through time. A bare area to the north near the 1st Street bridge is due to public access and associated trampling of vegetation.

2.1.3.4 1st Street - Lower (Downstream of 1st Street Bridge)

Left Bank 1st Street Lower (FST-LBL) exhibits a steep slope with a shallow bench within a narrow riparian corridor. The vegetation is dominated by weedy annual species and bare coir erosion matting. The multi-layer erosion matting and wood chips are preventing growth of any vegetation in some areas or even aggressive perennial weeds. Limited perennial cover is concentrated within a few feet of the water's edge or anywhere the erosion matting has been staked or torn. A sizable stand of Russian and spotted knapweed is located at the southern end of the unit near the BNSF bridge. Two active head cuts are located within this area and other areas of erosion matting are showing signs of slumping. It is unlikely that this area will develop mature, perennial vegetation without intervention.

Reduction of concentrated water flows from upslope should be addressed before remediation of the area is attempted.

Right Bank 1st Street Lower (FST-RBL) exhibits a variety of vegetative cover types ranging from mature tree galleries, dense willow stands, meadows, wetland pockets, and annual weedy patches. This area is somewhat diverse in terms of vegetative structure and encompasses a wide riparian area of over 70 meters in some places. Dense stands of introduced sweet clover dominate sizable swaths of this unit and were impassable during field surveys. Sweet clover is biennial and will not bloom every year; there may be serviceable perennial vegetation beneath the sweet clover canopy that was undetectable. Other areas of annual cheatgrass would benefit from intervention. Additionally, introduced perennial grasses dominate much of the understory of the galleries. The unit exhibits the lowest native diversity of all sites.

2.1.3.5 North Platte Park

Left Bank North Platte Park (NPP-LB) was not sampled due to access limitations.

Right Bank North Platte Park (NPP-RB) exhibits a variety of vegetative cover types ranging from mature tree galleries, grassy swaths, and dense willow stands. This area is somewhat diverse in terms of vegetative structure and encompasses a wide riparian area of over 70 meters in some places. Russian olive removal and willow rejuvenation had recently been executed within this unit leaving wide swaths of bare areas. Mechanically treated areas were excluded from sampling. The area is characterized by mature tree galleries, with understories of reed canary grass, smooth brome, and quackgrass. Dense willow stands wind their way back and forth from the water's edge. Forb diversity is lacking and is dominated by sweet clover and Canada thistle.

2.2 Soils

2.2.1 Overview

The need to consider soils when conducting ecological restoration projects is compelling – it is logical that degraded soils (like any other resource) need restoring, and that land managers should seek to maintain beneficial ecosystem legacies and avoid actions that reduce soil health. Despite this need, there has been relatively little work that explicitly (or experimentally) examines the role that soils play with respect to restoration outcomes. This is particularly true when project goals are complex, for example, the restoration of "a diverse, native plant community". In such a case, soil processes and functions are necessarily tied to directly targeted biological and ecological functions. Soil health is defined as the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans. To date, the soil health concept has been applied primarily to agriculture landscapes and only recently is being employed in other land use and land management contexts.

Soils are natural bodies, formed over time by climate and organisms acting on geologic material, influenced by slope, terrain, hydrology, and other site characteristics. It is the interrelation of disturbance regimes, soil characteristics, biological processes, and life-history variation that is responsible for the high degree of heterogeneity generally observed in riparian vegetation at the reach scale. In comparison to most upland soils, however, riparian floodplain soils have limited (and variable) life spans. In the active floodplain where soils are subject to frequent disturbance by flooding, for example, one would expect that soils are maintained in relatively early states of pedogenic development compared to soils in adjacent uplands.

The relationship between soil and its respective vegetation is an intimate one, and the basic characteristics of the soil in terms of its texture, water holding capacity, and inherent fertility all influence the type and amount of plant life that a soil can support. Of course, the plants themselves can exert tremendous reciprocal influence on the soils they inhabit. But what can be expected when a river restoration project is implemented, bed and banks are significantly regraded, and the riparian corridor requires complete revegetation on soils that have been significantly disturbed? And how might the disturbance associated with project implementation affect the suitability of resulting riparian soils to support the desired plant communities? This research project aimed to begin exploring those questions through soils sampling and laboratory analysis paired with the previously discussed riparian vegetation sampling. Preliminary results from analytical soil testing are presented in Attachment A.

2.2.2 Field Procedures

Composite soil samples were collected from each Sample Unit to assess the integrity of soil chemical composition and microbial community and to identify any growth media challenges for current or future reclamation efforts. Soil samples were collected in the riparian zones of the North Platte River throughout four Study Areas. Samples were collected in the zone below the elevation of the floodplain (top of bank) and above the bankfull elevation. Individual soil sample collection sites were distributed throughout the riparian corridor within each Sample Unit. Soil samples were taken from areas with different microsites or vegetation performance within the riparian zone of each Sample Unit to best characterize a given site. Samples were taken next to plants or near rooting structures. All individual soil samples taken from a given Sample Unit were composited. A subsample of each composited soil sample was sent to Ward Labs in Kearney, Nebraska. Analytical testes performed included soil health [1]and PLFA[2] analyses.

2.2.3 Soil Health Assessments

Preliminary analysis of the soil health results indicates that most physical and chemical metrics across all reaches are within expected or normal ranges. Results appear typical of western, arid soils. Higher carbon to nitrogen (C:N) ratios are typical of native perennial systems. Lower nitrogen ratios are advantageous to the establishment of native perennial species and a site's resistance to weedy species. Comparative analysis was done between the reference site (NPP) and all reclaimed reaches with no significant differences in soil health or PLFA data.

Morad Park Right Bank appears to exhibit some elevated levels of salt and nitrogen. This is likely due to the more intense recreational use of the site and the nature of Morad Park being an area that allows dogs off-leash. These soil metrics do not appear to have adversely affected the vegetative success of this Sample Unit.

2.2.4 PLFA Testing

The aim of PLFA testing is to provide a real-time snapshot of the soil microbial community. The microbial community is greatly influenced by the vegetation present on site, and it also varies with

[1] A soil health score is calculated based on soil respiration, water extractable organic carbon, and water extractable nitrogen. This analysis also included measurements of soil nutrients and trace elements.

[2] Phospholipid fatty acids (PLFAs) are found in the membranes of all active organisms. Certain fatty acids are used to indicate the bacteria, fungi, or other types of microbes. Quantifying the fatty acid content in a soil sample can indicate the size of a specific microbial group as well as the size of the entire microbial biomass.

season. Based on a cursory review of the test results, all Sample Units appear to exhibit average- to above average- soil microbial communities. Lack of rhizobia and protozoa in these soils may be due to testing methods and not a deficiency within the soil communities. These results will be explored further.

Areas with more mature trees generally exhibited higher soil fauna biomass and increased fungi to bacteria ratio. These areas include MOR-RB, FST-URB, FST-ULB, FST-LRB, and NPP-RB.

Section 3: Management Implications

3.1 Early Thoughts

Riparian plant species typically exhibit a spectrum of life-history strategies that are either tolerant of flooding and associated sedimentation, only found on surfaces no longer receiving overbank flows, or those that are adapted to some intermediate condition (Nanson and Beach 1977). The flow regime thus plays an important role in driving the structure of riparian vegetation patches, illustrated by declines in diversity where flow regimes are transformed by dams (Nilsson et. al. 2002). Being a tailwater, the North Platte River in Casper has a flow regime that is highly regulated with significantly truncated flow dynamics. This novel flow regime effects the size, quality, and volume of the sediment transported in-, through-, and out- of the project reaches. The sediment dynamics in-turn affect the quality and quantity of sediment deposition (and erosion) in the river's riparian areas, and ultimately has implications for what, where, and how many plant species are likely to thrive in the riparian corridor.

Successional processes associated with disturbance events and subsequent recolonization are responsible for much of the heterogeneity observed in riparian vegetation communities. As a result of the episodic nature of disturbance, riparian vegetation patches can be found at different states of succession at the reach scale. But the successional sequence of the Study Areas has been significantly re-set through the removal of vegetation within the prescribed construction limits, extensive regrading of the river, its banks, the riparian corridor and all of the soils associated with these areas. In practical terms, these riparian areas have been significantly homogenized. Because these sites require near complete revegetation of newly-graded soils, the resulting plant community will be relatively even-aged for some time and will lack the heterogeneity in species and structure characteristic of most high-functioning riparian corridors. In other words, there are some limits on what is immediately achievable in terms of plant community restoration. But this does not mean there are not management opportunities to be actively embraced.

Short-term target communities for revegetation should likely differ from long term target communities. A spatially explicit, preferred vegetation trajectory should be clearly identified during project planning. Time is required for the sites to develop and successional sequences to occur. This, too, needs to be recognized, appreciated, and incorporated into the planning and design of future projects. The *Restoration Potential*, or limits to what is possible and practicable through restoration activities, should also be determined. The baseline data collected as part of this research is the first step in that process.

The setting of restoration project goals requires knowledge of, and a consensus on, an appropriate baseline for healthy soils and healthy vegetation in a landscape, considering the starting (current or existing) conditions. Objectives associated with soil restoration should aim to recover soil functions by reversing degradation and returning soils to healthy conditions where it is determined to be deficient or degraded. Goals for healthy soil communities (and success metrics associated with them) should be established as part of a river restoration project's broader goals.

3.2 Next Steps

The 1st Street Study Area has been seeded but has not been outplanted with vegetative stock aside from the incorporation of live cuttings (live brush layering and live staking) during project construction. This Study Area has low native species diversity, is dominated by weedy annual and introduced species in many locations and lacks structural diversity. It is highly recommended that a small pilot-scale planting study be initiated to examine a combination of native seed, planting stock, soil amendments, and mulches that may improve revegetation success and correct the ecological trajectory of this site. Results generated by the current study should be leveraged in developing alternatives and in informing the experimental design. Because the 1st Street reach is a highly visible riparian corridor in Downtown Casper, any experimental planting should incorporate aesthetic planting components as well as functional components.

References

Nanson, G. C., and H. F. Beach. 1977. Forest succession on a meandering-river floodplain, northeast British Columbia, Canada. *Journal of Biogeography* 4: 29-48.

Nilsson C. and M. Svedmark. 2002. Basic principles and ecological consequences of changing water regimes: riparian plant communities. *Environmental Management* 30: 468-480.

Attachment A: Soils Testing Results Summary

Reach	Morad Park		WY Blvd		1st Street Upper		1st Street Lower		N Platte Park		Rating Notes
Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Excellent / Very Good / Good / Slightly Above Average / Average / Slightly Below Average / Poor / Very Poor
Sample Code	MOR-LB	MOR-RB	WYB-LB	WYB-RB	FST-LBU	FST-RBU	FST-LBL	FST-RBL	NPP-LB	NPP-RB	
PLFA Analysis											
Total Biomass	2036	2095	3100	1594	2297	3160	2502	3437	2020	3718	Phospholipid fatty acids (PLFAs) are found in the membranes of all active organisms. Certain fatty acids are used to indicate the bacteria, fungi, or other types of microbes. Quantifying the fatty acid content in a soil sample can indicate the size of a specific microbial group as well as the size of the entire microbial biomass.
Diversity Index	1.37	1.45	1.45	1.43	1.50	1.48	1.45	1.43	1.50	1.47	
Fungi:Bacteria	0.31	0.39	0.33	0.36	0.45	0.38	0.51	0.54	0.33	0.44	Bacteria tend to dominate in systems with fewer organic inputs or residues possibly leading to a lower C:N ratio. While bacteria are important and needed in the soil ecosystem, fungi are desired and more often considered indicators of good soil health.
Gram(+):Gram(-)	0.67	0.89	0.87	0.70	1.12	0.83	1.01	0.66	1.18	0.76	Gram (+) bacteria typically dominate early in the growing season and/or following a fallow period. They also survive better under certain environmental conditions or stressors such as drought or extreme temperatures due to their ability to form spores. A gram (-) dominated soil may be due to anaerobic conditions or other stressors such as pesticide application or heavy metal contamination.
Soil Health											
1:1 Soil pH	8.3	8.1	8.2	8.0	8.0	8.1	8.1	8.2	8.0	7.9	6.5 to 8.5 pH is typical for native western soils.
1:1 S Salts mmho/cm	0.21	1.23	0.30	0.24	0.36	0.63	0.86	0.56	0.28	0.19	EC measurements give us an idea of how salty the soil is but does not express what kinds of salts are present.
CEC/Sum of Cations me/100g	8.6	18.3	16.8	18.7	20.7	22.5	23.7	21.6	17.3	13.7	Cation Exchange Capacity (CEC) Regardless, the number represents the total milliequivalents (meq) or positively charged cations that 100-grams of this soil can hold. CEC is calculated from the primary cations : hydrogen, calcium, magnesium, potassium, and sodium.
Organic C:N H2O	14.5	14.3	13.5	13.1	10.8	22.2	23.4	23.9	12.2	19.4	High C:N ratio is desirable for native perennial systems. A low ratio is indicative of an early seral system or cropping system.
CO2 Soil Respiration	20.5	79.1	18.2	28.5	43	37.1	40.2	31.8	33.6	46.7	Potential for microbial activity, nutrient cycling, and residue decomposition. Low nutrient cycling is indicative of a poor soil biome, elevated cycling is more appropriate for cropping.
SAR	0.20	2.05	0.32	0.14	0.13	0.21	0.80	0.50	0.09	0.12	The sodium hazard of soil usually is expressed as the sodium adsorption ration (SAR). The SAR must be compared to EC to determine if sodium is problematic. Soils with an EC of < 4 and an SAR of < 14 are considered non-saline and non-sodic.