BLACKFOOT TRADITIONAL KNOWLEDGE, BISON DRIVE LINES, AND GEOSPATIAL ANALYSIS

by

Kendall Rae Edmo

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Earth Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

May 2024

©COPYRIGHT

by

Kendall Rae Edmo

2024

All Rights Reserved

DEDICATION

To Medicine Stab and Pretty Eagle Woman,

This thesis is dedicated to you, my two pillars of strength and unwavering support, whose love and encouragement have illuminated every step of my journey through this vast terrain of academia. As a mother balancing the demands of an advanced degree in Earth Sciences with the sole -responsibility of nurturing and providing for our family, your presence has been my guiding light, propelling me forward even through the most challenging times.

My dearest children, your resilience and understanding have been nothing short of miraculous. You've witnessed the late nights, the early mornings, the tears, and the endless hours spent pouring over literature and analyzing data, yet never once did you falter in your belief in my aspirations. Your patience and understanding during times when my attention was divided between my research, work, basketball practices and bedtime stories are testaments to your remarkable maturity and love.

As Blackfoot people, we carry the legacy of resilience instilled by past generations. It is our profound connection to the land that I embarked on this academic journey—a journey not solely for personal gain, but with a fervent commitment to bringing back knowledge to our community. Education has always been the cornerstone of empowerment for Indigenous people, a tool through which we can reclaim our narratives, preserve our traditional practices, and shape our collective future. By pursuing higher education, I aim not only to honor your great-great grandmother Helen Sherman and great- grandfather Jack Edmo Sr., who firmly believed in education, but also those who came before me as we pave the way for future generations of Indigenous scholars, including you, to thrive in academia.

My beloved children, you are my greatest teachers, reminding me daily of the importance of perseverance, humility, and love. As you grow and carve your own paths in the world, may you carry with you the wisdom of our ancestors and the knowledge that with determination and a steadfast heart, you can accomplish anything you set your minds to-- and may you always remember, love and grace always win.

With all my love,

Mom
Warrior's Horse

ACKNOWLEDGEMENTS

I stand at the culmination of a decade-long journey of my personal growth, guided by the unwavering support and mentorship of Mr. John Murray and the late Mr. Virgil “Puggy” Edwards. As I reflect on the trajectory of my career and the transformation of my identity as a Blackfoot woman, I am grateful for the profound impact Mr. Murray and Mr. Edwards has had on my life and research.

Mr. Murray’s and Mr. Edwards mentorship has been the cornerstone of my personal, academic, and professional development. Through their guidance and steadfast belief in my potential, they empowered me to push the boundaries of my capabilities and to strive in excellence in all aspects of my life. Their mentorship has not only shaped my professional career and research endeavors, but also instilled in me a deep sense of purpose and identity.

The influence of Mr. Murray’s and Mr. Edwards’s mentorship extends beyond the confines of the little log cabin. They have been a source of inspiration, encouraging me to navigate challenges with resilience and determination. Their valuable insights, comedic story-telling, and “drive -by” archaeological methods have been instrumental in the shaping of my research and professional growth. I extend my deepest gratitude to Mr. Murray and Mr. Edwards for their unparalleled mentorship, friendship, guidance, and knowledge. Their wisdom will continue to inspire and guide me.

TABLE OF CONTENTS

1. INTRODUCTION 1

Geospatial Analysis: Methodological Approach 4
Geospatial Analysis Methods 6
Statistical Analysis 8

2. TRADITIONAL BLACKFOOT KNOWLEDGE, BISON DRIVE LINES, AND GEOSPATIAL ANALYSIS 10

Contribution of Authors and Co-Authors 10
Manuscript Information 11
Abstract 12
Introduction 12
Blackfoot Knowledge and Bison Hunting 16
Bison Hunting Practices 18
Ancient Landscape Management 20
Blackfoot Seasonal Rounds 22
Red Blanket Bison Drive Line 27
Geospatial Analysis: Methodological Approach 30
GIS Analysis Methods 32
Statistical Analysis 34
Discussion 37

3. CONCLUSION 41

CUMULATIVE REFERENCES CITED 43

APPENDICES 49
R SCRIPT FOR VIOLIN PLOTS 50
TABLE OF AVERAGE DISTANCES BETWEEN 53
SITE TYPES AND ENVIRONMENTAL 53
VARIABLES 53
TABLE OF LANDCOVER CLASSES (NLCD) 55
FOR LOCATIONS OF SITE TYPES 55

LIST OF TABLES

Table Page

1. Table 1. Average distances (km) between site types (drive lines and null sites) and environmental variables 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes. 54

2. Table 2. NLCD 2019 of site types (bison drive lines and null sites). 56

LIST OF FIGURES

Figure Page

1. Figure 1. Traditional Blackfoot Territory with Blackfoot geographic place-names; jurisdictional boundaries intentionally left out. 15
2. Figure 2. Rock cairn a part of the Red Blanket Drive Line. 19
3. Figure 3. Red Blanket drive line situated on a glacial moraine flanked by a kettle lake. 28
4. Figure 4. Terminus of the Red Blanket drive line at Cut Bank Creek. 29
5. Figure 5. Map of bison drive lines and null sites in study area. 31
6. Figure 6. Map of site types (bison drive lines and null sites) and locations according to landcover (National Landcover Database 2019). 33
7. Figure 7. Small - scale map of drive lines and null sites in study area. 34
8. Figure 8. Violin plots of site types (drive lines and null sites) and their geospatial distributions of log-transformed distances (km) to 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes. 36

ABSTRACT

Bison drive lines provide material evidence of ancestral Blackfoot practices. The spatial dimensions of drive lines highlight a sophisticated understanding of bison-environment interactions and the strategic use of geographic landforms and environmental features to maintain a critical lifeway. Here we examine broad-scale landscape use patterns among prehistoric Blackfoot bison hunters on the Northwestern Plains through an analysis of a network of drive lines in traditional Blackfoot territory (US) using Geographic Information Systems (GIS) and previous archaeological and anthropological research. The findings of this study show that ancestral Blackfoot designed bison drive lines to be positioned in proximity to key landscape resources including water, forested areas, and wetlands and kettle lakes. This study builds on previous research that applies an Indigenous archaeological framework that incorporates ethnohistoric narratives and traditional knowledge to provide important context for understanding the relationship between ancestral Blackfoot, bison, and the cultural landscape. Examining the relationship between drive lines and landscape features helps advance our understanding of the Blackfoot knowledge system that has adapted and endured for millennia.

INTRODUCTION

For millennia, the Blackfoot people have been active stewards of landscapes throughout their ancestral homelands that extend along the Continental Divide, from Montana's Yellowstone River and span north into Alberta, Canada. Ancestral Blackfoot adapted to thousands of years of climate variability and environmental change as evidenced by changes in their spatiotemporal landscape engineering practices, including the development and use of bison drive lines that are abundant throughout Blackfoot homelands. The ancient relationship between the Blackfoot, bison, and their homelands is embodied in the engineered landscape— "a resilient setting created for this task through the construction of permanent stone features and manipulation of people and resources" (Zedeño et al. 2014). To construct drive lines, Blackfoot hunters required comprehensive knowledge of bison behavior and the environment, including the local geography, regional climate patterns, wind direction, and proximity to resource materials, such as firewood for fuel and abundant water for processing activities (Kehoe 1960:433; Kehoe 1973:6; Bethke 2016). Additionally, kettle lakes along the Northern Front served as a water source for bison on the plains and provided a "gathering basin" (Oetelaar 2014), from which the drive lines were strategically designed. In this study, I use Geographic Information Systems (GIS) to examine an engineered landscape, more specifically, a network of drive lines made up of stone features, and integrate Blackfeet ethnohistorical data to better understand the deep-time relationship between the Blackfoot, bison, and the environment.

Chapter two provides the detailed methodology of the geospatial and statistical analyses I conducted to address the central question of the research. This geospatial analysis was critical in identifying the spatial relationships between the drive lines and environmental variables. I

utilized the R programming language to compute the statistical analyses and create violin plots, which assisted in the visualization of the spatial distributions between the drive lines and null sites. Together, geospatial and statistical analyses advance our understanding of the relationship between the drive lines and important environmental features.

Chapter three consists of a manuscript entitled: "Traditional Blackfoot Knowledge, Bison Drive Lines and Geospatial Analysis" to be submitted to the journal, "Plains Anthropologist." This manuscript discusses the results of the research analyzing the geospatial relationship of drive line sites in Blackfoot territory in Montana, and important landscape features. My research question asks: "Given previous anthropological research to which we have direct access, how can geospatial analyses inform our understanding of the location of bison drive lines and their proximity to environmental features?" This study uses geospatial analyses to identify the proximity of drive lines to specific landscape features including: 1) forested areas and forest resources (wood for fuel, construction material), 2) water (for subsistence and bison processing activities), and 3) wetlands and kettle lakes (that draw and concentrate bison herds). This research examines the relationship between the location of drive lines and environmental features for 61 drive line sites within traditional Blackfoot territory, comparing this relationship with a selection of 61 randomly generated sites within the same land cover types (approach detailed in Chapter 2). Ethnohistoric documentation outlines traditional Blackfoot knowledge of the environment, connecting Blackfoot land use practices with the seasonal weather patterns. As John C. Ewers writes, "Indians who preyed upon the buffalo had to adjust their way of life to the habits and movements of their prey. In Spring, summer and fall, buffalo grazed on the rich grasslands in open country. But in winter, the harsh season of sub-zero temperatures, deep snows,

and strong winds, these animals sought food and shelter in wooded valleys and broken country where hills offered protection from the wind. So the Indians' buffalo-hunting techniques varied with the seasons" (1958:9).

Chapter four provides overarching implications for research that integrates GIS and Indigenous knowledge systems. It was important to integrate the Blackfoot creation story to provide context to the deep-time relationship between the Blackfoot people and the cultural landscape. This approach provides valuable insights critical for tribal land managers working to protect and preserve cultural landscapes and traditional lifeways for future generations.

CHAPTER TWO

METHODS AND METHODOLOGY

Geospatial Analysis: Methodological Approach

Geospatial analysis enables us to visually and quantitatively reconstruct patterns of Blackfoot traditional land use across large landscape scales, highlighting their social investment in landscape engineering practices within their traditional territory (limited to Montana for the purposes of the study). I obtained GIS data for 61 drive line sites from the Blackfeet Tribal Historic Preservation Office (THPO), the Montana State Historic Preservation Office (SHPO), and the University of Arizona Bureau of Applied Research in Anthropology. I completed a data-use agreement to access the Montana SHPO database. Per SHPO recommendation, I used the search term "game drives" in the counties only in the study area; this yielded 91 game drive sites which each have an associated Cultural Resource Information System (CRIS) form. Next, I reviewed each CRIS form to ensure that all sites were truly "game drives." The sites were quality checked by using the following criteria, 1) classified as game drive and 2) CRIS form description of drive line. I did not include sites that were described as "hunting blinds," as they were not used to "drive" or manipulate bison behavior. Next, I recorded the Smithsonian number of each site that was classified as a game drive and met the description of a drive line, and requested the GIS data from the MT SHPO. The MT SHPO provided GIS data for 50 sites as not every documented site in the database had GIS data. The remaining 11 drive line sites and GIS data were obtained from the Blackfeet THPO Office (2) and the University of Arizona BARA (9), with a total of 61 drive line sites to analyze in this study.

To better understand whether the location of drivel lines was associated with specific landscape features, I analyzed the Euclidean distances between the 61 drive lines and three environmental variables compared to randomly generated null sites and their relationships to three variables: 1) forest areas, 2) rivers and streams, and 3) wetlands and kettle lakes. The drive line sites represented in Figure 5 are offset by 1 km, following the guidance of the Blackfeet Tribal Historic Preservation Officer (THPO), John Murray, and the Montana State Historic Preservation Officer (SHPO), Damon Murdo. Consultation with the Blackfeet THPO and MT SHPO was crucial to ensure culturally sensitive data remained protected to preserve site integrity. It is important to note that the dating of the material used to build the drive lines spans from recent centuries to 2,000 years and not all have been clearly identified as being utilized by the Blackfoot people. Highlighting the significance of the ontological relationship between the Blackfoot and the environment and integrating ethnohistoric documentation provides a framework from which to conduct this geospatial analysis and provides context to the spatial mapping of these sites.

Blackfoot oral traditions and ethnographic research provide clear evidence that drive lines were not established on landscapes randomly, but that they were specifically located in proximity to important landscape features such as bluffs, cliffs, and coulees that helped drive bison towards an intended kill site (Grinnell 1892:228; Lewis 1947:8; Ewers 1949:355; Kehoe 1973:6, Reeves 1978:63; Schaeffer 1978:245; Verbicky-Todd 1984; Barsh and Marlor 2003:275; Kornfeld et al. 2010; Oetelaar 2014:11; Zedeño et al. 2014: 26; Bethke 2017;800; Brink 2017). Blackfoot traditional territory encompasses the Northern Front and foothills which is marked by

the legacy of glacial activity that carved out u-shaped river valleys, coulees, and kettle lakes, and provided topographic diversity suitable for communal bison hunting practices. As the ethnohistoric documentation has highlighted, drive lines were heavily dependent on environmental conditions because kill sites required cliffs and topographic features necessary to trap and kill bison. Surface water near kill sites was necessary for drawing bison in, and additionally, was used for harvesting and processing activities (Bethke 2016). Vegetation was also important as forested areas provided fuel and construction materials for pounds and drive lines.

Geospatial Analysis Methods

I conducted the geospatial analysis in the software program ArcGIS Pro (Version.3.1.3). First, I created a polygon shapefile of the study area (Traditional Blackfoot Territory in Montana). I achieved this by using the "Trace" tool and followed the boundary line shapefiles of the Continental Divide, Yellowstone River, and the eastern and northern border of the Montana state boundary line. This resulted in a polygon of the study area, which was projected into the North American Datum 1983 (Figure 5).

Next, I imported the point shapefiles (Blackfeet THPO and University of Arizona BARA) for the drive lines and created a 1 km buffer for each drive line to remain consistent with the MT SHPO drive lines which all had buffers (polygon shapefiles). Next, I obtained GIS data of the environmental variables: 1) land cover data (Figure 7) from the National Landcover Database 2019 (Dewitz and U.S. Geological Surve; 2019), rivers and streams from the Montana GIS Library (1993), and 3) wetlands and kettle lakes from the Montana State Library (Ecological Mapping, Monitoring and Analysis Group; 2022). I used the "Extract by Mask" tool to clip the

landcover raster to the study area boundary, and the “Clip” tool to clip the rivers/streams and wetlands/kettle lake vector data to the study area. In order to randomly generate 61 null sites for the comparison analysis, it was necessary to create a polygon shapefile with landcover that was representative of “bison habitat,” so that null sites were not generated on locations such as open water, forested areas, barren land, and perennial ice and snow. To achieve this, I used the “Extract by Attribute” tool to create a raster that excluded those particular land cover classes. I used the following expression: “Where landcover is not equal to open water.” I used the same expression for the following landcover classes: perennial snow/ice, evergreen forest, deciduous forest, and mixed forest.

Next, I used the “Raster to Polygon” tool which converted the “bison habitat” landcover raster into polygon shapefiles representing the remaining landcover classes. Next, I used the “Dissolve” tool and checked the “Create Multipart Features” option. The output created a polygon of “bison habitat.” Finally, we used the “Create Random Points” tool, where the “bison habitat” layer was the “Constraining Feature Class”; the number of points was set to 61. The output created 61 randomly generated (null) points within the “bison habitat” polygon.

Next, I created a polygon of the forested areas. We used the “Raster Calculator” tool to isolate three NLCD landcover classes: 41 Mixed Forest, 42 Evergreen Forest, and 43 Deciduous Forest. We used the following expression: (“nlcd_landcoverClip == 41)” | “(nlcd_landcoverClip== 43)” | (“nlcd_landcoverClip” == 43). The output resulted in a raster layer of only those forest landcover classes. The value of the cells representing the forested areas were equal to 1, and all other landcover classes were equal to zero. I used the “Extract by Attributes” tool to create a raster that only had cells equal to one (1), excluding cells equal to

zero (0). Then I used the “Polygon to Raster” tool, which created a polygon of the forested areas. This step was critical for calculating distances between drive line/null sites, to the nearest forested area, because the tool requires the forested area to be a point, polyline, polygon of multipoint feature (not raster).

Statistical Analysis

In ArcGIS Pro, I used the “Central Feature” tool to identify the central point of the drive lines (polygons), which resulted in 61 point features representing the drive lines, likewise, the null sites were point features. Next, I calculated the distances between the drive lines and null sites, to the environmental variables 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes. I did this by using the “Generate Near Table” tool, which created a standalone table of the nearest (input) environmental feature. The distances were calculated in kilometers using the Planar Method, which uses the straight-line Euclidean distance. This tool created additional fields in the attribute tables of the drive lines and null sites that provide the nearest distance to 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes; I used the “Summary Statistics” tool to calculate the average distances between site types and environmental variables (Table 1. in Appendix).

Lastly, I exported each table as a CSV file and imported them into Microsoft Excel (version 16.78). I formatted the data into two columns, 1) site type (drive lines and null sites) and 2) distance (km). The six site types were: 1) drive lines distance to forested areas, 2) drive lines distance to rivers and streams, 3) drive lines distance to wetlands and kettle lakes, 4) null sites distance to forested areas, 5) null sites distance to rivers and streams, and 6) null sites distance to

wetlands and kettle lakes. This table was exported as a CSV file and imported to Rstudio for further statistical analysis.

Using Rstudio (version 2023.09.1+494), I created Violin Plots which depict distributions of numeric data for one or more groups using density curves, with box plots and jitter points to visualize and compare the distribution of distances between drive line sites and null sites; additionally, we ran a KS – Test to enhance the validity of the results. To create the plots, I used the `ggplot2` package, and to address data normality, I applied a log transformation to the "distance" variable within each subset. The R script used to create the violin plots and statistical analysis is outlined in the Appendix. I applied a log transformation to the data because there was a wide range of distances between the two site types, and they were not evenly spread out. The log transformation function compressed the larger values and spread out the smaller values, which made the data more symmetrical and closer to the normal distribution, improving the interpretation of the data.

CHAPTER THREE

TRADITIONAL BLACKFOOT KNOWLEDGE, BISON DRIVE LINES, AND GEOSPATIAL ANALYSIS

Contribution of Authors and Co-Authors

Manuscript in Chapter 3

Author: Kendall Rae Edmo

Contributions: K.R.E. designed main conceptual ideas to integrate Traditional Blackfoot knowledge, performed field investigation, analyzed data, created the maps and data visualization, wrote the manuscript with input from co-author D.M and consultation with María Nieves Zedeño and Scott Powell. All committee members provided critical feedback and helped shape the research, methodology, analysis and manuscript. T. K. assisted K.R.E. with statistical analysis.

Co-Author: Dave McWethy

Contributions: D.M. advised K.R.E. in the design of the geospatial analysis and methodology and provided critical feedback on the figures and tables and helped edit the content of the manuscript.

Co-Author: María Nieves Zedeño

Contributions: M.N.Z. provided original GIS data for the analysis.

Manuscript Information

Kendall Rae Edmo, Dave McWethy and María Nieves Zedeño

Plains Anthropologist

Status of Manuscript: [Put an x in one of the options below, then delete instruction in brackets]
x Prepared for submission to a peer-reviewed journal
☐ Officially submitted to a peer-reviewed journal
☐ Accepted by a peer-reviewed journal
☐ Published in a peer-reviewed journal

Abstract

Bison drive lines provide material evidence of ancestral Blackfoot practices. The spatial dimensions of drive lines highlight a sophisticated understanding of bison-environment interactions and the strategic use of geographic landforms and environmental features to maintain a critical lifeway. Here we examine broad-scale landscape use patterns among prehistoric Blackfoot bison hunters on the Northwestern Plains through an analysis of a network of drive lines in traditional Blackfoot territory (US) using Geographic Information Systems (GIS) and previous archaeological and anthropological research. The findings of this study show that ancestral Blackfoot designed bison drive lines to be positioned in proximity to key landscape resources including water, forested areas, and wetlands and kettle lakes. This study builds on previous research that applies an Indigenous archaeological framework that incorporates ethnohistoric narratives and traditional knowledge to provide important context for understanding the relationship between ancestral Blackfoot, bison, and the cultural landscape. Examining the relationship between drive lines and landscape features helps advance our understanding of the Blackfoot knowledge system that has adapted and endured for millennia.

Introduction

Traditional Blackfoot oral stories, songs, and practices animate the landscape with deep-time knowledge, distinctive attributes, and ancient narratives (Zedeño et al. 2021), all of which serve as an ontological foundation for understanding the relationship between the physical and nonphysical dimensions of the landscape through space and time. Bastien (2004:226) relates that much of Blackfoot life is spent in the "process of trying to understand the spiritual existence etc. and all that is related to ontology." Previous anthropological research recognizes the importance of this ontology, advancing our understanding of the traditional relationship between the Blackfoot and the environment. This research builds on anthropological findings by examining the spatial context of Blackfoot ontology to better understand the interconnectedness between tangible and intangible resources on the landscape that reflect a comprehensive and holistic knowledge system (e.g., LaPier 2017). Very little research has been conducted to better understand the spatial dimensions of the Blackfoot knowledge system. Previous research

integrating Indigenous Knowledge and geospatial analysis focused on facilitating historic site inventory, evaluation, and preservation (Droj; 2010). This integration of spatial information on cultural resources is important work because it protects this information for descendant generations and continues to be a powerful way to safeguard and house culturally sensitive data associated with sacred sites and geographies. However, there is little information on the spatial dimensions of Indigenous ontologies to assist in developing our understanding of land use patterns and the material evidence of traditional practices left on the environment thousands of years later. As Pickering (2020:71) notes, “It is important to consider alternative ontologies in anthropological scholarship to generate more equitable and informed research.” When this approach is applied to research focused on geospatial analysis, it contributes to a more pluralistic and diverse understanding of our physical and metaphysical environment and has the potential to hold relevance to the Blackfoot community.

The objective of this work is to integrate traditional Blackfoot knowledge and ethnohistoric documentation with geospatial analyses to better understand the spatial dimensions of ancestral Blackfoot landscape engineering practices related to communal bison hunting. This approach will provide a deeper understanding of the relationship between permanent Blackfoot landscape architecture and environmental features on the cultural landscape. For this paper, the concept of a “cultural landscape” looks at the relationship between people, environments, land, and tangible and intangible resources (Anshuetz et al. 2001; Bowser and Zedeño 2009; Scheiber and Clark 2008; Bethke 2017). Cultural landscapes extends beyond the conventional Western understanding of landscapes as physical spaces and natural resources, and encompasses the spiritual, social, and ecological dimensions embedded within the traditional practices of

Indigenous peoples over multiple temporal and spatial scales This research asks: “Given previous anthropological research to which we have direct access, how can geospatial analyses inform our understanding of the location of bison drive lines and their proximity to environmental features?” This study uses geospatial analyses to evaluate the relationship between the location of drive lines and specific environmental features including: 1) forested areas and forest resources (wood for fuel, construction material), 2) water (for subsistence and bison processing activities), and 3) wetlands (that draw and concentrate bison herds). We examine the relationship between drive lines and environmental features for 61 drive line sites within aboriginal Blackfeet lands (Figure 1) and compare these with a selection of 61 randomly generated sites within the same land cover types (approach detailed in methods). We also consider more detailed information for one drive line site to inform our analysis and interpretation.

This study addresses a knowledge gap in research examining the geospatial dimensions of Indigenous landscape use. More specifically, this study analyzes GIS data associated with bison drive lines because they represent permanent landscape architecture and are direct evidence of traditional Blackfoot practices. Geospatial analysis allows us to identify and quantify Blackfoot land use patterns and provides a way to: 1) visualize these patterns in relation to the environment and prominent landscape features such as the northern Rocky Mountain Front (hereinafter “Northern Front”) and the landscapes of the northwestern plains and, 2) identify patterns between bison drive lines and landscape features. Reviewing ethnohistoric documentation is important because it provides information about Blackfoot bands as highly mobile, whereas drive lines provide a record of permanent landscape architecture that helps us

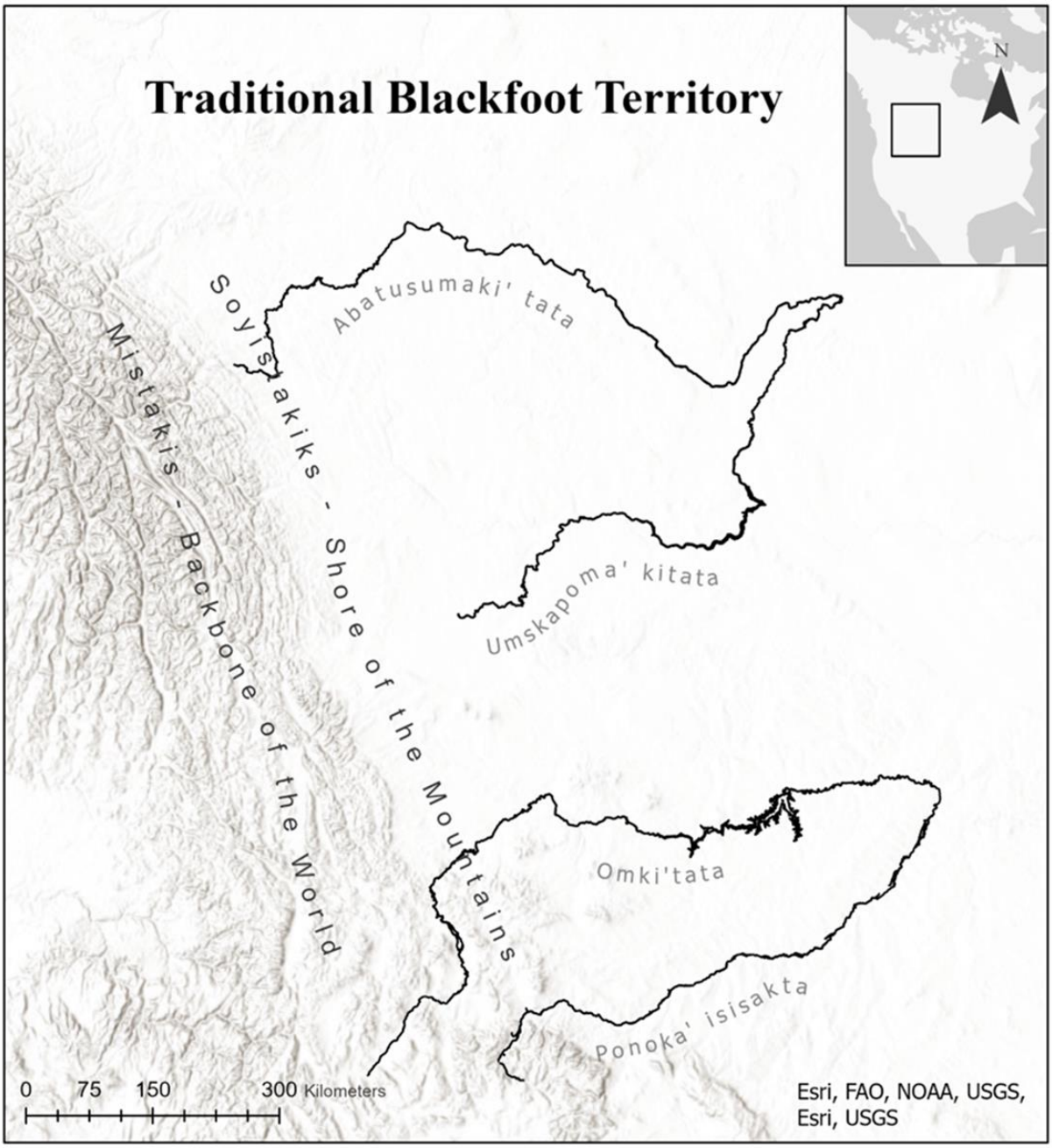


Figure 1. Traditional Blackfoot Territory with Blackfoot geographic place-names; jurisdictional boundaries intentionally left out.

understand the fall and winter periods of the seasonal rounds. During this time, drive lines were strategically located near heavily timbered river valleys along the Northern Fron which provided

shelter and additional resources for the harsh winter conditions, whereas the summer hunting sites were ephemeral and opportunistically built pounds or corrals (piskun or "blood kettles") (Zedeño 2023 personal communication).

Blackfoot Knowledge and Bison Hunting

Traditional knowledge and ethnohistoric documentation provide insight into the seasonality of communal bison hunting practices that are spatially and temporally organized according to the Blackfoot annual calendar of ceremonial activities. These ceremonial activities coincided with seasonal weather patterns, geographic variability, and access to resources as they became available. Blackfoot ontology provides a pathway to unpack these complex land use patterns. Bastien (2004:9) notes that Napi creation story reveals the origin of prominent geographic features and reveals the distinct relationship between the Blackfoot ancestors, plants and animals, and the environment, and Zedeño et al. (2021:7) relate that Napi stories are encoded with geological, paleontological, and archaeological localities. It is important to consider the Napi creation story as part of this study because it helps us understand the deep-time relationship between the Blackfoot and their traditional territory, which travels along the Continental Divide, spanning the northwestern plains up to the North Saskatchewan River and as far south as the Yellowstone River in southern Montana (Figure 1).

The creation story of Napi or Old Man provides a meaningful framework for understanding the complex relationship between the Blackfoot and their traditional homelands. In a version recorded by George Bird Grinnell (Blackfoot Lodge Tales 1892:137-138),

> Old Man was travelling about, south of here, making the people. He came from the south, travelling north, making animals and birds as he passed along. He made the mountains, prairies, timber, and brush first. So he went along, travelling northward, making things as he went, putting rivers here and there and falls on

> them, putting red paint here and there in the ground, —fixing up the world as we see it to-day. He made the Milk River (the Teton) and crossed it, and, being tired, went up on a little hill and lay down to rest. As he lay on his back, stretched out on the ground, with arms extended, he marked himself out with stones, —the shape of his body, head, legs, arms, and everything. There you can see those rocks to-day. After he had rested, he went on northward, and stumbled over a knoll and fell down on his knees. Then he said, "You are a bad thing to be stumbling against"; so he raised up two large buttes there, and named them the Knees, and they are called so to this day. He went on further north, and with some of the rocks he carried with him he built the Sweet Grass Hills.
>
> Old Man covered the plains with grass for the animals to feed on. He marked off a piece of ground, and in it he made to grow all kinds of roots and berries, —camas, wild carrots, wild turnips, sweet-root, bitter-root, sarvis berries, ball berries, cherries, plums, and rosebuds. He put trees in the ground. He put all kinds of animals on the ground. When he made the bighorn sheep with its big head and horns, he made it out on the prairie. It did not seem to travel easily on the prairie; it was awkward and could not go fast. So he took it by one of its horns, and led it up into the mountains, and turned it loose; and it skipped about among the rocks, and went up fearful places with ease. So he said, "This is the place that suits you; this is what you are fitted for, the rocks and the mountains." While he was in the mountains, he made antelope out of dirt, and turned it loose, to see how it would go. It ran so fast that it fell over some rocks and hurt itself. He saw that this would not do, and took the antelope down on the prairie, and turned it loose, and it ran away fast and gracefully, and he said, "This is what you are suited to."

It is important to relate this story because Old Man created geographic and environmental features such as mountains, prairies, buttes, rivers, and forests that shaped the way ancestral Blackfoot interacted with plant and animal resources including bison. Additionally, Old Man showed the Blackfoot how to hunt bison.

> "He took them to the cliff, and made them build rock piles like this, >; and he made the people hide behind these piles of rock, and said, "When I lead the buffalo this way, as I bring them opposite to you, rise up." (Grinnell 1892:142).

As Zedeño and Scheiber (2015:188). point out, "transferring these stories through generations shapes how individuals learn about and transform the landscape." As ancestral Blackfoot interacted with this landscape, they created political and social institutions – societies – and followed protocols and practices to renew alliances with the natural world and maintain a

balance in the cosmic universe that enabled them to acquire a profound sense of emplacement within their traditional territory. Blackfoot groups not only interacted with the environment but adapted to it, and actively managed and maintained the landscape for hunting bison, their "staff of life," (Ewers 1958:1).

Bison Hunting Practices

Over the past 13,000 years, ancestral Blackfoot lived with bison and developed various hunting strategies that evolved through time. Previous archaeological research provides information on different types of bison kill sites employed by hunters on the northwestern plains, including buffalo pounds (corrals), steep embankments, cliffs, and bluffs (buffalo jumps), and geohydrological traps associated with water features such as bogs or wetlands (Ewers 1949; Grinnell 1962; Reeves 1978; Schaeffer 1978; Kehoe1973; Kornfeld et al. 2010; Peck 2010; Oetelaar 2014; Zedeño et al. 2014; Bethke 2017).

Permanent drive line construction is a hallmark of Blackfoot hunting technology. The Blackfoot built drive lines by constructing a "funnel" or "v" shape with cairns, or stacked stones (Figure 2), designed them according to the local geography, and oriented them toward an intended kill site (Grinnell 1892:228; Lewis 1947). These cairns assisted in guiding bison towards a steep embankment, coulee, or cliff and served as physical markers that allowed hunters to understand where to turn bison (Frison 1974:16). In an archaeological study at Head-Smashed-In Buffalo Jump Reeves (1978) originally speculated that ancestral Blackfoot utilized bison drive lines as far back as 5,500 years ago but this early date has never been confirmed. The rise of drive line construction likely began during the Terminal Archaic Period and intensified



Figure 2. Rock cairn a part of the Red Blanket Drive Line.

through the late Prehistoric Period ca. 1,350-250 BP (Peck 2011; Kornfeld et al. 2010). During the Terminal Archaic Period, evidence suggests fire was introduced into the landscape to manage bison herds and improve the grassland, a practice that likely increased environmental carrying capacity and attracted larger groups of hunters (Roos et al. 2018).

To construct drive lines, Blackfoot hunters required comprehensive knowledge of bison behavior and the environment, including the local geography, regional climate patterns, wind

direction, and proximity to resource materials, such as firewood for fuel and abundant water for processing activities (Kehoe 1960:433; Kehoe 1973:6; Bethke 2016). Additionally, kettle lakes along the Northern Front served as a water source for bison on the plains and provided a "gathering basin" (Oetelaar 2014), from which the drive lines were strategically designed. It was common for drive lines to exhibit multiple alignments and extensions that form large-scale complexes, such as the Kutoyis site that was documented in 2007-10, as part of the Kutoyis Archaeological Project (KAP) on the Blackfeet Indian Reservation in Montana. This site consists of a bison drive line complex in the Two Medicine River Valley and is exemplary of large-scale landscape architecture as it is one of the largest drive line complexes recorded, covering approximately 16 km^2, is 4 km in length, and dates to the Late Prehistoric period (Zedeño et al. 2014).

Ancient Landscape Management

A steady record of archaeological evidence demonstrates a deep connection between the Blackfoot and bison, as Bethke (2016:799) states, "archaeology can provide a picture of Blackfoot landscape use within their homeland." Ancestral Blackfoot developed extensive environmental knowledge of their traditional homelands that encompass diverse ecotones, complex ecological processes, local topography, seasonal weather patterns, distribution and organization of plant communities, astronomical observations, and bison abundance and behavior. Previous archaeological research and ethnohistoric documentation provide context from which to analyze and understand the interconnectedness between ancestral Blackfoot and the environment. Drive lines represent permanent landscape architecture that provides information about the spatial arrangement of communal bison hunting practices, and

ethnographic documentation provides further insight into Blackfoot land use related to the seasonality of resources on a large scale. Ancestral Blackfoot "observed bison moving between their winter and summer ranges, enabling them to strategically plan and establish drive line systems and adjacent camps in specific areas to "intercept" bison herds," (Ewers 1958; Bamforth 1988; Barsh and Marlor 2003; Brink 2008; Hamilton et al. 2014; Vickers and Peck 2004 and Bethke 2017). The Blackfoot adapted their communal hunting practices based on environmental and ecological variables that were heavily dependent on climate and elevation, and even planned drive lines to allow hunters to take advantage of the wind, contours of the land, long hills, and surrounding cliffs (Lewis 1947:2). Furthermore, oral stories reference Napi and the use of fire-leggings to set fire to the grass for hunting bison (McClintock 1999: 347).

Blackfoot ancestral homelands spanned the Northern Front and out onto the northwestern plains. The ecoregions encompassed by this vast territory were diverse not only in climate but in elevation as well. The Northern Front is characterized by the northwestern forested mountains and foothills and the valleys are covered with moraines, fluvial and lacustrine deposits, and kettle lakes. The Rocky Mountains are oriented north-south and create prevailing westerly winds, resulting in an extreme climatic gradient extending from the western flanks of the mountains to the eastern side (Cairns, Butler, and Malanson 2002). The major east-west climatic gradient is not continuous because of the alternating importance of the orographic uplift of moist air over the Rocky Mountains and associated rain shadow effects from the west to east across the series of ranges (Changnon, McKee, and Doesken 1991; Grace 2020). Elevation is the primary environmental variable that influences vegetation communities along the Northern Front (Habeck 1987), which the Blackfoot understood as they had knowledge of the types of plants

that became available at different elevations on the plains and foothills. This area is characterized by short-grass prairie influenced by the rain shadow of the Rocky Mountains. The Northern Front and foothills area is a particularly important ecoregion as it is situated between the Rocky Mountains and the northwestern Plains and was shaped by a legacy of glaciation that marked the landscape with kettle lakes, deep ridges, coulees, fluvial valleys, and wetlands, which created a diverse terrain that was critical for bison habitat and provided the ideal topography for gathering and driving bison herds. Furthermore, kettle lakes along the Northern Front provided permanent water, shelter from weather and enemies, and ease of access to a range of mineral (tool stone) and plant resources (including fuel and berries) (Lanöe et al. 2021). The Northern Plains were shaped by similar geomorphic processes that left a variety of glacial deposits consisting mostly of undulating terrain and glacial till, and level to gently rolling lacustrine deposits. Ancestral Blackfoot interacted with this landscape and "harvested and transplanted selected plants, managed specific resource patches, and used controlled burns to influence animal behavior (e.g., Oetelaar and Oetelaar 2007, 2008).

Blackfoot Seasonal Rounds

Ethnohistoric documentation authored by John C. Ewers provides detailed information on Blackfoot land use patterns about communal bison hunting and their annual ceremonial activities and refers to this relationship as a seasonal round, or "the annual cycle of camp movements that varied with the seasons. It was influenced not only by the availability of game and the ripening of wild plant foods but also by the severity of the winter weather and the demands of the Indian's own ceremonial calendar," (Ewers 91:1958).

> "Indians who preyed upon the buffalo had to adjust their way of life to the habits and movements of their prey. In Spring, summer and fall, buffalo grazed on the rich

> grasslands in open country. But in winter, the harsh season of sub-zero temperatures, deep snows, and strong winds, these animals sought food and shelter in wooded valleys and broken country where hills offered protection from the wind. So the Indians' buffalo-hunting techniques varied with the seasons." - The Blackfeet: Raiders on the Northwestern Plains, John C. Ewers (1958:9).

Ethnohistoric documentation highlights the connection between the seasonal weather patterns and the annual "ceremonial calendar," which is important because it provides insight into the complex temporal relationship between traditional practices, land use, and bison.

Additional anthropological research organized Blackfoot land use activities by the season and specific ecotones on the landscape they occupied during a specific time of year. For example, it was noted that during the spring, Blackfoot groups collected tubers and roots in the foothills and mountains. The prairie turnip (Psoralea esculenta) was collected in the spring and was known as pomme blanche by French fur traders of the Hudson's Bay and American Fur Company (McClintock 1999:204). Kornfeld et al. (2010:351) note, that different plant resources are distributed at different elevation gradients, therefore, plant resources would be available throughout the spring and early summer as plants ripened much later during the season because they were located at higher elevations. Every Spring they went to the mountains to cut new lodge poles and camas roots (McClintock 1999:53). Winter camps (which were in river valleys) were abandoned for upland areas to avoid spring runoff dampness (Morgan 1979:175). Spring was the time when Blackfoot harvested buffalo tongues for specific traditional practices that were to be held later in the summer (McClintock 1999:160) and Wissler (1910:41) noted that bulls were in the best condition to hunt in June. Ancestral Blackfoot movement from the spring to summer followed an east-west axis, which makes sense as different plant communities came into season according to their elevation gradients.

As bands moved out onto the plains during the summer, both communal and

opportunistic hunts were carried out. Bison were harvested and bones were processed to extract grease, which was combined with ripe chokecherries and berries to make pemmican (Grinnell 1892; Bamforth 2011:30). As they became ripe, chokecherries, sarvis berries, and bullberries were collected on the plains in riparian areas. Mineral resources such as red ochre was collected, which could be found in small pockets of sandstone and limestone (Kornfeld et al. 2010). One location documented for mineral collection is located out on the plains along present-day Armell Creek or Itsis'kiotop or "It Crushes Them Creek." According to an unpublished manuscript in the Blackfeet THPO Archives, a group of Blackfoot women were gathering red paint along the edge of the creek when the bank caved in and crushed them to death. Yellow Paint Coulee (located outside of present-day Shelby, MT) is named for the yellow paint minerals collected by the Blackfeet (accessed Blackfeet THPO records July 2022). Both locations are farther away from the Northern Front out on the plains and provide evidence that the Blackfoot travelled to and inhabited the plains during the summer season to hunt and gather resources.

According to Schultz (1962), during the summer the Blackfoot occupied the plains in favor of river valleys and foothills, since low-lying river valleys would be hot, infested with insects, and foul with the smell of decomposing kills. This is supported by more recent anthropological research which argues that pedestrian hunters, dogs, and bison could all depend on surface water bodies such as kettle lakes and small seasonal springs; the pedestrian Blackfoot could afford to camp on the open plains and hunt using pounds or traps that required less topographic relief (Bethke 2017:809). When multiple bands camped together during these summer months, it provided opportunities to form, renew, and strengthen political alliances and to discuss the "economic, political, and military problems of the entire tribe and to make plans

for the future (Ewers 1958:90-91). Blackfoot bands aggregated into larger bands of ~100 or more people, which provided enough labor to design, construct, and refortify drive line complexes up until early fall (Grinnell 1892:234; Zedeño et al. 2014).

Communal hunting episodes intensified during the fall and early winter as Blackfoot processed enough storable food that would last them through harsh winter conditions (Ewers 1958; Grinnell 1892) . Fall was particularly important as hunters recognized the quality of meat and hides during this time, and Wissler (1910:41) observed that the cows were prime when the leaves began to fall. As bison migrated back towards the mountains and wooded areas for shelter, the Blackfoot likewise moved their camps to the river bottoms, which provided shelter, access to water, and additional subsistence such as deer and elk (Ewers 1955:76; Arthur 1962; Grinnell 1892: 234; Schaeffer 1978:) Ewers (1958:12) notes that "as the days grew shorter and colder in late fall, the hunting camp moved to the edge of a wooded area in anticipation of the buffalo migration to winter shelter."

Winter camps, especially those associated with the jumping and processing of communal kills would favor riparian zones that provided not only the suitable topography for the hunt, but also the large amounts of water and wood necessary to process large kills (Vickers and Peck 2004). According to Catlin, Blackfoot would winter in heavily timbered bottoms near streams and close to surrounding bluffs which provided more shelter from the wind (Catlin 1965). During the winter, Blackfoot headmen or medicine men kept track of winter by notching a stick (Ewers 1958) and provided a way for the Blackfoot to know when it was time to move from their winter camps. According to McClintock (1999:423), Iron Shirt kept track of winter counts and noted a winter moose came into camp, and "there was one winter the Blackfoot caught antelope

in the deep snow.

Anthropological and ethnohistoric documentation furnishes a comprehensive description of the traditional relationship between the Blackfoot, the environment, and bison, and research indicates that this information was inextricably embedded within the traditional Blackfoot knowledge system. This knowledge was transferred to descendant generations through traditional protocols and practices through songs and stories. As recorded by the early 18th-century anthropologist, McClintock attended a traditional ceremony and documented a song that demonstrated the knowledge base of ancestral Blackfoot of bison behavior:

> "The Buffalo likes to live in the mountains during the autumn.
> He comes down from the mountains to the plains.
> The Mountains are his Medicine" (1999:82).

The documentation of this song provides evidence that the Blackfoot people thoroughly understood complex ecological processes, including bison behavior and their movements in response to the climatic and environmental conditions, demonstrating how interconnected bison are to traditional Blackfoot practices. As noted earlier, as Blackfoot bands aggregated to carry out communal hunts, and while they gathered into these larger *suprafamily* bands, they carried out traditional practices, that served as important community functions, including traditions that were known to call bison to nearby hunting grounds (Ewers 1958:167-169; McClintock 1999; Wissler 1912:175). The traditional practices associated with bison hunting brought bands together and served as important community functions and bands organized into "esoteric" societies which functioned as regulatory institutions that were responsible for planning all aspects of the hunt, including the location of drive lines and adjacent camps (Ewers 1955:248; Bastien 2004; Zedeño et al. 2014).

> "The pipes and bundles form the societies that shape the organizational behavior of the people, Balance is the mission of Siksikaitsitapi culture, and through the organization of societies, balance is manifested in the values, norms, and roles of the people," (Bastien 2014:11).

One Blackfoot ceremonial bundle in particular played a critical role in communal bison hunting and was used in bison hunting ceremonies (Reeves 1993; Peck 2002; Zedeño 2008; Zedeño 2017). Ethnographic documentation is especially important to consider because it helps us understand the social and environmental organization of the Blackfoot that is directly related to resource availability and topographic diversity as they followed their ceremonial calendar on the landscape. Vickers points out, "Any discussion of the Native seasonal round should consider not only resource distributions in space and time, but also the human social organization. It is the human group that formed the economic unit which harvested the resources of the environment."

Red Blanket Bison Drive Line

The Red Blanket study area is located on the Blackfeet Indian Reservation and lies between the North Fork and South Fork of Cut Bank Creek. The study area covers ~8 km^2 and contains the Red Blanket drive line (Figure 3) which is located on an east-northeast trending moraine terminating at the Cut Bank Creek river valley. The Blackfeet Tribal Historic Preservation Office documented each cairn of the drive line to better understand the spatial use of this landscape. A comprehensive field survey documenting the full extent of the Red Blanket drive line provided an opportunity to engage and interact with the physical environment to gain a nuanced understanding of the topography, vegetation, and other intrinsic features that could not be conveyed with GIS data alone. This first-hand experience was critical for interpreting patterns identified during the analysis of the larger network of 61 sites. The length of the drive line is ~3.5



Figure 3. Red Blanket drive line situated on a glacial moraine flanked by a kettle lake.

km and is made of 622 rock cairns that were documented in 2021 and 2022. This complex is made of a primary line spanning the entire length of the site; secondary and tertiary lines were identified during the field survey, both of which are located parallel to the primary line. Furthermore, THPO staff identified additional drive line extensions oriented perpendicular to the primary line. The local vegetation includes short grass prairie and juniper, and the rock cairns were moderately and heavily sodded with lichen. During the field survey, additional archaeological sites were identified and recorded, including fasting beds and lodge rings.



Figure 4. Terminus of the Red Blanket drive line at Cut Bank Creek.

Although a kill site was not identified, spatial patterns such as the terminus of the drive line at the edge of a bluff allow us to infer a kill site at the bottom of the fluvial plain (Figure 4). The Red Blanket study area was dramatically shaped by the legacy of glaciers that formed the U-shaped Cut Bank Creek Valley and left glacial-fluvial topographic features such as moraines, kettle lakes, meltwater channels, post-glacial streams and river terraces, and outwash till. The unique attribute of the Red Blanket drive line is that it is heavily defined by post-glacial topography and is situated on top of a glacial moraine with steep banks, which served as a natural barrier to guide bison movement in a southeasterly direction towards the Cut Bank Creek River valley. Grazing areas and kettle lakes are present to the north and south of the study area, providing a gathering basin to draw bison to the area. The drive line trends to the southeast and terminates at the fluvial valley. The surrounding glacial till provided ample resource materials for the extensive fortification of the drive line complex (Figure 2). Wissler and Duvall's (1908) ethnographic work further connects the importance of the environment to bison as written,

> "Buffalo is going to drink.
> Water is my medicine
> Buffalo is going to eat.
> Grass is my medicine" (1908:101).

Water was a critical resource for survival, not only for the Blackfoot people but for bison as well. According to the Blackfeet worldview, water was home to nonhuman entities and is the birthplace of the medicine elk, also known as Wind Maker (Zedeño and Murray 2015). The legacy of the last glaciation significantly influenced the spatial layout of the Red Blanket drive line complex which resulted in an environment highly attractive to bison and optimal topography for drive line design and communal bison hunting.

Geospatial Analysis: Methodological Approach

Geospatial analysis enables us to visually and quantitatively reconstruct patterns of Blackfoot traditional land use across larger landscape scales, highlighting their social investment in landscape architecture within their traditional territory (limited to Montana USA for the purposes of the study). We obtained GIS data for 61 drive line site locations from the Blackfeet THPO, Montana State Historic Preservation Office (SHPO), and the University of Arizona BARA. We completed a data-use agreement to access the Montana SHPO database. Per SHPO recommendation, we used the search term "game drives" in the counties only in the study area; this yielded 91 game drive sites which each have an associated Cultural Resource Information System (CRIS) form. Next, we reviewed each CRIS form to ensure that all sites were truly "game drives." The sites were quality checked by using the following criteria, 1) classified as game drive or 2) classified as drive line. We did not include sites that were described as "hunting blinds." Next, we recorded the Smithsonian number of each site that was classified as a game drive or drive line and requested the GIS data from the MT SHPO. The MT SHPO provided GIS data for 50 sites as not every documented site in the database has GIS data. The remaining 11

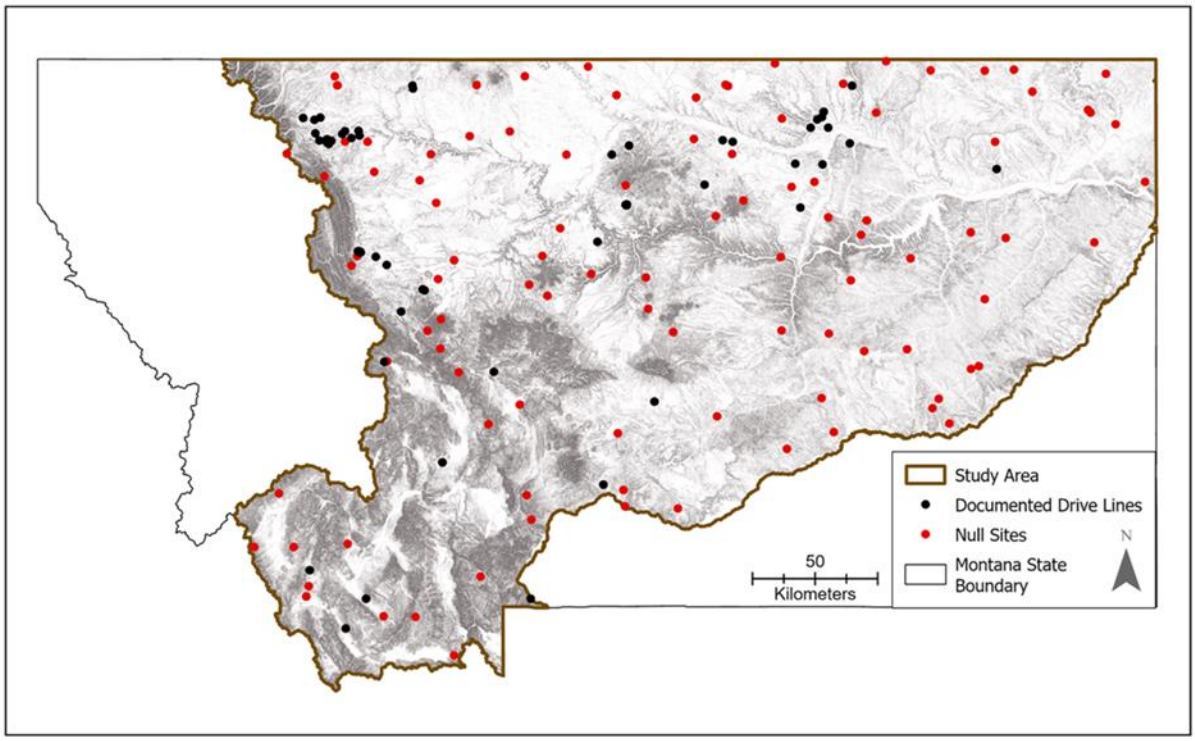


Figure 5. Map of bison drive lines and null sites in study area.

drive line sites and GIS data were obtained from the Blackfeet THPO Office (2) and the University of Arizona BARA (9), with a total of 61 drive line sites to analyze in this study.

To better understand whether the location of drivel lines was associated with specific landscape features, we compared the distances between the 61 drive lines and randomly generated null sites (Figure 5), with three environmental variables: 1) forest areas, 2) rivers and streams, and 3) wetlands and kettle lakes. The drive line sites represented in the map above are offset by 1 km, following the guidance of the Blackfeet Tribal Historic Preservation Officer (THPO), John Murray, and the Montana State Historic Preservation Officer (SHPO), Damon Murdo. Consultation with the Blackfeet THPO and MT SHPO was crucial to ensure culturally sensitive data remained protected to preserve site integrity. It is important to note that the dating

of the material used to build the drive lines spans from recent centuries to 2,000 years and not all have been clearly identified as being utilized by the Blackfoot. Highlighting the significance of the ontological relationship between the Blackfoot and the environment and integrating ethnohistoric documentation provides a framework from which to conduct this geospatial analysis and provides context to the spatial mapping of these sites.

Blackfoot oral traditions and ethnographic research provide clear evidence that drive lines were not established on landscapes randomly, but that they are specifically located in proximity to important landscape features such as bluffs, cliffs, and coulees that helped drive bison towards an intended kill site (Grinnell 1892:228; Lewis 1947:8; Ewers 1949:355; Kehoe 1973:6, Reeves 1978:63; Schaeffer 1978:245; Verbicky-Todd 1984; Barsh and Marlor 2003:275; Kornfeld et al. 2010; Oetelaar 2014:11; Zedeño et al. 2014: 26; Bethke 2017;800; Brink 2017). Blackfoot traditional territory encompasses the Northern Front and foothills that is marked by the legacy of glacial activity that important as forested areas provided fuel and construction materials for pounds and drive lines.

GIS Analysis Methods

The geospatial analysis was conducted in the software program ArcGIS Pro (Version 3.1.1). First, we created a polygon shapefile of the study area of Traditional Blackfoot Territory in Montana; the study area polygon was projected into the North American Datum 1983. Next, we imported the GIS data (Blackfeet THPO and University of Arizona BARA) for the drive lines and created a 1-kilometer buffer for each drive line to remain consistent as the MT SHPO drive lines which all had buffers (polygon shapefiles). Next, we obtained GIS data of the environmental variables: 1) forested areas from the 2019 National Landcover Database

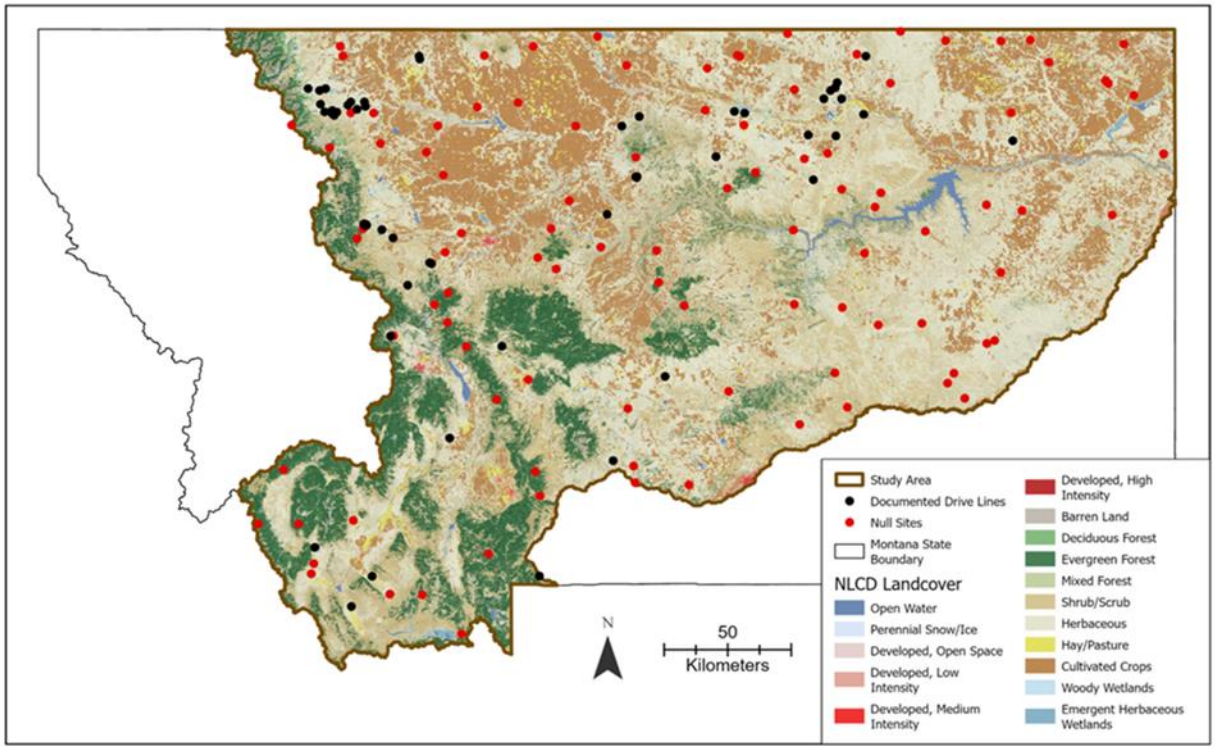


Figure 6. Map of site types (bison drive lines and null sites) and locations according to landcover (National Landcover Database 2019).

(USGS and Dewitz 2021), rivers and streams (Montana GIS Library), and 3) wetlands and kettle Lakes (Ecological Mapping and Monitoring Group;2022). All datasets were imported into the software program and clipped to the study area. (Figure 6).

In order to randomly generate 61 null sites for the comparison analysis, we had to create a polygon shapefile (of the study area) that was most representative of "bison habitat," so the

null sites were not generated on locations where bison would not normally live (i.e. open water, forested areas, barren land, and perennial ice and snow). To achieve this, we used the "Extract by Mask" tool to create a raster that excluded those particular land cover classes, then we used the "Convert to Polygon" tool; the output created a polygon shapefile; this was required. utilizing the "Create Random Points" tool, which randomly generated the 61 null sites (points).

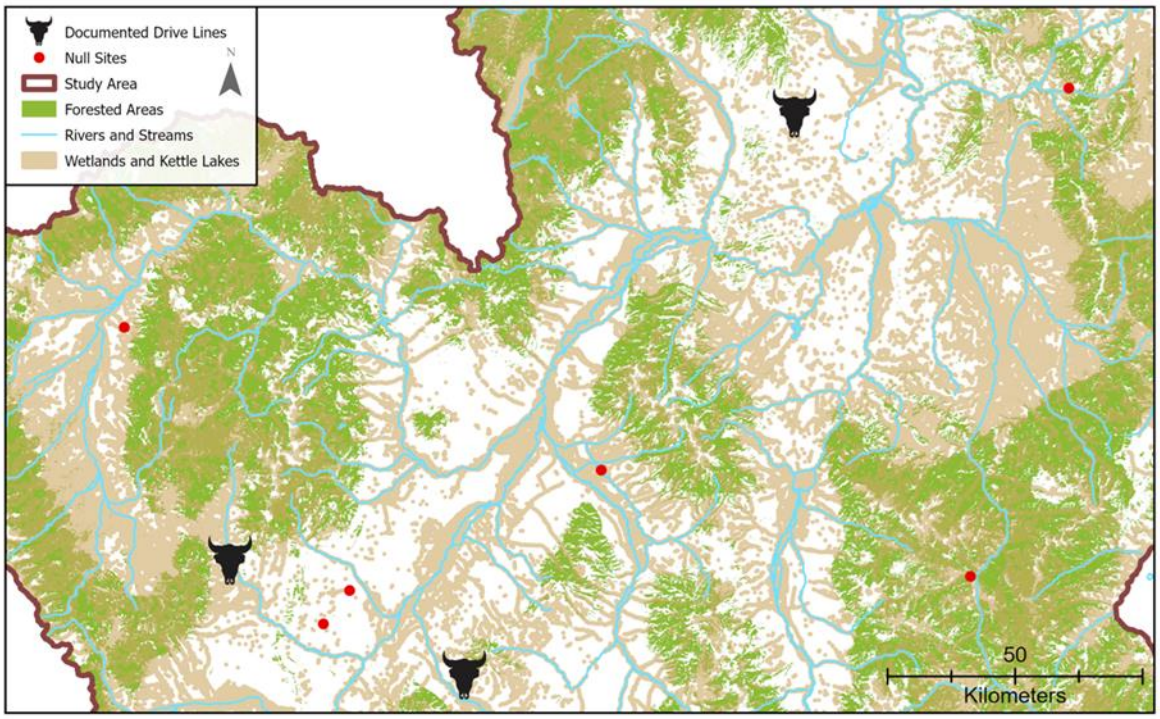


Figure 7. Small - scale map of drive lines and null sites in study area.

Statistical Analysis

In ArcGIS Pro, we calculated the distances between the environmental variables (forested areas, rivers and streams, wetlands and kettle lakes), to the drive lines and null sites. We did this by using the "Generate Near Table" tool; the distances were calculated in kilometers using the Planar Method, which uses the straight-line Euclidean distance. This tool created additional fields in the attribute tables of the drive lines and null sites that provide the nearest distance to: forested areas 2) rivers and streams 3) wetlands and kettle lakes. We used the "Summary Statistics" tool to calculate the average distances between site types and environmental variables. Lastly, we used Rstudio (version 2023.09.1+494), to create Violin Plots with box plots and iitter points (Figure 8) to visualize and compare the distribution of distances between site type (drive line and null sites) and the environmental variables (forested areas, rivers and streams, wetlands

and kettle lakes). Additionally, we ran a KS – Test to determine if the results of the proximity analysis between the drive lines and null sites were statistically different. To create the plots, we used the "ggplot2" package and the R script outlined in the Appendix. We applied a log transformation to the data because there was a wide range of distances between the two site types, and they were not evenly spread out. The log transformation function compressed the larger values and spread out the smaller values, which made the data more symmetrical and closer to the normal distribution, improving the interpretation of the data.

Results

The comparison of the average distances (km) between the site types (drive lines/null sites) and the selected environmental variables are shown in Table 1 in the Appendix. The average distance between the forested areas (Deciduous, Evergreen, and Mixed Forests) and the drive lines was 0.2 km (SD = 0.0), compared to 4.3 km (SD = 6.1) for null sites. The average distance between the rivers and streams and drive lines was 0.02 km (SD = 0.02), compared to 2.8 km (SD = 2.63) for null sites. The average distance between the wetlands and kettle lakes and drive lines was 0.03 km (SD = 0.05), and 4.5 km (SD = 0.0) for null sites. These results suggest that on average, drive lines were located closer to the environmental variables than the null sites. The results of the Violin plots provide a visual representation of the spatial distribution of the drive lines and null sites for each environmental variable (Figure 8), allowing us to visualize their spatial distributions. The results of the KS test results are as follows: distance to the nearest forested area: $D = 0.93443$, p-value of < 0.001; the distance to the nearest river or stream: $D = 0.95082$, p - value < 0.001, and distance to the nearest wetlands and kettle lakes: $D = 0.77049$, p - value <

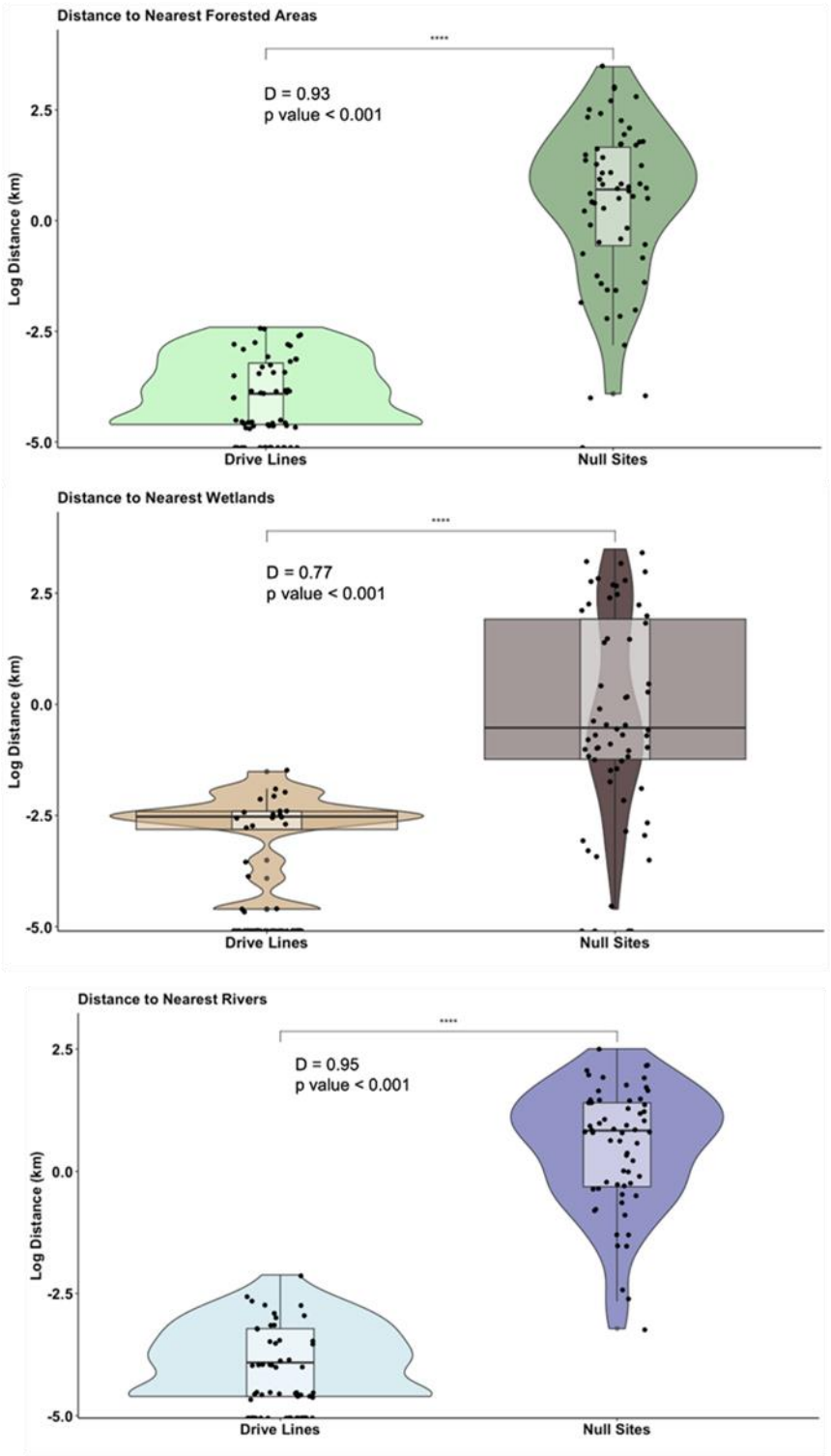


Figure 8. Violin plots of site types (drive lines and null sites) and their geospatial distributions of log-transformed distances (km) to 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes.

0.001. The KS test provided the "D" value; when this value is closer to 1, the distributions of the datasets are significantly different. Notably, the "p – value" for the statistical analysis comparing the distances between the site types (drive lines/null sites) were all less than 0.001, indicating that there is a low probability that the difference observed between the two site types are due to random chance.

The findings of the analysis advance our understanding of the geospatial dimensions of Blackfoot land use by quantifying the distances between the location of drive lines and their proximity to important environmental resources. We were able to determine that the drive lines on average, were located closer to the forested areas, rivers and streams, and wetlands and kettle lakes, compared to the null sites. This geospatial analysis is further enhanced by an overview of ethnohistoric documentation and previous anthropological studies, which provide detailed information about the seasonality of Blackfoot land use related to communal bison hunting. The quantitative results of this analysis provide evidence that traditional Blackfoot practices are embedded with deep-time knowledge of the environment. The violin plots are particularly important as they provide a way for us to visualize this complex relationship, comparing the distributions of the drive lines and the null sites and their distances (km) to each environmental variable.

Discussion

The overall results of this analysis demonstrate that ancestral Blackfoot strategically designed and constructed drive lines integrating specific landscape features. A simple comparison of documented drive lines and randomly generated null sites suggests drive lines were built close to important resources and landscape features (fresh water, forested areas, and

wetlands and kettle lakes). Drive lines were established close to wooded areas, which provided critical resources including fuel for firewood, construction materials for lodges, pounds and traps, and shelter during the harsh winter months (Ewers 1958; Kehoe 1973:6; Bethke :2017; Vickers and Peck, 2004; Zedeño et al. 2014:31and Bethke 2017:800). Proximity to fresh water was required for subsistence and bison harvesting and processing activities (Kehoe 1973:6; Bethke 2016), and wetlands and kettle lakes served as a water source for bison and gathering basin from which to orient the drive lines toward the kill site (Oetelaar 2014).

Highlighted in this text are the Red Banket and Kutoyis drive line complexes which were uniquely designed to the topographic contours and geographic nuances of each landscape. Similarly, the drive lines conform to the funnel shape and were strategically built on the southern banks of river valley systems and planned according to the westerly prevailing winds; adjacent to these areas is immediate access to the availability of construction material, firewood, sheltered river valley bottoms, and an abundance of fresh water. The surrounding landscape is marked with undulating foothills, kettle lakes, small drainages, coulees, and river valley systems.

Comprehensive research by Zedeño et al. (2014) provides detailed information about the Kutoyis drive line complex, topography, and environmental conditions. This site is located on the high, steep ridges and sandstone cliffs that confine the Two Medicine River Valley (35-40 m above the valley floor) above the mouth of Badger Creek; the drive line extends along the gently rolling hillslopes upwards towards the precipice of steep valley. The kill site below contains stratified evidence of repeated communal bison- hunting episodes, a primary butchering area, a processing area, and an encampment that extends across the floodplain. Alternatively, the Red Blanket drive line complex is located closer to the Northern Front and was built on a glacial

moraine which terminates in a small drainage abruptly descending into the Cut Bank Creek valley floor. This drive line is heavily fortified in areas prone to erosion and where bison could easily escape; this site has not been systematically surveyed; however, multiple drive line extensions were identified, along with lodge rings and fasting beds. Given the common topographic and environmental characteristics, it is important to emphasize that each drive line is uniquely engineered to the landscape. This has implications pertaining to the other 59 drive line sites as part of this analysis. "Regularities in orientation, exposure, elevation, and angle of the slope leading to the jump shaped the decisions about funnel layout and hunting tactics and helped to predict future system uses," (Ballenger, Zedeño, and Fenner 2009 and Zedeño et al. 2014). Additional research by Zedeño and Jansson (2021), utilizes geospatial tools to conduct viewshed analyses of ten drive lines systems located in the Two Medicine River Valley (Montana). This study provides evidence that the terminus of these drive lines is generally hidden from the lead bison cow's viewshed. Of the ten drive lines, two had the intervisibility of 25% and 22%, three jumps had 0% visibility, and the remaining had between 0% and 2%. The three jumps were considered moderately to highly successful as evidence of drive line refortifications, two or more falls, and substantial bonebeds (2021:25). This research is important as it provides a unique suite of GIS methods to better understand the drive lines and the surrounding geographies.

Mapping the locations of drive lines provides a visual representation of the geospatial dimensions of Blackfoot land use patterns on a broader scale. Given previous anthropological documentation and research, we can infer which drive line sites were utilized in the fall and winter versus which drive lines were utilized in the spring and summer. This study advances our

understanding of the environmental information held within the Blackfoot knowledge system, and how the Blackfoot used knowledge of bison behavior and resource availability according to the seasons, as they moved across the landscape following their ceremonial calendar and established complex landscape architecture. Further research evaluating the geospatial positioning of drive lines could reveal finer-scale features associated with drive line design and positioning.

In conclusion, the geospatial analysis presented here complements ethnohistoric documentation and previous anthropological research and providing evidence of a comprehensive deep-time knowledge system practiced by ancestral Blackfoot. This knowledge system encompasses an understanding of the environment inclusive of tangible resources such as bison and environmental resources, and intangible resources such as songs, stories, and traditional practices, all of which contributes to the story of the cultural landscape. Ethnographic information including a song documented by Walter McClintock demonstrates Backfoot having knowledge of bison behavior, specifically the season in which bison migrate to the mountains and onto the plains, and organized their land use patterns accordingly. The bison hunting complex is a product of physical and metaphysical knowledge and experience that speaks to the ancient and intricate relationships among Blackfoot, bison, and the cultural landscape.

CHAPTER FIVE

CONCLUSION

This study integrates traditional Blackfoot knowledge, ethnohistorical data, and geospatial science to study a cultural landscape and address potential blind spots in both fields of cultural heritage preservation and GIS. I used a transdisciplinary approach to provide a more "complete" biographical record of the Blackfoot cultural landscape, and in this case, contributing to a more thorough understanding of ancestral bison hunting practices on a broader scale. Geospatial analysis enhanced this study and provided a unique way to examine and visualize the ancient relationship between Blackfeet, bison, and the environment.

This innovative framework appropriately integrated Blackfoot epistemology and ethnohistorical data pertaining to both tangible and intangible resources associated with ancestral Blackfoot bison hunting practices and the cultural landscape. The Blackfoot creation story explains how Old Man shaped the ancestral territory of the Blackfoot including the mountains or *Mistakiiks*, meaning "backbone of the world," the Rocky Mountain Front or *Soystakiiks,* meaning "shore of the mountains", and other important features including the rivers, buttes, and prairies. Additionally, Old Man created the flora and fauna, and the first man and woman. This creation story is embedded within the Blackfoot cultural landscape, which encompasses tangible elements such as archaeological sites, and intangible elements such as traditional practices, songs, stories, and reciprocal relationships with the plants, animals, weather, and night sky. As a Blackfoot scholar, it was important to connect my heritage to my research, as I seek to challenge and reshape dominant narratives, ensuring that Indigenous perspectives are elevated in academic discourse.

This work has broader implications for academia conducting research on cultural landscapes, which are dynamic living systems, shaped by the deep-time relationship between an Indigenous community and the environment. Cultural landscapes go beyond the conventional Western understanding of landscapes as physical spaces and natural resources, and encompasses the spiritual, social, and ecological dimensions embedded within the traditional practices of Indigenous peoples over multiple temporal and spatial scales. It is critical that academia conduct research alongside Indigenous communities, as I have demonstrated, working under the guidance of the Blackfeet Tribal Historic Preservation Office. Lastly, this research has broader implications for Indigenous communities working to protect and preserve their cultural landscapes using GIS, which remain an interconnected living system and lifeway for future generations.

CUMULATIVE REFERENCES CITED

Anschuetz, K. F., et al. (2001). An archaeology of landscapes: perspectives and directions. Journal of Archaeological Research 9: 157-211.

Bamforth, Douglas B. (1988). Ecology and Human Organization on the Great Plains. Plenum Press, New York.

Barsh, R. L., & Chantelle Marlor. (2003). Driving Bison and Blackfoot Science. Human Ecology, 31(4), 571–593.

Bastien, B. (2004). Blackfoot ways of knowing: The worldview of the Siksikaitsitapi, University of Calgary Press.

Bethke, B. E. (2016). Dog Days to Horse Days: Evaluating the Rise of Nomadic Pastoralism Among the Blackfoot, The University of Arizona.

Bethke, B. (2017). The archaeology of pastoralist landscapes in the Northwestern Plains. American Antiquity 82(4): 798-815.

Brink, Jack (2008). Imagining Head-Smashed in: Aboriginal Buffalo Hunting on the Northern Plains. AU Press, Edmonton.

Brink, J. W. (2017). Communal bison drives of the Northern Plains of North America. The Gazelle's Dream, Game Drives of the Old and New Worlds.

Bowser, B. J. and María Nieves Zedeño (editors) (2009). The Archaeology of Meaningful Places. University of Utah Press, Salt Lake City.

Changnon, D., et al. (1991). Hydroclimatic variability in the Rocky Mountain region, Colorado State University. Libraries.

Clark, B. J. and L. L. Scheiber (2008). A sloping land: an introduction to archaeological landscapes on the High Plains. Archaeological landscapes on the High Plains: 1-16.

Droj, G. (2010). "Cultural heritage conservation by GIS." GISOPEN; Nyugat-Magyarországi Egyetem, Geoinformatikai Kar: Székesfehérvár, Hungary.

Dewitz, Jon. (2021). National Land Cover Database (NLCD) 2019 Products [Data set]. U.S. Geological Survey.

Ecological Mapping, Monitoring and Analysis (EMMA) Group. (2022). Montana Wetland and Riparian Framework. Montana State Library. Helena, Montana.

Ewers, J. C. (1949). The last bison drives of the Blackfoot Indians. Journal of the Washington Academy of Sciences 39(11): 355-360.

Ewers, J. C. (1955). The horse in Blackfoot Indian culture, with comparative material from other western tribes. Bureau of American Ethnology Bulletin.

Ewers, J. C. (1958). The Blackfeet: Raiders of the Northwestern Plains. Norman, University of Oklahoma Press.

Frison, G. C. (. (1974). The Casper site: a Hell Gap bison kill on the high plains. Academic Press,

Grinnell, G. B. (1892). Blackfoot Lodge Tales: The Story of a Prairie People. New York, Charles Scribner's Sons.

Habeck, J. R. (1987). Present-day vegetation in the northern Rocky Mountains. Annals of the Missouri Botanical Garden: 804-840.

Hamilton, Marcus J., José Lobo, Eric Rupley, Hyejin Youn, and Geoffrey B. West. (2014) The Ecology and Energetics of Hunter-Gatherer Residential Mobility. Santa Fe Institute Working Papers 2014:1–20.

Hollenback, K. L. (2014). Elevated Landscapes in the Northern Plains, Hidatsa Butte-Top Settlements as Places of Refuge. Engineering Mountain Landscapes: An Anthropology of Social Investment., The University of Utah Press: 186-190.

Kehoe, T. F. (1960). Stone tipi rings in north-central Montana and the adjacent portion of Alberta, Canada: their historical, ethnological, and archeological aspects, US Government Printing Office.

Kehoe, T. F. and F. Eyman (1973). The Gull Lake site: a prehistoric bison drive site in southwestern Saskatchewan. Milwaukee Public Museum.

Kornfeld, M., Frison, George G., Larson, Mary Lou (2010). Prehistoric Hunter-Gatherers of the High Plains and Rockies. New York, NY, Left Coast Press Inc.

Lanoë, F., Zedeño, M. N., Jansson, A., Holliday, V., Reuther, D. (2021). "Glacial kettles as archives of early human settlement along the Northern Rocky Mountain Front." Quaternary Research: 1-16.

LaPier, R. R. (2017). Why is water sacred to Native Americans? Open Rivers: Rethinking Water Place & Community (8).

Lewis, H. P. (1947). Copy of an Unpublished Manuscript About the Buffalo Kills of Montana. Conrad, Montana, Midwest Archaeological Center, National Park Service.

Malanson, G. P., et al. (2002). Variability in an edaphic indicator in alpine tundra. Catena 49(3): 203-215.

McClintock, W. (1999). The Old North Trail: Life Legends and Religion of the Blackfeet Indians. Lincoln, University of Nebraska Press.

Meyer, G. A. O. and David (2006). "Movement of Native American Landscapes: a comparative approach." Plains Anthropologist 51(199): 355-374.

Montana State Library. (1993). Montana Streams and Lakes, Generalized. Montana State Library. Helena, Montana.

Morgan, R.G. (1979). An Ecological Study of the Northern Plains as Seen Through the Garratt Site. Department of Anthropology, University of Regina, Occasional Papers in Anthropology 1. Regina.

Morgan, R. G. (2020). Beaver Bison Horse: The Traditional Knowledge and Ecology of the Northern Great Plains. Regina, Saskatchewan, Canada, University of Regina Press.

Odum, E. P. (1971). Fundamentals of Ecology. Philadelphia, London, Toronto, W.B. Saunders Company.

Oetelaar, G. A. O. and D. Joy (2006). People, places, and paths: the Cypress Hills and the Niitsitiapi landscape of southern Alberta. Plains Anthropologist 51(199): 375-397.

Oetelaar, G. A. and D. J. Oetelaar (2008). Indigenous stewardship: lessons from yesterday for the parks of tomorrow. Contributed paper for the Canadian Parks for Tomorrow: 40th Anniversary Conference, May

Oetelaar, G. A. (2014). Better homes and pastures: Human agency and the construction of place in communal bison hunting on the Northern Plains. Plains Anthropologist 59(229): 9-37.

Peck, T. R. (2010). Light from ancient campfires: archaeological evidence for native lifeways on the northern Plains, Athabasca University Press.

Pickering, E. (2020). Reaching Environmental Sovereignty Through Cultural Resilience: Blackfeet Water Compact, The University of Arizona.

Peck, Trevor. (2004). Bison Ethology and Native Settlement Patterns during the Old Women's Phase on the Northwestern Plains. BAR International Series 1278. Archaeopress, Oxford.

Reeves, B. O. K. (1978). Bison Killing in the Southwestern Alberta Rockies. Plains Anthropologist.

Reeves, B. O. K. (2003). Mistakiis: The Archaeology of Waterton-International Peace Park. L. B. D. Bourges and Claire. Final Report prepared for the National Park Service under agreement with Montana State University.

Roos, C. I., Zedeño, N.M., Hollenback, K., Erlick, M.M. H. (2018). Indigenous impacts on North American Great Plains fire regimes of the past millennium. Proceedings of the National Academy of Sciences of the United States of America 115(32): 8143-8148.

Roos, C. I. (2020). Scale in the study of Indigenous burning. Nature Sustainability 3: 898-899.

Schaeffer, C. E. (1978). The Bison Drive of The Blackfeet Indians. Plains Anthropologist 23(82): 243-248.

Scheiber, L. L. (2014). Paths, Places, and Positions: Exploring Rocky Mountain Landscapes as a Resource, Symbol, Wilderness, and Refuge. Engineering Mountain Landscapes: An Anthropology of Social Investment. Engineering Mountain Landscapes. L. L. S. Zedeño and N. Maria, The University of Utah Press: 23-48.

Schultz, J. W. (1962). Blackfeet and buffalo: Memories of life among the Indians, University of Oklahoma Press.

Service, N. P. (2022, June 15, 2021). Cultural Landscapes. Retrieved September 14, 2022, from https://www.nps.gov/subjects/culturallandscapes/understand-cl.htm.

Verbicky-Todd, E. (1984). Communal buffalo hunting among the Plains Indians: an ethnographic and historic review, [Edmonton, Alta.]: Alberta Culture, Historical Resources Division.

Vickers, J. R. (1991). Seasonal round problems on the Alberta Plains. Canadian Journal of Archaeology/Journal Canadien d'Archéologie: 55-72.

Vickers, J. R. and T. R. Peck (2004). Islands in a sea of grass: The significance of wood in winter campsite selection on the Northwestern Plains. Archaeology on the Edge: New Perspectives from the Northern Plains: 95-124.

Zedeño M. N., J. A. M. B., and J. R. Murray (2014). Landscape Engineering and Organizational Complexity among Late Prehistoric Bison Hunters of the Northwestern Plains. Current Anthropology 55(1): 23-58.

Zedeño M. N., W. F. M., and J. R. Murray (2015). Central Places in the Backcountry: The Archaeology and Ethnography of Beaver Lake, Montana. Engineering Mountain Landscapes: An Anthropology of Social Investment. L. L. S. Zedeño and N. María. Salt Lake City, The University of Utah Press: 7-22.

Zedeño, M. N. (2008). Bundled Worlds: The Roles and Interactions of Complex Objects from the North American Plains. Archaeological Method Theory 15: 362-378.

Zedeño, M. N. (2017). Bison hunters and the Rocky Mountains: An evolving partnership. Quaternary International 461: 80-101.

Zedeño, M. N. (2017). Art, as the Road to Perfection: The Blackfoot Pained Tipi. Cambridge Archaeological Journal 27(4):631-642.

Zedeño, M. N. and L. L. Scheiber (2015). People and mountains. Engineering mountain landscapes: An anthropology of social investment: 186-192.

Zedeño, M. N., Pickering, E., Lanoë, F. (2021). Oral tradition as emplacement; Ancestral Blackfoot memories of the Rocky Mountain Front. Journal of Social Archaeology 0: 1-23.

Zedeño, M. N. and A. Jansson (2021). The bison hunting complex in the Northern Rockies. In The Gazelle's Dream, pp. 55-80. Sydney University Press.

APPENDICES

APPENDIX A

R SCRIPT FOR VIOLIN PLOTS

Below is the script used in RStuido to create the violin plots with box plots and jitter points:

```
###Violin plots with Box Plots and Jitter Points###
library(ggplot2)
library(readr)
library(tidyverse)
library(ggpubr)
setwd("/Users/kendallr.edmo/Desktop/Violin Plots Rstudio")
short_data <- read_csv("~/Desktop/Violin Plots Rstudio/short_data.csv")
View(short_data)
#subset dataset to only include fores drive lines and forest random data
forest<-subset(short_data, site_type == "forest_dl" | site_type == "forest_r")
river<-subset(short_data, site_type == "river_dl" | site_type == "river_r")
wetland<-subset(short_data, site_type == "wetlands_dl" | site_type == "wetlands_r")
##LOG TRANSFORM##
forest$log_d<-log(forest$distance)
river$log_d<-log(rivers$distance)
wetland$log_d<-log(wetland$distance)
##library(ggpubr)
#plot figures with violin plot, raw data, boxplot, and significance values###
my_comparisons <- list(c ("forest_dl", "forest_r"))
ggplot(data =forest, aes(x=site_type, y=log_d, fill=site_type)) +
  geom_violin(alpha = 0.5)+
  geom_boxplot(alpha=0.5, width=0.1, fill="white")+
  geom_jitter(position = position_jitter(width = 0.1, height = 0.1))+
  scale_fill_manual(values=c("lightgreen", "darkgreen"))+ #Use this line of code to change the color of your violin plot
  theme_classic()+
  theme(axis.text.x = element_text(face="bold", color="black",
                                   size=14),axis.text.y = element_text(face="bold", color="black", size=14),legend.position = "none", plot.title = element_text(face="bold", size = 14),
        axis.title.y = element_text (face= "bold", size = 14))+
  scale_x_discrete(labels=c("forest_dl" = "Drive Lines", "forest_r" = "Null Sites"))+
  stat_compare_means(comparison = my_comparisons, label = "p.signif") +
  labs(title="Distance to Nearest Forested Areas", x="" ,y = "Log Distance (km)")
library(dplyr)
##Load subsets in environment##
forest_dl <- short_data$distance[short_data$site_type == "forest_dl"]
forest_r <- short_data$distance[short_data$site_type == "forest_r"]
# Perform KS test
ks_result <- ks.test(forest_dl, forest_r)
print(ks_result)
```

```
##River violin Plot##
my_comparisons <- list(c ("river_dl", "river_r"))
ggplot(data =river, aes(x=site_type, y=log_d, fill=site_type)) +
  geom_violin(alpha = 0.5)+
  geom_boxplot(alpha=0.5, width=0.2, fill = "white")+
  geom_jitter(position = position_jitter(width = 0.1, height = 0.1))+
  scale_fill_manual(values=c("lightblue", "darkblue"))+ #Use this line of code to change
the color of your violin plot
  theme_classic()+
  theme(axis.text.x = element_text(face="bold", color="black",
                                   size=14),axis.text.y = element_text(face="bold", color="black",
size=14),legend.position = "none", plot.title = element_text(face="bold", size = 14),
        axis.title.y = element_text (face= "bold", size = 14))+
  scale_x_discrete(labels=c("river_dl" = "Drive Lines", "river_r" = "Null Sites"))+
  stat_compare_means(comparison = my_comparisons, label = "p.signif") +
  labs(title="Distance to Nearest Rivers", x="" ,y = "Log Distance (km)")
##Wetlands###
my_comparisons <- list(c ("wetlands_dl", "wetlands_r"))
ggplot(data =wetland, aes(x=site_type, y=log_d, fill=site_type))+
  geom_violin(alpha = 0.8)+
  geom_boxplot(alpha=0.5)+
  geom_boxplot(alpha=0.5, width=0.2, fill = "white")+
  geom_jitter(position = position_jitter(width = 0.1, height = 0.1))+
  scale_fill_manual(values = c("tan", "#321414"))+
  theme_classic()+
  theme(axis.text.x = element_text(face="bold", color="black",
                                   size=14),axis.text.y = element_text(face="bold", color="black",
size=14),legend.position = "none", plot.title = element_text(face="bold", size = 14),
        axis.title.y = element_text (face= "bold", size = 14))+
  scale_x_discrete(labels=c("wetlands_dl" = "Drive Lines", "wetlands_r" = "Null
Sites"))+
  stat_compare_means(comparison = my_comparisons, label = "p.signif")+
  labs(title="Distance to Nearest Wetlands", x="" ,y = "Log Distance (km)")
```

.

APPENDIX B

TABLE OF AVERAGE DISTANCES BETWEEN SITE TYPES AND ENVIRONMENTAL VARIABLES

Table 1. Average distances (km) between site types (drive lines and null sites) and environmental variables 1) forested areas, 2) rivers and streams, and 3) wetlands and kettle lakes.

Site Type	Forested Areas Mean Distance (km)	Rivers/Streams Mean Distance (km)	Wetlands/Kettle Lakes Mean Distance (km)
Drive Line	0.22	0.2	0.3
Null Site	4.3	2.8	4.5

APPENDIX C

TABLE OF LANDCOVER CLASSES (NLCD)

FOR LOCATIONS OF SITE TYPES

Table 2. NLCD 2019 of site types (bison drive lines and null sites).

Landcover Class	Drive Lines	Null Sites
11- Open Water	1	0
12- Perennial Ice/Snow	0	0
21 - Developed Open Space	0	0
22 - Developed Low Intensity	0	1
23 - Developed, Medium Intensity	0	0
24 - Developed, High Intensity	0	0
31 - Barren Land	0	2
41 - Deciduous Forest	0	0
42- Evergreen Forest	1	0
43 - Mixed Forest	0	0
51- Dwarf Scrub	0	0
52- Shrub/Scrub	18	15
71 - Grassland/Herbaceous	38	25
72 - Sedge/Herbaceous	0	0
73 - Lichens	0	0
74 - Moss	0	0
81 - Pasture/Hay	0	2
82 - Cultivated Crops	0	11
90 - Woody Wetlands	2	2
95 - Emergent Herbaceous	0	2