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The Bad Pass Trail: An Examination as a Route of Least Resistance

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The Bad Pass Trail: An Examination as a Route of Least Resistance

by

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Abstract

The Bad Pass Trail is a 10,000-year-old prehistoric cairn-marked trail system, located within the naturally occurring Bighorn Canyon corridor. Its braided path marks a passable route across rugged terrain, connecting the Bighorn Basin of northcentral Wyoming and the Yellowstone River Basin of southcentral Montana. Until recently a comprehensive synthesis of locational data of all associated cairns was not available for application in spatial analyses. Using this most recent data I will test my hypothesis that the culturally created cairns of the Bad Pass Trail's route follow a path of least resistance through the Bighorn Canyon corridor as determined by terrain slope.

Measurements of near distance between cairn locations and computer-generated paths of least resistance comprise my dataset values. The application of critical values and numeric thresholds identify statistically significant occurrences. Cairns located within numeric thresholds likely share terrain slope as a primary influencing factor. My results demonstrate that terrain slope likely serves as primary influence upon cairn locations within the Bighorn Canyon corridor.

With an additional application of predictive intervals, I provide measurements which may one day aid in determining areas of increased likelihood for containing similar cairn features as measured from paths of least resistance. However, it is imperative to acknowledge caveats of examining prehistoric activities by quantitative testing alone. The ability to fully encapsulate complete understandings of complex stimuli acting upon prehistoric people through these tests is limited. Therefore, measurements and assumptions produced from quantitative tests are best used as tools for the development of future inquiries.

Acknowledgments

I am indebted to the many people who have offered their guidance throughout this thesis process. First, I would like to recognize my thesis committee members for their patience and their knowledgeable feedback: Dr. Kelly Branam Macauley, Dr. Mark Muñiz, Dr. Judson Byrd Finley, and Dr. Jeffrey Torguson. My gratitude extends to Dr. Molly Boeka Cannon and the Spatial Data Collection, Analysis, and Visualization Lab at Utah State University for offering such hospitality to visiting students.

An immense thank you to Kelly Branam Macauley and Chris C. Finley for inviting me to participate in this research opportunity. I am thankful for the open doors and endless humor offered to myself and my team by Chris and Grandma Inez. My appreciation does not fall short of my 2014 field crew, and I am honored to have been a member of our team. I would like to recognize as well the friends and family who provided encouragement in times when my own levels seemed waning. And a most sincere thank you to Rosemary Ginger for providing me with a family in an otherwise unfamiliar place.

I am grateful to the Rocky Mountains Cooperative Ecosystem Studies Unit, the Bighorn Canyon National Recreation Area, St. Cloud State University, and Northwest College, for providing students with the opportunities to participate in the research and management of our archaeological and cultural resources.

For my mother, Jean.
The influence of a strong mother is truly immeasurable.

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Chapter 1: Introduction

The Bad Pass Trail, a 10,000-year-old prehistoric braided cairn-marked trail system, spans 12 miles (nearly 20,000 kilometers) of rugged terrain through the Bighorn Canyon corridor of northcentral Wyoming and southcentral Montana (Figure 1.1). Within the corridor, the cairn-marked route is bound by the Bighorn River and Bighorn Mountains to its east, and the Pryor Mountain Range at its west. The Bad Pass Trail's route marks a spatial means for what was once a seasonal migration of prehistoric bison herds and connects Wyoming's more arid Bighorn Basin to the northern grasslands of Montana's Yellowstone River Basin (Oster 1994; Finley and Branam 2012; Loendorf and Brownell 1980). In a post-Pleistocene period of drastically changing glacial landscape and changing floral and faunal diversity, increased dependence upon bison procurement for means of subsistence caused prehistoric peoples to adapt their pedestrian movements to those of migrating bison herds (Oster 1994). Pedestrian movement in conjunction with bison migration is evident within the Bighorn Canyon well into the Historic period (Loendorf and Brownell 1980; Finley and Branam 2012).

Problem Statement and Research Goals

Listed on the National Register of Historic Places in October of 1975, the Bad Pass Trail is recognized for its associations with prehistoric and historic archeology, commerce, communication, and transportation, from prehistory through the 19th century (Finley and Branam 2012). Studies of the trail, as well as associated archaeological resources scattered along its corridor, delineated the route as it is currently understood: a travel corridor following a bison herd migratory route, and a foot trail utilized into the mid-1830s (Loendorf and Brownell 1980;

Finley and Branam 2012). It is a common theory that the Bad Pass Trail likely follows, in addition to a prehistoric bison migration route, a path of least resistance through the Bighorn Canyon. This thesis uses a comprehensive synthesis of locational data of all known associated Bad Pass Trail cairns made recently available for application towards this special analysis.

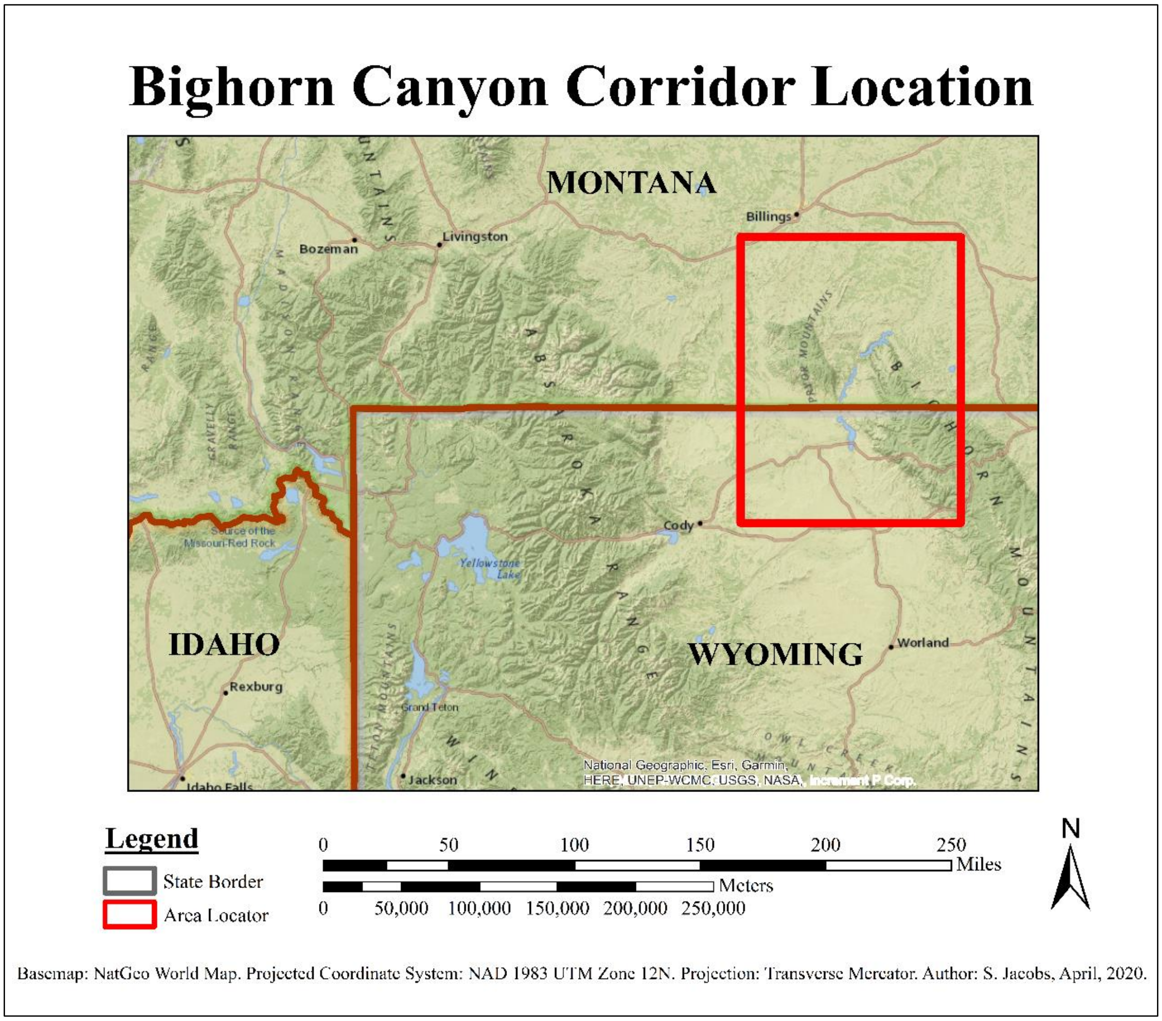

Figure 1.1. Bighorn Canyon corridor location to surrounding states.

My analyses make use of data recorded during the 2014 Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU) Cultural Landscape Inventory, and applies to it the Geographic Information Sciences (GIS) software required in order to explore the spatial relationship between the cairn-marked trail route to a path of least resistance through the Bighorn Canyon corridor. I compare newly discerned figures with previous archaeological records and support relevance of ethnohistoric and ethnographic observations. This thesis produces quantifiable data for purposes of future research; research which could even further explain relationships of the cairn-marked route to the natural landscape and nearby archaeological sites. The following questions guide my research.

- Does the Bad Pass Trail's cairn-marked route follow a path of least resistance through the Bighorn Canyon Corridor? If not, why not?
- What degree of variation lies between the routes of the Bad Pass Trail to that of least resistance? More specifically, is there a predictable distance from the path of least resistance within which associated cairns are expected to occur?
- How do the archaeological interpretations of the Bad Pass Trail relate or compare to the 2014 Cultural Landscape Inventory (CLI) native participants' view of this trail system?
- What future research may provide additional or refined understanding of the trail system?

In July of 2012 a Bad Pass Trail Ethnographic Research/Fieldwork and Revised National Register Nomination was initiated through a collaboration with the University of Wyoming and St. Cloud State University of Minnesota. Included within this multi-phase project was the completion of a 2014 Landscape Field Inventory of the Bad Pass Trail. The Landscape Field Inventory, or Cultural Landscape Inventory (CLI), delineated a project area within political bounds of the National Park Service, Bighorn Canyon National Recreation Area (BICA-NRA) in Bighorn Canyon. The project area would ultimately extend from an area near the Historic Lockhart Ranch within the recreation area, to the Montana/Wyoming state border (Figure 1 2).

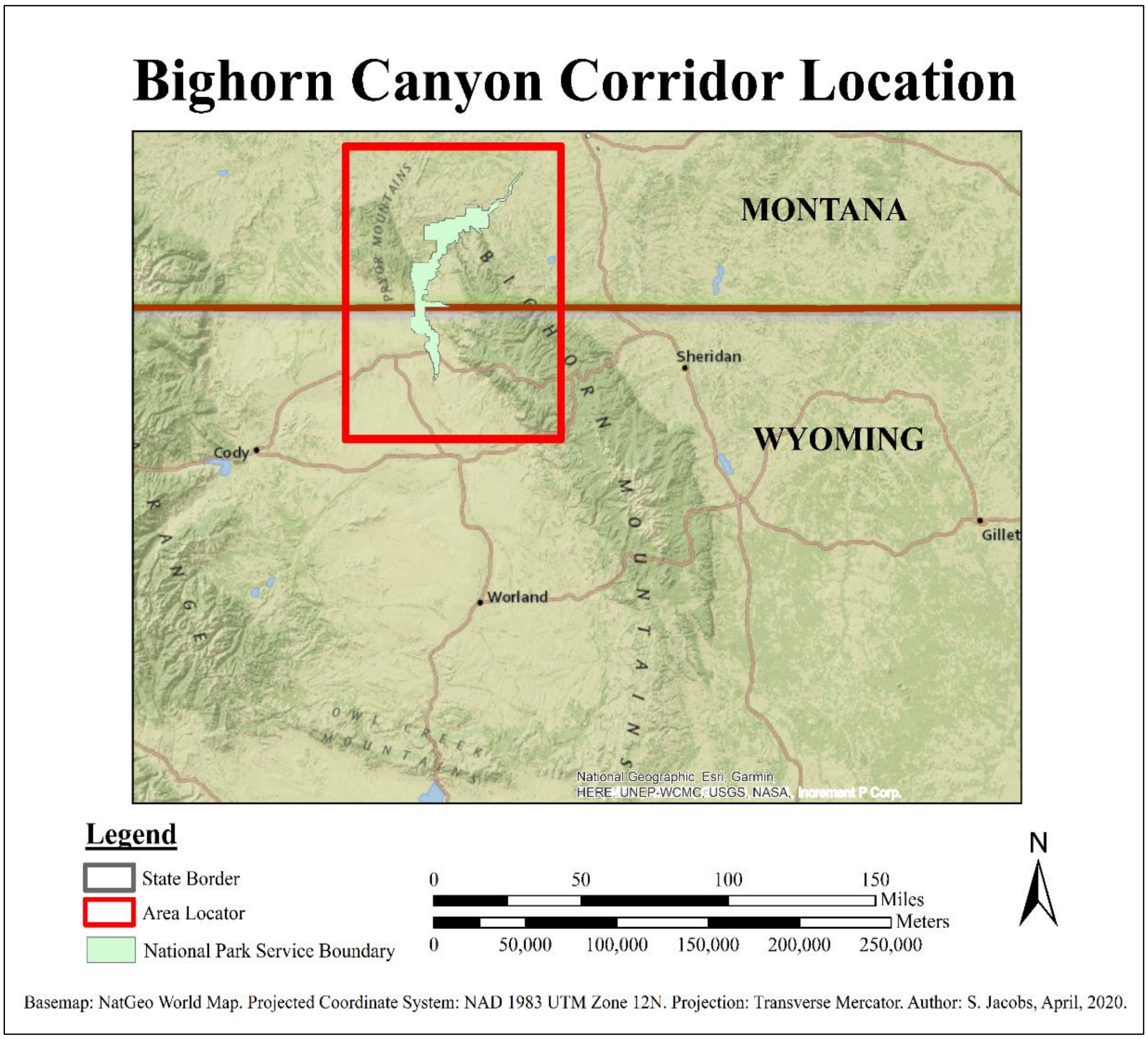

Figure 1.2. Bighorn Canyon National Recreation Area location to surrounding states.

The goal of the 2014 inventory was to record the Bad Pass Trail corridor as well as the contributing and non-contributing features located within it (Finley and Branam 2012). This CLI fieldwork was conducted by hiking the entire length of the trail, documenting historic landscape features and recording contributing and non-contributing features for purpose of creating site plans and future CLI inventories (Finley and Branam 2012). Characteristics recorded during field inventory for each cairn included measurements of cairn size and orientation, stone size and quantity, sedimentation, historic modification, any visible signs of offerings, signs of destruction or looting, and any noted atypical stone materials. The locational data for Bad Pass Trail cairns serves as a building block upon which I expand my own project design.

During the culmination of this thesis I completed an independent literature review, managed geodatabase for GIS analyses, and conducted statistical tests on dataset distributions, to inform my final interpretations of spatial relationships of the Bad Pass Trail to computer-generated slope-derived paths of least resistance (also referred to as least cost paths throughout this thesis) through the BICA corridor. A combination of ArcGIS mapping software maintained by the Environmental Systems Research Institute (ESRI), digital elevation model (DEM) information from the United States Department of Agriculture Geospatial Data Gateway, and orthorectified imagery, contour maps, and topographic information obtained from the U.S. Geological Survey by the Bighorn Canyon National Recreation Area, were used in exploration of spatial patterns.

In mathematically driven cost studies, a least cost path is a path of least resistance between an origin and destination point. My least cost path and its defining ‘cost’ is the factor of just one variable: terrain slope. By doing so, I provide spatial connection between Wyoming’s

Bighorn Basin and Montana's Yellowstone River Basin. Near measurements between cairn locations and the nearest point along my computer-generated path comprise the dataset of values from which I will apply general statistics. If found to lie within a mathematical or statistical area of probability to the path of least resistance, the assumption can be made that slope serves as a primary influence (albeit not the only influence) for determining cairn construction locations.

User-defined study area boundaries and user-assigned origin and destination points may greatly influence generated routes through the canyon corridor. I afford great consideration towards landform transformations as seen through river terracing when establishing area bounds. Additionally, user-defined origin and destination points representing prehistoric activities must remain general in location but relevant in association. A balance was created by choosing locations which would produce a valuable work while also allowing greatest freedom from bias.

It is imperative to acknowledge caveats of measuring prehistoric activities by use of quantitative tests alone. Assumptions of past behaviors based upon quantifiable numbers alone can negatively limit our approach in feature classification and determining cultural landscape study areas. As seen in any past or present population, those behaviors which would have influenced pedestrian movement across a landscape are products of both external and internal driving factors. It remains implausible and truly irresponsible to assume we can obtain a genuinely conclusive understanding of the motives and values held by prehistoric populations through mathematical calculations. In the Bighorn Canyon, for example, a stone culturally created stone cairn may have been constructed to mark a passable route but could have also been used for activities associated with driving big game (or vice versa). Additionally, a stone cairn for instance can serve as an identifier for a resource such as a spring location but also be used as a marker in a broader transportation system.

As researchers we must clearly acknowledge that this type of work is limited in its ability to truly encapsulate a complete understanding of the complexity of those motivations which influenced prehistoric peoples. A combination of approaches should be considered when examining past populations and cultures; the use of mathematics and statistics should be some of several tools in our larger academic toolkit. By combining approaches, we can attempt to minimize the risks associated with applying a formula to past activities, and acknowledge the overlapping utilization of past resources, spaces, and landscapes to those people who transverse the landscape.

These quantifiable measurements or assumptions should not be used as a limit on our research, but rather as a guide for expansion. Quantifiable results allow us to more quickly and easily compute and store massive datasets, more easily identify trends and patterns within samples, feature characteristics, and sites, and allows us to produce from our research a baseline to promote consistency and transparency. Acknowledging caveats in research allows for a more accurate approach and respectful consideration for the interconnected complexities in human conditions which could have influenced prehistoric populations.

I support the incorporation of archaeological research with the consultation of ethnohistoric resources for a better understanding of the driving factors acting upon the creation of pre-contact transportation routes. I acknowledge the existence of other possible influences in the determination of cairn locations through the Bighorn Canyon corridor. My thesis should not be used for the purpose of supporting the limiting of coverage area considered for a landscape inventory of transportation routes. I hope my results represent the advanced and interwoven roles which archaeological resources express within a landscape.

Expected Outcomes

This research results in a final thesis for partial completion of the SCSU CRM-Archaeology Master of Science degree. This final thesis provides:

- An organized compilation of data from the 2014 Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU) Cultural Landscape Inventory delineating prehistoric and historically modified portions of the Bad Pass Trail.
- Calculated path(s) of least resistance through the identified Bighorn Canyon corridor.
- Measurements of individual cairn and segment variation, distribution, and degree of significance to the path(s) of least resistance.
- A brief comparison of locational data to nearby occupational sites.
- A discussion comparing the archaeological data associated with the Bad Pass Trail to the Native participants' view of the trail system throughout the 2014 cultural landscape inventory.

At its foundation, this thesis builds upon an archaeological-based framework to present data derived from the Bighorn Canyon. It includes a blend of both archaeology and ethnography to aid future exploration of trail significance to contemporary Crow people. It provides quantitative and qualitative interpretation for the trail's creation, spatial patterns, and continued use. This thesis results in a marriage of method and theory and provides data exploration and analyses for future arguments of monumentality of the Bighorn Canyon landscape.

Chapter 2: Literature Review

Cairns and Linear Arrangements

Rock cairns are re-arrangements of naturally occurring stones into stacked features on a landscape (Figures 2.1 and 2.2). Creating cairns and linear cairn arrangements serves a cognizant purpose to the people who originally constructed them, and their presence conveys meaning to others who later encounter them (Kornfeld et. al 2010). In the archaeological record cairns have been found marking burials, fasting locations, resource locations, bison kill sites, trail routes, and places of other spiritual significance (Skillman 1962; Malouf 1962a, Loendorf 1980). When winter snowfalls obscure much of the ground, cairns leave a more clearly defined marker in their wake (Loendorf and Brownell 1980).Cairns are sometimes found near stone features such as stone circles, tipi rings, fasting beds, or spokes of medicine wheels (Malouf 1962a, 1962b, 1962c). During historic times, sheep herders, trappers, and fur traders constructed cairns as locational markers upon the landscape. To homesteaders, cairns could provide additional support to fence lines (Figure 2.3) or could delineate land ownership by marking property bounds (Malouf 1962a, 1962b, 1962c; Skillman 1962; Malouf and White 1963). When combined with a single wooden post and/or proper documentation, historically stacked stones act as a tool for staking mining claims (Figure 2.4).

Figure 2.1. Stone cairn with incorporated juniper growth.

Figure 2.2. Stone cairn with incorporated grasses.

Figure 2.3. Recent NPS cairn construction supporting fence post.

Figure 2.4. Abandoned Mine Lease cairn and post.

Generally, isolated cairns lack context—diagnostic artifacts or datable material—used in determining relative age and cultural affiliation (Kornfeld et al. 2010). Some researchers have also encountered cairns within their work which they believed may be a result of an individual's passing of time or busy work (Malouf and White 1963). This data gap is the product of multiple factors which include: a lack of precisely known cultural affiliation of cairn creators, a lack of recollection by present-day tribal members whom archaeologists believe may be of closest association, and the frequent inability to directly and accurately date a cairn itself without a presence of datable material.

Travel Routes and Natural Pathways

Throughout this thesis I hypothesize that culturally created cairns of the Bad Pass Trail's braided route follow a path of least resistance through the Bighorn Canyon corridor. Created from repeated or habitual use, early travel routes often lack large recognizable signs of landscape modification. Early travel routes frequently follow natural pathways provided in landscape topology through valleys, watercourses, ridgetops, and animal migration routes. Many natural routes exist along the Bighorn Mountain's northwest flank. The product of canyon erosion of the Bighorn's sedimentary rock plateaus, these routes run northward from the Bighorn Basin (Platt 1992). However, issues of funding, location, and access, all impact the thoroughness to which some travel routes are documented.

Culturally created trails can provide information about the social complexities of earlier populations. Many early routes function as connections to other archaeological sites (Platt 1992).

Routes of cultural diffusion, trade, and of everyday life are gleaned from studies of these early trails and trail creation (Malouf 1980).

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Practical and useful natural pathways do not lose their utility over time. These pathways are often adapted for new purposes or to meet new demands (Platt 1992). Highest visibility of trails resulted from their continued use by game and small hunting parties, especially if used year after year. Less defined trails were a result of less repeated use, from routes leading to temporary camps, or as a result of not being kept clear of fallen trees or erosion (Malouf 1980). Some trails were further defined by stone cairn markers and deeply worn game trails (Frison 1982). Game trails can be physically enlarged to serve as routes for other commodities such as plants, minerals, curing springs, and trade. Trails marking seasonal bison migration routes were more well-defined, as were those marking major passes. Well-marked or well-developed trails that are still visible today are those that saw continued use (Malouf 1980).

The re-use and re-modification of earlier trails would have been implemented in order to better meet people's current needs (Nabokov and Loendorf 1994). Reeves (1992) provides descriptive measurements of physical patterns left upon the landscape, as observed in his study of the Old North Trail. Reeves states that the transition to horse and its wider-setting travois required the clearing of larger and loosened rocks from within a trail to that trail's edges. As wagons became more common, the sets of narrow marks and internal impressions left from the horse and travois were replaced with uniform wheel well tracks, typically measuring two or more meters apart (Reeves 1992).

Historic trail modification of a substantial size is visible within the context of the Bighorn Canyon and Bad Pass Trail (Figure 2.5 and 2.6). A large undertaking of trail marker modification in route of the Bad Pass trail was made in order to improve the existing route for now-historic wagon transportation (C. Finley 2014 personal communication). This evidence of modification can be seen along the mid portion of the mapped Bad Pass Trail route. This classification of historically modified cairns was determination both by crew in the field, as well as by confirmation by retired Bighorn Canyon NPS archaeologist and cultural resource manager Chris Finley.

Figure 2.5. Cairn modified for creation of wagon route.

Figure 2.6. Cairn modified for wagon route, with close-up of counting tool.

Roadway Impacts

Not until more recently in history are the cut and fill practices used in road construction and road improvement encountered across landscapes. Borrowing and filling introduced a type of landscape modification that, in affected areas, can completely decimate physical evidence of Indian travel routes (Platt 1992). In the Bighorn Canyon this practice was mostly adopted for the creation of park roadways and powerline access roads (Loendorf and Brownell 1980). Results of cut and fill, or borrowing and filling, are visible in areas of the Bad Pass Trail (Figure 2.7).

Roadways through Bighorn Canyon today receive traffic from both personal vehicles as well as from ranchers pushing cattle to their summer grazing grounds. The use of roadways for continued cattle driving purposes results in more condensed and predictable impacted areas. However, heavy traffic from stock animals can still pose a threat towards obscuring Indian trails underfoot (Platt 1992). Present-day cattle trails are seen along the roadsides of the Big Horn Canyon Road. Trails running parallel to the Big Horn Canyon Road during our 2014 inventory are noted in southern sections of the Bad Pass Trail.

Figure 2.7. Evidence of cairn disturbance in road construction borrow area.

The Bad Pass Trail as a Linear Feature

For areas that could not support agriculture, such as those of Montana east of the continental divide, bison provided a major means of subsistence for larger populations (Kehoe 1965). Evidence for the Bad Pass Trail aligning with a prehistoric bison migration route is substantial and is apparent when viewing the still-visible prehistoric bison ruts (Figure 2.8). The physical overlap of prehistoric bison ruts to the culturally created stone cairns of the Bad Pass Trail serve to further solidify a connection between migrating bison and the people who moved within the area.

Figure 2.8. Prehistoric bison migration ruts in proximity of Segment C.

The Bad Pass Trail's linearly arranged cairns represent two types of arrangements: pedestrian transportation markers, and game drive lines (Carlson 2012; Loendorf and Brownell 1980). Differences between these two types of linear arrangements lie within their respective size, spacing, and topological location (Frison 1991; Loendorf and Brownell 1980; Malouf 1980; Kornfeld et al. 2010). The drive lines were often constructed from piles of rock or brush placed at certain intervals, or as a solid wall near a corral entrance (Lowie 1982[1954]). Cairns leading to a final procurement site were smaller in size than other culturally created cairns. Where large numbers of smaller cairns spaced at intervals mark animal procurement, taller-standing cairns spaced more according to terrain viewshed make ideal markers for travel though rugged terrain (Frison 1982).

Bison Drive Lines

Collective hunting incorporates many members of a group for the procurement of game. Groups of people may have chosen to impound game or drive game from cliffs (Lowie 1982[1954]). Collective hunting incorporating drive lines was used for the procurement of large game such as antelope, deer, or bison. Drive lines are often constructed from two linear arrangements converging at a final corral or final cliff (Lowie 1982[1954]). Drives were well-organized and often incorporated religious practices for enlisting supernatural aid for sanctioning a drive (Kehoe 1965; Malouf 1980). Sometimes these lines consisted of plate-sized flat rocks upon which burning cedar was placed (Nabokov 1992).

Within the Bighorn Canyon area, Carlson (2012) recorded several drive lines, two of which lie within the bounds of the 2014 inventory study area. Carlson identified one line as comprising the northern portion of Segment B, per 2014 inventory labeling system (Figure 2.9). The second line comprised the northern portion of Segment E per 2014 labeling system or named as the Two Eagle Encampment site (Finley et al. 2013). Cultural resource manager of the Bad Pas Trail cairn inventory, Chris Finely, suspects the existence of additional cairn lines to the south of the Bighorn Canyon park bounds.

Figure 2.9. Bison drive line of Segment B.

The Bad Pass Trail as a Cultural Resource

As is suggested by its name, the Bad Pass Trail marks a passable route through the rugged terrain of the Bighorn Canyon Corridor (Loendorf and Brownell 1980). Cairns with the greatest number of included stones are in already heavily rocky areas, suggesting the creation of the cairns was influenced by people clearing the route through habitual or seasonal use of the trail (Nabokov and Loendorf 1994; Loendorf and Brownell 1980; Platt 1992). The Bad Pass Trail cairns are created from locally available rocks which were not likely carried great distances (Frison 1982).

Cairns, such as those of the Bad Pass Trail, are created from an accumulation of piled stones from passing travelers for a successful journey, good health, long life, good luck, or to keep in the good graces of the spirits. Travelers made offerings to stay in the good graces of the spirits that reside on the land (Malouf 1962a, 1962b). Offerings of stones, beads, or other small artifacts were placed on cairns (Malouf 1980). The action of placing stones was considered acts of devotion, one which over time increased the size of respective stone cairns (Frison 1982; Malouf 1962a, 1962b, 1962c, 1980).

Two early accounts—provided by James H. Bradley of the Montana Column in 1876, and by Meriwether Lewis regarding the Indian Post Office Mountains in 1806—reflect special consideration to cairns by tribal members traveling within their respective parties (Loendorf 1980; Malouf 1964). Bradley recounts Crow scouts in his party picking up stones before spitting on them and casting them onto cairns. He was informed that this action was done to ensure good fortune of their enterprise. Bradley also states that Crow people left such piles scattered along their migration route (Frison 1982). Lewis recounts Nez Perce guides requesting a pause at cairns to smoke before continuing their journey.

Crow interview participants provide important insights into the Bad Pass Trail's existence as a cultural resource as well as its use by Crow tribal members in recent history. Pottery recovered during the early sixteenth to eighteenth century attribute many sites across northcentral and northeastern Wyoming to the ancestral Crow (Frison 1976, 1980). Investigation into the Bad Pass Trail provide a radiocarbon date after calibration of 1620 +/- 85 B.P. or A.D. 350 +/- 27, and an estimate of initial construction to a time during the early Late Prehistoric or Late Archaic period (Loendorf and Brownell 1980; Frison 1982; Kornfeld et al. 2012; Voget 2001).This time period pre-dates Crow occupation of the Bighorn Canyon. As explained in the work of Peter Nabokov and Larry Loendorf (1994) Crow Tribe interview participants acknowledge with respect the people who dwelled in their homelands prior Crow culture and respect the responsibility of managing and protecting both cultures' cultural sites (Nabokov and Lawrence 1994). The viewpoint of holding responsibility for the material history of the area was a prominent point discussed and implemented to the best of our ability in the 2014 landscape inventory fieldwork.

Historic documents prove an important means for determining Indian use of trails (Platt 1992). However, the greatest contribution is made from a compilation of archaeology, anthropology, ethnology, and ethnography, and accounts by members of descendant communities. These significant studies comprise a great deal of what is known today regarding tribal occupation, cultural affiliation, and cairn feature constructions during prehistoric times. A recent natural resource historic properties nomination revision actively sought participation from affiliated Crow and Eastern Shoshone tribes regarding the construction and use of the Bad Pass Trail as a migration route (Finley and Branam 2012). When completed, this research will hopefully add even more information to what is currently understood of this cultural landscape.

Paths of Least Resistance

Analytic limitations will always prevent researchers from fully interpreting the exact influence(s) acting upon prehistoric humans as they modified landscapes. Numerous studies explore the cost-benefit relationships of prehistoric activities and assign cost grids in order to understand likely motivations for past movement (Harvey 2012). The application of foraging models, optimal diet breadth, and cost models of front-loaded and back-loaded resources can prove informative in understanding past activities regarding cost expenditure (Harvey 2012). However, without first having a thorough understanding of *how* the Bad Pass Trail is related to these past activities, one cannot discern *to what extent* they are related. The understanding I provide through examining slope as a driving factor to cairn location provides a basic understanding of cairn location without being subjected to the constraints of user-defined level of costs.

Origin and destination points for my path of least resistance remain user defined. The use of two calculated paths serve to represent travel both paralleling the Pryor Mountain foothills, as well as paralleling the Bighorn River. Utilizing two generated routes of least resistance allows for a broader consideration of possible transected routes, and better represents the corridor’s wide northern and narrower southern extents. The examination and comparison of a path of least resistance to the geographical locations of culturally created cairns along the Bad Pass Trail represents only one aspect of spatial relationship to the landscape. External factors such as available river crossings, threats by neighboring populations, and availability to food and water reserves, could all present influences towards the braided behavior of the Bad Pass Trail's cairn-marked route. My thesis provides the basic analyses required to begin to understand these factors.

Study Area Descriptions

Bighorn Canyon

The Bighorn Canyon study area is located within a topographical and structural basin of south-central Montana and north-central Wyoming (Richards 1955). Bisected by the Bighorn River and its canyon, the basin is geographically divided into a northern Dry Head Creek area and a southern Garvin Basin. The basin is bordered to its east and south by the northern portion of the Bighorn Mountain range, its west by the Porcupine Creek anticline of the Bighorn Mountain's western flank as well as the Pryor Mountain range, and to its north by a ridge of Triassic and Jurassic rock. Most of the basin's surface stratigraphy is comprised of the Pennsylvanian Amsden formations (Richards 1955).

Located within the political bounds of the Bighorn Canyon National Recreation Area (BICA-NRA), the Bighorn Canyon and its corridor connect the more arid Bighorn Basin in Wyoming to the grasslands of Montana's Yellowstone River Basin (Loendorf and Brownell 1980). The entrance to the canyon, its mouth, lies three and a half miles south of the Montana-Wyoming state line (Husted 1991). The canyon extends northward along the axis of the Bighorn Mountains until terminating near the town of Fort Smith, Montana, while the Bighorn River continues across the floodplains of the Great Plains to join the Yellowstone River near Bighorn, Montana.

The Bighorn Canyon and northern Bighorn Basin are included within the Great Basin Division, Upper Sonoran Zone (Cary 1917), and lie within the Montanian biotic province (Dice 1943). The Wyoming portion of the Great Basin Division is most accurately characterized by its climate and supported vegetation, of which Cary (1917) provides a detailed description. However, a further division, specific to the Pryor Mountain area, is provided in the form of life zones. Loendorf (1973) provides a detailed description of life zone divisions which are, for the most part, smaller in area and more exclusive than those provided by the larger Great Basin Division.

The Bad Pass Trail is located within the juniper break life-zone division (Figure 2.10). The juniper break zone runs along the lower sides of the Pryor mountains, ranging in width from less than one mile to more than seven miles at its maximum extent. Broken topography and a dominant presence of juniper vegetation characterize this zone (Haberman 1973). The juniper zone’s broken topography is the result of erosional processes upon underlying sandstone and limestone stratigraphy. Many of the Pryor’s canyons terminate at this juniper break zone, while other canyons and drainage features dissect the more easily eroded strata to create numerous buttes and ridges (Loendorf 1973). The sides of the Pryor Mountains, with exception to its eastern scarp, have a mantle of soil to support vegetation. This is confirmed through the large presence of juniper, as deep mesic soils are needed in order to support the plant’s large distribution. Other vegetation, such as limber pines appear to not be restricted to one zone, but rather to certain soil types (Knight et al. 2014). The soils of the juniper zone consist of sandy loam surface layers with a brown silty clay loam subsoil. The sub-stratum is comprised of a white to pale brown highly calcareous silty clay loams.

Figure 2.10. Bighorn Canyon juniper break zone.

The Bighorn Canyon study area experiences a semiarid middle-latitude and steppe climate which typically involves a warm, wet season and cool, dry season, with a growing season of 141 days (National Centers for Environmental Information 2019). The Absaroka Range and Beartooth Mountains to the west of the Pryor Mountain range, as well as the Northwest Block of the Pryor Mountains act as a barrier to moisture, casting a rain shadow over much of the Pryor Mountain and Bighorn Canyon areas. Rainfall amounts for the Bighorn Canyon vicinity average some 7-10 inches (17-20 centimeters) annually, with Bighorn Canyon proper thought to receive even less. Precipitation remains greater in the mountains to both east and west of the Bighorn Canyon locality.

Wind patterns acting upon the Pryor Mountains are interrupted by the Bighorn Mountains to the east. Air during summer months is generally dry, with periods of low humidity introducing possibilities for electrical storms which result in very little additional precipitation. Whereas summer and autumn months present precipitation in form of rain, the winter months bring it by means of snowfall. Winter snowfall averages some 21 inches (53 cm) annually from the months of November-May.

Pryor Mountains

The Pryor Mountains are located fifty miles south of Billings, Montana and fifteen miles north of Lovell, Wyoming. The range's southern flank ends at the Porcupine Creek anticline of the Bighorn Mountains' western flank (Richards 1955), just north of the Montana-Wyoming state line (Loendorf 1973). The structures of the Pryor Mountains are like that of the many other ranges in the Central Rockies but differ in their stages of development (Loendorf and Brownell 1980). Initial uplift of the mountain mass took place towards the end of the Cretaceous period during the mountain lifting Laramide Orogeny 40 million years ago. The uplift left the Pryor Mountains and surrounding areas covered with Tertiary deposits (Loendorf 1969) until a second Cascadian Revolution uplift during the later Pliocene raised the mountains to their present position (Schulte 1961).

Topographically, the Pryor Mountains are desribed as a moderately dissected block mountain divided into four major structural units: West Pryor, Northwest Block, Big Pryor, and East Pryor Mountain (Blackstone 1940) (Figure 2.11). Each unit is comprised of asymmetric anticlines uplifted in their northeast corner, respectively. The western slopes are broken by narrow, parallel-cutting box canyons, and the eastern slopes are much steeper and terminate at abrupt scarps. Surrounding the mountains, the countryside is broken into rims, canyons, coulees, and buttes. The mountains are drained by the Bighorn River, Clark Fork River, Yellowstone River, and associated tributaries. Erosion processes of the late Pliocene time (Schulte 1961) are still present in the form of an upland terrace along the Pryor's sides at about 5,000 feet.

Figure 2.11. Pryor Mountains from the Ewing Snell Historic range (looking south).

Bighorn River

The Pryor Mountains' continuation with the Bighorn Mountains is bisected by the Bighorn River and its deeply cut canyon. (Figure 2.12). The Bighorn River is a continuation of the Wind River (Brown 1969) and enters the south end of the Bighorn Basin by means of the Wind River Canyon through the Owl Creek Mountains. The Bighorn River lies between the Great Plains and the Middle Rocky Mountains provinces, making it partly in the Bighorn Mountains and partly in the Bighorn Basin. The southern portion of the Bighorn River spills onto the floodplains of the Bighorn Basin before racing north to enter the mouth of the Bighorn Canyon, located 3.5 miles (roughly 5,600 meters) south of the Montana-Wyoming state line. The mouth of the Bighorn Canyon marks a stark transition from floodplains to a steep-walled gorge, with walls reaching some 1,000 feet (300 meters) in height. The river leaves the mouth of Twenty Mile Creek and continues its northern course until reaching downstream of Dry Head Creek. From there it transects the northern flanks of the Bighorn Mountains, traveling across expansive floodplains to meet with the Yellowstone River.

Until recently, the trajectory of the Bighorn River has remained relatively unchanged over the past 10,000 years. The Missouri River, into which the Bighorn and Yellowstone Rivers drain, has historically experienced prominent flooding events. Following the passage of the 1944 Pick-Sloan Flood Control Act, the Missouri River Basin Project of 1961 offered control of the river and its flooding events. In addition, the creation of over 50 dams across the Missouri River Basin provided a means by which to harness the rivers' power. The Yellowtail Dam's groundbreaking in 1961 established its construction southwest of Fort Smith, Montana. Upon its completion in 1967, the water levels of the north-flowing river were drastically altered, spilling into the floodplains of the Bighorn Basin to prompt the creation of the Bighorn Lake (once referred to as Yellowtail Lake). Because of these relatively recent cultural modifications of the Bighorn River, what is seen today when observing the river drastically differs from what would have been observed merely 70 years ago.

Figure 2.12. Bighorn River and deeply cut canyon from Sullivan's Knob foot path.

Impacts from damming activities and past geologic processes have altered the present-day appearance of the Bighorn River. The presence or absence of riverbank terracing must be considered when establishing prehistoric river-bank boundaries for the study area's eastern boundary (Figure 2.13). In 2011, a geologic resource inventory report was conducted as part of a larger National Park Service Inventory and Monitoring Program in order to increase understanding of geologic processes within Bighorn Basin (KellerLynn 2011). The study of fluvial geomorphology and Quaternary stratigraphy of the Bighorn Basin has provided a more detailed understanding of the fluvial process and tectonic activity over the past 2.02 million years. Digital geologic data of the Bighorn Canyon National Recreation Area (BICA-NRA) presented within the report depict evidence of terracing along both the Bighorn and Shoshone Rivers of the Bighorn Canyon Corridor. According to the report, the well- preserved terraces present along the Bighorn River show the dynamic nature of fluvial and tectonic processes that took place over the past two million years. These mapped occurrences are absent along the central, steep-walled portion of the BICA area. This evidence of terracing, combined with the understanding of the chronological sequence represented by earlier noted paired terracing patterns, depicts the Bighorn River's downward erosion to the modern-day flood plain.

The evidence presented by the 2011 BICA Geologic Resources Inventory Report dates the major terracing events of BICA to the Quaternary period and suggest a lack of terracing within the past 11,000 years (KellerLynn 2011); the time period within which the Bighorn Canyon Corridor and Bad Pass Trail is understood to have experienced cultural activity. For this reason, terracing events do not influence the establishment of a study area boundary, and digitalization utilizing the 2,600 feet (roughly 790 meter) elevation contour seems appropriate.

Figure 2.13. Bighorn River and deeply cut canyon from Barry’s Landing.

Bighorn Mountains

Bisecting the Garvin Basin, the Bighorn River and deeply cut Bighorn Canyon are bound by the Pryor Mountains to the west and the two branches of the Bighorn Mountains to the south and east. The Bighorn Mountains rise from the Great Plains as an outlying portion of the Rocky Mountains (Darton 1906) and the easternmost range of the Central Rocky Mountain physiographic province (Fenneman 1931).They are located in south-central Montana and north-central Wyoming as one of the largest island mountain systems on the Northern Plains (Platt 1992). The range’s northern extent lies near the Montana-Wyoming state line, where its bisection by the Bighorn River separates it from the Pryor Mountain range. The Bighorn range extends some 90 miles south in a general north-northwest trend (Darton 1906) to its southern flanks at the Middle Fork of the Powder River near the town of Kaycee, Wyoming (Platt 1992). Its southern portion adopts an east-west trend and meets with the Owl Creek Mountains and Bridger Range of central Wyoming (Darton 1906). When combined with the Owl Creek Mountains, the Bighorn range outlines the eastern and southern bounds of the more arid Bighorn Basin.

The Bighorns are characterized as a great anticline from an uplift which raised thick series of Paleozoic and Mesozoic sedimentary rocks to high above the adjacent Great Plains (Darton 1906). They are the youngest of the ranges uplifted largely during the Eocene Epoch some 50 million years ago (Brown 1993). Madison limestone and lower beds of the Amsden formation comprise the surface strata of the range's northern crest (Richards 1955), with central pre-Cambrian granite flanked by sedimentary rock plateaus serving at its nucleus. Deep canyon erosion of softer sedimentary rock plateaus resulted in ridges of limestone, dolomite, and sandstone. Along the range's northwest flank, ridges running from the Bighorn Basin created natural travel routes (Platt 1992).

Early Investigations

Perhaps the most well-known early account of the Bad Pass Trial and its utility as a transportation route is provided in 1962 by Plainfeather as part of a United States Government's hearing held prior to the construction of the Yellowtail Dam. Plainfeather provided an affidavit at the age of 95, discussing the navigability of the Bighorn River and recounted his own use of the Bad Pass Trail to traverse from north of the Bighorn Mountains to the Bighorn. He recounted his use of the trail system as a young boy, and the discovery of the Bad Pass by a Crow Indian woman named Falls Down Old, long before his lifetime. Plainfeather describes the Bad Pass Trail's route as extending across the Bighorn Mountains from the range's north side and then extending to the south side of the same mountain (Plainfeather 1961; Nabokov 1992).

Archaeological survey work conducted by Loendorf in 1968 and 1969—in cooperation with the U.S. Department of Interior, Bureau of Land Management, the U.S. Department of Agriculture, Forest Service, and the National Park Service—led to the designation of the entire Bad Pass Trail as 24CB853. Investigations during 1971 revealed that the Bad Pass was comprised of braided trail segments extending from Horseshoe Bend area of Wyoming to the area of Barry's Landing Montana (Loendorf 1971; Loendorf and Brownell 1980). Listed on the National Register of Historic Places in October of 1975, the Bad Pass Trail was recognized for its "associations with prehistoric and historic archeology, commerce, communication, and transportation from prehistory through the 19^{th} century" (Finley and Branam 2012). Studies of the trail, as well as the associated archaeological resources scattered along its corridor, delineated the route as it is currently understood: a travel corridor following a bison herd migratory trail, as well as a foot trail utilized into the mid-1830s (Finley and Branam 2012).

Research conducted by Loendorf and Brownell in 1980 comprises the formal investigation of the Bad Pass Trail prior to the construction of the proposed Transpark Highway by the National Park Service through the Bad Pass corridor. The road's proposed construction entailed the imminent destruction of portions of the trail's segments. The research they conducted represents the most in-depth inventory of the cairn-marked route after initial designation of the Bad Pass Trail completed by Loendorf in 1969, up until the Bad Pass Trail cultural landscape inventory of 2014. Loendorf and Brownell's project included within its methodology the recording of physical characteristics for 173 of the cairns identified as comprising the Bad Pass Trail. Together Loendorf and Brownell estimated that at least 300 rock cairns composed the dividing and reuniting braided trail segments, with estimates of the original trail comprising some 600 to 750 cairns. The trail was plotted on United States Geological Survey maps and additional maps were created of the recognized trail route. Additionally, test excavation and total excavation was conducted on 16 selected cairns; 6 in the direct path of the proposed Transpark Road, and 10 additional cairns in order to better understand archeologically the reason for initial cairn construction (Loendorf 1971; Loendorf and Brownell 1980).

1980 Rock Piles

Individual rock piles were selected for excavation. Six of these cairns laid in the direct path of the proposed Transpark Road and faced imminent destruction as a result of the project, and 10 were chosen to be excavated in the hopes of better explaining the age and function of each feature before then being re-built. Noted during their survey and excavation were height, diameter, and percent lichen coverage, amount of soil fill, stone sizes, existing vegetation, and condition of each cairn including any modification or destruction. Additional details recorded include the soil type found under each excavated cairn, the general proximity of each cairn to the Bad Pass Trail route or existing routes, and any trends which existed in the location of each cairn such as being located along a ridge (Loendorf and Brownell 1980). Although cultural material was recovered from 10 of these cairns, five cairns produced significant cultural material. Loendorf and Brownell (1980) provide a detailed account of the characteristics of each excavated cairn and any recovered cultural material. In addition, they also outlined general noted trends including a general increase in diameter of cairns as they proceeded north along the trail; cairns located north of Rock Pile Zero being comprised of mostly limestone while further south cairns being comprised of both sandstone and limestone; 91 percent of all recorded cairns supporting lichen growth; 16 percent of cairns did not support vegetation; 60 percent of cairns were recorded as being of good condition; 20 percent having experiencing what appeared to be weathering or scattering from natural causes; 20 percent showing disturbance from human activity (Loendorf and Brownell 1980).

1980 Chipped Stone Artifacts

Chipped stone artifacts of culturally diagnostic significance were found in the form of projectile points. Three diagnostic projectile points were uncovered in total, all within Rock Pile Zero: one side notched triangular projectile point classified as a Paskapoo Point, a side notched triangular projectile point classified as a Lewis Point, an indented base-stemmed projectile point classified as a Hanna Point. Also uncovered within Rock Pile Zero was a bifacially flaked blade, a bifacial flaked blade fragment, a plano-convex scraper, and a water-smoothed pyriform pebble identified as a hammerstone. Rock Pile 28 South produced a side notched triangular projectile point classified as a Paskapoo Point and a plano-convex scraper. Other surface finds included an incomplete end scraper and a retouched flake (Loendorf and Brownell 1980).

1980 Surface Debitage

A total of 216 chipped stone flakes and one purple glass fragment comprised the surface debitage collected from the immediate vicinity of the trail in the 1980 excavations. Debitage recovered totaled 175 chert pieces; this included 150 purple chert pieces, 3 basalt pieces, 4 obsidian pieces, 9 pieces of Big Springs quartzite, 8 pieces of river quartzite, 6 pieces of jasper, 5 agate pieces, 1 piece of porcellanite, and 5 additional miscellaneous pieces. A large amount of the chert debitage exhibited cortex, and Loendorf describes the difficulty in determining natural breaking patterns from human modification when examining chert of the area. Jasper, basalt, Big Springs quartzite and river quartzite can be found locally, obsidian most likely represents an outside source material likely from Yellowstone Park (Loendorf and Brownell 1980).

1980 Ceramics

Five potsherds were recovered during the excavation of Bad Pass Trail cairns in 1980. (Loendorf and Brownell 1980). Two of these sherds were later refit with each other, making the total final count four sherds. Two sherds were recovered from Rock Pile 28 South, and the remaining two were recovered from Rock Pile Zero.

The first of the two sherds from Rock Pile 28 South was made of fairly course paste, texture, and grit temper which was comprised of quartzite particle. It had a brownish yellow surface and interior colored light to dark grey. The surface is very smooth and shows evidence for having been wiped by soft and pliable material. The second of the two Rock Pile 28 South sherds was a rim sherd tempered with a grit of sand. This sherd had a brownish grey exterior, and dark gray interior with variable firing.

The last two sherds recovered from Rock Pile Zero were a rim and body sherd, thought to be from the same pot, as they display the same grit and temper comprised of quartzite particles (Loendorf and Brownell 1980). The color of the rim and body sherd range from dark gray to black on the surface, with rough smudging and striations on the interior surfaces. The rim sherd appears to be a distinct shoulder with a presumed patching hole. Though difficult to associate historic tribes with prehistoric sites, a comparison of these recovered sherds to the Intermountain tradition, to the Mandan-Hidatsa tradition, to the typical Mandan form of pot, and to those recovered from Arrow Rock Cairn in the Pryor Gap, provides substantial support concluding the recovered sherds are indeed affiliated with the Crow tribe (Loendorf and Brownell 1980).

1980 Rock Pile Complexes

Four major complexes of rock piles and rock structures were located, recorded, and mapped on several of the high ridges located adjacent to the Bad Pass Trail in 1980. The Bad Pass Trail final report gives a detailed account as to the location and characteristics of these complexes ((Loendorf and Brownell 1980). Complex A contains 57 rock piles among extensive amounts of chipped stone materials. These chipped stone materials included numerous flakes, a purple chert biface, and a red chert corner-notched projectile point. This complex provided a range of rock pile sizes, spacing, and orientation along the ridgeline, and included both cairn arrangements as well as isolated cairns. Complex B included 27 rock piles expressing a more central concentration along the ridge. There were recorded stone circles in association with the complex, and individual rock piles expressing considerable variation. Complex C consists of five rock structures. These rock structures include three rock cairns on the western half of the ridge, and two circular or oval-shaped stone outlines. Complex D includes 23 rock structures, arranged in circular structures, arrow structures, crescent shaped structures, and as stone piles (Loendorf and Brownell 1980).

Archaeological Dating Techniques

The ability to identify cairns and other culturally created stone features is a beneficial and necessary skill for both academic and non-academic field-based research. The inclusion of cairns in site reports can aid in determination of site significance under criteria of the National Historic Preservation Act of 1966, as amended. Unfortunately, isolated cairns are generally found to lack the required context—diagnostic artifacts or datable material—used in determining a relative age and cultural affiliation (Kornfeld et al. 2010. Therefore, archaeologists note that the interpretation of isolated cairns of prehistoric construction remains difficult (Kornfeld et al. 2010). A void in our understanding and interpretation of cairns leaves us, as researchers, with a data gap for prehistoric cairns. More recently, specialized methods are being used in an attempt to fill in these data gaps. Although a less feasible route for smaller cultural resource management companies or those with limited access to specialized analyses, the use of these specialized techniques could one day add to our current understanding of cairns by providing dates for current data gaps.

Lichen Dating

Lichenology is the study of lichen. Existing as neither plant nor animal, lichens survive through a symbiotic relationship between fungi and algae or fungi and cyanobacteria. Since lichen lack formal roots, stems, and leaves, they attach tightly to, and rely heavily upon the steady nature of their stone substrates. The reorienting of a cairn's stones or attempted removal of the tightly attached flattened crustose lichens, likely leads to the lichen's death (Innes 1985; Benedict 2009).

Lichenology is a study that implements lichenometry as a method for determining the geochronological age of deposits. In order to determine age, lichenologists measure the diameter, or other body size measurement, of the organism at a site to determine a growth curve for the species (Innes 1985; Benedict 2009). With a suitably large sample size of a single species from one study area, and with great consideration for growth rate variations due to climate and microclimates, lichenologists create a growth curve (Innes 1985; Benedict 2009). Archaeologist Steve Cassells (2002) applied the size-frequency technique to cairns located with the Rocky Mountain National Park. While individual stones could have been added to the cairns sometime after their initial construction, returned dates still provide valuable information to the scientific record (Cassells 2002).

A great many of the 1980 recorded cairns showed presence of lichen growth; a presence which carried over throughout the 2014 inventory (Figure 2.14). Loendorf and Brownell's 1980 report shows that only 15 of the measured 163 rock piles of the Bad Pass Trail did not show evidence of lichen cover. This leaves 91 percent of the total piles having lichen growth. A great deal of cairns presented lichen growth again during the summer of 2014. Loendorf and Brownell (1980) note that portions of the Bad Pass Trail, specifically those south of Rock Pile Zero, were comprised primarily of readily available limestone material. Not all lichen species can exist on calcite-rich stone and those species that can exist on these substrates tend to have less measurable growth rates (Williams 2012). Therefore, lichen coverage can aid in determining historic versus prehistoric components, and aid in identifying historically modified portions of the Bad Pass Trail, but the technique is not preferred as the primary means for determining construction dates of the Bad Pass's associated cairns.

Figure 2.14. Various lichens coloring Bad Pass Trail stones.

Radiocarbon Dating

Radiocarbon dating is a specialized process that provides dates based upon the dead or dying organic matter from within a cairn. This matter can exist in the form of naturally occurring or culturally placed plant materials and charcoal. As researcher Didi Kaplan (2005) observed, the dimensionality of cairns offers a sort of habitat with niches for plants and animals. Tall stones act as a wind buffer which causes wind to slow down and drop seeds, snow, and soil as it makes its way around the stone feature's extents. An insulating factor during winter's snows, paired with daytime heat reflection of the stones, provide a more regulated microclimate within some cairns themselves. Rainwater collection during rainstorms and the buildup of nighttime condensation could lend to more moisture and increased survival for nearby plants' roots (Williams 2012).

Charcoal deposits occasionally discovered within cairns may be results of past wildfires, the result of cultural activity such as cooking or campfires, or as a remnant of transported coals. In 1980, a small concentration of charcoal from an associated Bad Pass cairn was collected and sent for subsequent radiocarbon dating. The concentration's fragments were of excellent condition and were too large to have been transferred by blowing winds. A lack of evidence associated with hearth remains or scorched stone suggest the sample was quite possibly the remains of a burning ember from a slow match made of transported coals (Loendorf and Brownell 1980). The sample yielded a date after radiocarbon correction to A.D. 350 +/- 27 (Loendorf and Brownell 1980). These dates indicate portions of the Bad Pass Trail could be of Late Archaic or early Late Prehistoric age (Kornfeld et al. 2010). Because of the possibility of post-construction plant matter, post-construction charcoal deposition, or construction atop existing charcoal deposits, one must consider that the resulting radiocarbon dates may be younger than the host cairn itself. For this reason, radiocarbon dates' best utility is in conjunction with other archaeological data.

Radiocarbon dating has been an applied technique for dating tipi rings of occupation sites within the Bighorn Canyon National Recreation Area (Finley et al. 2012; Scheiber and Finley 2010). Tipi rings comprise the most common cultural feature within the canyon, with more than 2,300 tipi rings being documented in the BICA area since research of the 1970s (Scheiber and Finely 2010). Dating tipi rings also remains difficult due to a general lack of diagnostic artifacts used to inform cultural use periods. A project at the Two Eagles Tipi Encampment site, a site of some 150 tipi rings studied from 2008-2011, provided a rare opportunity to excavate and collect samples for radiocarbon dating from their shallowly buried surface contexts. Ten radiocarbon dates were returned which dated the archaeological site's cultural activity to the last 1500 years (Finley et al. 2012). The oldest sample returned a date of 2,500 years ago during the Late Archaic period, and observed patterns corresponded to the early Late Prehistoric and terminal Late Prehistoric at AD 700-1000 and AD 1300-1500 (Scheiber and Finley 2010). Given that many of these tipi rings are found in either close proximity or directly upon the Bad Pass Trail's cairn-marked route, the inclusion of these two dates helps build a database supporting time periods for cultural use and occupation within the Bighorn Canyon area.

Optically Stimulated Luminescence Dating

Optically stimulated luminescence dating, hereafter referred to as OSL dating, measures the number of trapped electrons within a mineral's crystal structure (Feathers 2003). OSL uses two of the most abundant minerals on the earth's surface, quartz and feldspar, to measure light energy, or luminescence. The release of electron build-up in a mineral's structure results from natural exposure to radiation either through cosmic rays or from underground decay of earth's elements (Feathers 2003). Without the presence of a stimulus such as sunlight—as in the case with particles trapped beneath a cairn's stones—these electrons continue to compile within the mineral's structure. When sunlight is finally applied the trapped particles are released through a process known as zeroing, or bleaching. If samples are obtained in the field through very controlled means without exposure to sunlight, a controlled release of electrons can later be measured in a scientific laboratory. Once exposed to a stimulus such as sunlight, the electrons and light energy depletes, and the clock begins again at zero ((Feathers 2003; Williams 2012).

Growing in popularity within the last several years, this dating technique has yet to be applied to cairns associated with the Bad Pass Trail. However, the technique of OSL age dating has been proposed for use within the Bighorn Canyon, specifically regarding dating stone circles sites. Optically Stimulated Luminescence provides a unique opportunity to apply an alternative surface feature dating method and compare those samples to known radiocarbon dates of previously recorded tipi rings. Applying OSL dating methods could provide broader impacts for understanding regional native culture, in part by adding to the understanding of cultural resources of the Bighorn Canyon and Bad Pass Trail (Finley 2017 personal communication).

Recent Investigations

Collaborative Research Initiatives

Following the creation of the BICA-NRA in 1966, residents were removed from within the recreation area's newly established political bounds. In addition, the creation of the Crow reservation and the forced relocation of tribal members to within its bounds prompted heavy travel restrictions for reservation residents. Restricted access to their traditional homelands and name-places increases risks of losing knowledge of cultural heritage. If permission to travel outside reservation bounds was granted for a resident of the reservation—a complicated and demeaning process in-and-of itself—there remained some 55 air-miles of impassable mountainous terrain separating Crow tribal members form their homelands within the Bighorn Canyon. Despite forced removal from BICA homelands to today's reservation, cultural resources remain integral to the Crow tribal community.

Ethnohistoric/Ethnographic Accounts

Current understandings of cultural resources improve through active consideration of ethnographic and ethnohistoric resources. The General Management Plan and 1967 Memorandum of Agreement supports this involvement by calling for the National Park Service's active participation with Crow Tribal members both on and off reservation lands. With acting legislation encouraging the opportunity for ethnographic communities to gain access to federal lands for traditional uses, there is additional legal incentive to document, record, and even implement ethnographic research techniques for the purpose of cultural resources management.

Beginning in the 1960s, Stuart Conner began conducting interviews of Crow tribal elders and Crow cultural informants to collect information on archaeological and historical sites (Connor 1993). Between the years of 1967-1992, he conducted 14 separate interviews to collect accounts from 8 individuals. Conner's work was important for the identification of sites within the Bighorn Canyon and surrounding area, however, archaeologist Lawrence Loendorf states that work prior to the 1990s afforded less attention to sites' cultural affiliations (Nabokov and Leondorf 1994; Conner 1993).

In 1994 Lawrence Loendorf and Peter Nabokov conducted a study for the National Park Service, Custer National Park, and the Bureau of Land Management, titled Every Morning of the World. Both men sought to present cultural affiliation and strengthen the ethnographic association between archaeological sites and the subject community. For their study they collected archaeological records, historical documents, and ethnographic and ethnohistoric accounts. In preparation for their work, Nabokov also conducted interviews with 17 Crow tribal members located throughout the Crow reservation, and four local Euro American ranchers, recording knowledge and accounts of cultural resources in the Bighorn Canyon and surrounding area. The two researchers were driven by three primary sources: the ethnographic accounts recorded in the 1960s by Stuart Conner titled Crow Conversations with Conner; the late Henry Old Coyote who served as liaison for the Crow tribe as well as member of the Crow Culture Committee; and the late Joe Medicine Crow who served in many titles including tribal historian for the Crow tribe (Nabokov and Leondorf 1994). Their work not only provided a general outline of pertinent sites and resources but also outlined the intimate association of cultural history to the tangible and intangible resources within the Bighorn Canyon and surrounding area.

Bighorn Canyon Field Schools

The Bighorn Canyon remains an archaeologically rich landscape located within Crow tribal homelands. More recent initiatives have been made by the National Park Service to explore the cultural significance of sites within BICA-NRA bounds. Collaboration between the National

Park Service officials and tribal nations is described in the Rowe et al. (2014) discussion of research within the Bighorn Canyon National Recreation Area. Collaborative research initiatives presented themselves in the form of a 30-day immersion-type archaeology field school hosted at the historic Ewing Snell ranch of the Bighorn Canyon National Recreation Area. This research arrangement allowed for students to live and work with each other within the landscape they were studying. The field school program began in 2005 under the direction of National Park Service officials and anthropologists Dr. Judson B. Finley and Dr. Laura Scheiber, and by its conclusion in 2012 had expanded to incorporate anthropologists Dr. Kelly Branam Macauley and Dr. Matthew J. Rowe. Students from the many universities and tribal nations who participated in the field school were exposed to archaeology, zoo-archaeology, and ethnography. Students witnessed first-hand how professors from the three fields could work together for the benefits of cultural resources management. Students completed field survey, mapping, site recording, and were tested on assigned course materials.

These unique field schools presented students an opportunity to meet with tribal elders, to highlight some of the Bighorn Canyon's significance to Crow culture, and to discuss the role the Canyon serves in strengthening ties to cultural heritage. Incorporating stories and language through guest lecturers from the neighboring Crow tribe provided students with valuable lessons in cultural heritage and tradition. Students who completed the field school gained skills required in becoming cultural monitors for THPO programs, added to the number of field archaeologists trained in cultural resource identification and recording, and in the final years of the program earned certification as Archaeological Technicians. Not only does the implementation of a field school of this nature promote lasting relationships between archaeologists and tribal stakeholder communities, it adds significantly to park datasets required for the management of cultural resources (Rowe et al. 2014).

2005 Research

In 2005, Ashley Wisehart conducted field work of the Bad Pass Trail for the completion of her master's thesis through the University of Montana. The purpose of her study was twofold: to re-trace the path of the Bad Pass Trail through the Bighorn Canyon by documenting any known or newly identified associated cairns, and by answering her research questions, promote a more holistic understanding of the cairn-marked route. Wisehart sought to address the size difference between trail cairns and drive line cairns, identify signs of historical trial modification, and locate other trails that may join with the Bad Pass Trail. Knowledge provided by park service archaeologist, and recordings from Wisehart's thesis, resulted in a total of 543 documented cairns through the Bighorn Canyon, adding an additional 370 cairns to the 1980s findings. A trail route was not gleaned from Wisehart's review of historical documents and documented oral histories, but fieldwork suggests the trail continues onto the lands of the Crow (Apsáalooke) Nation. Without access to the Crow Reservation, however, her northernmost study extent was restricted to an area some 5.5 miles north of the present-day Lockhart Ranch. By re-tracing the trail's route, Wisehart sought to better understand the segmented nature of the braided trail system.

Wisehart (2005) observed few notable differences between trail cairn and drive line dimensions. Those that were observed included an average increase of 10 cm in trail cairn height to average drive line height, and an average increase of 25 meters between the trail marker cairns to drive line cairns, and no notable difference between the average diameter of cairns delineating transportation routes versus known bison drive lines. Other than these observations, Wisehart was unable to locate any additional archaeology or ethnographic data to describe measurements of trail marker or driveline cairns.

Wisehart (2005) sought to recognize and record historical modification and use of the trail. She states that while cairns were also used within the canyon to mark mining claims. These features were also recorded in the 2014 landscape inventory and comprised cairns of smaller construction than many prehistoric cairns, and many contained remnants of central posts. Archival material indicated that the larger cairns paralleling the present-day road could likely have been the result of local ranchers who were at one time paid by the government to maintain the historic road. One cairn segment, located near a historic ranch site, included three fence posts and barbed wire. Wisehart (2005:39, 43) assumes it is likely that this segment may have been used by a rancher to mark field boundaries but was unable to locate historical records or testimony to support this assumption.

Although suggesting the Bad Pass Trail likely joins with other trails, Wisehart (2005:5, 72-77) concludes that further pedestrian survey is necessary for the identification and recording of these possible joining points. She suggests two trails running through the northern territory near Fort Smith—the Bozeman Trail and the Pryor Gap trail—likely join with the Bad Pass to create a more intricate highway of prehistoric trails. She suggests that a complete inventory of associated trail cairns, combined with the applications of Geographic Information Systems software, is required for closer examination of the Bad Pass Trail as a path of least resistance through the Bighorn Canyon (Wisehart 2005:77-78).).

On-going Research

Ethnographic research is currently underway in order to contribute to a final revised National Register nomination for the Bad Pass Trail. This work is serving to document landscape and trail changes through time, while fostering further relationships between the park, partners, and affiliated tribes for a (Finley and Branam 2012). This project has so far resulted in many hours of oral histories, tribal stories, and accounts by Crow Nation and Eastern Shoshone tribal members: 5 Shoshone elders were interviewed. 1 Cheyenne archeologists/Field Tech was interviewed and over 14 Crow tribal members were interviewed. These interviews once completely transcribed will be in the archives of the Bighorn Canyon and will provide an understanding of the physical removal of native populations from cultural sites, and the retention of knowledge under these extreme conditions of removal. Preliminary results emphasize the need to work collaboratively with Park Service representatives to preserve tribal knowledge and to share cultural understandings attached to the Bighorn Canyon's indispensable cultural resources.

Chapter 3: Culture Chronology

Pre-Historic

Terminology commonly used in archaeological reports and cultural chronologies can, at times, appear to divide two realms of time and space. Specifically, the words ‘prehistoric’ and ‘historic’—terms used to describe the time periods pre-dating and post-dating Europeans’ arrival and written records—may be misconstrued as assigning quantitative or measurable value to only that information recorded by historians or researchers during post-colonial times. The lack of a written record pre-dating European arrival does not mean, and should never imply, that those early people did not have and experience culture and history. My use of the term ‘prehistory’ is done only to reference the physical time pre-dating European/Euro American arrival to the region. In no way do I seek to introduce the suggestion, or to imply a meaning, of diminished or limited value to that information existing prior to European contact, or to the knowledge carried in formats outside of the historic written record. It is imperative to acknowledge that cultural knowledge acquired prior to European and Euro American contact is of no less value, and of no less legitimacy, than that documented by the historic written record.

Cultural chronology, or the chronological order of past occupation, is typically determined through examination of subsurface contexts from excavation. Stratigraphy, projectile point typology, tool typology, and ceramic typology from these excavations serve as the basis for chronologic determination. These typologies and stratigraphy are continuously strengthened through technological advances, and therefore flexibility should be granted for the inclusion of more exact data as it becomes available to the field of study (Kornfeld et al. 2010).

Information available for early chronologies of the northwestern Plains and Rocky Mountains were often derived from less systematic archaeological investigations than encountered today, and often as a result of salvage efforts limited to sites along stream courses (Husted 1991[1969]). Mulloy (1958) created a Plains regional chronology which focused largely on the classification of regional sequences. Updates by Frison (1978, 1991; Kornfeld et al. 2010) establish a chronology that not only provided classification for the Northwestern Plains, but also connected inter-regional or intra-regional relationships. Frison set Northwestern Plains chronology apart from both the northern Plains and Great Plains geographical regions. Frison expanded Mulloy's Early Historic period to include Early, Middle, and Late Paleoindian periods. In place of a Middle Prehistoric, Frison established an Archaic Period, comprised of an Early Plains Archaic, Middle Plains Archaic, and Late Plains Archaic within the Northwestern Plains and Rocky Mountains. Frison reserved Mulloy's designation of a Late Prehistoric classification (Frison 1991; Kornfeld et al. 2010). In the following pages I describe the cultural chronology of the Bighorn Canyon as according to Frison's most recent chronology, and present associated data ranges in the form of radiocarbon years before present (B.P.).

Paleoindian Period

The Paleoindian period is presented through temporal divisions of Early (ca 11,500 B.P.-10,000 B.P.), Middle (ca 10,300 B.P.-8,800 B.P.), and Late (ca 9,500 B.P.-7,500 B.P.) (Frison 1991; Kornfeld et al. 2010). Earliest evidence for human occupation on the Northwestern Plains and Rocky Mountains are placed within the Early Paleoindian period (Kornfeld et al. 2010). The Bighorn Mountains hosts a Paleoindian presence dating back to Clovis and Folsom occupation.

The Folsom complex fluted tools remain some of the most highly regarded of precolonial constructed stone tools (Kornfeld et al. 2010). The Agate Basin's long, narrow design with a thick lenticular cross-section is thought to make an excellent design for killing bison and other large game (Kornfeld et al. 2010). The Alberta and Alberta-Cody component projectile points, with their large parallel-sided stem and definite shoulders, led to a change in hafting technology (Kornfeld et al. 2010).

Archaic Period

The Early Plains Archaic (ca 7,500 B.P.-4,500 B.P.) was added to the cultural chronology by George Frison (1991) to describe the period previously referred to by Mulloy (1958) as a time gap or cultural hiatus in the archaeological record. The Early Plains Archaic spans a large portion of the warm, dry period known as the Long Drought (ca 7,500 B.P. to 4,000 B.P.) within the Altithermal division of the Holocene Epoch (Antevs 1955). The Early Plains Archaic marks the final transition from the Paleoindian period, and an abrupt change from lanceolate and stemmed projectile points to side-notched points (Kornfeld et al. 2010). It is common for rockshelters in the foothill-mountain areas, as well as sites of the Bighorn Basin and Bighorn Mountains, to demonstrate Late Paleoindian or Early Plains Archaic components (Surovell et al. 2009; Kelly et. 2013).

Middle Plains Archaic (ca 5,000 B.P.-3,000 B.P.) and the Late Plains Archaic (ca 3,000 B.P.-1,500 B.P.) (Kornfeld et al. 2010) spanned the last portion of the Altithermal division and just over half of the Medithermal division of the Holocene epoch (Antevs 1955). These divisions marked the transition of the long, warm, dry conditions of the Long Drought to the cooler, moist, and variable drought-like conditions of the climate experienced during historic times (Antevs 1955). The Middle and Late Plains Archaic are marked by a shift in subsistence from big game mammals of the Early Prehistoric period, to smaller game and increased reliance on plants (Platt 1992). The necessary change to food-gathering strategies, as well as hunters' ability to successfully concentrate their efforts to smaller areas, meant individuals could remain in smaller geographical areas for longer periods of time than earlier Paleoindians.

New styles of stone tools took advantage of indigenous cherts and quartzite. The projectile points include large, corner-notched points or darts, which sometimes transitioned to sharp points or barbs as they approach the edges and bases of blades. The increasingly common grinding stones and slabs that were noted as early as the Terminal Paleoindian now prove in the Middle Plains Archaic an even greater emphasis on plant foods. Late Plains Archaic sites, near the end of the Middle Prehistoric period, often contain perishable materials such as basketry fragments, woodworking debris, atlatl fragments, mounted points, cordage, sinew, hide, feathers, and shell (Kornfeld et al. 2010).

The Bighorn Canyon area was ideally suited for occupation during this period, providing a diverse environmental setting with various resources available at different seasons of the year. Studies of large communal bison kills from this period have received more extensive documentation, several showing use into the Late Plains Archaic period, and represent highly sophisticate bison hunting techniques (Kornfeld et al. 2010). The people of the Middle and Late Plains Archaic period drove bison in groups, sometimes several dozen, off cliffs as part of their bison jump techniques. These jumps are still present within the Bighorn Mountain area, as are other evidences of occupation in the stone circle campsites and rock shelter overhangs (Herrmann et al 2017).

A small concentration of charcoal from an associated Bad Pass cairn, thought to be the remains of a slow match of transported coals, was collected and sent for subsequent radiocarbon dating in 1980 (Loendorf and Brownell 1980). After radiocarbon calibration, the sample yielded a date of 1620 +/- 85 B.P. or A.D. 350 +/- 27, indicating that portions of the Bad Pass Trail could be of Late Archaic or early Late Prehistoric age (Kornfeld et al. 2010).

Late Prehistoric Period

The Late Prehistoric period (ca 1,500 B.P.-500 B.P.; A.D. 500-A.D. 1,500) (Kornfeld et al. 2010) is located within the Medithermal division of the Holocene epoch (Antevs 1955). The Late Prehistoric climate of the Bighorn Canyon supported vegetation for bison herds and other grazing animals. An increased efficiency of bison procurement and the continued use of buffalo jump technology is seen during this period.

The tipi ring sites within the Bighorn Canyon area suggest a seasonal group size fluctuation with an overall upward trend in numbers. Researchers studying tipi rings of Two Eagles Tipi Encampment site inside the BICA-NRA observe patterns corresponding to the early Late Prehistoric and terminal Late Prehistoric at AD 700-1000 and AD 1300-1500 (Scheiber and Finley 2010). Radiocarbon samples from the encampment site returned 10 dates, the oldest dating to 2,500 years ago during the Late Archaic period (Scheiber and Finley 2010). Many of these tipi rings were found in proximity to, or directly upon, the Bad Pass Trail’s cairn-marked route.

Changes in stone tools—particularly their size and style of side, corner, based, and tri-notching—reflect the introduction of the bow and arrow (Kornfeld et al. 2010). The increased use of obsidian for tools and the introduction of steatite for carving stone pipes and bowls suggest involvement with trade networks. The Avonlea culture group practiced burials with large numbers of projectile points, weaponry, bone tools, bone and shell decorative items, fire pit features, numerous grindings stone, and sites along buttes. Ceramics recovered from some of the other widely scattered Avonlea sites are thought to represent a possible relationship to the Woodland period (Frison 1991; Kornfeld et al. 2010).

Protohistoric Period

Determining cultural affiliation for archaeological sites to contemporary tribal or linguistic groups remains one of the greatest difficulties in regional archaeology. This difficulty stems from the degree to which tribes entered each other's territories and used friendly ties between groups, from the absence of well-defined physical boundaries, and from movements of individuals between tribal groups. Fortunately, the Bighorn Canyon and its vast history provides researchers with archaeological evidence, historical records, ethnohistoric accounts, and tribal migration stories. This rich source of information strengthens the timeline of cultural utilization reaching back some 10,000 years. The archaeologically rich landscape and vast ethnohistoric accounts combine to produce a priceless medley of information whose content easily proves immense archaeological and cultural landscape monumentality.

Assigning sites' cultural affiliation increases substantially with evidence of more permanent village sites (Malouf 1967). Hunter-gatherer societies practiced both intermittent and more long-term occupation of the Bighorn Canyon and surrounding region. Earliest occupants of the Bighorn Basin and Bighorn Canyon were hunter-gatherer societies who practiced exploitation of local plant and animal resources. Contemporary societies such as the Crow, Arapaho, Cheyenne, and Kiowa, practiced intermittent and long-term occupation in the lower Bighorn Canyon, extending from the Bighorn Basin to the bison migration grounds near the Grapevine Creek (Brown 1969). Early Shoshone bands practiced more intensive occupations in many areas of eastern Montana (Brown 1969). Recovered Mandan tradition pottery from the early sixteenth to eighteenth centuries attribute many sites of northcentral and northeastern Wyoming to the ancestral Crow (Frison 1976).

During the Protohistoric period the introduction of the horse to the Northwestern Plains and Rocky Mountains proved significant in regional culture change. The horse was introduced from the Spanish colonies to the south, and its influx to Shoshoneans was established during the first quarter of the eighteenth century. Not until 1630, and likely not before 1650, does evidence indicate the full adoption of horse culture by Plains groups. It is estimated that the horse was introduced to the Crow soon after (Nabokov and Loendorf 1994; Kornfeld et al. 2010). Earliest accounts place the Crow’s adoption of the horse by the year 1742 (Haines 1938), and to the Bighorn Canyon about A.D. 1730 (Voget 2001).

Around A.D. 1650, people within the Bighorn Canyon area began receiving European goods. With the introdution of trade goods also came the introduction of disease. By A.D. 1650 diesease had spread throughout indigenous populations and reached the hunters of the Bighorn Canyon. Smallpox decimated native popualtions and promoted additional movements as people attempted to escape the sickness’ reach or to establish new territory (Hoxie 1995). Pedestrian movements during the Protohistoric period brought the Blackfoot Indians and the Crow Indians to the Bighorn Canyon area. However, from 1800 to present the occupation of the Bighorn Canyon is nearly entirely attributed to the Crow.

Historic Occupation

Crow Occupation and Nineteenth Century Explorers

The nineteenth century brought trappers, traders, and explorers to the Northwest Plains. Much of the information related to tribal group locations has been obtained through accounts by these early explorer and traders. Among these men were popular historic figures like Jim Beckwourth and Jim Bridger, who recounted their interactions as they traversed the landscape (Good 1974). Other names of mountain men who floated furs from the mouth of the Bighorn canyon to the Yellowstone River include Jedidiah Smith, Alexander Henry, William Ashley, and Milton Sublette. There are three known instances of the Bad Pass trail being the primary route between the beaver trapping grounds of the Green River Basin in western Wyoming, and their connection point along the Yellowstone River. These instances are dated to 1815, 1824 and 1833 (Bearss 1970). The interior of the present BICA-NRA, however, did not prove as attractive to many early trapping partnerships or successive generations of trappers, explorers, and traders. The earlier Lewis and Clark Expedition bypassed the region entirely. Expeditions by Joseph Dickson, Forest Hancock, and John Colter may have wintered near the Pryor Creek headwaters or west of Clark’s Fork, but they did not pass through the Canyon. Most activity of following generations of trappers, explorers and traders took place on the Yellowstone River, further down the Bighorn River, or into Clark’s Fork country (Bearss 1970; Voget 2001).

The Bighorn Canyon lies within the heart of Crow territory. Crow peoples immigrated to the area as recently as late 16^{th} century (Scheiber et al. 2008). They were already well-established nomadic hunters by first explorers' arrival on the Northwestern Plains in the late 18^{th} century (Good 1974). Ethnographically speaking, the Crow (Apsáalooke) people, the Children of the Large- Beaked Bird, are among the better-known, and well-researched, Plains groups. Early recounted boundaries of aboriginal Crow include the Yellowstone River and its tributaries, the Musselshell River to the north, the Powder River to the east, and the Wind River to the south. The Bighorn Canyon is spatially and temporally located within this Crow territory, and prior to formal archaeological excavations it was already assumed that the campsites within the canyon likely represented Crow occupation (Good 1974). As stated in the previous section, pedestrian movements during the protohistoric period brought the Blackfoot Indians and the Crow Indians to the Bighorn Canyon area. From the early 1800s to present, however, occupation of the Bighorn Canyon is attributed to the Crow.

By the time of the designation of the Bighorn Canyon National Recreation Area, Euro-American expansion and colonialization had already resulted in drastic reduction of early Crow tribal lands (Hoxie1995). By the year 1904, following several treaties, land cessions, and allotments, Crow lands were reduced to the present-day size of 2.3 million acres, a fraction of their original acreage (Elser 2010). The park's designation as a national recreation area in 1966 would mark the official removal of all established occupants, homesteaders and Crow people alike, from within the Recreation Area. Despite the present-day physical separation of the Crow Tribe reservation from the Bighorn Canyon, the lands which comprise the BICA-NRA are very clearly identified as traditional Crow tribal homelands.

Chapter 4: Methods

Field Methods

Field Crew

The collaborators of the 2014 Bad Pass Trail research were granted the unique opportunity to employ field technicians, trained in Bighorn Canyon archaeology, for the purpose of updating and revising the Bad Pass Trail National Register of Historic Places nomination of 1975. By physically exploring the entire length of the trail as a team unit, documenting historical landscape features, and recording any contributing and noncontributing features, we created a database to aid in future site plans and landscape inventory efforts by the National Park Service's cultural resources management specialists (Finley and Branam 2012).

As a graduate student already involved with an earlier phase of the RM-CESU grant, I was honored to also be assigned as crew lead under the direction of (now retired) NPS cultural resource manager and Archaeologist, Chris Finley. My crew included two field archaeologists experienced in cultural resource management, who had both previously participated in Bighorn Canyon field schools, and who are both members of the Crow Tribal Nation. Another member of our crew included a field archaeologist experienced in cultural resource management, who likewise participated in Bighorn Canyon field school, and who is a member of the Northern Cheyenne Tribal Nation. The final member of our crew was a student of Northwest College local to the area, who was able to join our team mid-way through our fieldwork as part of an internship with his college and the National Park Service.

Our field team indeed proved to be a diverse and progressive collaboration, even in today's day and age. Our team very quickly discovered that our combination of educational backgrounds and cultural experiences fostered an uncommonly rich dynamic-one which I would now argue to be a necessary requirement for any archaeological team. We relished in our shared goals of archaeological knowledge, cultural resource preservation, and cultural understanding. Our work truly reflects a group of researchers whose passion for the Bighorn Canyon, its resources, and their successful management, solidified them as a team unit.

Park Access

Visitor access to the BICA-NRA is limited to the park's entrance located at the southern portion of its boundary, west of the Bighorn River and south of the Bighorn Canyon corridor. Guests can access this entrance by means of Highway 37 just outside the town of Lovell, Wyoming. Our crew began each day by taking this route, beginning at the Bighorn Canyon Visitor Center, and traveling for just over 2 miles via ALT Highway 14 before turning north on Highway 37. The recreation area boundary is located some additional 7.5 miles north on Highway 37. The WY/MT state border serves as a rough location marker for the southernmost Bad Pass Trail cairns. Another 11.5 miles of travel by highway through the canyon leads to the area of the northernmost cairns.

Knowledge of previously recorded cairn locations resulted largely from the efforts of Lawrence L. Loendorf and Louise Brownell in 1980 (Loendorf and Brownell 1980) and through the extensive knowledge of the area's cultural resources provided by park archaeologist Chris

Finley. These respective cairn locations are summarized in Ashley Wisehart's publication for partial completion of her Master of Science degree in 2005 (Wisehart 2005).

Once any previously recorded cairn locations were digitally displayed with ArcMap software by archaeologist Chris Finley, our team designed a plan of action for recording the braided nature of the trail system. The associated cairns appear in a segmented nature along the trail route, a pattern likely resulting from years of continued use and modification. This segmented nature proved beneficial for organizing the inventory of the 706 cairns over 27 days.

Pedestrian survey

While previous data provided us with a general guide to known cairn locations, there was still some uncertainty as to the extent of specific trail segments. In addition, it was our responsibility to record to the best of our ability the northernmost and southernmost associated Bad Pass Trail cairn within our proposed study area. Therefore, our field work began with pedestrian survey to identify what we believe to be this northernmost associated Bad Pass Trail cairn. The survey was organized in the area south of the historic Lockhart Ranch. Once having identified what we believed our northernmost cairn, we continued our survey southward, adjusting transects to run parallel to known cairn segments. Our process included flagging several cairns then back-tracking to record each location and attribute, consistently recording in a north-south progression. Our work verified the extents of each trail segment, and clarified which cairns were of direct association to the cairn system in areas with increased space between cairns, and areas lacking a clearly defined linear route.

Field Records

After individual cairns were identified and flagged, our crew then recorded the geographical locations for each cairn with handheld global positioning device (GPS) at an accuracy of eight feet (about 2.4 meters) using Universal Transverse Mercator projection and North American Datum of 1983 Zone 12 North. Dimensions were recorded by measuring maximum length, maximum width, height, and orientation of each stone pile. Details of the stones comprising each cairn were recorded by measuring the diameter of the maximum stone, diameter of the minimum stone, and a numeric range of average stone size. Additionally, the presence of incorporated organic material was recorded through the degree of sedimentation or sodding, amount of duff coverage from surrounding juniper trees, the presence of grasses or other plants growing within or in direct proximity to each cairn, and amount of lichen coverage. The physical condition of each cairn was recorded by noting any construction on substrate bedrock, any evidence of water washout or appearance of stone dispersion from colluvial processes, the presence of any cultural artifacts within or in direct proximity to each cairn, and any noticeable signs of destruction or looting. These attributes were recorded in our field log and then entered into our working Excel spreadsheet at each day-end and were organized per each unique assigned cairn identification number.

At the end of each workday our GPS recorded points were downloaded into Microsoft Excel and displayed as a spreadsheet before being imported and projected into ArcMap software. These visually verified point locations were then merged with other field recorded attributes in a working Microsoft Excel document for our final dataset. Photo numbers and geographical locations were recorded and compiled into a detailed photo log. Progress was reviewed each evening, and any additional questions were then discussed with our supervising archaeologist. Abandoned mine lease (AML) cairns, identified by their construction shape, location near test pits, presence of historic posts or cans, and historical research, were reviewed with our supervising archaeologist and labeled as historic abandoned mine lease cairns before being transferred into a separate working Excel spreadsheet. Additional time each morning was dedicated to revisiting any additional questions with the entire crew.

Photographs

Photographs were taken of several individual cairns in order to digitally record and represent current cairn trails. An additional purpose for collecting these photographs was to document current trail conditions, including visible cairn destruction and modification as represented through abandoned mine least (AML) cairn construction, looting activities, destruction resulting from road modifications, and changes noted by floral overgrowth. Individual artifacts found within cairns through visual observation were recorded, and artifact distributions in near vicinity of the cairn line were recorded and labeled as such. Any remaining ruts from past bison migration within view of the trail were also photographed and recorded as such. Photographs were recorded in the field log with geographic coordinates, a brief description, and were entered into the final photograph log for the National Park Service.

Burials

During the recording process of the trail system, based upon physical appearance and prior historic records, several cairn features were found to be likely marking burial locations. These cairns were recorded within a separate database and are not included within my main cairn dataset. Our Native American consultants provided additional steps that were followed while recording these extremely culturally sensitive features. Offerings of tobacco, prayers, and the use of bitterroot were made at each location to show respect. Our Northern Cheyenne crew member felt it most appropriate that she be excluded from recording these specific cairns, and the National Park Service as well as our entire crew acknowledged and respected these wishes. Cairns thought to exist in association with burials were recorded in the same manner as other recorded cairns: measurements taken, and GPS locations recorded. Additionally, locations and photographs were stored in a separate Excel file for park personal to share with local law enforcement for monitoring purposes.

Lab Methods

Study area and paths of least resistance

Elevation was obtained from the United States Department of Agriculture Geospatial Data Gateway for Carbon and Bighorn counties of Montana, and Bighorn and Park counties of Wyoming. Each county's elevation data TIFF tiles are merged through ESRI ArcMap mosaicking tools at a band width of 1 and pixel depth of 23. Overlapped edges and seamlines are smoothed and corrected into final digital elevation format with ESRI ArcMap Statistic Analyst.

The process of comparing a computer-generated path of least resistance to a braided trail system is comparing two routes of averaged means. First, the slope data originating from within the Digital Elevation Model is stored as raster format and categorized by slope. The regions of most likely traversed slope, or most plausible routes for travel, are then averaged by computer program software (ArcMap) in order to create a singular least cost line. A primary goal of computing a path of least resistance is to impart the least amount of bias while still forcing the cost path analyses through the Bighorn Canyon corridor, connecting the northern grasslands of the Yellowstone Basin of Montana with the southern Bighorn Basin of Wyoming. Since the exact prehistoric origin and destination points of the Bad Pass Trail's route are unknown, I chose to compare points at both the northern and southern extents of the currently understood corridor. Because the corridor is widest at its northern end, I chose to use two points for comparison: one point representing a more western route paralleling the Pryor foothills near East Pryor, and another paralleling the Bighorn River to the east near Fort Smith, Montana. As seen in Figure 4.1, the study area is wider at its northern extent and narrower at its southern extent. I chose a single point located near the current town of Lovell, Wyoming.

An initial attempt to compute a path of least resistance paralleling the Bighorn River resulted in a path whose route traced the river itself. I refined the eastern bounds in order to exclude the river's influence, and to limit the route to land area only. Since terracing activities of my specified area date to the early Quaternary period (KellerLynn 2011), a period prior to Bighorn Canyon cultural occupation, I was able to use current terrain data to define this bound. By using the 2,600 feet (roughly 790 meter) elevation contour as a guide, I created a digitized boundary along the west bank of the river and produced a path of least resistance paralleling the river course to connect extents of Fort Smith and Lovell (Figure 4.1).

Producing a second path of least resistance, this time running parallel to the East Pryor foothills, required several refinements. Initially, a path was produced with a course that traveled west of East Pryor, and then south by way of Pryor Gap. Refinement of my study are again resulted in a path that again traveled west of East Pryor, and south by way of Crooked Creek.

Another refinement to exclude the influence of Crooked Creek resulted in a generally parallel route to the East Pryor foothills, to the southern destination of Lovell, Wyoming (Figure 4.1).

Interestingly, the two independent routes join midway through the corridor near the point of Templeton Creek in Montana. From the point near Templeton Creek to the final point at Lovell, Wyoming, the two paths of least resistance overlap to create a singular route. The entirety of cairns recorded during the 20114 CLI lie within the limits of the joined paths. The combined paths' output is stored as a raster-based route requiring raster-to-polyline transformation. Once completed, the final polyline represents a vector-based route from which the near distance of each cairn (through ESRI's near distance tool) is measured. These distances will form the base dataset for the remainder of my thesis.

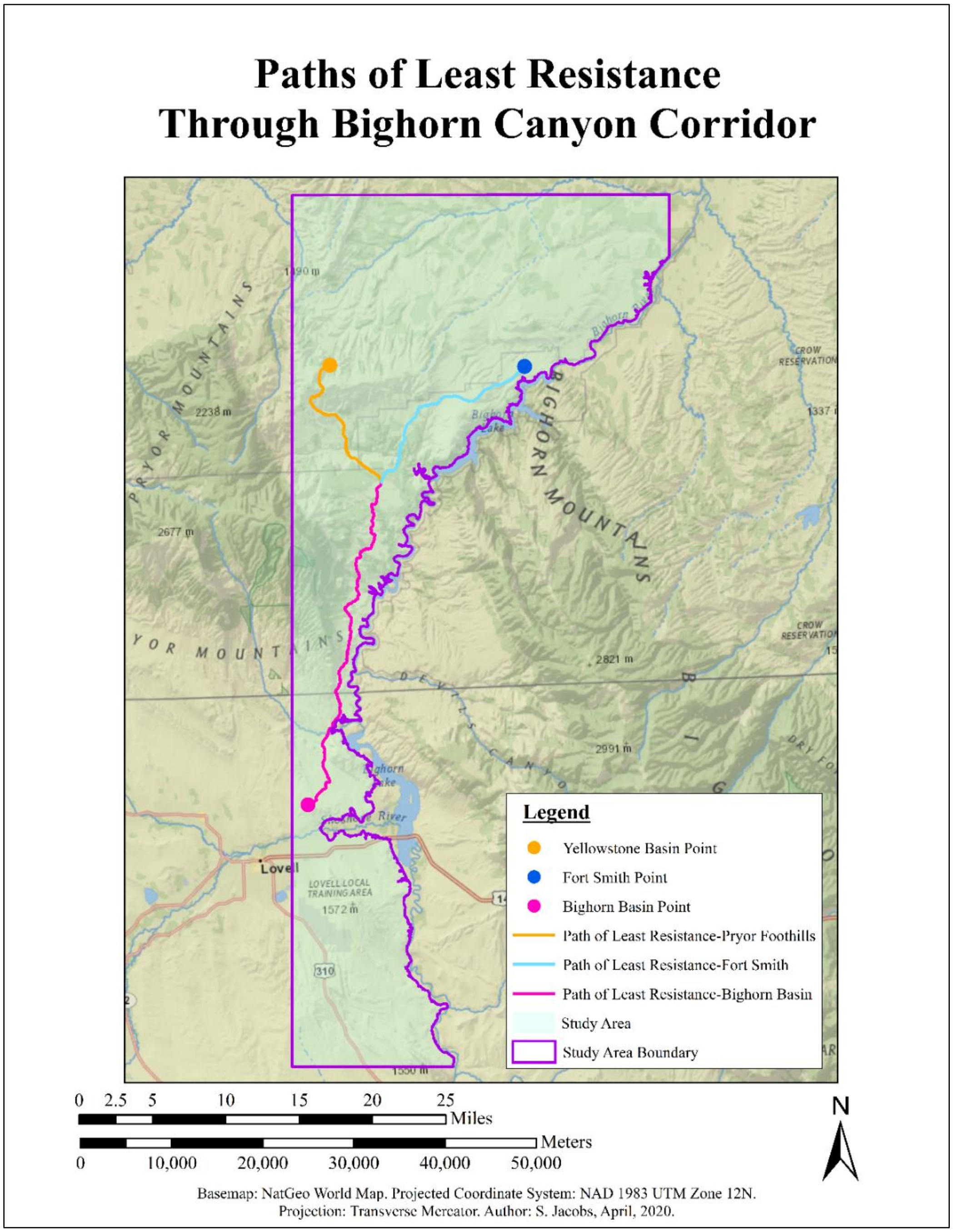


Figure 4.1. Bighorn Canyon corridor least cost path/ path of least resistance.

Data Exploration

Statistic tests based upon mean and standard deviation when measuring distribution remain the most applicable to my dataset. Despite a relatively non-normal frequency distribution, my dataset of 706 near distances far exceed the suggested 20+ to 30+ general recommendation. The trend in my frequency distribution, though generalized, is a right skewness positive correlation. Right skewness positive correlation represents an increase in total number of occurrences, or cairns, being located nearest the path of least resistance, and a gradual decrease in number of cairns as that distance increases. I present my near distance values as absolute values, and do not apply negative assignments in order to distinguish those cairns from the west verses the east side of the path of least resistance. The presence of several peaks in my frequency distribution, combined with a large standard deviation, numerically reflect the physically segmented nature within in larger population. By using the Geostatistical Analyst tools through ESRI's ArcMap, boxplots again display these peaks within the braided trail route.

Statistical Significance

Statistic similarity is again based upon measures of distributions around a data mean. Z-scores, or standard scores, are standardized values which measure this distribution. The measure of statistical similarity or statistical difference of individual data values in relation to the population mean is achieved by applying a critical value threshold to a dataset’s z-scores. A critical value is the numeric threshold for determining whether values express a statistically significant difference. The critical value *(CRrV*) is equal to the critical z-score (*CrZ*) multiplied by the standard deviation (*sd*). By adopting 95 percent confidence level, I am testing for significance (alpha) exceeding my critical value. Based on the near distances of all 706 recorded cairns I will produce a threshold outside of which cairn near distances most differ from that of the larger population. Cairns exceeding this threshold differ most greatly from the larger population and represent those cairns whose locations are most likely affected by additional factors beyond just terrain slope. Figure 4.2 shows an example of how cairns exceeding this threshold can be singled out with the use of ESRI software, based upon near distance and critical value. For my thesis I selected a threshold based upon 95% confidence and one-sided distribution (Table 4.1).

A two-sided distribution produces two thresholds for determining statistically significant near distances. These thresholds are produced by multiplying the critical value by the standard deviation, before then applying the resulting number to the dataset's mean distance. The final thresholds determine which cairns are located at distances far enough from the mean to express statistical significance. When mapped, these thresholds would be expected to appear as a halo-effect buffer around the mean value, reflected on either side, east or west, of the least cost path. However, this type of two-sided distribution does not best fit my dataset, as there would be a resulting overlap in thresholds when mirrored onto both the west and east sides of the computer-generated route of least resistance. Therefore, I will use the upper one-sided distribution to more appropriately represent my dataset.

An upper one-sided distribution produces a single threshold for determining beyond which distance from the least cost path a near distance will express statistically significant difference when compare to the rest of the dataset values. The threshold is produced by multiplying the critical value for one-sided distributions by the standard deviation, before finally adding that value to the mean distance. This final threshold is used for determining beyond what distance from the least cost path a cairn's location will show statistically significant difference. When mapped, this threshold will appear as a total area coverage, measuring from and include the computer-generated path of least resistance.

One could accept the mathematical assumption that a cairn's near distance exceeding a user-set confidence interval warrants exclusion from analysis; indeed, the math could be presented in such a way to support this argument. However, archaeological investigations strive to avoid hard 'yes' or 'no' answers to questions which are best answered in a qualitative approach. Just because a cairn's near distance exceeds the 95 percent confidence, does not n mean it exists in gross discourse from the remainder of the values. It is imperative to apply common sense to the interpretation of mathematically derived values in order to have more accurate interpretations and contextually complete conclusions. It also remains imperative to refrain from succumbing to analyst bias: to simply 'explain away' the anomalies of a "best fit" model to fit our end goals.

Table 4.1. Summary of cairns exceeding critical value for statistical significance.

Affected Trail Segment	***Total Segment Cairns***	***Cairns Exceeding Threshold for Statistical Significance***
C-West	77	43
G	41	41

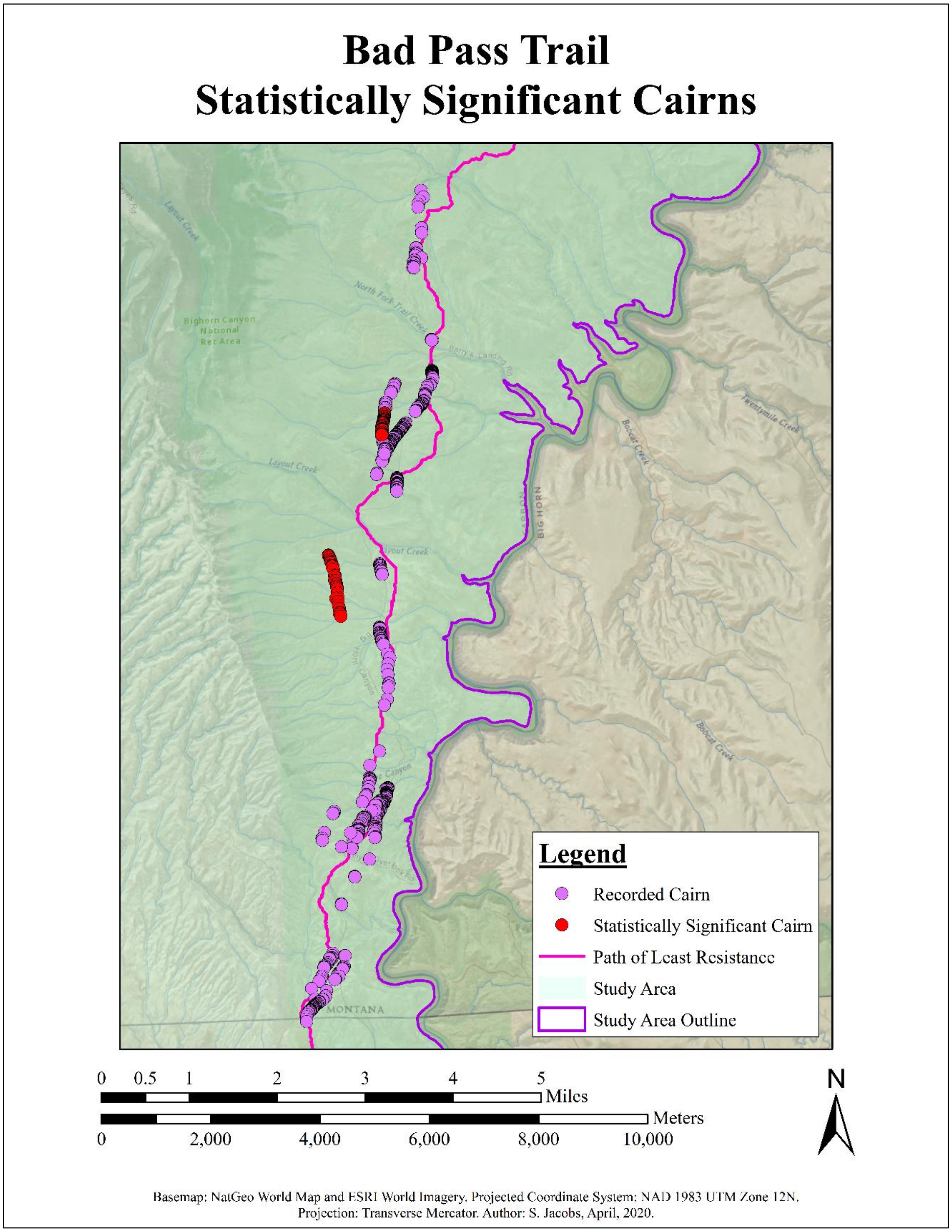


Figure 4.2. Bad Pass Trail and statistically significant cairns with least cost path.

Confidence Intervals

Confidence levels of 95 percent imply that, if the sampling was repeated 100 times, an expected population mean would lie within this interval range 95 of those 100 times. A two-sided confidence interval produces an expected interval of near distance measurements, distributed equally on either side from a dataset mean: half of the values on a left tail and half on a right. When mapped, this distribution appears as a halo-effect buffer, located on both the west and east sides of the Bad Pass Trail least cost path. An upper one-sided confidence interval produces an expected interval of near distance measurements, distributed on the positive side (greater side) of the dataset mean. When mapped, this distribution appears as a solid buffer extending from the least cost path outward on both its west sides.

As the user-chosen level of confidence increases, the resulting size of the interval will contract to include less area. As the user-chosen level of confidence decreases, the resulting size of each interval will expand to include more area. Any level of confidence can be used when examining a dataset, however, commonly used confidence levels are those that also correlate with the 1, 2, and 3 standard deviations of a normally distributed bell curve. Additionally, by comparing the output values produced from each neighbor confidence level, the viewer can compare the different interval ranges and sizes to each other. Included in each of my tables in my Results chapter are the neighboring confidence levels to my own: 90 percent and 97.5 percent.

Tolerance Intervals

In most of my tests to this point I am assuming a two-tailed distribution for my dataset. Two-sided data distributions are presented as both a both a positive and negative critical value placed about a data mean. However, the tests used to predict expected distance of associated Bad Pass Trail cairns to a path of least resistance, over currently undocumented acreage, will rely on one-sided tolerance intervals. Unlike two-sided intervals, the one-sided tolerance interval is based upon a single positive critical value extending from the data mean. Values falling beyond this critical value (in one-sided distributions) prove statistically significant and/or statistically different from the larger population.

Tolerance intervals are used in predicting locations of a specific proportion of a population based upon the distribution of all occurrences. Tolerance interval calculation requires a dataset have a known means and standard deviation, unlike confidence interval calculation which can produce results with a known mean and estimated sample error. When determining margin of error for tolerance intervals, the estimated standard error must be replaced with a known standard deviation. In a normally distributed dataset, or in a dataset of 30+ occurrences, if the mean and standard deviation are known, then the confidence interval and tolerance interval will both serve similar roles: the z-score can be transformed into a tolerance factor.

Tolerance intervals are most appropriately used in identifying bounds within arbitrary future samples and ascertaining the total portion of occurrences likely to lie within each bound. As it pertains to my examination of the cairns of the Bad Pass Trail, I believe tolerance intervals could have application in ground truthing inventories to better understand likelihoods that certain survey areas may produce occurrences of cairns most influenced by terrain slope. This information, I argue, could prove useful in future surveys designed to locate additional cairns, most influenced by terrain slope, to the northern and southern extents of the currently recorded trail system.

As I discussed in Chapter 1, it is imperative to acknowledge caveats of measuring prehistoric activities by use of quantitative tests alone. As researchers we must clearly acknowledge that this type of work is limited in its ability to truly encapsulate a complete understanding of the complexity of those motivations which influenced prehistoric peoples. These quantifiable measurements or assumptions should not be used as a limit on our research, but rather as a guide for expansion.

Chapter 5: Results

A total of 706 associated stone cairns of historic and pre-historic construction were identified. These cairns span some 19,300 km (or about 12-miles) of terrain within the political bounds of Bighorn Canyon National Recreation Area. The braided and segmented nature is apparent both in geographic and statistical representations. During inventory the Bad Pass Trail was divided into 15 segments, divided by their physical location and dispersion across the study area (Table 5.1 and Figure 5.1). A brief summary of values for statistical comparisons is provided within the following pages.

Table 5.1. Summary of recorded cairns' near distances.

Recorded Cairns Summary	
Total Recorded Cairns	706
Total Recorded Trail Segments	15
Minimum Near Distance	0.25 meters
Maximum Near Distance	1,040.47 meters
Mean Near Distance	317.61 meters
Standard Deviation of Population	287.68

Cairn Segments

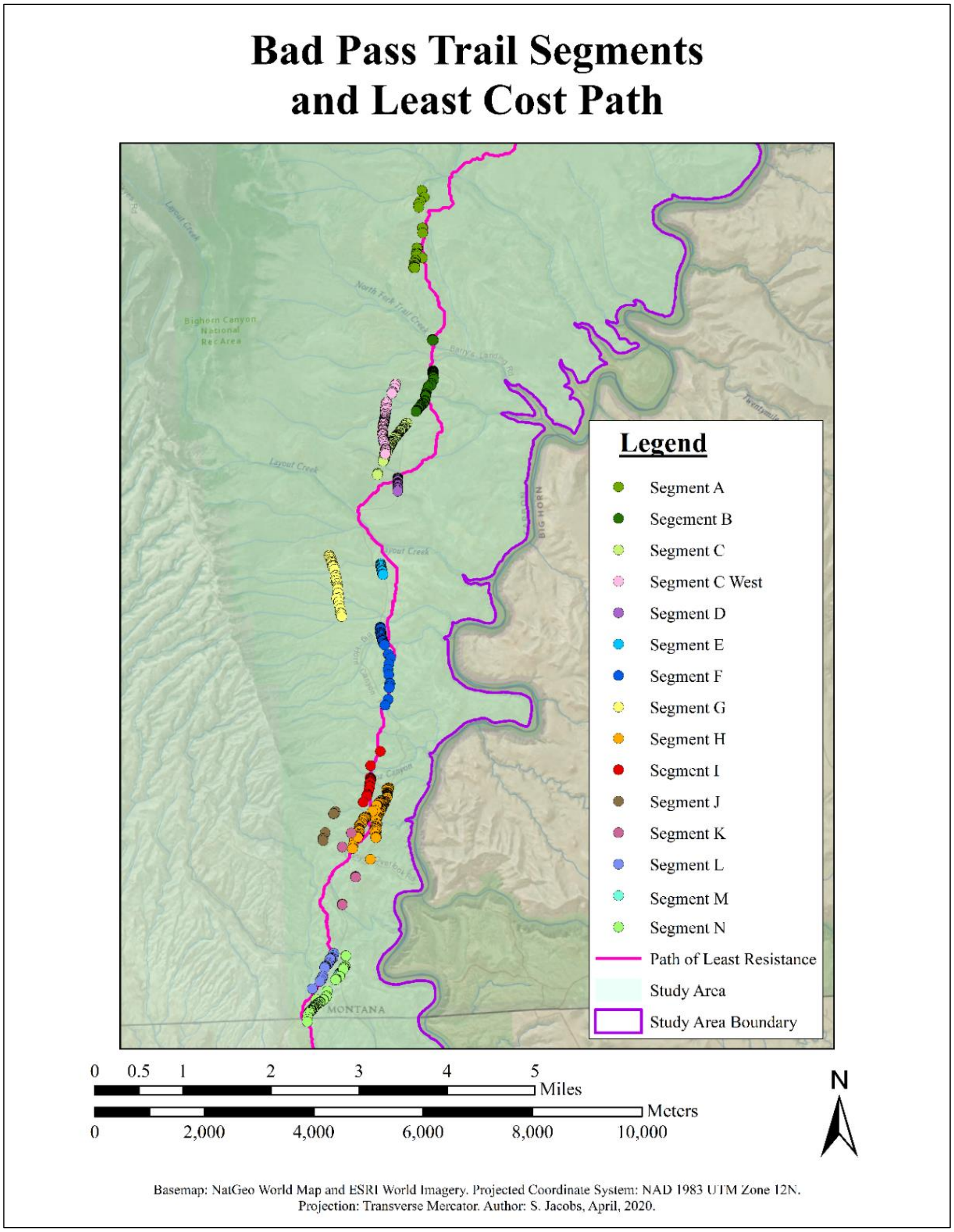


Figure 5.1. Least cost path and cairn segments.

Bad Pass Trail Segment A

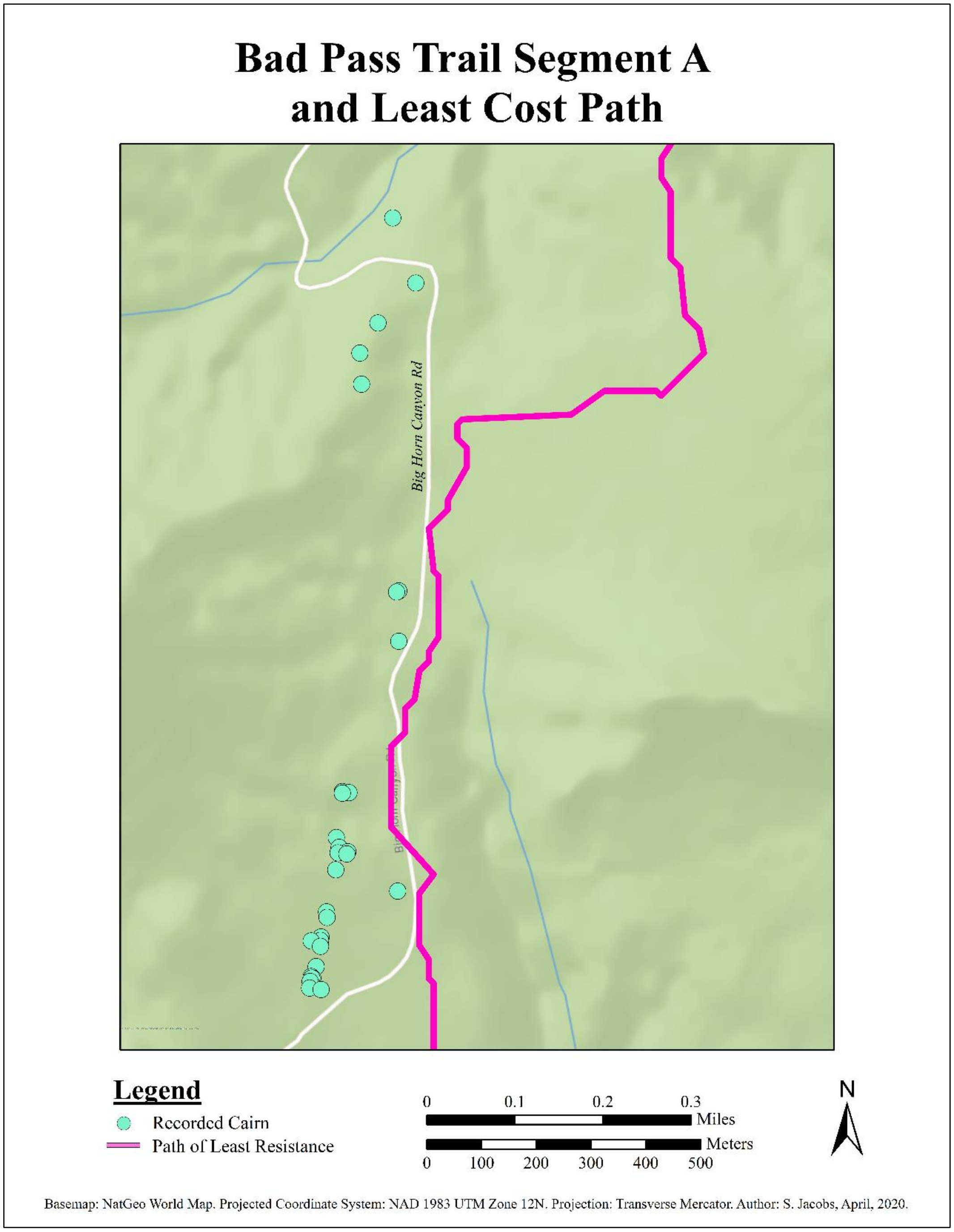
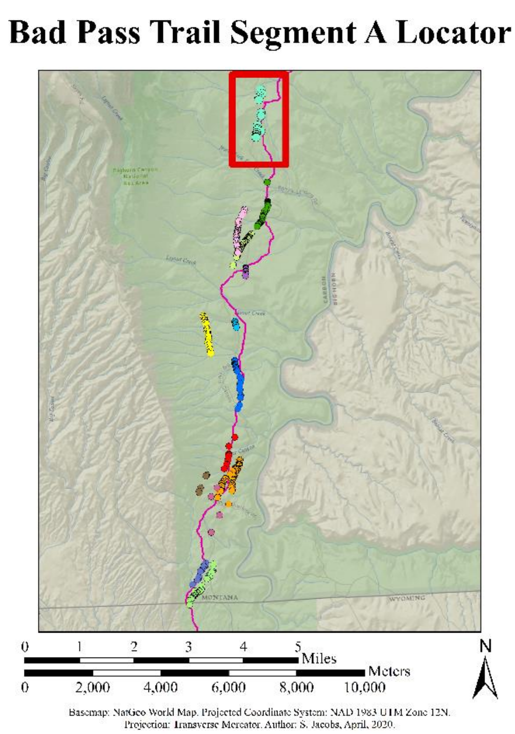


Figure 5.2. Bad Pass Trail Segment A and least cost path map.

Segment A was inventoried on 5/20/2014 and 5/21/2014 and contains 31 cairns. Its northernmost cairn is located just south of the Historic Lockhart Ranch. The segment extends 1,418 meters between Davis Creek and the South Fork Trail Creek. Of the recorded cairns, two show visible signs of disturbance at the time of recording, likely resulting from looting. The segment runs parallel to both the Big Horn Canyon Road and the path of least resistance (Figure 5.2 and Figure 5.3).



Segment Summary	
Segment Name	A
Total Segment Cairns	31
Minimum Near Distance	39.87 m
Maximum Near Distance	389.57 m
Average Near Distance	158.97 m
Standard Deviation	73.29
Total Statistically Significant Cairns	0

Figure 5.3. Segment A locator map and segment summary.

Bad Pass Trail Segment B

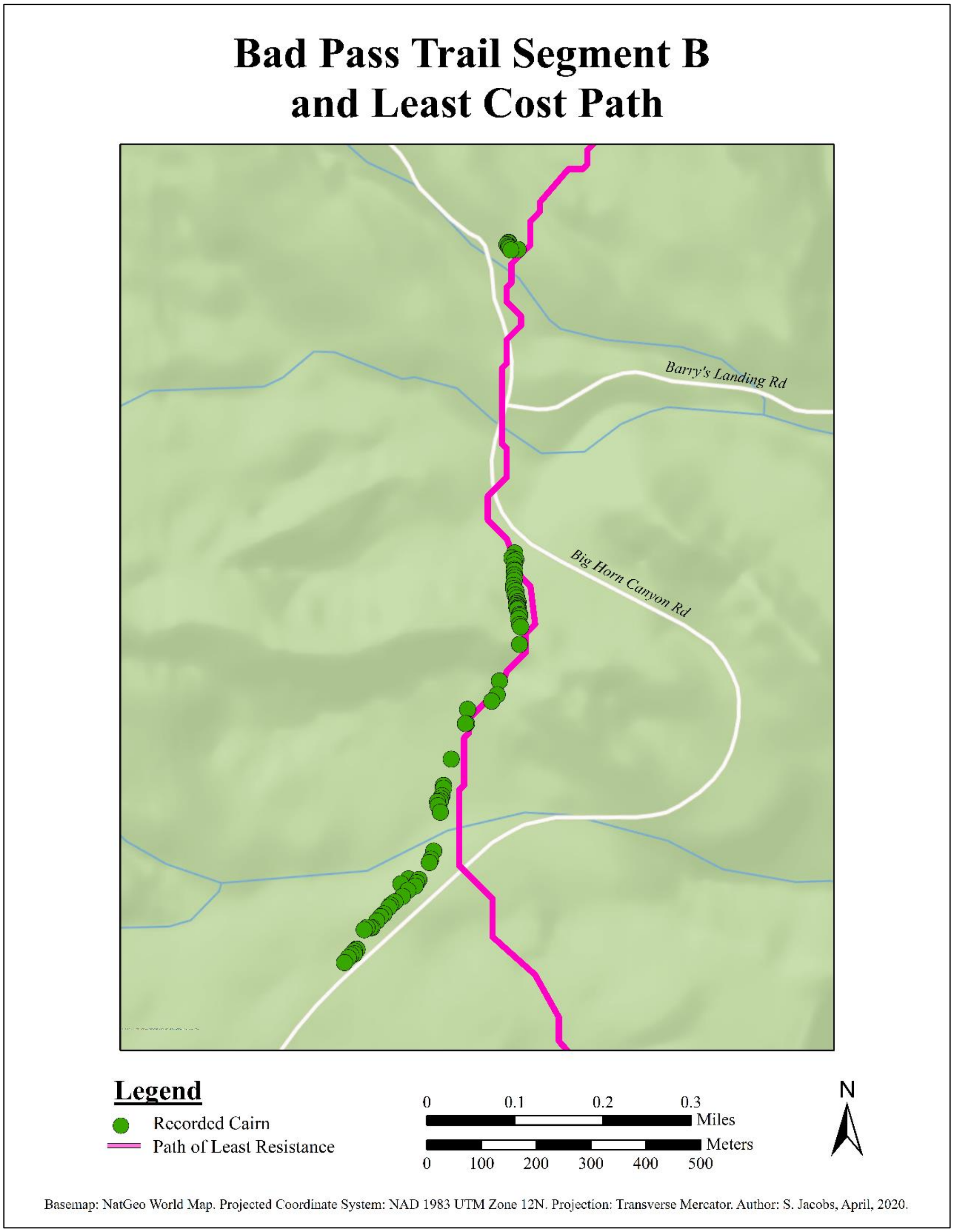
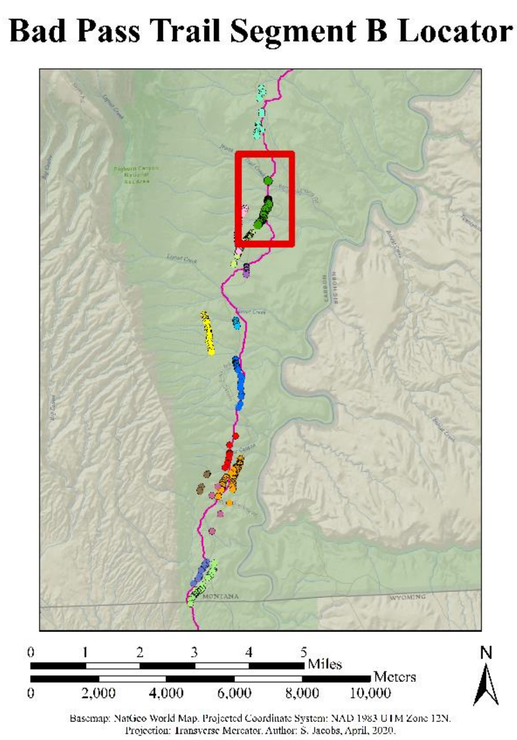


Figure 5.4. Bad Pass Trail Segment B and least cost path map.

Segment B was inventoried on 6/2/2014 and 6/3/2014 and contains 78 associated cairns. Segment B's northernmost cairn is located 70 meters northeast of the North Fork Creek's intersection with the Big Horn Canyon Road. The segment extends for some 1,420 meters before terminating at an area south of the South Fork Trail Creek and west of the Historic Hillsboro Ranch. (Figure 5.4 and Figure 5.5).



Segment Summary	
Segment Name	B
Total Segment Cairns	78
Minimum Near Distance	1.61 m
Maximum Near Distance	274.4 m
Average Near Distance	69.3 m
Standard Deviation	79.41
Total Statistically Significant Cairns	0

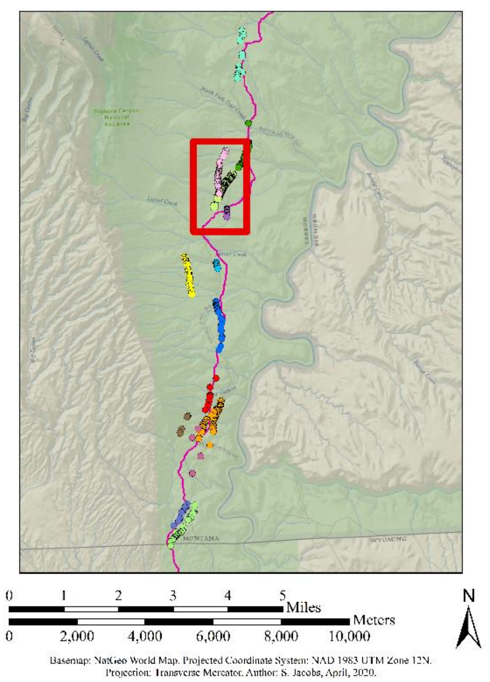
Figure 5.5. Segment B locator map and segment summary.

Bad Pass Trail Segment C

Figure 5.6. Bad Pass Trail Segment C and least cost path map.

The trail's Segment C is located northeast of the present-day National Park Service's Layout Creek Ranger Station. It was inventoried on 5/22/2014 and 5/27/2014. The segment's 99 associated cairns extend 1,096 meters from its northernmost point to terminate at an area identified used for agriculture during historic times. The area void of cairns to its north is likely a result of roadway construction, and the area to its south likely due to historic agriculture (Figure 5.6 and Figure 5.7).

Bad Pass Trail Segment C Locator



Segment Summary	
Segment Name	C
Total Segment Cairns	99
Minimum Near Distance	193.61 m
Maximum Near Distance	673.18
Average Near Distance	560.57 m
Standard Deviation	79.41
Total Statistically Significant Cairns	0

Figure 5.7. Segment C locator map and segment summary.

Bad Pass Trail Segment C-West

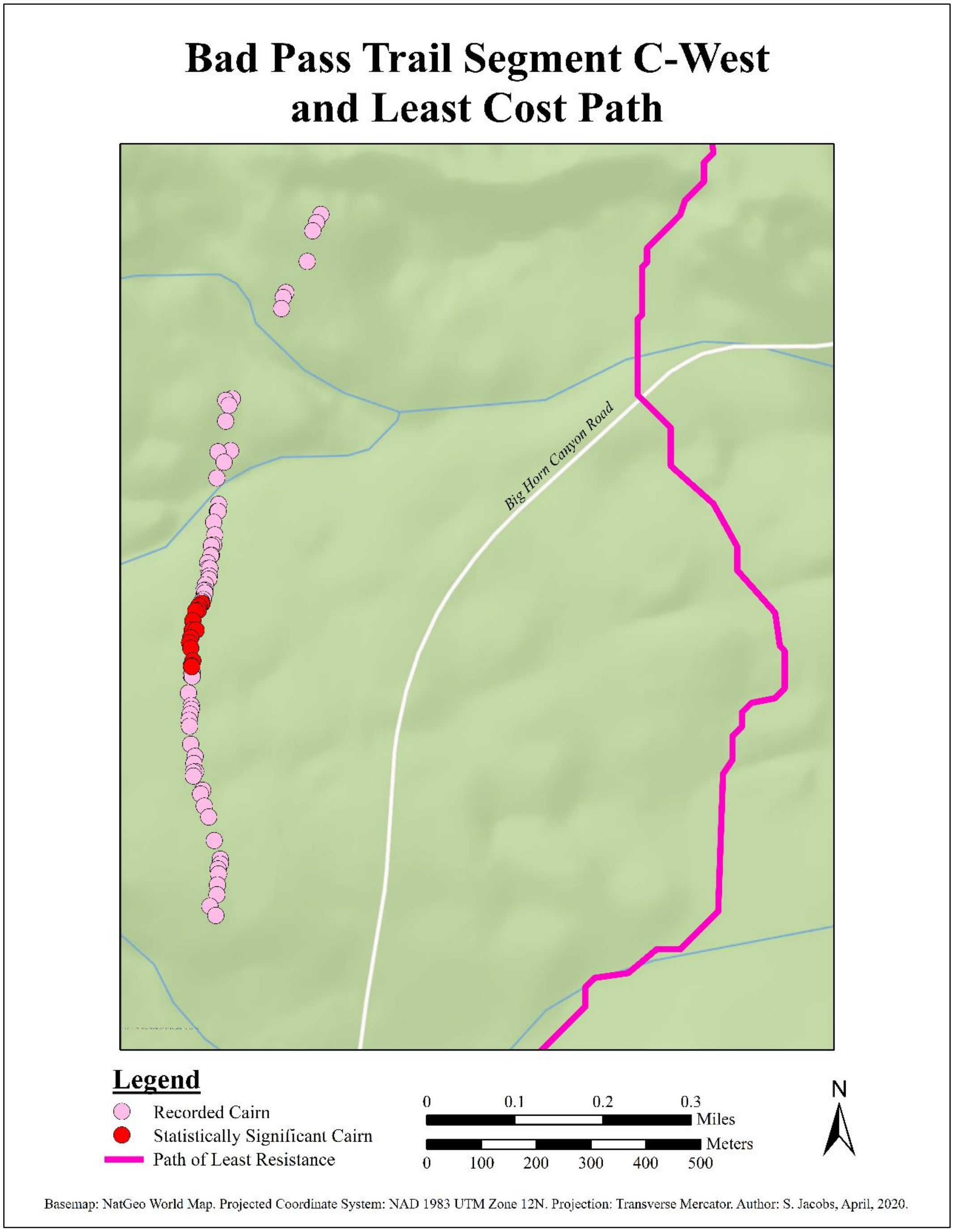
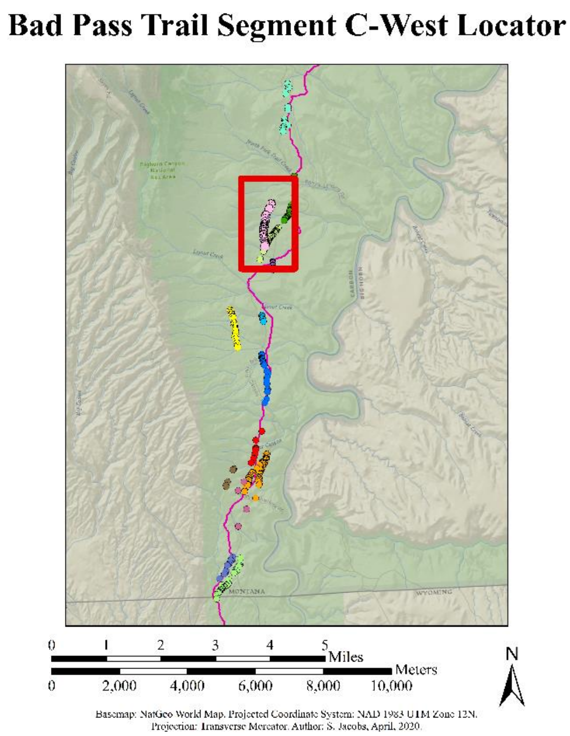


Figure 5.8. Bad Pass Trail Segment C-West and least cost path map.

Section C-West was inventoried on 5/28/2014 and 5/29/2014. Its 77 associated cairns extend 2,180 meters to create a western branch of Segment C. The two segments are apart from each other to the north and join into one branch at its south. The northernmost cairn of Segment C-West is located 540 meters north of South Trail Creek, and its southern extent joins with the main Segment-C (Figure 5.8 and Figure 5.9).



Segment Summary	
*Seg*ment Name	C West
Total Segment Cairns	77
Minimum Near Distance	479.1 m
Maximum Near Distance	931.34 m
Average Near Distance	768.65 m
Standard Deviation	122.7
Total Statistically Significant Cairns	15

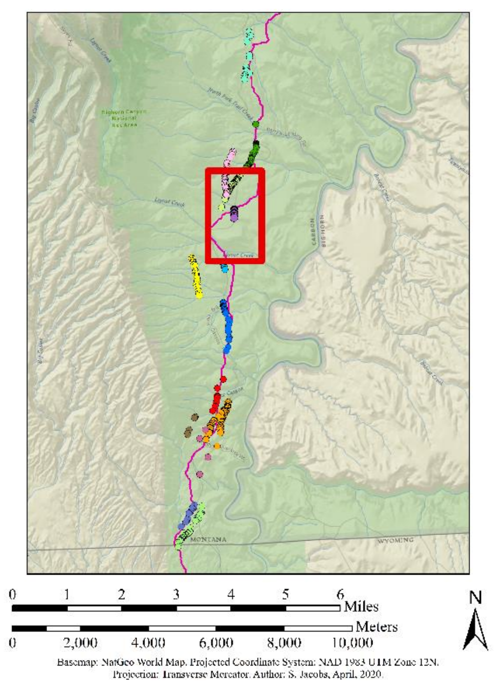
Figure 5.9. Segment C-West locator map and segment summary

Bad Pass Trail Segment D

Figure 5.10. Bad Pass Trail Segment D and least cost path map.

Segment D was inventoried on 6/4/2014 and 6/5/2014. The segment spans 245 meters paralleling the Big Horn Canyon Road. In 2005 trail Segment D was recorded by Ashley Wisehart as comprising a historic fence line. The presence of barbed wire and fence post remnants could reflect such historic utilization. However, the segment is nearly entirely constructed atop a visible solid stone substrate, discouraging post penetration into a soil base as often required by strung wire fences. Park Archaeologist Chris Finley believes that this segment is likely a result of prehistoric creation with a component of historic modification (Finley personal communication 2014) (Figure 5.10 and Figure 5.11).

Bad Pass Trail Segment D Locator



Segment Summary	
Segment Name	D
Total Segment Cairns	27
Minimum Near Distance	0.99 m
Maximum Near Distance	178.82 m
Average Near Distance	74.61 m
Standard Deviation	58.01
Total Statistically Significant Cairns	0

Figure 5.11. Segment D locator map and segment summary.

Bad Pass Trail Segment E

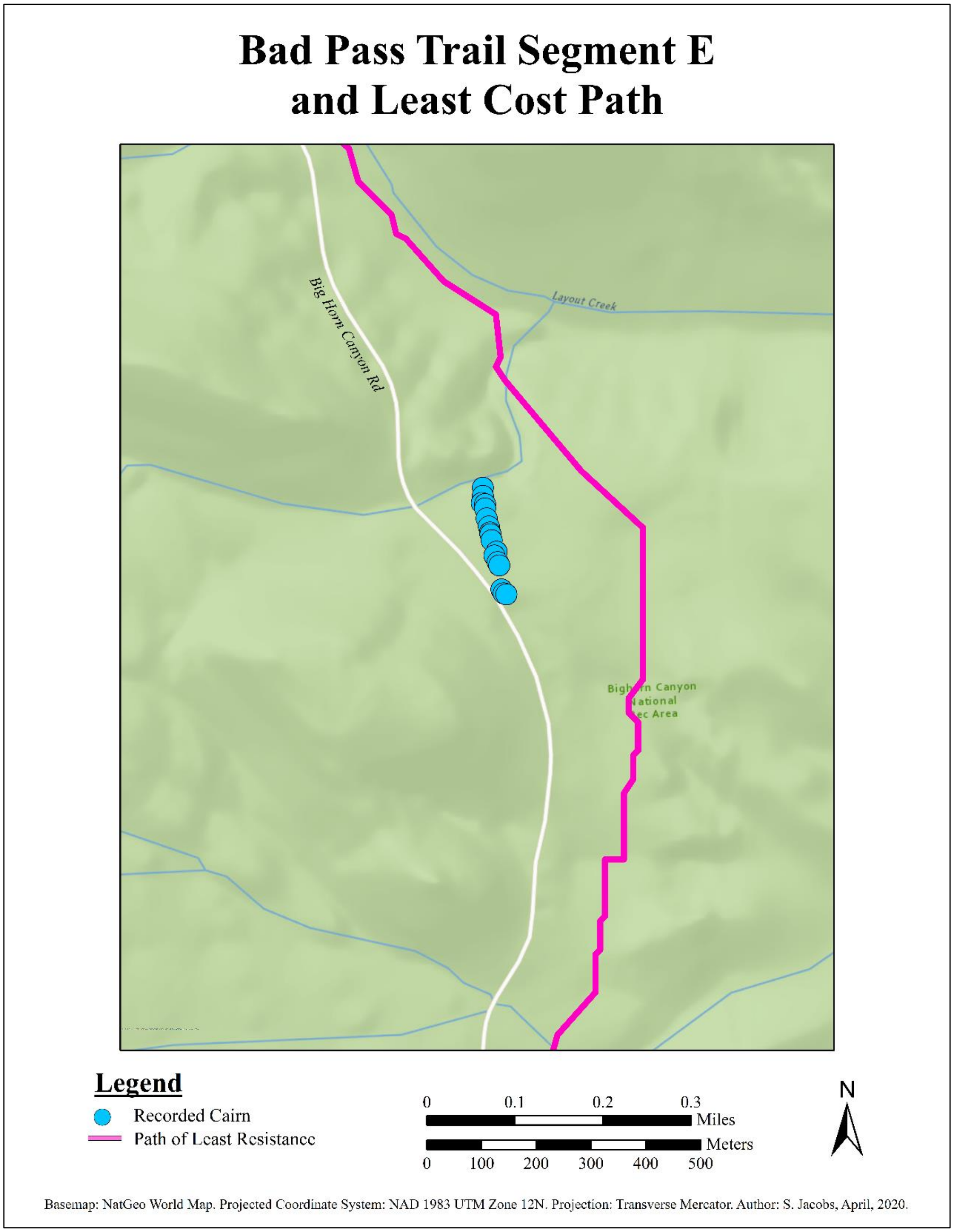
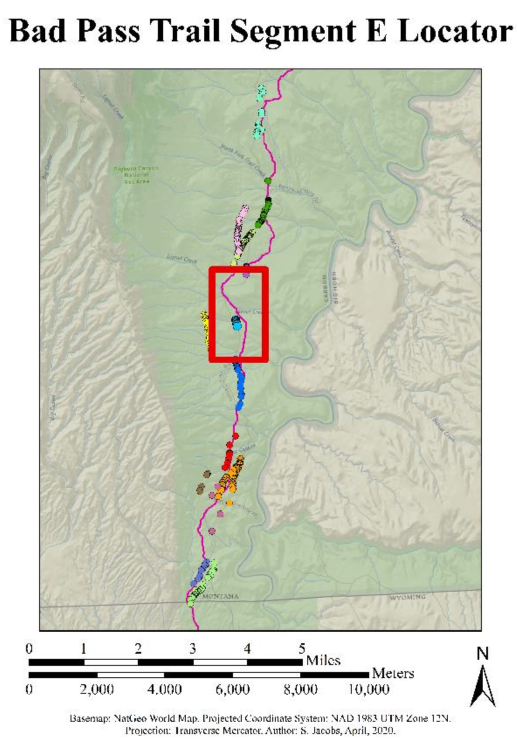


Figure 5.12. Bad Pass Trail Segment E and least cost path map.

Segment E was inventoried on 6/5/2014. The segment's 17 cairns are located entirely on the east side of the Big Horn Canyon Road. The segment is located both south and west of layout Creek and transects the Two Eagles Encampment Site. In the site description of the Two Eacles Encampment Site, Segment E is interpreted as a bison drive line. The segment extends for 200 meters before terminating at the Big Horn Canyon Road (Figure 5.12 and Figure 5.13).



Segment Summary	
Segment Name	E
Total Segment Cairns	17
Minimum Near Distance	157.33 m
Maximum Near Distance	249.36 m
Average Near Distance	205.71 m
Standard Deviation	29.91
Total Statistically Significant Cairns	0

Figure 5.13. Segment E locator map and segment summary.

Bad Pass Trail Segment F

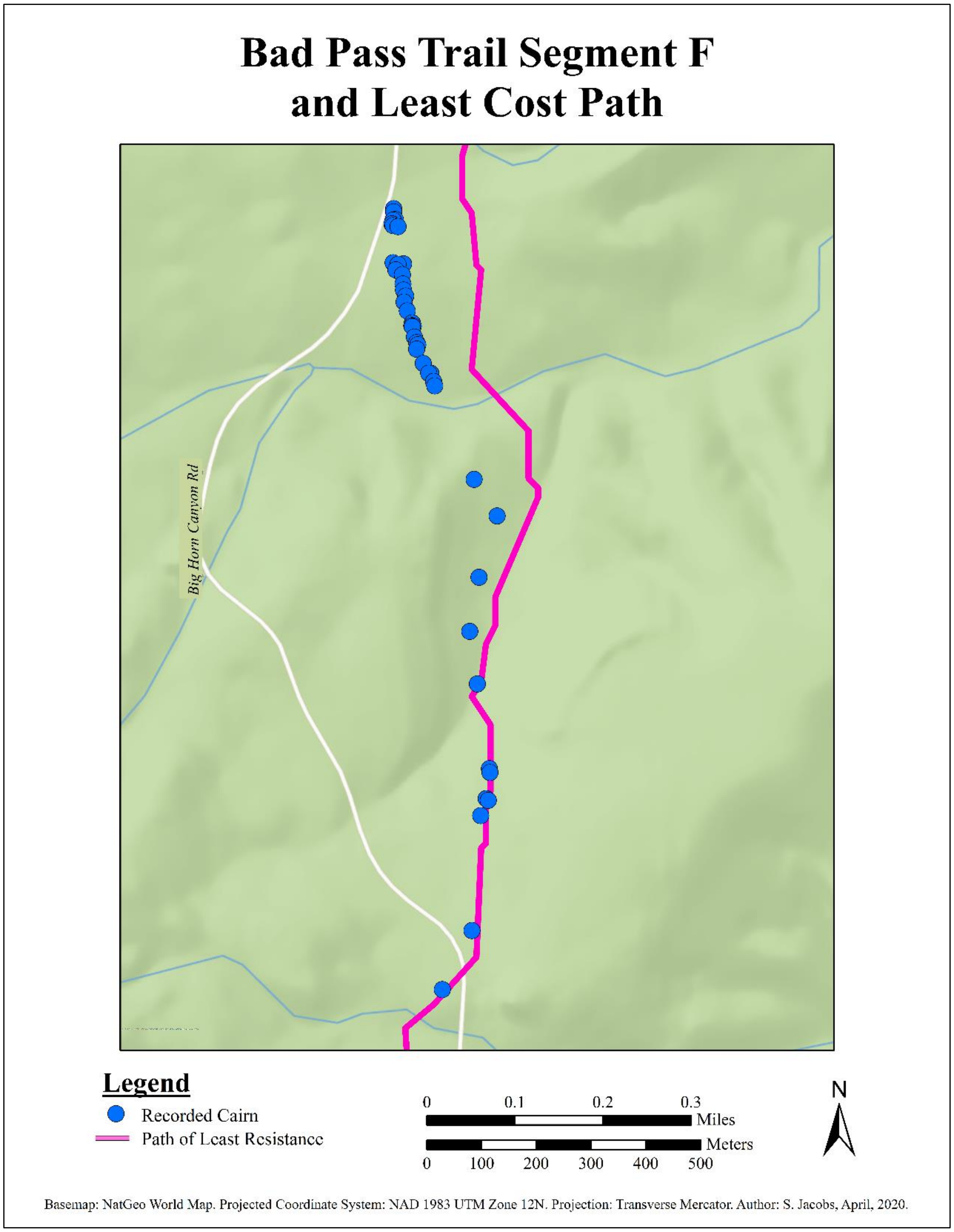
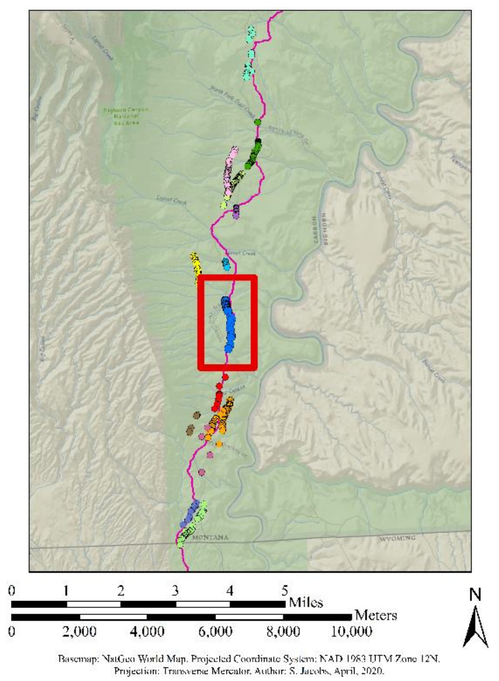


Figure 5.14. Bad Pass Trail Segment F and least cost path map.

The recording of segment F took place on 6/5/2014 and 6/9/2014. The segment includes 42 cairns spanning a linear measure of 1,480 meters across broken terrain proving difficult for anything aside from single-file hiking and careful foot placement. It is located wholly on the east side of the Big Horn Canyon Road as well as wholly on the west side of the computer-generated path of least resistance. The segment ends its path some 1,100 meters north of Booz Canyon. Both the northernmost and southernmost extents terminate as their points meet the highway (Figure 5.14 and Figure 5.15).

Bad Pass Trail Segment F Locator



Segment Summary	
Segment Name	F
Total Segment Cairns	42
Minimum Near Distance	0.64 m
Maximum Near Distance	151 m
Average Near Distance	91.23 m
Standard Deviation	49.73
Total Statistically Significant Cairns	0

Figure 5.15. Segment F locator map and segment summary.

Bad Pass Trail Segment G

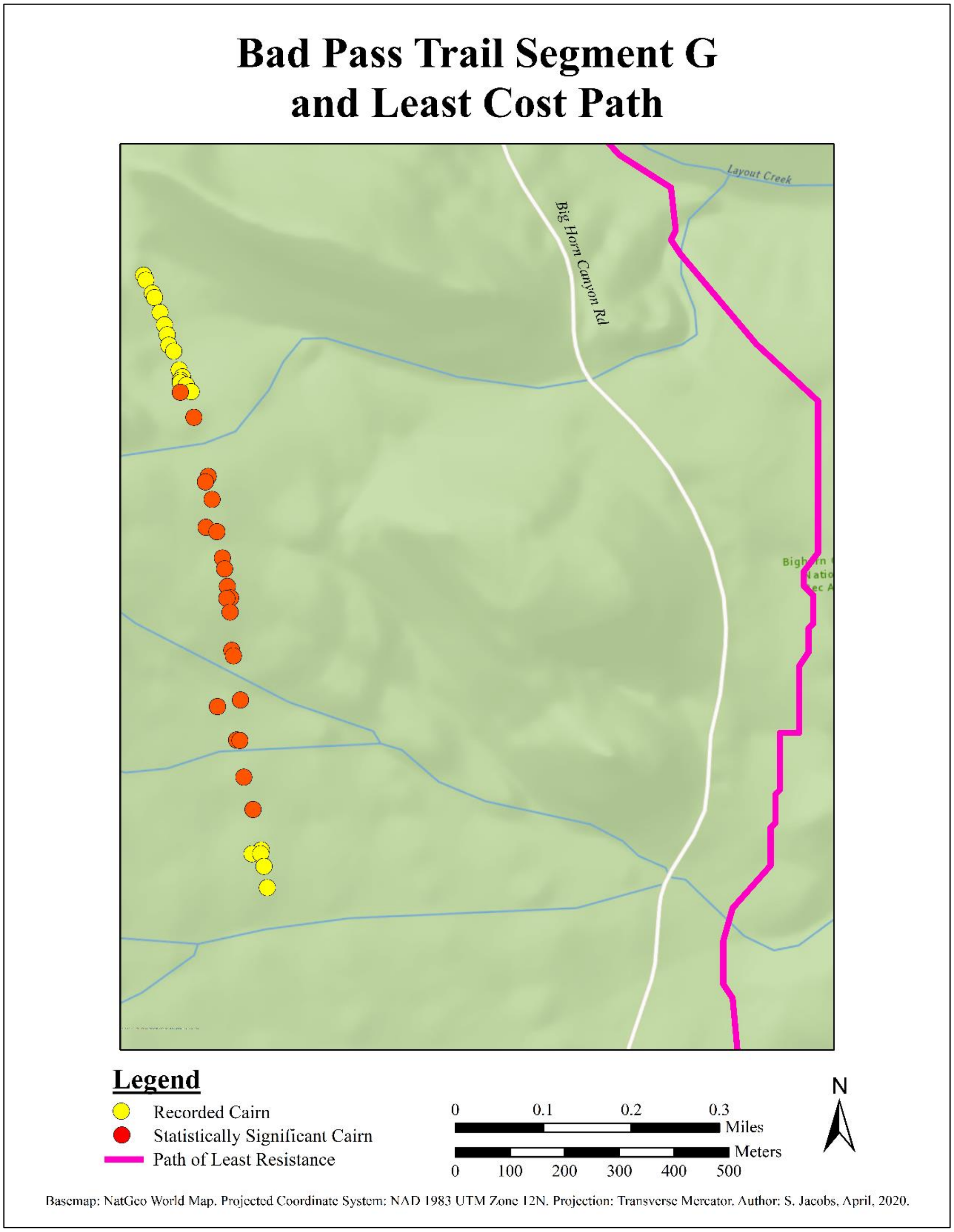
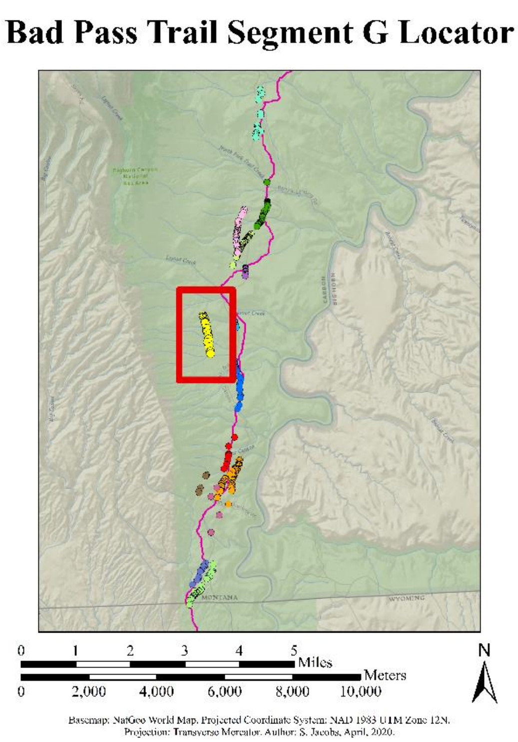


Figure 5.16. Bad Pass Trail Segment G and least cost path map.

Segment G is comprised of 41 cairns recorded on the dates 6/9/2014, 6/10/2014, and 6/11/2014. The entire segment sits atop a ridge at both a higher elevation and further distance from the path of least resistance than its other segment counterparts. Many small flakes and debitage were recorded in proximity of this segment and is reflected in the final report. South of the Layout Creek Ranger Station and West of the Two Eagles Encampment Site, Segment G spans an area of 1,150 meters (Figure 5.16 and Figure 5.17).



Segment Summary	
Segment Name	G
Total Segment Cairns	41
Minimum Near Distance	812.85 m
Maximum Near Distance	1040.47 m
Average Near Distance	914.42 m
Standard Deviation	73.60
Total Statistically Significant Cairns	21

Figure 5.17. Segment G locator map and segment summary.

Bad Pass Trail Segment H

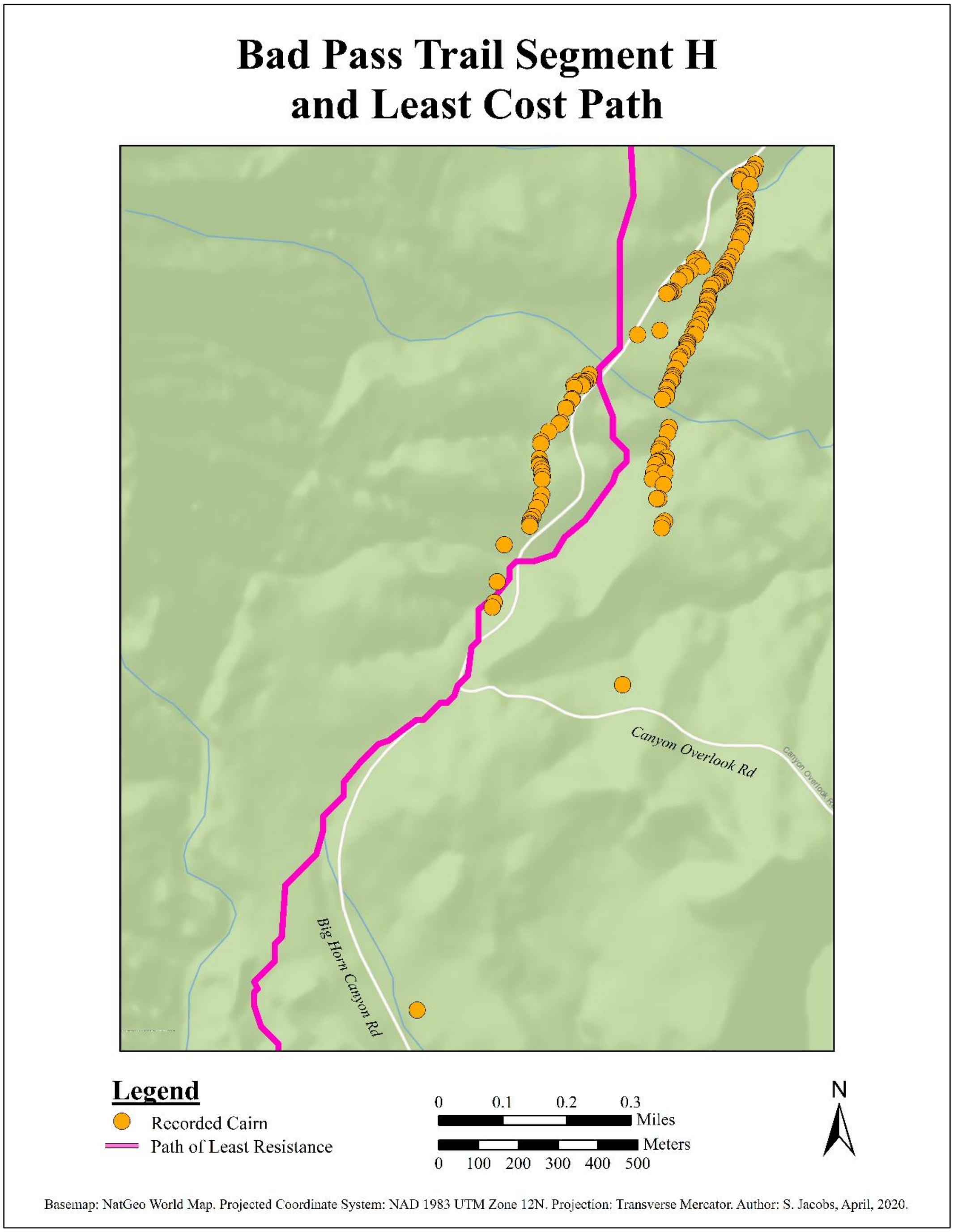
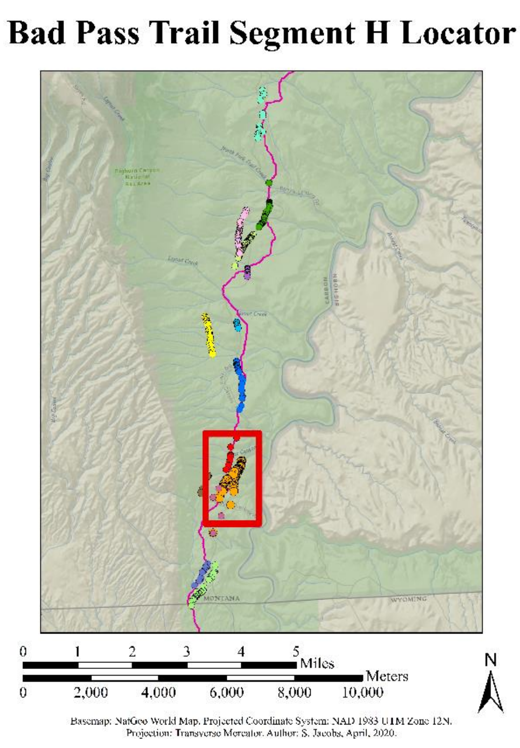


Figure 5.18. Bad Pass Trail Segment H and least cost path map.

Segment H contains 159 total cairns recorded on the dates of 6/24/2014 and 7/9/2014. The segment begins in the area of Sullivan's Knob, some 350 meters south of Booz Canyon. As it extends south, the segment forks into two paths diverging from each other. It was determined by park archaeologist Chris Finley that this segment represents prehistoric and historic components, a result of efforts made by Claude St. Johns as he expanded the trail to better suit the transportation by wagon through the canyon corridor The east tine of the fork represents the prehistoric component of the segment and ends at the Canyon Overlook. The west branch crosses the Big Horn Canyon Road and ends at Yellow Hill. The two tines of the fork lie 380 meters apart at their respective ending points (Figure 5.18 and Figure 5.19).



Segment Summary	
Segment Name	H
Total Segment Cairns	27
Minimum Near Distance	10.90 m
Maximum Near Distance	369.65 m
Average Near Distance	176.72 m
Standard Deviation	81.82
Total Statistically Significant Cairns	0

Figure 5.19. Segment H locator map and segment summary.

Bad Pass Trail Segment I

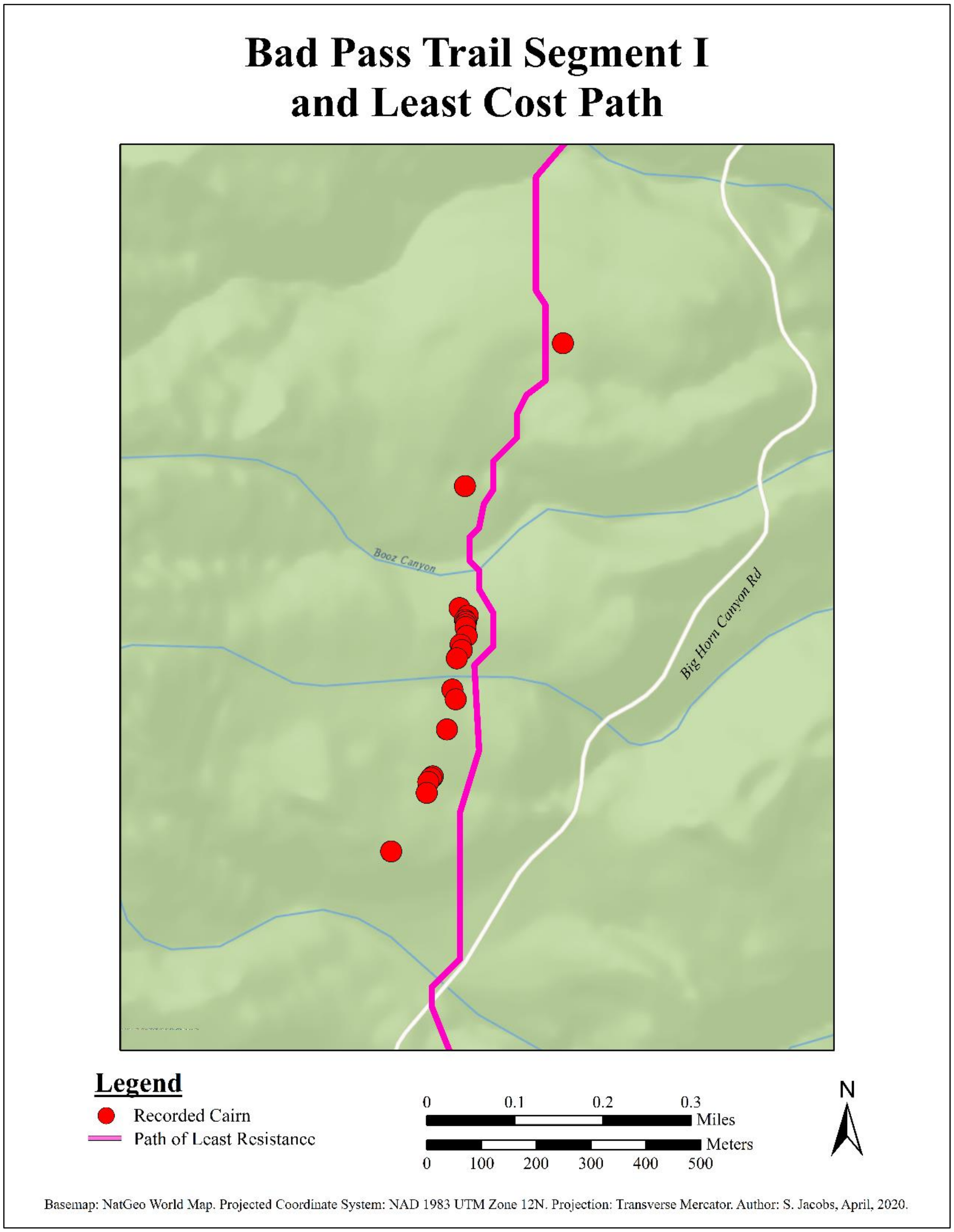
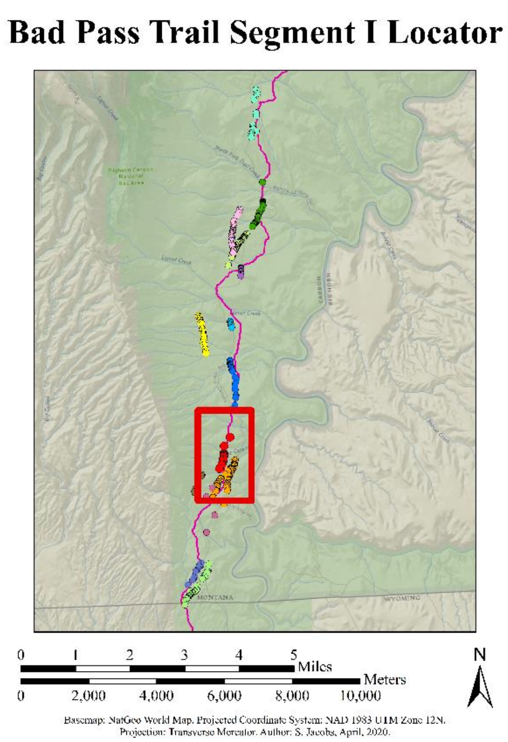


Figure 5.20. Bad Pass Trail Segment I and least cost path.

Segment I was inventoried on 7/1/2014 and 7/2/2014. The segment's 20 cairns extend across 1,010 meters of terrain. It begins its path at a point roughly 500 meters southwest of Bar Hill, and roughly 250 meters north of Booz Canyon. The opposite extent is located 700 meters south of Booz Canyon (Figure 5.20 and Figure 5.21). The segment straddles that path of least resistance, which is located west of Big Horn Road at this location. Prominent counts of AML cairns existed within the area of this segment.



Segment Summary	
Segment Name	I
Total Segment Cairns	20
Minimum Near Distance	31.96 m
Maximum Near Distance	126.04 m
Average Near Distance	53.6 m
Standard Deviation	20.16
Total Statistically Significant Cairns	0

Figure 5.21. Segment I locator map and segment summary.

Bad Pass Trail Segment J

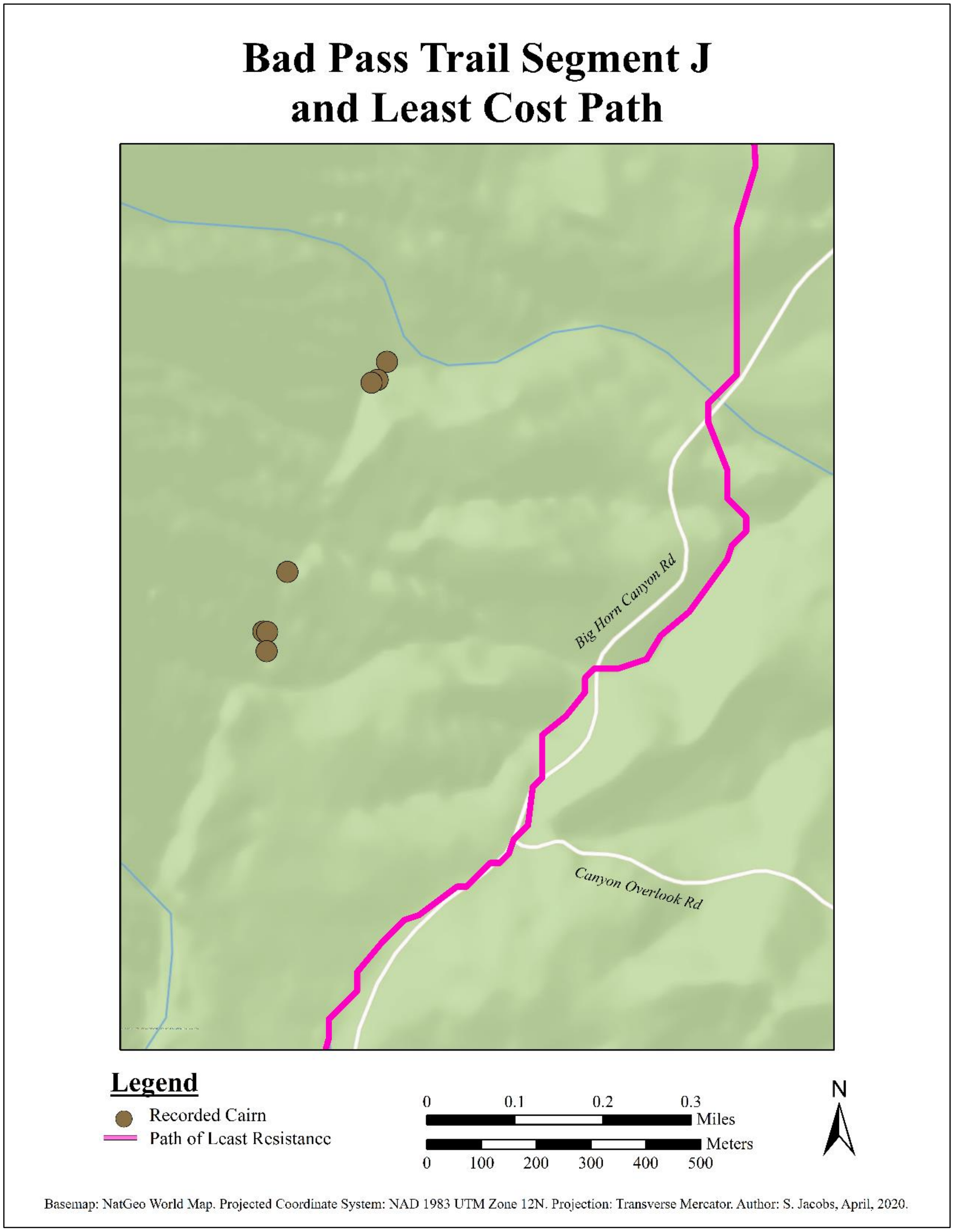
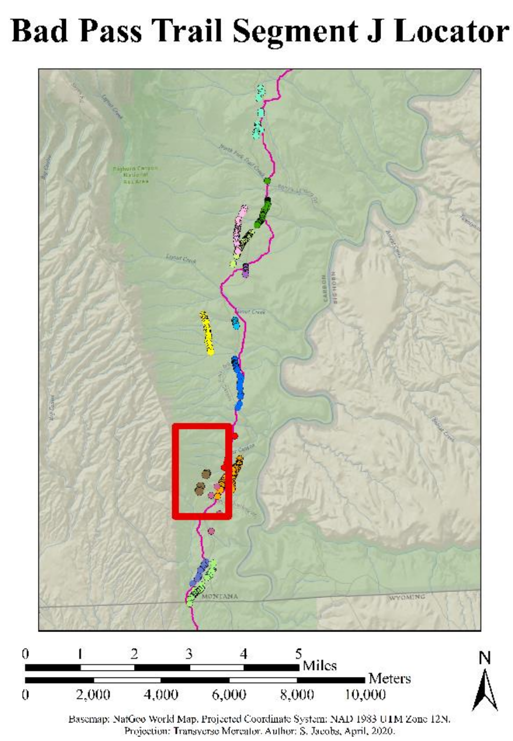


Figure 5.22. Bad Pass Trail Segment J and least cost path.

Segment J is one of two segments with only 7 cairns in their respective inventories. The segment was recorded on 7/9/2014. Segment J's cairns span over 580 meters and exhibit great special distancing between each cairns' location. Its cairns are very clearly located in terrain-driven areas as its route follows a ridge across the broken landscape. This segment contained prominent counts of AML cairns within its area (Figure 5.22 and Figure 5.23).



Segment Summary	
Segment Name	J
Total Segment Cairns	7
Minimum Near Distance	526.52 m
Maximum Near Distance	616.19 m
Average Near Distance	567.68 m
Standard Deviation	33.40
Total Statistically Significant Cairns	0

Figure 5.23. Segment J locator map and segment summary.

Bad Pass Trail Segment K

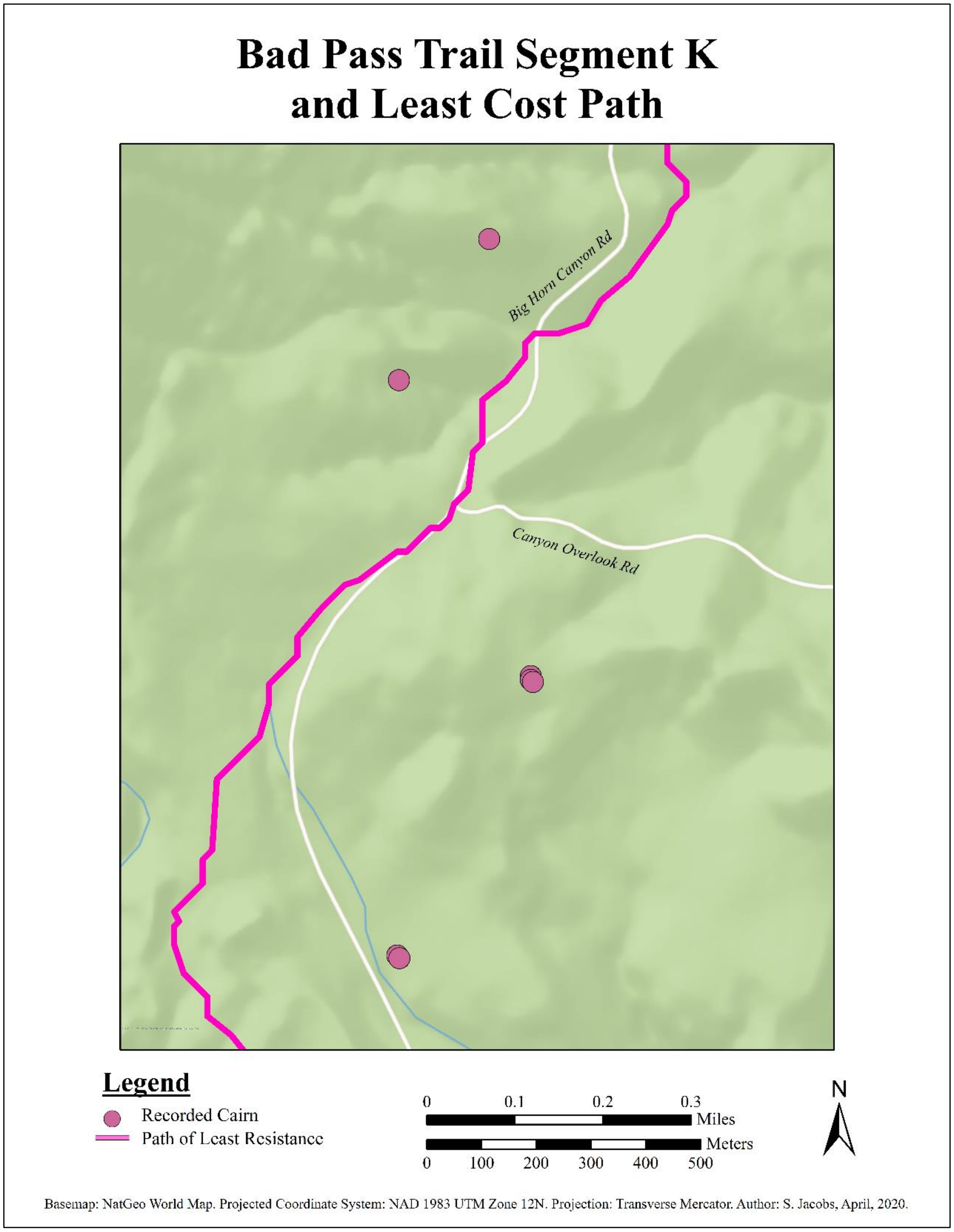
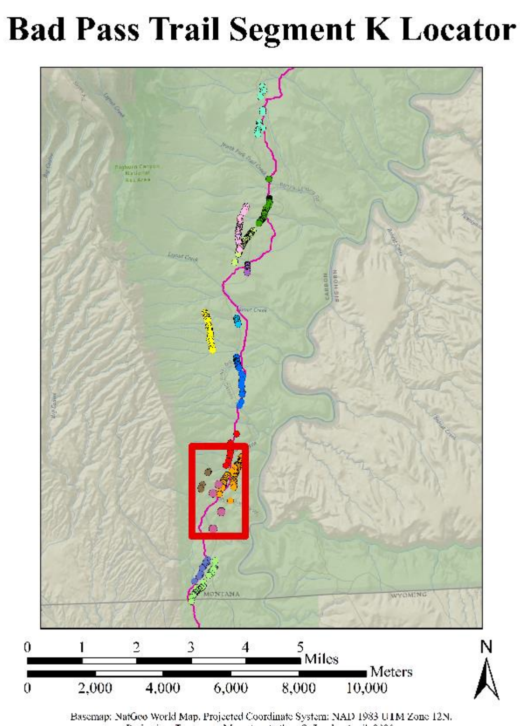


Figure 5.24. Bad Pass Trail Segment K and least cost path.

Segment K is the second of two segments that share a much smaller amount of total cairns that the other system segments. Segment K is comprised of just 7 cairns spanning over 470 meters from end to end. These cairns were recorded on 7/8/14 and relied more heavily on pedestrian survey to locate associated cairns than many other segments. The segment is more dispersed than Segment J, and its cairn locations were less linear in nature. The Segment's is transected by the Big Horn Canyon Road, and its associated cairns are located on both the west side and the east side of the path of least resistance (Figure 5.24 and Figure 5.25).



Segment Summary	
Segment Name	K
Total Segment Cairns	7
Minimum Near Distance	156.97 m
Maximum Near Distance	329.20 m
Average Near Distance	282.45 m
Standard Deviation	69.07
Total Statistically Significant Cairns	0

Figure 5.25. Segment K locator map and segment summary.

Bad Pass Trail Segment L

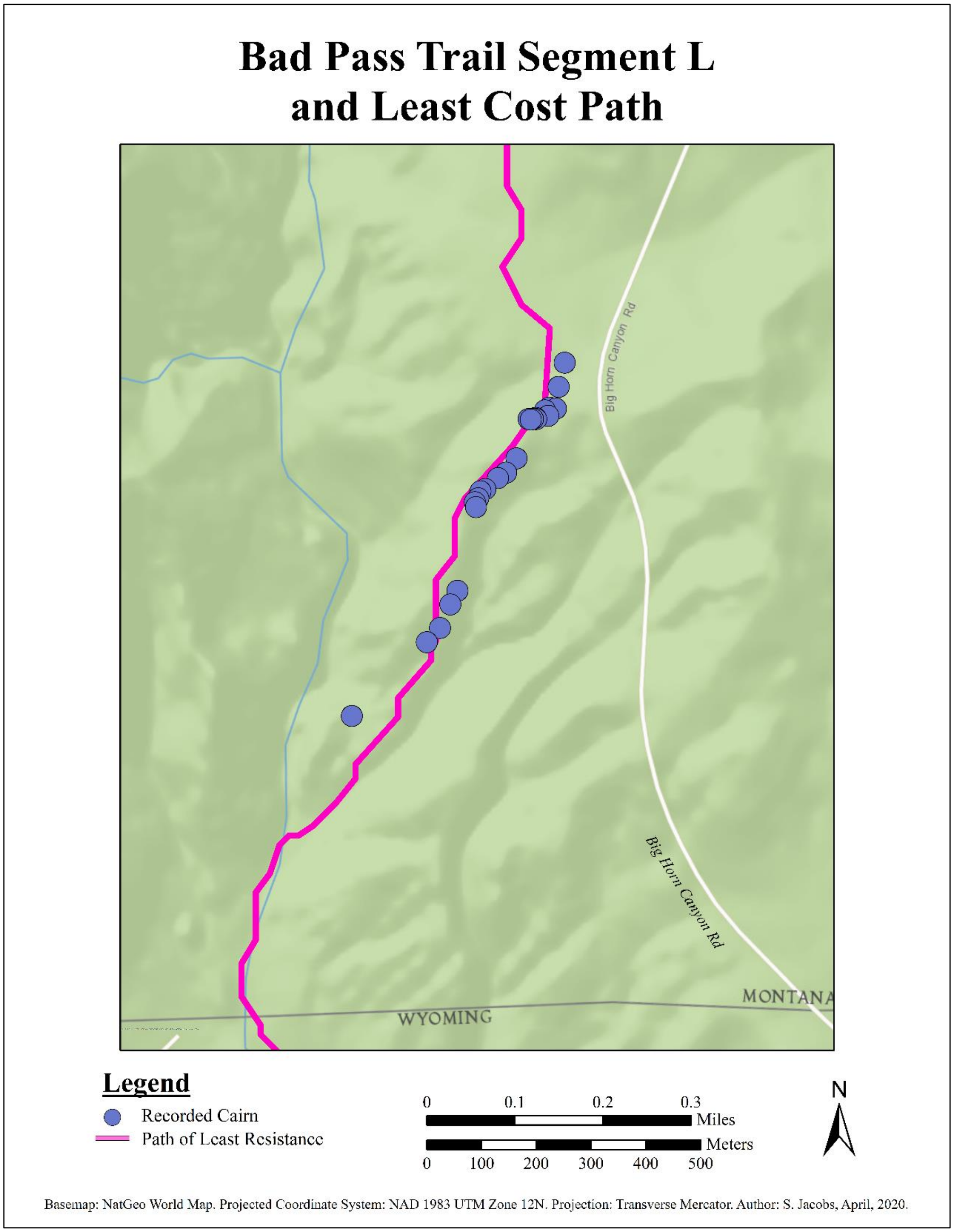
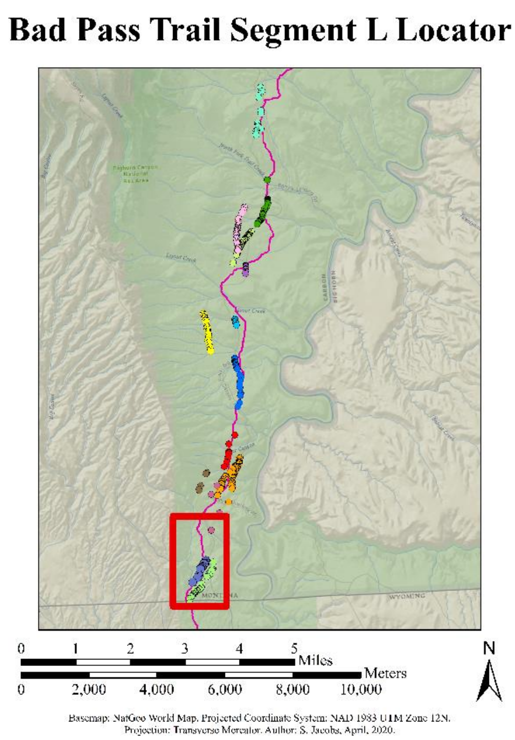


Figure 5.26. Bad Pass Trail Segment L and least cost path.

Inventoried on 7/3/2014, Segment L's route contains 24 cairns spanning over 770 meters. Its northernmost cairn is located 1,170 meters north of the Montana/Wyoming state border, and its southernmost only 540 meters. Segment L's route follows a narrow natural pathway in an otherwise steep side slope. The path in most areas shows visible bedrock under foot. Segment L represents the transition between rugged sidewalls and red iron ore rich soils of the inner canyon, to the more open expanse overlooking the lower terrain upon which the natural corridor opens onto (Figure 5.26 and Figure 5.27).



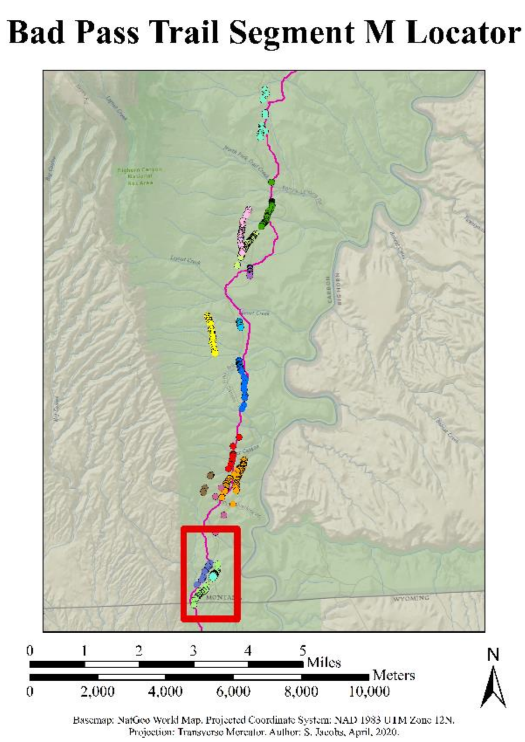
Segment Summary	
Segment Name	L
Total Segment Cairns	24
Minimum Near Distance	0.25 m
Maximum Near Distance	63.97 m
Average Near Distance	18.75 m
Standard Deviation	13.38
Total Statistically Significant Cairns	0

Figure 5.27. Segment L locator map and segment summary.

Bad Pass Trail Segment M

Figure 5.28. Bad Pass Trail Segment M and least cost path map.

One of the final cairns recorded, Segment M was inventoried on 7/7/14 and comprises one of the three southernmost segments of the system. Segment M contains 23 cairns spaced in close relation to each other over a total of 80 meters. Existing as an independent segment at the time of inventory, Segment M is closely located to the path of Segment N. When viewing as data layers with GIS mapping software, the two segments, Segment M and Segment N, almost seem to overlap. This segment lies along a relatively open area (Figure 5.28 and Figure 5.29).



Segment Summary	
Segment Name	M
Total Segment Cairns	23
Minimum Near Distance	288.51 m
Maximum Near Distance	299 m
Average Near Distance	295.69 m
Standard Deviation	2.55
Total Statistically Significant Cairns	0

Figure 5.29. Segment M locator map and segment summary.

Bad Pass Trail Segment N

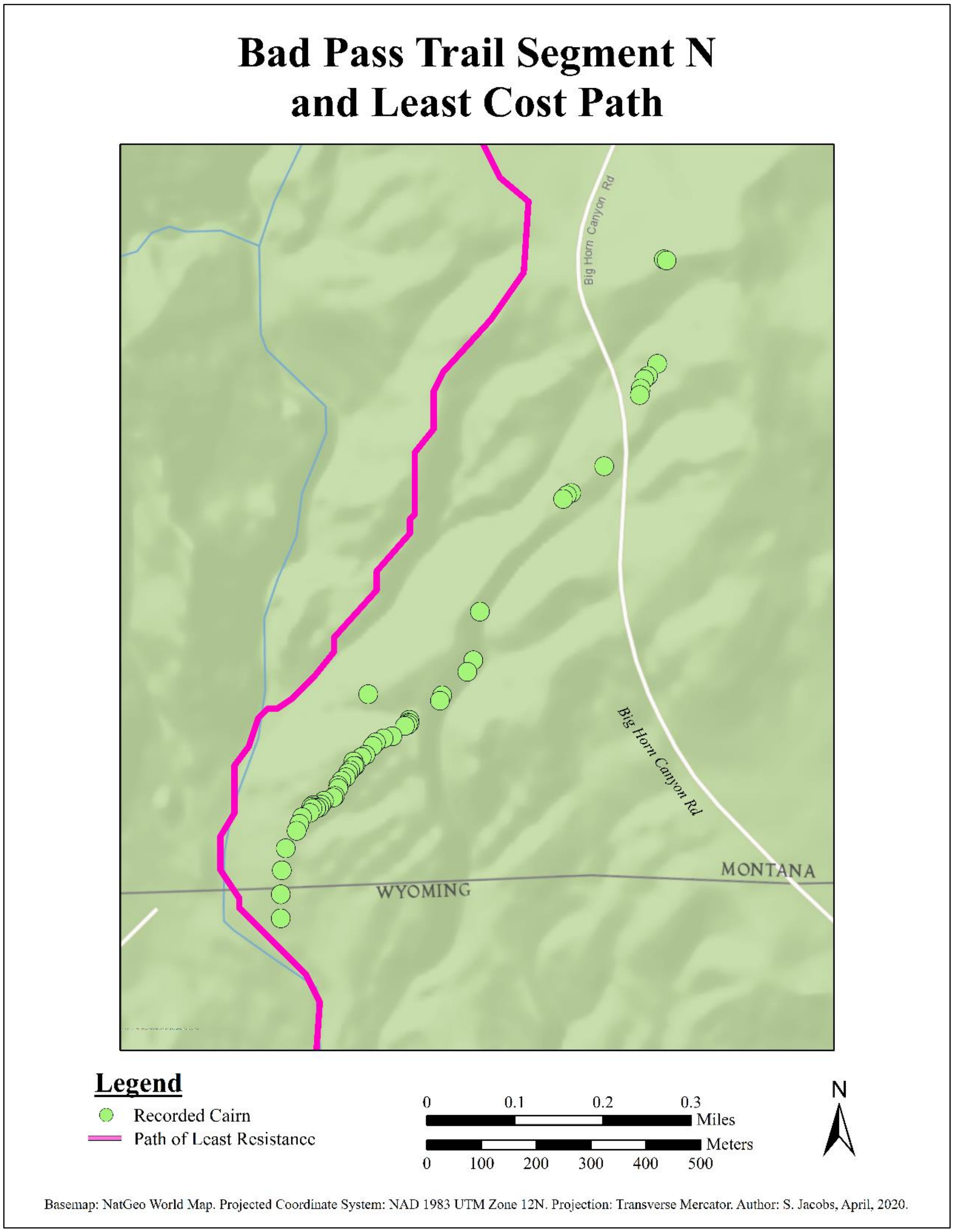
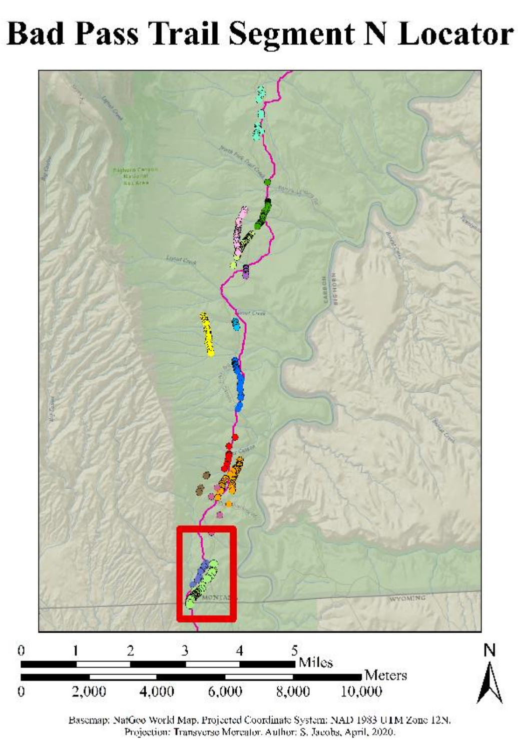


Figure 5.30. Bad Pass Trail Segment N and least cost path map.

Existing near Segment M, Segment N constitutes the southernmost extent of our recorded system in the 2014 inventory. Segment N contains a total of 54 cairns, whose route extends from 1,1300 meters north of the Montana/Wyoming state line and ends 45 meters south into the state Wyoming. Terrain at this location is comprised of exposed bedrock substrate extending into the more open landscape to the south. Cracks in the bedrock expose the nature runoff areas which create a topographically broken landscape (Figure 5.30 and Figure 5.31).



Segment Summary	
Segment Name	N
Total Segment Cairns	54
Minimum Near Distance	39.87 m
Maximum Near Distance	318.89 m
Average Near Distance	185.38 m
Standard Deviation	60.79
Total Statistically Significant Cairns	0

Figure 5.31. Segment N locator map and segment summary.

Confidence Intervals

At a 95 percent confidence, if I were to repeat my sampling, I would expect to find the mean values within a specified distance 95 percent of the time. As the user-chosen level of confidence increases, the resulting size of the interval will contract to include less area. As the user-chosen level of confidence decreases, the resulting size of each interval will expand to include more area.

A two-sided confidence interval produces an expected interval of near distance measurements, distributed on either side from a dataset mean (Table 5.20. This would result in a confidence interval of near distances whose thresholds measure 21.221 meters from either side of the dataset mean; 296-339 meters from the least cost path. On maps this would appear as a halo-effect buffer, located on both the west and east sides of the Bad Pass Trail least cost path.

Table 5.2 Two-sided confidence intervals for all 706 recorded cairns.

Two-Sided Confidence Intervals for all 706 Recorded Cairns								
Percent Confidence	Population Size	Mean Distance (meters)	Standard Deviation	Level of Significance	Critical Z Value	Standard Error	Margin of Error	Confidence Interval (meters)
90%	*706*	317.609	287.675	0.10	±1.645	10.827	±17.810	300-335
95%	*706*	317.609	287.675	0.05	±1.960	10.827	±21.221	296-339
97.5%	*706*	317.609	287.675	0.025	±2.24	10.827	±24.252	293-342

An upper one-sided confidence interval produces an expected interval of near distance measurements, distributed on the positive side (greater side) of the dataset mean (Table 5.3). This would result in a confidence interval of near distances whose threshold measures 17.810 meters past the dataset mean; 0-335 meters from the least cost path. On maps this would appear as a solid buffer extending from the least cost path outward on its west sides.

Table 5.3. Upper one-sided confidence intervals for all 706 recorded cairns.

Upper One-Sided Confidence Intervals for all 706 Recorded Cairns								
Percent Confidence	Population Size	Mean Distance (meters)	Standard Deviation	Level of Significance	Critical Z Value	Standard Error	Margin of Error	Confidence Interval (meters)
90%	*706*	317.609	287.675	0.10	±1.440	10.827	15.591	0-333
95%	*706*	317.609	287.675	0.05	±1.645	10.827	17.810	0-335
97.5%	*706*	317.609	287.675	0.025	±1.960	10.827	21.221	0-339

Statistical Significance

When applied to near distance values, a critical value determines a threshold beyond which cairns express statistically significance differences to each other and the population mean. The cairns exceeding this critical value threshold are most likely to have had their location be influence primarily by some factor other than terrain slope. The critical value (*CRrV*) is equal to the critical z-score (*CrZ*) multiplied by the standard deviation (*sd*).

Typical two-sided distributions produce two thresholds for determining statistical significance. Cairns exceeding this significance are shown below in Table 5.4). Thresholds produced from a 95 percent confidence level lie at 882 meters west of the computer-generated path of least resistance, and 247 meters east of the computer-generated path of least resistance. When mapped, these thresholds appear as a haloed buffer around the mean value, mirrored on each side of the least cost path. However, this type of two-sided distribution does not best fit my dataset, as there would be a resulting overlap in thresholds when mirrored onto both the west and east sides of the computer-generated route of least resistance.

Table 5.4 Two-sided confidence intervals for 622 statistically similar cairns.

Two-Sided Confidence Intervals for 622 Statistically Similar Cairns								
Percent Confidence	Population Size	Mean Distance (meters)	Standard Deviation	Level of Significance	Critical Z Value	Standard Error	Margin of Error	Confidence Interval (meters)
90%	*622*	240.789	209.203	0.10	±1.645	8.388	±13.798	227-255
95%	*622*	240.789	209.203	0.05	±1.960	8.388	±16.440	224-257
97.5%	*622*	240.789	209.203	0.025	±2.24	8.388	±18.789	222-260

An upper one-sided distribution produces a single threshold for determining statistically significance. Cairns exceeding this significance are shown in Table 5.5. The threshold produced from a 95 percent confidence level lie at 791 meters from the path of least resistance. When mapped, this threshold will appear as a total area coverage. This final coverage contains within its bounds 622 recorded Bad Pass Trail cairns and exclude 84 recorded cairns. By extracting the 622 most similar near distances from the larger dataset, we can more closely understand their physical locations from the least cost path. If confidence intervals were again applied to the near distances, which time only including those that express similarity to the dataset mean, we would produce the following confidence intervals for statistically similar cairns; cairns whose construction locations likely resulted from the same primary influence of terrain slope.

Table 5.5. Upper one-sided confidence intervals for 622 significant cairns.

Upper One-Sided Confidence Intervals for 622 Statistically Similar Cairns								
Percent Confidence	Population Size	Mean Distance (meters)	Standard Deviation	Level of Significance	Critical Z Value	Standard Error	Margin of Error	Confidence Interval (meters)
90%	*622*	240.789	209.203	0.10	±1.440	8.388	12.079	0-253
95%	*622*	240.789	209.203	0.05	±1.645	8.388	13.798	0-255
97.5%	*622*	240.789	209.203	0.025	±1.960	8.388	61.440	0-258

Tolerance Intervals

Tolerance intervals are used in predicting locations of a specific proportion of a population based upon the distribution of all occurrences. As it pertains to my examination of the cairns of the Bad Pass Trail, I believe tolerance intervals could have application in ground-truthing inventories to better understand likelihoods that certain survey areas may produce occurrences of cairns most influenced by terrain slope.

Once again, as I discussed in Chapter 1, and again in Chapter IV, it is imperative to acknowledge caveats of measuring prehistoric activities by use of quantitative tests alone. As researchers we must clearly acknowledge that this type of work is limited in its ability to truly encapsulate a complete understanding of the complexity of those motivations which influenced prehistoric peoples. These quantifiable measurements or assumptions should not be used as a limit on our research, but rather as a guide for expansion.

At a 95 percent confidence, the upper one-sided intervals for all recorded cairns produced a return of: 85 percent of cairns falling within 476 meters to the path of least resistance, 90 percent of cairns falling within 529 meters, 95 percent falling within 607 meters, and 97.5 percent falling within 676 meters near distance (Table 5.6). At a 95 percent confidence, the upper one-sided intervals for statistically similar cairns, representing those most influenced by terrain slope, provided the return: 85 percent of cairns falling within 476 meters from path of least resistance, 90 percent falling within 529 meters, 95 percent falling within 607 meters, and 97.5 percent of the cairns most influenced by terrain slope falling within 914 meters near distance (Table 5.7).

Table 5.6. One-sided tolerance intervals for 622 statistically significant cairns.

Upper One-Sided Tolerance Intervals for 622 Statistically Similar Cairns				
	Interval contains 85% of cairns	Interval contains 90% of cairns	Interval contains 95% of cairns	Interval contains 97.5% of cairns
85% Confidence	0-469m	0-521m	0-599m	0-667m
90% Confidence	0-472m	0-524m	0-602m	0-670m
95% Confidence	0-476m	0-529m	0-607m	0-676m
97.5% Confidence	0-479m	0-532m	0-612m	0-681m

Table 5.7. Upper one-sided tolerance intervals for all 706 recorded cairns.

Upper One-Sided Tolerance Intervals for all 706 Cairns				
	Interval contains 85% of cairns	Interval contains 90% of cairns	Interval contains 95% of cairns	Interval contains 97.5% of cairns
85% Confidence	0-630m	0-702m	0-809m	0-902m
90% Confidence	0-634m	0-706m	0-813m	0-906m
95% Confidence	0-639m	0-712m	0-820m	0-914m
97.5% Confidence	0-643m	0-716m	0-825m	0-920m

Chapter 6: Conclusion

As demonstrated in mapped cairn locations, the Bad Pass Trail marks a passible route through the Bighorn Canyon corridor. Although comprised of 15 segments, the trail system expresses an obvious linear quality throughout its entire length. I hypothesized that the culturally created stone cairns of this system follow a route of least resistance, as determined by slope. Cairn locations furthest from the path of least resistance will exhibit statistically significant difference from the rest of the population. Cairns within the threshold of statistical significance could likely share terrain slope as a primary influence upon their location of construction. Values exceeding the assigned threshold represent those cairns whose construction was most likely primarily influence by other factor(s) than terrain slope.

Using locational point data of individual cairns, and raster-to-polyline transformations data to create a path of least resistance I produced a dataset of near distance measurements from which I examine if the associated cairns of the Bad Pass Trail system follow a path of least resistance through the Bighorn Canyon corridor. Based on the measurements provided in this thesis and a 95 percent confidence level, cairns such as those recorded in the 2014 landscape inventory lie within 296-339 meters (one-tailed distribution) and within 0-334 meters (two-tailed distribution) of the computer-generated path of least resistance.

I provide a proposed means of predicting areas most likely to contain higher percentages of associated trail cairns, and for potential application in locating additional trail segments in relation to a computer-generated route of least resistance through an un-inventoried landscape. At a 95 percent confidence level, tolerance intervals outline a range of values of 0-639 meters encompassing 85 percent of cairns, 0-712 meters encompassing 90 percent of cairns, 0-820 meters encompassing 95 percent of cairns. And 0-914 meters from the path of least resistance as encompassing 97.5 percent of cairns.

I assign a confidence level and critical value to produce a threshold for extrapolating cairn locations that express heightened statistical significance per their dissimilar near distances. This data lends to the identification of cairns exceeding a critical range of confidence in relation to their location to the least cost route. Of the total recorded cairns, those most likely sharing the primary influencing factor of terrain slope, as determined by critical value, lie 0-255 meters (one-sided distribution), or 224-257 meters (two-sided distribution) of the path of least resistance.

At a 95 percent confidence level, tolerance intervals can also outline statistically significant cairns, or those sharing terrain slope as primary influence upon location. Based upon the recorded cairns of the Bad Pass Trail, a predicted 85 percent are located within 0-476 meters, 90 percent are located within 0-529 meters, 95 percent are located within 0-607 meters, and 97.5 percent of statistically cairns are located within 0-676 meters to the path of least resistance.

As I've stated throughout my thesis, it is imperative to acknowledge caveats of measuring prehistoric activities by use of quantitative tests alone. As researchers we must clearly acknowledge that this type of work is limited in its ability to truly encapsulate a complete understanding of the complexity of those motivations which influenced prehistoric peoples. These quantifiable measurements or any resulting assumptions should not be used as a limit on our research, but rather as a guide for expansion. My observations may prove meaningful for future comparison with other cairn-marked trail systems. And, if provided the opportunity, my research may just provide us with a hint at where to look first.

Future Research

External influences affecting cairn locations, other than that of terrain slope, will be mostly maintained as topics for future research. Considering the great range of possible influences which may have affected a cairns placement, these future studies are quite vast. It is reasonable to assume that cairns may have been constructed to attract or guide individuals to specific areas or resources. Likewise, it is another reasonable possibility that stone cairns were constructed to intentionally guide individuals away from specific resources or areas. Additionally, stone cairns could have served to mark neutral routes that lead individuals around or through areas of contention.

The segmented nature of the Bad Pass Trail deepens the appreciation for those individuals who monitor such resources daily. It became very apparent during cairn inventory that some segments of the Bad Pass appear to display a close association with neighboring cairns in their physical appearance, while other segments display fewer signs of direct association. Many of the continuous and non-continuous segments of the Bad Pass Trail have also seen impacts from historic modification and cairn destruction. Knowledge of the trail system by BICA's retired park archaeologist proved an invaluable resource for identifying the locations of cairn segments, and for making sense of its interwoven route through the corridor.

It is my hope that future studies will go even further to examine individual segments to compare not only their mean distance from the trail, but also their spacing (distance measure) between direct neighboring cairns. These studies could illuminate trends or patterns that may further aid in explaining what factors impacted cairn initial construction. Perhaps patterns may become more apparent if each segment was treated as its own independent sample from the whole. Perhaps this will illuminate more questions not yet considered in analyses. Where these cairns part of a drive line? Were they near an occupation or other site? Do they lead to water sources? Do cairns of historic and prehistoric construction exhibit characteristics uniquely specific to their time of construction? Do the cairns mark the most difficult and/or treacherous terrain?

Researchers have an ability to apply statistical software to these resources in order to better identify patterns of commonality or difference. These observations may lead to a better understanding of cairn functional differences per geographic locations. Statistical calculations could aid in producing testable, measurable, comparable, and consistent results. Researchers can further expand the analyses to compare specific groupings based upon physical appearance, directional orientations, source materials, cultural offerings, or surrounding sites and resources.

Bad Pass Trail Ethnographic Research

In July of 2012, a Bad Pass Trail Ethnographic Research/Fieldwork and Revised National Register Nomination was initiated through the Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU) in collaboration with the University of Wyoming and St. Cloud State University. The first of two primary components comprise the Cultural Landscape Inventory of 2014, which produced cairn locational data use in this thesis. The second primary component of this National Register nomination revision grant emphasizes ethnographic information relating to tribal perspectives and tribal history associated with the Bad Pass Trail. This information was gathered through interviews with members of Crow and Eastern Shoshone affiliated tribes.

Ethnographic field work serves to document landscape changes to the Bad Pass trail over time; describe the appearance of the trail through time; take into consideration tribal perspectives on integrity and significance when analyzing landscape features of the trail; identify contributing features to the Bad Pass Trail's eligibility and nomination to the National Register of Historic Places; and foster relationships between the park, partners, and affiliated tribes for a final revised National Register nomination (Finley and Branam 2012). This project has so far resulted in many hours of oral histories, tribal stories, and accounts by Crow Nation and Eastern Shoshone tribal members. These interviews emphasize the need to work collaboratively with Park Service representatives to preserve tribal knowledge and to share cultural understandings attached to the Bighorn Canyon's indispensable cultural resources. Recent research explores the significance the Bad Pass Trail's cairn-marked route serves to continued understandings of past cultures, and modern-day significance of cultural heritage to affiliated tribes.

Community Engagement

Determining cultural affiliation for archaeological sites to contemporary tribal or linguistic groups remains one of the greatest difficulties in regional archaeology. This difficulty stems from the degree to which tribes entered each other's territories and used friendly ties between groups, from the absence of well-defined physical boundaries, and from movements of individuals between tribal groups. Fortunately, the Bighorn Canyon and its vast history provides researchers with archaeological evidence, historical records, ethnohistoric accounts, and tribal migration stories. This rich source of information strengthens the timeline of cultural utilization reaching back some 10,000 years. The archaeologically rich landscape and vast ethnohistoric accounts combine to produce a priceless medley of information whose content easily proves immense archaeological and cultural landscape monumentality.

I implore readers to recognize the importance of seeking the qualitative importance of tangible and non-tangible resources. It is imperative to acknowledge, respect, and include the perspectives of Native American communities when studying areas of tribal homelands. The physical separation of tribal reservations from traditional homelands, such as those of the Bighorn Canyon, are much more complex than a simple separation of geographic miles.

Some elders of the Crow Tribe believe that individuals have a responsibility to act as caretakers of cultural resources. This view was unanimously adhered to, as best we knew how, as we meticulously recorded the stone cairns through the Bighorn Canyon corridor. We each reminded ourselves daily that we were responsible, in our own small way, for the care and respect of cultural resources holding immense significance by past, present, and future communities. It was not uncommon to pause to offer up a prayer before entering new areas. It was also not unheard of to smudge when we were required to approach cairns thought to mark burials. Other seemingly simple things, such as stepping aside to allow a male crew member to record cairns of a specific nature, were opening discussed by our members.

As I state in my introduction: it remains impossible to fully encapsulate the meanings or values held by prehistoric individuals as they constructed stone cairns. What *is* known, however, is that the presence of culturally created stone cairns along the Bad Pass demonstrates a type of intended permanence not observed in many other types of trail route. It represents one of the most significant and impressive cairn-marked transportation routes in the Northwestern Plains (Loendorf and Brownell 1980). The time and effort invested towards creating cairns, even if their stones are available in the surrounding landscape, implies a level of significance to those who used the space. My entire team, both those from tribal communities and those not, held a deep appreciation and honor for being able to record just some of the many cultural resources located within the Bighorn Canyon and its magnificent landscape.

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