LANDSCAPE STRUCTURE AND TERRAIN-BASED HUNTING RANGE MODELS: EXPLORING LATE PREHISTORIC LAND USE IN THE NUTZOTIN MOUNTAINS.

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LANDSCAPE STRUCTURE AND TERRAIN-BASED HUNTING RANGE MODELS: EXPLORING LATE PREHISTORIC LAND USE IN THE NUTZOTIN MOUNTAINS, SOUTHCENTRAL ALASKA

A

THESIS

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ABSTRACT

Striving for better delineation of site function, land use, and settlement patterns, the data and analyses presented in this dissertation aim to explore more robust and objective avenues of inquiry for addressing the variability and distribution of surface lithic scatters using terrain-based hunting range models. Using large mammal distributions, Athabascan hunting ranges, and topography, landscape metrics, and an exploratory data analysis (EDA) framework, landscape structure is quantified and compared across much of the Alaskan Interior to identify reoccurring patterns related to hunting land use and the range characteristics of caribou, moose, and sheep. Key components of the landscape structure are contrasted with topographic matrices associated with protohistoric and late prehistoric sites via discriminant function classification models. Projectile points, scrapers and bifaces from surface scatters in the Nutzotin Mountains are examined in relationship to these models and their constituent elements. The results show that the association of certain chipped-stone tools and landscape structure are highly autocorrelated. This suggests that landscape structure models can be useful in the generation of constructive hypotheses to test ideas concerning inter-assemblage variability, site function and varied forms of land use.

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CHAPTER 1.
INTRODUCTION

Research Focus and Direction

This dissertation is concerned with exploring the use of environmental context as an explicitly defined aid to addressing site function, resource acquisition, or generating hypotheses useful for interpreting the artifact variability often delineated in lithic scatter assemblages. In exploring the environmental context, this study draws from a diverse range of approaches both within and outside of the discipline of archaeology to address human-environment interaction in regard to large game hunting in the Alaskan Interior.

Archaeologists, anthropologists, geographers, and behavioral ecologists all study the complex relationship between hunter-gatherers and the natural environment, though each tends to do so utilizing different methods, frameworks, and scales. Though some correlates exist, such as archaeological settlement and an ethnographic village or an archaeological site and a geographic node (if each is properly defined and delineated), it is more often the case that static representations of the archaeological record and various spatial manifestations of dynamic systems are not directly comparable. In other cases, there is no spatial or systemic analogy, such as between culture areas and physiographic regions.

In hunter-gatherer studies there has always been a focus on human-environment relationships (Chang 1962; Coward 2005; Grossman 1977; Moran 2008; Renfew 1983) and some form of ethnographic analogy (e.g., Binford 1967; Costin 2000; Galanidou 2000; Shelley 1999; Yellen and Harpending 1972). While the direct historic approach, which can provide strong inferences and direct correlation, typically fails in prehistoric hunter-gatherer research, the moderately recent development of ethnoarchaeology has been successfully implemented to address a number of our assumptions and to strengthen our inferential reasoning. This work, however, often occurs at a very localized scale of a specialized use location or small village (e.g. Binford 1978a; Gould 1980); although forays into some aspects of land use have been made (Binford 1982). Unfortunately, the ethnoarchaeological data are typically collected in one place and used to interpret archaeological patterning in other places. In the case of the arctic and subarctic, the applications of ethnoarchaeological research are typically not used to address the archaeological record associated with locally extant peoples.

In many instances analogy is used, in conjunction with various types of analyses, to interpret lithic artifact scatters. Recent research into lithic scatters has taken various paths such as technological organization (e.g. Amick and Carr 1994; contributors to Carr 1994; Hall 2004; Rasic and Andrefsky 2001), reduction sequences (e.g. Amick et al. 1988; Ammerman and Andrefsky 1982; Shott 1996; Tomka 1989), and distribution at various scales including individual sites (e.g. Cowan 1999; Odell 1980) and landscape (Camilli 1988; Ebert 1992; Kvamme 1998; contributors to Rossignol and Wandsnider 1992). Whatever the research focus, surface lithic scatters are almost always loosely classified, *a priori,* into categories within Binford's (e.g. 1980) forager-collector model (e.g. retooling station, hunting camp, lookout), which results in a gross generalization of assemblage variability. A key component of the modeling used here is to overcome *a priori* assumptions of site function and provide a more contextual framework from which to ascertain site function from techno-environmental relationships.

To an extent, this research is guided by the principles, procedures, and assumptions contained within the Direct Historical Approach (DHA), in that it is assumed that certain stability exists among the modern, historic, and late prehistoric records of the Alaskan interior as it pertains to hunting strategies and land use (Lyman and O'Brien 2001). Unlike most of the early use of the DHA (Steward 1942), the approach advocated here is explicitly spatial. Instead of relying on prehistoric and ethnographic material culture continuity in a discrete stratigraphic context, this approach aims to identify a similar continuity in an areal extent in regards to hunting land use. The western subarctic record is, perhaps, uniquely suited for such an approach as the time depth of definitive Athabascan culture is well established (e.g. Dixon 1985; Workman 1974). Unlike most of the rest of North America today, Athabascans continue to inhabit the same areas as they have in the past, and though acculturated to various degrees, most northern Athabascans continue to rely heavily on hunting for subsistence and economic gain (Noss 1985; VanStone 1974). Even though hunting and transportation technology are substantially different in the present than they were in the past, the passing of traditional ecological knowledge from generation to generation forms a bridge concerning indigenous land use.

The DHA, although considered outdated by most archeologists, formed one of the main tiers of early North American archaeology (O'Brien et al. 2007; Willey and Sabloff 1993). More often than not, archaeologists employed the approach when working with a direct correlation between a modern indigenous population and an unbroken chronological sequence of material remains. As such, many of the societies and cultures studied with the DHA were sedentary and the approach had little application in situations that lacked any definitive correspondence between archaeological deposits and relatively mobile populations. Since mobile hunter-gatherers often leave little trace compared with their sedentary counterparts, linking many extant peoples with archaeological remains into the past beyond the historic and protohistoric periods has been difficult. While European contact had profound implications on the culture and being of all indigenous North American peoples, the effect was not concurrent across the continent's breadth. Instead, contact was more like a surge, often preceded by a smaller ripple, which expanded from the southern and eastern edges of the landmass culminating nearly 400 years later in what is now Alaska. The Athabascan populations of the subarctic interior remained, until the middle of the 19th century, the least acculturated native peoples in North America (Reedy-Maschner and Maschner 1999).

In looking at ways to interpret the archaeological record, archaeologists have often turned to modern hunter-gatherers for useful analogies. In most cases, however, the analogs sought are used as heuristic devices (Jochim 1991). In some instances, such analogies are used uncritically making the inferences tenuous (Binford 1967, see Newell and Constandse-Westermann 1996 for an example). In most instances, however, the use of ethnographic analogy has proved very useful in archaeological model building and interpretation (see, for example, Bettinger 1979; Thomas 1973). And, though fluid in many regards, most hunter-gatherers range along a continuum between collecting and foraging (Binford 1967; Chatters 1987; Gould 1982; Hayden 1981; Keely 1988; Testart 1982). Criticisms concerning the use of analogs in studying hunter-gatherers come from both archaeology and ethnography. For example, where Jochim (1991) views the mobility and seasonality data collected by ethnographers as too coarse, Stanislawski (1973) suspects that the archaeological reconstruction of such patterns fails to adequately account for ethnographic complexity.

While ethnographers collect data relevant to their research, the data are not always amenable to the building or detection of appropriate analogies for use in archaeological research. Termed ethnoarchaeology, this manner of research focused on identifying site formation processes and analogy construction. Where ethnographers cursorily examined issues like mobility, seasonal rounds, and spatial behavior, some ethnoarchaeologists concentrated their attention on such phenomena. This work quickly evolved in complexity, and when combined with behavioral ecology, became a major research focus in its own right (Smith 1991; Winterhalder 1986, 2001; Winterhalder and Smith 2000). In some cases, such as the applied anthropological studies of Alaskan subsistence, ethnographers have provided extremely useful data that archaeologists have yet to tap or even realize.

Given that hunter-gatherers are explicitly linked with environmental factors for their livelihood, many anthropologists and archaeologists studying them rely on some form of ecological orientation in theory building and interpretation. The most common orientation is some derivation of cultural ecology. The environmental elements in such studies are often presented in a very coarse grain. For example, it is not uncommon for researchers to use large physiographic regions, which in turn are assumed to relate to various biotic zones (for archaeological examples see Denevan 1996; Henry 1994; Stafford 1994) or site catchments (e.g. Hirth 1984, Hunt 1992; Seitsonen 2009; Tiffany and Abbott 1982). In other instances, archaeologists derive environmental data from primary (e.g. faunal remains) and ancillary (e.g. pollen) contexts. Recent attempts at elucidating more direct and relevant scales and environmental variability have proven ambiguous (e.g. Ebert 1992; contributors to Rossignol and Wandsnider 1992 for examples), and differ little from earlier work. Overall, the scale in ecologically focused research is either too broad or too narrow. Furthermore, the environment tends to form a very passive backdrop against which various data sets are compared. In reading many of these studies, it appears that the differences found in archaeological assemblages between disparate settings--geomorphic, hydrologic, or topographical--are assumed to relate to differential land use even if the environmental units do not relate to relevant hunter-gatherer behavior.

Here, I attempt be more explicit in my correlations between environment and behavior, as well as scale. Instead of relying on implicit assumptions concerning the correlation of geomorphic and biotic environmental variables, this work relies on the concepts, methods, and techniques of landscape ecology to standardize, analyze, and compare these data at human-relevant scales. In some regards, the use of landscape ecology is to address Buzter's (1982:12) plea for " . . . [the] development of an approach that will transcend the traditional preoccupation with artifacts and sites in isolation, to arrive at a realistic appreciation of the environmental matrix and its potential spatial, economic, and social interactions with the subsistence-settlement system."

Landscape ecology is the study of the structure, function, and change in interacting ecosystems (Forman and Godron 1986). The fundamental unit of observation is either the landscape or region. Landscape is defined as "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in a similar form throughout (Forman and Godron 1986:11)." The size of a landscape is scale-dependant and varies according to the size and mobility of the species or processes being studied. For example, elements in a landscape are very different for insects and large ungulates. As such, scale plays an integral part in landscape studies. Scale, then, is the level of spatial resolution considered in a particular study.

Whatever the scale and areal extent of a landscape, a general model exists concerning landscape structure. This model, referred to as the patch-corridor-matrix model (Forman and Godron 1986), forms the mechanisms with which to quantify landscape structure and extrapolate function. A patch is a nonlinear area that is relatively homogenous and differs from its surroundings (e.g. lawn, a stand of pine trees). A corridor refers to a linear area that differs from the areas on either side of it (e.g. roads, streams). The matrix is the background ecosystem or land type with high connectivity and influences local dynamics (a large meadow or closed needle leaf forest. These three landscape elements form a mosaic (Forman 1995). While the term landscape is used here, it does not necessarily refer to the exact definition provided by landscape ecology. Instead, mammal distribution and Athabascan hunting ranges are used as distinct landscapes. The latter is closely aligned with what Butzer (1982) calls the Human Ecosystem. The human ecosystem is that area required by a human group to exploit and acquire resources necessary for subsistence and economic pursuits. As such, the human ecosystem is nearly synonymous with range or territory.

Finally, advances in surface archaeology (see contributors to Sullivan 1998) and technological organization (see contributors to Carr 1994) lend themselves to refining our interpretations of land use and settlement patterns more readily than the simple locational analyses of decades past. Like behavioral ecology, many technological organization studies are guided by the principles of optimality theory (Bird and O'Connell 2006; Kuhn 1994; cf. Cahen et al. 1979). Whatever one includes in such studies, it is apparent that technology is an important aspect of human-environment relations. Given that hunting and gathering accounts for the majority of subsistence activities in human history, and, that lithic implements are the most lasting evidence of such activities, it comes as no surprise that artifact scatters, whether on the surface or buried, account for a large percentage of the archaeological record. It is also evident that lithic toolkits reflect, to a degree, the subsistence behaviors that they were created to assist.

Analytical Framework

This research has a strong exploratory perspective (Hartwig and Dearing 1979) and follows the underlying principles of Exploratory Data Analysis (EDA) (Tukey 1977; Hartwig and Dearing 1979). In general, EDA is a method as much as a set of techniques for exploring relationships in data. Unlike confirmatory data analysis, which is used to test hypotheses about data before they are produced, EDA inspects the data prior to the development of specific hypotheses in a open, or "model free" manner (Behrens 1997; Gelman 2004; Tukey 1977: Wheatley and Gillings 2002). In essence, "the goal of EDA is to discover patterns in the data (Behrens 1997:132)."

In exploring the relationships in a data set, the EDA approach focuses the researcher's attention on, among other things, uncovering structure in the data, extracting important variables, identifying outliers, and examining implicit assumptions about the data. Identifying these patterns in data are also applicable in more spatially explicit studies. Known as Exploratory Spatial Data Analysis (ESDA) has developed in tandem with the development of Geographical Information Systems (GIS) (Anselin et al. 2006; Burrough 2001).

This dissertation draws from EDA, the DHA, and ethnographic analogy to explore and model structural and compositional characteristics of contemporary Athabascan large mammal hunting ranges and to compare them with general and seasonal distribution ranges. This exploratory work is a necessary first step in gaining an appreciation of how modern Athabascans use the landscape relative to how large game are distributed throughout the environment. By comparing large areas within the Alaskan Interior it may be possible to develop landscape-based hunting range models that may be more amenable or complimentary to studying prehistoric land use and settlement than only site catchments (e.g., Hirth 1984; Hunt 1992; Seitsonen 2009; Tiffany and Abbott 1982) or foraging radii (or central place) models (e.g., Grove 2009; Morgan 2008, 2009).

Research Questions

Since the information presented here is more in line with EDA and not confirmatory data analysis, two sets of general questions guide the research. The first set of questions relate to identifying and quantifying land use patterns of modern Athabascan hunting ranges in regards to regional topography.

Question 1. What is the range of variability in hunting land use and hunting practices among different Athabascan populations?

Question 2. Is there a difference in hunting land use between the modern and the ethnographic records? What are the notable comparisons between the ethnographic and the modern records?

Question 3. What landscape correlations exist between modern hunting land use patterns?

The answers to these general questions provide the necessary information to construct appropriate analogs and inferences concerning the range of hunting-related land use in the northwestern subarctic. These analogs and inferences can then be applied to the interpretation of the archaeological record in general and, more specifically, the Wiki Peak-Ptarmigan Lake study area located in the Wrangell-St. Elias National Park.

Question 4. How, relative to modern hunting landscapes, is the environmental matrix of the Wiki Peak-Ptarmigan Lake area different from or similar to contemporary hunting ranges?

Question 5. What are the relationships between the archaeological assemblages and the environmental matrix of the Wiki Peak-Ptarmigan Lake Area?

Dissertation Organization

Chapter 2 introduces the concept of the "generic hunter-gatherer subsistence-settlement epistemology," which is inclusive of such disciplines as human geography, anthropology, archaeology, and behavioral ecology, and explores how these disciplines have collectively added to our understanding of hunter-gatherer subsistence, spatial organization, and land use. Using this framework, traditional Northern Athabascan subsistence patterns and spatial organization are presented.

Chapter 3 summarizes the Alaska Department of Fish and Game's (ADF&G) data from 21 interior Alaskan villages used to develop landscape models in subsequent chapters of this dissertation and provides an environmental context for each village. Information presented here is utilized in several meta-analyses. The meta-analyses of the subsistence data provides a useful frame of reference necessary for evaluating the usefulness of the subsistence data in generating landscape models and pushing those models farther and father back in time. The most important meta-analysis, in this regard, is the diachronic comparison, via correspondence analysis, of modern and traditional hunting efforts for various animal resources and seasonality.

Making comparisons among the different hunting ranges, both past and present, involves constructing models from which to draw the comparisons and determining how to quantify and operationalize those models. Chapter 4 presents the methods used to construct topographic models of animal distributional and hunting ranges from digital elevation models and the Topographic Position Index. The structure of these models is quantified utilizing a series of metrics developed in the field of landscape ecology. The calculations for a standard set of landscape metrics useful in quantifying landscape structure and composition are presented.

Chapter 5 focuses on comparing the landscape structure and composition of caribou, moose, and sheep distributions in areas surrounding each of the 21 communities used in this study. For moose and caribou, seasonal ranges are also examined. Based on these comparisons, classification functions, utilizing discriminant function analyses are developed. These functions can be used to classify the range characteristics of unknown cases to predict if the landscape structure is more similar to one of the three large mammals than it is to the other two. Chapter 6 follows the same basic flow as Chapter 5, but instead of quantifying the animal distributional ranges, the hunting ranges of moose, sheep, and caribou for each village are quantified. Based on the landscape metrics calculated for the hunting ranges, the classification functions derived in Chapter 5 are applied to the hunting ranges to determine if a species-specific hunting range can be predicted based on the distributional range structure. The generally fair results of the classification functions are examined through resemblance coefficients. Chapter 6 closes with the construction of a new set of classification functions based on the structure of the village hunting ranges themselves.

Chapters 8 and 9 represent two cases studies. Chapter 8 is an intermediate step of testing the set of classifications against historic and protohistoric sites with documented faunal assemblages forms the basis of Chapter 7. The chapter includes a brief description of the 12 sites used in the test sample, a discussion of the quantification of the faunal assemblages from these sites, the landscape structure and composition of 20 km catchment surrounding each site, and the results of the all the classification functions derived in Chapters 6 and 7.

In Chapter 8, the results of the landscape classification models applied to a set of lithic scatters in the within the Wrangell-St. Elias National Park and Preserve as a case study. The results of the classifications are then used to develop a set of working hypotheses concerning the spatial distribution of certain chipped stone tools (projectile points, scrapers, and bifaces) across the study area. Focusing on local indicators of spatial autocorrelation (LISA), the distribution of the chipped stone tools are compared to the model components to determine the potential for different prey allocation by location to aid in differentiating land use patterning in the study area.

The final chapter summarizes the usefulness of the approach present in this thesis and briefly explores different avenues for increasing the utility of this, and similar, models in addressing human-environment relationships in regards to ubiquitous lithic scatters.

CHAPTER 2.

TOWARD AN APPRECIATION OF THE ATHABASCAN HUNTING LANDSCAPE

Hunter-Gatherer Subsistence and Settlement Epistemology

Human-environment interaction is a central research topic in many disciplines including archaeology, anthropology, geography and behavioral ecology. It has been argued that human-environment interaction research is a common thread, or theme, that conceptually and practically links several of these disciplines together, particularly in regards to research methods and theory building (Goudie 1987; Head, et al. 2005; Renfew 1981). Within anthropology, archaeology, and evolutionary ecology, another link in the chain is the conception that relatively 'simple' hunting-gathering, pastoral, and horticultural societies are closely tied to the environment, more so than larger-scale and industrial societies, making small-scale societies the fundamental subject of human-environment studies (Balee 2006; Bettinger 1991:48-53). Given that this research draws, at least partially, upon the concepts, methods, and theories from many of these disciplines, and attempts to combine them in a nonlinear fashion, a brief overview of what can be collectively termed the hunter-gatherer subsistence-settlement epistemology is presented.

The generic subsistence-settlement epistemology is essentially the cumulative knowledge derived from historic and modern approaches to the study of hunter-gatherer-environment interaction as it relates to mobility, subsistence, territory, settlement patterns, and the method and theory behind collecting and interpreting hunter-gatherer data. Several scholars have provided detailed tomes over the years (e.g. Bettinger 1991; Jochim 1976; Kelly 1995); this review focuses on only the conceptual, theoretical, and methodological issues most relevant to this study. In doing so, it is not necessary to extend the discussion back any farther than the early part of the 20th century. Starting with cultural ecology and ecological anthropology and ending with the competing, but not necessarily incompatible, behavioral ecology and ethnoarchaeological approaches to hunter-gatherer studies, I explore subsistence and settlement as it pertains to hunter-gatherers in general, and Northern Athabascans specifically.

Cultural Ecology

Following the demise of the environmental determinism and superorganic paradigms, Julian Steward, a young ethnographer and archaeologist, headed to the Great Basin to record the traditional movements, subsistence and technology of Numic-speaking Native Americans; he focused primarily on the Shoshone and Paiutes. Coming out of the University of California, Berkeley in the early 1930s, Steward's mentors, professors, and friends, mainly Alfred Kroeber, Robert Lowie, and Carl Sauer, had a profound influence on his research orientation and perspective (Orlove 1980:237). Steward's research focus centered on human-environment relationships, particularly as it pertained to social organization, settlement patterns, and subsistence. While careful not to fall entirely back into the environmental determinist paradigm (cf., Judkins et al. 2008; Moran 2008; Trigger 1971), the underlying assumption in much of Steward's Great Basin work was that ecological relationships strongly limited population sizes, and greatly influenced settlement distribution, mobility, territory size, and economic livelihood (Steward 1938:230). The idea of environmental adaptation underlies Steward's vision of cultural ecology (Steward 1955:39)

Steward defines cultural ecology as both a "problem and a method (Steward 1955:36; see also Moran 1990:9-10)". The goal of cultural ecology is to "ascertain whether the adjustments of human society to their environments require particular modes of behavior or whether they permit latitude for a certain range of possible behavior patterns (Steward 1955:36)." Central to cultural ecology is the concept of 'cultural core', which is "the constellation of features which are most closely related to subsistence activities and economic arrangements (Steward 1955:37)." Despite the importance of the cultural core, Steward never explicitly states how the constellation of features is recognized; this shortcoming has been a source of major criticism of cultural ecology specifically, and mutlilinear evolution in general (Harris 1968:661; Pinkoski 2008).

As a method, cultural ecology has three major foci including analyzing the relationship of technology and environment, analyzing the spatial patterning of the technology within the environment, and analyzing how the techno-environment relationship affects other aspects of culture, such as social, political, and religious organization. In the anthropological consciousness of the 1950s and 1960s, cultural ecology had a profound impact on the practice of both ethnography and archaeology. In the cultural realm, Steward's work had a direct bearing on much of the hunter-gatherer ethnographic research conducted in southern and east Africa (e.g. Lee 1965; Woodburn 1968), Australia (e.g. Pilling 1968), and the North American Subarctic and Arctic (e.g. Damas 1969, Helm 2000). In archaeology, Steward's cultural ecology was most influential in the Great Basin of the U.S. where he originally conducted his classic Shoshone ethnology (e.g. Jennings 1978, see also Bettinger 1975; O'Connell 1971; and Thomas 1971).

Behavioral Ecology

Many view cultural ecology as foreshadowing the modern discipline of human evolutionary, or behavioral, ecology in that it provided "a rather primitive notion of adaptive optimization (Smith and Winterhalder 1992:21)." Evolutionary ecology, then, is the study of phenotypic (i.e., behavioral) adaptation to particular environmental context (Smith and Winterhalder 1992:2). The discipline of evolutionary ecology examines adaptation though the mechanisms of natural selection and rational choice (Smith and Winterhalder 1992:21; Winterhalder 2001; Winterhalder and Smith 2000). Within these two general mechanisms, evolutionary ecologists tend to focus their research endeavors on optimization models and interpreting data in light of optimal foraging theory.

Optimal foraging theory is a catchall for the application a set of optimization models aimed at examining the relationships among human behavior, subsistence strategies, and the environment predicated on the basic assumption that subsistence strategies are evolutionarily adaptive due to the selection of subsistence behaviors striving for the highest return, typically in terms of energy (kcal/hour), for the least amount of effort. While a detailed examination of each optimization model is beyond the scope of this essay, three of the most commonly applied models have some conceptual bearing on my research; for overviews of the other models see Smith and Winterhalder (1992), Dugatkin (2001), Pianka (2000). The three models relevant here include the diet-breadth model, the patch-choice model (also called contingency theory), which includes the marginal-value theorem, and the resource distribution model.

The diet breath model, a refinement on linear programming (see Reidhead 1979), essentially measures the energetic return of procuring resources in terms of both search and handling costs (Madsen and Schmitt 1998; Sutton and Anderson 2010). Separating search and processing costs allows for inferences to be made concerning a resource's density and procurement patterns (Kelly 1983, 1995). Assumptions necessary for the diet-breadth model to operate include that hunters or gatherers decide on which resources to pursue based on the density of a particular resource, alternative available resources, and the handling times relative to the different available resources. Given a group's knowledge of resource distribution, the model predicts that the resource with the higher return rate will be pursued.

The patch-choice model shares many similarities, and assumptions, with the diet-breadth model, but instead of focusing on specific resources the patch-choice model concentrates on the distribution of resources in specific places across a landscape. Resources, be they particular plants, watering holes, or large game, occur in varying densities across a spatial area, and through time, with little uniformity or homogenous structures, except in particular resource patches (Bettinger 1991:87; Burger 2009; Burger et al. 2005; Jones 2009; Kelly 1995:91). Patches, in evolutionary ecology, are simply considered clumps of particular resources that vary in time and space; the concept of patch is further discussed in subsequent chapters. The model assumes that patches are encountered randomly and sequentially across the landscape, that the time spent procuring a resource in any given patch involves the amount of the resource present, that there are diminishing returns in collecting the restricted resource, and that the foragers will spend the most time in areas where the return rates are highest (Kaplan and Hill 1992:178). Rates of diminishing returns relative to the costs for searching for new patches to exploit are generally interpreted in regards to the marginal value theorem (Charnov 1976). The marginal value theorem (MVT) states that an optimally foraging individual or group will exploit resources in patches and predicts that patch residence or procurement times will increase in patches that are energetically profitable, as the distance between patches increase, and/or when the surrounding patches or environment in general are less profitable.

A final noteworthy behavioral ecology model, one that has been used as an explanatory device in the Subarctic, is Horn's (1968) resource distribution model. Relative to the previous models, the resource distribution model makes predictions on the temporal and spatial cohesion of a group based on the behavior or patterning (predictable or unpredictable) of a particular resource and how that resource is distributed throughout the environment (clumped or evenly distributed). Heffley's (1981) application of Horn's model to the aggregation and dispersal of the Chipewyan, Ingalik, and Tanana Athabascans are discussed later in this chapter.

Ecological Anthropology

Another divergence from the cultural ecology paradigm was ecological anthropology (Moran 2008). Ecological anthropology is broadly defined as "the study of the relationships among population dynamics, social organization, and culture of human populations and the environments in which they live (Orlove 1980:235)." Relative to either behavioral ecology or cultural ecology, ecological anthropology derived its theoretical stance from strong functionalism or evolutionary perspectives, systems theory, and a reliance on negative feedback (Kottak 1999; Moran 2008; Orlove 1980).

In its infancy, anthropologists used ecological populations and ecosystems as their basic units of analysis. Rappaport (1971:238) defined an ecological population as "an aggregate of organisms having in common a set of distinctive means by which they maintain a common set of material relations within the ecosystem in which they participate." He further defined an ecosystem as "the total of living organisms and non-living substances bound together in materials exchanges within some demarcated portion of the biosphere (Rappaport 1971:238: see also Rappaport 1968:225)." These units of analysis, combined with a preoccupation with energy transference, the concepts of static equilibrium, and the perceived weakness of the functional to explain cultural phenomena, were quickly criticized by several scholars (Vayda and McCay 1975).

Early on ecological anthropologists centered their research on measuring, to the best of their abilities, the flow of energy. Unlike behavioral ecology, however, the calorie-based measurements were measured based on the ecological population and not the individual, although there is nothing in the approach that limits study to only larger aggregate groups of people (Moran 1990; Rappaport 1992). Because of the intensity of measurements needed and clearly established links between the ecological population and the ecosystem under scrutiny a fair proportion of early ecological anthropology work centered on small scale societies, but not only hunter-gatherers (e.g., Kemp 1971; Moran 1973; Rappaport 1968). As the subdiscipline matured, other subject matter, such as stability, reliance, and climate change, became incorporated into the paradigm (Abel 1998; Abel and Stepp 2003; Moran 2008) More recently, several researchers have begun to examine larger societies with less direct ties to the immediate environment (e.g., Alberti et al. 2003; Kottak 1999)

Ecological anthropologists made a considerable forays into some arctic cultures (e.g., Berkes and Jolly 2002; Ford et al. 2006; Krupnick 1993; Nuttall and Callaghan 2000) and the subarctic (e.g., Berkes et al. 2000; Loring et al. 2008; Peloquin and Berkes 2009; White et al. 2007). Most of these studies center on recent advances in ecological anthropology focusing on system resilience, adaptation of subsistence strategies, etc. in light of climate change, subsistence, nutrition, and anthropogenic environmental degradation.

Ethnoarchaeology

A third influential approach to the study of hunter-gatherers, from a perspective other than ethnography, is ethnoarchaeology. In a nutshell, ethnoarchaeology is the application of ethnographic methods and techniques towards archaeological ends (Gifford-Gonzalez 2010; Roux 2007). Or put another way, ethnoarchaeology compares patterns in material culture and its discard observed in modern populations to gain insights into archaeological patterning of similar materials (e.g., Bird and Bird 2000; Kuznar and Jeske 2008; Schmitt and Lupo 2008) . Lewis Binford, arguably the father of ethnoarchaeology and its use as a middle-range approach, has been enormously influential in the development of the approach, particularly through his substantial fieldwork among the Nunamiut (Binford 1978a, 1978b & 1983a). While the approach has been applied in various places around the world, including in the Arctic and Subarctic (e.g. Ackerman and Ackerman 1973; Arundale and Jones 1989; Brumbach et al. 1982; Dawson 1995; Hall 1984; Hanks 1983; Hanks and Winter 1986; Janes 1983; Jarvenpa and Brumbach 1983; Savelle 1995) for over four decades, there is little formal methodology to the approach.

Being mainly descriptive and circumstantial, when dynamic behaviors are rendered to interpretations of the static archaeological record, ethnoarchaeological observations are rarely combined with direct and ethnohistorical approaches to study the direct ancestors of the contemporary groups being studied (see Brumbach and Jarvenpa 1997; Hanks and Winter 1986; Janes 1983; and Townsend 1973 for exceptions relevant to western Subarctic). Instead, the general analogs and models derived from the approach are applied to the archaeological record in distant places and remote times. Despite the obvious neglect of coupling ethnoarchaeological work with the direct historical approach, great strides have been made in understanding not only how materials enter the archaeological record and other culturally-based taphonomic processes, but primary ethnographic observations made with the archaeologist's eye have provided much needed insight into settlement patterns, subsistence, spatial organization, and intra- and inter-site variation (e.g., Binford 1978a, 1983b; Kent 1984; Gould 1980; O'Connell 1987, Schiffer 1983, Yellen 1977; and contributors to Kroll and Price 1991).

Cultural ecology, ecological anthropology, evolutionary ecology, and ethnoarchaeology, though very different in terms of theoretical and epistemological orientation, share many common goals and objectives; mainly, the elucidation of subsistence and land use strategies and how the environment influences subsistence processes. In these regards, the three approaches have direct and indirect bearings on this research; however, they fall short, individually and collectively, in terms of being spatially and ecologically explicit. While the use of space is considered in a general manner, such as Binford's (1982) descriptions of life space or the use of the concept of patchiness in the ecological approaches, the actual structure of the environmental background is only cursorily examined. The optimality models assume a generic environmental matrix where patches, a concept never properly defined, occur randomly. Ethnoarchaeological research commonly deals with intra-site spatial patterning and relegates large-scale spatial patterning to a subservient role that is addressed relative to overall mobility. O'Connell (1995) argues that these spatial, and other, shortcomings of ethnoarchaeology can be overcome with the addition of behavioral models, though few have seriously attempted this amalgamation (but see Thomas 2002).

Another commonality among the three approaches is a strong ethnographic field component. Cultural ecology, especially as initiated by Steward, relied heavily on life histories and remembrances of key informants. Ethnoarchaeology and behavioral ecology both rely on direct observation of modern behaviors/actors. While the behavioral ecologist focuses on how hunter-gatherers procure resources and the choices they make in doing so, the ethnoarchaeologist focuses what is done with and to the resources once obtained.

The study of extant populations, however, is not without problems. Any researcher conducting any ethnographic research, even over long periods or on multiple occasions, is not likely to observe all possible outcomes for circumstances that are dynamic and in constant flux. This has been a major criticism of behavioral ecology, but is equally valid for ethnoarchaeological research. Acculturation and interaction are also continuing impediments to bridging modern observations and prehistoric patterns. Although cultural ecology has fallen by the wayside to other ecological approaches, the general approach is further endangered by the simple progression of time. As cultural traditions and past lifeways are changed or lost in newer generations, the pure form of cultural ecology becomes impossible and relegated to the use of ethnohistoric sources rather than the people themselves.

A majority of archaeologists and ethnographers working in the western North American Subarctic throughout much of the 20th century all applied varying ecological approaches to understanding indigenous populations both past and present. Alaska and neighboring portions of Canada have served as an outdoor laboratory for not only understanding local populations, but also developing various hunter-gatherer models used throughout the discipline and testing the validity of different ecological approaches.

Hunter Gatherer Subsistence, Spatial Organization and Land Use

Several nearly synonymous dichotomies, which are often portrayed as continuums, exist that categorize hunter-gatherers into those who are highly mobile with little capacity for storing resources and those who are less mobile and store or cache foodstuffs for later use. The most famous, or at least the most commonly used, of these is Binford's (1980) forager-collector model. Foragers, on the one hand, are found typically in relatively homogenous environments (e.g. tropics), have high residential mobility where by people move regularly to exploit seasonally available resource patches. The continual movement of people to resources, one an encounter basis, and the relatively stable ecological matrix and climate, alleviate the need for storage. Group size and the number of residential moves can vary dramatically over the course of any given year. Collectors, on the other hand, are logistically mobile where task groups typically bring resources from near and far to a residential camp. Collectors commonly practice storage allowing for the accumulation of foodstuff surpluses for those times of the year when resources are seasonally sparse or widely distributed, which is common in higher latitudes where environments tend to be more heterogeneous in structure compares with lower latitudes. Seasonal differences may also inhibit mobility resulting in the necessity of long-term residential bases.

Other similar models include Bettinger and Baumhoff's (1982; see also Bettinger 1999; Bettinger et al. 1997) traveler-processor model and Beardsley's et al. (1956) four wandering groups (restricted wandering, free wandering, center-based wandering, and semi-permanent wandering). Though the creators of these models were never conceived their models as typological, it is commonplace in hunter-gatherer studies to use these models in such a fashion. Instead, the Binford and Bettinger-Baumoff models are best conceived as extremes at either end of a hunter-gatherer subsistence strategy/mobility continuum (see also Kelly 1992:44 and Chatters 1987:337-338). These, and similar, models are mostly descriptive with little explanatory power; though, there is some correspondence between subsistence-mobility strategies and effective temperature which roughly translates into changes in latitude (Binford 2001; Kelly 1995:73). This, however, is not causation and cannot be considered explanatory except in a purely deterministic sense. Given the dramatic change in scholarly perspectives concerning hunter-gatherers in the 1950s and 1960s, culminating in the *Man the Hunter* symposium held in Chicago in 1966, it became evident that the 'simple' hunter-gatherers display a very high degree of variation in subsistence, social and territorial organization, interaction, and acculturation (Lee and DeVore 1968:5-8). These changes in perspective make it difficult to reconcile the mobility-subsistence models common in New World archaeology with the actual diversity demonstrated in recent historic and extant hunter-gatherer populations.

Ethnoarchaeologists focus much of their attention on intra-site patterning of hearth areas, camp organization, or other very small-scale spatial units (e.g., Binford 1978b, 1980; Yellen 1977). Detailed study of large-scale areas, such as those used for hunting, collecting, or trapping are lacking. Many behavioral ecologists heed the types of animals hunted, the time spent foraging for particular plants, and the effort expended in processing collected resources (e.g. Cashdan 1992; Fisher 2002; Kaplan and Hill 1992; Smith 1991; Zeanah 2002); it is rare to study the how and why of the areas that are exploited. Researchers rely instead on the assumptions of the resource distribution necessary for their models. Binford (1982) discusses various manners in which hunter-gatherers exploit the areas surrounding residential base camps. Segmented into zones, Binford describes many zones relevant to the Nunamiut including a play radius, foraging radius, and logistic radius; the patterning of mobility is described as point-to-point, half radius continuous, and complete radius leapfrog. Economic zonation is nearly tantamount to the concept of catchment. In archaeology, catchment analysis consists of "the study of the relationship between technology and those natural resources lying within economic range of individual sites (Vita-Finzi and Higgs 1970:5)."

The categorization of economic zonation or catchments is a useful heuristic; however, in most applications the ecological background is static and often very broadly defined (Foley 1977). Inherent in many of these models are assumptions similar to those found in behavioral ecology models, primarily that resources are randomly distributed, encountered by chance, and that there is little ecological diversity or variation within any given zone. Catchment analysis, aided recently with the application of geographical information systems (GIS) (Hunt 1992), allows for the clear delineation of particular resource distributions in hypothetical zones, but more commonly the actual resource distribution of a particular resource is inferred from the distribution of secondary environmental characteristics, such as broad vegetation classes, soil types, or topography. In the these types of studies there are no direct or explicit linkages between subsistence data (e.g. faunal remains, botanical macrofossils, protein residues, etc.) generated from individual sites, or locations in terms of contemporary hunter-gathers, to the surrounding environment matrix; this problem is not limited to catchment analysis but human-environment studies in general (Kelly 1992; Madsen 1981).

All three approaches invoke the concept of patch, though it is rarely defined and never spatially explicit. Patches are often considered quasi-spatial concentrations of a particular resource bounded in both time and space. Foley (1992:145) provides one of the better definitions when he defines a patch as . . .

> a location in either time or space at which resources are available. Usually this refers to an area of the landscape that is relatively rich in resources. Patches have certain qualities: They may be relatively rich or poor (patch quality), large or small, evenly dispersed or clustered, predictable or unpredictable, abundant or rare . . . (I)ndependent patch quality can affect the foraging behavior of a given species.

Smith (1991:249), likewise, provides a good working definition stating that a patch is a "spatially bound entity characterized by a set of prey. . . contained within it and by a predictable (expected) return rate." Winterhalder (2001:19) states that "patches are discrete, localized concentrations of resources, on a spatial scale such that a forager might encounter several in the course of a day." Conversely, in explaining the concept of patchiness, Cashdan (1992:242) simply states that the concept is an "elusive variable to measure," and for Kaplan and Hill (1992:178) patches consist of clumped resources. Explanations and definitions of the patch concept in both ethnoarchaeology and cultural ecology do not fair much better than the last two examples, if they are explicitly stated at all.

Taken as a whole, these definitions all lack a clear spatial component making it difficult to physically delineate a patch. If subsistence and mobility patterns correspond to resources, and resources are contained within patches, it follows that mobility, in its various forms, should be associated with distribution of resource patches. The existing definitions are not only vague, but also contradictory. Most of the ambiguity comes from not adequately defining 'resource'. For example, patches of particular plants are certainly not prey, and not all resources are clumped, and certain types of prey have very large ranges that do not conform to any of these patch definitions. Only Winterhalder's definition cursorily mentions concept of scale. Instead, it appears that patches are most often considered as points in a landscape where observations of certain subsistence or settlement behaviors are focused. This unilinear conception of patch allows researchers to make simple empirical observations and comparisons about the amount of time spent in Patch A, the return rate of foraging in Patch B, or the time it took to get from Patch A to Patch B. If a resource is collected, harvested, or processed, it is assumed that the area where these activities take place is part of a patch.

In many instances patch definitions are geographically biased. For example, Binford's (1978b) implicit and Smith's (1991) comprehensible definitions are keyed to the subsistence patterns of Eskimo populations who have subsistence practices tied almost exclusively to hunting and animal protein, whereas researchers studying hunter-gatherers in lower latitudes contend with groups who rely very little on animal protein relative to vegetal matter. This contrast between northern hunters, including the Inuit, Inupiaq, Northern Athabascans, Northern Algonquians groups, and many indigenous peoples of Siberia, and peoples farther south has long been noted. Lee (1968:42), for instance, explicitly excluded northern hunters from his generalization that "latitude appears to make little difference in the amount of hunting that people do."

Traditional Athabascan Subsistence and Spatial Organization

It is undeniable that the western Subarctic is a harsh environment offering few of the amenities of more southerly latitudes where humankind developed writing, architecture, agriculture, and science. Yet for all the severity of climate and environment, the great northern forests and tundra of North America have witnessed the coming and going of countless generations of people who not only manage to survive but flourish. Among the more recent and successful inhabitants of this region are the linguistically related Athabascan populations that occupy some 1,350,000 square miles of land and lake between Hudson Bay and Norton Sound (see Osgood 1970: Figure 1). Alternately known as the Dene or Na-Dene, the northern Athabascans have adapted not only to the environment, but also to incursions from foreign explorers, trappers, traders, missionaries, fortune seekers, and tourists.

For well over a century scholarly individuals, from military explorers to contemporary ethnographers, have deliberated nearly every aspect of Athabascan language and culture. Despite the history of research, much of what we know about their socio-spatial organization derives from generalizations and inferences about the varying Athabascan resources and simplifications of seasonal rounds used to exploit these. As Jarvenpa and Brumbach (1988:589) note, "ethnographic and ethnohistoric descriptions of foraging societies rarely offer clear or comprehensive descriptions of the placement and movements of people across a landscape," and when such information is available the "discourse . . . often occurs in a cartographic vacuum." In the last 25 years, there has been some remedial collection of spatial data. For example, anthropologists with the Division of Subsistence, Alaska Department of Fish and Game have focused on the size, composition, and geographic distribution of resource harvests for numerous traditional Athabascan communities (Wolfe and Walker 1987). To aid in the collection, analysis and interpretation of this data, cartographic and spatial methods and procedures were highly standardized (Ellanna et al. 1985), and though accessible, much remains in the gray literature; few practicing social scientists in Alaska or elsewhere utilize this important resource.

In the remainder of this chapter the existing ethnographic and ethnohistoric sources are examined to tease out information relevant to delineating similarities and differences in the socio-spatial organization of the various Northern Athabascan groups; unfortunately, information is insufficient to adequately address the geographic and cartographic criticisms noted above. The concept of socio-spatial organization is an expression of the association between a particular range or territory and the social responses developed to exploit the environmental mosaic within it.

Extremes of cold, dark, and resource availability characterize most of the landmass inhabited by the Athabascans. Despite the generalized characterizations of the western Subarctic in terms of expansive forests and unpredictable resources, the region consists of a complex mosaic of physiographic, climatic, and ecological systems that allows for a great biodiversity, even if that portion of the biodiversity exploited groups is relatively limited. Within this mosaic different groups have asserted claim, via occupation, to specific areas that early anthropologists interpret as tribal territories (Gillispie 1981a:161). The description of territories occurs regularly in ethnographic monographs and articles, though there are few descriptive treatises on Athabascan distribution in general (see Gillispie 1981a; McKennan 1969b; Osgood 1970; VanStone and Goddard 1981), and none are particularly comparative. While many Athabascan territories appear to have remained stable after contact with Europeans and Americans, ample evidence suggests shifting territories related to the fur trade and other factors (Brumbach and Jarvenpa 1989; Burch and Mishler 1995; Burch et al. 1999; Gillispie 1975 & 1976; Hadleigh-West 1959; Osgood 1934; Smith and Burch 1979; and Yerbury 1977).

A brief critique of the ethnography of the western Subarctic as it is practiced in Alaska compared with its practice in Canada is warranted here as this bears directly on our understanding of Athabascan socio-spatial organization. The initial and secondary studies of many Athabascan societies in both Alaska and western Canada followed the same descriptive formula covering kinship, seasonal rounds, social organization, religion, etc. After about 1970, however, different research trajectories formed on opposite sides of the Yukon-Alaska border (Krech 1980). As the descriptive data collected by ethnographers became readily available, the study of social organization became popular among those studying Athabascans in the Arctic Drainage Lowlands; while cultural anthropologists studying Alaskan Athabascan groups shifted primarily to examinations of expressive culture and psychodynamics. As such, much of the detailed examinations of socio-spatial organization derive from the inhabitants of the Arctic drainage, though correlates can be found in the ethnographic descriptions for the Alaska Athabascans, as well as other subarctic groups such as the Ojibwa, Montagnais, and Cree.

At their broadest spatial classification, save the generic geo-linguistic level (e.g. western Subarctic or Southwestern US), anthropologists group the Athabascans according to broad geographical or physiographical settings. The *Subarctic* volume of the *Handbook of North American Indians* (see Helm 1981 for reference) distinguishes between Athabascans inhabiting the Subarctic Shields-Mackenzie Borderlands, the Alaska Plateau, and the Subarctic Cordillera. McClellan (2001), VanStone (1974), and others use up to five physiographic regions including the Arctic Drainage Lowlands, the Cordilleran, the Yukon and Kuskokwim River Basins, Cook Inlet-Sustina River Basin, and the Copper River Basin. This scheme is a refinement of Osgood's (1936) regional classification between Athabascans in the Pacific drainage, with access to salmon runs, and the Arctic drainage, where no salmon spawned. Jenness (1977) includes a Cordilleran set of Athabascans into Osgood's Arctic-Pacific dichotomy. McKennan (1969a & b; see also Hosely 1977) challenged Osgood's Arctic-Pacific system under the premise that the importance of salmon to the Pacific drainage Athabascans may be a historic phenomenon.

At a finer scale, anthropologists typically divide Athabascan territories along socio-linguistic lines, meaning through relatedness of language and kinship. The degree of differentiation between language and kin systems, and hence territorial boundaries, is unclear. Despite largely endogamous marriage practices within interrelated bands, spatially associated but only peripherally related groups have been absorbed into other groups. For example, The Yellowknife Indians were successfully amalgamated into not only the Chipewyan social system, but the Dogrib social system as well (Gillispie 1981a), thus changing the territorial boundaries of two extant Athabascan groups. Likewise, bands of the Sekani assimilated some of the Tsetaut Athabascans of British Columbia (Duff 1981) sometime after displacement by the Tahltan Athabascans. On the opposite side of the coin, schisms also occurred, such as the split between the Sekani and Beaver Indians (Jenness 1937:5-16); the resulting changes in territories affected a number of Athabascan and Algonquian groups.

In the past, and still to some extent, these large socially and linguistically-based designations relate to tribes or societies; where tribe is defined not as a cohesive political unit, but as "the greatest extension of population throughout which there is sufficient intermarriage to maintain many-sided social communication (Helm 1968: 118; see also Krech 1980:83)." Helm's definition is consistent with Birdsell's (1958) definition of a dialect tribe. It is these general designations that commonly refer to distinct groups who speak very similar, if not identical, languages, intermarry, and occupy contiguous ranges. Examples of such groupings include generalized groups such as the Kutchin, the Chipewyan, or Upper Tanana Athabascans.

Shifting the scale down once again we come to the level where most ethnographic research has been conducted over the last five or six decades. Commonly referred to as the band, regional band (Helm 1968), macrocosmic group (Honigmann 1946), or concentrated summer band (Janes 1983), these designations differ from societies or tribes on the basis of relatively cohesive socio-territorial ranges, closer cosanguinal and affinal kinship ties, and group identity. Examples of such band designations are common in anthropological literature and include the Vunta Kutchin (Balicki 1963a; Osgood 1934), the Lynx Point people (Helm 1961), or the people of Tetlin (Guedon 1974).

At the band level, organizational shifts occur throughout the year, as well as over the course of an individual's lifetime. The regional band is a yearly or biannual gathering that occurs when enough resources are available, be they fish or caribou, to sustain a large aggregation of people over several weeks or months. During the rest of the year, however, bands disperse throughout the tribal territory into smaller and smaller groups. In the Arctic Drainage Lowlands the terms winter village (Jarvenpa and Brumback 1988), local band (Helm 1968), microcosmic band (Honigmann 1946), residential camp community (Janes 1983), and hunting unit or hunting group (Hiroko 1980; Sharp 1977; Smith 1978) are basically synonymous--referring to a social group that forms during the coldest parts of the year consisting of between 5 and 12 nuclear families and functioning as a staging, processing, and residential base. Despite the continued study of winter staging areas, the literature actually contains little information detailing how people choose particular locales for this settlement type.

There are some commonalities in terms of activities that lead to some general principles in the location of these semi-permanent villages. For example, in the Arctic Drainage Lowlands winter villages tend to be adjacent to larger lakes, centrally located relative to hunting territories, and near fuel sources (Hiroko 1980: 237; Janes 1983:17; Smith 1978: 84). But, the literature provides little in regard to distances between rendezvous areas and winter villages. By comparing the meager data, it is possible to delineate a range of distances. Janes (1983: Figure 3) shows a distance of 25 geographical miles between Fort Norman and the Willow Lake camp, while Jarvenpa and Brumback's map (1988: Figure 2) shows the maximum distance between the rendezvous point and the most remote winter camp at 160 miles. Both these examples, of course, specify historic trading posts as aggregation centers. The larger distances between the seasonal concentration locales and distant winter camps generally correspond well with the regional band's territory.

The task group has multiple and often contradictory meanings in the anthropological literature of the North. Among the Mackenzie drainage Dene the task group (Helm 1968 & 1972), winter hunting encampment (Jarvenpa and Brumback 1988), hunting group (Smith 1970 & 1978), or hunting unit (Sharp 1977) *typically* consists of two, sometimes three, very closely related people (e.g., father-son or a pair of brothers) who hunt or trap away from the winter village for several days at a time. However, the concept of task group is also used to signify a small aggregation of numerous families, from one or more local bands, who extract a plentiful, but short-lived resource, such as caribou or migrating fish. Whatever the size of the task group, it is resource dependent, if not resource specific. As Helm (1968:121) states:

> The task group is pre-eminently a grouping of persons concentrating upon the exploitation of a specific seasonal resource . . . [It] lacks temporal duration beyond a few weeks . . . [and] may either be based on the basic social building block, the family, composed of a conjugal pair with dependants, or it may be all male. Task groups vary in size and in sex-age composition, depending largely upon the nature of the resource that is the focus of task group creation.

Jarvenpa and Brumback (1988:90), on the other hand, define their winter encampment as "the smallest and most ephemeral units in the . . . settlements community hierarchy." The hunting camp, composed of task groups or work teams, served as primary processing locales and short-term habitation sites. Sharp (1977) also discusses the dual nature of this particular unit.

Again, there is little in the literature detailing particular ranges used by particular hunting units. Jarvenpa and Brumback (1988) detail one particular hunting-trapping area. The hunting trapping area is about 65 km to the north of the winter village and covers about 200 square kilometers. Within the hunting unit are six temporary camps, each occurring near one or more trap sets for lynx, beaver, and mink. The hunting of big game occurred on an encounter basis, and it is assumed that when animals, or their sign, were observed, hunting took precedence over trapping, as is noted by many ethnographers (e.g., Smith 1978; VanStone 1962). This patterning is also observed in some neighboring Cree groups (Winterhalder 1981 & 1983). The spatial relationships of several such hunting units are discussed in Jarvenpa and Brumback (1988). The authors also provide additional information concerning differences in hunting-trapping ranges utilized by male-male, male-female, and female-female extractive teams. The example described above is the result of a male-male team, which tends to exploit a larger range and travel longer distances. The female-female team, which exploits the smallest ranges and travels the shortest distances, typically accomplishes its tasks in day trips; exploiting areas around the winter camp for snaring small game, winter ice fishing, or, in appropriate seasons, berry picking and muskrat hunting-trapping.

Many of the Alaskan Athabascans have the appearance of similarity and evidence for such a system can be found in most of the ethnographies and general descriptions for most groups. McKennan (1969a & b) and Mishler and Simeone (2004), for example, superimpose Helm's tripartite socio-spatial organization system onto many of Alaska's interior Athabascans including the Han, the Kutchin, the Tanana, and the Upper Tanana. Osgood (1958) divides the seasonal settlements into home-base winter village, the canoe or spring camp, and the summer camp, though the distance between each was small relative to other Athabascan groups. Based on the available evidence, the Tanaina (Townsend 1965) and the Ingalik (Osgood 1958; VanStone 1976) deviate most from other Athabascans given their proximity to Eskimo populations and marine resources. The tripartite system also seems to hold for most, if not all, of the Athabascans occupying the southern stretches of the Subarctic Cordilleran such as the Kaska (Honigmann 1954), the Tutchone and the Tagish (McClellan 2001), and the Carrier (Tobey 1981). Some understudied groups, such as Tahltan (MacLachlan 1981), are described only as having no permanent villages.

Not all anthropologists used the three-tiered organizational model. In contrast to Helm, McKennan, and others, Slobodin (1962:58-59) recognizes six different groupings among the Peel River Kutchin. These include the paired family, the trapping party, the meat camp, the fish camp, the band assembly, and the local group. The names of the Pelly River Kutchin social groups suggest correlates with other organizational models; however, the gradations appear to be partly separated along discrete functional lines more so than the others.

Often implicit in the study of socio-spatial organization in Athabascan society are the concepts of territory and territoriality. Although research concerning territoriality among the !Kung (e.g., Cashdan 1983; Heinz 1972; Lee 1972), the Australian Aborigines (e.g., Blundell 1980; Peterson 1975), and, to an extent, the eastern Subarctic indigenous societies (e.g., Rogers 1969; Tanner 1979) is fairly common, Athabascan scholars often only give infrequent reference to the topic, mostly in passing. Helm (2000:10) suggests that, in an ecological perspective, the McKenzie Athabascan regional bands have "territory without territoriality." Dyson-Hudson and Smith (1978:23) define territoriality, quoting Wilson (1975:256), as "an area occupied more or less exclusively by an animal or group of animals by means of overt defense or advertisement." Cashdan (1983:47) recognizes territoriality as an area maintained by its residents through the control or restriction of one or more resources.

Despite Helm's postulate, the ethnographic and ethnohistorical records contain multiple examples of territoriality within Athabascan society; although, Helm is generally correct if her claim is limited to individual regional bands. Most often, territoriality becomes a significant issue when interregional bands have overlapping territories, or when Athabascan territories are adjacent to territories of non-Athabascan speaking peoples such as various Cree or Eskimo populations. In addition, most of the limited data concerning territoriality and territory in the literature typically begins no earlier than European contact, making it difficult to fully examine if territoriality issues are fully or partially correlated with the establishment of the two periods of the fur trade. References regarding territoriality amongst different Athabascan tribes pepper the literature; they only hint at the existence of the concept and do not necessarily address its breadth or weight. The same problem is found in the literature on the Yupik and Inuit (Andrews 1994:66). The following examples allude to the potential for territoriality.

Among the Upper Tanana Athabascans, Guedon (1974: 147) notes that local bands "controlled the access of other groups to its lands." Based on Guedon's limited discussion, 'other groups' appears to include nonlocal groups, such as those people from the Tanacross area, and other Upper Tanana bands. The restrictions do not generally relate to members of the same regional band in regard to hunting, but mainly to trapping (Guedon 1974:149). In this regard, Upper Tanana territoriality is very similar to the 'hunting territories' identified among many eastern Subarctic Indian populations (Hallowell 1949; Kinietz 1940; Leacock 1954; Rogers 1963; Snow 1968; Speck 1915 & 1923; Speck and Eiseley 1939 & 1942).

McKennan (1959) details feuding and warfare between the Upper Tanana and their neighbors: the Tutchone, the Ahtna, the Lower Tanana, and even the Tanaina. Most of the conflict, as related by informant narratives, consists of avenging the death of one or more members of a particular band, clan, or sib; however, the narratives make it clear that many of these transgressions were obliquely related to boundary transgression and boundary maintenance. This type of feuding was common in the Cordilleran and Pacific drainages of the Athabascan home range. For example, McFayden-Clark (1974:201) notes that competition for hunting territories is a primary source of conflict among the Koyukon, Kutchin, and Nunamiut. According to Honigmann (1954:88, 96), many of the Kaska regional bands had fairly loose and shifting territories where members of a particular regional band could hunt anywhere within the band's home range. Permission was sought if one family moved into an area that another was currently using. Particular areas, such as creeks or portions thereof, used for hunting beaver, were individually owned with exclusive rights retained by the owner. Retaliation warfare was common for territorial transgressions, in regard to property theft, murder, etc., made by surrounding groups such as the Nahani or Tahltan. VanStone (1974:50) notes that many of the Cordilleran Athabascans had more exclusive territories than their more northerly cousins, and often killed trespassers.

In the Arctic Drainage, Mason (1946:13) briefly describes warfare between the Dogrib and Yellowknives, though not enough information is given to discern if the tensions related specifically to territory. Hearne (1958) states the Yellowknives limited the passage of the Dogrib to trading posts which resulted in territoriality with a strong economic basis marking a distinct change in the control of portions of the landscape. The Yellowknives aggressively transgressed the territories of their neighbors forcing some bands of the Slavey, Hare, and Dogrib to encroach on other regional group territories (Gillispie 1981b; Helm 1981; Reedy-Maschner and Maschner 1999). Hiroko (1980:10) notes that within local and regional bands the Hare Indians had no specific claim to areas within the regional group's territory, but the tenacity of the aggressive Yellowknives forced them out on to the Barren Grounds to obtain caribou, thus bringing them into conflict with other groups.

Conflict between various Athabascan groups and their non-Athabascan neighbors is similar in form to typical Athabascan-Athabascan feuding, but in many cases evidence suggests that this form of warfare lead to shifting territorial boundaries. The time depth of many of the Athabascan-other conflicts is not well documented, but much of the ethnohistorical literature details one group attempting to monopolize middleman status in relation to trading posts (see Reedy-Maschner and Maschner 1999). Some of the violence that ensued after the establishment of the trading posts and the commercialization of fur trapping cannot be chalked up simply to territoriality, as Hearne's (1958) travels and observations indicate, inter-ethnic warfare between the Yellowknives and certain Eskimo groups had a deeper history (see also Slobodin 1962:24).

Those Athabascan groups that had territories or ranges that bordered or overlapped with non-Athabascan speaking peoples inevitably came into conflict with them; although, trade and intermarriage often occurred as well. Of these overlaps, none is better documented than the shifting territories, ranges, and conflict between certain Chipewyan bands and their Cree and Inuit counterparts (Gillispie 1975; Krech 1979; Smith 1975, 1976 &1981; Smith and Burch 1979; Yerbury 1977). The triad of ethnic groups in the area and the push of the fur trade west of Hudson Bay lead to the substantial reorganization of controlled space, and therefore resources, over a very short period of time. These changes had a ripple effect that moved west through the great northern Canadian lakes and affected many different Athabascan populations.

In Alaska, relations between various Nunamiut and Kutchin groups ebbed and flowed throughout the historic period resulting in the movement and displacement, primarily through small-scale, guerilla-like skirmishes, of some Kutchin bands (Hall 1969 & 1975; Slobodin 1962). Burch and Mishler (1995) detail some of this conflict that resulted in the annihilation of a particular Kutchin band (see also McKennan 193; Hadleigh-West 1959 & 1965). This outcome is markedly different from the long-standing boundary maintenance observed in southwestern Alaska between the Tanaina and Ingalik and their Yupik and Inuit neighbors (Burch et al. 1999; Burch and Correll 1971; McFayden-Clark 1970; Oswalt 1967; Osgood 1958; Townsend 1973).

During the protohistoric and historic periods, the Lower Ahtna managed to retain control over copper deposits in the Chitina Basin from other Athabascans, Eyak, Tlingit, Eskimos (Alutiiq), Russians, and for a significant time, the Americans. According to Pratt (1998), Chief Nikolai's band of the Lower Ahtna strategically placed villages and camps at key locations to control access into Chitina Basin by other groups such as the Upper Tanana, Southern Tutchone, Eyak, and Chugach Eskimo. Russians attempting to locate and access the copper deposits, after the collapse of the sea otter fur trade, met with great hostility resulting in the death of an exploratory party (Grinev 1993; Pratt 1998).

Three Models of Athabascan Settlement Systems and Land Use

Helm (1968), Smith (1978), Shinkwin et al. (1980), Heffley (1981) and Noss (1985) have all presented models describing the relationship between social organization and resources availability among various Athabascan groups, while others like Binford (1980) and Winterhalder (1980 & 1981) have developed more generalized models for other Arctic and Subarctic populations in similar habitats, which in turn have been adapted for explaining Athabascan socio-spatial organization (e.g., Arundale and Jones 1989). Each model has limits, though, in general, none are contradictory (cf. Krech 1978). None of these models incorporate trapping or territoriality.

Helm's (1968) model closely resembles her tripartite organization model with the inclusion of resource procurement; seasonality is inferred via resource abundance. The model, however, is not spatially explicit and lacks information concerning communication and relationships among different local and regional bands. Helm's model consists of an equilateral triangle with the levels of organization on the inside with local band at the top and the regional band and the task group in the lower corners. Associated with each level of organization on the outside of the triangle is the level's associated feature with the task group being most closely tied to particular resources, the regional band being tied to range, and the local band being tied to kinship. The line between the regional band and the local band represents temporal duration, while the line between the local band and task group represents spatial cohesion. While this model is derived from Arctic Drainage Athabascan data specifically, it is general enough to be used for most of the northern Athabascan groups.

Smith's (1978) model, on the other hand, does incorporate a spatial component, though it lacks an explicit scale and is not necessarily applicable to groups other than the Western and Eastern Caribou Eater Chipewyan and the closely related, but now extinct, Yellowknives. Smith's model is geared specifically toward caribou acquisition during the great Barren Ground caribou migrations out of the tundra into the boreal forest. Regional bands of the Chipewyan and the Yellowknives form a perimeter along this ecotone, just on the forest-side of the transition. Local band camps are situated along commonly used migration paths, and from these camps hunting groups distribute themselves across a given territory or range. This dispersion results in an effective communication system able to keep tabs on the Bathurst, Beverly, and Kaminuriak caribou herds. The relationship between the composition of the different band levels, bilateral kinship ties, and communication allow each individual band to adjust its location relative to caribou, either through simply relocating or through emigrating into an entirely different local or regional band.

The Shinkwin et al. (1980) model of land use focuses specifically on the Upper Tanana Athabascans and consists of 'spider distances' to various resource areas surrounding a village center and between villages and ancillary camps. The authors base this model on historic land use patterns collected from a variety of ethnographic, archaeological, historical, and ethnohistorical sources. The resources examined include caribou, sheep, moose, waterfowl, and white fish. Most post-contact village locations occur within a certain proximity to numerous resources. Sites defined as camps, kills, lookouts, etc. generally occur near at least two resources. Similar patterns are noted for precontact sites, with hunting/lookout/camps having ready access to at least two, but more often three or more, resources. Along similar lines, though not necessarily formulated as a model, Hanks and Winter (1986) propose a manner for delineating settlement patterns, and the types of sites within them, in relation to place names, which are often very descriptive of function.

Human ecologists have also addressed socio-spatial organization in regards to resource availability. Heffley (1981) uses Horn's (1968) model concerning the stability and predictability of resources to interpret the settlement patterns of the Chipewyan, Upper Tanana, and Ingalik. Resources are defined as evenly spaced and stable (moose, sheep, small mammals, bear, and fish) or mobile, clumped, and unpredictable (caribou). Heffley shows that the type of preferred resource is correlated with population aggregation and dispersal. For the Chipewyan, population aggregation closely follows the aggregation and migration of the Barren Ground caribou, on which they rely for nearly 90% of their diet. The settlement pattern for the Upper Tanana Athabascans is not nearly as bimodal as the Chipewyan, as they rely relatively evenly on both types of resources. The Ingalik, with their reliance on fish and the capabilities to store significant amounts, are able to live in larger aggregations for extended periods relative to the other two groups examined. Similar evolutionary ecological modeling is common in the Subarctic (Winterhalder 1980 & 1981) and Arctic (Smith 1991).

Still, others turn to ethnoarchaeological models of land use and settlement patterns to describe locational data and seasonal movements. For example, Arundale and Jones (1989) rely on Binford's forager-collector model, and its associated site types, and his "half radius continuous" and "point-to-point" (Binford 1982) foraging models to interpret historic and early modern mobility strategies among the Koyukon Athabascans (cf. McFayden-Clark 1974, 1975, & 1981).

Noss (1985), after a detailed analysis of the Athabascans and Inupiaq populations and resource distribution in the greater Yukon drainage, concludes that population distribution within a given linguistic, or regional band area covaries with the distribution of multiple resources and that the distribution of human populations and the resources they rely on remains very similar over the three periods (1880, 1950 and 1980). Human population densities, in all three periods, can be best correlated with salmon, and the distribution of salmon largely determines the population density in the Yukon drainage, despite a preference for larger, terrestrial mammals.

The dispersal and congregation of the Athabascans occupying Alaska and northwestern Canada correlate well with the availability of two main wildlife resources: Caribou and various fish species. A third resource, the moose, is also important in many areas and its exploitation corresponds to times of Athabascan dispersal. While causation is not implied here, the return from exploiting these resources is likely greater than all other resources combined. The different seasonal, behavioral, and spatial patterning of these major resources is countered by Athabascans through cultural adaptation via the modes of socio-spatial organization, technology, and traditional ecological knowledge.

Caribou

While Burch (1972) did much to alter the anthropological perception of caribou as a food resource, his work has several shortcomings. Burch's description of caribou behavior and its relation to human hunting are excellent, but the paper fails to account for the full range of variable human adaptation to the resource. For example, the two strategies, 'head'em off at the pass' and 'search and destroy,' are very general and the number of groups examined in the paper, only two and both Eskimo populations, is limited. While these generalizations may be appropriate, in some regards, for examining resource procurement patterns in the distance past, they are only marginally useful in understanding more specific spatial and behavioral responses to resource acquisition. The caribou fence or corral, for example, is an extreme form of the 'head'em off at the pass' strategy practiced by numerous Athabascan groups throughout the western Subarctic. Though not entirely contrary to Burch's arguments on caribou movement, the communal effort in time and energy to construct these features suggests that Athabascans who employed their use either had a better understanding of caribou migration patterns, at least in a smaller timeframe than many of the models assume, or that the use of fences was beneficial when they worked, but not absolutely necessary for subsistence purposes.

Nearly every Athabascan group in the Subarctic whose range overlaps with either the Barren Ground or Woodland caribou used, to some extent, caribou fences or surrounds (Guedon 1974; McKennan 1959:48). Despite the wide spread use of these features, there is only a nominal understanding of the effects of their use on spatial and social organization of the populations that use them. Osgood (1936:25) gives one of the more thorough descriptions of a caribou compound:

> Posts about four feet high are set up in the ground to form an enclosure roughly circular in form. Between these posts, poles and brush prevent the caribou from escaping except through narrow openings about eight feet apart in which snares are set. One side of the surround is open and from this entrance stretch out two lines of posts ever widening like the mouth of the funnel. This projecting line of posts is not a fence, strictly speaking, but a series of poles set up six feet high and hung with moss to represent men so that caribou which have entered the trap will be afraid to run in any other direction except that which leads to the snare-set enclosure. Some of these surrounds are so large that the inner part is a mile and a half in diameter.

Despite the common practice of individual ownership of fences and corrals in Athabascan society (Balicki 1963b, McClellan 2001:109, Mishler and Simeone 2004), the fence system required a communal effort to construct, maintain, and use. Since the communal caribou hunts typically occurred in the fall (Ellanna and Balluta 1992; Heffley 1981; Ives 1990; Janes 1983; McKennan 1959; Noss 1985; Smith 1978; etc.), and less often in the spring (Hadleigh-West 1965), the drive required a seasonal population concentration after, or before in the case of spring, the communal convergence for fish runs. In many of the documented cases, the surrounds and fences were near villages. For example, Hadleigh-West (1965:136) shows a total of 11 pounds in the Nutsin Kutchin territory and 4 of these are within 15 miles of Arctic Village; McKennan (1959) reports a corral and fence in the immediate vicinity of Chisana; and Mishler and Simeone (2004:65) identify several pounds and corrals a few miles from Eagle. Guedon (1974) mentions several fences and pounds near Tetlin.

Several variants of the caribou surround, such as the human surround and the use of natural landscape features such as lakes and various landforms such as narrow valleys and passes were also employed. Like traditional surrounds, the human surround requires many people, but for the latter this is not necessarily so. Unlike the use of physical structures, the variants of the surround are not necessarily dependant on place and time. Gordon (1977) describes in detail one such lake-crossing locale on Lake Rennie in the Northwest Territories. The Chipewyan, and probably their ancestors founded in the Tahtahli Shale tradition, strategically placed themselves at about five or six places at a narrow part of Lake Rennie allowing them to make numerous kills where the caribou began their crossing, during the water crossing, while crossing small islands in the lake, and upon their exit.

Traditional communal caribou hunting continued into the 20th century until the widespread use of repeating firearms became commonplace (Smith 1978:75; VanStone 1976:205). For example, a surround was maintained and used near Chicken, Alaska until 1900 and Smith (1978:75) notes that traditional communal hunting continued among the western Caribou-Eater Chipewyan until the 1920s or 1930s. In many instances, communal hunting continued, but the surrounds and corrals were dropped from the strategy. A dendrochronology sample taken from a corral near Arctic Village came back with a cut date of 1923 (Hadleigh-West 1965).

Traditionally, caribou hunting by individuals and small groups occurred throughout the year, when the animals were available. Though not found in the great herds outside of the migrations, small groups of caribou tend to be found in predictable places during certain times of the year within their seasonal ranges (Winterhalder 1981; Heffley 1981; Smith 1975). The methods of hunting small groups of caribou varied greatly and could include small fences and surrounds, dogs (Ellanna and Balluta 1992; Osgood 1936), or simple ambush-stalking techniques (e.g. Mishler and Simeone 2004; Burch 1972). More recently, evidence from the Yukon suggests a deep history of hunting caribou on mountain snow and ice patches (Farnell et al. 2004). Depending on the number of animals killed, the resource was either brought back to a camp if only a few animals were killed, or the camp may be moved to the vicinity of the kill site. A third option was to cache the meat and hides, then return for them at a later time.

Fishing

Contrary to communal caribou hunting, the fishing process does not necessitate the aggregation of people; it only facilitates it. Fish camps commonly served as base camps that lasted from several weeks to over a month. Communal efforts at such locations were limited and each family group, however formed, extracted and processed the resource independently from others in the same camp or village (cf. Helm 1961 for commercial fishing ventures in recent decades). The congregations of people at fishing villages were large enough that these locations were often listed as villages on large scale published maps despite their transitory nature (Slobodin 1962:58).

Traditional methods of mass fishing during spawning and runs, as opposed to various forms of ice fishing, included a variety of traps (McClellan 2001), weirs (Birket-Smith 1930:26-27; Guedon 1974; Honigmann 1946:37; Osgood 1936), dip-netting (Mishler and Simeone 2004; De Laguna and McClellan 1981), and spearing or hooking (Birket-Smith 1930:27); true gill nets and fish wheels were introduced after European-American contact and are commonly used today (VanStone 1962). Concerted and sustained fishing efforts often resulted in the accumulation of substantial stores of dried fish, whether salmon or some species of nonanadromous fish. Using either modern or traditional means of fishing, catching between 20 and 30 fish a day was considered good fishing (Balicki 1963a:14; Helm 1988:63). A small family or multifamily group could easily catch, clean, and strip for drying all the fish caught daily. The relative ease with which fish could be caught and processed allowed time for other subsistence activities and socialization. For example, Hiroko (1980) describes a typical day at a fish camp where several hours of each day could be dedicated to rabbit snaring, berry picking and socializing.

The number of people aggregated at a particularly good fishing spot varied greatly throughout the western Subarctic. The Ingalik (Osgood 1958; VanStone 1976 & 1979) and the Koyukon (McFayden-Clark 1974 & 1975), to a slightly lesser extent, were able to congregate in greater numbers and for longer periods, primarily due to the substantial runs of various salmon that occurred throughout the warmer months, and an aptitude for storage. The Ahtna, who also lived in an area with significant salmon runs, were more dispersed due in part to the turbid and fast running waters of the Copper River where dip netting was the most effective manner to fish (De Laguna and McClellan 1981). Among the Upper Tanana Athabascans, the people of Tetlin were unique in their position to maintain an almost year-round presence at the lakeside villages (Guedon 1974; McKennan 1959). This relative sedentism was the result of substantial runs of whitefish coupled with a proximity to other less reliable, but no less important, resources such as woodland caribou, moose, and large concentrations of waterfowl.

Moose

Next to caribou, moose served as a major terrestrial subsistence resource for many Athabascan groups. While there is little doubt that caribou served an important role in Athabascan subsistence in both modern and historic periods, the availability and use of moose in the late prehistoric period has been questioned. Yesner (1989) examines the faunal assemblages from several late prehistoric Athabascan village sites through Alaska and the western Yukon territories and finds that moose remains are not very common and concludes that moose were not an important resource until relatively recently. Numerous ethnographic studies (McClellan 2001:108; Nelson 1986), also suggest that moose may have only become an important resource within the historic period, although others suggest otherwise (e.g., Honigmann 1954:44).

Whether or not the hunting of moose was an important resource in prehistory, the ethnographic data shows that many Athabascan populations have an outstanding understanding of the animal's habits and manners and have devised a great variety of methods of hunting them. Nelson (1986) presents the most detailed account of these hunting methods for the Tranjik Kutchin, though Adney (1900) provides the earliest detailed account of a mass moose hunting effort. Given the mostly solitary nature of moose, relative to the gregarious caribou, the animal is generally hunted by individuals or very small groups of people. While the bow and arrow, and later firearms, served as the main stalking apparatus, moose were also taken in snares, fences, small drives, and with the aid of natural physiographic constraints (Nelson 1986).

Historically, moose hunting typically occurred year-round in most Athabascan communities, although late summer and fall appear to be the most common time to hunt, particularly in those areas where they are available in limited numbers (see Jarvenpa 1976; Mason 1946; VanStone 1962). In places where moose supersede caribou as the primary source of terrestrial protein, there is heavy moose hunting in the winter months as well (see Birket –Smith 1930; Helm 1961; Honigmann 1946; McFayden-Clark 1974; Nelson 1986). Despite the intensive hunting of moose, most of the ethnographic data suggest that in any particular community the number of moose taken annually is low, even before various hunting regulations were implemented (cf. Adney 1901). For example, among the Snowdrift Chipewyan, the entire community took only 14 moose in the summers of 1960 and 1961 (VanStone 1962). At Lynx Point, where moose are the primary source of protein (Helm 1961:32), only 17 moose were killed during a nine-month period between 1951 and 1952. In the recent past, it was often necessary for hunters to travel substantial distances in order to obtain moose meat (Arundale and Jones 1989), partially reflecting the low number of animals obtainable.

Sheep

Sheep hunting, common among many Athabascans with access to this particular resource, is understudied, or at least under reported in the ethnographic literature. Given the difficulties of procuring sheep, related to their general remoteness and limited utility compared with larger game, ethnographers typically suggest that the addition of sheep meat to the diet was mostly for dietary variety (McKennan 1959:34). Hunting sheep, typically occurring in the late summer and fall when the animals are in good condition, took two forms. The first was simple stalking with bow and arrow, and later rifles, and the second via snares; in either case the hunting party was small. As with moose and caribou, the Athabascans utilized their knowledge of sheep behavior to hunt the animal often approaching it from upslope or by spooking the animal toward an ambushed hunter conceal upslope from the animal. Little information concerning snaring is available, but McKennan (1959:34) notes it was a common hunting technique among the Upper Tanana Athabascans. On the other hand, Hadleigh-West (1965:141-142) notes that the Nesti Kutchin preferred stalking the animal. There is little information in the literature concerning storage of the meat, and although sometimes dried, it appears as if the animal was consumed in a relatively short period of time (Ellanna and Balluta 1992:160-161; cf. McClellan 2001:120). Besides the meat, the hide was used for various winter clothing articles, such as socks, mittens, coat liners, and blankets (Ellanna and Balluta 1992:160-161; Hadleigh-West 1965:141-142); horns were used to make highly prized spoons and similar implements.

Overall, the natural behavior and abundance of the Athabascan keystone species facilitate the need for dispersals and aggregations throughout the year, but they do not dictate it. During protohistoric and historic times, kinship, reciprocity, communication, storage, and mobility all act together to buffer any inconsistencies that may occur in wildlife patterns or the ability of the Athabascans to obtain them. The establishment of the fur trade, and the Athabascan participation in it, served to further buffer people from unpredictable resources by offering staples not obtainable from the bush. Today, wage labor, government programs, and education offer new means and modes of lifestyle, but subsistence is still an important part of the Athabascan culture. Thus, traditional patterns of subsistence, mobility, and organization continue to some degree despite acculturation, sedentism, and commercialization.

CHAPTER 3.

CONTEMPORARY LARGE MAMMAL HUNTING IN THE ALASKAN INTERIOR

Subsistence hunting forms the foundation of the rural Alaskan economy for both its indigenous and nonindigenous inhabitants. It is purely hunting and gathering antecedent spans nearly 12,000 years and constitutes the longest unbroken record of such activity in the U.S. Russian and American exploration, trade, and eventual settlement forever changed the hunting dynamic in the Alaskan Interior, but in many aspects hunting and gathering never deviated from its central position in the Native Alaskan economy. Despite its importance, acculturation, economics, changes in settlement systems, and other factors have appreciably altered the traditional hunting dynamic. Thanks mostly to the efforts of the Alaska Department of Fish and Game, modern subsistence practices are well documented. Early ethnographic fieldwork, likewise, resulted in many useful data pertaining to subsistence practices and patterns.

This chapter, consisting of two parts, presents an overview of the modern hunting practices of 21 interior Alaskan communities and then compares these practices with historically documented practices to arrive at an appreciation of the rate and amount of change that has occurred over the last 100 years. This comparison provides a useful frame of reference for understanding how hunting efforts have changed, in regard to effort and seasonality, in a relatively short period of time. Examining these two variables does not provide direct measures of how hunting land use practices may have changed during the same time. Indirectly, however, it provides a useful context for considering various effects on land use change.

Subsistence Studies and Hunting Ranges

Alaska Statute 16.05.940 (30), the first Alaska subsistence law that came into effect in 1978, defines subsistence as the. . .

> noncommercial, customary, and traditional uses of wild, renewable resources by a resident domiciled in a rural area of the state for the direct personal or family consumption as food, shelter, fuel, clothing, tools, transportation, for the making and selling of handicraft articles out of nonedible by-products of fish and wildlife resources taken for personal or family consumption, and for the customary trade, barter, or sharing for personal or family consumption.

The Alaska National Interest Lands Conservation Act (ANILCA), PL 96-480, signed into law in 1980, defines subsistence uses as the. . .

> customary and traditional uses by rural Alaska residents of wild renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.

Beyond the legal definitions of subsistence, the actual characterization of subsistence uses covers many interrelated segments of larger socioeconomic and sociospatial systems. According to Wolfe (2004:1), "subsistence uses are parts of localized traditions of wild food production, tied to specific places by ecology, community, and economy." After the state and federal subsistence laws were passed, the Alaska Department of Fish and Game (ADF&G), Division of Subsistence, in a statement to the ADF&G Boards of Fisheries and Game, characterized subsistence use as a continuum along nine interconnected trajectories including time depth, community base, social role, economic role, actual uses, range of uses, patterns of uses, variation in use level and pattern, and social and psychological products (ADF&G 1980:3-4). An implicit dimension, or a tenth trajectory, in the characterization of subsistence use revolves around the cultural and geographical distribution of rural towns through Alaska and the varying ecology of those areas.

Since 1978, the ADF&G has conducted numerous studies covering approximately 180 communities throughout Alaska (Wolfe 2004). While these cover a range of topics including food sharing (e.g. Langdon and Worl 1981; Wolfe et al. 2000), resource specific studies and comparisons (e.g. Anderson et al. 2004; Andrews 1986; Schroeder et al 1987; Wolfe and Ellanna 1983; Wolfe et al. 1990), and methodological, summary reports, and statements (e.g. Lonner 1980 & 1981; Ellanna et al. 1985), the vast majority of the technical reports published by the ADF&G include overviews and community profiles detailing the level and type of fish and wildlife resource use in relationship to social, economic, and traditional systems (Fall 1990). More often than not, there are detailed maps showing the areas used by a particular community to harvest fish, game, furbearers, edible plants, and firewood. While the actual methods of data collection vary slightly among studies, as does the scale of spatial data concerning hunting areas, the studies still contain comparable data. Besides the background information collected from census data, harvest permits, and the like, most of the subsistence studies relied on surveys, interviews, and participant observation as the main data collection devices (Fall 1990). While the survey interview data concerning harvest yields for fish and game were collected for a specific year, the spatial data detailing subsistence mapping of areas used for hunting or trapping particular species were often collected for a longer time period, sometimes at a generational scale.

Besides hunting regulations and permit restrictions, numerous other factors affect the interpretation of the subsistence data in regard to modeling late prehistoric resource procurement patterns. Many of the limitations concerning the data, which require that certain assumptions about the correlation between late prehistoric and modern hunting techniques and strategies, revolve around acculturation. While these assumptions are discussed in detail in the following chapters, a few examples will illustrate the profound changes that have occurred in subsistence strategies among the Athabascans of the Alaskan Interior just over the last 150 years. Beyond the acceptance of small, efficient technologies, such as small boats with outboard motors, snow machines, and rifles, harvest techniques have been altered as mixed economies became more prevalent through time. Two notable changes on the landscape have been the abandonment of both caribou corrals/fences and the abandonment of burning vegetation to spur new growth to attract moose.

Caribou enclosures were used occasionally into the 20th century (McKennan 1965: 31-32; Mishler and Simeone 2004:65; Slobodin 1962:21), though once firearms began making their way through the interior, even before actual traders step foot in the territory, the decline and eventual abandonment of enclosures, regardless of modern laws and regulations, was inevitable. As noted earlier, the pursuit of caribou, particularly during spring and fall migrations, required a relatively high mobility. The more a particular group depended on caribou, the more mobile that group was relative to other groups. With the loss of communal caribou drive, the practice of encounter hunting, which also has traditional, and probably prehistoric, antecedents, became the norm. Transportation and weapons technology allowed individuals and small groups of hunters to cover large areas of land in relatively short periods of time.

ADF&G studied over 180 rural Alaska communities; it is therefore necessary to determine a set of selection criteria in order obtain a sample of cases to use in the study. The criteria used include 1) location in the Alaska Interior, or ADF&G's Region 2 (Fall 1990: Figure 1); 2) any individual community had at least two nearby communities that were also studied and could be included here; 3) one of the neighbor communities serves as a hub (for comparison purposes); 4) the potential for harvesting at least two of the three major species (caribou, moose, and sheep) considered in this research; 5) adequate subsistence mapping data (data presented on USGS topographic quadrangles); 6) a predominately aboriginal population (except for the hub community); 7) subsistence data collected between 1980 and 1989; 8) the community could be tied to ethnographic and ethnohistoric literature relating to subsistence; and 9), the communities clusters must range across the Alaskan Interior and represent different interior Athabascan traditions occupying the major river basins in the Interior.

Based on these criteria, 21 communities are included in the analysis of modern subsistence-related land use. From the Upper Tanana region the sample includes Northway Village, Tetlin Village, Tok, Dot Lake, and Tanacross. From the Upper Koyukuk River area the sample includes Bettles/Evansville, Alatna/Allakaket, Hughes, and Huslia. Villages selected from the Middle Yukon region include Steven's Village, Beaver, Tanana, and Minto. The communities of Stony River Village, McGrath, Nikolai, and Telida, all occurring along the Kuskokwim River, serve as the westernmost sample. Finally, from the Upper Yukon and Porcupine River area, the villages included in the study include Arctic Village, Chalkyitsik, Fort Yukon, and Venetie. It should be noted that these groupings are primarily geographical and not cultural. While many of the groups consist of linguistically and socially related villages, both the Middle Yukon and Kuskokwim groups include villages whose inhabitants differ in language and cultural backgrounds.

The sample is not designed to be representative of subsistence practices throughout the interior. Instead, it explicitly contains a high degree of variability. Below is a brief description of each village considered in this study, with respect to location, demography, contemporary subsistence cycle, and land use area, and an overview of the physical geography of the associated regions. For detailed descriptions of each study, the reader is directed to the individual subsistence reports and other cited literature

Upper Tanana

As defined here, the Upper Tanana area consists of approximately 28,800 square kilometers bordered on the north by the Johnson River, on the south by Nutzotin Mountains, on the west by the Alaska Range, and on the east by the Fortymile River drainage. This area coincides with four major physiographic sections (Wahrhaftig 1965) including the Northway-Tanana Lowlands, the Northern Foothills, the Yukon-Tanana Uplands, and the central and east parts of the Alaska Range. The five Upper Tanana communities included here occur within the

Northway-Tanana Lowlands. The Northway –Tanana Lowlands include three distinct, and nearly level, basins separated by low hills, such as the Tetlin Hills and the Black Hills. Elevations in the section range between 510 meters in the low-lying areas to 950 meters in the hills dividing the three basins. The Northern Foothills of the Alaska Range are substantially higher than the Northway-Tanana Lowlands, with elevations ranging from 760 to 1370 meters above sea level. Topographically the Northern Foothills consist of broad (5-11 km) ridges trending east from the Alaska Range for distances up to 35 km (Wahrhaftig 1965:35). Immediately adjacent to and east of both the Northern Foothills and Northway-Tanana Lowland sections is the central and eastern portion of the Alaska Range physiographic section. The section averages in elevation from 1830 to over 2900 meters, though the range is dotted with extremely high peaks, including Mt. McKinley, which tops out at 6,178 meters above sea level. Of particular importance to the inhabitants of the Upper Tanana region are the Mentasta and Nutzotin Mountains, which form the easternmost portion of the Alaska Range (Wahrhaftig 1965:35); these ranges contain not only sheep but are the home of Chisana caribou herd. Finally, to the west of the Upper Tanana basin lays the Yukon-Tanana Uplands, an immense area that stretches from Cosna, Alaska in the west to Boundary, Alaska in the east. Wahrhaftig (1965:24) describes the section as similar to that of the Klondike Plateau in the Yukon Territory, consisting of rounded ridges, relatively gentle slopes, and undulating divides. Elevations range between 450 meters in the valleys to over 1500 meters on the higher ridges and low, rugged mountains.

Most of the drainage throughout the Upper Tanana region is through the Tanana River via its major tributaries including the Nabesna, Chisana, Tok, Robertson, and Johnson rivers. While waters from most of the eastern Alaska Range and Northern Foothills drain into the Tanana River, much of the central Alaska Range water flows into other, unconnected drainages. Likewise, much of the Yukon-Tanana Uplands east of the Upper Tanana basin drain northeast towards the Yukon River. The surface hydrology of the Upper Tanana Basin consists of numerous lakes and ponds, most formed through glacial and alluvial processes. The area surrounding Tetlin and Northway villages consists of a large wetlands comprised of numerous lakes, ponds, and sloughs covering roughly 1,600 square kilometers. Small lakes and ponds occur throughout the outwash plain near the interface of the Alaska Range and Northway-Tanana Lowland sections.

Wildlife in the basin and adjacent regions is similar to other areas within close proximity to the Alaska Range. Caribou and moose have a relatively wide distribution throughout the basin, though caribou tend not to frequent the Tanana River bottoms north of Tok. Caribou winter ranges are found in the Yukon-Tanana Uplands along the Fortymile River and its tributaries. In the Alaska Range, caribou wintering grounds are in the vicinity of Mentasta and Nutzotin Mountains. During the summer, caribou are commonly found in the lower elevations between Chicken, Alaska, and the Yukon River. Moose occur throughout the region with winter, spring, and summer ranges scattered throughout the Upper Tanana Basin. Dall's sheep occur discontinuously in the eastern Alaska Range, with large concentrations found throughout the Mentasta and Nutzotin Mountains. Brown and black bear are common in and around the basin. Furbearers, including red fox, wolverine, marten, and beaver, also have a wide distribution. Native fish to the region include several species of whitefish, longnose suckers, grayling, lake trout, and northern pike. Salmon do not typically occur in the waters of the Upper Tanana River and its tributaries, though several species ascend the Copper River to the west. Birdlife is plentiful and includes a variety of passerines, raptors, waterfowl, and game birds. Spruce grouse and willow ptarmigan are common year round residents.

Only two major ethnographies are available for the Upper Tanana region (Guedon 1974; McKennan 1959); however, McKennan does address the social and spatial organization of the Upper Tanana Athabascans in several other publications (McKennan 1969a & b). Other specific work includes research on hunting practices (Vitt 1971) and settlement patterns and house types (Pitt 1972). More recently, Norman Easton, from the Yukon College, has been conducting ethnohistoric research within the basin focusing on the Scottie Creek and Chisana drainages (Easton, personal communication).

McKennan (1959:17-19) defines the Upper Tanana cultural area as that region occupied by five bands including the Upper Chisana-Upper Nabesna, Last Tetlin, Tetlin, Lower Nabesna, and Scottie Creek bands. The area occupied by these bands extends from the headwaters of the Fortymile and LaDue Rivers in the north to the White River in the south, and from west to east the territory extends from the Suslota Pass to the confluence of Beaver and Snag Creeks. Guedon (1974:19-23) extends the Upper Tanana cultural area to include other Tanana River villages as far north as Dot Lake, and including Tok and Tanacross. Even larger groupings are possible (Guedon 1974:22).

During McKennan's fieldwork among the Upper Tanana Athabascans in 1929, he stated that the subsistence practices he observed varied little from those practiced during the 19th century and possibly earlier (McKennan 1959:46). Utilizing the seasonal variation of resources, the

Upper Tanana Athabascans lead a 'nomadic' existence and relied heavily on caribou, moose, whitefish, and small game. The primary difference, as observed by McKennan, between aboriginal accounts of subsistence in the remote ethnohistoric past and that observed directly during the first quarter of the 20th century was the commercial wintertime trapping in addition to subsistence hunting.

None of the ethnographic literature on the Upper Tanana Athabascans gives much detail on the areas exploited by individual family groups over the course of a given year, but several inferences, based on the annual subsistence cycle can be made. Communal fishing and caribou hunting, utilizing fences and surrounds, required the use of semi-permanent villages or extended camps. Fishing camps were typically found around larger lakes in the lower elevations of the region and not directly on the Tanana River itself. These villages often consisted of several semi-subterranean houses, caches, and storage pits (Guedon 1974; Pitt 1972). Fish, fowl, and caribou resources at Last Tetlin were so abundant, that the village location could be occupied on a nearly permanent basis (McKennan 1959:35).

During the spring and fall, most families were nomadic exploiting the countryside for moose, sheep, small game, fish, and edible plants. The acquisition of small game and plants appear to be a secondary subsistence focus relative to group efforts aimed at large game hunting and fishing. Sheep hunting, by necessity, took place in the higher elevations of the Nutzotin and Mentasta ranges, while moose hunting occurred in lower elevations where lakes and forage are more hospitable to moose. The camps occupied during the resource-focused wanderings of the people typically consisted of moose-hide tents and brush lean-tos capable of housing two families (Guedon 1974; Pitt 1972). Traditional subsistence rounds are presented below, as comparisons with the modern subsistence practices for each study village (Table 3.1).

Dot Lake

Dot Lake is an Upper Tanana Athabascan village (cf. Guedon 1974; McKennan 1959) located adjacent to Tanana River between the Johnson and Roberts Rivers 80 km east of Delta Junction (Figure 3.1). Gayle Martin (1983) conducted subsistence research at Dot Lake in 1981 and 1982. During this study the village consisted of approximately 50 individuals living in 15 households.

The contemporary annual cycle for the inhabitants of Dot Lake is not identical to the traditional annual cycle due to several factors including acculturation and hunting regulations.

However, despite apparent differences, many aspects of the seasonal subsistence activities remain similar (Martin 1983). A comparison of the contemporary annual round and generalized historic Upper Tanana annual cycle is presented in Table 3.1. For the most part, large and small game hunting takes place in the fall. In the past, moose were taken primarily during the late summer and early fall, and occasionally through the winter, but hunting restrictions, at least in 1982, limited the season to a short period at the beginning of September. Caribou hunting seasons and hunting areas, too, are shortened or restricted by hunting regulations. Like other Upper Tanana Athabascans, the residents of Dot Lake historically depended on the seasonal migrations of caribou (Martin 1983:44; McKennan 1959:32). Sheep and black bear are taken primarily taken in August and into September. Smaller game, such as game fowl, ground squirrel, and porcupine are typically hunted during the late fall and early winter and occasionally in the late winter. Fishing, mostly for whitefish, occurs throughout the year, with ice fishing important during the late winter and early spring. As depicted in the use area maps (Martin 1983:Maps 1-4), the majority of the area utilized for subsistence activities by the inhabitants of Dot Lake follows the course of the Tanana River between the Gerstle and Robertson Rivers. The Sand Creek, George Creek, Macomb Plateau and Bear Creek areas offered access into locations away from the floodplain. A detailed map of the Dot Lake resource use area is presented in Figure 3.1.

Tanacross

Tanacross, a contraction of Tanana Crossing, is a small community of fewer than 100 people located approximately 19 km northwest of Tok, Alaska. Permanently established in the early 1930s, the native inhabitants of Tanacross traditionally occupied Lake Mansfield and the surrounding area. The subsistence study conducted by Marcotte (1992) during 1987 and 1988 included a sample of 20 of the 28 households in the community.

The annual subsistence cycle for Tanacross is similar to other nearby communities (Table 3.1). Fishing for whitefish and other species typically occurs at the height of summer, but can occur throughout the summer, fall, and winter. Only arctic graying is fished in the spring. Large mammals, including moose, caribou, and sheep are taken in the fall, primarily in August and

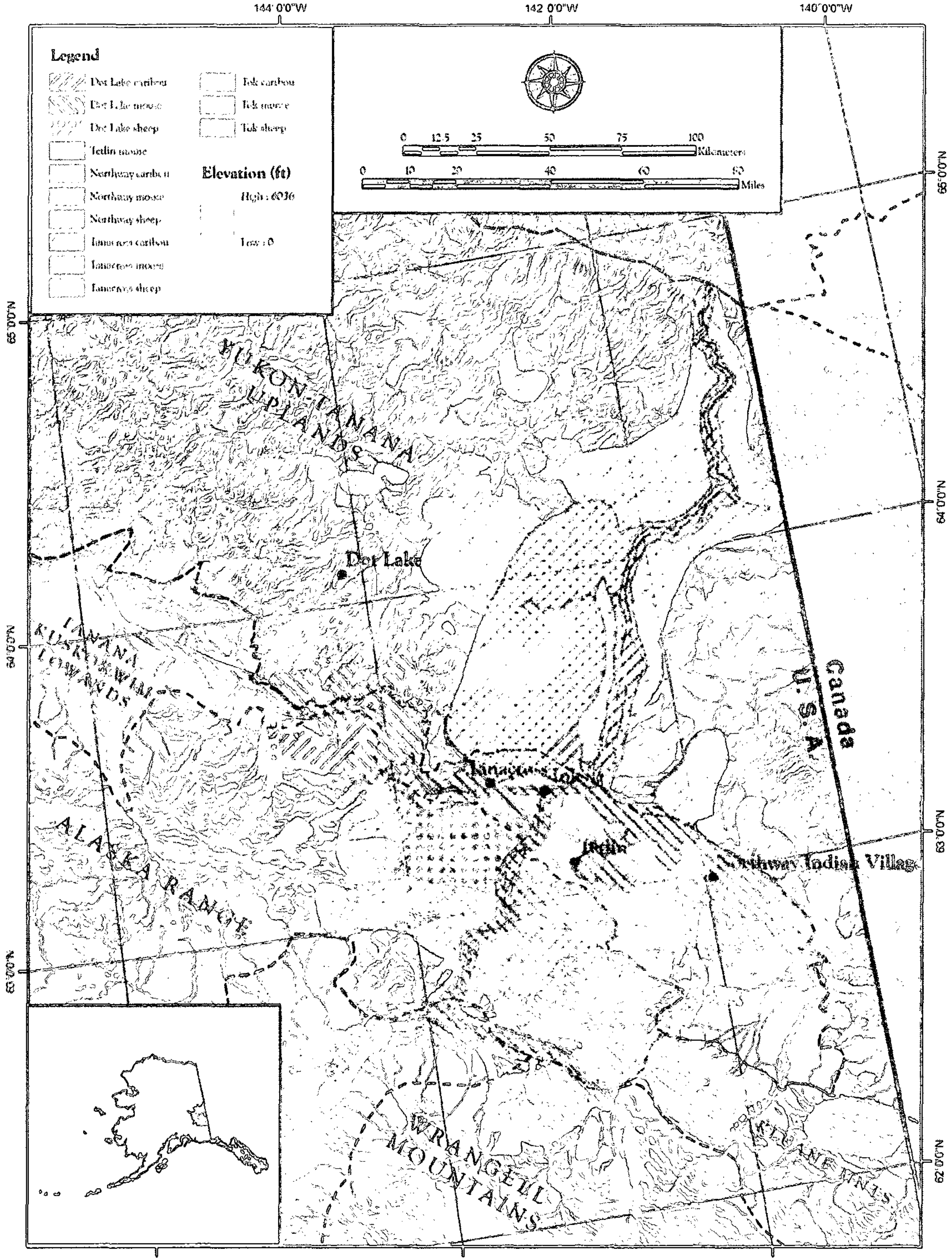


Figure 3.1. Upper Tanana Study Communities, Hunting Ranges, and Physiographic Regions. Hunting Range Data from Martin 1983; Marcotte 1992; Halpin 1987, Case 1986.

Table 3.1. Contemporary and Historical Subsistence Cycles for the Upper Tanana Region (Black=Intensive Hunting; Grey=Occasional Hunting; White=No Hunting)

Resource	Community	January	February	March	April	May	June	July	August	September	October	November	December
Caribou	Dot Lake	■	■						■	■		■	
	Tanacross								■	■			
	Tok		■						■	■		■	■
	Tetlin												
	Northway	■	■										■
	Traditional				■	■	■				■	■	■
Moose	Dot Lake									■			
	Tanacross	■					■	■		■			
	Tok								■	■			
	Tetlin	■	■	■				■	■	■	■	■	■
	Northway									■			
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Sheep	Dot Lake								■	■			
	Tanacross									■			
	Tok								■	■			
	Tetlin												
	Northway												
	Traditional								■	■			
Bear	Dot Lake								■	■			
	Tanacross						■	■	■	■			
	Tok				■	■	■	■	■	■			
	Tetlin												
	Northway	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional												
Small Game	Dot Lake	■	■	■	■	■				■	■	■	■
	Tanacross	■	■	■			■	■	■	■	■	■	■
	Tok	■	■	■	■	■	■	■	■	■	■	■	■
	Tetlin	■	■	■	■	■	■	■	■	■	■	■	■
	Northway	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Fish	Dot Lake				■	■	■	■	■	■	■	■	■
	Tanacross				■	■	■	■	■	■	■	■	■
	Tok		■	■	■	■	■	■	■	■	■	■	■
	Tetlin												
	Northway	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional						■	■	■		■	■	
Fowl	Dot Lake	■	■	■						■	■	■	■
	Tanacross	■			■	■	■	■	■	■	■	■	■
	Tok	■	■						■	■	■	■	■
	Tetlin	■		■		■	■	■	■	■	■	■	■
	Northway	■	■	■					■	■	■	■	■
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Roots/Berries	Dot Lake				■	■	■	■	■	■			■
	Tanacross	■	■	■	■	■	■	■	■	■	■	■	■
	Tok	■	■	■	■	■	■	■	■	■	■	■	■
	Tetlin		■	■	■	■	■	■	■	■	■	■	

September; although brown and black bears are hunted throughout the summer and fall. Residents of Tanacross harvest small mammals, such as hare, and fowl throughout most of the year. Like Dot Lake, resource use has changed from traditional patterns in many significant ways.

In regard to harvest areas, the inhabitants of Tanacross utilize a diverse area (Figure 3.1). Moose hunting typically occurs along the Alaska and Taylor Highway corridors, but also in the Mosquito Flats area that extends from Tanacross to Chicken, Alaska. This latter moose hunting area closely parallels the area used to harvest caribou. Sheep hunting occurs in the foothills of the Alaska Range between the Glenn Highway on the south and the Robertson River in the north.

Tok

Tok, the largest community and regional hub of the Upper Tanana region, had in the 1980s a population of just over 1,000, of which only 11% was Alaskan Native (Marcotte 1992:100). The modern subsistence cycle for the residents of Tok is similar to other nearby communities (Table 3.1). Common subsistence harvests include fish, large and small game, game birds, and furbearers. Fishing occurs primarily during the summer and fall, and less occasionally in the earlier winter. Caribou, moose, and sheep hunting most commonly occur in the fall, though early winter caribou hunts also occur. Brown and black bears are hunted through the spring, summer, and fall. Game birds and waterfowl hunting takes place in late fall and, in the case of ptarmigan, early winter.

The hunting, fishing, and trapping areas reported by the subsistence study participants are extensive compared with the other Upper Tanana communities and in many instances overlap with the hunting areas often used by people in Tanacross, Tetlin, Dot Lake and Northway (Figure 3.1). Caribou and moose hunting areas typically overlap to a great extent. The areas commonly used by the residents of Tok for hunting moose include the area between Lake George and the Alaska-Yukon border, and from Tanada Lake to the Yukon River. Caribou are hunted over a slightly smaller area than are moose; typically this occurs in the Mentasta Mountains south and west of Tok, and throughout the greater Fortymile River drainage between Tetlin and the Yukon River. Sheep hunting areas are also large and widespread throughout the Nutzotin and Mentasta Mountains.

Tetlin

Tetlin Village is in the Upper Tanana Basin situated between Tetlin Lake and the Tanana River about 32 km southeast of Tok, Alaska. Of the major Athabascan communities in the Upper Tanana Basin, Tetlin is one of the better-ethnographically documented (Guedon 1974, Halpin 1987; McKennan 1959). At the time of the subsistence study, Tetlin consisted of 107 residents in 28 households (Halpin 1987:14-15).

The contemporary annual cycle of the Tetlin Athabascans is considerably different than the historical cycles described by McKennan (1959) and Guedon (1974). The most notable difference in the modern cycle is a near total reliance on moose as the large game resource. Moose are most intensively hunted during August and September and sporadically through the fall, winter, and very early spring. Traditionally, caribou were taken primarily in the fall and winter (Guedon 1974), but the absence of caribou in recent times severely limits the number taken. For example, during Halpin's (1987:31) Tetlin subsistence study, conducted between 1983 and 1984, no caribou were harvested by village residents. Sheep hunting in recent times has declined to the point where few even make the attempt (Halpin 1987:36). In the recent past, sheep were generally hunted in the Nutzotin and Mentasta Mountains during the late summer and early fall. Small game hunting, particularly for hares, occurred year round, though most porcupine hunting occurred during August. Waterfowl are taken when seasonally abundant, and game birds are typically harvested in the fall and winter. Fishing is most commonly a summer activity and great quantities of whitefish are taken during the summer. Burbot fishing typically occurs during the early winter. Tetlin Villagers collect edible roots in the spring and fall, whereas the seasonal availability of berries limits collection to the fall.

Northway

Northway Village sits just off the Alaska Highway on the south banks of the Nabesna River, and between Tetlin Junction and the US-Canadian border; it represents the farthest south permanent settlement in the Upper Tanana Basin in Alaska. The Tetlin National Wildlife Refuge, which lies west of the Alaska Highway between the border and Tetlin Lake, surrounds the village and covers much of the traditional hunting and historic trapping areas utilized by the native Northway populace. In the early 1980s Northway village, and its adjacent areas, contained 88 households, 15 of which participated in the subsistence study (Case 1986).

Historically (1920-1960), the annual cycle of subsistence activities carried out by occupants of Northway Village was similar to those of other Upper Tanana Athabascans (Case 1986:25). Intensive fishing, primarily for whitefish, occurred in June and again between August and October. Dip nets, conical traps, and weirs were commonly used methods until gill nets began to be used in the 1950s (Case 1986:26). During the early fall, hunting for small game and fowl, and collecting berries and edible roots were commonly interspersed with fishing. Hunting parties often went for moose in the early to middle fall. Hunting of sheep and caribou occurred after moose hunting; sheep hunting took place before the end of September or beginning of October when the first snows fell in the higher elevations (Case 1986:28; McKennan 1959). Relative to modern conditions, caribou played a more vital role in the subsistence practices at Northway (McKennan 1959:32). Trapping occurred throughout the winter, as did encounter hunting of caribou. In the spring (April-June), caribou hunting, egg collecting and waterfowl hunting, some ice fishing, and occasionally moose hunting, rounded out the subsistence year. As is apparent in Table 3.1, this pattern is similar to the one recorded during 1983-1984 by Case (1986), though in the contemporary pattern there is much more winter fishing.

Upper Koyukon

Relative to the Upper Tanana region, the Upper Koyukuk region is much more physiographically complex consisting of eight different physiographic sections completely or partially exploited for resource procurement by the inhabitants of Bettles/Evansville, Alatna/Allakaket, Hughes, and Huslia. The sections include the Kanuti Flats, the Central and Eastern Brooks Range, the Ambler-Chandalar Ridge and Lowland section, the Koyukuk Flats, the Pah River section, and the Indian Uplands (Figure 3.2).

From north to south, the Eastern and Central Brooks Range section consists of craggy, glaciated mountain ridges reaching upwards of 1830 meters above sea level (ASL) in the vicinity Bettles and Alatna (Wahrhaftig 1965:21). Intervening valley bottoms are considerably lower, attaining elevations of no more than 305 meters ASL. Immediately south of the Brooks Range is the Ambler-Chandalar Ridge and Lowland section characterized by several east-west trending ridges, ranging between 8 to 16 kilometers in width and 40 to 120 km long, flanked on either side by lowlands (Wahrhaftig 1965:22). Elevations of the middle ridges are between 915 and 1370 meters ASL, with the surrounding lowlands attaining elevations between 60 and 610 meters ASL. To the south and at the far east edge of the Koyukuk exploited area is the Kanuti Flat section. It

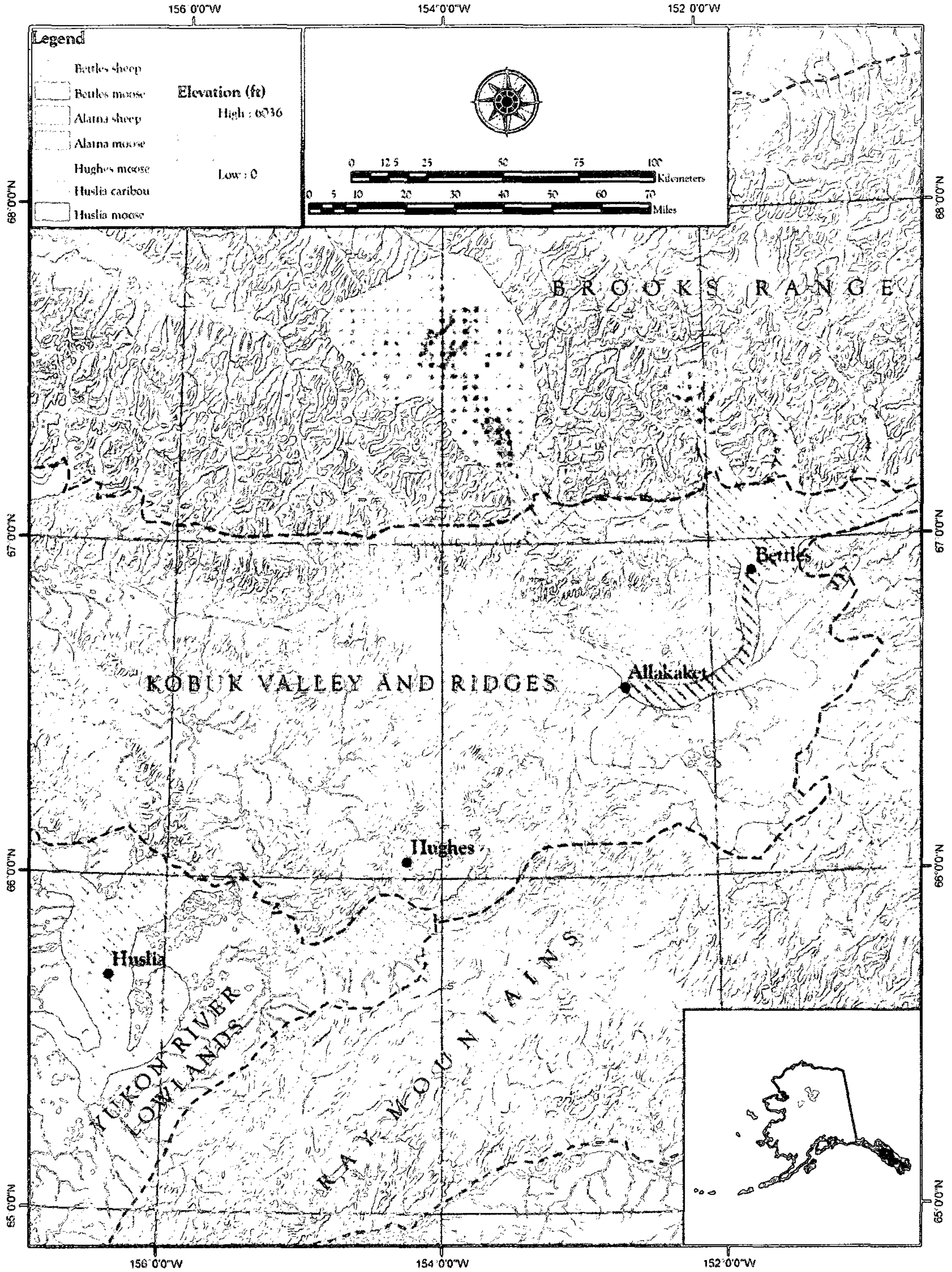


Figure 3.2. Koyukon Study Communities, Hunting Ranges, and Physiographic Regions. Hunting Range Data from Marcotte 1986; Marcotte and Haynes 1985.

consists of a relatively level plain, with a slight western aspect, crossed by both the Koyukuk and Kanuti Rivers (Wahrhaftig 1965:26). Elevations range between 120 feet to 305 meters ASL on the few isolated hills that occur throughout the flats. Numerous lakes and meanders typify the section, as they do other lowland areas through the state. To the west of the Kanuti Flats is the Indian River Uplands consisting of low, rounded ridges averaging 460 to 610 meters ASL (Wahrhaftig 1965:26). A few larger mountains occur within the section including Indian Mountain, which tops at 1290 meters ASL. The Pah River section is topographically diverse and includes low plateaus topped by low mountains rising to 1220 meters ASL. Between the plateaus are wide, 8-16 km across, flats or lowlands (Wahrhaftig 1965:27). Finally, the south of the Pah River section lies the Koyukuk Flats, which Wahrhaftig (1965:27) characterizes as an "extensive lowland . . . at the junction of the Yukon and Koyukuk Rivers . . . [that consist of] plains 8-32 km wide along the major rivers."

Drainage of the entire Upper Koyukuk region is generally to the southwest via the Koyukuk River. Besides the Koyukuk River, major drainages include, from north to south, the Alatna, John, Kanuti, Huslia, Kateel, and Gisana Rivers. Many of the lowland areas, in particular the Kanuti and Koyukuk Flats, contain numerous lakes, which in some areas cover over 50% of the surface (Wahrhaftig 1965:26). Numerous small thaw lakes and larger, moraine-dammed lakes occur throughout the entire region.

The Koyukuk study area contains many of the same types of terrestrial wildlife as many other areas in the Alaskan Interior. Large mammals include caribou, moose, and, very rarely, muskoxen. Dall's sheep are well distributed throughout the Brooks Range, but devoid in roughly 90% of the study area. Moose occur throughout the Koyukuk region with the exception of the higher elevations in the Brooks Range, though they are often found in the large drainages along the southern flanks of the range. There are considerable seasonal changes in moose distributions with concentrations along the river and its major tributaries in the winter and in the Kanuti Flats during the rest of the year. Caribou are widely distributed through the region in the winter, but mostly absent the rest of the year.

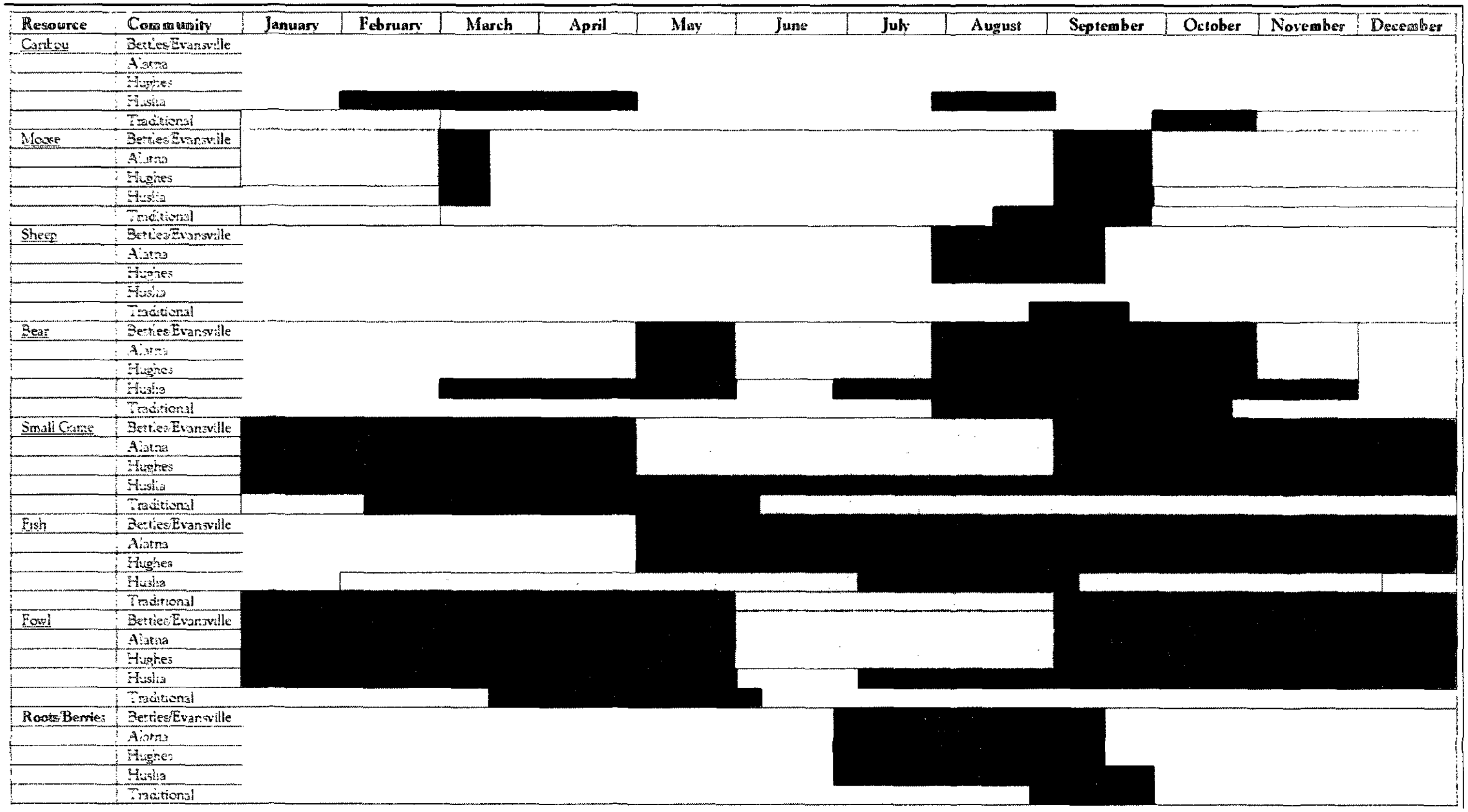
Major ethnographic research among the Koyukuk Indians includes work primarily by McFayden-Clark (1974, 1975), though other substantial efforts include unpublished work by Robert McKennan (see Mishler and Simeone 2004), Richard Nelson and others (1982) William Loyens (1966). McFayden-Clark (1975:152-154) defines four primary Koyukuk-speaking Athabascan bands including, from west to east, the Yukon-Kateel, the Huslia-Dalbi-Hogatza, the

Todadonten-Kanuti, and the South Fork bands; each band being named after the area each exploits. The study villages in this study include at least one village from each of these four traditional territories.

While band territories are identified, there are few ethnographic data concerning the spatial land use practices of the Koyukuk Athabascans, beyond description of generalized settlement patterns and subsistence rounds. More recent work by Arundale and Jones (1989) attempts to remedy this particular shortcoming through the use of ethnohistory and ethnoarchaeology, wherein numerous life histories in a diachronic perspective to examine change in land, in a roundabout manner tested the collected data against Binford's (1980) forager-collector model. In general, seasonal movements decreased in duration and distance with the progression of time and acculturation. By the late 1950s, with the establishment of permanent schools, most Koyukuk Indians became semi-permanent residents of the modern villages and reorganized subsistence efforts along a more logistical phase of the forager-collector continuum. Not entirely commensurate with McKennan's (1959:46) statement concerning the state of subsistence practices, the Koyukuk Athabascan data, suggests that subsistence practices do change substantially more slowly than in other arenas of culture.

McFayden-Clark (1974:92-94) reconstructs the traditional subsistence cycle for the Koyukon Athabascans from informant accounts. During the summer fishing is the primary activity focused on runs of various salmon species. Secondary activities included moose and small game hunting and subsidiary activities related to fishing and resource processing (e.g. net mending, drying fish and moose meat, etc). Mobility, except for trading expeditions and short hunts, was relatively limited. In the fall, after late summer berry picking and the last of the big salmon runs, families moved away from the main rivers to various lakes where freshwater fish species could readily be obtained. Caribou, and occasional moose, sheep, and bear, hunting often took place in the fall, with stores of the meat being cached for winter consumption. Winter witnessed little subsistence activity, with the people living off stores, trapping small game, and some ice fishing. Winter activities tended to be more social than economic, though trading commonly occurred among the Koyukuk Athabascans and their Eskimo neighbors to the north (Nunamiut) and west (Kobuk). Spring subsistence activities included lake fishing, waterfowl hunting, and occasional moose hunting. As the season progressed, people moved back to their fish camps to prepare for the upcoming salmon harvests. The annual subsistence cycle, as it pertains to the acquisition of these and other various resources, is presented in Table 3.2.

Table 3.2. Contemporary and Historical Subsistence Cycles for the Koyukon River Region (Black=Intensive Hunting; Grey=Occasional Hunting; White=No Hunting)



Resource	Community	January	February	March	April	May	June	July	August	September	October	November	December
Caribou	Bettles/Evansville												
	Alatna												
	Hughes												
	Huslia		■	■	■				■				
	Traditional										■		
Moose	Bettles/Evansville			■						■			
	Alatna			■						■			
	Hughes			■						■			
	Huslia			■						■			
	Traditional								■	■			
Sheep	Bettles/Evansville								■	■			
	Alatna								■	■			
	Hughes								■	■			
	Huslia												
	Traditional								■	■			
Bear	Bettles/Evansville					■			■	■	■		
	Alatna					■			■	■	■		
	Hughes					■			■	■	■		
	Huslia			■	■	■		■	■	■	■	■	
	Traditional								■	■	■		
Small Game	Bettles/Evansville	■	■	■	■					■	■	■	■
	Alatna	■	■	■	■					■	■	■	■
	Hughes	■	■	■	■					■	■	■	■
	Huslia	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional		■	■	■	■							
Fish	Bettles/Evansville					■	■	■	■	■	■	■	■
	Alatna					■	■	■	■	■	■	■	■
	Hughes					■	■	■	■	■	■	■	■
	Huslia							■	■				
	Traditional	■	■	■	■	■				■	■	■	■
Fowl	Bettles/Evansville	■	■	■	■	■				■	■	■	■
	Alatna	■	■	■	■	■				■	■	■	■
	Hughes	■	■	■	■	■				■	■	■	■
	Huslia	■	■	■	■	■		■	■	■	■	■	■
	Traditional			■	■	■							
Roots/Berries	Bettles/Evansville							■	■	■			
	Alatna							■	■	■			
	Hughes							■	■	■			
	Huslia							■	■	■			
	Traditional								■	■			

Bettles/Evansville

Bettles, a small native town on the south bank of Koyukuk River, is approximately 290 km northwest of Fairbanks. Initially established after 1945 when the U.S. Navy built an airfield, the population of Bettles is predominately non-native. Relocating from Old Bettles during the construction and subsequent operation of the Navy airfield, the Athabascans established a new town site near the north end of the airfield (Marcotte and Haynes 1985:19); this town is known as Evansville.

Though the Bettles-Evansville is the newest of the Koyukon villages, and the Athabascan population of Evansville is generally the least traditional of the Koyukon Indians (McFayden-Clark 1974), the historical Koyukon presence in the area is well documented and the modern resource exploitation area incorporates the settlement of Old Bettles. The entire resource area for Bettles and Evansville covers 5100 square kilometers of mostly contiguous land area. The area extends along the Koyukuk River from the villages of Alatna and Allakaket to the south fork of the Koyukuk River, where the area widens substantially. At its greatest width the resource area extends from the Dalton Highway in the east to Iniakuk Lake in the west. Where the resource area penetrates into the Brooks Range, it tends to follow the major drainages of the Alatna, John, Wild, and North Fork of the Koyukuk Rivers (Figure 3.2). Though large, the use areas determined during the DWR subsistence study are underrepresented primarily due to limitations imposed by study participation and the common use of small planes to access remote areas (Marcotte and Haynes 1985:10).

Marcotte and Haynes (1985) recorded the annual subsistence rounds for the communities of Bettles/Evansville, Alatna/Allakaket, and Hughes for 1982. They represent an annual round that is an amalgamation of the activities of all five communities. Hunting small game, particularly hare, occurs through the winter, fall and spring, and occasionally throughout the summer. Waterfowl are seasonally abundant and collected in the spring and fall. Moose hunting occurs occasionally throughout the long winter, but the animals are most intensively hunted during the late summer, early fall and early spring. Likewise, sheep are taken in the late summer. Historically, caribou were hunted during fall and spring during migrations (McFayden-Clark 1974), but no caribou were harvested during the period of the 1982-83 subsistence study (Marcotte and Haynes 1985).

Alatna/Allakaket

Alatna and Allakaket are two villages immediately across the Koyukuk River from one another: Alatna is an Athabascan settlement and Allakaket is primarily inhabited by Kobuk Eskimos (Marcotte and Haynes 1985). The two villages are 105 km west-southwest of Hughes, Alaska and 330 km west of Fairbanks, Alaska (Figure 3.2). At the time of the subsistence study, the population of both towns consisted of 152 people in 22 households (Marcotte and Haynes 1985:17).

The Alatna/Allakaket resource area stretches 124 kilometer west to east from Norutak Lake to Kaldolyeit Lake. North to south, it covers the area between the Alatna Hills and Sushgetit Hills. A second portion, primarily utilized for sheep hunting, occurs in the Endicotte Mountains of the Brooks Range. The two large resource areas are connected by Alatna River, which is utilized for moose hunting. The seasonal round described for these villages is identical to Bettles/Evansville.

Hughes

The Hughes subsistence range includes the area south of the Norutak Hills, north of the Hoohandochta Mountains, east of Winthrop Point on the Koyukuk River and west of Macaroni Creek. This area crosses three physiographic sections including the Pah River, Indian Uplands and Koyukuk Flats. Most of the subsistence range is utilized for trapping. Moose hunting is restricted to the Koyukon River corridor north and south of the village and the portion of the Koyukon Flats between Indian Mountain and Hochandochtla Mountain.

Huslia

Huslia is a Koyukon Athabascan village located on the Koyukuk River approximately 115 km north of Ruby, Alaska and 305 km southeast of Kotzebue, Alaska. Preceded by the nearby village of Cutoff, which suffered severe flooding in the 1950s, the village of Huslia was established in the early 1950s (Marcotte 1986:13).

The modern subsistence range of Huslia inhabitants extends from the Selwik River in the north to the Nikolai Slough in the south. From east to west, the area ranges from Melozitna River to near the headwaters of the north fork of the Huslia River. The modern subsistence cycle is similar to other Koyukon River inhabitants and revolves around fishing and large game hunting.

Fishing occurs mainly between May and December. A variety of salmon are harvested during the summer and early fall. While salmon fishing, particularly for chum salmon, is important, white fish makeup a substantial portion of the yearly fish harvest (Marcotte 1986:26). Large game hunting, limited to moose, caribou and black bear, occurs in the early spring and early fall (Table 3.2). Game fowl are taken primarily in the winter and waterfowl when seasonally available in the late spring and early fall. Small game is taken year round, with hare and muskrat the most important. The subsistence cycle approximates the historical season round with the most notable differences in the timing of moose and caribou hunting (cf. McFayden-Clark 1974; Marcotte 1986; see also Table 3.2).

Lower Tanana and Middle Yukon

The four villages near the confluence of the Tanana and Yukon rivers used here are widely scattered relative to those in the other study areas. The inhabitants of the area are of three distinct Athabascan traditions including, from west to east the Tanana (Tanana and Minto), the Koyukuk (Steven's Village), and the Kutchin (Beaver).

Physiographically, the Lower Tanana-Middle Yukon study area includes seven distinct sections: the Kokrine-Hodzana Uplands, the Kanuti Flats, the Nowitna Lowlands, the Kuskokwim Mountains, the Kuskokwim-Tanana Lowlands, the Yukon Flats, and the Yukon-Tanana Uplands (Figure 3.3). Given the intermediary position of the study area it is not surprising that many of these physiographic sections co-occur in the hunting ranges of the surrounding study areas, even if different portions of the sections are exploited. In fact, only the Nowitna Lowlands section is unique to the study area. The Nowitna Lowlands, located west of the Yukon-Tanana confluence, consist of a wide lowland area separating the Kuskokwim Mountains and the Kokrine-Hodzana Uplands, through which the Yukon River continues westward toward the Bering Sea. Elevations in the shallow valley range between 75 and 275 meters ASL, with topographic relief not exceeding 75 vertical meters relative to the surrounding area. Brief descriptions of the remaining physiographic sections are included in the Upper Koyukuk, Upper Yukon-Porcupine, Kuskokwim, and Upper Tanana study areas.

Numerous creeks and rivers flow through the region, ultimately adding their flow to the Yukon directly, or through one of its major tributaries including the Tanana, Melozitna, Nowitna, and Tozitna Rivers. Portions of the region, particularly the western portion of the Yukon Flats,

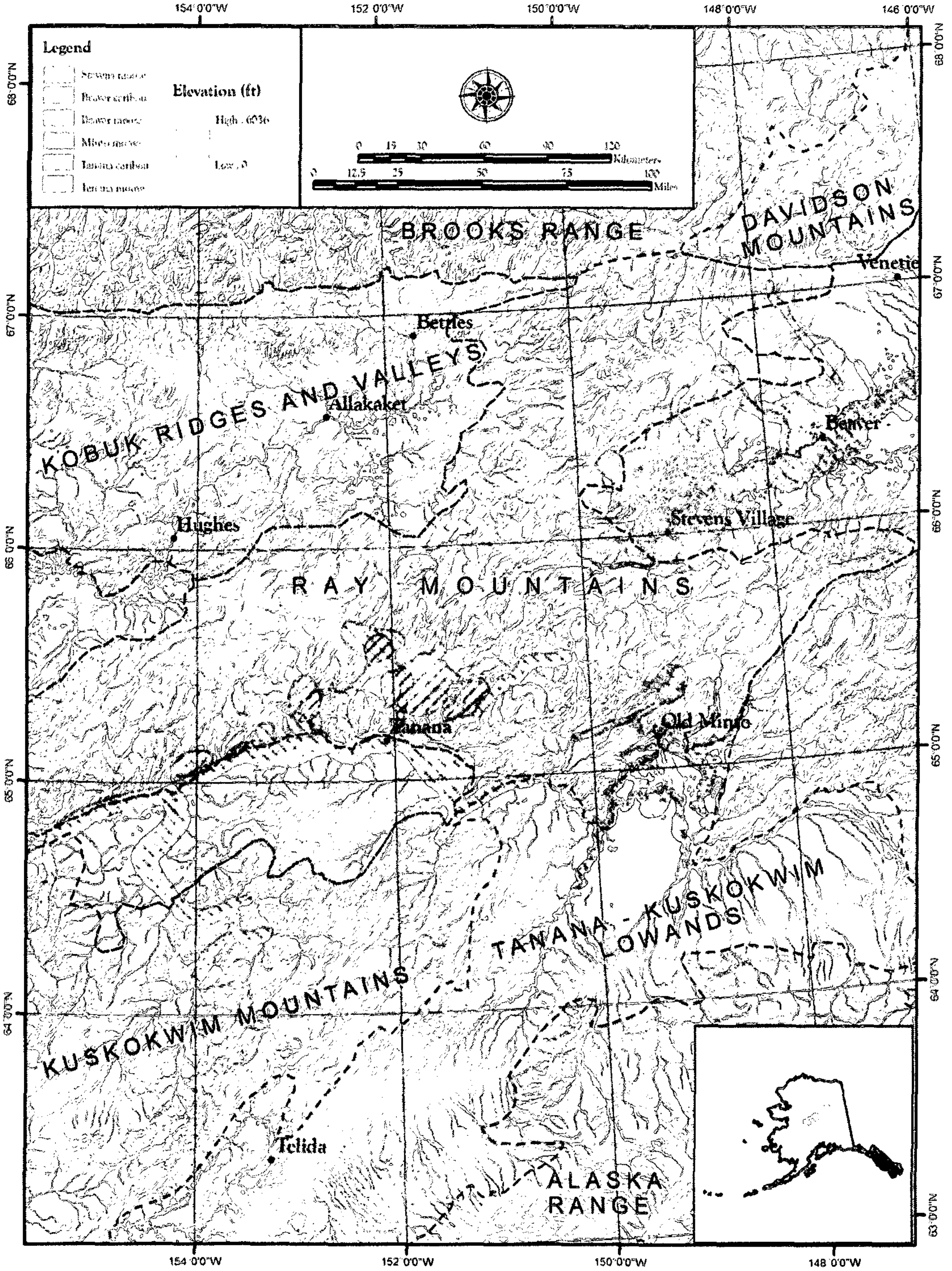


Figure 3.3. Middle Yukon Study Communities, Hunting Ranges, and Physiographic Regions. Hunting Range Data from Andrews 1986; Case and Halpin 1990; Sumida 1989.

Minto Flats, and the lowlands of the Nowitna River, include numerous lakes, ponds, and oxbow lakes that in places represent more than 70% of the surface.

In general, caribou are scarce in the region; they are almost absent from large parts of the Yukon Flats, Minto Flats, Nowitna Lowlands, and the eastern portion of the Kuskokwim-Tanana Lowlands. They do occur in the upland areas on both sides of the Yukon River. Only the villages of Beaver and Tanana were recorded as having pursued caribou in the 1980s. Moose have a much wider distribution though the low-lying sections of the Middle Yukon-Lower Tanana area. Although they can be found throughout the entire study area, they tend winter along much of the Yukon River west of its confluence with the Tanana River, as well as along some of the major Yukon tributaries farther east. During the late spring, summer, and early fall moose also occupy some higher ground. Black bear similarly have a far-reaching distribution. Sheep occur only in the higher elevations, typically in the White Mountains. Smaller mammals, including furbearers, can be found throughout the region. The numerous ponds, lakes, sloughs, rivers, and creeks, offer a great abundance of waterfowl.

Again, the villages considered include one located within the historic territories of the Kutchin (Beaver), the Lower Tanana (Minto), and the Koyukon (Tanana and Steven's Village). While some ethnographies cover the general cultural areas surrounding these villages (e.g. McFayden-Clark 1974; Olson 1968), few cover any village specifically or detail; there have been no major ethnographic studies of relevance conducted in the region. Besides the subsistence studies conducted by the ADF&F, several gray literature resources are available; the most notable include Andrews 1977; Nelson et al. 1982; Schneider 1976; and Loyens 1966.

Beaver

The town of Beaver, Alaska is 180 km north of Fairbanks and 95 km southwest of Fort Yukon. Like Steven's Village, which is 80 km to the west, Beaver is entirely within the Yukon Flats National Wildlife Refuge.

The present-day annual cycle, as recorded by Sumida (1989) in 1984, consists of heavy fishing for salmon and other nonanadromous fish for a substantial portion of the year; fishing of one sort or another continues from the middle of May to the end of November. Moose are mostly taken in September, though occasional hunting occurs during December, January, and February. When available, caribou are most often hunted during both migration periods in late fall and early spring. Concentrated black bear hunting occurs in the late summer and early fall, though some hunting also occurs during the summer months. Small game is mostly taken during the winter, but occasional hunting and snaring of porcupine and ground squirrels occurs at other times of the year. Comparisons between the contemporary and traditional Kutchin annual cycles are presented in Table 3.3.

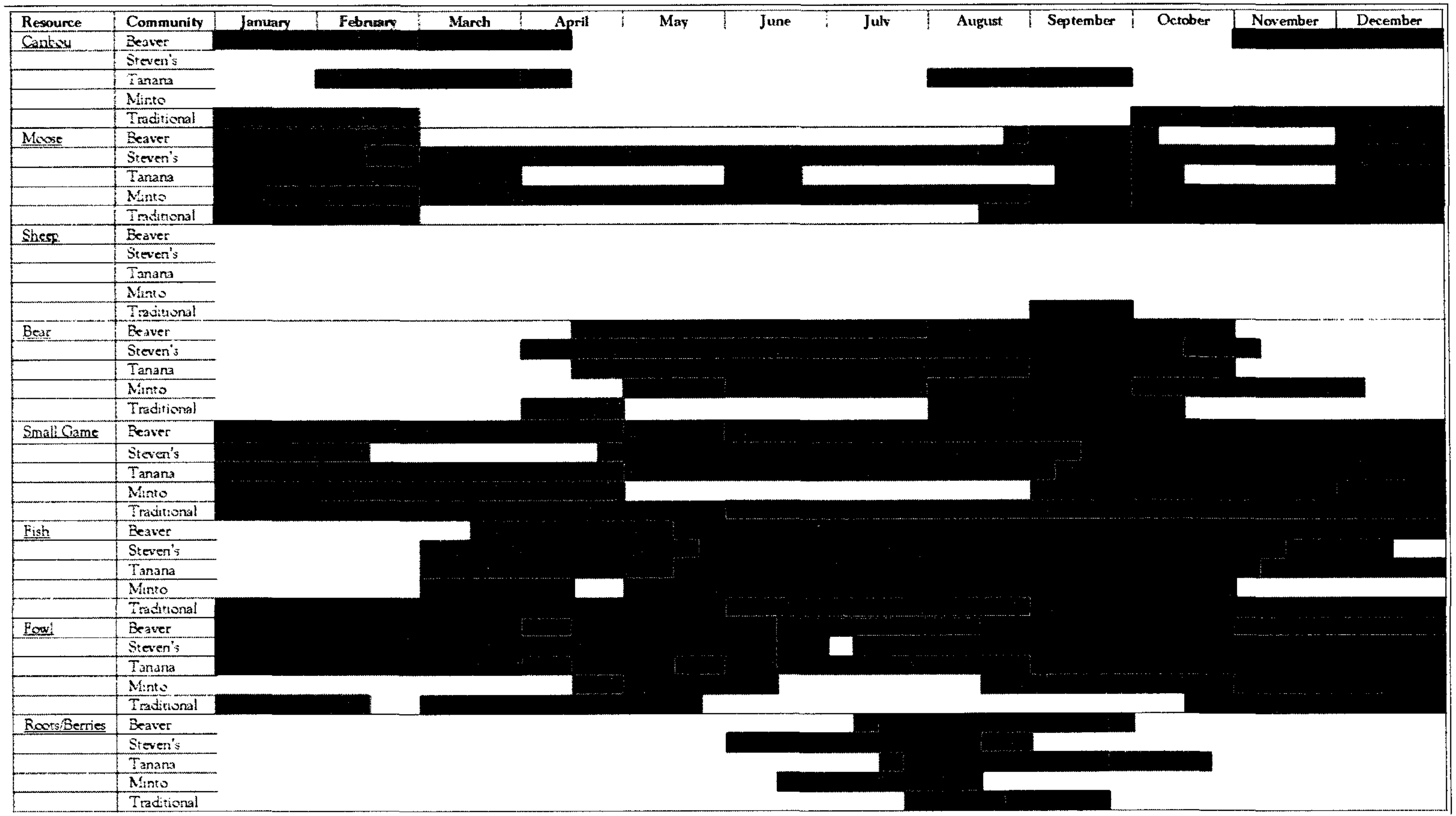
The caribou hunting area for Beaver, as delimited by Sumida (1989: Figure 8) is limited to the Government Trail between the Chandalar River, near Caro, and the Arctic Circle. This area (Figure 3.3) is approximately 65 km long and crosses the Hadweenzic River and numerous creeks named after the mileposts of the Government Trail. The moose hunting area surrounding Beaver is much more expansive. Moose hunting occurs on both sides of the Yukon River, though the area to the north of the watercourse is substantially larger. South of Beaver, the hunting range extends about 16 km to the edge of the flats near the course of Beaver Creek. North of the river, the hunting area begins in between Nelson and Lone Mountains and follows the course of the Hodzana River south corresponding to the lowlands areas in the drainage bottom. Along the Yukon River, it extends from Jokinaugh Island in west to Fort Yukon in the east. The lowlands of the Hadweenzic River are also utilized. There is no overlap between the moose and caribou hunting areas. Dall's sheep are not available in the vicinity of Beaver.

Steven's Village

Steven's Village is approximately 145 km north-northwest of Fairbanks and 185 km southwest of Fort Yukon. The village, located on the north bank of the Yukon River, is within the Yukon Flats National Wildlife Refuge, though native allotments occur throughout the refuge (Sumida 1989). Within 80 km of Steven's Village are three other prominent Alaskan interior villages, Beaver, Rampart, and Livengood.

Steven's Village presents the easternmost Koyukon Athabascan settlement (Sumida 1989:19), though much of the interaction of the village inhabitants occurs with Kutchin villages and settlements farther up the Yukon River. The traditional land use area for Steven's Village extends as far north as Lone Mountain and entirely encompasses the Dall River. South of the village, on the south side of the Yukon River, the use area is much more restricted extending only to the heads of Waldron and Rogers Creeks. The eastern boundary of the territory extends northward following a portion of Lost Creek north to the Hodzana River. To the west, the land use area follows the Ray River upstream for 24 km from its confluence with the Yukon River Sumida 1989: Figure 3). The land use area of the Steven's Village inhabitants during Sumida's

Table 3.3. Contemporary and Historical Subsistence Cycles for the Lower Tanana Region. (Black=Intensive Hunting; Grey=Occasional Hunting; White=No Hunting)



Resource	Community	January	February	March	April	May	June	July	August	September	October	November	December
Caribou	Beaver	■	■	■	■							■	■
	Steven's												
	Tanana		■	■	■				■	■			
	Minto												
	Traditional	■	■								■	■	■
Moose	Beaver	■	■							■			■
	Steven's	■	■	■	■	■	■	■	■	■	■	■	■
	Tanana	■	■	■			■			■	■		■
	Minto	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional	■	■						■	■	■	■	■
Sheep	Beaver												
	Steven's												
	Tanana												
	Minto												
	Traditional									■			
Bear	Beaver				■	■	■	■	■	■	■		
	Steven's				■	■	■	■	■	■	■		
	Tanana				■	■	■	■	■	■	■		
	Minto					■	■	■	■	■	■	■	
	Traditional				■				■	■	■		
Small Game	Beaver	■	■	■	■	■	■	■	■	■	■	■	■
	Steven's	■				■	■	■	■	■	■	■	■
	Tanana	■	■	■	■	■	■	■	■	■	■	■	■
	Minto	■	■	■	■					■	■	■	■
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Fish	Beaver			■	■	■	■	■	■	■	■	■	■
	Steven's			■	■	■	■	■	■	■	■	■	■
	Tanana			■	■	■	■	■	■	■	■	■	■
	Minto			■	■	■	■	■	■	■	■		
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Fowl	Beaver	■	■	■	■	■	■	■	■	■	■	■	■
	Steven's	■	■	■	■	■	■	■	■	■	■	■	■
	Tanana	■	■	■	■	■	■	■	■	■	■	■	■
	Minto				■	■	■		■	■	■	■	■
	Traditional	■	■	■	■	■					■	■	■
Roots/Berries	Beaver							■	■	■			
	Steven's						■	■	■				
	Tanana							■	■	■	■		
	Minto						■	■	■				
	Traditional							■	■	■			

1989 study was remarkably similar to the traditional land use area, though the most extensive subsistence activity was trapping and the traditional land use area many of the subsistence activities took was along the Yukon River up to Beaver, Alaska terminating near the modern Dalton Highway corridor, located about 48 km west of the village.

Sumida (1989:22-25 and 48-52) provides an excellent overview of the historic and contemporary seasonal subsistence activities for the Koyukon Athabascans, in general, and Steven's Village inhabitants, specifically. Here, I briefly highlight these patterns with specific attention to large and medium game hunting; a comparison between the historic and contemporary patterns is presented in Table 3.3. Historically, large salmon fishing camps were established in early June; these were communal efforts needed to acquire and process the abundant resource. Some hunting and waterfowling took place while the fish camps were occupied. Bear and moose hunting took place during the early fall. Caribou hunting, primarily using corrals and surrounds, occurred during the late fall migration through the area. Throughout the winter, hunting forays and continual shifting of camp locations were the norm. In spring, people returned to the caribou hunting camps in anticipation of the spring migration. Interspersed though all the seasons, other subsistence activities included late summer and early fall berry picking, year-round small game hunting and snaring, spring and fall fowling, and limited fishing.

The contemporary pattern, particularly in regards to large mammal hunting is similar, but with some significant differences. Fishing, berry picking, and waterfowling, are essentially the same. Moose are hunted year round, but concentrated efforts are made during late winter, the fall rut, and again in December. Whereas in the past, winter months were spent pursuing what game was to be had, the contemporary winters are spent trapping furbearers. Black bears are hunted throughout the spring, summer and early fall. Since the 1940s caribou have been scarce in the vicinity of Steven's Village, though they are occasionally harvested.

Tanana

Tanana is near the confluence of the Yukon and Tanana Rivers approximately 210 km west-northwest of Fairbanks, Alaska (Figure 3.3). The majority of the residents of Tanana are Koyukon Athabascans (79%) that historically occupied the village of Tanana and the surrounding area (Case and Halpin 1990:12). The village is near Nuklukayet, a traditional rendezvous for trading among the various Athabascans occupying the Koyukuk, Tanana, and Yukon River drainages (McFayden-Clark 1981:595-596; Case and Halpin 1990:12; VanStone and Goddard 1981:559-560).

The modern subsistence range stretches from Rampart Village to the confluence of the Yukon and Nowitna Rivers near Ruby, Alaska, and up (south) the Nowitna River to its headwaters (Figure 3.3). The area between the Yukon-Tanana confluence and Manly Hot Springs is utilized extensively. In addition to the caribou hunting areas within the larger contiguous subsistence range, two isolated areas were used for caribou hunting during the course of Case and Halpin's (1990) study. These areas are both in the Ray Mountains near Mt. Tozi and Mt. Henry Eakin.

The historic subsistence cycle at Tanana was very similar to those of other Koyukon Athabascans, as well as nearby Kutchin and Lower Tanana Athabascans, despite some changes in the duration of some resource harvest periods, or duration of stay in a particular fishing or hunting location. In general, subsistence related activities in the spring revolve around fishing for nonandronomous fish, small game hunting, waterfowl hunting, and occasional moose hunting. Most of the summer and early fall is spent fishing for various species of salmon, waterfowl hunting, and small mammal trapping and hunting. In fall that most large mammal hunting occurs, there is occasional hunting of moose, caribou, and bear throughout the year; bears are hunted both in the open and in their winter dens.

Minto

The village of Minto, permanently established in 1970 on the western edge of the Minto Flats, on the Tolovana River, about 65 km from Fairbanks, Alaska, is inhabited primarily by Lower Tanana-speaking Athabascans (Andrews 1986:16). Prior to its permanent settlement, but after 1900, Minto served as a seasonal base in the fall and winter. During the ADF&G subsistence study in 1983-1984, Minto's population numbered 179 people in 48 households, of which 45 households participated in the subsistence study.

The subsistence area utilized by Minto residents extends from near the confluence of the Tolovana and Tanana Rivers in the west to near the headwaters of Washington Creek in the east. From north to south the traditional use area begins near the Elliot Highway and ends roughly 24 km north of Nenana, Alaska. This area encompasses the Minto Flats, as well as a portion of the Sawtooth Mountains. The seasonal subsistence cycle, as recorded between 1960 and 1984 is fairly typical of most Interior communities; a major exception is the absence of caribou hunting

(Figure 3.3). Of the communities considered here, only Tetlin shares this distinction with Minto. Fishing for various species of salmon occurred in late summer and early fall; fishing for freshwater fish, particularly whitefish and Northern pike, overlaps with the salmon fishing period but begins earlier and ends later in the year. Occasional moose hunting occurred year round, with the most intense hunting in fall and winter. Bears are the only other large animal species hunted by Minto residents and this typically occurred in spring and fall, but occasionally throughout the summer. Small game and terrestrial game birds were sought during the late fall and early winter, and occasionally into the spring. Waterfowl were hunted when migrating in the spring and sometimes in the fall.

Kuskokwim

Like the Middle Yukon study area, the villages forming the Kuskokwim study area include both Ingalik (Stony River) and Upper Kuskokwim Athabascans (McGrath, Telida, and Nikolai), or the Kolchan (Hosely 1961 & 1968). The Upper Kuskokwim study area, as defined here, covers approximately 47,234 square kilometers. The hunting ranges of the villages run from the northern slopes of the Alaska Range in the southeast to Innoko Lowlands and Kuskokwim Mountains in the northwest. From the southwest to the northeast the area follows the course of the Kuskokwim River from its confluence with the Stony River to the upper reaches of the Kuskokwim's North Fork.

The area covers three main physiographic sections including the Kuskokwim Mountains, the Tanana-Kuskokwim Lowlands, and the Nushagak-Big River Hills. The Kuskokwim Mountains are low, rounded mountains with the average elevation not exceeding 610 meters ASL, though some isolated peaks approach 1370 meters ASL (Wahrhaftig 1965:30). Portions of the mountains utilized by the people in the study area consist of the southernmost ridges and slopes immediately adjacent to the Kuskokwim River, though near McGrath the West Fork and Nixon Fork of the Kuskokwim allow relatively easy access farther north into the interior of the mountain chain and beyond to the periphery of the Innoko Lowlands. The western portion of the Tanana-Kuskokwim Lowlands consist of low slopes, with a northerly aspect, originating at the base of the Alaska Range and extending north-northwest for 65 or 80 km to the Kuskokwim River (Wahrhaftig 1965:30). Alluvial and glacial sediments originating in the Alaska Range cover much of the surface area of the section. The Nushagak-Big River Hills section extends from the Big River in the north to Illiama Lake, well south of the study area. Wahrhaftig

(1965:30) describes the section as containing large, rounded ridges reaching elevations of 760 meters in its eastern portion. Like the Kuskokwim Mountains to the north, isolated mountains within the hills reach over 1220 meters ASL.

Wildlife in the Upper Kuskokwim study area is similar to that in the adjacent Tanana and Yukon River basins, though given the more western longitude the number of fish and bird species is greater. Dall's sheep occur in the higher portions of the Nushagak-Big River Hills section and in the higher elevations of the Alaska Range. Moose and caribou have overlapping distributions, though the caribou tend to more common in higher elevations while moose tend to cluster along the major river drainages and in the interceding flats. Bears, both brown and black, can be found throughout the region, as can many of the furbearers and other small game animals. Different species of salmon are common at various times from the late spring through early fall and many freshwater fish species are plentiful in the rivers, lakes, and ponds that dot the landscape.

Ethnographic studies of the study area are few, though Osgood's study (1958) of the Ingalik are one of the more thorough documentations of any Interior Athabascan group. Supplementing, and complimenting, Osgood's ethnographic research is VanStone's ethnohistoric work (VanStone 1979). Anthropological research directly related to the people of the Upper Kuskokwim River is limited to that conducted by Hosley during the early 1960s (Hosley 1961 & 1968).

Briefly, Hosley divides the Upper Kuskokwim Indians into six main bands firmly established between 1835 and 1969 (Hosley 1968 & 1981). From southwest to northeast these are the Tatlawiksuk, the Vinasale, the Takotna, the Nikolai, the East Fork, and the Telida-Minchumina bands. Relative to the Ingalik inhabiting the Yukon River drainage, little is known directly about the Ingalik populations residing along the Kuskokwim River. There is little information concerning the spatial distribution of different clans, though it is evident that there is a clear delineation between the Yukon and Kuskokwim Ingalik. The only village located within the traditional Kuskokwim Ingalik territory in this study area is Stony River. The relationship between the Upper Kuskokwim and Ingalik Athabascans, at least at contact, appears to have been hostile, with most aggressions related to resource control (e.g. caribou fence locations) and cultural differences (Hosley 1981, Osgood 1958, Snow 1981).

Historical accounts suggest that the Kuskokwim River was resource poor compared to the Yukon Basin to the north. Early explorers and traders noted that the inhabitants of the Kuskokwim River relied more heavily on hunting than fishing (Zagoskin 1967). The Kuskokwim

Ingalik traded heavily with Eskimo populations farther down river, possibility alleviating local resource shortfalls by obtaining sea mammal and other products. Subsequently, the trade resulted in strong alliances, cultural sharing, and intermarriage between the coastal groups and the farthest-west Athabascans. By contrast, the Upper Kuskokwim Athabascans had little contact with the Eskimo populations farther west, though they maintained fair to good relations with Tanana Athabascans to the east (Hosley 1981).

McGrath

Like Tok, McGrath is a regional center, located 360 km northwest of Anchorage, serving a number of communities along the Kuskokwim River. In the mid-1980s the town had a population of just over 530 people, of which 40% were Native Alaskan. The subsistence study conducted by Stokes (1985) included all 181 households in the community. Like other communities included in this sample, the town of McGrath does not have a deep history. The town site was permanently established on the south bank of the Kuskokwim River just prior World War II (Stokes 1985:35). However, the location had long been used in the past as an aboriginal and historic trading center.

McGrath residents, both native and non-native alike, rely on wild foodstuffs, though they do so to a lesser degree than people in the surrounding communities such as Nikolai and Telida.

The subsistence round in McGrath consists of fishing, large and small game hunting, trapping, and harvesting wild plants and berries (Figure 3.4). Salmon fishing, for various species, occurs between June and the beginning of September. Fishing for other species overlaps with salmon fishing occurring on and off between March and November. Large game hunting of moose, caribou, bear, and more rarely sheep, is primarily a mid-fall and early winter activity, although bears are also hunted in the summer and fall. Small game hunting, including hare, porcupine, fowl, and muskrats, typically coincides with the parts of the year devoted principally to fishing. Berries and plants are collected during the late summer and early fall.

The McGrath subsistence resource use area is fairly large, though the areas used for moose and caribou cover only a fraction of area used for trapping. Moose hunting occurs mostly along river corridors including the Kuskokwim River between Medfra, in the north, to about 12 km south of Deacons Landing, through the flats along the Big and Pitka Rivers, along the Innoko River between Takotna and Folger Creek, and the Nixon Fork of the Takotna River through the flats just north of McGrath. The caribou hunting area is discontinuous consisting of five separate

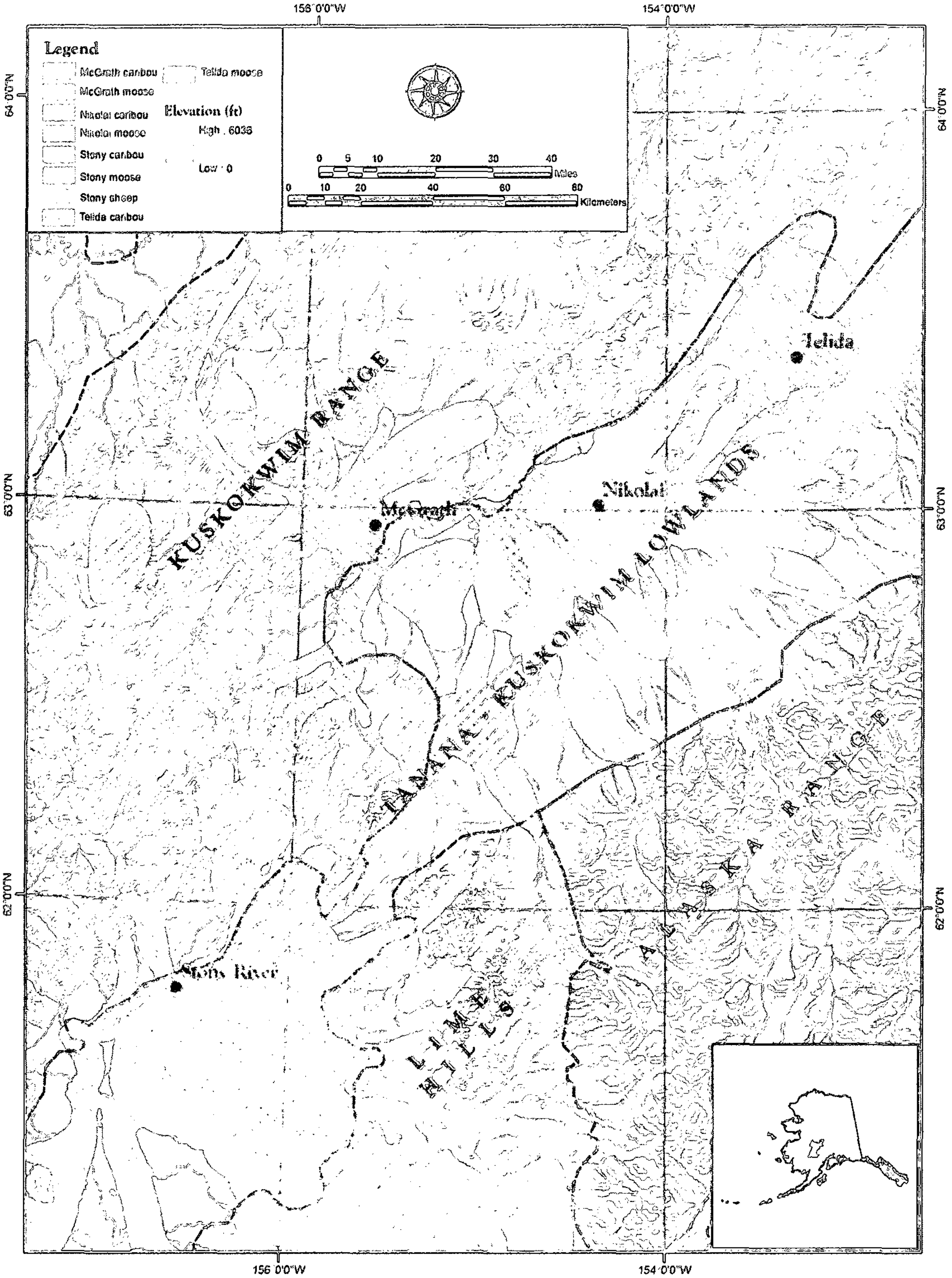


Figure 3.4. Kuskokwim Study Communities, Hunting Ranges, and Physiographic Regions. Hunting Range Data from Kari 1985 and Stokes 1985.

areas varying between 8 and 61 km from McGrath. The closest area consists of the Nixon Creek Flats between The Forks and Hidden Creek. The second area, just to the west covers much of the South Fork of Folger Creek between Cloudy and Twin Mountains in the south and Fossit Mountain in the north. To the south of McGrath are two large, globular-shaped hunting areas, one between the Katlitna River and Black Creek and the other Lone Mountain and the Selatna River. Both these areas are bisected by the winter trail lead south out of McGrath. The final caribou hunting area encompasses the entire Beaver Mountain landform approximately 65 km west of the community.

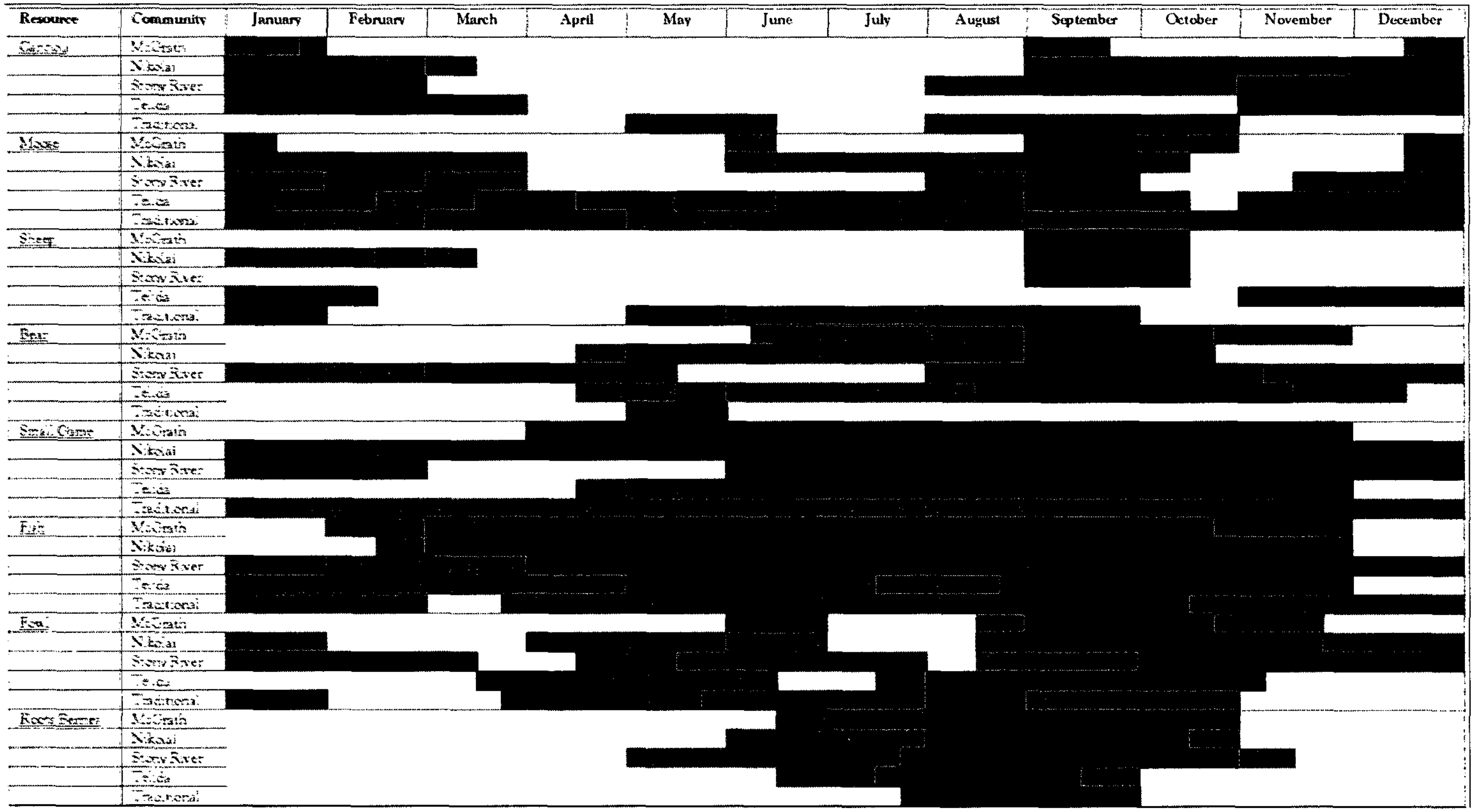
Nikolai

Nikolai, established in 1918, is on the South Fork of the Kuskokwim River about 80 km east of McGrath and 20 km southeast of Medfra. The predominately Upper Kuskokwim Athabascan community (90% native population in 1980) consists of 107 people in 29 households (Stokes 1985:51), all of which participated in the ADF&G subsistence study.

The subsistence cycle practiced in Nikolai consists of seasonal large game hunting, trapping, and fishing (Table 3.4). Fishing, for various salmon species, as well as freshwater fish, typically occurs between June and October, though Nikolai residents harvest some species, particularly whitefish and sheefish, as early as May. Caribou is hunted occasionally in the fall, but more commonly, at least in recent times, in the winter months of December, January, and February. Moose harvests take place not only in the winter, but also in the spring and summer. Dall's sheep hunts typically occur during the fall, but some occupants of Nikolai noted occasional sheep hunting in late winter and a concentrated hunt occurring in late February (Stokes 1985). During spring, summer, and early fall the village populace spends some time hunting brown and black bears. Small game hunting, not including traditionally trapped species, happens sporadically throughout the year. Berries and other plant harvests occur in the late summer and early fall; this also coincides with the most intensive harvests of hare.

The immense moose hunting area used by the residents of Nikolai extends along the Kuskokwim River from the Big River Roadhouse north and east to the end of the East Fork Hills. South of the Kuskokwim, the hunting area extends up many of the major drainages, including the South Fork of the Kuskokwim and Windy River, toward the northern flanks of the Alaska Range. This area encompasses the alluvial piedmont of the Alaska Range and the extensive flats of the Tanana-Kuskokwim Lowlands. Like McGrath, the caribou hunting areas utilized by the

Table 3.4. Contemporary and Historical Subsistence Cycles for the Kuskokwim Region.
(Black=Intensive Hunting; Grey=Occasional Hunting; White=No Hunting)



Resource	Community	January	February	March	April	May	June	July	August	September	October	November	December
Caribou	McGrath	■								■			■
	Nikolai	■	■	■						■	■	■	■
	Stony River	■	■						■	■	■	■	■
	Telida	■	■	■								■	■
	Traditional					■	■		■	■	■		
Moose	McGrath	■					■			■	■		■
	Nikolai	■	■	■			■	■	■	■	■		■
	Stony River	■	■	■					■	■		■	■
	Telida	■	■	■	■	■	■	■	■	■	■	■	■
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Sheep	McGrath									■	■		
	Nikolai	■	■	■						■	■		
	Stony River									■	■		
	Telida	■	■									■	■
	Traditional	■				■	■	■	■	■			
Bear	McGrath						■	■	■	■	■	■	
	Nikolai				■	■	■	■	■	■	■		
	Stony River	■	■	■	■	■			■	■	■	■	■
	Telida				■	■	■	■	■	■	■	■	■
	Traditional					■							
Small Game	McGrath				■	■	■	■	■	■	■	■	
	Nikolai	■	■	■	■	■	■	■	■	■	■	■	■
	Stony River	■	■				■	■	■	■	■	■	■
	Telida				■	■	■	■	■	■	■	■	
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Fish	McGrath		■	■	■	■	■	■	■	■	■	■	
	Nikolai		■	■	■	■	■	■	■	■	■	■	
	Stony River	■	■	■	■	■	■	■	■	■	■	■	■
	Telida	■	■	■	■	■	■	■	■	■	■	■	
	Traditional	■	■	■	■	■	■	■	■	■	■	■	■
Fowl	McGrath						■		■	■	■	■	
	Nikolai	■			■	■	■		■	■	■	■	■
	Stony River	■	■	■	■	■	■	■	■	■	■	■	■
	Telida			■	■	■	■	■	■	■	■	■	
	Traditional	■		■	■	■	■	■	■	■	■		
Roots Berries	McGrath						■	■	■	■	■		
	Nikolai						■	■	■	■	■		
	Stony River					■	■	■	■	■	■	■	
	Telida						■	■	■	■			
	Traditional							■	■	■			

inhabitants of Nikolai are noncontiguous consisting of six widely scattered areas. Unlike McGrath, most of the caribou hunting areas used by Nikolai residents overlap with moose hunting areas. The largest caribou hunting area is centered on the Big River between Blackwater Creek and Bear Creek. South of this area is another large caribou hunting area centered on the Windy Fork, which abuts the Alaska Range. The remaining four hunting areas are smaller than the first two and located east of the village; they are scattered between Telida and the South Fork of the Kuskokwim River.

Stony River

Situated at the confluence of the Stony and Kuskokwim rivers in southwestern Alaska, Stony River Village is roughly 35 km east-northeast of Sleetmute and 80 km northwest of Lime Village.

Historically, Stony River Village served as a seasonal camp utilized by Ingalik Athabascans; it did not become a year-round settlement until the early 1960s (Kari 1985). According to Kari (1985:10-11) the traditional use area of the Stony River inhabitants consisted of a narrow strip of the Kuskokwim Mountains opposite the river from the village to the north and west, the Inowak Creek and Muskrat Creek areas in the west, Tishimna Lake on the south, and the Lyman Hills and Big River to the east. The traditional use area is larger than the use area recorded by Kari in the early 1980s (Figure 3.4).

The Stony River people have a mixed economy dependant on wage labor and subsistence activities. Subsistence activities include big and small game hunting, wild plant harvesting, and fishing. Big and medium game pursued at various times throughout the year includes moose, caribou, sheep (historically), and black bear. Most of the moose and caribou hunting occur during the fall and winter, while black bear hunting is mostly restricted to spring and fall. Porcupine, hare, game and water fowl hunting accounts for much of the small game acquired, though historically hoary marmots were sought in the fall often in conjunction with fall sheep hunts (Kari 1985:886-94). Waterfowl were hunted when available during the summer and grouse and ptarmigan were taken late fall and winter. Stony River inhabitants fish for salmon and white fish in the spring and summer, though burbot and some whitefish are taken through the ice in the winter. Wood harvesting is a nearly year-round occupation and berry picking typically occurred in the fall.

Relative to the other Kuskokwim River communities discussed here, the hunting ranges of Stony River people are extremely large, although this may be a function of the actual time period mapped by researchers. The time considered in mapping the resource area for Stony River village consisted of a lifetime use area as opposed to one or two years. This problem is explored in more detail in the following section. The residents of Stony River exploit an extremely large moose hunting area that extends along the Kuskokwim River from Vinasale Mountain south to the community of Sleetmute, and up most of the major southern Kuskokwim tributaries including the Hotlina River, the Hoholitna River, Stony River, Swift River and its Cheeneetnuk tributary, and the Tallawiksuk River. The caribou hunting area centers on the Stony River between the Kuskokwim River to south of Lime Village, as well as several smaller areas in the Kuskokwim Mountains north of the Kuskokwim River and east of the Swift River. The two small sheep hunting areas include the Lone Mountains east of the Swift River and in the Revelation Mountains of the Alaska Range near the headwaters of the Swift River.

Telida

As of the mid-1980s, the unincorporated village of Telida had a population of 26 individuals, all of whom, save two, were Native Alaskan. The village, which occurs on the Swift Fork River, is approximately 160 km east-northeast of McGrath and 32 km southwest of Lake Minchumina. At the time of the ADF&G subsistence study in 1983 (Stokes 1985), the village had no electricity, except at the school, and it was entirely reliant on air service to import nonlocal goods. The current village location was established in 1915; prior to this, the village was farther downstream on the opposite bank of the Swift River.

The annual subsistence cycle for Telida, adapted from Stokes (1985) is presented in Table 3.4. Fishing for various nonanadromous species, particularly whitefish and sheefish, occurs sporadically through the summer, but once salmon make their appearance, fishing intensity increases during August, September, and October. Moose hunting persists throughout much of the year, though the most concentrated efforts occur during the fall in the late winter and early spring. Bears, both brown and black, are commonly harvested in the fall. Caribou, on the other hand, are hunted regularly from November to February. Game and waterfowl are hunted seasonally in both the spring and fall. Winter is devoted mostly to trapping and caribou hunting.

The moose hunting area surrounds the village extending north to the North Fork of the Kuskokwim and south to the Tonzona River. East of the village an arm extends north and east, through a portion of the Denali National Reserve, to Thirtyeight Mile Lake. Another extension of the moose hunting area extends up Baker, Stone, and Figure Creeks. The caribou hunting areas, two widely separated areas, are both small relative the moose hunting area. The first is just south of Thirtyeight Mile Lake in the vicinity of Yoder Lake and the second is roughly equidistant from Telida and the Denali National Preserve boundary.

Upper Yukon-Porcupine

The country incorporating the Upper Yukon and Porcupine Rivers is markedly diverse ranging from large, flat wetlands to vast expanses of the eastern Brooks Range. The hunting ranges of the four villages considered, Chalkyitsik, Fort Yukon, Venetie, and Arctic Village, cover a minimum area of 82,130 square kilometers; yet, the hunting ranges overlap with only three physiographic sections: the Yukon Flats, the Central and Eastern Brooks Range, and the Porcupine Plateau. The Brooks Range, in the vicinity of the study area, consists of rugged ridges, which trend to the east, and peaks ranging in elevation between 1220 and 2130 meters ASL. The Porcupine Plateau, in contrast, averages no more than 760 meters ASL and consists of low, rounded to flat, ridges with isolated mountain peaks surmounting the plateau by an additional 305 meters. Wide valleys commonly separate the low ridges and the subsurface geology, mostly sedimentary in origin, results in a very irregular landscape pattern in the section. The Yukon Flats are briefly described above in the Middle Yukon-Lower Tanana section.

The Upper Yukon-Porcupine region of the Alaskan Interior supports a diverse wildlife, much of which has an economic function in rural communities and for subsistence purposes. Moose concentrations are highest in the low-lying areas, particularly throughout the Yukon Flats National Wildlife Refuge, along the Yukon River and most of its meandering tributaries. Waterfowl also occur throughout large portions of the refuge and in surrounding areas from spring through the fall. Caribou are occasionally encountered, but most occur north of the Yukon River. The caribou seasonally migrate through the area, but can be found almost year round in the southern reaches of the Brooks Range and beyond. Likewise, Dall's sheep occur through most of the central and eastern portions of the Brooks Range. Furbearers are widely distributed throughout the region.

Anadromous and freshwater fish can be found in the Yukon River, its sloughs and tributaries, and many of the lakes scattered throughout the area. Four species of salmon (Chinook, Coho, Chum, and Pink) occur seasonally in the Yukon River and tributaries. Various species of whitefish, char, lake trout, and burbot, and sheefish abound in many of the waterways and lakes.

Fort Yukon

Fort Yukon, located near the confluence of the Yukon and Porcupine Rivers, is the largest community in the Upper-Yukon Porcupine region with a 1980 population of 661 people in 187 households. The 1983 subsistence study only collected subsistence map data from 10 households in the community (Caulfield 1983:8). Unlike other hub communities in the sample where the Indian population is in the minority, 70% of the population of Fort Yukon is Native Alaskan.

Based on the typical annual subsistence round between 1970 and 1982 (Caulfield 1983:154-157), harvest activities vary seasonally, fluctuating with differing resource abundances (Figure 3.5). Spring usually involves waterfowl hunting, muskrat trapping and occasional black bear hunting. In the late spring, fishing nets are often set to catch whitefish, pike, and other species. Summer subsistence activities focus on salmon fishing for both chum and king salmon, though there is occasional moose, caribou, and bear hunting. Wild plants and berries ripen in the late summer and early fall and residents harvest these resources at that time. Fall serves as the main time for hunting moose and caribou. Occasional moose and caribou hunting and ice fishing occurs in the winter, although trapping is an important activity. Small game, such as hare and porcupine are taken opportunistically throughout the year (Table 3.5).

The residents of Fort Yukon utilize two disparate caribou hunting areas separated by over 175 km. The western area is the Three Lakes area near Birch Creek at the interface between the Yukon Flats and Crazy Mountains. The eastern area is along the Porcupine River just downstream from Upper Ramparts portion of the river. The moose hunting territory includes corridors along major rivers and their interceding flats. Along the Yukon River, moose are hunted between the communities of Beaver and Takoma Bluff. The Black River corridor extends from its Yukon confluence, past Chalkyitsik and Salmon villages, south to Bear Mountain. The Porcupine River is followed upstream as far as Old Rampart.

Arctic Village

Arctic Village is the farthest north community in this study. The village is 170 km north of Fort Yukon and 260 km east of Anaktuvuk Pass. In 1980, Arctic Village had a population of

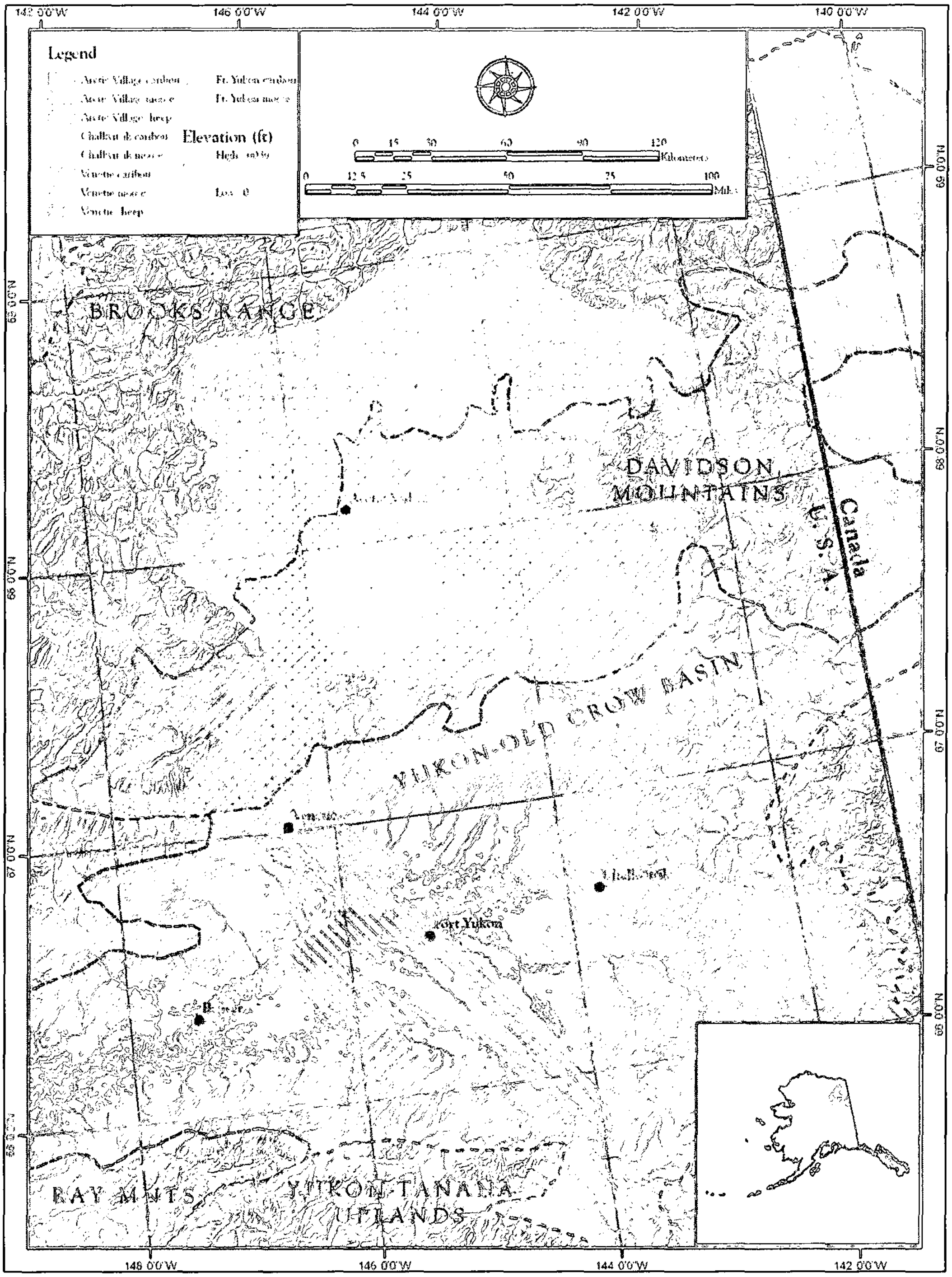
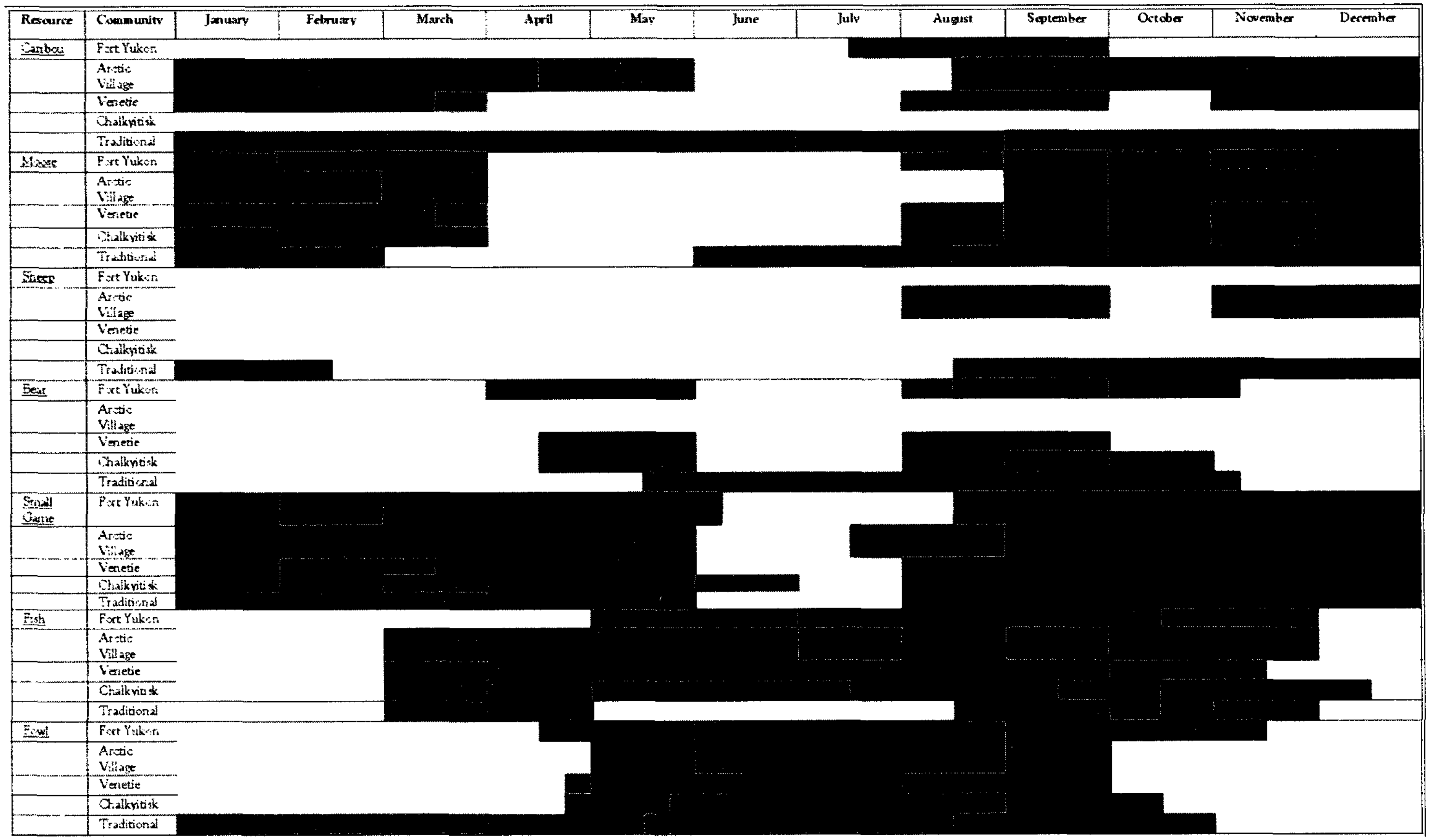


Figure 3.5. Upper Yukon Study Communities, Hunting Ranges, and Physiographic Regions. Hunting Range Data from Caulfield 1983.

Table 3.5. Contemporary and Historical Subsistence Cycles for the Upper Yukon Region. (Black=Intensive Hunting; Grey=Occasional Hunting; White=No Hunting)



111 people residing in 18 households, of which 11 households provided subsistence data (Caulfield 1983). Like Tetlin in the Upper Tanana area, the village is well documented ethnographically.

Compared with other villages in the Upper Yukon-Porcupine region, Arctic Village occupies a mountainous area with proximity to a greater ecological diversity the Yukon Flats area to the south. The Arctic Village caribou hunting area is extensive extending from the community of Christian in the south to the headwaters of the Chandalar River in the north, and from the Keche Mountain in the west to the Sheenjek River in the east. Moose hunting occurs in one large and two smaller areas. The large area centers on Arctic Village and extends out in all direction for 35 (north and west) to 95 (south and east) km. The sheep hunting area is exceptionally large encompassing much of the Phillip Smith Mountains and straddling the Continental Divide.

Venetie

Venetie, permanently established in the early 1900s, is roughly 45 northwest of Fort Yukon on the northern bank of the Chandalar River. At the time of Caulfield's (1983) subsistence study, the village was home to 132 people living in over 24 households. Of these households, nine participated in providing subsistence mapping data; the resulting 38% sample fraction is the second lowest, after Fort Yukon, for the communities studied in the Upper Yukon-Porcupine region.

The area surrounding Venetie includes portions of the Yukon Flats and the foothills on the eastern Brooks Range. The diversity of resources, and the reasonable access to them, provides a dynamic seasonal subsistence pattern. Between 1970 and 1982 the subsistence round consisted of the seasonal harvest of several species of salmon and other fish, moose, caribou, bears, small game, and various types of flora (Caulfield 1983:177-180). Spring is a time devoted to harvesting waterfowl, freshwater fish, and hunting and trapping small mammals, such as hare and muskrats. In the past, caribou were often hunted during the spring migration. Residents of Venetie also devote a significant amount of time preparing for summer and early fall salmon fishing along the Yukon River. Besides salmon and nonanadromous fishing so prevalent in the summer, foraging for firewood, berries, and other vegetal products, as well as small game and bear hunting, are essential activities. Large game hunting, particularly for moose, occurs in the fall. Caribou hunting often begins in the fall and continues through the end of winter, often in conjunction with trapping.

The caribou hunting commonly occurs in a large territory north of the village between the village and Big Rock Mountain in the north and to the confluence of the Chandalar River with its East Fork. This area includes numerous upland areas, flats, and lakes. The moose hunting areas encompasses much of the caribou hunting range and continues south-southeast of the community to into the Yukon Flats ending at the Yukon River. Sheep hunting commonly takes place in two mountainous areas 85 km southwest of Arctic Village and 91 km north-northwest of Venetie in the vicinity of the Middle Fork of the Chandalar River.

Chalkyitsik

Chalkyitsik, a community of 100 people in 1980 (Caulfield 1983:132), is on the Black River approximately halfway between the Yukon River and Salmon Village, about 80 km east of Fort Yukon. In the past this location served as a fishing camp, but it became permanently settled in the early 1940s (Nelson 1986:17). Of the 13 households in Chalkyitsik during the time of the ADF&G subsistence study in 1983, 8 participated in providing subsistence mapping data.

The yearly subsistence cycle mimics those of the other communities in the Upper Yukon-Porcupine region and includes harvest of fish, game, and fowl, as well as gathering plants and berries. Like Venetie, Chalkyitsik's central location to a number of different environments allows for access to a moderately diverse range of resources. Muskrat and waterfowl hunting are important activities in the early spring immediately following breakup. Fishing, too, begins in earnest soon after the waterways, ponds, and lakes thaw. Net fishing at this time typically produces whitefish and pike. Fishing and waterfowling continue through the summer, and as the season progresses Chum salmon are also harvested. In the fall there is a shift to moose and black bear hunting, which becomes more important than fishing although this continues with lower productivity. Waterfowl, too, are harvested until they migrate south. Berries and other plant products are often harvested in the late summer and early fall. Trapping is the primary winter activity, though some ice fishing and moose hunting occur occasionally. Caribou are hunted in the fall and winter; however, caribou hunting often requires extensive trips, as the caribou do not frequent the portion of the Black River near Chalkyitsik. Thus hunting areas utilized by the inhabitants of Chalkyitsik are away from the village. The northern area, located along the Porcupine River between Bootleg Bend and Old Rampart, begins about 15 km from the village, while the southern hunting area, which covers the area between Big Mountain and Rocky Mountain, is 90 km to the southeast of Chalkyitsik. The inhabitants of Chalkyitsik also hunt over an impressive area for moose from the Porcupine River near its confluence with the Black River, northeast to just shy of the US-Canadian border. A second major river corridor for moose hunting includes the Black River between the Porcupine River and Bear Mountain Lake. Besides the river corridors, the area surrounding the village from John Herbert's Village in the north to Grass River in the south is also used for hunting moose.

Frames of Reference

Lewis Binford (2001:47-48) argues that properly constructed frames of reference consist of at least two dimensions reflecting first and second-order derivative patterning. First-order derivative patterning consists of "regularities in the way vectors of circumstantial evidence distribute with respect to one another...(Binford 2001:47)." Second-order derivative patterning is an attempt to correlate first-order patterning with an additional, independent data set. This chapter attempts to identify first-order derivative patterning in the yearly subsistence rounds of the communities described in the previous chapter; second-order derivative patterning is the focus of subsequent chapters. Before proceeding with these pattern recognition exercises, it is necessary to briefly critique the original data to ensure that any interpretations of the first order patterning reflect cultural behavior and not sampling or observation bias.

The land use mapping data collected by ADF&G anthropologists, though standardized in many respects, does contain some variability that needs to be considered when comparing these data and in their interpretation. Though I note these inconsistencies individually below, the effects of the inconsistencies are not mutually exclusive and affect the interpretation of the data at many levels. The most important differences include the sampling methods and fractions employed during the original fieldwork, differences in the scale at which spatial data were collected and presented, the period of time the spatial data represents, and the number of resources mapped or considered (Table 3.6).

The sampling fraction in most case is excellent, and where the sampling fraction is low, random sampling techniques ensure that the sample is theoretically representative of the community. The smallest samples occur in the hub communities of Fort Yukon (6%), McGrath (18%), Tanana (23%), and Tok (25%). The communities of Bettles and Evansville have the highest sampling fraction among the hub communities at 80%. Of the smaller communities, the sampling fractions, with a couple of minor exceptions, are substantially higher ranging between

61 and 100%. The two exceptions include the communities of Venetie (37.5%) and Northway (17%). While Case (1986:3) specifically designed the Northway sample to be representative, Caulfield (1983:7-8) makes no such claim for the Venetie sample.

The sampling fraction is important when interpreting the mapped resource use areas and, to a lesser extent, the periods represented by the mapped resource use areas. The area represented in the mapped resource areas is the cumulative area used by all the households within the sample. Where the sampling fraction is low, it is possible that the mapped area is not representative of the area used by the entire community to hunt or gather a particular resource. In these cases, it is necessary to assume that the areas reflected in the mapping are representative of the actual community use area for a particular resource and that additional cases would not significantly increase the size of the area or add additional locations to the data. In regard to the period of time presented by the mapping, it is necessary to assume that the sample is again representative. When the period mapped is relatively brief or related specifically to the time period of the subsistence study (see below), this is not too problematic. However, when long periods of time are represented on a map and the sampling fraction is low, such as at Venetie, it is possible that individuals who collected resources in other areas were missed. This has the potential to reduce the variability represented in the mapping data.

Careful considerations of the periods of time represented by the resource use mapping data are also required, particularly when comparing different studies. As shown in Table 3.6, the land use mapping data represents a wide range of time periods ranging from a single year to entire lifetimes. Based on the differences in mapping periods among the different subsistence studies, and that the hunting ranges are not static through time, those communities that have longer mapped time periods should have larger resource acquisition areas. At a qualitative level this observation is somewhat supported in that some villages or communities where mapping represents long-term use (e.g. Arctic Village, Stony River) have relatively large hunting areas mapped while other communities where mapping represented only a single year (e.g. Hughes) have substantially smaller areas (Table 3.7). However, a t-test of the size of different hunting areas grouped by resource and into short-term (<10 years) and long-term (>20 years) shows that there are no significant differences (Table 3.8) between these two groups. Several possible reasons for this discrepancy include continued (traditional) use of a particular area, stability and predictability of resources within the areas, proximity of resource areas to communities, population size of a particular community, and accessibility to particular areas.

Table 3.6. Comparison of Subsistence and Mapping Data Acquisition for 21 Interior Alaska Communities

Community	**Time Period Mapped**	**Data Collection Scale**	**Number of Households Inventoried**	**Number of Households-Community**	**Resources Mapped/ Considered**	**Source**
Alatna/ Alakaket	1981-1982	1:250k	35	39	Sh, M, BB, T, F, WG, BP, SG	Marcotte and Haynes 1985
Arctic Village	Life time	1:250k	11	18	GB, BB, C, F, S, SG, T, M, Sh, BP, WC, WF, Fo	Caulfield 1983
Bettles/ Evansville	1981-1982	1:250k	20	25	Sh, M, BB, T, F, WG, BP, SG	Marcotte and Haynes 1985
Beaver	1984-1985	1:250k	15	32	S, F, M, C, Sh, SG, Wf, T, BP	Sumida 1989
Chalkyitsik	Life Time	1:250k	8	13	GB, BB, C, F, S, SG, T, M, Sh, BP, WC, WF, Fo	Caulfield 1983
Dot Lake	Late 1940s-1982	1:63,360	11	15	M, C, Sh, BB, B, FO, Wf, T, F, BP	Martin 1983
Fort Yukon	Life time	1:250k	10	160	GB, BB, C, F, S, SG, T, M, Sh, BP, WC, WF, Fo	Caulfield 1983
Hughes	1981-1983	1:250k	19	22	Sh, M, BB, T, F, WG, BP, SG	Marcotte and Haynes 1985
Huslia	1981-1983	1:250k	56	57	M, C, BB, T, S, F, WC, BP, Wf, SG	Marcotte 1986
McGrath	1965-1985	1:250K	33	181	M, C, Sh, BB, GB, SG, T, Wf, F, S, BP, WC	Stokes 1985
Minto	1984	Multiple	45	48	M, F, S, T, WC, Wf, SG, BB, GB	Andrews 1986
Nikolai	1965-1985	1:250k	29	29	M, C, Sh, BB, GB, SG, T, Wf, F, S, BP, WC	Stokes 1985
Northway	1974-1984	1:250k	15	88	F, S, M, C, Sh, BB, T, SG, Wf, BP; WC	Case 1986
Steven's Village	1984-1985	1:250k	22	30	S, F, M, BB, C, Wf, Fo, SG, T, BP	Sumida 1989
Stony River Village	1900-1983	Not Specified	20	20	M, C, Sh, BB, GB, SG, T, F, BP, WC	Kari 1985
Tanacross	1987-1988	1:250k	27	34	F, M, C, BB, SG, Wf, T, BP	Marcotte 1992
Tanana	1968-1988 1983-1988	Not Specified	30	128	S, F, M, C, Bear, T, SG, BP, WC	Case and Halpin 1990
Telida	1965-1985	1:250k	7	7	M, C, Sh, BB, GB, SG, T, Wf, F, S, BP, WC	Stokes 1985
Tetlin	1983-1984	1:63,360	20	28	M, BP, T, SG, Wf, F	Halpin 1987
Tok	1987-1988	1:250k	93	367	F, M, C, BB, SG, Wf, T, BP	Marcotte 1992
Venetie	Life Time	1:250k	9	24	GB, BB, C, F, S, SG, T, M, Sh, BP, WC, WF, Fo	Caulfield 1983

B=Bison; BB=Black Bear; BP=Berry Picking/plants; C=Caribou Hunting; F=Freshwater Fish; Fo=Fowl; GB=Grizzly Bear; M=Moose Hunting; S=Salmon; SG=Small Game; Sh=Sheep Hunting; T=Trapping; WC=Wood Collecting; Wf=Waterfowl

Table 3.7. Total Acreage of Hunting Area by Species for the Study Villages.

Village	Caribou Hunting Area (Ha)	Moose Hunting Area (Ha)	Sheep Hunting Area (Ha)	Total Area [Caribou. Moose, Sheep] (Ha)
Alatna/Allakaket	0	227391	306651	534042
Arctic Village	2079175	957621	1325214	4362010
Beaver	19144	228060	0	247204
Bettles/Evansville	0	240330	94273	334603
Chalkyitsik	249201	408978	0	658179
Dot Lake	34036	115440	24654	174130
Fort Yukon	69938	556722	0	626660
Hughes	0	134313	0	134313
Huslia	64986	214592	0	279578
McGrath	263706	189173	0	452879
Minto	0	214592	0	214592
Nikolai	132697	436172	0	568869
Northway	79436	269954	3518	352908
Steven's Village	0	384058	0	384058
Stony River Village	777660	804309	9311.0	1591280
Tanacross	536294	736471	117638	1390403
Tanana	170282	575461	0	745743
Telida	2678	163038	0	165716
Tetlin	0	111965	0	111965
Tok	1373170	1918316	832367	4123853
Venetie	425839	532954		958793

Table 3.8. Results of t-Tests for Short-Term and Long-Term Resource Mapping Areas

Resource Area	t	df	Sig (two-tail)
Caribou	-1.004	19	.328
Moose	-0.262	19	.796
Sheep	-1.02	19	.920
Total Area (for caribou, moose, & sheep)	-0.561	19	.581

An examination of two cases serves as a fair example of how population size and accessibility, among other factors, affect the size of mapped resource areas. Based on the data in Table 3.7, the two largest mapped resource areas belong to the communities of Tok and Arctic Village. The total resource area for Tok represents the actual area utilized by the sampled Tok residences (n=93) for a period of a single year. The total resource area for Arctic Village represents the area utilized by only 11 individuals for their entire lives. The number of subsistence hunters in Tok is not only higher, but the accessibility to hunting areas from Tok is considerably easier than it is from Arctic Village. Centrally located on the Alaska Highway between the US-Canadian border and Fairbanks, a vast network of roads, by Alaskan standards, connects Tok to many areas. The road network clearly has advantages in that it is not difficult, expensive, or time consuming to drive several hours to exploit areas just off a main road. Such transportation luxury is nonexistent around Arctic Village. The two communities with the third and fourth largest resource use areas, Tanacross and Stony River, follow the same trends as the first two, but the number of persons in each sample is much more consistent. In this particular case, there is a more or less equal number of people in the samples, one remote and one connected community, and roughly equal exploitation areas, but the mapped time period is only one year for the community of Tanacross and over 80 years for Stony River. Since the size of the area does not appear to be a function of population size, the amount of time, transportation, and traditional (habitual?) use are the most viable alternatives to describe this particular case. Examining the remaining cases, it is clear that such combinations of variables probably relate to the size of the resource area, but no discernible, consistent pattern is recognizable in the data.

The time depth of the mapped resource use also has consequences on the number of species considered in any particular study. The short-term studies, such as those in the Koyukuk region and the majority of communities in the Kuskokwim region, may miss resources that are commonly, or even occasionally exploited, but were not during the course of the study. Subsistence practices along the Koyukuk River serve as a perfect example. While a few caribou where taken during the 1985 subsistence study, the caribou hunting areas were not mapped since this type of hunting "happened too infrequently during this time to provide a basis for a pattern (Marcotte and Haynes 1985: 56). However, studies that are more recent show that caribou hunting regularly occurs in the communities of Bettles, Evansville, Allakaket, and Alatna.

In all, the number of harvested caribou in these communities was 35 for 1997-1998, 83 for 1998-1999, and 36 for 1999-2000 (Andersen et al. 1998; Andersen et al. 1999; Andersen et al.

2001). Although the harvest levels are less than those identified at Huslia, which collectively harvest 422 caribou during the same time period, regular and sustained hunting of caribou did and does occur. While the absence mapped procurement areas is disappointing, it has little impact here except to decrease the sample size. With the possible exception of Minto, the unmapped resource areas for caribou for the communities of Tetlin, Bettles/Evansville, Alatna/Allakaket, Hughes, and Steven's Village reduce the sample by almost 25%. Documentation of sheep hunting areas is also related to the short-term nature of some of the subsistence studies.

Fairly standardized methods were employed by the ADF&G anthropologists when collecting resource area data; these methods are described in the individual subsistence reports. The scale of the base maps was mostly 1:250,000 USGS topographic maps representing one degree of latitude and three degrees of longitude. In a few instances, 1:63,360 scale maps were used; roughly equivalent to 15 by 20 minutes of latitude and longitude. The differences in mapping scale affect the precision and accuracy of the mapped resource areas. Also problematic is that in many instances, despite the small scale, the edges of some resource harvest areas fall outside the edges of the presented map. This is particularly true for harvest areas in some of the Upper Tanana communities, Arctic Village, and Stony River. For this study, the areas as they appear in the original subsistence reports are assumed to be representative of the entire area and that difference in precision and accuracy between the different mapping scales used is negligible.

Binford often uses the phase frame of reference to refer to a common denominator that is useful when using ethnographic analogy to structure interpretations of the archaeological record (Binford 1983b, 1987 & 2001). Often, the frame of reference is an economic measure, such as the economic anatomy of a particular species, or environmental measure, like effectual temperature or environmental productivity, that explains some of the variability observed in the ethnographic record. Comparing ethnographic data to archaeological data screened through the filter of the frame of reference is a basic component of the systemic approach. The scales at which frames of reference are applied vary, but Binford tends to use them in a global context comparing different cultures, commonly hunter-gatherers, latitudinally from the Equator to the Arctic Circle. While such large-scale comparisons may serve to find broad patterning in organizational behavior, such gross scale patterning is insufficient to compare ethnographic cases that are contiguous, occur in the same biome, and closely related physically, culturally, and linguistically.

While environmental and economic factors serve as useful frames of reference and are, for all intents and purpose, outside the sociocultural realm, there are any number of frames of reference that one can utilize. Here, where the aim is to explore prehistoric land use patterns, the topography of different hunting ranges serves as one frame of reference. However, a temporal frame of reference is also available. This is a comparison of modern and traditional hunting practices viewed in terms of seasonality and yearly efforts in resource acquisition; it is possible to derive these measures from the seasonality tables presented in the first part of this chapter. Comparison of seasonality and subsistence efforts from the not-too-distant past and the present aid in evaluating change through time and allow for some general observations concerning how and to what extent the ethnographic patterns have changed due to changes in hunting and transportation technologies and modern hunting laws. These implications can then serve as models that attempt establish similar patterns even further back in time. In essence, this use of a frame of reference is diametrically opposed to Binford's concept. Where Binford examines for environmental variability on which to project cultural and behavioral adaptations, this comparison uses cultural and behavioral variability (hunting efforts and changes in the effort in two different time periods) projected against a common set of resources and topographical variables.

Utilizing the qualitative seasonality data readily available in the modern subsistence studies and the traditional reconstructions found in the earlier ethnographies of Alaskan Athabascans is a relatively straightforward task and consists of calculating a nonparametric effort estimate based on the seasonal harvest intensities for different species or classes of resources. In the seasonality tables presented earlier in this chapter, the periods typically used to acquire a particular resource are shown as either intensive/usual or less intensive/occasional. Assigning numerical values to these two different effort levels, per week, and summing the total results in a relative measure that can be use to directly compare the effort between different locations, different resources, different seasons, and different time periods. Occasional harvests are assigned a value of 1 and usual harvests a value of 2; no harvest activity receives a value of 0. The examination considers a strict four weeks per month (and not the average of 4.33) and 12 months per year resulting in a total of 48 weeks resource weeks. The maximum effort that can be devoted to any one resource is 96 (effort level 2 x 4 weeks x 12 months); the minimum effort is 0.

With numerical values calculated for all the data (Table 3.9), it is possible to analyze the seasonality data with correspondence analysis. Correspondence analysis (CA) is a method of "visually displaying the association between two discrete variables, based on their cross-

Table 3.9. Contemporary and Traditional Subsistence Efforts.

Village	Cultural Area	J	F	M	A	M	J	J	A	S	O	N	D
Caribou													
Dot Lake	Upper Tanana	8	8	0	0	0	0	0	8	8	0	8	0
Tanacross	Upper Tanana	0	0	0	0	0	0	0	8	8	0	0	0
Tok	Upper Tanana	0	4	0	0	0	0	0	8	8	0	8	8
Tetlin	Upper Tanana	0	0	0	0	0	0	0	0	0	0	0	0
Northway	Upper Tanana	8	8	0	0	0	0	0	0	0	0	0	8
Traditional	Upper Tanana	0	0	0	4	8	4	0	0	0	4	8	4
Bettles/Evansville	Koyukuk	0	0	0	0	0	0	0	0	0	0	0	0
Alatna/Allakaket	Koyukuk	0	0	0	0	0	0	0	0	0	0	0	0
Hughes	Koyukuk	0	0	0	0	0	0	0	0	0	0	0	0
Huslia	Koyukuk	0	8	8	8	0	0	0	8	0	8	4	4
Traditional	Koyukuk	4	4	0	0	0	0	0	0	0	8	4	4
Beaver	Middle Yukon	4	4	8	4	0	0	0	0	0	0	8	8
Minto	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Steven's Village	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Tanana	Middle Yukon	0	7	8	2	0	0	0	4	8	0	0	0
Traditional	Middle Yukon	4	4	0	0	0	0	0	0	0	8	4	4
Arctic Village	Upper Yukon	8	8	8	6	4	0	0	4	8	8	8	8
Chalkyitsik	Upper Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Fort Yukon	Upper Yukon	0	0	0	0	0	0	2	4	4	0	0	0
Venetie	Upper Yukon	8	8	6	0	0	0	0	4	4	0	8	8
Traditional	Upper Yukon	4	4	4	4	4	4	8	8	4	4	4	4
McGrath	Kuskokwim	5	0	0	0	0	0	0	0	6	0	0	2
Nikolai	Kuskokwim	8	8	2	0	0	0	0	0	4	4	4	8
Stony River	Kuskokwim	8	8	0	0	0	0	0	4	4	4	8	8
Telida	Kuskokwim	8	8	8	0	0	0	0	0	0	0	8	8
Traditional	Kuskokwim	0	0	0	0	8	4	0	8	8	8	0	0
Moose													
Dot Lake	Upper Tanana	0	0	0	0	0	0	0	0	8	0	0	0
Tanacross	Upper Tanana	4	0	0	0	0	4	4	0	8	0	0	0
Tok	Upper Tanana	0	0	0	0	0	0	0	4	8	0	0	0
Tetlin	Upper Tanana	4	4	4	0	0	0	4	5	8	4	4	4
Northway	Upper Tanana	0	0	0	0	0	0	0	2	8	0	0	0
Traditional	Upper Tanana	4	4	6	8	4	4	6	8	8	4	4	4
Bettles/Evansville	Koyukuk	4	4	4	0	0	0	0	0	8	4	4	4
Alatna/Allakaket	Koyukuk	4	4	4	0	0	0	0	0	8	4	4	4
Hughes	Koyukuk	4	4	4	0	0	0	0	0	8	4	4	4
Huslia	Koyukuk	0	0	4	0	0	0	0	0	8	0	0	0
Traditional	Koyukuk	4	4	0	0	0	0	0	4	8	4	4	4
Beaver	Middle Yukon	4	4	0	0	0	0	0	1	8	1	0	4
Minto	Middle Yukon	6	8	8	4	4	4	4	4	8	4	4	4

Table 3.9. Contemporary and Traditional Subsistence Efforts (Continued)

Village	Cultural Area	J	F	M	A	M	J	J	A	S	O	N	D
Steven's Village	Middle Yukon	4	6	4	4	4	4	4	6	8	4	4	7
Tanana	Middle Yukon	4	4	4	0	0	3	0	0	6	2	0	4
Traditional	Middle Yukon	4	4	0	0	0	0	0	4	8	4	4	4
Arctic Village	Upper Yukon	4	4	8	0	0	0	0	0	8	4	4	4
Chalkyitsik	Upper Yukon	4	8	8	0	0	0	0	4	8	4	8	4
Fort Yukon	Upper Yukon	4	8	8	0	0	0	0	4	8	4	8	4
Venetie	Upper Yukon	8	8	6	0	0	0	0	4	8	4	8	4
Traditional	Upper Yukon	4	4	0	0	0	4	4	6	8	4	4	4
McGrath	Kuskokwim	4	0	0	0	0	2	0	0	8	4	0	4
Nikolai	Kuskokwim	8	8	8	0	0	6	4	6	8	0	0	4
Stony River	Kuskokwim	4	8	4	0	0	0	0	4	8	0	4	6
Telida	Kuskokwim	6	6	6	6	6	6	4	8	4	4	4	4
Traditional	Kuskokwim	4	4	8	8	4	4	4	4	4	4	4	4
Sheep													
Dot Lake	Upper Tanana	0	0	0	0	0	0	0	8	8	0	0	0
Tanacross	Upper Tanana	0	0	0	0	0	0	0	0	8	0	0	0
Tok	Upper Tanana	0	0	0	0	0	0	0	8	4	0	0	0
Tetlin	Upper Tanana	0	0	0	0	0	0	0	0	0	0	0	0
Northway	Upper Tanana	0	0	0	0	0	0	0	0	0	0	0	0
Traditional	Upper Tanana	0	0	0	0	0	0	0	8	8	0	0	0
Bettles/Evansville	Koyukuk	0	0	0	0	0	0	0	8	8	0	0	0
Alatna/Allakaket	Koyukuk	0	0	0	0	0	0	0	8	8	0	0	0
Hughes	Koyukuk	0	0	0	0	0	0	0	8	8	0	0	0
Huslia	Koyukuk	0	0	0	0	0	0	0	0	0	0	0	0
Traditional	Koyukuk	0	0	0	0	0	0	0	0	6	2	0	0
Beaver	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Minto	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Steven's Village	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Tanana	Middle Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Traditional	Middle Yukon	0	0	0	0	0	0	0	0	8	0	0	0
Arctic Village	Upper Yukon	0	0	0	0	0	0	0	4	4	0	8	4
Chalkyitsik	Upper Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Fort Yukon	Upper Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Venetie	Upper Yukon	0	0	0	0	0	0	0	0	0	0	0	0
Traditional	Upper Yukon	0	0	0	0	0	0	0	2	4	4	6	8
McGrath	Kuskokwim	0	0	0	0	0	0	0	0	8	4	0	0
Nikolai	Kuskokwim	0	0	0	0	0	0	0	0	8	4	0	0
Stony River	Kuskokwim	0	0	0	0	0	0	0	0	8	4	0	0
Telida	Kuskokwim	0	0	0	0	0	0	0	0	0	0	8	8
Traditional	Kuskokwim	4	0	0	0	8	4	4	8	8	0	0	0

tabulation in the form of a two-way table of frequencies (Greenacre 2007:2)." Briefly, CA consists of determining a chi-square distance matrix for contingency table from row, column, and row/column profiles. The identified interpoint distances in each profile can be plotted in two-dimensional space against the centroid of the matrix. Following the same principles as principal component analysis (PCA), the x axis of the plot is rotated for proximity to the points. The result is that the x axis is able to account for the largest proportion of the variation, or inertia in CA, in the data matrix; successive dimensions explain less of this variability (Clausen 1998). Though uncommon in anthropology and other social sciences in the recent past, CA is now considered an extremely useful procedure for examining the underlying structure and associations in data; part of its usefulness derives from its ability to examine qualitative datasets (Beh 2008). In anthropology, CA has been used mostly biological anthropology (e.g., Coppa et al 1998; Irish 2005; Luca et al. 2007) and archaeology (e.g., Ramenofsky et al. 2009; Smith and Munro 2009; Smith and Neimen 2007), although CA is a potentially useful tool in many other anthropological applications.

Caribou hunting was a common activity in 14 of the 21 communities examined. As noted, no substantial caribou hunts occurred during the subsistence study at Bettles, Alatna, and Hughes; this does not reflect an absence of caribou hunting. Subsequent research at these villages shows that caribou hunting occurs in years when the animals are available in the area. Figure 3.6 and Table 3.10 detail the results of the correspondence analysis for the monthly caribou hunting efforts by village. The CA identified six interpretable dimensions which explain 25.8% of the variance; of this first two dimensions account for only 67.5% of the 25.8% of the total inertia. The X-axis mostly represents seasonality with winter and summer being on either end of the first dimension. The Y-axis represents hunting effort or intensity with low efforts occurring near the top of the graph and intensive efforts being lower in the second dimension.

It is immediately obvious that none of the villages are particularly similar to any of the traditional caribou hunting efforts and that the traditional efforts themselves are quite different. It is further apparent that all of the contemporary villages, with the exception of Ft. Yukon,

Table 3.10: Caribou Hunting Effort Dimensions and Their Associated Eigenvalues and Inertia.

Dimension	Inertia (Eigenvalue)	Chi Square	Sig.	Proportion of Inertia	Cumulative Proportion
1	.132			.513	.513
2	.042			.162	.675
3	.036			0.138	.813
4	.024			.092	.905
5	.018			.070	.975
6	.006			.025	1.000
Total	.258	80.592	.700	1.000	1.000

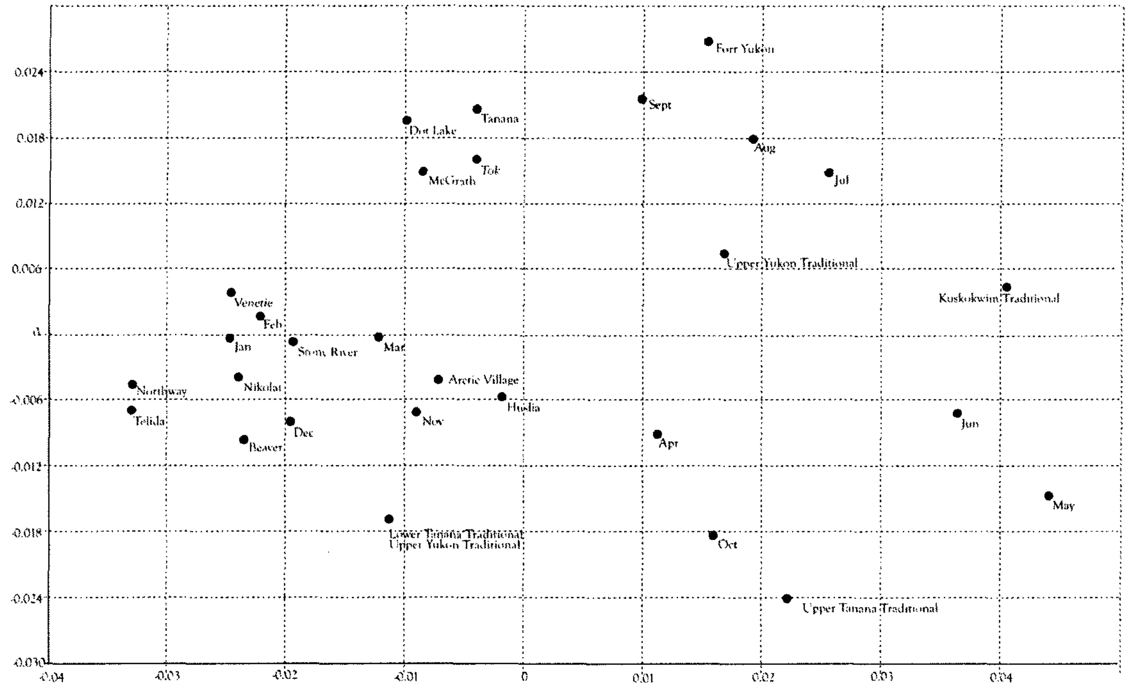


Figure 3.6. Correspondence Analysis of Seasonal Caribou Hunting of All Participating Study Villages and Traditional Hunting Seasons.

fall on the negative side of the first dimension and three of the five traditional measures for caribou hunting effort occur on the positive side of this same axis. The timing of state-sanctioned caribou hunts do not necessarily reflect traditional preferences or caribou availability mostly explain this disparity.

Despite the immediate dissimilarities in the figure, there are several subtle patterns. First, the cluster of villages including Tanana, Tok, Dot Lake, and McGrath is similar to the Upper Tanana traditional caribou effort in that they all share a two, noncontiguous seasonal caribou-hunting pattern. The only differences are in the intensity of the hunting and a slight shift in the seasons of hunting: Upper Tanana traditional caribou hunting centers closer to May and October, while those of the modern villages center closer to March and September. Huslia and Arctic Village both have long caribou hunting seasons spanning seven or more months a year. However, the effort level fluctuates; overall, both villages have fairly intensive caribou hunting efforts, particularly in the late fall and the middle of spring. The closest similarities, however, occur between the Middle Yukon/Koyukon Traditional hunting efforts and three clusters of contemporary villages including Northway and Telida in one group, Venetie, Stony River, Beaver, and Nikolai in a second group, and the Huslia and Arctic Village group discussed above. Moderate to intensive winter caribou hunting is the underlying link between these villages and the traditional effort. Overall, there is little correspondence between villages within a particular region with their associated caribou hunting traditions.

Fort Yukon remains an outlier well separated from the other contemporary villages and the all the traditional effort estimates. The comparatively low caribou hunting effort occurs in an off-season (summer). Villages with no documented caribou hunting effort in the subsistence studies include Tetlin, Bettles/Evansville, Alatna/Allakaket, Hughes, Minto, Steven's Village, and Chalkyitsik. Given that each geographic traditional system had some effort regarding the harvest of caribou, these cases are disparate. Again, this partially relates to sampling bias as it pertains to resource availability during the subsistence studies.

Moose hunting effort occurs in all the contemporary villages as well in each of the traditional subsistence rounds; however, the level of effort varies considerably. The effort ranges from a low of 8 at Dot Lake to a high of 64 at Telida, an eight-fold increase. As noted in Chapter 3, the low effort at Dot Lake reflects a very short state sanctioned hunting season during the course of the subsistence study. Traditional moose hunting efforts vary between 32 in the Middle

Yukon and Koyukon area and 64 in the Upper Tanana region. Table 3.11 contains the dimensions, eigenvalues, and inertia calculated during the correspondence analysis. The first three dimensions explain approximately 88.7% of the total inertia (81.7%) in the dataset. In Figure 3.6, the time of year progresses, more or less, from left to right (x-axis) and hunting intensity, or effort, increases from top to bottom along the y-axis.

The majority of contemporary and traditional cases group on the left side of Figure 3.7, which represents limited hunting seasons occurring in fall and winter. The effort of these cases, however, shows substantial variation. The most intensive hunting effort occurs three villages in the Upper Yukon region (Arctic Village, Venetie, and Chalkyitsik), three villages in the Koyukon area (Bettles, Alatna, and Hughes), and Stony River Village in the Kuskokwim region. These contemporary villages are closely associated with the traditional hunting efforts and seasonality of the Middle Yukon and Koyukuk regions. Together these efforts can be interpreted as intensive, winter and fall hunting.

Table 3.11: Moose Hunting Effort Dimensions and Their Associated Eigenvalues and Inertia.

Dimension	**Eigenvalue**	**Chi Square**	**Sig.**	**Proportion of Inertia**	**Cumulative Proportion of Inertia**
1	.479			.586	.586
2	.150			.183	.769
3	.097			.119	.887
4	.050			.061	.948
5	.035			.042	.990
6	.008			.010	1.000
Total	.817	153.637	.000	1.000	1.000

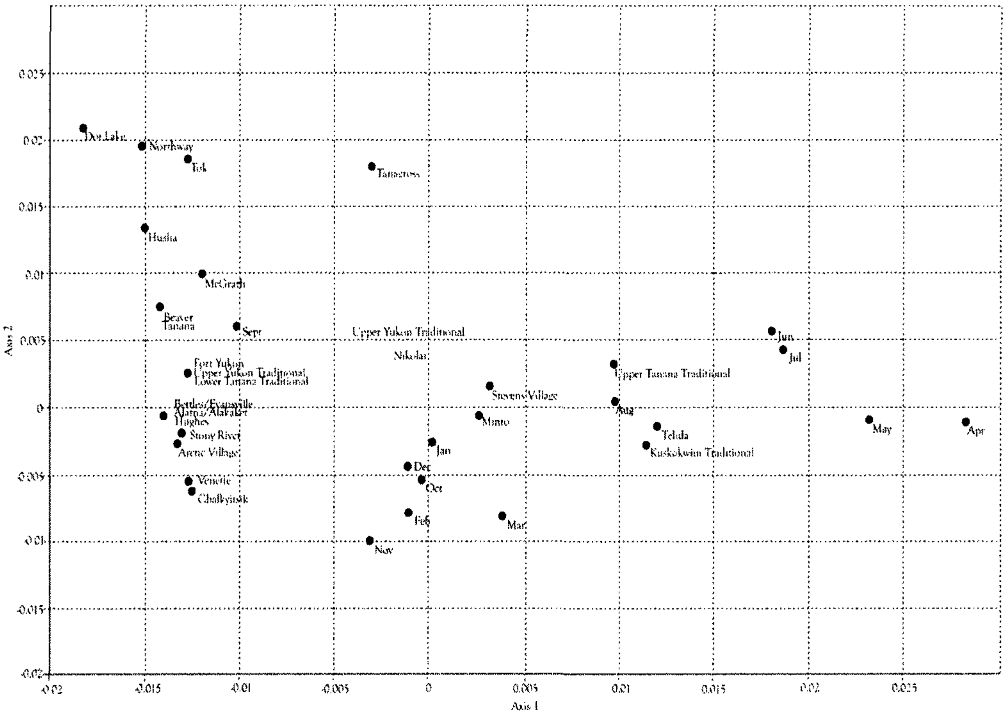


Figure 3.7. Correspondence Analysis of Seasonal Moose Hunting of All Participating Study Villages and Traditional Hunting Seasons.

The villages of Tanana, in the Middle Yukon Region, and Tetlin, in the Upper Tanana region, are very similar to the previous group, though the hunting seasons are either longer or encompass three seasons. Moose hunting effort in these two villages is also intensive. Huslia, McGrath, and Beaver villages have long two to three season moose hunting efforts, though the intensity of the effort is substantially lower than in either Tetlin or Tanana. The least intensive and shortest efforts are limited to three villages in the Upper Tanana region including Dot Lake, Northway, and Tok. Relative to other villages the yearly effort in moose hunting is low, but during the short legal moose-hunting season, the hunting is very intensive. The Upper Tanana village of Tanacross shares a similar effort level with its neighboring villages, but the effort extends over a greater period of time represented by at least two seasons.

Moderate to Intensive multi-season hunting efforts are limited to the modern village of Nikolai in the Kuskokwim region and the traditional hunting efforts of the Upper Yukon Athabascans. Year-round, or nearly year-round, moose hunting efforts occur in three villages and two traditional subsistence harvests. The contemporary villages include Steven's Village and Minto, which have moderate hunting efforts, and Telida, which has a more intense hunting effort.

The traditional moose subsistence efforts, which are most closely associated with those at Telida, include those from Upper Tanana and Kuskokwim.

With the exception similarities between Telida and traditional Kuskokwim moose hunting, and similar ties between the Koyukuk area and three of its associated villages, there is a great disparity between past and present moose hunting efforts and seasonality. The greatest overall difference is with the Upper Tanana villages. These villages, particularly Dot Lake, Tok, and Northway, are the most dissimilar from their traditional practice of any of the villages. Although the hunting effort seasons have altered slightly through time, most of the Kuskokwim villages in the study maintain a moderate to intensive moose hunting effort; this same observation transfers directly to the villages in the Middle Yukon region. Moose hunting efforts among the contemporary villages of the Upper Yukon area appear to be shorter, but more intense, than they were in the past.

Fewer contemporary villages participate in sheep hunting than in either moose or caribou hunting despite the fact that in each traditional region there is some evidence of hunting this resource. Villages in the sample that did not hunt sheep during the subsistence studies conducted by the ADF&G include Tetlin, Northway, Huslia, Beaver, Minto, Steven's Village, Tanana, Chalkyitsik, Fort Yukon, and Venetie. The remaining 11 villages participated in sheep hunting at some level. Based on the effort estimates, the traditional sheep hunting effort varies between 8 and 32 and contemporary village efforts vary between 8 and 20. The correspondence analysis resulted in the identification of seven dimensions that explain the variability in the sheep hunting data; the first three dimensions represent 94% of the total inertia (38.8%) (Table 3.12). As with moose and caribou, the first two dimensions in Figure 3.8 are easily interpretable by yearly position of the hunting effort (x-axis) and the intensity of the hunting effort (y-axis).

Among the three datasets considered thus far, the sheep hunting correspondence shows the greatest congruency between the contemporary and traditional hunting efforts, as well as relatively tight clustering of most of the cases. The two most noticeable outliers include Telida and the Kuskokwim traditional efforts. The traditional Kuskokwim sheep hunting effort estimate is very different from most of the contemporary villages it includes, in particularly Telida. The traditional Kuskokwim effort includes a sustained moderate to intense sheep hunting effort throughout the summer and fall and a moderate effort in the middle of winter. Telida, on the other hand, has an intense hunting effort in very late fall and early winter. The other Kuskokwim villages, including McGrath, Nikolai, and Stony River, have moderate to intense hunting efforts

Table 3.12: Sheep Hunting Effort Dimensions and Their Associated Eigenvalues and Inertia.

Dimension	**Eigenvalue**	**Chi Square**	**Sig**	**Proportion of Inertia**	**Cumulative Proportion**
1	.309			.796	.796
2	.057			.147	.943
3	.019			.050	.993
4	.003			.007	1.000
Total	.388	120.594	.012	1.000	1.000

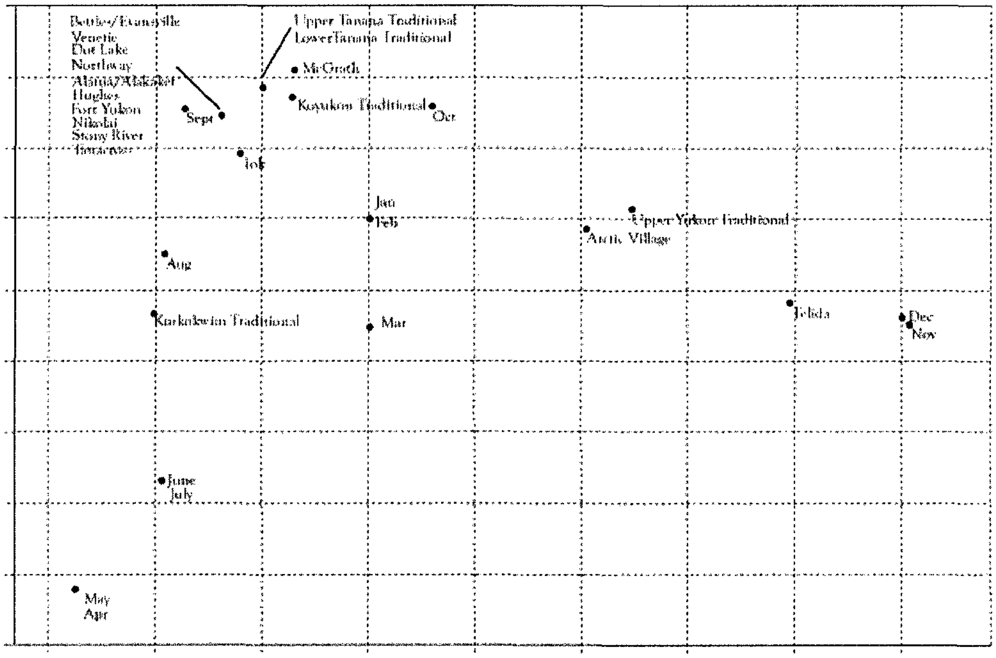


Figure 3.8. Correspondence Analysis of Seasonal Sheep Hunting of All Participating Study Villages and Traditional Hunting Seasons.

during the early or middle fall period. Arctic Village and its associate Upper Yukon traditional effort are very similar in intensity and timing. The remaining contemporary villages and traditional efforts fall in the upper left of Figure 3.8. Hunting efforts in these cases are moderate to intense, though the hunting seasons are brief, lasting only a month or two.

The efforts extended to the acquisition of large terrestrial mammals are insightful, but cannot be reasonably interpreted in isolation from the remainder of the subsistence effort. The inclusion of the remaining primary subsistence efforts, mainly efforts extended towards fish, small game (not including trapping), bears, and fowl, into the analysis allows a more holistic understanding of changes through time in the subsistence cycle and how these efforts affect the hunting of the larger animals. Using the same effort calculations for monthly efforts for large mammals, the yearly effort for each subsistence resource class is calculated (Table 3.13). Several of the groups contain multiple, but related, animal groups. For example, the fowl category includes both water and terrestrial fowl (ducks, geese, swans, ptarmigan, and grouse) and the fish category lumps both anadromous and nonanadromous species.

The total yearly traditional efforts range from a low of 258 in the Koyukuk region to a high of 400 in the Upper Tanana region. In the contemporary village dataset, the range is from 219 at Fort Yukon to 382 at Stony River. With the exception of Stony River, most of the contemporary villages fall within the range of the traditional efforts. It is possible that the Fort Yukon subsistence round, with its long and direct association with a substantial regional trading post, more quickly shifted to trapping and a currency economy to meet subsistence needs. Such economic changes may also partially explain the dramatic drop in hunting efforts in the Upper Tanana region. Here the establishment of the Alaska Highway, and its usefulness a transportation corridor for substantial nonlocal resources, has more profound effects on the local economy than the more remote regions considered in this study. In the more remote communities, those defined as not being connected to the major Alaska road system or those beyond the ground-based transportation system outside the major population centers, appear to have subsistence efforts that are higher in the contemporary period than in the recent past.

The correspondence analysis resulted in the identification of six dimensions that explain 15.7% variability in the dataset; the first three dimensions explain 78.3% of the total inertia (Table 3.14). The first two dimensions, however, are not as readily interpretable as those

Table 3.13. Effort Estimate per Resource per Year.

Village/Resource	Caribou	Moose	Sheep	Bear	Small Game	Fish	Fowl	Total
Upper Tanana								
Dot Lake	40	8	16	16	70	48	36	234
Tanacross	16	20	8	20	72	56	44	236
Tok	32	12	12	32	80	68	52	288
Tetlin	0	33	0	0	84	88	64	269
Northway	24	10	0	56	88	68	52	298
Traditional	32	64	16	32	96	96	64	400
Upper Koyukuk								
Bettles/Evansville	0	32	16	44	80	64	84	320
Alatna/Alakaket	0	32	16	44	80	64	84	320
Hughes	0	32	16	44	80	64	84	320
Huslia	48	12	0	64	96	48	88	356
Traditional	24	32	8	22	64	84	24	258
Lower Tanana-Middle Yukon								
Beaver	36	22	0	38	92	66	82	336
Minto	0	62	0	40	44	60	40	246
Steven's Village	0	59	0	56	56	60	93	324
Tanana	29	27	0	34	80	58	82	310
Traditional	24	32	8	24	64	84	40	276
Upper Yukon-Porcupine								
Arctic Village	70	36	20	0	80	64	28	298
Chalkyitsik	0	48	0	35	80	57	34	254
Fort Yukon	10	48	0	35	38	44	44	219
Venetie	24	50	0	28	74	58	35	269
Traditional	56	42	24	23	62	57	50	314
Middle Kuskokwim								
McGrath	13	22	12	31	64	74	26	242
Nikolai	38	52	12	40	96	58	54	350
Stony River	44	38	12	60	72	88	68	382
Telida	40	64	16	46	58	64	50	338
Traditional	36	56	36	8	48	60	52	296

Table 3.14. Hunting Effort Dimensions and Their Associated Eigenvalues and Inertia.

Dimension	Eigenvalue	Chi Square	Sig.	Proportion of Inertia	Cumulative Proportion of Inertia
1	.067			.426	.426
2	.035			.224	.650
3	.021			.133	.783
4	.020			.127	.911
5	.010			.062	.973
6	.004			.027	1.000
Total	**.157**	**1216.9**	**.000**	**1.000**	**1.000**

described above. In Figure 3.9, the x-axis represents the reliance on large game and small game resources or alternatively the relative effort extended to the procurement of large and small game. The y-axis is rather complicated but reflects the number of resource groups exploited by effort. The center of the y-axis represents relatively even efforts for all resource categories. The positive area along the axis represents fewer resource groups but a higher number of smaller resources. In the negative area of the axis, the number of resources also drops but there is a preference for larger resources. Given the distribution of cases in the y-axis, it is likely that the z-axis represents the number of resource or resource groups hunted.

Starting with the negative portion of the x-axis in Figure 3.8, the Upper Yukon traditional effort represents a subsistence effort centered nearly equally on small (particularly small game and fish) and large resources (particularly caribou and sheep). Although not closely associated, the Arctic Village subsistence effort falls in the same general description. Dot Lake is similar to Arctic Village in many regards, but the restricted moose hunting efforts and relatively limited fishing effort pushes the village slightly closer to a primary reliance on small game and caribou. The last case on the negative side of the x-axis is the Kuskokwim traditional effort, which is a combination of large and small game efforts; for the large resources efforts focus on focused on sheep and moose, though caribou efforts are still relatively high.

Based on these interpretations of the dimensions that explain three-quarters of the inertia, it is clear that the Upper Tanana, Koyukon, and Middle Yukon traditional efforts focus on the smaller resources, and secondly on large mammal hunting. Contemporary village efforts that fall into this same grouping include Tanacross, Stony River, Nikolai, McGrath, Venetie, and Telida. A loosely associated cluster of cases that rely primarily on small game resources and secondarily on moose include the contemporary villages of Tetlin, Chalkyitsik, Fort Yukon, Steven's Village,

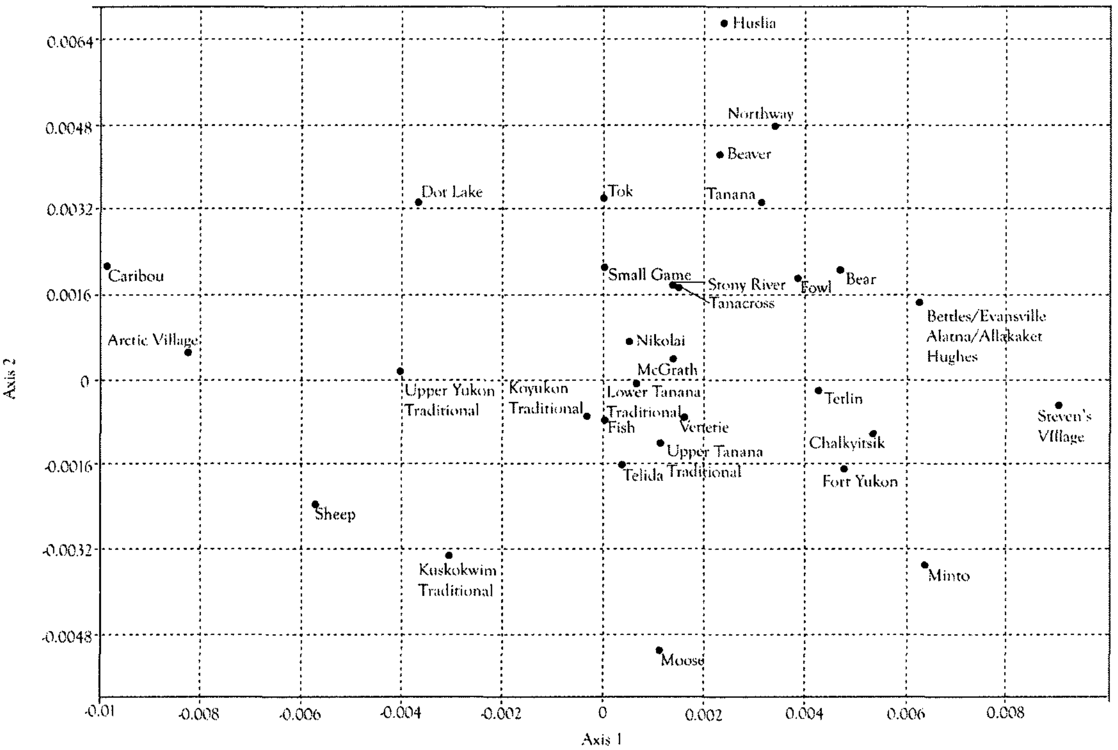


Figure 3.9. Correspondence Analysis of Yearly Hunting Effort by All Study Villages and Traditional Hunting Seasons for Caribou, Moose, Sheep, Small Game, Fowl, and Fish.

and Minto. While none of these villages have caribou or sheep hunting efforts, they are variable in the types of the resources where the greatest efforts are extended. The final cluster of cases occurs in the upper right hand quadrant of the correspondence map. Here the villages of Huslia, Northway, Beaver, Tok, Tanana, Hughes, Bettles/Evansville, and Alatna/Allakaket form a loose association where small game resource efforts are high and there is some effort placed on two large mammal resources, either moose and sheep or moose and caribou.

Discussion

Taken as a whole these correspondence analyses demonstrate that there is little cohesion between traditional and contemporary hunting efforts within any particular region. There are, however, exceptions. The first major exception is sheep hunting effort. Relative to moose and caribou, there is a strong correspondence spatially and temporarily among the villages that participate in sheep hunting in regards to seasonality, temporal stability of the practice, and regional consistency. Sheep distributions throughout Alaska are much more restricted than either moose or caribou resulting in a strong geographical bias in the villages that have access to this resource and those that do not. However, the simple presence or accessibility of sheep does not necessarily dictate their utilization in any given contemporary village. In the Upper Tanana region, where a road system exists that can take hunters quickly to areas where sheep occur in abundance, four of the five villages in the study actually reported sheep hunting activities. The village of Tetlin, though near excellent sheep range, did not utilize this resource.

The consistency in the seasonality of sheep hunting, almost always during the fall, appears to be present in the past as well as in the present, making it unlikely that modern hunting laws have substantially affected this diachronic patterning. There is little direct information presented in the ethnographic literature to why sheep hunting occurred in the fall, but indirectly it appears to be related to the dramatic decrease in more stable resources, particularly fish runs, as the winter season approaches and the physical condition of the animals.

Moose hunting efforts, on average, are higher than those for caribou across most of the cases considered here. As noted in Chapter 2, the prehistoric use of moose has been questioned, but it is clear that moose was an important subsistence resource in the recent past, as well as today. The seasonality of moose hunting and the effort extended varies greatly not only between regions, but also within them. In some cases, such as Dot Lake, the timing and effort of moose hunting is not dictated by choice, but rather by state hunting regulations.

The closest correspondence between contemporary and traditional moose hunting efforts and seasonality is between the three farthest Koyukon River villages and the traditional Koyukuk practices. This may be somewhat misleading as the exact same subsistence round is used for Bettles, Alatna, and Hughes (Marcotte and Haynes 1985:35 & 49). When interpreted as an average, however, it is safe to assume that this grouping is real, though the exact correspondence may differ slightly. The only other close correspondence is between the village of Telida and the traditional Kuskokwim River area effort and seasonality. In this example, both cases represent year-round intensive moose hunting efforts, a property that is also shared by the Upper Tanana traditional moose hunting practices.

While the Upper Tanana and Kuskokwim moose hunting efforts are similar, the relationship between the villages in the Upper Tanana area and their traditional effort are the most divergent of entire data set. All five Upper Tanana villages show lower intensity of effort, more pronounced seasonality or both. This divergence occurs in other villages. In all, 11 of the sample villages do not cluster with any traditional effort. These communities include Dot Lake, Northway, Tok, Tanacross, Huslia, McGrath, Beaver, Tanana, Tetlin, Steven's Village, and Minto. Villages associated with traditional efforts other than their own include Arctic Village, Venetie, Chalkyitsik, Stony River, Nikolai, and Fort Yukon. The grouping of three of the Upper Tanana villages and all the Upper Yukon villages suggest that, while not closely associated with their traditional efforts, there is still some geographical cohesion. Although conditioned by hunting regulations, the congruent seasonality of these may allow for inter-village cooperative efforts between extended families or hunting partnerships.

The correspondence analysis of the caribou hunting effort shows the most disparity between contemporary and traditional hunting efforts, seasonality, and geographical cohesion. The most telling aspect of the correspondence is the near complete separation between the traditional efforts, which primarily fall on the right side of the plot, and the contemporary efforts, which occur opposite the same graph. There are several explanations for this large separation in Euclidean space including hunting regulations and changes in the seasonality and timing of resource availability. The closest correspondence between contemporary and traditional caribou hunting efforts is between Huslia and the Koyukuk tradition. Even within particular geographical regions within the interior, there is little correspondence among closely associated villages and communities. The closest geographical correspondence tie is between the Upper Tanana communities of Tok and Dot Lake. However, these two communities occur farther away from the communities of Northway and Tanacross than most other intraregional communities in the sample. Another example is the small distance between Telida, Stony River, and Nicolai and the large distance between these three communities and the regional hub of McGrath. There are several explanations for this variation including hunting regulations, changes in the resource seasonality, the timing of resource availability, increased sedentism, and the ability to get to hunting areas.

The yearly effort correspondence analysis confirms the general ethnographic observations that, while there is a general preference for the large mammals, smaller resources, including fish, small game, and fowl form the staples of the subsistence requirements. The central location of fishing efforts relative to both the vertical and horizontal axes and its proximity to three of the five traditional subsistence efforts suggests that this resource was extremely important in the past. The clustering of these three traditional subsistence rounds also suggests that through a large portion of the Alaskan Interior, the annual subsistence efforts were fairly predictable across multiple regions. In these cases, fish served as the main subsistence focus, followed by small game, and finally large game. The two outliers, namely the Upper Yukon and Kuskokwim traditions, and their positions in the correspondence analysis suggest that fish and large game were more or less equally important and that smaller game formed a smaller part of the overall subsistence effort.

The dispersal of modern communities within this matrix reveals that relative to their respective traditional subsistence efforts, there is little patterning. However, several contemporary and traditional efforts cluster around the center of the correspondence space; within this area are all of the contemporary Kuskokwim villages as well as the villages of Tanacross and Venetie. If we construct an imaginary polygon that completely encompasses all the resources, the community of Arctic Village and the two remaining traditional efforts, the Upper Yukon and the Kuskokwim, would also be included in his cluster. The remaining 14 modern communities, or two-thirds of the sample, fall outside this area indicating that relative to the traditional resource base, either there are resources that are not exploited or that the hunting efforts are substantially different.

CHAPTER 4.

MEASURING LAND USE BY THE HUNTERS AND THE HUNTED

Introduction

As described previously, this dissertation centers on quantifying the structure and composition of large mammal and contemporary hunting ranges in order to elucidate late prehistoric land use practices in the Wiki Peak area of the Wrangell-St. Elias National Park and Preserve. This chapter presents methods and procedures used to classify, analyze, and examine these landscapes. Focusing on the GIS data, methods, and techniques used to construct and analyze each landscape. Details for specific statistical tests (e.g. t-tests, analysis of variance, etc.) and other analyses (e.g. resemblance analysis) follow in additional chapters in which different landscapes are compared.

Harvest Areas

This section describes the compilation of the harvest area data for each community previously described and the development of a geospatial database used in the analysis of landscape structure. Ultimately all the harvest area data for moose, sheep, and caribou comes from the subsistence studies, but compiling them took two forms. First, electronic data and hard copy maps of all the study villages were acquired the Alaska Department of Fish and Game. The electronic data were acquired for the villages of Alatna, Bettles, Hughes, Dot Lake, Northway, Tanacross, Tetlin, and Tok. ADF&G supplied blue-line copies of harvest areas for the villages of Huslia, Stony River, Beaver, Minto, Steven's Village, and Tanana. Data for McGrath, Nikolai, Telida, Arctic Village, Chalkyitsik, Fort Yukon, and Venetie were not available. In these cases, the maps in the subsistence reports were scanned and converted into tagged image format files (tiffs) and the scanned images georectified using the i.rectify function in GRASS GIS. Heads-up digitizing to create the shape files for these hunting ranges was used and where the subsistence studies present the harvest areas on a much reduced scale versions of 1:250,000 scale topographic maps, the correcting and digitizing was fairly straightforward and digitizing error was minimal. However, the presentation of harvest areas for Telida, McGrath, and Nicolai are simple line maps. Though the digitizing error parameters were met, these harvest areas likely have slightly more digitizing error than any of the other harvest areas.

Digitizing of the supplied large format blue-lines obtained from the ADF&G followed the same general procedure. All hard copy maps were digitized with a GTCO Super L V1 Series digitizing table from ArcView 3.3 running the Digitizer extension (v. 3.2). The root-square mean error (RMS) was set to 0.004; at least six control points were selected for each map. The stream tolerance level was set to 250 meters. Since most of the subsistence data were mapped on 1:250,000 USGS topographic quadrangles, these maps were used as the base map allowing for relatively quick and low error digitizing. All base maps were projected in NAD 27, UTM, and meters; the zone varied according to location within the state. Only the harvest areas for moose, sheep, and caribou were digitized. GIS layers were created for each type of harvest area by species hunted, quadrangle, and UTM zone. After digitizing was complete, all the data were reprojected into an Alaska-centric Albers Equal Area Conic projection (Clarke 1866 Spheroid, central meridian = -154, reference latitude = 50, first parallel = 55; second parallel = 65, false easting and northing = 0), the layers merged by harvest area and species, and the data were cleaned using standard methods. Individual species harvest area layers were created for each village.

Caribou, Moose, and Sheep Distributions

The digitizing methods and compilation procedures for the moose, caribou, and sheep distributions were identical to those used for the harvest areas. The distribution data were obtained from the *Alaska Wildlife and Habitat* atlas (ADF&G 1973). Prior to digitizing the distribution maps, it was necessary to photocopy each relevant map from the atlas. Although great care was taken to flatten maps and limit the amount of distortion inherent in copying, it was necessary to digitally rectify several of the maps and utilize heads-up digitizing to meet the RMS error level obtained for the majority of the digitizing. GRASS' *i.rectify* and linear affine transformations were used for this procedure; control points were determined from the corresponding 1:250,000 USGS topographic quadrangles.

While the Atlas is short in detail concerning the data acquisition methods used in determining wildlife distributions, for many species, particularly moose and caribou, seasonal distributions are very detailed. This level of detail was maintained in the digitizing and coded into the geospatial database. For caribou, coding included common distribution (presence/absence), summer range, winter range, and calving areas. In many instances, arrows on the maps indicate seasonal caribou migration routes; this data were not digitized and is not considered here. For moose, distribution types included the common distribution, spring and summer range, fall range, winter range, or some combination of two or more of the seasonal ranges. The Dall's sheep distributions contained no data on seasonal variation.

After digitizing, merging, cleaning, and reprojecting, individual layers for the distribution of the three species, the ranges were clipped for each study area. For this purpose, the study area consists of all the one degree quadrangles that cover all the hunting ranges for the regional communities included in this dissertation (Table 4.1).

Topographic Position Index

The Topographic Position Index (TPI) serves as one of two mosaics from which landscape level comparisons are made. In general, the final result of calculating a TPI is a landform classification scheme (Weiss 2001). The TPI calculates the elevation position of a pixel, or a specified set of pixels, in a digital elevation model (DEM) relative to all other pixels within a specified neighborhood surrounding it. By combining a small neighborhood's and a large neighborhood's TPI values via a simple algorithm, a new grid is generated that classifies pixels into a set of landforms. As used here, landform is "any physical feature on the earth's surface, having a characteristic shape, and produced by natural causes (Soil Science Society, www.soils.org)." In these regards, the TPI is equivalent to Butzer's (1982: 58) topographic matrix, even if the classification scheme is different.

Relative to the land cover data described below, certain landforms are considerably more stable through time (Waters 1992), and of course this too is scale-dependant. With the exceptions of extremely geologically active regions and large scale, human-induced change (agricultural leveling, urbanization, mining subsidence, etc,), landforms are often a stable feature of any given landscape. Furthermore, landforms strongly influence ecological and hydrological patterns in a landscape (Butzer 1982: 61-63; Judex et al. 2006:184; Turner et al. 2001:80-83), making them extremely useful in archaeological studies where time obscures all but the most generalized ecological matrices.

As described by Weiss (2001) the use of a TPI, calculated at multiple scales, a landscape can be classified by both slope position and a predefined set of landform categories. The classification of a particular pixel in a grid, in this case a DEM, is relative to the surrounding pixels at two different scales. A user-defined algorithm identifies relative changes in elevation

Table 4.1. Study Area Definitions

Region	**Communities**	**USGS One Degree Quadrangles**	**Total Area (Ha)**
Koyukuk Study Area	Alatna Bettles Hughes Huslia	Survey Pass, Wiseman, Shungnak, Hughes, Bettles, Kateel River, Melozitna[1]	10,433,729 Ha
Kuskokwim Study Area	McGrath Nikolai Stony River Telida	Ophir, Medfra, Mt. McKinley, Iditarod, McGrath, Sleetmute, Lime Hills	13,963,615 Ha
Lower Tanana Study Area	Beaver Minto Steven's Village Tanana	Beaver[1], Fort Yukon[1], Melozitna[1], Tanana, Livengood, Circle, Ruby, Kantishna River, Fairbanks	12,867,528 Ha
Upper Tanana Study Area	Dot Lake Northway Tanacross Tetlin Tok	Big Delta, Eagle, Mt. Hayes, Tanacross, Gulkana, Nabesna	9,988,731 Ha
Upper Yukon Study Area	Arctic Village Chalkyitsik Ft. Yukon Venetie	Phillip Smith Mountains, Arctic, Table Mountain, Chandalar, Christian, Coleen, Beaver[1], Fort Yukon[1], Black River	12,017,651 Ha

[1] Areas that overlap between two different study areas. Despite the correspondence between some of the areas, the hunting ranges used to define the study areas are independent.

of a target pixel and its neighbors, and in some instances its slope position, at each scale considered. For any given point in a grid two different relations are calculated. Compared with its neighbors, a point may be higher, lower, or similar in elevation. At a larger scale, the pixel is compared with its neighbors only a short distance away, while at the smaller scale a large areal unit is considered. Likewise, a particular pixel can be examined in regard to its slope position (steepness) and the slope positions of its neighbors. Each pixel is then assigned a particular TPI value of a standardized unit reflecting its elevation position in relationship to the surrounding pixels; commonly, standard units fell between –160 and 265.

Utilizing the small-scale and large-scale neighborhoods, the classification algorithm compares the value of each pixel and places it in an appropriate landform category. The TPI generation used in this research follows the original 10-class system defined by Weiss (2001) and modified by Jenness (2006). Table 4.2 presents the classification criteria of this system. Here the Topographic Position Index ver. 1.3a ArcView 3.x extension written by Jenness (2006) and based on Weiss' (2001) original concepts and general algorithms is used. However, before the TPIs could be calculated, it was necessary to prepare the base DEMs.

One-degree DEM models, obtained from the Alaska Geospatial Data Clearinghouse (http://agdc.usgs.gov/data/usgs/geodata/dem/250K/dem1deg.html), served as the base grids for the TPI generation. Because of edge masking effects in the TPI extension, it is necessary to create overlapping borders between a target DEM and its surrounding neighbors in order to fully evaluate an entire composite DEM. The DEM for each one-degree quadrangle was loaded into Global Mapper (v. 4.74), along with its surrounding neighbor DEMs. A 2500 meter buffer was placed around the target DEM and a new composite DEM was created and exported (Figure 4.1).

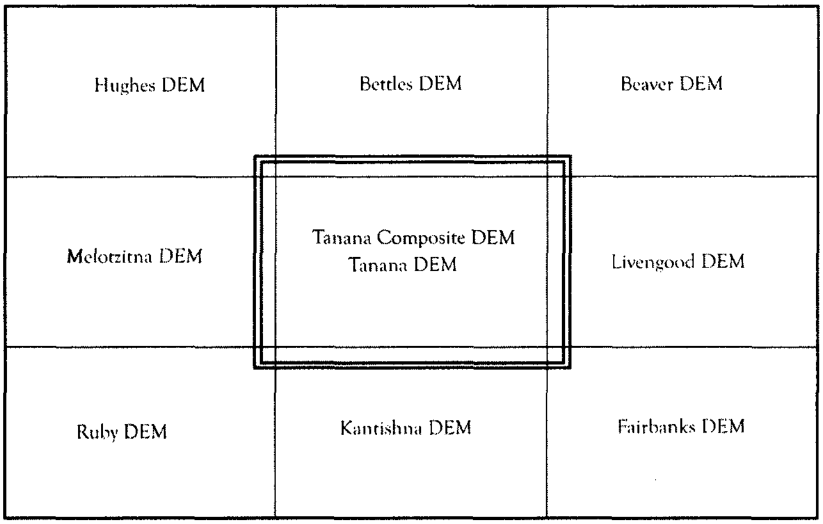


Figure 4.1. Example of a Composite DEM consisting of the target DEM (Tanana) and its eight surrounding neighbors.

Table 4.2. Topographic Position Index 10-Class Landform Classification Scheme

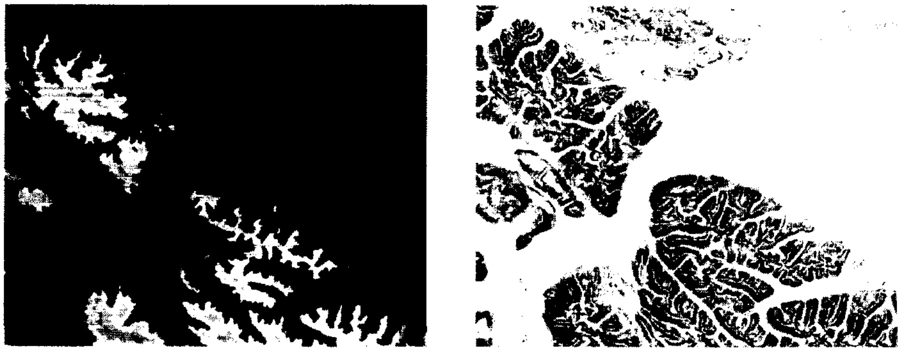
Landform	Small Neighborhood TPI	Large Neighborhood TPI	Slope (degrees)
Canyon, Deeply Incised Stream	TPI ≤ -1	TPI ≤ -1	N/A
Midslope Drainage/Shallow Valley	TPI ≤ -1	-1 < TPI < 1	N/A
Upland Drainage/Headwater	TPI ≤ -1	TPI ≥ 1	N/A
U-Shaped Valley	-1 < TPI < 1	TPI ≤ -1	N/A
Plain, Small	-1 < TPI < 1	-1 < TPI < 1	≤5
Open Slope	-1 < TPI < 1	-1 < TPI < 1	>5
Upper Slope/ Mesa	-1 < TPI < 1	TPI ≥ 1	N/A
Local Ridge/Hill in Valley	TPI ≥ 1	TPI ≤ -1	N/A
Midslope Ridge/Hill in Plain	TPI ≥ 1	-1 < TPI < 1	N/A
Mountain Top/High Ridge	TPI ≥ 1	TPI ≥ 1	N/A

Calculating the large area neighborhood for the TPI (see below), then, effectively masked the composite DEM to the original size of the target DEM.

After importing each composite DEM into ArcView, the necessary slope grid was generated utilizing the ArcView Spatial Analyst extension (Figure 4.2a and b). Small and large neighborhood TPIs were calculated at 500 and 2500-meter radii, respectively (Figure 4.2c and d); the shape of the neighborhood was a circle. The extended buffer for each TPI grid was clipped leaving a complete land classification that corresponds exactly to the edges of the one-degree elevation model (Figure 4.2e). Individual TPI grids were merged together to form the landscape mosaic for each study area. To facilitate using the data in ArcView GIS 3.3 and for the sake of consistency with the other vector data generated from digitizing animal distributions and hunting ranges, the raster TPI coverages were converted to vector data.

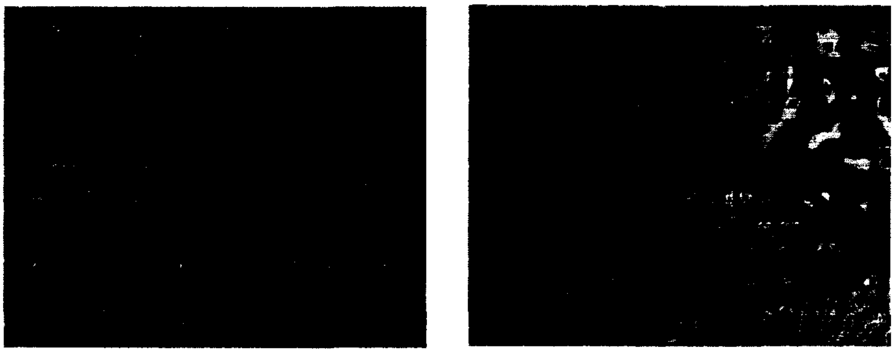
Landscape Metrics

To aid in comparisons between different uses of hunting territories among the different villages, and to compare these landscapes with one another and the general distribution of the animals hunted, the areas are quantified using a set of landscape metrics derived primarily from landscape ecology and richness and diversity indices. As this is essentially an exercise in pattern recognition, species- specific landscapes are constructed and quantified via a basic set of



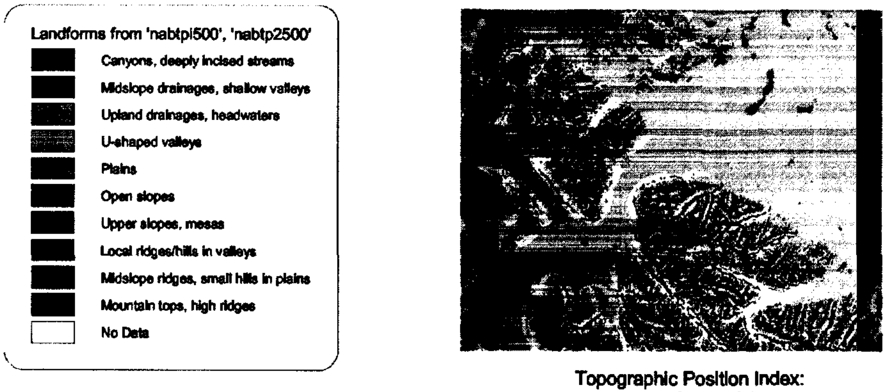
DEM (a)

Derived Slope (b)



Small Neighborhood Slope Index (250,000m2)
(c)

Large Neighborhood Slope Index (6,250,000m2)
(d)



Topographic Position Index:
"Landforms" (e)

Figure 4.2. Example of the TPI generation process from a small portion of the Nabesna One Degree Quadrangle including a sample of a DEM (a) and a slope coverage derived from it (b), small and large neighborhood indices (c and d, respectively), and the final TPI showing the derived landforms (e).

landscape metrics. The metrics of both the landscape and class levels are calculated, though there is no change in scale, grain, or resolution. As is apparent in the equations for the metrics given below, the landscape level metrics measure the overall structure of an area regardless of the different patch types; the landscape level equations consider the area (patch), perimeter (edge), and shape of all patch types. The class level metrics address the structure of individual patches, in this case landforms, but also allow for examining the composition of patches within a landscape. In following chapters, a standard suite of vector-based landscape metrics available in Patch Analyst (ver. 3) extension for ArcView 3.x is presented. The Patch Analyst extension is essentially an ArcView compatible version of the FragStats software commonly used in landscape ecology studies. Though limited in the number of metrics relative to FragStats, Patch Analyst provides for the most common landscape metrics at the class and landscape level.

Landscape Metrics Introduction

In landscape ecology, landscape metrics serve as the foundation for identifying and quantifying landscape structure and composition. Geographers and landscape ecologists have developed hundreds of landscape metrics (Gustafson 1998; Haines-Young and Chopping 1996; McGarigal and Marks 1995; Riiters et al. 1995; Wickham and Norton 1994), but many of these metrics are correlated and may not necessarily be measuring different qualities of a landscape; instead they often provide redundant information about landscape patterns (Riiter et al. 1995; Turner et al. 2001:107). Redundant and correlated metrics have some applicability to this study insofar as meeting the assumptions of various statistical analyses used, in particular in the discriminant function analyses. However, at a general descriptive level redundancy is not necessarily an evil. For example, two edge metrics, total edge and edge density, calculated in this study are typically redundant; however, because the sizes of the study areas are different, interpreting differences in the total edge of each study area is meaningless. The edge density, thus, provides a meaningful metric for interregional comparisons. Based on the data presented in Chapters 5 and 6, the edge density and patch density are also highly correlated. Though qualitatively interpreted separately, these two measures are not included together in any of the statistical analyses where their correlation would violate an assumption of the test.

Landscape metrics are useful for quantifying landscape structure and composition at three general levels including an individual patch, all the patches of a particular class, and all the patches in a particular landscape. Forman and Godron (1986:11) define structure as "the spatial relationships among distinct ecosystems or elements present—more specifically, the distribution of energy, materials, and species in relation to the sizes, shapes, numbers, kinds, and configurations of the ecosystems." As used here, structure specifically refers to the relationship between particular species and the landscape composition in regards to its "elemental" composition. I have dropped the ecosystem concept in lieu of focusing on animal distributional ranges and human hunting ranges, which can be defined as landscapes.

There are essentially two classes of landscape metrics including those that measure composition and those that measure configuration. As noted, metrics measuring different qualities of a landscape are not necessarily mutually exclusive and many metrics are correlated. Three types of metrics including area, edge, and shape are used here. Area metrics focus on quantifying patch size characteristics, such as mean, median, and largest patch size, patch density, and number of patches, useful in quantifying landscape composition. Also useful in examining composition, diversity, richness, and evenness indices provide a means for comparing different landscapes. Edge metrics, likewise, also measure landscape composition, but instead of relying on patch area, the perimeter of patches, classes of patches, or the cumulative perimeter of all patches in a landscape, are the basic unit of measurement in these metrics. Unlike the area metrics, edge metrics fall in the configuration realm, though edge metrics are not spatially explicit (McGarigal and Marks 1995:30). Shape metrics also fall into the configuration class of metrics. In general, shape metrics quantify the shape complexity of a patch or set of patches, commonly relative to a fixed standard, such as a square or a circle.

All the following landscape metric definitions come from McGarigal and Marks (1995). To eliminate redundancy, notations for subscripts and symbols are presented only the first time they occur in the following equations and not where they occur subsequently.

Patch Metrics

The area at the landscape level, or the total landscape area (TLA), is simply the area of the landscape, however defined, stated in hectares. It is calculated as

$$TLA = A\left(\frac{1}{10{,}000}\right) \qquad 4.1$$

where A is the total landscape area in meters. At the class level, the class area (CA) is relative to each patch type and calculated as

$$CA = \sum_{\frac{j=1}{A}(100)}^{n} a_{ij}\left(\frac{1}{10{,}000}\right) \qquad 4.2$$

where A is the total landscape area, a_{ij} is the area of patch *ij*, and n is the number of patches in the landscape of patch type (class) *i*. The metric is commonly presented in hectares. Beyond being necessary for calculating other metrics and indices, the class area is useful for interpreting differences between hunter landscapes and mammal landscapes. For example, we might expect hunter landscapes to have a higher percentage of a particular patch type favored by a particular mammal relative to that patch type in the general area of distribution for that mammal.

Mean Patch Size, Standard Deviation, and Coefficient of variance

The mean patch size (MPS) measures the average patch size of all patches in a landscape. At the landscape level, all patches are included in the calculation of the metric; at the class level the metric is patch type specific. At the landscape level the MPS is defined as

$$MPS = \frac{A}{N}\left(\frac{1}{10{,}000}\right) \qquad 4.3$$

where A is the landscape area and N is the total number of patches in the landscape. At the class level, where the MPS relates to a specific class type, the metric is calculated as

$$MPS = \frac{\sum_{\frac{j=1}{A}}^{n} a_{ij}}{n_i}\left(\frac{1}{10{,}000}\right) \qquad 4.4$$

where *a* is the area of patch *ij*, *n* is the number of patches of class type *i*, A is the total landscape area, and *j* is the number of *i* patches. Essentially this mean is the average area of all patches of a particular type converted to hectares. The MPS value, coupled with its standard deviation (PSSD) and coefficient of variance (PSCOV) provide very useful measures for comparing two or more landscapes. Utilizing this metric at the landscape and class level, differences in the patch size of the different mammal distributions and hunting ranges can be directly compared. Where patch sizes are similar, the PSSD and PSCOV can be examined for additional differences. These metrics are calculated in the same manner as their standard statistical counterparts. The patch size standard deviation is defined at the class level as

$$PSSD = \sqrt{\frac{\sum_{j=1}^{n}\left[a_{ij} - \left(\frac{\sum_{j=1}^{n} a_{ij}}{n_i}\right)\right]^2}{n_i}}\left(\frac{1}{10{,}000}\right) \qquad 4.5$$

and at the landscape level as

$$PSSD = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[a_{ij} - \frac{A}{N}\right]^2}{N}}\left(\frac{1}{10{,}000}\right) \qquad 4.6$$

The patch size coefficient of variance for the class and landscape level are both computed as

$$PSCOV = \frac{PSSD}{MPS}(100) \qquad 4.7$$

Patch Density (PD)

Patch density (PD) is a basic component of landscape structure useful in comparing the fragmentation of patches (McGarigal and Marks 1995:26), as well as in interpreting composition and structure. Patch density is examined to discriminate between differences in the landscape and class heterogeneity of patches between hunter and mammal landscapes. The class and landscape level PD are computed as

$$PD = \frac{n_i}{A}(10000)(100) \qquad 4.8$$

and

$$PD = \frac{N}{A}(10000)(100) \qquad 4.9.$$

A is the landscape area, n_i is the number of patches in a landscape of patch type I, and N is the total number of patches in the landscape. The metric is presented as the number of patches per 100 hectares.

Edge Metrics

Two edge metrics, total edge (TE) and edge density (ED), are calculated for each landscape. The total edge is the total length of the patch edge of a particular class and is useful for examining edge effects, identifying corridors, and examining landscape partitioning, or fragmentation. Although I do not rely on TE, it is necessary to calculate the ED. The TE is determined by

$$TE = \sum_{k=1}^{m'} e_{ik} \qquad 4.10$$

At the landscape level, the metric is simply

$$TE = E \qquad 4.11$$

At the class level, m' is the number of patch types present in the landscape and e_{ik} is the total length of edge in a landscape between patch types i and k; E is the total edge of all patches in the landscape. In order to standardize the TE metric, the edge density (ED) and mean patch edge (MPE) are calculated for each data set at both the landscape and class levels.

Edge density (ED) is a more standardized metric useful in comparing two or more landscapes of different sizes. The edge density is computed as

ED (Class)

$$ED = \frac{\sum_{k=1}^{m'} e_{ik}}{A}(10{,}000) \qquad 4.12$$

ED (Landscape)

$$ED = \frac{TE}{A}(10{,}000) \qquad 4.13$$

where m’ is the number of patch types present in the landscape, e_{ik} is the total length of edge in a landscape between patch types i and k, and A is the area of the landscape. The edge density is presented as the number of meters of edge per hectare.

The last edge metric calculated is the mean patch edge, which like the MPS, serves to provide an average edge value for all the patches in a landscape or, at the class level, for a particular class type. The MPE at the class level is determined as

$$MPE = \frac{\sum_{k=1}^{m'} e_{ik}}{n_i} \qquad 4.14$$

At the landscape level simply as

$$MPE = \frac{TE}{N} \qquad 4.15$$

Shape Indices

Several shape indices are calculated at both the class and landscape level including mean perimeter to area ratio (MPAR), the mean shape index (MSI), the area weighted mean patch size (AWMSI), the mean patch fractal dimension (MPFD), and the area weighted mean patch fractal dimension (AWMPFD). The mean perimeter to area ratio is essentially the ratio of the perimeter of each patch in the landscape relative to the total landscape area; at the class level, it is the ratio for a specific patch class perimeter and the area of that patch class. The MSI, and its variant the AWMSI, measure how much the shape of a patch deviates from a circle (or a square if the coverage in a raster format). Essentially, the MSI and AWMSI are indices that compare the MPAR values to a circle. Generally the larger the MPAR value, the larger its shape deviates from a circle. The MSI at the class level is computed as

$$MSI = \frac{\sum_{j=1}^{n} \left(\frac{p_{ij}}{2\sqrt{\Pi \circ a_{ij}}} \right)}{n_i} \qquad 4.16$$

and at the landscape level as

$$MSI = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} \left(\frac{p_{ij}}{2\sqrt{\Pi \circ a_{ij}}} \right)}{N} \qquad 4.17$$

The AWMSI is similar to the MSI, but the larger patches in the landscape or class are given a greater weight in the calculation. These metrics are calculated at the class level as,

$$AWMSI = \sum_{j=1}^{n} \left[\left(\frac{p_{ij}}{2\sqrt{\Pi \circ a_{ij}}} \right) \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right) \right] \qquad 4.18$$

and at the landscape level as

$$AWMSI = \sum_{i=1}^{m} \sum_{j=1}^{n} \left[\left(\frac{p_{ij}}{2\sqrt{\Pi \circ a_{ij}}} \right) \left(\frac{a_{ij}}{A} \right) \right] \qquad 4.19$$

Fractal Dimension

Another way of examining patch shape is through its fractal dimension, although conceptualizing the fractal dimension is difficult. Despite this fact, many landscape studies describe patch shape using fractals (McGarigal and Marks 1995:36). The mean patch fractal dimension (MPFD) and the area weighted patch fractal dimension (AWMPFD), like the MSI and AWMSI, rely on the MPAR values. Essentially, the fractal dimensions elucidate patch shape relative to a line, where the fractal dimension is equal to one, or to a plane, where the fractal is equal to two. As patch shapes increase in complexity, their perimeters also increase, resulting in deviation from a line to something that begins to fill a plane. Although I calculated the fractals, as described below, the more simple-shape indices proved to be more readily interpretable. At the class level, the MPFD is calculated as

$$FRAC = \frac{2\ln p_{ij}}{\ln a_{ij}} \qquad 4.20$$

and at the landscape level as

$$MPFD = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)}{N} \qquad 4.21$$

Like the area weighted variant of the MSI, the AWMPFD places an emphasis on the large patches in the landscape or class when the calculations are made. The AWMPFD at the class level is defined as

$$AWMPFD = \sum_{j=1}^{n}\left[\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)\left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}\right)\right] \qquad 4.22$$

And at the landscape level as

$$AWMPFD = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)\left(\frac{a_{ij}}{A}\right)\right] \qquad 4.23$$

Diversity and Evenness

Though often utilized in landscape ecology, the last two indices are relatively common richness and evenness measures, including in archaeology. These include the Shannon's Diversity index (SHDI) and the Shannon's Evenness Index (SHEI). The SHDI simultaneously measures the richness and diversity, while the SHEI is a proportional measure of evenness. Both indices are useful for comparing different landscapes or the same landscape at different points in time. These indices are only applicable at the landscape level. The Shannon's Diversity Index is computed as

$$SHDI = -\sum_{i=1}^{m} \left(Pi \circ \ln Pi \right) \qquad 4.24$$

and the SHEI is computed as

$$SHEI = \frac{-\sum_{i=1}^{m} \left(Pi \circ \ln Pi \right)}{\ln m} \qquad 4.25$$

CHAPTER 5.
LARGE GAME LANDSCAPE COMPARISONS

Introduction

The distribution of caribou, moose, and sheep throughout the Alaskan Interior is discontinuous, varies seasonally, and changes through time dependant on animal behavior, changes in vegetation due to wildfires and environmental change, development, and many other factors. Modeling the distribution and movement of these animals in the present is complicated; modeling these same distributions in the recent or distant past is fraught with compounding difficulties. Yet, this is exactly what I attempt to do at a generalized level in this and the following chapters. This chapter focuses on identifying the landscape characteristics, based on landform structure, common to different types of caribou, moose, and sheep ranges throughout a vast portion of the Interior. The distributional data used here represents a snapshot from a short time period, essentially the 1970s. Numerous assumptions are necessary of the data in order to use them for the classification of present day ranges, and eventually for extrapolating animal distributions farther back in time.

The first assumption is that regardless of shifting ranges and the factors that cause the shifts, each of the three major mammal groups tend to utilize those ranges to which they are best adapted. Therefore, if the distributional range for an individual animal or herd changes, then the new range shares structural similarities with the previous range. Along the same lines, it is necessary to assume a high degree of stability in animal behavior and the environment. This assumption is not particularly relevant in this chapter, but becomes increasingly important in following chapters where the structural landscape characteristics are pushed back to historic, protohistoric, and prehistoric periods. The last major assumption is that each species, in spite of location within the Interior, shares landscapes that are more structurally similar to one another than those of the other mammals. For example, I assumed that the structural landscape characteristics for caribou in the Kuskokwim and Koyukuk regions are more similar to one another than they are to moose ranges in the same regions. Stated another way, the variation in landscape structure of one species throughout the Interior is less pronounced than the variation between the landscape structure of two different species in the same region.

This chapter consists of two parts. Part 1 presents the results of the landscape metrics and structure analyses conducted for the distributional ranges of caribou, moose, and sheep in the five study areas at both the landscape and class scales. The landscape level data relates to the overall structure of the landscapes while the class level data pertains to the landform composition of these landscapes. I present these two scales of analyses for the general distribution of each species, as well as for the seasonal ranges of moose and caribou. In the second part of the chapter, I present the results of several ANOVA and discriminant analyses used to compare the data generated from the landscape metrics and identify classification functions necessary in subsequent chapters.

Landscape and Class Level Metrics Description

General Caribou Range Characteristics (Landscape Level)

Even given the differences in the sizes of the five study areas (Figure 5.1), the landscape metrics for the general caribou ranges are relatively similar. Table 5.1 presents the results of the landscape metrics calculated for the five study areas. The general caribou range in each of the study areas is extremely large. The Lower Tanana study area has the smallest range at nearly 7.6 million hectares and the largest range is in the Kuskokwim study area and comprises almost 11.4 million hectares. The remaining three caribou ranges vary between 8.4 and 10.7 million hectares. Although the size of the caribou ranges are arbitrarily defined in this study, they reflect the potential exploitable caribou ranges in each of the study areas. The total number of patches within each range varies between 203,259 in the Lower Tanana study area to over 486,000 in the Upper Yukon study area. The mean patch size (MPS) and the patch density (PD) metrics are very similar to one another with the exception of the Upper Yukon study area. The MPS varies between 37.4 hectares and 39.6 hectares in four of the study areas, but drops considerably to 21.4 hectares in the Upper Yukon study area. Likewise, the PD is approximately three patches per 100 hectares in the Lower and Upper Tanana, Kuskokwim, and Koyukuk study areas, but increases to over five patches per 100 hectares in the Upper Yukon area. Together, the decreased patch size and increased patch density reflect that, compared with the other study areas; the caribou range in the Upper Yukon study area is patchier.

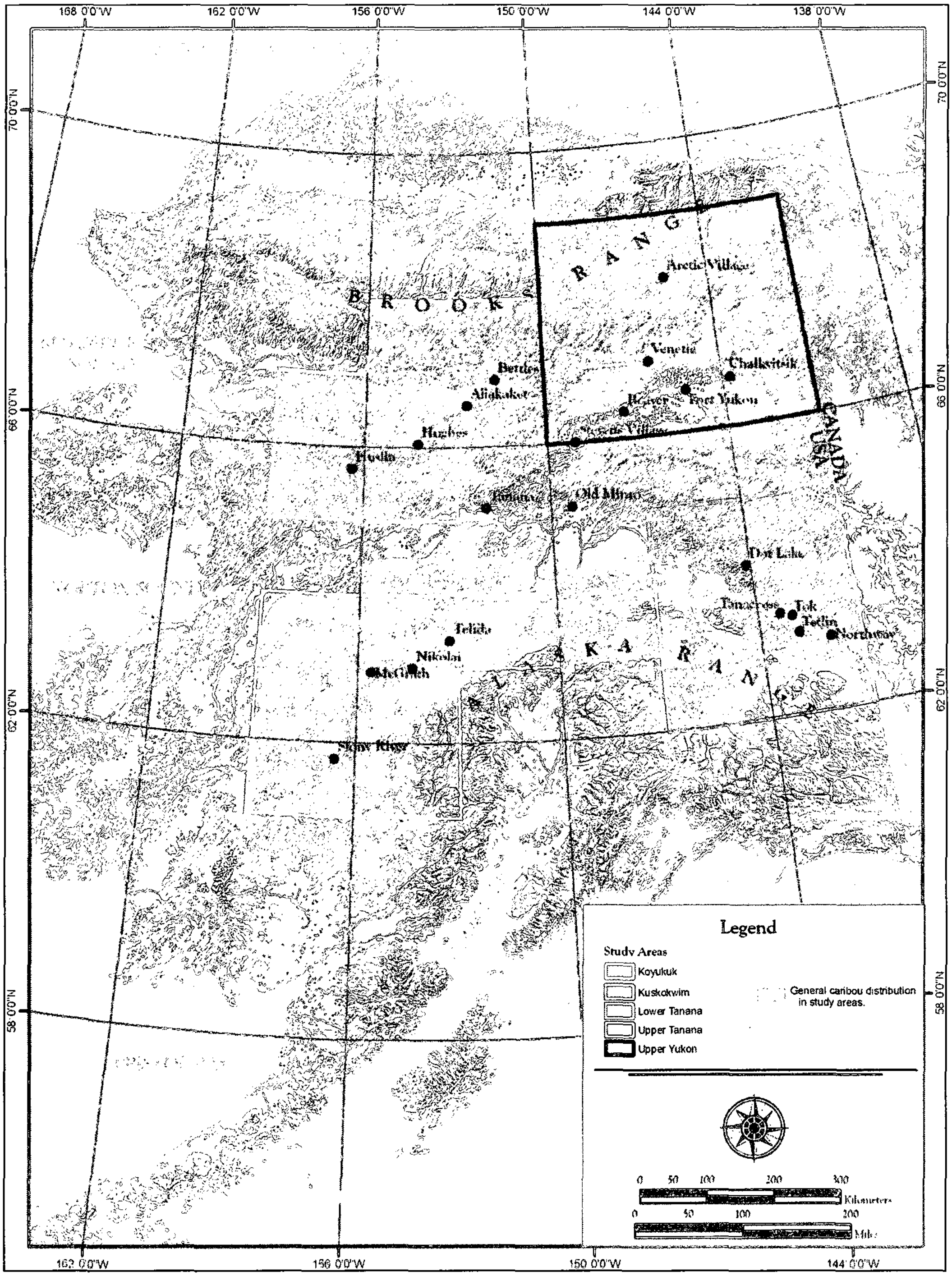


Figure 5.1. Five Study Areas and the General Distribution of Caribou in Each. Distribution Derived from ADF&G 1973.

Table 5.1. General Caribou Range Landscape Metrics for the Five Study Areas

	Study Area				
	Koyukuk	Kuskokwim	Lower Tanana	Upper Tanana	Upper Yukon
Total Landscape Area (ha)	10,678,651.48	11,393,519.26	7,594,997.93	8,407,724.12	10,395,633.56
No. of Patches	274,409	303,505	203,259	212,213	486,403
Patch Density	0.03	0.03	0.03	0.03	0.05
Mean Patch Size (ha)	38.92	37.54	37.37	39.62	21.37
Patch Size Standard Deviation (ha)	9,262.61	5,846.12	3,451.71	3,880.64	3,404.79
Total Edge (m)	5.27E+08	5.28E+08	3.88E+08	4.49E+08	7.18E+08
Edge Density	49.34	46.31	51.14	53.41	69.08
Mean Patch Edge (m)	1,919.95	1,738.55	1,910.79	2,116.03	1,476.40
Mean Shape Index	1.40	1.39	1.40	1.39	1.44
Mean Perimeter to Area Ratio	411.74	513.48	383.09	362.87	987.82
Mean Patch Fractal Dimension	1.31	1.32	1.31	1.31	1.39
Area Weighted Mean Patch Shape Index	21.16	13.53	7.97	9.30	21.09
Area Weighted Mean Patch Fractal Dimension	1.36	1.34	1.32	1.34	1.38
Shannon's Diversity Index	2.07	2.02	2.09	2.02	1.97
Shannon's Eveness Index	0.90	0.88	0.91	0.88	0.86

The edge metrics for the general caribou ranges are likewise similar. The edge density (ED) is between 46.3 meters/hectare in the Lower Tanana and 69.1 meters/hectare in the Upper Yukon area. The EDs of the caribou range in remaining study areas average about 51 meters/hectare. The mean patch edge (MPE) is highest in the Upper Tanana study area and lowest in the Upper Yukon study area; overall, the mean patch edge varies between 1,476 meters/patch and 2,116 meters/patch, with the average being close to 1,832 meters/patch. The higher ED and low MPE in the Upper Yukon caribou range suggests a caribou range comprised of smaller patches than those found in the other study areas. Although the MPEs in the other four study areas cluster more tightly, the Upper Tanana study area MPE suggests that, relative to most of the other study areas, the patch shapes are more complex.

The shape indices calculated for the general caribou ranges in the five study areas are more variable than the patch and edge metrics at the landscape level. Although the mean shape index (MSI) is remarkably similar across all five caribou ranges, the area weighted mean shape index (AWMSI) varies substantially, indicating an importance of large and complex patches in the landscape matrix of some of the study areas. Both the Lower and Upper Tanana study areas have general caribou ranges that have much more regularly shaped patches with AWMSI values of less than 10. This observation can also be made for these two study areas given the low mean perimeter to area ratio (MPAR) values. Both the Upper Yukon and Koyukuk have AWMSI values over 21, suggesting the patches in these two study areas are more irregular. The AWMSI for the Kuskokwim study area falls nearly halfway between the low and high values. The Upper Yukon study area has a very high MPAR value of over 980, which is almost twice the value of the second largest MPAR value held by the Kuskokwim study area. The mean patch fractal dimension (MPFD) for all the study areas falls between 1.31 and 1.39 indicating that patch shapes, relative to a circle, are simple. Even when weighted against the large patches in the landscape mosaics (AWMPFD), the relative patch shapes remain moderately simple (AWMPFD = 1.32 to 1.38).

Although I calculated the diversity and evenness indices for comparing landscapes between the different species ranges, it is clear that the class type proportions are very similar across the five study areas. The Shannon's Diversity Index (SHDI) varies between a low of 1.97 in the Upper Yukon study area to a high of 2.09 in the Lower Tanana study area. The Shannon's Evenness Index (SHEI) varies between 0.86 and 0.91.

Seasonal Caribou Range Characteristics (Landscape Level)

Relative to the general caribou landscape metrics, the seasonal range metrics show considerably more variability among the different study areas. Table 5.2 presents the calculated landscape metrics for each study area and available seasonal ranges. In general, the three seasonal ranges include a summer and winter range, as well as a caribou calving area for the Koyukuk and Upper Tanana study areas. The caribou calving period corresponds with spring. As with the general caribou range, the seasonal caribou ranges are not inclusive of the study areas they represent, so direct cross-landscape comparisons are best made utilizing the landscape indices. The maps in Figures 5.2 and 5.3 depict the general seasonal caribou ranges in each study area.

Based on the landscape metrics, summer caribou ranges in the four of the five study areas are similar; though the Upper Yukon study area contains a summer caribou range that is structurally different from the others. Summer range MPS varies very little across the five study areas, with the largest average patches occurring in the Koyukuk region and the smallest average patches occurring in the Lower Tanana and Upper Yukon regions. The MPS ranges between a high of 36.43 and 21.48 hectares. While the mean patch size standard deviation (MPSSD) for the Kuskokwim and Upper Yukon areas are large, the remaining three study areas have relatively small standard deviations. The edge metrics, ED and MPE, vary moderately among the study areas. The Upper Yukon summer caribou range, in terms of all the shape indices calculated, is more complex than the other study areas; the remaining study areas are roughly equivalent. Likewise, the SHDI and SHEI measures for the Upper Yukon are very different from the other study areas indicating more diversity in the patch structure and a more even distribution of patch classes.

Like the summer ranges, the landscape metrics for the winter ranges show a moderate amount of consistency among the study areas. In general, the MPS of the winter ranges are larger than the summer MPS and the very large standard deviations suggest that the patch sizes utilized by caribou during the winter are highly variable. The winter MPS, compared with summer ranges, increases by 10 hectares to 30 hectares, except in the Upper Yukon area where the MPS actually decreases by about 2 hectares. The increased MPS in four of the five study areas corresponds with a general decrease in the patch ED, though the MPE remains more variable. Compared with the summer patches, the AWMSI increases substantially in the Koyukuk study area and moderately in most of the other study areas; indicating more complexity in patch shape

Table 5.2. General Caribou Seasonal Range Landscape Metrics for the Five Study Areas

	Study Area											
	Koyukuk			**Kuskokwim**		**Lower Tanana**			**Upper Tanana**		**Upper Yukon**	
	Summer	**Winter**	**Calving**	**Summer**	**Winter**	**Summer**	**Winter**	**Calving**	**Summer**	**Winter**	**Summer**	**Winter**
Total Landscape Area (Ha)	80081	7590426	19942	2058422	3078829	819691	3380055	439166	2487711	3710754	340890	5637932
No. of Patches	2,198	152,028	898	70,678	49,523	37,326	105,806	13,820	97,623	80,325	15,871	285,132
Mean Patch Size (Ha)	36.43	49.93	22.21	29.12	62.17	21.96	31.95	31.78	25.48	46.20	21.48	19.77
Patch Size Standard Deviation	343.98	11,526.23	133.63	2,215.41	4,752.04	246.56	2,617.27	521.01	367.50	3,855.45	2,009.05	4,716.07
Total Edge (m)	4.81E+06	2.91E+08	1.55E+06	1.20E+08	8.24E+07	6.74E+07	2.01E+08	2.81E+07	1.96E+08	1.74E+08	2.23E+07	3.59E+08
Edge Density	60.02	38.38	77.80	58.18	26.77	82.18	59.60	63.95	78.79	46.79	65.47	63.75
Mean Patch Edge (m)	2,186.72	1,916.01	1,727.74	1,694.37	1,664.26	1,804.76	1,903.94	2,032.17	2,007.79	2,161.43	1,406.26	1,260.49
Mean Shape Index	1.39	1.40	1.39	1.40	1.41	1.40	1.41	1.41	1.39	1.39	1.50	1.43
Area Weighted Mean Shape Index	5.18	22.82	2.64	6.52	7.54	3.25	7.54	4.19	5.74	8.15	37.01	37.55
Mean Perimeter to Area Ratio	446.95	389.48	439.73	528.47	606.41	405.55	381.73	470.32	387.31	385.58	1,187.10	1,147.07
Mean Patch Fractal Dimension	1.31	1.31	1.32	1.33	1.34	1.31	1.31	1.31	1.31	1.31	1.42	1.40
Area Weighted Mean Patch Fractal Dimension	1.33	1.36	1.30	1.31	1.29	1.31	1.33	1.31	1.33	1.33	1.46	1.41
Shannon's Diversity Index	1.88	2.08	2.04	2.05	1.93	2.11	2.10	2.02	2.01	1.99	0.87	1.88
Shannon's Eveness Index	0.81	0.91	0.89	0.89	0.84	0.92	0.91	0.88	0.87	0.87	0.38	0.82

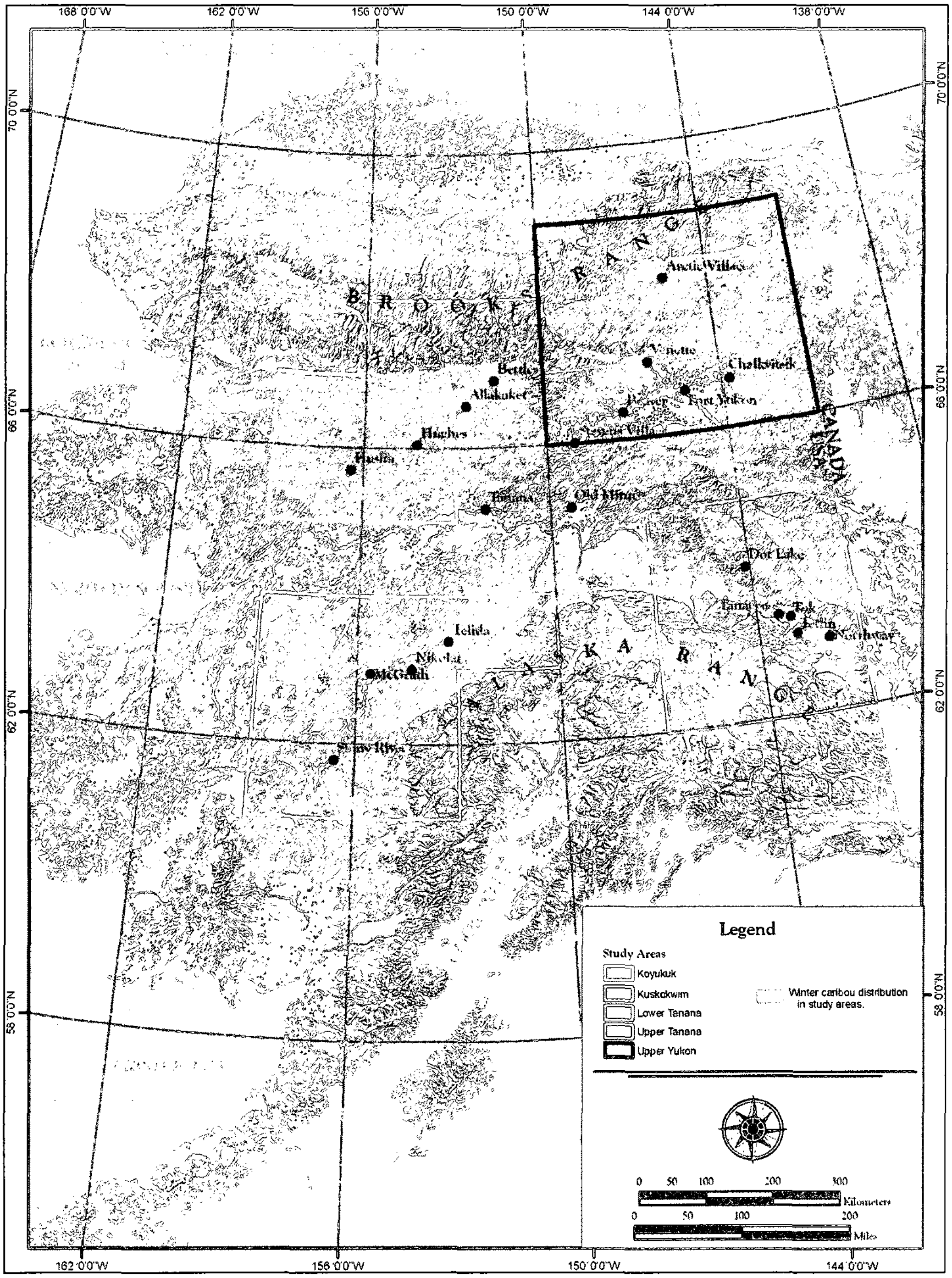


Figure 5.2. Five Study Areas and the Winter Distribution of Caribou in Each. Distribution Derived from ADF&G 1973.

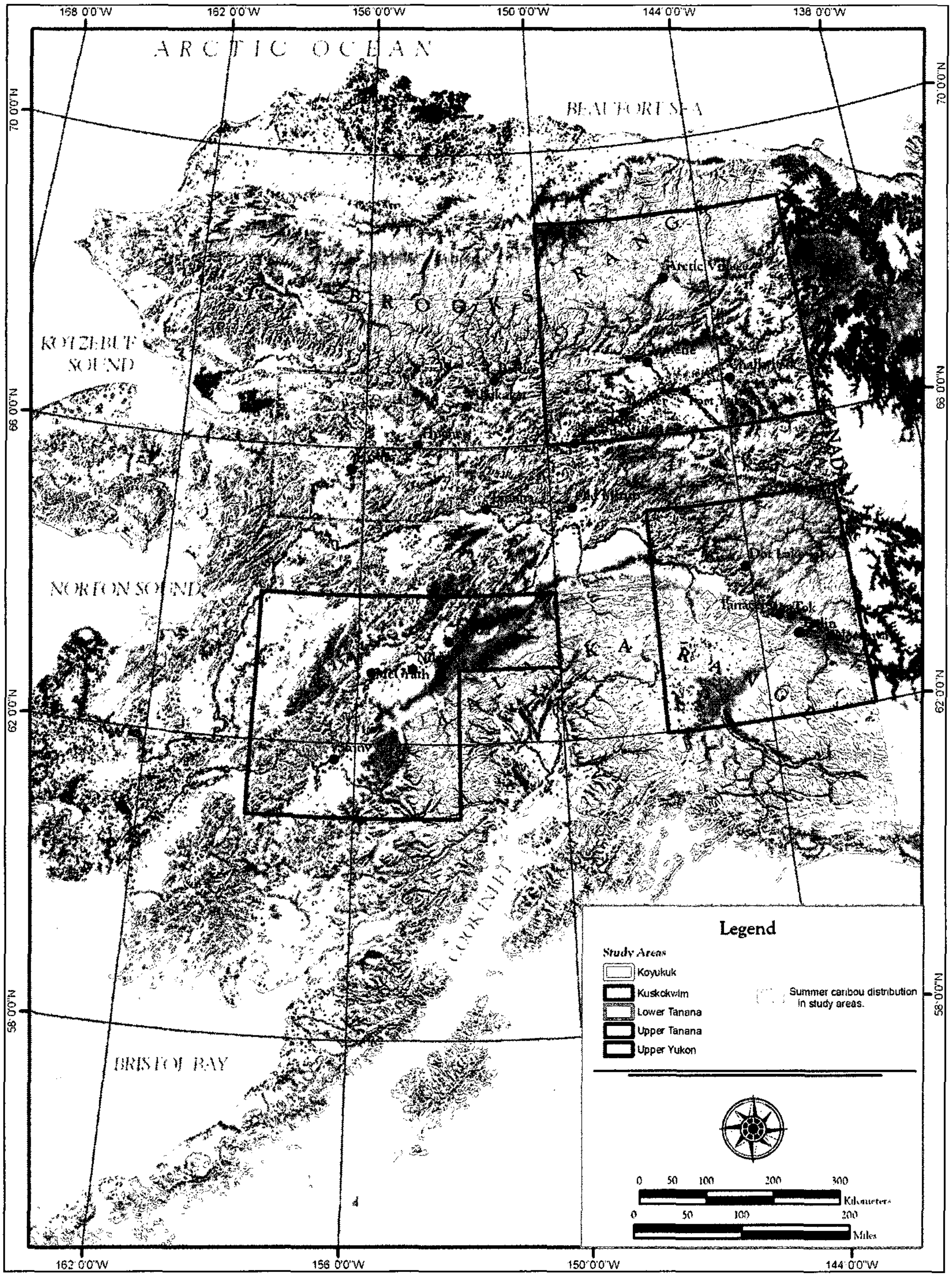


Figure 5.3. Five Study Areas and the Summer Distribution of Caribou in Each. Distribution Derived from ADF&G 1973.

in the caribou's winter range. There is no clear trend in the SHDI and SHEI scores between summer and winter ranges with some study areas, such as the Koyukuk and Upper Yukon, showing an increase in evenness and diversity, while the remaining study areas show a slight decrease. Overall, the Koyukuk region has the greatest amount of variability in patch composition between summer and winter ranges and the Upper Yukon region has nearly identical metrics for both the summer and winter caribou ranges.

Of the five study areas, only the Upper Tanana and Kuskokwim areas contain any mapped caribou calving grounds. With the exception of slightly different MPS metrics, the two calving grounds share nearly identical landscape level metric values.

General Caribou Range Characteristics (Class Level)

Like the landscape level metrics, the general caribou ranges at the class level are very consistent among the five study areas. Table 5.3 provides the calculated metrics for the five study areas by class type. Across all five study areas, the plains and open slope patches combined comprise between 66 and 75.5% of the caribou range. In each area plains patches alone account for 41.6 to 60.8% of the general caribou range with the Kuskokwim area having the largest percentage and the Upper Tanana having the smallest. Likewise, the percentage of open slope patches varies between 14.7 and 26.2% with the Upper Tanana area having the largest percentage and the Kuskokwim area having the smallest. The least common patch types in all five areas include upland drainages and local ridges. Typically, these two patch types account for less than one percent of the caribou range in each study area. The MPS for plains is at least twice as large for the MPS for open slopes in all the study areas, though in the Lower Tanana, Koyukuk, and Kuskokwim areas, the magnitude of the plains MPS to open slopes is closer to four or five times larger.

The edge metrics bear out this relationship with the ED of the open slope patches being the highest among the open slopes in all the study areas. The MPE of open slopes is also consistently higher than the MPE for plains, but other patch types, particularly high ridges, often have the highest MPE due to small patch sizes.

Given the large average size and PD of the plains class, the AWMSI metrics deviate consistently from relatively simple shapes. In every case, except for the Upper Tanana, the AWMSI metric is at least twice as large as the AWMSI for open slopes, and four to eight times larger than the AWMSI for the remaining patch classes. This suggests that as patch size

Table 5.3. General Caribou Range Class Metrics for the Five Study Areas

		Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge
Koyukuk	Canyon	445,232.42	4.17	0.04	26.87	3.77	2,430.53
	Midslope Drainage	455,609.95	4.27	0.12	8.57	5.72	1,149.17
	Upland Drainage	43,982.40	0.41	0.30	3.34	0.87	706.28
	U-shaped Valley	761,787.75	7.13	0.03	29.81	4.76	1,989.27
	Plains	5,317,412.83	49.79	0.00	263.32	5.58	2,951.97
	Open Slope	2,019,852.34	18.91	0.02	51.93	12.98	3,563.15
	Upper Slope	643,521.48	6.03	0.06	16.70	6.16	1,706.22
	Local Ridge	9,272.65	0.09	0.43	2.33	0.22	591.13
	Midslope Ridge	309,591.94	2.90	0.16	6.32	4.50	980.35
	High Ridge	672,387.72	6.30	0.02	43.78	4.78	3,322.32
Kuskokwim	Canyon	375,753.40	3.30	0.04	25.27	3.04	2,330.93
	Midslope Drainage	441,337.26	3.87	0.12	8.38	5.30	1,145.56
	Upland Drainage	49,184.91	0.43	0.27	3.64	0.87	732.93
	U-shaped Valley	611,927.85	5.37	0.04	25.57	3.57	1,699.82
	Plains	6,925,748.83	60.79	0.00	240.16	7.02	2,771.85
	Open Slope	1,674,124.21	14.69	0.04	27.14	13.51	2,494.93
	Upper Slope	423,447.43	3.72	0.10	10.04	4.77	1,288.32
	Local Ridge	5,890.46	0.05	0.57	1.75	0.15	506.52
	Midslope Ridge	307,735.29	2.70	0.16	6.28	4.23	984.29
	High Ridge	578,369.63	5.08	0.02	42.92	3.86	3,263.81
Lower Tanana	Canyon	385,884.20	5.08	0.03	33.76	4.28	2,845.71
	Midslope Drainage	266,300.30	3.51	0.13	7.49	5.09	1,086.42
	Upland Drainage	32,790.51	0.43	0.26	3.82	0.86	759.23
	U-shaped Valley	575,544.08	7.58	0.04	26.08	5.49	1,891.02
	Plains	3,956,543.95	52.09	0.00	259.89	6.98	3,481.57
	Open Slope	1,146,149.84	15.09	0.03	31.35	12.64	2,626.57
	Upper Slope	532,403.95	7.01	0.05	20.94	6.15	1,835.62
	Local Ridge	12,234.07	0.16	0.38	2.60	0.39	629.61
	Midslope Ridge	227,584.29	3.00	0.14	6.90	4.56	1,049.96
	High Ridge	459,562.73	6.05	0.02	42.82	4.70	3,326.19

Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
1.51	2.76	333.73	1.31	1.31
1.34	1.67	378.81	1.31	1.28
1.28	1.45	434.98	1.32	1.29
1.38	4.26	463.87	1.32	1.32
1.32	37.45	392.36	1.31	1.39
1.54	8.70	393.10	1.32	1.37
1.42	2.85	410.95	1.32	1.32
1.27	1.41	467.13	1.32	1.30
1.32	1.60	503.24	1.31	1.28
1.54	2.39	271.79	1.30	1.29
1.48	2.60	346.03	1.31	1.31
1.33	1.67	435.53	1.31	1.28
1.29	1.48	509.75	1.32	1.29
1.36	3.73	562.56	1.33	1.31
1.34	19.47	577.03	1.33	1.36
1.54	7.28	552.03	1.34	1.37
1.38	2.62	700.57	1.32	1.32
1.26	1.42	620.94	1.34	1.30
1.31	1.57	429.58	1.31	1.28
1.52	2.47	299.64	1.29	1.29
1.53	3.12	321.81	1.31	1.32
1.33	1.64	380.28	1.31	1.28
1.29	1.46	409.87	1.31	1.29
1.38	3.46	423.08	1.32	1.32
1.35	12.54	385.51	1.31	1.34
1.52	3.57	365.95	1.32	1.33
1.41	2.96	406.81	1.32	1.31
1.27	1.43	443.12	1.32	1.30
1.33	1.66	395.08	1.31	1.29
1.57	2.63	289.65	1.30	1.30

Table 5.3. General Caribou Range Class Metrics for the Five Study Areas (continued)

		Class Area (ha)	**% Class**	**Patch Density**	**Mean Patch Size**	**Edge Density**	**Mean Patch Edge**	**Mean Shape Index (MSI)**	**Area Weighted MSI**	**Mean Perimeter to Area Ratio**	**Mean Patch Fractal Dimension (MPFD)**	**Area Weighted MPFD**
Upper Tanana	Canyon	399,143.24	4.75	0.03	28.79	4.13	2,502.06	1.49	2.68	308.60	1.31	1.30
	Midslope Drainage	385,358.64	4.58	0.11	9.09	5.93	1,176.23	1.33	1.64	362.00	1.31	1.28
	Upland Drainage	35,265.64	0.42	0.24	4.15	0.79	785.33	1.28	1.42	507.27	1.31	1.28
	U-shaped Valley	600,040.46	7.14	0.04	28.27	4.93	1,953.48	1.37	4.00	411.92	1.31	1.32
	Plains	3,501,865.35	41.65	0.01	185.09	5.95	2,645.35	1.33	12.90	333.63	1.30	1.33
	Open Slope	2,187,809.51	26.02	0.01	84.24	16.17	5,235.03	1.58	11.78	378.69	1.33	1.39
	Upper Slope	498,345.65	5.93	0.05	18.65	5.78	1,818.08	1.42	2.76	367.10	1.31	1.31
	Local Ridge	6,379.51	0.08	0.47	2.11	0.20	566.66	1.25	1.36	454.23	1.32	1.30
	Midslope Ridge	293,474.50	3.49	0.13	7.44	5.05	1,077.80	1.32	1.55	356.23	1.31	1.28
	High Ridge	500,041.62	5.95	0.02	41.04	4.47	3,084.63	1.49	2.58	242.60	1.29	1.29
Upper Yukon	Canyon	448,681.74	4.32	0.04	24.96	4.02	2,324.55	1.52	3.41	648.49	1.35	1.33
	Midslope Drainage	509,826.05	4.90	0.12	8.02	6.77	1,107.83	1.39	2.00	798.30	1.36	1.30
	Upland Drainage	44,037.97	0.42	0.41	2.46	1.00	581.76	1.32	1.52	843.47	1.37	1.30
	U-shaped Valley	793,126.16	7.63	0.04	22.72	5.36	1,596.71	1.42	4.70	1,014.18	1.39	1.34
	Plains	4,449,615.16	42.80	0.02	43.56	11.49	1,169.63	1.37	40.27	1,217.39	1.42	1.41
	Open Slope	2,430,497.54	23.38	0.05	20.69	22.22	1,965.86	1.56	11.84	1,170.53	1.41	1.40
	Upper Slope	654,188.50	6.29	0.07	14.57	7.06	1,635.17	1.51	3.16	909.13	1.38	1.33
	Local Ridge	9,325.08	0.09	0.69	1.44	0.27	438.31	1.29	1.49	931.43	1.38	1.31
	Midslope Ridge	362,141.17	3.48	0.18	5.61	5.63	906.49	1.35	1.70	761.76	1.35	1.29
	High Ridge	694,194.19	6.68	0.02	41.89	5.25	3,295.29	1.53	3.21	587.78	1.32	1.31

decreases, the shape of the patches becomes simpler. MPAR values fluctuate among patch classes, and among the study areas these values show no large deviations; though, it is clear that the Upper Yukon study area has the greatest MPAR across the study areas. Again, this reflects the more regular distributions of patches in all classes throughout the landscape for this study area.

Seasonal Caribou Range Characteristics (Class Level)

As at the landscape level, the class metrics by season are very different from those of the general distributions, but are somewhat internally consistent among the different study areas, particularly the winter ranges. Table 5.4 breaks down the class level metrics by study area, season, and class type. The percentage of the different class types in the summer ranges varies considerably. In the Koyukuk, Lower Tanana, and Upper Tanana areas, the majority of the caribou range occurs on open slopes, though in the Lower Tanana area this dominance is marginal. In the Kuskokwim and Upper Yukon areas, the primary summer caribou range occurs in plains settings, and in the Upper Yukon this patch type comprises almost 80% of the seasonal range. Combined the percentage of all the other class types accounts for less than 20% of the summer caribou ranges. Comparatively, the class ages in the caribou winter ranges are much more regular across the five study areas. Plains patches are the most common and account for 45 to 80% of the winter ranges. Open slopes are the second most common patch type by area and vary between 8 and 25%.

The MPS by class in the summer caribou ranges varies considerably among the five study areas. In terms of the plains and open slope classes, the results mimic those for the PERCLASS results. The open slope patches in the Koyukuk and Upper Tanana, which account for the largest percentage of the range, have the largest MPS in this class. Similarly, plains patches in the remaining study areas are the largest patch type particular to class. The remaining class types, however, show consiserable variability across the Alaskan Interior. High ridge MPS values are often large and in several instances are the second or third largest patch type. Likewise canyon patches tend to be large. Patch types with small MPS include midslope drainages, upland drainages, local ridges, and midslope ridges. Upper slope and U-shaped valley patch MPS values are typically intermediary. Despite differences in MPS values for the different landform classes, several trends in the data are apparent. In the five study areas, it is clear that the MPS for plains patches is significantly larger than any other class MPS; the exception to this being the Upper

Table 5.4. Seasonal Caribou Range Class Metrics for the Five Study Areas

			Class Area (ha)	**% Class**	**Patch Density**	**Mean Patch Size (ha)**	**Edge Density**
Koyukuk	Summer	Canyon	1,899.96	2.37	0.06	15.57	2.64
		Midslope Drain.	3,393.51	4.24	0.14	7.20	5.92
		Upland Drainage	91.63	0.11	0.65	1.53	0.35
		U-shaped Valley	3,738.23	4.67	0.05	20.21	3.81
		Plains	20,794.20	25.97	0.02	62.26	10.03
		Open Slope	38,714.71	48.34	0.00	237.51	21.58
		Upper Slope	4,386.26	5.48	0.06	15.89	6.04
		Local Ridge	3.00	0.00	1.33	0.75	0.02
		Midslope Ridge	2,482.92	3.10	0.18	5.63	4.90
		High Ridge	4,576.78	5.72	0.03	32.23	4.73
	Winter	Canyon	238,937.44	3.15	0.03	28.78	2.80
		Midslope Drain.	226,125.59	2.98	0.13	7.87	4.29
		Upland Drainage	27,996.98	0.37	0.26	3.84	0.74
		U-shaped Valley	384,141.90	5.06	0.04	26.92	3.53
		Plains	4,940,309.53	65.09	0.00	486.39	5.93
		Open Slope	881,438.10	11.61	0.03	34.86	9.21
		Upper Slope	377,555.31	4.97	0.05	18.38	4.66
		Local Ridge	6,838.99	0.09	0.38	2.61	0.22
		Midslope Ridge	164,155.16	2.16	0.16	6.21	3.44
		High Ridge	342,927.46	4.52	0.02	40.99	3.56
Kuskokwim	Spring	Canyon	1,403.72	7.04	0.06	17.77	7.36
		Midslope Drain.	790.66	3.96	0.16	6.23	6.39
		Upland Drainage	71.91	0.36	0.44	2.25	0.94
		U-shaped Valley	2,932.38	14.70	0.03	30.23	10.17
		Plains	6,034.06	30.26	0.01	81.54	11.30
		Open Slope	4,569.40	22.91	0.04	27.04	20.94
		Upper Slope	2,196.30	11.01	0.05	20.15	8.50
		Local Ridge	27.21	0.14	0.44	2.27	0.38
		Midslope Ridge	592.64	2.97	0.22	4.63	5.54
		High Ridge	1,323.82	6.64	0.05	18.65	6.28
	Summer	Canyon	102,881.58	5.00	0.03	32.39	4.26
		Midslope Drain.	113,376.90	5.51	0.11	9.33	7.15
		Upland Drainage	15,918.87	0.77	0.25	3.93	1.49

Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fracal Dimension (MPFD)	Area Weighted MPFD
1,729.65	1.47	2.04	415.66	1.32	1.30
1,006.11	1.32	1.54	399.89	1.31	1.27
473.47	1.25	1.27	511.67	1.33	1.30
1,650.60	1.35	3.41	468.82	1.32	1.33
2,405.84	1.39	3.10	623.03	1.29	1.28
10,603.91	1.72	7.87	434.34	1.33	1.37
1,751.16	1.44	2.53	413.88	1.32	1.31
381.97	1.27	1.27	560.38	1.34	1.33
888.98	1.29	1.45	443.64	1.32	1.27
2,668.04	1.47	1.96	245.79	1.29	1.28
2,563.69	1.52	2.95	325.61	1.31	1.31
1,132.54	1.35	1.70	384.80	1.31	1.29
765.47	1.29	1.49	452.94	1.32	1.29
1,875.72	1.38	3.27	419.72	1.32	1.31
4,432.96	1.35	33.39	406.79	1.31	1.39
2,764.67	1.53	4.14	376.39	1.32	1.33
1,722.93	1.41	2.87	414.73	1.32	1.31
629.78	1.27	1.43	449.91	1.32	1.30
988.40	1.33	1.65	397.57	1.31	1.29
3,226.35	1.56	2.48	274.14	1.30	1.30
1,857.46	1.40	1.87	305.98	1.30	1.28
1,002.77	1.33	1.72	502.03	1.32	1.29
588.01	1.35	1.40	832.42	1.36	1.30
2,091.71	1.40	2.71	451.87	1.32	1.30
3,044.55	1.40	3.08	334.36	1.30	1.29
2,471.49	1.53	2.89	368.66	1.32	1.32
1,554.44	1.35	2.76	521.77	1.32	1.30
629.66	1.35	1.39	1,321.93	1.38	1.30
863.03	1.30	1.43	435.39	1.31	1.28
1,764.39	1.37	1.47	295.26	1.29	1.26
2,764.03	1.52	2.79	381.06	1.31	1.31
1,212.19	1.35	1.77	527.29	1.35	1.29
756.43	1.30	1.58	581.99	1.33	1.29

Table 5.4. Seasonal Caribou Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size (ha)	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fracal Dimension (MPFD)	Area Weighted MPFD
Kuskokwim (cont.)	Summer	U-shaped Valley	120,725.39	5.86	0.05	18.80	4.54	1,454.99	1.37	3.26	668.31	1.34	1.31
		Plains	1,002,140.01	48.68	0.01	161.19	6.92	2,290.18	1.35	7.19	588.72	1.32	1.29
		Open Slope	399,093.14	19.39	0.03	31.87	16.77	2,757.70	1.52	11.52	539.16	1.34	1.39
		Upper Slope	80,711.36	3.92	0.13	7.69	6.00	1,176.69	1.40	2.55	526.52	1.33	1.32
		Local Ridge	2,155.14	0.10	0.60	1.68	0.30	482.24	1.27	1.55	743.03	1.36	1.31
		Midslope Ridge	76,496.42	3.72	0.15	6.58	5.69	1,007.71	1.32	1.61	468.75	1.32	1.28
		High Ridge	144,923.41	7.04	0.02	52.72	5.05	3,784.41	1.55	2.70	273.39	1.29	1.30
	Winter	Canyon	38,360.91	1.25	0.05	18.22	1.27	1,852.40	1.43	2.24	422.11	1.31	1.30
		Midslope Drain.	56,261.15	1.83	0.14	7.13	2.70	1,054.51	1.33	1.66	482.31	1.32	1.29
		Upland Drainage	5,505.01	0.18	0.30	3.31	0.37	689.72	1.29	1.52	597.62	1.34	1.29
		U-shaped Valley	63,524.93	2.06	0.05	19.80	1.58	1,520.16	1.37	2.67	659.26	1.34	1.30
		Plains	2,482,101.60	80.62	0.00	379.87	5.83	2,745.25	1.35	8.54	765.62	1.36	1.29
		Open Slope	245,238.64	7.97	0.05	19.73	8.15	2,019.24	1.56	4.96	727.85	1.36	1.35
		Upper Slope	71,284.69	2.32	0.08	12.76	2.64	1,453.28	1.41	2.87	565.28	1.33	1.32
		Local Ridge	451.82	0.01	0.59	1.70	0.04	473.06	1.26	1.57	740.42	1.35	1.31
		Midslope Ridge	39,994.25	1.30	0.18	5.42	2.15	898.35	1.32	1.58	525.32	1.32	1.29
		High Ridge	76,105.91	2.47	0.03	31.06	2.03	2,551.79	1.46	2.19	384.28	1.30	1.28
Lower Tanana	Summer	Canyon	86,731.56	10.58	0.02	45.77	8.21	3,553.37	1.58	3.19	273.94	1.30	1.31
		Midslope Drain.	48,418.65	5.91	0.12	8.05	8.20	1,117.02	1.32	1.61	370.67	1.31	1.28
		Upland Drainage	8,002.16	0.98	0.26	3.85	1.94	765.72	1.28	1.46	399.87	1.31	1.29
		U-shaped Valley	108,432.67	13.23	0.04	24.19	10.18	1,860.88	1.39	3.87	527.97	1.32	1.33
		Plains	154,046.15	18.79	0.02	65.55	6.12	2,136.15	1.34	4.15	574.48	1.31	1.29
		Open Slope	187,482.81	22.87	0.03	28.69	19.94	2,500.72	1.51	3.45	377.65	1.32	1.33
		Upper Slope	87,620.94	10.69	0.06	16.07	10.90	1,639.35	1.40	2.93	391.64	1.32	1.32
		Local Ridge	2,923.82	0.36	0.40	2.49	0.88	618.24	1.26	1.42	501.84	1.31	1.30
		Midslope Ridge	40,904.98	4.99	0.14	7.39	7.35	1,088.31	1.33	1.63	390.14	1.31	1.28
		High Ridge	95,126.85	11.61	0.02	52.53	8.45	3,826.47	1.59	2.76	270.79	1.30	1.30
	Winter	Canyon	210,973.56	6.24	0.03	36.93	5.09	3,013.50	1.54	3.05	296.14	1.30	1.31
		Midslope Drain.	151,152.72	4.47	0.12	8.17	6.28	1,146.19	1.34	1.67	369.92	1.31	1.28
		Upland Drainage	21,025.09	0.62	0.25	4.01	1.22	785.58	1.30	1.48	402.44	1.31	1.29
		U-shaped Valley	282,338.56	8.35	0.04	24.96	6.34	1,892.84	1.39	3.33	410.38	1.32	1.32
		Plains	1,463,598.40	43.30	0.01	189.44	7.10	3,107.96	1.36	13.44	390.85	1.30	1.34
		Open Slope	624,376.37	18.47	0.03	32.93	15.19	2,709.05	1.53	3.76	394.39	1.32	1.33

Table 5.4. Seasonal Caribou Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size (ha)	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fracal Dimension (MPFD)	Area Weighted MPFD
Lower Tanana (cont.)	Winter	Upper Slope	252,013.49	7.46	0.05	18.47	7.05	1,746.89	1.41	2.93	399.12	1.32	1.32
		Local Ridge	7,046.39	0.21	0.37	2.70	0.50	644.37	1.28	1.43	444.36	1.32	1.29
		Midslope Ridge	124,061.56	3.67	0.14	7.39	5.41	1,089.78	1.34	1.66	380.77	1.31	1.29
		High Ridge	243,468.71	7.20	0.02	45.83	5.42	3,447.42	1.56	2.61	302.69	1.30	1.30
Upper Tanana	Spring	Canyon	27,557.87	6.28	0.03	28.62	5.21	2,374.31	1.50	2.76	666.05	1.32	1.31
		Midslope Drain.	21,412.12	4.88	0.12	8.10	6.55	1,089.07	1.34	1.63	517.91	1.31	1.28
		Upland Drainage	1,170.73	0.27	0.36	2.77	0.64	661.08	1.30	1.43	635.09	1.31	1.29
		U-shaped Valley	41,173.66	9.38	0.03	30.70	6.55	2,144.95	1.40	4.04	598.32	1.31	1.32
		Plains	120,798.64	27.51	0.01	81.40	7.28	2,154.43	1.36	4.05	380.68	1.31	1.28
		Open Slope	141,163.18	32.14	0.01	79.53	18.96	4,692.12	1.57	6.23	429.10	1.32	1.36
		Upper Slope	35,640.18	8.12	0.04	22.53	6.99	1,940.19	1.43	2.79	400.16	1.32	1.31
		Local Ridge	427.85	0.10	0.49	2.06	0.28	582.23	1.30	1.45	481.38	1.33	1.31
		Midslope Drain.	17,841.56	4.06	0.14	7.09	5.96	1,039.49	1.34	1.59	403.99	1.31	1.28
		High Ridge	31,980.23	7.28	0.03	36.18	5.54	2,750.23	1.48	2.03	386.98	1.29	1.28
	Summer	Canyon	192,633.11	7.74	0.04	27.60	6.93	2,470.17	1.49	2.53	308.42	1.30	1.30
		Midslope Drain.	158,117.83	6.36	0.12	8.11	8.60	1,097.03	1.32	1.59	365.68	1.31	1.28
		Upland Drainage	7,608.98	0.31	0.37	2.68	0.73	642.75	1.28	1.39	497.65	1.32	1.29
		U-shaped Valley	267,161.80	10.74	0.04	23.68	8.33	1,836.61	1.37	3.85	414.65	1.32	1.33
		Plains	316,586.49	12.73	0.03	31.41	6.70	1,654.71	1.33	3.91	492.85	1.30	1.29
		Open Slope	950,730.93	38.22	0.01	92.35	23.68	5,720.97	1.60	10.36	386.88	1.32	1.39
		Upper Slope	240,258.91	9.66	0.05	21.66	8.80	1,973.65	1.42	2.97	382.90	1.31	1.32
		Local Ridge	2,022.02	0.08	0.61	1.65	0.25	507.50	1.25	1.33	476.34	1.32	1.30
		Midslope Ridge	138,831.31	5.58	0.13	7.66	7.92	1,087.35	1.33	1.57	388.59	1.31	1.28
		High Ridge	213,760.11	8.59	0.03	34.43	6.85	2,744.00	1.48	2.25	259.82	1.29	1.29
	Winter	Canyon	141,895.27	3.82	0.04	25.81	3.52	2,375.94	1.48	2.54	317.06	1.30	1.30
		Midslope Drain.	130,085.15	3.51	0.13	7.97	4.84	1,100.11	1.32	1.61	378.60	1.31	1.28
		Upland Drainage	8,284.32	0.22	0.28	3.63	0.45	731.46	1.29	1.44	438.55	1.32	1.29
		U-shaped Valley	222,843.46	6.01	0.04	26.12	4.34	1,886.57	1.37	3.56	415.36	1.31	1.32
		Plains	1,819,898.02	49.04	0.00	222.05	6.14	2,778.90	1.34	9.40	345.26	1.30	1.31
		Open Slope	912,109.24	24.58	0.01	97.45	14.59	5,783.34	1.62	11.68	440.90	1.32	1.38
		Upper Slope	199,207.98	5.37	0.04	22.38	4.81	2,007.14	1.43	2.92	384.23	1.31	1.32
		Local Ridge	1,815.72	0.05	0.51	1.95	0.14	544.34	1.25	1.34	479.80	1.32	1.30
		Midslope Ridge	109,053.85	2.94	0.14	7.21	4.31	1,058.78	1.32	1.55	406.56	1.31	1.28
		High Ridge	165,561.37	4.46	0.03	31.88	3.65	2,610.27	1.46	2.18	296.16	1.29	1.28

Table 5.4. Seasonal Caribou Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size (ha)	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fracal Dimension (MPFD)	Area Weighted MPFD
Upper Yukon	Summer	Canyon	263.79	0.08	0.05	18.84	0.07	1,708.69	1.49	2.55	1,060.91	1.39	1.31
		Midslope Drain.	417.42	0.12	0.30	3.34	0.26	696.49	1.38	1.56	903.58	1.38	1.30
		Upland Drainage	8.40	0.00	0.83	1.20	0.01	359.18	1.27	1.42	1,214.49	1.40	1.31
		U-shaped Valley	1,042.56	0.31	0.03	31.59	0.19	1,913.43	1.37	4.02	1,161.73	1.40	1.33
		Plains	262,998.79	77.15	0.02	53.05	31.23	2,147.42	1.43	44.44	1,245.67	1.42	1.47
		Open Slope	71,396.68	20.94	0.14	6.96	32.05	1,065.28	1.54	12.80	1,178.81	1.42	1.43
		Upper Slope	2,615.54	0.77	0.05	19.67	0.72	1,849.75	1.50	2.62	1,032.87	1.39	1.31
		Local Ridge	5.32	0.00	3.01	0.33	0.01	182.14	1.16	1.34	1,402.95	1.41	1.34
		Midslope Ridge	753.23	0.22	0.33	3.04	0.49	676.72	1.34	1.55	816.12	1.36	1.30
		High Ridge	1,387.84	0.41	0.06	17.35	0.45	1,897.83	1.44	1.87	455.73	1.31	1.29
	Winter	Canyon	186,682.58	3.31	0.05	18.43	3.11	1,731.57	1.45	3.43	879.97	1.36	1.32
		Midslope Drain.	189,836.90	3.37	0.17	5.76	5.13	877.64	1.37	1.95	945.88	1.38	1.30
		Upland Drainage	19,596.85	0.35	0.35	2.89	0.74	617.25	1.34	1.61	947.93	1.38	1.30
		U-shaped Valley	362,547.66	6.43	0.05	20.85	4.47	1,450.17	1.41	4.54	1,253.65	1.41	1.33
		Plains	2,906,665.34	51.56	0.02	40.09	14.90	1,159.11	1.38	66.24	1,258.80	1.42	1.45
		Open Slope	1,169,370.08	20.74	0.07	13.50	21.21	1,380.44	1.52	12.16	1,300.34	1.43	1.41
		Upper Slope	358,621.11	6.36	0.05	21.34	5.88	1,971.57	1.53	3.69	1,081.89	1.40	1.34
		Local Ridge	4,466.70	0.08	0.67	1.48	0.23	424.09	1.31	1.58	1,110.13	1.40	1.31
		Midslope Ridge	143,116.08	2.54	0.20	5.05	4.09	814.23	1.34	1.66	881.35	1.36	1.29
		High Ridge	297,029.07	5.27	0.04	28.00	3.98	2,116.03	1.41	2.39	787.81	1.35	1.29

Yukon area that has very similar MPS values across most of the common class types. The plains MPS varies between about 200 and 500 hectares in the Upper Tanana, Lower Tanana, Koyukuk, and Kuskokwim areas, but is just over 50 hectares in the Upper Yukon area. All the remaining class MPS values, with the exception of open slopes in the Upper Tanana area, are under 50 hectares.

The highest ED in both winter and summer seasonal ranges, across all study areas, occurs in the open slope class. In the summer caribou ranges the ED is at least twice as large as the next nearest class except for in the Upper Yukon area where both the EDs for both open slopes and plains are just over 30. There is a substantial drop in the ED of open slopes between the summer and winter ranges, and a slight corresponding increase in the EDs of the other classes, especially in the Upper Yukon area. The MPE metrics are highly variable between the two seasonal ranges and among the study areas and no immediate patterning is descernible. The most noteable differences occur between the summer and winter ranges in the Koyukuk area where a very high open slope MPE of roughly 10,500 drops to less than 3,000. In this particular case there is a corresponding and inverse relationship with the MPE for plains, which increases from about 2,500 to 4,500 from summer to winter. In most of the other cases, the MPE metrics for canyons and high ridges are similar to MPE metrics for open slopes and plains.

With the exception of the AWMSI, the class shape metrics show little variability among the study areas or between seasonal ranges. The open slope AWMSI for the Koyukuk, Kuskokwim, Upper Tanana, and Upper Yukon ranges between 10 and 13. In the Lower Tanana area, the open slope AWMSI is substantially lower and more inline with the other patch AWMSI values for this particular study area. The Upper Yukon area has an inordinately large plains class AWMSI, which is four to five times larger than it is anywhere else. The AWMSI metrics show that in the winter range, plains patches tend to have the most convoluted shape. The AWMSI in the Upper Yukon remains the highest, but the plains patches here tend to be at least twice as complex as those in the other study areas. Execpt in the the Upper Yukon and Upper Tanana, the open slope patch shapes decrease substantially from their summer counterparts.

General Moose Range Characteristics (Landscape Level)

The majority of the information provided here on the moose's natural history is summarized from Franzmann (1981). The moose (*Alces alces*) is the largest member of the Cervidae family weighing, on average, over 500 kg. The mammal occurs throughout the northern boreal forests in North America, Asia, and Europe. In North America, at least three subspecies are recognized including *A. a. shirasi*, which ranges in the western continental United States, and *A. a. gigas*, which occupies Alaska, the Yukon Territories, and British Columbia. The third subspecies is A. a. Americana lives throughout Maine, Nova Scotia, Quebec, and eastern Ontario.

Moose need large quantities and high quality forage, both of which are often associated with early succession growth of disturbed areas. In Alaska and surrounding areas willow serves as a major resource, but seasonally available plants, such as aquatic plants in the summer and low bush cranberry bushes in the winter, account for considerable portions of the moose diet. Moose are known to exploit upwards of 360 different plant species. Deep or hard winter snows are considered strong limiting factors in moose winter survival rates. Population size is also strongly determined by predators. In Alaska, nonhuman predators include wolves, brown bears, and, in some places, black bears. Unlike wolves, bears mostly prey almost exclusively on calves.

Relative to many other cervids, moose are mostly solitary and nonterritorial animals, though they generally are partial to distinct home and seasonal ranges. Home ranges and seasonal ranges tend to be small covering only 2 km^2 to 17 km^2. Season-specific ranges, however, may be tens to hundreds of km apart. Travel routes between the moose's different ranges tend to be very similar from year to year.

Moose ranges, in aerial extent, are remarkably similar to their caribou counterparts. Table 5.5 presents the landscape level metrics for the general moose range in each study area, and Figure 5.4 displays the general moose ranges in relationship the study communities. The general moose range is smallest in the Upper Tanana area, at about 8.15 million hectares, and largest is the Lower Yukon area --almost 13.4 million hectares. The number of patches contained within each study areas moose range is lowest in the Lower Tanana area, with about 203,000 patches, and is highest in the Upper Yukon area, which has over 485,000 patches. Patch densities range between three and five patches per 100 hectares, a slight decrease relative to the caribou metrics. The MPS varies little among the general moose ranges in the Koyukuk, Kuskokwim, Lower Tanana, and Upper Tanana Areas, but is notably smaller in the Upper Yukon region. The MPS varies between 21.4 in the Upper Yukon region to 39.6 in the Upper Tanana area. Again, it appears that the Upper Yukon area is patchier than the other study areas.

The general moose range edge densities vary little among the five study areas, with each having ED metric values between 40.8 and 49.3 meters per hectare. The MPE values, however, vary considerably. MPE values are highest in the Upper Tanana, where the MPE is just over

Table 5.5. General Moose Range Landscape Metrics for the Five Study Areas

	Study Area				
	Koyukuk	**Kuskokwim**	Lower Tanana	Upper Tanana	Upper Yukon
Total Landscape Area (ha)	9,501,988.72	11,441,415.47	13,363,291.13	8,815,472.15	10,169,721.31
No. of Patches	222,671	301,616	283,190	204,327	376,655
Patch Density	0.02	0.03	0.02	0.02	0.04
Mean Patch Size (ha)	42.67	37.93	47.19	43.14	27.00
Patch Size Standard Deviation (ha)	10,230.82	8,558.67	9,025.55	5,492.87	8,285.18
Total Edge (m)	4.21E+08	5.20E+08	5.45E+08	4.35E+08	4.93E+08
Edge Density	44.27	45.47	40.80	49.34	48.46
Mean Patch Edge (m)	1,889.30	1,724.67	1,925.26	2,128.64	1,308.32
Mean Shape Index	1.41	1.39	1.40	1.39	1.43
Mean Perimeter to Area Ratio	506.10	523.63	376.99	398.02	1,148.72
Mean Patch Fractal Dimension	1.32	1.32	1.31	1.31	1.40
Area Weighted Mean Patch Shape Index	22.29	18.21	14.44	13.12	36.17
Area Weighted Mean Patch Fractal Dimension	1.36	1.36	1.34	1.35	1.40
Shannon's Diversity Index	2.07	2.02	2.08	1.98	1.84
Shannon's Eveness Index	0.90	0.88	0.90	0.86	0.80

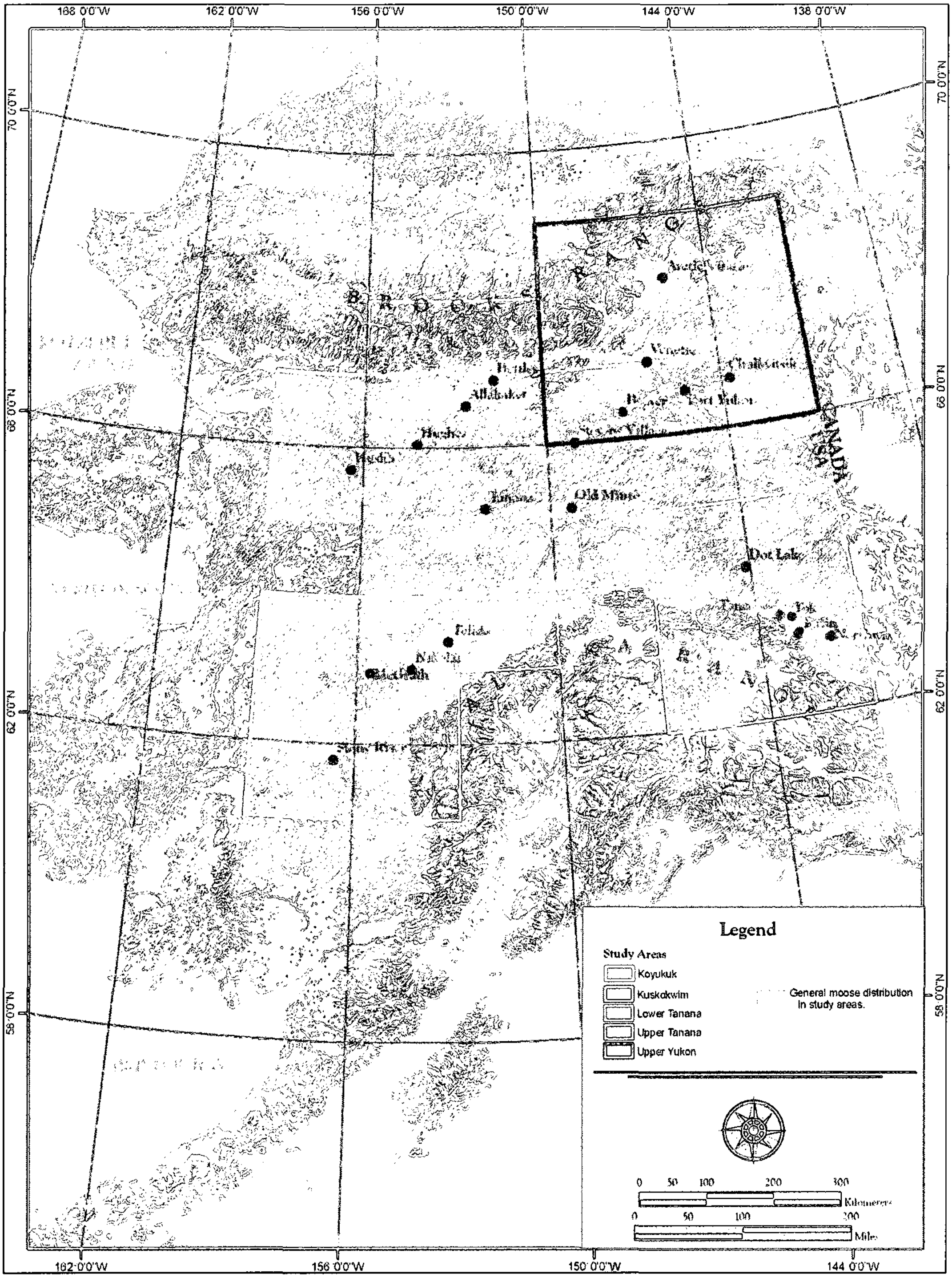


Figure 5.4. Five Study Areas and the General Distribution of Moose in Each. Distribution Derived from ADF&G 1973.

2,100 meters/patch. The Koyukuk area has a similar MPE value of approximately 1920 meters/patch. The lowest MPE value belongs to the Upper Yukon area; it is just under 1500 meters/patch.

The calculated shape indices have mixed results. The MPFD, the AWMPFD, and the MSI values vary little among the different study areas, though the Upper Yukon consistently has the highest values for these metrics making it stand out from the other study areas. The AWMSI and the MPAR results show considerably more variability than the unweighted measures. The AWMSI is below 20 in the Upper and Lower Tanana areas, as well as in the Kuskokwim region; the highest AWMSI belongs to the general moose range associated with the Upper Yukon. The Upper and Lower Tanana study areas have the lowest MPAR values while, the highest, not surprisingly, occurs in the Upper Yukon.

Again, the large overlap between caribou and moose ranges in each of the study areas is apparent in the gross patterning observed in the landscape structure. This is reflected when comparing the SHDI and SHEI scores, which are very consistent between the moose and caribou ranges in each study area.

Seasonal Moose Range Characteristics (Landscape Level)

Mapped seasonal moose ranges include those for fall, winter, and summer. The Upper Tanana, Kuskokwim, Lower Tanana, and Upper Yukon study areas include data for all three seasons, while the Koyukuk region contains data only for fall and winter ranges. Table 5.6 presents the seasonal moose range metrics for each study area and Figures 5.5 and 5.6 shows the location of the seasonal ranges relative to the study communities.

The fall moose range in the Koyukuk region consists of only 37,450 hectares and includes only 27 patches. Despite its small area, the overall MPS of 1,387 hectares is very large compared to the other study areas, which have MPS values of less than 75 hectares. Although the MPS values are relatively small, the standard deviations are quite large, particularly in the Kuskokwim and Lower Tanana areas. Although the MPS and SD for the five fall moose ranges vary considerably, it is evident based on the PD that the structure of the different ranges varies only moderately. Given the large difference between the Koyukuk region and the other study areas, it is not surprising that the edge metrics are also substantially different. Edge density is lowest and MPE is highest in the Koyukuk regions, and the remaining study areas show only minor variation. MSI values are highest in the Upper Yukon and Koyukuk areas and lowest in

Table 5.6. General Moose Seasonal Range Landscape Metrics for the Five Study Areas

	Study Area													
	Koyukuk		Kuskokwim			Lower Tanana			Upper Tanana			Upper Yukon		
	Season		Season			Season			Season			Season		
	Fall	Winter	Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter	Summer	Fall	Winter	Summer
Total Landscape Area (ha)	37450	462397	416326	701783	203679	646067	950378	337885	685323	1089875	480743	241180	1666241	283517
# of Patches	27	2,116	5,814	7,812	764	18,632	8,839	1,416	14,579	11,441	3,213	8,095	69,659	8,585
Patch Density	0.00	0.00	0.01	0.01	0.00	0.03	0.01	0.00	0.02	0.01	0.01	0.03	0.04	0.03
Mean Patch Size (ha)	1,387.06	218.52	71.61	89.83	266.59	34.68	107.52	238.62	47.01	95.26	149.62	29.79	23.92	33.02
Patch Size SD (Ha)	7,036.53	5,317.04	1,429.39	2,425.10	3,930.59	2,286.96	4,615.23	8,265.34	706.73	2,325.36	3,689.39	861.97	1,739.14	967.76
Total Edge (m)	1.48E+05	5.69E+06	1.38E+07	1.72E+07	2.55E+06	3.00E+07	1.88E+07	2.92E+06	3.27E+07	2.87E+07	8.38E+06	1.20E+07	8.88E+07	1.27E+07
Edge Density	3.95	12.31	33.18	24.58	12.52	46.44	19.78	8.65	47.67	26.30	17.42	49.61	53.32	44.88
Mean Patch Edge (m)	5,479.73	2,690.34	2,376.05	2,208.08	3,336.51	1,610.36	2,126.62	2,065.07	2,241.03	2,505.79	2,606.99	1,478.11	1,275.42	1,482.03
Mean Shape Index (MSI)	1.47	1.48	1.44	1.46	1.50	1.39	1.46	1.42	1.43	1.45	1.51	1.51	1.46	1.51
Area Weighted MSI	1.71	4.98	4.52	6.42	3.28	3.03	4.84	3.29	4.38	4.83	3.25	7.58	11.01	7.21
Mean Perimeter to Area Ratio	365.32	808.58	633.89	973.33	811.81	458.10	1,163.62	624.64	1,159.64	1,903.47	3,661.32	3,790.83	1,574.69	3,831.02
Mean Patch Fractal Dimension (MPFD)	1.32	1.34	1.33	1.36	1.39	1.25	1.34	1.33	1.32	1.32	1.33	1.39	1.40	1.40
Area Weighted MPFD	1.18	1.28	1.30	1.30	1.24	1.26	1.28	1.23	1.30	1.29	1.25	1.34	1.35	1.34
Shannon's Diverusty Index	0.68	1.50	1.83	1.73	1.59	2.10	1.95	1.90	1.92	1.75	1.65	1.49	1.86	1.48
Shannon's Evenness Index	0.49	0.65	0.79	0.75	0.69	0.91	0.85	0.82	0.83	0.76	0.72	0.65	0.81	0.64

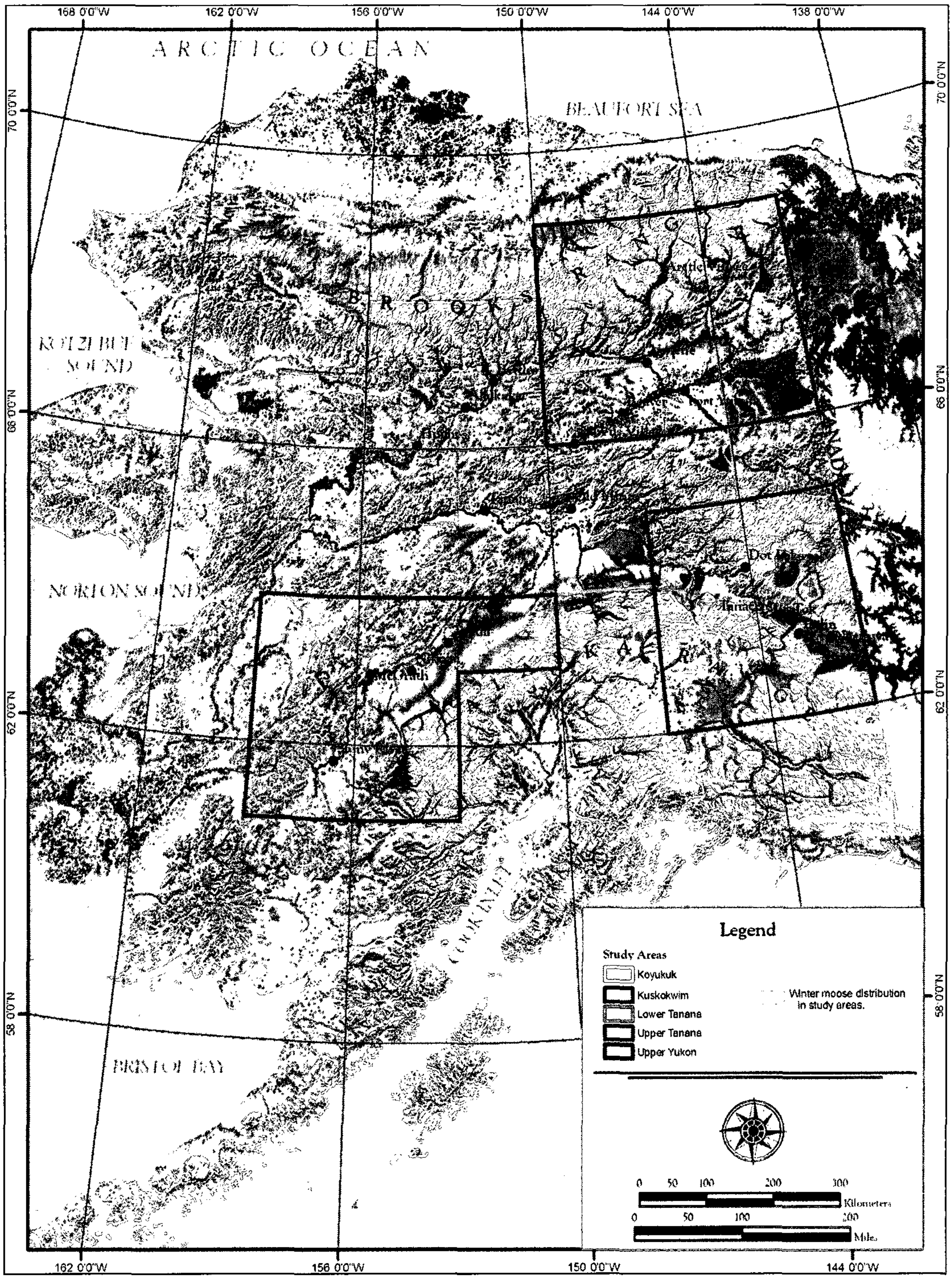


Figure 5.5. Five Study Areas and the Winter Distribution of Moose in Each. Distribution Derived from ADF&G 1973.

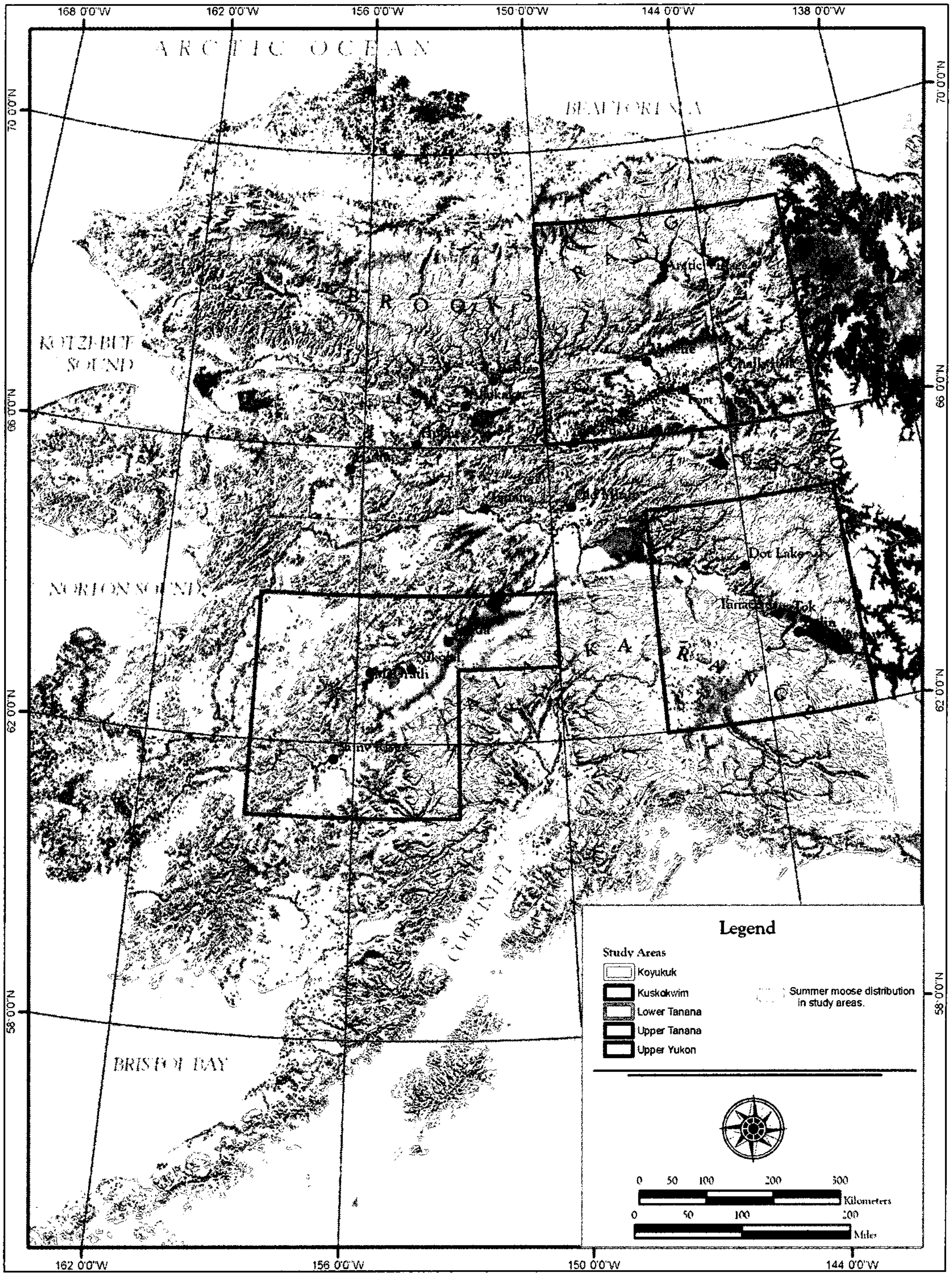


Figure 5.6. Five Study Areas and the Summer Distribution of Moose in Each. Distribution Derived from ADF&G 1973.

the Lower Tanana area. The AWMSI values, however, are more uneven and suggest increasing patch complexity with increased number and size of patches in a particular landscape. The increase in the AWMSI more or less corresponds with increases in the MPAR values for the different study areas. Based on these values, it is clear that the Upper Yukon fall moose range is significantly patchier than the Koyukuk range and moderately patchier than the remaining three study areas. The SHDI and SHEI values for the Koyukuk, Kuskokwim, Upper Yukon, and, to a much more limited extent, the Upper Tanana, are considerably lower than hey are for the general caribou range in each area; this indicates less diversity and more evenness in the distribution of patch types in the fall ranges relative to the general range. On the other hand, the Lower Tanana area SHDI and SHEI values indicate a strong similarity between the general and fall ranges.

Winter moose ranges in the five study areas are substantially larger than their autumn and summer counterparts varying between 462,400 and 1.66 million hectares. Despite the larger ranges, the MPS is unpredictable. The MPS, compared to those of the fall range, decreases dramatically in the Koyukuk area and slightly in the Upper Yukon area, while the MPS in the remaining three areas increases with the increased range size, but not proportionately. Patch densities are one or less patches per 100 hectares, except in the Upper Yukon where the PD is about four patches per 100 hectares. Edge densities are lowest in the Koyukuk region and highest in the Upper Yukon, with the average ED being approximately 23.5 for the remaining three study areas. The MPE varies only by a couple hundred meters in all the areas except the Upper Yukon where the MPE is about half that of the other areas. In terms of MSI, the complexity of the patches, at a general level, is very similar; however, the AWMSI in the Upper Yukon is about three times larger than it is in the other four study areas, detailing a higher patch shape complexity. This complexity also manifests itself in the slightly higher MPFD and AWMPFD values for the Upper Yukon. The SHDI values vary between 1.5 in the Koyukuk area to 1.95 in the Lower Tanana area; the SHDI values are, generally, substantially lower than the SHDI for winter caribou ranges.

Generally, the summer ranges are one-half to one-third smaller than the mapped winter ranges, but the MPS is considerably larger in all the ranges except for in the Upper Yukon, where the MPS is only slightly larger than the MPS of the winter range. There is a slight to moderate drop in the ED and a slight increase in the MPE for each of the four study areas that have both winter and summer ranges. The shape indices show substantial variation among the different areas, as well as between the summer and winter ranges. Both the Upper Yukon and Upper Tanana have exaggerated MPAR values. The AWMSI values are similar among the Kuskokwim, Upper Tanana and Lower Tanana areas, though the Upper Yukon AWMSI is at least three times larger. The MPFD and AWMPFD values are also variable among the study areas, but there is a general trend of less shape complexity between the summer and winter ranges. The SHDI scores are all below 2.0; with the Upper Yukon being the lowest at 1.48 and the Lower Tanana being the highest at 1.90. Relative to the corresponding seasonal caribou range, the SHDI scores are substantially, but not significantly, lower--indicating slightly less patch diversity. The SHEI scores vary between 0.64 in the Upper Yukon area to 0.82 in the Lower Tanana. Again, these values are slightly lower than the corresponding SHEI values for the caribou ranges in each study area.

General Moose Range Characteristics (Class Level)

The class level metrics for the general moose range in each of the five study areas are given in Table 5.7. By far, the two most common patch types in the five study areas are plains and open slopes. The plains patch type consists of between 47 and 63% of the total moose range. Despite the high percentage of the patch type in each moose range, the MPS varies considerably between 66 hectares, in the Upper Yukon region, to 388 hectares in the Lower Tanana area.

In all cases, the PD is less than two patches per 100 hectares. Open slopes account for between 12 and 25% of the general moose range in the study areas. Like the plains patches, the MPS for open slopes is also variable. In the Upper Tanana, Kuskokwim, Upper Yukon, and Koyukuk, the MPS for open slopes is between 14 and 46 hectares, but jumps to just over 100 hectares in the Lower Tanana area, which is just slightly smaller than the MPS for plains patches in the same area. The PD varies between one and four patches per 100 hectares.

The remaining patch types, individually, do not exceed more than seven percent of the general moose range in any of the study areas. These percentages are substantially, but not significantly, lower than the percentages of the same patch types in the general caribou range. The MPS for patch types other than plains and slopes varies considerably, but there is some general consistency for similar patch types among the different study areas. For example, high ridges and canyons commonly exceed 20 hectares, while local ridges, midslope ridges, midslope

Table 5.7. General Moose Range Class Metrics for the Five Study Areas

		Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density
Koyukuk	Canyon	370,705.43	3.90	0.04	25.31	3.62
	Midslope Drainage	316,113.44	3.33	0.14	7.30	4.87
	Upland Drainage	33,239.07	0.35	0.28	3.52	0.73
	U-shaped Valley	694,283.13	7.31	0.03	31.85	4.71
	Plains	5,336,132.15	56.16	0.00	333.53	5.86
	Open Slope	1,568,912.27	16.51	0.02	46.15	11.44
	Upper Slope	479,073.34	5.04	0.06	16.85	4.96
	Local Ridge	8,668.22	0.09	0.43	2.35	0.23
	Midslope Ridge	238,885.90	2.51	0.16	6.17	3.98
	High Ridge	455,975.77	4.80	0.03	36.17	3.88
Kuskokwim	Canyon	380,486.38	3.33	0.04	24.91	3.08
	Midslope Drainage	419,233.12	3.66	0.13	7.97	5.12
	Upland Drainage	39,835.42	0.35	0.30	3.29	0.74
	U-shaped Valley	634,203.71	5.54	0.04	25.96	3.65
	Plains	7,053,173.60	61.65	0.00	238.89	7.06
	Open Slope	1,669,650.14	14.59	0.04	26.98	13.40
	Upper Slope	405,586.17	3.54	0.10	10.25	4.44
	Local Ridge	6,296.04	0.06	0.57	1.77	0.16
	Midslope Ridge	303,721.69	2.65	0.16	6.24	4.17
	High Ridge	529,229.21	4.63	0.03	37.70	3.65
L. Tanana	Canyon	519,790.52	3.89	0.03	32.91	3.30
	Midslope Drainage	400,042.70	2.99	0.13	7.78	4.27
	Upland Drainage	42,977.52	0.32	0.27	3.64	0.66
	U-shaped Valley	777,970.40	5.82	0.04	26.32	4.19
	Plains	8,291,992.41	62.05	0.00	388.22	5.65
	Open Slope	1,624,587.06	12.16	0.03	32.01	10.25
	Upper Slope	720,100.95	5.39	0.05	21.02	4.77
	Local Ridge	16,238.24	0.12	0.38	2.63	0.29
	Midslope Ridge	337,269.31	2.52	0.14	7.11	3.78
	High Ridge	632,322.02	4.73	0.02	43.19	3.64

Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
2,349.26	1.51	2.79	370.81	1.31	1.31
1,068.86	1.34	1.66	435.92	1.32	1.29
730.09	1.29	1.46	557.13	1.32	1.29
2,052.31	1.39	4.17	446.49	1.32	1.32
3,478.92	1.34	36.79	433.92	1.32	1.39
3,197.73	1.55	5.19	547.77	1.32	1.34
1,656.73	1.42	2.84	569.07	1.32	1.32
593.98	1.27	1.41	560.96	1.32	1.30
976.49	1.33	1.60	588.39	1.32	1.29
2,923.61	1.54	2.35	537.56	1.32	1.29
2,309.11	1.48	2.63	353.83	1.31	1.31
1,114.88	1.33	1.67	499.55	1.31	1.28
698.09	1.29	1.49	549.19	1.33	1.29
1,709.90	1.36	3.85	561.35	1.33	1.32
2,733.93	1.34	26.79	603.18	1.34	1.38
2,476.75	1.54	7.46	572.38	1.31	1.37
1,284.33	1.38	2.68	514.92	1.33	1.32
509.45	1.26	1.42	650.00	1.32	1.30
981.16	1.32	1.57	458.05	1.31	1.28
2,971.55	1.50	2.31	548.39	1.30	1.29
2,792.84	1.52	3.05	321.53	1.31	1.31
1,110.37	1.33	1.65	369.50	1.31	1.28
745.33	1.29	1.46	410.11	1.32	1.29
1,892.04	1.38	3.44	406.97	1.32	1.32
3,534.15	1.35	21.42	405.79	1.31	1.35
2,698.60	1.53	3.62	363.94	1.32	1.33
1,859.56	1.41	2.97	394.06	1.32	1.32
635.17	1.27	1.43	456.17	1.32	1.30
1,065.32	1.34	1.65	382.32	1.31	1.29
3,325.41	1.56	2.69	288.60	1.30	1.30

Table 5.7. General Moose Range Class Metrics for the Five Study Areas (continued)

		Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
Upper Tanana	Canyon	347,084.61	3.94	0.04	25.62	3.58	2,329.46	1.48	2.53	315.67	1.30	1.30
	Midslope Drainage	346,325.87	3.93	0.12	8.06	5.39	1,106.16	1.32	1.59	400.10	1.31	1.28
	Upland Drainage	17,888.00	0.20	0.29	3.41	0.42	713.73	1.29	1.43	458.87	1.32	1.29
	U-shaped Valley	542,068.35	6.15	0.04	26.90	4.34	1,896.97	1.37	3.79	416.43	1.31	1.32
	Plains	4,152,710.57	47.11	0.01	187.32	6.42	2,553.60	1.33	18.98	337.96	1.30	1.35
	Open Slope	2,256,822.36	25.60	0.01	102.28	15.68	6,263.37	1.63	13.65	413.10	1.32	1.40
	Upper Slope	448,975.43	5.09	0.05	20.08	4.71	1,857.77	1.42	2.84	473.09	1.32	1.31
	Local Ridge	5,008.07	0.06	0.50	2.00	0.16	555.61	1.26	1.35	635.59	1.32	1.30
	Midslope Ridge	297,079.49	3.37	0.14	7.39	4.87	1,068.48	1.32	1.53	386.87	1.31	1.28
	High Ridge	401,509.41	4.55	0.03	30.64	3.76	2,531.38	1.46	2.10	360.62	1.29	1.28
Upper Yukon	Canyon	239,386.63	2.35	0.06	16.88	2.34	1,679.96	1.45	3.06	836.39	1.36	1.32
	Midslope Drainage	227,388.10	2.24	0.19	5.23	3.64	851.26	1.37	1.96	937.72	1.37	1.30
	Upland Drainage	15,953.68	0.16	0.38	2.62	0.35	581.64	1.33	1.57	974.97	1.36	1.30
	U-shaped Valley	594,491.43	5.85	0.04	27.34	3.53	1,652.87	1.40	4.01	1,143.60	1.40	1.32
	Plains	6,442,918.85	63.35	0.02	66.25	12.29	1,284.98	1.38	53.62	1,316.78	1.41	1.43
	Open Slope	1,646,404.02	16.19	0.07	14.02	16.47	1,425.56	1.53	9.76	1,270.59	1.43	1.39
	Upper Slope	462,743.21	4.55	0.04	22.22	3.83	1,872.71	1.48	3.56	1,048.14	1.39	1.33
	Local Ridge	5,269.14	0.05	0.64	1.56	0.15	443.57	1.30	1.51	997.01	1.38	1.31
	Midslope Ridge	197,671.19	1.94	0.19	5.21	3.15	842.81	1.35	1.65	876.57	1.36	1.29
	High Ridge	337,495.06	3.32	0.04	23.66	2.71	1,931.28	1.42	2.16	942.39	1.34	1.28

drainages, and upslope drainages average less than 10 hectares; U-shaped valleys have the most variable MPS values among the study areas. In terms of the edge metrics, the ED is highest for open slopes in all five regions. The corresponding MPE for open slopes is similar to the MPE values for plains, except in the Upper Tanana area where the MPE for open slopes is still twice as large as the plains MPE. Perhaps the most telling in the metrics suite are the AWMSI values. Here the AWMSI for plains patches is very high, over 20.0, while the AWMSI values for all the other patch classes are mostly below 5.0. Again, the Upper Tanana area is the exception. In this particular case, the AWMSI for open slopes is almost 14.0 and almost 19.0 for plains. The AWMSI values demonstrate that relative to the shape of plains patches, most patch classes have simpler shapes. The AWMPFD for plains and open slopes are slightly higher in all five regions when compared with the other class types. The MPFD, however, is similar among all the patch types.

Seasonal Moose Range Characteristics (Class Level)

At the class level, the seasonal moose ranges show less diversity, for landforms present, than the seasonal caribou ranges. Plains patches dominate all the autumn moose ranges and account for between 51 and 69% in the Upper Tanana, Lower Tanana, Upper Yukon, and Kuskokwim study areas (Table 5.8). In the Koyukuk, the plains patches in the small mapped range (37,500 hectares) account for nearly 100% of the landscape. Open slope patches are the second most common patch types, in terms of frequency and area. The percentage of open slopes in the fall moose range is between 10 and 25%, except in the Koyukuk region where open slopes account for less than 1/2 of 1%. Fall moose range in U-shaped valleys is common to all the study areas, except the Koyukuk region, but accounts for less than 12% of the total range. The remaining landform classes either account for very small portions of the landscape, or are absent altogether. Although the plains patches tend to be large, the MPS varies considerably among the different study areas. The plains MPS in the Koyukuk region is over 12,000 hectares, while the remaining areas vary between 82.72 hectares in the Upper Yukon to 446.24 hectares in the Kuskokwim region. Though ED values are variable, they tend to be highest for open slopes and lowest for plains patches. In general, the AWMSI scores become larger as the size of the different patches increased, but this relationship is by no means linear; there is also considerable variation in the AWMSI scores among the same patch types in the different regions.

Table 5.8. Seasonal Moose Range Class Metrics for the Five Study Areas

			Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge
Koyukuk	Fall	Midslope Drainage	9.00	0.02	0.44	2.25	0.06	592.35
		Plains	37,267.92	99.51	0.00	12,422.64	3.14	39,193.89
		Open Slope	127.78	0.34	0.11	9.13	0.51	1,366.90
		Midslope Ridge	46.02	0.12	0.13	7.67	0.24	1,477.53
	Winter	Canyon	1,008.00	0.22	0.10	9.60	0.34	1,490.77
		Midslope Drainage	2,729.11	0.59	0.19	5.35	1.05	948.40
		Upland Drainage	0.74	0.00	1.36	0.74	0.00	394.95
		U-shaped Valley	4,975.19	1.08	0.02	52.93	0.59	2,920.83
		Plains	436,627.14	94.43	0.00	3,074.84	6.20	20,182.28
		Open Slope	12,699.29	2.75	0.05	21.49	2.70	2,111.41
		Upper Slope	1,181.99	0.26	0.10	9.69	0.29	1,114.42
		Local Ridge	6.88	0.00	1.02	0.98	0.01	389.12
		Midslope Ridge	2,089.19	0.45	0.21	4.66	0.83	860.64
		High Ridge	1,079.54	0.23	0.09	11.25	0.30	1,454.20
Kuskokwim	Fall	Canyon	5,852.63	1.41	0.08	12.53	1.74	1,547.68
		Midslope Drainage	6,771.39	1.63	0.17	5.83	2.69	965.68
		Upland Drainage	313.52	0.08	0.31	3.20	0.16	691.04
		U-shaped Valley	30,275.48	7.27	0.01	68.19	2.89	2,708.19
		Plains	289,166.26	69.46	0.00	446.24	9.65	6,197.37
		Open Slope	62,656.84	15.05	0.02	61.25	10.09	4,104.88
		Upper Slope	7,942.94	1.91	0.06	15.48	1.86	1,510.27
		Local Ridge	76.10	0.02	0.54	1.86	0.06	558.80
		Midslope Ridge	5,813.40	1.40	0.19	5.39	2.36	910.92
		High Ridge	7,457.48	1.79	0.05	21.93	1.69	2,072.13

Means Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
1.17	1.20	340.22	1.29	1.28
1.45	1.71	367.90	1.29	1.18
1.52	1.60	390.78	1.33	1.29
1.55	2.01	321.37	1.32	1.33
1.59	2.33	786.92	1.36	1.33
1.38	1.82	970.53	1.34	1.30
1.30	1.30	535.70	1.34	1.34
1.47	2.40	389.19	1.31	1.28
1.61	5.14	624.18	1.34	1.28
1.60	2.59	583.46	1.35	1.31
1.41	1.64	735.08	1.35	1.27
1.25	1.24	588.03	1.34	1.31
1.37	1.55	897.83	1.33	1.29
1.51	1.71	1,737.12	1.45	1.29
1.46	2.02	508.95	1.33	1.30
1.34	1.55	559.80	1.33	1.28
1.28	1.36	1,156.47	1.27	1.29
1.42	3.00	518.97	1.33	1.29
1.45	4.89	627.62	1.31	1.29
1.67	4.98	582.04	1.38	1.34
1.43	2.62	755.66	1.34	1.31
1.30	1.35	3,885.59	1.28	1.30
1.32	1.44	533.40	1.32	1.28
1.48	1.76	969.00	1.30	1.27

Table 5.8. Seasonal Moose Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Means Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
	Summer	Canyon	858.46	0.42	0.10	10.10	0.55	1,307.54	1.47	2.15	534.04	1.34	1.30
		Midslope Drainage	911.04	0.45	0.16	6.24	0.75	1,052.71	1.40	1.74	1,307.98	1.31	1.29
		Upland Drainage	10.12	0.00	0.59	1.69	0.02	547.97	1.21	1.25	360.98	1.30	1.30
		U-shaped Valley	8,518.35	4.18	0.01	152.11	1.21	4,407.54	1.47	3.06	476.39	1.32	1.28
		Plains	181,663.00	89.19	0.00	2,018.48	5.72	12,953.68	1.54	3.31	903.77	1.35	1.23
		Open Slope	9,486.28	4.66	0.02	56.80	3.00	3,660.23	1.71	3.32	880.35	1.60	1.31
		Upper Slope	970.98	0.48	0.04	28.56	0.37	2,210.24	1.52	2.72	394.00	1.32	1.31
		Local Ridge	15.96	0.01	0.50	1.99	0.02	610.32	1.33	1.37	439.07	1.33	1.31
		Midslope Ridge	525.05	0.26	0.26	3.86	0.52	776.35	1.35	1.44	674.65	1.34	1.29
		High Ridge	719.31	0.35	0.05	19.98	0.35	1,984.50	1.53	1.93	500.00	1.32	1.29
	Winter	Canyon	7,517.59	1.07	0.07	13.64	1.34	1,712.34	1.54	2.47	622.28	1.34	1.32
		Midslope Drainage	7,805.09	1.11	0.19	5.15	1.91	883.59	1.37	1.71	878.68	1.35	1.29
		Upland Drainage	203.68	0.03	0.55	1.80	0.08	485.19	1.28	1.38	1,039.02	1.37	1.30
		U-shaped Valley	36,809.25	5.25	0.02	57.42	2.15	2,348.66	1.42	3.13	1,031.47	1.38	1.29
		Plains	589,501.31	84.00	0.00	798.78	9.74	9,259.71	1.50	7.00	1,028.75	1.40	1.30
		Open Slope	41,588.70	5.93	0.05	22.00	5.82	2,162.11	1.63	4.78	1,018.29	1.35	1.34
		Upper Slope	4,749.36	0.68	0.13	7.72	0.91	1,037.06	1.39	2.03	1,460.86	1.41	1.30
		Local Ridge	52.39	0.01	1.13	0.89	0.03	354.84	1.32	1.49	1,309.09	1.41	1.33
		Midslope Ridge	6,422.82	0.92	0.21	4.79	1.62	850.34	1.35	1.49	744.28	1.34	1.28
		High Ridge	7,132.60	1.02	0.05	20.50	0.98	1,974.27	1.51	1.74	1,415.15	1.35	1.27
Lower Tanana	Fall	Canyon	30,012.72	4.65	0.03	30.44	3.93	2,572.49	1.49	2.75	576.20	1.30	1.31
		Midslope Drainage	24,247.04	3.75	0.13	7.69	5.33	1,091.06	1.33	1.65	391.92	1.31	1.28
		Upland Drainage	3,097.40	0.48	0.26	3.91	0.94	769.65	1.30	1.47	531.66	1.30	1.29
		U-shaped Valley	35,748.32	5.53	0.05	18.93	4.58	1,566.38	1.37	2.99	457.44	1.32	1.31
		Plains	400,301.02	61.96	0.00	307.69	5.68	2,821.33	1.38	3.31	614.33	1.30	1.24

Table 5.8. Seasonal Moose Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Means Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
Lower Tanana (cont)		Open Slope	68,424.44	10.59	0.06	17.76	11.62	1,948.53	1.49	2.99	418.50	1.32	1.33
		Upper Slope	26,651.21	4.13	0.09	10.99	4.93	1,314.21	1.38	2.51	468.81	0.81	1.31
		Local Ridge	1,172.97	0.18	0.39	2.57	0.44	624.19	1.26	1.39	433.59	1.32	1.29
		Midslope Ridge	20,967.78	3.25	0.14	7.15	4.82	1,063.14	1.33	1.60	447.99	1.31	1.28
		High Ridge	35,443.99	5.49	0.02	42.05	4.16	3,191.82	1.53	2.54	457.35	1.31	1.29
	Summer	Canyon	1,090.08	0.32	0.05	18.48	0.32	1,835.73	1.46	2.43	345.46	1.31	1.30
		Midslope Drainage	2,358.26	0.70	0.13	7.83	1.00	1,117.07	1.35	1.60	476.02	1.32	1.28
		Upland Drainage	43.61	0.01	0.67	1.50	0.04	483.89	1.23	1.27	592.14	1.33	1.30
		U-shaped Valley	2,491.25	0.74	0.02	48.85	0.44	2,897.18	1.51	2.49	1,775.72	1.46	1.29
		Plains	318,053.83	94.13	0.00	2,944.94	2.35	7,357.93	1.35	3.34	525.77	1.33	1.23
		Open Slope	7,338.15	2.17	0.03	29.59	2.22	3,025.34	1.67	3.12	402.76	1.33	1.33
		Upper Slope	1,849.29	0.55	0.14	7.25	0.80	1,060.51	1.36	2.02	414.54	1.32	1.31
		Local Ridge	12.59	0.00	0.79	1.26	0.01	451.83	1.31	1.31	754.15	1.35	1.31
		Midslope Ridge	1,652.42	0.49	0.17	5.92	0.79	952.84	1.35	1.62	1,153.80	1.32	1.29
		High Ridge	2,995.65	0.89	0.03	39.42	0.69	3,053.62	1.50	2.02	279.91	1.29	1.28
	Winter	Canyon	21,417.04	2.25	0.04	24.76	2.14	2,356.20	1.57	2.94	1,547.50	1.34	1.32
		Midslope Drainage	7,965.35	0.84	0.19	5.24	1.42	890.78	1.35	1.65	723.26	1.34	1.29
		Upland Drainage	184.57	0.02	0.63	1.58	0.06	506.72	1.29	1.32	699.50	1.35	1.30
		U-shaped Valley	57,019.11	6.00	0.02	54.51	3.30	2,996.14	1.50	3.58	941.47	1.34	1.31
		Plains	798,134.68	83.98	0.00	1,226.01	5.20	7,585.64	1.49	5.23	683.17	1.37	1.27
		Open Slope	40,379.22	4.25	0.04	24.61	4.12	2,388.84	1.63	2.56	1,161.89	1.34	1.31
		Upper Slope	6,617.22	0.70	0.13	7.95	0.97	1,109.93	1.40	1.91	1,206.31	1.33	1.30
		Local Ridge	477.94	0.05	0.58	1.71	0.15	518.70	1.28	1.33	529.70	1.33	1.30
		Midslope Ridge	8,567.19	0.90	0.17	5.78	1.47	945.40	1.36	1.52	1,996.98	1.33	1.28
		High Ridge	9,615.18	1.01	0.04	23.68	0.93	2,177.93	1.51	1.88	783.92	1.33	1.28

Table 5.8. Seasonal Moose Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Means Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
Upper Tanana	Fall	Canyon	22,396.94	3.27	0.05	19.13	3.32	1,941.42	1.47	2.25	402.04	1.31	1.30
		Midslope Drainage	19,616.45	2.86	0.16	6.36	4.48	996.07	1.33	1.52	1,475.74	1.31	1.28
		Upland Drainage	618.58	0.09	0.39	2.54	0.22	608.84	1.29	1.38	708.70	1.35	1.29
		U-shaped Valley	49,014.85	7.15	0.03	34.69	4.38	2,124.05	1.41	3.56	4,848.08	1.32	1.31
		Plains	353,357.04	51.56	0.00	209.71	9.55	3,885.05	1.43	3.79	518.61	1.31	1.27
		Open Slope	172,644.45	25.19	0.01	86.15	15.30	5,232.83	1.69	7.27	579.00	1.33	1.36
		Upper Slope	29,175.68	4.26	0.04	23.99	3.58	2,017.48	1.43	2.98	813.48	1.32	1.31
		Local Ridge	221.66	0.03	0.62	1.62	0.10	509.18	1.28	1.29	585.23	1.34	1.30
		Midslope Ridge	17,680.42	2.58	0.15	6.51	3.96	999.75	1.33	1.49	521.88	1.31	1.28
		High Ridge	20,597.29	3.01	0.04	22.68	2.78	2,097.69	1.46	1.85	373.00	1.31	1.28
		Upland Drainage	51.77	0.01	0.21	4.71	0.02	813.01	1.43	1.32	680.37	1.35	1.27
		U-shaped Valley	18,323.94	3.81	0.01	72.71	1.61	3,073.21	1.45	3.85	25,330.70	1.32	1.30
		Plains	417,775.38	86.90	0.00	1,285.46	6.26	9,261.80	1.50	3.29	641.27	1.33	1.24
		Open Slope	31,693.17	6.59	0.02	43.47	5.42	3,573.01	1.80	3.10	634.41	1.35	1.32
		Upper Slope	1,328.77	0.28	0.13	7.91	0.36	1,031.78	1.37	1.90	558.79	1.33	1.29
		Local Ridge	6.56	0.00	0.91	1.09	0.01	415.01	1.28	1.40	710.58	1.36	1.32
		Midslope Ridge	3,043.54	0.63	0.20	4.95	1.12	872.04	1.36	1.42	1,044.02	1.28	1.28
		High Ridge	1,734.79	0.36	0.07	14.34	0.40	1,597.78	1.50	1.60	510.01	1.32	1.27
	Winter	Canyon	12,443.01	1.14	0.06	16.84	1.26	1,855.93	1.52	2.98	515.52	1.33	1.32
		Midslope Drainage	14,614.98	1.34	0.17	5.89	2.22	975.22	1.35	1.65	1,827.42	1.32	1.29
		Upland Drainage	535.78	0.05	0.24	4.25	0.09	793.60	1.31	1.38	447.20	1.32	1.28
		U-shaped Valley	36,272.83	3.33	0.02	42.57	1.80	2,304.37	1.41	3.57	7,924.77	1.33	1.31
		Plains	847,832.41	77.79	0.00	606.03	8.04	6,265.07	1.43	5.02	534.10	1.32	1.28
		Open Slope	139,797.77	12.83	0.02	63.98	8.67	4,325.17	1.73	5.31	2,618.74	1.34	1.34
		Upper Slope	13,050.35	1.20	0.06	17.13	1.13	1,617.73	1.40	2.60	526.02	1.33	1.30
		Local Ridge	161.72	0.01	0.46	2.19	0.04	586.15	1.26	1.39	451.27	1.32	1.30
		Midslope Ridge	14,262.97	1.31	0.16	6.29	2.09	1,003.68	1.34	1.51	1,304.14	1.32	1.28
		High Ridge	10.903.09	1.00	0.05	19.72	0.96	1.889.12	1.43	1.72	343.02	1.30	1.27

Table 5.8. Seasonal Moose Range Class Metrics for the Five Study Areas (continued)

			Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Means Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
Upper Yukon	Fall	Canyon	2,976.02	1.23	0.11	8.80	1.74	1,243.50	1.47	1.98	1,137.97	1.34	1.30
		Midslope Drainage	2,202.90	0.91	0.28	3.55	1.89	734.76	1.40	1.64	1,813.65	1.35	1.30
		Upland Drainage	57.66	0.02	0.69	1.44	0.07	415.97	1.30	1.36	971.60	1.38	1.30
		U-shaped Valley	27,155.63	11.26	0.01	84.86	3.95	2,979.39	1.43	3.57	1,700.66	1.37	1.29
		Plains	161,217.59	66.85	0.01	82.72	17.55	2,172.32	1.44	9.71	1,569.30	1.44	1.36
		Open Slope	41,178.90	17.07	0.09	11.06	20.17	1,306.73	1.59	3.57	6,487.95	1.42	1.34
		Upper Slope	1,411.48	0.59	0.23	4.26	1.10	800.19	1.47	1.76	1,329.26	1.41	1.30
		Local Ridge	4.12	0.00	2.92	0.34	0.01	240.24	1.27	1.31	1,125.06	1.40	1.36
		Midslope Ridge	2,372.90	0.98	0.24	4.11	1.91	798.89	1.39	1.55	1,016.01	1.15	1.29
		High Ridge	2,602.52	1.08	0.07	14.14	1.21	1,582.14	1.50	1.63	1,851.35	1.38	1.27
	Summer	Canyon	3,209.71	1.13	0.11	8.94	1.59	1,252.67	1.47	1.96	1,108.90	1.34	1.30
		Midslope Drainage	2,310.94	0.82	0.28	3.56	1.70	739.64	1.42	1.64	2,014.60	1.41	1.30
		Upland Drainage	57.66	0.02	0.69	1.44	0.06	415.97	1.30	1.36	971.60	1.38	1.30
		U-shaped Valley	28,495.81	10.05	0.01	82.84	3.59	2,959.88	1.43	3.51	1,649.88	1.37	1.29
		Plains	199,230.80	70.27	0.01	100.98	15.91	2,286.87	1.44	8.88	1,563.57	1.44	1.34
		Open Slope	43,634.11	15.39	0.09	10.71	18.31	1,274.25	1.59	3.49	6,041.36	1.42	1.34
		Upper Slope	1,452.96	0.51	0.24	4.18	0.97	790.82	1.47	1.77	5,238.13	1.40	1.31
		Local Ridge	4.12	0.00	2.92	0.34	0.01	240.24	1.27	1.31	1,125.06	1.40	1.36
		Midslope Ridge	2,450.37	0.86	0.24	4.13	1.68	803.43	1.39	1.56	999.15	1.15	1.29
		High Ridge	2,670.16	0.94	0.07	13.91	1.06	1,565.41	1.55	1.63	2,364.62	1.40	1.27
	Winter	Canyon	49,331.56	2.96	0.06	15.98	3.03	1,638.02	1.46	3.61	1,024.27	1.37	1.33
		Midslope Drainage	38,737.43	2.32	0.22	4.46	4.01	769.96	1.37	1.94	1,200.12	1.36	1.31
		Upland Drainage	3,197.06	0.19	0.45	2.24	0.46	535.41	1.33	1.57	1,058.58	1.38	1.31
		U-shaped Valley	141,215.77	8.48	0.04	28.27	4.64	1,547.39	1.42	3.47	1,298.88	1.41	1.31
		Plains	1,086,788.80	65.22	0.01	72.39	14.54	1,613.63	1.40	15.07	1,360.33	1.42	1.37
		Open Slope	187,445.48	11.25	0.12	8.11	16.70	1,203.74	1.57	4.21	2,248.85	1.42	1.37
		Upper Slope	63,063.41	3.78	0.06	17.24	3.72	1,692.73	1.50	3.68	1,603.60	1.41	1.34
		Local Ridge	870.85	0.05	0.88	1.13	0.17	372.89	1.31	1.54	1,241.34	1.41	1.32
		Midslope Ridge	32,594.30	1.96	0.20	4.96	3.24	821.21	1.37	1.70	993.15	1.36	1.29
		High Ridge	62,996.02	3.78	0.04	26.93	2.81	2,002.39	1.44	2.13	1,007.22	1.37	1.28

Mapped summer moose range is present in all the study areas except the Koyukuk. As with the fall moose ranges, the plains patches dominate the summer moose ranges, though to a substantially higher degree. The percentage of the summer moose range composed of plains patches is lowest in the Upper Yukon at approximately 70%, and is highest in the Lower Tanana area at 94%. Open slopes and U-shaped valleys comprise most of the remaining 6 to 30% of these landscapes. The Kuskokwim and Lower Tanana areas have plains MPS values in excess of 2,000 hectares, and the Upper Tanana has a plains mean patch size of nearly 1,300 hectares. The Upper Yukon region, however, has a plains MPS value of only 100 hectares; not much larger than the third most common patch type in the same region, U-shaped valley, which has a MPS of about 83 hectares. This is likely attributable to the more mountainous terrain that this area occupies, making it a patchier environment. Edge densities are variable, but are generally higher for the dominant patches in a particular landscape. The ED values for plains and open slopes in the Upper Yukon are two to three times larger than they are for the other three areas with summer moose range. With the exception of plains patches in the Upper Yukon region, the AWMSI values for the dominant patches are very similar and vary between 3.1 and 3.8. Given these similarities, it is evident that the patch shapes, regardless of type, share a very similar morphology. Again, the Upper Yukon plains AWMSI is about 2.5 times larger than it is in the other study areas. Likewise, the AWMPFD scores are very similar in each of the study areas.

The winter moose ranges, which occur in all five study areas, are also dominated by plains, open slopes, and U-shaped valleys, though there is a slight decrease in the proportion of plains patches, which comprise between 65 and 94% of the ranges, to open slopes and U-shaped valleys when compared with the summer ranges. The MPS values differ considerably among the different study areas for most of the patch types, but are most notable in the dominant patch classes. For example, the MPS for plains is lowest in the Upper Yukon region, at a mere 72.4 hectares, and is highest in the Koyukuk area, at just over 3,000 hectares. Almost without exception, the remaining MPS values for all the other patch classes are below 55 hectares. The edge metrics for winter moose ranges contrast with one another with the ED values being much more consistent than the MPE values. There is little correlation between the average size of a patch type with the edge density metric, but larger MPE values correspond to larger MPS areas. Like with the summer moose ranges, the AWMSI scores are larger for the dominant patch types, but highly variable for the less common patch types. The MPAR values show little similarity among the different patch types and regions.

General Sheep Range Characteristics (Landscape Level)

Dall's sheep (*Ovis dalli*) remain understudied compared with moose and caribou. The information provided here comes primarily from Bowyer and Leslie (1992). Several subspecies of Dall's sheep are recognized in Alaska and neighboring regions in Canada. These include *O. d. dalli*, *O. d. kenaiensis*, and *O. d. stonei*. *O. d. dalli* is common throughout the Alaska Range and Brooks Range. Though physically smaller and different in color, Dall's sheep are genetically very similar to Rocky Mountain Bighorn Sheep (*Ovis canadensis*). Male sheep tend to be considerably larger than females weighing between 80 and 110 kb; females typically weigh a third less. Horn masses are a second major sexually dimorphic characteristic in the species.

Like their bighorn cousins farther to the south, Dall's sheep inhabit steep terrain in mountainous areas. In Alaska, sheep can be found in the Alaska Range, the Chugach Range, the White Mountains, and the Brooks Range (Figure 5.7). Within these ranges, sheep tend to have distinct seasonal ranges. Males tend to move between different seasonal ranges more frequently than females. Seasonal ranges include various types of winter and summer ranges, and specialized ranges related to mineral licks and lambing areas. Seasonal ranges vary in size from less than 0.5 km^2 to 30 km^2. Winter ranges tend to be smaller than summer and autumn ranges. Sheep rely primarily on various grasses, sedges, and and forbs for grazing. Seasonally important plants also include *Artemisia*, willow, and, in some cases, mosses or lichens. Males preparing for the fall rut also frequent mineral licks.

Given the total landscape areas and the number of patches presented in Tables 5.9 and 5.10, it is evident that the distribution of sheep varies greatly from one study area to the next. Although these two variables are not directly comparable among the different study areas, intuitively it is clear that the distribution of Dall's sheep, compared with moose and caribou, is much less even across the Alaskan Interior. At the landscape level, however, certain similarities do present themselves. As discussed in the following chapter, the presence of sheep in a study area does not necessarily indicate that sheep were hunted. Although sheep are present in the Lower Tanana study area, there is no subsistence data to indicate that they were hunted during the subsistence study or any other time in the recent past.

At the landscape level, the PD varies between 5.0 in the Koyukuk and Upper Tanana regions to 8.0 patches per 100 hectares in the Lower Tanana area. Relative to moose and caribou,

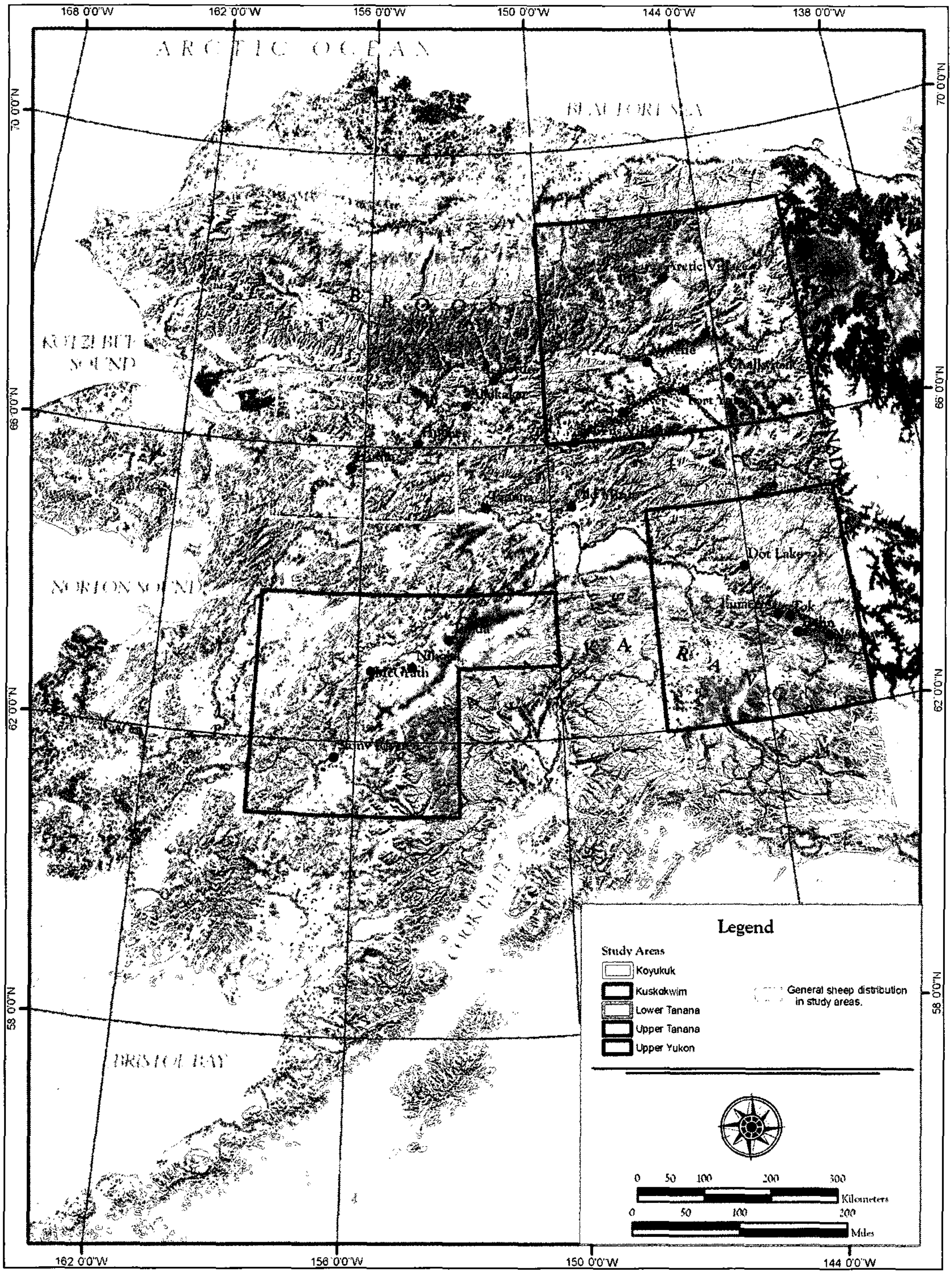


Figure 5.7. Map Five Study Areas and the General Distribution of Sheep in Each. Distribution Derived from ADF&G 1973.

Table 5.9. General Sheep Range Landscape Metrics for the Five Study Areas

	Study Area				
	Koyukuk	**Kuskokwim**	**Lower Tanana**	**Upper Tanana**	**Upper Yukon**
Total Landscape Area (ha)	1,963,062.38	923,798.72	131,211.83	1,568,527.88	2,907,718.00
No. of Patches	90,184	52,095	10,902	80,357	181,794
Patch Density	0.05	0.06	0.08	0.05	0.06
Mean Patch Size (ha)	21.77	17.73	12.04	19.52	15.99
Patch Size Standard Deviation (ha)	252.73	97.29	44.76	161.51	176.65
Total Edge (m)	1.73E+08	9.00E+07	1.52E+07	1.45E+08	3.04E+08
Edge Density	88.21	97.45	115.88	92.52	104.52
Mean Patch Edge (m)	1,920.13	1,728.11	1,394.63	1,806.01	1,671.78
Mean Shape Index	1.40	1.40	1.39	1.40	1.47
Mean Perimeter to Area Ratio	497.99	611.56	545.26	446.51	927.12
Mean Patch Fractal Dimension	1.32	1.31	1.32	1.31	1.39
Area Weighted Mean Patch Shape Index	5.41	3.09	2.38	3.68	5.15
Area Weighted Mean Patch Fractal Dimension	1.34	1.31	1.30	1.32	1.35
Shannon's Diversity Index	1.98	2.07	2.13	2.08	2.02
Shannon's Eveness Index	0.86	0.90	0.93	0.90	0.88

Table 5.10. General Sheep Range Class Metrics for the Five Study Areas

		Class Area (ha)	% Class	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension (MPFD)	Area Weighted MPFD
Koyukuk	Canyon	141,405.96	7.20	0.04	24.50	6.58	2,239.10	1.50	2.40	405.82	1.31	1.30
	Midslope Drainage	185,373.57	9.44	0.10	10.20	11.27	1,217.10	1.34	1.63	423.70	1.31	1.27
	Upland Drainage	10,260.92	0.52	0.41	2.44	1.28	595.85	1.27	1.36	469.12	1.32	1.29
	U-shaped Valley	201,382.67	10.26	0.04	25.19	8.16	2,004.72	1.41	4.02	623.20	1.33	1.33
	Plains	63,198.54	3.22	0.12	8.46	3.74	983.22	1.31	1.69	696.35	1.31	1.27
	Open Slope	795,661.78	40.53	0.01	87.93	27.10	5,879.27	1.66	9.75	789.75	1.33	1.39
	Upper Slope	198,052.31	10.09	0.07	14.08	11.99	1,673.33	1.44	2.70	428.61	1.32	1.32
	Local Ridge	758.43	0.04	0.69	1.46	0.12	468.86	1.27	1.36	564.33	1.34	1.31
	Midslope Ridge	110,104.31	5.61	0.16	6.31	8.43	948.40	1.31	1.52	429.30	1.32	1.28
	High Ridge	256,863.90	13.08	0.02	47.02	9.52	3,421.95	1.53	2.28	318.89	1.29	1.29
Kuskokwim	Canyon	114,768.87	12.42	0.02	41.31	9.24	3,073.44	1.54	3.22	644.26	1.31	1.32
	Midslope Drainage	99,345.37	10.75	0.08	12.60	12.08	1,414.56	1.35	1.72	1,680.40	1.30	1.28
	Upland Drainage	24,288.01	2.63	0.18	5.41	4.41	907.54	1.28	1.43	373.66	1.30	1.28
	U-shaped Valley	124,319.20	13.46	0.04	23.51	10.76	1,879.68	1.42	3.52	421.12	1.32	1.32
	Plains	18,067.48	1.96	0.06	17.31	1.34	1,183.74	1.34	1.97	1,722.81	1.32	1.26
	Open Slope	228,936.33	24.78	0.04	24.21	23.30	2,275.61	1.48	4.00	363.32	1.31	1.34
	Upper Slope	93,741.19	10.15	0.11	9.01	15.10	1,340.82	1.41	2.20	360.56	1.31	1.31
	Local Ridge	3,259.28	0.35	0.40	2.49	0.89	629.80	1.26	1.35	412.99	1.31	1.29
	Midslope Ridge	54,511.76	5.90	0.14	7.17	8.77	1,066.13	1.31	1.54	367.84	1.31	1.28
	High Ridge	162,561.24	17.60	0.01	88.25	11.57	5,802.05	1.71	3.69	321.53	1.30	1.32
Lower Tanana	Canyon	19,441.30	14.82	0.02	48.12	11.06	3,590.47	1.61	2.90	629.82	1.33	1.31
	Midslope Drainage	14,323.60	10.92	0.10	9.84	14.09	1,269.75	1.36	1.65	562.17	1.31	1.28
	Upland Drainage	4,294.04	3.27	0.22	4.61	5.97	839.88	1.30	1.53	472.71	1.32	1.29
	U-shaped Valley	11,213.06	8.55	0.11	9.28	11.34	1,232.10	1.41	2.14	660.83	1.35	1.31
	Plains	3,306.32	2.52	0.11	8.82	2.89	1,009.88	1.33	2.05	495.92	1.32	1.29
	Open Slope	22,592.84	17.22	0.10	10.18	23.96	1,416.20	1.44	2.47	518.49	1.34	1.32
	Upper Slope	16,424.30	12.52	0.13	7.75	18.84	1,167.21	1.38	2.46	444.28	1.32	1.32
	Local Ridge	1,205.81	0.92	0.32	3.12	2.08	708.73	1.30	1.54	601.49	1.34	1.30
	Midslope Ridge	8,845.60	6.74	0.15	6.45	10.58	1,012.84	1.34	1.61	716.24	1.31	1.29
	High Ridge	29,564.96	22.53	0.01	68.44	15.07	4,575.88	1.63	2.80	325.15	1.30	1.30

Table 5.10. General Sheep Range Class Metrics for the Five Study Areas (continued)

		Class Area (ha)	**% Class**	**Patch Density**	**Mean Patch Size**	**Edge Density**	**Mean Patch Edge**	**Mean Shape Index (MSI)**	**Area Weighted MSI**	**Mean Perimeter to Area Ratio**	**Mean Patch Fractal Dimension (MPFD)**	**Area Weighted MPFD**
Upper Tanana	Canyon	178,984.63	11.41	0.02	41.42	8.67	3,148.55	1.55	2.82	383.43	1.31	1.31
	Midslope Drainage	163,766.93	10.44	0.08	12.70	11.69	1,421.48	1.35	1.70	476.84	1.31	1.28
	Upland Drainage	32,514.96	2.07	0.20	5.11	3.56	878.46	1.28	1.43	366.34	1.31	1.28
	U-shaped Valley	196,379.06	12.52	0.04	24.15	9.67	1,864.00	1.40	3.86	522.97	1.32	1.32
	Plains	88,282.32	5.63	0.03	29.63	3.01	1,584.75	1.34	3.93	643.29	1.31	1.29
	Open Slope	413,175.40	26.34	0.03	29.86	23.28	2,639.87	1.50	6.02	430.94	1.30	1.36
	Upper Slope	155,138.58	9.89	0.09	10.93	13.04	1,440.88	1.41	2.40	364.01	1.31	1.31
	Local Ridge	4,859.45	0.31	0.40	2.52	0.76	615.96	1.26	1.38	449.92	1.32	1.29
	Midslope Ridge	92,387.46	5.89	0.14	7.36	8.64	1,079.08	1.32	1.55	465.44	1.30	1.28
	High Ridge	243,039.08	15.49	0.01	77.30	10.20	5,088.30	1.64	3.42	550.13	1.30	1.32
Upper Yukon	Canyon	245,348.47	8.44	0.03	29.62	7.85	2,756.54	1.59	3.53	609.40	1.35	1.33
	Midslope Drainage	305,553.05	10.51	0.10	10.25	13.45	1,312.75	1.42	2.02	837.84	1.36	1.30
	Upland Drainage	30,175.76	1.04	0.42	2.39	2.50	575.39	1.32	1.53	867.17	1.37	1.30
	U-shaped Valley	359,551.92	12.37	0.05	19.37	9.86	1,544.73	1.45	4.79	1,073.21	1.39	1.34
	Plains	88,419.57	3.04	0.22	4.62	3.72	566.25	1.37	3.29	1,259.51	1.53	1.32
	Open Slope	1,000,967.95	34.42	0.02	44.27	30.72	3,950.88	1.71	8.72	1,064.38	1.41	1.39
	Upper Slope	277,980.53	9.56	0.10	10.10	14.26	1,505.77	1.54	2.95	931.98	1.38	1.34
	Local Ridge	4,079.33	0.14	0.85	1.18	0.48	400.13	1.30	1.52	1,010.82	1.39	1.32
	Midslope Ridge	192,206.91	6.61	0.17	5.74	10.80	937.48	1.37	1.75	834.80	1.36	1.30
	High Ridge	403,434.50	13.87	0.02	64.43	10.87	5,046.04	1.69	3.84	375.74	1.31	1.33

the landscape PD values for sheep are higher. The sheep MPS values, likewise, are considerably smaller than those for either moose or caribou. The MPS values range from a low of 12.04 hectares in the Lower Tanana study area to a high of 21.77 hectares in the Koyukuk study area. Edge density values are lowest in the Koyukuk region at 88.21 and highest in the Lower Tanana area, at 115.88. The MPS values are inversely proportional to the ED values with the Lower Tanana region having the lowest MPE and the Koyukuk area having the highest. The MSI and MPFD scores are similar among five of the study areas, though the Upper Yukon region has slightly higher values in both cases. The MPAR values are more variable and range between 446.51 and 927.12; the high value here belongs to the Upper Yukon area as well. The Upper Yukon MPAR value is a third larger than the next nearest value indicating a much patchier environment in relation to the sheep distribution. The AWMSI scores are similar between the Upper Yukon and the Koyukuk (5.15 and 5.41, respectively) and between the Kuskokwim and Upper Tanana regions (3.09 and 3.68, respectively). With a score of 2.38, the Lower Tanana AWMSI is substantially lower than the other values. The MPFD and AWMPFD scores are highest in the Upper Yukon area. The MPFD for the remaining four study areas are nearly identical, while the AWMPFD scores are more inconsistent with the Koyukuk region sharing similar patch shape complexities with the Upper Yukon. Less patch complexity is observable in the Lower Tanana, Upper Tanana, and Kuskokwim areas.

Classification of Caribou, Moose, and Sheep Ranges

To be useful in modeling late prehistoric land use, there must be a preferred differential landscape use for caribou, moose, and sheep that is somewhat consistent, or at least quantifiable, among the different study areas. To this end, the remainder of this chapter focuses on quantitatively identifying differences among the caribou, moose, and sheep ranges. To examine differences between the different mammal landscapes, I use Analysis of Variance (ANOVA) to determine if there are statistically significant differences among the groups. At the general landscape level, I supplement the ANOVA with Bonferroni post-hoc tests to assist in determining between which groups the significant differences occur. I follow the ANOVA with discriminant function analysis to determine which landscape metrics are most useful for delineating among the different mammal ranges. This analysis also has the benefit of producing classification functions that I use in the following chapter to compare species-specific hunting ranges with the species-specific ranges.

Given the data presented in Part I, it is apparent that the landscape metrics for the general sheep range vary considerably from the metrics for both moose and caribou. It is also apparent that the differences between moose and caribou landscape metrics, at the general range level, are more subtle. The results of the ANOVA (Table 5.11) and the post hoc tests (Table 5.12) bear out this general observation. Of the 16 landscape metrics included in the ANOVA, which due to the small sample size I used a probability level of .10, 10 are statistically significant. Three of these variables—Total Landscape Area, Number of Patches, and Total Edge—are not directly comparable across the study areas due to the arbitrary manner with which the study areas where chosen. The remaining landscape metrics that are significantly different among the three groups include patch density (PD), mean patch size (MPS), patch size standard deviation (PSSD), edge density (ED), area-weighted mean shape index (AWMSI), and the area weighted mean patch fractal dimension (AWMPFD). The Bonferroni post-hoc tests illustrate that more of the significant differences among these metrics occur between caribou-sheep and moose-sheep ranges; only one of the landscape metrics is significantly different between the general caribou and moose ranges (PSSD, p=.05). There are, however, four metrics that show some variation between these two landscapes; these metrics include MPS (p=.88), ED (p=.44), PSCOV (p=.16), and AWMSI (p=.47). The remaining metrics all have probabilities of 1.0, making them of little use in differentiating between the two species-specific ranges.

Table 5.11. Between Group Analysis of Variance Summary Table of Landscape Level Metrics for General Large Mammal Distributions

	Sum of Squares	df	Mean Square	F	p
Total Landscape Area*	2.53E+14	2	1.27E+14	54.83	.000
Number of Patches*	1.39E+11	2	6.96E+10	9.58	.003
Patch Density	0.003	2	0.002	15.188	.001
Mean Patch Size	1368.9	2	684.451	15.5	.000
Patch Size Covariance	1.15E+09	2	573060897.37	21.97	.000
Patch Size Standard Deviation	1.70E+08	2	84939478.33	27.43	.000
Total Edge*	4.28E+17	2	2.14E+17	21.58	.000
Edge Density	8486.29	2	4243.15	60.83	.000
Mean Patch Edge	43526.76	2	21763.39	0.342	.717
Mean Shape Index	0.00	2	0.00	0.277	.763
Area Weighted Mean Shape Index	730.67	2	365.34	8.60	.005
Mean Perimeter to Area Ratio	15254.43	2	7627.22	0.111	.896
Mean Patch Fractal Dimension	0.00	2	0.00	0.007	.993
Area Weighted Mean Patch Fractal Dimension	0.003	2	0.002	4.02	.046
Shannon's Diversity Index	.008	2	.004	.80	.471
Shannon's Evenness Index	.002	2	.001	.80	.471

*Not directly comparable

Table 5.12. Bonferroni Post Hoc Tests of the Analysis of Variance of Landscape Level Metrics for General Large Mammal Distributions.

	Resource (I)	Resource (J)	Mean Difference (|I-J|)	Std. Error	Sig.
Total Landscape Area	Caribou	Moose	964272.49	961230.30	1.00
	Caribou	Sheep	8195241.51	961230.30	.000
	Moose	Sheep	9159513.99	961230.30	.000
Number of Patches	Caribou	Moose	18266.00	53905.78	1.00
	Caribou	Sheep	212891.40	53905.78	.006
	Moose	Sheep	194625.40	53905.78	.011
Patch Density	Caribou	Moose	.004	.007	1.00
	Caribou	Sheep	.030	.007	.002
	Moose	Sheep	.033	.007	.001
Mean Patch Size	Caribou	Moose	4.63	4.20	.878
	Caribou	Sheep	17.55	4.20	.004
	Moose	Sheep	22.18	4.20	.001
Patch Size Covariance	Caribou	Moose	6948.55	3230.10	.158
	Caribou	Sheep	14064.96	3230.10	.003
	Moose	Sheep	21013.51	3230.10	.000
Patch Size Standard Deviation	Caribou	Moose	3149.44	1113.0	.46
	Caribou	Sheep	5022.58	1113.0	.002
	Moose	Sheep	8172.03	1113.0	.000
Total Edge	Caribou	Moose	39249582.20	63021823	1.00
	Caribou	Sheep	376525784.0	63021823	.000
	Moose	Sheep	337276202.0	63021823	.001
Edge Density	Caribou	Moose	8.19	5.28	.441
	Caribou	Sheep	45.86	5.28	.000
	Moose	Sheep	54.05	5.28	.000
Mean Patch Edge	Caribou	Moose	37.10	159.50	1.00
	Caribou	Sheep	128.21	159.50	1.00
	Moose	Sheep	91.12	159.50	1.00
Mean Shape Index	Caribou	Moose	.000	0.15	1.00
	Caribou	Sheep	.009	0.15	1.00
	Moose	Sheep	.009	0.15	1.00
Area Weighted Mean Shape Index	Caribou	Moose	6.24	4.12	.469
	Caribou	Sheep	10.67	4.12	.071
	Moose	Sheep	16.90	4.12	.004
Mean Perimeter to Area Ratio	Caribou	Moose	58.89	165.64	1.00
	Caribou	Sheep	73.89	165.64	1.00
	Moose	Sheep	15.00	165.64	1.00
Mean Patch Fractal Dimension	Caribou	Moose	.002	0.02	1.00
	Caribou	Sheep	.002	0.02	1.00
	Moose	Sheep	.002	0.02	1.00
Area Weighted Mean Patch Fractal Dimension	Caribou	Moose	.011	.013	1.00
	Caribou	Sheep	.025	.013	.236
	Moose	Sheep	.036	.013	.050
Shannon's Diversity Index	Caribou	Moose	.036	.045	1.00
	Caribou	Sheep	.020	.045	1.00
	Moose	Sheep	.056	.045	.705
Shannon's Evenness Index	Caribou	Moose	.016	.019	1.00
	Caribou	Sheep	.009	.019	1.00
	Moose	Sheep	.024	.019	.705

Based on the results of the ANOVA and Bonferroni post-hoc tests, I selected four variables for the discriminant analysis. These include PSSD, AWMSI, and ED. I used SPSS ver. 12 to conduct the analysis using the Wilks' lambda stepwise method utilizing an F value of 3.84 for entry and 2.71 for removal of variables. The stepwise method resulted in the identification of a single function consisting of a single variable, ED, with the other variables being dropped because they failed to provide any additional discriminating power. The derived discriminant function is statistically significant (chi-square of Wilks' lambda 28.93; p=.000) and useful for delineating between the three species-specific general ranges. The classification results of the discriminant function resulted in the correct classification rate of 86.7%. All the sheep and moose ranges were correctly classified for the five study areas and the failure in classification was from two caribou cases that were classified as belonging to the moose group. The cross-validated classification resulted in a correct classification rate of 80%. Again, the sheep ranges were correctly classified. The misclassified cases included the two cases noted above as well as one moose case that was classified as representing a more caribou-like range.

Although the ED discriminant function proves more than satisfactory for separating sheep ranges from moose and caribou ranges, its ability to separate between moose and caribou ranges is good but not perfect. The seasonal data for moose and caribou, however, provide better differentiation between moose and caribou ranges, than those found at the general landscape level. Because the mapped distributions for moose and caribou ranges do not cover the exact same seasons, I consider only the two seasons, summer and winter, with data common to both species. An ANOVA between the moose summer and fall ranges demonstrated that there were no statistically significant differences between the metrics for moose fall and summer ranges. Likewise no significant differences in the landscape metrics were identified between the caribou summer ranges (n=5) and the spring calving areas (n=2). Using the same methods and analyses for the general mammal landscapes, the winter and summer moose and caribou data were subjected to ANOVA and discriminant analysis.

The winter data for caribou and moose ranges consists of 10 cases. Table 5.13 presents the results of the ANOVA comparing the metrics for winter moose and caribou ranges. Eight of the metrics--MPS, patch size coefficient of variance (PSCOV), total edge (TE), ED, mean shape index (MSI), mean perimeter to area ration (MPAR), Shannon's diversity index (SDI), and Shannon's evenness index (SEI)--differ significantly, again at the .10 level, between moose and caribou winter ranges. While the differences in the remaining metrics are not significant, there is considerable variation. With the exception of PD, which is strongly correlated with ED, all the metrics were used in the stepwise discriminant analysis.

The discriminant function analysis resulted in the identification of a single function that is able to differentiate correctly cold season moose and caribou ranges with a 100% success rate for both the original grouped cases and the cross-validated groups. The stepwise approach removed all the variables except MPS and MPAR. The chi-square of the Wilks' lambda for this function is statistically significant (chi-square=10.4, p=.006). The resulting classification coefficients are presented in Table 5.14.

The summer range data for moose and caribou ranges includes nine cases including five caribou summer ranges and four moose summer ranges (the Koyukuk study area does not include any summer moose range). The ANOVA results comparing these broad seasonal ranges for caribou and moose are given in Table 5.15. Of the 13 variables in the ANOVA, eight are significantly different between the two types of ranges. These metrics include PD, MPS, PSSD, TE, ED, MSI, MPAR, and, AWMPFD. Again, because of the small sample size, a slightly less stringent probability level of .10 was set prior to the analysis. In general, these differences indicate smaller, less variable, patch sizes, higher patch density, smaller edge densities, and lower perimeter to area ratio for summer caribou ranges than the moose ranges during the same portion of the year.

The discriminant analysis resulted in the identification of a single function composed of the MPS and MPAR metrics. The chi-square of the Wilks' lambda (13.78; p=.001) reflects a high degree of separation among these variables when discriminating between groups. Classification rates for both the original cases and the cross-validated cases were both perfect at 100%. The resulting classification coefficients for both caribou and moose warm period ranges are given in Table 5.16.

At the general landscape level, it is possible to delineate, with moderate to high success, among caribou, moose, and sheep ranges utilizing the landscape metrics and the topographic position index coverages. Sheep ranges differ more from moose and caribou ranges than moose and caribou ranges differ from one another. Although the landscape metrics for the general range of the two cervids can be distinguished with a fair degree of certainty at the general range level, the seasonal ranges for moose and caribou are quantifiably different in both the winter and summer.

Table 5.13. ANOVA Results Comparing Winter Range Landscape Metrics for Caribou and Moose.

	Sum of Squares	F	Sig
Patch Density	.000	1.87	.21
Mean Patch Size	10565.51	4.05	.08
Patch Size Covariance	270214799.71	7.14	.03
Patch Size Standard Deviation	12199621.22	1.67	.232
Edge Density	979.81	4.15	.076
Mean Patch Edge	361041.19	1.751	.222
Mean Shape Index	.007	59.59	.000
Area Weighted Mean Shape Index	265.51	2.87	.129
Mean Perimeter to Area Ratio	1234402.97	7.96	.022
Mean Patch Fractal Dimension	.001	0.73	.418
Area Weighted Mean Patch Fractal Dimension	.005	3.19	.112
Shannon's Diversity Index	.143	7.76	.024
Shannon's Evenness Index	0.27	7.76	0.24

Table 5.14. Classification Function Coefficients for Winter Caribou and Moose Ranges.

	Resource	
	Caribou	Moose
MPS	.048	.115
Mean Perimeter to Area Ratio	.007	.017
(*Constant*)*	-3.833	-17.56

Table 5.15. ANOVA Results Comparing Summer Landscape Metrics for Caribou and Moose Ranges.

	Sum of Squares	F	Sig
Patch Density	.002	15.71	.005
Mean Patch Size	46767.31	9.82	.017
Patch Size Covariance	5069025.67	.522	.493
Patch Size Standard Deviation	22426317.38	5.03	.06
Edge Density	5133.00	27.92	.001
Mean Patch Edge	678771.42	2.13	.188
Mean Shape Index	.011	5.31	.055
Area Weighted Mean Shape Index	117.93	.997	.351
Mean Perimeter to Area Ratio	5985041	4.34	.076
Mean Patch Fractal Dimension	.001	.625	.455
Area Weighted Mean Patch Fractal Dimension	.016	5.07	.06
Shannon's Diversity Index	.037	.222	.652
Shannon's Evenness Index	.007	.222	.652

Table 5.16. Classification Function Coefficients for Summer Caribou and Moose Ranges.

	Resource	
	Caribou	**Moose**
Edge Density	.502	.053
Mean Perimeter to Area Ratio	-.003	.001
(*Constant*)*	-17.20	-2.68

CHAPTER 6.
ATHABASCAN HUNTING LANDSCAPES DESCRIPTIONS AND COMPARISONS

Introduction

This chapter focuses on the structure and composition of the actual hunting ranges used by the communities for hunting caribou, moose, and sheep. As with the distributional ranges, the examination of the hunting ranges focuses on quantifying the hunting area landscapes in order to identify any similarities among ranges for a particular species throughout the Alaskan Interior. This chapter examines the landscape metrics for the hunting ranges at both the landscape and class levels. It also makes general comparisons among the different hunting ranges and with the distributional ranges. The classification functions derived in the last chapter are used to determine how well these functions are able to differentiate among the three different types of hunting ranges. Resemblance analysis is applied to the hunting ranges comparing the amount of overlap between multiple species (with a focus moose and caribou). A new set of ANOVA and discriminant analyses result in an additional set of discriminant classifications that can, when cross validated against the functions derived in Chapter 6, further refine the interpretation of the structure of landscapes as they correspond to the hunting of the different animals.

Caribou Hunting Ranges

Fifteen of the 21 villages used in this study either participated in caribou hunting during or prior to the ADF&G subsistence studies (Table 6.1). The mapped areas of these hunting ranges vary greatly within and between the different regions in the Interior. The size of the hunting ranges among all the regions varies between 2,600 hectares to over 2.3 million hectares. Within any given region, the range is also highly variable. In the Upper Tanana region the largest caribou hunting area (Tok) is 40 times larger than the smallest (Dot Lake) and in the Upper Yukon area the largest hunting area (Arctic Village) is about 33 times larger than the smallest (Fort Yukon). The absolute largest difference, however, occurs in the Kuskokwim region where the largest caribou hunting area (Stony River) is almost 300 times larger than the smallest hunting range (Telida). The number of patches in each hunting range is also variable and highly correlated with the area of the hunting range (Pearson's r = .924, p=.000). These differences are

Table 6.1. Caribou Hunting Range Landscape Level Metrics

		Total Landscape Area (ha)	No. of Patches	Mean Patch Size (Ha)	Patch Size Covari- ance	Patch Size Standard Deviation	Patch Dens- ity	Total Edge	Edge Den- sity	Mean Patch Edge	Mean Shape Index (MSI)	Area Weight - ed MSI	Mean Peri- meter to Area Ratio	Mean Patch Fractal Dimen- sion	Area Weight- ed MPFD	SHDI	SHEI
Koyukuk	Huslia	64982.4	1418	45.8	2355.3	1079.4	2.2	2.5E+06	39.0	1789.4	1.39	3.10	424.5	1.32	1.27	2.07	0.90
Kuskokwim	McGrath	277007.9	7789	35.6	3025.7	1076.1	2.8	1.1E+07	41.2	1463.7	1.40	2.53	703.7	1.35	1.24	2.14	0.93
	Nikolai	132698.3	57	2328.0	485.0	11292.0	0.0	4.4E+05	3.3	7763.9	1.47	1.45	346.0	1.30	1.16	0.63	0.35
	Stony	792657.8	6543	121.1	5891.2	7136.9	0.8	1.5E+07	18.7	2263.6	1.40	6.03	370.9	1.31	1.29	1.76	0.77
	Telida	2678.1	2	1339.1	15.5	206.9	0.1	2.7E+04	10.2	13597.8	1.05	1.05	10.3	1.16	1.16	0.00	0.00
Lower Tanana	Beaver	19459.3	149	130.6	1042.3	1361.2	0.8	4.0E+05	20.4	2666.3	1.46	3.04	860.9	1.42	1.26	1.73	0.83
	Tanana	173702.4	7316	23.7	1259.3	299.0	4.2	1.3E+07	76.7	1820.7	1.41	3.11	416.9	1.32	1.30	2.13	0.92
Upper Tanana	Dot Lake	35440.9	907	39.1	1332.3	520.6	2.6	2.0E+06	55.8	2181.5	1.37	6.89	422.4	1.31	1.32	1.87	0.81
	Northway	82088.2	2213	37.1	1184.9	439.5	2.7	4.7E+06	57.2	2122.7	1.43	3.67	569.4	1.33	1.30	1.90	0.83
	Tanacross	549268.1	9895	55.5	3545.5	1968.1	1.8	2.4E+07	43.0	2387.6	1.40	7.27	730.3	1.31	1.33	1.89	0.82
	Tok	1432235.1	38982	36.7	2367.1	869.7	2.7	8.5E+07	59.0	2168.3	1.40	5.95	605.6	1.31	1.32	2.01	0.87
Upper Yukon	Arctic	2327486.2	136663	17.0	11955.6	2036.1	5.9	1.8E+08	75.3	1281.8	1.42	22.95	1,151.6	1.40	1.40	1.90	0.83
	Chalkyitsik	250647.8	8690	28.8	5181.7	1494.6	3.5	9.3E+06	37.0	1067.6	1.44	6.25	1,244.8	1.41	1.32	1.87	0.81
	Ft. Yukon	69937.4	2597	26.9	2019.4	543.8	3.7	3.2E+06	45.7	1229.4	1.39	2.74	1,021.0	1.38	1.26	2.05	0.89
	Venetie	444703.4	22170	20.1	6232.6	1250.2	5.0	2.8E+07	62.1	1246.4	1.43	13.38	1,480.1	1.42	1.38	1.73	0.75

mostly related to two major factors. The first is the time period considered in the mapping of hunting ranges and the second is the size and composition of the community. The MPS among the different hunting ranges does vary but by only a slight degree; 10 of the 15 hunting ranges have average patch sizes of less than 100 hectares and two villages have average patch sizes of less than 131 hectares. The caribou hunting ranges for Teldia and Nikolai, both in the Kuskokwim region have extremely large MPS values that exceed 1300 hectares. With the exception of these two extreme cases, the MPS is not particularly affected either by the number of patches in a hunting range or by the overall size of that range. The PD, likewise, is mostly consistent across most of the village caribou hunting areas. Nine of the 15 villages have hunting ranges with PDs between 2.0 and 5.0. Arctic Village has the highest PD, at 5.9, while the Beaver, Telida, Nikolai, and Stony River hunting ranges have PDs of 1.0 patch per 100 hectare or less. Overall, the Upper Yukon hunting ranges tend to have the highest patch densities, while the Kuskokwim region has the lowest. Huslia, the only Koyukuk village with mapped caribou hunting range, and the Upper Tanana hunting ranges have intermediary PD values. The two mapped caribou hunting ranges from the Lower Tanana region have the most variable range of patch densities.

Edge density values vary more greatly than the PDs both among all the different hunting ranges and within each region. Overall, the ED is lowest for Nikolai at 3.3 and highest in Tanana at 76.7. The Upper Tanana region has the most consistent set of EDs varying between 43 and 59 meters, the Upper Yukon, Kuskokwim, and Lower Tanana areas have EDs with much more variation, typically consisting of high EDs that are two to three times larger than the lowest EDs in the same region. The TE metrics are highly correlated (r=.981; p=.001) with the number of patches in the hunting ranges. With two notable exceptions, the MPE values for most of the hunting ranges fluctuate between 1000 and 2300 meters. Telida, which has a MPE of over 13,000 meters, and Nikolai, with a MPE, of over 7,000, reflect the extremely high MPS values for these two hunting ranges. Generally, there is a strong correlation between MPS and MPE values (r=.804; p=.001).

The shape indices calculated for the 15 hunting areas reflect several interesting patterns. With the exception of the Telida caribou hunting range, the MSI values are relatively consistent varying between 1.37 and 1.47. Telida has a MSI of 1.05 verifying the observation that both small areas included in this hunting range deviate little from a circle. The AWMSI, however, illustrates that when large patches are taken into account the patch shape complexity among the different hunting ranges vary considerably. This variability is greater than that identified in the caribou distributional ranges. The AWMSI for Telida remains static while most of the other ranges show a substantial increase in patch complexity. Arctic Village and Venetie each have very high AWMSI scores, 22.95 and 13.38 respectively, indicating that hunting ranges that have extremely complex patch shapes. The MPAR values also indicate a high patch complexity in the Upper Yukon area. The caribou hunting ranges for the four Upper Yukon villages are above 1000, while the majority of the remaining hunting areas throughout the Interior have MPAR values between 350 and 700. The lowest value belongs again to Telida's hunting range, which has an exceedingly MPAR of 10.3. Likewise, the MPFD scores are highest in the Upper Yukon and substantially lower elsewhere. Beaver's hunting range is more similar with the Upper Yukon ranges than the other villages and Telida again has the smallest fractal dimension. The AWMPFD values are more variable than the MPFD indicating that when the large patches are considered, there is an overall drop in shape complexity contra to the patch shape complexity with observed with the AWMSI.

The caribou hunting ranges in Huslia and Tok share identical, or nearly so, SHDI and SHEI scores with the general caribou distribution range in each of these areas. In the Kuskokwim region, the diversity and evenness measures are variable to that of the general caribou range. While the McGrath hunting range is more diverse and even than the general caribou range, the remaining three villages in the area have substantially lower scores indicating much lower patch diversity and a less even distribution of those patches. This pattern carries over into the remaining three regions. With the exception of Tok, the remaining three village hunting ranges have lower indices than the general range. In the Lower Tanana region, the hunting range for Tanana has more diversity and greater evenness than the general caribou range, while Beaver's scores are significantly lower. In the Upper Yukon area, Fort Yukon has a hunting area that is more diverse than the rest of the villages and the general caribou range; Arctic Village, Chalkyitsik, and Venetie have lower indices. Given only the minor differences between the evenness and diversity indices for the winter and summer caribou ranges, it is not surprising that the same indices calculated for the village hunting areas, for the most part, differ little from either of these ranges in the different regions. The exception to this occurs in the Upper Yukon where the hunting range diversity and evenness indices are most similar the caribou's winter, and not summer, range.

Overall, the caribou hunting ranges consist mostly of large plains and open slope patches. Figure 6.1 presents cumulative percentages of landscape classes for each of the caribou hunting ranges in the study. The Telida and Nikolai caribou hunting ranges immediately stand out when compared with the other hunting ranges consisting almost entirely of a single class type, in this case plains (100% and 99.6% respectively).

Likewise, many of the villages have caribou hunting ranges where plains patches are dominant. These include Huslia, McGrath, Stony River, Beaver, Chalkyitsik, and Fort Yukon; in these hunting ranges, plains comprise between 65 and 86% of the hunting range. In the remaining villages, which include Tanana, Dot Lake, Northway, Tanacross, Tok, and Arctic Village, plains, though often dominant, account for between 25 and 53% of the hunting landscape. In these cases, open slopes, upper slopes, canyons, high ridges, and U-shaped valley patches cumulatively account for at least half of the patches in the hunting ranges.

Overall, there is considerably less variability in the patch shapes for each class than in found in the general and seasonal caribou distribution ranges. For example, the AWMSI values for each class type are much more consistent among the different patches in each hunting range and cumulatively among all the hunting ranges. Although some of the shaped larger patch types retain more complexity than the less frequent and smaller patches, the range of variability is less in the hunting ranges. Most often, plains and open slope patch shapes are equivalent to other patch types. This is also observable in the MPFD and AWMPFD scores that are almost identical detailing that the area of patches in the hunting ranges has little effect on patch shape complexity. The greatest variation in patch shapes occurs in those study areas that have two dominant patch types. In places such as Dot Lake, Arctic Village, and the like, the shape complexity jumps substantially for plains and open slope patches. The complexity of these patches, however, is still considerably smaller than that found in the general and seasonal distribution ranges. In other words, people are exploiting only a small percentage of the potentially exploitable patches and the areas being exploited are not necessarily characteristic of broader animal ranges.

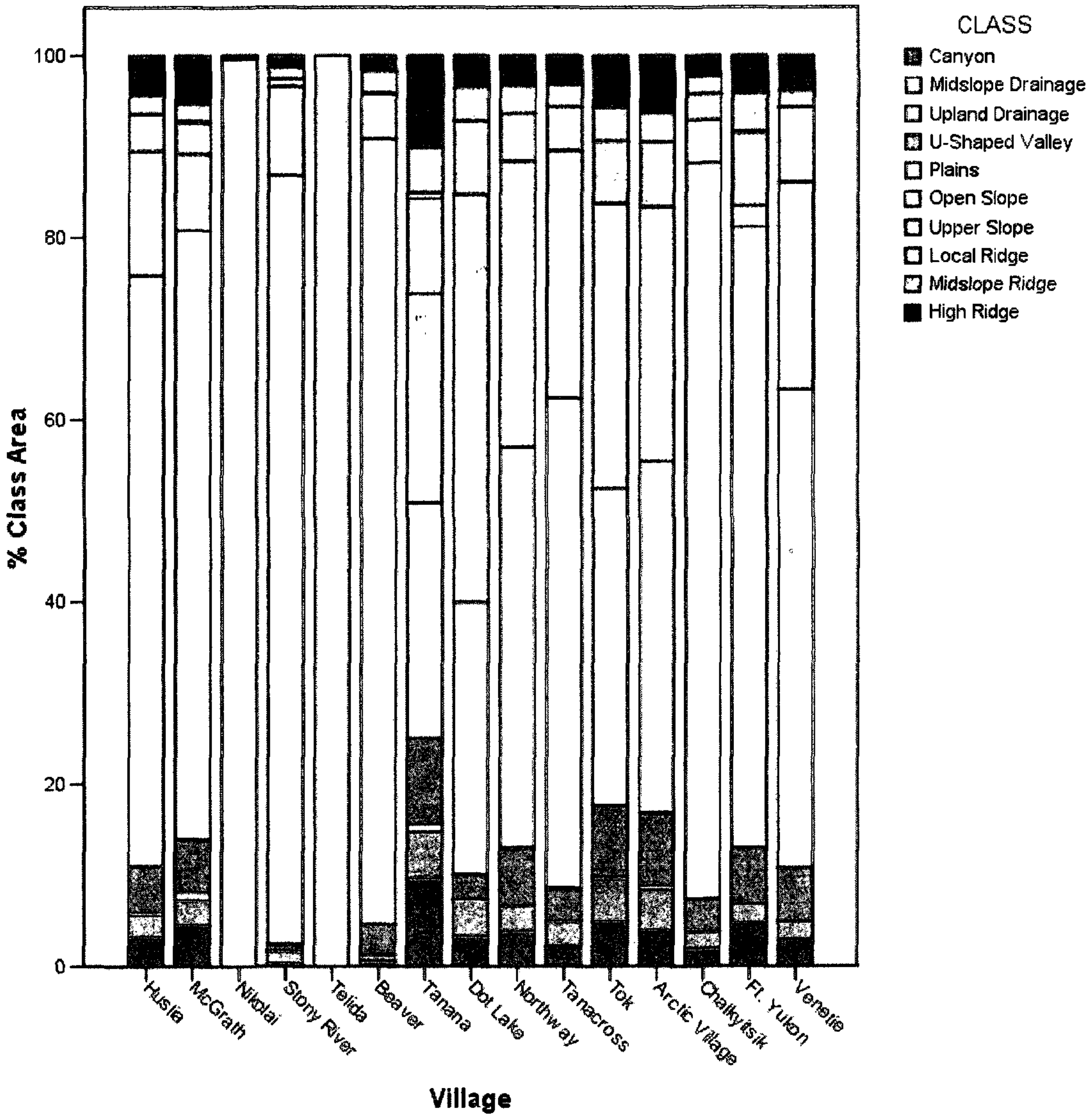


Figure 6.1. Cumulative Percentage Bar Graph of Caribou Hunting Range Class Areas.

Moose Hunting Ranges

Moose is the only prey hunted that is common to all 21 villages included in this study. Given this, and the results of the landscape metric results presented in Table 6.2, it is clear that there are substantial differences among some intraregional and interregional cases. The total area utilized for moose hunting varies from a low of 45,000 hectares at Tetlin to a high of over 2,000,000 hectares at Tok. As both of these ranges occur in the Upper Tanana, it is obvious that this area encompasses the widest range of variability of the five regions. Moose hunting range areas for villages in the Koyukuk region are most consistent of the five varying between 136,000 and 244,000 hectares. Intraregional villages in the three remaining areas have a considerable amount variation in the size of moose hunting areas, but the overall disparity is not as great as it is in the Upper Tanana. There is a strong and significant correlation between the size of a hunting area and the number of patches it contains ($r = 0.80$; $p = .001$). Despite this strong correlation, there remains considerable inconsistency in the PD of the different hunting ranges that result, in part, from the vast size differences. Generally, patch densities are highest in Upper Yukon and Upper Tanana regions and lower in the remaining areas.

The ED pattern mimics the PD results with the lowest values occurring in the Koyukuk, Kuskokwim, and Lower Tanana regions and the higher EDs occurring in the Upper Yukon, especially Arctic Village, and Upper Tanana areas. As with the PD and ED values calculated for the general moose distribution ranges, as well as sheep and caribou ranges, these two values are highly correlated and are essentially measuring the same thing. While the edge densities are inconsistent among the study villages, the MPE is typically between 1,000 and 2,700 meters. Beaver's moose hunting area, which has a MPE of over 4,000 meters, is the only exception.

The AWMSI scores for moose hunting ranges are somewhat more regular than they are for the caribou hunting ranges and overall lower indicating slightly more regular patch shapes. The MPAR values also reflect this general pattern. With the exception of MPAR values in the Upper Yukon region, which are more or less equivalent to between moose and caribou hunting ranges, the MPAR values for moose hunting ranges are generally higher than for caribou hunting ranges and on average are slightly higher than the MPAR values for the general moose distribution range overall. The MPFD scores are similar in all but the Upper Yukon area, where the patch shapes are consistently more complex. Overall, there is little change in the AWMPFD when compared to the MPFD scores --exceptions include Tetlin, Beaver, and Fort Yukon—indicating similarly shaped patches regardless of patch size. This, again, is contrary to the

Table 6.2 Moose Hunting Range Landscape Level Metrics.

		Total Landscape Area (ha)	No. of Patches	Mean Patch Size (Ha)	Patch Size Covariance	Patch Size Standard Deviation	Patch Density	Total Edge	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD	SHDI	SHEI
Koyukuk	Alatna	231,026.9	1,415	163.3	2,688.3	4,389.2	0.61	3.5E+06	15.1	2,466.4	1.44	6.23	882.03	1.33	1.30	1.73	0.75
	Bettles	244,326.7	1,676	145.8	3,010.4	4,388.5	0.69	4.5E+06	18.6	2,706.7	1.44	6.13	702.16	1.32	1.30	1.62	0.74
	Hughes	136,868.8	1,643	83.3	2,623.4	2,185.4	1.20	3.2E+06	23.1	1,921.2	1.42	3.71	484.04	1.33	1.27	1.79	0.78
	Huslia	215,873.2	670	322.2	2,505.2	8,071.6	0.31	1.5E+06	6.8	2,182.2	1.39	3.94	431.38	1.32	1.25	1.60	0.70
Kuskokwim	McGrath	213,567.3	5,343	40.0	4,364.2	1,744.4	2.50	8.7E+06	40.8	1,632.1	1.45	5.40	840.50	1.32	1.31	2.05	0.89
	Nikolai	438,559.6	1,055	415.7	3,116.1	12,953.7	0.24	2.6E+06	6.0	2,509.3	1.41	4.00	501.65	1.32	1.24	1.70	0.78
	Stony	837,513.8	8,120	103.1	6,520.4	6,725.3	0.97	1.8E+07	21.7	2,237.3	1.42	8.57	529.51	1.30	1.31	1.82	0.79
	Telida	168,194.0	977	172.2	2,683.8	4,620.2	0.58	2.3E+06	14.0	2,404.1	1.41	3.45	417.47	1.31	1.25	1.96	0.85
Lower Tanana	Beaver	230,166.1	192	1,198.8	1,358.1	16,280.3	0.08	8.2E+05	3.5	4,252.8	1.44	3.14	690.39	1.35	1.23	1.24	0.56
	Minto	213,252.1	1,647	129.5	3,213.9	4,161.3	0.77	4.1E+06	19.2	2,481.2	1.45	6.19	516.08	1.33	1.30	1.81	0.78
	Stevens	386,621.2	1,777	217.6	3,835.6	8,345.2	0.46	4.0E+06	10.3	2,233.5	1.45	4.63	607.18	1.33	1.26	1.80	0.78
	Tanana	585,337.1	9,603	61.0	6,194.2	3,775.6	1.64	1.9E+07	32.3	1,968.9	1.42	6.54	602.13	1.31	1.31	2.00	0.87
Upper Tanana	Dot Lake	120,415.0	1,543	78.0	2,413.1	1,883.2	1.28	4.0E+06	33.1	2,583.2	1.45	5.70	1,952.62	1.30	1.31	1.63	0.74
	Northway	271,191.5	2,756	98.4	3,251.7	3,199.7	1.02	7.3E+06	26.9	2,644.8	1.49	6.29	847.04	1.32	1.31	1.68	0.73
	Tanacross	761,650.9	12,623	60.3	4,708.2	2,840.8	1.66	3.0E+07	39.7	2,393.4	1.41	8.45	511.69	1.31	1.33	1.91	0.83
	Tetlin	45,436.5	310	146.6	1,495.5	2,191.9	0.68	8.2E+05	18.0	2,645.1	1.47	3.42	2,942.65	1.47	1.26	1.36	0.65
	Tok	2,016,841.3	45,901	43.9	5,187.6	2,279.4	2.28	1.0E+08	50.1	2,200.1	1.40	7.10	424.95	1.31	1.33	2.02	0.88
Upper Yukon	Arctic	1,034,516.4	63,565	16.3	8,489.5	1,381.7	6.14	8.0E+07	77.1	1,254.7	1.43	18.47	1,227.66	1.41	1.39	1.87	0.81
	Chalkyitsik	484,391.1	16,401	29.5	7,710.4	2,277.2	3.39	1.7E+07	35.8	1,058.1	1.43	7.68	1,236.60	1.41	1.31	1.79	0.78
	Ft. Yukon	552,076.2	5,471	100.9	6,116.7	6,172.3	0.99	7.2E+06	13.1	1,320.6	1.46	5.40	1,386.30	1.42	1.28	1.72	0.75
	Venetie	543,505.1	14,538	37.4	8,959.9	3,349.7	2.67	1.8E+07	32.8	1,227.4	1.43	13.32	1,288.77	1.42	1.36	1.68	0.73

AWMSI results, which show that large patches are complex resulting in a richly complex landscape.

The diversity and evenness indices indicate that there is substantial deviation among the different hunting areas and with the general moose distribution ranges. In most cases, there is a slight to moderate drop in hunting range landscape diversity and evenness relative to the general moose range. Compared with the moose winter and summer ranges the results the SHDI and SHEI scores for the moose hunting ranges are mixed. In the Koyukuk region, where there is no mapped summer moose range, the hunting range is more diverse than the winter range. Higher landscape diversity in the Kuskokwim hunting range for most of the villages is also higher than both seasonal moose ranges. With the exception of Tanana in the Lower Tanana sample, the hunting ranges have less diversity than the either the summer or winter moose ranges. In the Upper Yukon area Arctic Village has a hunting range that shares a similar diversity with the seasonal moose ranges, but in general, the Upper Yukon villages have hunting ranges with substantially lower diversity than either major moose range. In regard to the landscape diversity and evenness, villages in the Upper Tanana, which have immediate access to a road system, display the most complexity. In the Upper Tanana region, Tok and Tanacross both have hunting ranges that are substantially more diverse than the winter and summer moose ranges. The villages of Dot Lake, Northway, and Tetlin have moose hunting ranges that are of lower diversity than the winter moose range and equivalent to or lower than the moose summer range.

The class level metrics for the 21 moose hunting ranges appear in Appendix A. Like the class level for the four moose distributional ranges, plains patches comprise a very large percentage of the landscape composition for the individual hunting ranges. Figure 6.2 presents a cumulative percentage bar graph of the percentage of the class types found in the different moose hunting areas. In all cases, plains patches dominate the hunting ranges. In all but two cases, the moose hunting range plains make up at least 55% of the hunting area, though most hunting ranges consist of over 75% plains and less than 12% open slopes. The two major exceptions include Tok and Arctic Village that have moose hunting ranges comprised of roughly 45% plains and 25% open slopes. The villages of Dot Lake and Tanacross have about 20% of their hunting ranges covered by open slopes. In most villages, like moose ranges themselves, the plains patches remaining exceptionally large particularly when compared with the MPS of open slopes, the second most common landform. The variation in MPS for plains patches is staggering ranging from a low of 20.3 hectares to a high of 22,629 hectares; the average is closer to 3,000 hectares.

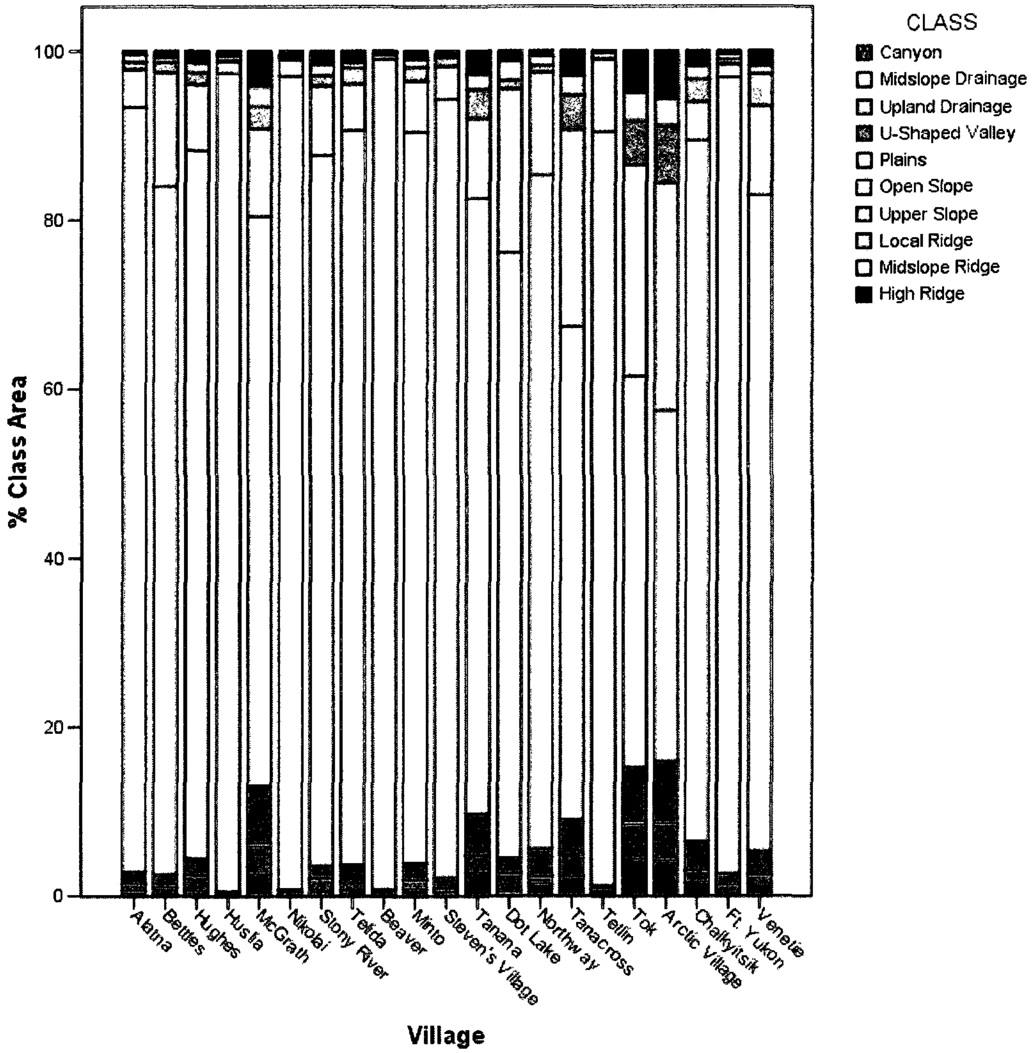


Figure 6.2. Cumulative Percentage Bar Graph of Moose Hunting Range Class Areas.

Open slope patch areas, however, range between 4 and 124 hectares. The differences in mean patch sizes for open slopes and plains are only marginal in the Arctic Village, Dot Lake, and Tanacross moose hunting ranges.

As with the caribou hunting ranges, there is less variation in patch complexity when one compares the hunting ranges with the distributional ranges. Again, the larger patch types, such as plains and open slopes, tend to be more complex, but the range of variation is minor relative to the distributional ranges. Here too, as with the caribou hunting ranges, the most dramatic variation occurs in those hunting ranges that have at least two major patch types in the hunting area. The general trend in the class data is that moose hunting areas have similar or lower patch complexities than the general moose distribution range.

Sheep Hunting Ranges

Only nine villages, or roughly 43% of the sample, hunted sheep. The only region not represented is the Lower Tanana area where no documented or reported sheep hunting occurred during the subsistence studies. Stony River did not participate in sheep hunting during the ADG&F subsistence study, but reported sheep hunting in the past and provided hunting range data that were used in this study. The landscape level metrics for the sheep hunting ranges are given in Table 6.3. The size of sheep hunting ranges varies considerably among the nine hunting ranges. Tok and Arctic village have the largest hunting ranges. Interestingly, the Arctic Village and Alatna sheep hunting ranges are actually larger than their respective moose hunting ranges. Despite the large variation of the size of hunting ranges, which is between 3,881 and 1.3 million hectares, the MPS is more or less similar. The average MPS for all nine ranges is 20.6 hectares and in contrast to moose and caribou hunting ranges the PSSD is relatively small. The PD values are consistently higher for sheep hunting range than either moose or caribou hunting ranges varying between 3.33 and 6.67 patches per 100 hectares clearly indicating that sheep hunting ranges are significantly more patch than the other hunting areas. Overall, the PD values are similar between sheep distributional ranges and the hunting ranges.

Edge densities and patch densities are highly and significantly correlated ($r = .94$; $p = .001$). Given the more patchy nature of sheep hunting landscapes, it comes as no surprise that the ED values are substantially higher and the MPE values are much lower than they are in other hunting ranges. Like PD, all the edge metrics indicate that sheep hunting occurs in very patchy environments. Overall, the edge metrics for the sheep hunting ranges are slightly lower than the edge metrics calculated for the general sheep distribution ranges.

The shape metrics also indicate a patchy environment with small, regularly shaped patches. The MPAR values are mostly between 400 and 500 except in the upper Yukon

Table 6.3. Sheep Hunting Range Landscape Level Metrics.

		Total Landscape Area (ha)	No. of Patches	Mean Patch Size (Ha)	Patch Size Covariance	Patch Size Standard Deviation	Patch Density	Total Edge	Edge Density	Mean Patch Edge	Mean Shape Index (MSI)	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD	SHDI	SHEI
Koyukuk	Alatna	306,628.4	12,339	24.9	1,134.9	282.0	4.02	2.4E+07	79.3	1,970.9	1.39	5.88	407.86	1.32	1.34	1.98	0.86
	Bettles	94,266.1	3,137	30.0	842.8	253.3	3.33	6.3E+06	66.9	2,008.9	1.40	4.02	540.79	1.32	1.32	1.96	0.85
Kuskokwim	Stony	9,310.4	522	17.8	306.1	54.6	5.61	9.4E+05	100.7	1,795.6	1.43	2.36	502.71	1.30	1.30	1.97	0.86
Upper Tanana	Dotlake	25,383.0	1,050	24.2	780.2	188.6	4.14	1.9E+06	76.3	1,845.7	1.42	3.70	501.79	1.32	1.31	2.07	0.90
	Northway	3,881.5	259	15.0	256.0	38.4	6.67	4.1E+05	106.1	1,590.0	1.40	2.09	378.86	1.31	1.29	2.01	0.87
	Tanacross	126,898.3	7,141	17.8	739.5	131.4	5.63	1.2E+07	93.6	1,663.8	1.39	3.30	417.44	1.31	1.31	2.12	0.92
	Tok	895,242.6	42,832	20.9	846.2	176.9	4.78	8.0E+07	88.8	1,856.8	1.41	3.74	404.35	1.31	1.32	2.09	0.91
Upper Yukon	Arctic	1,359,947.2	74,119	18.3	2,081.8	382.0	5.45	1.2E+08	89.7	1,645.2	1.44	6.82	815.27	1.36	1.35	2.02	0.88
	Venetie	25,514.2	1,566	16.3	824.5	134.3	6.14	2.3E+06	89.9	1,464.4	1.45	4.69	1,427.09	1.40	1.34	1.86	0.81

where they jump substantially to 814 and 1,427. The high MPAR values in the Upper Yukon consists of patches that are substantially more complex than other regions. Patch complexity as indicated by the AWMSI and AWMPFD scores also point to high patch shape complexity in the Upper Yukon, but also in the Alatna sheep hunting area. As a general observation, the patch shape of sheep hunting ranges is more complex in the Brooks Range than it is in the lower mountains of the Alaska Range.

The diversity of sheep hunting ranges relative to sheep distribution ranges show some consistent patterning. The diversity of sheep hunting ranges in the Upper Yukon, Kuskokwim, and Koyukuk regions are equal to or less than the diversity identified in the general sheep distribution range. With the exception of the Northway sheep hunting range, the villages in the Upper Tanana sample have landscape diversities that are greater than the general sheep range. As should be expected, the SHEI scores also result in this same pattern.

As shown in Figure 6.3, the sheep hunting range landscape composition is strikingly different from either the moose or caribou hunting ranges. The class level metrics (Appendix A) for the nine sheep hunting ranges in the study are more patchy than the other hunting ranges and consist of a more even distribution of the various landform types. Open slopes tend to be the most common patch type in area but not necessarily in frequency. Although open slopes constitute the largest percentage of the hunting ranges, they by no means cover the majority of the range. At Venetie and the two sheep hunting ranges in the Koyukuk region, open slopes account for just over 40% of the entire range, while elsewhere this patch type covers approximately 20 to 30% of the sheep hunting range. The remaining 60 to 70% of each range typically consists of canyons, midslope drainages, U-shaped valleys, plains, high slopes, and high ridges. Though variable from one village to the next, these landform patches each represent between 5 and 20% of the hunting range. The patch densities, which are two to three times higher than the two other hunting ranges, indicate a substantially patchier environment. Region to region, the sheep hunting range individual landform PDs are comparable to those found among the general sheep distribution landform PDs.

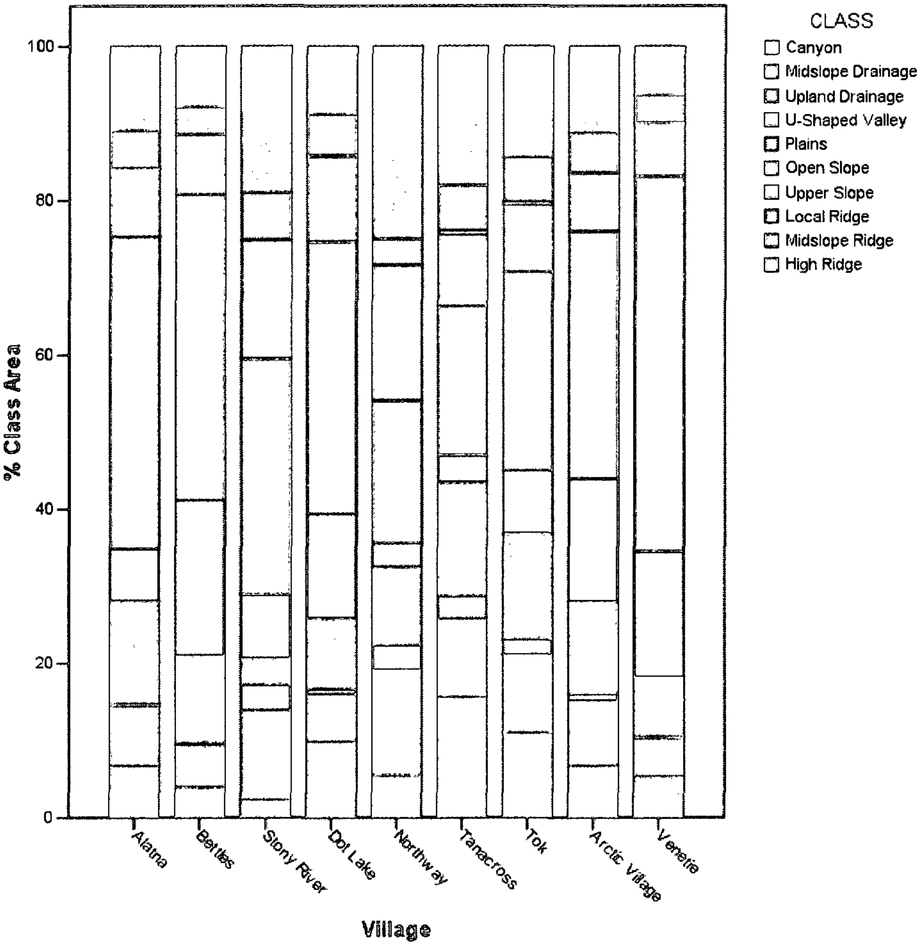


Figure 6.3. Cumulative Percentage Bar Graph of Sheep Hunting Range Class Areas.

Classification of Hunting Ranges by Distribution Functions

Utilizing the discriminant classification functions derived in Chapter 5, all of the hunting ranges for caribou, moose, and sheep, were classified to determine how well these functions predict the type of hunting range based on the landscape parameters. Results of the classification for the caribou, moose, and sheep hunting ranges and discussion of the utility of discriminant classification functions are presented below.

Table 6.4 presents the results of the general caribou range classification function applied to the 15 caribou ranges included in the sample. The classification function correctly classified

Table 6.4. Classification of Caribou Hunting Ranges by Discriminant Classification Scores for General Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Huslia	9.53	Moose
Kuskokwim	McGrath	10.91	Moose
	Nikolai	-13.87	Moose
	Stony River	-3.81	Moose
	Telida	-9.40	Moose
Lower Tanana	Beaver	-2.68	Moose
	Tanana	37.31	Caribou
Upper Tanana	Dot Lake	21.21	Caribou
	Northway	22.29	Caribou
	Tanacross	12.12	Moose
	Tok	23.67	Caribou
Upper Yukon	Arctic Village	36.22	Caribou
	Chalkyitsik	8.19	Moose
	Fort Yukon	13.85	Moose
	Venetie	26.08	Caribou

only 40% of the cases. Those cases correctly classified include Tanana, Dot Lake, Northway, Tok, Arctic Village, and Venetie. Relative to the general caribou landscape metrics, the seasonal range metrics show considerably more variability among the different study areas. Given that the discriminant classification relies solely on the ED variable, and the constant, it is clear that those hunting ranges with higher edge densities were classified as caribou range. All of the ED values for the correctly classified cases are above 55, while those misclassified as moose hunting ranges have ED values below 45. The poor classification rates likely result from two causes. First, the hunting areas are relatively small compared to the general caribou distribution. This alone suggests that, in terms of the landscape parameters, the caribou hunting ranges are not necessarily representative of the general caribou range. Also, the many cases classified as moose ranges suggests that hunters utilize caribou hunting ranges that significantly overlap with moose ranges or that share moose-like landscape characteristics. This latter possibility is examined in more detail below (see Hunting and Distribution Range Correspondence). Despite the poor classification rate, it is clear that the discriminant classification function served to identify those cases with ED values similar to the general caribou distributions.

Tables 6.5 and 6.6 provide the classification scores and group predictions for the hunting ranges based on the winter and summer caribou ranges discriminant classification functions. Compared with the correctly classified cases in Table 6.4, the caribou hunting ranges were more often correctly classified, each at a rate of 66.6%, utilizing both the summer and winter range classification functions. The winter range discriminant classification function correctly classified 10 of the 15 cases in the sample. The misclassified cases include Nikolai, Telida, Beaver, Chalkyitsik, and Venetie. The winter classification function focuses on MPS and MPAR values. The misclassified cases represent those hunting areas with extremely large patches (Nikolai and Telida), large perimeter to area ratios (Chalkyitsik and Venetie), or both (Beaver). While some of the correctly classified cases have MPAR values that are high (e.g. Arctic Village and Fort Yukon), the threshold in the classification function was not met. Of the 10 correctly classified cases, four have caribou and moose classification scores that are very similar.

Table 6.5. Classification of Caribou Hunting Ranges by Discriminant Classification Scores for Winter Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Huslia	Caribou=1.34 Moose =-5.09	Caribou
Kuskokwim	McGrath	Caribou=2.80 Moose =-1.52	Caribou
	Nikolai	Caribou=110.33 Moose =256.03	Moose
	Stony River	Caribou=4.58 Moose =2.67	Caribou
	Telida	Caribou=60.51 Moose =136.6	Moose
Lower Tanana	Beaver	Caribou=8.46 Moose =12.08	Moose
	Tanana	Caribou=0.22 Moose =-7.75	Caribou
Upper Tanana	Dot Lake	Caribou=1.00 Moose =-5.90	Caribou
	Northway	Caribou=1.93 Moose =-3.63	Caribou
	Tanacross	Caribou=3.94 Moose =1.22	Caribou
	Tok	Caribou=2.17 Moose =-3.05	Caribou
Upper Yukon	Arctic Village	Caribou=5.06 Moose =3.97	Caribou
	Chalkyitsik	Caribou=6.26 Moose =6.91	Moose
	Fort Yukon	Caribou=4.61 Moose =2.88	Caribou
	Venetie	Caribou=7.49 Moose =9.90	Moose

Table 6.6. Classification of Caribou Hunting Ranges by Discriminant Classification Scores for Summer Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Huslia	Caribou=1.13 Moose =-0.19	Caribou
Kuskokwim	McGrath	Caribou=1.35 Moose =0.20	Caribou
	Nikolai	Caribou=-16.56 Moose =-2.16	Moose
	Stony River	Caribou=-8.93 Moose =-1.32	Moose
	Telida	Caribou=-12.13 Moose =-2.13	Moose
Lower Tanana	Beaver	Caribou=-9.53 Moose =-0.74	Moose
	Tanana	Caribou=20.05 Moose =1.80	Caribou
Upper Tanana	Dot Lake	Caribou=9.56 Moose =0.70	Caribou
	Northway	Caribou=9.82 Moose =0.92	Caribou
	Tanacross	Caribou=2.20 Moose =0.33	Caribou
	Tok	Caribou=10.61 Moose =1.05	Caribou
Upper Yukon	Arctic Village	Caribou=17.13 Moose =2.46	Caribou
	Chalkyitsik	Caribou=-2.35 Moose =0.52	Moose
	Fort Yukon	Caribou=2.66 Moose =0.76	Caribou
	Venetie	Caribou=9.56 Moose =2.09	Caribou

The summer range classification function also correctly classified 10 of the 15 (66.6%) hunting ranges into the appropriate type of range. Of the misclassified cases, four of the five are the same cases misclassified with the winter range classification function including Nikolai, Telida, Beaver, and Chalkyitsik; Stony River is the remaining misclassified case. The summer classification function concentrates on ED, like the general range function, and MPAR, like the winter range classification function. The three misclassified Kuskokwim cases have low ED and MPAR values indicating large patches in general. The Beaver caribou hunting range has a low ED value but a high MPAR, as does the Chalkyitsik hunting range. The five misclassified hunting ranges have the smallest overall ED values, all below 37.0, but variable MPAR values.

Based on the misclassified cases in the caribou hunting ranges, it comes as little surprise that correct classification rates for moose hunting ranges are substantially higher (Table 6.7). The general range classification for differentiating among caribou, moose, and sheep ranges correctly predicts moose hunting ranges in 19 out of 21 cases, a correct classification rate of 90.5%. The

Table 6.7. Classification of Moose Hunting Ranges by Discriminant Classification Scores for General Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Alatna	-6.16	Moose
	Bettles	-3.89	Moose
	Hughes	-0.94	Moose
	Huslia	-11.61	Moose
Kuskokwim	McGrath	10.69	Moose
	Nikolai	-12.10	Moose
	Stony River	-1.84	Moose
	Telida	-6.90	Moose
Lower Tanana	Beaver	-13.73	Moose
	Minto	-3.50	Moose
	Steven's Village	-9.33	Moose
	Tanana	5.11	Moose
Upper Tanana	Dot Lake	5.63	Moose
	Northway	1.56	Moose
	Tanacross	9.93	Moose
	Tetlin	-4.23	Moose
	Tok	16.77	Caribou
Upper Yukon	Arctic Village	37.86	Sheep
	Chalkyitsik	7.42	Moose
	Fort Yukon	-7.48	Moose
	Venetie	5.45	Moose

two misclassified hunting ranges Tok and Arctic Village. These two hunting ranges represent the two largest moose hunting ranges in the entire sample. The classification function misclassified the Tok hunting range as caribou range and the Arctic Village hunting range was misclassified as sheep range. Given the extremely high ED value of Arctic Village moose hunting range, this outcome is not entirely unexpected. In general, the cases correctly classified as moose range all have ED values below 40, while Tok's is 50 and Arctic Village's is a very high 77.

There is a drop in successful classification rates based on the winter range classification function and a minor decrease successful classification rates based on the summer range function. Table 6.8 presents the results based on the winter range classification function. Here 7 of the 21, or 33.3%, cases were misclassified being more representational of winter caribou ranges. These cases include Hughes, McGrath, Stony River, Tanana, Tanacross, Tok, and Arctic Village. All the misclassified hunting ranges have average patch sizes below 100 hectares; Chalkyitsik and Venetie, two correctly classified cases, also have MPSs below 100 hectares. MPAR values for the misclassified cases vary considerable and so no clear correlation with their corresponding MPS. The classification of hunting ranges by the summer range classification function for moose and caribou resulted in a correct classification rate of 86% (Table 6.9). Again, Tok and Arctic Village are two of the misclassified cases.

Table 6.8. Classification of Moose Hunting Ranges by Discriminant Classification Scores for Winter Ranges.

Region	Village	Classification Scores	Predicted Group
Koyukuk	Alatna	Caribou=10.18 Moose =16.20	Moose
	Bettles	Caribou=8.08 Moose =11.13	Moose
	Hughes	Caribou=3.55 Moose =0.24	Caribou
	Huslia	Caribou=14.65 Moose =26.82	Moose
Kuskokwim	McGrath	Caribou=3.97 Moose =1.31	Caribou
	Nikolai	Caribou=19.63 Moose =38.76	Moose
	Stony River	Caribou=4.82 Moose =3.29	Caribou
	Telida	Caribou=7.35 Moose =9.32	Moose
Lower Tanana	Beaver	Caribou=58.54 Moose =132.03	Moose
	Minto	Caribou=5.99 Moose =6.09	Moose
	Steven's Village	Caribou=10.86 Moose =17.77	Moose
	Tanana	Caribou=3.31 Moose =-0.33	Caribou
Upper Tanana	Dot Lake	Caribou=13.58 Moose =24.60	Moose
	Northway	Caribou=6.82 Moose =8.14	Moose
	Tanacross	Caribou=2.64 Moose =-1.93	Caribou
	Tetlin	Caribou=23.80 Moose =49.31	Moose
	Tok	Caribou=1.25 Moose =-5.29	Caribou
Upper Yukon	Arctic Village	Caribou=5.54 Moose =5.17	Caribou
	Chalkyitsik	Caribou=6.24 Moose =6.84	Moose
	Fort Yukon	Caribou=10.71 Moose =17.60	Moose
	Venetie	Caribou=6.98 Moose =8.63	Moose

Table 6.9. Classification of Moose Hunting Ranges by Discriminant Classification Scores for Summer Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Alatna	Caribou=-12.26 Moose =-1.00	Moose
	Bettles	Caribou=-9.98 Moose =-1.00	Moose
	Hughes	Caribou=-7.07 Moose =-0.98	Moose
	Huslia	Caribou=-15.09 Moose =-1.89	Moose
Kuskokwim	McGrath	Caribou=0.77 Moose =0.32	Moose
	Nikolai	Caribou=-15.67 Moose =-1.86	Moose
	Stony River	Caribou=-7.89 Moose =-1.00	Moose
	Telida	Caribou=-11.44 Moose =-1.52	Moose
Lower Tanana	Beaver	Caribou=-17.48 Moose =-1.80	Moose
	Minto	Caribou=-9.13 Moose =-1.15	Moose
	Steven's Village	Caribou=-13.87 Moose =-1.53	Moose
	Tanana	Caribou=-2.79 Moose =-0.37	Moose
Upper Tanana	Dot Lake	Caribou=-6.44 Moose =1.02	Moose
	Northway	Caribou=-6.25 Moose =-0.41	Moose
	Tanacross	Caribou=1.18 Moose =-0.07	Caribou
	Tetlin	Caribou=-16.96 Moose =1.21	Moose
	Tok	Caribou=6.64 Moose =0.40	Caribou
Upper Yukon	Arctic Village	Caribou=17.82 Moose =2.63	Caribou
	Chalkyitsik	Caribou=-2.92 Moose =0.45	Moose
	Fort Yukon	Caribou=-14.78 Moose =-0.60	Moose
	Venetie	Caribou=-4.58 Moose =0.35	Moose

The results of the sheep hunting range classifications (Table 6.10) show that seven of the nine sheep hunting ranges were correctly classified; this is a correct classification rate of almost 78%. The two cases misclassified are Bettles and Dot Lake ranges; the general range discriminant classification function classified these cases as caribou ranges. The two misclassified cases have ED values of 76.3 and 66.9 and the correctly classified cases all have EDs above 79 (though most are closer 90 or above).

Table 6.10. Classification of Sheep Hunting Ranges by Discriminant Classification Scores for General Ranges.

Region	Village	Classification Score	Predicted Group
Koyukuk	Alatna	39.34	Sheep
	Bettles	29.72	Caribou
Kuskokwim	Stony River	71.58	Sheep
Upper Tanana	Dot Lake	37.05	Caribou
	Northway	79.33	Sheep
	Tanacross	61.51	Sheep
	Tok	54.65	Sheep
Upper Yukon	Arctic Village	55.84	Sheep
	Venetie	56.15	Sheep

The ability of the discriminant classification functions to correctly classify a hunting range by general landscape parameters of various distributional ranges for caribou, moose, and sheep is reasonably successful. Moose and sheep hunting ranges consistently had the highest success rates, particularly using the general range discriminant classification function.

The classification of caribou hunting ranges by this same function had the poorest success rate of any of the functions. The summer classification function collectively resulted in the best classification rates for moose and caribou. The winter classification had an acceptable success rate of 66% for both moose and caribou. In all cases, the correct classification rates are lower than the leave-one-out classifications conducted as part of the initial discriminant analysis (Chapter 5), which had across the board success rates between 80 and 100%.

The results of the descriptive landscape metrics and the moderately successful classification of hunting ranges based on animal distributional range landscape characteristics, raises an obvious question: Where they exist, are the differences between hunting and distributional ranges a result of human preferences or are the differences related to inadequacies in the assumptions, methods, and analyses used thus far? Put another way, what factors contribute to a case being misclassified? The following section follows multiple lines of investigation to understand better the variations in the data that may account, at least partially, for some of the misclassifications. This serves not only as an independent, somewhat qualitative, assessment of how well the classification functions work, but also to provide additional insight into the relationships between hunting and distributional ranges.

Hunting Range and Distributional Range Correspondence

It is clear that the characteristics of the hunting ranges cursorily mimic those of the animal distributional ranges in the most cases, but there are some substantial differences and, at least between moose and caribou hunting ranges, considerable overlap. This overlap is not just figurative, but also spatial. Numerous methods are available for examining overlapping areas including chi-square overlay analysis, coefficients of areal correspondence, raw overlap percentages, and resemblance matrices. Each method has benefits and limitations, but given the types of data used here, resemblance matrices, or more specifically the resemblance coefficients, are most amenable to examining the areal relationship between hunting and distributional ranges. In essence, the resemblance coefficients reflect areal correspondence as a ratio of the difference between overlapping areas and nonoverlapping areas divided by the total area (Court 1970). Or,

$$q = \frac{R i - j}{A} \qquad 6.1$$

Where q is the resemblance coefficient, R is the respective hunting range, *i* is the area of overlap within R, *j* is the area with no overlap in R, and A is the total area of R. This results in a standardized coefficient range of -1.0 to 1.0, where -1.0 reflects a perfect negative correspondence, or a complete lack of overlap between the hunting range and the distributional range. The standardization of q normalizes its distribution making it amenable to significance testing (Court 1970:435). As used here, the coefficients are limited to each specific hunting range and used as a heuristic aid in the interpretation of landscape differences.

Caribou Range Resemblance

Table 6.11 presents the resemblance coefficients comparing caribou hunting ranges with the caribou and moose distributional ranges. The footnotes in the table represent major hunting seasons as detailed in Chapter 3. There is no autumn distribution data available for caribou, but this season is, and was in the recent past, an important season for caribou hunting. There is very good correspondence between the general caribou distribution and the various hunting ranges. Nine of the hunting ranges entirely overlap with this range and another four ranges have very high resemblance coefficients. The correspondence with the general moose distribution is also

Table 6.11. Resemblance between Caribou Hunting Ranges and Caribou Distributional Ranges.

Region	Village	q Caribou Hunting Range to Caribou Distribution	q Caribou Hunting Range to Moose Distribution	q Caribou Hunting Range to Summer Cairbou Distribution	q Caribou Hunting Range to Summer Moose Distribution	q Caribou Hunting Range to Winter Caribou Distribution	q Caribou Hunting Range to Winter Moose Distribution
Koyukuk	Huslia	1.00	1.00	-1.00	-1.00	1.00	-1.00
Kuskokwim	McGrath	1.00	0.89	-0.52	-0.93	-0.30	-0.92
	Nicolai	1.00	1.00	-0.75	-0.50	0.26	-0.87
	Stony River	1.00	0.96	-0.96	-1.00	0.54	-0.93
	Telida	1.00	1.00	-0.95	-1.00	1.00	-1.00
Lower Tanana	Beaver	1.00	1.00	-1.00	-1.00	-1.00	-1.00
	Tanana	-0.30	1.00	-1.00	-1.00	-0.30	-1.00
Upper Tanana	Dot Lake	0.84	0.97	-1.00	-0.80	-1.00	-0.80
	Northway	1.00	0.89	-0.68	-1.00	-0.06	-0.66
	Tanacross	0.88	0.99	-0.35	-0.96	-0.25	-0.43
	Tok	0.96	0.90	-0.18	-0.95	0.05	-0.68
Upper Yukon	Arctic	1.00	0.37	-1.00	-0.89	0.58	-0.75
	Chalkyitsik	0.95	0.99	-1.00	-1.00	0.85	-0.19
	Ft. Yukon	0.24	-0.40	-1.00	-1.00	-0.33	-1.00
	Venetie	1.00	0.91	-1.00	-1.00	0.19	-0.80

high. The Fort Yukon caribou hunting area has a low, but positive, correlation with the caribou general distribution. The Tanana village caribou hunting range stands out as the smallest coefficient in the sample, which reflects very little overlap between the two ranges. Overall, the correspondence between the general caribou ranges and caribou hunting ranges is 0.83 and for caribou hunting range and moose distribution, the coefficient is also 0.83. Though not a perfect indicator, the general trend in the resemblance coefficients is that those cases that have greater variation in the amount of overlap with either caribou or moose distributions tend to be correctly classified by the discriminant function. Two exceptions are noteworthy. First, the two coefficients for McGrath, which was misclassified, show slightly more variability than those for Venetie, which was correctly classified. With the differences in patchiness between the Kuskokwim and Upper Yukon regions, this result suggests that the discriminant function works in identifying very slight differences in the ranges. Relative to the discriminant function, Venetie's hunting range, despite slightly more overlap with moose range relative to McGrath, is more similar to caribou than moose. The second exception relates to Ft. Yukon, which has very little correspondence between both ranges. Since much of the hunting area falls outside any mapped wildlife distribution it is not particularly surprising that it was misclassified by the discriminant classification function.

The correspondence between summer caribou ranges and hunting ranges are all negative, eight of the villages have absolutely no overlap and the remaining six hunting ranges have few minor correlations. The same general pattern is observable in the overlap between caribou hunting ranges and the summer moose distributions. The overall resemblance coefficient for all the areas is -0.76 for caribou and -0.94 for moose. Only one community, Fort Yukon, has an appreciable summer caribou hunting period, but its hunting range does not overlap at all the with summer caribou range in the Upper Yukon region. The general trend appears to be that the more separate the two summer ranges, the higher the classification rate. Again, this is not a perfect correlation, as some cases with complete separation are still misclassified. These cases are attributable to the actual hunting range landscape composition and structure. Relative to the summer ranges, the caribou hunting areas have a substantially higher correspondence with the winter caribou ranges and a lower correspondence with winter moose ranges. Despite this difference, an examination of the coefficients reflects no immediately discernible patterning. It is understandable that the two winter distribution ranges are structurally different and that the success of the discriminant classification depends primarily on the landscape structure of the hunting range. Eight of the communities have positive coefficients indicating substantial overlap with winter caribou ranges. The overall resemblance coefficient for all the areas is weak, but positive (q=0.10). Twelve of the 15 villages practice caribou hunting in the winter. Of these villages, seven share no common territory in the hunting area with the winter caribou range.

Moose Range Resemblance

With the exception of the general moose distribution, the resemblance between seasonal moose distributions and moose hunting ranges is very low (Table 6.12). As for the caribou hunting ranges, there is significant overlap between the moose hunting range and the general moose distribution range. Nineteen of the villages have ranges that are entirely within the general moose range; the three remaining villages, Tok, Arctic Village, and Chalkyitsik, have correlation coefficients above 0.70. For all the villages, the overall resemblance coefficient is 0.97, or nearly perfect correspondence.

The overlap between the seasonal moose ranges and hunting ranges, however, is very low. Only one community, Tetlin, has a positive resemblance coefficient with the summer range. Thirteen communities have hunting ranges that do not overlap the summer moose range at all; the remaining seven villages have small, negative coefficients. The overall resemblance coefficient for the correspondence between summer moose ranges and moose hunting ranges is -0.81. Just over one-third of the villages hunt moose, either casually or intensively, during the summer. Of these, only Tetlin has a hunting range that reflects this timing. Unexpectedly, the fall moose range has a slightly lower overall resemblance coefficient of -0.82 despite the fact that 20 of the 21 communities have casual or intensive fall moose hunting. All the fall resemblance coefficients are negative indicating less than half, and often less the one quarter, of the hunting areas overlap with the fall moose ranges. Although the resemblance between winter moose ranges and hunting areas is also negative (q=-0.51), the winter range has the largest resemblance coefficient of any of the seasonal ranges. Hughes is the only community that has a hunting range that is positively correlated with the winter range, though only marginally. Sixteen villages practice either casual or intensive moose hunting during the winter. Interestingly, villages that do not hunt moose in the winter have higher, though still negative, resemblance coefficients than villages that do hunt moose during the winter.

Table 6.12. Resemblance between Moose Hunting Ranges and Moose Distributional Ranges

Region	Village	q Moose Hunting Range to Moose Distribution	q Moose Hunting Range to Caribou Distribution	q Moose Hunting Range to Summer Moose Distribution	q Moose Hunting Range to Summer Caribou Distribution	q Moose Hunting Range to Winter Moose Distribution	q Moose Hunting Range to Winter Caribou Distribution
Koyukuk	Alatna	1.00	1.00	-1.00	-1.00	-0.38	0.83
	Bettles	1.00	1.00	-1.00	-1.00	-0.44	0.43
	Hughes	1.00	1.00	-1.00	-1.00	0.06	1.00
	Huslia	1.00	1.00	-1.00	-1.00	-0.02	1.00
Kuskokwim	McGrath	1.00	1.00	-0.68	-0.94	-0.22	-0.58
	Nicolai	1.00	1.00	-0.65	-0.72	-0.64	-0.02
	Stony River	1.00	1.00	-1.00	-0.96	-0.78	-0.31
	Telida	1.00	1.00	-0.83	-0.97	-0.65	0.43
Lower Tanana	Beaver	1.00	-0.55	-1.00	-1.00	-0.91	-1.00
	Minto	1.00	-0.88	-1.00	-1.00	-0.72	-1.00
	Stevens	1.00	-0.41	-1.00	-1.00	-1.00	-1.00
	Tanana	1.00	-0.58	-1.00	-1.00	-0.65	-0.81
Upper Tanana	Dot Lake	1.00	-0.10	-0.71	-0.92	-0.71	-1.00
	Northway	1.00	0.91	-0.14	-0.81	-0.31	-0.61
	Tanacross	1.00	0.68	-0.85	-0.54	-0.28	-0.30
	Tetlin	1.00	1.00	0.55	-1.00	-0.91	-1.00
	Tok	0.90	0.74	-0.75	-0.52	-0.56	-0.39
Upper Yukon	Arctic	0.84	0.77	-1.00	-1.00	-0.60	0.75
	Chalkyitsik	0.73	0.77	-1.00	-1.00	-0.04	0.46
	Ft. Yukon	1.00	-0.18	-1.00	-1.00	-0.23	-0.58
	Venetie	1.00	0.53	-1.00	-1.00	-0.67	0.53

Sheep Range Resemblance

Compared with moose and caribou hunting ranges, which mostly either overlaps with distributional ranges or not at all, the sheep hunting ranges are a mixed bag. Of the nine communities with sheep hunting ranges, five overlap with mapped sheep distributions and four do not. Of the five with positive resemblance coefficients, only those for Alatna and Tanacross have substantially high values (Table 6.13). Why these coefficients are markedly different from the ranges of other nearby villages cannot be ascertained from the available data; however, in the Upper Tanana, road access to sheep hunting areas may be part of the explanation. The four villages with negative hunting range coefficients, with the exception of Stony River, are not particularly low. Overall, the overlap between sheep distribution and sheep hunting ranges is between 40 and 60% and the overall resemblance coefficient for all the areas is weakly positive at 0.10. The Stony River sheep hunting range, which is the only one in the sample that has a complete separation between hunting and distributional sheep ranges, reflects a historical range that was not in use during the time the subsistence study occurred. It is uncertain if abandonment was because sheep hunting has generally been neglected in the Kuskokwim area or if the sheep populations in the area of the hunting range decreased substantially resulting in wasted efforts.

Table 6.13. Resemblance between Sheep Hunting Ranges and Sheep Distributional Ranges.

Region	**Village**	**General Resemblance Coefficient**
Koyukuk	Alatna	0.75
	Bettles	0.22
Kuskokwim	Stony River	-1.00
Upper Tanana	Dot Lake	-0.18
	Northway	-0.14
	Tanacross	0.72
	Tok	0.39
Upper Yukon	Arctic Village	0.31
	Venetie	-0.20

Caribou and Moose Distribution and Seasonal Range Resemblance

The final coefficients examined are those for the general distributional ranges of moose and caribou. Table 6.14 presents the resemblance coefficients comparing the general caribou and moose distribution, as well as the summer and winter ranges. I calculated the coefficients both for caribou range overlapping moose range and vise versa. In both cases, the overlap area is identical, but the overall range of each species is different. The calculation of these coefficients is identical to those calculated above with the exception that A (the total area), represents the area of the particular range and not the area regional study areas.

It is clear the general distribution of moose and caribou significantly overlap in all regions, though the general moose distribution has slightly higher resemblance scores indicating that more of the moose distribution area overlaps with caribou range than caribou range does with moose range. The lowest resemblance coefficients occur in the Lower Tanana region, though the actual area of overlap between the two ranges is still substantial at 8,185,200 hectares. The Upper Yukon region has the greatest variation in corresponding moose and caribou distributional ranges. The resemblance measures indicate that there are large areas of caribou range that are outside the moose range, but that moose range substantially overlaps with the caribou range. In most cases, these two range types are highly commingled.

The picture concerning seasonal moose and caribou ranges is very different from that of the general distribution ranges of the two species. The winter ranges have very little overlap in general. Only the winter moose range in the Koyukuk region significantly overlaps with the caribou range. Apart from this case, all the resemblance coefficients are negative. Overall, moose ranges overlap more with caribou ranges than caribou do with moose. With one exception, there is no correspondence between moose and caribou summer ranges. The single exception is in the Tanana region where there is a minor convergence of the two ranges, about 10,000 hectares.

Table 6.14. Resemblance between Caribou and Moose Ranges.

Range	Region	Caribou to Moose Resemblance	Moose to Caribou Resemblance
General Distribution	Koyukuk	0.87	0.95
	Kuskokwim	0.89	0.92
	Lower Tanana	0.59	0.61
	Upper Tanana	0.73	0.83
	Upper Yukon	0.68	0.86
Winter Range	Koyukuk	-0.84	0.73
	Kuskokwim	-0.83	-0.25
	Lower Tanana	-0.89	-0.62
	Upper Tanana	-0.77	-0.23
	Upper Yukon	-0.62	0.28
Summer Range	Koyukuk	-1.00	-1.00
	Kuskokwim	-1.00	-1.00
	Lower Tanana	-1.00	-1.00
	Upper Tanana	-0.99	-0.95
	Upper Yukon	-1.00	-1.00

Resemblance and Classification of Hunting Areas

An examination of the resemblance coefficients in relationship to the hunting range classification results indicates that success rates depend heavily on convergence between distributional ranges. At the general distribution level, where there is the greatest amount of overlap between moose and caribou ranges, the success rate of classification of caribou hunting areas is lowest, but the success rate of moose hunting areas is the highest. Given the large overlap between these two ranges, the inverse relationship in classification rates is understandable. The greater overall resemblance of moose range to caribou range is a major contributing factor to the overall success rates of the discriminant classification functions. That the caribou hunting ranges typically overlap with substantial areas of moose range results in the misclassification of some cases where the landscape metrics, particularly those retained in the discriminant functions, remain ambiguous. This poses the largest obstacle to classifying unknown cases due to the inability to identify false positive moose classifications. This can be partially addressed by examining the landscape composition, as opposed to the purely structural parameters, on a case-by-case basis to further test the validity of a classification. Another aid, detailed in the remaining section of this chapter, is identification and quantification of the landscape structure of the different hunting ranges.

Hunting Range Discriminant Function Analysis and Classification Functions

As with the wildlife distributions, the hunting range data were subjected to discriminant analysis to identify a classification function that may be useful in delineating between landscape structure and the type of game pursued. Again, I began by examining which landscape metrics differed significantly among the three hunting range types. The results of ANOVA and Bonferroni post-hoc tests are given in Tables 6.15 and 6.16. Because of the small sample size, I increased the significance level to 0.10. The number of cases used in the analysis includes 21 moose hunting ranges, 15 caribou hunting ranges, and 9 sheep hunting ranges. All of the landscape metrics show some variability, but only four are significantly different. These include the PSCOV, PSSD, PD, and ED. Examining the results of the post-hoc tests it is immediately clear that many of the sheep hunting ranges are responsible for much of the significant and nonsignificant differences identified. Of the four significantly different metrics, the patch size covariance shows that the sheep hunting ranges have lower patch size variance than either moose or caribou ranges. The patch size standard deviation is larger in the moose hunting ranges than either the caribou or sheep hunting ranges. Both PD and ED differ among all of hunting ranges,

Table 6.15. Between Group Analysis of Variance Summary Table for Hunting Range Landscape Metrics.

	Sum of Squares	df	Mean Square	F	p
Total Landscape Area	1.42E+11	2	7.19E+11	0.258	.774
Number of Patches	5.18E+8	2	2.58E+8	0.396	.676
Mean Patch Size	396894.48	2	198447.24	1.14	.330
Patch Size Covariance	74573849	2	37286924	6.63	.003
Patch Size Standard Deviation	1.60E+8	2	80220102	7.97	.001
Patch Density	83.89	2	41.95	19.71	.001
Total Edge	1.13E+15	2	5.67E+14	.402	.671
Edge Density	24474.19	2	12237.10	36.36	.001
Mean Patch Edge	9923923	2	4961961	1.25	.296
Mean Shape Index	.015	2	.008	2.14	.130
Area Weighted Mean Shape Index	39.36	2	19.68	1.15	.327
Mean Perimeter to Area Ratio	743301.77	2	371650.88	1.46	.244
Mean Patch Fractal Dimension	.002	2	.001	.341	.713
Area Weighted Mean Patch Fractal Dimension	.006	2	.003	1.24	.301
Shannon's Diversity Index	.56	2	.28	2.01	.147
Shannon's Evenness Index	.09	2	.04	1.86	.169

Table 6.16. Bonferroni Post Hoc Tests of the Analysis of Variance of Landscape Level Metrics for Hunting Ranges.

	Resource (I)	Resource (J)	Mean Difference (|I-J|)	Std. Error	Sig.
Total Landscape Area	Caribou	Moose	19730.48	177581.87	1.00
	Caribou	Sheep	127324.93	221483.51	1.00
	Moose	Sheep	147055.41	209282.24	1.00
Number of Patches	Caribou	Moose	6967.68	8645.7	1.00
	Caribou	Sheep	474.40	10738.1	1.00
	Moose	Sheep	6493.28	10189.1	1.00
Patch Density	Caribou	Moose	1.45	0.50	0.075
	Caribou	Sheep	2.50	0.61	0.001
	Moose	Sheep	3.65	0.58	0.001
Mean Patch Size	Caribou	Moose	111.22	141.21	1.00
	Caribou	Sheep	265.11	176.12	0.42
	Moose	Sheep	153.88	166.42	1.00
Patch Size Covariance	Caribou	Moose	1114.07	801.83	0.52
	Caribou	Sheep	232487	1000.1	0.075
	Moose	Sheep	3438.95	944.96	0.002
Patch Size Standard Deviation	Caribou	Moose	2810.14	1072.60	0.037
	Caribou	Sheep	1922.55	1337.77	0.470
	Moose	Sheep	4732.69	1264.07	0.002
Total Edge	Caribou	Moose	8785187.73	12694603.00	1.00
	Caribou	Sheep	2857809.15	15832951.00	1.00
	Moose	Sheep	11642996.90	14690733.00	1.00
Edge Density	Caribou	Moose	17.36	6.20	0.023
	Caribou	Sheep	44.94	7.73	0.001
	Moose	Sheep	62.30	7.31	0.00
Mean Patch Edge	Caribou	Moose	797.52	672.60	0.73
	Caribou	Sheep	1243.26	838.88	0.44
	Moose	Sheep	445.74	792.67	1.00
Mean Shape Index	Caribou	Moose	0.04	0.02	0.14
	Caribou	Sheep	0.02	0.03	1.00
	Moose	Sheep	0.02	0.02	1.00
Area Weighted Mean Shape Index	Caribou	Moose	0.60	1.39	1.00
	Caribou	Sheep	1.89	1.74	0.85
	Moose	Sheep	2.49	1.64	0.41
Mean Perimeter to Area Ratio	Caribou	Moose	215.31	170.7	0.64
	Caribou	Sheep	90.96	212.95	1.00
	Moose	Sheep	306.27	201.22	0.41
Mean Patch Fractal Dimension	Caribou	Moose	0.01	0.02	1.00
	Caribou	Sheep	0.01	0.02	1.00
	Moose	Sheep	0.02	0.02	1.00
Area Weighted Mean Patch Fractal Dimension	Caribou	Moose	0.01	0.02	1.00
	Caribou	Sheep	0.03	0.02	0.40
	Moose	Sheep	0.02	0.02	0.65
Shannon's Diversity Index	Caribou	Moose	0.04	0.12	1.00
	Caribou	Sheep	0.30	0.16	0.20
	Moose	Sheep	0.26	0.15	0.26
Shannon's Evenness Index	Caribou	Moose	0.02	0.05	1.00
	Caribou	Sheep	0.12	0.06	0.23
	Moose	Sheep	0.10	0.06	0.30

with both density measures increasing from moose to caribou to sheep hunting ranges. Of the four significantly different variables, two are chosen for discriminant analysis. Removing two variables prior to conducting the analysis is necessary given that the pairings (PSSD/PSCOV and ED/PD) are strongly correlated. ED and PSCOV are used here primarily because the previous discriminant analyses showed that these metrics are useful in delineating among the different wildlife distributions. The discriminant analysis followed the same methods and procedures identified in Chapter 5. The stepwise procedure retained both variables in the analysis. ED served to separate out sheep hunting ranges while the PSCOV primarily differentiated between moose and caribou hunting ranges.

The discriminant analysis resulted in the identification of two functions that are able to differentiate among the different hunting range types. The first function, which accounts for 100% of the variance in the sample, is statistically significant (chi-square of the Wilks' lambda =13.78; p=.001). The cross-validation results are good, but generally less so than the cross-validation results of the functions derived for the distributional ranges in Chapter 5. In all, 75.6% of the cases were classified correctly utilizing the discriminant classification function. The function correctly classified all the sheep hunting areas. Caribou hunting ranges had mixed results with only 60% of the cases correctly classified; five cases were classified as moose hunting ranges and one case was classified as a sheep hunting range. Seventy-six percent of the moose hunting ranges were classified correctly; the discriminant function misclassified five cases as representing caribou hunting ranges. Table 6.17 presents the classification function derived from the discriminant analysis.

Conclusions

The results of the ANOVA and discriminant analysis confirm the notion that the hunting ranges, particularly moose and caribou hunting areas, are more similar to one another than to the general and seasonal distributional ranges of these species. Several factors may account, either individually or collectively, for this. Besides the substantial amount of overlap between moose and caribou ranges, the size of the hunting area likely has a profound effect. The sizes of hunting ranges relative to the distributional ranges used in the study are very small. The small hunting area probably lacks the full range of variation identified in the distributional ranges. Whether this is intentional or incidental cannot be determined. It is probable that the location of the communities and the "central base use area (Wolfe 2004:25)," land use practice serve to limit the

Table 6.17. Classification Function Coefficients for Caribou, Moose, and Sheep Hunting Ranges.

	Resource		
	Caribou	**Moose**	**Sheep**
PSCOV	.000	.001	-.001
ED	.120	.038	.324
*(Constant)**	-3.88	-2.94	-14.877

variability in the landscape structure. In essence, the need to originate from and return to the same location for multiple hunt types limits the exploitable area considerably. The locations of many of the communities used in this study occur near major rivers and lakes, which serves to restrict further the landscape structure of the exploited hunt areas.

Regardless of the disparity between classified and misclassified cases, it remains evident that the general and distributional range classification functions performs well in classifying most of the hunting ranges by their respective prey animals. The results, however, are not without ambiguity and using these functions may result in false positive classifications. The most common false positive is classifying caribou hunting ranges as moose hunting ranges, particularly at the general distribution level. Classifying hunting ranges based on their landscape structure adds some improvement using distributional mean, but again, classification is still imperfect. It appears the best approach to classifying a particular area where the type of hunting is not known is two classify the area using both sets of classification functions and cross validating the results. While not a perfect solution, it should limit the number of false-positive classifications. In part, the following chapter tests this method against independent cases dating to the protohistoric or early historic period where faunal assemblages can serve as direct line of evidence for the types of animals hunted and a proxy for the frequency that different species were hunted.

CHAPTER 7.

LANDSCAPE METRICS AND PROTOHISTORIC ATHABASCAN SITES: A TEST

Introduction

The level of precision in classifying large mammal ranges, both in general and seasonally, and hunting ranges based on the landscape model and discriminant function is relatively good when considering the leave-one-out classifications. Although the success rate of each model is commonly above 70%, it remains unclear as to how well the models will accurate classify truly independent cases. To this end, this chapter focuses on testing how successfully the models can forecast the most likely large mammal prey based on its location in relationship to the surrounding topographic matrix. Using a series of very late prehistoric, protohistoric, and historic sites with faunal assemblages, I test the ability of the models to accurately predict or classify the dominant large mammal remains that occur at each site. The major assumption that pervades this analysis and the subsequent discussion is that the dominant large mammal faunal remains at a site correspond with surrounding landscape matrix as measured by the classification functions.

Sample

The archaeological literature concerning the late prehistoric and historic periods in the Alaskan Interior is meager. When considering the number of excavated sites with faunal assemblages that contain quantifiable remains, at least at the NISP level, of moose, caribou, or sheep, there are even fewer cases. Prior to conducting a literature search for applicable cases to include in the sample, I developed the sample criteria. These criteria include 1) that the case be in the Alaska Interior, 2) that the case had a component that dated within about the last 500 years; 3) that the case, because of its location and date, could be reasonably attributed to the Athabascan tradition; and 4) the case contained a faunal assemblage with quantified caribou, moose, or sheep remains. Only 12 studies meeting the criteria were identified. Though not intended, the 12 cases fall outside any of the mapped moose, caribou, and sheep hunting ranges that I used in the developing the landscape model in Chapter 6. Furthermore, ten of the cases fall outside the wildlife distributional ranges used to develop the models in Chapter 6. The cases selected (Figure 7.1) are the Kame Terrace site (Mills et al. 2005), the Nenana Gorge site (Plaskett 1977), Old Fish Camp (Ream 1986), MMK-4 (Holmes 1984 & 1986), Paxson Lake (Yesner 1980), Siruk

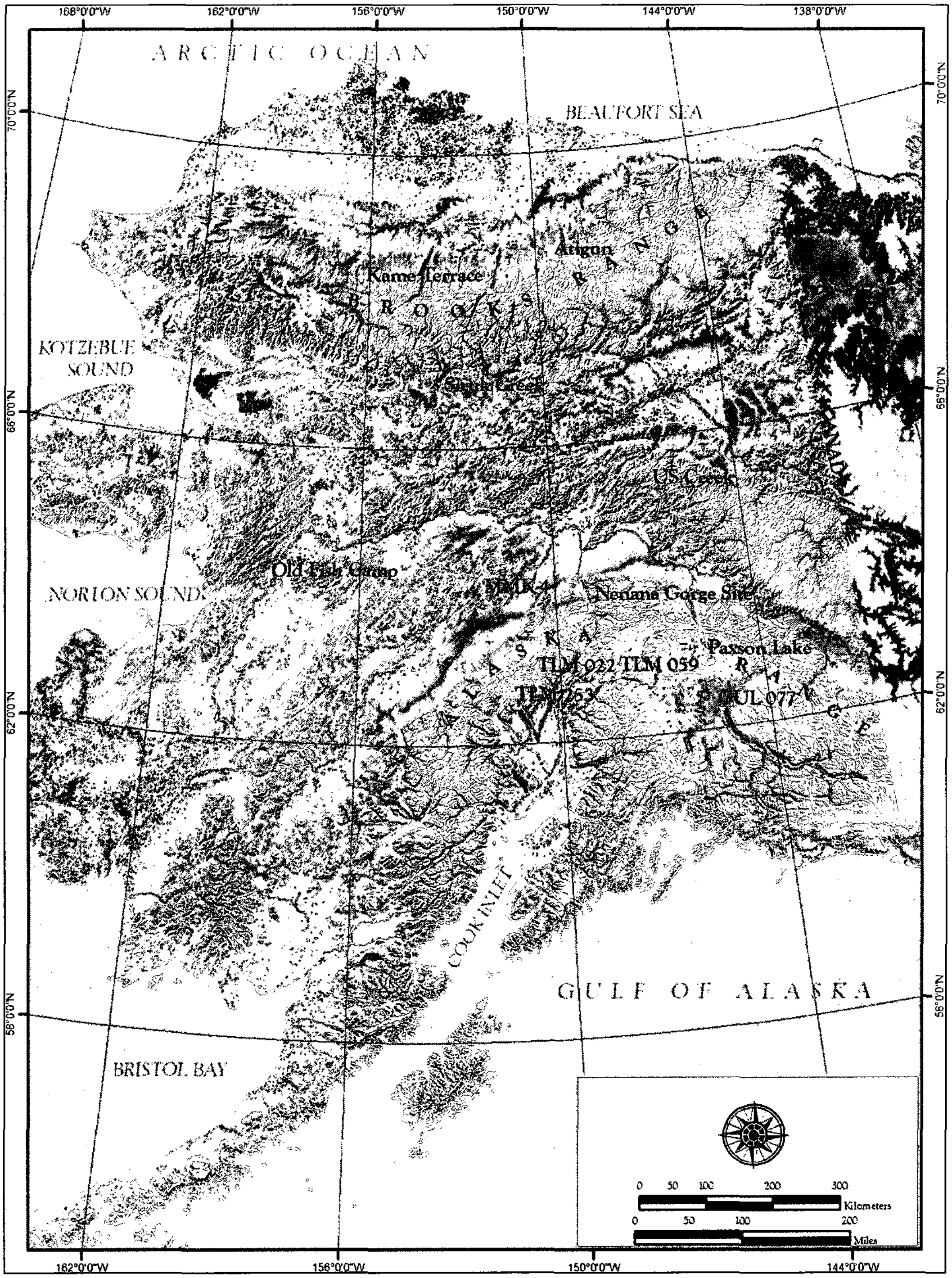


Figure 7.1. Location of Sample Sites.

(Morlan 2000), Atigun (Wilson 1968), US Creek (Mills, personal communication); and three sites (TLM-022, TLM-059, and TLM-253) from the Susitna Hydroelectric Project (Dixon et al. 1985; Skeete 2008). These cases, and minor variations used in the selection criteria, are briefly described below.

The Kame Terrace site (Mills et al. 2005) is a multi-component site in Anaktuvuk Pass consisting of numerous surface features, including stone circles, fire-cracked rock concentrations, and depressions, and artifacts scattered over an area of approximately 11,200 square meters. Based on radiocarbon dates, artifact assemblages, and oral histories, three areas within the site represent late 19th and early 20th century occupations. Although Kavik occupations cannot be entirely ruled out for the site, much of the recovered material culture reflects historic Nunamiut use of the three areas considered here. Mills et al. (2005) interprets Area 1, consisting of a stone tent ring, lithic debitage, and Euroamerican artifacts, as representing a late spring caribou hunting or residential camp. Caribou remains dominate the faunal assemblage, though a single sheep carpal was among the remains. The highest Minimum Animal Unit (MAU) for caribou in Area 1 is 3.00, while for sheep it is only 0.07. Area 3, which includes a stone tent ring, a depression, and an assemblage containing both aboriginal and Euroamerican artifacts, is a hunting or residential camp used for sheep hunting in the fall or spring. The few identifiable faunal remains recovered from this area are all sheep. The final historic area of the site, Area 5, likely served as a spring caribou and sheep hunting camp. Features associated with this area include two stone tent rings, an associated exterior hearth, an ambiguous concentration of rocks; artifacts associated with the excavated portion of this area reflect a historic Nunamiut occupation. The excavated portion of Area 5 produce about equal numbers of bones attributed to sheep and caribou; the highest MAU for each animal is 1.5.

The Nenana Gorge site, HEA-062, is a prehistoric and historic site located where the Athabascan occupants focused on sheep and caribou hunting and processing. Located at the northern end of the Nenana Gorge near where the Parks Highway and the Alaskan Railroad cross, the site's placement offered a very good view of the valley and may have served as an exceptional animal intercept location as game moved north through the gorge (Plaskett 1977:16). The excavated portion of the site revealed three features including two hearths and a bone pit. Plaskett (1977:144) interprets the bone pit, which contained only sheep remains and fire-cracked rock, as a boiling pit of some sort. Radiocarbon dates from the site indicate a late prehistoric occupation for the majority of the material recovered from the excavations (Plaskett 1977, Potter

2008a). The 18,000 faunal remains, most of which were unidentifiable, recovered from the excavation of the site represent much of the large local fauna available in the area today including moose or bison, caribou, sheep, and brown bear. Caribou (NISP=243) and sheep (NISP=330) account for the bulk of the faunal assemblage. Plaskett (1977: Table 11) estimates at least five individual sheep and three individual caribou account for represented remains.

As its name suggests, Old Fish Camp represents a summer fishing camp used by Koyukuk Indians during the protohistoric and historic periods (Ream 1986). The site, located on the Khotol River not far from the Yukon River, consists of at least 100 house depressions, cache pits, and other depressions covering an area of over 60,000 square meters. The site has witnessed two episodes of investigation, first by Fredricka deLaguna in the 1930s and in the early 1970s by James Dixon (Ream 1986:43-52). Ream's thesis, in part, focuses on analyzing the data collected during 1972 and 1973, which concentrated on the excavation of eight features at the site including several house pits, subsurface caches, and an anomalous depression (Ream 1986:62-102). Faunal remains identified in the recovered assemblage include fish, caribou, hare, and bird. As is often the case, most could not be identified beyond the class level. The NISP for caribou bones is 27, which is less than 2% of the entire faunal assemblage. An additional 157 medium and large mammal bones were recognized; Ream (1986:549) remarks that most of these unknown remains are likely caribou. No definitive moose remains were identified.

Holmes (1984) identified, tested, and excavated several sites along the shores of Lake Minchumina in the mid-1970s. The two upper components of the MMK-4 site date to within the last 2,000 years, with the artifacts recovered from the sod layer representing the last 200 years. Holmes (1984) identified few features in the upper levels at MMK-4; those that were found include a hearth and a cremation burial. Faunal remains in the recovered assemblage included mostly large mammal bones, snowshoe hare, beaver, and fish. With the exception of 18 caribou and 2 moose bones, the majority of the large mammal remains could not be identified. In the sod layer and level 1, Holmes calculated an MNI of 10 for caribou and 2 for moose.

GUL-077, also commonly known as the Ringling site, is near the confluence of the Gulkana and Copper Rivers. GUL-077 is a complex site consisting of numerous pit features, hearths, artifacts, and other occupational debris located on a long, north-south trending, ridge above Bear Creek. Excavations conducted during 1975 and 1976 resulted in the complete excavation of six storage pits, the testing of 15 additional pits, and the excavation of "2 large camps and a number of smaller ones (Workman 1976:1)." Calibrated radiocarbon dates (n=6) of charcoal samples from pit features result in an average date of 721-562 years BP (Potter 2008a:203), though there is some evidence of a historic occupation based on the presence of trade beads. The recovered faunal assemblage reflects the assigned site function of a late winter/early spring camp (Workman 1976:158). Smaller mammals, namely snowshoe hare and beaver, account for the majority of the faunal remains recovered; however, moose and caribou remains did occur, though in substantially smaller quantities. Overall the MNI for moose was determined to be seven and for caribou five (Workman 1976: Table 9).

The Paxson Lake site, which actually consists of two sites separated by about 150 meters, is interpreted as an early historic caribou processing camp where the occupants focused on butchering, cooking, and caching caribou carcasses (Yesner 1980). The late 19th or early 20th century site is within the traditional Ahtna territorial range. The overwhelming abundance of caribou bone (n=6169) relative to other remains (n=65) clearly supports such an interpretation. Yesner's (1980) analysis of the remains recovered from excavations suggests that at least 112 caribou are represented in the assemblage and, given the dentition of immature animals, that the caribou were likely taken in spring. Based on the glass trade beads recovered during the excavations, assessments of late 19th and early 20th century occupations are secure.

Atigun, like the Kame Terrace site, is deep in the Brooks Range of northern Alaska. Unlike the Kame Terrace site, which is in the center of the traditional Nunamiut range, Atigun occurs near the historic boundary of the Nunamiut and the Chandalar Kutchin Athabascans. In his thesis, Wilson (1968) interprets the site as belonging Kavik complex and similar to the Kavik type-site in Anaktuvuk Pass. Campbell (1968) interprets the Kavik site as being a caribou hunting base camp, which is in many regards not unlike the Kame Terrace site described above. Although Wilson does not present any radiocarbon dates from any of the features he excavated, the interpretation of the site as belonging to the Kavik complex implies probable use of the site sometime between 500 and 100 years B.P. by Athabascans, most probably related to the Kutchin. The only features encountered at Atigun include hearths and the artifact assemblage consists chiefly of chipped stone and faunal remains. Ground squirrels and fish remains dominate the faunal assemblage. Using two different MNI calculations, Wilson (1968: Table VIII) reports a squirrel MNI between 342 and 369, for caribou between 13 and 16, and for sheep the MNI under both methods is 1. Other faunal remains in the assemblage include marmots (MNI=4), undifferentiated birds (MNI=8), and fish (MNI=5).

The U.S. Creek site, CIR-029, is a late prehistoric and protohistoric caribou hunting and processing camp that dates as late as AD 1850. Caribou remains account for the almost all the faunal remains recovered from the initial work at the site, which is interpreted as a caribou intercept and processing site with a few storage pits (Robin O. Mills 2008, personal communication). In many regards, the site is similar to the Paxson Lake site, though the terrain is somewhat different.

The Siruk site represents two historic winter houses located near the confluence of the Alatna River and Siruk Creek (Morlan 2000). The two houses are about 30 meters apart and a more recent, but abandoned, cabin is nearby. Though there are no radiometric dates, it is clear, based on the artifact assemblage, that the people last lived in the house during the 1870s. Though meager, the artifact assemblage included Tci-thos, a hammerstone, a stone chopper, a retouched flake, a wooden handle fragment, bark trays, a metal saw blade, tin sheet metal, 20 glass beads, and a portion of worked caribou antler. Snowshoe hare and other small mammals, fish, and ptarmigan bones account for most of the recovered faunal assemblage, with large mammal remains consisting of the worked caribou antler and moose rib fragments. Morlan (2000:55) does not consider the caribou antler to reflect evidence of human consumption; in fact he argues that the inhabitants of the Siruk occupied the site during a caribou population crash known to have occurred in the area during the 1870s (Morlan 2000:58). The moose rib fragments, nine in all, represent at least two ribs from at least one animal.

Three sites identified during the Susitna Hydrological Project, including TLM-022, TLM-059, and TLM-253, all date to about the last 500 years (Dixon et al. 1985; Potter 2008a; Skeete 2008). A recent re-analysis of the faunal remains from these sites (Skeete 2008) provides the necessary data required to determine the primary large game represented in the faunal assemblages. TLM-022, also referred to as the Tsusena Creek site, consisting of six hearths in an area of 57 square meters, contained numerous faunal remains, most too small or fragmented to identify to any specific taxon (n=694). Of the few bones that could be identified, the majority belong to moose (NISP=14) and caribou (NISP=9). While the NISP for moose is higher, the MNE for distal and proximal ends fragments are higher for caribou (MNE=5) than for moose (MNE=4). As with GUL-077, the quantifiable difference between moose and caribou is slight. Given the more reliable quantification of MNE compared to the straight NISP, I predict caribou hunting for this site. Though this interpretation does not necessarily contradict Skeete's, she does imply, based on the available moose forage, that moose hunting was the focus of the campsite.

TLM-059, or Little Bones Ridge, appears to be a midden deposit that dates to between 793-552 years Cal. B.P. (Potter 2008a). The only identifiable faunal remains from the site included caribou (NISP=11; MNE-ends=7), though these bones represent less than 2% of the entire assemblage (Skeete 2008). The final site from the Susitna Hydroelectric Project used in this sample is TLM-253, which is interpreted as representing a caribou hunting and processing site (Skeete 2008), which dates between 688 and 0 years Cal. B.P. (Potter 2008a). Although the assemblage contains over 6,300 bone fragments, only 43 (0.7%) could be identified caribou, with the remainder being classified as terrestrial mammal (8.1%) or remaining unidentified (91%) (Skeete 2008).

Methods

Table 7.1 provides an overview of the main sample parameters. To test the landscape models and discriminant classification functions, I made a TPI coverage for each location following the same TPI generations described in Chapter 4. I used a standard circular catchment with a diameter of 20 kilometers to define the landscape matrix around each site. Though the catchment is arbitrary, the diameter used is similar to those commonly used in standard archaeological site catchment analyses (Chisholm 1968:7, Vita-Finzi 1978:26, Hastorf 1980:90). My use of the catchment concept, however, is very different from the manner it is used in site catchment analyses, which focus on the economic utility of resources within an area surrounding a site. As used here, the catchment does not serve as a method to elucidate the economic potential of an area, but as a snapshot of a larger environmental template the characteristic of which can be used to identify limitations of resource potential in regards to large mammal distributions and potential human perceptions of those distributions.

As explained in more detail below, the use of small catchment areas brings some complications to the analyses presented so far. Although the grain and resolution of the data used in the catchments and the larger distributions and hunting ranges are the same, the reduction in the area, which in several instances is substantial, might have scale-related implications that need to be explored further as the models are refined.

Table 7.1. Overview of Large Faunal from Sample Assemblages.

Site	*General Site Type*	*Large Fauna Present*	*Quantification Measure*	*Dominant Large Mammal*
Kame Terrace	Hunting/Residential Camp	Caribou Sheep	MAU	Caribou
Nenana Gorge Site		Caribou Sheep	MNI	Sheep
Old Fish Camp	Summer Fish Camp	Caribou	NISP	Caribou
MMK-4	Camp	Caribou	MNI	Caribou
GUL-077	Camp	Moose Caribou	MNI	Moose
Atigun	Camp	Caribou Sheep	MNI	Caribou
Paxson	Caribou Processing Camp	Caribou	MNI	Caribou
Siruk	Winter Residence	Moose	MNI	Moose
US Creek	Hunting and Processing Camp	Caribou	MNI	Caribou
TLM-059	Midden	Caribou	MNE	Caribou
TLM-022	Favored Camp	Caribou Moose	MNE	Caribou
TLM-253	Caribou Hunting and Processing Camp	Caribou	MNE	Caribou

Landscape Metrics

The landscape level metrics for each of the sample catchments are in Table 7.2. It is apparent that many of the metrics vary considerably between the cases. While the landscape area is constant, the number of patches and the MPS differ substantially from one case to the next. The highest number of patches occur in the Kame Terrace, Nenana Gorge, Atigun, and US Creek catchments, while the lowest number of patches are found in the GUL-077 and Siruk catchments. The corresponding MPS values show the predictable relationship with the number of patches where as the number of patches increases the MPS decreases. This relationship, however, is curvilinear and not linear (Figure 7.2). The highest amount of variability in patch size, as indicated by the PSSD and PSCOV measures, occurs in Old Fish Camp, Paxson Lake, MMK-04, and Atigun catchments. As described in more detail below, the variation noted in patch sizes in these cases is closely related to the topographic composition of the catchments and not merely to their structure. Edge metrics correspond well with the MPS values where as the number of patches increases so does the TE and ED. The MPE values vary between a low of 1414 meters at the Kame Terrace site to a high of 4012 meters at GUL-077; there is no immediately obvious patterning in the MPE values relative to the other metrics.

Table 7.2. Landscape Level Metrics for the 12 Sample Catchments.

Site	TLA	NumP	MPS	PSCoV	PSSD	TE	ED	MPE	MSI	AWMSI	MPAR	MPFD	AWMPFD	SDI	SEI
Kame Terrace	31256.67	1624.00	19.25	865.32	166.55	2484927.80	79.50	1530.13	1.40	2.40	457.21	1.32	1.29	2.11	0.92
Nenana Gorge	31256.67	1151.00	27.16	630.43	171.20	2378436.23	76.09	2066.41	1.41	3.33	4617.01	1.31	1.31	1.96	0.85
Old Fish	31256.67	574.00	54.45	1658.70	903.23	994954.96	31.83	1733.37	1.37	2.28	373.88	1.31	1.24	2.07	0.90
MMK-4	31256.67	229.00	136.49	1110.12	1515.22	800284.85	25.60	3494.69	1.40	4.52	434.97	1.31	1.29	1.12	0.62
GUL-077	31256.67	64.00	488.39	766.66	3744.25	256793.38	8.22	4012.40	1.54	2.06	326.69	1.31	1.21	1.21	0.87
Paxson Lake	33546.66	364.00	92.16	1353.43	1247.34	998884.33	29.78	2744.19	1.43	4.36	341.53	1.31	1.30	1.61	0.73
Siruk	31256.67	88.00	355.19	882.87	3135.87	278364.10	8.91	3163.23	1.44	2.24	418.00	1.32	1.22	1.36	0.62
Atigun	31256.67	2008.00	15.57	1306.34	203.35	2839867.57	90.86	1414.28	1.44	7.06	1192.45	1.40	1.37	1.77	0.77
US Creek	31256.67	1264.00	24.73	659.32	163.04	2545371.73	81.43	2013.74	1.40	4.13	386.91	1.31	1.32	1.95	0.89
TLM-059	31256.67	335.00	93.30	730.65	681.72	1041806.63	33.33	3109.87	1.39	4.25	319.81	1.30	1.29	1.53	0.73
TLM-022	31256.67	412.00	75.87	740.93	562.11	1369060.73	43.80	3322.96	1.42	4.92	373.16	1.31	1.32	1.41	0.68
TLM-253	31256.67	568.00	55.03	755.49	415.74	1581338.16	50.59	2784.05	1.41	5.03	365.99	1.31	1.32	1.69	0.77

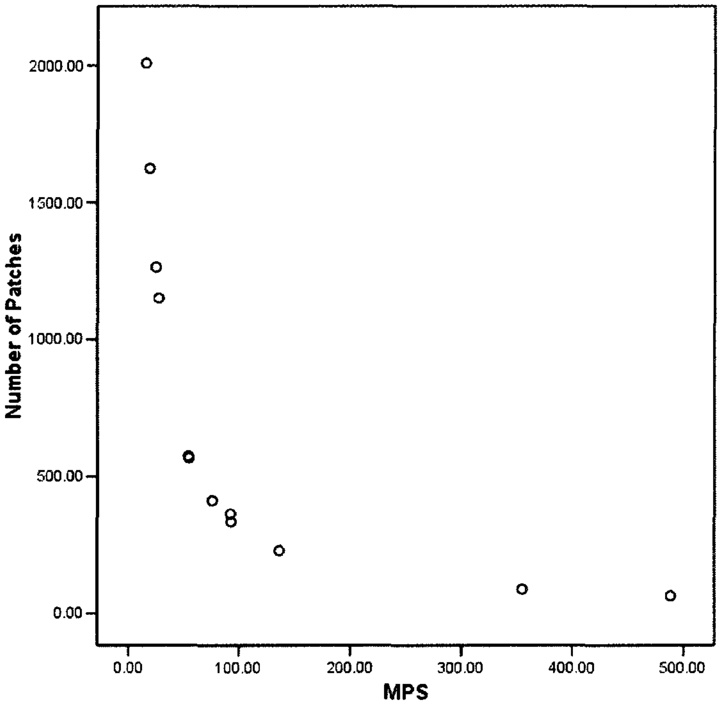


Figure 7.2. Curvilinear Relationship Between Mean Patch Size and Number of Patches for the 12 Sample Catchments.

The MSI values vary between 1.37 and 1.54, with the mode being 1.40 indicating that patches in all the cases deviate moderately from a circular shape. As in both the distributional ranges and the hunting ranges, the more complex patch shapes tend to be associated with those areas with larger MPS sizes, but this pattern is not consistent across the board. For example the Siruk and Atigun cases, which have very different MPS values, share identical MSI values. The MPFD values are even more consistent among the 12 cases ranging from 1.30 to 1.40, with the mode being 1.31. When controlling for the large patches within the catchment mosaics, the patch shape complexity, as measured by the AWMSI, increases substantially. The catchment mosaic at Atigun has an AWMSI of over 7.0, the highest in the sample, indicating extremely complex patch shapes relative to the other 11 cases. Siruk, GUL-077, Old Fish Camp, and the Kame Terrace site catchments tend to have the most regularly shaped patches.

Diversity and evenness scores, as measured by the SHDI and SHEI, indicate that the largest landscape diversity is found in the Kame Terrace, Old Fish Camp, US Creek and Nenana Gorge catchments. The lowest diversity, conversely, occurs in the MMK-4, GUL-077, and Siruk catchments. Evenness is lowest in the MMK-4 and Siruk catchments indicating that more of these catchments are composed of few patch types. Those catchments with more evenly distributed patches, and thus higher SHEI values, include those of the Kame Terrace site, Old Fish Camp, and US Creek.

The class level metrics for the catchments of the 12 cases are given in Table 7.3. I limit the discussion here primarily to the compositional differences among the cases in the sample (Figure 7.3), though additional interpretation of the results are interspersed throughout. The Kame Terrace catchment consists primarily of U-shape valley, plains, and open slope patches. The dominance of U-shape valley patches (21.7%) is unique in this sample, as well as in the hunting range data. Plains patches are the largest patch types, followed by U-shaped valley and high ridge patches.

Over 50% of the Nenana Gorge site catchment consists of open slope and plains patches, with secondary patches including high and midslope ridges, U-shaped valleys, and midslope drainages. Relative to the Kame Terrace catchment, which is also in a mountainous area, the AWMSI for the Nenana Gorge site suggests that the patch shapes are much more complex.

Almost 75% of the Old Fish Camp catchment consists of plains patches (n=35). None of the other patch types in the catchment exceeds 10% of the total area. Given the dominance of large plains patches and the relatively small sizes of the remaining patches, the ED and AWMSI values are moderately consistent for all the patches. The AWMSI values also indicate that the more common patch types (plains, open slopes, U-shaped valleys) are more complex than the less frequently occurring patch types.

Table 7.3. Class Level Metrics for the 12 Sample Catchments.

	Class	Class Area	% Class	# of Patch	Mean Patch Size
Kame Terrace	Canyon	2710.57	8.67	126	21.51
	Midslope Drainage	2009.60	6.43	265	7.58
	Upland Drainage	815.29	2.61	143	5.70
	U-shaped Valley	6795.85	21.74	132	51.48
	Plains	6218.77	19.90	50	124.38
	Open Slope	4789.57	15.32	304	15.76
	Upper Slope	2708.60	8.67	315	8.60
	Local Ridge	47.96	0.15	30	1.60
	Midslope Ridge	940.55	3.01	175	5.37
	High Ridge	4219.92	13.50	84	50.24
Nenana Gorge	Canyon	1879.59	6.01	68	27.64
	Midslope Drainage	2771.83	8.87	271	10.23
	Upland Drainage	129.04	0.41	62	2.08
	U-shaped Valley	1916.51	6.13	87	22.03
	Plains	6351.00	20.32	91	69.79
	Open Slope	11583.17	37.06	137	84.55
	Upper Slope	1854.98	5.93	137	13.54
	Local Ridge	8.47	0.03	6	1.41
	Midslope Ridge	1920.26	6.14	235	8.17
	High Ridge	2841.82	9.09	57	49.86
Old Fish Camp	Canyon	810.04	2.59	44	18.41
	Midslope Drainage	499.01	1.60	110	4.54
	Upland Drainage	101.29	0.32	19	5.33
	U-shaped Valley	2055.43	6.58	46	44.68
	Plains	22838.11	73.07	35	652.52
	Open Slope	1983.15	6.34	130	15.25
	Upper Slope	1480.11	4.74	55	26.91
	Local Ridge	5.12	0.02	1	5.12
	Midslope Ridge	417.25	1.33	100	4.17
	High Ridge	1067.16	3.41	34	31.39

PS Covariance	PS Standard Deviation	Total Edge	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dim.	Area Weighted MPFD
217.26	46.74	260194.2	8.32	2065.03	1.45	2.26	342.00	1.31	1.30
219.92	16.68	283148.5	9.06	1068.49	1.33	1.71	394.68	1.31	1.29
156.05	8.90	130503.0	4.18	912.61	1.30	1.43	515.78	1.32	1.27
441.83	227.47	322158.1	10.31	2440.59	1.43	2.84	801.44	1.36	1.29
672.20	836.05	97139.1	3.11	1942.78	1.32	2.24	495.96	1.33	1.23
362.23	57.07	519839.7	16.63	1710.00	1.45	2.65	391.56	1.32	1.32
229.08	19.70	411562.3	13.17	1306.55	1.44	2.21	448.89	1.33	1.32
151.02	2.41	14479.2	0.46	482.64	1.27	1.34	558.22	1.34	1.30
167.61	9.01	156848.1	5.02	896.27	1.31	1.53	424.02	1.32	1.28
201.89	101.42	289055.6	9.25	3441.14	1.53	2.60	465.41	1.32	1.30
207.32	57.31	159919.5	5.12	2351.76	1.49	2.22	317.11	1.31	1.29
204.65	20.93	322366.2	10.31	1189.54	1.31	1.66	371.17	1.31	1.28
123.69	2.57	36401.3	1.16	587.12	1.24	1.38	410.00	1.31	1.30
527.94	116.30	153101.3	4.90	1759.78	1.34	3.69	400.06	1.31	1.33
659.36	460.17	194077.6	6.21	2132.72	1.34	2.37	360.20	1.30	1.25
334.62	282.92	791997.6	25.34	5781.00	1.73	4.81	314.58	1.31	1.35
240.85	32.61	246056.4	7.87	1796.03	1.50	2.66	414.16	1.32	1.33
84.65	1.20	3147.9	0.10	524.65	1.27	1.41	434.98	1.32	1.32
192.21	15.71	257297.0	8.23	1094.88	1.32	1.58	386.66	1.31	1.28
251.71	125.49	214071.5	6.85	3755.64	1.54	3.23	331.24	1.30	1.32
208.96	38.47	95703.4	3.06	2175.08	1.53	2.46	296.14	1.31	1.31
221.18	10.03	91558.0	2.93	832.35	1.30	1.78	464.94	1.32	1.30
114.03	6.08	16942.7	0.54	891.72	1.26	1.30	324.67	1.30	1.27
424.02	189.47	108737.2	3.48	2363.85	1.36	3.20	386.18	1.31	1.31
550.74	3593.66	189669.5	6.07	5419.13	1.42	2.14	261.69	1.29	1.21
331.13	50.51	215291.5	6.89	1656.09	1.41	2.76	376.47	1.32	1.32
428.29	115.26	111497.8	3.57	2027.23	1.38	3.20	369.87	1.31	1.32
0.00	0.00	966.5	0.03	966.51	1.21	1.21	188.80	1.27	1.27
183.31	7.65	78427.5	2.51	784.28	1.27	1.52	402.95	1.31	1.29
140.40	44.07	86160.7	2.76	2534.14	1.44	1.77	222.84	1.28	1.27

Table 7.3. Class Level Metrics for the 12 Sample Catchments (Cont.)

	Class	Class Area	% Class	# of Patch	Mean Patch Size	PS Co-variance	PS Standard Deviation	Total Edge
MMK-04	Midslope Drainage	137.48	0.44	40	3.44	103.99	3.57	28647.0
	Plains	24447.46	78.22	74	330.37	787.44	2601.46	356457.8
	Open Slope	6291.12	20.13	36	174.75	426.97	746.14	346652.4
	Upper Slope	42.72	0.14	10	4.27	166.16	7.10	7506.0
	Midslope Ridge	256.97	0.82	61	4.21	166.03	6.99	49497.4
	High Ridge	80.93	0.26	8	10.12	83.86	8.48	11524.3
GUL-077	Midslope Drainage	206.01	0.66	21	9.81	177.61	17.42	29966.4
	Plains	30206.56	96.64	1	30206.56	0.00	0.00	126315.8
	Plains	618.63	1.98	25	24.75	168.28	41.64	69260.8
	Midslope Ridge	225.47	0.72	17	13.26	107.29	14.23	31250.4
Paxson Lake	Canyon	121.35	0.39	6	20.22	80.57	16.29	15165.1
	Midslope Drainage	338.79	1.08	83	4.08	115.00	4.69	70084.8
	Upland Drainage	9.33	0.03	1	9.33	0.00	0.00	1294.0
	U-shaped Valley	444.27	1.42	7	63.47	225.58	143.17	20241.9
	Plains	24491.11	78.35	45	544.25	641.64	3492.09	336480.9
	Open Slope	6180.21	19.77	80	77.25	368.50	284.68	355452.9
	Upper Slope	1006.74	3.22	40	25.17	230.12	57.92	80699.2
	Midslope Ridge	365.66	1.17	75	4.88	141.08	6.88	64226.3
	High Ridge	589.19	1.89	27	21.82	114.57	25.00	55239.1
Siruk	Canyon	0.36	0.00	1	0.36	0.00	0.00	274.3
	Midslope Drainage	52.17	0.17	7	7.45	108.73	8.10	9835.3
	Upland Drainage	3.70	0.01	3	1.23	20.20	0.25	1456.4
	U-shaped Valley	60.73	0.19	2	30.36	95.59	29.03	4608.2
	Plains	29622.16	94.77	6	4937.03	223.39	11029.00	141880.7
	Open Slope	858.70	2.75	34	25.26	197.14	49.79	73325.3
	Upper Slope	562.61	1.80	12	46.88	306.38	143.64	30458.8
	Midslope Ridge	19.59	0.06	13	1.51	95.77	1.44	6596.0
	High Ridge	76.66	0.25	10	7.67	157.33	12.06	9929.2

Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dim.	Area Weighted MPFD
0.92	716.17	1.26	1.24	374.30	1.31	1.27
11.40	4817.00	1.39	3.84	308.48	1.30	1.28
11.09	9629.23	1.84	7.41	880.16	1.36	1.37
0.24	750.60	1.21	1.44	381.43	1.30	1.28
1.58	811.43	1.29	1.49	395.70	1.31	1.29
0.37	1440.54	1.37	1.53	271.50	1.29	1.28
0.96	1426.97	1.40	2.02	373.75	1.31	1.31
4.04	126315.78	2.05	2.05	4.20	1.20	1.20
2.22	2770.43	1.66	2.38	262.61	1.31	1.31
1.00	1838.26	1.51	1.83	381.77	1.31	1.30
0.45	2527.52	1.66	1.77	158.18	1.29	1.29
2.09	844.40	1.31	1.42	347.69	1.31	1.29
0.04	1294.03	1.20	1.20	138.70	1.25	1.25
0.60	2891.70	1.46	1.97	336.36	1.31	1.26
10.03	7477.35	1.50	4.76	346.17	1.31	1.29
10.60	4443.16	1.68	4.03	384.64	1.33	1.33
2.41	2017.48	1.39	1.96	310.91	1.30	1.28
1.91	856.35	1.28	1.41	365.24	1.31	1.28
1.65	2045.89	1.40	1.55	216.28	1.28	1.26
0.01	274.29	1.29	1.29	758.00	1.37	1.37
0.31	1405.04	1.41	1.89	228.36	1.29	1.31
0.05	485.46	1.23	1.24	398.00	1.31	1.31
0.15	2304.12	1.63	1.42	317.25	1.32	1.25
4.54	23646.78	1.62	2.25	387.27	1.32	1.21
2.35	2156.63	1.53	1.91	459.83	1.33	1.28
0.97	2538.23	1.42	2.59	355.69	1.31	1.29
0.21	507.38	1.27	1.31	488.65	1.33	1.31
0.32	992.92	1.31	1.29	402.07	1.31	1.25

Table 7.3. Class Level Metrics for the 12 Sample Catchments (Cont.)

	Class	Class Area	% Class	# of Patch	Mean Patch Size	PS Co-variance	PS Standard Deviation	Total Edge	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dim.	Area Weighted MPFD
Atigun	Canyon	631.63	2.02	44	14.36	238.78	34.28	78408.8	2.51	1782.02	1.52	2.58	647.11	1.35	1.32
	Midslope Drainage	1783.36	5.71	203	8.79	241.83	21.24	230365.8	7.37	1134.81	1.40	2.00	835.36	1.37	1.30
	Upland Drainage	76.09	0.24	51	1.49	158.71	2.37	22740.0	0.73	445.88	1.31	1.46	1056.25	1.39	1.31
	U-shaped Valley	1808.25	5.79	78	23.18	431.26	99.98	131210.5	4.20	1682.19	1.42	2.94	1052.88	1.39	1.31
	Plains	9742.77	31.17	550	17.71	1629.20	288.60	615919.0	19.71	1119.85	1.41	6.44	1227.89	1.42	1.36
	Open Slope	12568.25	40.21	526	23.89	1091.62	260.83	1120858.7	35.86	2130.91	1.52	10.76	1423.39	1.44	1.42
	Upper Slope	1519.50	4.86	196	7.75	390.81	30.30	237351.5	7.59	1210.98	1.47	3.35	1079.73	1.40	1.36
	Local Ridge	3.47	0.01	15	0.23	260.76	0.60	2296.8	0.07	153.12	1.16	1.37	1474.23	1.42	1.35
	Midslope Ridge	1009.80	3.23	297	3.40	199.95	6.80	209211.8	6.69	704.42	1.37	1.81	1266.81	1.37	1.31
	High Ridge	2113.54	6.76	48	44.03	129.93	57.21	191504.7	6.13	3989.68	1.71	2.43	549.41	1.32	1.31
US Creek	Canyon	2220.96	7.11	97	22.90	155.78	35.67	237243.2	7.59	2445.81	1.58	2.18	421.31	1.32	1.30
	Midslope Drainage	1674.45	5.36	273	6.13	201.24	12.34	259597.0	8.31	950.90	1.30	1.66	392.39	1.31	1.29
	Upland Drainage	7.13	0.02	4	1.78	92.94	1.66	2217.7	0.07	554.42	1.28	1.31	449.80	1.32	1.30
	U-shaped Valley	2870.78	9.18	151	19.01	465.03	88.41	262621.8	8.40	1739.22	1.40	3.19	390.71	1.32	1.32
	Plains	4861.11	15.55	152	31.98	695.61	222.46	262889.4	8.41	1729.54	1.32	2.58	333.74	1.30	1.28
	Open Slope	13470.39	43.10	91	148.03	338.05	500.40	819758.7	26.23	9008.34	1.77	6.55	328.58	1.31	1.36
	Upper Slope	2357.38	7.54	156	15.11	247.02	37.33	229994.7	7.36	1474.32	1.35	1.99	504.67	1.32	1.29
	Midslope Ridge	1714.78	5.49	269	6.37	168.85	10.76	262223.2	8.39	974.81	1.31	1.54	392.83	1.31	1.28
	High Ridge	2079.69	6.65	71	29.29	126.14	36.95	208826.0	6.68	2941.21	1.59	2.12	214.72	1.29	1.30
TLM-022	Canyon	471.48	1.51	22	21.43	307.20	65.84	49758.9	1.59	2261.77	1.52	3.06	271.75	1.31	1.33
	Midslope Drainage	510.93	1.63	86	5.94	154.23	9.16	85893.5	2.75	998.76	1.31	1.59	365.30	1.30	1.29
	U-shaped Valley	615.33	1.97	50	12.31	334.87	41.21	51366.5	1.64	1027.33	1.24	1.65	466.21	1.31	1.26
	Plains	17219.36	55.09	79	217.97	519.64	1132.65	483125.1	15.46	6115.51	1.44	4.77	287.05	1.29	1.31
	Open Slope	11669.63	37.33	72	162.08	365.87	593.00	594268.0	19.01	8253.72	1.80	5.76	401.42	1.33	1.35
	Upper Slope	256.02	0.82	16	16.00	177.92	28.47	22893.3	0.73	1430.83	1.34	1.51	413.58	1.31	1.26
	Midslope Ridge	451.02	1.44	72	6.26	186.33	11.67	70256.1	2.25	975.78	1.29	1.52	344.01	1.30	1.28
	High Ridge	62.92	0.20	15	4.19	113.93	4.78	11499.4	0.37	766.63	1.29	1.28	671.53	1.33	1.27

Table 7.3. Class Level Metrics for the 12 Sample Catchments (Cont.)

	Class	Class Area	% Class	# of Patch	Mean Patch Size	PS Co-variance	PS Standard Deviation	Total Edge	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dim.	Area Weighted MPFD
TLM-059	Canyon	401.10	1.28	20	20.05	363.73	72.95	36404.7	1.16	1820.24	1.40	3.04	352.03	1.31	1.32
	Midslope Drainage	548.38	1.75	76	7.22	228.25	16.47	77591.4	2.48	1020.94	1.29	1.66	333.99	1.30	1.28
	U-shaped Valley	291.94	0.93	42	6.95	289.32	20.11	35139.4	1.12	836.65	1.25	1.53	378.98	1.31	1.27
	Plains	20930.94	66.96	54	387.61	377.18	1461.97	330235.1	10.57	6115.46	1.42	2.63	288.81	1.29	1.25
	Open Slope	8131.47	26.02	39	208.50	442.41	922.43	436373.2	13.96	11189.06	1.82	9.04	339.94	1.32	1.39
	Upper Slope	257.98	0.83	20	12.90	185.71	23.95	30699.0	0.98	1534.95	1.39	1.89	311.94	1.30	1.29
	Midslope Ridge	397.33	1.27	75	5.30	103.20	5.47	71875.7	2.30	958.34	1.29	1.36	291.12	1.29	1.28
	High Ridge	297.54	0.95	9	33.06	93.88	31.04	23488.3	0.75	2609.81	1.48	1.52	207.71	1.28	1.25
TLM-253	Canyon	1581.93	5.06	16	98.87	337.45	333.64	120199.7	3.85	7512.48	1.83	6.46	267.77	1.31	1.38
	Midslope Drainage	327.53	1.05	78	4.20	164.48	6.91	61846.1	1.98	792.90	1.28	1.41	368.93	1.31	1.28
	U-shaped Valley	1311.74	4.20	101	12.99	353.39	45.90	160503.6	5.14	1589.14	1.44	2.86	370.80	1.32	1.33
	Plains	11917.91	38.13	116	102.74	454.67	467.14	401410.1	12.84	3460.43	1.39	2.72	274.55	1.29	1.27
	Open Slope	14367.74	45.97	55	261.23	423.59	1106.55	612259.1	19.59	11131.98	1.76	7.49	772.35	1.35	1.36
	Upper Slope	707.28	2.26	23	30.75	144.82	44.54	54843.4	1.75	2384.50	1.42	1.79	273.28	1.29	1.27
	Local Ridge	7.47	0.02	6	1.24	42.74	0.53	2871.0	0.09	478.49	1.23	1.24	409.57	1.31	1.31
	Midslope Ridge	823.27	2.63	144	5.72	146.79	8.39	136121.2	4.35	945.29	1.30	1.39	322.79	1.30	1.27
	High Ridge	211.79	0.68	29	7.30	109.35	7.99	31284.0	1.00	1078.76	1.29	1.29	269.60	1.29	1.26

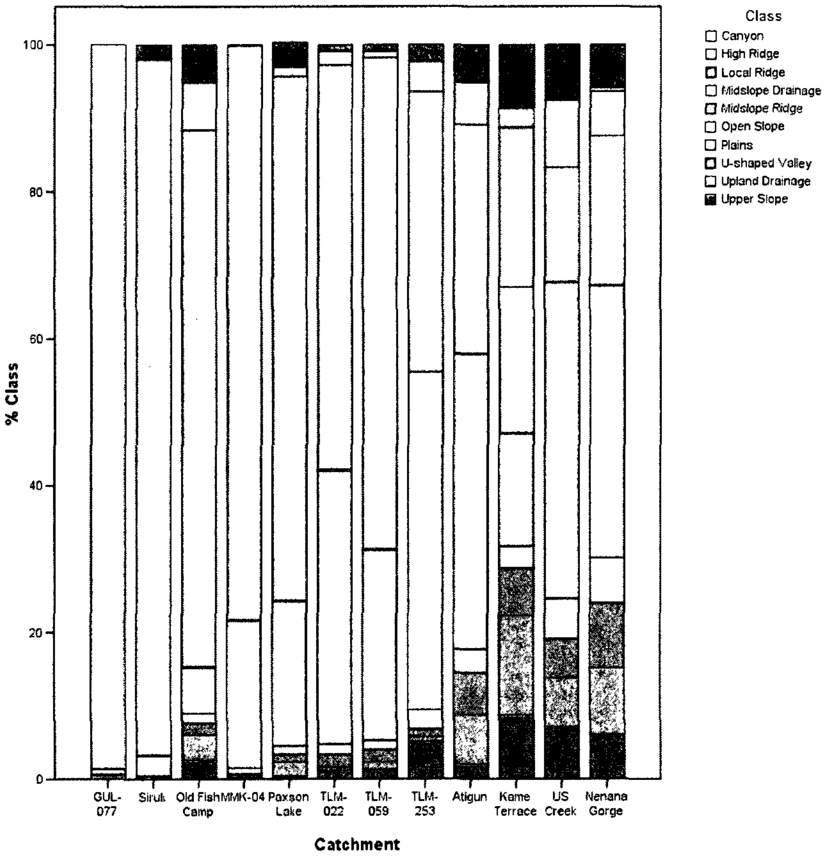


Figure 7.3. Cumulative Percentage Bar Graph of Class Area for Test Catchment.

The MMK-4 catchment comprises mostly plains (78%) and open slope (20%) patches; the remaining two percent of patch types are insignificant. The edge density for the two dominant patches is nearly identical despite the differences in their size and frequency. The open slope patches have very complex shapes (AWMSI=7.41) relative to the plains patches (AWMSI=3.84).

The majority, almost 97%, of the GUL-077 catchment is made of plains patches; or more precisely a single large continuous patch of 30,206 hectares. Given the size of the patch and that it mostly fills the catchment, it is somewhat surprising that the MSI (AWMSI is redundant because only one patch is present) that is above 2.0 and not closer to 1.0. The remaining three percent of the patches sufficiently dissect the patch to convolute its shape.

The Paxson Lake catchment is very similar to the MMK-04 catchment. Like MMK-4, plains and open slope patches comprise 78% and 20%, respectively, of the catchment. In the Paxson Lake catchment, however, the plain patches are on average substantially larger than those in the MMK-4 catchment. Also, whereas the MMK-04 catchment contains only six patch types, the Paxson Lake catchment includes nine patch types. The plains and open slope ED values are slightly smaller than those at MMK-04. The plains and open slope patches are complex (AWMSI=4.76 and 4.03), but are internally more similar than the two patch shapes in the MMK-4 sample.

Whereas the composition of the Paxson Lake and MMK-4 catchments are similar so too is the Siruk catchment similar, in some regards, to that of GUL-077. The Siruk catchment, like that of GUL-077, is almost exclusively composed of plains patches (95%). Unlike GUL-077, however, the Siruk catchment consist of six plains patches as opposed to one. Also, the Siruk catchment includes nine patch types compares with GUL-077's four. The plains patches in the Siruk catchment are moderately complex as indicated by the AWMSI (2.25) and the ED (4.54). Open and upper slopes account for the bulk of the remaining area within the Siruk catchment; these patch types also have moderately complex shapes.

The Atigun site catchment consists primarily of open slope (40%) and plains (32%) patches. Situated mostly in the Atigun Valley, the plains and open slopes are not unexpected; however, the frequency and small sizes of these two patch types is atypical for these patch types. The largest plains patch, which exceeds 6,600 hectares, is really not indicated by the MPS for plains, which is a small 18 hectares. The high frequency of small plains patches (n=550) and open slopes (n=526) substantially increases the ED for these patch types (20 and 36 respectively). In turn, the AWMSI values indicate highly convoluted shapes for these patches. The ED and AWMSI values for these two patch types are uncharacteristic of the similar patches in this sample and in the hunting range sample.

As the SHEI value for the US Creek catchment presented in Table 7.2 suggest, the distribution and proportion of different patch types is highly uniform. All patch types are presented and compared to other catchments in the sample, with the exception of the Kame Terrace catchment; the different patch types are strongly presented. The two most prevalent patch types include open slopes (43%) and plains (15%). With the exception of upland drainages, all the other patch types compose between five and nine percent of the catchment. Given the number and evenness in the distribution of patches, it comes as no surprise that the ED for each patch type is relatively high. Likewise, the AWMSI for each patch type are slightly higher; MPS values are, in general, smaller than many of the other cases in the sample.

Despite being relatively close to one another, the three Susitna Hydroelectric project sites in the sample have distinctly different catchments. Although plains and open slope patches dominant each, the percentages of each patch type vary considerably. Plains patches in the catchments of TLM-022 and TLM-059 comprise between 55 and 66%, while in the TLM-253 catchment, this patch types accounts for only 38%. The proportion of open slopes in the TLM-253 catchment is slightly larger than the proportion of plains patches at 46%; in the other two catchments open slopes compose between 26 and 37%. In the TLM-022 and TLM-059 catchments none of the other patch types account for more than two percent of the catchments. In TLM-253's catchment, canyon, U-shaped valley, upper slope, and midslope ridge patches individually account for between two and five percent of the topographic composition.

Classification Results

This section focuses on applying all the discriminant classification functions, both at the mammal distribution and hunting range levels, to determine how well these functions perform in regards to correctly classifying the 20 kilometer diameter catchment relative to the dominant large mammal remains recovered at the sites forming the center of each catchment. Before conducting the classification, each catchment was inspected to ensure it did not overlap with any other nearby catchments did not overlap. The remainder of this chapter concentrates on presenting the results of the classifications saving the interpretation and discussion for the conclusion of this chapter. Overall, three of the four classification functions perform very well correctly classifying between 75 and 100% of the cases in the sample. I begin with the general distributional range classification function, which has the lowest correct classification rate of about 17%.

The distribution range classification function, which discriminates between caribou, moose, and sheep ranges based on the landscape structure of each animals' distributional range within each study area (see Chapter 5), correctly classified only two, or 16.6%, of the 12 cases in the protohistoric sample (Table 7.4). The two correctly classified catchments include those of the GUL-077 and Siruk sites. In both these cases, moose where determined to be the most prevalent large mammals in the faunal assemblage and the classification function correctly classified the catchments as being most similar to general moose distributional ranges. The Nenana Gorge site

Table 7.4. Classification of Sample Cases Based on Distributional Ranges.

Site	*Classification Score*	*Catchment Classification*	*Dominant Large Game Archaeofauna*
Kame Terrace	Caribou=39.47 Moose=36.82 Sheep=41.31	Sheep	Caribou
Nenana Gorge	Caribou=36.84 Moose=34.55 Sheep=36.43	Caribou	Sheep
Old Fish Village	Caribou=2.67 Moose=5.12 Sheep=-26.86	Moose	Caribou
MMK-4	Caribou=-2.13 Moose=0.98 Sheep=-35.77	Moose	Caribou
GUL-077	Caribou=-15.56 Moose=-10.59 Sheep=-60.63	Moose	Moose
Paxson Lake	Caribou=1.09 Moose=3.75 Sheep=-29.80	Moose	Caribou
Siruk	Caribou=-15.02 Moose=-10.13 Sheep=-59.64	Moose	Moose
Atigun	Caribou=48.24 Moose=44.37 Sheep=57.54	Sheep	Caribou
US Creek	Caribou=40.97 Moose=38.10 Sheep=44.07	Sheep	Caribou
TLM-059	Caribou=3.83 Moose=6.11 Sheep=-24.72	Moose	Caribou
TLM-022	Caribou=11.91 Moose=13.08 Sheep=-9.75	Moose	Caribou
TLM-253	Caribou=17.16 Moose=17.59 Sheep=-0.03	Moose	Caribou

catchment, which I predicted would be most closely related to sheep hunting based on the faunal assemblage at the site, resulted in a misclassification for caribou range. The caribou dominant faunal assemblages at sites Old Fish Camp, MMK-4, Paxson Lake, TLM-022, TLM-059, and TLM-253 all suggested that a caribou-similar landscape structure was most likely, but the classification function incorrectly classified each of the catchments surrounding these sites as being more similar to typical moose ranges. The final three misclassified catchments, including Kame Terrace, Atigun, and US Creek, resulted in classification of sheep ranges where caribou was expected, again based on the faunal assemblages at each site.

Eight of the cases, including Old Fish Camp, MMK-4, GUL-077, Paxson Lake, Siruk, and the three Susitna sites, have no sheep remains in the assemblage or are not associated with sheep ranges. These cases are amenable to additional classification utilizing the seasonal classification functions derived from caribou and moose winter and summer ranges. As detailed in Table 7.5, the winter classification function correctly classifies each of the eight catchments relative to the dominant large mammal faunal remains at the sites. As above, both the GUL-077 and Siruk catchments are correctly classified representing moose and the remaining six catchments are correctly classified as representing caribou range.

The summer range classification function for moose and caribou performed moderately well with six of the eight, or 75%, cases being classified correctly based on the predictions made from the faunal assemblages (Table 7.6). The two misclassified cases are Old Fish Camp and TLM-059. In both these cases, the classification function placed the catchments in the moose-like summer range when caribou was anticipated. As in the two previous classifications, the summer classification function correctly placed the two moose cases, Siruk and GUL-077. The classification function correctly classified the remaining four cases (TLM-022, TLM-253, MMK-4, and Paxson Lake) as representing caribou range in accord to the faunal assemblage of each site.

Hunting Ranges

The classification of the catchments based on the landscape structure of large mammal hunting areas, as developed in the preceding chapter, are moderately successful with 75% of the cases being correctly classified relative to their respective faunal assemblages (Table 7.7). The three misclassified cases include the Kame Terrace, Atigun, and U.S. Creek catchments; in each case, caribou dominated the large mammal portion of the each faunal assemblage, but all three catchments were classified as being representative of sheep hunting ranges. The three misclassified cases are particularly interesting in two regards. First, each occurs in mountainous areas that share many physical characteristics with the Wiki Peak study area described in the following chapter. The consistency in the misclassified cases is also intriguing. I explore this issue in detail in the following section.

The hunting range classification function correctly classified the remaining eight catchments relative to the dominant large mammal remains in the faunal assemblages. As with all the other classification functions, the hunting range function again classified the GUL-077 and

Table 7.5. Caribou Moose Winter Discriminant Functions.

Site	*Classification Score*	*Catchment Classification*	*Dominant Large Game Archaeofauna*
Old Fish Village	Caribou=1.40 Moose=-4.94	Caribou	Caribou
MMK-4	Caribou=5.76 Moose=5.53	Caribou	Caribou
GUL-077	Caribou=21.90 Moose=44.16	Moose	Moose
Paxson	Caribou= 2.98 Moose=-1.16	Caribou	Caribou
Siruk	Caribou=16.14 Moose=30.39	Moose	Moose
TLM-022	Caribou=2.24 Moose=-2.49	Caribou	Caribou
TLM-059	Caribou=2.88 Moose=-1.39	Caribou	Caribou
TLM-253	Caribou=1.37 Moose=-5.01	Caribou	Caribou

Table 7.6. Caribou Moose Summer Discriminant Functions.

Site	*Classification Score*	*Catchment Classification*	*Dominant Large Game Archaeofauna*
Old Fish Village	Caribou=-2.34 Moose=-0.62	Moose	Caribou
MMK-4	Caribou=50.01 Moose=-0.89	Caribou	Caribou
GUL-077	Caribou=-14.06 Moose=-1.92	Moose	Moose
Paxson	Caribou=-3.28 Moose=-0.76	Caribou	Caribou
Siruk	Caribou=-13.98 Moose=-0.59	Moose	Moose
TLM-022	Caribou=3.67 Moose=0.01	Caribou	Caribou
TLM-059	Caribou=-1.43 Moose=-0.59	Moose	Caribou
TLM-253	Caribou=7.10 Moose=0.37	Caribou	Caribou

Table 7.7. Classification of Sample Cases Based on Hunting Ranges

Site	*Classification Score*	*Catchment Classification*	*Dominant Large Game Archaeofauna*
Kame Terrace	Caribou=5.66 Moose=0.95 Sheep=10.02	Sheep	Caribou
Nenana Gorge	Caribou=5.25 Moose=0.58 Sheep=9.15	Sheep	Sheep
Old Fish Village	Caribou=-0.06 Moose=-0.07 Sheep=-6.22	Caribou	Caribou
MMK-4	Caribou=-0.81 Moose=-13.97 Sheep=-7.69	Caribou	Caribou
GUL-077	Caribou=-2.89 Moose=-1.86 Sheep=-12.98	Moose	Moose
Paxson Lake	Caribou=-0.31 Moose=-0.46 Sheep=-6.58	Caribou	Caribou
Siruk	Caribou=-2.81 Moose=-1.71 Sheep=-12.87	Moose	Moose
Atigun	Caribou=7.02 Moose=1.82 Sheep=13.25	Sheep	Caribou
US Creek	Caribou=5.89 Moose=0.81 Sheep=10.85	Sheep	Caribou
TLM-059	Caribou=0.12 Moose=-0.94 Sheep=-4.81	Caribou	Caribou
TLM-022	Caribou=1.38 Moose=-0.53 Sheep=-1.42	Caribou	Caribou
TLM-253	Caribou=2.19 Moose=-0.26 Sheep=0.76	Caribou	Caribou

Siruk catchments as representing moose. This makes these cases the only two correctly classified by all four classification functions. The Nenana Gorge catchment, representing the only sheep dominant assemblage in the sample, produced a satisfactory result. As detailed below, because of the correct classification of this catchment, it becomes a key to understanding the reasons behind the three misclassified cases. The remaining six cases consist of caribou dominant assemblages, which match the results of the classification of their respective catchments.

The correct classification rate of the first classification function is very poor. The reasons behind the poor performance relate to the distributional range resemblance, a scale issue, and classification function itself. Given the results of this classification function against the hunting ranges as detailed in Chapter 6, it comes as no big surprise that the cases correctly classified were the two moose cases or that the misclassified cases represent mostly to caribou ranges, which account for most of the cases in the small sample. The resemblance matrices presented in the previous chapter, illustrate substantial overlap between the general distributional ranges of moose and caribou and that more caribou range overlaps with moose range than vice versa. This results in the general caribou distributional range being more similar, topographically, to moose range than the moose range is to the caribou range. This is manifest as poor classification success of both the caribou catchments and the modern caribou hunting range data. The range resemblance is likely the largest contributing factor to the misclassification of cases, but at least two additional factors add to the poor classification rates associated with the general range classification function.

Exacerbating the resemblance problem is a drastic reduction in the scale of the catchment relative to the distributional ranges used to formulate the classification function. While the grain and resolution of the underlying data remains unchanged, the area of the catchment is on average 310 times smaller than the moose and caribou range sizes used to determine the landscape structure, which was in turn used to calculate the discriminant classification function. The chances of an individual catchment being representative of an actual distributional range are exceedingly low, which further results in the misclassification of the caribou catchments. More carefully defined distributional ranges relative to potentially exploitable from individual villages may help resolve this problem.

To a minor extent, the classification function itself must also share in the blame for the poor classification rates. That the function consists of a single variable, edge density, can result in misclassification of cases. There is no internal correction, beyond the constant, in the classification function. Functions consisting of several variables, even if their discriminating power is slight, offers a second layer of comparison relative to the "all your eggs in the same basket" function. The extent to which a single variable function can contribute to the misclassification of cases appears to be directly related, at least in this analysis, to the amount of range resemblance and the relatively small size of the catchments. Increasing the size of the catchments would likely increase the ability of the function to correctly classify the catchment. For example, the correct classification of caribou cases increases from zero, at the catchment level, to 40% at the general caribou distribution level. While greatly increasing the size of the catchment may increase the classification success rate, doing so has little archaeological validity relative to this study and its assumptions unless those catchments are meaningfully correlated to potentially exploitable habitat from individual villages.

There are three types of misclassified cases in Table 7.4. These include classifying caribou as moose range, classifying sheep range as caribou range, and classifying caribou range as sheep range. Classification of caribou range as moose range occurs in six cases. In each case, the differences in the classification scores are small indicating that, since only a single variable is included in the function, the differences are mostly result of the constant used in the algorithm. In this classification, the moose and caribou function coefficients are not substantially different (.66 and .77, respectively) giving most of the discriminating power to the coefficient constants. In this particular classification, the moose coefficient constant of -16.05 results in slightly more control in the classification than the caribou coefficient constant of -21.9, hence the misclassification of caribou range as moose range.

At the Kame Terrace, US Creek, and Atigun sites, the function classified the catchments sheep ranges when caribou represented the largest portion the large faunal assemblage. The misclassification of these three cases relates mostly to the mountainous areas the sites occur in, or more specifically the patchiness of these environments. This is also partially related to the single variable of edge density used in the classification function and the small size of the catchments relative to the caribou and sheep ranges used to derive the function. As noted throughout most of Chapter 5, the large mammal distributional ranges in the Upper Yukon study area were consistently patchier than the other four study areas. That large portions of the Upper Yukon study area occurs in the eastern Brooks range due to the geographic location of Arctic Village and Venetie, it is evident that those cases in the protohistoric sample that occur in the Central Brooks range would also be in patchy environments. Given that the increase in the number of patches, and smaller patch sizes increases the edge density of patches, and that edge density is the only variable used in the classification function, the misclassification of caribou range and sheep range, which is typically they patchiest distribution range, is understandable. Although the US Creek catchment does not occur in the Brooks Range, it does occur along the southern slopes of the White Mountains. Though not nearly as high or as rugged as the Brooks Range, the White Mountains contain substantial sheep range indicating a patchy environment. The ED values for these three cases are above 80 meters/hectare, which is between the Upper Yukon caribou ED or 69.08 meters/hectare and the sheep range ED of 104.52 meters/hectare. However, the average caribou ED for all five study areas is only 53.85 meters/hectare; the average sheep ED is 99.71

meters/hectare. Given that the ED for the three misclassified cases falls much closer to the average sheep ED, it is evident why these cases were misclassified.

One case in the sample, the Nenana Gorge catchment, returned a result of caribou when sheep was expected. In this case, all three classification function scores are very similar, with caribou and sheep scores being with in 4/10th of a point of one another. The edge density calculated for the Nenana Gorge catchment is 76.09 meters/hectare, a value not too dissimilar to the ED value of the Kame Terrace catchment, which was classified as representing sheep range. The Nenana Gorge ED is well above the average for the general caribou range. Because this case was misclassified, it is clear that the threshold, or discriminating ability, of the constants for the caribou and sheep ranges falls somewhere between the ED values of 76.09 and 79.5.

The classification functions for delineating between moose and caribou ranges in both the winter and summer prove to have much more utility than the tripartite function for the general large mammal distribution. The winter moose-caribou classification function performed perfectly, even better than it did in classifying the known hunting ranges for these two mammals as described in the previous chapter. The success of this function appears to be related mostly lack of resemblance between moose and caribou winter ranges, but also because of the catchment size. While at the general distribution the size of the catchment does not adequately capture the overall parameters of the distributional range, at the seasonal range, the small catchment size, coupled with the lack of resemblance, appears to actually emphasize the general landscape parameters. The same holds true for the summer range function as well.

The results of the hunting range classification function performed extremely well, especially compared to the general distribution classification function. The three catchments misclassified include the same three cases, Kame Terrace, Atigun, and US Creek, misclassified by the general distribution classification as sheep ranges when caribou ranges were expected. For the most part, the same reasons these cases were misclassified by the general distribution function apply here.

There are some notable reasons as to why this particular function resulted in a substantially better classification rate compared with the results of applying the distributional range function to the catchments. Overall, the modern hunting ranges used to define the classification function are considerably smaller than the distributional ranges. Compared with the size of the catchments, the hunting ranges are only 20 to 100 times large than the catchments themselves. This substantially increases the chances that the catchment more accurately reflects the average parameters of the hunting landscapes. The inclusion of multiple variables classification function appears to increase considerably its discriminating power. Despite its greater discriminating power, the hunting range function still fails in properly delineating between caribou and sheep ranges in mountainous areas where patch densities are consistently high.

Plotting the two variables used in the hunting range classification function against one another in a scatterplot, it becomes clear that those cases in mountainous areas are widely separated from those cases in less rugged terrain (Figure 7.4). Although the sample size is admittedly small, there are several general trends in this data. First, the two moose cases, Siruk and GUL-077, occur very near one another and the low ED values separate these cases well from all the other cases. There is also considerable variation in the caribou cases. Six of the cases that occur outside of mountainous terrain, consists of two groups. The first group, containing the Susitna sites, includes higher edge densities than the second group, containing MMK-0, Paxson, Lake, and Old Fish Camp, which has minimal variation in edge densities, but a much greater range in the PSCOV values. This latter trend in the caribou cases is a useful heuristic in examining the three misclassified cases. Despite its substantially higher ED, the Kame Terrace catchment has a PSCOV value that is not substantially different from those of the Susitna sites. The Atigun catchment, as well, has a PSCOV value similar to the Paxson and MMK-4 catchments.

This observation confirms the notion that these two cases were misclassified because of their high ED values. The US Creek catchment, however, is very similar to the Nenana Gorge catchment in regards to both the ED and PSCOV values. That the classification function placed the US Creek catchment into the sheep hunting range is understandable given the close resemblance of the two cases. However, the pertinent question raised by this is "why do two very similar catchments have different representative large fauna?"

The simple answer to this question is that more than one species was sought in these locations. The limiting assumption concerning identifying a single dominant large mammal is not likely justified for cases from mountainous areas. In each of the four cases in mountainous areas both sheep and caribou are represented in the faunal assemblages, although to differing degrees. Though caribou remains are the most frequently encountered remains at the Kame Terrace site, sheep are represented in each of the three areas that have later temporal components. Mills et al. (2005:38) even interpret Area 3 as being a sheep hunting locality. Similar to Area 3 at the Kame

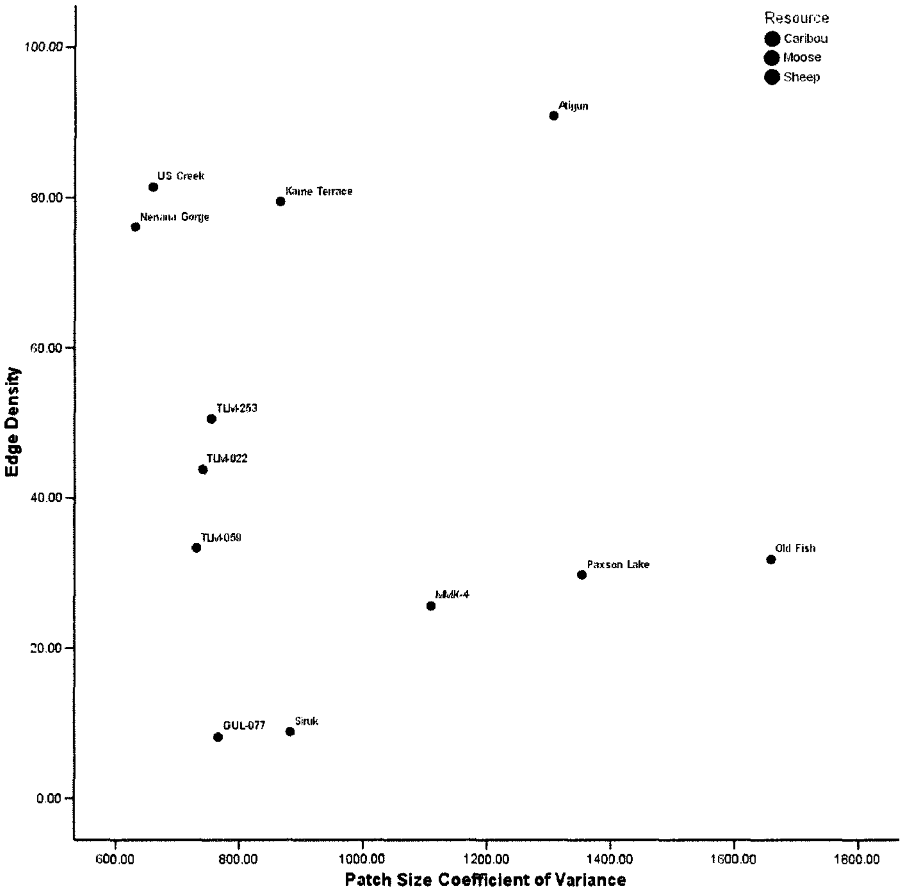


Figure 7.4. Scatterplot of Protohistoric Cases by Edge Density and Patch Size Coefficient of Variance. The case classification is by the dominant large mammal remains at each site and not by the hunting range classification.

Terrace site, the faunal assemblage at the Nenana Gorge site, though sheep dominant, contains a substantial caribou remains (Plaskett 1977). In all, these three cases tend to suggest dual large mammal exploitation and not single mammal utilization as originally assumed. The Atigun catchment is unique in the sample. The faunal assemblage consists mostly of caribou, but at least one sheep is present. The catchment itself differs substantially from all the others, but given the limited size of the data set, it is not possible to determine if the catchment is actually an outlier or simply the only case of its type in the sample. Based on the class composition (Figure 7.3), the relative percentages of the different landforms appears more similar, in terms of increased plains and open slopes and small percentages of other classes, to the other cases with definitive caribou correlations.

Discussion

Before applying the classifications to an archaeological case that contains no faunal remains to serve as a link between the model and archaeological record, it is necessary to examine the relationship between the first and second order derivative patterning. In Chapter 3, the correspondence analysis of modern and ethnographically documented hunting efforts varied dramatically, particularly in regards to large mammal hunting. While fishing and the use of small game remain important subsistence activities, the pattern in large game hunting in most of the communities included in the study illustrate a dramatic decrease in hunting effort and, in some instance, timing in the present relative to the recent past. The move from a primarily subsistence economy to a mixed economy based on subsistence hunting, trapping, and wage labor, and hunting regulation has had profound effects on traditional subsistence practices in a very short period of time. Associated with the change in economy, the establishment of year-round villages also had an effect on land use practices. Although transportation technology, such as snow machines, boat engines, and small aircraft, and transportation infrastructure, in some areas, allows for access to vast area of the Alaskan Interior, the move from a semi-sedentary to a sedentary existence essentially tethered people to one focal point in the landscape from which all exits were made and to which all returns occurred.

However, despite acculturation, economic change, and increased sedentism, the hunting territories of modern Athabascans and their ancestors appear to share great similarity. The characteristics of the hunting landscapes both past and present, as measured by the topographic position index and quantified by landscape metrics, are more similar to one another than they are different. The ability of the classification function to differentiate among different hunting ranges in the past and in the present at a rate of over 70% attests to a continued persistence of what could best be termed traditional ecological knowledge as it pertains to distribution and preferred habitats of moose, caribou, and sheep. While many ethnographers have described hunting methods for specific animals and the subsistence anthropologists with state and federal agencies have mapped resource areas, little attention is given to why these particular areas and hunting methods are used.

While examining the "why" questions of choice of resource extraction areas is beyond the scope of this dissertation, the recognition that there is a diachronic pattern that can be traced from the contemporary period back to the historic and protohistoric periods has positive implications for pushing the derived landscape models back farther in time. While blindly applying the models to prehistoric contexts to determine resource extraction where no faunal remains are present is unwarranted, the critical use of the models in conjunction with lithic assemblages, and other ancillary data, can be useful in hypothesis generation and testing, understanding lithic assemblage variability, and studying and settlement systems at a scale more in tune with land use than the common site-based model prevalent in Alaska and elsewhere.

CHAPTER 8.

LANDSCAPE METRICS AND THE WIKI PEAK AREA LITHIC LANDSCAPE

Introduction

In many areas around the world, surface lithic scatters are a common part of the archaeological record. Archaeological inventory work conducted in the Wrangell-St. Elias National Park and Preserve (WRST) in the vicinity of Wiki Peak resulted in the identification of numerous surface lithic scatters clustered and scattered across the landscape. Like many other surface scatters, those identified in the Wiki Peak area contained few chipped stone tools and even fewer temporally diagnostic artifacts. However, the sheer number of sites, their spatial distribution across different landforms, and the availability of different resources (obsidian tool stone and subsistence resources), indicate differential use of the landscape. This chapter focuses on examining these sites, and their associated chipped stone tools, in relation to the previously developed distribution and hunting range models. This case study is not meant to definitively address specific hypotheses concerning land use. Instead, it focuses on applying the classification functions to archaeological sites to further explore their utility. A second section examines the direct relationships between different classes of chipped stone tools (projectile points, scrapers, and bifaces) and the constituent elements (edge density and patch size coefficient of variance) of the hunting range model.

Wiki Peak Landscape Analysis

An overview of the results of three seasons of fieldwork conducted in the Wiki Peak area is provided in Appendix B. Briefly, the archaeological record in the area consists of over 110 discrete lithic scatters (Figure 8.1). While dating is problematic at many of the individual sites, temporally diagnostic artifacts from surface scatters and radiocarbon dates obtained from a couple of stratified sites found in the project area indicate that it is likely that most of the sites date to within the last 3,500 to 4,000 years.

Site Location Groups

Only sites identified in areas that were intensively inventoried in the Wiki Peak area are used in this analysis (n=104). Using topographic features that the sites were located on or adjacent to,

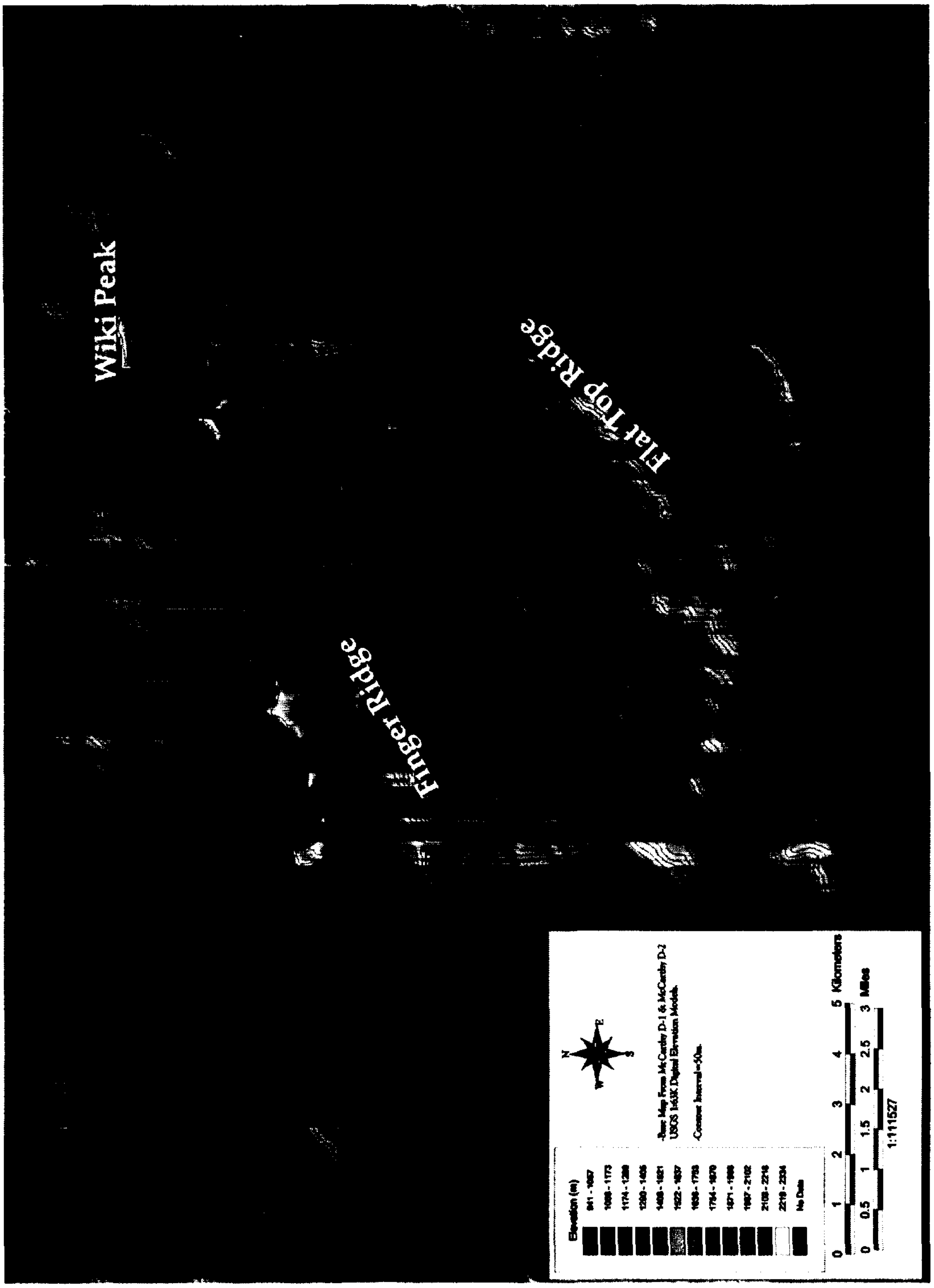


Figure 8.1. Study Area Showing Major Topographic Features and All Sites.

nine site locational groups were identified. These groups include Francis Creek (11 sites), Lower Cabin Creek (48 sites), Upper Cabin Creek (8 sites), Flat Top (4 sites), Ridge (16 sites), Moraine (10 sites), Wiki Ridge (4 sites), Ptarmigan Lake (3 sites), and Rock Lake (3 sites). The site groups essentially occupy three different elevation zones including low absolute elevations (Rock Lake and Ptarmigan Lake), high absolute elevation (Lower and Upper Cabin Creek, Francis Creek, Moraine), and high relative elevation (Ridge, Wiki Ridge, Flat Top).

Briefly, the Francis Creek Group occurs in the middle stretch of the Francis Creek drainage. The sites in the group are associated with a small ephemeral rill that runs between the steep mountain slopes and the creek bed. The Lower Cabin Creek Group covers the mouth of a small U-shaped valley. Farther up the valley, a second group of sites makes up the Upper Cabin Creek Group. Situated between the Francis Creek and Lower Cabin Creek Groups is a medial moraine that extends from the base of the mountain slope out into the Francis Creek drainage; the moraine as considerable relief compared to both the Francis and Lower Cabin Groups. The Ridge Group is to the east of the Cabin Creek with the sites occupying an elevated position. The Wiki Ridge Group is the eastern most site group, which occupies a relatively narrow ridge on the middle flanks of Wiki Peak. Flat Top, a large ridge bearing a large mesa-like structure forms the southern valley wall of Francis Creek. The Flat Top sites occupy the extreme eastern edge of this landform. The two lake groups, Ptarmigan and Rock, consist of sites located alone the northern shores of each respective lake.

Topographic Position Index and Viewsheds

Landscape comparisons are made based on the TPI and landscape metrics, which I calculated in an identical manner to the other indices previously described (Chapter 4).

Because of the proximity of the lithic scatters and the site groups themselves, the catchment approach used in the previous chapter is useless in this particular case due to the considerable overlap that would occur. These overlapping catchments would not necessarily be independent. To draw meaningful comparisons, an alternative viewshed approach is utilized here. Since hunting land use patterns are explored, the viewshed approach seems a reasonable approximation for landscape quantification. While there is a degree of overlap between viewsheds among the site groups, the viewshed of each site location group is independent from all the other site groups. To provide a measure for comparison, a 20 kilometer diameter catchment was placed over the study area.

The viewshed approach consists of quantifying the landscape structure of the viewable terrain from the geographic center of each site group. Through examining individual site viewsheds with in a single site group, it was determined that the intra-group viewsheds varied insignificantly. Viewsheds, based on the same DEM used to construct the TPI, were generated using the 3D Analyst Extension for ArcView 3.3. For ease of use, the raster-based viewsheds were converted to vector files. The TPI coverage was clipped against the viewshed for each group. The standard set of landscape metrics described in Chapter 4 was calculated for the TPI of each viewshed. Besides the use of viewsheds, the analyses conducted are identical those used in quantifying the hunting and distributional ranges.

Metrics

Table 8.1 presents the landscape level metrics calculated for each of the ten viewsheds and the overall Wiki Peak 20 km diameter catchment. The ten sample areas very greatly in their viewsheds. Not surprisingly, the two largest viewsheds belong to the Ridge (8163 ha) and Flat Top (7004 ha) groups, which have the highest relative elevations of any of the groups. Francis Creek has the smallest overall viewshed at a mere 1767 hectares. The remaining viewsheds vary between 3051 and 4496 hectares. While the absolute area of the viewshed for each group roughly corresponds to the number of patches within it, the MPS values do not rend well against either the viewshed size or the number of patches each contains. In some cases, there appears to be a relationship between the MPS and either absolute or relative elevation, but there are exceptions. The Rock Lake group has the second lowest absolute elevation and the largest MPS. The Ptarmigan Lake group, which has the lowest average absolute elevation, has a MPS value that is not substantially different from the substantially higher Ridge or Moraine groups. The Lower Cabin Creek, Upper Cabin Creek, and the Francis Creek groups, which represent the groups with the lowest relative elevations, have the smallest MPS values despite the moderately substantial differences in both the viewshed area and number of viewable patches. Only the Rock Lake and Flat Top groups have MPS values that approximate the overall MPS for the Wiki catchment.

Table 8.1. Landscape Mertics for the Study Groups and Wiki Catchment.

	Area (ha)	# of Patches	Mean Patch Size (ha)	PS Coefficient of Variance	PS Standard Deviation	Total Edge (m)	Edge Density	Mean Patch Edge	Mean Shape Index	Area-Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD	Shannon's Diversity Index	Shannon's Evenness Index
Flat Top	7004.53	263	26.6	651.5	173.5	489793.1	69.9	1862.3	1.50	3.04	927.95	1.36	1.30	1.69	0.77
Francis Creek	1767.27	113	15.6	277.7	43.4	191102.8	108.1	1691.2	1.58	2.14	716.07	1.35	1.30	1.65	0.79
Lower Cabin Creek	3591.75	226	15.9	322.0	51.2	369734.5	102.9	1636.0	1.48	2.32	3014.12	1.29	1.30	1.79	0.78
Moraine	3557.13	200	17.8	442.2	78.6	337348.9	94.8	1686.7	1.50	2.75	742.42	1.35	1.31	1.78	0.77
Upper Ophir Creek	4364.60	196	22.3	385.2	85.8	353917.7	81.1	1805.7	1.52	2.60	1759.21	1.34	1.29	1.74	0.84
Ptarmigan Lake	4470.37	226	19.8	465.2	92.0	372918.6	83.4	1650.1	1.50	2.71	1390.60	1.37	1.30	1.65	0.75
Ridge	8162.93	376	21.7	584.4	126.9	646868.4	79.2	1720.4	1.48	2.71	897.08	1.36	1.30	1.83	0.79
Rock Lake	4496.73	153	29.4	465.0	136.7	308713.9	68.7	2017.7	1.53	2.60	1013.41	1.36	1.29	1.59	0.89
Upper Cabin Creek	3051.13	215	14.2	335.8	47.7	327995.3	107.5	1525.6	1.48	2.39	1700.27	1.47	1.30	1.83	0.83
Wiki Ridge	4456.69	187	23.8	585.6	139.6	308395.2	69.2	1649.2	1.49	2.74	826.37	1.36	1.29	1.63	0.78
Wiki Catchment	32741.95	1178	27.8	1754.6	487.7	2350297.5	71.8	1995.2	1.36	9.58	342.47	1.31	1.36	1.91	0.83

Edge density measures, as expected, mimic those of the MPS. The highest ED values occur in the viewsheds that have the smallest MPS values. The Francis, Lower Cabin, and Upper Cabin site groups have viewsheds with ED values in excess of 100 meters per hectare; the Moraine group's ED is slightly lower at about 95 meters per hectare. The Ridge, Ptarmigan Lake, and Upper Ophir Creek groups, which for all intents in purpose collectively represent most of the variability of the Wiki Peak landform, have similar ED values clustered between 79 and 83 meters per hectare. The remaining four site groups have ED values of approximately 69 meters per hectare, which is similar to the catchment's ED of 71.8 meters per hectare. The MPE values are more variable among the different groups than their respective ED values. With the exception of the Rock Lake group's viewshed, the site groups all have MPE values that are lower than that of the general catchment.

Despite the variation in the area and edge metrics, the shape indices among the site groups are remarkably similar to one another, particularly in regards to the MSI. The MSI values for the site groups range between 1.48 and 1.58, while the Wiki Peak catchment is substantially lower at 1.36. When the area weights are considered, the differences in patch shape show considerably more variation with the site group values being as low as 2.14 to as high as 3.04. The catchment AWMSI, however, increases dramatically, likely reflecting the presence of relatively large patches dominating much of the area. Similarly, the MPFD values for the site group viewsheds display only moderate variation, though the Upper Cabin Creek has a higher value than all the other site groups. As with the MSI, the MPFD values for the site groups are higher than the general catchment and the AWMPFD values are lower. Overall, the patchiness of the most of the viewsheds for each site group coupled with the shape indices imply relatively simple patch shapes.

The SHDI has similar patterning to the number and size of the patches noted in regards to relative and absolute elevations. Generally, the site groups at lower absolute elevations and high relative elevations, and subsequently larger viewsheds, have lower landform diversity than those site groups that are at higher absolute elevations. The major exceptions to this trend are the ridge group site that has a large viewshed and one of the highest diversity scores and the Francis Creek group, which has a restricted viewshed with a comparably low diversity score. The overall Wiki Peak catchment has, not unexpectedly, the highest diversity of landforms. The site groups with high SHDI scores, including Lower and Upper Cabin, Upper Ophir, and the Ridge, are significantly higher than those that have lower diversity scores (t= -6.48; df= 8; p= 0.00) and all the diversity scores are significantly lower than the catchment value (t= -6.95; df= 9; p= 0.00). Although the diversity among different group locations has considerable variability, the SHEI is considerably more consistent varying primarily between 0.77 and 0.83. The Rock Lake group is the exception; its viewshed has a slightly higher evenness score of 0.89 indicating greater evenness. Overall, the moderately high evenness scores across all the groups points to the topographical complexity of the study area.

Examining the percentage of the different landforms in each group's viewshed (Figure 8.2), it is clear the there is only minor variation in the viewable composition. However, what variation is present represents patterns, as many of the other metrics, in terms of the relative and absolute elevations in the study area. The Upper Cabin Creek, Lower Cabin Creek, Moraine, and Francis Creek groups have viewsheds composed of substantially higher percentages of open slopes than the other groups.

The site groups in the lower elevations of the project area, namely the Rock Lake and Ptarmigan Lake groups, and those with the greatest relative elevations, including the Flat Top, Ridge, and Wiki Ridge groups, have recognizably higher amounts of plains topography than the site groups in the higher elevations with restricted viewsheds. With the exceptions of the Rock Lake and Ophir groups, much of the viewable plains terrain overlaps among the remaining groups. The Flat Top and Wiki Ridge groups have the highest percentage of plains, but the Wiki Ridge group occurs two kilometers from its nearest substantial plains patches; this distance is two to three times larger than the other site groups at high relative elevations.

Despite the overall small size of the viewsheds relative to the hunting and mammal distributional ranges and the standardized catchments discussed in previous chapters, the viewsheds are representative of the immediate areas surrounding the site location groups. Even though many of the site location groups are in close proximity to one another, changes in the relative and absolute elevations in the terrain provide for considerable variation in the viewable landscape composition and structure. It is possible to recognize two general patterns in the landscape metric data that correlate with elevation and location. Site groups occupying higher absolute elevations with no relative elevation relief have restricted viewsheds that are extremely patchy and diverse. As the size of the viewsheds increase in groups that have an elevated position or groups that occur in the lower elevations of the study, the diversity and patchiness of the viewable terrain begins to decrease. Although changes in the complexity of the viewable landscape changes throughout the study area, the study area itself represents an extremely patchy

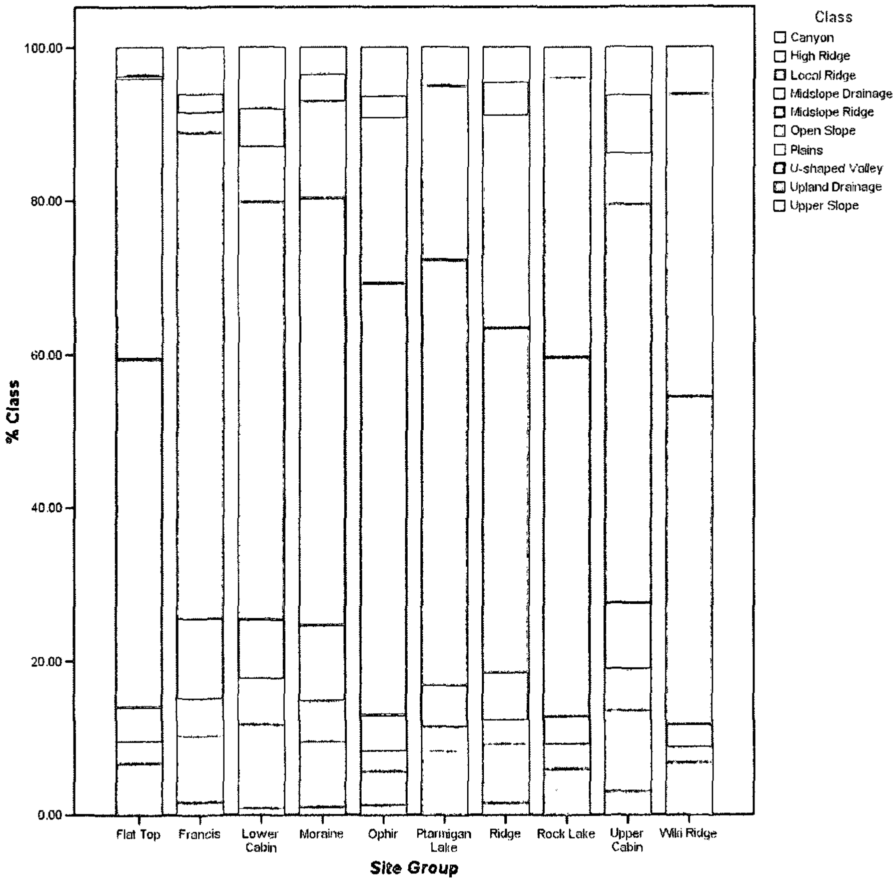


Figure 8.2. Cumulative Percentage Bar Graph of Class Area for the Wiki Study Area Site Groups.

environment, not unlike other mountainous areas utilized by modern Athabascans and their ancestors as detailed in proceeding chapters.

Classification Results

The results for the classification of the site group viewsheds based on the large mammal range distribution and the modern Athabascan hunting ranges are provided in Tables 8.2 and 8.3. Based on the classification function for the large mammal distributional ranges, the viewable terrain from the different site groups is most similar to either sheep range or caribou range. The function classified the Rock Lake, Wiki Ridge, and Flat Top viewsheds as caribou range. The viewshed for these three site groups all have large patch sizes, relatively low landform diversity, and considerable amounts of viewable plains topography. The Rock Lake group has a low absolute elevation and the remaining two site groups have high relative elevations. The discriminant classification function for mammal range placed the viewsheds of the Ridge and Ptarmigan Lake groups, which share similar qualities to the three groups classified as

Table 8.2. General Distribution Range Classification Function by Viewshed.

Site	*Classification Score*	*Viewshed Classification*
Flat Top	Caribou = 31.94 Moose = 30.45 Sheep = 27.61	Caribou
Francis Creek	Caribou = 61.36 Moose = 55.86 Sheep = 82.25	Sheep
Lower Cabin Creek	Caribou = 57.36 Moose = 52.41 Sheep = 74.82	Sheep
Moraine	Caribou = 51.12 Moose = 47.02 Sheep = 63.24	Sheep
Ophir Creek	Caribou = 40.54 Moose = 37.87 Sheep = 42.58	Sheep
Ptarmigan Lake	Caribou = 42.33 Moose = 39.42 Sheep = 46.91	Sheep
Ridge	Caribou = 39.12 Moose = 36.65 Sheep = 40.94	Sheep
Rock Lake	Caribou = 30.96 Moose = 29.60 Sheep = 25.79	Caribou
Upper Cabin Creek	Caribou = 60.87 Moose = 55.44 Sheep = 81.34	Sheep
Wiki Ridge	Caribou = 31.38 Moose = 29.97 Sheep = 26.57	Caribou
Catchment (20km dia.)	Caribou = 33.37 Moose = 31.69 Sheep = 30.27	Caribou

Table 8.3. Hunting Range Classification Function.

Site	*Classification Score*	*Viewshed Classification*
Flat Top	Caribou = 4.51 Moose = 0.37 Sheep = 7.13	Sheep
Francis Creek	Caribou = 9.10 Moose = 1.45 Sheep = 19.88	Sheep
Lower Cabin Creek	Caribou = 8.47 Moose = 1.29 Sheep = 18.15	Sheep
Moraine	Caribou = 7.50 Moose = 1.11 Sheep = 15.41	Sheep
Ophir Creek	Caribou = 5.85 Moose = 0.53 Sheep = 11.01	Sheep
Ptarmigan Lake	Caribou = 6.13 Moose = 0.70 Sheep = 11.69	Sheep
Ridge	Caribou = 5.63 Moose = 0.66 Sheep = 10.21	Sheep
Rock Lake	Caribou = 4.36 Moose = 0.13 Sheep = 6.90	Sheep
Upper Cabin Creek	Caribou = 9.02 Moose = 1.48 Sheep = 19.62	Sheep
Wiki Ridge	Caribou = 4.42 Moose = 0.28 Sheep = 6.96	Sheep
Catchment (20km dia.)	Caribou = 4.73 Moose = 1.54 Sheep = 6.63	Sheep

representing caribou range and are either at low absolute or high relative elevations, as representing sheep range. The remaining groups also represent sheep ranges based on the results of the classifications.

The hunting range classification function placed all the cases, including the catchment, into the sheep category. The generally good results of this classification function against the historic and protohistoric cases, which suggest that the modern landscape structure can be useful in understanding past land use patterns, leads to giving this function the most weight; however, as noted in Chapter 7, the cases misclassified by this function tend to be those in mountainous areas. The primary limitation of this function is its ability to distinguish correctly between caribou and sheep range in very patchy environments.

Plotting the two variables, ED and PSCOV, used in the discriminant function classification against one another several clusters are evident in the data (Figure 8.3). First, there is a general linear trend that as the ED decreases the PSCOV increases. In regards to the ED, there are four distinct clusters within the matrix. These clusters include 1) three site groups (Rock Lake, Wiki Ridge, and Flat Top) that have ED values below 70; 2) a set of site groups (Ophir, Ptarmigan Lake, and Ridge) with ED values of roughly 80; 3) a set of three site groups (Francis, Upper Cabin and Lower Cabin) with values over 100; and 4), a single site group (Moraine) that is between, but well separated, from groups 2 and 3. Based on the metric data and

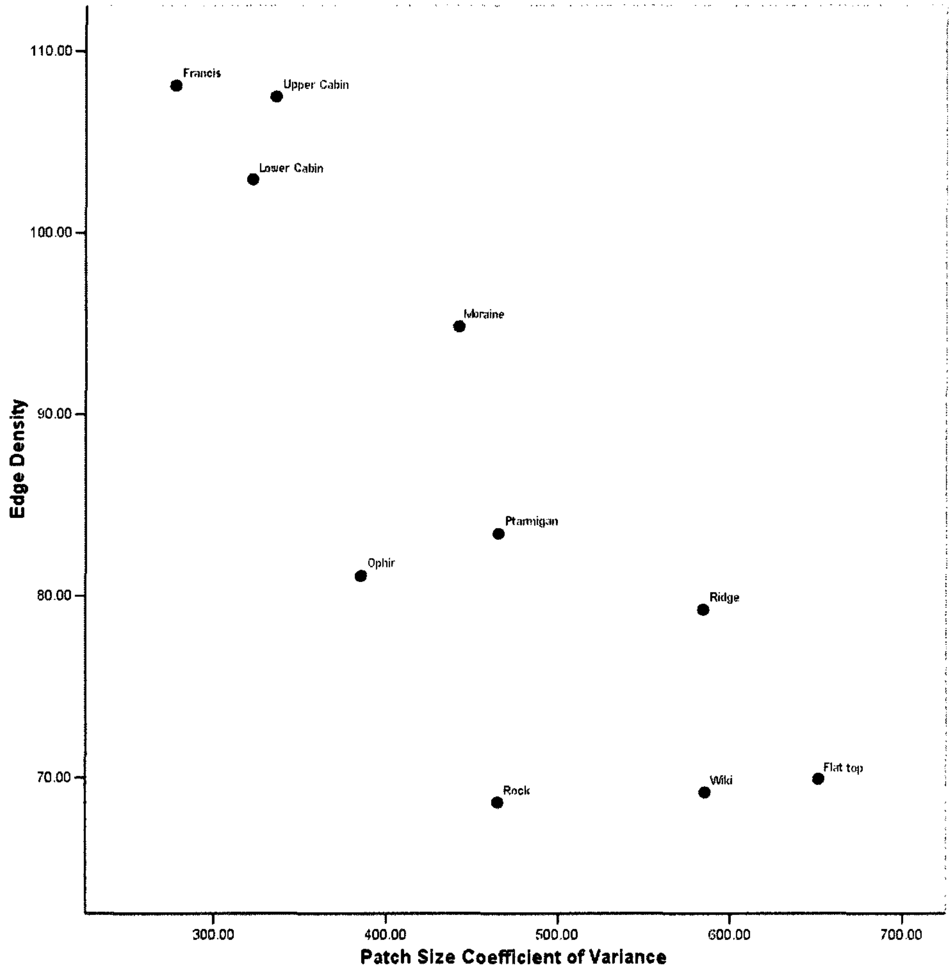


Figure 8.3. Scatter Plot of Study Cases by Edge Density and Patch Size Covariance.

comparisons discussed above, these groupings are not unexpected. Despite these differences, the classification of all the site groups into sheep ranges reflects the patchiness of the area as measured by ED and PSCOV.

Plotting the site group data with the protohistoric cases (Figure 8.4) illustrates just how patchy the Wiki Peak study area is relative to the general terrain of these other sites. The Wiki Peak site groups all cluster in the same general ED range as the other protohistoric catchments that also occur in mountainous areas, though four groups (Upper Cabin, Lower Cabin, Francis, and Moraine) have notably higher values. The remaining six groups cluster nicely with the US Creek, Kame Terrace, and Nenana Gorge catchments. Again, the hunting range classification function misclassified the Kame Terrace and US Creek catchments. I interpreted this discrepancy as being related to dual resource procurement and projected this interpretation to the Nenana Gorge catchment do to its similarity to the other to cases. If this interpretation is correct, then it appears that the majority of the site groups in the Wiki Peak area also represent, based solely on the configuration and structure of the landscape of contemporary hunting range models, the hunting of caribou and sheep. While the ED values are similar, the PSCOV values for the Wiki Peak site groups are, on average, smaller than the protohistoric catchments. This difference likely reflects the smaller size of the site group viewsheds relative to the size of the catchments; though based on the data alone the possibility that this reflects a tendency towards sheep range cannot be entirely dismissed.

While the protohistoric catchments do not contain ED and PSCOV values approaching the outlier cases in the Wiki Peak study area, a couple of the modern sheep hunting ranges do correspond well with these cases (Figure 8.5). The Northway and historic Stony River Village sheep hunting ranges fall near the Francis and Cabin site clusters, relative to ED and PSCOV. Although the PSCOV differs, the ED for the Tanacross sheep hunting range is similar to that of the Moraine site group's viewshed. The Venetie and Tok sheep hunting range values fall between the Francis and Cabin site groups and the other Wiki Peak site groups. Where the ED drops below 85 meters per hectare, the documented resource for known cases becomes more erratic with several additional caribou hunting ranges with high ED and low PSCOV values beginning to appear further suggesting that at higher elevations there is considerable overlap between caribou and sheep hunting ranges. Taken together, the protohistoric and modern cases indicate that both sheep and caribou hunting are plausible for most of the Wiki peak cases, but

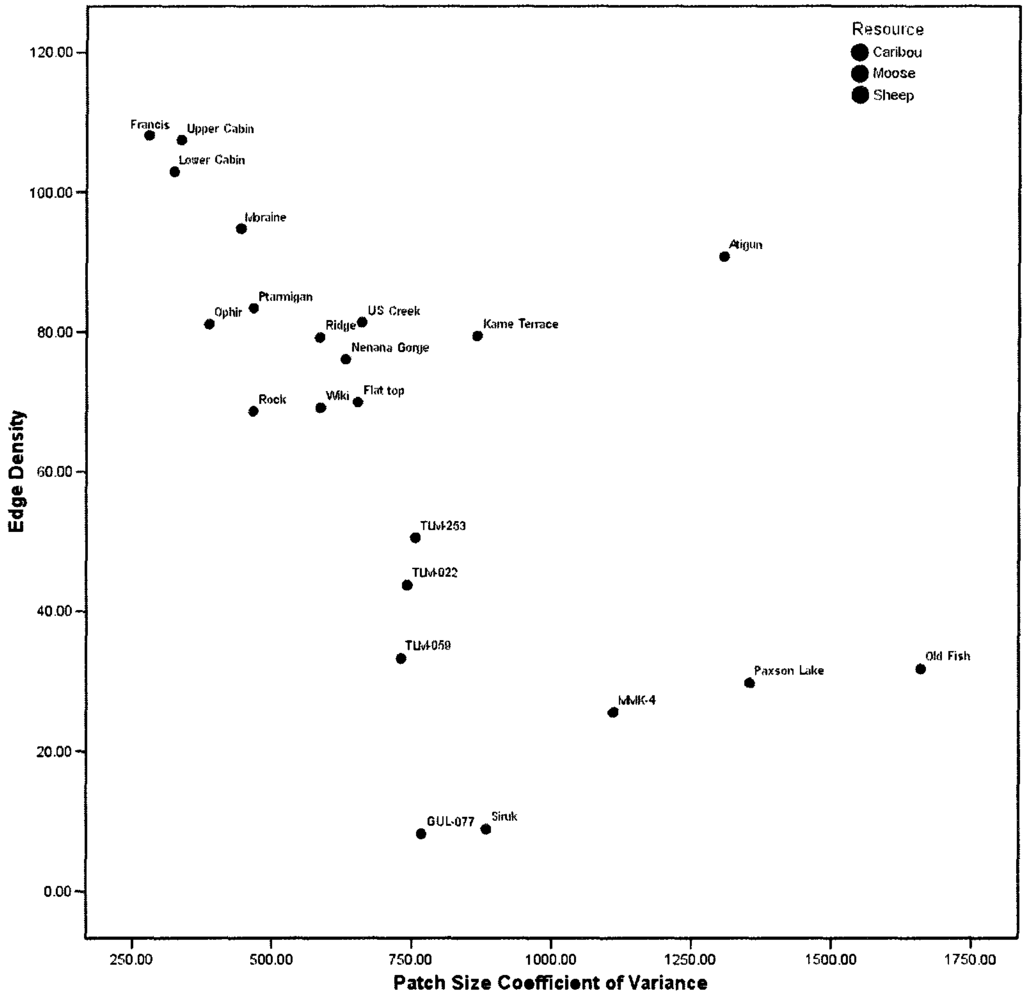


Figure 8.4. Scatter Plot of Protohistoric and Study Cases by Edge Density and Patch Size Covariance.

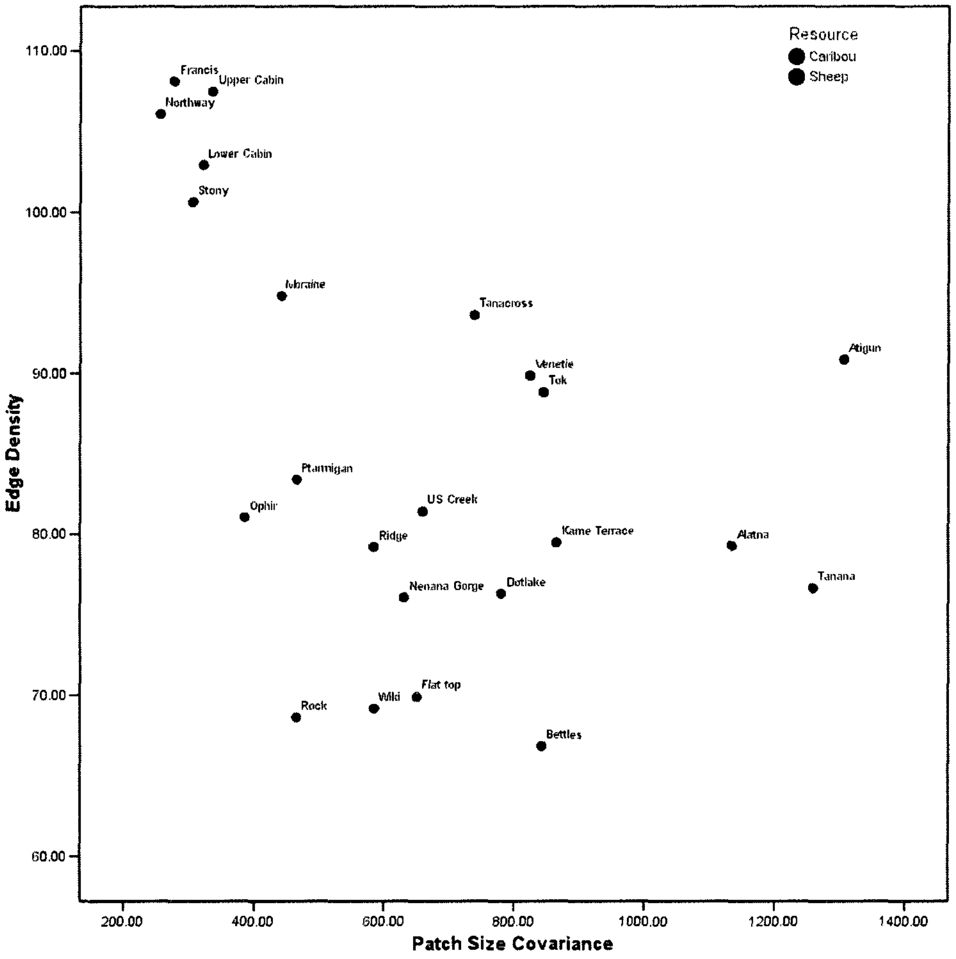


Figure 8.5. Scatter Plot of Relevant Modern, Protohistoric, and Study Cases by Edge Density and Patch Size Covariance.

that the Cabin and Francis site groups, and probably the Moraine case as well, are more closely related to sheep hunting ranges.

Spatial Analysis

Spatial analysis, in one form or another, has been part of the archaeological repertoire since archaeologists first plotted site locations and artifacts on maps (Daniel 1964; Renfrew 1983). Even before the revolution of the New Archaeology of the 1960s, spatial analyses were an important component of settlement pattern studies beginning as early as the late 1930s (see

Braidwood 1937). A proto-spatial paradigm in archeology, particularly in the New World, came to prominence through the efforts of Gordon Willey (1953) in Peru and subsequent studies by others spanning much of the globe (e.g., Adams 1961 & 1965; Bluhm 1960; Carneiro 1960; Chang 1962; Dittert et al. 1961; Herold 1961; Jones 1960, 1961a & b; Million 1964; Ritchie 1961; Sanders 1956 & 1960; Trigger 1967).

With the dawn of the New Archaeology and its focus on quantification, a spatial archaeology developed that subsumed settlement pattern studies and catchment studies (e.g., Vita-Finzi and Higgs 1970) aimed at studying "the spatial consequences of former hominid activity patterns within and between features and structures and their articulation within sites, site systems, and their environments. . . (Clarke 1977:9)." Spatial analysis in archaeology drew heavily from geography, incorporating many of its models and theoretical stances (e.g., Haggett 1965; Hodder and Orton 1976), but also from early manifestations of behavioral ecology and economic spatial theory. Rudimentary spatial statistics and analyses, such as the nearest neighbor index and point pattern analysis, were applied to a host of archaeological phenomena.

Through the 1980s, quantitative spatial analyses fell by the wayside due in part to the large time commitment to analyzing the copious amounts of data necessary and the lack luster results of many of the available spatial statistics. In the 1990s, however, two major advances began bringing spatial analysis back to a more prominent position in the discipline. First, the availability of computers and GIS software made it possible for many archaeologists to have access to the hardware, software, and processing power necessary to analyze complex spatial data sets. The second advancement consists of the development of a new generation of spatial statistics focused on generating local measures of indices from global statistics such as Moran's I and Geary's C developed in the early 1950s (these global indices never found a foothold in archaeological applications until the 1990s). The development of local versions of spatial autocorrelation indices, such as Anselin's Local Moran's I and G*I, are beginning to creep into archaeological spatial analyses (e.g., Fletcher 2008; Niknami and Amirkhiz 2008; Premo 2004).

The univariate and multivariate versions of the Local Moran's I statistics make it possible to compare the landscape metrics to hunting and processing tool kits in the Wiki Peak study area to assess the reliability of the results obtained from the discriminant classification functions for resource distribution and hunting ranges.

Anselin's Local Moran's I_i

The global Moran's I and its local variant, Anselin's Local Moran's I_i, are measures of spatial autocorrelation: the global statistic presents a general trend of spatial autocorrelation and the local variant makes it possible to examine the clusters of similar values that account for the global measure (Fotheringham et al. 2000:101-102). Spatial autocorrelation refers to the spatial arrangement of values of a single variable measured at either an interval or a ratio level. A datum consisting of particularly high value that occurs near other data points with similar high values, or data consisting of low values occurring near one another, constitutes positive spatial autocorrelation. Where high and low values co-occur in close proximity, the data represent negative spatial autocorrelation and are commonly considered spatial outliers. Local Moran's I_i allows for the observation of where in the spatial distribution of data that positive and negative spatial autocorrelation occur.

This analysis utilized GeoDa ver. 0.9.3 software for data processing. Used in this platform the univariate Local Moran's I_i is calculated as

$$I_i = z_i \sum_j w_{ij} z_j \qquad 8.1$$

where w_{ij} is the elements of the spatial weight matrix W between points i and j, z_i and z_j are the standardized observations, or values (deviation from the mean), for sites i and j, and the summation over j portrays the inclusion of only the neighboring values ($j \in J_i$). The multivariate local Moran's statistic for the i^{th} site is defined as

$$I_{kl}^{i} = z_k^{i} \sum_j w_{ij} z_j^{i} \qquad 8.2$$

where w_{ij} is the elements of the spatial weight matrix W between points i and j, z_k^i and z_j^i are the standardized observations sites i and j, and the summation over j portrays the inclusion of only the neighboring values ($j \in J_i$). There are multiple ways to calculate w_{ij}, though in this analysis w_{ij} is simply the distance between point i and j measured using Euclidian distance where $j \in J_i$, $J_i = 10$, and $j \neq i$.

The interpretation of the Ii statistic is relatively straight forward, but one must take into account the distance or neighborhood matrix, the alpha level, and the base data used in calculating the statistic in the first place. Generally, a positive Ii value indicates that location *i* is surrounded by similar values, either high or low and a negative Ii value indicates that location I is surround be dissimilar values. The higher the Ii value, the more similar the values surrounding a given point (Anselin 1994:10; Mitchell 2005:167-168).

As with many statistical endeavors, once a value is obtained the immediate question that arises is: "What is the probability that a spatial pattern as extreme as the one observed could have arisen by chance (Fotheringham et al. 2000:204)?" For most spatial statistics, and in particular in the GeoDa software, this question is best addressed by developing experimental data distributions through a permutation method. The experimental distribution, as per Fotheringham et al. (2000:204), consists of

1. Calculating I for the observed distribution of the attribute x and calling it I^*.
2. Randomly reassigning the n data values across the n spatial units.
3. Calculating I for the new spatial distribution of the attribute x and storing it.
4. Repeating steps 2 and 3 between 99 and, preferably, 999 times.

The resulting experimental distribution of I allows for comparison to the value of I*. By proportionally comparing I to I*, it is possible to provide an estimate, or probability, that the value of Ii as high as Ii* randomly arisen. In this analysis, I used 999 permutations for inferential purposes.

The GeoDa software allows for the calculation of I, p, and cluster membership based on the results of the permutations. Cluster membership consists of two clusters that have a positive spatial autocorrelation and two that do not (Aneslin 2005). The two positive autocorrelation groups consist of cases with high I values surrounded by neighbors with similar values (referred to as HH) and cases with low I values surrounded by neighbors also with low values (referred to LL). Cases with negative autocorrelation, or spatial outliers, consist of those with high I values surround by low I values (HL) or cases with low I values with neighbors with high I values (LH). When a case and its neighbors do not fall into one of these clusters, they are not spatially autocorrelated and, as such, are akin to being randomly distributed.

This analysis consists of determining spatial autocorrelation for the distribution of projectile points, bifaces, and scrapers, in and of themselves and in relation to the two variables (ED & PSCOV) used in the discriminant classification function. I conducted the analysis at two probability levels. The more restrictive probability scale ($p<= 0.001$) results in identifying the core clusters (Anselin 2005). The less restrictive probability ($p<=0.05$) identifies general trends in the data by expanding the core clusters to their neighbor cases. The purpose behind this analysis is to determine if any of the tool types, which are commonly associated with hunting and processing, are more likely to be associated with one of the two variables used in the classification function.

Working Hypotheses

Based on the results of the classification of the hunting territories for the Wiki Peak area and previous interpretations of land use in the central portion of the project area (Patterson 2008), I developed a set of working hypothesis to test the relationship between formal chipped stone tool types and their distribution across the study area. The hypotheses assume that ED is the diagnostic variable in predicting prey choice and is indirectly relates to PSCOV. Based on these assumptions the working hypotheses include:

1. If sheep were the targeted prey, then projectile points should be positively autocorrelated in HH clusters with sites with viewsheds with higher edge densities.
2. Alternatively, if projectile points are associated with sites with more variable patch sizes (i.e. higher PSCOV), the likelihood of sheep being the sought prey animal is less likely.
3. Scrapers represent more process oriented activities and not acquisition activities. If locations with HH projectile point clusters served exclusively as hunting stands or lookouts, it may be expected that scrapers should not co-occur with these clusters in a meaningful and predictable manner and not be positively spatially autocorrelated with same locations as the projectile point clusters.

Results

Core Clusters-Projectile Points

The mapped distributions of cluster types and Ii values for projectile points and their autocorrelation with the ED and PSCOV metrics are given in Figure 8.6 and Table 8.4. The distribution of projectile points in the study area, irrespective of any other variables, shows very little autocorrelation. A single site in the Upper Cabin Creek group is classified as a spatial outlier having a significantly higher Ii value than its neighbors. Despite the apparent groupings of

Table 8.4. Univariate and Multivariate LISA Results for Projectile Points, Edge Density and Patch Size Covariance.

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Proj. Point (PP) Ii	PP Cluster	PP Probability	PP/ED Ii	PP/ED Cluster	PP/ED Probability	PP/PSCOV Ii	PP/PSCOV Cluster	PP/PSCOV Probability
38	83.42	465.20	1.558713	1	0.014	-2.596573	3	0.001	2.740604	1	0.001
284	102.94	322.00	-0.177205	0	0.058	-0.204247	1	0.024	0.214816	3	0.014
285	102.94	322.00	-0.286224	0	0.483	1.053398	4	0.02	-1.167272	2	0.01
286	102.94	322.00	-0.286224	0	0.471	1.053398	4	0.015	-1.167272	2	0.007
287	102.94	322.00	0.061798	0	0.458	-0.227438	4	0.016	0.252025	2	0.008
288	102.94	322.00	-0.655211	4	0.001	1.053398	4	0.017	-1.167272	2	0.003
289	102.94	322.00	-0.017869	0	0.366	-0.227438	1	0.014	0.252025	3	0.005
290	102.94	322.00	-0.017869	0	0.377	-0.227438	1	0.014	0.252025	3	0.006
291	102.94	322.00	-0.655211	4	0.001	1.053398	4	0.016	-1.167272	2	0.004
292	102.94	322.00	-0.017869	0	0.361	-0.227438	1	0.019	0.252025	3	0.006
293	102.94	322.00	0.061798	0	0.467	-0.227438	4	0.015	0.252025	2	0.006
294	102.94	322.00	0.061798	0	0.44	-0.227438	4	0.01	0.252025	2	0.006
295	102.94	322.00	0.141466	0	0.18	-0.204247	4	0.028	0.214816	2	0.029
296	102.94	322.00	0.141466	0	0.177	-0.227438	4	0.015	0.252025	2	0.008
297	102.94	322.00	0.141466	0	0.192	-0.227438	4	0.009	0.252025	2	0.003
298	102.94	322.00	0.061798	0	0.411	-0.227438	4	0.011	0.252025	2	0.004
299	102.94	322.00	0.061798	0	0.286	-0.227438	4	0.01	0.252025	2	0.005
300	102.94	322.00	0.061798	0	0.283	-0.227438	4	0.016	0.252025	2	0.009
301	102.94	322.00	0.061798	0	0.473	-0.227438	4	0.008	0.252025	2	0.006
302	102.94	322.00	-0.655211	4	0.001	1.053398	4	0.014	-1.167272	2	0.006
303	102.94	322.00	-0.017869	0	0.365	-0.227438	1	0.019	0.252025	3	0.008
304	102.94	322.00	-0.017869	0	0.372	-0.227438	1	0.016	0.252025	3	0.008
305	102.94	322.00	-0.017869	0	0.315	-0.227438	1	0.013	0.252025	3	0.004
306	94.84	442.00	0.451751	0	0.159	0.194082	3	0.349	0.211421	1	0.339
307	102.94	322.00	0.061798	0	0.263	-0.227438	4	0.009	0.252025	2	0.007
308	102.94	322.00	0.061798	0	0.433	-0.227438	4	0.017	0.252025	2	0.005
309	102.94	322.00	0.061798	0	0.443	-0.227438	4	0.015	0.252025	2	0.008
310	102.94	322.00	0.061798	0	0.389	-0.227438	4	0.019	0.252025	2	0.007
311	102.94	322.00	0.141466	0	0.189	-0.227438	4	0.014	0.252025	2	0.004

Table 8.4. Univariate and Multivariate LISA Results for Projectile Points, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Proj. Point (PP) Ii	PP Cluster	PP Probability	PP/ED Ii	PP/ED Cluster	PP/ED Probability	PP/PSCOV Ii	PP/PSCOV Cluster	PP/PSCOV Probability
312	102.94	322.00	0.141466	0	0.176	-0.227438	4	0.021	0.252025	2	0.007
313	102.94	322.00	0.141466	0	0.171	-0.227438	4	0.015	0.252025	2	0.008
314	102.94	322.00	0.141466	0	0.183	-0.227438	4	0.014	0.252025	2	0.005
315	102.94	322.00	0.141466	0	0.187	-0.227438	4	0.014	0.252025	2	0.006
316	102.94	322.00	0.141466	0	0.19	-0.227438	4	0.011	0.252025	2	0.006
317	102.94	322.00	0.141466	0	0.184	-0.227438	4	0.01	0.252025	2	0.006
318	102.94	322.00	0.141466	0	0.167	-0.227438	4	0.012	0.252025	2	0.008
319	102.94	322.00	0.141466	0	0.164	-0.227438	4	0.011	0.252025	2	0.008
320	102.94	322.00	-0.017869	0	0.365	-0.227438	1	0.01	0.252025	3	0.007
321	102.94	322.00	-0.017869	0	0.289	-0.227438	1	0.019	0.252025	3	0.01
322	94.84	442.00	-0.177205	0	0.111	-0.041904	3	0.391	-0.045648	1	0.306
323	94.84	442.00	-0.177205	0	0.057	-0.041904	3	0.414	-0.045648	1	0.317
324	94.84	442.00	-0.177205	3	0.045	-0.065096	3	0.274	-0.008439	1	0.45
325	94.84	442.00	-0.017869	0	0.292	-0.088288	3	0.243	0.02877	1	0.404
326	94.84	442.00	-0.177205	3	0.05	-0.065096	3	0.301	-0.008439	1	0.478
327	94.84	442.00	0.451751	0	0.185	0.194082	3	0.375	0.211421	1	0.345
328	94.84	442.00	1.818681	0	0.066	0.66809	3	0.291	0.086608	1	0.439
329	94.84	442.00	-0.33654	3	0.006	-0.065096	3	0.314	-0.008439	1	0.44
330	102.94	322.00	0.061798	0	0.45	-0.227438	4	0.019	0.252025	2	0.007
331	102.94	322.00	0.061798	0	0.395	-0.227438	4	0.016	0.252025	2	0.01
332	79.24	584.40	0.141466	0	0.206	0.451136	2	0.001	-0.561613	4	0.001
333	79.24	584.40	0.061798	0	0.299	0.451136	2	0.001	-0.561613	4	0.001
334	79.24	584.40	0.061798	0	0.267	0.451136	2	0.001	-0.561613	4	0.001
335	79.24	584.40	0.061798	0	0.276	0.315421	2	0.002	-0.398885	4	0.002
336	79.24	584.40	-0.017869	0	0.281	0.451136	3	0.001	-0.561613	1	0.001
337	79.24	584.40	-0.017869	0	0.282	0.451136	3	0.001	-0.561613	1	0.001
338	79.24	584.40	0.061798	0	0.287	0.451136	2	0.001	-0.561613	4	0.001
339	79.24	584.40	-0.017869	0	0.361	0.383278	3	0.002	-0.480249	1	0.001
340	79.24	584.40	0.820738	0	0.091	-2.089471	3	0.001	2.601155	1	0.001

Table 8.4. Univariate and Multivariate LISA Results for Projectile Points, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Proj. Point (PP) Ii	PP Cluster	PP Probability	PP/ED Ii	PP/ED Cluster	PP/ED Probability	PP/PSCOV Ii	PP/PSCOV Cluster	PP/PSCOV Probability
341	79.24	584.40	0.284029	0	0.207	-7.170683	3	0.001	8.926691	1	0.001
342	79.24	584.40	1.189726	1	0.028	-2.089471	3	0.001	2.601155	1	0.001
343	79.24	584.40	0.061798	0	0.371	0.451136	2	0.001	-0.561613	4	0.001
344	79.24	584.40	-0.256873	3	0.024	0.451136	3	0.001	-0.561613	1	0.001
345	79.24	584.40	1.189726	1	0.031	-2.089471	3	0.001	2.601155	1	0.001
346	79.24	584.40	0.061798	0	0.456	0.451136	2	0.001	-0.561613	4	0.001
347	79.24	584.40	-0.256873	3	0.012	0.451136	3	0.001	-0.561613	1	0.001
348	79.24	584.40	-0.33654	3	0.009	0.451136	3	0.001	-0.561613	1	0.001
373	69.92	651.50	-0.33654	3	0.016	0.533939	3	0.001	-0.570915	1	0.001
374	69.92	651.50	-0.33654	3	0.012	0.545907	3	0.001	-0.607876	1	0.001
375	69.92	651.50	-0.33654	3	0.015	0.545907	3	0.001	-0.607876	1	0.001
376	69.92	651.50	-0.33654	3	0.015	0.501241	3	0.001	-0.563722	1	0.001
377	83.42	465.20	0.082764	0	0.277	-1.447238	3	0.004	1.419213	1	0.01
378	83.42	465.20	-0.097537	0	0.21	0.350524	3	0.002	-0.357366	1	0.002
379	108.13	277.70	0.141466	0	0.179	-0.376037	4	0.001	0.389388	2	0.001
380	108.13	277.70	0.141466	0	0.184	-0.376037	4	0.001	0.389388	2	0.001
381	108.13	277.70	0.141466	0	0.163	-0.376037	4	0.001	0.389388	2	0.001
382	108.13	277.70	0.141466	0	0.184	-0.376037	4	0.001	0.389388	2	0.001
383	108.13	277.70	0.141466	0	0.183	-0.376037	4	0.001	0.389388	2	0.001
384	108.13	277.70	0.141466	0	0.171	-0.376037	4	0.001	0.389388	2	0.001
385	108.13	277.70	0.141466	0	0.158	-0.376037	4	0.001	0.389388	2	0.001
386	102.94	322.00	0.061798	0	0.415	-0.227438	4	0.018	0.252025	2	0.008
387	102.94	322.00	0.061798	0	0.419	-0.227438	4	0.016	0.252025	2	0.006
388	102.94	322.00	0.061798	0	0.409	-0.227438	4	0.014	0.252025	2	0.005
389	102.94	322.00	0.061798	0	0.286	-0.227438	4	0.018	0.252025	2	0.006
390	102.94	322.00	0.061798	0	0.3	-0.227438	4	0.015	0.252025	2	0.011
391	102.94	322.00	0.141466	0	0.181	-0.227438	4	0.015	0.252025	2	0.005
392	102.94	322.00	0.141466	0	0.17	-0.227438	4	0.008	0.252025	2	0.005
393	102.94	322.00	0.141466	0	0.182	-0.253551	4	0.003	0.243466	2	0.01

Table 8.4. Univariate and Multivariate LISA Results for Projectile Points, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Proj. Point (PP) Ii	PP Cluster	PP Probability	PP/ED Ii	PP/ED Cluster	PP/ED Probability	PP/PSCOV Ii	PP/PSCOV Cluster	PP/PSCOV Probability
394	107.5	335.80	0.061798	0	0.41	-0.292719	4	0.001	0.230629	2	0.014
395	107.5	335.80	0.061798	0	0.379	-0.292719	4	0.001	0.230629	2	0.016
396	107.5	335.80	0.061798	0	0.394	-0.292719	4	0.002	0.230629	2	0.01
397	107.5	335.80	-0.655211	4	0.001	1.35575	4	0.001	-1.068178	2	0.017
398	69.92	651.50	0.082764	0	0.472	-1.444453	3	0.004	1.387618	1	0.004
399	68.65	465.00	0.061798	0	0.386	-0.079211	2	0.281	0.215095	4	0.02
400	68.65	465.00	0.061798	0	0.41	-0.079211	2	0.261	0.215095	4	0.03
401	68.65	465.00	0.061798	0	0.442	-0.008462	2	0.471	0.156955	4	0.086
402	69.92	585.60	-0.256873	3	0.02	0.53119	3	0.001	-0.562729	1	0.001
403	69.92	585.60	-0.256873	3	0.017	0.53119	3	0.001	-0.562729	1	0.001
404	69.92	585.60	-0.256873	3	0.029	0.53119	3	0.001	-0.562729	1	0.001
405	69.92	585.60	-0.256873	3	0.018	0.53119	3	0.001	-0.562729	1	0.001
406	108.13	277.70	0.141466	0	0.172	-0.376037	4	0.001	0.389388	2	0.001
407	108.13	277.70	0.141466	0	0.174	-0.376037	4	0.001	0.389388	2	0.001
408	108.13	277.70	0.141466	0	0.177	-0.337986	4	0.001	0.338443	2	0.001
409	108.13	277.70	0.141466	0	0.197	-0.376037	4	0.001	0.389388	2	0.001
410	102.94	322.00	0.141466	0	0.181	-0.227438	4	0.014	0.252025	2	0.007
411	102.94	322.00	0.141466	0	0.197	-0.253551	4	0.005	0.243466	2	0.011
412	107.5	335.80	0.061798	0	0.427	-0.292719	4	0.003	0.230629	2	0.012
413	107.5	335.80	0.061798	0	0.484	-0.292719	4	0.001	0.230629	2	0.018

Cluster Type: 1=HH; 2=LL; 3=LH; and 4=HL.

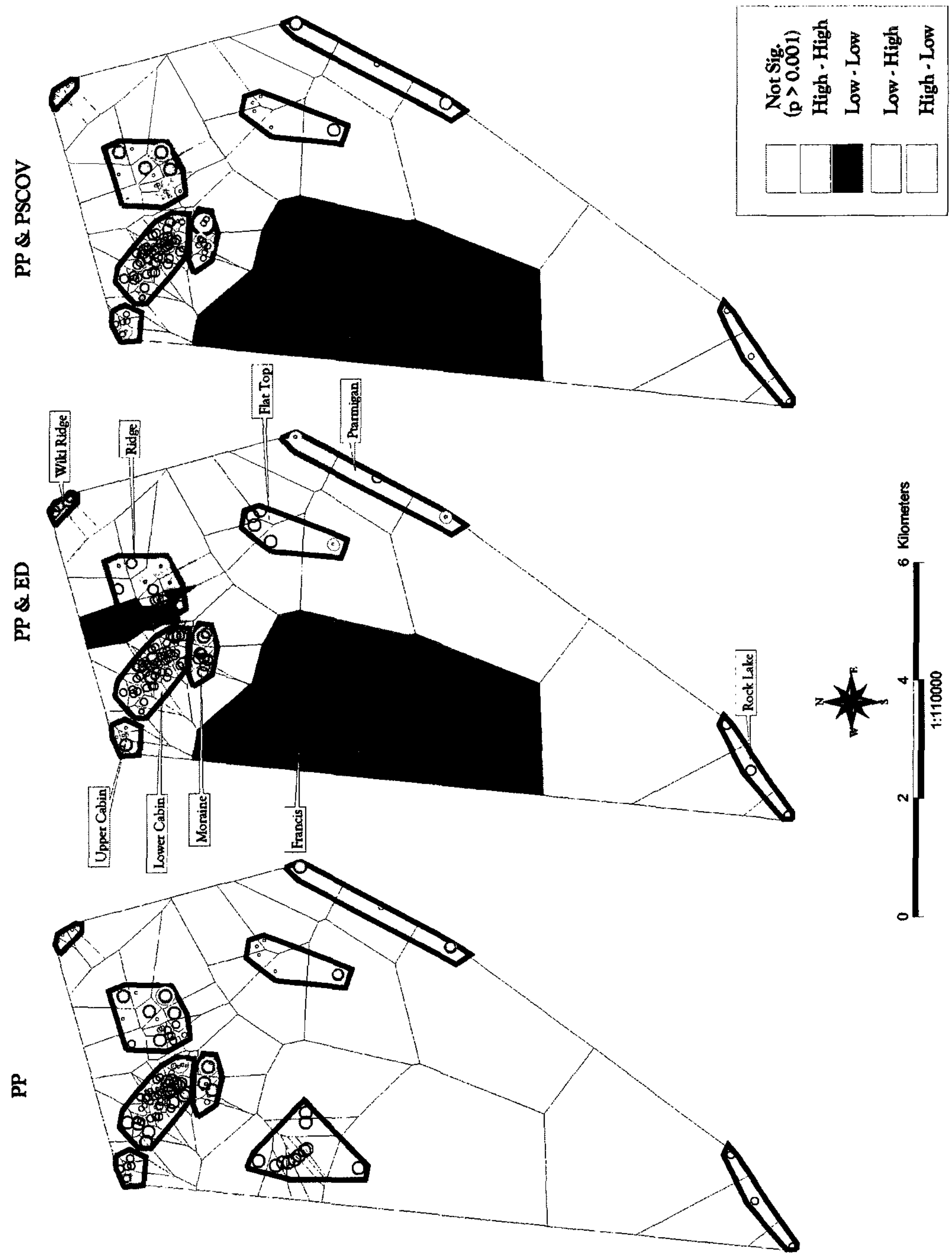


Figure 8.6. Comparison of Local Moran's I Core Cluster Membership for Projectile Points, Projectile Points/ED, and Projectile Points/PSCOV. Permutations=999. Probability = 0.001. Gray Circles Represent Sites with Projectile Points. Open Circles Represent Proportionally Scaled I Values.

projectile points in the Moraine, Ridge, and Lower Cabin Creek groups, none is spatially autocorrelated either positively or negatively. This result suggests that projectile points are randomly distributed throughout the project area and that the presence of a point at one site has no effect on the probability that neighboring sites will also have projectile points. When a multivariate solution is examined, however, a different pattern emerges.

Comparing the point distribution with edge density provides a different picture than examining projectile points alone. At the strict alpha level (p=0.001) used to define core clusters several clusters become apparent. A HH cluster, consisting appears in the Lower Cabin Creek Group, however, most of the points in this group are still randomly distributed with regards to edge density. Two LL clusters occur in the Francis Creek and Ridge groups. In the case of the Francis Creek group, the LL cluster reflects a complete lack of projectile points but a high edge density. The LL cluster in the Ridge group is more complex. Here, the LL cluster forms a divide between sites on the ridge and sites in the Lower Cabin Creek group with projectile points. In this case, the sites in cluster lack projectile points and have viewsheds with low edge densities. The final cluster type indentified in regards to the relationship between points and ED is a LH clustering that occurs in the Ridge, Wiki Ridge, and Ptarmigan Lake groups. The Wiki Ridge cluster reflects an absence of projectile points and a low ED value. The nearest neighbors of the Wiki Ridge group, which occur on the ridge, however considerably affect the Ii values for these four sites. Sites with projectile points in the Ridge group are negatively autocorrelated with edge density and surrounded by Ii values that are considerably higher (above 0). The same general trend is apparent for one site (XMC-038) in the Ptarmigan Lake group.

The cluster patterning identified in the autocorrelation between projectile points and PSCOV is inversed to the pattern found with ED, but the cluster types reflect stronger autocorrelation in some groups. Relative to PSCOV, no clusters occur in either the Upper or Lower Cabin Creek groups indicating no relationship between the points and the metric in these cases. Also lost is any autocorrelation in the Wiki Ridge group. The Francis group retains its LL cluster membership, but reflects the absence of projectile points and low PSCOV for this neighborhood. The sites with projectile points in the Ridge group and the one site in the Ptarmigan Lake group are positively autocorrelated with PSCOV. The majority of the sites without points in the ridge group occur in the HL cluster group indicating a high PSCOV relative to its neighbors with and without points in the Lower Cabin group. Again, this portion of the Ridge Group forms a distinct divide between the two most populous site groups.

Core Clusters-Bifaces

At the level of the core cluster, bifaces identified in the study area show some level of clustering (Table 8.5 and Figure 8.7). As singular phenomena, bifaces show little spatial autocorrelation. The only clustering identified is a single site in the Upper Wiki Peak group clustered as a spatial outlier (HL). None of the sites with bifaces in the remaining groups show any correlation even though some groups, such as Lower Cabin Creek, contain relatively high densities of this tool type. Clustering is more readily apparent when contrasting bifaces with ED and PSCOV.

The LISA resulted in the identification of three cluster types when correlating bifaces and ED. The only positive autocorrelation occur in the Ridge and Wiki Ridge Group where several sites were grouped into the LL cluster. Surrounding sites in the same group either grouped into a LH cluster or were neither positively or negatively autocorrelated. As with points and edge density, the clustering of the Wiki Ridge Group as LL has to do with more with nearest neighbors and the low ED values, as no bifaces occurred in any of these sites. Other LH clusters begin to appear in the Ptarmigan Lake and Flat Top Groups. High-Low clusters occur in the Upper Cabin Creek and Francis Creek Groups.

Slightly stronger (i.e. positive) autocorrelation occurs when considering bifaces and PSCOV simultaneously. The Francis Creek Group is clustered as LL and three HH clusters can be observed in the Ridge, Flat Top, and Ptarmigan Lake Groups. Admittedly, each of the HH clusters consists of a single site at the 0.001 alpha level. The most inclusive cluster occurs includes a HL cluster of sites in the Ridge Group. These outliers strongly influence the HH cluster in the same group. The differences between clustering in the ED and PSCOV are again imperfectly inversed.

Table 8.5. Univariate and Multivariate LISA Results for Bifaces,

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Biface (BF) Ii	BF Cluster	Biface Probability
38	83.42	465.2	0.179826	0	0.266
284	102.94	322	-0.116807	0	0.151
285	102.94	322	-0.069375	0	0.231
286	102.94	322	0.029503	0	0.273
287	102.94	322	-0.045659	0	0.299
288	102.94	322	0.014179	0	0.354
289	102.94	322	0.029503	0	0.277
290	102.94	322	-0.069375	0	0.205
291	102.94	322	0.104665	0	0.304
292	102.94	322	-0.069375	0	0.204
293	102.94	322	-0.045659	0	0.272
294	102.94	322	-0.045659	0	0.297
295	102.94	322	-0.045659	0	0.272
296	102.94	322	-0.330252	3	0.019
297	102.94	322	-0.16424	0	0.109
298	102.94	322	-1.812326	0	0.239
299	102.94	322	-0.28282	3	0.034
300	102.94	322	-0.28282	3	0.018
301	102.94	322	0.182745	1	0.032
302	102.94	322	-0.045659	0	0.262
303	102.94	322	-0.062443	0	0.163
304	102.94	322	0.096638	0	0.216
305	102.94	322	-0.069375	0	0.222
306	94.84	442	0.014179	0	0.357
307	102.94	322	-0.527278	0	0.329
308	102.94	322	-0.093091	0	0.17
309	102.94	322	-0.187956	0	0.086
310	102.94	322	0.0503	0	0.339
311	102.94	322	-0.184307	0	0.458
312	102.94	322	-0.093091	0	0.172
313	102.94	322	-0.093091	0	0.189

ED, and PSCOV.

BF/ ED Ii	BF/ED Cluster	BF/ED Probability	BF/ PSCOV Ii	BF/ PSCOV Cluster	BF/ PSCOV Probability
-2.228222	3	0.001	2.35182	1	0.001
-0.206118	1	0.029	0.216783	3	0.025
-0.229522	1	0.015	0.254333	3	0.003
0.148306	1	0.02	-0.164338	3	0.002
-0.229522	1	0.013	0.254333	3	0.007
0.148306	1	0.013	-0.164338	3	0.006
0.148306	1	0.014	-0.164338	3	0.003
-0.229522	1	0.01	0.254333	3	0.007
0.526134	1	0.012	-0.58301	3	0.004
-0.229522	1	0.015	0.254333	3	0.007
-0.229522	1	0.013	0.254333	3	0.002
-0.229522	1	0.015	0.254333	3	0.008
-0.206118	1	0.026	0.216783	3	0.025
-0.229522	1	0.013	0.254333	3	0.01
-0.229522	1	0.012	0.254333	3	0.006
4.304416	4	0.012	-4.769727	2	0.007
-0.229522	1	0.015	0.254333	3	0.008
-0.229522	1	0.014	0.254333	3	0.006
0.148306	1	0.009	-0.164338	3	0.009
-0.229522	1	0.019	0.254333	3	0.01
0.148306	4	0.012	-0.164338	2	0.004
-0.229522	4	0.012	0.254333	2	0.005
-0.229522	1	0.01	0.254333	3	0.01
0.027325	3	0.383	0.029766	1	0.34
1.659619	4	0.013	-1.839025	2	0.006
-0.229522	1	0.016	0.254333	3	0.009
-0.229522	1	0.016	0.254333	3	0.007
0.526134	1	0.014	-0.58301	3	0.006
1.659619	4	0.012	-1.839025	2	0.008
-0.229522	1	0.009	0.254333	3	0.01
-0.229522	1	0.016	0.254333	3	0.008

Table 8.5. Univariate and Multivariate LISA Results for Bifaces, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Biface (BF) Ii	BF Cluster	Biface Probability	BF/ ED Ii	BF/ED Cluster	BF/ED Probability	BF/ PSCOV Ii	BF/ PSCOV Cluster	BF/ PSCOV Probability
314	102.94	322	-0.093091	0	0.166	-0.229522	1	0.018	0.254333	3	0.004
315	102.94	322	-0.045659	0	0.257	-0.229522	1	0.017	0.254333	3	0.004
316	102.94	322	-0.093091	0	0.178	-0.229522	1	0.018	0.254333	3	0.007
317	102.94	322	-0.100388	0	0.496	0.903963	4	0.015	-1.001682	2	0.007
318	102.94	322	-0.093091	0	0.178	-0.229522	1	0.011	0.254333	3	0.007
319	102.94	322	-0.021943	0	0.346	-0.229522	1	0.016	0.254333	3	0.007
320	102.94	322	-0.045659	0	0.321	-0.229522	1	0.014	0.254333	3	0.006
321	102.94	322	0.001773	0	0.454	-0.229522	4	0.013	0.254333	2	0.007
322	94.84	442	-0.045659	0	0.305	-0.042288	3	0.352	-0.046066	1	0.321
323	94.84	442	-0.045659	0	0.279	-0.042288	3	0.367	-0.046066	1	0.337
324	94.84	442	-0.045659	0	0.29	-0.065692	3	0.304	-0.008516	1	0.478
325	94.84	442	0.049205	0	0.445	-0.089096	2	0.236	0.029034	4	0.429
326	94.84	442	-0.045659	0	0.311	-0.065692	3	0.312	-0.008516	1	0.457
327	94.84	442	-0.045659	0	0.312	-0.042288	3	0.357	-0.046066	1	0.355
328	94.84	442	-1.016924	0	0.138	0.691284	2	0.287	0.089614	4	0.465
329	94.84	442	-0.069375	0	0.198	-0.065692	3	0.278	-0.008516	1	0.442
330	102.94	322	-0.069375	0	0.203	-0.229522	1	0.01	0.254333	3	0.004
331	102.94	322	-0.069375	0	0.185	-0.229522	1	0.015	0.254333	3	0.005
332	79.24	584.4	-0.275888	4	0.041	-1.043615	2	0.002	1.299183	4	0.001
333	79.24	584.4	0.049205	0	0.47	0.455268	2	0.001	-0.566758	4	0.001
334	79.24	584.4	-0.047118	0	0.306	-0.294173	2	0.001	0.366213	4	0.001
335	79.24	584.4	0.072921	0	0.307	0.31831	2	0.001	-0.40254	4	0.001
336	79.24	584.4	0.025489	0	0.486	0.455268	2	0.001	-0.566758	4	0.001
337	79.24	584.4	0.025489	0	0.475	0.455268	2	0.001	-0.566758	4	0.001
338	79.24	584.4	0.049205	0	0.446	0.455268	2	0.001	-0.566758	4	0.001
339	79.24	584.4	0.049205	0	0.453	0.386789	2	0.001	-0.484649	4	0.001
340	79.24	584.4	-0.001146	0	0.383	-0.294173	2	0.001	0.366213	4	0.001
341	79.24	584.4	-0.407238	0	0.304	-2.542499	2	0.001	3.165124	4	0.001
342	79.24	584.4	-0.021943	0	0.281	0.455268	3	0.001	-0.566758	1	0.001
343	79.24	584.4	0.025489	0	0.472	0.455268	2	0.001	-0.566758	4	0.001
344	79.24	584.4	-0.069375	0	0.236	0.455268	3	0.001	-0.566758	1	0.001

Table 8.5. Univariate and Multivariate LISA Results for Bifaces, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Biface (BF) Ii	BF Cluster	Biface Probability	BF/ ED Ii	BF/ED Cluster	BF/ED Probability	BF/ PSCOV Ii	BF/ PSCOV Cluster	BF/ PSCOV Probability
345	79.24	584.4	-0.001146	0	0.383	-0.294173	2	0.001	0.366213	4	0.001
346	79.24	584.4	0.049205	0	0.446	0.455268	2	0.001	-0.566758	4	0.001
347	79.24	584.4	0.014179	0	0.347	-0.294173	3	0.001	0.366213	1	0.001
348	79.24	584.4	-0.021943	0	0.341	0.455268	3	0.001	-0.566758	1	0.001
373	69.92	651.5	0.044827	0	0.208	-0.348167	3	0.001	0.372278	1	0.001
374	69.92	651.5	-0.069375	0	0.217	0.550908	3	0.001	-0.613445	1	0.001
375	69.92	651.5	-0.069375	0	0.211	0.550908	3	0.001	-0.613445	1	0.001
376	69.92	651.5	-0.069375	0	0.213	0.505833	3	0.001	-0.568886	1	0.001
377	83.42	465.2	-0.001146	0	0.416	-0.203754	2	0.011	0.199809	4	0.005
378	83.42	465.2	-0.001146	0	0.378	-0.228567	2	0.003	0.233029	4	0.003
379	108.13	277.7	-0.047118	0	0.269	0.245204	4	0.001	-0.253909	2	0.001
380	108.13	277.7	0.049205	0	0.414	-0.379482	4	0.001	0.392955	2	0.001
381	108.13	277.7	0.049205	0	0.419	-0.379482	4	0.001	0.392955	2	0.001
382	108.13	277.7	-0.221523	0	0.169	0.86989	4	0.001	-0.900774	2	0.001
383	108.13	277.7	-0.047118	0	0.274	0.245204	4	0.001	-0.253909	2	0.001
384	108.13	277.7	0.049205	0	0.441	-0.379482	4	0.001	0.392955	2	0.001
385	108.13	277.7	0.049205	0	0.402	-0.379482	4	0.001	0.392955	2	0.001
386	102.94	322	-0.211672	0	0.074	-0.229522	1	0.016	0.254333	3	0.008
387	102.94	322	0.121448	0	0.096	0.148306	1	0.015	-0.164338	3	0.008
388	102.94	322	0.072921	0	0.285	-0.229522	4	0.018	0.254333	2	0.009
389	102.94	322	0.096638	0	0.236	-0.229522	4	0.012	0.254333	2	0.009
390	102.94	322	0.096638	0	0.224	-0.229522	4	0.015	0.254333	2	0.005
391	102.94	322	0.096638	0	0.212	-0.229522	4	0.014	0.254333	2	0.009
392	102.94	322	0.120354	0	0.13	-0.229522	4	0.013	0.254333	2	0.004
393	102.94	322	0.120354	0	0.14	-0.255873	4	0.012	0.245697	2	0.013
394	107.5	335.8	0.120354	0	0.072	-0.2954	4	0.001	0.232742	2	0.006
395	107.5	335.8	0.120354	0	0.061	-0.2954	4	0.001	0.232742	2	0.018
396	107.5	335.8	0.120354	0	0.08	-0.2954	4	0.001	0.232742	2	0.018
397	107.5	335.8	-0.093091	4	0.001	0.190874	4	0.004	-0.150387	2	0.017
398	69.92	651.5	-0.021943	0	0.295	0.314727	3	0.002	-0.302344	1	0.007
399	68.65	465	0.001773	0	0.407	-0.079937	2	0.273	0.217065	4	0.024

Table 8.5. Univariate and Multivariate LISA Results for Bifaces, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Biface (BF) Ii	BF Cluster	Biface Probability	BF/ ED Ii	BF/ED Cluster	BF/ED Probability	BF/ PSCOV Ii	BF/ PSCOV Cluster	BF/ PSCOV Probability
400	68.65	465	-0.01647	0	0.496	0.051652	2	0.274	-0.140257	4	0.038
401	68.65	465	0.001773	0	0.382	-0.00854	2	0.49	0.158393	4	0.078
402	69.92	585.6	0.001773	0	0.381	0.536056	2	0.001	-0.567884	4	0.001
403	69.92	585.6	0.001773	0	0.364	0.536056	2	0.001	-0.567884	4	0.001
404	69.92	585.6	0.001773	0	0.344	0.536056	2	0.001	-0.567884	4	0.001
405	69.92	585.6	0.001773	0	0.388	0.536056	2	0.001	-0.567884	4	0.001
406	108.13	277.7	0.049205	0	0.46	-0.379482	4	0.001	0.392955	2	0.001
407	108.13	277.7	0.049205	0	0.445	-0.379482	4	0.001	0.392955	2	0.001
408	108.13	277.7	0.049205	0	0.424	-0.341082	4	0.001	0.341543	2	0.001
409	108.13	277.7	0.049205	0	0.468	-0.379482	4	0.001	0.392955	2	0.001
410	102.94	322	0.120354	0	0.128	-0.229522	4	0.01	0.254333	2	0.01
411	102.94	322	0.120354	0	0.151	-0.255873	4	0.01	0.245697	2	0.008
412	107.5	335.8	0.120354	0	0.076	-0.2954	4	0.002	0.232742	2	0.023
413	107.5	335.8	0.120354	0	0.086	-0.2954	4	0.002	0.232742	2	0.011

Cluster Type: 1=HH; 2=LL; 3=LH; and 4=HL.

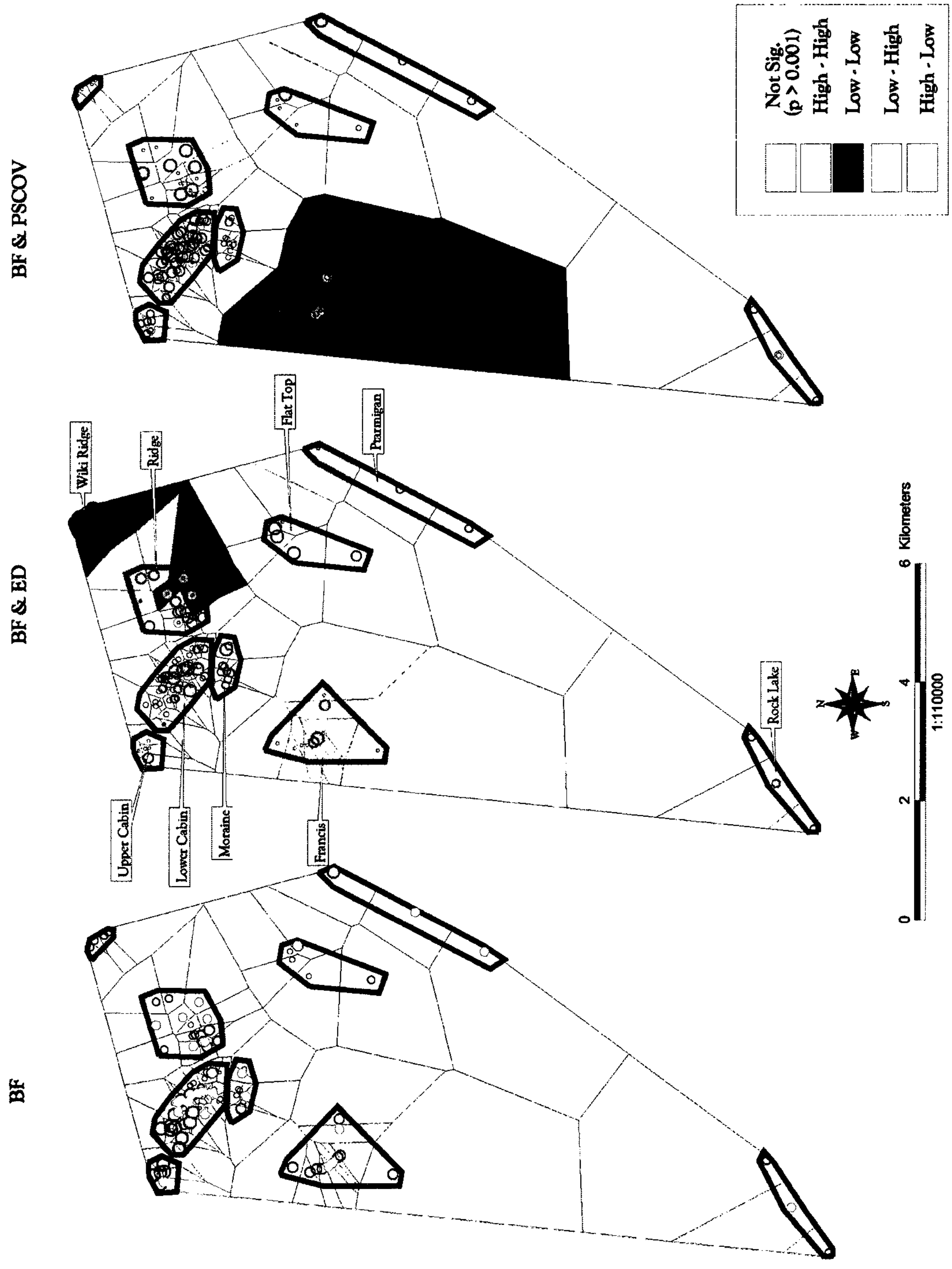


Figure 8.7. Comparison of Local Moran's I Core Cluster Membership for Bifaces, Bifaces /ED, and Bifaces /PSCOV. Permutations=999. Probability = 0.001. Gray Circles Represent Sites with Projectile Points. Open Circles Represent Proportionally Scaled I Values

Core Clusters-Scrapers

In many respects, the spatial autocorrelation and the locations for core clusters in the scraper data are similar to bifaces data (Table 8.6, Figure 8.8). The spatial distribution of scrapers shows no evidence of clustering at the high alpha level, despite the high rate of occurrence of these tools in several of the groups. With respect to ED, several clusters begin to appear. Some sites with scrapers in the Ridge, Wiki Ridge, and Ptarmigan Lake groups have LL cluster affiliations. Only one HH cluster appears on the map and is located in the Upper Cabin group, which is also associated with a HL cluster membership. A second HL cluster is in the Francis Creek group and the only other cluster at this level is a LH cluster on Flat Top. Although the general pattern in the clusters is similar to that of bifaces, several of the sites forming the clusters are not necessarily the same sites forming the clusters in the bifaces data.

The results of the LISA produced few positively autocorrelated clusters in terms of scrapers and PSCOV. The Francis Creek Group forms a tight LL cluster and a single site on Flat Top accounts for the only HH cluster at the high probability level. This latter result is clearly conditioned by the HL cluster of sites with scrapers in the Ridge Group, which forms half of the neighborhood for this particular location. A second HL cluster is evident in the Ptarmigan Lake Group.

Expanded Clusters-Projectile Points

At the more liberal alpha level, projectile points start to display evidence of being positively autocorrelated regardless of extraneous variables (Figure 8.9). Two HH clusters, one in the Ridge Group and one in the Ptarmigan Lake Group, appear. These two clusters represent the only independent positive autocorrelations identified in the study area and both occur in areas with high PSCOV and low ED values. Both the HH clusters are surrounded by LH cluster membership, which extends throughout the much of terrain throughout the study area with large viewsheds with high relative elevations. Of course, the HL clustering noted at the conservative alpha level remains at the .05 level.

Table 8.6. Univariate and Multivariate LISA Results for Scrapers, ED, and PSCOV.

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Scraper (SCRPR) Ii	SCRPR Cluster	SCRPS Probability	SCRPR/ ED Ii	SCRPR/ ED Cluster	SCRPR/ ED Probability	SCRPR/ PSCOV Ii	SCRPR/ PSCOV Cluster	SCRPR/ PSCOV Probability
38	83.42	465.2	-0.429222	0	0.321	-3.799656	2	0.001	4.010421	4	0.001
284	102.94	322	-0.204838	0	0.078	-0.255404	1	0.018	0.268621	3	0.028
285	102.94	322	-0.252176	3	0.046	-0.284405	1	0.01	0.315149	3	0.005
286	102.94	322	0.233515	0	0.065	0.324222	1	0.018	-0.35927	3	0.008
287	102.94	322	-0.062823	0	0.357	-0.284405	1	0.009	0.315149	3	0.009
288	102.94	322	-0.062823	0	0.305	-0.284405	1	0.017	0.315149	3	0.004
289	102.94	322	-0.062823	0	0.365	-0.284405	1	0.018	0.315149	3	0.009
290	102.94	322	-0.110161	0	0.193	-0.284405	1	0.012	0.315149	3	0.004
291	102.94	322	0.179549	0	0.147	0.324222	1	0.017	-0.35927	3	0.006
292	102.94	322	-0.062823	0	0.349	-0.284405	1	0.007	0.315149	3	0.008
293	102.94	322	-0.015485	0	0.44	-0.284405	1	0.016	0.315149	3	0.011
294	102.94	322	-0.062823	0	0.294	-0.284405	1	0.012	0.315149	3	0.009
295	102.94	322	-0.204838	0	0.096	-0.255404	1	0.023	0.268621	3	0.013
296	102.94	322	-0.299515	3	0.03	-0.284405	1	0.017	0.315149	3	0.01
297	102.94	322	0.031854	0	0.461	-0.284405	4	0.017	0.315149	2	0.007
298	102.94	322	-0.25975	0	0.29	0.932848	4	0.013	-1.03369	2	0.007
299	102.94	322	-0.299515	3	0.029	-0.284405	1	0.015	0.315149	3	0.011
300	102.94	322	-0.299515	3	0.029	-0.284405	1	0.017	0.315149	3	0.005
301	102.94	322	0.233515	0	0.102	0.324222	1	0.013	-0.35927	3	0.009
302	102.94	322	0.206059	0	0.332	0.932848	1	0.009	-1.03369	3	0.005
303	102.94	322	0.079192	0	0.352	-0.284405	4	0.017	0.315149	2	0.006
304	102.94	322	-0.090279	0	0.276	0.324222	4	0.016	-0.35927	2	0.007
305	102.94	322	-0.1575	0	0.133	-0.284405	1	0.022	0.315149	3	0.01
306	94.84	442	-0.110161	0	0.227	-0.0524	3	0.369	-0.057081	1	0.342
307	102.94	322	-1.227346	0	0.268	2.758727	4	0.015	-3.056948	2	0.008
308	102.94	322	-0.204838	0	0.098	-0.284405	1	0.014	0.315149	3	0.005
309	102.94	322	0.449378	1	0.009	0.324222	1	0.01	-0.35927	3	0.007
310	102.94	322	0.361329	0	0.195	0.932848	1	0.014	-1.03369	3	0.006
311	102.94	322	1.068563	0	0.187	2.758727	1	0.021	-3.056948	3	0.005
312	102.94	322	-0.346853	3	0.015	-0.284405	1	0.015	0.315149	3	0.004
313	102.94	322	-0.346853	3	0.016	-0.284405	1	0.018	0.315149	3	0.007

Table 8.6. Univariate and Multivariate LISA Results for Scrapers, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Scraper (SCRPR) Ii	SCRPR Cluster	SCRPS Probability	SCRPR/ ED Ii	SCRPR/ ED Cluster	SCRPR/ ED Probability	SCRPR/ PSCOV Ii	SCRPR/ PSCOV Cluster	SCRPR/ PSCOV Probability
314	102.94	322	-0.346853	3	0.022	-0.284405	1	0.016	0.315149	3	0.004
315	102.94	322	-0.204838	0	0.075	-0.284405	1	0.01	0.315149	3	0.009
316	102.94	322	0.287481	0	0.06	0.324222	1	0.022	-0.35927	3	0.007
317	102.94	322	0.3405	0	0.247	1.541475	1	0.012	-1.708109	3	0.007
318	102.94	322	-0.299515	3	0.039	-0.284405	1	0.015	0.315149	3	0.005
319	102.94	322	-0.1575	0	0.144	-0.284405	1	0.012	0.315149	3	0.004
320	102.94	322	-0.204838	0	0.065	-0.284405	1	0.011	0.315149	3	0.007
321	102.94	322	-0.110161	0	0.252	-0.284405	1	0.016	0.315149	3	0.007
322	94.84	442	-0.110161	0	0.195	-0.0524	3	0.355	-0.057081	1	0.323
323	94.84	442	-0.110161	0	0.207	-0.0524	3	0.364	-0.057081	1	0.325
324	94.84	442	-0.110161	0	0.256	-0.081401	3	0.306	-0.010552	1	0.429
325	94.84	442	0.017652	0	0.404	0.125857	3	0.228	-0.041013	1	0.448
326	94.84	442	-0.110161	0	0.24	-0.081401	3	0.287	-0.010552	1	0.46
327	94.84	442	0.050789	0	0.375	0.171872	3	0.376	0.187226	1	0.321
328	94.84	442	-0.598693	0	0.314	0.615388	2	0.298	0.079776	4	0.444
329	94.84	442	-0.110161	0	0.166	-0.081401	3	0.297	-0.010552	1	0.462
330	102.94	322	-0.204838	0	0.091	-0.284405	1	0.017	0.315149	3	0.007
331	102.94	322	-0.252176	0	0.065	-0.284405	1	0.009	0.315149	3	0.01
332	79.24	584.4	-0.19821	0	0.051	-0.64311	2	0.001	0.8006	4	0.001
333	79.24	584.4	0.079192	0	0.402	0.564132	2	0.001	-0.702281	4	0.001
334	79.24	584.4	-0.144245	0	0.136	-0.64311	2	0.001	0.8006	4	0.001
335	79.24	584.4	0.126531	0	0.219	0.394425	2	0.005	-0.498795	4	0.001
336	79.24	584.4	0.079192	0	0.405	0.564132	2	0.001	-0.702281	4	0.001
337	79.24	584.4	0.079192	0	0.395	0.564132	2	0.001	-0.702281	4	0.001
338	79.24	584.4	0.079192	0	0.391	0.564132	2	0.001	-0.702281	4	0.001
339	79.24	584.4	0.079192	0	0.359	0.479278	2	0.002	-0.600538	4	0.001
340	79.24	584.4	-0.144245	0	0.139	-0.64311	2	0.001	0.8006	4	0.001
341	79.24	584.4	-0.144245	0	0.146	-0.64311	2	0.001	0.8006	4	0.001
342	79.24	584.4	0.126531	0	0.216	0.564132	2	0.002	-0.702281	4	0.001
343	79.24	584.4	0.126531	0	0.233	0.564132	2	0.001	-0.702281	4	0.001
344	79.24	584.4	0.031854	0	0.441	0.564132	2	0.002	-0.702281	4	0.001

Table 8.6. Univariate and Multivariate LISA Results for Scrapers, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Scraper (SCRPR) Ii	SCRPR Cluster	SCRPS Probability	SCRPR/ ED Ii	SCRPR/ ED Cluster	SCRPR/ ED Probability	SCRPR/ PSCOV Ii	SCRPR/ PSCOV Cluster	SCRPR/ PSCOV Probability
345	79.24	584.4	0.126531	0	0.227	0.564132	2	0.001	-0.702281	4	0.001
346	79.24	584.4	0.079192	0	0.39	0.564132	2	0.002	-0.702281	4	0.001
347	79.24	584.4	0.126531	0	0.222	0.564132	2	0.001	-0.702281	4	0.001
348	79.24	584.4	0.126531	0	0.246	0.564132	2	0.001	-0.702281	4	0.001
373	69.92	651.5	-0.062823	0	0.248	0.667675	3	0.001	-0.713913	1	0.001
374	69.92	651.5	0.017652	0	0.371	-0.77821	3	0.001	0.86655	1	0.001
375	69.92	651.5	-0.062823	0	0.266	0.682641	3	0.001	-0.760131	1	0.001
376	69.92	651.5	-0.062823	0	0.241	0.626788	3	0.001	-0.704917	1	0.001
377	83.42	465.2	0.031854	0	0.497	0.390737	2	0.005	-0.383171	4	0.001
378	83.42	465.2	0.031854	0	0.495	0.438319	2	0.003	-0.446876	4	0.002
379	108.13	277.7	0.126531	0	0.27	-0.470224	4	0.001	0.486918	2	0.001
380	108.13	277.7	0.126531	0	0.23	-0.470224	4	0.001	0.486918	2	0.001
381	108.13	277.7	0.126531	0	0.247	-0.470224	4	0.001	0.486918	2	0.001
382	108.13	277.7	-0.19821	0	0.153	0.536055	4	0.001	-0.555087	2	0.001
383	108.13	277.7	-0.19821	0	0.147	0.536055	4	0.001	-0.555087	2	0.001
384	108.13	277.7	0.126531	0	0.237	-0.470224	4	0.001	0.486918	2	0.001
385	108.13	277.7	0.126531	0	0.274	-0.470224	4	0.001	0.486918	2	0.001
386	102.94	322	-0.062823	0	0.285	-0.284405	1	0.012	0.315149	3	0.004
387	102.94	322	-0.110161	0	0.215	-0.284405	1	0.017	0.315149	3	0.008
388	102.94	322	-0.015485	0	0.402	-0.284405	1	0.02	0.315149	3	0.011
389	102.94	322	-0.090279	0	0.304	0.324222	4	0.017	-0.35927	2	0.004
390	102.94	322	0.031854	0	0.433	-0.284405	4	0.022	0.315149	2	0.006
391	102.94	322	0.126531	0	0.242	-0.284405	4	0.015	0.315149	2	0.004
392	102.94	322	0.126531	0	0.232	-0.284405	4	0.01	0.315149	2	0.003
393	102.94	322	0.173869	0	0.13	-0.317057	4	0.012	0.304448	2	0.009
394	107.5	335.8	-0.015485	0	0.402	-0.366036	1	0.002	0.288395	3	0.017
395	107.5	335.8	-0.25975	0	0.301	1.200599	4	0.001	-0.945936	2	0.018
396	107.5	335.8	-0.25975	0	0.291	1.200599	4	0.001	-0.945936	2	0.019
397	107.5	335.8	-0.036313	0	0.473	0.417281	4	0.001	-0.328771	2	0.009
398	69.92	651.5	0.031854	0	0.487	0.389985	2	0.003	-0.37464	4	0.006
399	68.65	465	0.031854	0	0.435	-0.099052	2	0.283	0.268969	4	0.019

Table 8.6. Univariate and Multivariate LISA Results for Scrapers, ED, and PSCOV (Continued).

Site Number	Edge Density (ED)	Patch Size Covariance (PSCOV)	Scraper (SCRPR) Ii	SCRPR Cluster	SCRPS Probability	SCRPR/ ED Ii	SCRPR/ ED Cluster	SCRPR/ ED Probability	SCRPR/ PSCOV Ii	SCRPR/ PSCOV Cluster	SCRPR/ PSCOV Probability
400	68.65	465	-0.41502	0	0.14	0.324889	2	0.286	-0.88222	4	0.017
401	68.65	465	0.079192	0	0.266	-0.010582	2	0.483	0.196268	4	0.086
402	69.92	585.6	0.173869	0	0.118	0.664238	2	0.001	-0.703676	4	0.001
403	69.92	585.6	0.173869	0	0.131	0.664238	2	0.001	-0.703676	4	0.001
404	69.92	585.6	0.173869	0	0.116	0.664238	2	0.001	-0.703676	4	0.001
405	69.92	585.6	0.173869	0	0.136	0.664238	2	0.001	-0.703676	4	0.001
406	108.13	277.7	0.126531	0	0.231	-0.470224	4	0.001	0.486918	2	0.001
407	108.13	277.7	0.126531	0	0.267	-0.470224	4	0.001	0.486918	2	0.001
408	108.13	277.7	0.079192	0	0.381	-0.422641	4	0.001	0.423212	2	0.001
409	108.13	277.7	0.126531	0	0.251	-0.470224	4	0.001	0.486918	2	0.001
410	102.94	322	0.126531	0	0.248	-0.284405	4	0.014	0.315149	2	0.008
411	102.94	322	0.173869	0	0.111	-0.317057	4	0.007	0.304448	2	0.012
412	107.5	335.8	-0.015485	0	0.435	-0.366036	1	0.001	0.288395	3	0.013
413	107.5	335.8	-0.015485	0	0.451	-0.366036	1	0.002	0.288395	3	0.019

Cluster Type: 1=HH; 2=LL; 3=LH; and 4=HL.

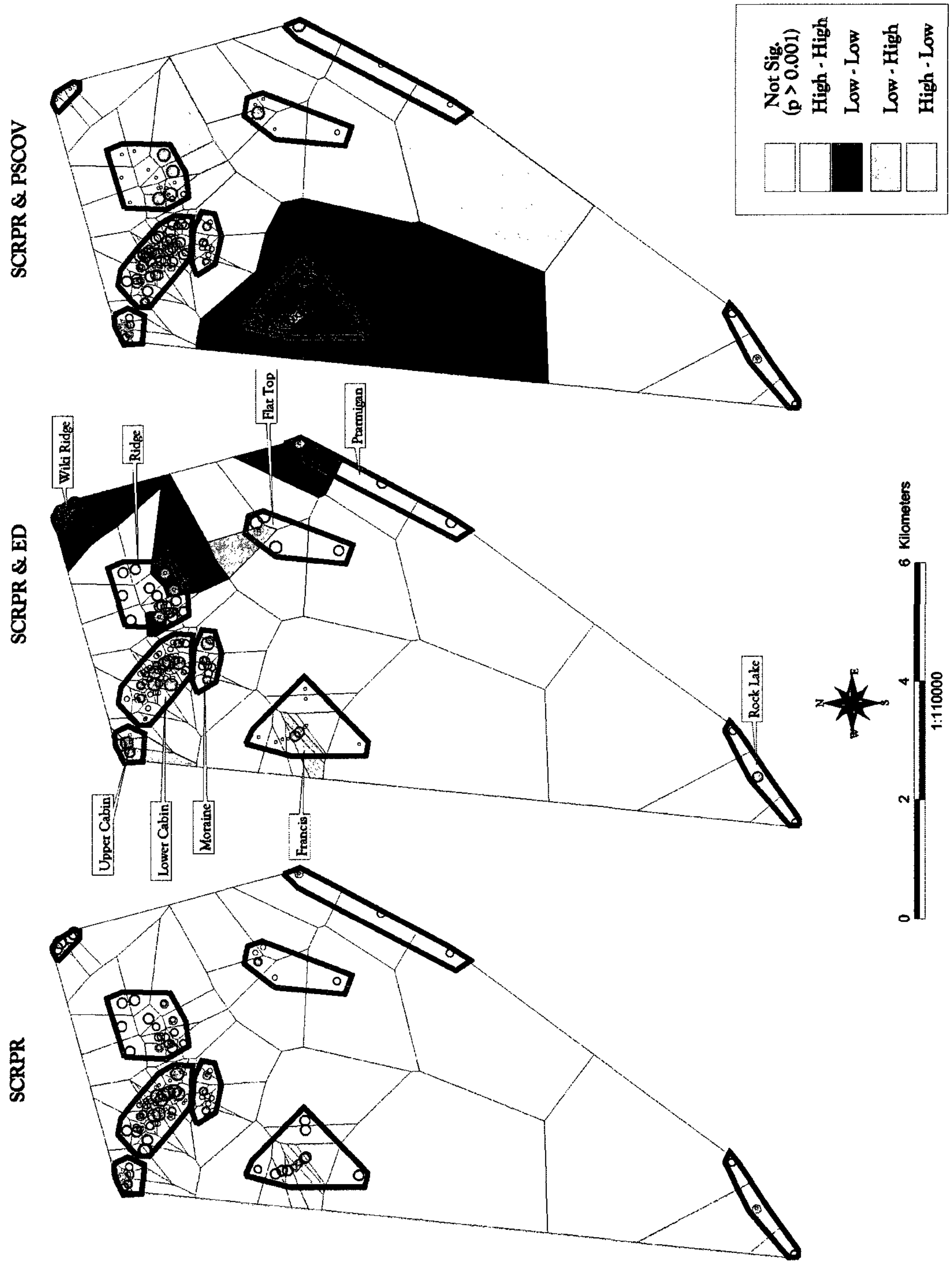


Figure 8.8. Comparison of Local Moran's I Core Cluster Membership for Scrapers, Scrapers /ED, and Scrapers /PSCOV. Permutations=999. Probability = 0.001. Gray Circles Represent Sites with Projectile Points. Open Circles Represent Proportionally Scaled I Values

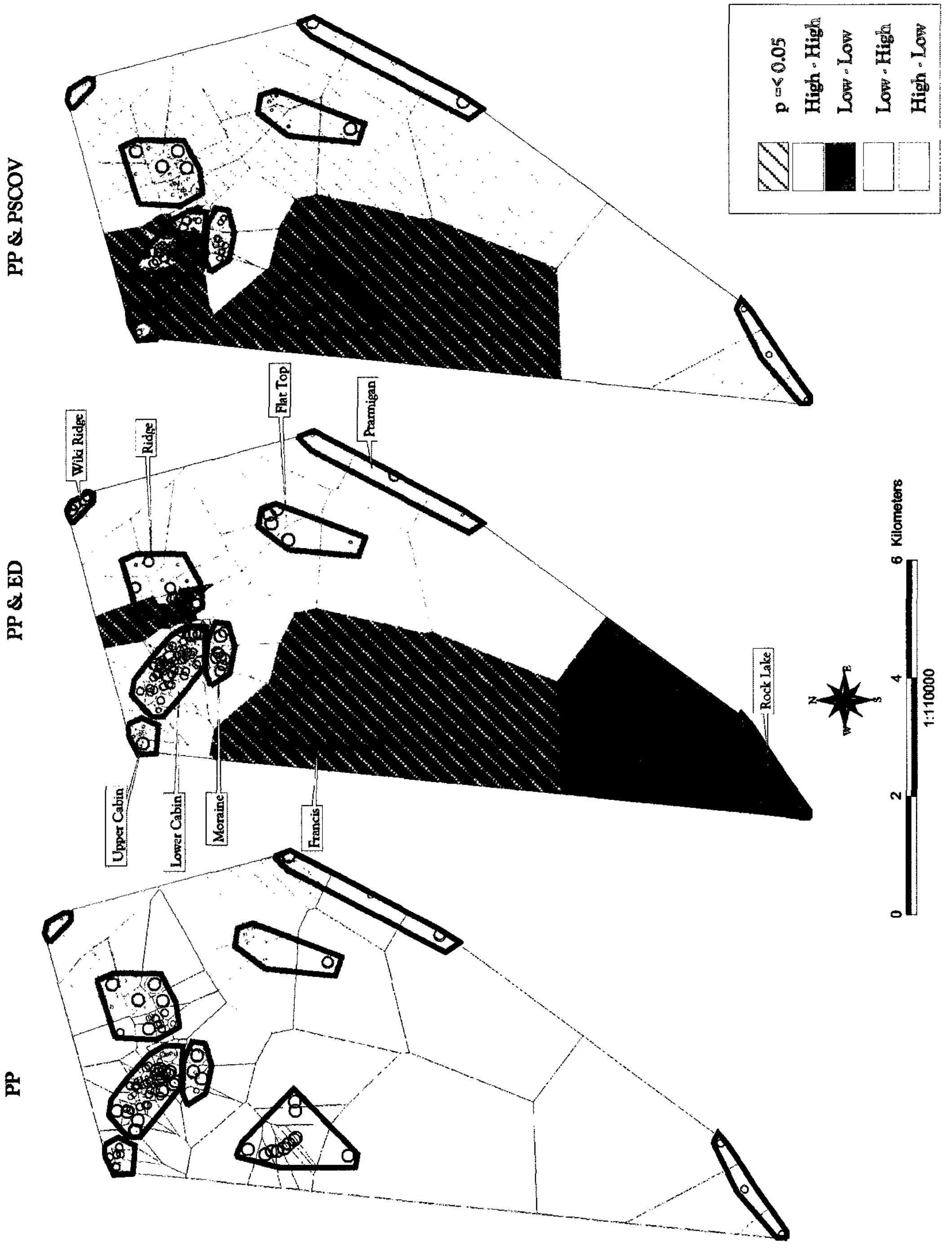


Figure 8.9. Comparison of Local Moran's I Cluster Membership for Projectile Points, Projectile Points/ED, and Projectile Points/PSCOV. Permutations=999. Gray Circles Represent Sites with Projectile Points. Open Circles Represent Proportionally Scaled I Values.

In regards to projectile points and ED, there is a clear expansion of cluster membership out from the core clusters. This is most apparent in the Lower Cabin Creek Group where the number of cases assigned to the HH cluster increases and the sites surrounding these become grouped in the HL cluster. The expansion of the LH cluster type encompasses most of the sites in the higher relative elevations and lower absolute portions of the study area. Though assigned to the LH cluster, the sites in the Moraine Group are not significantly autocorrelated. The same holds true for the Rock Lake Group that is a nonsignificant LL cluster.

The relationship between projectile points and PSCOV demarcate the sharpest contrast between HH and LL clusters, or positive spatial autocorrelation, in the data set.
A series HH cluster entirely covers the Ridge, Flat Top Wiki Ridge, Ptarmigan, and Moraine Groups. As before with ED, the cluster membership of the Moraine Group is not statistically significant. In contrast to the HH cluster, most of the remaining site groups, except the Rock Lake Group, are incorporated in LL clusters. The HL cluster separating the Ridge and Lower Cabin Groups, of course, is still present. Though no projectile points are present in the Rock Lake Group, the HL membership is the result of high PSCOV values and their association with members of their neighborhood with projectile points. The cluster membership of the Wiki Ridge Group, which also does not contain projectile points, is also related to these two factors.

Expanded Clusters-Bifaces

The results of the expanded bifaces clusters are given in Figure 8.10. There is very little change in the spatial autocorrelation results between the .001 and .05 alpha levels when examining bifaces alone. Besides the one HL cluster previously identified in the Upper Cabin Creek Group, only two other small clusters appear and both have a negative spatial autocorrelation. The first one is a LH cluster occurring near the interface of the Lower Cabin and Moraine Groups. The second one is a HL cluster focusing on a single site with numerous bifaces associated with the Ridge Group.

The distributional relationship between bifaces and ED at the tolerant alpha level differs considerably from its more restrictive counterpart. Several new clusters appear and the initial cluster centers identified previously expand considerably. Most notable among the emerging clusters is a large HH cluster that formed in the Lower Cabin Creek Group. A large LL cluster encompasses most of the Ptarmigan Group and all of the Rock Lake Group is also evident. The LL and LH clusters associated with the Ridge Group expand considerable, as does the LH cluster

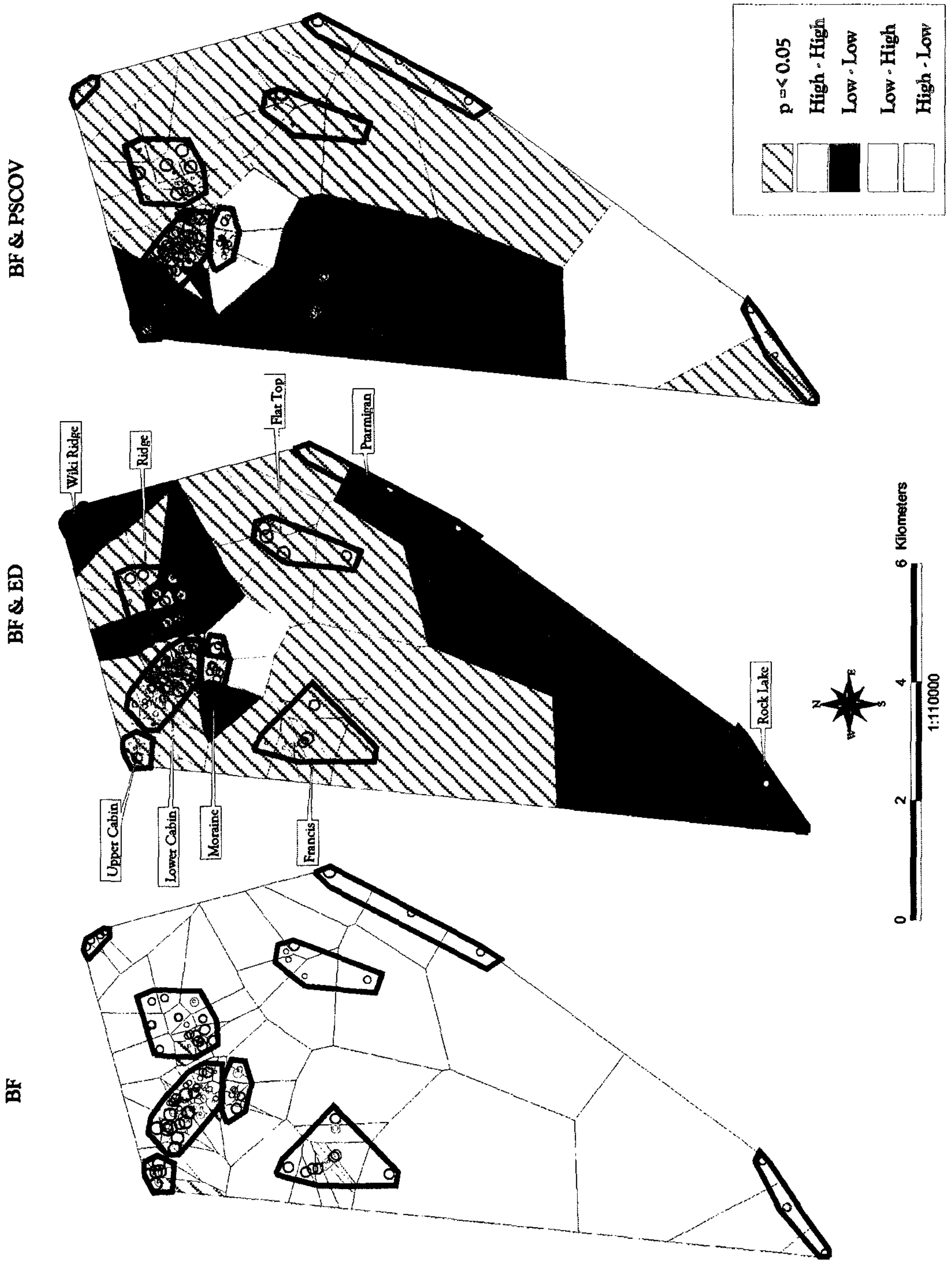


Figure 8.10. Comparison of Local Moran's I Cluster Membership for Bifaces, Bifaces/ED, and Bifaces/PSCOV. Permutations=999. Gray Circles Represent Sites with Bifaces. Open Circles Represent Proportionally Scaled I Values.

on Flat Top. The sites located on the moraine separating Francis Creek and Cabin Creek are grouped with LL or LH clusters, but neither cluster type is statistically significant.

The significance of the autocorrelation among bifaces, PSCOV, and location are highest in the Ridge (HH), Ptarmigan Lake (HH), Flat Top (HH), Upper Cabin (LL), Lower Cabin (LL), and Francis (LL) Groups. The HH clusters in the Ridge and Ptarmigan Lake Groups are also associated with HL clusters; The LL clusters in the Lower Cabin Creek Group are interspersed with a large LH cluster. Like in the many of the other cases at the looser alpha level, sites in the Moraine Group are assigned to one or more clusters, HH and HL in the cases of bifaces and PSCOV, but these groupings are not statistically significant. Two sites in the Rock Lake group form a significant HL cluster.

Expanded Clusters-Scrapers

Even at the 0.05 probability level scrapers, of themselves, show little evidence of either positive or negative spatial autocorrelation (Figure 8.11). A single small LH cluster emerges in the Lower Cabin Creek Group, but no other autocorrelation occurs in any of the remaining groups.

When examining scrapers and ED simultaneously, however, distinct clustering is evident. Two HH clusters occur in the Upper and Lower Cabin Creek Groups. A wedge of sites clustered as HL forms a clear break between these two HH clusters. Low-Low clusters clearly keyed to several of the groups with low ED values including the Wiki Ridge, Ridge, Ptarmigan Lake, and Rock Lake Groups. Of these LL clusters, all are significant expect for the Rock Lake Group. Two cluster types compose the Flat Top and Moraine Groups including LL and LH. The clustering observed on the medial moraine is, again, trivial.

In the final comparison at the liberal alpha level, that of scrapers and PSCOV, cluster formation is again considerably more extensive than at the 0.001 significance level. High-High spatial autocorrelation clusters are limited to the Flat Top and Moraine groups. As with all the other cases pertaining to the Moraine group, these cluster designations are not significant. Positive clustering of LL cases are most prominent in the Francis Creek Group and in the buffer area identified above separating the upper and lower portions of Cabin Creek. The majority of the cases in the Upper and Lower Cabin Creek Groups are in the LH spatial outlier group. The Ridge, Wiki Ridge, Ptarmigan Lake, Rock Lake, and Part of the Flat Top Groups fall under HL cluster membership.

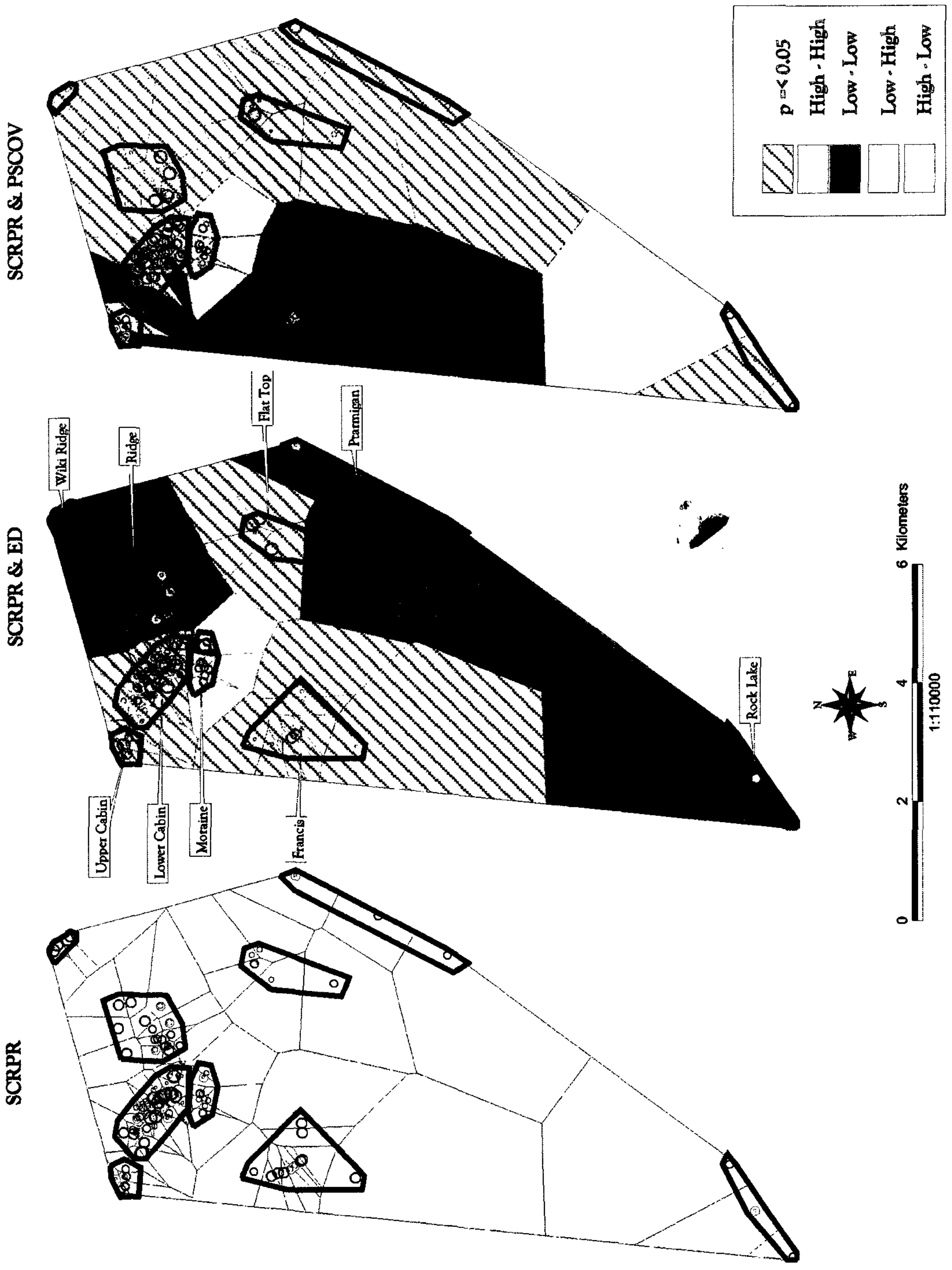


Figure 8.11. Comparison of Local Moran's I Cluster Membership for Scrapers, Scrapers/ED, and Scrapers/PSCOV. Permutations=999. Gray Circles Represent Sites with Scrapers. Open Circles Represent Proportionally Scaled I Values

Discussion

Based on the imperfect inverse relationships identified it is clear that the ED and PSCOV metrics strongly influence the LISA results. As pointed out in above, there is an inverse relationship between ED and PSCOV; as ED increases the PSCOV decreases. It is simultaneously apparent that this inverse relationship is not the only factor affecting the formation of the clusters. That the relationships identified by LISA analysis are mostly imperfect (e.g., changing from a HH cluster to a LH cluster, and not a LL cluster), indicates that the presence and frequency of tools have a significant role in cluster formation results. In addition, there are numerous cases where clustering associated with ED have no counterpart when associated with PSCOV. This is particularly true at the more stringent alpha level. Although numerous examples of negative spatial autocorrelation were identified, these results have little bearing in the following discussion. The HL and LH cluster types represent spatial outliers or cases that are exceptions. While these cluster types have important interpretative value in addressing a host of questions concerning land use, the working hypotheses proposed earlier do not concern these cluster types. For simplification, the results have been lumped for each site group. For example, if even a single site is clustered as HH or LL, this result is expanded to the entire site group.

The results of the positive spatial autocorrelation clustering for the 0.001 and the 0.05 probability levels are summarized in Tables 8.7 and 8.8. At the core cluster level, the Lower Cabin Creek Group, which has a high ED value, contains a small cluster of HH values indicating a very strong association between projectile points and ED meeting one of the expectations of the first working hypotheses that these two variables should be spatially autocorrelated. The Ridge and Ptarmigan Lake Groups, conversely, meets the both expectations for the second working hypothesis that projectile points and PSCOV are positively autocorrelated in a HH cluster. At the core cluster level, the results of the LISA suggest that in at least three site groups, projectile points co-occur in areas with sites that have either a high ED or a high PSCOV. The HH clusters formed in each of these groups is related only to projectile points and a single metric. In the case of the Ridge group where there is a significant clustering of HH values with PSCOV and with LL values with ED, only PSCOV and points are unequivocally related. Since projectile points alone are not spatially autocorrelated, the results point to a high probability that these locations reflect a differential use of the landscape. The dual nature of the relationship of projectile points and both metrics likely reflect a dual nature of caribou and sheep hunting.

Table 8.7. Summary of Spatial Autocorrelation at the p = 0.001 Alpha Level.

Site Group/Tool Type	*Tool Cluster*	*Tool/Edge Cluster Type*	*Tool/PSCOV Cluster Type*
Lower Cabin			
PP	--	**HH**	--
BF	--	--	--
SCRPR	--	--	--
Upper Cabin			
PP	--	--	--
BF	--	--	--
SCRPR	--	**HH**	--
Moraine			
PP	--	--	--
BF	--	--	--
SCRPR	--	--	--
Francis			
PP	--	--	LL
BF	--	--	LL
SCRPR	--	--	LL
Ridge			
PP	--	LL	**HH**
BF	--	LL	**HH**
SCRPR	--	LL	--
Flat Top			
PP	--	--	--
BF	--	--	**HH**
SCRPR	--	--	**HH**
Wiki			
PP	--	--	--
BF	--	LL	--
SCRPR	--	LL	--
Ptarmigan			
PP	--	--	**HH**
BF	--	--	**HH**
SCRPR	--	LL	--
Rock			
PP	--	--	--
BF	--	--	--
SCRPR	--	--	--

Table 8.8. Summary of Spatial Autocorrelation at the p = 0.05 Alpha Level.

Site Group/Tool Type	*Tool Cluster*	*Tool/Edge Cluster Type*	*Tool/PSCOV Cluster Type*
Lower Cabin			
PP	--	HH	LL
BF	--	HH	LL
SCRPR	--	HH	LL
Upper Cabin			
PP	--	--	LL
BF	--	--	LL
SCRPR	--	HH	LL
Moraine			
PP	--	--	HH*
BF	--	LL*	HH*
SCRPR	--	LL*	HH*
Francis			
PP	--	LL	LL
BF	--	--	LL
SCRPR	--	--	LL
Ridge			
PP	HH	LL	HH
BF	--	LL	HH
SCRPR	--	LL	--
Flat Top			
PP	--	--	HH
BF	--	--	HH
SCRPR	--	LL	HH
Wiki			
PP	--	--	HH
BF	--	LL	--
SCRPR	--	LL	--
Ptarmigan			
PP	HH	--	HH
BF	--	LL	HH
SCRPR	--	LL	--
Rock			
PP	--	LL	--
BF	--	LL	--
SCRPR	--	LL*	--

*assigned to cluster, but not significant at the 0.05 alpha level.

The strict nature of cluster membership at the higher alpha level does not lend itself well to addressing the co-occurrence of HH clusters with projectile points and scrapers. In all three cases with HH clusters containing projectile points, none co-occur with scrapers. While this technically meets the expectations of the third working hypothesis, the more liberal clusters obtained from loosening the alpha levels are likely more useful in meaningfully addressing it.

As previously noted, the examination of the cluster membership at the liberal alpha level is more difficult than it is at the considerably more restrictive one. The biggest problem lays in the fact that locations in neighborhoods with both high and low Ii values may erroneously be grouped into a HH cluster a high value is included in the neighborhood (Mitchell 2005:174). This is clearly the case for the Wiki Ridge Group, containing no projectile points, which is classified as a HH cluster based on its proximity to the Ridge Group. Significant clustering in the Flat Top Ridge, which does contain a projectile point, is *partly* related its proximity to high values in both the Ridge and Ptarmigan Lake Groups. However, the presence of the high value in the Flat Top Group also suggests that the clustering, though exaggerated, is real. The Moraine group, which cluster as HH in regards to all three tool types and PSCOV, is not statistically significant at the 0.05 probability level. The group's relational position in regards to moderate ED and PSCOV values, relative to the other groups, most likely accounts for its lack of significance.

Taking into account the discrepancies noted above, there is little change in the cluster membership for HH projectile point clusters. Given that the clustering observed in the Flat Top Group cannot be dismissed entirely, an additional case is added to the mix. This case, like the Ridge and Ptarmigan Lake cases, reflects an association between projectile points and PSCOV. Overall, projectile points are more commonly associated with locations that have higher PSCOV values than with locations with higher ED values.

There is a co-occurrence of HH clusters of projectile points and scraper clusters in both the Lower Cabin and Flat Top Groups. These groups contradict the expectation that clusters with HH projectile point clusters would be independent from scraper clusters. All the HH projectile point clusters associated with either ED or PSCOV, are also associated with bifaces. Bifaces could be processing tools or could represent manufacturing stages of other tool types (e.g. points, knifes, etc.). In regards to this research, which did not fully evaluate function of bifaces, this artifact type is ambiguous. The consistency in the co-occurrence of HH clusters of projectile points and bifaces is difficult to evaluate relative to the LISA analysis.

Based on the results of the spatial autocorrelation, the links between projectile points and the two landscape metrics are evident. The odds that these autocorrelations occur by chance alone are very low. The co-occurrence of scrapers with projectile points in certain site locations imply that multiple activities occurred in site groups such as Lower Cabin and Flat Top. Interestingly, the Moraine Group also has a co-occurrence of projectile points and scrapers, but is not significantly autocorrelated with either ED or PSCOV. The lack of significant positive autocorrelation hints at other factors that may be driving the patterning observed at this location. As noted in the site group descriptions, the sites on the moraine occur adjacent to a mineral lick that is known to be by both sheep and caribou. It is probable that local fauna have utilized this feature for a considerable time. Though it is beyond the scope of this work, the presence of the mineral lick remains a plausible explanation to the occurrence of tools identified on sites adjacent to the lick. This negative example also lends itself to elucidating that portions of a hunter's range is likely keyed to specific locals as well as landscape characteristics and structure.

Conclusions

Applying the general distribution and hunting range classification functions to the prehistoric lithic scatters proved ambiguous. The general distribution range classification, which performed very poorly in the protohistoric case, classified the viewshed of three of the site groups as being most similar to caribou range and the remaining six site groups as being more similar to sheep ranges. The hunting range classification function classified the viewsheds of all the site groups as representing sheep hunting ranges. Misclassification of sheep and caribou hunting ranges in the protohistoric test in the previous chapter reflects that more than one resource may have been targeted in certain areas that coincide with high edge densities. Without further modeling, this quirk of the hunting range classification makes it necessary to carefully evaluate the results.

Here, this evaluation consisted of comparing the spatial relationship of particular chipped stone tools and the two landscape components used in the hunting range classification function with the assumption that projectiles points should co-occur with site groups with high edge densities if sheep hunting was the primary subsistence use of the Wiki Peak landform and the surrounding area. The results of the LISA analysis demonstrated that projectile points are positively spatially autocorrelated with some site groups with high edge densities, while several other site groups show positively autocorrelated between projectile points and patch size covariance, which indicates larger patch sizes. If the stated assumptions are correct, then it is likely that use of locations over the Wiki Peak landform served as platforms for acquiring, and likely processing, different resources.

CHAPTER 9.
EVALUATION AND SUMMARY

Introduction

Using modern data (large mammal distributions, Athabascan hunting ranges, and topography), landscape metrics, and an exploratory data analysis (EDA) framework, landscape structure is quantified and compared across much of the Alaskan Interior to identify reoccurring patterns related to hunting land use and the range characteristics of caribou, moose, and sheep. Key components of the landscape structure are contrasted with topographic matrices associated with protohistoric and late prehistoric sites via discriminant function classification models. Prehistoric test cases show that the of certain chipped-stone tools and landscape structure are highly correlated. This suggests that landscape structure models can be useful in the generation of constructive hypotheses to test assemblage variability, site function and varied forms of land use.

Model Summary

In all, I generated four landscape classification models. These include classification models for the general distributional ranges for caribou, moose, and sheep; the winter and summer distributional ranges for caribou and moose; and a classification model for Athabascan hunting ranges for the same resource animals. The general mammal distributional model, based on the cross validation procedure, resulted in a correct classification rate of over 80 percent. In other words, the based on measures of landscape structure, the model was reasonably effective in differentiating among the three resource ranges. The models derived for the classification of winter and summer ranges of moose and caribou resulted in classification rates of 100 percent.

Applying these classification models to known hunting ranges for the three resource animals, however, resulted in mixed results. At the general distribution level, the landscape structure of 8 of the 15 caribou hunting ranges were classified as representing moose distributional range. Classifying moose hunting ranges was much more satisfactory with moose hunting ranges being correctly classified at a rate of 90%. The correct sheep classification rate was just over 75%. Despite the high success rate in classification rates of moose and sheep range, the poor classification rate for caribou range makes the model problematic. Additional analysis of the range data demonstrates that the poor classification rate for caribou is directly related to the substantial overlap between caribou and moose distributional ranges. The result of this overlap makes the model difficult to apply with any degree of certainty for distinguishing between moose and caribou range.

The two seasonal distributional ranges for moose and caribou, which have very little overlap with one another, resulted in considerably higher classification success rates than the general moose and caribou ranges. Classification of modern hunting ranges by the seasonal classification models varied from a low of 66% to a high of 86%. In general, the summer ranges resulted in more correctly classified cases than the winter ranges.

The hunting range model, derived from the landscape structure of modern hunting ranges for the three resources, resulted in good classification rates in the leave-one-out classifications. Overall, the cross validation of the classification function against the different hunting ranges result in correctly classified 75%t of the time. As with the general distribution range, caribou hunting ranges were the most problematic with success rate of only 60%. The discriminant classification function correctly classified 76% of the moose ranges and all of the sheep ranges.

Applying all these models to protohistoric and historic sites with faunal assemblages useful for a control, results were somewhat mixed. By and large, the general distribution range classification function performed very poorly in predicting the range surrounding a site in regards to its dominant species-specific faunal assemblage; less than 20% of the cases were correctly classified. The success rate for the seasonal distributions of moose and caribou performed exceptionally well. The winter classification model resulted in site catchments being classified in accordance with the dominant species in the faunal assemblage with 100%accuracy. Two of the eight cases in the test for the summer caribou-moose range classification, however, were incorrectly classified resulting in a success rate of 75%.

The hunting range model also correctly classified 75% of the test cases relative to the dominant fauna recovered from the sites. Unlike in any of the misclassification cases previously identified, the misclassified cases in this instance were between caribou and sheep range and not caribou and moose range. Examining the individual cases, it was evident that the three misclassified cases all occurred in extremely patchy environments at higher elevations and had mixed faunal assemblages containing both species.

Knowing the potential for misclassification of cases of high, patchy areas in regards to the hunting range model and despite the poor performance of the general distribution model, both were applied against viewshed-based catchments for a series of lithic scatters in the Wiki Peak-

Ptarmigan Lake of the Wrangell-St. Elias National Park. As expected, the results were mixed. The general distribution function characterized site group locations as representing sheep and caribou range while the hunting range function classified all the landscape matrices surrounding the site groups as representing sheep hunting range. Deconstructing the hunting range model into its constituent components and examining those components in regards to the distribution of projectile points, scrapers, and bifaces, I demonstrated that projectile points are spatially autocorrelated with both. This result most likely reflects that both caribou and sheep hunting occurred in the area, but in very different settings.

Model Evaluation

Taken as a whole, evaluating the landscape matrices in respect to potential resources appears a viable method in studying various aspects of ubiquitous lithic scatters that may not necessarily be addressed through more common approaches such as technological organization. However, such modeling is most effective when used in generate hypotheses to examine more fully inter-site variability in spatially related lithic scatters rather than generating any sort of confirmatory statements. Used in conjunction with ancillary studies, such as protein residue analysis and use wear studies, these types of models can prove beneficial in addressing questions concerning land use, resource acquisition, and economics. At a basic level, these and similar landscape models can provide a measure of objectivity to assumptions commonly made concerning surface lithic scatters.

As present here, the models represent a proof of concept, but numerous problems need to be overcome before models such as these are truly useful. There are many assumptions, scale issues, and methodological shortcomings that need to be explicitly identified and worked through. Although many different forms of standardization, such as the use of landscape metrics and the Topographic Position Index, were employed to ensure that the comparisons made were compatible, various scalar issues were essentially ignored.

Though the resolution and grain of the data were consistent throughout the analysis, there was considerable latitude with the spatial areas considered at each step. Beginning with mapped large mammal distributions and hunting ranges, the initial landscape models were applied to smaller and smaller areas at the generic catchment and viewshed levels. From a technical standpoint, the many landscape metrics account for areal extents making it possible to directly compare areas of disparate sizes. It is probable that, in this case, this comparability nature of these metrics were considerably taxed. Determining a minimum efficacy threshold in downscaling areal extents needs serious consideration.

Downscaling areal extents is potentially problematic, but it actually underlies a much more serious scale problems referred to as the ecological fallacy. Ecological fallacy refers to the interpretation of data where inferences made at one scale are applied to data collected at another scale (Harris 2006:46-47). In ecology, such a fallacy may occur when inferring various properties of individual trees based on parameters garnered from an entire forest (Wu 2007:123). This example is nearly identical to the modeling presented here. At one end of the spectrum, the hunting and distribution ranges reflects a broad level of abstraction representing collected land uses by humans and animals over generally long periods. At the opposite end, behavioral inferences made from the broad scale are applied to individual lithic scatters, most of which probably represent short-use localities. In essence, patterns identified at one scale may not necessarily apply at other scales. By examining patterning at multiple scales and discerning where and how patterns differ can problems with the ecological fallacy be fully addressed (Harris 2006:48, see also Bevan and Conolly 2006).

Besides examining effects of downscaling and scale shifts in the nature of the various data sets, several refinements and additional analysis would likely increase the effectiveness of these models. Refining the TPI models could prove extremely beneficial. The algorithm used to generate the index consists of a standard 10 class system developed by the TPI's creator. This system may not necessarily be the most useful set of landform features pertinent Interior Alaskan landscapes. Refinement of the landform types used in the model construction and ground-truthing the TPI would likely increase the quality of the results. Two classes not used in this analysis, but of utmost importance include standing and flowing water. Unfortunately, the hydrology GIS data available were too coarse relative to the TPI derived from the 1:250,000 equivalent DEMs. Although data for water bodies is being generated at this scale and resolution by the Alaska Division of Natural Resources, at this time the only adequate hydrology coverages are at a scale of 1:1,000,000.

Redefining the TPI need not only include the addition of more classes or the refinement of existing ones. The utility of the TPI generating algorithm is extremely simple to manipulate and very robust. With careful delineation and definition, Native Alaskan place names and indigenous geographies could easily be incorporated into these types of landscape models. Utilizing traditional knowledge and perceptions of the hunting landscapes could prove the best bridge in unlocking observed spatial patterning often observed in the archaeological record. While this would be directly beneficial in examining the historic, protohistoric, and late prehistoric portion of the record, appreciation of indigenous geographies could be useful in modeling hunting patterns and land use of hunter-gatherers from more remote times.

Final Thoughts

As with many archaeological endeavors, human and environment studies suffer from implicit and explicit assumptions that are taken for granted and rarely, if ever, tested. Often functional classifications are assigned to sites in an a priori manner based on these untested assumptions. Often these assumptions are derived from the site's location on the landscape and the presence or absence of certain artifact classes. By examining these assumptions in a rigorous manner, it is possible to derive models that can be used to explicitly test functional assumptions resulting in more meaningful realizations spatial patterning and prehistoric land use systems. Contextual landscape models, however, are most appropriately used in conjunction with other approaches and analyses and not a means of classifying site variability function in and of themselves (e.g., Potter 2008b and 2008c). As an assumption-testing device, these types of models can aid the research in developing hypotheses where the parameters of the assumptions can be objectively examined and quantified. Simply using the models as an alternative classification method would be deleterious to their purpose.

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APPENDIX A

CLASS LEVEL HUNTING RANGE METRICS FOR CARIBOU, MOOSE, AND SHEEP

Table A.1. General Caribou Hunting Range Class Level Metrics for the Five Study Areas

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
Koyukuk	Huslia	Canyon	2102.5	3.2	99.0	4.7	21.2	3.0	1956.2	1.4	2.2	367.5	1.3	1.3
		Midslope Drainage	1563.3	2.4	223.0	14.3	7.0	3.5	1026.7	1.3	1.7	428.1	1.3	1.3
		Upland Drainage	232.2	0.4	52.0	22.4	4.5	0.7	904.2	1.3	1.6	410.5	1.3	1.3
		U-shaped Valley	3255.5	5.0	129.0	4.0	25.2	3.8	1916.4	1.4	2.5	433.6	1.3	1.3
		Plains	42133.5	64.8	124.0	0.3	339.8	6.1	3207.3	1.3	3.5	431.0	1.3	1.3
		Open Slope	8824.1	13.6	262.0	3.0	33.7	10.4	2591.3	1.5	2.9	391.7	1.3	1.3
		Upper Slope	2661.3	4.1	187.0	7.0	14.2	4.3	1508.2	1.4	2.3	456.0	1.3	1.3
		Local Ridge	73.5	0.1	41.0	55.8	1.8	0.3	518.2	1.3	1.3	949.1	1.4	1.3
		Midslope Ridge	1344.0	2.1	214.0	15.9	6.3	3.4	1025.7	1.3	1.7	387.9	1.3	1.3
		High Ridge	2792.5	4.3	87.0	3.1	32.1	3.4	2541.1	1.5	1.9	339.4	1.3	1.3
Kuskokwim	Mcgrath	Canyon	12672.7	4.6	374.0	3.0	33.9	3.7	2776.2	1.5	2.9	453.7	1.3	1.3
		Midslope Drainage	7503.2	2.7	1138.0	15.2	6.6	4.2	1013.2	1.4	1.8	623.7	1.3	1.3
		Upland Drainage	2702.4	1.0	513.0	19.0	5.3	1.6	865.4	1.3	1.7	647.0	1.3	1.3
		U-shaped Valley	15848.1	5.7	845.0	5.3	18.8	4.4	1444.4	1.4	3.6	805.5	1.4	1.3
		Plains	185007.6	66.8	622.0	0.3	297.4	5.0	2238.3	1.4	2.2	707.6	1.3	1.2
		Open Slope	23340.5	8.4	1434.0	6.1	16.3	9.6	1849.1	1.5	4.1	949.7	1.4	1.4
		Upper Slope	9426.7	3.4	1288.0	13.7	7.3	5.0	1068.0	1.4	3.1	622.1	1.3	1.3
		Local Ridge	424.7	0.2	256.0	60.3	1.7	0.4	476.3	1.3	1.7	825.4	1.4	1.3
		Midslope Ridge	5517.6	2.0	1029.0	18.6	5.4	3.4	912.1	1.4	1.8	644.9	1.3	1.3
		High Ridge	14564.5	5.3	290.0	2.0	50.2	3.8	3673.6	1.5	3.2	382.0	1.3	1.3
	Nikolai	Midslope Drainage	11.4	0.0	2.0	17.6	5.7	0.0	1027.3	1.2	1.2	196.9	1.3	1.3
		Plains	132198.4	99.6	8.0	0.0	16524.8	2.8	46403.1	1.4	1.4	119.7	1.2	1.2
		Open Slope	303.1	0.2	25.0	8.2	12.1	0.3	1685.5	1.6	2.0	460.5	1.3	1.3
		Upper Slope	97.1	0.1	8.0	8.2	12.1	0.1	1454.5	1.4	1.8	340.2	1.3	1.3
		Midslope Ridge	35.8	0.0	11.0	30.7	3.3	0.1	781.0	1.3	1.4	341.5	1.3	1.3
		High Ridge	52.6	0.0	3.0	5.7	17.5	0.1	2299.9	1.5	1.6	125.5	1.3	1.3

Table A.1. General Caribou Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimen-sion	Area Weighted MPFD
Kuskokwim (cont.)	Stony River	Canyon	2787.0	0.4	211.0	7.6	13.2	0.4	1635.6	1.4	1.9	357.5	1.3	1.3
		Midslope Drainage	10556.0	1.3	1218.0	11.5	8.7	1.8	1190.7	1.3	1.6	349.6	1.3	1.3
		Upland Drainage	516.1	0.1	187.0	36.2	2.8	0.2	677.4	1.3	1.4	402.6	1.3	1.3
		U-shaped Valley	5758.4	0.7	238.0	4.1	24.2	0.5	1783.9	1.4	2.6	445.8	1.3	1.3
		Plains	668577.6	84.3	870.0	0.1	768.5	4.9	4435.9	1.4	6.2	384.4	1.3	1.3
		Open Slope	77266.5	9.7	1201.0	1.6	64.3	6.6	4343.1	1.6	6.9	389.6	1.3	1.4
		Upper Slope	7034.1	0.9	876.0	12.5	8.0	1.3	1169.8	1.4	2.2	415.5	1.3	1.3
		Local Ridge	14.0	0.0	17.0	121.8	0.8	0.0	379.0	1.2	1.2	581.8	1.3	1.3
		Midslope Ridge	9397.6	1.2	1392.0	14.8	6.8	1.8	1015.4	1.3	1.5	358.5	1.3	1.3
		High Ridge	10750.5	1.4	333.0	3.1	32.3	1.2	2834.9	1.5	2.1	206.2	1.3	1.3
	Telida	Plains	2678.1	100.0	2.0	0.1	1339.1	10.2	13597.8	1.1	1.1	10.3	1.2	1.2
Lower Tanana	Beaver	Canyon	118.0	0.6	20.0	16.9	5.9	1.1	1039.7	1.4	1.6	400.6	1.3	1.3
		Midslope Drainage	130.6	0.7	17.0	13.0	7.7	1.0	1096.1	1.3	1.3	318.3	1.3	1.3
		U-shaped Valley	656.6	3.4	13.0	2.0	50.5	2.3	3420.4	1.5	2.3	304.9	1.3	1.3
		Plains	16774.8	86.2	15.0	0.1	1118.3	8.2	10627.6	1.5	3.1	345.2	1.3	1.3
		Open Slope	972.4	5.0	35.0	3.6	27.8	4.1	2272.5	1.6	2.6	1015.2	1.4	1.3
		Upper Slope	459.9	2.4	21.0	4.6	21.9	1.9	1714.7	1.3	2.8	2695.6	2.0	1.3
		Midslope Ridge	40.2	0.2	18.0	44.8	2.2	0.6	646.2	1.4	1.5	513.0	1.3	1.3
		High Ridge	306.7	1.6	10.0	3.3	30.7	1.4	2679.3	1.5	2.1	433.1	1.3	1.3
	Tanana	Canyon	16809.9	9.7	369.0	2.2	45.6	7.2	3400.5	1.6	2.9	380.1	1.3	1.3
		Midslope Drainage	8743.4	5.0	1176.0	13.5	7.4	7.4	1087.8	1.3	1.5	392.4	1.3	1.3
		Upland Drainage	1602.1	0.9	393.0	24.5	4.1	1.8	782.6	1.3	1.5	435.2	1.3	1.3
		U-shaped Valley	16319.2	9.4	958.0	5.9	17.0	9.0	1631.2	1.4	2.7	427.5	1.3	1.3
		Plains	44905.4	25.9	490.0	1.1	91.6	6.5	2306.0	1.4	3.7	529.0	1.3	1.3
		Open Slope	39855.5	22.9	1257.0	3.2	31.7	18.9	2613.6	1.5	3.7	369.3	1.3	1.3
		Upper Slope	18075.6	10.4	831.0	4.6	21.8	9.9	2071.2	1.5	3.0	474.0	1.3	1.3
		Local Ridge	1120.4	0.6	367.0	32.8	3.1	1.5	694.7	1.3	1.5	491.4	1.3	1.3
		Midslope Ridge	8663.8	5.0	1096.0	12.7	7.9	7.0	1117.0	1.3	1.6	414.5	1.3	1.3
		High Ridge	17607.0	10.1	379.0	2.2	46.5	7.5	3430.4	1.6	2.8	304.7	1.3	1.3

Table A.1. General Caribou Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimen-sion	Area Weighted MPFD
Upper Tanana	Dot Lake	Canyon	1172.5	3.3	38.0	3.2	30.9	2.9	2661.6	1.5	2.0	212.0	1.3	1.3
		Midslope Drainage	1422.3	4.0	174.0	12.2	8.2	5.5	1113.3	1.3	1.6	420.9	1.3	1.3
		Upland Drainage	31.7	0.1	19.0	60.0	1.7	0.3	538.7	1.3	1.3	449.8	1.3	1.3
		U-shaped Valley	949.4	2.7	90.0	9.5	10.5	3.2	1252.5	1.3	2.0	403.9	1.3	1.3
		Plains	10587.4	29.9	194.0	1.8	54.6	10.4	1894.5	1.3	1.7	349.9	1.3	1.2
		Open Slope	15849.7	44.7	61.0	0.4	259.8	19.7	11455.3	1.7	13.1	471.9	1.3	1.4
		Upper Slope	2845.8	8.0	64.0	2.2	44.5	4.8	2668.8	1.5	2.3	491.0	1.3	1.3
		Local Ridge	9.7	0.0	4.0	41.2	2.4	0.1	617.1	1.3	1.4	603.9	1.3	1.3
		Midslope Ridge	1332.0	3.8	195.0	14.6	6.8	5.6	1021.8	1.3	1.5	510.4	1.3	1.3
		High Ridge	1240.4	3.5	68.0	5.5	18.2	3.4	1793.6	1.4	1.7	395.3	1.3	1.3
	Northway	Canyon	3209.4	3.9	167.0	5.2	19.2	4.1	2009.4	1.5	2.1	939.6	1.4	1.3
		Midslope Drainage	2261.1	2.8	432.0	19.1	5.2	4.7	892.9	1.3	1.5	410.1	1.3	1.3
		Upland Drainage	53.4	0.1	12.0	22.5	4.4	0.1	754.0	1.3	1.3	598.4	1.3	1.3
		U-shaped Valley	5189.7	6.3	255.0	4.9	20.4	5.2	1674.0	1.4	2.6	510.5	1.3	1.3
		Plains	36071.8	43.9	245.0	0.7	147.2	10.8	3633.1	1.4	4.0	765.9	1.4	1.3
		Open Slope	25766.9	31.4	291.0	1.1	88.5	18.9	5330.6	1.7	4.4	462.9	1.3	1.3
		Upper Slope	4306.1	5.2	222.0	5.2	19.4	4.8	1784.8	1.4	3.1	398.3	1.3	1.3
		Local Ridge	12.1	0.0	13.0	107.4	0.9	0.1	390.5	1.2	1.3	631.5	1.3	1.3
		Midslope Ridge	2495.8	3.0	419.0	16.8	6.0	5.0	971.3	1.3	1.5	718.2	1.3	1.3
		High Ridge	2721.9	3.3	157.0	5.8	17.3	3.5	1851.5	1.5	1.8	437.2	1.3	1.3
	Tanacross	Canyon	12269.0	2.2	595.0	4.8	20.6	2.3	2086.1	1.5	2.3	484.4	1.3	1.3
		Midslope Drainage	14934.4	2.7	2201.0	14.7	6.8	4.1	1029.7	1.3	1.5	357.6	1.3	1.3
		Upland Drainage	399.2	0.1	144.0	36.1	2.8	0.2	627.9	1.3	1.4	449.1	1.3	1.3
		U-shaped Valley	19680.2	3.6	887.0	4.5	22.2	2.8	1745.7	1.4	2.7	412.0	1.3	1.3
		Plains	295263.8	53.8	1151.0	0.4	256.5	8.5	4062.8	1.4	8.5	372.7	1.3	1.3
		Open Slope	149170.8	27.2	1026.0	0.7	145.4	14.4	7726.8	1.7	8.4	419.6	1.3	1.4
		Upper Slope	26711.2	4.9	1038.0	3.9	25.7	3.9	2060.3	1.4	2.7	483.5	1.3	1.3
		Local Ridge	84.6	0.0	59.0	69.8	1.4	0.1	476.4	1.3	1.3	596.1	1.3	1.3
		Midslope Ridge	13419.3	2.4	2012.0	15.0	6.7	3.8	1030.2	1.3	1.5	431.5	1.3	1.3
		High Ridge	17335.6	3.2	782.0	4.5	22.2	3.0	2091.3	1.4	1.7	4420.4	1.3	1.3

Table A.1. General Caribou Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimen-sion	Area Weighted MPFD
Upper Tanana (cont.)	**Tok**	**Canyon**	70991.0	5.0	2617.0	3.7	27.1	4.5	2448.5	1.5	2.4	377.7	1.3	1.3
		Midslope Drainage	65223.3	4.6	8155.0	12.5	8.0	6.3	1105.8	1.3	1.6	423.4	1.3	1.3
		Upland Drainage	5348.8	0.4	1225.0	22.9	4.4	0.7	797.7	1.3	1.4	416.6	1.3	1.3
		U-shaped Valley	111569.4	7.8	4095.0	3.7	27.2	5.3	1855.7	1.4	4.0	446.0	1.3	1.3
		Plains	498215.6	34.8	3978.0	0.8	125.2	7.8	2800.1	1.4	5.5	514.4	1.3	1.3
		Open Slope	448145.2	31.3	4128.0	0.9	108.6	18.1	6263.5	1.6	10.0	1081.2	1.3	1.4
		Upper Slope	97366.8	6.8	4533.0	4.7	21.5	6.1	1924.4	1.4	2.8	501.1	1.3	1.3
		Local Ridge	904.7	0.1	473.0	52.3	1.9	0.2	548.0	1.3	1.3	744.9	1.3	1.3
		Midslope Ridge	53621.5	3.7	7267.0	13.6	7.4	5.5	1083.1	1.3	1.6	888.8	1.3	1.3
		High Ridge	80848.9	5.6	2511.0	3.1	32.2	4.7	2658.2	1.5	2.3	492.4	1.3	1.3
Upper Yukon	Arctic Village	**Canyon**	93047.8	4.0	4869.0	5.2	19.1	3.8	1817.7	1.5	3.2	814.2	1.4	1.3
		Midslope Drainage	101746.8	4.4	15131.0	14.9	6.7	6.4	980.0	1.4	2.0	899.3	1.4	1.3
		Upland Drainage	11672.2	0.5	3939.0	33.7	3.0	1.0	617.6	1.3	1.6	924.8	1.4	1.3
		U-shaped Valley	185844.5	8.0	7935.0	4.3	23.4	5.2	1529.8	1.4	5.5	1189.6	1.4	1.3
		Plains	897965.0	38.6	38224.0	4.3	23.5	15.6	952.9	1.4	44.8	1275.4	1.4	1.4
		Open Slope	649190.4	27.9	36458.0	5.6	17.8	25.6	1631.4	1.5	16.2	1380.7	1.4	1.4
		Upper Slope	165047.6	7.1	9533.0	5.8	17.3	7.2	1762.7	1.5	3.9	1090.8	1.4	1.3
		Local Ridge	1974.3	0.1	1291.0	65.4	1.5	0.2	434.9	1.3	1.6	1039.3	1.4	1.3
		Midslope Ridge	72918.6	3.1	14364.0	19.7	5.1	5.2	836.5	1.4	1.7	872.4	1.4	1.3
		High Ridge	148079.1	6.4	4919.0	3.3	30.1	5.0	2368.5	1.4	2.4	685.7	1.3	1.3
	Chalkyitsik	**Canyon**	4897.7	2.0	287.0	5.9	17.1	1.9	1674.9	1.5	3.0	1611.0	1.4	1.3
		Midslope Drainage	4478.7	1.8	1116.0	24.9	4.0	3.1	685.2	1.4	1.9	1134.1	1.4	1.3
		Upland Drainage	342.0	0.1	116.0	33.9	2.9	0.3	610.7	1.3	1.5	943.1	1.4	1.3
		U-shaped Valley	8885.3	3.5	727.0	8.2	12.2	2.8	969.4	1.4	3.0	1312.7	1.4	1.3
		Plains	202507.8	80.8	1470.0	0.7	137.8	10.8	1838.5	1.4	7.1	1398.1	1.4	1.3
		Open Slope	11702.8	4.7	3366.0	28.8	3.5	10.6	791.4	1.5	3.6	1280.2	1.4	1.4
		Upper Slope	7199.2	2.9	357.0	5.0	20.2	2.6	1832.4	1.5	2.8	1322.3	1.3	1.3
		Local Ridge	103.6	0.0	109.0	105.2	1.0	0.1	303.7	1.3	2.2	1229.4	1.4	1.4
		Midslope Ridge	4895.9	2.0	857.0	17.5	5.7	3.0	870.9	1.4	1.7	921.4	1.4	1.3
		High Ridge	5634.7	2.2	285.0	5.1	19.8	1.8	1601.9	1.4	2.1	930.1	1.4	1.3

Table A.1. General Caribou Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weight-ed MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimen-sion	Area Weighted MPFD
Upper Yukon (cont.)	Ft. Yukon	Canyon	3320.3	4.7	87.0	2.6	38.2	4.0	3225.6	1.6	4.0	559.7	1.3	1.3
		Midslope Drainage	1416.0	2.0	299.0	21.1	4.7	3.4	794.7	1.3	2.0	938.1	1.4	1.3
		Upland Drainage	34.7	0.0	21.0	60.6	1.7	0.1	435.5	1.2	1.3	799.0	1.4	1.3
		U-shaped Valley	4311.1	6.2	471.0	10.9	9.2	5.8	855.2	1.4	3.6	1088.0	1.4	1.3
		Plains	47656.7	68.1	268.0	0.6	177.8	11.4	2966.0	1.4	2.6	1684.8	1.4	1.2
		Open Slope	1615.0	2.3	732.0	45.3	2.2	6.4	608.4	1.4	3.2	1139.0	1.4	1.4
		Upper Slope	5618.9	8.0	176.0	3.1	31.9	4.7	1861.4	1.4	2.8	682.3	1.3	1.3
		Local Ridge	115.9	0.2	116.0	100.1	1.0	0.5	312.9	1.2	2.1	1146.9	1.4	1.3
		Midslope Ridge	2984.6	4.3	306.0	10.3	9.8	5.6	1289.7	1.4	2.0	594.4	1.3	1.3
		High Ridge	2864.2	4.1	121.0	4.2	23.7	3.8	2179.4	1.5	2.2	602.6	1.3	1.3
	Venetie	Canyon	13210.2	3.0	654.0	5.0	20.2	2.8	1894.2	1.5	2.8	785.6	1.4	1.3
		Midslope Drainage	8630.3	1.9	2018.0	23.4	4.3	3.3	725.4	1.4	2.1	2544.7	1.4	1.3
		Upland Drainage	508.8	0.1	191.0	37.5	2.7	0.3	592.5	1.3	1.5	921.6	1.4	1.3
		U-shaped Valley	25783.1	5.8	1157.0	4.5	22.3	4.3	1637.2	1.4	4.9	1254.5	1.4	1.3
		Plains	233424.1	52.5	6882.0	2.9	33.9	17.8	1149.0	1.4	19.7	1291.7	1.4	1.4
		Open Slope	101178.0	22.8	8178.0	8.1	12.4	23.0	1248.0	1.5	9.6	1661.7	1.4	1.4
		Upper Slope	36613.4	8.2	690.0	1.9	53.1	5.0	3211.2	1.5	3.9	1203.4	1.4	1.3
		Local Ridge	260.1	0.1	237.0	91.1	1.1	0.2	356.6	1.3	1.5	1117.8	1.4	1.3
		Midslope Ridge	7846.0	1.8	1425.0	18.2	5.5	2.7	829.7	1.3	1.6	815.5	1.4	1.3
		High Ridge	17249.3	3.9	738.0	4.3	23.4	3.0	1798.2	1.4	2.1	1085.1	1.4	1.3

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
Koyukuk	Alatna	Canyon	1512.8	0.65	87	6	17.4	0.74	1973.1	1.56	2.61	404.6	1.33	1.32
		Midslope Drainage	1718.2	0.74	404	24	4.3	1.48	847.1	1.38	1.83	596.3	1.34	1.31
		Upland Drainage	32.2	0.01	10	31	3.2	0.03	607.8	1.48	1.35	1371.8	1.40	1.27
		U-Shaped Valley	3308.1	1.43	143	4	23.1	1.04	1681.2	1.37	2.10	470.4	1.32	1.28
		Plains	209177.3	90.54	74	0	2826.7	6.52	20368.9	1.63	6.59	4347.6	1.32	1.30
		Open Slope	10140.9	4.39	177	2	57.3	2.55	3325.8	1.53	3.82	402.1	1.32	1.31
		Upper Slope	2119.7	0.92	101	5	21.0	0.75	1716.7	1.49	1.78	2795.1	1.31	1.27
		Local Ridge	4.8	0.00	5	105	1.0	0.01	439.0	1.26	1.50	518.3	1.33	1.35
		Midslope Ridge	2077.3	0.90	326	16	6.4	1.46	1036.2	1.38	1.62	452.9	1.32	1.29
		High Ridge	935.6	0.40	86	9	10.6	0.52	1366.9	1.49	1.64	744.8	1.34	1.28
	Bettles	Canyon	597.3	0.24	75	13	6.0	0.37	1209.9	1.42	1.62	384.0	1.32	1.29
		Midslope Drainage	1785.2	0.73	384	22	4.6	1.34	854.1	1.38	1.67	673.4	1.31	1.30
		Upland Drainage	51.5	0.02	31	60	1.7	0.06	502.8	1.31	1.30	738.2	1.35	1.30
		U-Shaped Valley	3804.9	1.56	87	2	43.7	0.75	2095.5	1.37	2.12	415.9	1.31	1.26
		Plains	199086.3	81.48	207	0	961.8	6.40	7551.3	1.41	6.77	448.9	1.32	1.30
		Open Slope	32901.1	13.47	313	1	105.1	6.67	5208.4	1.67	3.85	616.5	1.34	1.32
		Upper Slope	2652.4	1.09	175	7	15.2	1.10	1535.5	1.42	2.20	1229.6	1.31	1.30
		Local Ridge	1462.3	0.60	306	21	4.8	1.11	889.4	1.35	1.50	470.9	1.32	1.29
		Midslope Ridge	1985.7	0.81	98	5	20.3	0.76	1893.6	1.49	1.65	1889.9	1.29	1.27
	Hughes	High Ridge	931.1	0.68	70	8	13.3	0.88	1727.1	1.48	1.93	317.2	1.31	1.30
		Midslope Drainage	2519.3	1.84	369	15	6.8	2.87	1063.8	1.36	1.71	393.3	1.31	1.29
		Upland Drainage	6.8	0.00	7	103	1.0	0.02	395.0	1.19	1.24	501.0	1.32	1.31
		U-Shaped Valley	2734.3	2.00	61	2	44.8	0.86	1937.9	1.38	2.52	546.5	1.33	1.28
		Plains	114586.9	83.72	124	0	924.1	6.17	6812.7	1.47	3.99	735.9	1.35	1.26
		Open Slope	10620.8	7.76	414	4	25.7	7.23	2390.4	1.56	2.67	489.1	1.33	1.31
		Upper Slope	1924.8	1.41	118	6	16.3	1.33	1537.1	1.45	1.79	516.9	1.33	1.27
		Local Ridge	0.6	0.00	1	175	0.6	0.00	302.7	1.13	1.13	528.6	1.32	1.32
		Midslope Ridge	1661.3	1.21	405	24	4.1	2.35	792.6	1.30	1.45	421.9	1.32	1.29
		High Ridge	1882.8	1.38	74	4	25.4	1.35	2500.0	1.56	1.97	877.9	1.42	1.29

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
	Huslia	Canyon	146.2	0.07	11	8	13.3	0.09	1678.5	1.47	1.62	297.0	1.31	1.28
		Midslope Drainage	512.6	0.24	127	25	4.0	0.48	808.8	1.33	1.44	456.8	1.32	1.29
		Upland Drainage	7.5	0.00	9	120	0.8	0.02	385.4	1.20	1.24	493.5	1.32	1.32
		U-Shaped Valley	475.7	0.22	12	3	39.6	0.15	2787.6	1.48	1.98	326.3	1.30	1.27
		Plains	209143.8	96.88	30	0	6971.5	3.08	22135.1	1.36	4.00	473.0	1.32	1.25
		Open Slope	3053.2	1.41	214	7	14.3	1.51	1526.0	1.49	2.26	473.4	1.34	1.30
		Upper Slope	1352.0	0.63	79	6	17.1	0.57	1568.9	1.38	2.05	422.7	1.32	1.29
		Local Ridge	3.7	0.00	2	54	1.8	0.00	508.6	1.14	1.15	389.8	1.30	1.28
		Midslope Ridge	451.3	0.21	139	31	3.2	0.45	704.8	1.28	1.40	425.1	1.32	1.29
		High Ridge	727.2	0.34	47	6	15.5	0.42	1923.6	1.49	1.71	226.1	1.30	1.29
Kuskokwim	McGrath	Canyon	5463.6	2.56	256	5	21.3	2.72	2265.1	1.52	2.95	448.4	1.32	1.32
		Midslope Drainage	7071.7	3.31	1,062	15	6.7	5.08	1020.9	1.38	1.91	1006.1	1.35	1.30
		Upland Drainage	892.4	0.42	234	26	3.8	0.81	736.2	1.35	1.58	841.8	1.36	1.29
		U-Shaped Valley	14529.5	6.80	499	3	29.1	3.40	1454.4	1.37	3.10	993.0	1.38	1.30
		Plains	143773.3	67.32	467	0	307.9	7.42	3393.3	1.40	6.39	828.9	1.36	1.30
		Open Slope	22223.3	10.41	820	4	27.1	10.07	2622.4	1.70	5.10	828.3	1.38	1.36
		Upper Slope	5606.4	2.63	682	12	8.2	3.71	1162.8	1.46	2.71	830.3	1.37	1.33
		Local Ridge	42.6	0.02	59	138	0.7	0.09	311.9	1.27	1.58	1142.1	1.40	1.34
		Midslope Ridge	4987.6	2.34	1,034	21	4.8	4.20	867.7	1.36	1.69	771.0	1.16	1.30
		High Ridge	8976.9	4.20	230	3	39.0	3.34	3105.7	1.53	2.39	512.1	1.31	1.29
	Nikolai	Canyon	467.0	0.11	46	10	10.2	0.14	1355.7	1.42	1.99	671.9	1.34	1.30
		Midslope Drainage	1617.7	0.37	197	12	8.2	0.54	1204.4	1.37	1.91	392.9	1.31	1.30
		Upland Drainage	59.3	0.01	30	51	2.0	0.04	573.0	1.27	1.42	474.2	1.32	1.31
		U-Shaped Valley	1294.6	0.30	31	2	41.8	0.17	2471.5	1.46	2.04	1398.9	1.39	1.27
		Plains	422106.9	96.25	98	0	4307.2	2.36	10569.3	1.32	4.06	426.0	1.31	1.24
		Open Slope	8467.4	1.93	212	3	39.9	1.55	3202.5	1.61	3.20	359.4	1.32	1.32
		Upper Slope	1750.6	0.40	155	9	11.3	0.44	1233.7	1.36	2.49	618.5	1.33	1.31
		Midslope Ridge	1039.6	0.24	217	21	4.8	0.43	872.9	1.32	1.54	417.7	1.32	1.29
		High Ridge	1756.6	0.40	69	4	25.5	0.36	2296.9	1.48	1.87	853.4	1.34	1.28

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
	Stony River	Canyon	4084.4	0.49	343	8	11.9	0.66	1616.0	1.45	1.75	390.7	1.31	1.29
		Midslope Drainage	13226.3	1.58	1,677	13	7.9	2.29	1144.1	1.34	1.58	390.8	1.31	1.28
		Upland Drainage	495.0	0.06	178	36	2.8	0.14	654.1	1.27	1.32	520.0	1.32	1.29
		U-Shaped Valley	12083.9	1.44	347	3	34.8	0.86	2064.9	1.37	2.46	401.0	1.31	1.28
		Plains	704189.3	84.08	899	0	783.3	6.04	5625.1	1.37	9.59	522.1	1.25	1.31
		Open Slope	69079.9	8.25	1,349	2	51.2	6.61	4105.4	1.72	4.30	994.9	1.32	1.34
		Upper Slope	9959.7	1.19	1,062	11	9.4	1.58	1249.9	1.37	2.23	484.6	1.32	1.31
		Local Ridge	3.8	0.00	3	78	1.3	0.00	539.9	1.37	1.41	476.7	1.34	1.34
		Midslope Ridge	10935.2	1.31	1,764	16	6.2	2.09	990.7	1.31	1.51	370.3	1.31	1.28
		High Ridge	13456.4	1.61	498	4	27.0	1.42	2387.9	1.47	1.82	597.6	1.29	1.27
	Telida	Canyon	1199.1	0.71	58	5	20.7	0.65	1892.9	1.41	1.83	298.0	1.30	1.28
		Midslope Drainage	1363.2	0.81	176	13	7.7	1.16	1110.7	1.32	1.64	329.5	1.30	1.28
		Upland Drainage	192.3	0.11	44	23	4.4	0.20	782.0	1.27	1.30	373.9	1.31	1.27
		U-Shaped Valley	3481.1	2.07	69	2	50.5	1.06	2582.8	1.39	2.15	347.9	1.30	1.27
		Plains	146225.5	86.94	105	0	1392.6	3.61	5782.2	1.33	3.48	332.4	1.30	1.24
		Open Slope	9252.2	5.50	117	1	79.1	3.46	4976.4	1.75	4.55	566.9	1.34	1.34
		Upper Slope	3036.8	1.81	125	4	24.3	1.55	2087.2	1.42	3.33	392.9	1.32	1.33
		Local Ridge	12.2	0.01	10	82	1.2	0.03	424.3	1.20	1.33	507.1	1.32	1.31
		Midslope Ridge	1154.0	0.69	197	17	5.9	1.14	972.1	1.35	1.70	612.5	1.32	1.29
		High Ridge	2277.6	1.35	76	3	30.0	1.10	2433.2	1.41	1.71	211.2	1.28	1.27
Lower Tanana	Beaver	Canyon	79.5	0.03	18	23	4.4	0.07	881.0	1.44	1.59	463.1	1.34	1.30
		Midslope Drainage	135.0	0.06	34	25	4.0	0.11	772.6	1.32	1.67	431.3	1.32	1.30
		U-Shaped Valley	1499.8	0.65	7	0	214.3	0.21	6845.3	1.50	2.81	355.0	1.30	1.28
		Plains	226294.0	98.32	10	0	22629.4	2.37	54452.5	1.55	3.16	361.5	1.31	1.22
		Open Slope	1124.4	0.49	38	3	29.6	0.41	2478.8	1.63	2.17	528.5	1.34	1.29
		Upper Slope	761.9	0.33	25	3	30.5	0.15	1388.0	1.26	1.72	453.5	1.32	1.24
		Local Ridge	8.3	0.00	1	12	8.3	0.01	1324.1	1.30	1.30	159.3	1.27	1.27
		Midslope Ridge	106.6	0.05	41	38	2.6	0.12	685.6	1.39	1.55	1464.7	1.44	1.31
		High Ridge	156.6	0.07	18	11	8.7	0.10	1313.2	1.55	1.93	656.8	1.36	1.31

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

		Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
Minto	Canyon	1640.3	0.77	120	7	13.7	0.95	1682.4	1.50	2.34	551.9	1.33	1.31
	Midslope Drainage	2364.9	1.11	293	12	8.1	1.59	1159.3	1.39	1.64	636.1	1.33	1.28
	Upland Drainage	46.8	0.02	29	62	1.6	0.07	525.5	1.25	1.38	456.6	1.32	1.31
	U-Shaped Valley	4260.2	2.00	129	3	33.0	1.32	2174.3	1.41	2.41	438.3	1.32	1.29
	Plains	184573.5	86.55	161	0	1146.4	6.98	9248.7	1.45	6.77	532.5	1.32	1.30
	Open Slope	12661.8	5.94	334	3	37.9	4.44	2838.0	1.61	2.94	578.6	1.34	1.31
	Upper Slope	3709.8	1.74	169	5	22.0	1.36	1717.7	1.36	2.50	414.1	1.31	1.30
	Local Ridge	1.2	0.00	2	161	0.6	0.00	369.8	1.34	1.35	636.2	1.36	1.36
	Midslope Ridge	1708.1	0.80	295	17	5.8	1.34	967.5	1.34	1.59	429.1	1.32	1.29
	High Ridge	*2265.3*	*1.07*	*115*	*5*	*19.9*	*1.11*	*2051.3*	*1.54*	*2.00*	*441.6*	*1.32*	*1.29*
Stevens Village	Canyon	1880.2	0.49	135	7	13.9	0.58	1659.6	1.50	2.50	519.0	1.33	1.32
	Midslope Drainage	1544.8	0.40	357	23	4.3	0.78	840.5	1.36	1.54	944.1	1.35	1.29
	Upland Drainage	57.0	0.01	18	32	3.2	0.03	744.8	1.34	1.60	471.3	1.33	1.31
	U-Shaped Valley	4995.6	1.29	152	3	32.9	0.79	2017.0	1.39	3.88	437.2	1.32	1.32
	Plains	356362.1	92.17	164	0	2172.9	3.32	7824.3	1.43	4.79	743.7	1.34	1.26
	Open Slope	14624.3	3.78	493	3	29.7	2.90	2270.4	1.53	2.58	520.4	1.33	1.30
	Upper Slope	3841.3	0.99	123	3	31.2	0.69	2166.3	1.42	2.93	426.4	1.32	1.31
	Local Ridge	3.1	0.00	5	159	0.6	0.00	325.5	1.18	1.17	554.4	1.33	1.32
	Midslope Ridge	1748.8	0.45	239	14	7.3	0.74	1197.8	1.44	1.78	532.7	1.33	1.30
	High Ridge	1563.9	0.40	91	6	17.2	0.43	1846.0	1.50	2.06	393.9	1.32	1.29
Tanana	Canyon	15870.5	2.71	555	3	28.6	2.46	2590.6	1.53	3.27	432.5	1.32	1.32
	Midslope Drainage	11543.0	1.97	1,858	16	6.2	3.15	991.7	1.33	1.69	483.6	1.32	1.29
	Upland Drainage	647.3	0.11	230	36	2.8	0.25	634.1	1.28	1.34	653.9	1.33	1.28
	U-Shaped Valley	28734.8	4.91	874	3	32.9	3.12	2087.5	1.39	2.89	1575.8	1.32	1.30
	Plains	426394.0	72.85	821	0	519.4	6.47	4609.6	1.39	8.01	618.4	1.31	1.31
	Open Slope	55690.7	9.51	2,054	4	27.1	8.73	2488.3	1.55	2.86	440.9	1.31	1.32
	Upper Slope	19499.5	3.33	920	5	21.2	2.83	1801.3	1.43	2.47	721.7	1.29	1.30
	Local Ridge	342.3	0.06	145	42	2.4	0.15	585.8	1.26	1.35	464.4	1.32	1.29
	Midslope Ridge	10410.4	1.78	1,656	16	6.3	2.81	991.9	1.33	1.58	456.6	1.31	1.28
	High Ridge	16204.6	2.77	490	3	33.1	2.35	2808.8	1.55	2.19	439.7	1.31	1.29

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patches	Patch Density	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
Upper Tanana	Dot Lake	Canyon	549.4	0.46	59	11	9.3	0.63	1292.7	1.41	2.09	380.0	1.32	1.30
		Midslope Drainage	2680.2	2.23	372	14	7.2	3.31	1071.5	1.36	1.56	6774.8	1.26	1.28
		Upland Drainage	3.7	0.00	3	80	1.2	0.01	475.6	1.29	1.26	493.2	1.33	1.31
		U-Shaped Valley	2200.4	1.83	57	3	38.6	1.13	2388.5	1.41	1.82	383.1	1.30	1.26
		Plains	86297.5	71.67	261	0	330.6	9.49	4380.2	1.39	6.47	466.8	1.32	1.31
		Open Slope	23243.7	19.30	218	1	106.6	12.70	7013.5	1.93	4.69	364.6	1.32	1.34
		Upper Slope	1229.0	1.02	114	9	10.8	1.18	1243.1	1.41	1.92	504.1	1.33	1.29
		Midslope Ridge	2735.2	2.27	390	14	7.0	3.40	1049.1	1.32	1.45	433.9	1.31	1.27
		High Ridge	1476.0	1.23	69	5	21.4	1.25	2179.5	1.47	1.97	274.1	1.29	1.29
	Northway	Canyon	3782.2	1.39	187	5	20.2	1.45	2098.8	1.57	2.18	766.0	1.34	1.30
		Midslope Drainage	2328.3	0.86	516	22	4.5	1.59	837.7	1.32	1.53	793.4	1.31	1.29
		Upland Drainage	16.3	0.01	5	27	3.7	0.02	816.5	1.35	1.45	404.2	1.32	1.30
		U-Shaped Valley	8959.7	3.30	302	3	29.7	2.15	1930.7	1.42	2.70	530.7	1.33	1.29
		Plains	216071.0	79.67	342	0	631.8	9.36	7424.8	1.51	7.17	936.6	1.49	1.31
		Open Slope	33094.4	12.20	516	2	64.1	8.66	4551.7	1.81	3.24	569.0	1.34	1.32
		Upper Slope	2057.5	0.76	216	10	9.5	0.95	1188.6	1.38	2.56	474.1	1.32	1.31
		Local Ridge	13.5	0.00	15	111	0.9	0.02	388.4	1.26	1.31	627.0	1.35	1.32
		Midslope Ridge	3055.4	1.13	527	17	5.8	1.86	958.7	1.36	1.48	1597.8	1.17	1.28
		High Ridge	1811.4	0.67	130	7	13.9	0.82	1704.1	1.52	1.99	397.7	1.32	1.30
	Tanacross	Canyon	17101.5	2.25	746	4	22.9	2.16	2207.1	1.47	2.31	917.8	1.30	1.30
		Midslope Drainage	19714.5	2.59	2,786	14	7.1	3.88	1059.8	1.32	1.53	418.8	1.30	1.28
		Upland Drainage	1123.6	0.15	272	24	4.1	0.28	786.7	1.30	1.44	433.1	1.32	1.28
		U-Shaped Valley	30506.6	4.01	1,168	4	26.1	2.72	1775.0	1.37	3.12	441.3	1.32	1.30
		Plains	444616.8	58.38	1,363	0	326.2	8.11	4529.3	1.39	10.75	367.7	1.30	1.33
		Open Slope	177621.0	23.32	1,429	1	124.3	12.86	6856.9	1.72	7.55	480.3	1.33	1.36
		Upper Slope	30665.9	4.03	1,326	4	23.1	3.44	1973.9	1.43	2.70	517.5	1.33	1.31
		Local Ridge	131.0	0.02	87	66	1.5	0.06	494.2	1.24	1.34	472.8	1.32	1.31
		Midslope Ridge	17159.5	2.25	2,515	15	6.8	3.45	1044.5	1.33	1.53	460.0	1.31	1.28
		High Ridge	23010.5	3.02	931	4	24.7	2.71	2220.0	1.44	1.81	969.2	1.29	1.27

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	% Class	# Patch-es	Patch Den-sity	Mean Patch Size	Edge Den-sity	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
	Tetlin	Canyon	54.7	0.12	16	29	3.4	0.25	701.0	1.39	1.44	1497.5	1.40	1.29
		Midslope Drainage	303.8	0.67	80	26	3.8	1.37	776.0	1.34	1.39	618.7	1.33	1.28
		U-Shaped Valley	194.5	0.43	17	9	11.4	0.42	1116.4	1.44	1.68	1178.6	1.37	1.27
		Plains	40526.9	89.19	53	0	764.7	8.22	7045.6	1.57	3.54	12816.7	1.56	1.26
		Open Slope	3910.8	8.61	46	1	85.0	6.11	6038.4	1.96	2.71	408.0	1.32	1.30
		Upper Slope	39.1	0.09	14	36	2.8	0.20	658.4	1.28	1.37	434.2	1.32	1.29
		Midslope Ridge	305.2	0.67	72	24	4.2	1.23	775.0	1.29	1.34	1258.2	1.72	1.27
		High Ridge	101.5	0.22	12	12	8.5	0.25	959.1	1.42	1.59	2000.2	1.44	1.27
	Tok	Canyon	87319.5	4.33	2,798	3	31.2	3.68	2654.8	1.49	2.83	434.7	1.30	1.31
		Midslope Drainage	83089.2	4.12	9,450	11	8.8	5.45	1163.0	1.33	1.61	390.3	1.30	1.28
		Upland Drainage	8984.3	0.45	1,801	20	5.0	0.78	871.0	1.29	1.44	411.9	1.31	1.28
		U-Shaped Valley	128012.3	6.35	4,661	4	27.5	4.37	1890.1	1.37	4.75	408.0	1.31	1.33
		Plains	933790.6	46.30	4,235	0	220.5	6.83	3254.6	1.36	8.44	382.9	1.30	1.31
		Open Slope	503811.2	24.98	5,287	1	95.3	15.05	5740.6	1.62	9.49	453.8	1.32	1.38
		Upper Slope	102279.8	5.07	5,497	5	18.6	4.97	1824.9	1.43	2.80	462.5	1.30	1.32
		Local Ridge	2025.5	0.10	858	42	2.4	0.26	599.5	1.25	1.34	484.1	1.32	1.29
		Midslope Ridge	67972.1	3.37	8,619	13	7.9	4.81	1125.7	1.33	1.55	490.8	1.30	1.28
		High Ridge	99556.6	4.94	2,695	3	36.9	3.87	2897.5	1.50	2.53	278.0	1.29	1.29
Upper Yukon	Arctic Village	Canyon	42383.5	4.10	1,966	5	21.6	3.77	1981.8	1.47	3.83	862.6	1.36	1.33
		Midslope Drainage	42092.6	4.07	6,917	16	6.1	6.18	924.6	1.38	2.05	962.8	1.38	1.31
		Upland Drainage	4452.9	0.43	1,574	35	2.8	0.91	599.5	1.33	1.65	1022.0	1.38	1.30
		U-Shaped Valley	75815.5	7.33	3,741	5	20.3	5.21	1440.5	1.42	4.62	1227.0	1.41	1.34
		Plains	429683.3	41.53	18,211	4	23.6	17.48	992.9	1.38	31.66	1407.0	1.42	1.42
		Open Slope	277681.8	26.84	18,215	7	15.2	26.90	1527.9	1.52	16.07	1417.0	1.44	1.43
		Upper Slope	69363.7	6.70	3,863	6	18.0	6.69	1790.7	1.54	3.49	1116.1	1.40	1.34
		Local Ridge	1264.1	0.12	831	66	1.5	0.34	418.4	1.31	1.58	1172.7	1.40	1.31
		Midslope Ridge	32935.9	3.18	6,150	19	5.4	5.05	850.1	1.35	1.68	875.4	1.37	1.29
		High Ridge	58843.1	5.69	2,097	4	28.1	4.56	2251.7	1.42	2.20	657.8	1.33	1.29

Table A.2. General Moose Hunting Range Class Level Metrics for the Five Study Areas (continued)

		Class Area	% Class	# Patch-es	Patch Den-sity	Mean Patch Size	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPFD
Chalkyitsik	Canyon	7675.3	1.58	611	8	12.6	1.73	1373.7	1.44	3.09	1071.3	1.37	1.33
	Midslope Drainage	6851.5	1.41	2,185	32	3.1	2.79	619.4	1.35	1.96	1107.0	1.39	1.31
	Upland Drainage	297.1	0.06	164	55	1.8	0.16	460.9	1.31	1.41	1038.6	1.39	1.29
	U-Shaped Valley	16528.2	3.41	1,462	9	11.3	2.71	896.8	1.36	3.19	1457.9	1.41	1.31
	Plains	401592.6	82.91	3,360	1	119.5	11.40	1643.6	1.40	8.60	1339.3	1.43	1.30
	Open Slope	22261.4	4.60	6,026	27	3.7	10.87	873.9	1.52	4.50	1267.6	1.42	1.40
	Upper Slope	12732.6	2.63	480	4	26.5	2.15	2166.8	1.50	3.48	1219.2	1.41	1.33
	Local Ridge	54.2	0.01	134	247	0.4	0.06	219.1	1.24	1.50	1321.6	1.42	1.35
	Midslope Ridge	7870.5	1.62	1,508	19	5.2	2.52	809.3	1.36	1.88	1050.7	1.37	1.30
	High Ridge	8527.7	1.76	471	6	18.1	1.44	1477.1	1.37	1.78	894.0	1.36	1.27
Ft Yukon	Canyon	3805.5	0.69	235	6	16.2	0.75	1758.9	1.53	2.70	858.2	1.37	1.32
	Midslope Drainage	3192.1	0.58	841	26	3.8	1.05	690.2	1.38	2.22	1190.9	1.40	1.32
	Upland Drainage	30.3	0.01	19	63	1.6	0.01	425.1	1.26	1.32	948.4	1.37	1.29
	U-Shaped Valley	7429.4	1.35	550	7	13.5	1.06	1061.6	1.38	2.53	1918.5	1.41	1.30
	Plains	520538.6	94.29	1,073	0	485.1	5.17	2657.9	1.43	5.56	1689.9	1.43	1.27
	Open Slope	8202.3	1.49	1,708	21	4.8	3.18	1026.5	1.58	4.21	1357.5	1.44	1.39
	Upper Slope	3024.8	0.55	207	7	14.6	0.44	1181.0	1.41	2.20	1518.7	1.43	1.29
	Local Ridge	35.5	0.01	72	203	0.5	0.03	237.7	1.27	1.99	1465.2	1.43	1.37
	Midslope Ridge	3620.0	0.66	598	17	6.1	1.01	933.7	1.40	1.75	961.0	1.37	1.29
	High Ridge	2197.7	0.40	168	8	13.1	0.39	1274.1	1.41	1.78	1081.7	1.38	1.27
Venetie	Canyon	7672.5	1.41	389	5	19.7	1.34	1870.9	1.47	2.86	822.9	1.36	1.32
	Midslope Drainage	5555.4	1.02	1,311	24	4.2	1.77	732.1	1.35	2.16	1028.8	1.39	1.32
	Upland Drainage	200.3	0.04	74	37	2.7	0.08	603.7	1.33	1.49	844.6	1.37	1.30
	U-Shaped Valley	15480.4	2.85	771	5	20.1	2.07	1461.3	1.41	3.99	1356.2	1.41	1.33
	Plains	421712.6	77.59	4,304	1	98.0	10.46	1320.6	1.40	15.28	1342.3	1.42	1.36
	Open Slope	57311.0	10.54	5,818	10	9.9	11.95	1116.2	1.50	10.20	1452.8	1.44	1.41
	Upper Slope	20607.4	3.79	392	2	52.6	2.31	3200.0	1.53	4.31	1112.5	1.40	1.33
	Local Ridge	147.1	0.03	146	99	1.0	0.09	333.6	1.27	1.47	1139.8	1.40	1.31
	Midslope Ridge	5519.7	1.07	914	17	6.0	1.44	856.1	1.33	1.66	838.1	1.36	1.28
	High Ridge	9298.8	1.71	419	5	22.2	1.33	1720.5	1.39	2.09	861.9	1.36	1.28

Table A.3. General Sheep Hunting Range Class Level Metrics for the Five Study Areas

			Class Area	# Patches	% Class	Mean Patch Size (ha)	Ptach Density	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPAR
Koyukuk	**Alatna**	**Canyon**	20677.0	995	6.74	20.78	4.81	6.56	2022.38	1.48	2.35	373.94	1.32	1.30
		Midslope Drainage	23646.2	2591	7.71	9.13	10.96	9.61	1137.87	1.33	1.58	396.96	1.31	1.27
		Upland Drainage	1058.3	502	0.35	2.11	47.44	0.92	563.90	1.27	1.35	502.28	1.33	1.30
		U-Shaped Valley	40878.8	1103	13.33	37.06	2.70	8.62	2396.25	1.40	5.02	472.00	1.32	1.34
		Plains	20676.5	987	6.74	20.95	4.77	3.46	1076.40	1.29	2.90	421.19	1.31	1.27
		Open Slope	124086.4	1142	40.47	108.66	0.92	24.23	6505.42	1.61	10.30	423.91	1.33	1.39
		Upper Slope	27086.6	1778	8.83	15.23	6.56	10.30	1776.99	1.45	2.78	402.58	1.32	1.33
		Local Ridge	73.8	65	0.02	1.14	88.04	0.09	428.61	1.26	1.31	557.59	1.34	1.31
		Midslope Ridge	14949.8	2421	4.88	6.18	16.19	7.40	936.70	1.31	1.48	410.49	1.31	1.28
		High Ridge	33495.0	755	10.92	44.36	2.25	8.11	3292.04	1.52	2.26	282.95	1.30	1.29
	Bettles	**Canyon**	3732.8	252	3.96	14.81	6.75	4.20	1572.71	1.44	1.94	443.54	1.32	1.29
		Midslope Drainage	5102.0	768	5.41	6.64	15.05	7.96	976.92	1.34	1.56	495.46	1.32	1.28
		Upland Drainage	310.4	99	0.33	3.14	31.89	0.71	680.41	1.29	1.37	470.67	1.32	1.28
		U-Shaped Valley	10651.4	252	11.30	42.27	2.37	6.18	2312.92	1.40	3.66	597.82	1.33	1.31
		Plains	19025.2	291	20.18	65.38	1.53	5.55	1797.71	1.31	3.36	422.22	1.31	1.28
		Open Slope	37339.9	262	39.61	142.52	0.70	21.83	7852.85	1.74	5.89	441.46	1.33	1.36
		Upper Slope	7316.8	412	7.76	17.76	5.63	8.51	1948.03	1.46	3.02	701.43	1.32	1.33
		Local Ridge	14.4	9	0.02	1.60	62.37	0.05	480.67	1.28	1.30	584.83	1.34	1.30
		Midslope Ridge	3399.1	563	3.61	6.04	16.56	5.51	922.14	1.32	1.46	717.51	1.31	1.27
		High Ridge	7374.0	229	7.82	32.20	3.11	6.35	2613.25	1.49	1.86	306.52	1.30	1.28

Table A.3. General Sheep Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	# Patches	% Class	Mean Patch Size (ha)	Ptach Density	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPAR
Kuskokwim	Stony River	Canyon	214.2	21	2.30	10.20	9.80	3.30	1463.98	1.42	1.96	490.78	1.32	1.30
		Midslope Drainage	1079.7	87	11.60	12.41	8.06	13.53	1447.44	1.36	1.41	276.97	1.29	1.26
		Upland Drainage	312.8	52	3.36	6.01	16.63	5.23	936.17	1.28	1.42	1647.05	1.20	1.27
		U-Shaped Valley	315.5	19	3.39	16.61	6.02	3.81	1869.22	1.56	1.87	605.90	1.34	1.29
		Plains	770.1	29	8.27	26.56	3.77	4.56	1463.30	1.31	1.72	383.16	1.30	1.25
		Open Slope	2853.0	98	30.64	29.11	3.43	28.37	2694.99	1.56	3.50	467.50	1.33	1.33
		Upper Slope	1428.5	99	15.34	14.43	6.93	18.94	1780.83	1.49	2.21	377.69	1.32	1.31
		Local Ridge	8.1	4	0.09	2.03	49.30	0.24	561.90	1.23	1.25	416.85	1.31	1.29
		Midslope Ridge	560.5	76	6.02	7.37	13.56	8.83	1082.16	1.32	1.43	360.20	1.30	1.27
		High Ridge	1768.0	37	18.99	47.78	2.09	13.86	3488.55	1.54	2.13	202.42	1.29	1.29
Upper Tanana	Dot Lake	Canyon	2490.5	57	9.81	43.69	2.29	7.02	3126.85	1.52	2.53	321.51	1.30	1.30
		Midslope Drainage	1568.5	171	6.18	9.17	10.90	7.83	1162.95	1.33	1.63	567.35	1.33	1.28
		Upland Drainage	176.2	62	0.69	2.84	35.18	1.56	638.43	1.27	1.29	458.16	1.32	1.28
		U-Shaped Valley	2336.1	120	9.20	19.47	5.14	8.92	1885.95	1.45	2.22	374.93	1.31	1.30
		Plains	3432.8	67	13.52	51.24	1.95	5.14	1946.48	1.38	1.95	666.72	1.33	1.24
		Open Slope	8970.8	145	35.34	61.87	1.62	21.80	3816.27	1.58	6.57	465.91	1.33	1.36
		Upper Slope	2754.2	117	10.85	23.54	4.25	8.14	1766.49	1.45	2.60	442.08	1.32	1.29
		Local Ridge	68.1	28	0.27	2.43	41.11	0.74	671.03	1.30	1.43	397.42	1.32	1.31
		Midslope Ridge	1351.1	210	5.32	6.43	15.54	8.13	982.92	1.38	1.47	618.39	1.33	1.28
		High Ridge	2234.7	73	8.80	30.61	3.27	7.06	2456.28	1.46	2.16	454.78	1.31	1.29

Table A.3. General Sheep Hunting Range Class Level Metrics for the Five Study Areas (continued)

		Class Area	# Patches	% Class	Mean Patch Size (ha)	Ptach Density	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPAR
Northway	Canyon	213.2	13	5.49	16.40	6.10	5.99	1787.71	1.49	1.74	308.97	1.31	1.28
	Midslope Drainage	530.1	33	13.66	16.06	6.23	14.23	1674.20	1.37	1.48	317.29	1.29	1.26
	Upland Drainage	123.7	32	3.19	3.86	25.87	6.55	794.18	1.29	1.37	352.51	1.31	1.28
	U-Shaped Valley	396.3	20	10.21	19.81	5.05	7.72	1498.21	1.29	1.75	344.82	1.30	1.26
	Plains	119.8	4	3.09	29.94	3.34	1.48	1435.29	1.24	1.17	387.63	1.30	1.21
	Open Slope	718.8	61	18.52	11.78	8.49	24.07	1531.89	1.43	1.86	485.08	1.32	1.30
	Upper Slope	673.7	42	17.36	16.04	6.23	20.99	1939.84	1.49	3.25	334.21	1.31	1.34
	Local Ridge	8.1	2	0.21	4.05	24.67	0.48	923.33	1.31	1.38	253.25	1.29	1.29
	Midslope Ridge	130.5	35	3.36	3.73	26.81	6.86	760.50	1.30	1.48	432.87	1.32	1.29
	High Ridge	967.3	17	24.92	56.90	1.76	17.73	4047.96	1.62	2.28	272.14	1.30	1.29
Tanacross	Canyon	19764.5	340	15.58	58.13	1.72	10.68	3985.91	1.56	3.26	328.49	1.30	1.32
	Midslope Drainage	12960.2	1034	10.21	12.53	7.98	11.35	1393.39	1.34	1.70	345.10	1.30	1.28
	Upland Drainage	3748.6	663	2.95	5.65	17.69	4.81	920.30	1.28	1.43	355.46	1.30	1.28
	U-Shaped Valley	18763.7	752	14.79	24.95	4.01	11.44	1930.73	1.41	5.48	440.41	1.32	1.34
	Plains	4430.5	169	3.49	26.22	3.81	1.72	1289.53	1.31	1.68	362.09	1.31	1.23
	Open Slope	24509.0	1361	19.31	18.01	5.55	19.32	1801.03	1.43	4.10	629.55	1.31	1.34
	Upper Slope	11722.4	1305	9.24	8.98	11.13	13.74	1335.96	1.41	2.33	368.11	1.31	1.32
	Local Ridge	714.0	303	0.56	2.36	42.44	1.44	602.78	1.26	1.32	422.09	1.32	1.29
	Midslope Ridge	7472.8	974	5.89	7.67	13.03	8.50	1106.93	1.33	1.52	354.67	1.31	1.28
	High Ridge	22812.8	240	17.98	95.05	1.05	10.64	5623.31	1.64	3.35	307.71	1.30	1.31

Table A.3. General Sheep Hunting Range Class Level Metrics for the Five Study Areas (continued)

			Class Area	# Patches	% Class	Mean Patch Size (ha)	Ptach Density	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPAR
	Tok	Canyon	98294.2	2470	10.98	39.80	2.51	8.41	3047.75	1.52	3.05	342.35	1.31	1.31
		Midslope Drainage	90745.3	6889	10.14	13.17	7.59	11.22	1458.15	1.36	1.69	494.92	1.30	1.28
		Upland Drainage	18123.5	3564	2.02	5.09	19.67	3.49	875.50	1.28	1.43	377.76	1.30	1.28
		U-Shaped Valley	122910.2	4318	13.73	28.46	3.51	9.62	1993.49	1.40	4.68	423.05	1.31	1.33
		Plains	73006.8	1540	8.15	47.41	2.11	2.91	1693.09	1.33	2.69	544.93	1.31	1.26
		Open Slope	230503.4	7035	25.75	32.77	3.05	22.42	2852.79	1.52	6.02	377.88	1.31	1.36
		Upper Slope	78129.1	7455	8.73	10.48	9.54	12.12	1454.86	1.43	2.43	376.30	1.31	1.32
		Local Ridge	2876.5	1165	0.32	2.47	40.50	0.81	619.71	1.26	1.35	418.86	1.32	1.29
		Midslope Ridge	51674.6	6756	5.77	7.65	13.07	8.36	1108.21	1.32	1.54	387.70	1.30	1.28
		High Ridge	128978.9	1640	14.41	78.65	1.27	9.49	5180.24	1.65	3.38	293.06	1.30	1.32
Upper Yukon	Arctic Village	Canyon	91814.4	3460	6.75	26.54	3.77	6.32	2485.96	1.55	3.08	521.87	1.33	1.32
		Midslope Drainage	114597.7	11803	8.43	9.71	10.30	10.99	1266.50	1.40	1.98	701.14	1.35	1.30
		Upland Drainage	11096.9	4493	0.82	2.47	40.49	1.93	583.40	1.30	1.48	760.74	1.36	1.30
		U-Shaped Valley	163881.0	6652	12.05	24.64	4.06	7.95	1625.56	1.41	5.67	922.80	1.38	1.34
		Plains	217130.1	10196	15.97	21.30	4.70	6.55	873.76	1.36	7.91	1155.96	1.40	1.34
		Open Slope	435700.4	10471	32.04	41.61	2.40	27.35	3552.41	1.63	11.93	945.47	1.38	1.40
		Upper Slope	102126.1	10611	7.51	9.62	10.39	11.10	1422.52	1.49	2.98	784.14	1.37	1.34
		Local Ridge	1057.1	947	0.08	1.12	89.58	0.28	400.05	1.28	1.43	866.40	1.37	1.32
		Midslope Ridge	70269.7	12720	5.17	5.52	18.10	8.61	921.04	1.35	1.70	713.25	1.35	1.30
		High Ridge	152273.8	2766	11.20	55.05	1.82	8.57	4214.91	1.60	3.17	321.71	1.30	1.31

Table A.3. General Sheep Hunting Range Class Level Metrics for the Five Study Areas (continued)

		Class Area	# Patches	% Class	Mean Patch Size (ha)	Ptach Density	Edge Density	Mean Patch Edge	Mean Shape Index	Area Weighted MSI	Mean Perimeter to Area Ratio	Mean Patch Fractal Dimension	Area Weighted MPAR
Venetie	Canyon	1365.8	46	5.35	29.69	3.37	4.66	2586.01	1.59	2.41	649.08	1.35	1.30
	Midslope Drainage	1258.0	169	4.93	7.44	13.43	6.79	1025.22	1.35	1.67	782.14	1.35	1.29
	Upland Drainage	79.6	37	0.31	2.15	46.46	0.77	529.49	1.35	1.72	1013.15	1.39	1.32
	U-Shaped Valley	1948.1	117	7.64	16.65	6.01	8.12	1769.87	1.49	3.71	1157.06	1.40	1.35
	Plains	4153.3	580	16.28	7.16	13.96	18.37	808.12	1.42	3.69	1640.89	1.41	1.34
	Open Slope	12412.6	290	48.65	42.80	2.34	32.61	2869.06	1.57	6.60	2105.87	1.46	1.37
	Upper Slope	1729.1	105	6.78	16.47	6.07	7.68	1866.34	1.59	2.93	1318.18	1.41	1.33
	Local Ridge	32.6	21	0.13	1.55	64.35	0.35	426.55	1.25	1.30	906.86	1.37	1.29
	Midslope Ridge	928.3	146	3.64	6.36	15.73	5.45	952.75	1.36	1.52	956.71	1.37	1.28
	High Ridge	1606.8	55	6.30	29.21	3.42	5.08	2356.96	1.41	1.96	733.99	1.32	1.28

APPENDIX B.

ARCHAEOLOGICAL OVERVIEW OF THE WIKI PEAK AREA

Late AK Interior Prehistory

In the 21st century, the immense Alaskan Interior remains one of the most understudied regions in the United States; many archaeologists working in the region tend to focus on deep prehistory, and problems associated with peopling of the New World. Even after 75 years of more or less continuous research, the Interior's cultural chronology remains coarse-grained following a basic, predictable tripartite trajectory of old, older, and oldest. Despite the vast size of the Interior, there is complacency in broad cultural patterns, covering broad regions, over broad temporal periods. Only minor differences in the various lithic technologies within a particular period offer any relief from a general assumption of cultural 'hyperhomogeneity'.

There is a substantial literature pertaining to Nenana and Denali complex sites, but the later prehistory, from about 5,000 B.P., in the Interior remains relatively unknown at all but the most rudimentary level. Generally divided into three periods, represented by the Northern Archaic Tradition, the Late Denali complex, and the Athabaskan tradition (Dixon 1985), the cultural chronology follows a limited set of radiocarbon dates and "diagnostic" artifacts implicitly interpreted as representing ethnicity. In the Yukon Territory, Workman (1974) derives a similar chronology, and interpretation, from sites excavated near near Aishihik and Kluane lakes. Utilizing a different set of nomenclature and slightly different temporal ranges, Workman identifies three phases, including the Taye Lake, the Little Arm, and the Bennett, that span the last 5,000 years. With minor exceptions concerning the co-occurrence of two lithic technologies, microblade and bifacial technologies, these two chronologies have more in common than not.

The dated portion of the archaeological record extends back in time approximately 3,500 years, but these dates come from only two sites. The presence of notched points suggests that use of the area may reasonably extend an additional 1,500 years to the beginning of the Northern Archaic tradition. This brief chronological overview, then, starts with the appearance of notched points in the Interior. In published accounts, notched points, the cornerstone element of the Northern Archaic tradition, are first recognized in the Yukon and Tanana valleys as early as 1936 (see Rainey 1939). However, it was not until excavations at Onion Portage in 1968 that the Northern Archaic tradition was formally defined (Anderson 1968, 1988). Though others had early questioned the significance of notched points (e.g., Ackerman 1964, Campbell 1961), not enough suitable material was available to date the point-bearing sites or to fill in the widely dispersed, and often disparate contexts (interior and coastal), in which these points occurred. Even in the seminal *Method and Theory in Archaeology*, Willey and Phillips (1958:138) note the difficulty in defining an Archaic presence in the far north. Based on analogies with other Archaic woodland-adapted technologies in Canada and the United States and the correspondence between the timing of the appearance of the technology at Onion Portage with the northward expansion of the boreal forest into the Kobuk area, Anderson (1968) interpreted the Northern Archaic tradition as reflecting a migration of Archaic peoples, or minimally a diffusion of an Archaic toolkit, advancing in a slightly delayed harmony with forest expansion. In a recent synthesis of Northern Archaic sites, Esdale (2008:11) notes that such a hypothesis is unlikely given that many of the oldest sites with notched points are in northern Alaska and may be associated with Paleoarctic assemblages.

In general, the typical Northern Archaic artifact assemblage consists of notched points, notched cobbles, side and end scrapers, and tci-tos (Anderson 1968; Clark 1992; Dixon 1985). The points themselves are highly variable and there are few studies of this variability (Esdale 2008:6). Clark (1992) refers to this type assemblage as a pure in that it lacks any form of microblade technology. Within 12 years of the defining the tradition, some archaeologists challenged the notion that the Archaic peoples microblade technology. The first major proponent of an amalgamated Northern Archaic tradition was Dumond (1981, 1987), who argued that in Alaska and northwestern Canada the two distinct technologies became intermingled resulting in their co-occurrence in some contexts. Though dated contexts are scarce (Esdale 2008:7), Dixon (1985) asserts that the amalgamated Northern Archaic tradition either represents a later resurgence of a microblade technology associated with notched points, which he calls the Little Denali complex to differentiate it from the earlier microblade industry predating the Northern Archaic, or that the two always existed together and the microblade technology was misidentified as belonging to the Denali or Paleoarctic period.

The later end of the tradition, which occurs between 1,000 and 2,000 years ago, has lead several archaeologists (Anderson 1988, LeBlanc 1984, Workman 1974) to interpret continuity in the development of the Athabaskan tradition from a Northern Archaic base. Northern Archaic assemblages with late dates occur at Onion Portage (Anderson 1988), Healy Lake (Cook 1975), Lake Minchumina (Holmes 1986), and in portions of the Yukon Territories (Workman 1974);

Dixon (1985) relates his Late Denali complex as ancestral to the Athabascan tradition. The most vocal dissenting voice belongs to Shinkwin (1979), who never necessarily disagreed with such an ancestral hypothesis. Instead, Shinkwin encouraged the reservation of judgment until such a link could be clearly established. This position derived from her work at two Athabascan sites, particularly Dixthada located on Lake Mansfeild, where little information linking the two periods was identified.

Though the Northern Archaic and Athabascan traditions occur stratigraphically back to back in many places, there remains a clear separation between technologies utilized during these two periods. Evidence of a transition from the Northern Archaic to the Athabascan period in the archaeological record is meager. Whereas taphonomic factors and time have obscured most of the organic component of the Northern Archaic technological system, such factors have had less impact on the identifiable technological organization of later Athabascans, which relied heavily on organic materials and not rocks. Though somewhat visible archaeologically, particular in later contexts, much of our understanding of Athabascan technological organization comes from early ethnographic and ethnohistoric sources. Archaeological excavations of later Athabascan sites, primarily semi-permanent villages, such as Klo-Kut (Morlan 1973), Rat Indian Creek (Le Blanc 1984), Healy Lake (Cook 1989), Dixthada (Shinkwin 1979), Dakah De'nin's Village (Shinkwin 1979), GUL-077 (Workman 1976), and Lake Minchumina (Holmes 1986), in conjunction with the historic record, offer a perspective of aboriginal settlement in the Interior not available for any other period. Whereas earlier Alaskan Interior hunter-gatherers are either explicitly or implicitly perceived in the classical, or romantic, view of small bands of nuclear or extended families wandering everywhere across the landscape in search of those resources, particularly large game, necessary for survival, the Athabascan record focuses on a much more organized, collaborative, and structured picture. For example, for the first time in nearly 12,000 years of history, there is evidence for communal and organization, storage, territoriality, regional interaction, and trade. This picture is more intimate, more human, detailing rapid changes in demography due to disease, warfare, starvation, settlement patterns, and acculturation.

Wiki Peak Physical Environment

The Nutzotin Mountains, a small mountain range at the southeastern tail of the greater Alaska Range, occur near the US- Canada border in the Wrangell-St. Elias National Park and Preserve. Generally, the range includes the area between the Nabesna and White Rivers and, to the southwest, Notch and Copper Creeks. The range covers approximately 8300 hectares (320 mi^2) and has an average elevation of 1575 meters (5167 feet). Brooks (1900:446), a USGS geologist, first noted the range as being distinct from other nearby ranges such as St. Elias Mountains. Relative to the surrounding ranges, such as the Wrangells, the St. Elias, and the Mentasta, the Nutzotin Range appears modest in relief, ruggedness, and expanse. This is particularly true near Wiki Peak, where the mountains are relatively low, flat topped, and free from everlasting snow and ice.

The Wiki Peak landform, which forms the backdrop of the general study area, is near the southern end of the Nutzotin Range. Encompassing an area of 58,000 hectares (224 mi^2), the Wiki landform is a distinct landmass bordered on the north by Beaver Creek, on the east by Ptarmigan Creek, on the south by Rock Lake, and on the west by Solo and Flat Creek Flats. The landform consists of several distinguishable components defined by topography, elevation, and drainages (Figure B.1). Wiki Peak, which reaches an elevation of 2,333 meters (7,655 feet), crests the landform forming a pyramidal mass rising 500 to 600 meters (1640 to 1960 feet) above a high ridge-like plateau. The plateau consists of relatively high flat ridges and steep slopes formed through glaciations and subsequent mass wasting (e.g. landslides). Numerous streams and creeks, including Sonya, Ophir, and Cabin, emanate from this plateau. Connected to the plateau by an arête or col between heads of Ophir and Cabin Creeks is a series of five finger ridges with a NW-SE orientation. Each ridge top is between 4,000 and 5,000 meters long and between 1675 and 1980 meters (5500 - 6500 feet) in elevation. A large crescent-shaped landmass surrounds the southern and western edge of the Wiki Peak landform. This landmass consists of two portions separated by the amply named Divide Creek. The eastern portion, which consists of several mesa-like structures situated on the spine of a broad ridge, is locally referred to as "Flat Top." Flat Top and its sister ridge complex are separated from the finger ridges and plateau by Francis and Ophir Creeks. The eastern and northern flanks of Wiki Peak consist of a complex series of midslope ledges, ridges, and knolls or pediments. To the southeast of Wiki Peak and Flat Top are Ptarmigan and Rock Lakes.

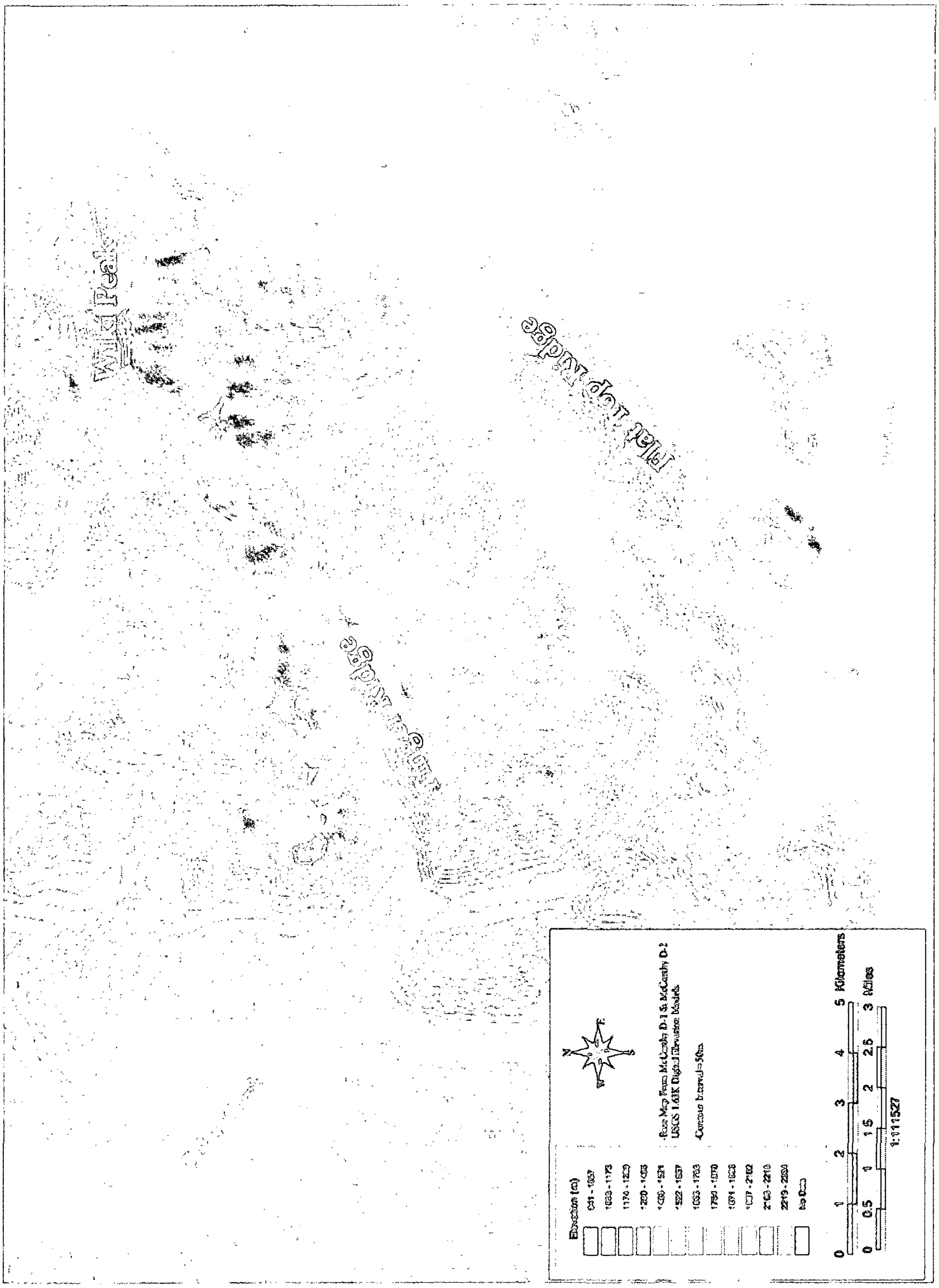

Figure B.1. Study Area Showing Major Topographic Features and All Sites.

For the most part, the Wiki Peak landform defined here corresponds to the Sonya Creek Shield Volcano, a 20 million year old nonexplosive caldera (Ricther et al. 2000). Much of the surface geology of the Wiki Peak landform consists of Tertiary-aged igneous rocks such as Wiki Peak lavas and rhyolite covering the high ridges and plateaus. Most of the slopes and drainage bottoms consist of Quaternary colluvial, alluvial, and glacial sediments. Several outcrops of obsidian occur on the ridges and plateaus, and several more were identified on the steep slopes of the Upper Cabin Creek drainage associated with pockets of the rhyolite flows atop the Wiki Peak Lavas. To date, all the identified obsidian outcrops are associated with these lavas, though numerous cobbles can be easily acquired from the alluvial deposits of Cabin and Francis Creeks. Tool quality basalt is readily available. Other possible toolstone sources, including cryptocrystalline cherts, in the immediate vicinity can be obtained from minor outcrops of Triassic and Cretaceous-aged outcrops along southern flanks of Wiki Peak.

Being north of the St. Elias range, the Wiki Peak and Ptarmigan Lake area experience a continental climate with short warm summers and long cold winters. Climate data from two nearby weather-recording stations (McCarthy and Nabsena) are close enough to Wiki Peak to provide meaningful modern climate summaries. The maximum average temperatures recorded at these two locations are 34.4 and 38.8 F; average minimum temperatures of the two sites are 15 F. Season average minimum temperatures are coldest in January with Nabesna averaging -12 F and McCarthy averaging -22.8 F. Based on precipitation rates in these two locations, the yearly precipitation in the vicinity of Wiki Peak is between 11.6 and 16.4 inches of precipitation per annum, with the wettest months being late summer and early fall. Winter snows are light and rarely average more than 24 inches in depth at any given point in the winter. The heaviest snows commonly occur in the late fall and early winter.

Vegetation in the study area varies considerably by elevation, slope, and aspect. The higher elevations of Wiki Peak and the high plateau are sparsely vegetated with common alpine tundra communities or are devoid of vegetation all together. Steeper slopes off the plateaus are sparsely covered with dwarf shrub vegetation consisting mostly of birch (*Betula nana*), but some willow (*Salix ssp.*), grasses, and sedges. Dense dwarf birch and willow densely covers the more moderate slopes and drainage bottoms in the higher elevations. Figure B.2 shows extensive needleleaf woodlands, but the extent is exaggerated in many areas. Most of the woodlands shown in the middle and upper stretches of the Francis, Cabin, and Ophir Creek drainages do not exist. Here, the dominant vegetation remains closed dwarf shrubs. Needleleaf woodlands do occur

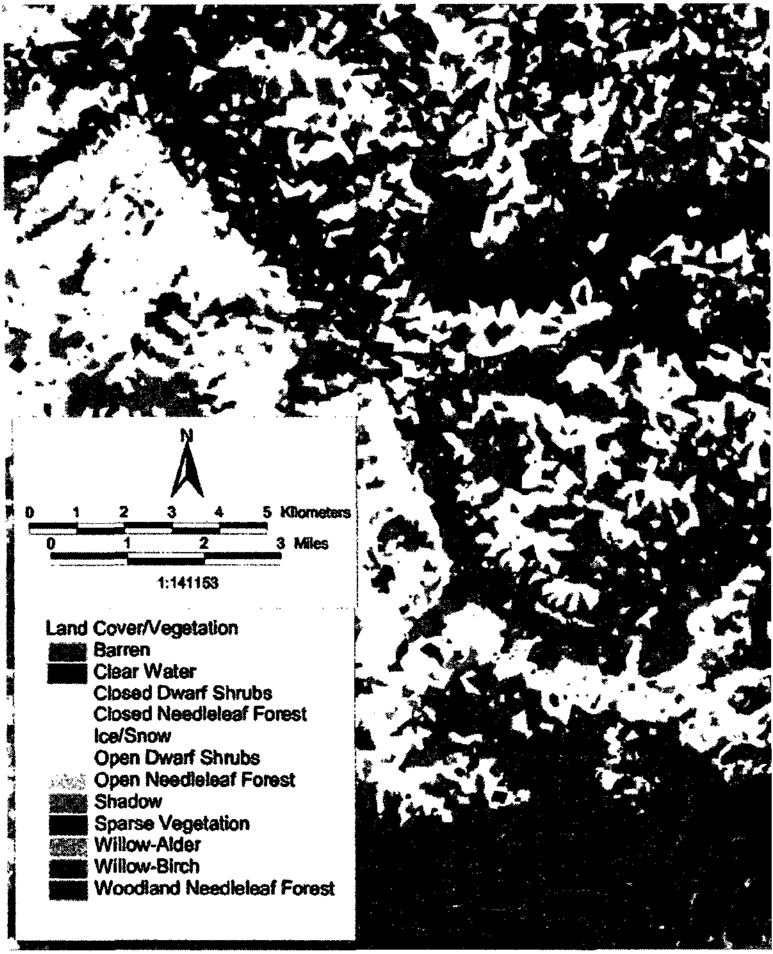

Figure B.2: Landcover for Wiki Peak Study Area.

throughout the lower elevations of the Wiki Peak landform along the lower stretches of Francis and Cabin Creeks, as well as along Ptarmigan Creek to the north and most of the flats surrounding Rock and Ptarmigan Lakes. Denser forest patches, mostly white spruce (*Picea glauca*), occur in lower Francis Creek and north of Ptarmigan Lake, but these patches are generally uncommon. Tall willow species are prolific along the banks of many of the creeks, both big and small, throughout the area.

Large and small mammals are relatively abundant in the Wiki Peak area and throughout much of the Wrangell St. Elias Park in general. Smaller mammals, including the members of the families Soricidae, Lagomorpha, and Rodentia, are most common. Several of these animals, particular snowshoe hares, collared pika, hoary marmots, Arctic ground squirrels, and porcupines, had economic and sustenance value to historic and prehistoric hunter-gatherers. Likewise, furbearers in the area, such as lynx, beavers, river otters, wolverines, minks, and weasels, had at least historic importance once trade relationships with fur companies were established.
Large mammals, though less common than their small counterparts, can be found in significant quantities. Caribou from the Chisana herd occupy much of the Wiki Peak vicinity year round, though they are more abundant in the spring when much of the area serves as calving grounds for females. As with most caribou herds throughout the Arctic and Subarctic, the Chisana caribou herd size fluctuates considerably over time (Lenart 1997). Moose primarily inhabit the flats surrounding the lakes and the lower reaches of the larger creeks where abundant willow grows. Bears, both brown and black, are common throughout the area, but not particularly abundant. Dall sheep reside in most of the higher terrain in the project area. Mountain groups are absent, but are currently within 65 kilometers to the northwest in portions of the Mentasta and Wrangell ranges.

With the exception of the effects of two massive eruption of Mt. Churchill, the past environments of the study were similar to the modern environment, especially in regards to the types and varieties of flora and fauna present. Core samples from several nearby lakes[1] indicate very little change in the pollen record for the last four millennia. Pollen in sample columns from Daylight Coming Out Lake (MacIntosh 1997), Island Lake (MacIntosh 1997), Sulphur Lake (LaCourse and Gajewski 2000), and Antifreeze Pond (Rampton 1971) suggest that modern

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[1] Daylight Coming Out Lake and Island Lake are approximately 10o kilometers north of the Wiki Peak Study Area. Sulphur Lake is just south of Kluane Lake about 250 kilometers to the southwest. Antifreeze Pond is near Snag, YT about 100 kilometers to the north-northwest.

vegetation communities established themselves between 5000 and 6000 years BP. Relatively recent reviews of the middle to late Holocene paleovegetation records (Cwynar and Spear 1995; Wang and Geurts 1991) note that some records from the southwest Yukon reflect at least three transgressions in the timberline in the last 5700 years BP.

The White River Ash represents two large Plinian eruptions of Mt. Churchill (Richter et al. 1995) located in the St. Elias Range 65 kilometers to the south-southwest of Wiki Peak. The two eruptions deposited the White River Ash, a volcanic tephra composed of glass, plagioclase, hornblende, and magnetite (Lerbekmo and Campbell 1969), covering some 324,000 square kilometers in various depths. Recently, evidence, evidence of the ash has been identified as far east as Great Slave Lake, substantially increasing the area covered by ash fall to a notable degree (Robinson 2001). Ash from the earlier eruption, which occurred approximately 1800 years BP, blew mostly north resulting in five centimeters of accumulation as far north as the Yukon River at the US-Canada border. The later eruption, dated to about 1250 years BP, blew ash primarily to the east. Most estimates of the ejecta related to each of these eruptions average 25 cubic kilometers of material (Richter et al. 1995).

The deposition of significant quantities of ash likely had profound impacts on the regional environment and, in turn, on the Athabascans occupying those areas affected. Workman (1974) hypothesizes that these eruptions, particularly the later one, may have served as a major contributing factor in triggering the Athabascan migration to the south into the Pacific Northwest and the Greater American Southwest. According to this argument, there is congruence between the date of the later eruption and estimated time needed to account for the linguistic differences between northern and southern Athabascan languages. Workman admits that the evidence is circumstantial, but more such evidence is slowly accumulating. Athabascan oral traditions (Moodie et al. 1992), modern archaeology (Matson and Magne 2006), and DNA studies (Malhi et al. 2008) are all lending themselves to elucidating the Athabascan migration that hereto could not be traced by archaeology alone. However, despite the increasing fruitful approaches being applied to the Athabascan migration question, it will still fall primarily to archaeologists and paleoecologists to establish mechanisms responsible for triggering the migration in the first place. As it stands now, the deposition of the White River Ash remains the most viable or major cause.

As the eruptions pertain to the Wiki Peak study area, the White River Ash occurs as a discontinuous layer found mostly in the lower, flatter terrain around Ptarmigan and Rock Lakes, and as pockets in the higher elevations of Francis and Cabin Creeks. In most places the ash is 10 to 20 centimeters below the modern ground surface. Archaeological sites located near Ptarmigan and Rock Lakes have pre- and post ash components, but the radiocarbon dates provided in the following section, though few in number, show a clean break during the time spanning the two eruptions.

Survey and Testing Methods

Between 1997 and 1999, archaeological investigations conducted in the immediate vicinity of Wiki Peak consisted of intensive and reconnaissance level surveys conducted primarily under the rubric of cultural resource management for WRST. Aside from the cultural resource inventories, limited subsurface testing occurred at two sites along the shores of Ptarmigan Lake. Intensive cultural resource inventory occurred along the southern flanks and major drainages of the Wiki Peak landform; more limited reconnaissance surveys occurred on the north side of the landform, along the east-west trending portion of Flat Top Mountain, and the high tablelands of the Wiki Peak landform. Similar site recording procedures for both survey intensities remained identical.

Prior to the initial fieldwork in 1996, several areas were selected for survey based on information provided by local land users, USGS geologists who noted cultural materials while conducting surface geology investigations, and two limited cultural resource inventories conducted by NPS personnel (Pittenger and Staley 1985; Anne Worthington 1997, personal communication). During 1996, survey focused on the lower portion of the locally named Cabin Creek, and two adjacent areas referred to here as the medial moraine and the ridge complex area. Intensive surveys conducted in 1997 occurred in the middle and upper portions of Cabin Creek, along the east end of the locally named Flat Top Mountain, the middle portion of Francis Creek, and the northern shores of Ptarmigan and Rock lakes. The following summer, under the auspices of the UAF Archaeology Field School, additional intensive survey was completed in the upper reaches of Cabin Creek, in an unnamed pass between Francis and Ophir Creeks, and along a series of ridges east of the ridge complex and above Ptarmigan Creek.

Inventory methods for the intensively surveyed areas commonly consisted of archaeologists walking widely spaced (15 to 20 meters) parallel transects across a predetermined area. It quickly became obvious that surface visibility of cultural materials was limited to elevated positions where vegetation was sparse and Aeolian erosion was occurring. This elevation difference was not necessarily great and the majority of the cultural materials identified in drainages such as Cabin and Francis creeks occupied the tops of esker-like ridges that extend only two or three meters above the surrounding terrain. Between these ridges, the extremely dense vegetation cover totally obstructed surface visibility. Although systematic shovel testing was not conducted, shovel tests excavated in areas off the ridges, in areas of heavy vegetation, never revealed any surface or subsurface artifacts. Using the widely spaced transects, it was possible to cover a substantial amount of ground and systematically locate and examine all the elevated and lightly vegetated locations in the survey block.

Reconnaissance level inventories occurred exclusively in 1998. With the assistance of a helicopter, four areas along the north side of the Wiki Peak Landform were briefly examined. These areas include the middle stretch of Ophir Creek, the upper portion of Sonya Creek, the area surrounding two small lakes on the northeast flanks of Wiki Peak, and some esker-like ridges near the confluence of Ophir and Beaver Creeks. Using horses to access greater distances, numerous areas on the top of Flat Top Mountain were examined for cultural resources. Finally, we briefly surveyed areas surrounding several known obsidian outcrops located on the high Wiki tablelands. More relaxed survey methods characterized the reconnaissance survey methods. Drawing on the experience garnered through the more intensive surveys, targeted areas for reconnaissance included those areas most likely to have cultural manifestations based on terrain, surface visibility, and topographic location. In all cases, the reconnaissance resulted in the location of archaeological sites.

For the purposes of WRST and its management of cultural resources in the park, the site definition adhered to during the fieldwork was very liberal and included a broad range of manifestations from isolated artifacts to multicomponent localities containing tens of thousands of artifacts and cultural features. All sites where recorded on AHRS site forms, which were supplemented with detailed in-field debitage analysis sheets based on the Sullivan and Rozen Typology (SRT) (Sullivan and Rozen 1985). Geographic position systems and traditional plotting methods served as the means for recording site locations and site sketch maps were made using Brunton Pocket Transits, tape measures, and pacing. Field crews used small shovel tests to determine the potential for subsurface deposits and to collect baseline data on deposition, stratigraphy, and post disturbance processes. In all but a few instances, all the surface artifacts were examined. Where, due to the shear amount of debitage, all artifacts could not be individually analyzed, a systematic sampling strategy was employed. Given the mostly elongated distribution of cultural materials on low esker-like ridges, circular sample units were evenly spaced across the length of the site. The number of sample units varied between 8 and 12, and in each case represented consisted of ten percent of the site area. In all, sampling occurred at only four sites including XMC-307, XMC-310, XMC-311, and XMC-317. Based on the results of the sampling, estimates were calculated for the type and frequency of debitage; all chipped stone tools identified during site documentation were recorded.

In addition to the cultural resource inventories, limited testing occurred at two stratified sites adjacent to Ptarmigan Lake. Testing at sites XMC-038 and XMC-377 focused on obtaining baseline information on local cultural chronology, changes in land use through time (particularly as related to occupations prior to and after the volcanic eruptions of Mt. Churchill), technological organization (particularly in regards to the co-occurrence of notched points and microblades), site function, and postdepositional processes. The limited testing consisted of small trench and block excavation. Instrument generated topographic maps were produced for each site using a theodolite, stadia rod, and measuring tapes and excavation grid baselines were set. The area of excavation at each site was very small. At XMC-038, which was tested in 1997 and 1998, 12 square meters were excavated. Of these, 8 1 x 1 meter units were contiguous and the remaining four units occurred across the site. At XMC-377, excavations consisted of a 6 x 1 meter trench and a 1x2 meter unit. Excavation occurred in five centimeter levels with each natural stratum. Debitage was collected by level and tools, when they could be identified upon excavation, were point provenienced.

Survey Results

In all, the archaeological surveys identified 116 sites including lithic scatters (n=113), a historic cabin, a tent platform, and a historic cache. The following discussion pertains only to the lithic scatters. Four of the lithic scatters, situated adjacent to the two major lakes, contain stratified deposits, but the majority of the remaining scatters are essentially surface manifestations. Shovel probes excavated at the majority of the upland sites demonstrated that subsurface artifacts are present, but the artifacts commonly occur in the upper 10-15 cm of fill and there is little, if any, stratigraphic relief. An exception to this is XMC-287, which contained an intact White River Ash deposit with bracketing artifacts.

Despite a great range in artifact frequencies (between 1 and an estimated 10,300), few formal tools, and fewer temporally diagnostic artifacts, occur in the surface lithic scatter assemblages (Table B.1). Obsidian comprises the bulk of the toolstone identified; other material

Table B.1. General Assemblage Overview of Recorded Sites in the Study Area

Site #	Elevation	Area	Total # Artifacts	Artifact Density	# of Concentrations	# Utilized Flakes	# Retouched Flakes	# of Projectile Points	# of Bifaces	# Scrapers	# of Cores	# of Tested Nodules	Misc. Tools	Total # of Tools
284	4,085	64	300	4.70	2	0	0	0	0	0	0	0	0	2
285	4,175	168	764	4.54	4	7	1	1	0	0	0	0	0	13
286	4,174	380	1,700	4.47	3	4	0	1	1	1	0	0	0	10
287	4,560	26	8	0.31	0	0	0	0	0	0	0	0	1	1
288	4,454	580	75	0.13	0	0	0	1	1	0	2	1	0	5
289	4,436	201	141	0.70	0	2	0	0	1	0	0	0	0	3
290	4,399	45	7	0.15	0	1	0	0	0	0	0	0	0	1
291	4,622	487	588	1.21	3	0	1	1	2	1	0	0	1	9
292	4,400	15	3	0.20	0	0	0	0	0	0	0	0	0	0
293	4,554	72	55	0.76	2	0	0	0	0	0	0	0	0	2
294	4,300	30	10	0.33	0	0	0	0	0	0	0	0	0	0
295	4,248	54	5	0.09	0	0	0	0	0	0	0	0	0	0
296	4,264	160	217	1.35	1	1	1	0	0	0	0	0	0	3
297	4,293	848	122	0.14	0	0	0	0	0	0	1	0	0	1
298	4,300	120	186	1.55	1	2	1	0	12	2	1	2	0	21
299	4,327	200	7	0.03	0	0	0	0	0	0	1	0	0	1
300	4,350	1327	324	0.24	2	7	0	0	0	0	2	0	0	11
301	4,350	125	93	0.74	1	2	0	0	1	1	1	0	0	6
302	4,423	1530	510	0.33	4	4	2	1	0	2	1	0	0	14
303	4,501	986	243	0.25	2	4	0	0	1	0	2	1	0	10
304	4,490	2	5	2.50	0	0	0	0	0	1	0	0	0	1
305	4,449	331	99	0.30	0	1	0	0	0	0	1	0	0	2
306	4,171	101	13	0.13	0	0	0	1	1	0	0	0	0	2
307	4,343	2392	2,619	1.09	0	36	0	0	5	5	5	5	0	56
308	4,320	86	56	0.65	0	0	1	0	0	0	0	0	0	1
309	4,335	153	31	0.20	0	0	0	0	0	1	0	0	0	1
310	4,297	230	2,330	10.11	0	21	2	0	2	2	2	2	0	31
311	4,274	1201	10,359	8.62	0	101	5	0	5	5	5	5	0	126
312	4,251	15	38	2.50	0	1	2	0	0	0	0	0	0	3
313	4,250	25	9	0.36	1	0	0	0	0	0	0	0	0	1

Table B.1. General Assemblage Overview of Recorded Sites in the Study Area (Continued)

Site #	Elevation	Area	Total # Artifacts	Artifact Density	# of Concentrations	# Utilized Flakes	# Retouched Flakes	# of Projectile Points	# of Bifaces	# Scrapers	# of Cores	# of Tested Nodules	Misc. Tools	Total # of Tools
314	4,244	16	9	0.56	1	0	0	0	0	0	0	0	0	1
315	4,040	760	368	0.48	0	1	0	0	0	0	2	0	0	3
316	4,284	575	250	0.43	1	5	1	0	0	1	0	0	0	8
317	4,218	863	3,458	4.01	1	0	0	0	3	3	3	3	0	13
318	4,206	20	3	0.15	1	0	0	0	0	0	0	0	0	1
319	4,241	96	51	0.53	0	1	0	0	0	0	2	0	0	3
320	4,264	106	262	2.47	2	1	0	0	0	0	1	0	0	4
321	4,229	5	7	1.44	1	1	0	0	0	0	0	0	0	2
322	4,229	53	1,108	21.08	3	2	0	0	0	0	3	0	0	8
323	4,204	201	561	2.79	2	1	1	0	0	0	0	0	0	4
324	4,253	24	46	1.93	0	1	0	0	0	0	0	0	0	1
325	4,306	207	139	0.67	1	0	0	0	0	1	0	0	0	2
326	4,192	3163	331	0.10	3	0	0	0	0	0	1	0	0	4
327	4,261	526	1,267	2.41	3	2	2	1	0	2	4	0	0	14
328	4,077	101	320	3.17	0	14	0	2	7	4	1	0	0	28
329	4,051	103	16	0.16	0	0	0	0	0	0	1	0	0	1
330	4,349	8	26	3.36	0	0	0	0	0	0	0	0	0	0
331	4,353	44	9	0.20	0	0	0	0	0	0	0	0	0	0
332	4,623	3125	163	0.05	1	5	1	0	2	1	3	1	0	14
333	4,431	255	90	0.35	1	1	0	0	0	0	0	0	0	2
334	4,395	10	12	1.20	0	0	0	0	1	1	1	0	0	3
335	4,440	450	131	0.29	0	5	0	0	0	0	2	0	0	7
336	4,535	3	8	3.14	0	0	0	0	0	0	0	0	0	0
337	4,495	2	37	22.16	0	1	0	0	0	0	1	0	0	2
338	4,475	17	16	0.96	1	0	0	0	0	0	0	0	0	1
339	4,205	48	3	0.06	0	1	0	0	0	0	0	0	0	1
340	4,327	22	8	0.36	0	1	0	1	1	1	0	0	0	4
341	4,405	492	703	1.43	1	17	0	3	4	1	8	0	0	34
342	4,762	75	16	0.21	1	0	0	1	0	0	0	0	0	2
343	4,770	227	25	0.11	0	0	0	0	0	0	0	0	0	0
344	4,693	1411	224	0.16	1	6	0	0	0	0	0	0	0	7

Table B.1. General Assemblage Overview of Recorded Sites in the Study Area (Contiued)

Site #	Elevation	Area	Total # Artifacts	Artifact Density	# of Concentrations	# Utilized Flakes	# Retouched Flakes	# of Projectile Points	# of Bifaces	# Scrapers	# of Cores	# of Tested Nodules	Misc. Tools	Total # of Tools
345	4,683	205	29	0.14	0	3	0	1	1	0	0	5	0	10
346	4,600	1	1	1.00	0	0	0	0	0	0	0	0	0	0
347	4,665	85	15	0.18	0	0	0	0	1	0	0	0	0	1
348	4,590	41	38	0.93	0	0	0	0	0	0	1	1	0	2
373	3,920	123	61	0.50	0	2	0	0	1	0	0	1	0	4
374	3,710	1	1	1.00	0	0	0	0	0	1	0	0	0	1
375	3,730	50	13	0.26	0	0	0	0	0	0	0	0	0	0
376	4,480	37	79	2.13	0	0	0	0	0	0	0	0	0	0
377	3,570	793	24	0.03	0	0	0	1	1	0	0	0	0	2
378	3,550	111	47	0.42	0	2	0	0	1	0	0	0	0	3
379	4,270	32	27	0.84	0	0	0	0	1	0	0	0	0	1
380	4,240	119	187	1.58	0	3	0	0	0	0	1	0	0	4
381	4,230	30	19	0.63	0	0	0	0	0	0	0	0	0	0
382	4,240	20	410	20.04	0	6	1	0	2	1	4	2	0	16
383	4,250	128	148	1.15	0	4	2	0	1	1	1	0	0	9
384	4,000	20	35	1.75	0	0	0	0	0	0	0	0	0	0
386	4,400	134	48	0.36	0	0	0	0	0	0	0	0	0	0
387	4,420	343	90	0.26	0	0	0	0	1	0	0	5	0	6
388	4,500	685	303	0.44	0	2	0	0	0	0	6	6	0	14
389	4,530	129	3	0.02	0	0	0	0	0	1	1	0	0	2
390	4,550	313	103	0.33	0	1	0	0	0	0	0	0	0	1
391	4,550	445	93	0.21	0	0	0	0	0	0	0	0	0	0
392	4,650	61	6	0.10	0	2	0	0	0	0	0	0	0	2
393	4,450	134	0	0.00	0	0	0	0	0	0	0	0	0	0
394	4,600	16	27	1.70	0	2	0	0	0	0	0	0	0	2
395	4,400	393	28	0.07	0	1	0	0	0	2	2	0	0	5
396	4,320	547	39	0.07	0	13	0	0	0	2	0	0	0	15
397	4,350	949	68	0.07	0	18	0	1	1	1	0	0	0	21
398	4,300	200	0	0.00	0	0	0	1	0	0	0	0	0	1
399	3,575	1	1	1.00	0	0	0	0	0	0	0	0	0	0
400	3,575	250	38	0.15	0	4	0	0	1	2	0	0	0	7

Table B.1. General Assemblage Overview of Recorded Sites in the Study Area (Continued)

Site #	Elevation	Area	Total # Artifacts	Artifact Density	# of Concentrations	# Utilized Flakes	# Retouched Flakes	# of Projectile Points	# of Bifaces	# Scrapers	# of Cores	# of Tested Nodules	Misc. Tools	Total # of Tools
401	3,575	100	7	0.07	0	0	0	0	0	0	0	0	0	0
402	4,400	360	85	0.24	0	0	0	0	0	0	0	0	0	0
403	4,400	155	16	0.10	0	2	0	0	0	0	0	0	0	2
404	4,300	95	24	0.25	0	0	0	0	0	0	0	0	0	0
405	4,250	136	32	0.24	0	2	0	0	0	0	0	0	0	2
406	4,280	1	1	1.00	0	0	0	0	0	0	0	0	0	0
407	4,320	5	6	1.20	0	0	0	0	0	0	0	0	0	0
408	4,590	5	5	1.00	0	0	0	0	0	0	0	0	0	0
409	4,310	3	12	3.87	0	0	0	0	0	0	0	0	0	0
410	4,430	1	2	2.00	0	0	0	0	0	0	0	0	0	0
411	4,360	1	2	2.00	0	0	0	0	0	0	0	0	0	0
412	4,240	25	7	0.28	0	0	0	0	0	0	0	0	0	0
413	4,770	56	0	0.00	0	0	0	0	0	0	0	0	0	0
414	4,930	80	17	0.21	0	0	0	0	0	0	1	0	0	1
415	4,500	15	0	0.00	0	0	0	0	0	0	0	0	0	0
416	4,470	98	0	0.00	0	0	0	0	0	0	0	0	0	0
Total			32,781		51	327	24	19	65	50	74	40	2	645

types, such as basalt, chert, and quartzite, are present, but in significantly lower quantities. Chipped-stone tools include a variety of projectile points, microblade cores, microblades, bifaces, and scrapers. Of the chipped stone projectile points and point fragments (n=19) identified, six are notched, three are triangular, three are lanceolates, and one is stemmed (Kavik-like) (see Figure B.3); three points are small blade fragments with no discernible morphology. In addition to lithic projectile points, a copper point was also found. All of the chipped stone points, with the exception of the obsidian Kavik-like point, are manufactured from chert or basalt. Bifaces (n=65) vary in form and, presumably, function (Figure B.4 and B.5). Occurring much more frequently than projectile points, the bifaces take on two general forms: lanceolate and triangular, with the lanceolate being slightly more common. Though some bifaces are manufactured from obsidian and chert, most are made with locally available basalt. Scrapers (n=50) identified in the assemblages include a variety of side and endscrapers, most of which are made from obsidian (Figure B.6). Microblade cores and microblades occur but are uncommon (Figure B.7). Only three microblade cores were recovered during the inventories, two are wedge-shaped. Twenty-two microblades were recorded from surface contexts; subsurface contexts at two stratified sites resulted in the identification of additional microblades.

Taking the limited data from the resource inventories and the testing, the archaeological record near Wiki Peak represents primarily late Holocene occupations. While circumstantial evidence, such as the presence of wedge-shaped microblades in the project area and the presence of Wrangell obsidian in earlier components at sites such as Dry Creek (Cook 1995:94) with dates in excess of 9,000 years BP (Powers and Hoffecker 1989: Table 1), suggest earlier utilization of the general area, there is no direct evidence to support such a hypothesis at present. Workman's (1974) chronology for the Tutchone area appears most applicable to the project area. While dates are lacking, the separation of temporal components relative to the deposition of White River Ash and the similarities in point types (Copper, Notched, and Kavik-like) are relevant to the Wiki Peak area in general. As with Workman's data, the relationship between microblade and chipped-stone technologies is ambiguous. In the Wiki Peak area both technologies are present, but the shear quantity of chipped stone debitage clearly marks the dominant technology. While both technologies occur in the area, no individual site has yielded either microblades or microblade cores and notched points. Given the lack of temporal controls, it is safest to assume that the material culture represents an amalgamated form of the Northern Archaic tradition (Clark 1992:76).

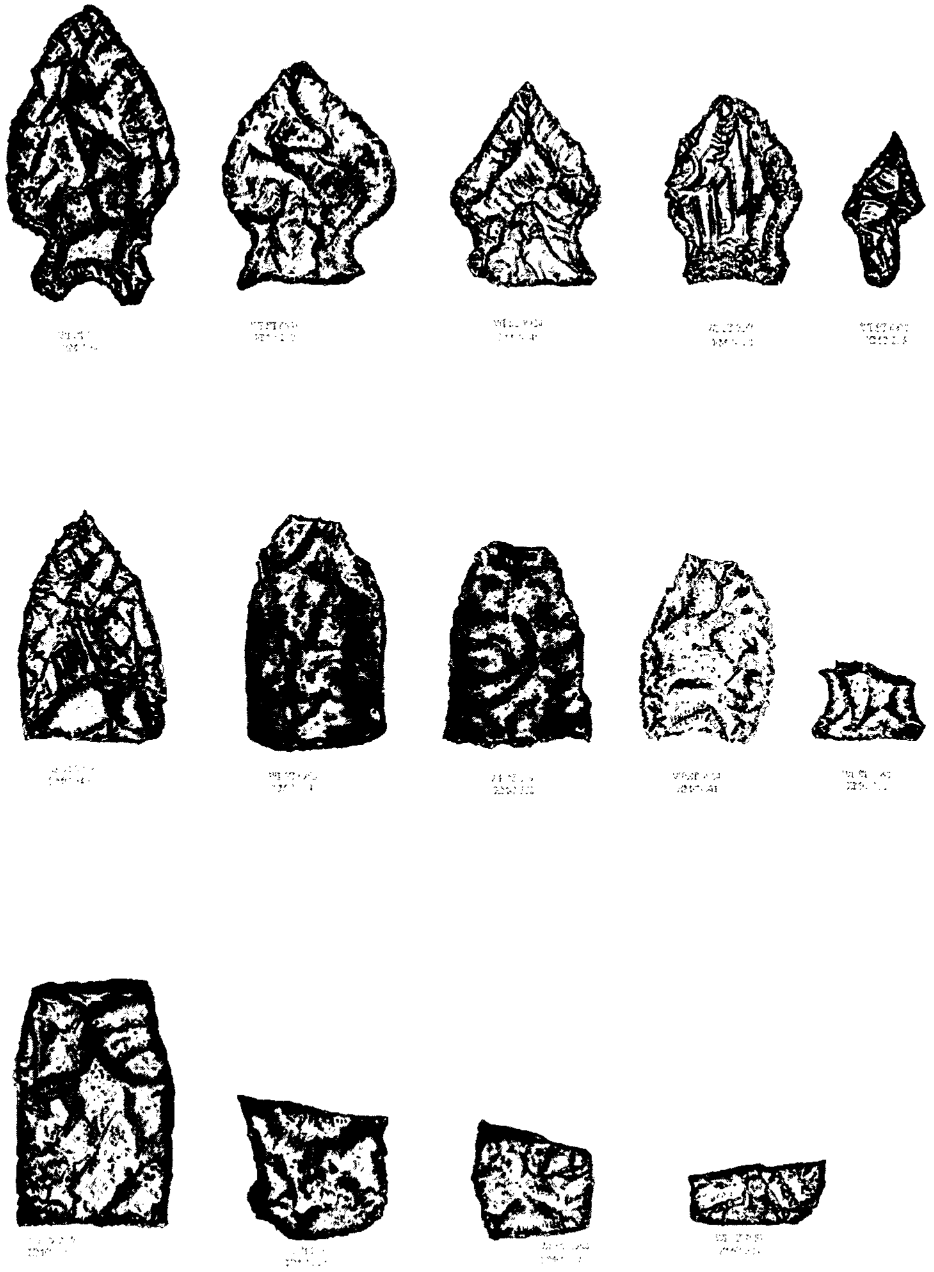

Figure B.3. Plate with the Majority of the Projectile Points Indentified in the Wiki Peak Study Area. Artifact Illustrations by Tom O'Brien.

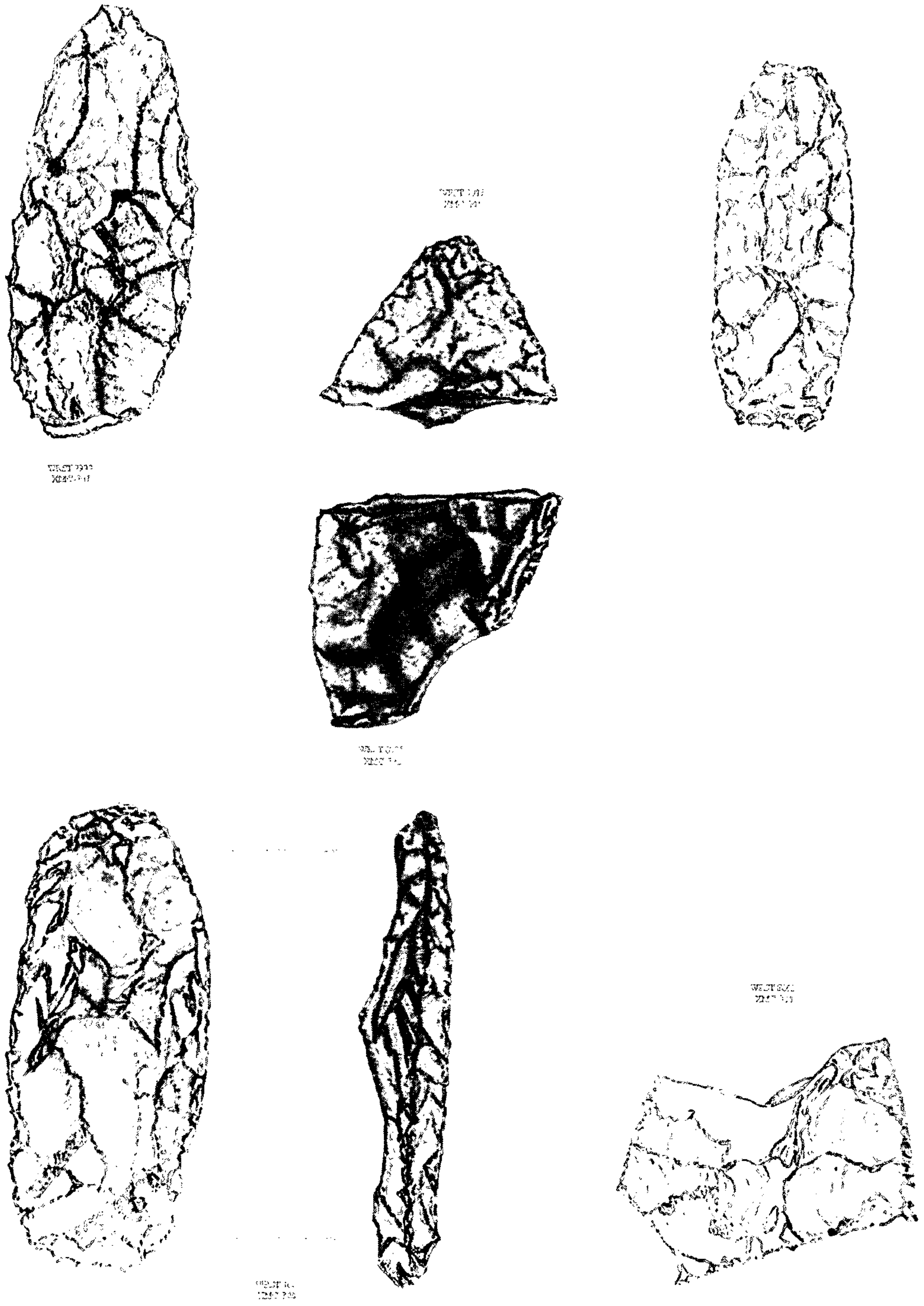

Figure B.4. Selection of Bifaces Indentified in the Wiki Peak Study Area. Artifact Illustrations by Tom O'Brien.

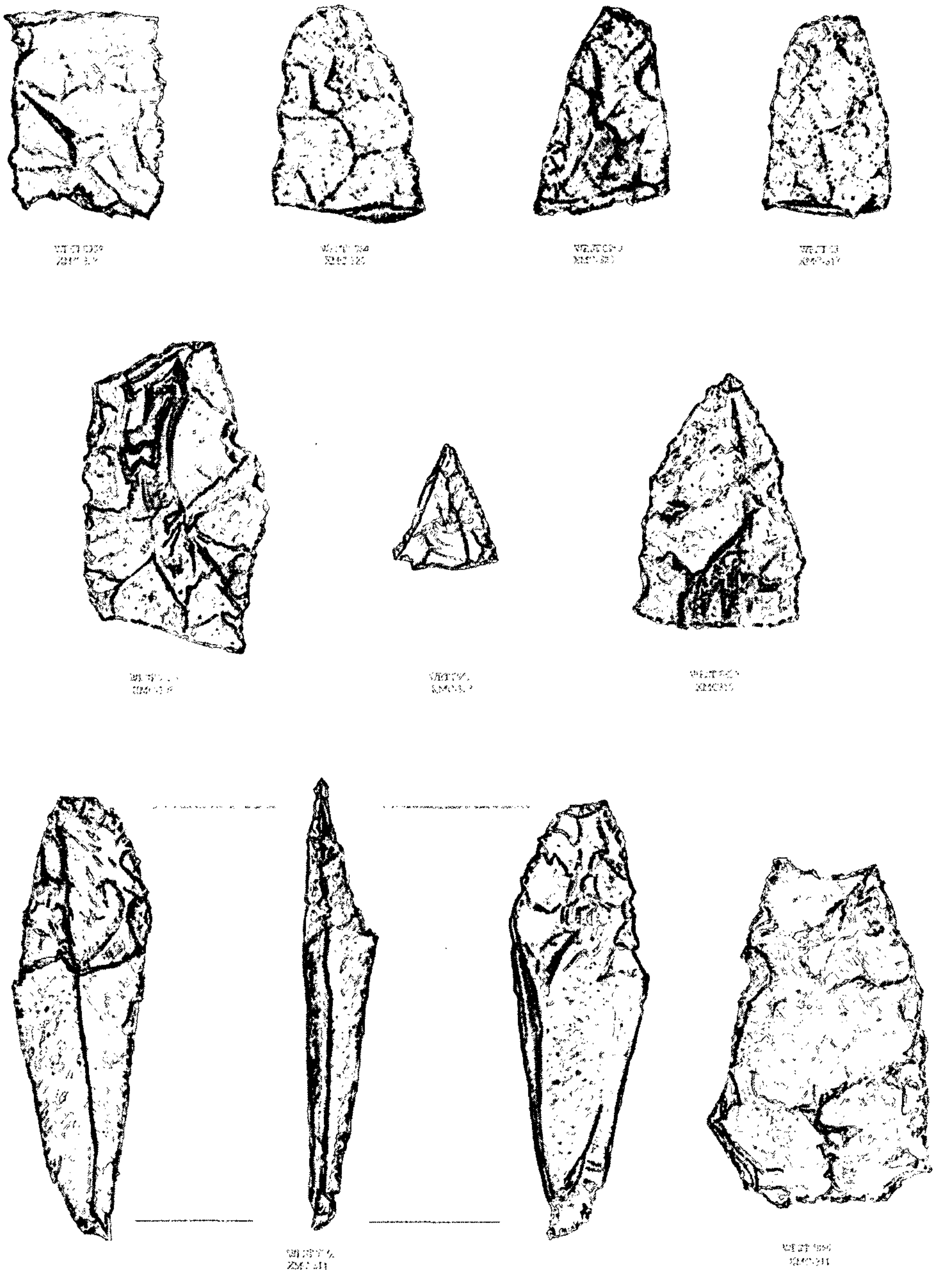

Figure B.5. Selection of Bifaces Indentified in the Wiki Peak Study Area. Artifact Illustrations by Tom O'Brien.

Figure B.6. Selection of Scrapers Indentified in the Wiki Peak Study Area. Artifact Illustrations by Tom O'Brien.

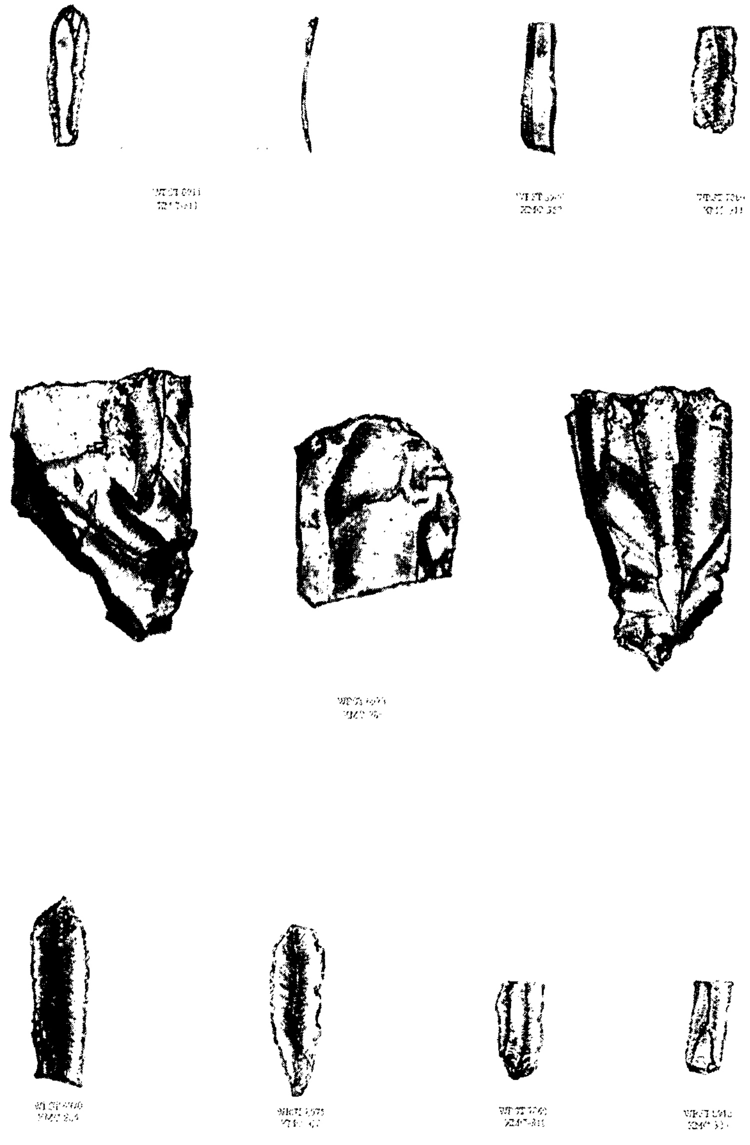

Figure B.7. Selection of Microblades and a Tabular Core Indentified in the Wiki Peak Study Area. Artifact Illustrations by Tom O'Brien

Testing Results

XMC-038 and XMC-377, both on the shores of Ptarmigan Lake, provide the best chronological controls for the project area (Table B.2). Testing conducted at these two sites identified moderately stratified sediments with cultural materials predating and post dating the deposition of the White River Ash (Figure B.8). With the exception of the basal deposits, the stratigraphy at both sites, which are only 1.5 kilometers apart, is identical and collectively discussed here. In both cases, approximately 45 to 50 centimeters of sediments overlay either Pleistocene alluvium (XMC-038) or glacial fluvial deposits (XMC-377). The primary difference in the two basal units is the clear stratification of the alluvial sediments relative to the poorly sorted matrix of silt, sand, gravel and boulders of the glacial outwash deposits.

Layer I consists of varying amounts of sand and humus depending on the presence or absence of vegetation. The surface of the layer typically holds only a 20% vegetation cover of dwarf birch and some grasses, but can be as high as 100%. Root penetration is high and includes roots of all sizes. Thickness of the layer varies between one and five centimeters. Artifacts are uncommon in the humus.

Layer II is a brown to light brown sandy loam with heavy root penetration. At least two sub-layers exist in the stratigraphic unit. Layer IIa differs from Layer II in that it is slightly more compact and slightly darker in color. Organic staining and some possible pockets of oxidized soil are present in the unit. Rocks are commonly encountered near the base of the layer and extending through it. Layer II appears consistently across the sites, though disturbances in some cases make it appear in thin layers or in pockets. Artifacts in Layer II are more common than in Layer I, but still not particularly numerous.

Layer III is White River Ash. The ash layer varies in thickness from one to eleven centimeters and consists of at least three visually distinct sub-layers. The unit contains no rocks or pebbles. Based on particle size, color, and moisture retention, several subunits were defined. Layer IIIa is dry, gritty in texture, and white-gray in color. The sub-layer is loosely compacted and well drained. This sub-layer accounts for the majority of Layer III. Layer IIIb is damper than IIIa and is slightly finer grained. The color is also slightly darker gray; likely, a function of the higher moisture content. Layer IIIb is more compact than Layer IIIa. Layer IIIc appears to be ash slightly mixing with Layer IV. Ash with the texture of sand is still the predominant matrix of the sub-layer. The sub-layer is brown-gray in color and moderately compact, but still well-

Table B.2. Radiocarbon Dates from XMC-038, XMC-285, and XMC-377

Site/Context/WRST #	**Lab Number**	**Material**	**Measured C^{14} Age (BP)**	**$^{13}C/^{12}C$ Ratio (‰)**	**Conventional C^{14} Age (BP)**
XMC-377/Stratum II/ WRST 9857	Beta 121647	Charcoal	680 ± 50	-25.0	680 ± 50
XMC-377/Stratum II/ WRST 9856	Beta-121646	Charcoal	960 ± 40	-21.9	1010 ± 40
XMC-286, Stratum III (White River Ash)/ WRST 6988	Beta-108862	Charcoal	1830 ± 80	-25.0	1830 ± 80
XMC-038/Upper Stratum IV/ WRST 7962	Beta-108865	Charcoal	2020 ± 70	-24.4	2030 ± 70
XMC-377/Stratum IV/ WRST 9853	Beta-121645	Charcoal	2470 ± 50	-24.0	2490 ± 50
XMC-038/Stratum IV/ WRST 7955 a+b (Split Sample from Possible Fire Pit)	Beta-108864	Charcoal	2490 ± 70	-25.1	2490 ± 70
XMC-038/Stratum IV/WRST 7955 a+b (Split Sample from Possible Fire Pit)	Beta-108863	Charcoal	2690 ± 80	-25.1	2690 ± 80
XMC-377/Stratum V/ WRST 9834	Beta-121643	Charcoal	3130 ± 40	-23.6	3150 ± 40

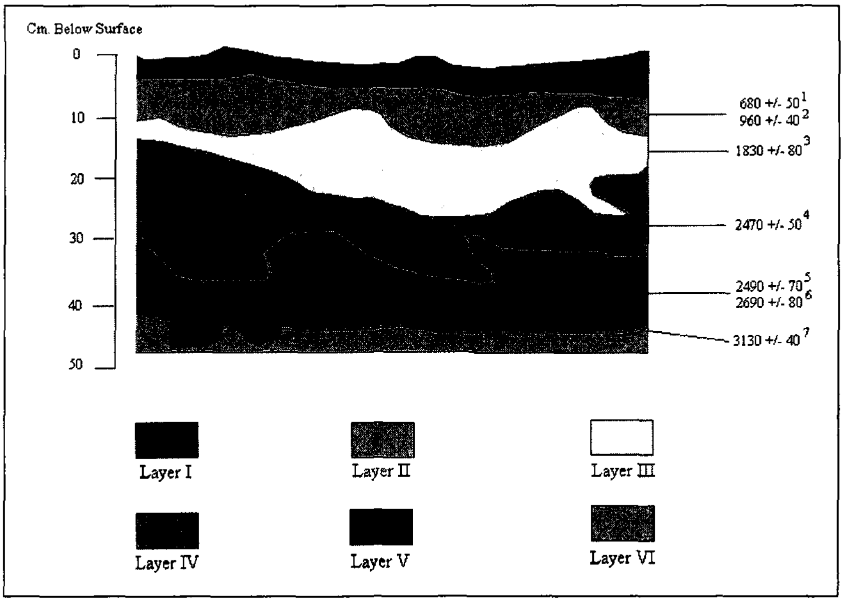

Figure B.8. Generalized Stratigraphic Profile for XMC-038 and XMC-377.

drained. Root penetration in Layer III is common but the root size is fine medium. Artifacts occur in the upper and lower contacts of the ash with surrounding sediments and are the result of mixing.

Layer IV is a compact silty loam dark brown to brown in color. Pebbles and small rocks are common but by no means dominate the matrix. The layer varies in thickness, generally ranging between 15 to 20 centimeters thick. The layer typically occurs within 20 centimeters of the modern ground surface. Charcoal smears and organic staining, as well as some possible oxidized matrix give portions of the layer a mottled appearance. The layer has little root penetration and those that are present are very fine. The layer holds more moisture than the upper layers making excavation and screening more difficult. Artifacts are extremely common in Layer IV.

Layer V is a green-brown clay loam with a high-moisture retention capacity. Pebbles and small and medium size rocks account for at least 45% of the matrix. Many of the rocks are in poor condition. The layer averages between 10 and 15 centimeters in thickness. Root penetration is nonexistent and there is little, if any, organic staining present. Artifacts are common in Layer V, but less abundant than in Layer IV. Layer VI represents the alluvial and glacial deposits noted above.