AN ABSTRACT OF THE THESIS OF

Michele Leigh Punke for the degree of Master of Arts in Interdisciplinary Studies in Anthropology, Anthropology, and Geography presented on May 29, 2001. Title: Predictive Locational Modeling of Late Pleistocene Archaeological Sites on the Southern Oregon Coast Using a Geographic Information System (GIS).

Abstract approved: Robson Bonnichsen

The search for archaeological materials dating to 15,000 yr BP along the southern Oregon coast is a formidable task. Using ethnographic, theoretical, and archaeological data, landscape resources which would have influenced land-use and occupation location decisions in the past are highlighted. Additionally, environmental data pertaining to the late Pleistocene is examined to determine what landscape features may have been used by human groups 15,000 years ago and to determine how these landscape features may have changed since that time. These landscape resource features are included in the modeling project as independent variables. The dependant variable in this modeling project is relative probability that an area will contain archaeological materials dating to the time period of interest.

Two predictive locational models are created to facilitate the search process. These models mathematically combine the independent variables using two separate approaches. The hierarchical decision rule model approach assumes that decision makers in the past would have viewed landscape features sequentially rather than simultaneously. The additive, or weighted-value, approach assumes that a number of conditional preference aspects were evaluated simultaneously and that different environmental variables had varying amounts of influence on the locational choices of prehistoric peoples.
Integration of the data and mathematical model structures into a Geographic Information System (GIS) allows for spatial analysis of the landscape and the prediction of locations most likely to contain evidence of human activity dating to 15,000 years ago. The process involved with variable integration into the GIS is delineated and results of the modeling procedures are presented in spatial, map-based formats.
Predictive Locational Modeling of Late Pleistocene Archaeological Sites on the Southern Oregon Coast Using a Geographic Information System (GIS)

By
Michele Leigh Punke

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APPROVED:

Redacted for Privacy

Major Professor, representing Anthropology
Redacted for Privacy

Committee Member, representing Anthropology
Redacted for Privacy

Committee Member, representing Geography
Redacted for Privacy

Chair of Department of Anthropology
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Michele Leigh Punke, Author
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CHAPTER 1. INTRODUCTION

Initial human migration into the Americas has been a source of contention among archaeologists since the first European contact with the New World. Many archaeologists argue that following the crossing of the Beringian land bridge, the first Americans made their way south into what is now the United States via an "Ice-free Corridor" through central Canada. The possibility that a coastal route may have provided a viable alternative pathway for migration has, in comparison, received limited attention (Fladmark 1979; Gruhn 1988, 1994; Easton 1992). However, recent work in the fields of geology, paleobiology, and archaeology has inspired a flurry of interest in the coastal migration theory (Barrie et al. 1993; Mann and Peteet 1994; Heaton et al. 1996; Dixon et al. 1997; Josenhans et al. 1997; Fedje and Christensen 1999; Fedje and Josenhans 2000).

Research is currently being conducted on the Pacific coast of southern Oregon to determine if any evidence of a coastally adapted group of people, dating to the late Pleistocene or early Holocene, exists in the area (Sea Grant Project R/CC-04). Such evidence would support the concept that an early migration into the New World took place via a coastal route. Unfortunately, much of the evidence that may have existed along this coastline has either been buried or destroyed by the effects of the melting of glaciers during the Pleistocene/Holocene transition. Glacial meltdown during this period caused sea level to rise significantly from its low sea-stand position of the late Pleistocene and inundation resulted on much of the former Pacific coastline in Oregon. Any archaeological materials that may have existed on this former coastline are now under water.
However, it is possible that late Pleistocene coastal sites do exist at locations slightly inland from the former shoreline. It is these locations that this project aims to locate. Information from environmental reconstruction, ethnographic analogy, coastal adaptation theory, and archaeological analogs is examined to isolate a number of landscape variables representative of prehistoric human needs and preferences. These landscape variables are used to produce two separate predictive models: the first, a model utilizing generalized variables which represent basic human needs and preferences; and the second, a model based on environmental, ethnographic, theoretical, and archaeological details specifically pertaining to a coastal adaptation type.

The two models are subsequently integrated into a Geographic Information System (GIS) in order to produce maps highlighting areas on the landscape with the greatest potential for containing an archaeological site dating to the time period of interest. Some natural formation processes are integrated into one of the models in order to further narrow the landscape area with the potential for containing late Pleistocene archaeological materials. The inclusion of a variety of variables into the models demonstrates the capabilities and flexibility of the models' production and integration into GIS technology.

The ultimate goal of this predictive locational modeling project is to produce results that allow for the formulation of hypotheses that indicate where future field-testing should occur in order to locate Pleistocene-aged coastal archaeological sites.
CHAPTER 2. PREDICTIVE MODELING

**Definition**

An archaeological predictive locational model is defined as "a simplified set of testable hypotheses, based either on behavioral assumptions or on empirical correlations, which at a minimum attempts to predict the loci of past human activities resulting in the deposition of artifacts or alteration of the landscape" (Kohler 1988:33). Predictive locational modeling has been widely used in archaeology, especially in the realm of cultural resource management (CRM). Its popularity has increased recently due to the advent of Geographical Information Systems (GIS), a technology which combines spatial data with database information in a digital format. Assemblage and analysis of geologic, hydrologic, pedologic, environmental, and archaeological data can be accomplished with relative ease using a GIS.

Many archaeological agencies have developed predictive models in order to, ideally, locate all archaeological materials which lie within the zone being surveyed. This is not the case for this modeling endeavor. Instead, the predictive models designed for this project aim to locate areas on the landscape which have the highest potential for containing archaeological materials dating to a specific time period, the late Pleistocene. Additionally, one of the models produced in this study attempts to locate those areas with the highest potential for containing archaeological materials originating from a late Pleistocene population with a coastal adaptation to the landscape. Therefore, information from environmental, ethnographic, theoretical, and archaeological sources directly pertaining to this time period and to a maritime or littoral adaptation will be used in the development of these predictive locational models.

Predictive modeling operates under the assumption that in the past humans oriented themselves in relation to certain features on the landscape. These features would have represented...
some sort of resource to ancient peoples, such as a subsistence, political, spiritual or even comfort resource. Another assumption of predictive modeling is that features of the present-day landscape represent features that would have existed in the past. This is probably the case, to a certain degree, for many environmental and landscape variables. However, an important consideration in the production of a predictive model is what the environment may have been like in the past, how it has changed, and how these changes can be accounted for in the creation of a model. Below is a discussion of the theoretical justification for explicitly associating humans and their environment. Chapter Three presents the environmental context within which the human population being modeled would have lived.

Theoretical Justification

"Theory is the way in which we think about things, particularly about the existence, nature, and direction of cause-and-effect relationships, and modeling is the way in which we go about dealing with data" (Kohler 1988:102). The basic operating premise of archaeological predictive locational modeling is the concept that quantifiable, mappable, environmental data are somehow related to locations of past human behavior. Humans beings' relationship with the environment has long been a topic of interest in the realm of cultural and ecological studies. Locational modeling assumes, to some extent, that humans operate in some predictable manner in relation to the environment. Determining the exact nature of this relationship between culture and the environment is accomplished by integrating into the modeling process cultural ecology, a theory progenitored by Julian Steward (1955).

Steward argued that a culture's structure could be explained by how it adapted to a specific environment using specific technological capabilities: "Cultural ecology pays primary attention to those features which empirical analysis shows to be most closely involved in the
utilization of environment in culturally prescribed ways" (Steward 1955:37). Those features of a culture most closely related to subsistence and adaptation were considered to be the primary factors delineating cultural organization, the “cultural core.” All features of a culture not directly related to the exploitation of the environment, those explained through a cultural historical examination of a society, were considered secondary features. For Steward, it was only through the examination of a society’s core features and subsequent classification as a specific “culture type” that comparison with other cultures could be accomplished (McGee and Warms 1996:221).

The cultural ecology approach is useful in locational predictive modeling in a number of ways. Unlike environmental determinism, Steward’s approach attempts to explain, rather than simply correlate, the existence of cultural features by examining them in relation to and as a reaction to their environmental context. In Steward’s approach, those aspects of a culture directly associated with resource acquisition are considered to be the “core” features. It is through the process of distilling cultural patterns down to these “core” features that cross-cultural comparisons, another aspect of the modeling process, can be accomplished. Cultural ecology “requires that primary attention be paid only to relevant environmental features as are affected by the adaptations” (Steward 1955:39). It is through the distillation process that relationships between techno-subsistence adaptations and the environment are discovered and isolated. This allows for specific environmental variables to be examined and modeled in relation to specific cultures.

In general anthropological terms, the value of the cultural ecological approach to examining societies has been questioned (Harris 1968; Moran 1979; Ellen 1982; Kohler 1988). Problems with the approach include ambiguity in the definition of “cultural core,” the assumption of a uni-directional influence of environment on culture, the limited mention of the role of culture history upon adaptation type, and the scale at which Steward addresses individual environmental variables.
Cultural ecology is not a total-culture approach; there are other factors outside of environmental stimuli which affect the subsistence and settlement strategies of a culture. For example, a culture's perception of the environment, its socio-political structure, demography, and religion are all important cultural features that potentially affect a group's relationship with the environment. These features are, unfortunately, difficult to incorporate into a predictive model, especially a model whose focus is on a population dating to thousands of years ago. However, if we keep in mind cultural ecology's limitations, the main concepts are still useful in a locational modeling study. The adaptation scheme required by a culture operating within the bounds of a particular environment, as expressed by a specific subsistence program and settlement system, can be proposed and the spatial manifestation of this behavior on the landscape can be modeled.

**Boundary Conditions**

**Time Period**

Before the modeling process can begin, certain parameters need to be defined. The first parameter involves the delineation of time period to be modeled. It was stated in the introduction that the goal of this project is to locate areas with a high probability of containing archaeological materials dating to the late Pleistocene. However, the late Pleistocene encompasses thousands of years. In order for this modeling project to be operationalized, a specific time period must be identified for modeling which represents a sample of the late Pleistocene period. For this modeling project, 15,000 years ago will be the sample time period of focus. Although not a perfect representation of the entire late Pleistocene period, 15,000 years ago does represent a time when sea levels were near a mid-point between low sea-stand period of ~21,000 years ago and levels at the end of the Pleistocene era at ~10,000 years ago (Hanebuth et al. 2000).
Location

Research is currently being conducted along the southern Coast of Oregon in order to locate archaeological sites dating to the late Pleistocene or early Holocene (Sea Grant Project R/CC-04). The study area for this Sea Grant project includes Coos and Curry Counties in Oregon (Figure 1, inset). Manipulation and modeling of the entire Sea Grant study corridor is beyond the scope of this thesis project. Instead, a smaller, sample portion of the project corridor will be addressed in order to present the methodological procedures involved in archaeological predictive modeling with a geographic information system (GIS).

This sample area includes much of the Coquille River Basin, including the areas featured on the following 7.5’ USGS quadrangles: Bullards, Riverton, Coquille, Bandon, Bill Peak, and Myrtle Point (Figure 1). Both Model Type One and Model Type Two will be applied to this sample project landscape. The sample area was chosen based on its inclusion of specific landscape features which appear all along the southern Oregon coast, such as an estuary system, coastal bluffs and beaches, marine terrace formations, an upland/lowland transition, alluvial deposits, and stream terraces. Data gathered and methodologies produced as a result of work on this sample corridor will be applicable to the larger project corridor of Coos and Curry counties, as well.

Model Type

The choice between an inductive or deductive approach to predictive modeling is an issue that must be addressed before model data can be gathered. Inductive, or pattern-recognition, models statistically examine environmental information from known archaeological sites in a
Figure 1. Sample study area, in detail, including elevation, cities, USGS quadrangle boundaries, and stream locations, and in relation to Coos and Curry counties in Oregon (gray shaded counties on inset map).
specific area or dating to a certain time period in conjunction with information from known non-site locations to determine the probability that a specified tract of land, exhibiting a particular set of environmental characteristics, will contain an archaeological site (Kvanme 1989; Warren 1990; Carmichael 1990; Maschner and Stein 1995). This method relies on correlation to predict where archaeological sites will be located—it does not try to give reasons for their locations. Inductive models require the use of a substantial archaeological site database in order for statistical analysis to be performed. Unfortunately, no sites dating to the time period of interest, ~15,000 years ago, have been found on the Pacific coast of North America. Therefore, no inductive information will be used for the formulation of the two predictive models in this project. Instead, the deductive approach will be used for this locational modeling study.

Deduction, as defined by Webster’s Dictionary, is “to infer by logical reasoning; reason out or conclude from known facts or general principles” (Guralnik 1982). Researchers who use deductive, or explanatory, models make conclusions regarding archaeological site location based on general, theoretical principles of past human behavior and informational analogs. Information gathered from theoretical, ethnographic, and pertinent archaeological sources helps to provide a better understanding of adaptive strategies that may have existed in a specific environmental setting during a certain time period in the past. Aspects of this mode of adaptation, such as subsistence and settlement activities, can then be reconstructed and modeled.

Model Data Requirements

Once the goal of the project has been defined and the method of modeling selected, acquisition of the data needed for model building begins. Deductive model data collection involves three primary sources: ethnography, adaptation theory, and archaeological analogs.
Information from each of these sources helps to determine the independent variables to be used for modeling and to delineate their relationships to each other and the dependent variable.

Equally important to the modeling process is the inclusion of environmental data to provide a context within which paleo-human groups would have operated and that may have affected the materials these groups left behind: “A truly useful predictive model... is one that puts human use of the area into this environmental context. Not only will it define those environmental variables or combinations of variables that would attract human use and thus predict site location, but also it will address post-site formation processes that could obscure or destroy these sites” (Church et al. 2000:146).

Dependent Variables

Before modeling can begin, the dependent and independent variables to be used in the study must be defined. For this project, the dependent variable is probability of site presence or absence, whether it be stated in a boolean fashion, (a “yes” or “no”), or by a relative probability measurement, (i.e., a particular area being more likely to contain a site than another area). Altschul (1988: 84) writes, "In an ideal setting a predictive model would be built by first identifying the characteristic of site location, such as site density or frequency (i.e., the dependent variable) and then identifying all the social, environmental, and geomorphic factors (i.e., the independent variables) that impinge upon it.” These independent variables become evident through the process of reviewing and evaluating the existing data.
Independent Variables

Many archaeological predictive locational models operate under the assumption that “settlement choices made by prehistoric peoples were strongly influenced by characteristics of the natural environment” in their delineation of independent variables (Warren 1990:202). Based on the cultural ecology theoretical approach from which this model is being constructed, environmental characteristics are important in that they represent proxy variables for subsistence and settlement needs or preferences of coastally adapted peoples. For example, the environmental variable of stream location is a proxy indicator for a source of fresh water required by humans in general, as well as a food resource location and a means of transportation for coastally adapted, boat-using peoples.

Some researchers have argued that multiple environmental variables should be considered in prediction processes: “Evaluations of topography, water, soils, vegetation, precipitation, temperature, and availability of outcrops or glacial till exposures are all important in decisions about the adequacy of shelter and the availability of economic resources” (Schermer and Tiffany 1985:220). Other researchers have focused their efforts on just a few variables: “Perhaps in building predictive models we are too ready to make the assumption that only a complex multivariate model can adequately account for human locational behavior, when in fact, a few (proxy?) variables, observed in the highly correlated database that is our environment, may be sufficient for forming locational decisions” (Kohler and Parker 1986:433).

For this predictive modeling study, several variables are discussed and utilized in the production of two separate models. It may be that the use of more or fewer variables would provide a better product. It will be shown that the models produced for this study possess the flexibility to include any number of variables, according to the parameters set by the researcher. As long as each variable is included in the model for a specific purpose, and that purpose is clearly explained by the author, any number of variables may be used.
CHAPTER 3: ENVIRONMENTAL DATA

Integration Considerations

"The archaeological record is a complex amalgam of patterning in material objects created by the organization of peoples' activities in the past and by the intervening cultural and natural processes that have preserved or rearranged these materials since they were lost or abandoned by their past owners" (Kohler 1988:101). The specific human activities important to this project are those governing site selection. One goal of the project is to model how past populations selected occupation sites by considering 1) settlement patterns and subsistence strategies in relation to the landscape as dictated by adaptation type, and 2) the decision making process involved with settlement and subsistence choices. The environmental context within which these choices were made and the processes involved in creating and preserving evidence of these choices on the landscape must first be considered if a true bridge between the archaeological record and the human population that created it is to be built.

The environment as a whole is composed of many smaller units which interact at various temporal and spatial scales. These units, or subsystems, include the climate, geology, geomorphology, pedology, hydrology, biology and tectonics of an environment. Each subsystem can be further subdivided and analyzed in relation to itself and to other subsystems. It is through an analysis of past subsystems and their interactions that paleoenvironmental reconstruction can be accomplished and a context for this predictive modeling study established.

To the modern day archaeologist, the environmental and social contexts of an archaeological site can be as important as the site itself in the quest for a thorough understanding of prehistoric human behavior. In cases where little or no information regarding early inhabitants of an area during a certain time period is known, environmental context becomes especially
important. This is the case with sites on the southern Oregon coast dating to the time of initial occupation of the Americas—the end of the Pleistocene (ca. 21,000 - 10,000 yr BP). No sites dating to earlier than 8,600 yr BP have been discovered on the southern Oregon coast, but it can be argued that this is due to the destruction of sites by post-glacial sea-level rise and inundation and/or simply because no one has looked in the right places. Evidence from areas along the coasts of Alaska, British Columbia, and California indicates possible late-Pleistocene occupation by maritime-adapted humans. An unglaciated Oregon coast would seem to be a viable option for occupation, as well. In order to explore this option further, two important contextual questions must be answered. First, what environmental parameters would early human migrants have encountered had they traveled to and stopped at the southern Oregon coast during the late Pleistocene? Second, how has this environment changed since that time and how will this have affected the archaeological record?

The nature of the environmental record is extremely complex. In order to come to an understanding of what may have occurred in the past to produce the record recovered in the present, three modes of reasoning can be used. These include reasoning from analogy, from proxies, and from correlations (Dincauze 1987:258-260). Reasoning from analogy involves the concept that patterns we see in the present also occurred in the past. For example, pollen assemblages recovered from Pleistocene-aged samples that are analogous to a modern day assemblage from a particular area imply that similar climatic conditions prevailed at that time or that similar flora and fauna may have inhabited the area as do in the analogous area today. However, it has been shown that some modern day biotic assemblages are not analogous to those of the past (Lundelius 1989). During the Pleistocene, many faunal species which today are allopatric lived in association with each other due to different climate regimes.

Gathering information that indirectly informs about past conditions is the method of reasoning by proxy. Climate is often inferred using proxy data such as pollen records, ice-cores, or chemical element ratios in soils. The more avenues of proxy investigation taken, the better the
inferred conclusion. Reasoning from correlation involves the observation of two or more factors that consistently occur together—in the same region, at the same time, and at the same rates. However, correlation must not be confused with coincidence or causation. Analogy, proxy data, and correlative reasoning should be used to gain a more thorough understanding of the mechanisms driving environmental variability (Dincauze 1987:259-260).

Although a complete understanding of all aspects of the environment on the southern coast of Oregon at the end of the Pleistocene is an impossible goal, a limited understanding of certain aspects may be attained. Using information from sciences such as climatology, geology, oceanography, sedimentology, and biology, a general picture of environmental conditions can be constructed on a regional and local scale and through time. The goal of this reconstruction is not to formulate how this environment would have dictated human behavior, but rather to understand how the environment provided "stressors and opportunities" (Dincauze 1987:257) to which humans would have responded.

**Environmental Subsystems**

**Climate / Vegetation**

The present-day climate of western Oregon, including mountains of the Coast Range, their foothills, and the lowlands of the coastal plane, is characterized by mild, wet winters and warm, dry summers (Grigg and Whitlock 1998). Vegetation on the Coast Range is dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and red alder (*Alnus rubra*) (Grigg and Whitlock 1998). Nearer to the shoreline, vegetated areas include conifer forests, lodgepole pine (*Pinus contorta*) stands, and Sitka spruce...
(Picea sitchensis), while non-forested areas along the southern portion of the Oregon coast produce prairie grasses and shrub fields (Maser et al. 1984).

Plant remains in a sedimentary record are examined to determine not only what types of vegetation were present at and through time in a region, but are also used as proxy data for other types of research, including climate studies. Plant material such as macrofossils, pollen, phytoliths, and aquatic diatoms can all provide information regarding past environmental regimes (Rapp and Hill 1998:90-96). A study conducted by Grigg and Whitlock (1998) used such information to glean an understanding of the climate near Little Lake, Oregon. Sections of a pollen core taken from Little Lake, located in the central coastal region of Oregon, were dated and materials dating from 15,700 to 10,200 yr BP were analyzed. Percentages of plant taxa were measured and environmental and climatic trends described according to transitional periods:

A subalpine forest was present at Little Lake, central Coast Range, between 15,700 and 14,850 cal yr BP. A warm period between 14,850 and 14,500 cal yr BP is suggested by an increase in Pseudotsuga pollen and charcoal. The recurrence of subalpine forest at 14,500 cal yr BP implies a return to cool conditions. Another warming trend is evidenced by the reestablishment of Pseudotsuga forest at 14,250 cal yr BP. Increased haploxylon Pinus pollen between 12,400 and 11,000 cal yr BP indicates cooler winters than before. After 11,000 cal yr BP warm dry conditions are implied by the expansion of Pseudotsuga (Grigg and Whitlock 1998).

Data from Little Lake pertaining to an earlier time period, including the time period of interest to this modeling study (~15,000 yr BP), is presented in a study by Worona and Whitlock (1995). Information gleaned from the pollen and macrofossil record obtained from a section of core dating to 24,770 to 13,377 yr BP indicates that, “the pollen and plant macrofossil data suggest a parkland composed of spruce, lodgepole pine, fir, and mountain hemlock. Macrofossils indicate the local occurrence of Engelmann spruce...and lodgepole pine” (Worona and Whitloock 1995:872). Vegetation conditions lead Worona and Whitlock (1995:872) to conclude that the climate in the area would have been characterized by high snow accumulation, cool summers, and generally drier conditions during this time period than at present. Although this pollen sample
was taken from a lake 45 miles east of the current coastline and 217 meters above sea level, the
colder, drier conditions proposed for the Coast Range are undoubtedly applicable to the entire
coast.

A worldwide climate database spanning the last 18,000 years has been formulated by
COHMAP (Cooperative Holocene Mapping Project) using pollen data, lake-level information,
data regarding marine plankton, oxygen-isotope studies, and radio-carbon dated plant
microfossils from pack rat middens (COHMAP 1988). Although not nearly as precise at the
Grigg and Whitlock (1998) or Worona and Whitlock (1995) data, the COHMAP study provides
correlative information regarding general timing of climatic warming and cooling. According to
this study, conditions in Oregon at 15,000 yr BP would have been colder, drier and more subject
to high winds than today.

Landforms / Sea Level

"Landforms contemporary with an archaeological site are crucial elements of the site's
context, the basis on which the site can be related to others in the area, and the essential
foundation of any efforts to understand the environment on the terms on which former humans
experienced it" (Dincauze 1987:263). The geomorphological conditions present on the southern
Oregon coast at the end of the Pleistocene would have been considerably different from today.
Probably the most drastic difference would have been the additional kilometers of shoreline
beaches present due to the lowered sea levels of the late Pleistocene.

Estimates of global sea level curves indicate that around 20,000 yr BP sea levels would
have been up to 100 meters lower than today (Figure 2) (Masters and Flemming 1983; Gearhart et
al. 1990). Even at the onset of the Holocene, around 10,000 yr BP, sea levels were still at least 40
meters below present levels (Gearhart et al. 1990; Rapp and Hill 1998:78). A more precise sea-
Figure 2. Former coastlines in relation to sample study area. Coastline data from Gearhart et al. (1990).
level curve produced in a study by Hanebuth et al. (2000) indicates that low sea stand occurred around 21,000 years ago, when levels reached 116 meters below present-day sea level. At 14,600 years ago, sea levels were at 96 meters below present and by 11,000 years ago they had reached a level of 48 meters below present (Hanebuth et al. 2000:1034). Due to the gently sloping nature of the continental shelf off the coast of Oregon (Orr et al. 1992: 187), shoreline beaches would have extended far westward of today’s coastline.

Studies concerning southwest Oregon stream morphology at the end of the Pleistocene indicate that up until the Pleistocene-Holocene transition streams would have been continually downcutting into underlying Eocene and Oligocene aged bedrock, forming deep, v-shaped valleys (Ritter 1986; Personius et al. 1993). At the time of transition into the post-glacial Holocene, fairly rapid regional stream aggradation occurred forming low, nearly continuous fluvial terraces along most of the central and southern Oregon coast (Personius et al. 1993; Personius 1993). Remnants of these terraces exist today and have been radiocarbon dated to about 9,000-11,000 yr BP. The cause of this change in stream morphology may be due to a change in stream water base-level caused by the rise in sea level at the end of the Pleistocene. Additionally, stream morphology change may be related to climate-induced landslides in the region. Increased storm intensities may have been one catalyst for the evacuation of colluvium from drainage basin hollows (Personius 1993). Also, loss of certain types of vegetation cover due to changing vegetation assemblages or an increased number of forest fires in the warmer, drier early Holocene may have encouraged the occurrence of landslides (Personius 1993). This rapid terrace development is also important in that pre-aggradation archaeological sites may have been covered during this time and remain securely capped by overlying terrace sediments.
Hydrology

Although today some rivers and streams on the southern Oregon coast have an estuary reach at their mouths, this was not always the case. It was not until sea-level began to rise that the lower, western ends of stream channels were drowned, forming estuaries. Subsequent dune activity blocked off many of these newly developed estuaries (Cooper 1958). Streams which lacked the erosive power to cut through the eolian deposits formed into coastal lakes. There are a number of such dune-formed lakes along the Oregon coast, including the relatively large Tahkenitch and Siltcoos Lakes on the central Oregon Coast and Croft, Floras, and Garrison Lakes south of Coos Bay (Cooper 1958; Johnson et al. 1985).

A study conducted by Peterson et al. (1984) indicates that estuary formation occurred around 7,500 yr BP on the Alsea River on the central Oregon coast. This date corresponds to evidence of an estuary-type environment at Tahkenitch Lake dating to approximately the same time period (McDowell 1986). McDowell (1986:92) argues that such hydrological changes in the form of channel drowning and estuary formation occurred along the Oregon coast from 10,000 to 7,500 years ago. However, it seems possible that these estuaries could have formed at any point during the period of sea-level rise which followed the low sea-stand of 21,000 years ago. If this is the case, estuary conditions may have existed at some of the present-day coastal lakes by the target age of this project, 15,000 years ago. Only detailed coring and dating of sediments from these lakes can provide an accurate picture of past conditions for these coastal hydrologic features.

Research on coastal landforms in this area was conducted by Cooper (1958) in order to gain a better understanding of dune activity. He proposed that dunes became active when older, stabilized dune complexes were eroded and increased amounts of sand became available for wind movement. This erosion activity occurred during periods of sea-level rise or during periods of increased storm frequency and/or intensity. He found that three major episodes of dune activity
had occurred in the past. The first episode occurred during the Pleistocene-Holocene transition, a
time of rapid sea-level rise and climactic instability, between 18,000 and 6,000 years ago. It was
during this period that most of the lakes located on the coast today were formed (Cooper 1958;
Johnson et al. 1985).

Soil studies in the area provide some additional information regarding the age of
stabilized dune formations created during this period in relation to marine terrace complexes in
the area (Nettleton et al. 1982). The amount of development of spodosols on the Whisky Run,
Pioneer, and Seven Devils terraces in comparison to the stabilized sand dunes south of Coos Bay
indicate “increasing soil development from the youngest to the oldest geomorphic surfaces,
but...relatively little difference in soil development on the stabilized dunes and the Whisky Run
marine terrace” (McDowell 1986:94). This may indicate that although the terrace itself was cut
approximately 80,000 years ago, the uppermost layer of the terrace is a later deposit, possibly
capping other older deposits. If this is indeed the case, then areas with stabilized dune formations
overlying the Whiskey Run terrace should be field examined in order to determine their potential
for containing buried surfaces. Examination of stabilized dune deposits located adjacent to former
estuaries may prove an especially fruitful endeavor for locating Pleistocene-aged archaeological
sites.

Tectonics

Another factor which has affected the landscape along the southern Oregon coast is
tectonic activity. Marine cut terraces run parallel to the Pacific coastline from just south of Coos
Bay to Port Orford. The youngest of these terraces, the Whisky Run Terrace, was cut around
80,000 yr BP (Muhs et al. 1990), a period of high sea stand during the late Pleistocene. The
marine terraces of the southern Oregon coast, especially the Whisky Run, have been the subject
of intensive geological investigation during the last few years because of the apparent uplift of these landforms (Kelsey et al. 1996; McInelly and Kelsey 1990; Muhs et al. 1990; Verdonck 1995).

Located along the forearc region of the Cascadia subduction zone, the convergence of the North American Plate and the Juan de Fuca Plate has led to deformation and uplift of the overriding North American Plate and the coastal landforms associated with it. Uplift estimates for the Whisky Run Terrace are from 0.45-1.05 and 0.81-1.49 m/kyr at the Coquille River outlet and Cape Blanco, respectively (Muhs et al. 1990:6685). Twenty thousand years ago, the Whisky Run Terrace could have been as much as 29.8 m lower in some areas as compared to present. This is important when considering human activity in the region during late Pleistocene times. Areas of high elevation along the edge of the terrace may have escaped complete post-glacial inundation due to this uplift activity, existing today as coastal headlands or bluffs. Archaeological sites located on such headlands may provide evidence of very early human occupation of coastal areas. Indian Sands and Blacklock Point, to be discussed later in this paper, may be examples of such early sites.

**Biota**

Although the frequency distributions of faunal species in the past are different than present-day distributions, many types of fauna still inhabit the coast. For example, studies indicate that terrestrial mammals such as elk, deer, beavers, and rabbits may have inhabited the Oregon coast during the Pleistocene (Maser et al. 1984). Terrestrial fauna may have been exploited along ecotone boundaries, areas that some mammals tend to utilize due to the "edge effect", a transition between diverse biological communities (Odum 1971:157). Although published data regarding the existence of now-extinct mega-fauna such as mammoth, mastodon,
or ground sloth on the coast are unavailable, Bonnichsen (personal communication 2001) reports that a fossil mastodon tooth has been found on the northern coast of Oregon.

Additionally, marine mammals such as whales, dolphins, and seals would have been available for exploitation. Salmon has been noted as a primary resource in many ethnographic and historic accounts. Evidence indicates that salmonids have inhabited the North Pacific Ocean since long before the Pleistocene (Pearcy 1992). Salmon, as well as other fish, would have been exploited by late Pleistocene peoples in both marine and riverine settings.

Ethnographic accounts indicate that certain types of flora were important subsistence resources for native peoples (Aikens 1993; Minor and Toepel 1983). Plant foods including roots, greens, berries, fruits, seeds, and nuts were utilized. Such resources were probably used by humans during the late Pleistocene as well. Unfortunately, exact locations of nut trees, berry bushes, or other such plant resources are extremely variable—they are not associated with any specific, bounded location through time, such as fish are with streams—and therefore will not be expressly included in the modeling process.

**Summary**

In summation, based on this paleoenvironmental reconstruction a number of landscape features that may have been important to late Pleistocene populations on the coast can be identified on the landscape today. First, any paleo-human activities that took place directly on the shoreline at 15,000 years ago are unavailable for modeling due to sea-level rise. However, although much of the former coastline was inundated by post-glacial sea-level rise, areas which would have been bluffs overlooking the former coastal plain during the Pleistocene may have escaped inundation because of their already elevated position or because of localized tectonic uplift. These bluff areas can be identified using Digital Elevation Model (DEM) information and
digitally included into models. Areas of upland/lowland transition, or “edges”, can also be modeled using DEM information.

Rapid sediment deposition along coastal streams during the Pleistocene-Holocene transition was caused by the evacuation of colluvial hollows in the Coast Range, and subsequent sea-level rise and tectonic activity resulted in stream down-cutting and the formation of extensive fluvial terrace deposits along many coastal streams (Personius 1993; Personius et al. 1993). Atop, within, or underneath these terrace deposits may be evidence of prehistoric human stream-side land use. Geological maps pertaining to the area are available (i.e. Beaulieu and Hughes 1975, 1976) and can be used to digitally recreate these terrace locations. Information from the Coos County soil survey (USDA 1989) will provide additional, finer-scale data regarding soil and sediment ages for these terraces, as well as for other landscape features.

The Coquille Estuary would have provided a variety of subsistence resources and its shores are an optimal location for digital modeling. Additionally, many present-day coastal lakes may have been estuaries during the late Pleistocene and would have been utilized for a variety of resources. These estuary features can be digitally included in the models, as can the locations of other hydrologic features important to paleo-human subsistence activities such as near-coast streams or rivers.

The environmental data presented above not only provides important landscape features to be directly included in model formation, but also provides the context within which late Pleistocene humans would have settled and subsisted. With this environmental context in mind, pertinent cultural data is presented in the following section.
CHAPTER 4. CULTURAL DATA

Integration Considerations

When creating a predictive locational model for a population which existed 15,000 years ago, it must be kept in mind that the human organizational system being postulated and modeled is almost completely unknown. There is no archaeological evidence of its existence. A construction of this population and its features is strictly conceptual in nature—a combination of theoretical conjecture, ethnographic analogy, and archaeological inferences. This paper offers one picture of a population which may have existed on the southern Oregon coast 15,000 years ago, and it is the site selection behavior of this postulated population that is being modeled.

Ethnography- Oregon Coast

Ethnographic data are often used in combination with other data to bring about a better understanding of past human-environmental interactions. Ethnographic information has proved to be a valuable resource in the task of archaeological predictive modeling in a number of studies (Dalla Bona 2000; Dalla Bona and Larcombe 1996; Thomas 1973). A study conducted by Maschner and Stein (1995) is of particular interest to this project because it focuses both on existing ethnographic and archaeological data to develop a predictive model reconstructing the decision-making processes that influenced site location. According to their ethnographic research on the historic Tlingit, settlement locations were based on the following variables: southerly exposures for winter warmth, sheltered coves to protect houses and canoes, fresh water, beaches of pebbles and small rocks so as not to damage the cedar canoes, level and well-drained terrain,
defensibility, and proximity to food resources (Maschner and Stein, 1994: 61). These factors were added to archaeological data and integrated into their predictive model to give a more rounded, explanatory base to their predictions. Studies such as this can help to provide explanations for the choice of certain settlement locations that may not be readily apparent in the archaeological record.

C. Melvin Aikens (1993:140) discussed coastal ethnographic reports of seasonal resource use in his text, *Archaeology of Oregon*: “Broadly speaking, a bi-seasonal subsistence cycle was practiced by all Northwest Coast cultures. From early spring through fall, village members would disperse into small temporary camps near resource areas, living on what they obtained and processing stores for winter. There were of course comings and goings between the village and its satellite camps; the main village was probably never wholly abandoned, but its population must have been much depleted at busy times. In late fall through winter, the whole populace reassembled in the main village. This was predominantly a time of repairing and manufacturing equipment, with some fishing, hunting, and collecting of shellfish to supplement dwindling winter stores.”

Aikens also argued that due to the fact that similar seasonal resources are available along the entire length of the Oregon coast, the following ethnographic depiction of the north-centrally located Alsea tribe’s subsistence practices is applicable to all former coastal tribes (Aikens 1993:139-140):

Chinook salmon entered the coastal rivers in midsummer, followed by coho and dog salmon in the early fall. The steelhead trout, which is often grouped with salmon, was an additional sea-run fish prized for its flesh that was taken in the late fall through winter months. Smelt, herring, flounder, perch, and lamprey eels were also harvested as available throughout the year. Clams, mussels, crabs, and sea anemones were collected by the women from estuaries, tide pools, and bays.

Sea mammal hunting was apparently confined to offshore rocks where seals and sea lions congregated; there they were clubbed or harpooned. Whale hunting was considered too dangerous, according to informants interviewed by Drucker (1943), although the occasional beached whale was highly prized for the oil rendered from its blubber.
Although their land was rich in game, the Alsea did not extensively exploit this source of food. Hunting was considered "an adventurously way of augmenting the fish diet (Drucker 1943:83)", and was not pursued with the same vigor as fishing. Deer and elk were stalked along trails or at small forest clearings, especially during the summer when animals were in fine flesh. Dogs were occasionally used in the hunt to hold an animal at bay until the hunter was within bowshot. Pitfalls were sometimes excavated to capture elk, a prized game animal, but the time required for preparation of the pits limited their use considerably. Less attention was given to other game, although it is reported that beaver were dug out of dens and clubbed, and that small fur-bearing mammals were shot with the bow. Quail and grouse were caught in basket traps, and waterfowl were shot. Children used a slip noose to catch seagulls, and seagull and cormorant ("shag") eggs were collected as a food resource.

A wide range of plant foods including roots, greens, berries, fruits, seeds, and nuts gave additional variety to the diet. Camas was dug in great quantities from summer through fall, with the surplus being prepared for winter storage. Roots of plants such as skunk cabbage and ferns were harvested in the spring. Salmonberries, blackberries, huckleberries, and strawberries, which grew in profusion along the coast, were important food supplements. Each was collected in its proper season, along with various greens. Acorns were also harvested in small quantities back from the coast. Tobacco was grown at sheltered plots away from the village; it was mixed with dried kinnikinnik leaves for smoking (Minor et al. 1980:86).

Minor and Toepel (1983) specifically discussed historic and ethnographic information pertaining to the peoples of the southern Oregon coast in their work, "Patterns of Aboriginal Land Use in the Southern Oregon Coastal Region." At the time of contact with Europeans, most of the southern Oregon coast, from the Coquille River to the Californian border, was occupied by Athapaskan-speaking Tututni, Chetco, and Tolowa peoples. Although the Tolowa group was concentrated for the most part in northern California, the authors argued that because the environments of all three local Athapaskan groups would have been very similar, their associated lifeways also would have been similar. Much ethnographic study has been conducted in regards to the Tolowa, and their subsistence and settlement activities were summarized by the authors (Minor and Toepel 1983:227-228). In terms of subsistence, ocean-based resources such as shellfish, surf fish (especially smelt), seals, sea lions, sea-otters, and the occasional beached whale were exploited. Fish were available from the rivers both seasonally, in the case of salmon, and year-round, in the case of steelhead. Adjacent terrestrial areas provided people with resources
such as seeds, nuts, roots, and berries, in addition to game resources, including elk, deer, and smaller mammals. The availability of resources utilized by the Tolowa is listed in Table 1.

Table 1. Availability of Resources Utilized by the Tolowa Indians (from Minor and Toepel 1983:244).

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Tolowa settlement systems consisted of three primary locations: village sites, coastal camps, and terrestrial camps. Village sites were generally located at the mouths of streams or on near-coast lakeshores. Villages were inhabited for most of the year, with occasional departures to camp locations for specific, seasonal resource procurement. Coastal camps were occupied when ocean-running smelt were present. Interior camps were utilized for the gathering of nuts, berries and other flora, or during seasonal salmon runs.

Minor (1997) has argued that ethnographic reports from the area are very useful for understanding former modes of adaptation to specific resources. His research regarding the oceanic activity of peoples living on the southern Northwest Coast provides evidence of the acquisition of offshore resources, such as sea mammals, shellfish, and marine fish, and the transportation of goods and people via sea-worthy boats (Minor 1997:275). Minor suggested that these ethnographic reports can be applied to historic and pre-historic populations: “Significantly, references to these offshore activities are imbedded in the oral literature, indicating that use of the offshore marine environment was not simply a postcontact development, but instead had substantial time depth on the southern Northwest Coast” (Minor 1997:275).
Draper (1988) has argued that most models of southern Oregon cultures based on ethnographic accounts do not portray prehistoric settlement patterns correctly. This is due to the fact that most ethnographic accounts were recorded after the period of contact with Europeans. He states, “I propose here that the introduction of Euroamerican diseases resulted in significant changes in traditional technologies, sociopolitical structure, subsistence practices, and settlement patterns in the study area [Coos and Curry Counties]” (Draper 1988:269).

The utility of the ethnographic reports discussed above is especially limited in the reconstruction of cultures dating as far back as 15,000 years before the reports were recorded, a time when the environment and the cultures operating within it were very different. However, the generalized portrait of marine and terrestrial resource use, as depicted in the ethnographic literature, does outline the possible types of resources utilized in the past. By focusing on the landscape variables involved in coastal adaptation and resource use, the ethnographic reports provide important features to be included in the modeling project as independent variables.

The Maschner and Stein (1995) study indicates that southerly exposures, sheltered coves, freshwater, small-grained beach sediments, and proximity to food were all landscape features considered in the choice of occupation locations by prehistoric peoples. Aikens’ (1993) Alsea ethnography study points to landscape features such as coastal rivers, estuaries, tide pools, bays, and offshore rocks as important features. The Tolowa study by Minor and Toepel (1983) suggests that ocean, river, and terrestrial-based resources were utilized in the past, and emphasizes coastal stream mouths and coastal lakes as former occupation locations. Based on these studies, the following features will be digitally reproduced and included in the study as independent variables: aspect (south-facing land), complex coastlines (including coves, bays, estuaries, and tide pools), stream locations (for fresh water and proximity to river resources), boat-beaching areas (represented by fine-grained bottom-sediment types), near-shore rocks (for ocean-based resources), coastal lakes, and ecotone boundaries (for terrestrial-based resources).
Theory - Coastal Adaptations

In keeping with the principles of cultural ecology, human cultural behavior can be viewed in terms of its economic interaction with the environment. Human behavior in the scope of this locational modeling task will be discussed in terms of cultural adaptation, specifically through the examination of spatial manifestations of subsistence and settlement behavior. Adaptation type is characterized by "normative patterns of environmental use that are sensitive to changes in both environmental and socioeconomic-technological characteristics" (Kohler and Parker 1986:406).

The relationship between environment and human adaptation in the case of non-agricultural, prehistoric cultures is fundamental, especially when considering a socio-cultural group migrating to and occupying a new, possibly unpopulated landscape. Numerous adaptation schemes for the Northwest Coast have been postulated by researchers (Draper 1988; Ames and Maschner 1999; Lyman 1991, 1997; Lyman and Ross 1988; Minor 1997; Yesner 1980). The following is a discussion of the different types of adaptation that may have been adopted by early Oregon coastal populations and their specific features.

Adaptation and Settlement System Theory

In an article by David Yesner (1980), the definition and characteristics of a maritime hunter-gatherer culture are discussed. He defined maritime-adapted hunter-gatherers as "those for whom marine foods form the largest portion of intake of either calories or protein in the diet" (Yesner 1980:728). He listed the general characteristics of such a culture as the following: high resource biomass; resource diversity; environmental stability; "unearned" resources (i.e. migratory species); coastal settlement; sedentism; technological complexity and cooperation in
Of primary importance to this modeling project, insofar as they are more directly related to the spatial landscape or specific landscape features, are the concepts of settlement and sedentism in relation to adaptation. According to Yesner, settlement patterns of coastal hunter-gatherers will be linear and favor the following areas: "(a) complex coastlines where protective and productive bays will be found, (b) areas associated with streams or lakes serving as additional habitat for waterfowl and fish as well as a source of fresh water, (c) areas close to upwelling [ocean] zones, (d) strandflats where shellfish and other invertebrates are available, and (e) good areas for beaching boats" (Yesner 1980:729-730). Yesner argued that the spatial nature of marine resources and the type of subsistence activities necessary to exploit these resources would have led to "logistical" (Binford 1980) collecting behavior by semisedentary communities. Communities such as these are defined as groups "whose members shift from one to another fixed settlement at different seasons or who occupy more or less permanently a single settlement from which a substantial proportion of the population departs seasonally to occupy shifting camps" (Binford 1980:13).

Two important points must be considered before applying this cultural description to the population being postulated for this study. First, these features of a maritime hunter-gatherer are described in general. Application to a specific culture in a specific biome will necessitate alteration and refinement of feature descriptions. This can be accomplished through a more detailed environmental reconstruction, as well as the acquisition of information regarding local and comparative ethnographic reports and archaeological sites. The second point for consideration is the relatively narrow definition of the maritime hunter-gatherer subsistence base. Yesner concentrates all of his efforts on maritime resources, ignoring the possibility for both terrestrial and maritime subsistence source utilization by a single population. Whether they be
Adaptation and Development Theory

R. Lee Lyman, in his work, *Prehistory of the Oregon Coast*, discussed adaptation to a coastal setting in three ways, differentiating specifically between the focus of subsistence pursuits. Maritime culture, he argued, "denotes those cultures which have a primary focus on the sea as a source of resources. Attendant technologies are specifically applicable to and adapted for exploiting sea resources, and the lifeways and philosophy of involved peoples are oriented towards the sea" (Lyman 1991:76). Those cultures which are considered littoral by Lyman "depend heavily on the sea as a source of resources, but do not possess the sophisticated technology to use the open sea as a hunting and fishing area" (Lyman 1991:76). In other words, shoreline, estuary, near-shore rocks and islands, and tide pool environments would be exploited, but resources requiring technologies such as sea-worthy boats would not be utilized. The third type of culture delineated by Lyman is the riverine/interior culture. This culture specializes in the use of upstream resources, those found in the interior, along rivers above tidewater (Lyman 1991:77).

Lyman also offered a model for the progression of cultural adaptation on the Oregon coast, focusing on the foraging/collecting behaviors of early coastal peoples (Lyman 1991:79-83; see also Lyman and Ross 1988). He suggests that initially, during the pre-littoral stage of cultural adaptation, (up to 8,300 years ago), Oregon coastal populations would have employed generalist foraging behaviors, exploiting resources in and adjacent to the coast, including upland and riverine areas, prior to 5,000 yr BP. Lyman further clarifies his definition of the pre-littoral stage in a later text: "pre-littoral peoples were explicitly conceived as having exploited littoral...resources but not having focused subsistence pursuits on such resources; they were..."
conceived to be generalists” (Lyman 1997:261, original emphasis). Lyman offers archaeological sites such as 35LA3 (the Neptune site) and 35DO130 (the Tahkenitch Landing site) as possible proof of this pre-littoral stage of occupation.

Ames and Maschner (1999:123-126) also discussed the archaeological signatures of maritime, littoral, and terrestrial adaptations on the coast. They proposed that evidence for maritime adaptation would come in the form of sea-worthy boats and specialized hunting and fishing tackle. Littoral archaeological assemblages might appear similar to those found in coastal California sites (Erlandson 1994). Faunal remains from these California sites indicate both terrestrial and littoral zone resource use, with floral and shellfish resources the dietary mainstays. Inland adaptation on the coast would be evident in archaeological assemblages consisting of both terrestrial fauna and river resources. Based on their reviews of archaeological evidence in the Northwest dating to the Archaic period, the authors argued that early coastal peoples would have been “hunter-gatherers similar to those in the interior, but adapted to exploiting the littoral zones, and nearby waters” (Ames and Maschner 1999:126).

The discovery of new archaeological sites on the Oregon coast and the re-dating of other sites have led some scholars to argue for a different model of coastal adaptation. Minor (1997), citing information from his work at Tahkenitch Landing, argued for an early adaptation to a marine-based economy:

Tahkenitch Landing is clearly an example of native peoples living adjacent to an estuary and making full use of that rich environment in their subsistence pursuits. It is apparent that the prehistoric inhabitants of this region had the knowledge, technology, and inclination to exploit saltwater fish, marine mammals, seabirds, and waterfowl long before the time of the early littoral stage proposed by Lyman and Ross. It is equally clear that, at least while occupying Tahkenitch Landing, these peoples exploited marine resources far more intensively than terrestrial resources (Minor 1997: 272).

Minor stated that based on Tahkenitch Landing’s dates, 6,880 yr BP and 7,960 yr BP, the site should be included in the “pre-littoral” stage of occupation, as defined by Lyman. He argued
that because "Tahkenitch Landing is the only site occupied during the pre-littoral time span that has produced faunal evidence from which inferences about adaptations [can] be made," it should be the "type-site" for defining the stage (Minor 1997: 271). This is despite the fact that Lyman's definition of the pre-littoral stage concentrated on a generalist subsistence regime rather than a marine-based subsistence.

These arguments concerning the exact nature of late Pleistocene or early Holocene adaptation on the Oregon coast are fundamentally based on evidence produced by a very small number of archaeological sites. This seems to be more an exercise in semantics than in archaeology. Perhaps a more fruitful endeavor would be to assume early coastal populations used a variety of maritime, estuarine, riverine, and terrestrial resources in the past (a generalized coastal adaptation), and to concentrate efforts on locating more evidence of their subsistence and settlement systems rather than simply trying to classify the tiny amount of information that already exists.

**Generalized Hunter-Gatherer Adaptation and Spatial Organization**

A generalized model of hunter-gatherer modes of adaptation, in terms of subsistence and settlement strategies, is discussed in Binford's (1980) work, "Willow Smoke and Dogs' Tails: Hunter Gatherer Settlement Systems and Archaeological Site Formation." Binford argues that in order to interpret the archaeological record, the past dynamics of cultural adaptation to specific environments must be understood. He proposes two adaptive systems: the "residential forager" and the "logistic collector." Foragers, according to Binford, are characterized by their great mobility. Foragers do not store food, but instead rely on foraging rounds during which resources are encountered and returned to residential bases for consumption on a daily basis. Residential
sites may be moved often and/or over long distances, according to variability of resources across the landscape.

Archaeologically speaking, two primary types of occupation locations would be represented: the residential base and the location. The residential base should be most visible in the archaeological record; it represents "the hub of subsistence activities, the locus out of which foraging parties originate and where most processing, manufacturing, and maintenance activities take place" (Binford 1980:9). The location is "a place where extractive tasks are exclusively carried out" (Binford 1980:9). Due to foragers' low bulk procurement and lack of storage, activity at extractive locations will be minimal, and "use, exhaustion, and abandonment of tools is at a very low rate" (Binford 1980:9). Typical environments that would support foraging adaptation systems would be equatorial or semiequatorial settings, where effective temperature is high and spatial and temporal incongruity of resources is low (Binford 1980:14-15).

In contrast, logistical collectors are characterized by food storage and low residential mobility (Binford 1980:10). Residences are located in close proximity to critical resources. When other resources located apart from the residence area are needed, specialized labor units may be utilized in order to procure that specific resource. These logistically organized task groups "may leave a residential location and establish a field camp or a station from which food-procurement operations may be planned and executed" (Binford 1980:10). Environments which encourage a logistical collector mode of adaptation tend to be temperate or boreal zones. Great spatial or temporal incongruity in resources encourages low residential mobility and high logistical task mobility (Binford 1980:14-15).

Field camps are temporary residences from which a logistical labor group lives and operates in the course of completing its subsistence task. Stations are locations where members of task groups can gather resource information, such as game-observation look-outs. Resources procured during these task-group outings are either brought back to the residential base or temporarily stored, either frozen or smoked, in a cache. In addition to the field camps, stations,
and caches described above, residential bases and resource extraction locations should be represented as specific site classes in the archaeological record. According to Binford’s model, “within each class we can expect further variability [in site composition] to relate to season and to the character of the resource targets of logistically organized task groups” (Binford 1980:12).

Binford’s model of forager/collector organization is not a presentation of polar opposites in subsistence-settlement adaptation. Instead, residential and logistical behaviors represent a continuum. They are to be viewed as “organizational alternatives which may be employed in varying mixes in different settings” (Binford 1980:19). While the population being studied by this paper is unknown, there are some indications that the environment of 15,000 years ago would have encouraged a subsistence-settlement organization towards the logistical collector end of the scale. The spatial patchiness of resources such as terrestrial game or chert outcrops, and the temporal inconsistencies of seasonal resources, such as nuts and berries, salmon runs, migrating sea and terrestrial mammals, and migrating birds, would lead to increased logistical behavior. In addition, climatic conditions are considered to have been relatively cool on the Oregon coast during the late Pleistocene, thus discouraging general foraging behavior.

Based on his own historic, ethnographic, and archaeological investigations, Draper (1988) contends that a logistic model of settlement patterns is most applicable to the prehistoric populations of the southern Oregon coast. Features of Draper’s model for prehistoric subsistence and settlement activities include: 1) high population densities, 2) a linear rather than radial or planar settlement pattern, 3) low residential mobility, and 4) repeated occupation and multiple function use of highly resource-productive areas on the landscape. Resources utilized would include those located in marine, estuarine, and inland habitats, with exploitation centered on those resources located near ecotone edges (Draper 1988:276).

Following Binford (1980), Draper argues that early coastal peoples would have been logistic collectors, producing two types of archaeological sites: residential bases (villages) and special purpose sites (field camps, locations for resource extraction, caches, stations) (Draper
1988:283-7). Village locations, according to Draper (1988:282), would be determined by access to water, proximity to resources, protection from the natural elements, and space available. Field camps are determined by similar factors as villages, but because they are often task specific, they may be located close to specific resources (Draper 1988:283). Resource extraction locations will be positioned in relation to the resources being exploited, as will caches when they serve as temporary holding areas until transport back to the village occurs (Draper 1988:284-5). Stations will be located at vantage points, such as coastal bluffs or inland ridge tops lacking fresh water sources, in order to gather information such as large game locations (Draper 1988:286).

As with the ethnographic section above, the theoretical section does not provide a concrete answer to the problem of recreating a culture that existed 15,000 years ago. It does, however, provide some clues as to what type of resources might have been utilized by coastal groups in the past and the locations of occupation in relation to these resources. As was discussed above, recent arguments concerning early coastal adaptation have centered on terminology and are based on a very small number of early archaeological sites. Instead of assuming a resource-use focus on one area of the coast or another, this researcher has argued for a generalized coastal adaptation, with marine, littoral, estuarine, riverine, and terrestrial resources all being utilized.

If a generalized use of coastal resources is assumed, then theoretical arguments concerning the exploitation of these coastal and near-coast resources can be used to provide locational clues for modeling. For example, Yesner (1980) argues that coastal hunter-gatherers occupy areas on complex coastlines, near streams or lakes, near upwelling zones, on strandflats, and near boat-beaching locations. Ames and Maschner’s (1999) discussion of coastal archaeological signatures implies the use the following landscape features in relation to a coastal adaptation: the use of near-shore rocks for off-shore, sea-mammal hunting; occupation of littoral zones, such as complex coastlines or strandflats, in relation to shellfish procurement; and occupation of lakeshores, locations near streams, or areas near ecotone boundaries in order to exploit inland coastal resources. Minor’s (1997) work emphasizes the use of estuaries by early
coastal peoples. Draper (1988) argues that early humans would have occupied protected areas with access to fresh water and in close proximity to resources, or areas which represent vantage points at which information can be gathered.

Each of the landscape features highlighted by these works has been discussed in modeling terms in the ethnographic section above except for strandflat locations and vantage points. Strandflats, wave-cut platforms which support shellfish and other invertebrates and line the coast and estuary mouths (Yesner 1980; Bates and Jackson 1984), are a landscape feature which can be included in the model as an independent variable. Additionally, coastal bluffs, which would have been optimal locations for viewing the coastal plain and gathering information, can be digitally included in the modeling process as an independent variable.

As argued above, early coastal populations' spatial organization on the landscape may have been that of logistic collectors. Although this organization scheme may not represent the precise organization of early coastal groups, it does provide a method of grouping resource use into specific, focused locations on the landscape. Logistic organization centers around areas used for residential bases, resource extraction locations, field camps, stations, and caches. These areas can be digitally modeled in terms of the features (independent variables) which would have influenced their placement on the landscape. A detailed description of this modeling process and the features included is discussed in Chapter Five: Model Building.

**Archaeology**

**Early Oregon Sites**

No late Pleistocene and only a handful of early Holocene archaeological sites have been found on the Oregon coast. Fortunately, new information regarding the antiquity of a few early
Holocene archaeological sites on the Oregon coast has recently become available. This information may provide important clues regarding the location of late Pleistocene sites in the area. Indian Sands, Blacklock Point, Tahkenitch Landing, and the Neptune locality are the earliest sites thus far dated on the Oregon coast, dating from around 6,900 to 8,600 yr BP, and each provides important details about early settlement practices and adaptation to the local environment (Figure 3). These details provide the correlatory information to be used in the production of the predictive locational model.

The site located at Indian Sands (35CU67) may represent “the earliest evidence of molluscan resource exploitation so far identified on the Oregon Coast” (Minor 1995:271), with dates of 7,790±70 yr BP (Beta-73004), 8,150±120 yr BP (Beta-66890), and 8,250±80 yr BP (Beta-66891) (Moss and Erlandson 1999:24). The Indian Sands site is located approximately 30 meters above present day sea level on a bluff overlooking the Pacific (Figure 4). Since sea levels were much lower around 15,000 years ago, Indian Sands’ position would have been on a topographic ecotone-boundary between the high bluffs of the raised marine terrace and the lower coastal plain which extended from the bluffs to the Pacific Ocean.

The archaeological assemblage at Indian Sands primarily consists of lithic artifacts, including fire-cracked rock, choppers, cores, hammers, cobble spall tools, and thousands of flakes. Diagnostic artifacts recovered from the site by amateur collectors primarily include leaf-shaped projectile points (Pullen 1982). Bedrock outcrops at the site are basaltic in nature, with some chert intrusions apparent (Figure 5). This implies that the site may have been a raw material source location. Artifacts are spread along the bluff edge for at least ½ mile and landward up to 200 meters.

The artifacts are found primarily atop a reddish-brown sand surface, possibly an old B horizon whose overlying A horizon has been deflated in most places. Some remnants of the undisturbed, complete soil profile do exist under areas of vegetation towards the back edge of the site. Further work at the site should focus on this relatively intact zone. In certain deflated zones
Figure 3. Location of early archaeological sites on or near the Pacific Coast of Oregon.
Figure 4. Indian Sands archaeological site (from USGS Carpenterville 7.5' Quadrangle). Scale 1:24000.
Figure 5. Chert inclusion in Otter Point Formation bedrock geological unit at Indian Sands.
on the bluff there are exposed spodosol layers overlain by thin, horizontally bedded layers of charcoal. This may be evidence of a forest-type environment extending to the edge of the headland in the past.

A small shell scatter was also discovered at the Indian Sands location, and dates derived from these burned and unburned mussel shells indicate an age of around 8,200 yr BP for the site (Moss and Erlandson 1995:115; Moss and Erlandson 1998:20). Questions regarding the site’s antiquity have focused on two primary issues. First, the radiocarbon dated shell was recovered from a deflated context. Therefore, the association between shell remains and lithic materials is not clear (Erlandson and Moss 1996:294; Lyman 1997). Second, there is no concrete proof that the burned state of the shells recovered was indeed caused by human action. Lyman (1997:266) states, “there is no established linkage between burning and human activity—the shell may have been burned by natural fires.”

However, Moss and Erlandson (1998:21) argue for the validity of the site’s antiquity and cultural association based on five factors: “(1) the localized and concentrated nature of the shell scatter; (2) its central location within a discrete cluster of stone tools and burned rock; (3) the lack of rounded shell fragments typical of raised beach deposits; (4) the presence of large barnacles, which are common in many Oregon coast shell middens, but extremely rare in noncultural biological deposits; and (5) the relatively high percentage of heavily burned shell, also common in Oregon coast shell middens of unequivocal cultural origin.”

Blacklock Point (35CU75) is considered the “type site” for bluff sites on the Oregon coast (Minor 1993). The vast lithic assemblage found at this site and its location on the edge of a coastal headland, see Figure 6, make it typical of the “bluff” type of site defined by Ross (1984). Cultural deposits at the location have been found within a distinctive dark, loamy soil referred to as Blacklock Sandy Loam. This soil is typically found atop the consolidated, undulating sands of the Pioneer Terrace (Minor 1993). Underlying the consolidated sand surface are uplifted beach cobbles, consisting primarily of fine and course grained basalt, serpentine, and chert, which may
Figure 6. Blacklock Point archaeological site (from USGS Cape Blanco and Floras Lake 7.5' Quadrangles). Scale 1:24000.
have been used as raw material for many of the lithic artifacts recovered at the site (Minor 1993: Sec.7.2). Diagnostic artifacts recovered from the site by amateur collectors include leaf-shaped, contracting stem, expanding stem, and broad stem projectile points (Pullen 1982). The earliest occupation of the site dates to 7,560 ± 80 yr BP (Beta 62391), based on charcoal recovered during a test-excavation conducted by Minor (1993).

Tahkenitch Landing (35DO130) represents a different sort of early occupation on the Oregon coast (Figure 7). Indian Sands and Blacklock Point are archaeological sites known for their lithic components and their locations on bluffs many meters above present sea level. In comparison, the Tahkenitch Landing site was discovered at the base of a small sandstone knob, only slightly elevated above present day Tahkenitch Lake, and the archaeological assemblage recovered from the site is extremely diverse (Minor and Toepel 1986).

The earliest occupational level at the site, a dark brown loamy sand deposit called Component I: Stratum 4A, has provided radiocarbon dates of 7,960 ± 90 yr BP (Beta-14870) and 6,880 ± 80 yr BP (Beta-11202), as reported in Minor and Toepel (1986:39). Geomorphological reconstruction of the area (McDowell 1986) indicates that sometime before 3,000 yr BP, the site would have sat next to a small, river-fed estuary directly open to the sea, which lay more than a kilometer away. As sea level rose to near present-day levels, windblown sand accumulated in the area, damming off the estuary and eventually creating freshwater Tahkenitch Lake. However, at the time of occupation, Tahkenitch Landing would have been located next to the estuary on the boundary between the former coastal plain and the bedrock uplands. This ecotone boundary position “may have afforded some advantages to prehistoric occupants in terms of access to a variety of hunting and foraging environments” (McDowell 1986:102).

Lithic artifacts recovered from this level include one scraper, one graver, three hammers, one chopper, and one sandstone abrader (Minor and Toepel 1986:104). One land mammal bone, one pinniped bone, as well as the remains of marine fish (n = 628) and birds (n = 251), were
Figure 7. Tahkenitch Landing archaeological site (from USGS Tahkenitch Creek 7.5' Quadrangle). Scale 1:24000.
recovered from Component I (Minor 1995:270). Identification of sculpin, tomcod, hake, and flatfish remains among the faunal assemblage indicates fishing in an estuarine environment (Aikens 1993:147). In addition to terrestrial and estuarine based economic practices, open ocean subsistence activities may have been practiced: "The considerable representation of hake in the assemblage could be taken to suggest, however, that people may have fished to some extent in the open ocean as well; hake rarely enter estuarine environments, more commonly schooling near the ocean bottom" (Aikens 1993:149).

Located on a high consolidated Quaternary dune surface near the bank of Gwynn Creek in central Oregon is 35LA3, the Neptune site (Figure 8) (Barner 1982; Zontek 1983). Reports of late Holocene house pits and midden deposits originally drew Oregon State University excavators to the site in 1973 (Lyman and Ross 1988; Minor 1986), but it is the dark, organic layer below the midden deposits that is of interest to this predictive modeling project. From this lower stratum came lithic flakes, non-diagnostic artifacts, and charcoal that produced a date of 8,310±110 yr BP (WSU-1644) (Lyman and Ross 1988:98). Unfortunately, a full report for the site has not been published. Because of this, questions regarding the validity of the radiocarbon date and the nature of the association between the charcoal and cultural materials have been posed (Minor 1995). Response to such challenges indicate the date was indeed valid (Lyman 1997:264) and that the dated charcoal and cultural materials were collected from the same stratigraphic layer (Lyman 1997:265).

Although not on the coast, the Marial site (35CU84) also may provide useful data for this predictive modeling project (Schreindorfer 1987). Located near the confluence of Mule Creek and the upper Rogue River in Curry County (Figure 9), the site lies on an ancient river terrace approximately 400 feet above sea level on "one of the few habitable areas in an otherwise steep, narrow river canyon environment" (Schreindorfer 1987:85). A date of 8,560±190 yr BP was procured from materials located directly below the lowest level at the site, component 6.
Figure 8. Neptune archaeological site (from USGS Yachats and Heceta Head 7.5' Quadrangles). Scale 1:24000.
Figure 9. Marial archaeological site (from USGS Marial 7.5' Quadrangle). Scale 1:24000.
Recovered from this level were a number of leaf-shaped projectile points similar in style to those recovered from some lithic, or "bluff", sites on the Oregon coast, such as Blacklock Point (Schreindorfer 1987:85). This similarity in point styles is especially interesting considering the new radiocarbon dates for Blacklock Point and Indian Sands, which fall into the same time-frame as the Marial site date. In terms of inland adaptation, this site has good potential for informing us of what type of landform might have been occupied by peoples utilizing riverine resources: Quaternary fluvial terraces near confluence locations.

In addition to the more well-documented sites discussed above, there have been isolated Clovis projectile point finds documented on the coast, as well (see Figure 3 for site locations). A Clovis point base was found on the surface near Siltcoos Lake (Aikens 1993), but additional documentation regarding this find is unavailable. On the Winchuck River in southern Oregon, a single point base identified as Clovis was discovered during test investigations (Hemphill 1990; Fagan 1990). No additional artifacts typical of Clovis technology were found at the site during testing or during the subsequent data recovery project conducted in 1991. Although it is possible that occupation at the Winchuck site (35CU176) dates as far back as Clovis times (~11,500 yr BP in central, southern, and southwestern United States), some investigators have suggested otherwise. They argue that the point base was perhaps brought to the site later, as a type of heirloom, or that the artifact has been misidentified due to its fragmentary nature, implying that the site is not as old as the point base would initially indicate (Flenniken et al. 1992:81).

Other Early Coastal Sites

Coastal archaeological sites in other areas on the west coast of North America may provide important information regarding early adaptation to marine and littoral landscapes.
A few archaeological sites have been discovered in coastal areas of California dating to the late Pleistocene/early Holocene. From the limited sample available, Jones (1991) argues that settlement occurred primarily in estuarine environments in northern California, while in southern California populations occupied semiprotected rocky coasts and islands in addition to estuaries.

The earliest excavated evidence for occupation on the coast of California comes from the northern Channel Islands. Daisy Cave on San Miguel Island has produced dates ranging from 10,180±70 to 10,390±130 yr BP (Erlandson 1993; Erlandson and Moss 1996). Daisy Cave is located across the Santa Barbara Channel from the California mainland, and sea-worthy boats would have been required to reach the island even during the last glacial maximum when sea levels were at their lowest. Identified faunal remains from the site include red abalone, mussel, turban, chiton, and crab (Erlandson 1993). Lithic materials recovered from the oldest securely dated level at the site are non-diagnostic chert and siliceous shale artifacts (Erlandson and Moss 1996). Both its location and the site’s faunal assemblage imply that a maritime adaptation was employed by the site’s residents.

At Arlington Springs on Santa Rosa Island, Orr (1962, 1968) discovered human remains in stratified arroyo fill deposits 11 meters below the surface. Original testing of associated charcoal, charcoal bearing soil, and bone collagen produced dates of ~10,000 yr BP (Olson and Broecker 1961). Redating of the human bone material using AMS methods resulted in very divergent ages, ranging from 6,610 ± 60 to 10,960 ± 80 yr BP (Johnson et al. 2000:543). Recent radiocarbon dating of charcoal and deer mouse remains associated with the human bone resulted in dates of 10,090 ± 70 yr BP and 11,490 ± 70 yr BP, respectively (Johnson et al. 2000:544). Based on these new dates, Johnson et al. (2000:544) are uncertain as to whether the human bone material and the associated charcoal and deer mouse remains were deposited into the arroyo at the same time.
Figure 10. Early North American coastal archaeological site locations discussed in the text.
Also located on Santa Rosa Island is the site known as CA-SRI-6, which dates to 8,360±80 yr BP (Erlandson et al. 1999). The lowest level of this deeply buried, stratified shell midden contains non-diagnostic lithic artifacts associated with numerous shellfish and vertebrate remains and a small botanical assemblage. Dietary reconstruction indicates shellfish was the primary source of meat for residents of the site, providing 85% of the estimated yield, with fish, birds, and sea mammals providing the remaining 15% meat yield (Erlandson et al. 1999:261). Researchers at the site suggest that this reliance on shellfish and fish for sustenance indicates a coastal adaptation: "the earliest occupants collected shellfish and fished in rocky littoral and nearshore habitats" (Erlandson et al. 1999:262).

However, settlement patterns on the island may have also been influenced by the dietary importance of terrestrial plant foods. Based on the location of this and other Santa Rosa Island shell midden sites proximal to the landward edge of the former coastal plain, a distance away from the early Holocene oceanic shoreline, researchers argue, "the earliest occupants of CA-SRI-6 may have settled near the base of foothills where plant foods and perhaps fresh water were more readily available" (Erlandson et al. 1999:261-62). This idea is important in the consideration of late Pleistocene/early Holocene archaeological site locations and preservation; if sites were located a distance from former shorelines, at the base of or atop bluffs overlooking the coastal plain, for example, then these sites may have escaped inundation and destruction from post-glacial sea-level rise. Early coastal bluff sites in Oregon like Indian Sands or Blacklock Point may represent such an occupational pattern.

A number of other shell midden sites dating to between 10,000 and 9,000 years ago have been located on the Californian coastal mainland. These sites include CA-SBA-931 near the mouth of the Santa Ynez River (Glassow 1991), CA-SLO-2 in San Luis Obispo County (Greenwood 1972), and CA-SDI-210 at Agua Hedionda Lagoon near San Diego (Moriarty 1967). Although no diagnostic artifacts have been reported at these sites (Erlandson and Moss 1996), faunal remains at the sites indicate a reliance on coastal resources, especially shellfish. By 8,000
years ago, a culture dependent upon shellfish as a primary source of protein appears to be well established on the California coast, as is indicated by the presence of at least 40 coastal sites dating to this time period (Erlandson and Moss 1996:289).

In Washington, evidence for early coastal occupation is scarce. Isolated fluted point finds have been reported on Whidbey Island and at Olympia, both on Puget Sound (Carlson 1990). Unfortunately, these were surface finds without contextual association. At the Manis site, located on the Strait of Juan de Fuca, bison bones and a partial mastodon skeleton were excavated from a depositional layer dating to between 12,000 and 11,000 yr BP (Carlson 1990:61; Gustafson and Manis 1984). Evidence of human interaction with the faunal remains is in two forms: a bone fragment embedded in the rib of the mastodon, and polishing and striations observed on other bones. However, some researchers argue that these forms of evidence are not conclusive proof of human presence (Carlson 1990).

The coast of British Columbia has produced a number of sites with evidence of early maritime adaptation. One of the most well known sites is Namu, located near the junction of Burke Channel and Fitzhugh Sound on the central British Columbia coast (Cannon 1991; Carlson 1979, 1991). The earliest assemblage excavated at the site, represented by Period 1A, is dated to as early as 9,720±140 yr BP (Cannon 1991; Carlson 1979, 1991). However, based on geological evidence, Carlson has argued that occupation at the site may date to an even earlier time period (Carlson 1996: 97). Although it is unknown if the lithics recovered from the Period 1A level, including macrolith artifacts such as a lanceolate quartzite projectile point, represent terrestrial or maritime adaptation, a broad-based marine economy is in place at the site by 6,000 yr BP (Cannon 1996:103).

Exploitation of a paleo-estuarine setting is implied by the archaeological assemblage recovered from the Arrow Creek 2 site. One diagnostic artifact was recovered—a microblade core manufactured from agate. Dates taken on barnacle remains attached to an artifact indicate the site was occupied as early as 9,300 yr BP and inundated by rising sea levels by about 9,000 yr BP.
Approximately 200 meters upstream of Arrow Creek 2 is Arrow Creek 1. Located on a raised marine terrace, the site consists primarily of lithic artifacts, such as microlith cores and microblade-like flakes, and was occupied from 8,200 ± 80 to 5,650 ± 70 yr BP. There have been no faunal remains recovered from the site, probably due to the highly acidic forest soils within which the site is situated (Fedje et al. 1996).

Numerous intertidal lithic sites have been recorded in the Lyell Island area, Queen Charlotte Islands. These sites include the Richardson Island, Echo Bay, Hoya Passage, and Lyell Bay sites, all dating to between 9,400 and 9,000 yr BP (Fedje et al. 1996). Contexts of these sites are often disturbed, but based on their locations and the resources that would have been available, researchers argue that the inhabitants of the sites would have been maritime adapted and would have used watercraft in the process of resource procurement (Fedje et al. 1996). Artifacts found at these sites include bifaces, microblades, microblade cores, and pebble tools (Fedje et al. 1996; Fladmark 1990).

A number of early sites have been located on the coast of Alaska. The Ground Hog Bay 2 site near Juneau, Alaska may date to as early as 10,180 ± 800 yr BP (Ackerman 1996; Ackerman et al. 1979), although a date of 9130 ± 130 is considered more accurate by some researchers (Dixon et al. 1997:690). Located on a glacio-marine terrace 18 meters above mean sea level, this microblade site would have been situated on an ancient beach along the edge of an embayment on the northern side of Icy Strait. The site would have been protected from heavy ocean action by an offshore reef and headlands to the northwest and southeast.

The Hidden Falls site rests within a cirque in the lower end of a hanging, glacier-formed valley on Baranof Island, one of the islands of the Alexander Archipelago (Davis 1996). Dated to ca. 10,000 yr BP, the site is located at the head of Kasnyku Bay, next to Hidden Falls Lake and Waterfall. Few faunal remains were recovered from the site, but both fish and shellfish remains were identified in association with a microblade-type assemblage. Environmental context at both
the Ground Hog Bay site and Hidden Falls implies a maritime adaptation in operation (Fedje and Christensen 1999:639). In addition, the island location of the Hidden Falls site “indicates boat travel and an economy oriented to coastal environments” (Moss 1998:92).

Recent work at the On Your Knees Cave site on Prince of Wales Island, Alaska has produced the oldest human remains yet recovered in Alaska (Dixon et al. 1997). A mandible of an adult male, three human vertebra, and a partial right pelvis were found about 10 meters from the entrance of the cave and may all be from the same individual. Dates from the mandible and pelvis are 9,730 ± 60 yr BP and 9,880 ± 50 yr BP. The only artifact recovered in association with the human remains was a piece of modified mammal bone, which displayed similar staining and preservation qualities to the human bone. Although the cave is located approximately 135 meters above modern sea level, the C-13 values for the human remains indicate a subsistence based primarily on marine resources (Dixon et al. 1997).

One of the oldest shell-bearing components on the northwest coast is found at the Chuck Lake site on Heceta Island in the Prince of Wales Archipelago (Ackerman et al. 1985). Test excavations at the site produced a microblade assemblage and fauna “characteristic of a well-developed maritime adaptation” (Fedje and Christensen 1999:639). Subsistence resources recovered include predominant numbers of shellfish and bottom and rock fish, with marine and terrestrial mammals and water fowl constituting only a small portion of the recovered assemblage (Dixon 1997: 691). Occupation at the site dates to 8,200 yr BP (Ackerman et al. 1985). At this time, what is now Chuck Lake was probably the upper end of an estuary system (Moss 1998:92).

Obsidian sourcing conducted on artifacts from early Alaskan sites such as Ground Hog Bay 2, Hidden Falls, and Chuck Lake indicates travel to and/or trade with regions hundreds of kilometers away (Dixon et al. 1997:693; Moss 1998:102). Moss (1998:102) argues that this exotic lithic procurement represents the strongest evidence for maritime activity in the area: “Considering the region’s geography and topography, such long-distance travel (and/or trade) would have been feasible only via marine routes.”
The Anangula Core and Blade site is located on Ananiuliak Island, one of the westernmost Aleutian Islands off the southwest coast of Alaska. It is argued that the earliest occupation on the island dates to between 8,250 and 8,750 yr BP (Aigner and DelBene 1982). Thousands of lithic artifacts were recovered from the site in addition to large quantities of bird and whale bones (Ainger 1976). The location and geology of the site, as well as the faunal assemblage recovered there, has led Black (1974) to conclude that boats were necessarily used to reach the islands and McCartney and Veltre (1996:448) to state that “a maritime economy would have been the only option available for the Anangula peoples.”

An assumption of this project is that evidence to be found on the Oregon coast was deposited in the course of a coastal migration along the Pacific Rim. Therefore, examination of archaeological records from areas where peoples may have migrated from may also be useful in the formation of a predictive locational model. Unfortunately, there are no archaeological sites that have produced unequivocal evidence for late Pleistocene coastal adaptations in the Soviet Far East. However, it has been suggested that the early maritime adaptations in western Beringia may have developed from riverine economies in the area (Ackerman 1996:124). The Ushki 1 site represents the remains of such an economy.

At the Ushki 1 site, on the Kamchatka Peninsula, numerous lithic artifacts were found in association with 11 dwelling structures and one human burial pit (Dikov 1996; Goebel and Slobodin 1999). Located on the Great Ushki Lake, a cut-off meander of the Kamchatka River, the lowest occupation horizons at the site date from 14,300 to 13,600 yr BP. Later components at the site date to around 10,360 yr BP. Although only small pieces of bone were recovered from the earliest occupation components, later components produced large numbers of fish bones (Dikov 1996:245), indicating a riverine adaptation.

Although there are no known archaeological sites on western coast of North America that date to 15,000 years ago, archaeological sites up to 8,500 years old have been found on the Oregon coast and up to 12,000 years old on other areas of the North American Pacific coast (see
Table 2). Information from these sites provides clues as to what landscape features may have influenced occupation location decisions in the past.

For example, the importance of being located in close proximity to complex coastlines such as bays or estuaries is implied by archaeological sites such as Tahkenitch Landing, Manis, Namu, Arrow Creek 1 and 2, Ground Hog Bay 2, Chuck Lake, and various California sites mentioned by Jones (1991). A number of archaeological sites have been discovered either along coastal lakeshores or at the mouths of streams, reflecting the importance of these features to ancient humans. These sites include Neptune, Marial, the California mainland coastal sites, Hidden Falls, and Ushki Lake. Because of the resources associated with nearshore rocks, islands, and reefs, archaeological sites such as Daisy Cave, Arlington Springs, CA-SRI-61, the Queen Charlotte Island sites, Ground Hog Bay 2, Hidden Falls, Chuck Lake, and Anangula are located on or in close proximity to these features. Evidence from sites such as Indian Sands, Blacklock Point, Tahkenitch Landing, Marial, and Ushki Lake supports the concept that inland stream terraces and ecotone boundaries would have been important considerations in prehistoric landscape occupation choices due to resources proximal to such features. The On Your Knees Cave archaeological site in Alaska is an example of cave or rockshelter landscape feature use. Coastal bluff locations, such as Blacklock Point or Indian Sands, may have been utilized as observation stations in the past. These locations also represent source locations for lithic raw materials, another landscape feature which would have been important for late Pleistocene peoples in terms of resource procurment.

As was the case with the landscape features highlighted in the ethnographic and theoretical section of this chapter, each of the landscape features emphasized in the archaeological section can be digitally modeled and incorporated into modeling procedures as independent variables. Additionally, these variables can be organized and weighted according to how they would have influenced the location of specific site types, such as residential bases,
resource extraction locations, field camps, stations, or caches. A more detailed description of this process follows in Chapter Five: Model Building.
Table 2. Early Coastal Archaeological Sites.

<table>
<thead>
<tr>
<th>Archaeological Site</th>
<th>Location (see Figures 3 and 10)</th>
<th>Diagnostic Artifacts</th>
<th>Radiocarbon Ages (yr BP)</th>
<th>Primary References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Oregon</td>
<td>Coast</td>
<td>leaf-shaped projectile points</td>
<td>7790±70, 8,150±120, 8,250±80</td>
<td>Moss and Erlandson (1995, 1998, 1999); Pullen 1982</td>
</tr>
<tr>
<td>Indian Sands</td>
<td></td>
<td>leaf-shaped, contracting stem, expanding stem, and broad stem projectile points</td>
<td>7,560±80</td>
<td>Minor (1993); Pullen (1982)</td>
</tr>
<tr>
<td>Blacklock Point</td>
<td>Southern Oregon Coast</td>
<td>none</td>
<td>7,960±90, 6,880±80</td>
<td>Minor (1995); Minor and Toepel (1986)</td>
</tr>
<tr>
<td>Tahkenitch Landing</td>
<td>Central Oregon Coast</td>
<td>none</td>
<td>8,310±110</td>
<td>Zontek (1983); Berner (1982); Lyman and Ross (1988)</td>
</tr>
<tr>
<td>Neptune</td>
<td>Central Oregon Coast</td>
<td>none</td>
<td>8,560±190</td>
<td>Schreindorfer (1987)</td>
</tr>
<tr>
<td>Marial</td>
<td>Southern Oregon Coastal interior</td>
<td>leaf-shaped projectile points</td>
<td>dates range from 10,180±70 to 10,390±130</td>
<td>Erlandson (1993); Erlandson and Moss (1996)</td>
</tr>
<tr>
<td>Daisy Cave</td>
<td>San Miguel Island, Southern California Coast</td>
<td>none</td>
<td>dates range from 6,610±60 to 11,490±70</td>
<td>Orr (1962, 1968); Johnson et al. (2000)</td>
</tr>
<tr>
<td>Arlington Springs</td>
<td>Santa Rosa Island, off the Southern California Coast</td>
<td>none</td>
<td>8,360±80</td>
<td>Erlandson et al. (1999)</td>
</tr>
<tr>
<td>CA-SRI-6</td>
<td>Santa Rosa Island, off the Southern California Coast</td>
<td>none</td>
<td>12,000?</td>
<td>Gustafson and Manis (1984); Carlson (1990)</td>
</tr>
<tr>
<td>California Coast Shell Midden Sites (CA-SBA-93, CA-SLO-2, and CA-SDI-210)</td>
<td>Southern California Coast</td>
<td>None</td>
<td>between 10,000 and 9,000</td>
<td>Moriarty (1967); Greenwood (1972); Glassow (1991); Erlandson and Moss (1996)</td>
</tr>
<tr>
<td>Strait of Juan de Fuca</td>
<td>British Columbia Coast</td>
<td>none</td>
<td>9,720±140</td>
<td>Cannon (1991); Carlson (1979, 1991)</td>
</tr>
<tr>
<td>Namu</td>
<td>British Columbia Coast</td>
<td>macroliths, including a lanceolate quartzite projectile point</td>
<td>9,300</td>
<td>Fedje et al (1996); Fedje and Josenhans (2000)</td>
</tr>
<tr>
<td>Arrow Creek Two</td>
<td>British Columbia Coast</td>
<td>microblade core</td>
<td>8,300 to 11,490</td>
<td>Fedje et al (1996)</td>
</tr>
<tr>
<td>Arrow Creek One</td>
<td>British Columbia Coast</td>
<td>microlith cores and microblade-like flakes</td>
<td>5,650±70</td>
<td>Fedje et al (1996)</td>
</tr>
<tr>
<td>British Columbia Intertidal Lithic Sites</td>
<td>Queen Charlotte Islands off the British Columbia Coast</td>
<td>Pebble tools</td>
<td>9,400 to 9,000</td>
<td>Fladmark (1990)</td>
</tr>
</tbody>
</table>
Table 2, Continued.

<table>
<thead>
<tr>
<th>Archaeological Site</th>
<th>Location (see Figures 3 and 10)</th>
<th>Diagnostic Artifacts</th>
<th>Radiocarbon Ages (yr BP)</th>
<th>Primary References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Hog Bay 2</td>
<td>Icy Straits off the Alaska Coast</td>
<td>microlith assemblage</td>
<td>as early as 10,180+-800</td>
<td>Ackerman (1996); Dixon et al. (1997)</td>
</tr>
<tr>
<td></td>
<td>Alexander Archipelago off the Alaska Coast</td>
<td>microlith assemblage</td>
<td>ca. 10,000</td>
<td>Davis (1996); Fedje and Christensen (1999)</td>
</tr>
<tr>
<td>Hidden Falls</td>
<td>Alaska Coast</td>
<td>microlith assemblage</td>
<td>10,180+-800</td>
<td>Ackerman (1996); Dixon et al. (1997)</td>
</tr>
<tr>
<td>Prince of Wales</td>
<td>On-Your-Knees-Cave Coast</td>
<td>mammal bone tool</td>
<td>9,730+-60</td>
<td>Dixon et al. (1997)</td>
</tr>
<tr>
<td>Chuck Lake</td>
<td>Prince of Wales Island off the Alaska Coast</td>
<td>microlith assemblage</td>
<td>-8,200</td>
<td>Ackerman et al. (1985); Dixon (1997)</td>
</tr>
<tr>
<td>Anangula</td>
<td>Aleutian Islands off the Alaska Coast</td>
<td>unifacial blades and cores</td>
<td>between 8,250 and 8,750</td>
<td>Aigner and DelBene (1982); Ainger (1976)</td>
</tr>
<tr>
<td>Ushki 1</td>
<td>Kamchatka Peninsula, Siberia</td>
<td>none</td>
<td>between 14,300 to 13,600</td>
<td>Dikov (1996); Goebel and Slobodin (1999)</td>
</tr>
</tbody>
</table>
CHAPTER 5. MODEL BUILDING

The systemic context in archaeological terms is the active context within which human behavioral systems operate and deposit materials. These materials, in turn, become the archaeological record. Human decision making processes are an integral part of human behavior: "regularities in choice making are seen as the fundamental process underlying the regularities of human behavior, and thus, much of archaeological patterning" (Limp and Carr 1985:129).

Anthropological theories concerning the process of human decision making historically have come from economic geography or marginalist economic concepts. On one end of the decision scale, some anthropologists have advocated a view of the decision process that assumes a nearly omnipotent, completely rational decision-maker (see von Newman and Morgenstern 1947). In this maximizing approach, decisions are based upon detailed measurable knowledge of variable choices, including their long-term and short-term costs and benefits, and a desire to maximize the preferability of the choices made. The opposite of this maximizing approach is the satisficer perspective on decision making (e.g. Jochim 1976; Simon 1959). This perspective is based on the argument that rather than weighing all alternatives in a situation, humans will instead make decisions based upon the first acceptable alternative encountered (Limp and Carr 1985:145). This theory stresses the basic human instinct to satisfy a need as opposed to action which maximizes among need-fulfilling choices.

Limp and Carr (1985) propose a theory which spans the continuum of theoretical approaches, including the maximizer and satisficer concepts. This approach to decision making, originally proposed by Arrow (1951), is the generalized theory of rational choice. The basic premise of this theory is that individuals or groups operating within an environment divide possible courses of action into sets. These courses of action may be in reference to any number of decision areas, but for this predictive modeling task choices made regarding landscape occupation
is the decision area of interest. This group of alternatives for action, the global choice set, is then partitioned into those choice sets which are considered attainable versus those that are not.

For example, when considering a location for occupation, a group of shellfish collectors will consider a large number of locations on the landscape as possible for settlement. These locations, the global choice set, are then considered in terms of their attainability. A location on a headland may overlook a shellfish bed on an offshore rock, but unless there is access by foot to the shellfish the location is not desirable and therefore unattainable. However, attainability is alterable. If new technology is added to the situation, like a watercraft which would provide access to offshore resources, then the location becomes an attainable choice set.

It is important to note that the actual mind-set of prehistoric choice-makers is not reproducible. The generalized theory of rational choice allows for the categorization of possible choices and the reasoning behind those choices, but many other factors may have been taken into account in the systemic context: "subtle social determinants of location are probably at work in all settlement systems, and the inability to take such factors into account is one sense in which predictive models are a simplification of reality" (Kohler and Parker 1986:401). This simplification of reality allows for the model to be built and operationalized, a necessary step in the predictive modeling process.

Once the global choice set has been divided into attainable and unattainable sets, the attainable sets are ordered according to their preferability. An example of preference ordering would be if the group of attainable location sets in the example above were partitioned into three subsets, based on their proximity to shellfish resources. These subsets, $X_1$ (0-500 m), $X_2$ (500-1000 m), and $X_3$ (>1000 m), could then be ordered, with the closest to the shellfish resources being the most preferred. The mathematical expression of this ordering can be stated as the following:

$$X_1 \text{ P } X_2 \text{ and } X_2 \text{ P } X_3 \therefore X_1 \text{ P } X_3,$$

where P = is preferred to
In this case, the closest subset $X_1$ is preferred over the farther subset, $X_2$. Also, because the second subset is preferred over the third, the concept of transitivity dictates that the first subset should be preferred over the third.

The ordering of partitioned subsets is based not on the physical properties of features, but by the conditional preference aspects of these physical properties: “A conditional preference aspect is a relevant choice-making characteristic of some physical property of an item” (Limp and Carr 1985:134). Following Limp and Carr (1985:134-135) an example of the conditional preference aspects of a physical property of an environmental feature might be the following:

<table>
<thead>
<tr>
<th>Physical Property:</th>
<th>Potential Conditional Preference Aspects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to</td>
<td>1. Access to potable water</td>
</tr>
<tr>
<td>permanent stream</td>
<td>2. Access to transportation</td>
</tr>
<tr>
<td></td>
<td>3. Access to aquatic food resources</td>
</tr>
</tbody>
</table>

In sum, the physical property of the environmental feature being ordered is a proxy variable for what that feature represents in the systemic, human behavioral context. It is a simplification of reality. The proxy variable is used rather than the conditional preference aspect because it is a quantifiable, reproducible variable which is able to be placed in an algorithm and operationalized. This is extremely important in terms of locational predictive modeling, as one of the main premises of deductive modeling is operationalism.

The degree to which any physical property of an environmental feature may be partitioned is dependent on two items: the measurability of the conditional preference aspects of a set of features and the information available for examination by the choice maker. The conditional preference aspects of a feature may be broken down into minute measurable increments; however, the ability of the decision maker to process these increments may not be at the same scale. A maximizer may argue that any number of partitions can be, and would have been, processed by humans. A satisficer might claim that a set of a feature’s conditional
preference aspects can be processed only to a minimal degree, such as a division into satisfactory versus unsatisfactory. The general choice theory does not require that a specified amount of partitioning occur. Instead, it is only necessary that each option be capable of being placed within a set and subsequently ordered:

“These sets could simply be ‘good,’ ‘better,’ and ‘best’ locations. All locations would have to be classifiable, but only into a subset, no further ordering would be necessary. There might be ten locations in the ‘best’ subset, which are, in fact, different, but among which the difference are such that the chooser is indifferent” (Limp and Carr 1985:139, italics original).

In the case of most prehistoric societies, detailed quantitative analysis and measurement of each conditional preference aspect of each pertinent physical environmental feature in each locational unit on a landscape would have been nearly impossible. Therefore, in most cases, partitioning would not have occurred at a level of extreme detail. This highlights one of the most attractive features of the generalized theory of rational choice – it is applicable to a variety of research problems. The generalized theory of rational choice “allows for variation in the number of conditional preference aspects and the complexity of their interrelationships which a person considers, and in the number of preference sets which a person recognizes” (Limp and Carr 1985:148).

More than just one environmental feature would have been considered important to prehistoric peoples when making choices regarding occupation locations on the landscape. Therefore, multiple sets of conditional preference aspects must have been evaluated, either simultaneously or sequentially, by the decision makers. In terms of methodology, analysis of the decision making processes of prehistoric people, within the scope of the generalized theory of rational choice, can be accomplished with the use of modeling techniques such as additive or hierarchical choice approaches.
For a sequential consideration of locational features' conditional preference aspects, modeling may be accomplished using a hierarchical decision rule approach. This approach assumes that decision makers consider their choices separately or sequentially rather than simultaneously. Using this model, if one aspect subset at a location is considered unacceptable, the whole location is considered unacceptable, regardless of whether other conditional preference aspect subsets are deemed acceptable or not. The mathematical expression of this model is as follows:

\[ \text{location choice } y (1: \text{accept}, 0: \text{reject}) = X_1 \cdot X_2 \cdot \ldots \cdot X_n \]

Limp and Carr (1985:157) suggest that a simultaneous decision making process be modeled using an additive linear regression equation (\( \text{location choice } y = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n \)). This method assumes that a number of conditional preference aspects were evaluated simultaneously by prehistoric decision makers in order to make the optimal choice. Additionally, this model operates under the assumption that different environmental variables, or the conditional preference aspects which they represent, had varying amounts of influence on the locational choices of prehistoric peoples.

This method of analysis is similar to the weighted value method proposed by Dalla Bona (2000:76) where each set of independent environmental variables is given different weights (\( W \)) in an additive equation, according to their amount of influence on land-use choices and how they would contribute to the potential for a location to contain an archaeological site. Additionally, each variable set can be broken down into subsets with each variable in the subset given a different value (\( V \)), again depending on its influence of prehistoric land-use choices and archaeological site potential. Each subset value (\( V \)) is then multiplied by the variable set weight (\( W \)) to calculate a weighted-value for each independent variable. Finally, for each area on the landscape being analyzed (dependent variable \( y \)) all weighted values for variables affecting land-
use decisions and archaeological site potential are added together to give the location a relative potential value for containing an archaeological site. Mathematically, this equation is written:

\[ \text{location } y = \text{independent variable}_1 (V*W) + \text{independent variable}_2 (V*W) + \ldots + \text{independent variable}_n (V*W) \]

Weights are assigned by the researcher and are necessarily subjective in nature. However, information gleaned from ethnographic, theoretical and archaeological data pertaining to the area being studied aids in the process of assigning weights. Also, as more information regarding the abilities and limitations of the model is discovered, refinement of the model can occur.

The decision of which approach to use for a particular modeling problem depends on the assumptions the researcher makes regarding the amount of processing practiced by a population. For a locational model which bases its predictions on generalized subsistence and settlement theory, the hierarchical decision rule approach may be better. The additive model, then, would be best for when a specific, detailed, adaptation-based culture is being modeled.

For this study, two separate model types predicting the relationship between dependent and independent variables have been created. The first model type is more general in nature. It breaks down the project area into tracts of land with the greatest potential for containing archaeological remains of the proper antiquity based on 1) generalized concepts of basic human needs and 2) depositional and post-depositional processes which affect the archaeological record. The decision making mechanism for this model is the generalized theory of rational choice. Because this model type is based on nonspecific theory and simply aims to narrow the scope of the project corridor to a more surveyable size, the hierarchical decision rule approach will be the mode of operationalization.

The second type of model is considerably more specific, with emphasis placed on particular types of land use by a coastally adapted population as outlined by the environmental, ethnographic, theoretical, and archaeological data discussed above. Again, the generalized theory
of rational choice is the assumed decision making mechanism. However, since this type of model is based on clearly delineated deductive data, the additive, or weighted-value, mode of operationalization is utilized to produce maps detailing relative probabilities for site potential on the landscape.

Model One

Production

This model type is general in nature, designed to locate areas with the highest probability of containing archaeological materials dating to the late Pleistocene and associated with a residential or settlement location. Environmental factors deemed important for site placement as a result of other predictive model studies include: slope, aspect, soil type, distance to lithic source, and distance to water (Altschul 1990; Carmichael 1990; Church et al. 2000; Dalla Bona 1996, 2000; Kvamme 1992, 1985; Warren 1990). For this particular generalized modeling exercise, only three of these variables are used to narrow the scope of the project corridor: distance to water, aspect and slope. These variables represent the most basic of landscape features essential to a comfortable habitation site: access to fresh water, solar heat, and a relatively flat tract of land for a camp site.

Each of these physical landscape variables is a proxy indicator for some feature of the human subsistence-settlement system as it operated in the systemic context. These features are termed conditional preference aspects and can be delineated according to their associated physical property:
An additional concept that can be incorporated into the model at this stage is the effect of formation processes on the archaeological record. Formation processes result from the interaction of many environmental subsystems, including the climatic, geologic, geomorphic, hydrologic, pedologic, climatic, and biotic (plants and animals) subsystems through time. In order to gain a complete understanding of the environmental context within which archaeological materials are to be or have been discovered, an understanding of how this context was formed and what types of alterations it has experienced must be known. This requires a knowledge of the properties of and interactions between the environmental subsystems listed in Chapter 3. Once the subsystem mechanisms are understood, their potential effects on the state and location of the archaeological record can be modeled. Unfortunately, a complete understanding of environmental subsystems, their relationships to each other through time, and their effects on the archaeological record is beyond the scope of this project. However, an example of the methodology used to incorporate certain environmental subsystem elements into a predictive model is outlined below.

Depositional and erosional geomorphological processes greatly affect the state of the archaeological record. While some areas may be periodically flooded and cultural deposits removed, other areas experience depositional capping—sediments deposited at a location cover...
older surfaces, resulting in the stabilization of any cultural deposits located on that surface. These stabilized, buried surfaces are the ideal setting for archaeological investigations, provided that the depositional process involves sediments dating to the time period of interest.

One avenue of exploration into the depositional history of a landscape is through the examination of bedrock and surficial geologic maps. Maps developed for Coos and Curry counties separate bedrock and surface geologic units based on their age and level of consolidation (Beaulieu and Hughes 1975, 1976). In depositional terms, many of the semi- or unconsolidated surficial geologic materials date to the time period of interest to this project.

*Quaternary fluvial terrace* (Qft) deposits date to the late Pleistocene. Formation of these surfaces occurred when continued uplift of the land and sea-level fluctuation forced the associated stream to downcut into its floodplain deposits and form a new floodplain at a lower elevation (Beaulieu and Hughes 1975:24). Remnants of the former floodplain are left as terraces along the sides of present day stream valleys. Because of the location and date of these deposits, they have a high relative potential for containing archaeological remains.

*Quaternary alluvium* (Qal) was deposited along the lower reaches of coastal streams during the early Holocene and late Pleistocene (Beaulieu and Hughes 1975:26). Exact dating of the flood events which produced these alluvial formations is unknown, but the sediment deposited during these events may have capped and preserved any cultural materials present on the stream banks at the time.

*Deflation plain and beach sand* (sdpb) deposits are sand sources for inland dunes. Although their age is estimated at a maximum of 5,000 years ago, they may overlie sediments of an older age, including older alluvial deposits and horizons of peaty material which developed in association with former deflation basins and interdunal lakes (Beaulieu and Hughes 1975:27). Cultural materials associated with these sand-capped older sediments would be preserved in such a depositional context.
Stable Sand (ss) deposits are stabilized dunes located in interdune and foredune locations and are associated with present systems of sand movement. Although too young to contain archaeological materials of interest to this project, they may overlie older archaeology-bearing deposits. Stable sand deposits do not include stabilized dunes located on Quaternary marine terraces (Qmt for Coos County; Qmtl and Qmtm for Curry County), which are associated with past sand movement systems. These older dune sediments may overlie or contain archaeological materials dating to the time period of interest to this project. Once these geologic units are identified, their mapped representations can be isolated and incorporated into Model One as an independent variable.

Another formational variable that can be included in this model involves pedology. The interaction between the pedologic environmental subsystem and the archaeological record can be modeled through the examination of the soil record. One section of the Coos County soil survey (USDA 1989) describes the geomorphological surface units which make up the county’s landscape, including the types of surfaces, their ages, positions on the landscape, and the soils associated with each surface. For this predictive modeling study, five surfaces have the potential to contain cultural deposits of the proper antiquity (Table 3):

1) Ingram Surface. This coastal marine terrace surface is associated with sediments deposited during the mid to late Holocene. Although this deposition occurred in the too recent past to contain cultural materials dating to the late Pleistocene, certain soils associated with the surface contain older, buried soils. It is these buried soils which may contain cultural materials dating to 15,000 yr BP. Clatsop, Coquille, and Langlois soils contain buried soil components.

2) Tenmile Surface. This surface is of the coastal marine terrace variety. Its sediments were deposited during the early to middle Holocene, 5,250 – 12,240 years before present. Because of the age of sediment deposition, the soils associated with this surface may contain or cover cultural materials dating to the late Pleistocene. Yaquina soils are affiliated with this surface.
Table 3. Coos County Landform Surfaces and Associated Soil Units.

<table>
<thead>
<tr>
<th>Landform Surface</th>
<th>Surface Type</th>
<th>Age of Associated Sediments</th>
<th>Soil(s) Associated with Surface</th>
<th>Soil Number</th>
<th>Buried Soil Associated?</th>
<th>Depth of Buried Soil</th>
<th>Soil Drainage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingram</td>
<td>Coastal Marine</td>
<td>Holocene (550 - 3,200 BP)</td>
<td>Clatsop</td>
<td>11</td>
<td>Yes</td>
<td>40 in</td>
<td>very poor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Terrace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coquille</td>
<td>12</td>
<td>Yes</td>
<td>36 in</td>
<td>very poor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Langlois</td>
<td>34, 35</td>
<td>Yes</td>
<td>28 in</td>
<td>very poor</td>
<td></td>
</tr>
<tr>
<td>Tenmile</td>
<td>Coastal Marine</td>
<td>Early/middle Holocene (5,250 - 12,240 BP)</td>
<td>Yaquina</td>
<td>64</td>
<td>No</td>
<td>somewhat poor</td>
<td></td>
<td>Associated with spodic soils</td>
</tr>
<tr>
<td></td>
<td>Terrace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winkle</td>
<td>Inland Alluvial</td>
<td>Early/middle Holocene (5,250 - 12,240 BP)</td>
<td>Elertsen</td>
<td>17</td>
<td>No</td>
<td>well</td>
<td></td>
<td>Located in convex areas of bars and channels</td>
</tr>
<tr>
<td></td>
<td>Valley</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zyzzug</td>
<td>65</td>
<td>No</td>
<td>poor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Meda</td>
<td>37</td>
<td>Yes</td>
<td>well</td>
<td></td>
<td>form on small alluvial fans overlying older surfaces</td>
</tr>
<tr>
<td>Whiskey</td>
<td>Coastal Marine</td>
<td>Late Pleistocene</td>
<td>Netarts</td>
<td>43</td>
<td>No</td>
<td>well</td>
<td></td>
<td>eolian deposits with weak spodic horizon</td>
</tr>
<tr>
<td>Run</td>
<td>Terrace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>eolian deposits</td>
</tr>
<tr>
<td>Senecal</td>
<td>Inland Alluvial</td>
<td>Late Pleistocene</td>
<td>Bullards</td>
<td>8B, 8C</td>
<td>No</td>
<td>well</td>
<td>moderately</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Valley</td>
<td></td>
<td>Chismore</td>
<td>10</td>
<td>No</td>
<td>well</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pyburn</td>
<td>47</td>
<td>No</td>
<td>poor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gauldy</td>
<td>25</td>
<td>No</td>
<td>somewhat excessively</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variant</td>
<td></td>
<td></td>
<td>excessive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Meda</td>
<td>37</td>
<td>Yes</td>
<td>well</td>
<td></td>
<td>form on small alluvial fans overlying older surfaces</td>
</tr>
</tbody>
</table>

3) **Winkle Surface.** This is an inland alluvial valley surface. Like the Tenmile surface, its sediments were deposited 5,250 – 12,240 years before present. It is the oldest surface associated with coastal Oregon’s present-day drainage system. The morphology of the Winkle surface is that of an abandoned flood plain or aggrading stream, and it is no longer susceptible to periodic flooding (USDA 1989:166). In the past, however, recurrent flooding may have occurred, capping previously deposited sediment surfaces and leaving any cultural deposits associated with these surfaces in situ. Elertsen, Zyzzug, and Meda soils occur on this surface. Meda soils may be particularly promising as they form on small alluvial fans that were deposited over older sediments. These fans are located at the juncture between second or third order streams with larger streams or rivers.
4, 5) *Whiskey Run and Senecal Surfaces.* These surfaces are the coastal marine terrace and inland alluvial valley types, respectively. They both date to the late Pleistocene, although the exact timing of their deposition is unknown. Depending on the exact timing of their formation, these units may contain cultural artifacts within the sediments or on their surfaces. Netarts, Bullards, Chismore, Pyburn, Gauldy, and Meda soils are associated with these surfaces.

Details regarding the geomorphological setting of archaeological sites are also important when examining formation processes. For example, the Marial site is set atop a relatively flat, ancient alluvial terrace deposit on the lower Rogue River near its confluence with Mule Creek. This upriver, alluvial terrace location may represent an inland habitation site chosen for its access to river and terrestrial resources. Six culture bearing strata were excavated at the location (Barner 1982). The sedimentary sequence at the site indicates a series of depositional events propagated by the flooding of Mule Creek. Confluence locations such as this often provide ideal deposition and preservation situations. Pinpointing such confluence locations is another example of the use of formation process information to aid in model production.

Once the physical landscape variables that are believed to be important to the cultural and formation process systems are identified, integration into the mathematical model can occur. Following Limp and Carr's (1985) hierarchical decision rule approach, variables can be divided into sets of landscape features. These feature sets can be further divided into acceptable and unacceptable subsets. For this model, these feature sets and subsets include the following:

A) Distance to water: (0-500 m) = acceptable; (>500 m) = unacceptable
B) Aspect: (145° - 235°) = acceptable; (0° - 145° and 235° - 360°) = unacceptable
C) Landform slope: (0-10%) = acceptable; (>10%) = unacceptable
D) Geological units: Quaternary fluvial terrace deposits (Qft), Quaternary alluvium (Qal), Quaternary marine terrace deposits (Qmt, Qmtl, Qmtm), deflation plain and beach sand (sdpb), and stabilized sand (ss) = acceptable; all other geologic units = unacceptable
E) Soil units: Clatsop, Coquille, Langlois, Yaquina, Eilertsen, Zyzzug, Meda, Netarts, Bullards, Chismore, Pyburn, and Gauldy soils = acceptable; all other soils = unacceptable
F) Confluence locations: (0-500 m to confluence) = acceptable; (>500 m) = unacceptable

In mathematical terms, acceptable landscape feature variable subsets are given a value of 1, while unacceptable subsets are given 0 values.

For this model, the landscape encompassing the project area can be subdivided into parcels or areas, and each of these areas (location choice y) is given a 0 or 1 value according to whether the location is accepted or rejected as potentially containing an archaeological site. The hierarchical decision rule approach assumes that prehistoric decision makers considered their choices separately rather than simultaneously, accepting those areas of land which met their settlement requirements and rejecting those areas that did not. Therefore, land parcels which do not meet all the requirements of the cultural system (those that do not display acceptable subsets for landscape feature sets A, B, and C) are rejected. The incorporation of formation process into this model allows for additional narrowing of settlement location possibilities. Those parcels which do not meet the formation process or depositional requirements (those that do not display acceptable subsets for landscape feature sets D, E, and F) are also rejected. The mathematical expression of this project’s hierarchical decision rule model is

\[\text{location choice } y \; (1:\text{accept, } 0:\text{reject}) = A \cdot B \cdot C \cdot D \cdot E \cdot F\]

Only those areas on the landscape with products = 1 are considered land parcels potentially containing late Pleistocene archaeological sites.

Geographic Information System (GIS) Integration

Once the independent and dependent variables to be modeled are identified and the relationships between them are mathematically delineated, integration into the geographic
information system (GIS) begins. A GIS is composed of four interrelated subsystems (Marble 1990:12; Maschner 1996:2). These include a data entry subsystem, which allows for new information to be transferred into GIS compatible digital format. Data entry may be performed through such activities as digitizing a paper map or downloading data points from a global positioning system (GPS). A second subsystem involves data storage and retrieval, through such devices as a computer and disks or CDs. A third subsystem, the data manipulation and analysis subsystem, is the software that allows data to be overlayed, queried, created, spatially analyzed, or otherwise manipulated. The GIS software used for this modeling project is ArcView GIS version 3.1. Finally, a data visualization and reporting subsystem allows for the visual display of data or data manipulation results. High resolution monitors, plotters, or printers are examples of this subsystem.

All of the independent variables identified above can be spatially represented by landscape feature data. These data originate from a variety of sources and are organized into layers or coverages. Data layers come in either raster or vector format. Vector data are in topological format and represent information as points, lines, or polygons. A raster coverage represents an area or parcel of land with a uniform grid matrix imposed upon it. Each unit in the grid is assigned row and column coordinates. Additionally, each x,y grid unit has a "z" value which represents the landscape feature data associated with that unit. Because the landscape feature data is to be incorporated into a mathematical model, all vector data representing each model's independent variables is converted into raster format. This format consistency facilitates the mathematical manipulation of the data. An example of the difference between vector and raster data is shown in Figure 11.
Figure 11. Vector versus raster data formats.

The landscape feature data representing the independent variables of Model One have been delineated above. A visual depiction of the digital landscape feature database development and GIS data manipulation performed for each modeling step is shown in Figures 12-17, associated with a written description of these processes.

The first step in the development of both Model One and Two was the digital delineation of the sample project area boundary. A vector shapefile representing the 7.5' quadrangle boundaries for all of Oregon was downloaded from the State Service Center for Geographic Information Systems (SSCGIS) at http://www.sscgis.state.or.us, and boundaries for the six quadrangles in the sample area were queried out. The outline of these six quadrangles was traced to produce the polygon shapefile *boundary.shp*. All other feature data sets used in the formation of the two models were clipped to this boundary. Additionally, all data were converted to the following projection and datum parameters:

- **Grid Coordinate System**: UTM (zone 10)
- **Planar Distance Units**: Meters
- **Ellipsoid**: Clarke 1866
- **Projection**: Lambert Conformal Conic
Central Meridian: 120.5 degrees  
Latitude of Origin: 41.75 degrees  
First Standard Parallel: 43.0 degrees  
Second Standard Parallel: 45.5  
False Easting: 1312335.958 (feet)  
Horizontal Reference Datum: North American Datum 1927 (NAD27)

Some of the landscape feature data sets used in the formulation of Model One were collected from different sources and each required specific modifications according to how they were to be included in the model. Data structure for each variable’s final file used in model computation is a 10 meter resolution grid file.

A) Distance to water (Figure 12):

Two sets of data were used to create the landscape feature grid depicting acceptable and unacceptable distances to water (watreclass.grd). The first data set was downloaded in digital format as a 1:100,000 scale 1992 TIGER hydrography line shapefile from http://www.epa.gov/enviro/html/nsdi/projects. The originator of the data was the Environmental Protection Agency’s (EPA) Office of Information Resources Management. This hydrography vector file includes lakes and all perennial first, second, and third level streams, but does not consider their ability to be used as a potable water source. This data was clipped to the sample study boundary to produce twater.shp.

In order to eliminate all non-freshwater streams from this data set, a second data set was downloaded in digital format from the Inforain (Bioregional Information System for the North American Rainforest Coast) website at http://www.inforain.org/nw.org. This data was originally collected as part of the National Wetlands Inventory (NWI) at a 1:58,000 scale and contains information on wetland and deep-water systems. This file includes an associated database listing whether the water system feature is riverine, marine, estuarine, lacustrine, or palustrine and if the system is tidal or non-tidal. Using the NWI file coos_pol.shp, a new file representing estuarine, marine, and tidal waters was created (nonpota.shp). By querying out and deleting all streams
Figure 12. Flow chart and graphical representation of production of waterclass.grd, raster grid file identifying all areas within 500m of a potable water source.
from the *water.shp* file which intersected with the *nonpota.shp* file, a shapefile representing potable water sources for the sample project area was created (*freshwater.shp*).

Next, a grid was created to assign values to each 10 meter x 10 meter grid square according to its distance from potable water in the *freshwater.shp* file. This grid file, *waudist.grd*, was then reclassed to assign binary values to each pixel based on whether it is an acceptable or unacceptable distance from a stream ([0-500m] = acceptable = cell value of 1; (>500m) = unacceptable = cell value of 0). This reclassed raster grid file was named *waatreclass.grd*.

B) Aspect (Figure 13):

In order to produce a grid coverage for the entire sample area depicting aspect of the landscape (*aspectreclass.grd*), the Digital Elevation Model (DEM) data for each quadrangle had to be downloaded. This data is available at 10 meter resolution from the Regional Ecosystem Office (REO) at http://www.reo.gov/reo/data/DEM_files/northwest.htm. Once these DEM data sets were downloaded, they were transformed into ArcView grid files using the import command. These six grid files were then merged using the ArcInfo mergegrids command to produce the combined elevation grid file *6grids.grd*. Using the derive aspect command in ArcView, a grid was created depicting the aspect of the landscape within the sample area boundary (*aspectgrid.grd*). Finally, this grid was reclassed to assign binary values to each cell based on the model subset criterion ([145° - 235°] = acceptable = 1; (0° - 145° and 235° - 360°) = unacceptable = 0) and the raster coverage *aspectreclass.grd* was created.

C) Landform slope (Figure 14):

The combined elevation grid for the six quadrangles, *6grids.grd*, was used to determine acceptable and unacceptable slope values for the sample study area (*sloperereclass.grd*). Using the ArcView command to derive slope, the grid file *slope.grd* was created. This file was then
Figure 13. Flow chart and graphical representation of production of aspectreclass.grd, raster grid file identifying all areas with aspect of 145 to 235 degrees.
Figure 14. Flow chart and graphical representation of production of slopereclass.grd, raster grid file identifying all areas with slope from 0 to 10 degrees.
reclassed according to the subset parameters outlined for Model One ((0-10%) = acceptable = 1; (>10%) = unacceptable = 0) to produce sloperereclass.grd.

D) Geological units (Figure 15):

To produce the coverage georeclass.grd, a raster file representation of surficial and bedrock geological units, the georeferenced digital image of the original 1:62,500 scale map series produced by the Oregon Department of Geology and Mineral Industries (Beaulieu and Hughes 1975) was digitized on screen to produce the polygon shapefile geology.shp. This shapefile was subsequently converted in ArcView into a 10m resolution grid file with “z” attributes based on geology type (geology.grd). Finally, the file was reclassed according to the subclass requirements for Model One (Quaternary fluvial terrace deposits (Qft), Quaternary alluvium (Qal), Quaternary marine terrace deposits (Qmt, Qml, Qmtm), deflation plain and beach sand (sdpb), and stabilized sand (ss) = acceptable = 1; all other geologic units = unacceptable = 0) to produce georeclass.grd.

E) Soil units (Figure 16):

The polygon vector file representing the soils of the sample study area was downloaded from the USDA Natural Resources Conservation Service (NRCS) website at ftp://soils.css.orst.edu/pub/webdocs/certified.html. This data file is at a mapping scale of 1:24,000. The vector polygon file representing soils (tsoils.shp) was converted in ArcView into a 10m x 10m grid format to produce a raster representation of the data (soils.grd). Next, this grid file was reclassed to generate soilsreclass.grd, a binary grid file representing acceptable and unacceptable soils according to the model parameters (Clatsop, Coquille, Langlois, Yaquina, Eilertsen, Zyzzug, Meda, Netarts, Bullards, Chismore, Pyburn, and Gauldy soils = acceptable = 1; all other soils = unacceptable = 0).
Figure 15. Flow chart and graphical representation of production of georeclass.grd, raster grid file identifying all areas with acceptable geologic unit types.
Figure 16. Flow chart and graphical representation of production of soilsreclass.grd, raster grid file identifying all areas with acceptable soil coverage.
F) Confluence locations (Figure 17):

Using the twater.shp vector file discussed above, intersections of lower and higher level streams were identified and recorded as a point vector file tconfluence.shp. A 10m resolution raster grid file was produced by calculating the distance each pixel was from a confluence location (confdist.grd). This grid file was then reclassed according to model requirements ((0-500 m to confluence) = acceptable = 1; (>500 m) = unacceptable = 0) to produce confreclass.grd.

**Outcome- patterns**

Once each final variable file was created, the map calculator was used to multiply the grid files by each other to produce the final, composite file finalcalc.grd (watreclass.grd * aspectreclass.grd * slopereclass.grd * georeclass.grd * soilsreclass.grd * confreclass.grd = finalcalc.grd). See Figure 18 for graphic representation of the calculation steps and result. Because each cell had a binary value of 1 (acceptable) or 0 (unacceptable), when the grids were multiplied together only those pixels with a value of 1 for each variable set are represented by a value of 1 (acceptable) in the finalcalc.grd grid file (see Figure 19 for grid multiplication process). It is these pixels, representing 10 meter x 10 meter areas on the landscape, that have the highest probability for containing an archaeological site according to this model’s parameters. Figure 20 displays these high probability pixels in relation to the sample project area topography, quadrangles, and other landscape features.
Figure 17. Flow chart and graphical representation of production of confreclass.grd, raster grid file identifying areas within 500m of a confluence location.
Figure 18. Graphical representation of map calculation in the production of finalcalc.grd, raster grid file representing areas within the sample study area with the highest potential for containing archaeological sites based on Model One calculations.
Figure 19. Raster grid multiplication.
Figure 20. Sample study area map showing locations with highest potential for containing archaeological sites based on Model One calculations.
Based on Model One variable manipulation and mathematical calculations, areas which meet all of the following model requirements are graphically represented in Figure 20 as those with the highest potential for containing archaeological materials dating to the late Pleistocene:

1) areas within 500 meters of potable water;
2) south-facing land surfaces;
3) land surfaces with less than 10% slope;
4) areas with surficial or bedrock geological units of Quaternary fluvial terrace deposits (Qft), Quaternary alluvium (Qal), Quaternary marine terrace deposits (Qmt, Qmtl, Qmtm), deflation plain and beach sand (sdpb), or stabilized sand (ss);
5) areas represented by soil units Clatsop, Coquille, Langlois, Yaquina, Eilertsen, Zyzzug, Meda, Netarts, Bullards, Chismore, Pyburn, or Gauldy soils; and
6) areas within 500 meters of a stream confluence location.

Predictive Model One produced a map (Figure 20) which is a generalized representation of where use would have occurred on the landscape. It involves a few, broad-spectrum variables that have been used in other locational modeling studies to predict site location. Each variable is considered to have been equally important in the settlement location choices of prehistoric peoples. It also includes three formation process variables that may have affected the location or preservation of archaeological remains. The primary function of this model is to demonstrate a modeling methodology. This methodology is most useful when site prediction is based on a few, generalized landscape features. When a larger number of variables is to be modeled, especially if it is hypothesized that these variables affected occupation locations to different degrees, then the weighted-value method of modeling becomes a more appropriate approach to the prediction problem. This is the approach used in Model Two.
Model Two

Production

Earlier in this paper it was argued that human groups on the southern Oregon coast during the late Pleistocene may have organized some of their subsistence and settlement systems as logistical collectors. If this was indeed the case, then the archaeological record would be manifest in such forms as *residential bases, resource extraction locations, field camps*, and *stations*. Different environmental variables are associated with each type of archaeological site modeled, depending on the types of variables required to meet the functional needs of the site type. Caches are not included in this modeling project—their detection on the landscape would be very difficult because of their minimal size, and because they are a low frequency feature.

Residential bases:

The *residential base*, as discussed above, represents "the hub of subsistence activities, the locus out of which foraging parties originate and where most processing, manufacturing, and maintenance activities take place" (Binford 1980:9). Landscape variables associated with resources at and locations of residential bases are garnered from theoretical, ethnographic, and archaeological sources. It is important to remember that these landscape variables are proxy representations for the basic subsistence-settlement features of a coastally adapted culture. Each physical landscape property can be associated with one or more conditional preference aspects.

Yesner’s (1980) arguments concerning maritime hunter-gatherers hypothesize that locations considered viable for settlement exhibit all or some of the following landscape features: complex coastline, stream or lake association, proximity to upwelling zones, strandflats, and boat-beaching areas. Lyman (1991) and Ames and Maschner (1999) both argue that early peoples
would have utilized marine and littoral resources, implying that the landscape features discussed by Yesner (1980) would have played a significant part in determining occupation locations.

In particular, the concept that proximity to complex coastlines may be an indicator of site location is supported by Minor's "pre-littoral" discussion (1997), as well as evidence from archaeological sites such as Tahkenitch Landing, Manis, Namu, Arrow Creek 1 and 2, Ground Hog Bay 2, Chuck Lake, and various California sites mentioned by Jones (1991). Additionally, ethnographic information discussed by Maschner and Stein (1995), Aikens (1993), Minor and Toepel (1983), and Draper (1988) implies the utilization of resources found in relation to complex coastlines.

The importance of proximity to coastal streams or lakes is mentioned by Maschner and Stein (1995) and Draper (1988). Ethnographic analogy based on Alsea accounts indicates ocean and river resources were exploited both year-round and seasonally, according to resource availability (Aikens 1993). Habitation locations (whether they be a "village" or "satellite camp") were located near water resources, both coastal and inland. Tolowa groups also exploited coastal, riverine, and terrestrial resources seasonally and year-round (Minor and Toepel 1983). Habitation sites were located either along coastal lakeshores or at the mouths of streams. Sites such as Neptune, Marial, the California mainland coastal sites, Hidden Falls, and Ushki Lake also highlight the importance of proximity to streams or lakes in determining site location. Research by Dixon (1997) and Moss (1998) indicates streams would have been especially important at sites such as Ground Hog Bay 2, Hidden Falls, and Chuck Lake in the act of procuring lithic materials from sources located kilometers inland from the sites.

Boat-beaching activities may have been practiced at many of the coastal archaeological sites, especially those on bays or estuaries. Maschner and Stein (1995) mention the importance of canoe-friendly beaches in their study on the Tlingit, and boat-beaching is implied in ethnographic studies by Aikens (1993), Minor and Toepel (1983), and Minor (1997), which discuss off-shore resource extraction activities.
According to Lyman’s (1991) definitions of coastal (littoral and marine) adaptations, resource exploitation would have centered on shoreline, estuary, nearshore island and rock, and tide pool environments. The conditional preference aspects of complex coastlines, including shoreline, estuary, and tide pool environments, are listed above. However, conditional preference aspects associated with nearshore rocks and islands need to be delineated. Minor’s (1997)...
discussion of early adaptation on the coast parallels Lyman's (1991) resource use depiction. Although not explicitly stated, areas near these food extraction locations may have served as residential bases due to their proximity to critical resources. Archaeological sites such as Daisy Cave, Arlington Springs, CA-SRI-61, the Queen Charlotte Island sites, Ground Hog Bay 2, Hidden Falls, Chuck Lake, and Anangula may be located on or in proximity to nearshore rocks, islands, and reefs because of the resources associated with these features.

<table>
<thead>
<tr>
<th>Physical Property:</th>
<th>Potential Conditional Preference Aspects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to nearshore rocks, islands, and reefs</td>
<td>1. Access to invertebrate food resources</td>
</tr>
<tr>
<td></td>
<td>2. Access to vertebrate food resources (esp. marine mammals)</td>
</tr>
</tbody>
</table>

Lyman (1991), Ames and Maschner (1999), Aikens (1993), Minor and Toepel (1983), and Draper (1988) suggest that early adaptation on the coast may have contained an interior element, with the exploitation of terrestrial fauna and river resources included in subsistence pursuits. Groups focused on interior coastal resource acquisition would have occupied areas further off the coast than other groups, perhaps beyond a river's tidal reach. Such areas along the rivers of the southern Oregon coast are often characterized by steep mountain slopes running sharply down to the river's edge. A few small terrace deposits do exist in upriver locations, however, and these areas would have been utilized as occupation and/or resource extraction locations.

Additionally, interior groups may have occupied areas near ecotone boundaries. It is difficult to predict exactly where on the late Pleistocene landscape such a transition would have occurred, but topographically a boundary does exist between the upland mountain slopes of the Coast Range and the lowland marine terrace deposits along the coast edge, as well as between the coastal bluffs and what would have been the expansive coastal plain which extended to the Pacific Ocean from the bluff edges at 15,000 years ago (Figure 21). It is possible that this change
Figure 21. Ecotone boundaries.
in topography would have encouraged a change in floral conditions, as well. The conditional preference aspects associated with river terraces and ecotone boundaries are listed below. Evidence from sites such as Indian Sands, Blacklock Point, Tahkenitch Landing, Marial, and Ushki Lake supports the idea that inland stream terraces and ecotone boundaries would have been important considerations in prehistoric landscape occupation choices.

**Physical Property:** Inland coastal stream terraces

**Potential Conditional Preference Aspects:**
1. Relatively flat areas for habitation
2. Access to river food resources
3. Access to potable water
4. Access to terrestrial plant food resources

**Physical Property:** Proximity to ecotone boundaries

**Potential Conditional Preference Aspects:**
1. Increased availability of terrestrial mammal resources
2. Access to terrestrial plant food resources

Caves and rockshelters have been used for habitation or camp sites throughout prehistory. The On Your Knees Cave archaeological site in Alaska is an example of early use of this landscape feature. The primary conditional preference aspect associated with this feature is that it provides protection from a myriad of natural elements. This aspect alone would have made it an important property affecting occupational choices in the past.

**Physical Property:** Cave or rockshelter locations

**Potential Conditional Preference Aspects:**
1. Protection from the elements

A final physical landscape element that may have had an effect on occupation locations in the past is the coastal bluff. As cited above, Erlandson et al. (1999:261-62) argue that many of the Santa Rosa Island shell middens are located on the landward edge of the former coastal plain,
near a topographic divide, because plant foods and fresh water may have been more readily
available in these areas compared to the coastal edge. The Indian Sands and Blacklock Point sites
in Oregon may be examples of such bluff occupation locations.

<table>
<thead>
<tr>
<th>Physical Property:</th>
<th>Potential Conditional Preference Aspects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluffs on inland edge of coastal plain</td>
<td>1. Increased access to potable water</td>
</tr>
<tr>
<td></td>
<td>2. Access to terrestrial plant food resources</td>
</tr>
<tr>
<td></td>
<td>3. Increased access to terrestrial mammal food resources</td>
</tr>
<tr>
<td></td>
<td>4. Decreased exposure to hazardous coastal climatic events</td>
</tr>
</tbody>
</table>

Based on the information listed above, it appears that on a generalized scale residential
sites may have been located in relation to two types of spatially divided resources: coastal versus
inland resources. Coastally oriented residences would have had a subsistence focus on resources
from the ocean, littoral zone, or nearshore environments, such as estuaries or bays. Residential
bases on inland coastal lakes, upriver terraces, or coastal bluffs would have centered around a
more diverse resource base, including terrestrial biota and freshwater and anadromous fish. The
designation of coastal versus inland resource orientation does not necessarily represent the
systemic context – it is more likely that residential base choices were made based on a continuum
of resource types and spatial resource availability. However, by modeling inland and coastal
resource use separately, a more accurate prediction of the land use associated with these
subsistence sources is achieved.

Resource Extraction Locations:

Resource extraction locations represent places on the landscape where “extractive tasks
are exclusively carried out” (Binford 1980:9). Variables associated with resources extraction
locations are garnered primarily from ethnographic and archaeological sources. Ethnographic
data regarding the Alsea (Aikens 1993) and Tolowa (Minor and Toepel 1983) indicate that
seasonal exploitation of resources such as anadromous fish, marine invertebrates, marine mammals, terrestrial mammals and plants occurred. The areas where resources were extracted may appear in the archaeological record as either locations or as field camps, depending on duration of stay. Regardless of exact type of site produced, resources would have been extracted at these locations. Archaeological sites all along the Northwest Coast may represent resource extraction locations or field camps. Most of the physical properties and associated conditional preference aspects of resource extraction locations or field camps, such as proximity to complex coastlines, proximity to nearshore rocks, islands, or reefs, proximity to streams or lakes, and proximity to ecotone boundaries, have been listed above.

One additional landscape feature related primarily to resource extraction is the location of lithic sources. Lithic raw materials may have been the resource extracted at archaeological sites such as Indian Sands and Blacklock Point in Oregon. Both of these locations are known for being sources of lithic raw materials, and the archaeological assemblages recovered from these areas support this idea.

**Physical Property:**

Proximity lithic source areas

**Potential Conditional Preference Aspects:**

1. Access to raw materials for production of flaked stone tools

Field Camps:

Field camp locations were used as temporary residences by logistical collectors in the process of gathering resources in a given area. Although occupied for a longer duration than resource extraction locations, the land use of field camps was for a similar purpose. Therefore, archaeological materials would have been deposited in similar areas. Both archaeological location types can be predicted using the same variables.
Stations:

This final archaeological location type is associated with areas of resource information gathering. There are two examples of this type of location gleaned from the data presented above. The first is from Draper’s (1988) arguments concerning station locations on coastal bluffs. The second is from the archaeological record—the bluff archaeological sites at Indian Sands and Blacklock Point may represent terrestrial game observation points. Their location on the landscape during the late Pleistocene, at an ecotone boundary and/or overlooking the expansive coastal plain, would have been ideal for gathering information about terrestrial game locations and movements. The physical property and associated conditional preference aspect of coastal bluff locations was listed above, but use of this type of location for resource information gathering requires that an additional potential conditional preference aspect be included:

<table>
<thead>
<tr>
<th>Physical Property:</th>
<th>Potential Conditional Preference Aspects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluffs on inland edge of coastal plain</td>
<td>1. Increased access to information about locations and movements of terrestrial game resources</td>
</tr>
</tbody>
</table>

Following Limp and Carr (1985), modeling the probability that a location would have been occupied requires that physical properties be broken down into sets and subsets. For example, modeling a residential base requires that the landscape features listed above under Physical Properties (the attainable choice set) be separated into landscape feature sets (the independent variable component of the predictive model). These sets include such features as proximity to streams, lakes, upwelling zones, strandflats, etc., as listed above. Each landscape feature in the set is broken down into subsets based on distance to feature and ordered according to preferability. Preferability is based on assumptions about human behavior in the systemic context. For example, proximity to stream subsets could include: Subset1 (0-250 m) P Subset2 (250-500 m) P Subset3 (500 - 1000 m) P Subset4 (>1000 m). Subset1 is the most preferred because it is postulated that the human group being modeled would have preferred to live in close
proximity to streams, allowing for easier access to stream resources. Additionally, each of these subsets is given a numerical value of 3 to 0, according to their potential for containing an archaeological site. Those subsets considered most preferable by prehistoric peoples have a higher likelihood of containing a site. Numerically, the stream example above would be written as Subset1 = 3, Subset2 = 2, Subset3 = 1, Subset4 = 0 (three represents highest potential, zero equals lowest potential).

The following is a list of landscape feature sets, their subsets, and subset values used in the process of mapping all the site types discussed above (subsets listed in order of preferability):

A) Proximity to stream: Subset A1 (0-250 m) = 3, A2 (250-500 m) = 2, A3 (500-1000 m) = 1, and A4 (>1000 m) = 0
B) Proximity to coastal lake: B1 (0-250 m) = 3, B2 (250-500 m) = 2, B3 (500-1000 m) = 1, and B4 (>1000 m) = 0
C) Proximity to complex coastline: C1 (0-250 m) = 3, C2 (250-500 m) = 2, C3 (500-1000 m) = 1, and C4 (>1000 m) = 0
D) Proximity to upwelling zone: D1 (0-500 m) = 3, D2 (500-750 m) = 2, D3 (750-1500 m) = 1, and D4 (>1500 m) = 0
E) Proximity to strandflat: E1 (0-250 m) = 3, E2 (250-500 m) = 2, E3 (500-1000 m) = 1, and E4 (>1000 m) = 0
F) Proximity to boat-beaching area: F1 (0-500 m) = 3, F2 (500-750 m) = 2, F3 (750-1500 m) = 1, and F4 (>1500 m) = 0
G) Proximity to nearshore rock, reef, or island: G1 (0-250 m) = 3, G2 (250-500 m) = 2, G3 (500-1000 m) = 1, and G4 (>1000 m) = 0
H) Proximity to ecotone boundary: H1 (0-500 m) = 3, H2 (500-750 m) = 2, H3 (750-1500 m) = 1, and H4 (>1500 m) = 0
I) Proximity to coastal bluff: I1 (0-100 m) = 3, I2 (100-200 m) = 2, I3 (200-300 m) = 1, and I4 (>300 m) = 0
J) Proximity to cave or rockshelter: J1 (0-50 m) = 3, J2 (50-100 m) = 2, J3 (100-200 m) = 1, and J4 (>200 m) = 0
K) Proximity to lithic source: K1 (0-250 m) = 3, K2 (250-500 m) = 2, K3 (500-1000 m) = 1, and K4 (>1000 m) = 0
L) Slope: L1 (0-5%) = 3, L2 (5-10%) = 2, L3 (10-20%) = 1, L4 (>20%) = 0
M) Stream terrace locations: M1 (Qal or Qft) = 3, M2 (all other geological units) = 0

The landscape encompassing the project area is subdivided into 10m x 10m areas, and each of these areas (location y) is given a value according to the likelihood that it contains an archaeological site. This likelihood is calculated for each 10m x 10m area by taking the value (V) assigned to the area for each landscape feature based on the subset values listed above and multiplying it by the weight (W) that each set of resource features is assigned (Figure 22).
Figure 22. Weighted-value method of raster grid manipulation.
These weights are based on the amount of influence each resource feature would have had on locational choices for a particular archaeological site type. Once the values and weights for each variable are multiplied together, these products are added together to produce a final numerical result representing the areas’ relative potential for containing the type of archaeological site being modeled. The following equation represents this process:

\[
\text{location } y = \text{independent variable}_1 (V \times W) + \text{independent variable}_2 (V \times W) \ldots + \text{independent variable}_n (V \times W)
\]

By applying this mathematical formula to all 10m x 10m areas on a landscape, the numerical value for each area is calculated and their results compared. Areas with the highest relative numerical value would represent locations with the greatest potential for containing a specific type of archaeological site.

One strength of the weighted value modeling method is that assignment of weights and values are based on ideas regarding the systemic, behavioral context. It is important to keep in mind, however, that the weight and value assignment stage of the modeling process is, to a large extent, subjective, based on the author’s conclusions about prehistoric subsistence and settlement choices in relation to land use (Dalla Bona 2000:76). In order to account for this subjectivity, assignment of weights and values for each model requires explicit explanation. If any new or contradictory information about the human system being modeled is produced, weights and values of individual variables can be changed accordingly. This allows for expedient model refinement and testing.

Based on the archaeological, theoretical, and ethnographic data discussed above, weights and values for each archaeological site type model have been assigned and listed in Table 4. The rationalization for weight and value assignments is explained below.
Table 4. Weights and Values Assigned to Landscape Feature Sets.

<table>
<thead>
<tr>
<th>Landscape Feature Set (Independent Variable X)</th>
<th>Subsets</th>
<th>Value (V)</th>
<th>Weight (W)</th>
<th>Weighted Value (WxV)</th>
<th>Weighted Value (WxV)</th>
<th>Value (V)</th>
<th>Weight (W)</th>
<th>Weighted Value (WxV)</th>
<th>Weighted Value (WxV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to stream:</td>
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<tr>
<td>A1 (0-250 m)</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>3</td>
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<tr>
<td>A2 (250-500 m)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>6</td>
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<tr>
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<tr>
<td>A4 (&gt;1000 m)</td>
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<td>B1 (0-250 m)</td>
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<td>Proximity to upwelling zone:</td>
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<td>3</td>
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<tr>
<td>Proximity to boat-beaching area:</td>
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<tr>
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<tr>
<td>Proximity to nearshore rock, reef, or island:</td>
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<td>9</td>
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<td>G2 (250-500 m)</td>
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<tr>
<td>Proximity to ecotone boundary:</td>
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<td>6</td>
<td>0</td>
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<tr>
<td>H3 (750-1500 m)</td>
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<td>0</td>
<td>3</td>
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<td>Proximity to coastal bluff:</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>I1 (0-50 m)</td>
<td>3</td>
<td>0</td>
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<td>3</td>
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<tr>
<td>I2 (50-100 m)</td>
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<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
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</tr>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>I4 (&gt;200 m)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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Table 4. Continued.

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<tr>
<th>Landscape Feature Set (Independent Variable X)</th>
<th>Subsets</th>
<th>Value (V)</th>
<th>Weight (W)</th>
<th>Weighted Value (W*V)</th>
<th>Weighted Value (W*V)</th>
<th>Value (W)</th>
<th>Weighted Value (W*V)</th>
<th>Weighted Value (W*V)</th>
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<tr>
<td><strong>Residential Base</strong></td>
<td></td>
<td>Coastal</td>
<td>Inland</td>
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<td>Coastal</td>
<td>Inland</td>
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<tr>
<td><strong>Proximity to cave or rockshelter:</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>J1 (0-50 m)</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>9</td>
<td>0</td>
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<tr>
<td>J2 (50-100 m)</td>
<td>2</td>
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<td>3</td>
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<tr>
<td>J3 (100-200 m)</td>
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<tr>
<td>J4 (&gt;200 m)</td>
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<td>3</td>
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<td><strong>Proximity to lithic source:</strong></td>
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<tr>
<td>K3 (500-1000 m)</td>
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<tr>
<td>K4 (&gt;1000 m)</td>
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<td><strong>Slopes:</strong></td>
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<tr>
<td>L1 (0-5%)</td>
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<td>3</td>
<td>9</td>
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<td>1</td>
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</tr>
<tr>
<td>L2 (5-10%)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L3 (10-20%)</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L4 (&gt;20%)</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
<td><strong>Inland stream terrace:</strong></td>
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<td></td>
<td></td>
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<tr>
<td>M1 (terrace unit)</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>3</td>
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<td>2</td>
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</tr>
<tr>
<td>M2 (non-terrace unit)</td>
<td>0</td>
<td>3</td>
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<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Values and weights are ranked on a scale from 3 to 0, with 3 having the highest contribution to archaeological site potential.
Value Assignments:

Residential Base

Coastal resource focus: for late Pleistocene groups whose subsistence activities focused on coastal resources, residential bases would have been placed in relation to marine, littoral, and nearshore resources. Areas on the landscape in close proximity to such resources have the highest potential for containing archaeological materials which represent this type of residential base. Landscape feature sets involving proximity to complex coastlines, strandflats, and nearshore rocks, reefs, and islands represent these coastal resources and are therefore given the highest weight for their influence on archaeological site potential. Additionally, because the residential base type of site represents a location of long-term habitation by a group of people, proximity to a potable water source and low landscape slope are primary indicators of site potential. Although they do not represent systemic necessities, areas providing access for boat-beaching activities and areas near upwelling zones or lithic sources may have positively influenced residential choices. Finally, although not necessary for a residential base to exist, caves and rockshelters are excellent indicators of habitation sites because of their ability to provide shelter.

Inland resource focus: as was the case for coastal resource focused residential bases, inland residential bases would have been located in close proximity to inland subsistence resources, represented in proxy by landscape features such as streams, lakes, ecotone boundaries, and coastal bluffs. Landform slope was also very important in residence location choices, and therefore is given a high weight for contributing to archaeological site potential. Locations near to boat-beaching areas, lithic sources, or caves and rockshelters may have positively influenced residence base choices, as well.
Resource Extraction Location or Field Camp

**Coastal resource focus:** archaeological evidence of littoral, nearshore, and marine resource extraction should be in close proximity to the resources being extracted. Therefore, landscape feature sets pertaining to complex coastlines, upwelling zones, strandflats, nearshore rocks, reefs, and islands, and coastal lithic sources contribute the most to archaeological site potential. Because duration of stay at these extraction locations is unknown, some basic residence needs such as potable water, shelter, or flat terrain may have contributed to the land-use choices involved with resource extraction. These residence needs are represented by the landscape feature sets proximity to stream, proximity to cave or rockshelter, and slope. Additionally, depending how far these resources were from the residential base, transportation (represented by proximity to boat-beaching area) may have been a factor in associated land-use.

**Inland resource focus:** inland extraction of aquatic resources would have been concentrated on coastal streams and lakes. Areas proximal to these landscape features, especially inland stream terrace locations, represent locations with a high potential for containing archaeological sites. Evidence of terrestrial resource extraction would most likely be spatially associated with ecotone boundaries. Lithic raw material procurement activities would have resulted in cultural material deposition in close proximity to lithic sources. As was the case with extraction locations associated with coastal resources, duration of stay in the area may have been extended. Therefore, proximity to stream, proximity to cave or rockshelter, and the slope of the landscape may have contributed to land-use choices. Access to transportation may also have been a factor, as with the coastal resource extraction focus.
Station

Archaeological evidence associated with stations should be located in areas which allowed extensive viewing of the landscape, especially in areas overlooking the coastal plain or ecotone borders where terrestrial game frequent, such as along the edges of topographic boundaries. Landscape feature sets involving coastal bluffs and ecotone boundaries are assigned the highest weights in terms of their contribution to archaeological site potential.

Geographic Information System (GIS) Integration

The landscape feature data representing the independent variables of Model Two have been delineated above. A visual depiction of the digital landscape feature database development and GIS data manipulation performed for each modeling exercise is shown in Figures 23 - 31, associated with a written description of these processes. Each of the landscape feature data sets used in the formulation of Model Two required specific modifications according to how they were to be included in the model. Data structure for each variable’s final file used in model computation is a 10 meter resolution grid file. Modeling of locations in relation to former sea-level was conducted in terms of the estimated coastline position at 15,000 years ago (Figure 2).

A) Proximity to stream (Figure 23):

The hydrography line shapefile twater.shp used in the creation of Model One was also used to model proximity to stream for Model Two. Since the hydrography file included lake boundaries, these features needed to be eliminated before any other calculations could occur. In order to do this, polygons representing lakes were selected from the NWI coos_pol.shp file and intersected with twater.shp to isolate hydrography lines which represented lakes. These line
Variable A: Proximity to Stream

- Delete all features representing non-stream features.
- Identify all lacustrine (lake) features.
- Compute pixel distance to streams and reclass according to subset parameters.

Figure 23. Model flow chart and final grid (streamreclass.grd) of Variable A: Proximity to Stream.
features were then deleted from the twater.shp data set to produce tstreams.shp. Next, a grid was
created to assign values to each 10 meter x 10 meter grid square according to its distance from a
stream in the tstreams.shp file. This grid file, streamdist.grd, was then reclassed to assign pixel
values (following the weighted-value modeling method) according to the variable subset
parameters to create streamreclass.grd: Subset A1 (0-250 m) = 3, A2 (250-500 m) = 2, A3 (500-
1000 m) = 1, and A4 (>1000 m) = 0.

B) Proximity to coastal lake:

Presently, six lakes exist along the coast within the sample study area boundary: Laurel, Lost, Bradley, Fahys, Chrome, and Round lakes. However, evidence from the study of prehistoric
dune production and movement indicates that these lakes were probably estuaries or streams
15,000 years ago (Cooper 1958). Therefore, no modeling of this variable was performed for this
sample study area.

C) Proximity to complex coastline (Figure 24):

Most of the former coastline, including bays, tidepools, and many estuaries, has been
inundated by the post-glacial rise in sea level. However, outlets of many streams or estuaries were
blocked or in-filled with sand during a period of increased dune activity, from 18,000 to 6,000 yr
BP, producing coastal lakes such as Laurel, Lost, Bradley, Fahys, Chrome, and Round Lakes of
Coos County (Cooper 1958:134). Since these present-day lake features may have been part of an
estuary system around 15,000 years ago, they can be included in Model Two as complex
coastline features. Using some lake features from the NWI coos_pol.shp file and creating some
lake features through on-screen digitization of lake boundaries as depicted on USGS 1:24,000
quadrangle maps, a file representing the possible former estuaries listed above was created
(tlakes.shp). Next, present-day estuaries, which may have been estuaries 15,000 years ago as
well, were isolated from the coos_pol.shp NWI file to create estuaries.shp. Tlakes.shp and
Variable C: Proximity to Complex Coastline

identify all natural lake features
identify all extant complex coastline features
merge
compute pixel distance to complex coastline feature and reclass according to subset parameters

USGS 1:100,000 Quadrangle

query for lakes
combine on-screen digitization

query

$tiles.shp$
$estuaries.shp$

identify all estuarine features

$coos\_pol.shp$

$coos\_pol.shp$

identify all extant complex coastline features

Figure 24. Model flow chart and final grid (comcreclass.grd) of Variable C: Proximity to Complex Coastline.
estuaries.shp were subsequently merged to produce one file (complexc.shp) representing complex coastline features not inundated by Holocene sea-level rise. A 10m resolution raster grid file was produced by calculating the distance each pixel was from a complex coastline feature (complexdist.grd). This grid file was then reclassed according to model requirements (C1 (0-250 m) = 3, C2 (250-500 m) = 2, C3 (500 -1000 m) = 1, and C4 (>1000 m) = 0) to produce the file comcreclass.grd.

D) Proximity to upwelling zone:

The entire coast of Oregon is considered an upwelling zone, with particular areas being more nutrient productive depending on the season (Smith 1964). However, at 15,000 years ago the coastline would have been approximately 10,000 meters from the present-day shoreline (see Figure 2), so all locations on land today would fall under the subset D4 (>1500 m) and would have a value of zero. Therefore, no modeling of this variable was performed.

E) Proximity to strandflat:

Strandflats, wave-cut platforms which support shellfish and other invertebrates (Yesner 1980; Bates and Jackson 1984), would have lined the coast and estuary mouths 15,000 years ago. But, as with variable D in this model, these areas are no longer available for modeling due to inundation (see Figure 2). Therefore, since all pixels representing today’s land surface fall under the subset E4 (>1000m) = 0, no modeling of this variable was performed.

F) Proximity to boat-beaching area (Figure 25):

In order to model areas which may have been used for canoe landings, environmental systems, subsystems, and classes listed in the NWI coos_pol.shp file were examined. Marine system features were not used because these features represent today’s coastline, not the coastline of 15,000 years ago. Lacustrine (lake) systems also were not used for modeling this variable.
Variable F: Proximity to Boat-Beaching Area

- coos_pol.shp
- coos_arc.shp
- canoe_poly.shp
- canoe_arc.shp
- canoe_poly.grd
- canoe_arc.grd
- c-polyreclass.grd
- c-arcreclass.grd
- c-combine.grd
- c-reclassmax.grd

**Identify all fluvial bed-types which allow canoe beaching**
- convert to grid
- reclass according to subset parameters
- combine suitable bed-type features to grid and reclass according to subset parameters
- c-reclassmax.grd

**Figure 25. Model flow chart and final grid (c-reclassmax.grd) of Variable F: Proximity to Boat-Beaching Area.**
because at 15,000 years ago they would have been stream or estuary systems, and since that time their outlets have been blocked off and their bottoms filled with sediment from their associated stream inlets. Therefore, their subsystem and class descriptions as listed today are probably not the same as they would have been 15,000 years ago.

Estuarine and riverine environmental systems were examined for modeling. Subsystems for these indicate bottom type, and class describes a subset of bottom type (see metadata regarding this file at http://www.inforain.org/maps/metadata/oregon/nwi/coos.htm for more information). Estuarine and riverine systems with sand or mud unconsolidated bottoms (represented as UB2 or UB3 in the database), aquatic beds (AB1-7), sand or mud flat bottoms (FL2,3), sand beach bars (BB2), or sand or mud stream beds (SB2,3) were queried from the NWI coos_lin.shp and coos_pol.shp data sets to produce line and polygon shapefile representations of streams or estuaries with viable bed types for a canoe landing (canoearc.shp and canoepoly.shp, respectively).

These two shapefiles were subsequently converted to grids (canoearc.grd and canoepoly.grd) and then reclassed according to the variable subset parameters (F1 (0-500 m) = 3, F2 (500-750 m) = 2, F3 (750 -1500 m) = 1, and F4 (>1500 m) = 0) to produce c-arcreclass.grd and c-polyreclass.grd. The two reclass grid files were combined to form c-combine.grd. In this combination file's database, the value assigned to each pixel in the two original reclass grids was listed in two separate columns (fields). The maximum value from these two fields was computed using the “max” command in ArcView's table editor, and this field was used to create a new grid (c-reclass.grd). This file represents areas on the landscape within a certain distance to canoe-beaching areas valued according to the variable subset definitions listed above. Because these bottom types may not represent hydrological feature bottom types in the past, this variable is not heavily weighted for any of the site types modeled.
G) Proximity to nearshore rock, reef, or island:

As was the case with variables D and E in this model (proximity to upwelling zone), at 15,000 years ago the coastline would have been around 10,000 meters from the present-day shoreline (see Figure 2). Therefore, all former nearshore rocks, reefs, or islands are also 10,000 meters from today's coastline. Since this subset defines all areas greater than 1,000 meters from these nearshore features with a value of zero, no modeling of this variable was performed.

H) Proximity to ecotone boundary (Figure 26):

Two primary ecotone boundaries would have existed in the sample study area ~15,000 years ago. The first would have been along the back edge of the former coastal plain. This boundary can be drawn today by identifying areas along the current coastline which would have been bluffs 15,000 years ago. Tectonic studies on the coast included in the sample study area indicate the land has been uplifting at a rate of 3.6 mm/year (Verdonck 1995). Fifteen thousand years ago the land in this area would have been approximately 5400 mm (5.4 m) lower than today. If a coastal bluff is arbitrarily defined as a surface at least 15 meters above beach or sea level, then an elevation difference of 20.4 meters would be necessary for a coastal bluff of today to have been a bluff 15,000 years ago. Therefore, areas along the present-day shoreline (within 100 meters of high tide line) with an elevation of greater than 20.4 meters above sea level are considered former coastal bluffs.

Digital identification of these areas was accomplished by querying out the marine polygons from the National Wetlands Inventory (NWI) data file coos_pol.shp to produce the shapefile marine.shp. Next, the marine polygon shapefile was buffered to 100 meters to produce buff100.shp, and subsequently converted to a grid file (buff100.grd). This buffer grid file was then reclassed, with pixels within the buffer region assigned a value of one and those outside of the buffer assigned a value of zero, to produce the file 100buffre.grd.
Variable H: Proximity to Ecotone Boundary

Figure 26. Model flow chart and final grid (ecotone.grd) of Variable H: Proximity to Ecotone Boundary.
Using the combined elevation grid for the six quadrangles, 6grids.grd, pixels with an elevation of greater than 20 meters were selected out to create the grid file greater20m.grd. The grid files 100buffre.grd and greater20m.grd were then multiplied together to select all pixels with an elevation over 20 meters and within 100 meters of the shoreline. The grid file coastbluff.grd was produced. Out of this grid, all pixels with non-zero values were selected and distance to them was computed to produce the file cstblfdist.grd. Finally, cstblfdist.grd was reclassed according to variable subset parameters (H1 (0-500 m) = 3, H2 (500-750 m) = 2, H3 (750 -1500 m) = 1, and H4 (>1500 m) = 0) to produce cstblfdire.grd.

The second ecotone boundary would have been at the topographic border between the interior uplands along the foothills of the Coast Range and the relatively horizontal, terraced lowlands nearer to the present-day coastline. This boundary was roughly identified on the shaded relief representation of the sample area’s digital elevation model, hillshade.grd, and digitized on-screen as a line file, ecobndry.shp. Pixel distance to the ecotone boundary was computed to produce the file ecodist.grd and subsequently reclassed according to the variable subset guidelines (H1 (0-500 m) = 3, H2 (500-750 m) = 2, H3 (750 -1500 m) = 1, and H4 (>1500 m) = 0) to produce ecoboundre.grd.

The final step in the production of a file representing reclassed distance to ecotone boundary was to combine the two grids, cstblfdire.grd and ecoboundre.grd to produce botheco.grd. The fields in botheco.grd’s database table representing reclassed values for the two combined grids were put into the table calculator to find the maximum value between the two. The maximum value was used to create the final raster grid file ecotone.grd.

1) Proximity to coastal bluff (Figure 27):

The same steps used to produce the first ecotone boundary type for Variable H were used to model Variable I, up to the point where subset parameters were applied to the file to produce a
Variable I: Proximity to Coastal Bluff

- Identify all pixels within 100m of high-tide line
- Identify all pixels within 100m of high-tide line
- Identify all pixels representing a coastal bluff location
- Find distance to coastal bluff and reclass according to subset parameters

Figure 27. Model flow chart and final grid (bluffreclass.grd) of Variable I: Proximity to Coastal Bluff.
reclassed grid. The non-reclassed file created for variable H, cstbldist.grd, was reclassed instead according to variable I’s guidelines, I1 (0-100 m) = 3, I2 (100-200 m) = 2, I3 (200 –3 00 m) = 1, and I4 (>300 m) = 0, to produce the final fine bluffreclass.grd.

J) Proximity to cave or rockshelter:

Although many smaller caves and rockshelters probably exist along the southern Oregon coast, none has been documented in the available literature. Intense field survey of the study area would probably produce evidence of such structures, but such a search is not within the scope of this thesis project. Therefore, this variable will not be included in the formation of Model Two.

K) Proximity to lithic source (Figure 28):

Many lithic materials have been used in the past to produce tools. Chert is one of the most often used lithic types, and the presence of chert can be spatially modeled by mapping the locations of chert-containing bedrock formations on the landscape. The lithology of bedrock units in Coos County, Oregon is described in a Department of Geology and Mineral Industries Bulletin compiled by Baldwin and Beaulieu (1973). The following is a list of bedrock units with significant chert inclusions: Otter Point Formation (upper and lower members), Myrtle Group (Humbug Mountain Conglomerate and Riddle Formation), and the Lookingglass Formation. The only map unit located in the sample study area representing one of the above bedrock formations is the Lookingglass Formation (Telg) (Beaulieu and Hughes 1975).

To compute distance to lithic source for each pixel, the polygon shapefile geology.shp (discussed above in the production of Model One, variable D) was used. The map unit representing a possible lithic source (Telg) was queried out to produce lithic.shp. The distance to this bedrock type was subsequently computed to produce the raster grid file lithicdist.grd and then reclassed according to the variable subset parameters (K1 (0-250 m) = 3, K2 (250-500 m) = 2, K3 (500 -1000 m) = 1, and K4 (>1000 m) = 0) to produce lithicreclass.grd.
Variable K: Proximity to Lithic Source

identify all geological features with potential for chert intrusions

compute pixel distance to lithic source and reclassify according to subset parameters

Figure 28. Model flow chart and final grid (lithicreclass.grd) of Variable K: Proximity to Lithic Source.
L) Slope (Figure 29):

The combined elevation grid for the six quadrangles, 6grids.grd, was used to determine slope values for the sample study area. Using the ArcView command to derive slope, the grid file slope.grd was created. This file was then reclassed according to the subset criterion outlined for Model Two (L1 (0-5%) = 3, L2 (5-10%) = 2, L3 (10-20%) = 1, L4 (>20%) = 0) to produce slope4.grd.

M) Stream terrace location (Figure 30):

Using the geology.shp file, which portrays surface and subsurface geology for the sample project area, Quaternary fluvial terraces and Quaternary alluvial terraces were selected out to form the file Qal+Qft.shp. This variable was included in Model Two in order to isolate inland coastal riverine resource exploitation. Therefore, the shapefile produced for variable H, ecobndry.shp, which defines the border between upland and lowland areas, was used to select out only upland terraces from the Qal+Qft.shp shapefile. This file, Qft+Qalclip.shp was then converted to grid format to produce geology.grd and reclassed according to the subset guidelines which state M1 (terrace units) = 3 and M2 (non-terrace units) = 0, to produce the final file terrace.grd.

N) Water versus land features (Figure 31):

Because the final product of combining variables A through M, which produces a grid file representing relative pixel probabilities, includes areas that are currently under water, a file was produced to give all pixels representing water features values of zero. To produce this file, riverine, marine, and estuarine features were queried out of the NWI coos_pol.shp polygon file and combined with the lakes.shp file to produce hydropoly.shp. This file was then converted to the grid file hydropoly.grd and merged with the grid representation of the twater.shp file,
Variable L: Slope

- `6grids.grd`
  - derive slope

- `slope.grd`
  - reclass

- `slope4.grd`
  - compute pixel slope and reclass according to subset parameters

**Figure 29. Model flow chart and final grid (sloperclass.grd) of Variable L: Slope.**

Sample Area Boundary

Grid Pixel Value (subset parameters)
- L4 (>20%) = 0
- L3 (10-20%) = 1
- L2 (5-10%) = 2
- L1 (0-5%) = 3
Variable M: Upland Stream Terraces

- **geology.shp**: query
- **QaL+Qft.shp**: identify stream terrace features
- **QaL+Qftclip.shp**: identify all stream terrace features within coastal uplands
- **geology.grd**: clip with polygon
- **hillshade.grd**: on-screen digitization
- **ecobndry.shp**: identify boundary between coastal lowlands and inland uplands
- **terrace.grd**: convert upland stream terrace features to grid and reclass according to subset parameters

Figure 30. Model flow chart and final grid (terrace.grd) of Variable M: Upland Stream Terraces.
Variable N: Water Versus Land Features

1. Identify all natural hydrological polygon features
2. Combine marine.shp, riverine.shp, estuarine.shp, lakes.shp
3. Convert to grid hydropoly.shp
4. Convert to grid twater.shp
5. Merge hydropoly.grd and twater.grd
6. Convert line and polygon hydrological features to a single grid file
7. Reclass hydro.grd
8. Identify water versus land features and reclass according to subset parameters (in order to eliminate water pixels from model results)
9. Final grid (hydrobad.grd)

Figure 31. Model flow chart and final grid (hydrobad.grd) of Variable N: Water Versus Land Features.
hydroarc.grd, to produce hydro.grd, a raster representation of all natural hydrological features on today's landscape. Hydro.grd was reclassed to produce hydrobad.grd, a file which classifies all water features as zero and all land features as one.

Outcome- patterns

Following Limp and Carr's (1985) additive method and Dalla Bona's (2000) weighted-value method, the mathematical operation for predicting each site was performed. Weights and values were assigned to each 10m x 10m landscape area, which are represented digitally by pixels in the raster grids. Each pixel, therefore, is given a numerical value, based on the variable subset parameters, which is then multiplied by the variable weight assigned to each variable based on site type. Next, pixels from each variable's grid representation are added together to form the final grid for each site type.

As mentioned above, one additional step was added to each site type math equation: the multiplication of the results from manipulation of Variables A-M by Variable N in order to eliminate all pixels representing water from the final grid representation of relative site potential. The results of the data manipulation are depicted in the five grid files resbascl.grd, resbasin.grd, relfcscl.grd, relfcin.grd, and station.grd (Figure 32). Full-page depictions of these grid files are shown in Figures (33-37).

Figure 33 depicts the results of the weighted-value method of modeling a coastal residential base. Areas with the highest total pixel values, which represent areas with the highest relative potential for containing an archaeological site, are located in relation to the following landscape features:
Figure 32. Calculation of weighted-value models for each site type to produce relative potential maps.
Figure 33. Relative archaeological site potential results for Residential Base (Coastal) calculated using the weighted-value method.
- *Areas with the highest relative potential* include low-slope areas located near coastal streams and in close proximity to complex coastlines, such as the present-day Coquille estuary and the six former estuaries which have since been blocked to form coastal lakes.

- *Areas with the next highest relative potential* include low-slope locations near coastal and inland streams.

Highest total pixel values for **inland residential bases** (Figure 34) are focused near the following landscape features:

- *Areas with the highest relative potential* are on low-slope surfaces at the intersections of streams or estuaries with ecotone boundaries or on the low-slope surfaces of coastal bluffs, which are also modeled as ecotone boundaries.

- *Areas with the next highest relative potential* are concentrated on low-slope terraces along inland stream channels.

Figure 35 displays the areas with the highest probability of containing **coastal resource extraction locations or coastal field camps**. Landscape features associated with these high-value pixels are listed below:

- *Areas with the highest relative potential* include those surrounding the present-day and former estuaries (complex coastlines) and locations near stream and lithic source intersections.

**Inland resource extraction locations or field camps** (Figure 36) have the highest probability of being located in relation to the following landscape features:

- *Areas with the highest relative potential* are located near the intersections of streams and ecotone boundaries or near the intersection of streams and lithic sources.

- *Areas with the next highest relative potential* are on terraces along inland streams.
Figure 34. Relative archaeological site potential results for Residential Base (Inland) calculated using the weighted-value method.
Figure 35. Relative archaeological site potential results for Resource Extraction Location or Field Camp (Coastal) calculated using the weighted-value method.
Figure 36. Relative archaeological site potential results for Resource Extraction Location or Field Camp (Inland) calculated using the weighted-value method.
Station archaeological sites (Figure 37) have the highest probability of being located in relation to the following features:

- **Areas with the highest relative potential** are on the ecotone boundary coastal bluffs overlooking the former coastal plain.

Once these five final grids pertaining to site type were created, grid pixel values in the top twentieth percentile for each grid were queried out and reclassified (top 20% = 1, lower 80% = 0) to produce the files `resbas cst20%.grd`, `resbasin20%.grd`, `reflecst20%.grd`, `reflecin20%.grd`, and `station20%.grd`. These grids were then merged together to produce the file `model2sites.grd`. This file, overlayed on the project area elevation figure to produce Figure 38, displays areas where the top values for the five site-type grid files occur. Where there is overlap between top values, the pixel value increases according to how many top value files have overlapped.

Based on the `model2sites.grd` grid file and graphical representation (Figure 38), it is apparent that the area with the highest probability for containing any type of archaeological site dating to the time period of interest is associated with the following landscape features:

- **The area with the highest relative potential for archaeological materials related to any type of site to occur** lies along the Coquille River, at the upper end of its estuary, where it intercepts the upland/lowland ecotone boundary. Four out of the five site-type weighted-value grid files predicted this as a high probability area because of the conditional preference aspects associated with particular landscape features. For example, this is a location associated with a river which would have provided aquatic and terrestrial subsistence resources, water, and access to transportation. It is on the Coquille estuary, a complex coastline which provides access to marine and riverine resources, protection from harsh coastal storms, and access to transportation. It is on an ecotone boundary, which increases access to terrestrial resources, and, finally, it is a low-slope surface, which makes it a more hospitable location for a habitation site or field camp.
Figure 37. Relative archaeological site potential results for Station calculated using the weighted-value method.
Figure 38. Sample study area displaying top 20% pixel values for each of the five site types, showing overlap. Yellow pixels indicate areas with the highest probability of containing archaeological materials of any type.
CHAPTER 6. CONCLUSIONS

The contention that human groups may have entered the Americas via a coastal route is not a new concept (Fladmark 1979; Gruhn 1988, 1994; Easton 1992). Support for this idea could come in archaeological form if cultural materials dating to the late Pleistocene can be unearthed. The search for such archaeological evidence is a formidable task. This predictive modeling project endeavors to provide a methodology for narrowing the scope of this search.

Two separate models are produced and applied to a sample study area in Coos County, Oregon, an area with landscape features comparable to the southern coast of Oregon as a whole. Environmental data pertaining to the late Pleistocene is examined to determine what landscape features may have been used by human groups 15,000 years ago and to determine how these landscape features may have changed since that time. Cultural data, in the form of ethnographic information, theoretical conjecture, and archaeological analogs, are examined in order to extrapolate those environmental features which may have influenced landscape occupation choices in the past. These landscape features, called conditional preference aspects, are proxy representations of basic human needs or preferences, such as the need for fresh water or the preference of a low-slope.

Landscape features deemed important to prehistoric occupation location decisions are incorporated into two archaeological predictive locational models as independent variables. The dependent variable for each model is the relative probability that an area will contain archaeological materials.
Significant Conclusions from Model One

Model One recreates the prehistoric choice making process using the hierarchical decision rule approach. This approach assumes that decision makers in the past would have viewed landscape features sequentially rather than simultaneously. Independent variables in the form of three physical landscape features, which represent generalized human needs or preferences (conditional preference aspects), and three landscape features, which represent the effects of formation processes on the archaeological record, were identified. These variables were converted to digital format, combined in a mathematical equation, and graphically modeled to produce a map portraying areas within the sample study corridor with the highest potential for containing archaeological sites dating to 15,000 years ago (see Figures 12-20 for a graphical representation of the modeling process).

Based on the information provided by the output of Model One, graphically displayed in Figure 20, the following testable hypothesis can be presented:

** Within the sample study area, archaeological materials dating to ca. 15,000 yr BP will be found more frequently in the yellow highlighted areas depicted in Figure 20 than in other locations within the sample study area.

Significant Conclusions from Model Two

Model Two integrates simultaneous decision making processes using an additive, weighted-value equation. A number of variables were identified as being important to prehistoric occupation location choices in terms of the conditional preference aspects that they represent to a late Pleistocene, coastally adapted population. By digitally depicting these variables, weighing them according to the amount of influence they would have had on specific site-type locational
choices, and adding them together to form final grids, areas with the highest potential for
containing archaeological materials dating to 15,000 years ago were highlighted for each specific
site type (Figures 23-37). Finally, by combining the high-potential areas from all five site-type
grids, a grid was formed which clearly displays the location within the sample study area most
likely to contain evidence of ancient human occupation (Figure 38).

Based on this resulting grid from the processing of Model Two, graphically displayed in
Figure 38, the following testable hypothesis can be proffered:

** Within the sample study area, archaeological materials dating to ca. 15,000 yr BP will be
found more frequently in the yellow highlighted areas depicted in Figure 38 than in other
locations within the sample study area.

Discussion

A visual examination of the final grids from Model One and Model Two, Figures 20 and
38 respectively, reveals an obvious difference in model results. Model One produced small, finite
areas with the potential for archaeological materials. This is a result of the type of modeling
approach employed in Model One—areas were considered in a boolean fashion, either as
possibilities or not. Model One does not allow for different levels of probability based on
different combinations of variables. Conversely, Model Two displays larger areas with the
potential for containing archaeological materials, and these areas are displayed in relative
measurements based on a variety of variable value and weight combinations.

While the more finite, boolean Model One may be easier to model (requiring fewer steps
and explanations), and eventually field test (representing smaller areas on the landscape), Model
Two allows for much more flexibility in results and probably represents a more accurate
depiction of the decision making processes of prehistoric human groups. For example, an
occupation location may have been chosen because it allowed easy access to shellfish, fresh
water, and protection from storms while another location may have been located next to fresh
water and a lithic outcrop on a coastal bluff. Both locations may have been considered good for
habitation, but neither represents all the possible variables that may have been considered in
choosing an occupation location. If these variables had been integrated into Model One, neither
location on the landscape would have been highlighted as a high probability area. However, both
would have been depicted as areas with high potential in Model Two.

Model Two allows for additional variable manipulation in the form of weight
assignments, which are based on information particular to a specific adaptation or occupation site
type. These assignments may be subjective, but explanations included in the text regarding these
weights allow for interpretation of results and the possibility of weight alteration as more
information regarding the modeling subject becomes available. In conclusion, while Model Two
may be slightly more difficult to operationalize and eventually field test, it offers a versatility in
production, ease in refinement, and flexibility in results unavailable to Model One.

A factor to consider in regard to both modeling exercises concerns the data used to
represent environmental variables. Data used to produce both models come in digital format.
Digitizing is a simplification of reality and introduces a source of error to the models.
Additionally, many of the data sets used were originally produced at a variety of scales and
subsequently rasterized into a finer-scaled resolution of ten meters. This manipulation of data is
another source of error in the modeling process.

In addition, the quality of the data itself may be limited. For example, the formation
process variable of geology included in Model One was originally produced as a map providing
information about gross-scale bedrock and surface geological units. This information does not
separate Quaternary geological units into those units deposited in the Holocene versus those
deposited in the Pleistocene. This grouping of units leads to additional error in the model results.
Such sources of error must be noted when analyzing model results and using these results to
guide future field work.
Perhaps the most significant source of error in the modeling process lies in the assumption that the present-day digital representations of landscape features accurately depict the locations of these features in the past. It is very probable that the locations of certain features, for example stream locations, have changed over the last 15,000 years. Research into the evolution of the landscape's natural features should be conducted in order to produce a more accurate model of land-use activities and the locations of these activities in the past.

**Generalization of Results and Implications for Future Work**

In terms of generalizing the results of this modeling project, the specific areas highlighted in the final grids produced by Models One and Two are applicable only to the sample project area. However, because landscape features in the sample project area are representative of many landscape features found on the southern Oregon coast as a whole, Models One and Two can both be applied to southern Oregon coast using the same variables, variable values, and variable weights. The methodology used to analyze the environmental and cultural data required for such a project, to isolate the independent variables used in the production of these models, and to integrate data variables into the mathematical and geographic information system structure of the models is applicable to any landscape.
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