

**Calibration/Validation of Classified Remote Sensing Imagery  
using Archaeological Data from  
the Gates of the Arctic National Park and Preserve**

**Submitted to:**

**Gates of the Arctic National Park and Preserve**

**by**

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## **Executive Summary**

The use of classified remote sensing satellite data offers the National Park Service (NPS) a non-invasive tool in cultural resource management. The NPS is charged with the management of cultural resources in the 8.5 million acres in the Gates of the Arctic Park and Preserve, in the central Brooks Range of northern Alaska. The entire jurisdiction is beyond the reach of roadways and NPS protocols mandate minimal impact to maintain the park's wilderness character. Satellite-based radiometry and telemetry promise easier mapping, often at the site level. Before satellite imagery can be employed as a replacement for commercial aerial photos and field reconnaissance, it is necessary to assess satellite capabilities. The research proposed will first establish ("calibrate") the limits of present classified imagery by using sites recorded, mapped and tested by field personnel from 1950-1995. Ethnographic and archaeological data bases from this previous research are reviewed and prioritized to guide in the selection of areas for imagery and study. Satellite images will be compared to this data base, itself digitized and placed on geographic information systems. Once the search image is established for satellite systems, then unmapped areas of GAAR can be surveyed using satellite images. Ground-truthing efforts will be used in confirming inferred artifact distributions and site identifications.

## **Introduction**

The National Park Service (NPS) is charged (Ring 1985) with the management of cultural resources in the 8.5 million acres in the Gates of the Arctic Park and Preserve, in the central Brooks Range of northern Alaska. The entire jurisdiction is beyond the reach of roadways and NPS protocols mandate minimal impact to maintain the region's wilderness character (Ring 1985). Cultural resource management concerns such as impact mitigation require locational data on archaeological and cultural properties. Until the advent of satellite telemetry, the acquisition of archaeological data required time-intensive pedestrian surveys and labored under severe logistical constraints that required substantial monetary outlays. Over the last generation, archaeologists across northern Alaska routinely have used aerial photogrammetry to identify disturbance vegetation associated with sites, to determine survey routes, as locational aids while surveying and recording sites and to infer geomorphic changes. The NPS quickly accepted aerial photogrammetry as a low-impact method to map and assess cultural resources (Lyons and Avery 1977, Lyons and Mathien 1980). Nonetheless, on-the-ground inspection was necessary to record feature and artifact distribution on sites due to the coarse resolution of commercially available small scale (1:60,000) aerial photos. Advances in satellite-based remote sensing, propelled by National Defense requisites, has brought the resolution capacity down to the scale of reading 15 cm long objects from images (Richelson 1988:49). In addition, satellite radiometry and telemetry may offer the possibility of ground-penetrating radar and increased ease of digitization and data base management. Further, satellite costs may be more efficient, easier and involve less effort than contracting fixed-wing conventional aerial photography.

Archaeological surveys indicate that the human occupation of the Brooks Range can be traced back several thousand years; the earliest firm evidence is from 6000 year old sites in Anaktuvuk Pass (Campbell 1962, Gal 1982). Undated artifacts on the surface indicate that humans first lived in the Brooks Range more than 10,000 years ago, based on comparisons with dated occupations along the northern foothills of the Brooks Range which reflect "Paleo-Indian" visitations (Reanier 1995, Kunz and Reanier 1994, 1995). Settlement in the austere, largely treeless Brooks Range depends on a combination of advantageous climatic conditions and adequate logistical materials (Mason and Gerlach 1995). Despite its lengthy prehistory, the Brooks Range presents archaeologists with both daunting challenges for site discovery and opportunities for research. Gates of the Arctic Park and Preserve (GAAR) is typical of the range; it is rugged, roadless and topographically complex. Much of its upper elevations were repeatedly glaciated during the Pleistocene and throughout the Holocene (Hamilton 1986).

## **Problem Orientation: Management Concerns**

For the last fifty years, archaeologists have used field-based methods to assess the extent of past human occupation in the Brooks Range. Logistics have largely determined the progress of archaeological research; many of the first efforts (Irving 1951, 1953; Campbell 1959, 1961, 1962) focused on the immediate vicinity of Anaktuvuk Pass, perhaps not co-incidentally the largest Native settlement in the Range. Survey efforts are often constrained by the three month warm season and the restricted capabilities of high-cost fixed wing, float planes or helicopters. The

most intensive survey effort during the mid-1980's by Kunz et al. (1984, 1986, 1991) produced only a small sample (<2%) but required three calendar years to complete only 9 months of field survey; the total expenditures involved totaled over \$500,000, with most of the monies used for helicopter and other logistical costs. The use of remote sensing in surveying for cultural resources will help the NPS to restrict helicopter overflight. In addition, a remote sensing approach could speed the survey of GAAR, accomplishing years of survey and recording in weeks of photogrammetric efforts rather than years of on-the-ground survey.

The imagery obtained from remote sensing will be readily transferable to the emerging Geographic Information Systems (GIS) data bases in development by the NPS. GIS promises data manipulation on regional scales, lending cultural resource Managers and research archaeologists instantaneous mapping capabilities (cf. Aldenderfer and Maschner 1996, Maschner 1996).

### **Aerial Survey and Remote Sensing in Alaskan Archaeology**

The utility of aerial photogrammetry was readily appreciated by archaeologists working in remote areas of Alaska. As early as 1939, oblique aerial images suggested to Larsen and Rainey (1948) that vegetation differences could reveal subsurface deposits. By the mid-to-late 1950s, Giddings (1962) mapped settlements on Cape Krusenstern beach ridges using photos obtained from the U.S. Coast and Geodetic Survey. Beach ridges presented ideal circumstances for photo-mapping, considering the predictable linear trend of the well-drained gravel ridges and the house remains identifiable from vegetation patterns. However, the need to ground-truth inferences derived from photogrammetry was also recognized by researchers in the 1970's. While Andrews et al. (1977) surveyed several of the Ipiutak and Jabbertown sites on the Point Hope beach ridges, ground-truthing showed that photo interpretation did yield reliable results, and could be improved with larger scale photos (1:500 was recommended), photos shot after a light snow, and with improved knowledge of plant phenology (Andrews et al. 1977:53-54).

Aerial photogrammetry specifically commissioned by the BLM for archaeological purposes commenced in 1979 with Gal's (1980) attempt to map lake side villages in the Brooks Range. By the mid-1980's, the inspection of aerial photos had become a standard part of field operations, used only as a first cut in designing research, in undertaking field surveys and in locating sites (Davis et al. 1981, Kunz et al. 1984, 1986, 1991, Reanier 1992). In the mid-1990s, classified remote sensing data were first employed by the NPS on the Cape Krusenstern beach ridges (Klingler, 1997, pers. comm.); the results are not yet released to the public.

### **Archaeology Data Base and Visibility: Questions of Scale**

Most frequently, in designing survey strategies Alaskan archaeologists meld ethnographic data with topographic or geomorphic considerations to predict site location. Northern Alaska benefits from the presence of informants still knowledgeable in pre-industrial subsistence techniques (Binford 1978b, Hall et al. 1985). In northern and central Alaska, a variety of site types are reported, ranging from localized berry-picking areas and hunting blinds to caribou drive lines that extend over kilometers. A wide variety of sites can be identified by observations of contemporary Native hunters from Anaktuvuk Pass (Rausch 1951, Campbell 1968, Binford 1978a, 1978b, 1983, Hall et al. 1985). Collector based strategy prevails in northern latitudes, enforced by the patchy distribution of foods (Binford 1983). The sites occupied by several families could reach a staggering number over the

course of a generation or two. In just two years in the 1940s (before the introduction of the snowmachine), one Anaktuvuk family used or established about 40 sites and used a number of other pre-existing sites. Several of the eight site types were subject to only transitory use; for example, kill sites might be used just once (Binford 1983:328). Five principal types of settlement (Campbell 1968:15ff) characterize Anaktuvuk (or Tuluqmiut) people, based on variations in size, length of use and seasonality. About half the year (April, May, August to October) was spent in a lake side settlement of 10 to 12 surface dwellings of willow and hide, sufficient for roughly 50 people. Much of the winter was spent in a sheltered canyon within the forest boundary, with access to sheep or caribou. The winter camps were comprised of only two families, and consisted of hide structures, occasionally walled with rocks (still roofed with hides). The other settlement sites were used only for several days; these include hunting and fishing camps, other resource extraction camps (stone, feathers, spruce wood) and trading camps (Campbell 1968:16-17). Anaktuvuk people made sporadic use of rockshelters (Binford 1978b:459-461).

The occupation of the tundra-covered portion of the Brooks Range is constrained by available fuel and construction materials. In much of the range, the several species of willow (*Salix* spp.) provide the only reliable source of material for fuel and tools (Campbell 1968:8). In great measure the patchy distribution of willow thickets (at times 16 km apart) is a good predictor of settlement sites used for more than a couple of days (Campbell 1968:9). As Binford (1978b:425) observed: "every effort was made to construct winter houses in or very near a substantial stand of willows." Willow stands were very susceptible to depletion, roughly half a century was required for a stand to recover after human settlement (Binford 1978b:425).

A host of geomorphic factors influence the use and placement of caribou drive lines, reflecting the necessity of guiding caribou in relation to topography, e.g., precipitous talus, low cliffs, linear features such as eskers (Binford 1983:332). Willow groves again could be instrumental as blinds for hunters. The final caribou killing operations often used lakes as a drive site, requiring the launching of kayaks. The construction elements used in caribou drive lines involve both a corral region of small scale snares (piles, of sod, moss and willow) and a laterally extensive series of scare-crows ("inuksuk") composed of stone, sod and moss (Gubser 1965:173).

On the micro-scale, ethno-archaeological data is useful in establishing the likely parameters of sites used for hours to days. At the Mask Site, Binford (1978a) describes the artifacts used and mapped the location of men sitting around fire hearths at hunting blinds. Wind direction and the use of large boulders as wind breaks influenced the placement of individuals around hearths (Fig. 1). The archaeological residues mapped by Binford (1978a) include shell casings used in target practice, wood shavings produced by sharpening, and a number of discarded items such as pop and sardine cans, rope segments and worn gloves.

### Geologic/Geomorphic Constraints

Glacial expansion in the Brooks Range was limited to valley basins with the most extensive glaciations occurring during the early and middle Pleistocene (1,900,000 to 500,000 years ago). Weathered end moraines from these earliest glaciations extend tens of kilometers north of the Brooks Range foothills (Hamilton 1986). A variety of glacial land forms can be preserved; including the residua of terminal and ground moraines, ice-cored moraines, outwash terraces, lake sediments and basins (Brown and Krieg 1983). Deposits associated with the last glacial/deglacial cycle, 28,000 to 14,000 <sup>14</sup>C years ago, are particularly well-mapped in Anaktuvuk Pass (Porter 1966) as well as in several other parts of the Brooks Range (Hamilton and Porter 1975, Hamilton 1973, 1980, 1982a,

1982b, 1986). Localized glacial expansion continued throughout the Holocene, restricted to the higher valleys (Ellis and Calkin 1984). Once emplaced, landforms can be transformed (re-activated) by different geomorphic processes. For example, dunes and blowouts are now forming within lake sediments originally deposited within a proglacial lake during the late Pleistocene (before 14,000 BP) (Chapman et al. 1964, Hamilton 1973, 1980, 1982b, Tedrow 1977:329). Glacial activity has produced much of the better drained, elevated topography along and within valley bottoms that are conducive to human use in siting drive lines, watching game and in locating house pits and fish camps.

Soils and cryogenic processes are a major concern in this study because natural processes continually transform the landscape, often releasing a wide variety of clastic materials on to the surface (Brown and Krieg 1983, Tedrow 1977 Washburn 1980). Many fractured rocks can be readily confused with artifacts by the casual observer, even on visual inspection. The sediments and clasts comprising glacial landforms are within the same size and shape (Reineck and Singh 1980) as stone artifacts and offer a challenge to detection by remote sensing techniques. One approach to mitigate these effects is choosing known sites with exotic lithologies; e.g., obsidian (volcanic glass). Thus, it is extremely essential to analyze the geomorphic evolution of landforms underlying archaeological sites selected for study. In specific, the cryogenic processes capable of producing geofacts (cf. Washburn 1980) must be identified and incorporated into remote sensing interpretations.

Vegetation distribution and history also is a major constraint on both human use of the landscape and in archaeological visibility. Pollen stratigraphy revealed in lacustrine cores especially in the Walker Lake drainage has enabled the reconstruction of vegetation history for the central Brooks Range (Brubaker et al. 1985). Fell-field and arctic desert tundra dominated the nunataks of the Range during the Pleistocene. Intense warming during the late Pleistocene/early Holocene led to the colonization of the newly exposed valley bottoms by dwarf birch by 12,000 BP, with the entry of Poplar by 11,000-10,000 BP. Human colonization of the Brooks Range might have been limited by the availability of wood (Mason et al. n.d.).

The age and history of land forms conditions archaeological discovery; obviously, old sites will not be found within eolian or alluvial deposits that are only tens to hundreds of years old. Geologic mapping is a necessary preface to any systematic archaeological survey or regional analysis. Quaternary surficial geologic mapping should be incorporated in any GIS layers used in this study. Sites of various likely ages will be selected for inclusion, providing cultural resource managers with the full range of variability likely to be encountered in the field. The rates of geologic processes, for example, eolian deflation and riverbank or lake shore erosion, are often fairly rapid, and readily documented using sequential aerial photographs.

#### **Remote Sensing Methodological Expectations**

Remote sensing techniques developed by the Intelligence community include the same range of multi-spectral systems and side-scanning radar that are commercially available (Lillesand and Kiefer 1994). The various electromagnetic scanning media (Drury 1993, Vincent 1997) include: (a) optical; (b) radar; and (c) infrared. Pixel resolution for commercial products rarely attain less than 15-20 m across (Drury 1993:55-67), although the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) may provide close to 1 m resolution (Vincent 1997:Appendix B).

Several possible archaeological applications of higher resolution imagery can be envisioned. Site recording and mapping are the principal targets for research. SAR (synthetic aperture radar) offers the capability of ground penetration up to 2 m subsurface; considering that most/if not all Brooks Range archaeological sites are <50 cm below the surface, this capability could be used to assess the density and location of buried remains.

Digital photogrammetry (extraction of GIS data from photos) offers (Vincent 1997:164) the seemingly utopian possibility of satellite-based mapping of artifact scatters and caribou drive lines. Digital elevation extraction software will allow the transfer of remote sensing derived imagery directly into GIS databases. Satellite mapping of archaeological data requires that remote sensors can detect and record 3-dimensional coordinates for discrete lithic artifacts (flakes, cores, bifaces). Caribou drivelines could be depicted in three dimensions, and analysis of line-of-sight between sites will be possible. Ultimately, remote sensing data will allow the GIS depiction of the entire range of prehistoric occupation in GAAR.

### **Archaeological Mapping as a "Cal/Val" Issue in Remote Sensing**

Archaeological data offers the remote sensing community an opportunity to calibrate satellite-derived imagery with on-the-ground characteristics of the landscape. The challenge of this project involves stretching the envelop of resolution of satellite imagery. In terms of the remote sensing concerns, archaeological mapping by satellite represents a "cal/val" problem. Teillet et al. (1997:402) define calibration as "the system response to known controlled signal inputs" and validation as "assessing the quality of data products by independent means." The satellite images are identified by conventional parameters (wavelength, band width, etc.) while archaeological ground-truthing offers the possibility of cross-checking the satellite products.

The criteria useful in scheduling satellite time include numerous meteorological, biotic and geomorphic factors. For example, thin snow cover could prove useful to recover subsurface artifact distribution, considering the purported capabilities of SAR to penetrate the ground by up to 1 m (K. Dean, pers. comm., 1998). Archaeological site visibility depends on vegetation characteristics; while artifact scatters may be more evident if plant leaves are lacking (pre-green-up and fall conditions), high nutrient (nitrate or phosphate) areas associated with hearths show up well with the seasonal florescence of disturbance vegetation. Scheduling for satellite time will thus involve considering the phenology of vegetation (i.e., average date of leaf-out, end of snow cover, etc). Topographic factors, for example, slope and aspect, may be crucial in avoiding persistent snow banks and in isolating sites that green-up early. The use of some sensing techniques (i.e., side-scanning radar) may require decisions about the angles of site features; for example, the orientation of house depression and cache pits, deflation hollow, or large rock features.

### **Research Methods and Protocols**

#### **Site Selection: Archaeological and Geomorphic Criteria**

The proposed research involves several steps. First, archaeological sites will be selected for satellite remote sensing. The process of selecting sites considers the ethnographic and archaeological factors described in this proposal. In view of the limited number of temporally defined (i.e., dated) sites, the emphasis will be on the representation of site types not on temporal placement. Site characteristics of concern (Table 1) include

geomorphologic parameters (lake, prominence/lookout, dune), site function (i.e., habitation, kill or processing, etc.) and extent of documentation (existing site map, previous history of research (i.e., radiocarbon dating). Site visibility (size and scale) will influence and be a major focus of the selection process because larger sites (i.e., house depressions) can be easily identified with conventional commercially available imagery with less cost and effort than resorting to classified satellite imagery. Questions of site selection are addressed in this proposal and several sites are selected for inclusion for the first year of satellite time. Additional sites and areas will be selected in future years using the criteria outlined in this proposal. After securing images, the research process involves several further procedures.

#### **Deciphering Imagery, Digitizing and Translating to GIS databases**

Definitions of cultural evidence will be isolated from non-cultural background ("noise") features such as vegetation, rocks, and exposed sediments (sand, gravel). Remote sensing data will be transferred (cf. Lillesand and Kiefer 1994:524ff, Vincent 1997:164) into digital GIS, with the aim of elevational mapping and display on a multi-layered GIS. To aid in comparisons between maps produced by commissioned photos, commercial and archived aerial photographs will be digitized. This will assist in cross-referencing site characteristics observable on black and white photos shot prior to 1955, before archaeological recording in the 1970's and 1980's.

#### **Ground Truthing**

The GIS maps and site maps produced by Remote Sensing images will be validated using data derived from on-the-ground site inspection, photography and mapping. Data from site files and the extant literature will provide the first cross-check. To further realize the validation of remote sensing data, the investigators will visit several sites and compare both previous field efforts and the maps generated by the remote sensing project.

#### **Archaeological Sites Selected for Remote Sensing in FY 1997-1998**

##### **Kurupa Lake (KIR-124)**

The Kurupa Lake site, excavated by Schoenberg (1985) during 1979-1982, consists of several surface features: seven tent rings, and several surface and subsurface archaeological components spanning the last five to seven thousand years (Schoenberg 1995). KIR-124 lies 1 km from the south margin of Kurupa Lake, on a bedrock lobe adjacent to the third of several "terraces" south of the lake (Schoenberg 1985:70-71). The terraces are possibly ice push ridges or beach ridges associated with a higher stand of Kurupa Lake. The extent of the Kurupa Lake site is unknown, although materials outcropped over 5000 m<sup>2</sup> within several discrete scatters of lithic artifacts (Schoenberg 1985:74-75). Archaeological research at Kurupa Lake produced 15,000 artifacts from 1100 m<sup>2</sup> of surface collections and 10m<sup>2</sup> of excavation. In view of its close proximity (<5 km) to siliceous rock outcrops, the site apparently served as a lithic reduction center

##### **KIR 139**

Roughly 20 km NW of KIR-124, on north aspect of Kurupa Lake, KIR-139 describes a line of inuqsuq in area of Kurupa Lake (KIR-124). Recorded are 19 piles of rocks covering over 110 m. The size of "large stone or boulders" involved is not quantitatively stated in Schoenberg (1985:186ff), but the piles extend 50 cm above the surface. The inuqsuq terminates in a small depression which apparently served as the kill site for the impounded caribou; a small lithic scatter may be associated with the site.

#### **Tuktu-Naiyuk Site, XCL-003**

Tuktu-Naiyuk, one of the oldest (if not the oldest) archaeological sites in the central Brooks Range, extends across c. 100 m on the western margin of a glacial kame terrace, 7 km from Anaktuvuk village (Campbell 1961:62ff, Kunz et al. 1991:325-326). The site contained several features likely associated with tent structures and/or hearths; charcoal from one of the latter provides an age estimate of  $5688 \pm 183$  BP (SM-916) (Gal 1982:177) for the disposal of notched points ("Northern Archaic"), microblade cores, endscrapers, worked flakes, etc. The Tuktu site, despite its discovery in 1959, remains unique, providing discrete evidence of an early occupation. The association of notched points with microblades although common in Alaska cannot be authenticated so definitively as at the Tuktu site. Several late prehistoric cache pits were not "investigated in detail" by Campbell 1961:64). The site offers two opportunities for the present project; first, to cross-check Remote sensing data with records from previous excavation and recording and secondly, to monitor disturbance and the exposure of artifacts at a known site.

#### **Mask Site**

The Mask site is a multi-use hunting blind produced in the 1970s by Anaktuvuk Pass Inupiaq, documented and mapped by Binford (1978a). The locations of discarded sardine cans, string and other items, as well as large boulder features, are precisely mapped and interviews with informants (both in Anaktuvuk and the PI) should prove complementary. The site extends over a comparatively small area (less than  $25 \text{ m}^2$ ) and should provide a thorough test of the resolution capabilities of the DOD imagery.

#### **Tukuto Lake**

Over 120 prehistoric house depressions and 400 cache pits were placed on beach ridges parallel to the shores of Tukuto Lake, mapped in 1968 and 1970 by E.S. Hall (1975, 1976). The Tukuto Lake concentration represents one of the largest lake shore occupations in the Brooks Range, with house form topology indicating that occupation first occurred c. AD 1400 (Gerlach and Hall 1988). Hall tested roughly 10% of the houses and <2% of the cache pits; thus, most of the site remains intact. Detailed contour and/or plan maps are published for a few houses (Hall 1976:110-111). The Croxton site (XHP-311) on the south shore witnessed substantial excavation in 1981-82 by Gerlach (1989:127); roughly 30 grid squares (4 by 4 ft), or 15% of the site. Croxton had no surface features but reveals a considerable complexity of subsurface hearth and bone concentrations (>16,000 caribou elements (Gerlach 1989:254). The capabilities of ground penetrating radar radiometry should be quantifiable in the remaining portions

of the site. Several time periods are represented at Croxton, primarily Arctic Small Tool, as early as the 4<sup>th</sup> millennium BP and Ipiutak, c. AD 800-1000.

The Sikoruk site offers considerable potential for remote sensing calibration efforts. Hall (1976) produced several detailed topographic maps of house depressions; also available are large scale aerial photos, produced in 1980 by BLM. Several inuksuk are probably associated with sites on the north side of the lake (Gerlach 1989:124).

#### **Bateman (PSM-138)**

Remains of an Ipiutak house occurred at the Bateman site, located on the western shore of Itkillik Lake, a remnant of a proglacial lake formed after the deglaciation after 15,000 BP (Reanier 1992:144ff). In 1985, Reanier (1992:161ff) excavated 20 m,<sup>2</sup> exposing most of the inner surface of the 4 by 2.5 m house, dated to cal AD 440-660, the overlap of five <sup>14</sup>C ages (Gerlach and Mason 1992:70). The archaeological research at the Bateman site allows the quantification of remote sensing techniques and the monitoring of post-excavation vegetation recovery and erosion effects on the adjacent lake shore.

#### **Avingak (XCL-011)**

The remnants of at least three occupations occur along the southeast shore of Tuluak Lake, within Anaktuvuk Pass (Campbell n.d., Spearman 1991). Three discrete site areas include (a) late prehistoric to historic cache pits, along with exposed caribou bone; (b) 2 house depressions (1.3 by 1.3 m) with , and (c) six semi-subterranean house depression; one associated with two smaller pits. Campbell (n.d.:3) excavated two of the semi-subterranean depressions and tested the remainder. The excavations provided enigmatic to Campbell (n.d.), evidence of both microblades, small projectile points and a technology transitional between Arctic Small Tool and Ipiutak. A radiocarbon age reported in Gal (1982:170) indicates an age of 1470±80 BP (Gak-2304), cal AD 421-756. The Avingak site provides the possibility of identifying a variety of structural features and exposed bone.

#### **Tingmiakpak (KIR-273) and Killik River Dunes**

Several lithic scatters are reported from blowouts within the extensive dunes formed atop late Pleistocene lacustrine beds (Hamilton 1973, 1980, 1982b). Blowout sites offer several opportunities for remote sensing cal/val mapping. First, the artifacts are super-imposed on fine to medium sand which presents a monotonous fine-grained background. Second, site maps, with each artifact plotted (Fig. 2), are available for most, if not all, sites (Spearman et al. 1990, n.d.). Third, due to NPS non-collection policy, artifacts remain at most sites. Radiocarbon-dated caribou bone from KIR-273 reveals at least three occupations in the dunes: 8435±85 BP (Beta-49163), 7060±70 BP (Beta-49166), 3425±60 BP (Beta-49164) (A. Demma, NPS, written comm., 1998). Thus, the Killik River dune field offers an excellent opportunity for establishing maximum resolution of the imagery. Although no other sites are adjacent the early Holocene Tingmiakpak microblade site (diagnostic artifacts collected by T. Birkedal in 1991), an area 6 km to the north has a concentration of six sites of variable age and constitution.

## **Kobuk and Reed River Localities**

Several sites in the southwest portion of GAAR offer considerable potential for remote sensing mapping and reconnaissance. Over 30 sites, mostly small lithic scatters, are reported along the margins of Walker Lake (Hall in Kunz 1984). Another set of promising locations includes several obsidian flake and tools scatters on the upper Kobuk River, foremost are HUG-029 and HUG-037, separated by c. 1.5 km (Kunz 1984:131ff, 143ff). Kunz (1984:145) termed HUG-037 "of high significance....probably the oldest site encountered in [the 1984] survey." The site lies on a north/south trending ridge adjacent the Kobuk River and consists of a surface scatter within a 7m diameter, with "in excess of 100 microblades of various colors of chert" atop a surface "littered with pebbles weathered out of the conglomerate" bedrock (Kunz 1984:143).

Two other sites in the Reed River valley offer promise: XSP-124 and XSP-134 (Kunz 1984:192-193, 205ff). XSP-124, on the prominence of a bedrock knob, also describes a 15m<sup>2</sup> area, "littered with chert flakes, chunks and microblade fragments; a large flake knife (7.5 cm long) was "embedded" into the surface. XSP-134 lies less than 1 km to the southeast and included two scatters, one with "numerous large chert flakes and blades" over "a 19 by 24 m area on the promontory of a hill" (Kunz 1984:205). Micro and macro cores suggest lithic reduction, similar in method to the purportedly early site, the Gallagher Flint Station (Kunz 1984:206).

HUG-059 and 091, along Lake Selby, have a number of important features suitable for inclusion in the project. HUG-059 is a large depression, 6 by 4 m. The stratigraphy of the trench indicates its use, minimally, as a cache pit (few artifacts recovered). Kunz (1984:250ff) secured charcoal and obsidian from the site, using these data to construct a hydration curve for the Kobuk region (Kunz 1984:340ff). HUG-091, on a arcuate ridge at the lake's south margin, contains 12 circular depressions; soil stratigraphy and obsidian hydration age estimates indicate an age similar to HUG-059 (i.e., about 1500 years radiocarbon years BP or AD 500-600).

## **Summary of the Data Base**

Several time periods are represented in the sites selected for the initial photogrammetry. The range of ages of the sites covers most of the cultural manifestations in GAAR (Denali, Notched Point, ASTt, Norton and Numamiut) from the 8000 year old Tingmiakpak site on the Killik River, 6000 year old Tuktu site, 3500 year old Kurupa Lake, 1200 year old Croxton, Thule houses at Sikoruk to the Mask Site created just twenty years ago by Anaktuvuk residents. A number of geomorphic environments are included, including lake beach ridges, moraine and kame, dune and alluvial sites. Sites range in size from the large villages along Tukuto Lake and drive lines adjacent Kurupa Lake to small flake scatters near Walker Lake. Sites from across GAAR are included from the southwest to the northeast. Sites vary also in terms of lithology (chert, obsidian) and in subsurface components, including the complex faunal debris at Croxton to the alluvial sequence in some of the Anaktuvuk sites. In sum, the sites provide a wide range of possibilities for calibrating and testing the resolution capabilities of classified remote sensing imagery.

## **Research Schedule and Products**

### **FY 1997-98**

#### **Training, Acquisition of Data Sources, Security Clearance**

Preparation will dominate Year 1, FY1997-1998. Obtaining security clearance is a necessary prerequisite for conducting any future analytical research; hence, the PI will undergo training in Security procedures, attain proficiency in evaluating remote sensing products and techniques and in using Geographic Information Systems software and data analysis packages used by the NPS. In addition,, the PI will assemble archival and photogrammetric evidence collected by field archaeologists during 1950-1997 during the excavations and reconnaissance level surveys conducted in GAAR. This body of data will be first sought within collections archived at NPS (Anchorage and Fairbanks) and AHRS site records (SHPO office, Anchorage), the BLM Resources Library (Anchorage) from University of Alaska (Fairbanks) Museum collections, from Grant Spearman (North Slope Borough—Anaktuvuk). In specific, the PI will seek copies of site documentary evidence from principal Brooks Range researchers; specifically, William Irving (deceased), John Campbell (Univ. of New Mexico), Lewis Binford (Southern Methodist University), Michael Kunz (BLM-Fairbanks), Craig Gerlach (UAF Museum), Richard Reanier (Reanier and Ass., Seattle) and Edwin S. Hall (SUNY-Brockport)

A principal aim of the first season will be the identification of sites to be included in the remote sensing component; part of this task is accomplished in the Research Design. Selected sites will be used in planning satellite over flight operations; applications for satellite time will be submitted in last quarter of FY 1998. Overflight priorities include subsurface data inferences. Commercially available imagery for sites will also be secured through the Geophysical Institute, SAR and other agents.

Selecting the graduate Research Assistant will commence during the first quarter of FY 1998-1999; AQC will advertise Nationwide, if necessary, for an interdisciplinary archaeology student, with either a BA, preferably a MA incorporating GIS and database management with a sufficiently strong archaeological field experience.

### **FY 1998-99**

#### **Data Analysis and Ground Truthing**

In order to analyze the images obtained by DOD overflights, it will be necessary to classify and distinguish surface characteristics, including clast size and lithology, the identification of vegetation to species composition and percent of cover. These data provide the background, non-cultural component from which the archaeological patterns will be distinguished. This phase of analysis will rely on standard search images employed by remote sensing users in northern Alaska. Soil and vegetation maps will be generated by the Research Assistant.

Remote Images will be analyzed for archaeological content; this effort will be guided by the archived field data; known landmarks from site maps and excavation grids should render comparison straightforward. The limits of detection will be probed in the hopes of reading individual artifacts (projectile points, cores, debitage, bone). Remote

sensing images of likely artifacts will be digitized and transferred into database files and onto GIS. Large scale "drawings" will be assembled for artifacts and features tentatively identified from remote sensing images. These drawings will provide the database for future ground truthing efforts. Topographic maps will be generated from satellite generated data files. If detection is adequate, site maps will include elevation of features and artifacts. Several field reconnaissance visits will be during summer season of 1999. Finally, decisions will be made on the unsurveyed areas to be examined by satellites in Year 3.

### **Year 3, FY 1999-2000**

#### **Synthesis**

The third year will focus on the analysis of imagery obtained during satellite shots of Years 1 and 2. By this time, sophisticated algorithmic models to predict archaeological features/sites may be possible. This will involve comparisons of the products with similar results in the literature and in other DOD research. A large priority in this year will be the expansion of satellite mapping into unmapped valley(s), as selected during Year 2. Further, the Research Associate will be involved in comparing and defining the results from field-based ground-truthing and maps generated from remote sensing. This comparison should result in a fine-tuning of the map with the field data and the generation of more precise mapping results from Year 1 as well. By this time, final map products and GIS databases will be submitted to GAAR and articles on the research will be composed for publication; this will form portions of the Ph.D. dissertation.

### **Year 4, FY 2000-01**

#### **Completion of Report/Theses**

The final year will be oriented around finishing maps, synthesizing data sources, products and models used in predicting sites. All inferred sites/artifacts distributions will be plotted on GIS. The final report will recount the successes and failures of the mapping effort, as well as reporting on observed regularities in the GIS. Part of the final report will involve assessing the statistical significance of Mapping effort and the reliability of the mapping procedures. A cost/benefit analysis will complement the technical discussions and provide guidance for use of the results by cultural resource specialists in the NPS and academic community. The Ph.D. dissertation will be completed by this time, incorporating many of the concerns addressed by the research.

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**Table 1. Considerations in Selecting Archaeological Sites for Remote Sensing**

**Archaeological Criteria**

Features: Presence of House walls, Cache Pits, Rock Alignments, Hearths

Size/Scale: <5 m<sup>2</sup>, Lithic Scatter, Hunting Blinds, etc. as compared to

Drive lines extend over hundreds of kilometers

Number of Occupations—Stratigraphic complexity, Subsurface components

Function in Settlement Pattern

Extraction (berry picking, lithic material, peat or wood-cutting)

Hunting Blinds/Outlook

Fish Camps/Facilities (Drying Racks, weirs, netting sites)

Processing (Activity Areas): Kill Sites, Bone Processing and Fishing/Smoking

Settlement (related to duration of occupation)

Tent Ring

House Depressions/Sod Houses

Frame Cabins

Caribou Drive Lines

Grave/Cemetery

Temporal Placement

**Landform/Biotic Criteria**

Exposure and Aspect—Vistas

Degree of Consolidation Blowouts, Bedrock knobs)

Slope/Crest/Ridge Line

Process Alluvial—River Terraces, Bed (transverse bar etc.), River margin

Glacial—Esker, Kame, Moraine)

Lacustrine

Rockshelter

Slope Talus

Solifluction lobe

Vegetation Cover: Arboreal, Tundra, Unvegetated

**Table 2. Scheduled Plan of Research, Fiscal Years 1997-2000**

**Year 1, FY 1997-1998**

- Initial identification of Research Sites
- Training of PI and Student in Use of Classified Imagery and Use of the NPS GIS system
- Photogrammetry of Selected sites by DOD agent
- Secure Standard Imagery, commercially available, include SAR, ASTER, etc.
- Assemble Published and Unpublished site Records
  - Photographs, Field notebooks

**Year 2, FY 1998-99**

- Identify Soil Types and Vegetation on selected site, using archived sources,
  - inference from Aerial Photos)
- Analysis of NPS GIS to identify topographic, elevational parameters influencing site occurrence
- Analyze Remote Imagery from DOD, prepare maps and site description from Remote Images
- Comparison of Published with Collected Remote Imagery
- Ground Truthing of Remote Sensing and Archived Journals
- Input of Results onto GIS
- Completion of Research Products (i.e., maps and articles)
- Select Additional Sites for Remote Sensing
- Field visits to Ground Truth Remote Sensing Survey Results
- Initiation of Research and Academic Products (i.e., Thesis, articles)

**Year 3, FY 1999-2000**

- Analysis of Year 2 Acquisitions
- Compare Ground Truthed Results with Map Expectations
- Fine-Tune Models/ Interpretations of Maps generated from Year 1 and 2
- Completion of Maps, Submission of Articles for Publication

**Year 4, FY 2000-2001**

- Expansion of Satellite Mapping to Unsurveyed Valley(s)
- Plot expected sites on GIS
- Select sites for Remote Sensing Mapping
- Compare Results with previous field reconnaissance
- Calculate Statistical Significance of Mapping effort
- Assess Reliability of Mapping Procedures
- Completion of Ph.D. dissertation by Research Assistant and Publication of Articles



