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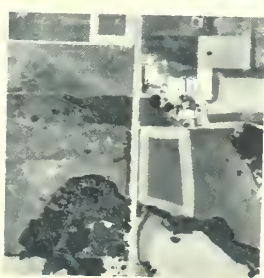
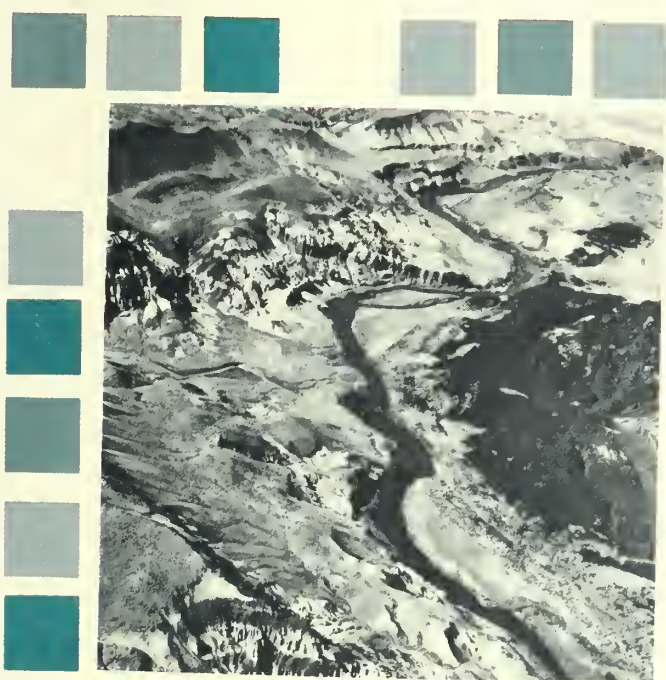
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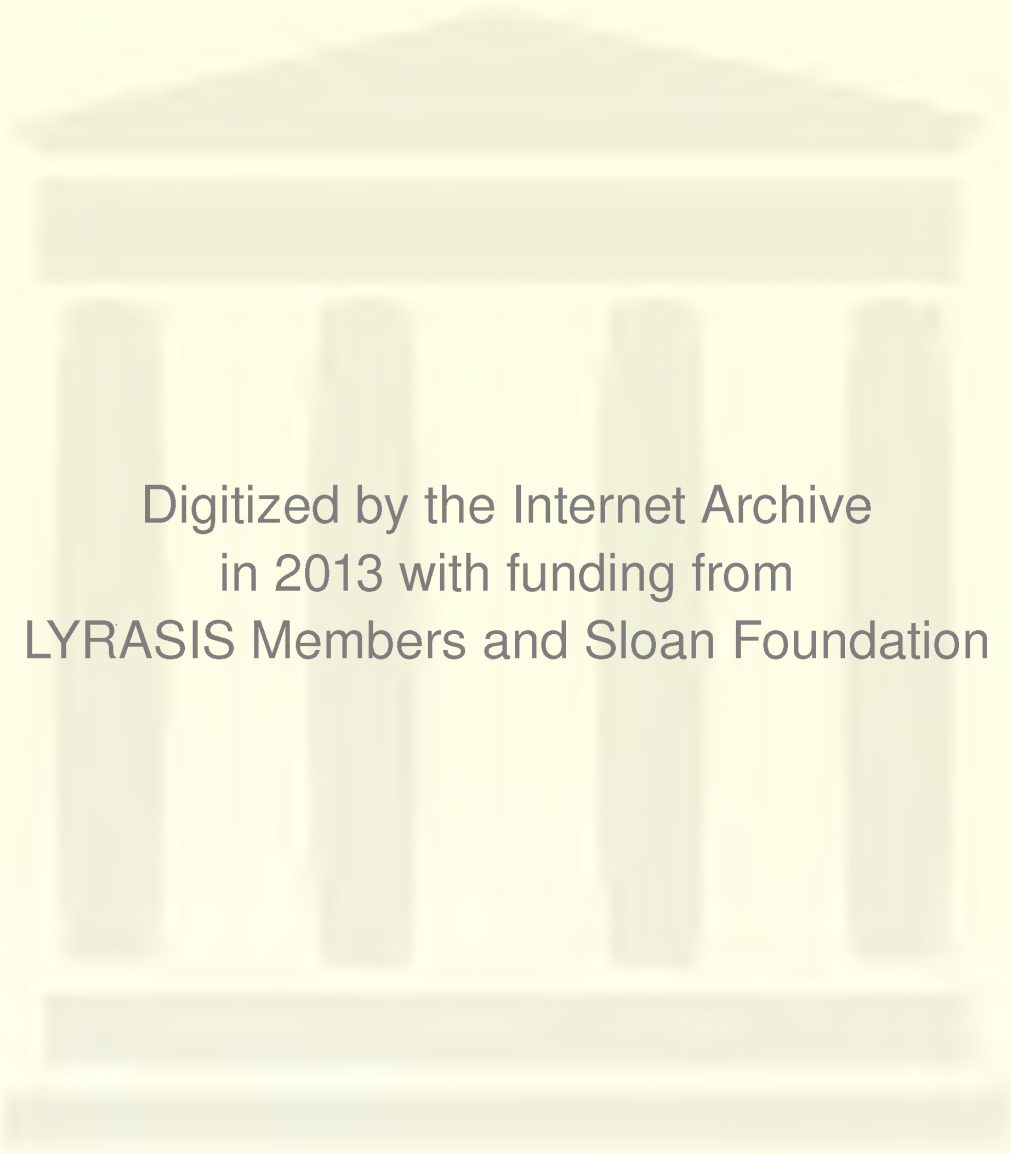
## Basic Manual Supplement: Oregon

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# REMOTE SENSING

## A Handbook for Archeologists and Cultural Resource Managers

### Basic Manual Supplement: Oregon

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## Supplement 4

to Remote Sensing: A Handbook for Archeologists and Cultural Resources Managers

Edited by Thomas R. Lyons  
Series Editor: Thomas R. Lyons

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## Introduction

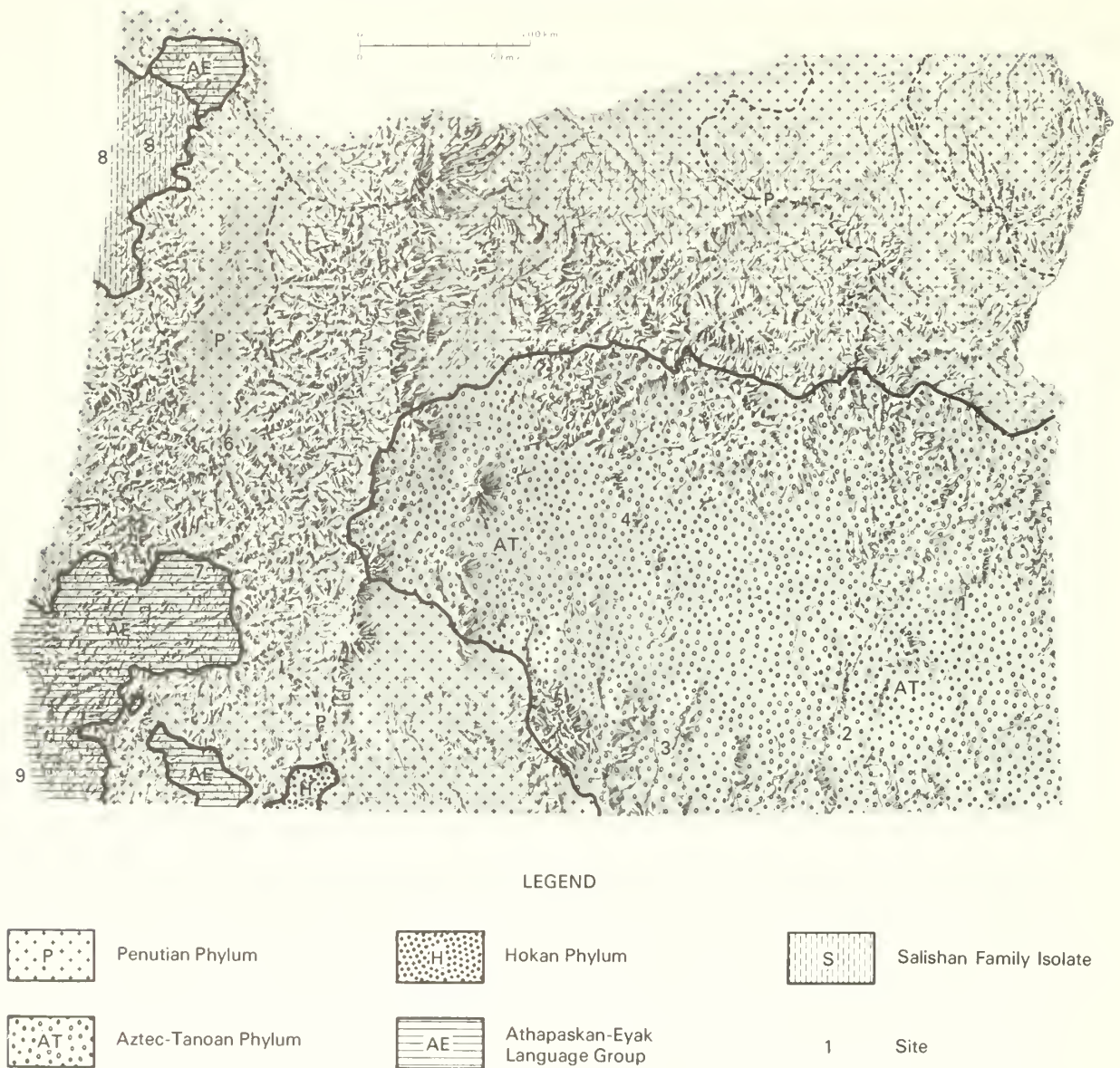
This supplement is designed to exemplify some concrete, practical uses of aerial imagery for research oriented archeologists and management oriented cultural resource or land use planners. The state of Oregon is environmentally diverse encompassing 1) a long Pacific coastline, 2) the low but extremely rugged and heavily wooded Coast Range, 3) the broad, unwooded Willamette Valley, 4) the forested Cascades and other ranges, 5) a vast area of open basin-and-range desert country, and 6) extensive lava uplands into which stream courses are deeply incised. This environmental diversity is reflected in the economic and sociocultural patterns characteristic of both its aboriginal and its historic occupants. The examples discussed here span a considerable range of geographical variation and will, it is hoped, prove informative both to local archeologists and managers and to those whose actual areas of concern may be distant, but of similar geographic and cultural character.

The main theme of the book is simply that air photos are a major aid to locating archeological sites and to understanding their patterns of occurrence in the landscape in terms of environmental variables. In addition to their usefulness in analyzing site distribution patterns, air photos can be a tool of first importance for defining and mapping the major environmental zones and subzones within a region. Such information is crucial to the construction of stratified sampling schemes for cultural resource surveys, to postulating the structure of regional human subsistence—settlement systems, and to estimating the distribution and density of human occupation sites within a region. Finally, aerial photographs indicate the extent of recent disturbance of the cultural landscape—knowledge that is important in determining the

statistical bias in the sample of sites that remain available for study.

A brief sketch relating Oregon's natural environment and ethnographic culture areas identifies the major resources of importance to the aboriginal people. Following this, a series of local case studies is presented, each of which illustrates in concrete terms one or more of the concerns just outlined. In each case study, archeological sites known from previous ground survey were plotted on aerial photographs, and these photos became primary data used to address questions of archeological relevance. The case examples are followed by a discussion of remote sensor data acquisition, imagery interpretation, and signature development, after which a concluding summary reiterates the major practical application described in the body of the paper.

# LINGUISTIC PHYLA AND FAMILIES OF OREGON IN 1850



**Figure 1** Linguistic phyla and families of Oregon in 1850. Index of nine study sites. Sites: 1 = Owyhee River, 2 = Alvord Basin, 3 = Warner Valley, 4 = Glass Butte, 5 = Coffeepot Flat, 6 = Upper Willamette Valley, 7 = Upper Umpqua Valley, 8 = Oregon Coast: Netarts, 9 = Oregon Coast: Brookings. USGS shaded relief base map. Adapted with permission from *Atlas of Oregon*, pp. 6 and 7. Copyright University of Oregon, 1976. Original compilation by Stephen Dow Beckham.



## Environment and Human Settlement

What is now the state of Oregon was inhabited in aboriginal times by many small groups, whose people spoke languages of over a dozen different families. Most of those language families belong to the great Penutian phylum, implying that they gradually diverged from a common ancestral proto-Penutian tongue over a long period of time. The antiquity of the family groupings is further indicated by the fact that the families themselves were often subdivided, as a result of gradual internal linguistic changes, into two or more individual languages. This observed pattern of divergence between the languages of related neighboring peoples bespeaks social and natural boundaries long established in a landscape long settled, and makes it reasonable to believe that the aboriginal territories recorded by early White observers are of ancient standing. There is a striking degree of congruence between the distribution of native groups and certain salient characteristics of the natural environment, as superimposition of linguistic boundaries over a physiographic map of the state shows (Fig. 1). This, too, is an indication of long occupation, and a long period of adaptation by aboriginal peoples to the dominant characteristics of their particular environments. The most recently established territories, probably carved out within the last thousand years or so, are those of several small groups of immigrant non—Penutian Salish and Athapaskan speakers, and of a large group of Northern Paiute speakers. The other territories are probably much older.

A brief ethnographic sketch of subsistence and settlement patterns will identify the major native culture types for which we are able to discuss archeological remote sensing applications, and will indicate the dominant environmental factors to which the people were adapted. Cultures of the

Lower and Middle Columbia River are omitted from the following accounts, since we lack the archeological data to discuss them in terms of this paper's objective.

### Coastal Peoples

The Oregon coast lies along the southern reaches of the Northwest Coast culture area, which extended north as far as the Gulf of Alaska and south a short distance beyond the California border (Barnett 1937; Drucker 1965). The southern portion of this area did not exhibit the degree of cultural elaboration characteristic farther north, a phenomenon that may be related at least in part to environmental factors. The southern coastline is relatively straight and open, and does not afford easy access from the numerous bays and estuaries to the sea. It is a high energy coast where waves distribute a relatively large sand supply along the shore, creating treacherous bars across all of the rivers; many of the smaller streams along the Oregon coast do not reach the sea at all. In winter the sea is rough and difficult, and cold currents in the summer make boating accidents potentially deadly. The exposed coast here did not facilitate intercoastal traffic and exploitation of the open waters in the fashion that is possible in many other oceans or seas, including the sheltered intercoastal waterways of Puget Sound and the Pacific Coast farther north.

Oregon's coastal peoples inhabited a long, narrow strip of land immediately backed by the heavily dissected and rainforest-covered Coast Range. Villages were frequently located near the mouths of rivers and along the edges of bays where

tidal flats were exposed. Brush fences, or weirs, were built across rivers to channel fish into open-work basketry traps, or to places where they could be speared or clubbed. Clams were dug on tidal flats, and a variety of marine fauna including oysters and mussels were gathered from tidal pools or from rocky strands between high and low tide. Birds and their eggs were taken from rookeries on rocky headlands, as were seals. Deer, elk, bear and smaller animals were hunted in the forested hills back from the coast, and salmon berries, wapato roots, camas bulbs, and other edible plants were gathered from suitable localities both in the mountains and along the coast.

The Tillamook, Coos, and others who inhabited the region (Fig. 1) lived in rectangular plank houses, some as much as 50 feet long and providing shelter for several families (Newman, 1959). A small village might consist of four or five structures, a large village of two or three times that number. The village was the largest social and economic unit, and was surrounded by smaller sites used briefly but repeatedly by small parties ranging out on short term hunting, fishing, collecting, or trading trips. The extent and character of inland occupation is not clear. Although groups claimed the mountainous country behind their coastal habitat as far east as the crest of the Coast Range, the accounts do not describe regular settlements there.

### **Peoples of the Southwestern Interior**

The mountainous node of interior southwestern Oregon, where the Coast Range and Cascades are connected by the Calapooya and Siskiyou mountains, is an area of steep conifer covered hills surrounding two major valley systems covered by oak—savanna vegetation. These are the Rogue River Valley in the south, occupied by the Takelma, and the Upper Umpqua River Valley farther north, occupied by the people who gave their name to the region (Fig. 1). The ethnography of the area is poorly known. Catastrophic epidemics in 1782 and 1830, along with other results due to the White invasion, destroyed the Umpqua people before their culture was recorded, but some information is available concerning the Takelma (Sapir, 1907).

A major staple was the acorn, which was ground up, leached with hot water to remove the bitter tannic acid, and made into a gruel. Camas bulbs were baked in earth ovens, and various seeds and berries were collected. Salmon, trout, mussels, deer, elk, bear, and smaller animals were taken from forest and stream.

Houses were rectangular, with plank walls and a floor excavated one or two feet below ground level. In summer, temporary brush shelters were occupied. Villages were composed of a few plank houses, and perhaps a single brush-covered sweat lodge. Each village was an autonomous unit. Presumably each village laid claim to a hinterland from which it drew its sustenance, but few details of the aboriginal settlement system have been recorded.

### **Willamette Valley Peoples**

The Willamette Valley is unique in being the only major unforested tract in the Northwest Coast area. In aboriginal times, much of the 120-mile-long valley was prairie-grassland with scattered oaks. Gallery forests occurred along the streams, and extensive shallow lakes and swamps were maintained by regular flooding of the Willamette River and its tributaries. The landscape was maintained in an open condition by periodic fires, set by the Kalapuya Indians to drive game, improve seed production, and reduce brush (Fig. 1) (Johannessen *et al.*, 1971:288-292).

The aboriginal occupants depended heavily on vegetable foods. Camas was abundant on the alluvial valley floor, and wapato root, acorns, hazel nuts, and berries were other regular staples. Fish were available in the Willamette and its tributaries, although salmon runs were comparatively meager as a result of the formidable barrier posed by high falls on the lower reaches of the river. Wildfowl were taken from the lakes and swamps, and small game was regularly hunted, snared, and trapped. Deer, elk, and bear were available in the surrounding hills.

Winter houses large enough for several families were in use. These were apparently rectangular; floors were excavated two or three feet below ground level and the spoil dirt packed around the walls. The superstructure was of bark, laid against a shed or gabled framework. Conical

or domed sweat houses framed with poles and covered with boughs and earth were also constructed. During the summer, people erected windbreaks of fir boughs at temporary hunting and gathering camps, when the winter villages were seasonally abandoned. The Kalapuya apparently recognized political entities larger than the village, for they were divided into a number of bands with fairly well-defined territories, but the structure of the larger organization remains unclear (Jacobs *et al.*, 1945; Mackey, 1974).

### **Peoples of the Western Cascades**

The Western Cascades, from Mount Hood on the Columbia River to the vicinity of Crater Lake in the south, were occupied by the Molalla (Fig. 1). The country is steep and heavily forested but most of it does not exceed four thousand feet in elevation, and the lower valleys are snow-free most of the year.

Vegetal foods are less abundant in the Cascades than in the more open Willamette Valley to the west, and the Molalla were said to live chiefly by hunting. Deer, elk, bear, and smaller animals were abundant. Rivers and lakes, of which there are many in the western Cascades, yielded salmon, trout, eels, and other kinds of fish. In late summer, roots and berries could be gathered at higher elevations.

Winter houses, apparently semisubterranean earthlodges, were established along streams at lower elevations. The actual size of Molalla settlements is not known, but they probably comprised only a few families, jointly occupying a handful of earth lodges. The character of the structures used during the summer, when people were away from the village, is not known (Minor and Pecor, 1977).

### **Peoples of the Desert**

The southeastern quarter of Oregon is desert, dominated by sagebrush covered plains and valleys, and forested with juniper and pine at higher elevations. During glacial times, many of the region's enclosed drainage basins were filled with vast lakes, shrunken remnants of which still persist

in the Warner Valley, Harney–Malheur Basin, and other places. The Northern Paiute occupied this enormous territory at a very low density, and were accustomed to traveling long distances to exploit favorable hunting and gathering locations. Economic emphasis was placed on wild seeds, roots, berries, jackrabbits, ground squirrels, fish, waterfowl and the like, which were dietary mainstays. Deer, antelope, mountain sheep and bison were also hunted, but large game was not common enough, nor readily enough taken, to be a regular item of fare.

Winter dwellings consisted of small domed wickiups framed with willows and covered with brush or grass thatch. Where available in a suitable location, caves might have been used. Summer dwellings were simple brush windbreaks, open to the sky. In winter, a number of families would congregate at a favorable spot, but during the remainder of the year the people were widely dispersed, hunting and gathering in small groups (Stewart, 1939).

The Klamath-Modoc, who occupied slightly higher, forested country in south central Oregon (Fig. 1), followed a similar way of life, but greater abundance of water and food allowed them to maintain fairly large winter villages of substantial semisubterranean earthlodges along rivers or on the shores of Upper and Lower Klamath Lake. In keeping with the abundance of permanent fresh water in their territory, they also placed a stronger emphasis on fishing, fowling, and general exploitation of lake-marsh environmental zones than did the neighboring Northern Paiute.

### **Time Perspectives**

It was asserted at the beginning of this section that linguistic evidence warrants the assumption that the ethnographic culture areas here are of considerable time depth. In some regions, archeological evidence confirms essential continuity back in time. In the Klamath, country archeological records from Kawumkan Springs Midden and the Nightfire Island Site trace the distinctively Klamath lifeway back to at least 6,000 B.P. (Cressman, 1956; Grayson, 1976; Aikens and Minor, 1978). For the Northern Great Basin, sequences from the Fort Rock Valley (Bedwell, 1973) and the Owyhee Upland (Aikens, Cole, and

Stuckenrath, 1977) show that the main outlines of the desert lifeway were established prior to 7,000 B.P., and perhaps even two or three millenia earlier.

For western Oregon, the archeological picture is not as well established, but there are indications of long occupation. Human presence in the Western Cascades by 8,000 B.P. is attested by projectile points, knives, and scrapers found at Cascadia Cave (Newman, 1966) and Baby Rock Shelter (Olsen, 1975). A Carbon-14 data of 7,900 B.P. was obtained from a lower occupation level at Cascadia Cave, and in Baby Rock Shelter, similar artifacts were found beneath a layer of wind-borne volcanic ash ejected by the eruption of Mount Mazama (the present Crater Lake) approximately 7,000 years ago. From the Willamette Valley, a hearth containing charred acorns, Carbon-14 dated at 5,200 B.P. (Reckendorf and Parsons, 1966), gives evidence of quite early occupation of the valley floor. After 3,000 B.P., evidence becomes more abundant, and by 2,000 B.P., if not earlier, a way of life very like that known for the historic Kalapuya is attested (White, 1975). On the coast and in the Umpqua and Rogue River Valleys, little archeological research is available as yet, and no dates of more than a few hundred years ago can be confidently assigned to the ethnographic pattern of life there. There is, nevertheless, sufficient scattered evidence to suggest that people have occupied the region for a long time (Hanes, 1977).

The initial occupation of Oregon, as of North America in general, no doubt occurred during the closing phases of the last glaciation, when the climate was cooler and moister and vegetation patterns were rather different from those of the present. A Carbon-14 date of 13,200 B.P. for materials associated with stone points and scrapers at Fort Rock Cave establishes the human presence there at a time when elephant, camel, and horse were still extant in the west (Bedwell, 1973). The finding of Clovis fluted points in both western and eastern Oregon (Aikens, 1978) also indicates occupation at this time.

Clearly, in the late glacial period, cultural as well as environmental patterns were quite different from what they later became. But for the greater part of postglacial time, the native people of Oregon had to cope with an environment sufficiently like that of modern times that we may justifiably use the ethnographic sketches just presented as tentative models of their regional subsis-

tence and settlement patterns. All groups exploited the largest animals in their environment: deer, elk, and bear west of the Cascades, and deer, antelope, sheep, and bison east of the Cascades. Similarly, all exploited a series of smaller game animals, along with waterfowl and fish. Vegetal foods included berries, nuts, seeds, and roots of different kinds according to the different localities the people occupied. In short, a diverse set of resources, widely distributed over the landscape, was sought by all groups. Correspondingly, a seasonal subsistence round involving periodic movement to obtain these foods was characteristic of all groups, although the range and frequency of movement varied greatly, according to the distribution and abundance of natural foods in a people's environment. Village size and stability were, of course, conditioned by the same factors and site locations were chosen to meet economic demands.

This model is simple in the extreme, yet useful for guiding archeological research into aboriginal lifeways. In the present rather specialized instance, interest is focused on those questions posed about past cultures that may be approached using aerial imagery as an aid to investigation. The problems to be addressed, mentioned in the introduction to this paper, may be rephrased here as a preliminary to their further examination in one or another of the specific case studies to follow:

- 1) Where, specifically, do the sites occupied by a given regional prehistoric group tend to be located, and what are the environmental factors apparently conditioning their occurrence?
- 2) What was the relative degree of a group's exploitation of different environmental zones within its region?
- 3) To what extent is our understanding of the above questions limited by factors of bias introduced into the archeological record by modern modification of the landscape?

The last item requires some general comment at the outset, even though it is also specifically addressed in several of the following vignettes.

## Archeological Applications of Aerial Remote Sensing

When studying modern air photos to obtain information about an ancient environment, the interpreter must constantly consider the massive and widespread environmental alterations that have occurred during the past century. Even though it is true that some elements of the landscape, such as mountain peaks or hardrock cliffs, change insignificantly when measured in human time scales, many other landscape elements change rapidly. Stream channels in alluvial valleys meander miles in decades, bays fill noticeably within a few years (especially if there has been logging or agricultural land clearing upstream), and vegetational changes can be as rapid as fire or as slow as species-mix changes due to grazing. Perhaps the most monumental changes occur in the area of water control. Massive investments by government agencies have wrought radical changes in formerly marshy areas. Whole lakes have been drained and huge marshes converted into farmland. The interpreter must also consider the widespread effect of smaller water control efforts such as farmers' ponds. The factor of environmental alteration must always be considered before an air photo interpreter suggests that an element of the environment visible on the photos was available to the ancient people of the area.

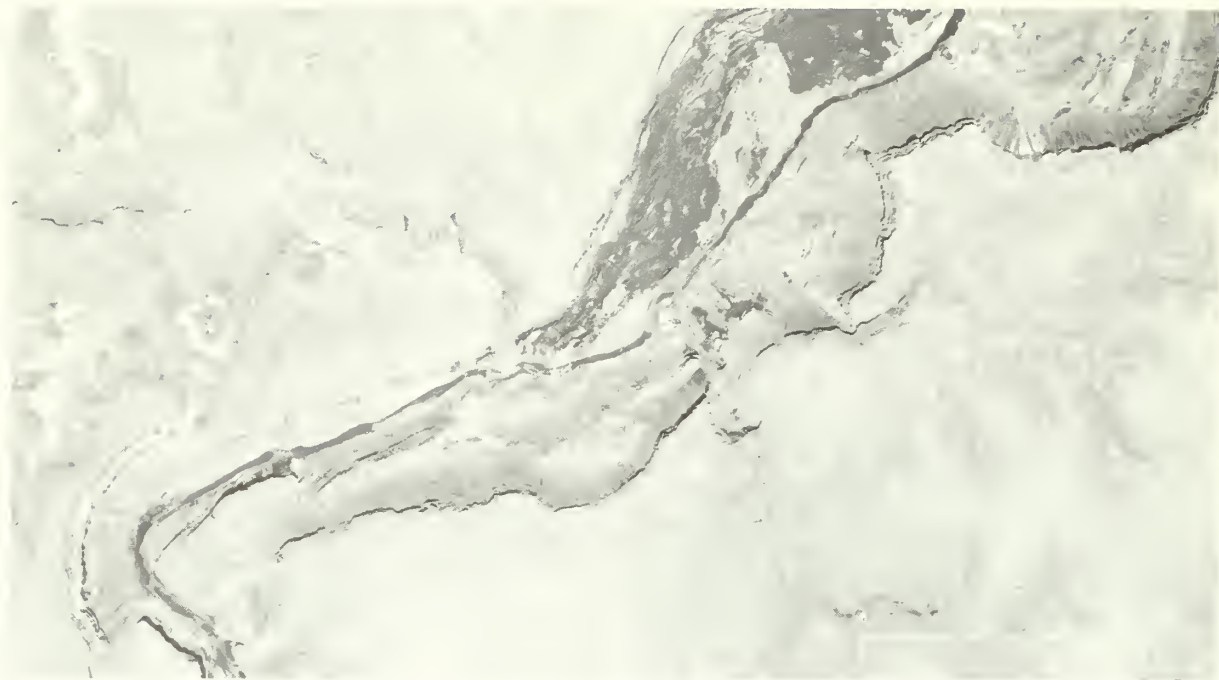
### **Owyhee Canyon**

The Owyhee River flows through a winding canyon cut deep into the rolling lava upland of the Owyhee Plateau. The area chosen for study lies between the town of Rome and the upper end of the Owyhee Reservoir, in extreme southeastern Oregon (Fig. 1). In this section, the canyon is in-

cised 300 to 400 feet deep into the plateau surface and is relatively broad, the rim-to-rim distance varying between one-quarter and three-quarters of a mile.

The two major vegetational environments along the Owyhee are a narrow canyon bottom and a much more extensive area of sloping canyon walls and adjacent uplands. Big sagebrush dominates both zones, and the upper slopes also support several kinds of grasses and sego lilies. Willow, arrowgrass, service berry, cattail and sunflower occur along the canyon bottoms. Bulbs and roots such as camas, yampa, and wild onion are to be had on nearby upland prairies. Salmon and other fish, as well as mussels and crayfish, are common in the river. Cottontail rabbit, beaver, ducks, and geese occupy the canyon bottom habitat, and pronghorn antelope, mountain sheep, deer, elk, bison, and jackrabbits are native to the rolling, sagebrush-covered plateau above the canyon rim. The Owyhee Canyon, sheltered from the winter wind and extreme cold of the uplands, and favored with water and relatively abundant food resources, was undoubtedly the locus of winter settlements, and the axis around which aboriginal people circulated throughout the year. In historic times, the area lay at the juncture of Shoshoni and Northern Paiute territory, and was apparently used by both groups.

The canyon was surveyed by a Bureau of Land Management archaeologist whose primary assignment was to locate and evaluate cultural resource sites which might be threatened by recently increased public activity in the canyon stemming from its designation as a Wild and Scenic River (Pullen, 1976). Because of this emphasis, attention was focused on areas near the river, although all the terrain enclosed by the canyon walls was subject to examination, and spot checks



**Figure 2** Vertical aerial photograph of a section of the Owyhee Canyon showing site locations. S = site. ASCS photo BBC-18N-123, August 2, 1954. Original scale 1:20,000.

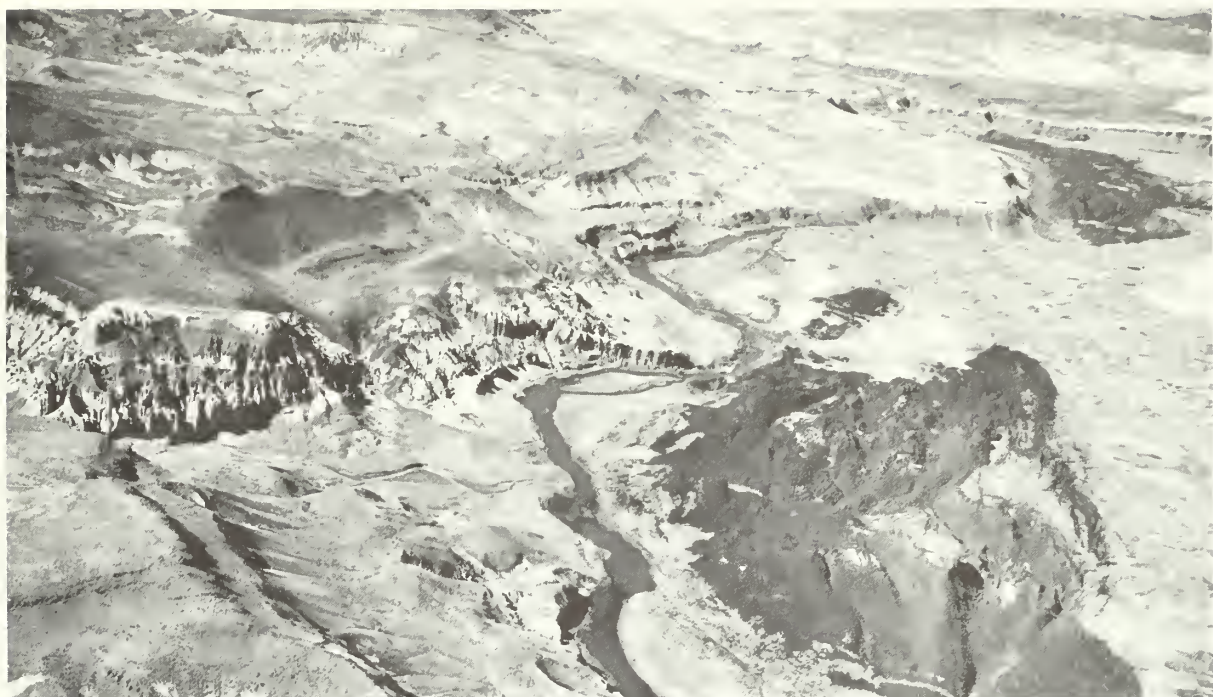
were made of places where sites might be likely to have occurred.

Human occupation of the canyon is conditioned by the fact that the Owyhee River is deeply incised through many layers of lava and sedimentary rocks (Figs. 2, 3). As the river erodes these beds, a series of rapids and pools are created in the channel, lending a rich diversity to the riverine environment. The tabular nature of these beds also favors the existence of numerous benches or terraces within the canyon where more resistant layers have withstood erosion as the river cut deeper. These benches are not gravel terraces such as can be found in broad alluvial valleys, and most of them are elevated enough that human occupation sites on them would not be subject to destruction by periodic flood erosion. Inspection of the air photos under the stereoscope reveals the cliffed bedrock edges of the benches; gravel terrace edges would appear less steep. The fact that the edges of resistant beds form cliffs further indicates that a good possibility of overhangs or shallow caves suitable for human use exists in this geologic environment.

Other important elements in the land forms of the canyon are the talus slope and the debris cone. Lava, where well-jointed, is attacked by expansion and contraction due to heating and cooling and by frost action when moisture is available. Angular debris slopes are common and in places water worked cones form small areas of relatively level land. Any human occupation sites situated on these small water-worked debris cones would be subject to rapid erosion or burial during flash floods. Preservation of sites in these situations, if indeed they ever existed there, is relatively unlikely.

In the Owyhee River canyon area examined, the known sites are found where there is a bit of relatively level land that has access to the river without being flood-prone. Modern trails can be seen angling down the slopes from the sites to the river. The sites are on either side of the river, in some cases on both sides as a pair. All of the known sites are within the canyon, none are on the exposed upland far above the water.

To predict the occurrence of archeological



**Figure 3** Oblique aerial view of a section of the Owyhee Canyon. Photo A138-55 Oregon State Highway Department.

sites in other parts of the Owyhee River canyon, or in a comparable incised canyon in an arid zone elsewhere, the investigator would need to answer several questions concerning how people might obtain the essentials for life in the area, utilizing the technology available to them. Access to water could be by trail to the river or, more conveniently, from a spring in the canyon wall. In the Owyhee River canyon access appears to be adequate.

The essentials for life in the Owyhee Canyon could be gathered by people situated on any bench within the canyon. The most promising benches for archeological sites seem to be those that are relatively broad, with an existing trail (perhaps ancient?) down to the water. A small cliff near to the bench appears desirable, perhaps to serve as one side of a shelter. Location near a rapids of the river does not appear necessary, as sites are found overlooking pools and rapids equally. Similarly, location along routes of access to the upland does not appear to be particularly favored.

If several sites are known in such a canyon, the best preliminary to a further search procedure

is to plot the known sites on aerial photographs and to determine their topographic position, sun aspect, water access, food availability, shelter from adverse weather, and access to natural routes. Places with similar characteristics are the most likely locations of additional sites. In the case of the Owyhee River canyon, this procedure suggested that many benches were acceptable and that the existence of a bench seemed to be the only constraint on site location. The upland rim can apparently be discounted as a likely location for sites. These conclusions, though tentative because of the limited sample on which they are based, would nevertheless be considerations of major importance to the design and logistical planning of a more extensive stratified sampling scheme for the region (e.g., Mueller, 1975).

The difficulty of the terrain increases the utility of air photos as a tool to plan field activities. Currently used trails appear as white threads angling across slopes. Cliffs that bar access may be seen in stereoscopic images. Careful stereoscopic study and access route planning should precede all

excursions into a canyon such as that of the Owyhee River in southeastern Oregon.

### **Alvord Basin and Warner Valley**

The Alvord Basin in southeastern Oregon is the now dry bed of an ice-age (Pleistocene) lake that was approximately 100 miles long at its maximum extent (Figs. 1, 4, 6). The Warner Valley, some 70 miles to the west, held a great lake of similar size, of which a series of smaller remnants still exist, strung out along the valley floor over a distance of some 40 miles (Figs. 1, 7). Around the remnant lakes of the low-lying northern end of the Warner Valley are extensive areas of flooded dune and slough topography, which support abundant marshland vegetation, waterfowl and other game. The Alvord Basin is far more arid, but in several places, dune fields and small spring-fed marshes occur, and in one place, a stream from the adjacent highlands supports a fairly extensive area of marshland.

Game available in aboriginal times in both regions included pronghorn antelope, waterfowl, deer, elk, bison, mountain sheep, jackrabbit, cottontail and a variety of smaller animals. Native grasses of several species—along with bulrush, cattail, bitterroot, and camas—provided edible seeds, roots and rhizomes. Arrowcane, greasewood and sagebrush provided raw material for wood and fiber manufactures.

In historic times, both the Alvord Basin and the Warner Valley lay within the range of the Northern Paiute. There are no ethnographic data pertaining directly to the Alvord region, but the Warner Valley is known to have been occupied by the Surprise Valley Paiute band. It was an important hunting-gathering area, and groups regularly wintered at several favorable locations within the valley.

A portion of the Alvord Basin was surveyed for the U.S. Bureau of Land Management (BLM) to provide a preliminary assessment of cultural resource values in the area (Pettigrew, 1975). The archeological survey was organized by existing one mile-square cadastral survey sections. A random sample of 61 sections of BLM land was selected for ground search, and an additional four sections were picked for examination after a site recognition pattern had been established. Survey teams

systematically combed the areas chosen and the effort yielded a total of 224 prehistoric sites, of which 149 were found in the randomly selected sections.

A sizable area in the northern half of the Warner Valley was chosen for intensive examination (Weide, 1968, 1974). Within this area, personnel of the local Hart Mountain Antelope Refuge led the investigators to many sites, and others were discovered by exploration of places that the investigators came to recognize as likely site locations. Valley-bottom and upland locations are about equally represented in the total of some 32 sites recorded for the North Warner Valley area (Fig. 7).

Interpretation of air photos of the Alvord Basin's Buckbrush Spring area, from which a number of archeological sites are known, shows the perennial water sources, which evidently attracted people to the area, as being clearly the darkest images on the generally light-toned photos (Fig. 5). The season during which photography is accomplished—in this case, late August at the height of the dry season—is crucial for the mapping of perennial water sources. Wet-season photography is not useful for identifying perennial springs because a puddle can easily be confused with a spring in the wet season.

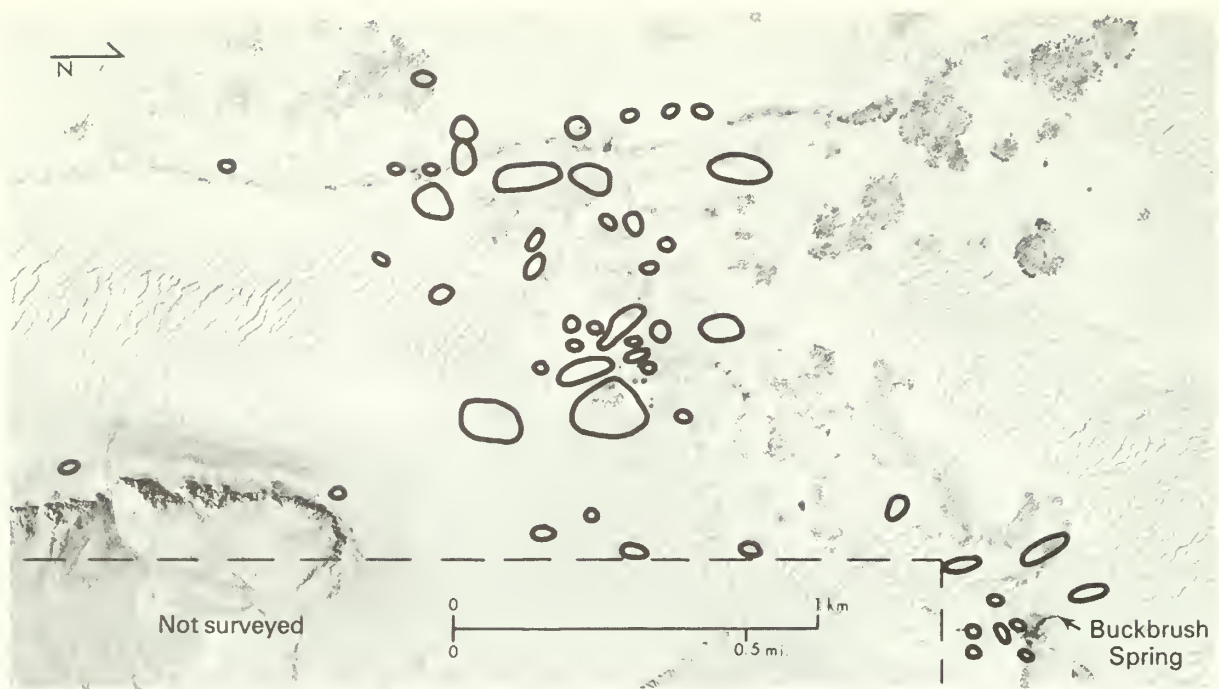
Although common panchromatic film was used for this interpretation (the wetter areas being revealed by their dark tones), black-and-white infrared or false-color infrared films would have shown the wetter areas starkly. Water is jet black on black-and-white film sensitive in the photographic infrared portion of the spectrum; the vegetation associated with perennial water sources shows blood red on color infrared images. Because water surfaces often reflect the shorter sun's rays into the camera like a mirror, it is possible, using panchromatic film, to miss a pond that infrared films would show. For the interpretation of water features, infrared films are superior.

Minor topographic features of relevance to human use of the area may be delineated under the stereoscope. In this case, the undisturbed upland, the old lake shorelines and minor post-lake faults, are evident. Along the uppermost shoreline, lighter-toned areas indicate places where small lagoons might have existed when the pluvial lake stood at its highest level, and where water might have collected at later times, making the old lagoons potential habitation sites. Old shorelines





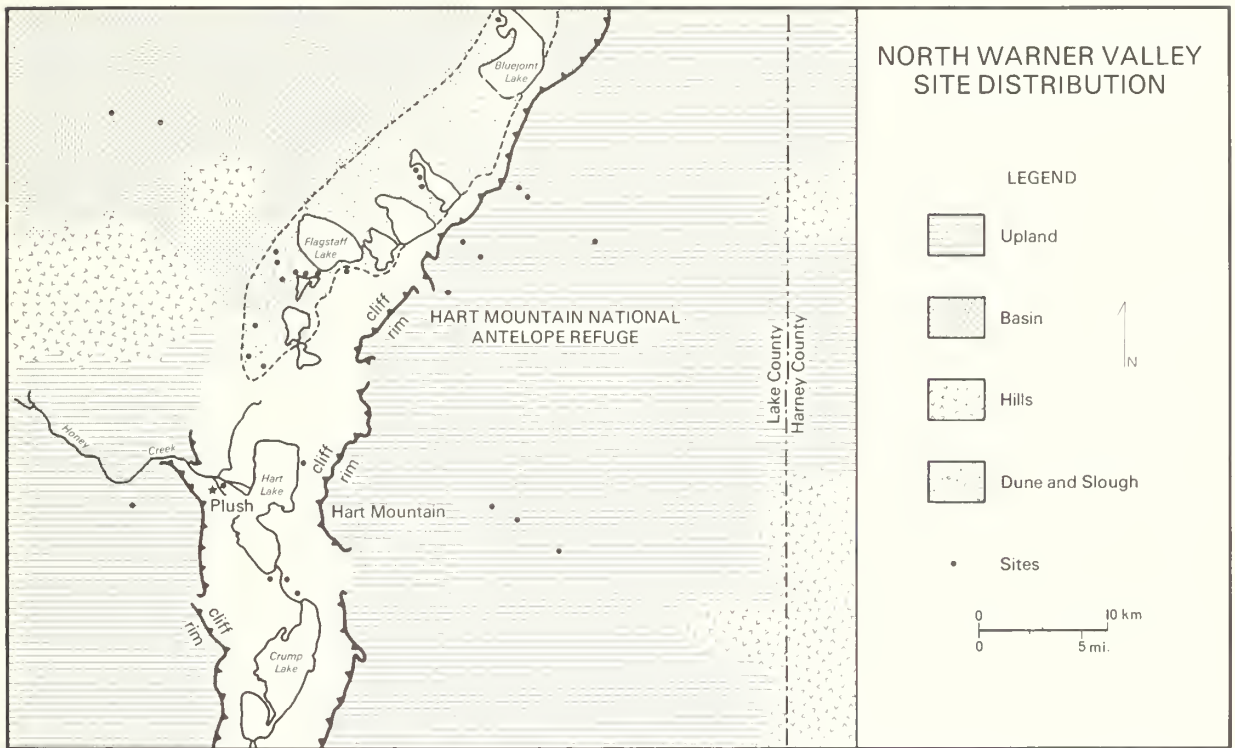
**Figure 4** Landsat image of the Alvord Basin, southeastern Oregon. NASA scene E-1092-18102-5 01, Band 5, October 23, 1972. Original and printing scale 1:250,000. A = Andrews, ADP = Alvord Desert Playa, AL = Alvord Lake, AR = Alvord Ranch, BS = Buckbrush Spring, MS = Mickey Springs (hot), and SM = Steens Mountain.



**Figure 5** Vertical aerial photograph of area east of Alvord Lake, including Buckbrush Spring. Sites occur among hummocks and troughs, and around springs. Artifact scatters are circled in black. ASCS photo EFI-30V-165, August 27, 1958. Original scale 1:20,000.



**Figure 6** Oblique aerial view of the southern Alvord Basin from above Steens Mountain. Photo A 138-44 Oregon State Highway Department.



**Figure 7** North Warner Valley site distribution. Sources: Margaret L. Weide, 1974, and USGS-AMS map *Adel*, 1:250,000 series.

descend in steps from the uppermost beach down to the playa flat. The water-washed gravels of these old strands exhibit a high infiltration capacity, so that even heavy rains soak through the surface leaving them to dry quickly. Because of the inhospitability of these gravels, it seems likely that both habitation and activity sites of the earliest people would have remained above the highest strand lines until the lake dropped to the level of the fine-grained bottom sediments. This is a point to be taken into account in developing settlement pattern hypotheses and contemplating archeological sampling strategies for the region.

On stereo photographs of the playa flat around Buckbrush Spring, minor post-lake faults can be seen breaking the lake sediments into a series of low steps descending toward the modern lake remnant (Fig. 5). Such minor faults would be expected in the basin and range physiographic province where the earth's crust is relatively thin, especially because of the isostatic rebound following unloading of the weight of a large lake from the crust.

These minor faults in the lake sediments have apparently disrupted the aquifers of the basin sediments. Where the aquifer is lifted above the lower block or where it is blocked by an impervious bed, springs result. The expression of these faults and their line of springs is accentuated by the line of vegetation that forms in response to the availability of water. The vegetation in turn is able to trap blowing sand and silt, causing the fault-line to form a small ridge. Vegetation may also be favored in the fault zone if a fault has fractured commonly occurring impervious layers that often preclude even long-rooted plants from tapping subsurface waters in basin areas. Human occupation sites cluster along such vegetated sediment ridges in the area around Buckbrush Spring.

The Warner Valley is a structural depression similar in size, elevation, climate, and surrounding rock types to the Alvord Basin, yet it provides a distinctly dissimilar environment in which to live. The overriding concern in the Alvord Basin would have been obtaining water in the dry season, but a major concern in the Warner Valley would have



**Figure 8** High oblique of the North Warner Valley showing dune and slough topography. Eastward dipping layered basalts on the left and gently westward dipping basalts in the distance. The Warner Valley is a partially inundated rift valley that lacks an outlet. View is east, with Hart Mountain in the background. C.M. Aikens photograph.

been a dry habitation site convenient to the foods available in the extensive marshes.

The basic reason for the differences between the two regions is the orientation of their adjacent fault-block mountains. Steens Mountain rises 4,500 feet above the western margin of the Alvord Basin, the Steens Basalts dipping to the west. Consequently, the Alvord Basin is in the rain shadow of the Steens block, and the moisture that falls on Steens Mountain runs off to the west. The result is an especially arid basin in a desert region. The Warner Valley, in contrast, is bordered on the east by high mountains and ridges that cause the prevailing westerly winds to drop their moisture over the valley, creating a relatively wet zone in the desert region.

Air photo study of the North Warner Valley shows an elongated basin with a well developed sand dune field, part of which is now inundated. In contrast to the Alvord Basin, old lakeshore gravels are not major features, nor are post-lake faults in the floor of the valley evident. The area of inundated dunes (Fig. 8) is large, and the water features grade from large lakes, to an elaborate

labyrinthine interfingering of land and water, to recently dried-up areas, and finally to areas that appear to have been dry for some time. The mass of dunes apparently formed during a period after the ice-age lake had disappeared, when the area was somewhat drier than it is at present. Air photo study of the inter-dune depressions suggests that more dunes were once separated by water than is true at present. The interdune marshes in these spots may have dried up due either to a recent lowering of the water table or to filling of the interdune depressions by windblown sand.

Field work in the zone of inundated dunes can be facilitated by advance study of air photos. Many dunes are islands or they are reachable on foot only by circuitous routes. Possible habitation sites that are convenient to food sources, have access to the upland and are still dry in wet weather, may easily be identified on any type of air photo. In this circumstance, air photos are especially useful for field work route planning.

## Glass Butte

Glass Butte, named for the abundance of obsidian (volcanic glass) around its sides and base, rises out of the high lava plains of central Oregon as a major prominence visible from many miles away. The elevation of the peak is nearly 6,400 feet, that of the surrounding plain approximately 4,500 feet. Glass Butte and the plateau from which it rises have been complexly faulted, and the mountain is surrounded by many low scarps and graben valleys. In the grabens, and in flatter areas south and west of Glass Butte, small playa lake beds occur. Except in the grabens, where alluvium has accumulated, the soil throughout the area is very thin, and much of Glass Butte itself is exposed bare rock. Obsidian occurs throughout the general area as outcrops, as boulders and cobbles in dry stream beds, and as surface float material.

The local vegetation is dominated by sagebrush, but juniper trees are common on the fault scarp ridges and on Glass Butte itself. Native edible-seeded grasses were formerly common; deer, pronghorn antelope, jackrabbit, cottontail and smaller mammals occur now, as do native sage grouse. Waterfowl, grasses, and sedges occur on some of the small playa lakes, and at higher elevations, mountain mahogany, quaking aspen, and willow stand sporadically in small groves.

Glass Butte lies within the historic territory of the Northern Paiute, but its obsidian has been long and widely used by aboriginal people. Projectile points of ancient types, made of this obsidian, are found in the Glass Butte area itself; obsidian from archeological contexts on the lower Snake River over 200 miles away dating between 8,000 and 10,000 B.P. has been identified as Glass Butte obsidian by trace element analysis (Galm, 1975).

A cultural resource survey commissioned by the BLM sampled approximately 14 per cent of a 132-square-mile area centered on Glass Butte (Mack, 1975). Five terrain types identified from existing information as archeologically significant formed the basis for a stratified sampling approach, which was supplemented by an intensive search of a randomly drawn sample of one-mile-square cadastral survey sections. All areas selected for sampling were combed by surveyors walking at intervals of 150 to 300 feet. In all, 131 sites were

recorded within about 19 square miles of intensively surveyed area.

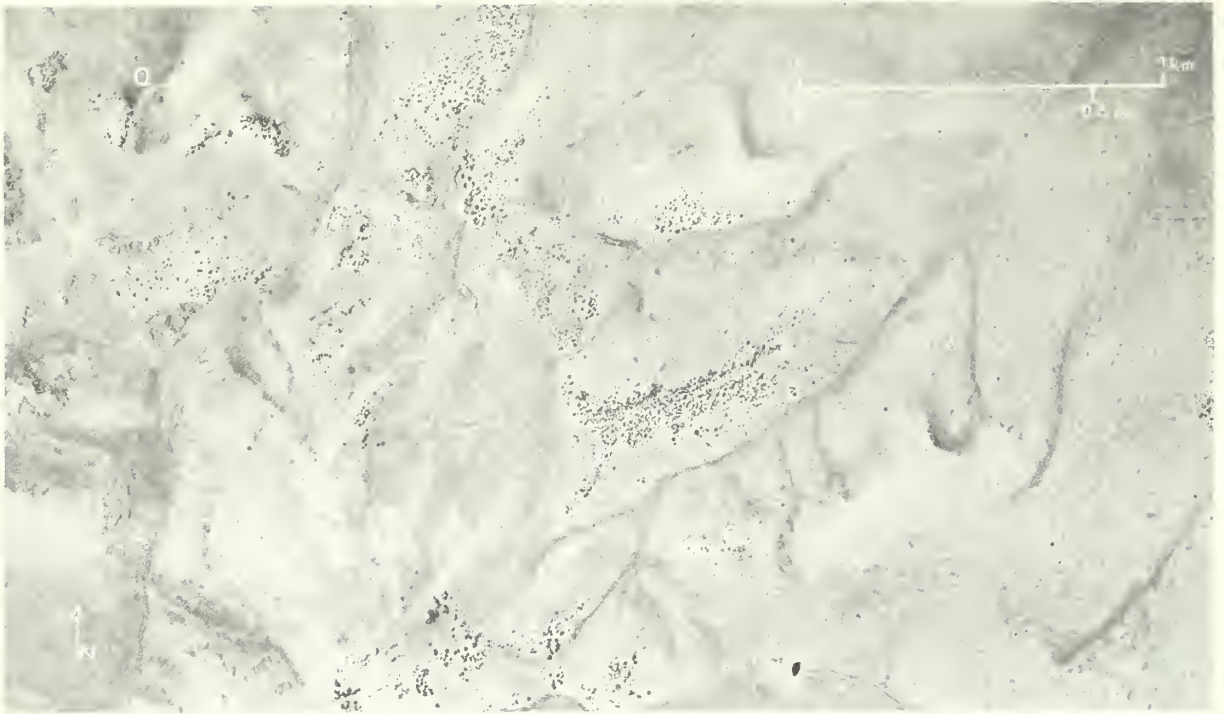
Sites judged to be camps were found on terraces, ridges or dunes surrounding small playas and at springs. A number of piled boulder alignments along scarp edges may have been aboriginal hunting blinds or drive lanes, though it is also possible they were built by White stockmen. Quarry sites, characterized by vast amounts of worked and unworked obsidian, occurred on eminences on the slopes of Glass Butte. Knapping stations, marked by scatters of worked obsidian flakes, occurred adjacent to stream beds, on scarp crests around stream heads, and in sand dunes. Some of the knapping stations were only a few feet across, but others were much larger, including one that extended for nearly a half-mile along a stream course.

Because of the poor quality of the available maps, aerial photos were extensively used in identifying areas to be examined within the stratified sample, and in recording site locations. They were also used in estimating the amount of various kinds of terrain in the area, and amounts of area actually surveyed, in order to offer estimates of site distribution and density within the study area (Mack, 1975).

Post-survey stereoscopic analysis of air photos showing known site locations revealed that boulder alignments recorded on the ground were readily detectable on the air photos (Fig. 9). A scan of areas not recorded as sites failed to identify any additional alignments, but it is evident that air photo reconnaissance would offer a rapid and inexpensive initial approach to a specialized study of cultural features of this sort.

Probable obsidian quarry sites were also visible on air photos, detected by their occurrence near ledges or on steep slopes recognizable stereoscopically, and by the reflection of the broken volcanic glass, which showed on the photographs as white spots (Fig. 9). Many small obsidian workshop sites known to exist were not detected on the photos, however, probably because of a relatively low density of flaking debris (Fig. 10).

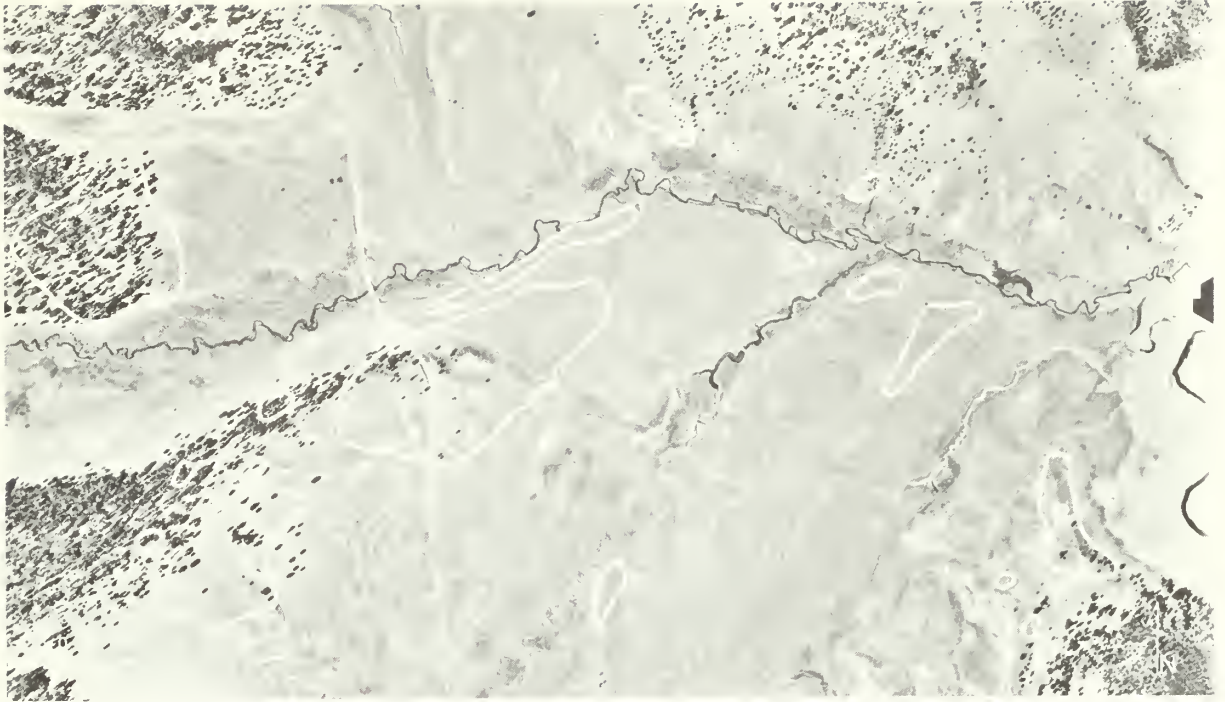
As in other localities, water sources were detectable. Springs in the lower-lying areas were recognizable as black spots surrounded by clumps of brush; at higher elevations, the quaking aspen that mark areas of ground water availability were distinguishable from darker-toned juniper and pine. Because the vegetational differences would



**Figure 9** Vertical aerial photograph of Glass Butte area, showing quarry locations. Q = quarry, P = ground photo site. ASCS photo CHZ 54K-73, July 22, 1954. Original scale 1:20,000.



**Figure 10** Ground photograph of an obsidian quarry, Glass Butte. Joanne Mack photograph.



**Figure 11** Vertical aerial photograph of Coffeepot Flat, showing base camps (A,B,C). USFS photo EIK-6-88, September 6, 1960. Original scale 1:12,000.

stand out more clearly on color infrared photos than on the black-and-white panchromatic imagery used, use of color infrared photos would allow increased confidence in the identification of water sources.

Finally, air photo reconnaissance offers a fast and straightforward way of developing a census of likely site localities in dunes and around playa lake beds. Ground survey showed that these features, readily recognizable on aerial photos, are high-probability areas for archeological sites.

### **Coffeepot Flat**

Coffeepot Flat occupies a mountain valley some 20 miles south of Summer Lake, in south central Oregon (Fig. 5). A few miles to the east, across a single low range of mountains, is a typical trough-shaped Great Basin valley that is now a vast hayfield, but was in aboriginal times the great Chewaucan Marsh. The marsh is fed by the

Chewaucan River, on a small tributary of which Coffeepot Flat is located (Aikens and Minor, 1977).

The open flat itself is approximately three miles long and a mile wide. Coffeepot Creek, which flows along its northern side, is lined by wet meadow vegetation, including lush grasses and sedges, with willows and currant occurring in places (Figs. 11, 12). Away from the stream, the thin soils of the flat are covered with sagebrush, which gives way with a slight increase in elevation to Ponderosa pine forest. Deer, elk, bighorn sheep, bear, jackrabbit, cottontail and several kinds of smaller rodents occupy the forests, flats, and meadows, along with occasional beaver and waterfowl.

Coffeepot Flat and the Chewaucan Marsh lie close together, on either side of a topographic and vegetational boundary separating wooded uplands from desert lowlands. It is inferred that aboriginal populations of the region exploited both environments in the course of their annual subsistence round. An ethnic boundary between the Northern



Figure 12 Oblique photograph of Coffeepot Flat, showing base camps (A.B.C). C.M. Aikens photograph.

Paiute and the Klamath followed approximately this same environmental division in historic times, and the Klamath were known to come down to the marsh, while the Paiute undoubtedly entered the mountains as well (Spier, 1930).

An archeological survey was performed to provide a complete cultural resource assessment of the area to be inundated by a proposed reservoir (Aikens and Minor, 1977). Teams of surveyors combed Coffeepot Flat and an adjacent portion of the Chewaucan River Valley up to the elevation of the surrounding tree line, which coincided with the pool limits of the proposed reservoir. The survey was also extended some distance into the edge of the forest in order to examine areas that would be affected by increased public activity along the shoreline of the projected lake. Because of the intensity of the survey coverage accorded the area, the site sample is believed to constitute an essentially complete inventory of the reservoir basin.

Two archeological sites, identified from their artifact assemblages and abundance of flaked stone as probable base camps, occur on the tips of lightly wooded ridges. A third site, identified from its ar-

tifact assemblage as having served at least some base camp functions, occurred on a terrace harboring a light clump of trees (Figs. 11, 12). None of the three were far from water, but neither were they immediately adjacent to it. Other sites, believed to be more limited purpose activity places, occurred on the edges of the open sagebrush flat immediately overlooking Coffeepot Creek. A third group of sites occurred around the outer edges of the flat just at the juncture of the forest and sagebrush zones. No artifact assemblages from this latter group of sites were analyzed. In relative sparseness of artifacts, the sites were like the creek-side activity loci; in being near trees, they were like the base camps; and in their relatively great distance from water, they formed a class by themselves. It is also of interest that sites were few along the Chewaucan River—probably resulting from the river being more deeply incised than Coffeepot Creek and from the restricted zone of water-loving vegetation.

A historic cabin occurs near a spring on the north edge of the flat, near the point at which a minor, usually dry, tributary of Coffeepot Creek



joins it from the south. This was also the locus of an aboriginal site. Traces of a homestead farm lot also exist near the east end of the flat, adjacent to a ford across the Chewaucan River. The historic site lies immediately east of one of the aboriginal base camp locations. No sites, prehistoric or historic, occur in the middle of the open flats, far from water.

In the case of Coffeepot Flat, an intensive ground survey preceded the use of air photos, and air photo interpretation served to confirm rather than predict information. The photos, which were taken with black-and-white panchromatic film, showed the known springs clearly as dark areas, and habitation sites as lighter areas. Their lightness probably results from disturbance of the thin soils or from their compaction as a result of human activity, which has reduced survival of vegetation in the former site areas (Figs. 11, 12).

Perhaps the greatest utility of air photo interpretation in this case would be in extension to similar contexts of the knowledge gained through ground survey at Coffeepot Flat. Comparable valleys in the region can be initially located on Landsat imagery, topographic maps, or, most conveniently, on air photo index sheets. When an area is photographed for mapping or land management purposes, an index is made by laying out a set of the photographic prints, matching images by eye. This uncontrolled mosaic is then photographed at a reduced scale, primarily as a locator index for the ordering of individual photographs (Lyons and Avery, 1977:28-9). These indexes can serve other uses, however, including regional analysis. Promising general areas may be located on the index sheets, and these same sheets also embody the information needed to order specific photos for further detailed stereoscopic study.

Detailed study of additional valleys should be preceded by a review of the photos of the known valley to establish the interpreter's image of desirable topographic locations and the appearance of springs in the landscape. The interpreter should then scan the entire scene, concentrating on low ridges, terrace edges, and the edges of the forest, keeping in mind the ever present human need for a water supply. As a final step, the level of confidence to expect in such a photo-aided extension of the original ground survey results could be established through a well-designed ground-truth checking program that could be conducted for a fraction of what it would cost to repeat the original

survey procedure over and over again in each of the valleys under consideration.

## Upper Willamette Valley

The Coast Fork of the Willamette River, in the upper end of the Willamette Valley, is 40 miles long. For the upper 20 miles of its length, the Coast Fork follows a meandering course through an alluvial valley that varies from a half-mile to two miles in width and is bounded by forested uplands on either side. Three, and in some instances four, terraces resulting from successive erosional cycles are identifiable in this segment of the valley. Elevational differences between successive erosional surfaces range from three feet to approximately five feet. Small tributary streams from the surrounding uplands follow sub-parallel courses before converging with the main stream. The alluvial soils of the valley vary from clays to gravelly loams, but all are characteristically dark to very dark brown or grayish brown in color. Most of the rural land in the upper Willamette Valley is planted in small grains or used for pasture, although a portion of the cultivated acreage is devoted to orchards. There are also a number of non-farm rural homesites. Individual farms are small, and this factor, coupled with the existence of non-farm rural homesites, has produced a complex land ownership pattern.

During the summer of 1970, a team from the University of Oregon conducted an extensive site survey program in the Upper Willamette Valley (White, 1975). Conditions existing at the time precluded any but an opportunistic sampling approach. Pastures were excluded from the survey because the heavy ground cover totally obscured the ground surface; areas with standing crops were also excluded, for obvious reasons. In addition, some landowners would not grant the survey team permission to enter their lands.

Prior to the 1970 site survey program, little formal knowledge existed concerning site locations in the Willamette Valley as a whole, but one apparent pattern did offer some hope. Sites along the main stem of the Willamette River north of the survey area seemed to be associated with the leading edges of terraces and/or the present or former courses of tributary streams. Along the Coast Fork, terraces and abandoned stream courses were not always readily discernible on the ground, and ex-



**Figure 13** Vertical aerial photograph of Creswell, Oregon, vicinity with map overlay. S = site. ASCS photo DBQ-2JJ-189, June 24, 1968. Original scale 1:20,000.

isting aerial photographs were utilized as an aid in locating these features.

The relevant geomorphic features were easily recognized on the photographs, but a hope that archeological sites associated with them might also be discernible was not realized. The dark-colored alluvial soils of the area effectively masked any midden associated with the sites. The accompanying photograph (Fig. 13) illustrates these points. Two sites are situated along the leading edge of the third terrace, another is associated with the present Coast Fork channel, and a fourth with a former channel of Hill Creek. This last site is one of the few found on the entire survey that had a recognizable signature.

Aerial photographs were also extensively used by the survey team as supplements to the U.S. Geological Survey 15-minute quadrangle sheets covering the area. The most recent quadrangle sheets available at the time of the survey, based on field work conducted in the mid-1950's, were badly out-of-date from the standpoint of modern cultural features. (Existing aerial photographs used by the survey team dated from 1968.) Use of aerial photographs greatly simplified decisions on how best to reach a certain area the team wished to examine. Used in conjunction with county plat maps, the photographs also facilitated the task of determining ownership of particular tracts to be examined.

Finally, a simple but highly practical use for the photographs was found when working with local artifact collectors who agreed to act as informants. In a number of instances, these informants found it difficult to pinpoint the location of a site on a quadrangle map, but could do so with ease on an aerial photograph. Landmarks such as fence-lines, small drainage ditches, small groves or isolated trees, and other pertinent features not shown on the quadrangle sheets were key factors in this success.

## **Upper Umpqua Valley**

The Upper Umpqua Valley of southwestern Oregon is a nexus of many small valleys composing the Umpqua River drainage, situated in an interior mountainous node where the Cascades, Siskiyou, and Coast Range come together. Dominant landforms in the valleys are alluvial fans, terraces, and floodplains. Vegetation consists of extensive grass-

lands interspersed with scattered oak woodlands that are dominated by overstories of California black oak and Oregon white oak. The hills and mountains in and around the dispersed valleys are covered by dense stands of Douglas-fir, but Ponderosa pine, incense cedar, sugar pine, white fir, and Pacific madrone are also common. The rugged mountainous areas, which constitute the majority of land at higher elevations, contain few large level places.

In this temperate region, particular food resources are not necessarily distributed in one environmental zone exclusively. Anadromous fish are available not only in the main water courses winding through the valleys, but also in many tributaries in the mountainous regions. Large land game such as elk were no doubt most plentiful in lower valley grasslands, but were also available in localized upland prairies. River mussels, camas bulbs, and other root crops are predominantly valley resources; acorns are more widely distributed. Berries are especially plentiful on disturbed southern sunny slopes in the mountains.

The valleys of the inland southwestern portion of Oregon contain almost all of the relatively level land suitable for year-around human activity. Regular seasonal settlements probably also existed in the mountainous areas, however, since fluid establishment and abandonment of activity loci in proximity to more established settlements is ethnographically described for other nearby regions.

The U.S. Geological Survey maps for this region are in the 15-minute series, approximately one inch per mile. The area was surveyed in the 1940's and early 1950's; some of the maps, therefore, do not reflect the high photogrammetric standards of newer maps. Thirty years ago the area was masked by a dense canopy of almost unbroken forest which no doubt affected the accuracy of the topographic maps, especially in remote areas where field verification was most difficult.

The canopy cover is still a hindrance, but the recent extensive cutting of forest stands by logging companies has exposed much of the surface. The new detailed aerial photographs, approximately five inches to the mile, clearly show the smallest landforms in cut areas. Therefore, although the older topographic maps provide a broad regional perspective of the Upper Umpqua Valley, the aerial photographs provide more precise information concerning detailed geomorphic features.

Over 400,000 acres of public lands in the Upper Umpqua region are currently being inventoried by a BLM archeologist in order to locate and evaluate cultural resource sites (Hanes, 1977). The public lands are almost exclusively located in the mountainous Douglas-fir zone, ranging from the valley edges to over 4,000 feet elevation. These holdings consist of one-mile-square sections, distributed largely in checkerboard fashion. Alternate sections are primarily owned by private timber companies, and the valley bottomlands are divided into small individually owned farms. Several small towns also occur in the valleys.

The archeological survey, initiated in mid-1976, accumulates archeological data through on-the-ground surface inspection of public lands, interviews with private landowners, and observation of private collections. First-hand site inspection is minimal. In valley lowland areas, several sites exhibiting visible housepit features have been identified. These have yielded a variety of chipped and non-chipped stone implements, exposed by decades of plowing and stream erosion. Most abundant on the forested public lands are surface lithic scatters consisting principally of projectile points, small uniface scrapers, and lithic reduction debris.

All valley sites known so far are located on stream terraces adjacent to principal water courses of the Umpqua drainage. For the valley zone, aerial photography has been useful for mapping existing terraces to define other probable site locations. River features of potential economic significance to the aboriginal people, such as riffles and falls where salmon can most easily be caught, may also be identified from air photos. On the uplands, open sites have been found associated with such physical features as small stream terraces, falls, prominent ridgetops near springs, and intermediate benches along ridge lines. Stereoscopic viewing of air photos allows rapid identification of such potential site locations.

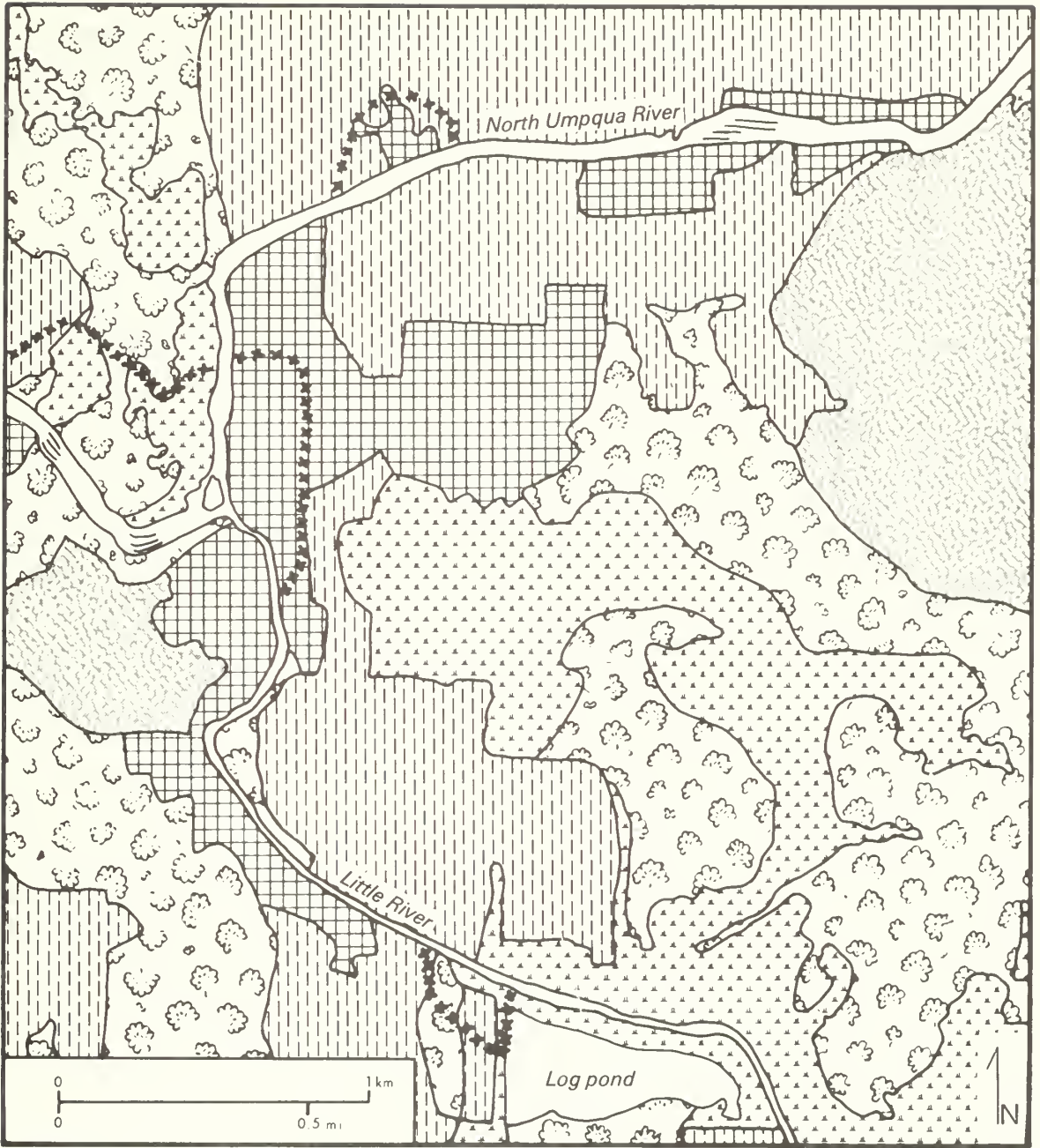
In heavily wooded terrain such as that of the Upper Umpqua region (Figs. 14, 15, 16, 17), understories of dense brush and thick blankets of conifer needles greatly hinder identification of sites, making archeological ground survey very time consuming. Under these circumstances, areas to be examined by ground search must be well chosen. Use of air photos is extremely helpful in selecting potential survey areas. Where heavy vegetation conceals archeological remains, a rational approach to broad-scale archeological inventory

survey demands that relatively open areas be chosen for examination. An attempt to measure the sampling bias inherent in an opportunistic inventory survey strategy which focused on man-made openings in the forest is reported here. Air photos provided the basic data, which was supplemented by topographic maps and forest type maps developed by the Bureau's timber specialists.

A study area composed of 12 one-mile-square sections of land drawn from two adjacent townships on the lower North Umpqua River east of Roseburg was examined, using these data sources (Tables 1, 2). The BLM administers 50 to 100 percent of each section, a total of 7,118 acres. All 12 sections are located in the Douglas-fir forest zone; they vary in altitude from 1,200 to 3,500 feet above sea level.

Distinguishing between clear-cut, partially cut, and old growth forest areas is very important for archeological survey since the amount of land actually free of vegetation greatly affects chances of site discovery. Of equal importance is the age of clear-cut areas. In clear-cuts less than about five years old, much of the soil surface is still visible and the possibility of identifying cultural material is enhanced. In older clear-cut areas, a thick understory of grasses, blackberry vines, and fern has usually developed, and, as a result, ground visibility becomes extremely limited. A quick scan of available recent air photos is all that is needed to reveal the location of clear-cut areas, and to provide a preliminary identification of the extent of vegetational regeneration. More detail is available from dated timber type maps of individual areas, if needed.

The total percentage of public land included within each of four sampling strata based on steepness of slope (determined by stereoscopic viewing of air photos and use of contour maps) is shown in the first column of Table 1. The second and third columns indicate what proportion of each sampling stratum has been clear-cut or partially cut. The table shows that the less steep ground has so far been preferred for logging activity. Land with less than a 20 per cent gradient constitutes about 27 per cent of the total study area. Of such land, about half has been clear-cut and about one-fourth partially cut, leaving the remainder as standing old-growth forest. Steeper land of 40 to 60 per cent slope occupies roughly the same amount of area (29 per cent of the total), but only about a quarter of it has been clear-cut, and less than a tenth has been partially cut.



LEGEND



Mixed Woodland



Grasslands



Residential and Industrial



Cropped Land

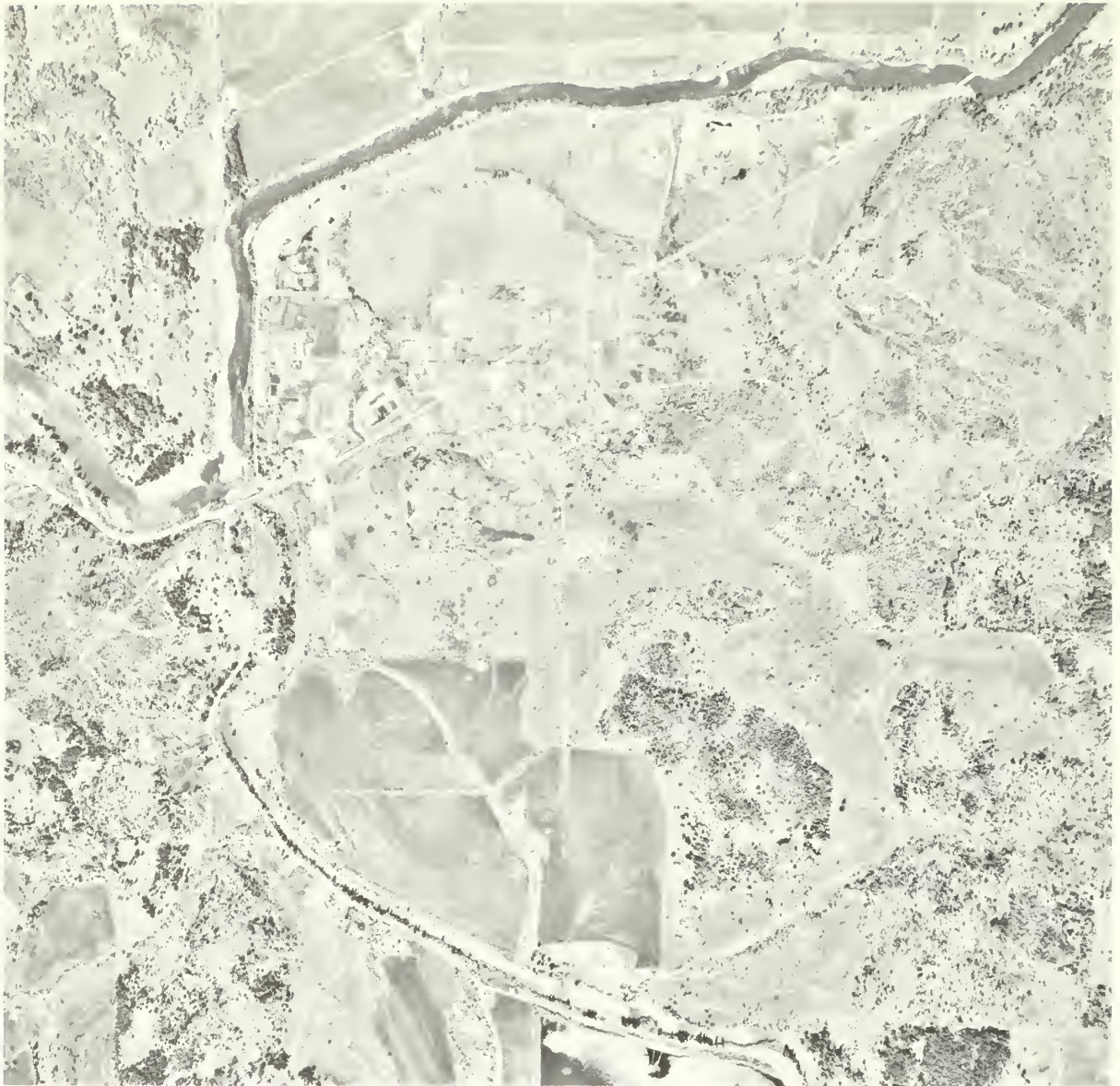


Logged Areas



Site Boundary

Figure 14 Map of Colliding Rivers area shown on next page.



**Figure 15** Vertical aerial photography of the confluence of North Umpqua River and Little River. SCS photo BTR-5HH-137, May 7, 1967. Original scale 1:20,000. Stereoscopic viewing with an overlapping photograph enables detailed distinction of major river and terrace features, the latter of which has been fully developed into agricultural fields and residential areas. The map on the previous page shows correspondence of post-occupational cultural developments and three archaeological sites. A village site at the confluence of the two rivers has suffered minimal disturbances. Pit features are still distinguishable through on-the-ground inspection. Another site lies to the east in agricultural fields on the bank of the North Umpqua at the mouth of a small creek. Several structures have been constructed in the immediate vicinity of the site. The third site, on the south bank of Little River, still contains a visible pit feature, and many items have been recovered from the plowed fields and gardens. No doubt highway construction and excavation of the large mill pond significantly impacted this site location.

To statistically describe this pattern, the Coefficient of Variation (Thomas, 1976:83-4) was adopted as a means of measuring the dispersion of cleared areas across the four sampling strata. With this measure, a coefficient value approaching zero

indicates a regular distribution, and increasing values provide a relative means of measuring variability of dispersion. The values arrived at for dispersion of total area and cleared area in each of the four sampling strata are shown in Table 2.



**Figure 16** Vertical aerial photograph of a section of the North Umpqua River. Distribution of logged areas, location of roads and logging trails, and general stage of forest regeneration may be seen. OSFD photo ORE-72, 15-33, June 28, 1972. Original scale 1:64,000.



**Figure 17** Oblique aerial view of a section of the North Umpqua River. The swatch through the forest paralleling the river is the same powerline right-of-way shown on the previous figure. U.S. Forest Service Photo.

**Table 1.** Composition of public lands from North Umpqua River sample, shown for four slope gradient sampling strata.

per cent slope sampling strata	per cent of total land. Acres are shown in parenthesis	per cent clear-cut	per cent partially-cut
0-20	27 (1950)	49	27
20-40	33 (2349)	34	10
40-60	29 (2043)	27	7
60-90	11 ( 776)	22	4
total	100 (7118)		

The first column gives values for amount of area in each slope category; the second and third columns give values only for those portions that have been cleared by logging activities.

**Table 2.** Coefficients of Variation for four slope gradient sampling strata.

per cent slope sampling strata	total land dispersion	cleared land dispersion
0-20	52.9	68.3
20-40	46.5	90.7
40-60	69.9	97.8
60-90	102.9	138.0

The first column gives values of variation for the total amount of land within each stratum; the second gives values for the cleared portions only.

Values in the two tables suggest that archeological survey of the cleared areas on the less steep slopes of the valley would achieve an adequate representation of site patterning. As the degree of slope becomes steeper, the distribution of cleared areas becomes more variable, and in the sampling stratum of 60 to 90 per cent slope, the distribution becomes strongly clumped. Thus, for lands with slopes up to about 60 per cent ( virtually all of the area studied), archeological survey of cut-over tracts should give an adequately representative sample of the terrain gradient types that exist with-

in the study area as a whole. Extremely steep lands are a special case, comprising a small fraction of the total area, that would have to be approached differently.

The impact of logging upon archeological sites in forested areas is a problem inherent in the sampling strategy described above; the deleterious effects of logging must be assessed in the field. The impact of residential, industrial, and agricultural land use on sites of the valley bottomlands can, however, be at least partially assessed using air photos. This type of analysis is particularly impor-



tant for a region like the Umpqua River Valley where available flat land is limited. Figures 16 and 17 show the effect of modern land use on terrain occupied in aboriginal times, and illustrate the extent to which the surviving record of aboriginally utilized localities is likely to have been distorted by recent cultural modifications of the landscape.

## Oregon Coast

Two locations on the Oregon Coast have been selected to illustrate potential archeological uses of aerial photography in seaside terrain. The Netarts sand spit at Netarts Bay, on the north central coast, was the site of a major Indian village in the late prehistoric period, and of several smaller sites as well. Immediately south of the bay is Cape Lookout, also the locus of several archeological sites. The second locality is on the extreme south coast, a few miles north of the Oregon-California border near the town of Brookings (Fig. 1).

The Netarts sand spit protects a broad, shallow bay that has excellent potential for fishing and clam digging. The rocky slopes and caves of Cape Lookout, a long narrow headland thrust into the sea, support rookeries of sea birds and sea lions, as well as an abundance of mussels and other creatures of the intertidal zone (Fig. 18). The coast north of Brookings is rocky and indented. Although it has no features as spectacular as those of Cape Lookout, the rocky shore and small offshore islands provide habitats for the same food species. Both the northern and the southern locales are backed by dense coastal forest, which support elk, deer, bear, and smaller games, as well as a variety of edible roots, berries, and greens. In historic times, the Netarts-Cape Lookout area was in the territory of Salish-speaking Tillamook Indians, and the Brookings area was in that of the Athapaskan-speaking Chetco (Fig. 1).

Both localities are Oregon state parks, and were surveyed as part of an inventory of the cultural resources of all state parks on the Oregon coast (Ross, 1975). Since each area was systematically searched on the ground, the inventories are believed to be reasonably complete, although extremely dense vegetation back of the beach strand may have concealed some cultural remains. Neither of the parks, of course, is fully

representative of the whole range of micro-environmental zones occurring along the coast.

Netarts Bay, five miles southwest of the town of Tillamook, is nearly closed by a six-mile-long sand spit—typical of spits formed along coasts where sand-sized sediments occur over low-gradient sediments. A muddy, shallow, flat tidal bay, protected by this sand spit extending from the base of Cape Lookout to the rocky cliffed shore west of the town of Netarts (Fig. 18) is noted as a producer of shellfish, the major beds of which are adjacent to the sand spit.

The archeological sites occur on the leeward side of the sand spit in openings in the dense vegetation (Fig. 19). There is but one narrow access route to the sites via the connection of the spit to the base of Cape Lookout. If defense was a consideration in the choice of a residential area, a better situation would be difficult to find.

Air photo interpretation confirms that the known sites represent the best locations in the area of Netarts Bay for exploitation of the clam beds, the obtaining of fresh water from small ponds or shallow wells in the sand, and protection from offshore winds. The tidal channels show plainly on the vertical air photo (Fig. 19), revealing that perhaps nine-tenths of the clam bed area is accessible from the sand spit, and but a minor portion of it accessible without a boat from the shoreward side of the bay.

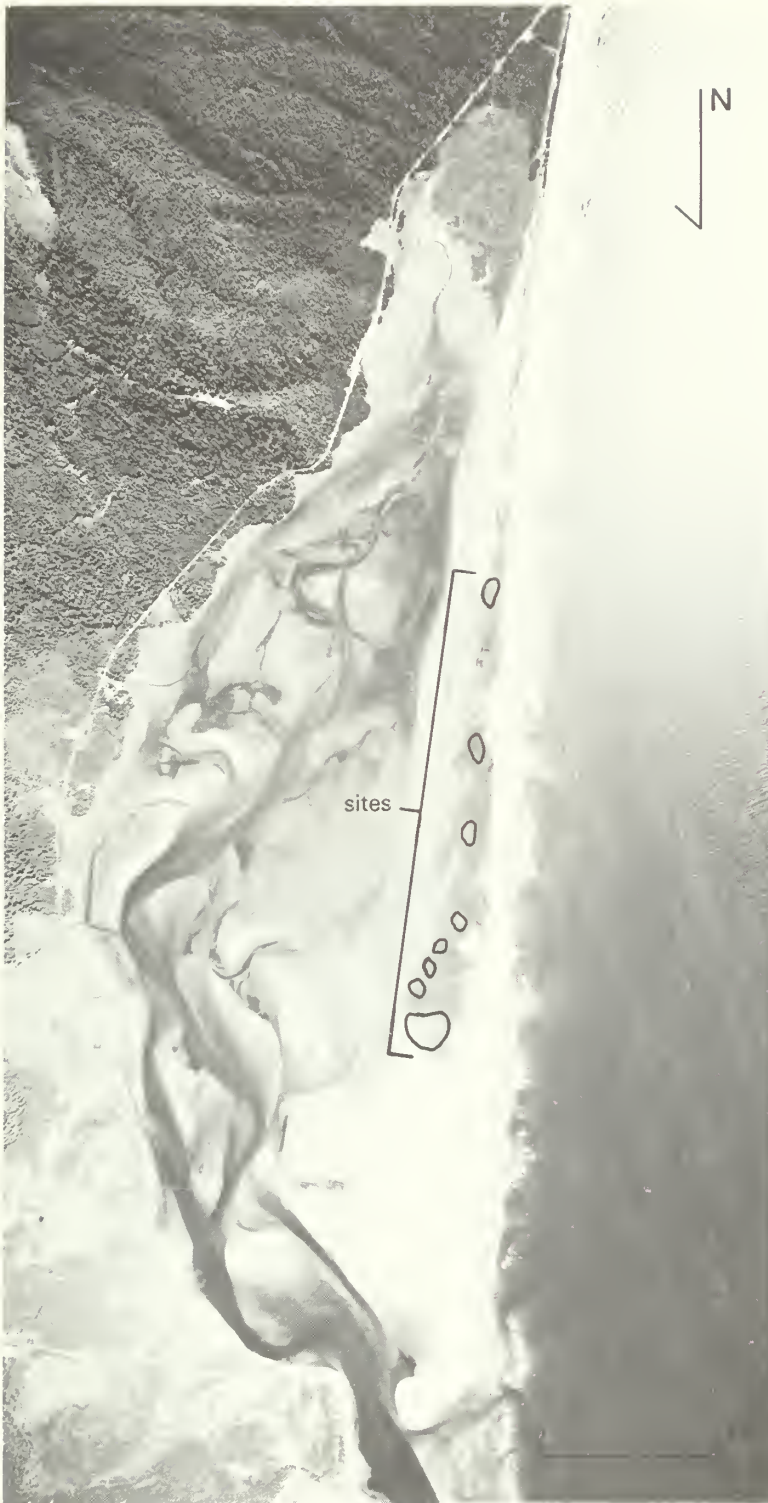
Apparent on the air photos are small dark areas in the sand spit, probably the fresh water ponds that can be expected in this geographic zone. Stereoscopic inspection of the sloping margin of the bay shows that possible site locations along the margin of the mainland would have been windy. In general, sand spits are likely locations for habitation sites if vegetation were adequate to provide protection from the wind and if adjacent clamming beds existed. It is probable that little food was available from the open ocean.

A mile south of the Netarts Bay sand spit is Cape Lookout, a cliffed promontory fringed by reefs and indented by rocky coves. These rocky intertidal ledges yielded foods that complemented the food available in the bay. However, the headland itself would not have been as hospitable as the sand spit for human habitation.

On the southern Oregon coast marine terraces are common landforms that result from the interplay of sea level change and crustal movements. The coastline north of Brookings is a series of



**Figure 18** Oblique aerial view of Netarts sand spit with Cape Lookout in the distance, showing some site locations. Photo A615-48 Oregon State Highway Department.

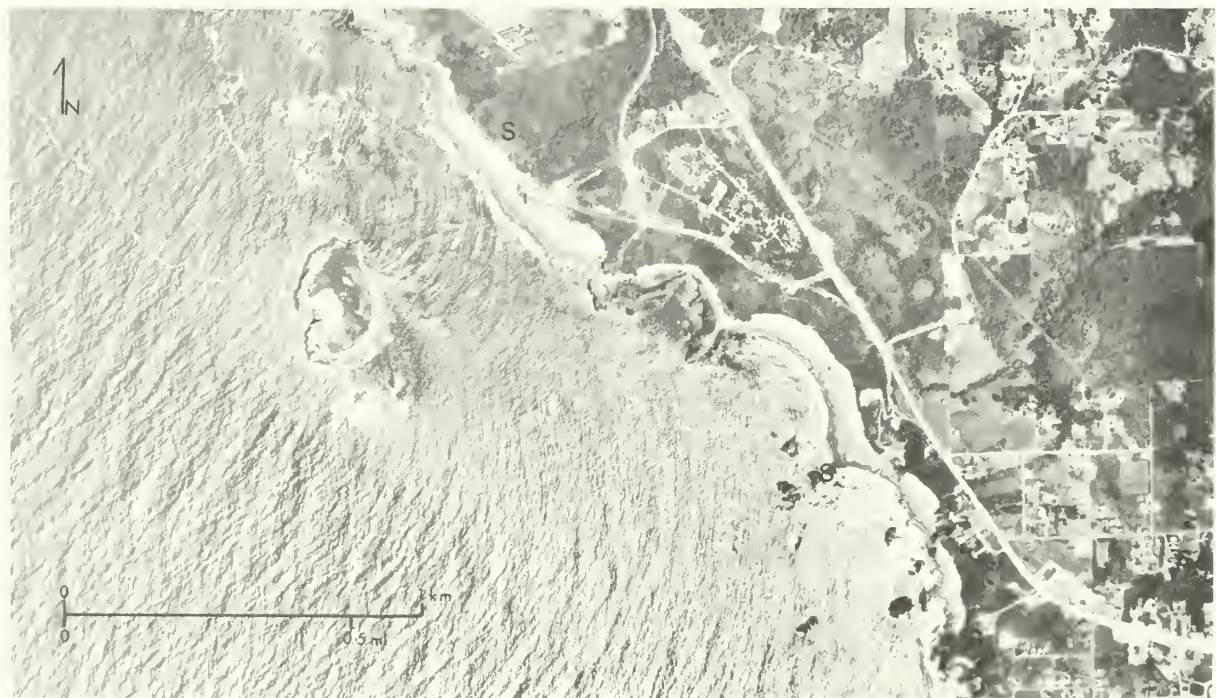


**Figure 19**

Vertical aerial photograph of Netarts sand spit, showing site locations. Deeper tidal channels are darker; the unchanneled area next to the sites is a clam bed. USGS photo GS-YX, 5-22, July 31, 1953. Original scale 1:37,400.



**Figure 20** Oblique aerial view of coastline north of Brookings, Oregon. Photograph-sketch pair is of an area immediately northwest of Harris Beach campground. Photo A491-90 Oregon State Highway Department.



**Figure 21** Vertical aerial photograph of coastline north of Brookings, Oregon, showing site locations. ASCS photo EOS-1FF-78, June 22, 1965. Original scale 1:20,000.

coves and spurs. The extent of the original terrace, now much eroded, is indicated by a few offshore rocks. Habitation sites occur commonly on low rises along the terrace edge, perhaps one per mile, where access to the beach and rocky areas is easy (Fig. 20). It would appear that these locations were chosen primarily as bases from which to exploit the rocky intertidal zone. Two of the three sites shown on the vertical air photo (Fig. 21) occur on the edge of the present terrace overlooking the ocean; the third is located on the rocks seaward of the beach. It is not known archeologically whether the sites on the terrace were permanently occupied or were only visited occasionally, but their exposed location along an open, windy coast suggests the latter.

## Section 4

# Remote Sensor Data Acquisition

Acquiring remotely sensed imagery, normally air photos, is fundamentally different from buying printed materials because stocks of the images desired may not exist. When original negatives are filed somewhere, the trick is to find them and have them converted to positive images according to your specifications. Section 4 of *Remote Sensing: A Handbook for Archeologists and Cultural Resource Managers* discusses strategies for obtaining ordering information from U.S. Government sources, county offices, the Canadian Government, and commercial firms. Suggestions for taking your own photographs are also given.

Recently, the Map Information Office of the U.S. Geological Survey was restructured into the National Cartographic Information Center (NCIC). Inquiries concerning aerial imagery in the western states of Arizona, California, Idaho, Nevada, Oregon and Washington should be addressed to:

National Cartographic Information Center  
Western Mapping Center  
U.S. Geological Survey  
345 Middlefield Road  
Menlo Park, California 94025

In addition to the sources listed above, the searcher should determine whether there is a state agency that maintains indexes of all aerial photography in the state. In Oregon, the Oregon State Forestry Department in Salem maintains an index of all major aerial photography projects in the state as part of its role as a leader in developing cost-sharing multiple-agency photography contracts. Historical files contain aerial records back to the 1930's. The Department of Natural Resources in Washington State maintains indexes for Washington. It may be that in every state an agency that performs similar functions can be located.

When searching for imagery, the basic question to pose is "Who is responsible?" At least one major land managing organization is responsible for every part of the United States, and all land managing organizations rely on periodic photographic flights to obtain the air photos they need. For example, the U.S. Army Corps of Engineers is responsible for ports and waterways. A search of the indexes at the Corps office in Portland, Oregon, yielded 11 flights over the entrance to Coos Bay in recent years. If there is an area of archeological interest near a Corps facility, obtaining imagery should not be a problem.

Regional archeological surveys require air photos of a usable scale taken during the proper season, often the period of highest vegetational stress. Fortunately, land managers need similar photography and the most readily available imagery is usually well-suited to archeological uses. Scales ranging around 1:20,000 appear ideal; in the opinion of this interpreter (W.G.L.) 1:40,000 is to be preferred to 1:10,000. The interpreter's primary need is to see several square miles in one view, not to identify an object between two trees. If identification of a specific object is important, it is far better to have less-detailed air photos that show the environs of that object and the routes that may be followed to get there. In any case, positive identification can be made only on the ground. It should be remembered that to study an area photographed at 1:10,000 scale requires 16 times as many individual photos as 1:40,000 scale photos.

The use of air photos in archeology has evolved since its major introduction in the early years following World War I. In the first two decades, *primary* evidence, such as actual walls, traces of roads, and canal depressions, was sought on the photographs. This primary evidence was

easily observable in desert areas, but not in heavily vegetated areas. The training of many photo interpreters during World War II and the explosion in the number of air photos produced pursuant to the war effort resulted in a greater sophistication of air photo use, and *secondary* evidence came into use. Crop marks and soil marks are typical kinds of secondary evidence; subtle differences in the growth rates of annual crops or the variations of tone that indicate soil moisture differences suggest the existence of archeological remains.

During the past 10 to 15 years, methods have been developed to use *tertiary* evidence for archeological purposes. Even where no walls, ditches, roadways, shadow sites, or soil marks can be discerned, the utility of air photos remains great. Using air photos, an interpreter can locate perennial water supplies, arable land, and landforms suitable for habitation sites. The interpretation of the total landscape is possible—an interpretation that can serve the regional archeologist better than bits and pieces of walls (Lyons and Avery, 1977).

An example of this approach is the Minnesota Messenia Expedition project in Greece. The entire study area of 1,400 square miles was perused on 1:30,000 scale panchromatic air photos (McDonald and Rapp, 1972), which proved more than adequate for locating possible Mycenaean sites. Specific areas of concern were then photographed at a scale of 1:7,200, a scale sufficient to map the smallest drainage ditch. Excavation photos were made later using balloon and bipod methods. One scale does not fit all purposes, and each of the major purposes—regional survey, site neighborhood mapping, excavation photography—must utilize properly scaled imagery.

Films and cameras have evolved over the decades, improving greatly from the dark-cornered blurry-edged early air photos to the incredibly sharp flat modern products. Besides the better cameras, which allow smaller scale air photos to serve more detailed uses, the most dramatic development has been color infrared film. Because infrared film is sensitive in the longer wavelengths, it literally cuts the haze, yielding a clear image. By assigning bright red to healthy vegetation, perennial water supplies can be identified in dry-season photography with maximum ease on color infrared film. Black-and-white infrared film serves most of the purposes of color infrared, if less dramatically. For over-all interpretability, however, standard

panchromatic film, used with a minus-blue filter, retains its utility, since its black-and-white rendition of reality is most familiar to most interpreters. True color negative images are of least use because of the scattering of the blue wavelengths of the spectrum. Color transparencies, however, are often most valuable for cultural information content.

The primary limitation in the air photo interpretation process is not the imagery or the stereoscope, but the imagination of the interpreter. It is the interpreter who must empathize with the former inhabitants of the land under study; it is the interpreter who must imagine walking the land searching for a place that possesses the essential elements of life: water, food, shelter, access, and suitable microclimatic niche (Lyons and Avery, 1977:59). Too often interpreters feel that the solution to a problem is a stereoscope of greater magnifying power or imagery of some esoteric nature. These are not solutions. The solution lies in maximum knowledge of the peoples involved and a personal feeling for the terrain obtainable only by a dusty-boots familiarity with it.

The most productive strategy for developing site-location signatures is to alternate between imagery interpretation and fieldwork. Initially, most of the time should be spent in the field; later, as experience is gained, more time can be spent in the office with the air photos alone.

If one is to do a regional study, the first step, after acquiring the imagery, is to assemble the air photos into an uncontrolled mosaic. In this way, the interpreter can grasp the general lay of the land and, incidentally, make sure that there are no holidays in the stereoscopic coverage. General familiarization with the region and the imagery should be done thoroughly with a map in hand, and the air photos should not be gathered up until major points are identified on them. A field reconnaissance should follow, visiting the major points and walking the ground, air photos in hand.

The next major step in a regional study is to plot all known sites on the air photos by positively identifying them, pin-pricking the photo, and annotating the reverse of the photo. The environs of known sites can then be studied and the reasons for their locations surmised. Better site-location signatures will be developed if the interpreter can field-check a selection of the sites.

After the interpreter is as familiar as possible with the peoples in question and a selection of sites they chose, general interpretation may proceed.

Using a systematic scheme (Miller and Miller, 1961: 60-63) the interpreter can then visually search every hill, terrace, valley and the environs of every spring in the region for probable habitation sites. "Possibles" can be circled with grease pencil on the air photos and specific directions written detailing the best access route to the location. At the same time the set of air photos is being searched for habitation sites, the interpreter can efficiently delineate trails, mark springs, and even prepare a landforms map.

Once the set of air photos has been interpreted and the validity of the interpretation field-checked, inferences can be made based on the patterns revealed. A hierarchy of sites can be inferred utilizing central place theory from urban geography, if we can assume that the more important places were located on the more favorable sites that dominated the most productive land and controlled the best transportation routes. Sites can be grouped into sub-sets based on physiography as a check on sub-sets based on other criteria. If it is felt that a rather complete count of the sites in an area is available, then site densities and the area required to support a site can be calculated. Anomalies in a map where all of the land is apportioned can be considered areas where more searching is needed to complete the habitation pattern.

It is difficult to specify equipment to accomplish the above tasks, as each type of equipment serves a special purpose and interpreters have different physical capabilities. Monocular inspection of Landsat imagery and air photo indexes can be useful in determining general patterns; indeed, single-print study (usually of enlargements) may be profitable where vertical differences are not important. It is the stereoscopic image, however, that is most useful. Because of their portability, pocket stereoscopes are preferred by some over more expensive mirror stereoscopes. Through the mirror stereoscope, the stereo model can be seen more completely and scanned more easily than through a pocket stereoscope. Further most mirror stereoscopes can be fitted with binoculars for 3x to 6x enlargement viewing. The interpreter should have access to both types of instrument.

## Summary: Applications in Oregon

Air photos proved to be useful in each of the varied environments in Oregon, though to varying degrees and in strikingly different ways. For the deserts of eastern Oregon, panchromatic mapping photography was available. Although it does not permit positive identification of water as readily as infrared films, the panchromatic film was exposed in the height of the dry season and many water sources in the area were seen. Landforms were evident on this imagery, and modern transportation routes, trails, and jeep tracks showed up clearly as white lines. In the Glass Butte area, obsidian quarries could be discerned, and at Coffeepot Flat, major habitation sites were somewhat lighter in tone (though light-toned areas were caused by other factors as well). In the areas of difficult access, such as the Owyhee River canyon and the flooded dunes in the North Warner Lakes area, the more utilitarian uses of the air photos were seen to be of importance.

In western Oregon, dramatically different situations prevail. The heavily wooded slopes of the Western Cascades and the interior of the Coast Range are not amenable to the same uses of air photos as the more open areas of the region. Although the ground is obscured in areas of almost complete coniferous crown coverage, an interpreter can use air photos to study the general topography and work out possible ridge-line trail systems in an environment where passage is difficult. Air photos may also be used to locate easy stream crossings or rapids that may have been fishing loci. One problem to be noted is that the mapping or land management air photos in these areas of heavily dissected mountains with long slopes have a large ratio of elevational differences to flight height. If the ratio is too high, an interpreter may not be able to create a stereoscopic image under a pocket stereoscope and may find that a mirror stereoscope yields better results.

The more open areas of western Oregon, however, contain habitation sites that can be studied with air photos. In the upper Willamette Valley, sites normally occur on the first terrace above what was the annual floodplain before flood control dams were built upstream. These terraces are easily visible on mapping air photos, usually available from the Agricultural Stabilization and



Conservation Service. Along the lower North Umpqua River, known sites (probably fishing villages) located near rapids are evident on the available panchromatic air photos. Searching along terrace edges and near rapids would no doubt yield other sites.

Along the Oregon coast, a general interpretation of the standard panchromatic air photos revealed that the best topographic locations were places sheltered from the often ferocious oceanic westerlies yet close to clamming grounds or to rocky intertidal flats that supported mussels in great quantity.

In summary, demonstration that a place was once inhabited is not always possible through the study of air photos. On the other hand, it is possible to study the stereoscopic image of a landscape, and, calling on prior knowledge of the peoples in question, predict possible locations of ancient sites. Fieldwork can then be scheduled in a relatively efficient manner. It is comforting to know that fieldwork cannot be eliminated; it is even more comforting to know that it can be made more efficient.

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