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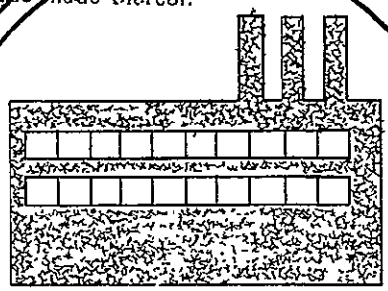

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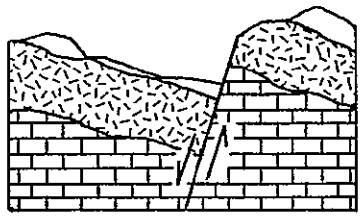

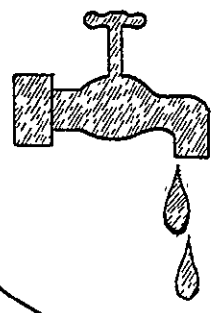

University of Wyoming

SPECIAL REPORT: LAND-USE IN THE MOORCROFT AND KEYHOLE RESERVOIR AREAS, CROOK COUNTY, WYOMING

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August, 1975

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Figure 2. Technical Report Standard Title Page

Abstract

A study was made of the Moorcroft-Keyhole area of northeast Wyoming to evaluate and compare the LANDSAT, Skylab, and high-altitude aircraft imagery as tools for comprehensive land-use mapping. The use and development of the test area is of particular concern due to the increased activity prompted by the development of energy resources in the adjacent Powder River Basin.

Land-use maps (1:62,500 scale) compiled from the image data showed the LANDSAT data to be suitable for rapid reconnaissance mapping but not sufficiently detailed to provide a comprehensive land-use mapping base. The Skylab S-190B photography provided adequate detail for mapping of all major land-use types and proved suitable for change detection and identification of most land-use subclasses (specific agriculture uses, extractive industries, etc.). The regional coverage of the Skylab and LANDSAT imagery are both amenable to reconnaissance mapping of large areas, but the Skylab data provides essential detail not available from the LANDSAT imagery.

The 1:120,000-scale aerial photography allows accurate identification of all major land use categories and all major subclasses. Upon field checking, the land-use interpretation compiled from aerial photography proved accurate for more than 97% of the area. The interpretation of the aerial photography requires much more time (about 5 to 1) than the interpretation of either the LANDSAT or Skylab data.

The Skylab S-190B photography was judged superior for reconnaissance mapping at a scale suitable for regional planning and resource management, but the high-altitude photography is more useful for planning and management in local areas of concentrated activity.

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INTRODUCTION

The study area lies in the northeast corner of Wyoming between latitudes $44^{\circ}15'$ and $44^{\circ}30'$ north and $104^{\circ}45'$ and 105° west (Fig. 1). It encompasses 210 square miles of mixed rangeland, farmland, forest, and water. Relief in the area is moderate with the major topographic elements being the Belle Fourche River valley and a series of NNW-trending ridges formed by differential erosion of Paleozoic sedimentary rocks lapping onto the western flank of the Black Hills uplift. Elevations range between 4,000 and 4,750 feet. Keyhole reservoir (32 sq. mi.) occupies the east central portion of the area and is the major recreational attraction in the area. Moorcroft (population $\simeq$ 1200) is the only major settlement in the area; but Pine Haven, a new development along the south shore of Keyhole reservoir, is growing rapidly.

The climate of the area is semi-arid with the average annual precipitation of approximately 15 inches and a mean annual temperature of $42^{\circ}F$ (maximum $> 100^{\circ}F$, minimum $< -30^{\circ}F$).

Access to the area is by Interstate 90, which transects the southern part of the area; U.S. Highway 16, to Upton; U.S. Highway 14, which trends northeasterly across the study area; and numerous county and private roads. Devil's Tower national monument lies approximately 9 miles to the northeast and brings a considerable amount of tourist trade to the area.

The Moorcroft-Keyhole area is currently undergoing rapid change in response to the development of energy resources of the Powder River Basin. Agriculture, petroleum, and mining have long been the chief industries of the area; but now, recreational and homesite potential of the area is being realized. The need for a comprehensive program for mapping and monitoring change in the area is apparent, and the possibility of obtaining much of the needed data through interpretation of satellite imagery prompted this study which evaluates and compares LANDSAT, Skylab, and high-altitude aircraft imagery.

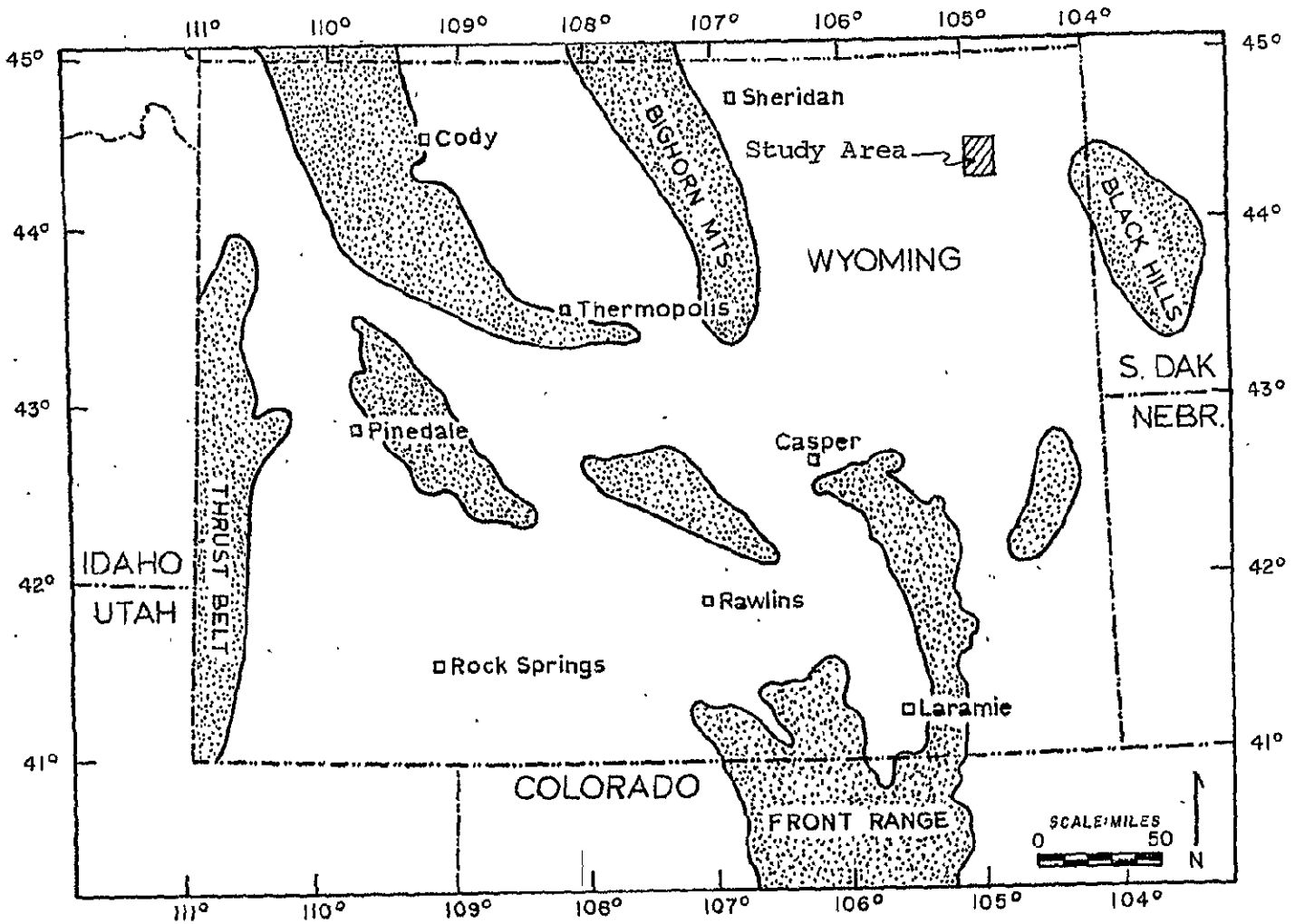

Figure 1. Index map showing the location of the Moorcroft-Keyhole study area.

METHODS OF INVESTIGATION

A separate land-use interpretation was first made from the LANDSAT imagery, the Skylab S-190B photography, and the high-altitude aerial photography. Each interpretation was compiled at a scale of 1:62,500 by direct interpretation from an enlarged color print (LANDSAT and Skylab interpretations) or by direct transfer using a Kern PG-2 plotter equipped with SSL pantograph (aerial photography). This approach eliminates much of the bias introduced by mapping at different scales and allows direct comparison of the different image products, the land-use interpretations, and the topographic map used as a mapping base.

The ERTS interpretation was made first, the Skylab map second, and finally a map was compiled from aerial photography. This mapping sequence allowed the interpreter to proceed from the general information to more specific data and eliminated the possibility of unconsciously adding detail to the interpretations of the lower resolution images. The interpreter was unfamiliar with the study area when the interpretations were made but had a general knowledge of land-use practice, geology, and physiography of the area. After the interpretations were complete, the area was field checked and a corrected version of the land-use map was prepared incorporating detail on the level of that interpreted from the aerial photography. This field-corrected map was then used as a basis for comparative evaluation of each of the image interpretations.

LANDSAT IMAGE INTERPRETATION

A land-use interpretation was made for the Keyhole area from a single color-composite LANDSAT scene (1353-17183, July 11, 1973). This scene was chosen for its excellent quality and because it can be readily correlated with the Skylab photography obtained September 13, 1973. The mapping base was a 16X enlargement of the LANDSAT scene (1:62,500 scale) enlarged from a 1:1,000,000-scale diazo

composite of the four MSS bands. The color/band configuration of the composite was such that a presentation equivalent to the standard false-color mode was achieved (green band in yellow, red band in magenta, infrared bands in cyan). Enlargement to 1:62,500 produced a working print (Fig. 2) lacking sharpness but allowing direct comparison with the Skylab (Fig. 3) and high-altitude aerial photography (Fig. 4), both enlarged to the same scale, and with the 1:62,500 topographic base (Fig. 5). The LANDSAT land-use interpretation was compiled on an adhesive-backed transparent overlay material applied directly to the print surface.

Interpretation of the selected LANDSAT scene for land-use resulted in a ten-category land-use map of the Keyhole area (Fig. 6). Comparison of this map with field-verified land-use data demonstrates the value of the LANDSAT data for rapid identification and delineation of generalized land-use classes. Laboratory identification of these broad classes was achieved with accuracy greater than 85%. However, important subclasses present within several of the generalized categories could not be identified. Consequently the utility of the resulting map for planning and resource management is limited. The limitations are apparent in the following descriptions of the mappable land-use categories:

> 0101 Urban: The only major urban center in the study area is Moorcroft, Wyoming (population 1200). The populated area appears as a light-buff colored area contrasting sharply with the surrounding rangeland but appearing similar to naturally occurring barren areas. The urban area is identifiable largely because of its polygonal boundary and its location along the interstate highway. Individual street patterns are not distinguishable on the color-composite LANDSAT image but may be seen on some winter scenes where the snow-free streets stand out strongly against the white background. Industrial and commercial zones in Moorcroft are small and are not distinguishable from the residential areas.

0104 Extractive: Clay strip mines are common in the Belle Fourche shale cropping out east of Moorcroft along the flank of the Black Hills uplift. These mines are visible on the LANDSAT image. They are not particularly distinctive in tone or texture but exhibit a peculiar bluish hue which may represent water or dark soil accumulating in the bottom of the pits. The smaller strip mines often do not have the bluish color and are difficult to distinguish from barren rock, urban areas, or some farmed areas.

Little or no effort has been made to reclaim the stripped areas and no distinction was possible between abandoned and active mines. Little or no vegetation is present on either the stripped areas or the spoils.

Several large oil fields occur in the western part of the Keyhole area but the individual well sites are not detectable on the LANDSAT image. Some intensely developed areas appear as barren areas or areas of poor range contrasting with the surrounding crops or grassland because the normal vegetation cover has been partially destroyed by the operators activity.

In general, the oil fields in this area could not be reliably identified and mapped from the LANDSAT imagery, so they are not included in the areas mapped as "extractive".

0105 Transportation: Transportation routes in the area include one railroad, one four-lane highway (I-90), two asphalt-paved, two-lane highways and numerous improved and unimproved gravel roads. Only the four-lane interstate highway is detectable on the color-composite LANDSAT image, and it is only faintly detectable in some regions. The highway has a light-toned, concrete surface that contrasts strongly with dark- or medium-toned areas, but shows essentially no contrast in the light-toned areas. The four-lane, divided highway shows as a single, light-toned line.

0204 Cropland or Improved Meadow: Cropland is one of the most difficult classes to identify accurately from the LANDSAT data. On the color infrared composite, the croplands appear in colors ranging from bright red (lush growth) to white (ripe grain or stubble). Some of these colors are not at all distinctive. The brilliant red tones representing the irrigated hay meadows, grain, and corn growing along the floodplain are impossible to distinguish from pasture and deciduous vegetation that grows naturally along the floodplain. Consequently, the floodplain was mapped as a single use category (0305) regardless of the various uses of the land along the floodplain. Likewise, irregularly shaped, plowed fields can be confused with barren areas, regions of active erosion or mined areas. Maturing vegetation and moisture-stressed fields commonly have a color similar to rangeland or forested areas. In a few cases, these fields may be identified by their distinctive geometric pattern and polygonal outline rather than hue or tone. Also, with LANDSAT data it is possible to use images representing several different seasons. Having the croplands imaged at different stages of maturity greatly increases the potential for correct identification of even those fields that have irregular boundaries.

0303 Rangeland: Rangeland covers a greater percentage of the mapped area than any other land-use category. Major differences in the range-

land are apparent on the LANDSAT imagery. These differences are largely manifested in the brightness of the image and differences in the red coloration. The best grassland (other than irrigated pasture along the major floodplains) is moderate- to dark-red in color and has a mottled appearance. Areas where sage dominates the grassland have a purple cast. Areas of poorer range appear lighter in tone because of the amount of light-toned soil not covered by vegetation. Consequently, the brightness of the image is the best indicator of the amount of vegetation present and can be used as a criterion for grading the grassland into poor, moderate, and good range. These quality grades are actually an estimation of the amount of vegetation present at the time of overpass rather than the true range quality or grazing capacity. No effort was made to take grazing pressure or special use factors into consideration. Color is of little or no value in determining range quality but can serve as an indicator of the type and condition of the range vegetation.

Floodplains: Lack of detail and stereoscopic presentation of the LANDSAT data precludes accurate segregation of floodplains from surrounding croplands and older river terraces. However, it is reasonable to assume that the heavily vegetated, irrigated and sub-irrigated lands along the major streams and rivers lie mostly within the floodplains in this area. Therefore, the very bright red, red-orange, white, and dark purplish-grey areas along these major waterways were interpreted as floodplains. The different hues within the floodplain areas are related to moisture content, variations in the natural floodplain vegetation, and crops that are grown in the rich bottomland.

0307 Barren Land: Barren areas appear as light buff- or grey-colored areas which are easily confused with plowed fields, harvested crops, and mined areas. However the barren soils and rock outcrops included in this class tend to be somewhat lighter grey than the mined areas and somewhat less yellow than harvested cropland. The barren areas usually grade laterally into poor range and can be identified by this association, or by their color and extremely irregular boundaries.

0402 Evergreen Forest: Forest lands are largely restricted to the northeastern portion of the study area where northwest trending forested ridges alternate with parallel strips of range and farmland in the intervening valleys. Ponderosa pine, juniper, and deciduous and evergreen shrub are the major constituents of these forests. There are no sizeable stands of deciduous trees in the forest areas. The only major occurrences of deciduous trees are along the river valleys. Here, cottonwood trees are common in patches too small to be mapped from LANDSAT imagery.

The coniferous forests are displayed in a mottled, purplish-red color which contrasts sharply with most other land-use categories. A few areas of improved range and some maturing crops are similar in tone and color but usually lack the mottled appearance of the evergreen forest land. Variations in tree density and tree size occur within the forest areas but the overall color and pattern of the forested area is homogenized on the low-resolution LANDSAT data to the point that it is impossible to tell whether the variations in tone and color are due to changes in tree density, tree size, or a complex mix of dense tree

cover and open meadow land. The coniferous forest area was mapped as a single unit and no attempt was made to provide a quality or density judgment from the LANDSAT imagery.

0502 Stockponds and Reservoirs: Water is undoubtedly the easiest land-use category to identify reliably. It presents a smooth coloration which varies from light blue to almost black depending upon the depth and turbidity of the water. The sediment-laden waters flowing into a major lake or reservoir (such as Keyhole) are imaged in light blue and reveal both the flow pattern and possible areas of major silting in the main water body.

Contrast is generally very good between the water and surrounding range or forest land. In fact, careful comparisons of the enlarged image with the topographic base indicate that the boundaries of major water bodies can be located on the imagery with an accuracy of $\pm$ 200 feet where the water is clear and within $\pm$ 500 where the water is turbid and contrast is relatively low. Stock ponds as small as one acre in size can be detected on the color-composite LANDSAT imagery but the shape and size of these ponds cannot be determined with confidence unless they are at least 5 to 10 acres in size.

SKYLAB S-190B PHOTOINTERPRETATION

A second land-use interpretation was compiled from interpretation of Skylab S-190B photography (Track 59, Pass 28, Frame 21) obtained September 13, 1973. A portion of the 4,600-sq.-mi. area of this photograph covering the Moorcroft-Keyhole area was enlarged (15.2X) from its original scale of 1:950,000 to 1:62,500 for interpretation and direct comparison with the 15-minute topographic map, the LANDSAT imagery, and the high-altitude aerial photography. S-190B stereo coverage was not available for the study area, so the interpretation was compiled directly on the 1:62,500 enlarged photo using no intermediate transfer devices or mapping equipment. The map data was then traced directly onto a land-grid base. The marked difference in quality of the Skylab and LANDSAT images is apprent in the comparison of Figures 2 and 3. The Skylab provides essential detail which allows better definition of most major land-use categories and some important subclasses. Secondary roads, farm yards, and individual well sites are readily identifiable.

However, the natural color rendition of the area presented on the Skylab color photograph does not provide the broad range of color contrast seen in the vegetation on the LANDSAT false-color composite. This is particularly significant because many of the land-use classes reflect (or are related to) changes in vegetation type or condition. The Skylab photointerpretation produced a land-use map (Figure 7) which is considerably improved over the LANDSAT image interpretation. All of the major land-use categories are readily recognized on the Skylab photograph as are many important subclasses. Again, the capabilities and limitations of the Skylab data are demonstrated in a review and description of the map units defined in the Skylab interpretation:

0101 Urban and Residential: Street patterns are easily discerned on the Skylab S-190B photography, so urban areas are readily identifiable and can be subdivided into several zones on the basis of dominant light and dark tones which correspond generally to the amount of vegetation in each block. The concentration of vegetation is largely a reflection of the type of development and activity in each area. The residential areas have a high density of trees, shrubs, and lawns and house tops are often shingled with dark-colored tiles. These areas appear dark-green or grey on the Skylab color photography.

0102 Commercial, Industrial, and Institutional: In contrast to the dark-green residential areas, commercial, industrial, and institutional areas are characterized by large buildings with steel or gravel-topped roofs surrounded by large areas of pavement or bare ground. Their overall reflectance is much higher than the residential areas and they appear light-grey or white in color on the Skylab photography. In addition the commercial and industrial areas are characteristically located along a major highway or railway.

The commercial, industrial, and institutional areas in and around Moorcroft are small and cannot be distinguished from one another on the S-190B photointerpretation. In fact, there is some mixing of residential and commercial activities in the area such that even these classes cannot be differentiated in some areas.

0104 Extractive: Strip-mined areas are readily apparent on the Skylab photography and, as was the case for the LANDSAT imagery, they are displayed in buff and light-grey shades against the darker background of forest and range. However, the Skylab photography provides sufficient detail to discern the individual pits within the disturbed areas; a feature which facilitates the identification of mined areas versus areas of active erosion or other barren areas.

Oil-well sites and related tank or transmission facilities are also visible on the Skylab image. These sites appear as very light-toned dots (barren areas) connected by a network of gravelled or unimproved roads. The individual sites can be located with precision, but no difference is apparent between pump-jack locations, holding tank sites, and sites of other installations. Therefore, the oil fields were mapped as a generalized area of extractive use on the land-use map derived from the Skylab photointerpretation.

The areas of oil production are customarily used jointly by the operator and the land-owner. These joint-use areas are indicated on the map.

0105 Transportation: Transportation was one of the major land-use categories showing the most improvement when using Skylab photography in lieu of the LANDSAT imagery. All major roadways (paved and gravel-surfaced) and many unimproved roadways can be mapped. Street patterns, railways and airstrips are also identified with little difficulty. Thus, it was possible to map all the major transportation facilities in the area and to subdivide them into sub-categories according to the mode of transportation.

Rivers and streams in this area are not generally considered navigable and Keyhole reservoir, although popular for recreational boating, is not included in the "transportation" category. Pipeline and powerlines would normally be included under "transportation" but none were mapped from the Skylab photography.

A secondary benefit of the improved resolution of transportation routes is the assistance these lend in the identification of other cultural features and uses by their association with the transportation facilities. For example, industrial facilities are often located along railways, commercial enterprises are usually found along major highways or in urban areas (identifiable by street patterns), and oil fields have a complex network of roads connecting wells and tank sites.

0106 Recreation: Recreational uses of certain forested areas, range, and water can be inferred from roads and trails which give access to popular fishing and camping spots. These roads and trails can be mapped from the Skylab photography and allow the popular recreation sites to be identified either as single- or joint-use areas.

0204 Cropland or Improved Meadow: The Skylab photography offers opportunity to delineate boundaries of crop areas or individual fields with confidence, but the color rendition lacks much of the striking color contrast of the LANDSAT false-color composite. Harvested fields and most grain and forage crops contrast strongly with forest and rangeland, but the vigorous green crops cannot be distinguished from native hay and other natural floodplain vegetation along the Belle Fourche river.

Likewise certain grazing or range-improvement practices produce rangeland that has the same visual characteristics (on the Skylab photography) as some crops. Thus, the distinction between use classes 0204 and 0308 is often very tenuous.

0303 Rangeland: The problems encountered in identification and mapping of cropland also limits the ability of the interpreter to subdivide rangeland into relative quality classes. Fortunately, most differences in rangeland vegetation affect both the color and tone of the photograph so that the areas of poor, moderate, and good rangeland can be identified by differences in tone even though the color differences seen on the LANDSAT image are not apparent on the Skylab photograph. The excellent resolution of the Skylab photograph allows much better definition of the very intricate boundaries that usually separate different range classes.

0305 Floodplain: The lush vegetation along the floodplain of rivers and streams in the Moorcroft-Keyhole area contrasts strongly with the poor to moderately good range vegetation that borders the floodplain in most areas, but this distinction is much more difficult to make in areas where the floodplain is adjacent to forested areas, cropland, or good range. In a few places there is almost no contrast either in color or tone between the floodplain and the good rangeland or forest. Fortunately this lack of contrast occurs in only a few locations. Such situations would present little problem if S-190B stereo coverage were available for this area. The floodplain boundary could then be accurately defined on the basis of topographic relief. Although not essential, the stereo presentation would be very helpful in defining some other land-use classes as well, such as areas of active erosion.

0307 Actively Eroding Areas: Areas of active erosion are identifiable on the basis of their irregular light and dark tones and their intimate relationship to the drainage system.

Most of the areas markedly affected by erosion lie in the southeast quarter of the study area where non-resistant clay and shale units are exposed in a series of northwest-trending bands. The stream pattern parallels these units and the major drainages lie along the soft clay/shale zones which are topographically low. The streams in this area flood whenever the hilly area to the southeast receives a large amount of rain. Some erosion occurs along most of the stream channels but is particularly pronounced in areas where the mining, agricultural, or grazing practices have disturbed the surface or removed the protective vegetation.

0308 Modified Range: Grassland has been mapped as "modified range" whenever grazing or range improvement attempts have significantly altered the dominant range patterns. These areas, segregated with some difficulty from the croplands, include over-grazed pastures, pastures unused for several seasons, areas of sagebrush removal, areas of grass seeding, and areas once cultivated but presently being returned to rangeland.

Areas of modified range usually contrast with the surrounding rangeland but are only distinguishable from some croplands by their mottled texture. Croplands usually have a more even texture and color.

0402 Evergreen Forests: The Skylab photography records evergreen forests in even shades of dark green that are concentrated along ridges and

intertongue intricately with other classes in a pattern largely controlled by topography. The forested areas are relatively easy to distinguish from other land-use classes (except floodplains) and their intricate patterns are very well-represented on the Skylab photointerpretation.

0501 Rivers: Only one river in the study area, the Belle Fourche, is large enough to be seen on the Skylab photography. The river channel is seen as a narrow, light-colored line winding along the floodplain. The sediment and vegetation patterns in the shallow, western edge of Keyhole Reservoir indicate that the river channel extends for some distance on into the reservoir. The river channel can only be seen along part of its course in its lower reaches below Keyhole Dam.

0502 Lakes and Reservoirs: As with the LANDSAT imagery, the lakes and reservoirs are very easily mapped. Definition of the water boundaries is much superior with the Skylab photography (stock ponds as small as one acre can be mapped) and sediment patterns are recorded in even greater contrast and detail with the blue and green colors of the Skylab color photography. Even abandoned shorelines marking previous high-water can be mapped with ease.

0703: Bedrock Outcrop: Bedrock crops out along several ridges in the eastern part of the area. These outcrops are generally in sandy units that are relatively resistant to erosion and stand high above the local topography. Only the larger outcrops are included in the 0703 class. Many smaller bedrock outcrops occur along some of the ridges but these were often generalized into the rangeland classes.

REFERENCE LAND-USE MAP INTERPRETED FROM AERIAL PHOTOGRAPHY AND FIELD CHECKED

A separate interpretation of land-use was made from 1:120,000-scale aerial photography flown by NASA/AMES U-2 on flight 72-135 (August 9, 1972) and by NASA/JSC WB-57 on mission 239 (June 20, 1973). This interpretation was to provide a base for comparison of the Skylab S-190B interpretation and as a starting point for compilation of the field-checked reference land-use map (Fig. 8). The photointerpretation was made using a Kern PG-2 stereoplotter, so the initial map was compiled directly on the topographic base rather than on photo enlargements. Two flights were used in making the interpretation because the area was only partially covered on each of these flights. Unfortunately, only the mission 239 photography (June 20, 1973) correlates well with the LANDSAT imagery (July 11, 1973) and the Skylab S-190B photography

(September 13, 1973). The older photography from flight 72-135 reveals some substantial changes in land use that took place between the two flight dates (August 9, 1972 to June 20, 1973). These changes were largely in those use classes that involve intense cultural or climatalogical interaction with the earth's surface (farming, grazing, mining, recreation, water supply, erosion).

This problem with land-use change was even more noticeable in field checking the area during the summer of 1975. The interpretation made from the combined 1972-73 aerial photography proved very accurate ($\geq$ 97%) for all areas where change had not occurred since August, 1972. In fact the bulk of the "misidentifications" noted in field checking were found to accurately represent the land-use at the time the photography was flown. Unfortunately, the actual land use (crop type, range quality, etc.) occurring at the time of overflight could not be determined for some areas. Consequently, no definitive determination of the accuracy of the photointerpretation could be made, the accuracy could only be estimated for those areas where it was unlikely that any major change had taken place since August 1972.

The final reference map (Fig. 8) incorporates all corrections to the photointerpretation indicated by the field checks which were conducted over a period of five weeks during June and July 1975. Therefore, it represents the land use at that time. It is assumed that the reader can best assess the accuracy of the Skylab and LANDSAT image interpretations by direct comparison of this map with the images (Figures 2, 3, and 4) and image interpretations (Figures 6 and 7) while keeping in mind the changes in land-use that may have occurred. The level of detail presented on the reference map is entirely compatible with information that can be interpreted from 1:120,000-scale

photography; so a comparison of land-use classes on this map with those mapped from Skylab and LANDSAT imagery serves as a measure of the relative utility of the three types of data.

0101 Urban and Residential: Individual buildings, trees, and automobiles are just barely resolved on the high-altitude aerial photography. Thus, urban residential areas, farm houses, and cabin sites are readily identified unless overhanging trees obscure the dwellings and related roads and outbuildings. Abandoned homesteads are not included in this class although some were erroneously identified as "residences" in the interpretation.

0102 Industrial, Commercial, and Institutional: No attempt was made to subdivide this class even though some subdivision is possible through interpretation of location and context. For example, the school is identified as a large building in a dominantly residential area surrounded by lawn and parking and adjacent to athletic fields.

0104 Extractive: Both mines and oil-well installations are clearly visible on the aerial photography and with some difficulty, one may even identify pump-jack locations versus tank sites etc. Yet some barren spots in the rangeland (water tanks, salt licks, etc.) are almost impossible to distinguish from oil well installations.

Strip mines were mapped in detail from the photointerpretation but areas of major petroleum production were generalized as "oil fields" rather than mapping individual installations.

0105 Transportation: All major highways, roads, trails, railroads and airstrips can be accurately mapped from the aerial photography. Even major pipelines are visible as cleared areas cutting across topography, range and timber. No power lines were mapped on the photointerpretation but a large new line (presently under construction) was mapped in the field and should be visible on future aerial coverage.

0106 Recreation: The recreation potential of Keyhole reservoir is being developed rapidly. Many new trails, roads, camping areas, and cabin sites were mapped in the field. Continued development will undoubtedly require periodic revision of the land-use map in these areas. Only the areas of most intensive recreational use were included under this category.

0204 Agriculture: The aerial photography yields some textural detail which aids the interpreter in identifying crop type, but most crops cannot be positively identified from the color or color infrared aerial photography. This and the annual rotation of some crops makes it impractical to map agricultural land on a crop-type basis. Consequently, the cropped areas are lumped under a single category, "agricultural land."

The agricultural lands might reasonably be grouped into "irrigated" and "dryland" sub-classes. However, the irrigated fields, which are

largely confined to the floodplain of the Belle Fourche river, are not entirely unique in crop type or appearance. Irrigation ditches are not resolved on the aerial photography and the generally good condition of the dryland crops in this area prevents distinction of some dryland crops from those that are irrigated or sub-irrigated.

0303 Rangeland: The aerial photography offers little or no advantage in delineation of rangeland classes other than allowing the interpreter to judge range quality on the basis of topography as well as color and tone. Differences between the Skylab and high-altitude aerial photo interpretations are very minor. It is also interesting to note that little difference was apparent between the field estimates of range quality and those made from the older imagery. This indicates that grazing practices are well-established and do not vary radically from year-to-year so that the overall change in range quality is minimal. This situation might change drastically during a period of unusual climatic conditions.

0305 Floodplains: Floodplains are much more readily defined on the aerial photography due to stereo presentation with the PG-2 plotter. Even river terraces and the inactive floodplain (most of which is farmed) can be distinguished from the present, active floodplain. The farmed areas along the floodplain were mapped as a "mixed" use category reflecting their propensity to occasional flooding.

0307 Actively Eroding Areas: Comparison of the Skylab and aerial photo interpretations shows that the actively eroding areas are mapped with good accuracy with either system. However, the stereo presentation of the photography allowed the interpreter greater confidence in his interpretation of the aerial photography. Individual stream channels and gulleys may be mapped from the aerial photography, but this amount of detail was not considered essential to the presentation of the 1:62,500-scale land-use map.

0308 Modified Range: By definition, the "modified" range areas are those that have undergone or are undergoing some sort of change. Therefore it is not surprising to find that this category shows poor correlation between the different maps (representing a period of several months) and showed considerable change during the period between the overflights and the field checks. The use conditions affecting these areas include plowing, seeding, sage removal, spraying, and intense grazing. The parcels mapped as "modified range" are in various stages of improvement or damage and are gradually returning to their natural state.

0401 Deciduous Forest: The aerial photography provides sufficient detail for mapping the cottonwood groves along the floodplain of the Belle Fourche river. Because these are along the active floodplain they represent a joint-use category but were mapped as a single use unit to prevent confusion of patterns in the complex floodplain area.

0402 Evergreen Forest: The detail of the aerial photography is such that tree densities can be estimated within the evergreen forests. This allowed the evergreen forest to be subdivided into areas of "poor" and "moderately good" timber on the basis of tree density. Field verification of these subdivisions indicates that this scheme is generally accurate even though it does not take into account the size of the trees.

0501 Rivers and Streams: Although the interpretation of aerial photography included rivers, major streams, and even some minor drainages, this information was not included on the final reference map in order to avoid confusion with other important land-use details along the stream and river valleys. The streams and rivers are mapped on the topographic quadrangle map. Comparison of this map with the aerial photo interpretation shows very little change in stream courses since 1957 when the map was compiled. However there have been a number of changes in stock ponds (0502) which occur along many of the stream valleys.

0502 Lakes and Reservations: Sufficient detail is available from the aerial photography to map all stock ponds and reservoirs that contain water. Those that are dry are much more difficult to detect and there are usually no indications as to whether or not they ever fill with water. As with the Skylab photography, sediment patterns in Keyhole reservoir are strikingly recorded in the blue/green range of the aerial photography.

0701 Playa Lakes: Two small mud flats in sections 26 and 27, T 51 N, R 66 W were mapped as playas. These are actually shallow, low areas which collect rainwater and retain it long enough to destroy the vegetation in that area. Consequently, they appear as small grey-brown patches on the aerial photography.

0703 Bedrock Outcrop: Stereoscopic coverage is very helpful in locating areas of bedrock outcrop which typically occur along steep ridges and capping small knobs in the eastern part of the area. Many small, bedrock outcrops throughout the area were not mapped as such because they do not significantly affect the land use of the local area. Larger outcrops do affect the land-use patterns and were mapped.

CONCLUSIONS

A comparison of land-use maps compiled from LANDSAT and Skylab imagery at a scale of 1:62,500 demonstrates that the LANDSAT imagery lacks the spatial resolution necessary to detect and map some important land-use classes. Joint land-use situations are seldom detectable on the LANDSAT imagery, but the information content and scale of the LANDSAT data allows for rapid reconnaissance mapping of most major land-use categories.

Skylab S-190B photography provides spatial detail sufficient to allow identification of all major land-use categories in the Moorcroft-Keyhole area and all joint-use areas within major categories. Sub-classes within some mapped categories (such as agricultural land) are generally identifiable but sub-classes of smaller areal extent (such as commercial installations) are seldom distinguishable. The resulting map is sufficiently detailed and accurate enough to serve as a base for planning and resource monitoring in this area.

The 1:120,000-scale aerial photography provides all the detail necessary for identification of major classes and sub-classes and allows comprehensive mapping and monitoring by direct compilation from stereo photography to the 1:62,500 base. Field checking of the map compiled from the aerial photography showed that the interpretation was accurate through more than 97% of the area except where specific land use had changed since the photography was flown in 1972. Detail available from the aerial photography is very useful in areas of concentrated human activity where significant land-use patterns affect small areas or are expressed in textural contrasts. However, the compilation of the land-use map from aerial photography required approximately five times more time than from the more comprehensive satellite photography. Both the high-altitude aerial photography and the Skylab S-190B photography yield land-use information suitable for planning and monitoring surface resources. The aerial photography provides more information about specific sub-classes but its interpretation is more time consuming and some of the information gained is non-essential to the regional land-use pattern.

A small but significant number of errors were made in the identification of land-use categories. A brief but comprehensive field check is required to eliminate these errors.

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PLATES 1 thru 6 Not Filmed


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