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Landsat Enhancement Procedures and Key, Central Yukon Planning Area

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ABSTRACT

Enhancements of Landsat satellite scenes of lands within the Central Yukon Planning Area were made during FY '84. Computer manipulations improved our ability to interpret basic vegetation types. The enhancements were made to provide basic fuels and land cover information which could then be used for fire management planning and to depict the general distribution of wildlife habitat. Information could also be used to assess the general suitability of any area for settlement. Necessary work included overflights of BLM land and manipulation of Landsat computer data at the U.S. Geological Survey EROS Field Office in Anchorage. Work was performed by personnel from the BLM Northwest Resource Area and BLM Alaska State Office Branch of Photogrammetry.

FIELD PROCEDURES

It was necessary to create a master set of air photos on which vegetative cover type could be accurately interpreted. These photos would provide a basis both for subsequent image enhancement and for creation of interpretive keys of vegetation features. Color infrared aerial photographs at 1:60,000 scale were available for all BLM lands in the Northwest Resource Area. For each large discrete block of BLM land, photographs were selected which represented the range of topographic position and land cover features. An attempt was made to include photos with all major variations in color, tone, and pattern which could represent differences in vegetation types. Ninety-five photos were used. Photos were placed in clear plastic covers, and labelled with 1:250,000 map quad name, line, and photo number.

During the summer of 1983, overflights of the area of each air photo were made in a light plane. On selected polygons on each photo, notations were made of the dominant plant species which contributed to the differences in color, tone and pattern which occurred on the air photos.

OVERVIEW OF LANDSAT DATA

A brief overview of the nature of Landsat data is necessary to understand enhancement procedures. Five Landsat satellites have been launched since 1972. Every 14 to 18 days, satellites collect data for all areas of the earth's surface between 82 degrees north and 82 degrees south latitude. Landsat sensors record data for reflected light in four bands, ranging from the visible green to near infrared portions of the electromagnetic spectrum. Four sensors, one per band, simultaneously collect data by continuously scanning the amount of reflected light from distinct 79 m^2 blocks of the ground, recording it as one of 126 brightness values, or gray levels. The land is scanned from west to east as the satellite moves from north to south. The data is arbitrarily divided into scenes which contain information for a 115 km^2 area. The resultant data for one scene is arrayed in 2,340 rows which contain about 3,240 picture images (pixels) each. Each band for one scene contains data for about 7.6 million pixels, covering approximately 7.5 million acres.

Differences in brightness values are related to geology, soils, land cover, plant phenology, slope, aspect, clouds, cloud shadows, and water bodies and their degree of turbidity. Each Landsat band has distinctive reflectance values for different cover types or features. Most vegetation reflects over a range of about 30 values, with differences in brightness values caused by Landsat band, plant species, and time of the growing season. For example, coniferous trees and the moss with which they are commonly associated in Alaska reflect much less light than most species, and appear relatively dark in infrared wavelengths. The leaves of deciduous vegetation have a higher reflectance in the infrared wavelenghts and are bright red on standard Landsat imagery. Lichens reflect much more light and appear to be almost white. Table 1 shows Landsat bands, light wavelengths, the total range of brightness values, and the values reflected by vegetation.

Table 1.

Landsat Bands, Wavelengths, and Brightness Values

Band	Wavelength	Brightness Values	
		Total Range in Band	Approximate Range for Most Vegetation
4	0.5-0.6 microns (visible green)	0-127	0-35
5	0.6-0.7 microns (visible red)	0-127	0-30
6	0.7-0.8 microns (near infrared)	0-127	10-40
7	0.8-1.1 microns (near infrared)	0- 63	5-25

A standard false color Landsat scene is made by combining information from Bands 4, 5, and 7, using blue, green, and red filters, respectively. The resulting image resembles a color infrared photograph. However, vegetation features are difficult to interpret because almost all vegetation has a red tone.

A computer enhancement can be made to emphasize selected features of interest such as vegetation, water bodies, or geologic structures. Computer manipulations stretch recorded values to fit a much wider range. A linear stretch of data in Band 7 could simply reassign values from 0 to 40 to fit a range of 0 to 255 (see Figure 1). Tones would become sufficiently different to be distinguished by the interpreter. Light tones would become lighter and dark

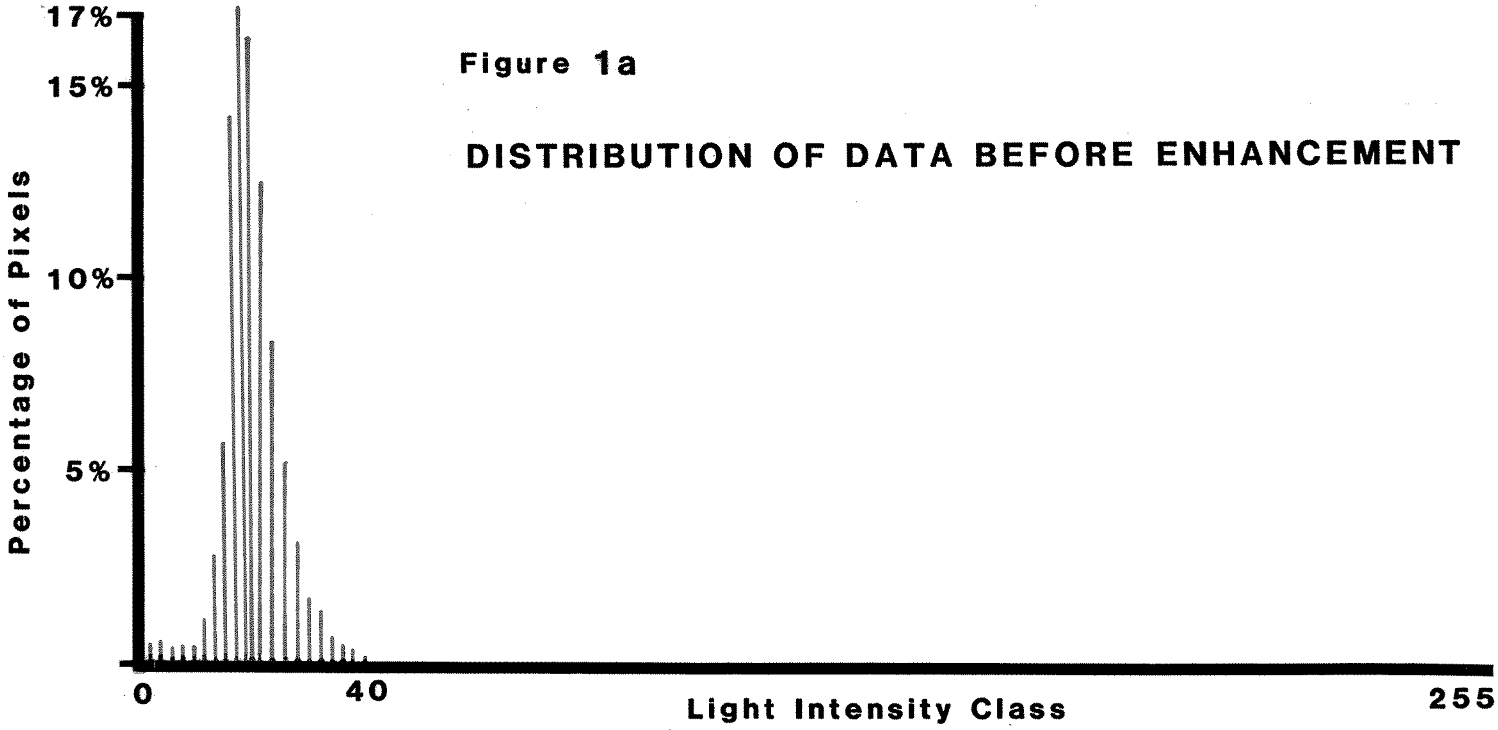
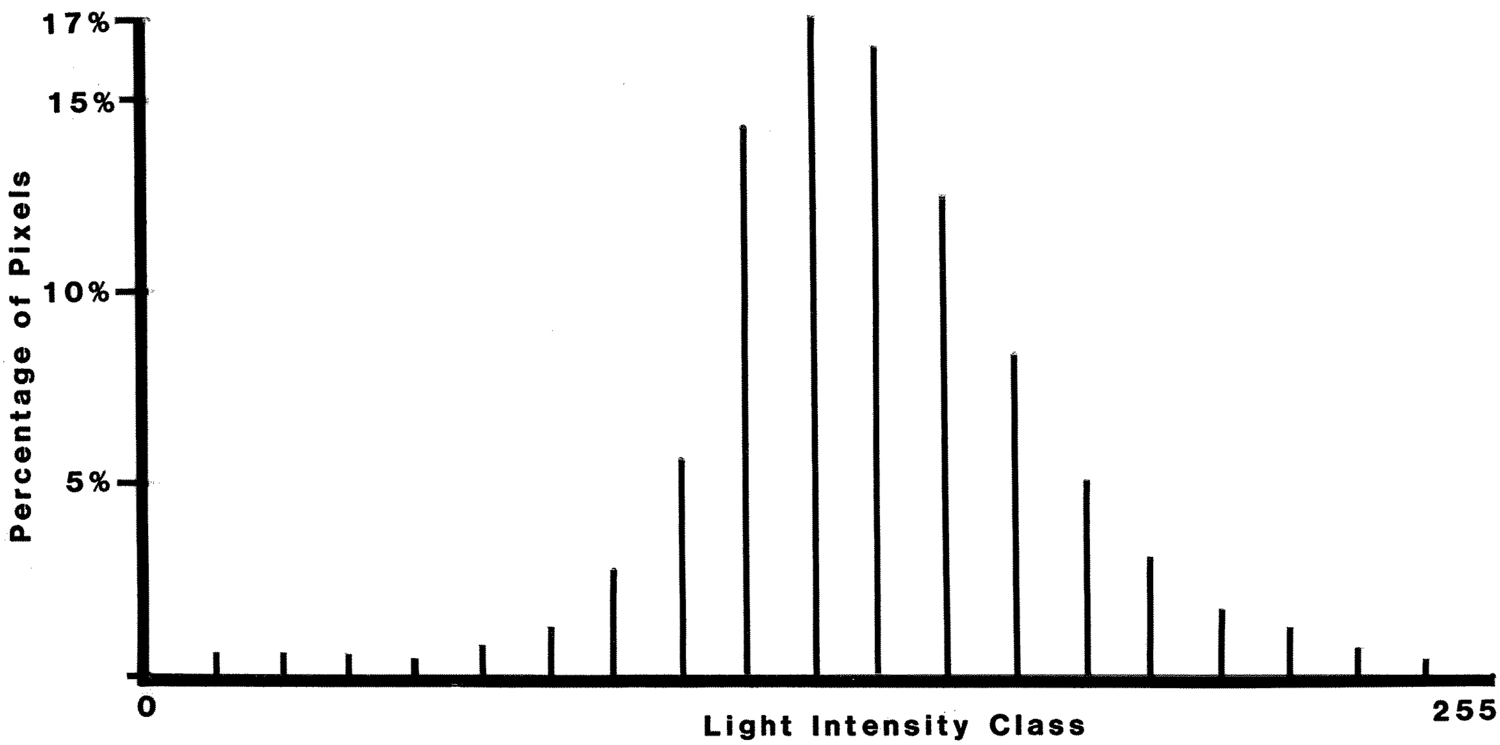


Figure 1a

DISTRIBUTION OF DATA BEFORE ENHANCEMENT

Figure 1b DISTRIBUTION OF DATA AFTER LINEAR CONTRAST STRETCH ENHANCEMENT



tones would become darker. The enhancement can be improved by removing reflectance values which give information of no interest. For example, data in Band 4 might be represented by values from 0 to 130, but the vegetation features of interest might only be found in values from 6 to 22. The data could be stretched by reassigning values from 6 to 22 to 0 to 255. All values from 0 to 5 and greater than 22 would be eliminated. Unwanted detail from water, rocks, and clouds would be omitted, and contrast among vegetation features would be greatly increased.

A non-linear stretch would assign a broader range to a specific set of values of interest, such as deciduous forest, and place less emphasis on other vegetation types. Values from 20 through 75 and 76 through 135 could be arrayed from 0 through 100 and 100 through 255, placing emphasis on the higher numbers.

ANALYSIS PROCEDURES

Preparatory to computer analysis, tapes of suitable Landsat scenes had to be obtained for the seven major blocks of BLM land in the planning area. Computer tapes of some BLM lands were already owned by BLM or were available for use at the EROS Field Office. Additional scenes were identified by reviewing files of black and white prints or negatives of all Landsat images for Alaska at the Landsat library at the University of Alaska, Geophysical Institute. For purposes of vegetation interpretation, it is desirable to select cloudfree scenes collected during July and August when vegetative biomass is at its peak. Tapes were purchased for selected scenes for which computer data were not available in Alaska. Ten tapes were used because some scenes did not completely cover a block of BLM land.

The actual computer analysis procedure had several steps. First, the tape of the entire image was loaded onto the U.S.G.S. EROS Field Office computer. Analysis was done using the IDIMS system, a special computer system for analyzing and interpreting remote sensing data. Histograms of the frequency of occurrence of each spectral class in each band were obtained for a subsample of the pixels in the scene. A subsample of the entire scene, every 10th row and pixel, was shown on a display screen which is connected to a the IDIMS computer. That portion of the scene showing the exact land areas of interest was then selected. Ranges of values that were thought to represent the vegetation features of interest were stretched to new sets of selected values. The process was repeated for each band, and then the three bands were combined to produce a color image on the television display. Color infrared aerial photos were used to determine whether the image adequately differentiated among the key vegetation types. If not, new manipulations of the data were made, usually one band at a time, until an image was produced which best displayed the variation in vegetative cover types.

Once the appropriate ranges, or mappings, were selected for a particular image, values in the original full set of data for the scene were numerically reassigned. Using an Optronix film recorder, data for the three bands were combined with blue, green, and red filters. A color 9 by 9 inch transparency was produced, from which photographic enlargements were made. The resulting image had green, pink, beige, black, and brown tones, in addition to the reds and blues found in standard false color images. Mylar overlays of 1:250,000 topographic maps were used during the printing process to obtain prints of each enhanced image at approximately 1:250,000 scale.

This procedure had to be repeated for each scene because most images were taken in different years on different dates, and subtle differences in vegetation caused differences in reflectivity. However, adjacent scenes taken subsequently on the same day were used for the Ray River and Tozitna enhancements, and, for the Hughes and Dulbi areas. The same mappings were used for each of these image pairs. Geographic areas, scene identification numbers, dates, and mappings are given in Appendix I.

To produce an enhancement which emphasized contrast among vegetation types, stretches were made in Bands 4, 5, and 7 for most images. Band 6 was substituted for Band 7 for the North Fork Kuskokwim image because of low quality of Band 7 data. Simple linear stretches were used for Band 4 data, and for Band 5 data in all cases but one. Rocks, lichens, barrens, and sandbars were emphasized in the two Nulato Hills images by doing a non-linear stretch in Band 5.

Distinction among vegetation features of interest could most often be improved through manipulation of Band 7, near infrared, the band with the most information about vegetation. Non-linear stretches were frequently used for Band 7 data to increase the contrast among deciduous types, and to make mixed spruce-hardwood forests more distinctive. The omission of values between 100 and 110 in the expanded ranges for the Dulbi River and Hughes images increased the visual difference between areas of moss and shrubs which had a black spruce overstory and those which did not. The differentiation between black spruce and boggy vegetation at lower elevations was emphasized in the two Nulato Hills enhancements by omitting data in spectral classes 31 and 32. Red saturation in the color balance of the central Nulato Hills image was reduced by eliminating values greater than 225 in the expanded Band 7 mappings.

Key to Vegetation Features

A key for each image which assigns colors to each major vegetation type is on the following pages (Table 2). The assignment of colors for this key was a fairly subjective process. Subtle variations in color are caused by small shifts in the composition of a particular vegetative community, such as the amount of shrubs or lichen in a tussock tundra community. Because communities are frequently a mosaic of small subunits of vegetation, two intermixed colors describe the community. A lichen tussock tundra community can be described as beige gray with light blue gray, indicating a mottling of these two colors with beige gray the more common. The second color indicates areas where lichens are a more dominant feature of the tussock community.

TABLE 2
KEY TO VEGETATION FEATURES ON LANDSAT ENHANCEMENTS
CENTRAL YUKON PLANNING AREA

	Northeast Nulato Hills	Central Nulato Hills	Buckland	Melozitna/ Dulbi	Hughes
Bare Rock	Very Light Blue	Very Light Blue	Dk. Blue Grey; Lt. Blue Grey	Steel Blue	Steel Blue
Recent Burn	Grey or Blue Black		Grey		Charcoal Grey; Blue Grey
Older Burn	Light Grey w/Pale Red	Light Grey w/Pale Red		Grey w/Pale Red	Grey with Pale Red
Alpine Communities	Pale Salmon Pink	Very Pale Salmon Pink	Yellow; Pale Salmon Pink	Pale Orange; Pale Pink; Pale Yellow Orange	Pale Orange; Pale Pink; Pale Yellow
Black Spruce/Lichen			Dark Grey w/ very Light Grey	Dark Grey w/ very Light Grey	Dark Grey w/ very Light Grey
Closed Black Spruce	Grey Black	Grey Black	Grey Black	Grey Black	Grey Black
Open Black Spruce	Dark Grey	Dark Grey	Dark Grey	Dark Grey	Dark Grey
Mixed Forest	Red Brown	Red Brown	Red Brown	Red Brown	Red Brown
Deciduous Forest	Orange Red	Dk. Orange Red	Dk. Orange Red	Red	Red
Shrubs	Red Orange	Red Orange	Red, Dark Red-Orange	Light Red Orange	Light Red Orange
Tussock Tundra	Beige Grey	Beige Grey	Beige Grey	Beige Grey	Beige Grey
Lichen Tussock Tundra	Silvery Grey Beige Grey	Blue Grey Beige Grey	Light Beige Grey	Beige Grey w/ Lt. Blue Grey	Beige Grey w/ Lt. Blue Grey
Lichen	Silvery Grey; Beige Grey	Blue Grey; Beige Grey	Light Beige Grey	Beige White; Blue White	Beige White; Blue White

TABLE 2, (continued)
KEY TO VEGETATION FEATURES ON LANDSAT ENHANCEMENTS
CENTRAL YUKON PLANNING AREA

	Kaiyuh Hills	Tozitna	Ray River	Titna	Kantishna River
Bare Rock	Blue; Steel Blue	Blue; Steel Blue	Blue; Steel Blue	Steel Blue; Blue	Steel Blue; Blue
Recent Burn	Lt. Blue Grey;				Black or Blue Black
Older Burn	Lt. Grey with Pale Red	Light or Medium Grey w/ Pale Red	Light or Medium Grey w/ Pale Red	Medium Gray with Pale Red	Beige Green
Alpine Communities	Pale Salmon Pink; Pale Orange Pink	Pale Salmon Pink; Pale Orange Pink	Pale Salmon Pink; Pale Orange Pink	Very Pale Orange	Very Light Beige
Black Spruce/Lichen	Medium Grey w/ Light Grey	Medium Grey w/ very Light Grey	Medium Grey w/ very Light Grey	Medium Grey w/ very Light Grey	Purple Blue with Silvery Blue
Closed Black Spruce	Grey Black	Grey Black	Grey Black	Dark Grey	Dark Purple
Open Black Spruce	Dark Grey	Dark Grey	Dark Grey	Medium Grey	Medium Purple
Mixed Forest	Red Brown	Red Brown	Red Brown	Red Brown	
Deciduous Forest	Light Red	Dk. Orange Red	Dk. Orange Red	Orange	Pink
Shrubs	Lt. Red Orange	Lt. Red Orange	Lt. Red Orange	Light Orange	Light Pink
Tussock Tundra		Lt. Beige Grey	Beige Grey	Beige Grey	Beige
Lichen Tussock Tundra	Lt Beige Grey	Lt Beige w/very Lt Blue Grey	Beige Grey w/ very lt Blu Grey	Beige Grey w/ very lt Blue Grey	
Lichen	Blue White	Blue White	Blue White	Blue White	Blue White

Interpretation of the vegetation features on these enhancements requires that the user have a basic understanding of the distribution of vegetation types in the Alaskan interior. For example, a user familiar with the Buckland basin would know that reddish patches in tussock tundra areas represent deciduous shrubs, not deciduous trees. At higher elevations, what appears to be a mixed forest of conifers and deciduous trees may be an open white spruce forest with a well developed tall shrub layer.

To assist in vegetation interpretation, the air photos on which vegetation features were noted are filed in the Northwest Resource Area air photo file. A list of aerial photography used is attached (Appendix II). A set of paper maps with photo locations indicated is also on file in the NWRA air photo file.

APPLICATIONS

The enhancements for the Central Yukon Planning Area serve as a map of its basic vegetation features. Areas dominated by conifers, deciduous vegetation, and tussock tundra are apparent. More subtle variation, such as differences between deciduous forests and deciduous shrub communities, or open and closed black spruce stands can be interpreted. Barren ridges can be distinguished from those with alpine communities. The locations of lichen dominated areas, and past forest and tundra fires can be discerned. In the Buckland Basin, areas of tussock tundra which have burned prior to the period for which we have fire records can be found because of patterns caused by different densities of lichens.

These enhancements have been valuable for fire management planning. Fuel types of different flammabilities, and natural barriers to fire spread, such as sparsely vegetated ridges, were located. The fire potential in particular areas, and the potential for fire to spread to adjacent areas was assessed. This information was used when assigning fire management options, protection levels, to different areas of BLM land, and in determining the best boundaries between areas requiring different amounts of protection from wildfire.

The enhancements are being used to map forest and tundra fuels for entry into the Alaska Initial Attack Management System. Mapping from enhanced Landsat images can be done more quickly and accurately than from standard Landsat images. Fuel types corresponding to vegetation types of black spruce, white spruce, hardwoods/brush, lichens, tussock tundra, nonburnable tundra, and rocks and water are being delineated.

Enhancements will also be used to assess wildlife habitat. General information can be gained about the location, amount, and relative distribution of various habitat types in the planning area. Habitats at the locations of wildlife sitings will be noted, and stored with other wildlife observation data.

REFERENCES

Lillesand, Thomas M. and Ralph W. Kiefer. 1979. Remote sensing and image interpretation. Chapter 10: Remote sensing from space. John Wiley and Sons, New York. pp. 528-597.

Appendix I

CENTRAL YUKON PLAN ENHANCEMENTS
Landsat Scenes and Mappings

GEOGRAPHIC AREA	SCENE NUMBER	DATE	BAND	MAPPINGS
Northeast Nulato Hills	01741 - 21270	8-03-74	4	12 33 to 0 255
			5	1 13 14 26 to 0 120 121 255
			7	12 30 33 65 to 0 125 126 255
Central Nulato Hills	02575 - 21163	8-19-76	4	5 23 to 0 255
			5	0 25 to 0 255
			7	0 30 33 70 to 0 110 111 225
Buckland	20900 - 21081	7-10-77	4	3 33 to 0 255
			5	4 29 to 0 255
			7	14 44 45 65 to 0 125 126 255
Melozitna/Dulbi	21635 - 21061	7-15-79	4	6 35 to 0 255
			5	4 29 to 0 255
			7	20 75 76 135 to 0 100 110 255
Hughes	21635 - 21060	7-15-79	4	6 35 to 0 255
			5	4 29 to 0 255
			7	20 75 76 135 to 0 100 110 255
Kaiyuh Hills	02951 - 20484	8-30-77	4	3 25 to 0 255
			5	0 25 to 0 255
			7	7 32 33 55 to 0 150 151 255
Tozitna River	22029 - 21004	8-12-80	4	6 22 to 0 255
			5	0 25 to 0 255
			7	16 100 to 0 255
Ray River	22029 - 21002	8-12-80	4	6 22 to 0 255
			5	0 25 to 0 255
			7	16 100 to 0 255
Titna and Lost Rivers	30901 - 20565	8-22-80	4	6 20 to 0 255
			5	0 19 to 0 255
			7	16 50 51 95 to 0 100 101 255
North Fork Kuskokwim	01772 - 20574	9-03-74	4	5 27 to 0 255
			5	0 24 to 33 255
			6	0 30 to 0 255

Appendix II

COLOR INFRARED AIR PHOTOS
WITH NOTES ON VEGETATION
Central Yukon Planning Area

1:250,000 Quadrangle	Row	Photo No.
Bettles	58	1829
	60	269
Candle	63	2687
	64	5896
	66	2586
	66	2595
	68	2552
	68	2557
	69	2469
	69	2473
	69	2483
	70	2359
	70	2361
	70	2363
	70	2373
Hughes	55	1763
	55	1772
	56	1888
	56	1900
	57	1932
	57	1940
	57	1949
	58	1848
	59	357
Kantishna River	71	3712
	73	074
	74	053
	74	054
	75	7341
	76	338
	76	7312
	76	7318
	78	177
	78	185
	78	188
	79	166
	79	3703
	79	3708
Kateel River	60	8046
	61	8085
	62	2651
	63	2695
	63	2704
	64	2667
	65	2772
	65	2774
	66	2799
	66	2801
	66	2805
	67	2811
	67	2813
	67	2814

1:250,000 Quadrangle	Row	Photo No.
Melozitna	60	309
	60	313
	61	278
	62	210
	63	182
	65	029
	66	2754
	66	2759
	67	2837
	69	2939
Norton Bay	69	2322
	72	2325
	73	038
	74	7436
	75	7491
	75	7499
	76	7461
	76	7469
	77	278
	78	248
	79	094
	79	108
Nulato	73	2943
Ruby	77	324
	77	326
	78	193
	78	201
	79	154
Tanana	61	282
	61	289
	62	202
	62	205
	62	210
	63	189
	63	196
	64	083
	64	089
	65	048
	65	052
	65	056
	66	5640
	66	5645
	67	5635