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## **Photographic Aerial Transects of Fort Wainwright, Alaska**

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Patricia Nelsen

August 2022



Cover image: A photograph from this aerial transect series illustrating lake environments fringed by spruce and broadleaf forest and showing the effects of a recent wildfire and some young vegetation re-growth.

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# Photographic Aerial Transects of Fort Wainwright, Alaska

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Final Technical Report (TR)

Approved for public release; distribution is unlimited.

Prepared for Strategic Environmental Research and Development Program (SERDP)  
Resource Conservation and Resiliency Program Area  
4800 Mark Center Drive, Suite 16F16  
Alexandria, VA 22350-3605

Under Project RC18-1170; funding provided by MIPR W74RDV90988946

## Abstract

This report presents the results of low-altitude photographic transects conducted over the training areas of US Army Garrison Fort Wainwright, in the boreal biome of central Alaska, to document baseline land-cover conditions. Flights were conducted via a Cessna™ 180 on two flight paths over portions of the Tanana Flats, Yukon, and Donnelly Training Areas and covered 486 mi (782 km) while documenting GPS waypoints. Nadir photographs were made with two GoPro™ cameras operating at 5 sec time-lapse intervals and with a handheld digital camera for oblique imagery. This yielded 6,063 GoPro photos and 706 oblique photos. Each image was intersected with a land-cover-classification map, collectively representing 38 of the 44 cover categories.

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## Preface

This study was conducted for the Strategic Environmental Research and Development Program under Project RC18-1170, “Interior Alaska DoD Training Land Wildlife Habitat Vulnerability to Permafrost Thaw, an Altered Fire Regime, and Hydrologic Changes,” with funding provided by MIPR W74RDV90988946.

The work was performed by the Biogeochemical Sciences Branch of the Research and Engineering Division, US Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL). At the time of publication, Mr. Nathan J. Lamie was branch chief, Dr. Caitlin A. Callaghan was division chief, and Dr. Robert E. Davis was technical director for Geospatial Research and Engineering/Military Engineering. The acting deputy director of ERDC-CRREL was Mr. Bryan E. Baker, and the laboratory director was Dr. Joseph L. Coriveau.

We thank our pilot, Mr. Mike Allen of Mallen Air, Fairbanks, Alaska, for skillfully following our meandering flight lines and providing aerial visual access to many otherwise inaccessible locations on the Fort Wainwright training grounds. We thank Mr. Joshua Buzby, Integrated Training Area Management Coordinator, Fort Wainwright, for reviewing the manuscript. Mr. Marcot acknowledges support from Pacific Northwest Research Station, US Forest Service, Portland, Oregon.

COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

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# 1 Introduction

## 1.1 Background

This study was part of a broader project, funded by the Department of Defense's Strategic Environmental Research and Development Program, investigating wildlife habitat vulnerability to permafrost thaw, fire regimes, and hydrologic changes on the vast training areas of US Army Garrison Fort Wainwright. Their 1,000 km<sup>2</sup> training lands are in the boreal biome of interior Alaska, stretching from Fairbanks south to the Alaska Range (Douglas et al. 2014).<sup>1</sup> This portion of that study focused on documenting vegetation and land-cover conditions along selected aerial photographic transects.

## 1.2 Objectives

The objective of conducting a low-level aerial photographic transect of the Fort Wainwright study area was to document current vegetation and landscape conditions along flight paths that were selected to intersect a wide variety of environments. This project also provides a baseline of archived images and information from which replication of the transects can be used in future change-detection studies.

## 1.3 Approach

This report presents methods and findings from a low-level photographic aerial transect of the training lands managed by US Army Garrison Fort Wainwright in Alaska. Presented here are the structure of the aerial photo transect study, a summary of the vegetation and landscape conditions represented in the photo series, examples comparing previous and current site conditions, examples of the use of nadir photos to create panoramic images, and information on archival access to the photo series results.

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<sup>1</sup> For a full list of the spelled-out forms of the units of measure used in this document, please refer to US Government Publishing Office Style Manual, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–252, <https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

## 2 Methods

### 2.1 Study area

The study area included the main training areas of US Army Garrison Fort Wainwright, which are in the boreal biome of interior Alaska, south of Fairbanks. The study area contained a variety of environments, including lacustrine (e.g., pond and lake), riverine (e.g., open water, floodplain, and riparian), and lowland and upland (e.g., fen, tussock, herbaceous, shrubland, woodland, and forest) conditions. Wildfire, thermokarst, lake draining and drying, slope slumps, and insect defoliation are some of the various drivers and disturbance dynamics that are increasingly affecting these environments.

On 4 June 2019, we chartered Mallen Air LLC (pilot Mike Allen) to conduct an overflight of the Fort Wainwright study area on two flight paths intersecting portions of the Tanana Flats, Yukon, and Donnelly Training Areas near US Army Fort Greely (Figure 1). The flights were conducted out of Fairbanks, and access was granted by Fort Wainwright and Fort Greely Range Control. The aircraft used was a Cessna™ model 180.

Flight path 1 ran 2 hr 35 min, over 20:10–22:45 GMT (12:10–14:45 Alaska time), and covered the Donnelly Training Area of Fort Greely with 275 flight miles (442 km). Flight path 2 ran 1 hr 30 min, over 23:50–01:20 GMT (15:50–17:20 Alaska time), and covered the Tanana Flats and Yukon Training Areas with 211 flight miles (340 km). Total flight time was 4 hr 5 min over a total flight distance of 486 mi (782 km), with a return to Fairbanks between the two flights (Figure 2).

Figure 1. Flight paths used for the low-level aerial photographic transect of the Fort Wainwright training land study area on 4 June 2019, showing the main training areas (*white lines*). TFTA = Tanana Flats Training Area, YTA = Yukon Training Area, and DTA = Donnelly Training Area. Imagery was not acquired over the Gerstle River Training Area (GRTA).

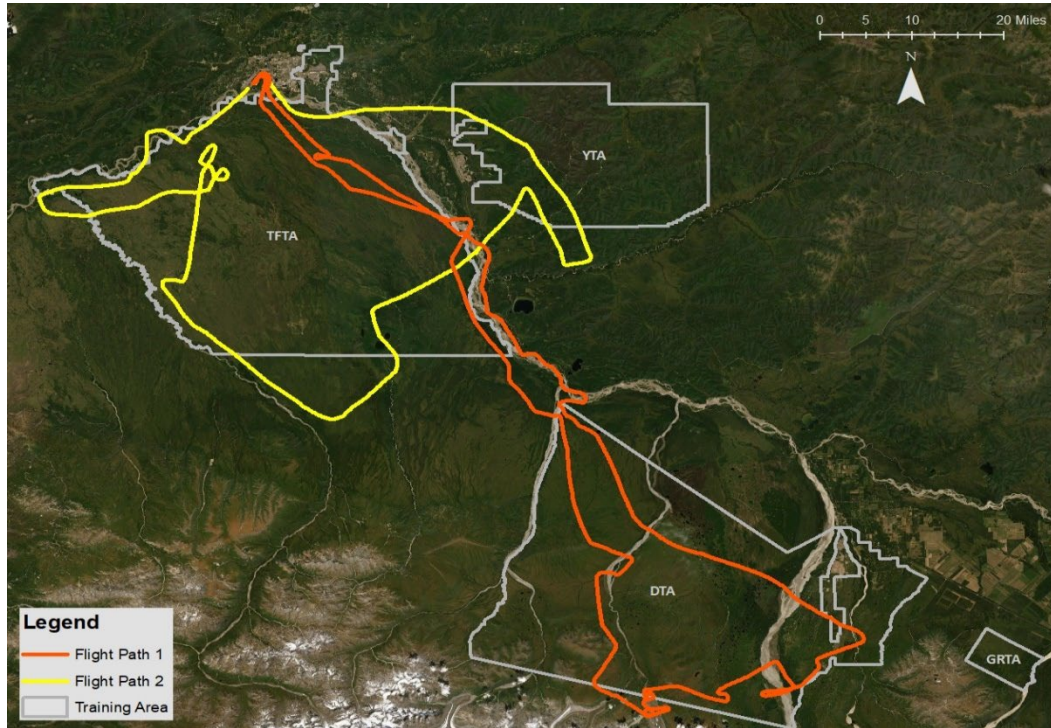
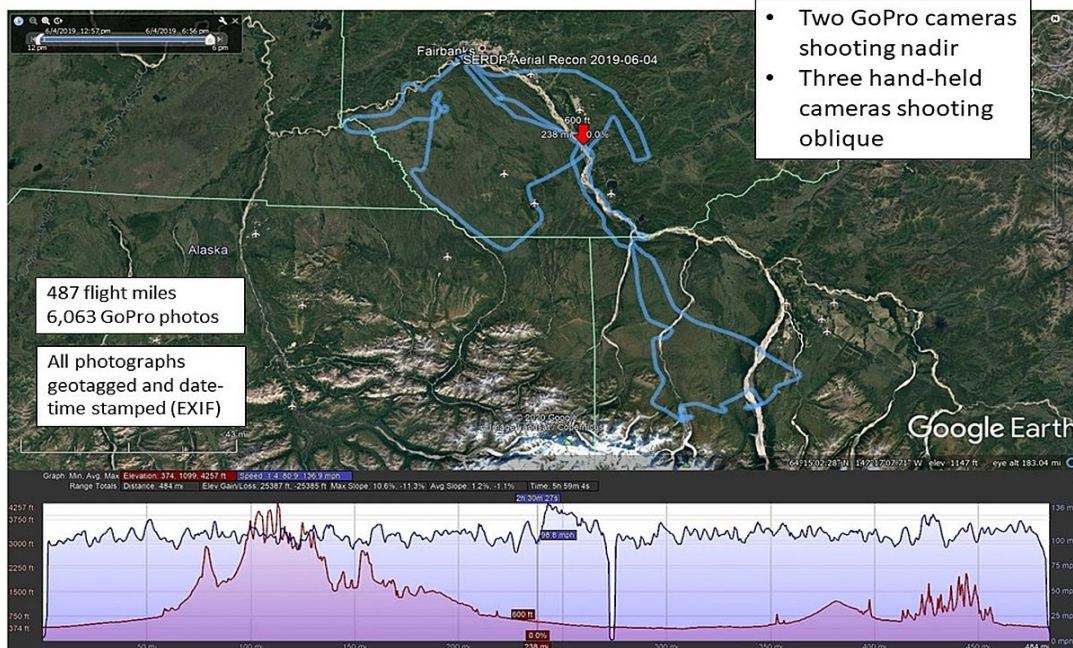


Figure 2. Flight paths (*blue lines*) and flight profiles of velocity (*light blue curve*) and altitude above sea level (*purple curve*) of the two flights conducted for the low-level aerial photographic transect of the Fort Wainwright training lands on 4 June 2019.

Low-Altitude Photographic Transects – June 4, 2019  
for Change-Detection



## 2.2 Flight transects and photography methods

The intent of the flights was to provide photographic documentation of landscape conditions. We affixed two GoPro™ (GoPro Inc.) cameras, a GoPro3™ and a GoPro5™, to the under-struts of the aircraft. We set each camera for 5 sec interval, time-lapse photos, shooting mostly at nadir angles but slightly offset from one another to provide complementary imagery. Both cameras were set to wide-angle (1,700) mode. The 5 sec interval was set to provide photos that overlapped by at least one-third of the frame to facilitate stitching adjacent photos into panoramic images at a later time. The interval was calculated based on expected flight velocity and altitude above ground level (AGL), using methods from a similar, previous flight transect conducted in northwest Alaska (Marcot et al. 2014). Additionally, two of us (Marcot and Jorgenson) shot oblique photographs, with handheld cameras from the plane cabin, of selected landscape, ground-cover, aquatic, and vegetation conditions; Marcot's photographs are included in the archived set. Another passenger, photographer Richard Murphy, also took handheld, oblique-angle photographs; his series is not included in this report but is described in Douglas et al. (2021).

The specific flight paths were selected to intersect the greatest variety of land-cover and ecotype conditions. The flight paths respected a temporary flight restriction caused by a fire in the northern section of the Donnelly Training Area and were generally restricted from entering the airspace of the eastern portion of the Yukon Training Area. Flight-line locations were documented by two concurrent GPS units and saved in GPX, CSV, and SHP file formats. We directed the pilot to fly approximately 1,000 ft (300 m) AGL and at a ground speed of approximately 100 mph (160 kph or 87 kn) to facilitate the GoPro time-lapse calculations (see Appendix 1 in Marcot et al. 2014).

All photographs were GPS-tagged, date- and time-stamped (stored in each photo file's exchangeable image file format [EXIF] data), saved in JPEG format, and made available for public access. We subsequently corrected each GoPro photo for wide-angle-lens distortion using PTLens version 8.9 ([www.epaperpress.com/ptlens/](http://www.epaperpress.com/ptlens/)) and cropped the superfluous edges of each image. This reduced the coverage angle to about two-thirds of the original images. All GoPro photos were taken at 4,000 × 3,000 pixels (12-megapixel images) with an aspect ratio of 4:3. After lens-distortion correction and

cropping, at the average flight altitude AGL, each GoPro image covered, on average, 175 ac (71 ha).<sup>2</sup>

### 2.3 Ecotype comparisons

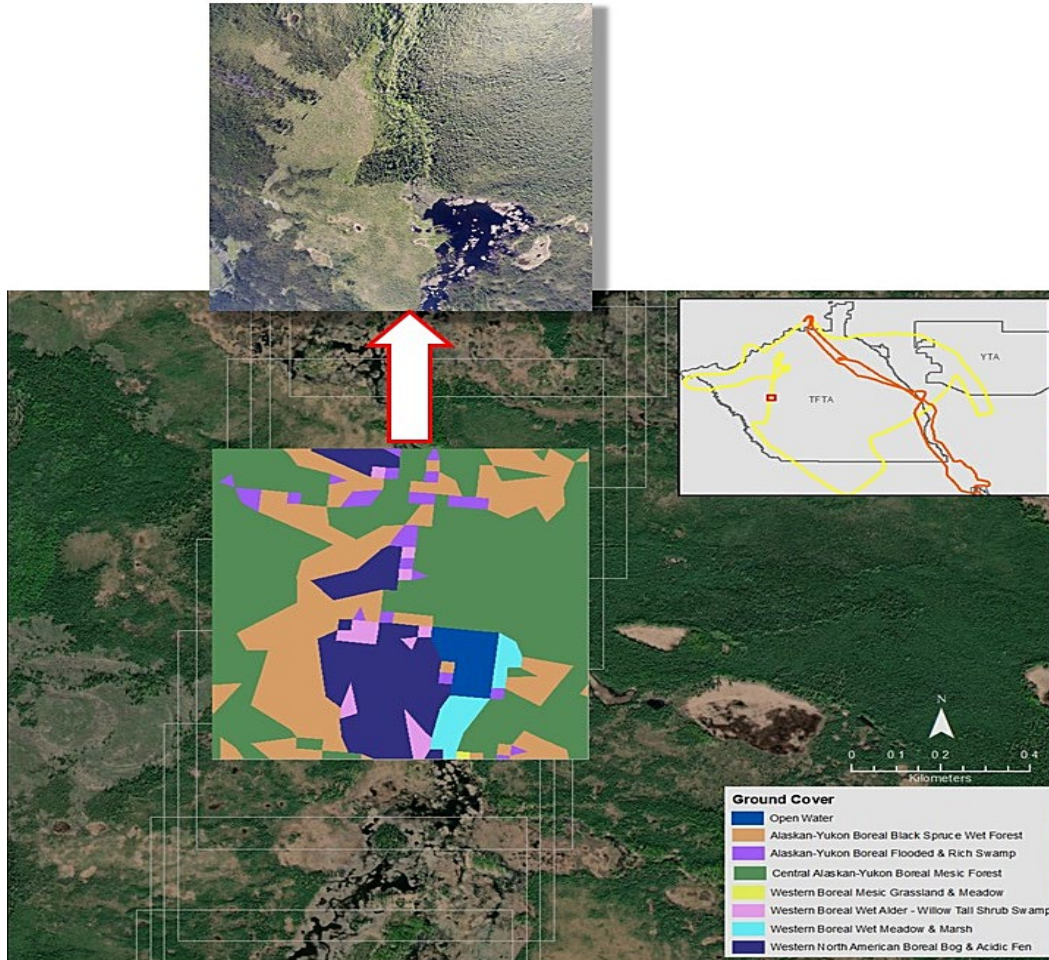
Next, in ArcGIS™, we created a square buffer around the GPS center point (in latitude and longitude) of each photo to represent the average image area of 175 ac (71 ha). We then intersected these areas with the most recent National Vegetation Classification (NVC) produced by Landfire (2021). There were 44 vegetation and land-cover conditions present across all photo locations. We used this land-cover and vegetation classification because of its coverage over our study area and its similarity to the ecotype classification used for other portions of the project. An example for one photo is illustrated in Figure 3.

After the intersection, we summed the area coverage of each NVC category across all photos on each camera and flight transect as a measure of relative areal coverage represented in the photo series.

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<sup>2</sup> Area represented in each photo varied depending on the specific altitude AGL, whether the plane was turning in flight, and whether the camera was positioned slightly off true nadir, as angling the cameras perfectly at nadir was not possible given the limitations of the attachments to the plane's undercarriage struts and the objective of slightly offsetting the frames to provide complementary imagery. Regardless, this setup sufficed for successfully gauging relative representations of vegetation and land-cover conditions in the photos.

Figure 3. An example of intersecting ArcGIS data for vegetation and land-cover mapping in Fort Wainwright (Landfire 2021) with a low-level aerial transect photograph taken during two flight transects on 4 June 2019 (*upper-right inset*; TFTA = Tanana Flats Training Area, YTA = Yukon Training Area), superimposed over a recent Google Earth™ image. The actual flight-line GoPro photograph is shown (*offset*) above the mapped coverage for that photo for comparison. The *light white squares* show outlines of adjacent time-lapse photographs taken on that transect flight line.



## 3 Results

### 3.1 Photographic flight transects

A total of 6,063 photos were taken by two GoPro cameras over two flight paths.<sup>3</sup> These were in addition to the handheld photos, which included 706 oblique photos taken by Marcot with a Panasonic Lumix™ digital camera.

### 3.2 Ecotype coverage

In total, the GoPro photos represented 38 of the 44 cover categories shown in the ArcGIS map. Among all 6,063 GoPro photos, and on each of the two flight paths, the most common vegetation conditions, in decreasing order of area photographed, were

- Central Alaskan-Yukon Boreal Mesic Forest,
- Western North American Boreal Bog and Acidic Fen,
- Alaskan-Yukon Boreal Black Spruce Wet Forest,
- Western Boreal Alpine Mesic Dwarf Birch–Willow Shrubland, and
- Open Water.

The six categories not represented in any photo included

- Alaskan Maritime Western Hemlock–Sitka Spruce Rainforest,
- Alaska-Yukon Northern Boreal Mesic Woodland,
- Recently Disturbed Other–Herb and Grass Cover,
- Recently Disturbed Other–Shrub Cover,
- Recently Logged–Shrub Cover, and
- Southern Alaskan Boreal Mesic Forest.

Along flight path 1—with 3,829 GoPro photos that covered the northeast of the Tanana Flats Training Area, Donnelly Training Area, and the Tanana River between these areas—the five most commonly photographed conditions were (in decreasing order of area photographed)

- Central Alaskan-Yukon Boreal Mesic Forest,
- Western Boreal Alpine Mesic Dwarf Birch–Willow Shrubland,
- Western North American Boreal Bog and Acidic Fen,

---

<sup>3</sup> Additional GoPro time-lapse photos included takeoff and landing situations not useful for change-detection imagery; they were excluded from this tally.

- Open Water, and
- Alaskan-Yukon Boreal Black Spruce Wet Forest.

The five least commonly photographed conditions (excluding the six not-represented categories listed previously) in flight path 1 were (in increasing order of area photographed)

- Agriculture–Cultivated Crops and Irrigated Agriculture,
- Western North American Boreal Alkaline Fen,
- Alaskan Boreal Dry Aspen Forest,
- North American Glacier and Ice Field, and
- Arctic Herbaceous Tundra.

Along flight path 2—with 2,234 GoPro photos that covered the remaining perimeters of Tanana Flats Training Area and the western portion of Yukon Training Area—the five most commonly photographed conditions were (in decreasing order of area photographed)

- Central Alaskan-Yukon Boreal Mesic Forest,
- Western North American Boreal Bog and Acidic Fen,
- Alaskan-Yukon Boreal Black Spruce Wet Forest,
- Western Boreal Wet Alder–Willow Tall Shrub Swamp, and
- Open Water.

The five least commonly photographed conditions (excluding the six not-represented categories listed above) in flight path 2 were (in increasing order of area photographed)

- Agriculture–Pasture and Hay,
- Western Boreal Alpine Acidic Mesic Meadow,
- Arctic Herbaceous Tundra,
- Alaskan Boreal Dry Aspen Forest, and
- Western North American Boreal Alkaline Fen.

A full summary of land-cover and vegetation conditions represented by each flight path and camera system is shown in the Appendix.

### **3.3 Examples of comparing previous and current site conditions**

Part of the change-detection objective for this project was a comparison of the photos taken on the flight-path transects to past aerial or remote-

sensing images taken at the same locations. Here we present examples (Figures 4 and 5) using selected transect photos paired to previous-year images from Google Earth. These examples illustrate landscape changes under various disturbance or environmental developmental conditions and processes.

**Figure 4.** Two examples of matching prior-year conditions from Google Earth imagery (*left*) with this study’s low-level aerial photographic transects conducted on 4 June 2019 (*right*). *Top.* An example of changes in major riverine flood levels, meanders, the sandbar, and riparian conditions (Tanana River near Sam Charley Island). *Bottom.* Impacts of aspen leaf miner (*Phyllocnistis populiella*) on stands of trembling aspen (*Populus tremuloides*).

**Examples of Photos Compared With Google Earth Imagery**

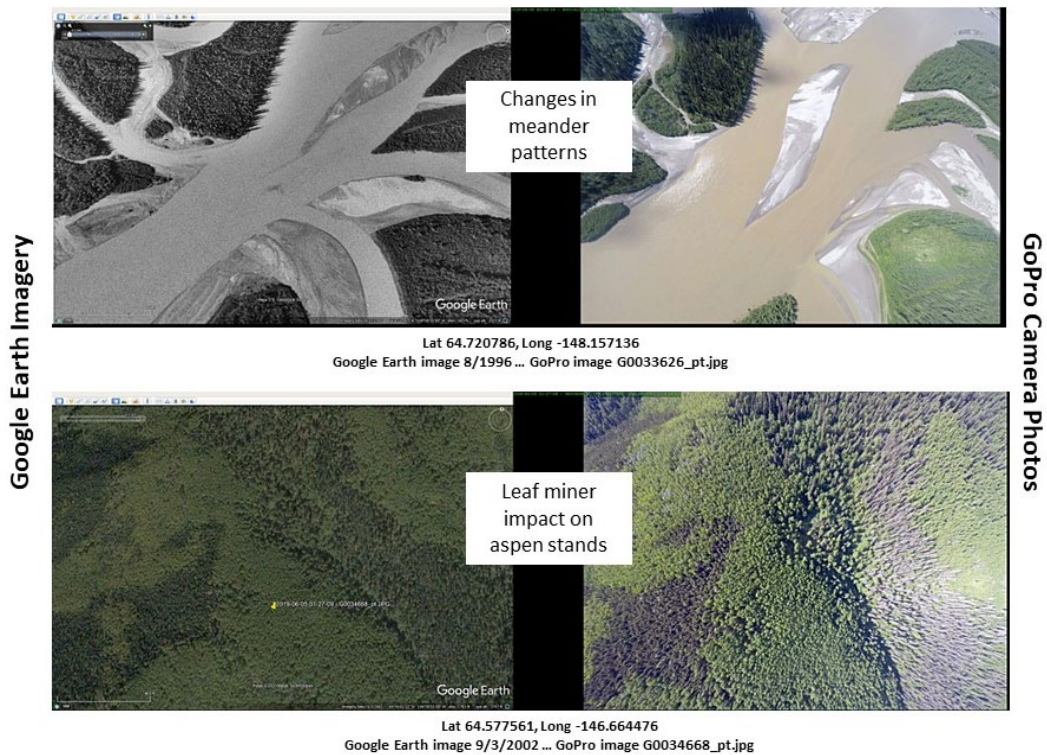
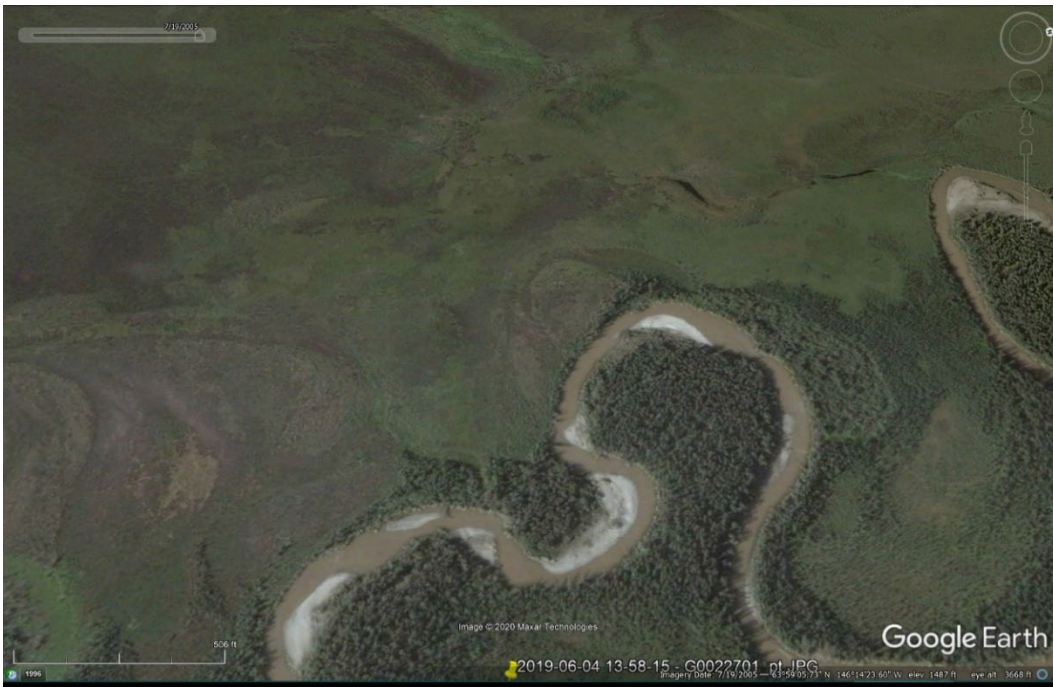


Figure 5. An image from the GoPro5 camera, taken 4 June 2019 in flight path 1 over Donnelly Training Area (Fort Greely), showing recent wildfire scars (*top*), compared with a Google Earth image of the same location taken 19 July 2005, prior to the burn (*bottom*).



### 3.4 Examples of use of nadir photos to create panoramic images

As the GoPro photos were taken at time-lapse intervals of 5 sec, and at the specified flight altitude AGL and ground speed, sequential images overlapped by about one-third. This allowed us to stitch together sequential images into panoramas of the desired number of photos. The resulting panoramas are more useful if they were created from photos taken during level flight.

Figures 6 and 7 present examples of panoramic images, each stitched from five sequential photos. Figure 6 shows a panorama of the Tanana River, centered on the GoPro photo from the upper part of Figure 4 and turned 90°. Figure 7 is a panorama centered on drainage wetlands and thermokarst ponds in the western section of Tanana River (Figure 1). Both examples are from GoPro5 photos taken on flight path 2.

Figure 6. Panoramic image stitched from five sequential GoPro5 photos of the Tanana River taken on flight path 2, centered on the example image shown in Fig. 4.



Figure 7. Panoramic image stitched from five sequential GoPro5 photos of drainage wetlands and thermokarst ponds in western Tanana River, taken on flight path 2 (Fig. 1).



As shown, creating selected panoramic images may be a useful means of displaying the broader landscape context of specific sites and features. This may be helpful for interpreting causal events and identifying disturbances in future change-detection studies.

A final potential use of the aerial photo transect images is to create animations of the flight path nadir images. This can be accomplished using video editing software or by combining sequential photos into animated GIF images. Animating photos in this way can also helpfully display the broader landscape context of a given image or feature to give a quick visual overview of selected flight-path segments and to generally elicit interest during presentations of project results. Some examples of the animation of sequential images are available from the senior author.

## 4 Conclusions and Recommendations

In this study, we provided a photographic portfolio of vegetation and land-cover conditions in the Fort Wainwright training grounds.

The low-level aerial photographic transects could be repeated along the same flight paths at future intervals to facilitate change-detection studies of relatively fine-grained landscape features. Repeat photography has a high value in change detection, such as to document shrub expansion in northern Alaska and elsewhere (Sturm et al. 2001; Tape et al. 2006; Myers-Smith et al. 2011), tree and shrub expansion in Denali National Park and Preserve (Brodie et al. 2019), landscape change in southwest Alaska National Parks (Jorgenson et al. 2006), and ecological recovery after the Katmai volcanic eruption (Jorgenson et al. 2012). The objective is to aid in identifying early warning signals and evidence of more subtle landscape changes, such as thermokarst slumps, the spread of effects of insect defoliators, localized patterns of wildfire and impacts on habitat fragmentation, rates of pond and lake formation and drying or draining, shifts in river courses and riparian conditions, and much more.

Material associated with this project has been archived for public and research access for future change-detection studies; see Marcot et al. (2022). Materials include GPS flight line data; all photographs, GPS-tagged and date- and time-stamped, and all GoPro photos, corrected for lens distortion and cropped; and associated metadocumentation of all materials.

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## Appendix: Land Cover and Vegetation Conditions

Table A-1. Total area of each land cover and vegetation condition represented in 6,063 GoPro camera photographs taken during two low-altitude photographic flight transects in Fort Wainwright (see text Figs. 1 and 2). Values here are total square meters of each cover category summed across all photos.

| Cover category   | Flight Path 1 | Flight Path 2 | SUM           |
|--|---------------|---------------|---------------|
| Agriculture–Cultivated Crops and Irrigated Agriculture   | 44,266        | 483,244       | 527,510       |
| Agriculture–Pasture and Hay                              | 0             | 9,972         | 9,972         |
| Alaskan Boreal Dry Aspen Forest                          | 253,513       | 35,820        | 289,333       |
| Alaskan Maritime Western Hemlock–Sitka Spruce Rainforest | 0             | 0             | 0             |
| Alaskan-Yukon Boreal Black Spruce Wet Forest             | 174,105,786   | 175,802,286   | 349,908,072   |
| Alaskan-Yukon Boreal Flooded and Rich Swamp              | 79,524,807    | 63,516,579    | 143,041,386   |
| Alaskan-Yukon Boreal Montane Alder–Willow Shrubland      | 19,520,438    | 165,414       | 19,685,852    |
| Alaska-Yukon Northern Boreal Mesic Woodland              | 0             | 0             | 0             |
| Arctic Herbaceous Tundra                                 | 912,275       | 33,159        | 945,434       |
| Arctic Low Shrub Tundra                                  | 14,572,441    | 8,379,939     | 22,952,379    |
| Central Alaskan Boreal Montane Woodland                  | 37,816,683    | 448,889       | 38,265,572    |
| Central Alaskan-Yukon Boreal Mesic Forest                | 884,096,598   | 610,162,013   | 1,494,258,611 |
| Developed–High Intensity                                 | 11,382,780    | 4,960,785     | 16,343,565    |
| Developed–Low Intensity                                  | 36,330,366    | 17,978,417    | 54,308,782    |
| Developed–Medium Intensity                               | 12,253,384    | 5,174,425     | 17,427,809    |
| Developed–Open Space                                     | 22,910,005    | 17,632,069    | 40,542,074    |
| Developed–Roads  | 28,849,009    | 15,349,830    | 44,198,839    |
| North American Glacier and Ice Field                     | 591,168       | 0             | 591,168       |
| Open Water   | 194,333,623   | 68,571,996    | 262,905,620   |
| Quarries–Strip Mines–Gravel Pits–Energy Development      | 1,874,970     | 1,306,729     | 3,181,699     |
| Recently Burned–Herb and Grass Cover                     | 18,063,412    | 4,910,934     | 22,974,346    |
| Recently Burned–Shrub Cover                              | 133,906,307   | 12,272,376    | 146,178,682   |
| Recently Burned–Tree Cover                               | 12,438,093    | 2,753,995     | 15,192,087    |
| Recently Disturbed Other–Herb and Grass Cover            | 0             | 0             | 0             |
| Recently Disturbed Other–Shrub Cover                     | 0             | 0             | 0             |
| Recently Logged–Herb and Grass Cover                     | 0             | 37,662        | 37,662        |
| Recently Logged–Shrub Cover                              | 0             | 0             | 0             |
| Southern Alaskan Boreal Mesic Forest                     | 0             | 0             | 0             |
| Southern Alaskan Boreal Montane Woodland                 | 21,520,050    | 0             | 21,520,050    |

**Table A-1 (cont.). Total area of each land cover and vegetation condition represented in 6,063 GoPro camera photographs taken during two low-altitude photographic flight transects in Fort Wainwright (see text Figs. 1 and 2). Values here are total square meters of each cover category summed across all photos.**

| Cover category   | Flight Path 1 | Flight Path 2 | SUM         |
|--|---------------|---------------|-------------|
| Western Boreal Alpine Acidic Mesic Meadow                | 8,221,733     | 12,159        | 8,233,892   |
| Western Boreal Alpine Cliff, Scree and Rock Vegetation   | 105,147,011   | 146,581       | 105,293,592 |
| Western Boreal Alpine Dwarf-Shrubland                    | 69,003,678    | 2,900,093     | 71,903,771  |
| Western Boreal Alpine Mesic Dwarf Birch-Willow Shrubland | 285,517,117   | 239,411       | 285,756,528 |
| Western Boreal Cliff, Scree and Rock Vegetation          | 54,170,295    | 1,224,678     | 55,394,973  |
| Western Boreal Dry Shrubland and Grassland               | 1,081,118     | 439,868       | 1,520,985   |
| Western Boreal Dune Shrubland and Grassland              | 1,270,856     | 348,165       | 1,619,021   |
| Western Boreal Mesic Alder-Willow Shrubland              | 22,794,767    | 757,786       | 23,552,553  |
| Western Boreal Mesic Birch-Willow Low Shrubland          | 59,939,238    | 63,630,018    | 123,569,256 |
| Western Boreal Mesic Grassland and Meadow                | 3,670,464     | 4,969,441     | 8,639,905   |
| Western Boreal Wet Alder-Willow Tall Shrub Swamp         | 103,071,600   | 70,173,874    | 173,245,474 |
| Western Boreal Wet Birch-Willow Low Shrubland            | 2,596,284     | 404,308       | 3,000,592   |
| Western Boreal Wet Meadow and Marsh                      | 16,420,501    | 34,116,417    | 50,536,918  |
| Western North American Boreal Alkaline Fen               | 207,178       | 36,672        | 243,850     |
| Western North American Boreal Bog & Acidic Fen           | 280,183,815   | 396,757,282   | 676,941,098 |

## Abbreviations

|       |  |
|-------|--|
| AGL   | Above Ground Level                               |
| ERDC  | Engineer Research and Development Center         |
| DTA   | Donnelly Training Area                           |
| CRREL | Cold Regions Research and Engineering Laboratory |
| GRTA  | Gerstle River Training Area                      |
| NVC   | National Vegetation Classification               |
| TFTA  | Tanana Flats Training Area                       |
| USACE | US Army Corps of Engineers                       |
| YTA   | Yukon Training Area                              |

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

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|   |                                    |                                     |   |                            |  |  |
|---|------------------------------------|-------------------------------------|---|----------------------------|--|--|
| <b>1. REPORT DATE (DD-MM-YYYY)</b><br>August 2022   |                                    |                                     | <b>2. REPORT TYPE</b><br>Technical Report/Final |                            | <b>3. DATES COVERED (From - To)</b><br>FY19–FY21                           |  |
| <b>4. TITLE AND SUBTITLE</b><br>Photographic Aerial Transects of Fort Wainwright, Alaska  |                                    |                                     |   |                            | <b>5a. CONTRACT NUMBER</b>   |  |
|   |                                    |                                     |   |                            | <b>5b. GRANT NUMBER</b>  |  |
|   |                                    |                                     |   |                            | <b>5c. PROGRAM ELEMENT</b>   |  |
| <b>6. AUTHOR(S)</b><br>Bruce G. Marcot, M. Torre Jorgenson, Thomas A. Douglas, and Patricia Nelsen  |                                    |                                     |   |                            | <b>5d. PROJECT NUMBER</b>  |  |
|   |                                    |                                     |   |                            | <b>5e. TASK NUMBER</b>   |  |
|   |                                    |                                     |   |                            | <b>5f. WORK UNIT NUMBER</b>  |  |
| <b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b><br>US Army Engineer Research and Development Center (ERDC)<br>Cold Regions Research and Engineering Laboratory (CRREL)<br>72 Lyme Road<br>Hanover, NH 03755-1290  |                                    |                                     |   |                            | <b>8. PERFORMING ORGANIZATION REPORT NUMBER</b><br><br>ERDC/CRREL TR-22-14 |  |
| <b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b><br>Department of Defense Strategic Environmental Research and Development Program (SERDP)<br>Resource Conservation and Resiliency Program Area<br>4800 Mark Center Drive Suite 16F16<br>Alexandria, VA 22350-3605  |                                    |                                     |   |                            | <b>10. SPONSOR/MONITOR'S ACRONYM(S)</b><br>SERDP                           |  |
|   |                                    |                                     |   |                            | <b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>                              |  |
| <b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b><br>Approved for public release; distribution is unlimited.   |                                    |                                     |   |                            |  |  |
| <b>13. SUPPLEMENTARY NOTES</b><br>This study was conducted for SERDP under Projects RC18-1170, "Interior Alaska DoD Training Land Wildfire Habitat Vulnerability to Permafrost Thaw, an Altered Fire Regime, and Hydrologic Changes," with funding provided by MIPR W74RDV90988946.   |                                    |                                     |   |                            |  |  |
| <b>14. ABSTRACT</b><br>This report presents the results of low-altitude photographic transects conducted over the training areas of US Army Garrison Fort Wainwright, in the boreal biome of central Alaska, to document baseline land-cover conditions. Flights were conducted via a Cessna™ 180 on two flight paths over portions of the Tanana Flats, Yukon, and Donnelly Training Areas and covered 486 mi (782 km) while documenting GPS waypoints. Nadir photographs were made with two GoPro™ cameras operating at 5 sec time-lapse intervals and with a handheld digital camera for oblique im-agery. This yielded 6,063 Go-Pro photos and 706 oblique photos. Each im-age was intersected with a land-cover-classification map, collectively rep-representing 38 of the 44 cover categories. |                                    |                                     |   |                            |  |  |
| <b>15. SUBJECT TERMS</b><br>Aerial photography; Baseline; Boreal; Fort Wainwright (Alaska); Land cover; Landscapes; Transects; Vegetation mapping   |                                    |                                     |   |                            |  |  |
| <b>16. SECURITY CLASSIFICATION OF:</b>  |                                    |                                     | <b>17. LIMITATION OF ABSTRACT</b>               | <b>18. NUMBER OF PAGES</b> | <b>19a. NAME OF RESPONSIBLE PERSON</b>                                     |  |
| <b>a. REPORT</b><br>Unclassified  | <b>b. ABSTRACT</b><br>Unclassified | <b>c. THIS PAGE</b><br>Unclassified |   |                            | <b>19b. TELEPHONE NUMBER (include area code)</b>                           |  |