Further Evaluation of a Low-Cost Drone for Monitoring Restoration of Well Pads

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Executive Summary

Former well pad sites must be restored upon decommissioning. Fieldwork was conducted in July and September 2017 to evaluate the use of a small, low-cost drone for assessing restoration at well pads near Hudson's Hope, BC. This work found that using a drone can provide a safe and efficient mean to assess site conditions and restoration. The drone also provided data that cannot be easily observed or measured from a field inspection at the ground surface.

Additional fieldwork was conducted on August 30, 2018, at the four of the same well pads that were inspected in 2017. A Phantom 4 Pro drone was flown over each well pad to capture aerial images 50 m above the ground. The drone was flown in a pre-configured grid pattern over a 5 to 10 minute flight time. The aerial images were used to generate orthophotos, which were compared with orthophotos created from aerial images taken in 2017.

The purpose of the 2018 fieldwork was to further evaluate the use of the drone to assess vegetation growth and conditions on the well pads after a one year period. Vegetation was just starting to become established when the well pads were flown in 2017. In 2018, there was significantly more variation in vegetation height and density on each of the well pads. The fieldwork performed in 2018 further supports the use of a drone to acquire aerial images of a well pad to evaluate a range of restoration criteria.

Acknowledgments

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1 Introduction

Oil and gas development activities disturb the land surface at well pads. These sites must be restored upon decommissioning, and this process takes several years to accomplish. Assessment of restoration progress typically involves field inspections of the well pad to evaluate a series of restoration criteria. The premise of this research project was the expectation that using a drone during the field inspection would enhance both the qualitative and quantitative assessment of restoration objectives. The key data acquired with the drone was a series of overlapping aerial photographs.

Fieldwork was conducted in July and September 2017 at four well pads near Hudson's Hope, BC. The research activities were designed to evaluate the use of a small, low-cost drone to assess well pad restoration. These sites had an "abandoned" status for one year, were under the same operator, and had not yet received a Certificate of Restoration. The research findings from the 2017 fieldwork confirmed that a drone could be an efficient and useful tool to acquire field data (Tannant and Smith, 2018). The 2017 photographs were used to explore different ways to quantify the state of land disturbance and restoration activities under natural field conditions. The approach used in the research was to evaluate the usefulness of the drone photographs to evaluate as many requirements as possible for a Certificate of Restoration.

Fieldwork was conducted again in August 2018 to evaluate further the capabilities of a small, low-cost drone for assessing the state of restoration on the same four well pads near Hudson's Hope, BC. The well pads were easily accessible by road and were located on crown land. Three sites (WA 19518, 23947, and 24004) were clustered close to each other approximately 8 km west of Hudson's Hope. One site (WA 16077, 16726, 24673) had three wells on it, and this well pad was located 7.4 km northwest of Hudson's Hope. In this report, this well pad is referred to herein as 24673. A map detailing the locations of these four well pads can be found in the first report submitted to BC OGRIS in January 2018 titled "Evaluation of a Low-Cost Drone for Monitoring Restoration of Well Pads" (Tannant and Smith, 2018). A drone was flown over each well pad to take a series of photos in August 2018. The purpose of repeating the flights and capturing photos in 2018 was not to repeat the same analyses that were performed a year earlier, but rather to evaluate restoration progress (vegetation growth). This report presents the results of the investigation and discusses the advantages and limitations of using a drone for well pad restoration assessment purposes.

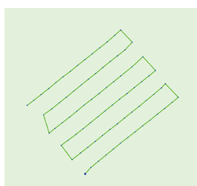
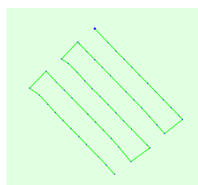
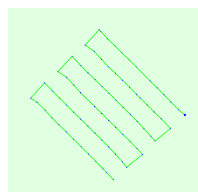
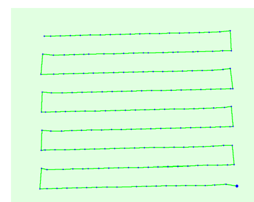
2 Drone and Flight Planning

A DJI Phantom 4 Pro drone was used. This drone can be easily carried to the site and rapidly deployed. It carries a relatively good camera with a mechanical shutter. The specifications for the drone and camera are given in the previously submitted report (Tannant and Smith, 2018).

The drone was pre-configured to fly a grid pattern over the well pads. PixCapture software was used to set up the flight plans. Photographs were set to be taken with 80% overlap. Although the planned flight speed was the same for each well pad at approximately 5 m/s, there are small differences in the distances between photographs due to differences in wind, length of runs, etc. The details of each of the 2018 flight plans are listed in Table 1. No ground control was used during the fieldwork.

The fieldwork at the four well pads was completed in 3 hours including travel time to and from the well pads from Hudson Hope and the equipment setup. This illustrates the ease in acquiring field data from multiple well pads in a day. The travel time to and from the sites is as significant as the time needed to fly at each site.

Table 1 Flight details for each well pad (Aug. 30, 2018)

	Well Pad			
Flight Details	19518	23947	24004	24673/16077/16726
Drone height (above takeoff point) [m]	50	50	50	50
Flight path (80% overlap)	Grid 	Grid 	Grid 	Grid 
Average distance between photograph centres [m]	9.62	9.15	9.46	9.72
Planned Flight speed [m/s]	4.9	4.9	4.9	4.9
Area covered [ha]	1.99	1.39	1.72	3.58
Flight start time	09:31	09:51	10:16	08:28
Flight duration [minutes]	6	5	5	10

3 Image Processing

Pix4D, a structure-from-motion photogrammetry software tool, was used to create point clouds and a high-resolution orthophoto using the vertical aerial photographs captured over each well pad. Information about structure-from-motion photogrammetric analysis, Pix4D, and various 3D models and outputs that can be extracted from the imagery are discussed in the report by Tannant and Smith (2018). Details on the post-processing with the 2018 photographs are found in Table 2.

Table 2 Image processing details for the 2018 photographs

	Well Pad			
Model Details	19518	23947	24004	24673/16077/16726
Photographs taken	82	57	77	186
Calibrated photos	82	56	76	152
Median number of matches per image	22369	19673	7418	3448
Points in point cloud	10,278,553	6,665,072	8,880,807	14,231,296
Point density [points/m^2]	1332	1433	1403	997
SfM processing Time [h:mm:ss]	1:30:11	1:09:03	1:05:51	2:13:50

4 Restoration Progress

The purpose of this section is to compare the orthophotos created from the September 2017 aerial photographs with the orthophoto from the August 2018 photographs for each well pad.

4.1 Well Pad 19518

Figure 1 shows there is noticeably more variation in the vegetation density and height, particularly in the west corner. The defined path that vehicles have been taking through the centre of the well pad seen in 2017 seems to be filling in with vegetation as of 2018. However, the bare spots in the eastern corner remain bare in 2018, which are even more noticeable with the increased vegetation elsewhere on the well pad.

4.2 Well Pad 23947

Figure 2 shows a comparison for well pad 23947. Similar to well pad 19518, there is greater variance in vegetation height and density in 2018 compared to 2017. The bare spots that existed in 2017 can still be seen in the 2018 orthophoto, although they appear to be filling in with vegetation.

There is evidence of vehicles driving on the well pad and impeding the growth of vegetation. There is no place to turn a vehicle around outside the well pad, so if a vehicle drives down the road to the well pad, it will turn around on the well pad.

4.3 Well Pad 24004

Well pad 24004 is shown in Figure 3. The increase in the vegetation height and density on this well pad has made the bare spots on the well pad clearly evident, particularly on the east side of the well pad. From ground level, it was observed that this well pad has less vegetation than the previous two. In the previously submitted report, it was noted that this well pad had more variety in topography and that ponding of water on this well pad was a possibility because of topographic low spots seen in the contour plots and the digital surface models generated from the point cloud. These low areas could be inhibiting vegetation growth.

As with well pad 23947, there is clear evidence of vehicles driving on the well pad and impeding the growth of vegetation.

4.4 Well Pad 24673

Well pad 24673 is larger than the previous three locations and was occupied by three different wells. As discussed in the previous report, this well pad was smaller at one stage and later expanded northward to accommodate one or more additional wells. In the September 2017 orthophoto, the outline of the original shape of the well pad could still faintly be seen. However, in the August 2018 orthophoto, this outline is almost nonexistent, and the vegetation appears much more uniform (Figure 4). It seems that the bare spots that existed the previous year have filled in with vegetation.

When visiting the well pad in 2018, the vegetation was noticeably higher on this well pad than on the other three well pads. There is no evidence of vehicle activity on this well pad, or of impact from the adjacent farm lands. The presence of a fairly steep ditch across the access to the well pad is a deterrent to vehicles driving over the site and hence contributes to better restoration of the site.

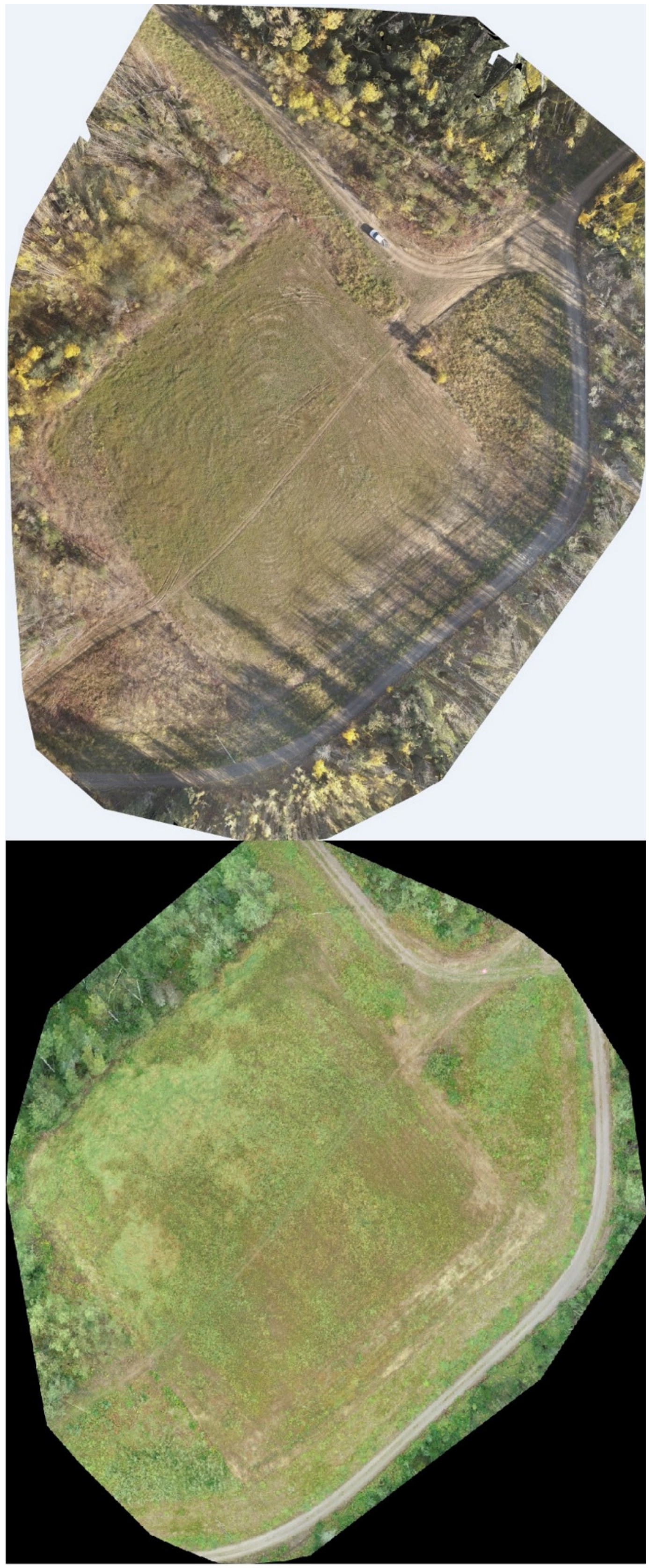


Figure 1 Well pad 19518 in September 2017 (top) and August 2018 (bottom)

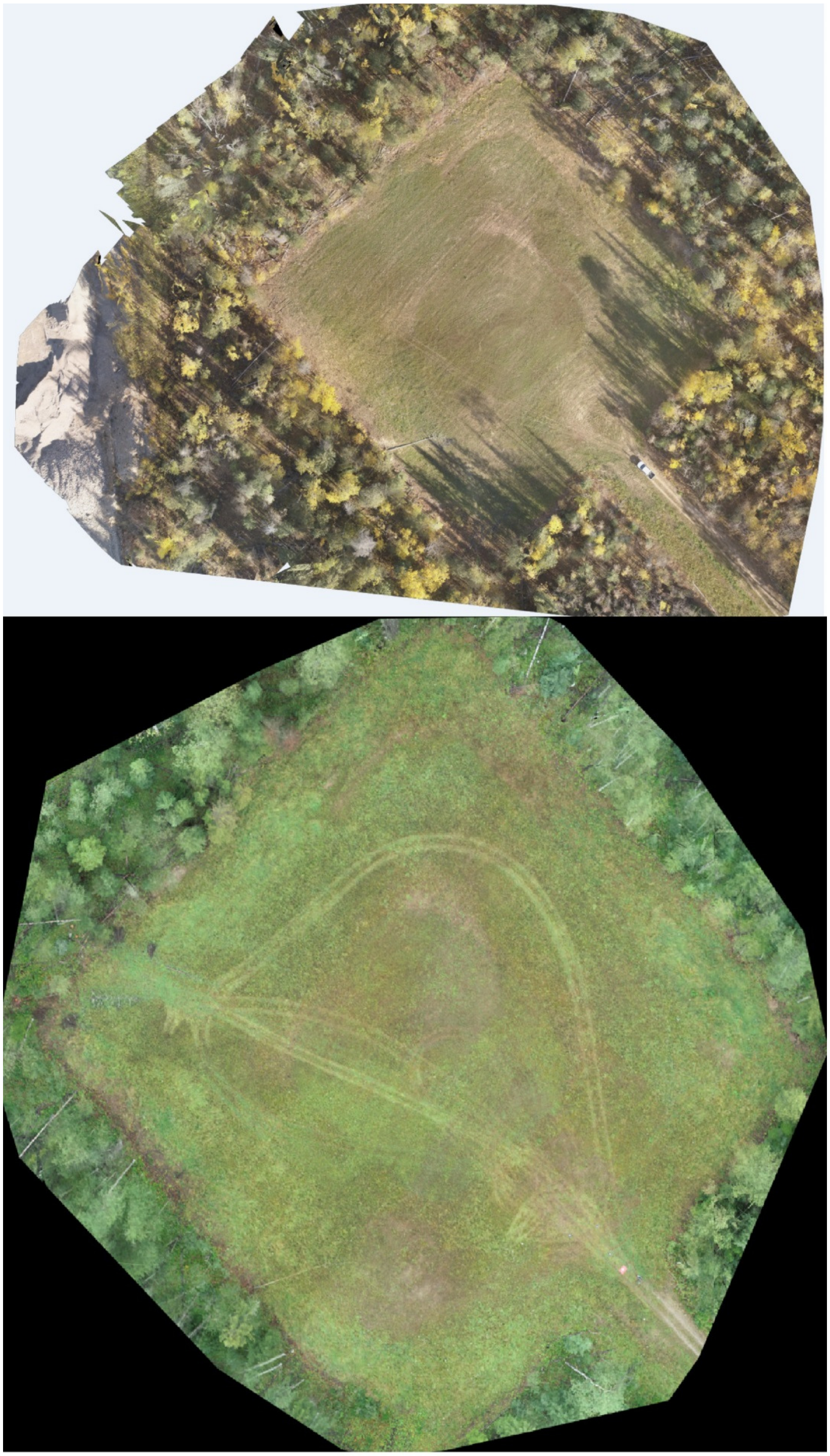


Figure 2 Well pad 23947 in September 2017 (top) and August 2018 (bottom)

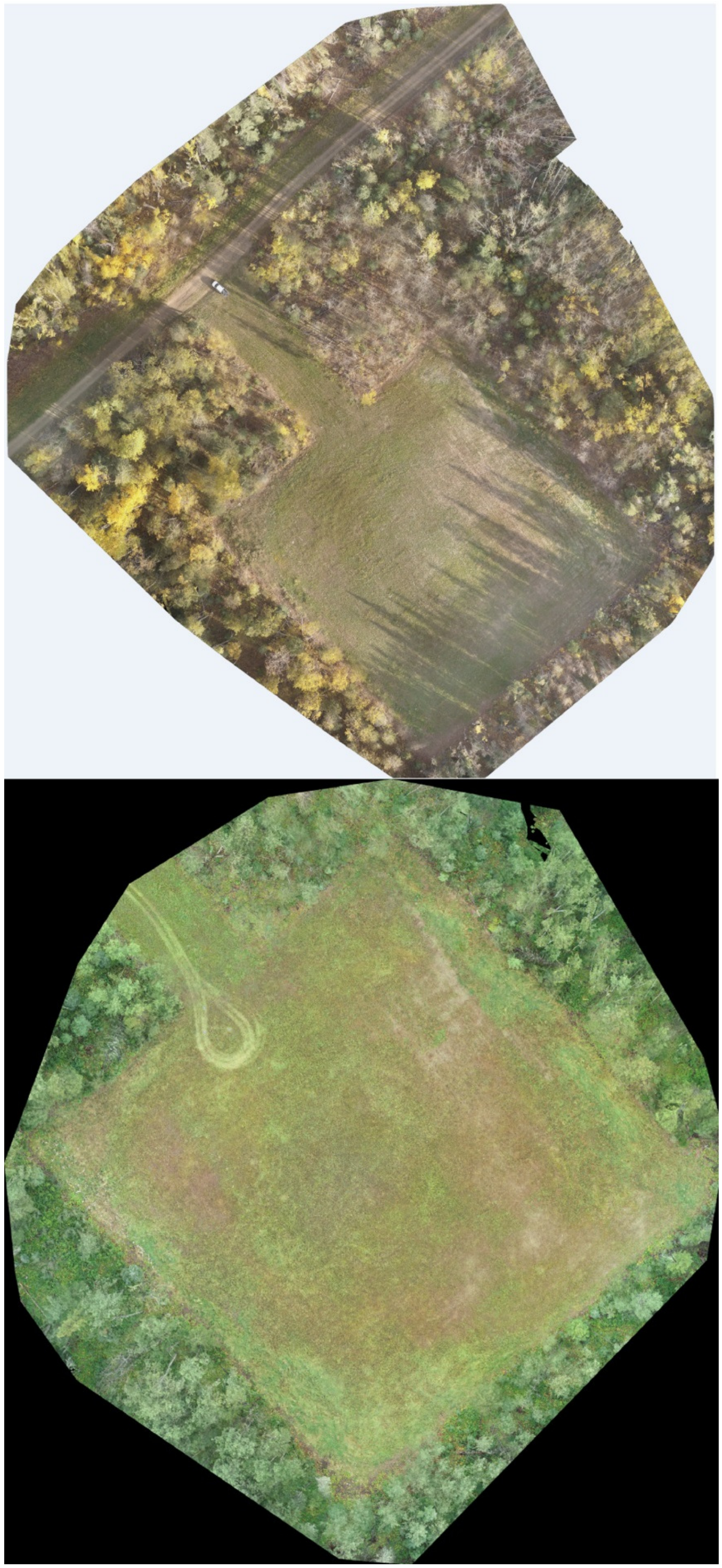


Figure 3 Well pad 24004 in September 2017 (top) and August 2018 (bottom)

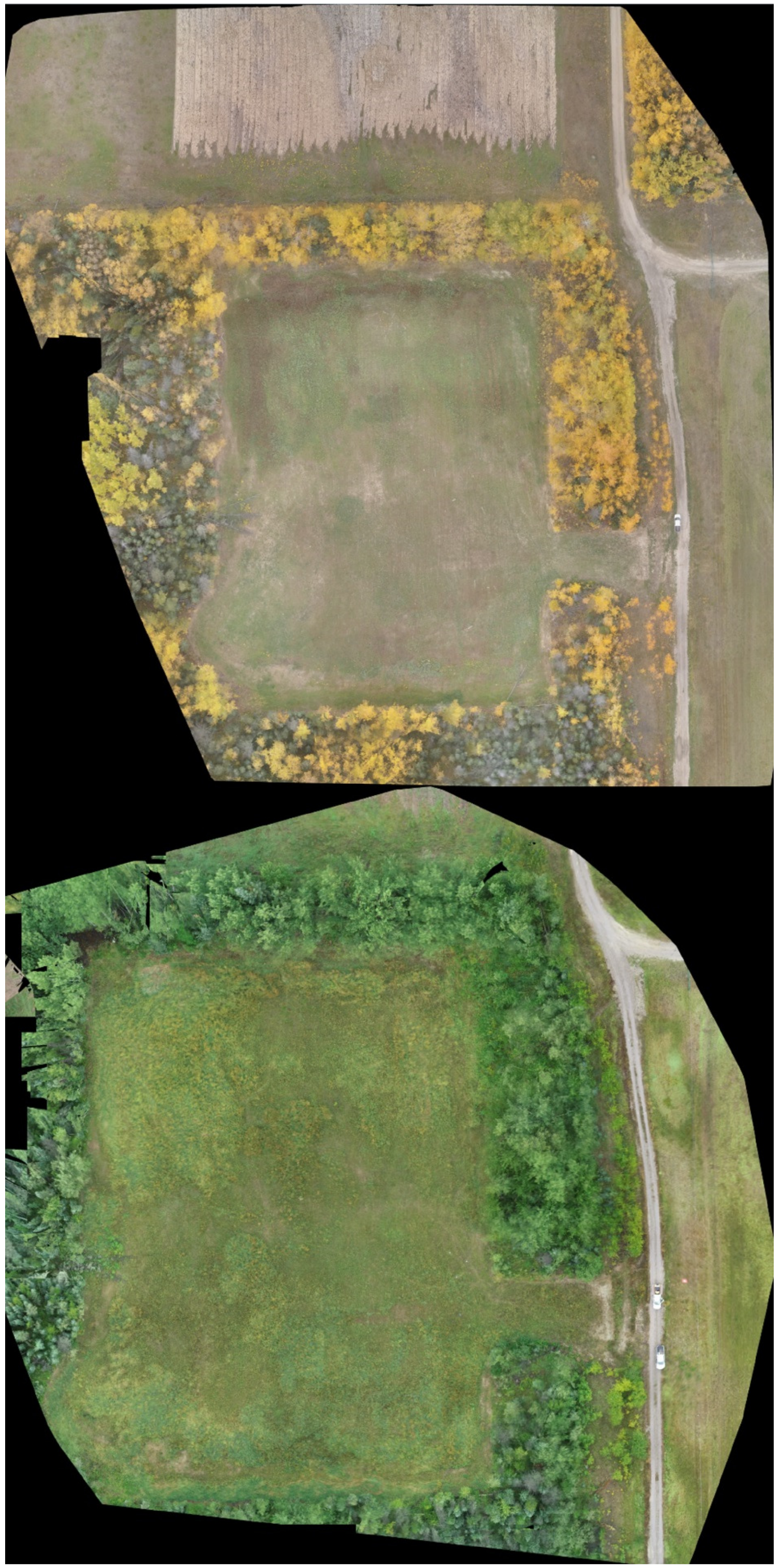


Figure 4 Well pad 24673 in September 2017 (top) and August 2018 (bottom)

5 Discussion and Conclusions

It is noteworthy that the conditions in which the fieldwork took place were much different in August 2018 compared to September 2017. While the flights were conducted at the same well pads, at the same height above ground and in grid patterns with similar drone speeds, it can be seen from the comparisons of orthophotographs in Section 4 that three of the September 2017 flights were done under sunny conditions, and shadows from trees around the well pad make it difficult to see some features on the well pads. These flights were done between 9:00 and 10:30 AM in late September. However, the August 2018 flights were conducted in late August under overcast conditions with light rain, which greatly reduced shadows in the photographs and enables seeing the bare spots and vegetation much more clearly. Overcast conditions with light winds and no rain are ideal for this type of fieldwork.

When Pix4D is used to generate a contour plot or surface model, as a default it uses the 3D coordinates of a dense point cloud, which can include features captured in the aerial photographs, such as trees, rocks, debris, and vegetation. Unless the features above the ground surface are correctly classified and removed before the contouring process, the generated contour plots and surface models may not correspond to the bare-earth topography and can be affected by variance in vegetation height over the well pads. The ideal time to fly to create detailed topographic maps would be immediately after the well pad reclamation activities have been completed and before the vegetation begins to grow. Then later flights can be used to assess the state of vegetation development on the well pad.

In the 2017 fieldwork, restoration was still in very early stages, and therefore the contour plots that were created to analyze slope and drainage criteria for a Certificate of Restoration were somewhat representative of bare earth topographic models. However, this analysis was not repeated in 2018 because of the amount that the vegetation has grown, and the fact that it has grown much more in some parts of the well pads than in others. This variance in vegetation height would result in contour plots that are less representative of bare earth conditions and therefore not useful in evaluating slope and drainage.

The results of the study suggest that drones can be a valuable tool to evaluate restoration progress of well pads. In many cases, the data that can be produced from the drone imagery can be used to assess multiple qualitative and quantitative requirements needed for a Certificate of Restoration. A drone should be used to acquire aerial photographs immediately after the well pad has been restored and before the vegetation begins to grow. At this time, the drone imagery can be used to create very detailed topographic maps and assess subtle changes in drainage and site disturbance. Aerial photographs acquired before the vegetation begins to grow can provide a convenient baseline to assess factors that may affect future vegetation growth. Additional drone flights taken in subsequent years can be used to quickly assess the vigour of vegetation growth as well as patterns of vegetation density and height.

6 References

Tannant D. and Smith K. 2018. Evaluation of a Low-Cost Drone for Monitoring Restoration of Well Pads. Report to the British Columbia Oil and Gas Research and Innovation Society, January 15, 2018.