Drone Use Extension and Demonstrations Supporting Management of Riparian Areas, Grazing Land, and Water Quality

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Abstract.

Agricultural and natural resource managers have explored a variety of ways in which drones might be used as a tool in their toolbox. One of the most useful ways may be the production of orthorectified aerial photography which can have very high spatial and temporal resolution. Such photography offers new opportunities for visualizing and measuring features on the landscape. Not just measuring the two-dimensional characteristics of landscape features, but also measuring three-dimensional characteristics. While orthorectified aerial photos require very many individual georeferenced photos with a high degree of overlap, simpler methods can be applied to generate useful products. Only a few individual drone photos are needed to stitch together a 360-degree panorama image which can be used for observing much larger areas than what would be covered in other drone aerial photos. Also, there are several freely available software and online services available that can be used for analyzing individual drone photos for characteristics such as percent ground cover and species frequency. This paper will provide examples of how drone imagery and analysis tools have been demonstrated to a variety of Extension audiences. Extension audiences have included livestock producers, Research and Extension personnel and other natural resource professionals in Kansas, and tribal nations. Examples of drone demonstration projects will include use of orthorectified aerial photography and digital surface models for improving management of feedlots and riparian areas. Additionally, 3D measuring technique for estimating dormant season grassland biomass with digital surface models will be presented. Finally, examples of how to easily use individual still photos to assess percent ground cover, and brush species frequency will also be presented.

Keywords.
Drone, Extension, Demonstration, Water Quality, Vegetation, Monitoring, Aerial Photography.

Introduction

The state of Kansas has a long history of providing water quality education and technical assistance to agricultural producers in priority watersheds. Funding for this work has been primarily through grants from USEPA section 319 of the Clean Water Act and the Kansas Water Plan. Emphasis of the Extension Watershed Specialist program has been on water quality improvement associated with livestock management, but crop production and urban issues are also covered. Aerial photography which is georeferenced and orthorectified has been an essential tool in providing education and designing water quality improvements. Public availability and quality of statewide aerial photography has improved over this period; improving from one meter spatial resolution black and white taken in 1991 and 2002, to .3 meter color taken every two to three years since 2012. Vastly superior spatial and temporal resolution of aerial photography taken from drones inspired the initial adoption of this technology for designing water quality improvements for small feedlots. Additional water quality related drone uses, mostly regarding measurement and monitoring of vegetation, have since been explored.

Extension Drone Use in Kansas Watersheds

Incorporation of high resolution drone orthophotography was introduced and adopted into the Extension Watershed Specialist planning toolbox after a four year learning period. That period included graduate student coursework and involvement in the remote control model aircraft hobby, A drone model (DJI Phantom 4 Pro) that was used personally was also purchased with university funds to support feedlot runoff planning and design. The novelty of the technology and consequently the curiosity and interest of local audiences created ample opportunities to demonstrate other natural resource management applications. Drone demonstrations and presentations were provided to three main audiences: 1) livestock producers, 2) state and tribal agency personnel, 3) university research and extension personnel. In addition to flights for feedlot planning, flights were also conducted to facilitate management of grazing land, riparian areas, wetlands and woodlands. A summary of demonstrations provided to the three audiences over about an eight year period is shown in Table 1. Over that same period, drone presentations were provided at 4 livestock producer workshops, 2 state agency conferences, 2 research and extension workshops and 1 tribal nations workshop

Table 1 Number and type of flight demonstrations provided to three audiences.

Audience	Type and Number of Flight Demonstrations			
	Feedlot Water Quality	Grazing Land Vegetation	Riparian, Wetlands and Woodlands	Live-View Flight Demonstration
Livestock Producers	6	3	-	2
Agencies and Tribes	-	-	4	1
Research and Extension	-	3	2	-

Small Feedlot Water Quality Planning

Kansas Extension Watershed Specialists have been providing education and design assistance to livestock producers to improve water quality for over twenty years. Aerial photography that was available for planning during much of that period had relatively poor spatial and temporal resolution. Although it has improved in recent years, higher resolution drone photography is still needed on many projects depending upon the circumstances. Additionally, the digital surface models made available when processing orthorectified aerial photos can be useful. Surface models of bare ground in a feedlot area have been used as a substitute for outdated LIDAR to generate elevation contours and runoff flow lines. Surface models have also been used to estimate the volume of manure to be hauled and applied to cropland (Figure 1).

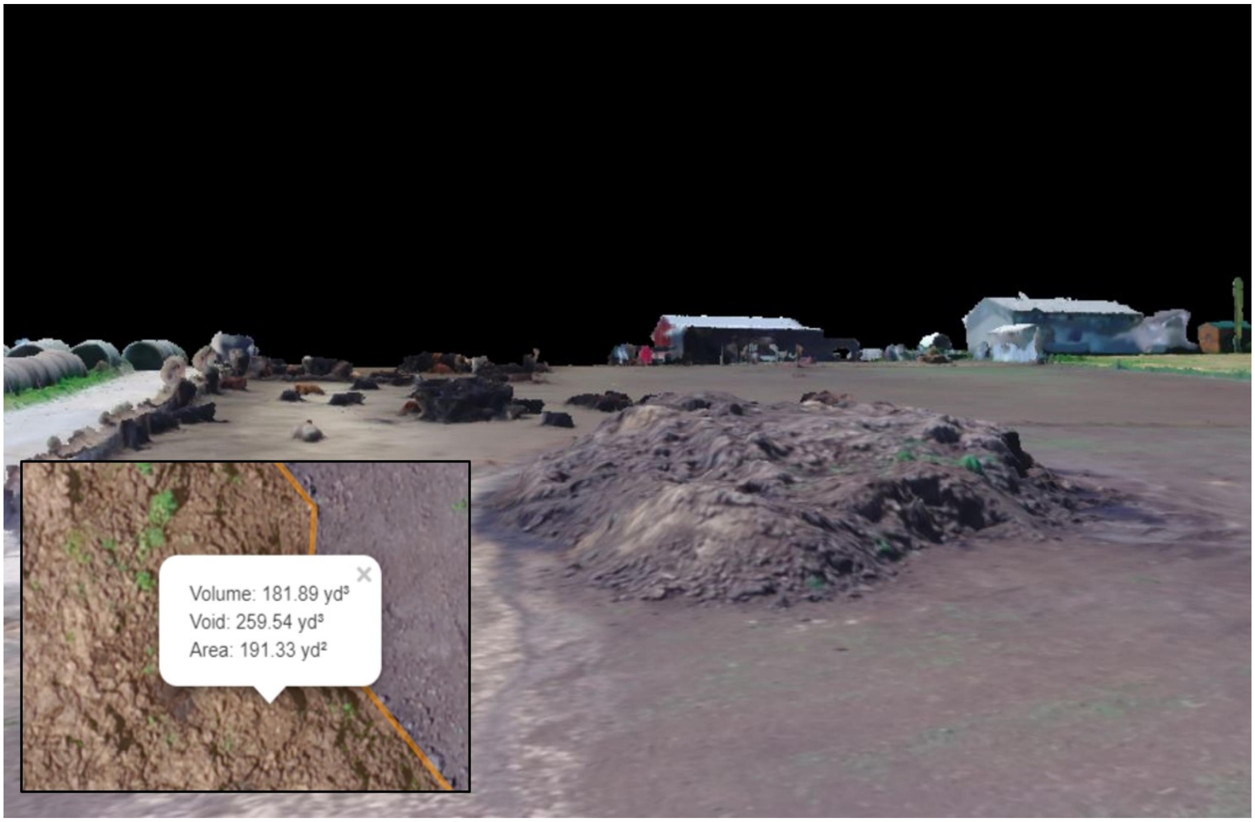

Figure 1. Feedlot manure stockpile shown in 3D view and volume calculation (inset image) from digital surface model.

Riparian Zone, Wetland and Woodland Demonstrations

Three riparian zone flights were demonstrated; two for state conservation program personnel and one for tribal nation agency personnel. Clear and current ortho-photography was a product desired in all three cases. One project that involved extensive ground survey work was also interested in comparing the value of rapidly collected ground surface elevation data by a drone to ground based data collection with a laser level and differentially corrected GPS. Both of the other projects made use of the aerial photography for measuring and monitoring riparian area improvements. One pre-construction wetland project was flown for a different tribal nation. Weeks prior to the wetland project flight, a hands-on flight demonstration was also provided to a larger group of their tribal agency personnel. Two flights were conducted for university forestry researchers. One involved using digital surface models to measure tree height in a bur oak plantation. The other was used to assess the potential to detect small evergreen coniferous eastern redcedar trees below a leaf-off deciduous woodland canopy.

Grazing Land Management, Monitoring and Research

A large portion of the drone flight demonstrations that were provided involved grazing land management. Examples that follow include: 1) a research oriented proof of concept on estimating dormant prairie biomass which requires a mosaic of numerous overlapping drone images, 2) techniques to monitor vegetation status and change using much fewer individual drone images, 3) the use of the drone live view camera for accomplishing ranch management tasks.

Dormant season prairie biomass estimation

Improved management of smoke from prescribed burning of tallgrass prairie is needed due to negative health effects that may be experienced by people downwind. One factor important to predicting the intensity of smoke is the amount of dormant prairie biomass present. Recognizing a correlation between grassland canopy height and biomass, researchers developed a linear regression model for predicting biomass using drone imagery. The model compared clipped and weighed biomass from a 1m square frame to drone estimated canopy height within the frame. The drone measured canopy height was derived from structure from motion processing of highly overlapped oblique drone images taken from 40 meters above ground level. Image pixel size was about 1cm.

In order to validate the model and help demonstrate its potential use, I flew double grid drone missions at two tallgrass prairie sites. Ten flights per site were conducted producing approximately 60 oblique images with a high degree of overlap on each flight. The regression model did a good job of predicting (R squared values of 0.907 and 0.744) the actual clipped biomass for these sites (Merwe et al., 2020).

Woody plant species frequency monitoring

Baseline frequency of occurrence data for two evergreen woody plant species on sandhills prairie rangeland were collected from individual still photos. Drone photos taken at spacing that was evenly distributed across a pasture were analyzed using a free federal agency produced software. SampleFreq (Figure 2) aids the user in determining presence or absence of species of interest within areas of pre-determined sizes (Cox et al., 2021). Another easy option for qualitatively monitoring change in tree cover in a pasture is use of 360-degree panorama photographs. Only a few individual drone photos are needed to stitch together a 360-degree panorama image. These panoramic images can be used for observing much larger areas than what would be covered in other types drone aerial photos taken below the allowed 400 feet above ground level elevation.

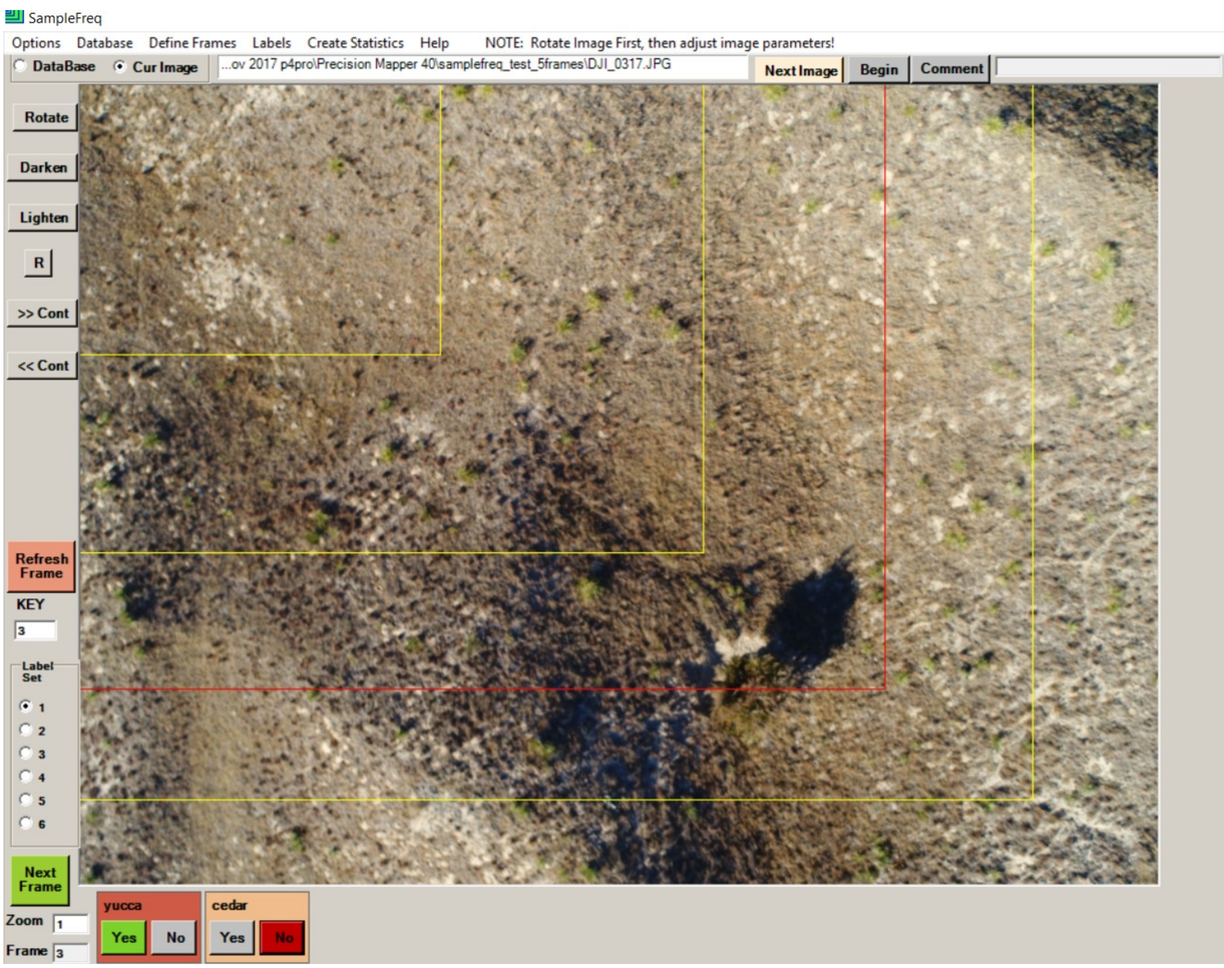

Figure 2. Samplefreq interface showing 3rd of 4 frames in red (500, 1500, 2500 and 3500 sq meters). Yucca presence result for this image was the 500 sq meter frame size. Cedar presence result for this image was the 3500 sq meter frame size since the center of the cedar tree was just outside of the 2500 sq meter frame.

Percent ground cover in grazed cover crop field

SamplePoint is a well-tested free photo analysis tool that systematically samples individual pixels of photos, aiding the user in identifying percent cover (Booth et al., 2006). Photos from a low-altitude drone belt transect flight over a grazed cover crop field were analyzed using SamplePoint. The Samplepoint assessment of 400 pixels showed that the belt transect area was 96.4% covered. Manual line transect cover assessment of 100 points found that the transect line was 97% covered. Repeating image collection and analysis later in the grazing season could be help determine when the targeted percent cover for livestock removal is reached. Proper timing of grazing removal to fully achieve water and soil health benefits of cover crops.

Live-view camera demonstrations for ranch management

Most of the potential drone applications imagined by ranchers seem to involve the live-view feature of the drone control system. This feature allows the user to get a drone-eye view from the drone video camera as it is displayed onto a tablet screen or live-view goggles. One live-view flight demonstration was conducted with a livestock producer to assess the potential for drones to aid in finding missing cattle. Two live-view flight demonstration were conducted with livestock producers to evaluate the potential for checking the condition of fences in areas of difficult terrain.

Conclusion

High spatial and temporal resolution aerial orthophotography obtained from complex drone image processing has been helpful in designing of feedlot runoff treatment plans. Drone images were particularly helpful when major changes had occurred at a site such as new construction or tornado damage. The 3D surface models generated as a step in the image processing can also be helpful under some circumstances. Broadening the scope of my drone use to include a variety of vegetation monitoring uses and other simpler forms of drone camera use was enlightening. It was helpful for seeing that quick and simple uses of drone imagery can also be quite beneficial and consequently, may be easier for people to adopt.

Cattle ranchers and other natural resource professionals have imagined quite a number of potential applications for the use of drones in their work. Some have adopted the technology and used it in both expected and unexpected ways. Others are still considering it, or have found to be unnecessary at this time. Those who have observed drone demonstrations and adopted the technology in their work seem to have particular needs that match well with the capabilities of the drone technology. Also it seems that one's interest in drone use is, in large part, dependent upon individual preferences and not just on the prospect of improving the efficiency of their work. Continuing to explore existing and new drone uses with interested natural resource managers will surely be informative and rewarding.

Acknowledgement

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