Unmanned Aerial Vehicles (UAVs) for Rangeland Remote Sensing

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Introduction

Aerial photography from unmanned aerial vehicles (UAVs) bridges the gap between ground-based observations and remotely sensed imagery from aerial and satellite platforms. UAVs have several advantages: they can be deployed quickly and repeatedly; they are less costly and safer than piloted aircraft; they are flexible in terms of flying height and timing of missions; and they can obtain very high-resolution imagery. This imagery allows for observation of individual plants, patches, gaps, and patterns over the landscape not previously possible. High resolution imagery has important rangeland applications such as monitoring vegetation change, developing grazing strategies, determining rangeland health, and assessing remediation treatment effectiveness.

UAV Requirements for Rangeland Management Applications

UAVs for rangeland management applications have to able to fly at relatively low altitudes (100-500 m above ground) and slow airspeeds; need to be able to takeoff and land on dirt roads, playas, or uneven vegetated areas; require a flight duration of one to several hours; and have sufficient payload capability for a variety of lightweight sensors (camera, video, thermal, etc.). At the Jornada Experimental Range (JER) in New Mexico, ongoing research is aimed at determining the utility of UAVs for rangeland mapping and monitoring. Our efforts are focused on developing a complete and efficient workflow for UAV missions, consisting of flight planning, image acquisition, image rectification and mosaicking, and subsequent image classification.

Current UAV Experiments at the JER

We are currently pursuing two parallel tracks for UAV applications in rangelands. The UAV platforms differ in size/weight, payload capacity, flight duration, GPS guidance capability and cost. While the first system (BAT 3 UAV) emphasizes a more technically advanced platform for research, the second system (Modified Model Airplane) emphasizes minimizing costs and maximizing simplicity for monitoring purposes. Both units provide a data file containing GPS and elevation for each image, but the BAT also records roll, pitch and yaw data. Both systems acquire high quality, high-resolution images of approximately 5 cm ground resolution at 150 m flying height.

BAT 3 UAV

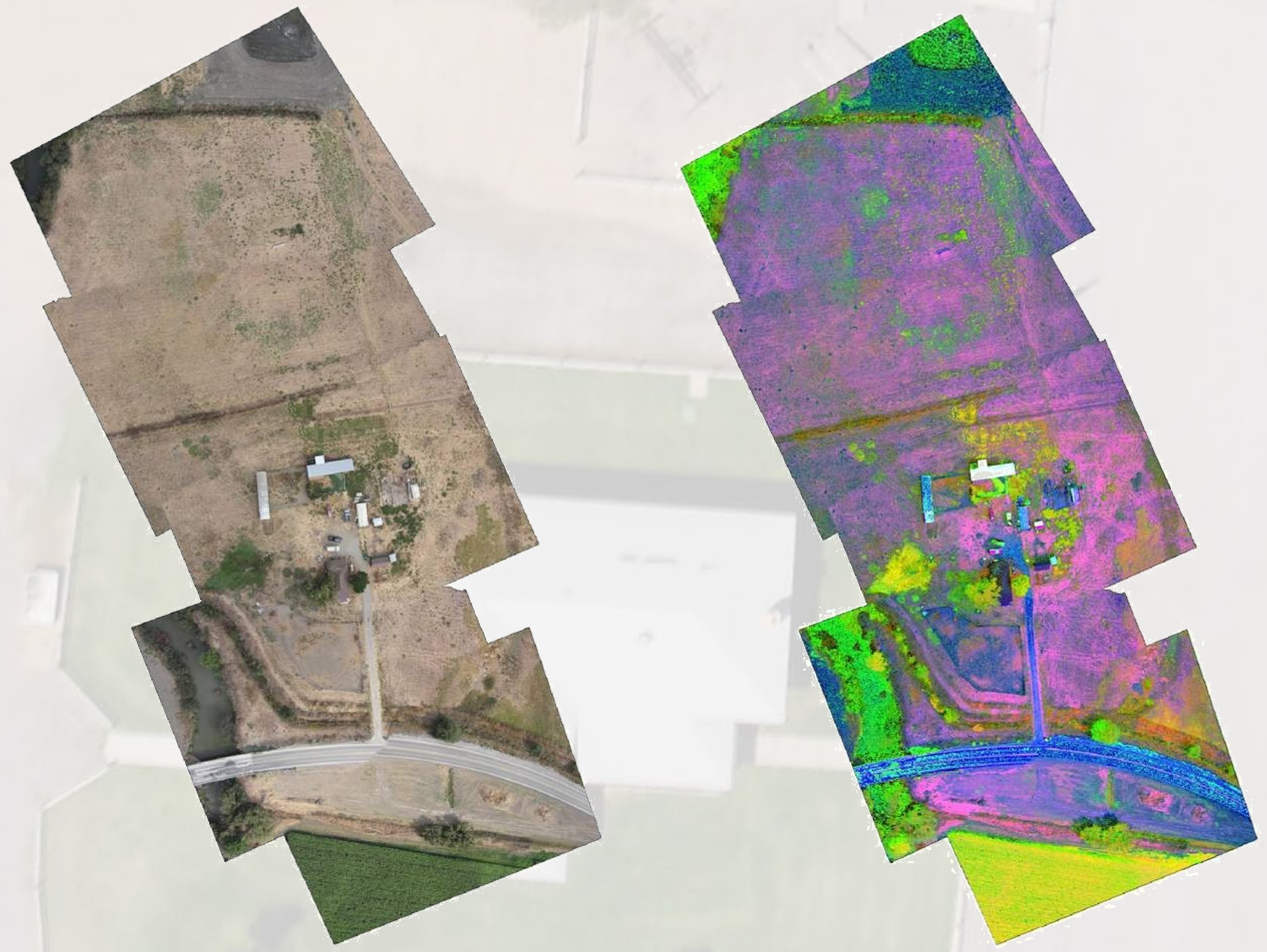
Modified Model Airplane

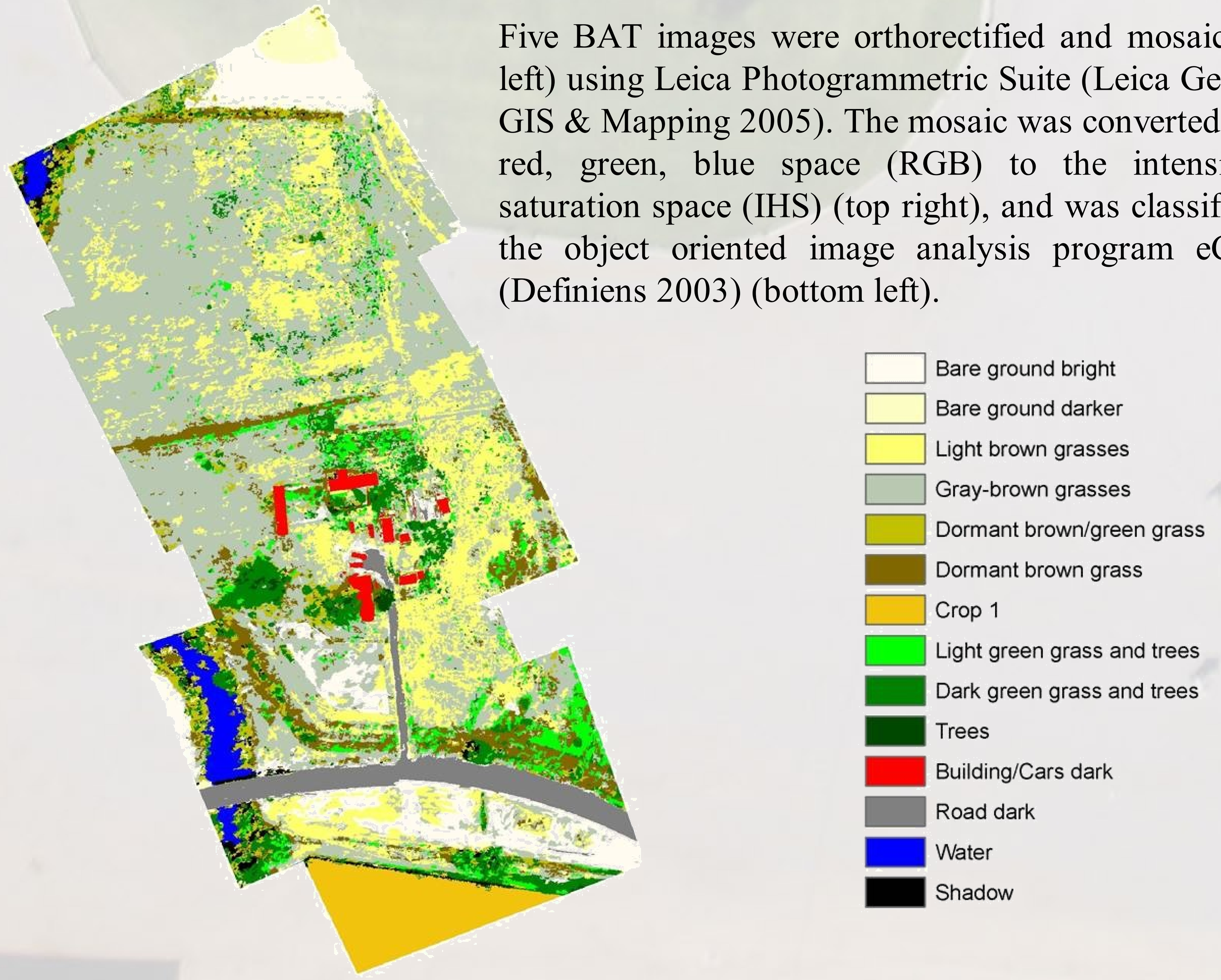
	BAT 3 UAV	Modified Model Airplane
Size/Weight	1.8 m wingspan/10 kg	1.8 m wingspan/5.2 kg
Payload capacity	1.2 kg with current sensor, 1.8 kg without	1.1 kg
Flight duration/max. altitude	2-6 hours/2700 m	30 min./1500 m
Sensors	Color video w. live downlink, Canon SD 500 7 MP camera	Sony DSC P200 7 MP camera
Takeoff and landing	Catapult launch, autonomous landing	Radio controlled takeoff and landing
Guidance system	Fully autonomous GPS guided by flight computer	Flies along preloaded waypoints
Data recorded	X,Y,Z, roll, pitch, yaw	X,Y,Z
Cost	~ $48,000	~ $2,000

BAT imagery

Footprints of BAT UAV imagery overlaid on DOQ (left). Eight flightlines and 476 images were acquired in 40 minutes flight time. The average flying height was 150 m.

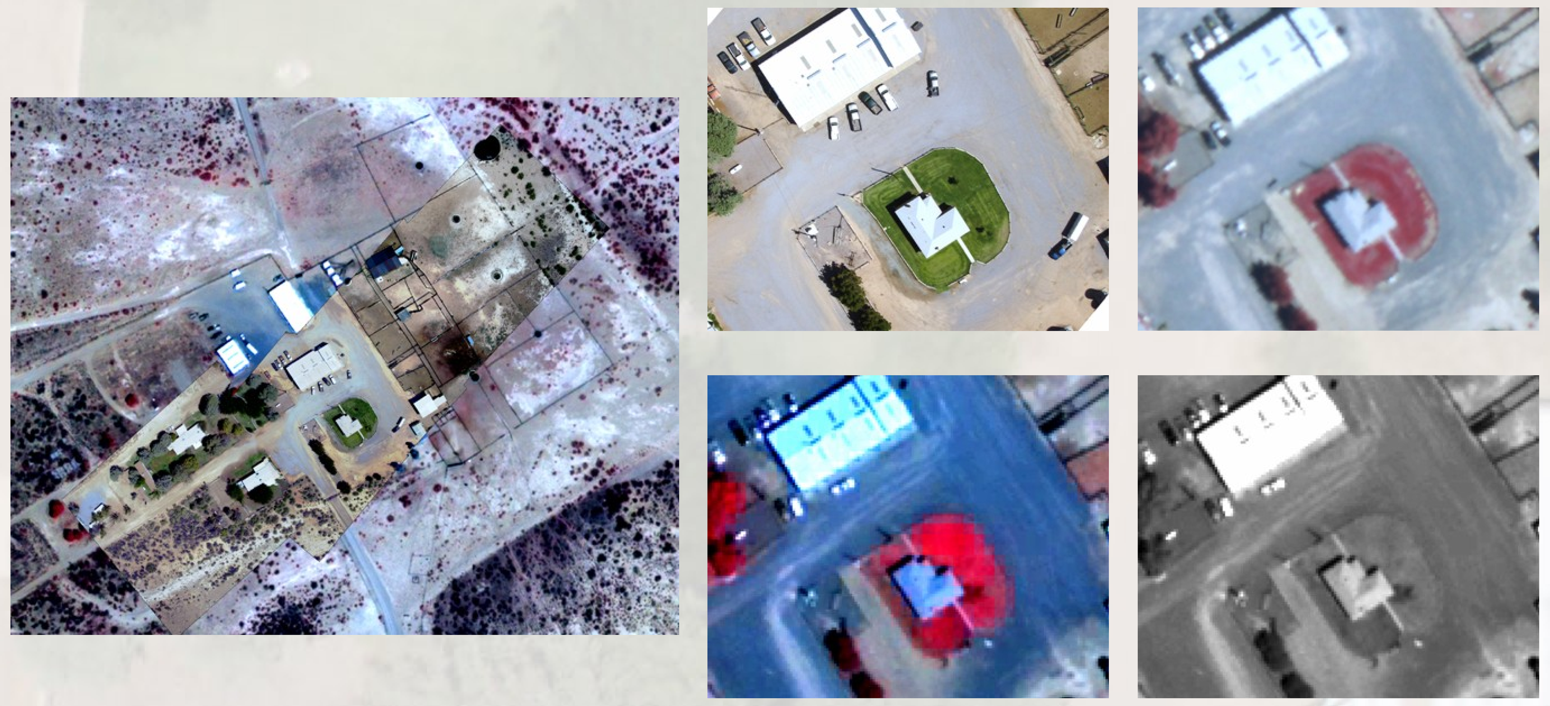
Orthorectified image (middle). The footprint is 89 m x 120 m and the pixel size is 5 cm. Details of the image are shown on the right.



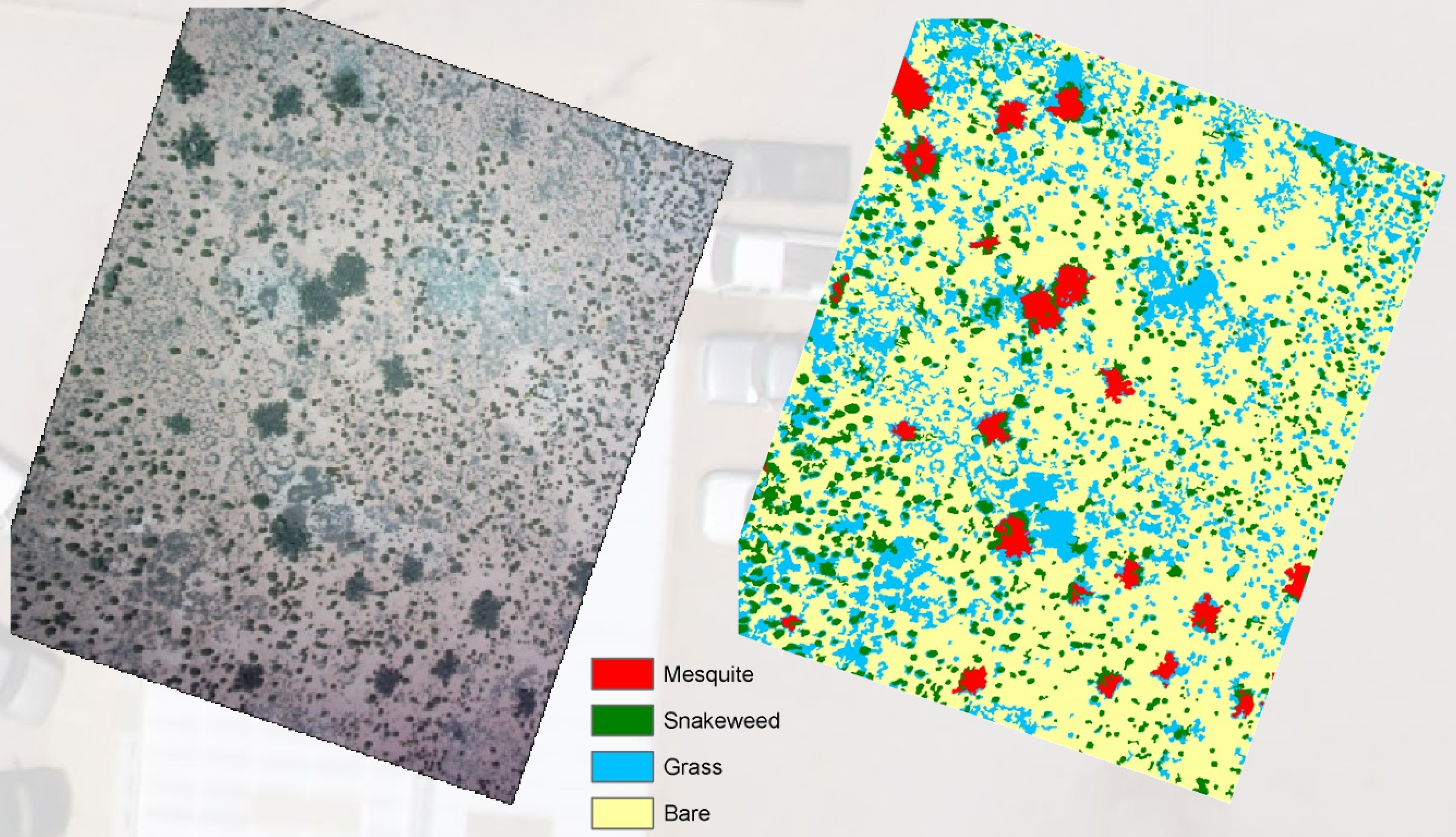


Five BAT images were orthorectified and mosaicked (top left) using Leica Photogrammetric Suite (Leica Geosystems GIS & Mapping 2005). The mosaic was converted from the red, green, blue space (RGB) to the intensity, hue, saturation space (IHS) (top right), and was classified using the object oriented image analysis program eCognition (Definiens 2003) (bottom left).

Modified Model Airplane imagery



Mosaic of orthorectified MMA images overlaid on pansharpened QuickBird satellite image (left). Comparison of MMA image at 5 cm resolution (top middle), aerial photo at 24 cm resolution (top right), panchromatic band of QuickBird image at 61 cm resolution (bottom right), and pansharpened band of QuickBird image at 61 cm resolution (bottom middle).



Classification of MMA image over mixed rangelands at JER. Subshrubs such as snakeweed and patches of grass are visible and can be classified and quantified.

Discussion and Conclusions

Both the BAT and the MMA provide high resolution images that clearly fill a gap between plot information from the ground and aerial or satellite imagery. Even though the BAT represents a more complex system, flight planning and image acquisition are currently more straightforward than with the MMA due to the fully autonomous flight capability and flight computer of the BAT.

Image rectification and mosaicking can present a challenge for imagery from both systems, because inaccuracies with aircraft attitude information increase the errors that arise in aerotriangulation of the images.

The BAT has greater stability, better GPS accuracy, and pitch, roll, yaw information, and is therefore better suited for aerotriangulation, orthorectification and mosaicking than the imagery from the MMA. However, the model airplane offers comparable image resolution and a cost effective alternative to the larger and more expensive UAV systems. As the accuracy of small, lightweight GPS units increases, image processing will improve in the future. Classification of imagery from both systems was comparable and highly successful using object-oriented image analysis procedures.

We foresee that in the future, land managers and resource agencies will be able to use small, lightweight UAVs to acquire imagery at a reasonable cost for making appropriate rangeland management decisions.