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Past, Present, and Future Capabilities of Remote Sensing for Assessing Watershed and Rangeland Change

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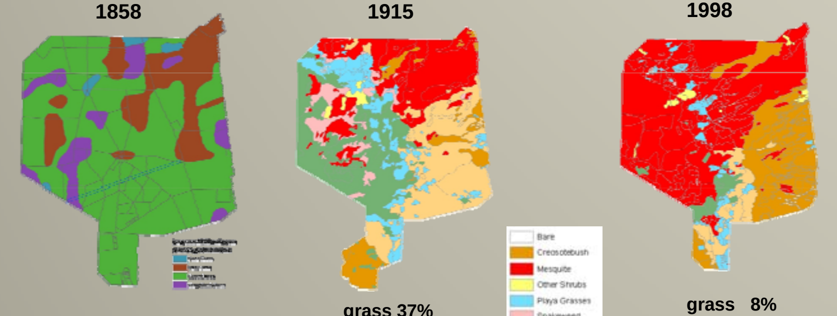
Introduction

Historic data of many types are available for watershed and rangeland management, monitoring, and assessment of change. Remote sensing data for the past is available, and both traditional and recently developed technologies are currently in use. One should not overlook historic land and vegetation surveys extending back to the 1850s that can be combined with historic aerial photos and current day aerial and satellite imagery.

Historic General Land Office Survey Data

The USA has a spatially comprehensive database that can be used to provide a representation of vegetation prior to most settlement in the Midwest and West documented in General Land Office (GLO) surveys. There is, in most cases, a wealth of information on historic plant communities and ecosystems (see Whitney and DeCant, 2001 in *The Historical Ecology Handbook*). The Jornada Experimental Range (JER) has used these surveys as a baseline for evaluation of change in desert grassland from 1858 to 1998.



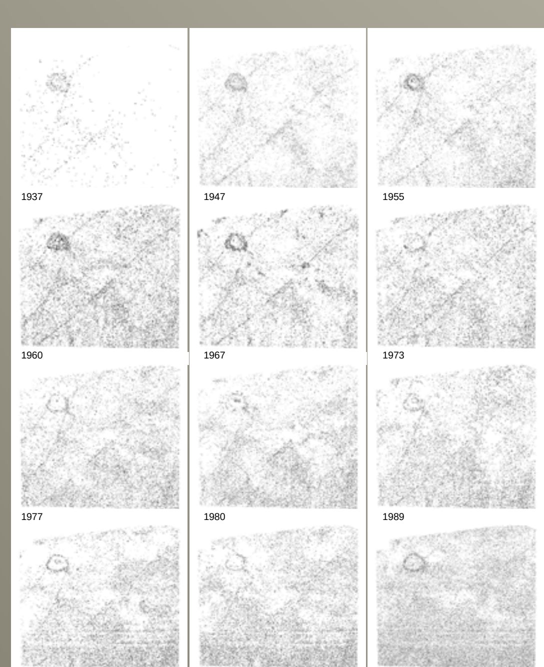
Grassland dominance GLO Survey

Gibbens et al. 2005. JAE

Ground survey assisted by aerial photography

Nationwide Historic Aerial Photo Database

In long-term studies, aerial photography which extends back to the mid-1930s is often overlooked. Many archives possess some portions of this photography database, so it is difficult to acquire the images in a systematic fashion, but it is possible if one approaches it in a persistent manner. We have been able to uncover 5500-6000 aerial photos for the JER (783 km^2) that provide excellent coverage each decade from 1930s onward.

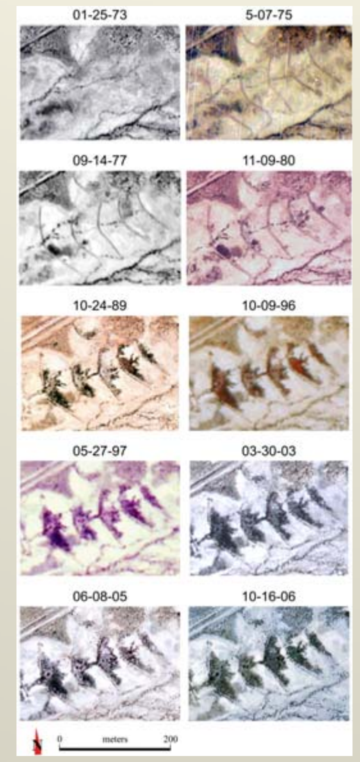


Shrub cover change from 1937 to 2003 based on results from object-based classification of aerial photos (1937-1996) and a QuickBird image (2003) over Pasture 2 of the Chihuahuan Desert Rangeland Research Center north of Las Cruces, NM.

The historic aerial photography requires certain preparation:

- Almost all aerial photography is inexpensive but not always so, some additional funds will be required at certain archives
- You must try to obtain positive or negative transparencies if possible in preference to prints, then scanning of the data is required for digital analysis
- Several large servers are required for storage, the Jornada aerial photo database will eventually require a storage capacity of about 50 terabytes

The JER has been a test area for relatively recent evaluations of water ponding dikes like these at Ace Tank and Taylor Well which were constructed in 1975.



Aerial photo sequence of the Ace Tank water ponding dikes prior to installation in 1973, during installation in 1975, and in subsequent years through 2006. Minimal vegetation growth occurred in the first 15 years, but in 20 years, the vegetation behind the dikes had strong growth due to increases in soil moisture.

New Technologies

New technologies are important to test for improving our capabilities for management of wild lands. For this reason we have taken into consideration comments by land use managers who have stated that the spatial resolution of normal aerial photography and satellite data are not sufficient for generating data useful for decision making in applications like rangeland health and for inputs to high resolution deterministic hydrological models. To address these comments we have begun flying unmanned aerial vehicles (UAVs) that are capable of providing imagery with spatial resolutions of approximately 5 cm.

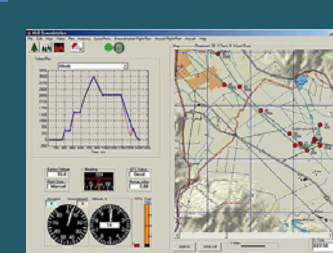
Complete Bat-3 system in use at the Jornada Experimental Range.

- Fully autonomous, GPS-guided UAS
- 1.8 m wingspan, 10 kg weight
- Flight duration: 2-5 hours
- Canon SD900 10 mp
- 75% forward, 40% sidelap
- Data file: X,Y,Z, roll, pitch, heading

Bat-3 prepared to launch

Field tracking station

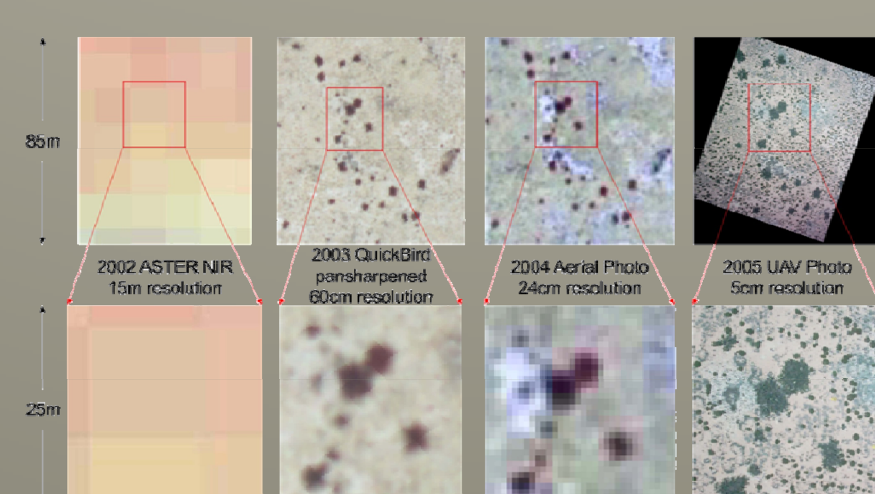
Bat autonomous catapult launch



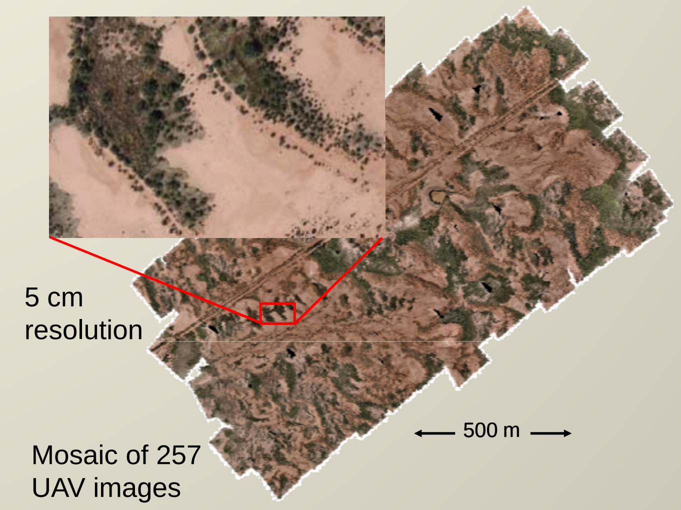
Screenshot of Bat 3 ground station during flight

Back with data

Comparison of satellite, piloted aircraft, and UAV imagery on the JER over the same area at different spatial resolutions to illustrate different rangeland patterns, patches, and gaps needed for rangeland health determinations.

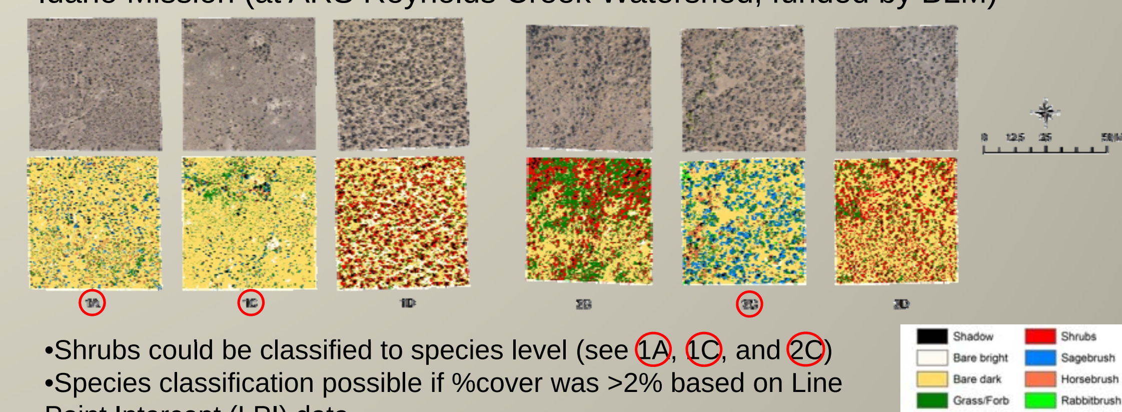


What Products Can Result From UAVs?



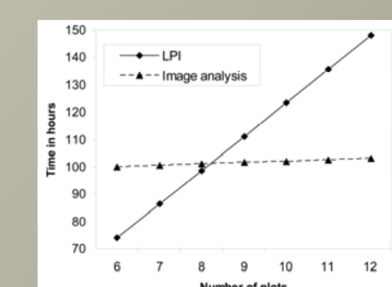
Off line, image data needs to be downloaded upon landing and those data need to be processed with our custom software to produce orthorectified image mosaics from 200-400 images.

Idaho Mission (at ARS Reynolds Creek Watershed, funded by BLM)



- Shrubs could be classified to species level (see 1A, 1C, and 2C)
- Species classification possible if %cover was >2% based on Line Point Intercept (LPI) data
- 2 classes of bare soil: bright, and dark

UAV Image Analysis becomes more cost effective than the ground-based LPI Approach when study plots > 8. When compairing UAV classification with LPI data, R^2 values range from 0.86-0.98.

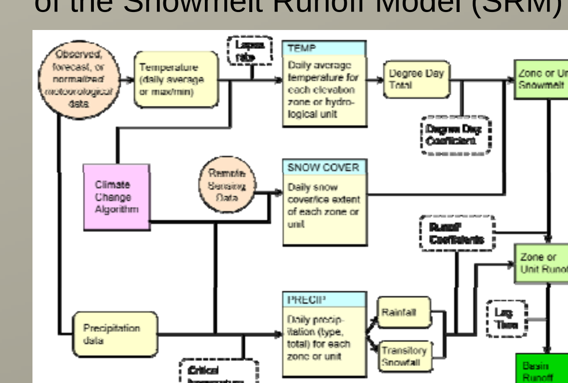


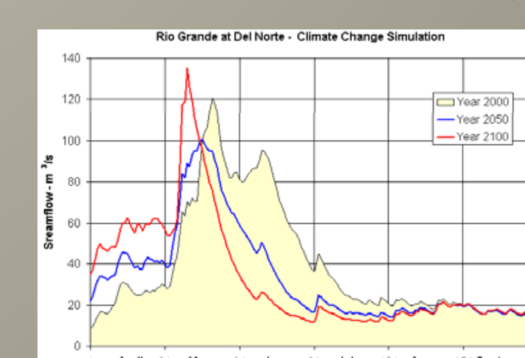
Update: The Jornada Bat-3 now caries both a Canon broadband camera and a 6-band multispectral camera.

Satellite Data is Still Useful

For mountain snow covered area, satellite data can supply the necessary data for water resources forecasting and evaluation of future climate change effects.

Schematic diagram of the organization of the Snowmelt Runoff Model (SRM)





Climate change simulation Rio Grande at Del Norte with periodic changes throughout the 21st century. By 2100, temperature has increased by 4°C, the diurnal temperature range has decreased by 1.4°C, model parameters are shifted, and a 10% increase in precipitation is expected. SRM has a formalized climate change algorithm to assist the user.

Conclusions

Historic remote sensing data are extremely valuable for monitoring vegetation change and evaluating the effects of climate change for both watershed and rangeland science. Aerial photography begun in the mid 1930s serves as the remote sensing data needed for this application. New advances in high spatial resolution (5 cm) UAV imagery is also very important for assessments of rangeland health and for input to hydrological models with very fine resolution unit areas. This does not mean that satellite data with coarser resolutions are not useful, e.g., the Snowmelt Runoff Model requires snow covered area data obtained from the frequent overpasses of earth observation satellites. Future systems will likely include integration of data from all types of sensors and platforms, and the managing and processing of the rapidly iincreasing data volume will be a major challenge.