Remote sensing to segregate grass and shrub mixed habitats in Janos Grassland Priority Conservation Area

Bird Conservancy of the Rockies

Final report for agreement # F13AP00675

July 31, 2017

A double rainbow spans grasslands in the Janos Grassland Priority Conservation Area in Chihuahua, MX.

Primary contact:
Maureen Correll
230 Cherry St. #150
Fort Collins, CO 80521
Maureen.correll@birdconservancy.org

Suggested citation:
D. Pool, M.D. Correll, and A.O. Panjabi. 2017. Remote sensing to segregate grass and shrub mixed habitats in Janos Grassland Priority Conservation Area. Final report. Bird Conservancy of the Rockies, Brighton, Colorado, USA.

BIRD CONSERVANCY OF THE ROCKIES
Mission: conserving birds and their habitats through science, education and land stewardship

Bird Conservancy of the Rockies conserves birds and their habitats through an integrated approach of science, education and land stewardship. Our work radiates from the Rockies to the Great Plains, Mexico and beyond. Our mission is advanced through sound science, achieved through empowering people, realized through stewardship and sustained through partnerships. Together, we are improving native bird populations, the land and the lives of people.

Goals

1. Guide conservation action where it is needed most by conducting scientifically rigorous monitoring and research on birds and their habitats within the context of their full annual cycle
2. Inspire conservation action in people by developing relationships through community outreach and science-based, experiential education programs
3. Contribute to bird population viability and help sustain working lands by partnering with landowners and managers to enhance wildlife habitat
4. Promote conservation and inform land management decisions by disseminating scientific knowledge and developing tools and recommendations.

Bird Conservancy accomplishes its mission by:

Monitoring long-term bird population trends to provide a scientific foundation for conservation action

Researching bird ecology and population response to anthropogenic and natural processes to evaluate and adjust management and conservation strategies using the best available science

Educating people of all ages through active, experiential programs that create an awareness of and appreciation for birds

Partnering with state and federal natural resource agencies, private citizens, schools, universities and other non-governmental organizations to build synergy and consensus for bird conservation

Fostering good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win situations for wildlife and people

Sharing the latest information on bird populations, land management and conservation practices to create informed publics

Delivering bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in western North America and beyond.

Executive Summary

This project attempts to classify shrub cover from 0-20% in desert grassland areas using a variety of remote sensing approaches in the Janos Grassland Priority Conservation Area (GPCA) in Chihuahua, MX. We found that the use of traditional remote sensing techniques such as supervised and unsupervised classification were unsuccessful at classifying lower shrub densities in Landsat multispectral imagery, and that additional research is necessary to classify shrub densities at this scale. We suggest that lack of high-resolution imagery specific to the timing of green-up in the Chihuahuan Desert of shrubs and grasses may contribute to the difficulties we encountered, and suggest the use of alternative classification techniques such and Random Forests or Support Vector Machines to further classify Landsat imagery. We also suggest the exploration and use of Unmanned Aircraft Systems, or drones, for fine-scale mapping of shrub densities because of the increased resolution and timing accuracy these emerging technologies afford researchers.

Project Objectives

The goals/objectives of this proposal were to:

- Identify which approach or combination of remote sensing approaches results in the best delineation between levels of shrub encroached grasslands
- Assess whether any combination of these approaches can be used at an implementation scale to delineate grass-shrub at threshold levels with biological meaning for species with available information (i.e. birds, antelope, herptiles or other grassland endemic species)
- Classify the grasslands and shrublands of the Janos GPCA
- Evaluate the compatibility for cross-walks of the classification outputs with existing classification products

Introduction

Desert grasslands often contain a mix of shrubland and grassland plant species. However, shrub encroachment is a widespread and ongoing concern in this ecosystem. Grassland endemic species are often attracted to different proportional mixes of these vegetation types; recent studies demonstrate a relationship between percent shrub cover within grassland areas and overwinter survival (e.g., Grasshopper Sparrow, Macias-Duarte et al. in review, Ruth 2017). Classifications of grassland land cover generally classify areas of 20% or more shrub cover as a separate cover type, however classifications lose accuracy with less than 20% shrub. This accuracy loss is particularly prevalent in areas outside of the U.S., where access to affordable satellite imagery used to produce land cover classifications is limited (1m vs. 30m resolution). Unfortunately for many species, it is specifically these low shrub grasslands that are their preferred habitats; the level of shrub component on the landscape, from <1%, 1-4%, 4-10% and 10-20%, influences habitat suitability. However, our ability to fully assess the spatial extent and degree of shrub encroachment in desert grasslands is reliant upon landscape data that quantify these metrics.

The need for a consistent and detailed land cover classification was highlighted by several CMQ teams within the Desert LCC (CMQ's 2, 3 ,5 & 6) for use in habitat inventory, fire-fuel modeling, landscape change and risk assessments. The team leading CMQ 3 specifically identified the need to better segregate the grass and shrub composition that make up much of the desert habitats. The Rio Grande Joint Venture Grassland Bird Conservation Plan also identified significant relationships between grassland birds and shrub levels in grasslands (Pool et al. 2012). The results of this plan articulate parametric relationships that could be used to estimate the capacity of the landscape to support grassland birds and produce a detailed and spatially-consistent land cover layer to refine and target conservation actions. The Sonoran Joint Venture also identified grasslands as a conservation target and has expressed a similar need to quantify shrub levels in grassland in the US and Mexico.

This project attempts to classify shrub cover from 0-20% using a variety of remote sensing approaches in the Janos Grassland Priority Conservation Area (GPCA), which is located in Mexico and contains the majority of the Janos Biosphere Reserve, including The Nature Conservancy's 'El Uno' Ecological Reserve. We aimed to identify the best techniques for assessing grass-shrub intermix at low densities and identify the best

approaches for large scale application of remote sensing to classify the desert grasslands and shrub lands. This project was supported by, and included members of, the CMQ 3 applied science team.

Methods

Study area

The Janos GPCA is located in the northern Chihuahuan Desert, roughly 40 miles south of the New Mexico/Mexico border. This GPCA has several advantages as a pilot area. LandFire data from the US Forest Service can be leveraged for both training and comparison where remote sensing scenes cross the border. Further, The Nature Conservancy's 'El Uno' Ecological Reserve has data available for training and validation as well as staff that can visit questionable areas. Bird Conservancy also has considerable *in situ* research ties and preexisting habitat data available for potential training and validation.

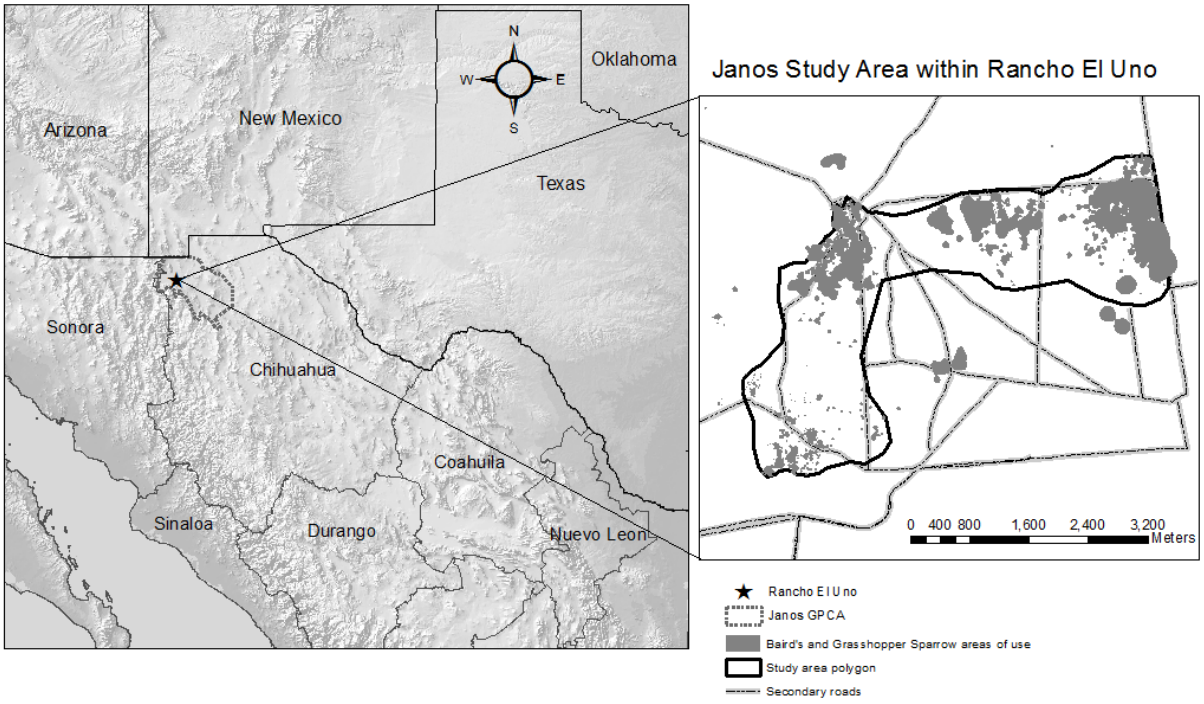

Figure 1. Map of the Janos Grassland Priority Conservation Area, The Nature Conservancy's El Uno Ranch.

Data sources

We used imagery from the Landsat program (www.glovis.gov) from the satellite Landsat 8. This satellite records multispectral imagery at a 30 X 30m resolution across the globe with a temporal resolution of 16 days. We downloaded imagery for the Janos GPCA for September 2013 to August 2014. When images were unavailable due to cloud cover, we used the next available scene with a collection date closest to the intended scene. We then stacked all Landsat bands to form composite band imagery

for our study area. We used vegetation transect data collected during bird surveys in Mexican GPCAs (Macias-Duarte et al. 2011) to ground truth our classifications.

Classification methods

We first calculated several vegetation indices for the study area. We calculated Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and Tasseled cap indices for greenness, wetness, and brightness. We then added these indices to the composite image stacks for each scene. In the Landsat scene over the El Uno Ranch, we also made separate stacks of band by band differences including indexes for each sequence of collection dates.

We then ran an Unsupervised Classification using 240 classes and default convergence factors. We ran this classification for September, April, May, and June imagery and used Cluster Busting (CB, e.g. Rivera et al. 2012) to separate classes in identified uncertain clusters. We also conducted a supervised classification on the same scenes, and used cluster busting using 10, 20, 30 unsupervised classes for each supervised classification. We included a tassel cap transformation to use Eigen Values specifically for greenness, wetness and brightness to help further separate shrub and grassland signature values. To address emergent difficulties in the classification process, we also ran a regular Eigen Transformation and used the top 3 contributing vectors in one additional composite image for Sept, April, May and June.

Results

We were unsuccessful at classifying low (<20%) shrub density with Landsat imagery using the methods described above. Correlation of all classifications with ground-truthed data showed correlation <0.5, rendering the classified cover types unusable for research or mapping efforts.

Discussion

We found that traditional remote sensing classification methods did not succeed in the quantification of shrub density within previously classified grassland areas in the Janos GPCA. We believe this is due to several factors: 1) resolution of available data leading to confoundment of shrub and grassland signatures within single pixels, and 2) availability of imagery during green-up of shrubs vs. grasses.

Landsat imagery is available to the public at no cost, making this resource invaluable in large-scale classification efforts across the US/Mexico boundary. This dataset, however, has limits due to the relatively large resolution (30 X 30m) at which imagery is provided. While 30 X 30m imagery is relevant to the classification of many common cover types (water, grassland, forest, bare ground, developed lands, etc.) it is less useful when trying to discern smaller habitat features such as shrub cover. Shrubs common to the Chihuahuan Desert include mesquite, Ephedra spp., Acacia spp., salt bush and creosote, all shrubs with heights from 0.5 – 3 m (E. H. Strasser, unpublished data) with comparable widths of canopy cover. The relative size of these individual shrubs in comparison to a 30 X 30m pixel make the detection of low shrub densities difficult using imagery with pixels of this size.

This issue could be further confounded by overlap of green-up of shrubs within the time span of the imagery we used in our analysis. Shrubs tend to green up in spring, while grasses reach highest biomass/green-up in the fall. The overlap in our imagery necessitated by limitations in cloud cover, etc. may have been too large of a window

and created overlap between green-up periods for these different vegetation types, therefore further obscuring results.

Next steps

Our findings highlight the need for exploration of alternative methods and forms of remote sensing to create a reliable method for discerning low concentration of shrub cover in grassland areas within the Desert LCC. Based on our findings and recent efforts incorporating alternative forms of remotely sensed data, we recommend the following:

Use of emerging remote sensing analysis techniques

Much advancement in remote sensing methodology has occurred since the development of this agreement, including the current availability of tools less accessible for general use at the development of this project. Analysis techniques such as Classification and Regressions Trees (CART), Random Forests (RF), and Support Vector Machines (SVMs) may yield more accurate classification accuracies than the ones produced by this effort.

Use of Unmanned Aircraft Systems (UASs) for individual shrub detection

Unmanned Aircraft Systems, more commonly known as drones, are an exciting emerging technology useful for mapping landscapes. At Bird Conservancy of the Rockies we are beginning to explore the use of drone technology to map grasslands of North America, from the Northern Great Plains to the Chihuahuan Desert in Mexico (Figure 2). We use a combination of field methods, drone technology, and software to create maps of grassland habitat using principles of photogrammetry resulting in photo mosaics and Digital Surface Models (DSMs) at very high resolutions (~2-10 cm pixels) of our field sites. We use these high-resolution DSMs to measure elevation at our field sites and identify the location of individual shrubs on the landscape. We can also combine images produced from visible and infrared wavelengths of light to measure plant structure and biomass on the ground for calculation of NDVI and other vegetation indices at similar resolutions. Further, this technology allows us to obtain imagery from within a few days of the target date, generally hindered only by logistics and weather. We can therefore obtain high resolution imagery at dates appropriate to be collecting this type of information, alleviating the two main shortcomings in the analysis described in this report.

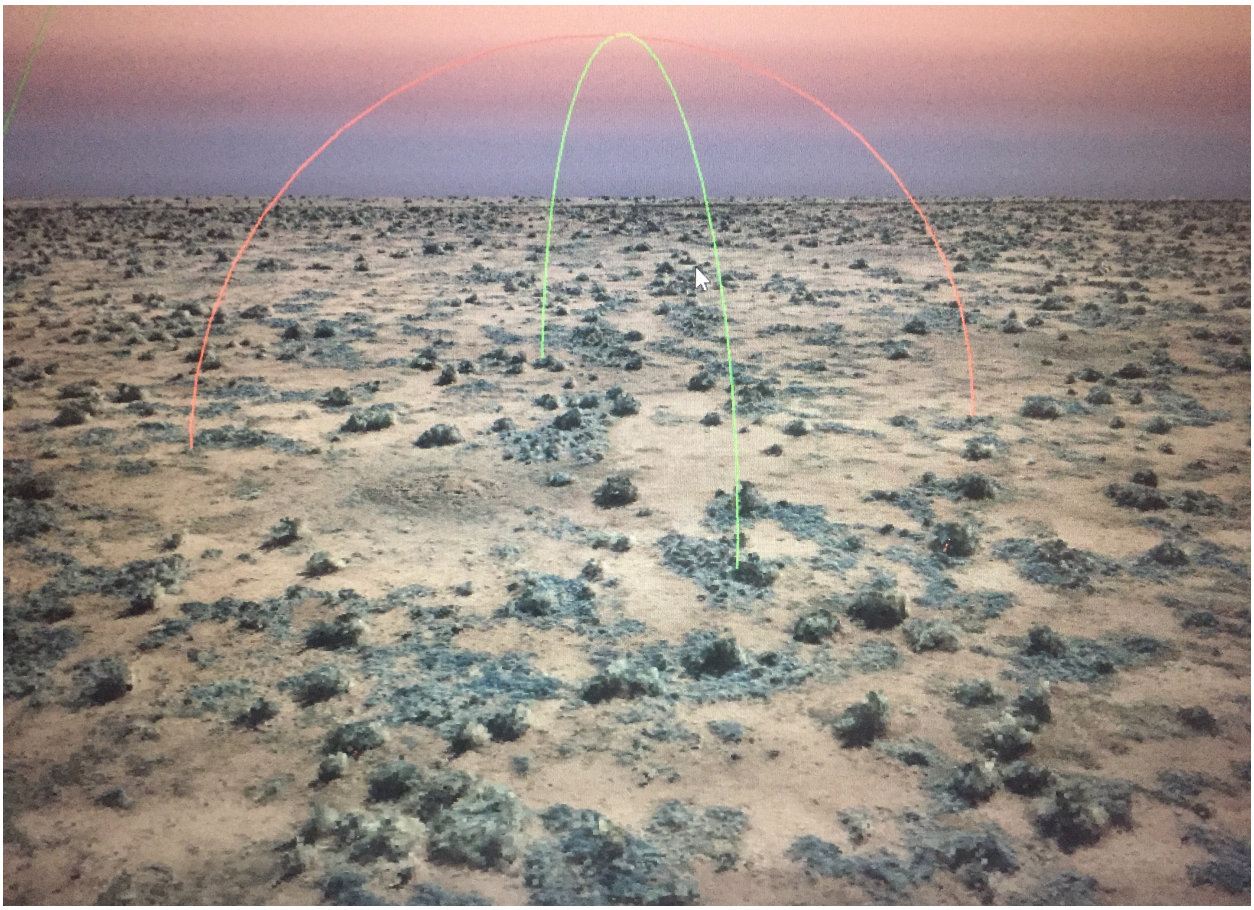

Figure 2. Mixed shrub and grassland landscape mapped using an Unmanned Aircraft System (UAS) in Janos Grassland Priority Conservation Area.

Literature cited

Macías–Duarte, A., A. O. Panjabi, E. H. Strasser, G. J. Levandoski, I. Ruvalcaba–Ortega, P. F. Doherty Jr., and C. I. Ortega-Rosas. 2017. Low winter survival of declining North American grassland birds is driven by weather and grassland condition in the Chihuahuan Desert. Journal of Field Ornithology, *in review*.

Macias-Duarte, A., A. O. Panjabi, D. Pool, Erin Youngberg and Greg Levandoski. 2011. Wintering Grassland Bird Density in Chihuahuan Desert Grassland Priority Conservation Areas, 2007-2011. Rocky Mountain Bird Observatory, Brighton, CO, RMBO Technical Report INEOTROP-MXPLAT-10-2. 164 pp.

Pool, D. B., A. Macias-Duarte, A. O. Panjabi, G. Levandoski, and E. Youngberg. 2012. Chihuahuan Desert Grassland Bird Conservation Plan, version 1.0. Rocky Mountain Bird Observatory, Brighton, CO, RMBO Technical Report I-RGJV-11-01. 74 pp.

Rivera, S., J. H. Lowry, A. J. Hernandez, R. D. Ramsey, R. Lezama, and Miguel A. Velasquez. 2012. A comparison between cluster busting technique and a classification tree algorithm of a moderate resolution imaging spectrometer (MODIS) land cover map of Honduras. Geocarto International 27(1).

Ruth, J.M. 2017. Life history attributes of Arizona Grasshopper Sparrow *(Ammodramus savannarum ammolegus*) and comparisons with other North American subspecies. American Midland Naturalist 178: 64-81.