MAPPING SHRUB ENCROACHMENT FROM 1937-2003 IN THE JORNADA BASIN OF SOUTHERN NEW MEXICO

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ABSTRACT

Shrub encroachment into arid and semi-arid grass-dominated landscapes has been noted in many parts of the Southwestern United States. Although it is well known that shrubs have increased over time, we have little quantitative information related to the rate of vegetation change over a particular time period. Our objective was to use aerial photos to measure the rate of shrub advance which is influenced by outside factors such as persistent drought periods and, in turn, has a direct influence on changes in the water, carbon, and energy cycles of these arid lands.

In the Jornada basin of southern New Mexico, shrub increase has been measured with various ground survey techniques extending back to 1858. Researchers at two rangeland research field stations, the Jornada Experimental Range (JER) (USDA-ARS) (783 km^2) established in 1912 and the adjacent Chihuahuan Desert Rangeland Research Center (CDRRC) (New Mexico State University) (259 km^2) established in 1927, have been attempting to remediate the shrub-invaded grasslands with a number of rangeland treatments since the early 1900s. Initially, manual and mechanical removal techniques were used along with experimentation with various chemicals and fire in certain pastures. Starting in the 1950s, herbicides were applied to many pastures through the 1970s. Herbicides were effective in controlling the shrub advance if used on a regular basis. Record keeping was not consistent, but it seems that herbicide treatments were applied to much of the basin where shrubs were present. This widespread use of herbicides has made it difficult to assess how rapidly the shrubs were invading grassland in the last 60+ years.

According to CDRRC records, only Pasture 2 has not been treated with herbicides. We have chosen Pasture 2 to monitor the shrub advance unaffected by herbicide treatments since the mid 1930s when aerial photographs were acquired over the Jornada basin for the first time. Since 1936, thirty-seven separate aerial photography missions have been flown over parts of JER/CDRRC. Recently, the area has been imaged with high resolution commercial satellites. We selected 11 aerial photos that covered the study area and had sufficient resolution for shrub detection. A QuickBird satellite image was used for the 2003 coverage of the area. All photos were scanned, georectified and resampled to a common resolution of 86 cm.

For our analysis, we used an object-oriented classification approach. In a pixel-based classification, the difficulty with analyzing single band aerial photos is associated with the low spectral resolution. This makes it often impossible to differentiate shrubs from the background in different areas of the image. An object-oriented approach allows the user to apply locally different strategies for analysis. We used the fractal net evolution approach (FNEA), which is an object-oriented multi-scale image analysis method embedded in the software eCognition (Baatz and Schaepe 2000, Definiens 2003). The first step is a segmentation of the image based on 3 parameters: scale, color (spectral information) and shape, which segments the image into object primitives based on the chosen parameters. Classification is then performed using those objects rather than single pixels. The multiresolution segmentation approach allows for segmentation at different scales, which is used to construct a hierarchical network of image objects representing the image information in different spatial resolutions simultaneously. This allows for differentiation of individual shrubs on the lower level, and determination of different shrub density classes on a higher level. The classification is based on fuzzy logic theory combined with user-defined rules. Spectral, shape and statistical characteristics as well as relationships between linked levels of the image object primitives can be used to combine them into meaningful classes.

The total area covered by individual shrubs in pasture 2 increased from 0.9% in 1937 to 13.1% in 2003. In 1960, shrub cover increased to 10.9%, then decreased in 1967 before resuming a gradual increase until 2003. Most of the shrub cover increase occurred during and just after the 1951-1957 drought which is believed to be the most

severe in the past 350 years. The high shrub cover in 1960 may be partially attributed to image quality. Although all images were resampled to the same pixel size, shrubs appeared larger and separate shrubs tended to merge together in the 1960 image. In the 2003 QuickBird image, shrubs appeared to be less defined, however, visual inspection confirmed that a larger proportion of small shrubs were captured. This is due to the larger bit depth (11 bits) in the QuickBird image compared to the 8 bit range in aerial photography. Due to limitations in pixel size, the smallest shrub we could classify was 0.74 m^2 (1 pixel), although many of the small shrubs were not captured due to lack of contrast. Therefore, our shrub cover estimate is likely an underestimation of the actual shrub cover.

In this Pasture 2 study area, the average rate of increase of shrub cover percentage is about 0.2% per year over the 66 year period. More rapid increases are noted in specific years, such as after the 1951-1957 severe drought. Certain years illustrate that shrub cover can also decline. It is difficult to say if this is a real effect or one resulting from varying image quality.

The object-oriented multi-scale image analysis method used in this study has several advantages over a pixel based classification approach when the goal is the extraction of relatively small objects such as shrubs from panchromatic aerial photos and high resolution satellite images. This method approximates the way humans interpret information visually from aerial photos, but has the advantage of an automated classification routine. Combining several scales of analysis in a hierarchical segmentation method is appropriate in an ecological sense.

The difficulties we encountered were related to varying image qualities (resolution, contrast, sun angle) as well as separating image quality from ecological variations (moisture conditions, time of year). Nevertheless, historical photos provide an important record of shrub increase over time. This technique shows promise for evaluating shrub encroachment using historical aerial photography and high resolution satellite imagery.

REFERENCES

Baatz, M., and A. Schaepe. 2000. Multiresolution segmentation: an optimization approach for high quality multi-scale image segmentation. In: *Angewandte Geographische Informationsverarbeitung*. Vol.XII ed., J. Strobl, and T. Blaschke (Eds.), 12-23. Wichmann, Heidelberg, Germany.

Definiens. 2003. "Definiens Imaging, eCognition." Web page, [accessed 7 October 2003]. Available at http://www.definiens-imaging.com