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Tamarisk Remote Sensing Inventory and Assessment

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Overview

Tamarisk was introduced to the Western United States during the late 1800s and has drastically changed plant and wildlife communities along the Colorado River Basin (figure 1). Early detection and removal of tamarisk have become goals of land managers. A project sponsored by the Remote Sensing Steering Committee (RSSC) assessed how effectively remotely sensed imagery can detect tamarisk. Imagery analyzed in this study varied in both spatial and spectral characteristics. An aerial survey crew collected natural color and color-infrared digital-camera imagery in early and late summer of 2002 near Grand Junction, CO. A field crew collected hyperspectral data during midsummer of the same year. Analysts tested both automated and semiautomated image interpretation techniques on the data. The analysts mapped the hyperspectral images using a mixture-tuned matched-filtering partial-unmixing technique. The results showed that both data sources can efficiently map larger stands of tamarisk but may not work as well for early detection.

Figure 1—Tamarisk thickets along the bank of the Colorado River near Grand Junction, CO.

Introduction

Tamarisk (Tamarix spp.) or salt cedar is an exotic shrub that replaces native plant communities in riparian ecosystems of the Southwestern United States. Tamarisk degrades wildlife habitat, reduces biodiversity, alters stream channel morphology, uses large quantities of ground water, and increases wildfire frequency and soil salinity (DeLoach and others 2000).

Remote sensing imagery has successfully detected tamarisk in the past when imagery was collected during leaf color changes in late fall. However, predicting the window of opportunity between the time when tamarisk leaves change color and when the plants lose their leaves, especially at varying elevations, is difficult (Everitt and DeLoach 1990). Using a technique to map tamarisk reliably from imagery acquired during the growing season is preferable.

Study Area

Analysts collected digital camera and hyperspectral data over two study areas during the 2002 growing season. One study area is located west of Grand Junction along the Colorado River on the Mack 7.5-minute U.S. Geological Survey (USGS) quadrangle. The second study area is northeast of Grand Junction on the De Beque 7.5-minute quadrangle (figure 2). Analysts chose both

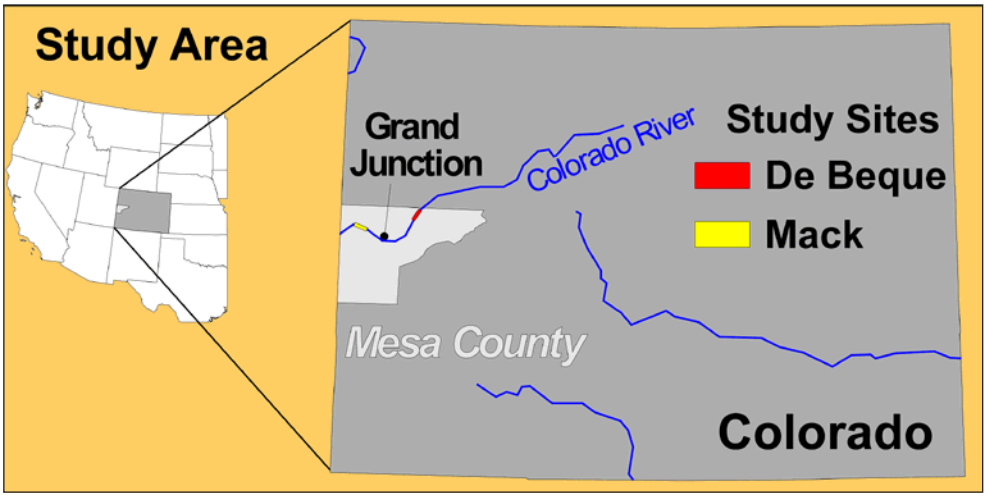

Figure 2—Location of the Mack and De Beque study areas.

areas for their easy accessibility and varying densities of tamarisk. Although both locations were analyzed, this report focuses on results from the Mack study area. Additional details on both study areas are included in the final report, which can be found on the U.S. Department of Agriculture (USDA), Forest Service Intranet site at http://fsweb.rsac.fs.fed.us.

Data Preparation

Digital Camera Imagery

Initially, the aerial survey crew collected natural color (NC) and color-infrared (CIR) digital camera images at the onset of the 2002 growing season. The imagery differed both spectrally and spatially and was acquired using Kodak DC 620 and 420 digital cameras. These initial flights served to determine the best scale and image type for separating tamarisk from surrounding vegetation. A 1-foot spatial resolution provided enough detail to differentiate riparian vegetation types such as tamarisk, Russian olive, skunk brush, greasewood, and cottonwood trees. A followup flight in September 2002 collected 1-foot spatial-resolution images in both CIR and NC.

The individual digital-camera images had to be georeferenced and mosaicked to prepare them for interpretation. They were first georeferenced to 1997 NC digital orthophotos. Then these images were mosaicked to create a larger project area for subsequent analysis (figure 3). Coregistration between the CIR and NC photographs was imperfect because a true orthorectification process was not used and the imagery had not been collected with a stabilized camera mount.

To aid in the interpretation, analysts created a texture image for both the NC and CIR data. This texture image became an additional information band in the semiautomated image interpretation.

Hyperspectral Imagery

Analysts acquired imagery from the HyMap hyperspectral sensor in June 2002. The hyperspectral image, called a data cube, consists of 128 spectral bands. The band widths are narrow, varying between 14 and 17 nanometers (nms). The hyperspectral data cube was accompanied by a geolocation file. This file contains information about the aircraft position and orientation while the imagery was collected. The geolocation file was used to georeference the data cube and derived interpretations.

When using hyperspectral imagery, it is important to derive a reflectance image to represent the reflectance of actual Earth surface features as close as possible (e.g., vegetation) and remove the effects of atmosphere. Only the reflectance-corrected dataset was used in this analysis process. The spatial resolution of the georeferenced data cube was 4 meters and covered an area 10 kilometers long and 2.5 kilometers wide. The images at the Mack study area were acquired along a nearly east-west path (figure 4).

Prior to performing the hyperspectral image analysis, the volume of data was reduced from 128 to 40 bands using the minimum-noise-fraction transformation algorithm in the ENVI software. This standard spectral data-reduction technique uses a principal-component transformation to determine the inherent data dimensions.

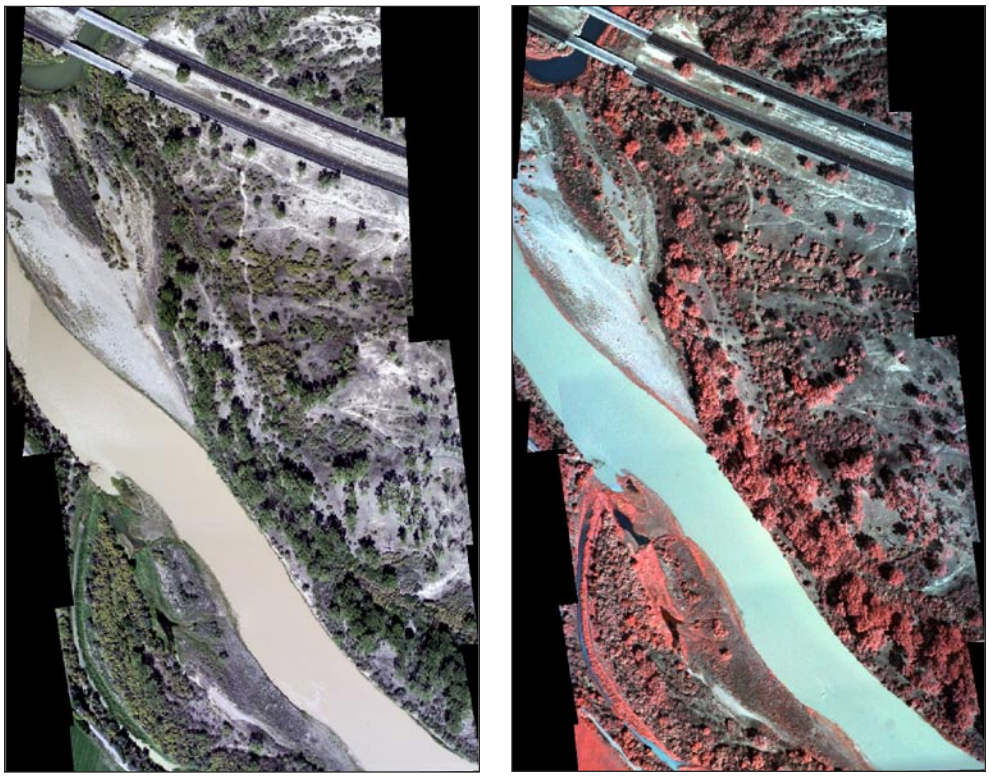

Figure 3—NC *(left)* and CIR *(right)* digital-camera images for a portion of the Mack study area.

Figure 4—Hyperspectral imagery of the Mack study area showing the location of the digital-camera imagery in yellow.

Image Interpretation

Digital Camera Imagery

An iterative classification procedure was used to identify tamarisk in both the NC and CIR digital-camera imagery. Visual Learning System's Feature Analyst classified each digital-camera mosaic together with its coregistered texture image. The process required the analyst to identify known areas of tamarisk on the image. The software then highlighted areas in the image similar to those selected by the analyst. The computer-derived classification was reviewed to identify areas incorrectly classified, and the process was run again until the analyst was satisfied with the results. Details about the Feature Analyst's program elements can be found in Vanderzanden and Morrison's report (2002). The classifications are shown in figure 5.

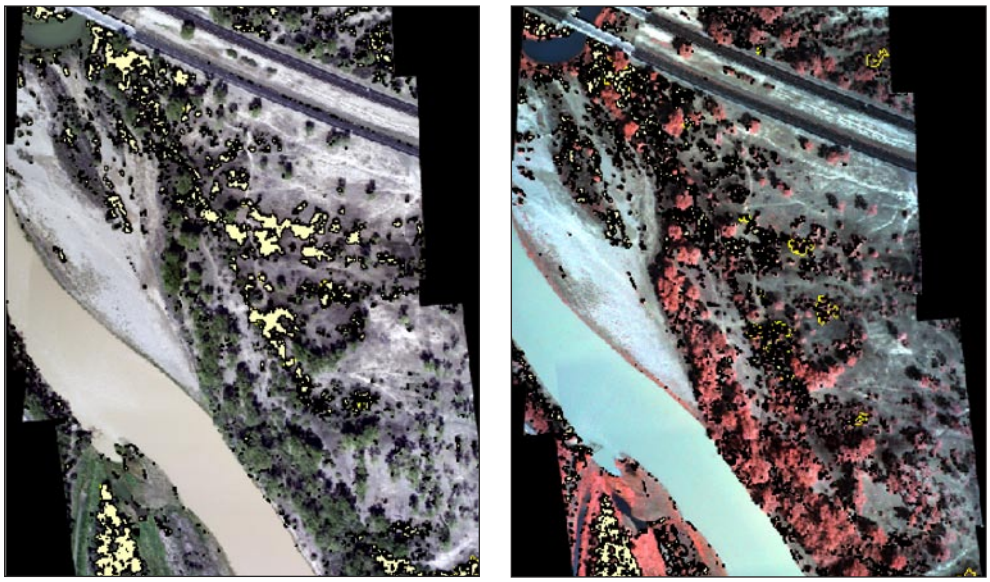

Figure 5—NC *(left)* and CIR *(right)* Feature Analyst interpretations of digital-camera imagery. The yellow pixels represent tamarisk.

Hyperspectral Imagery

Numerous methods are available to interpret hyperspectral imagery. Out of three approaches tested in this study, one referred to as mixture-tuned matched filtering (MTMF) worked best. The MTMF process requires input reference spectra (spectral representation of pure tamarisk). The input reference spectra for this analysis were extracted from the imagery itself. In other studies, input spectra may be collected in the field with a spectrometer or in a laboratory.

Field reconnaissance at the Mack area verified that tamarisk exists in nature in at least two forms: plants with abundant green leaves and plants with few leaves and mostly dead branches (figure 6). These are found intermixed or individually. Analysts extracted these two spectra from the data cubes (figure 7).

The MTMF process outputs two images: The first image, called the matched-filter score, depicts how closely the spectrum extracted from an image pixel matches the reference spectrum. The second, called an infeasibility image, reflects the likelihood that the corresponding pixel in the matched-filter image is correctly classified. Analyzing the two images together helps pinpoint the location of a specific feature, in this case, tamarisk. The results of the hyperspectral image classification are shown in figure 8.

Results and Conclusions

A visual comparison of the digital-camera classifications with known field locations of tamarisk showed that the NC images worked better than the CIR ones in

Figure 6—Green, leaf-bearing tamarisk *(left* and senesced tamarisk *(right).*

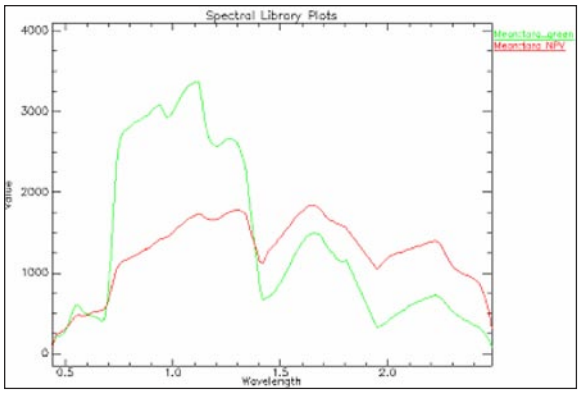

Figure 7—Average spectra for leaf-bearing tamarisk *(red)* and senesced tamarisk *(green)*.

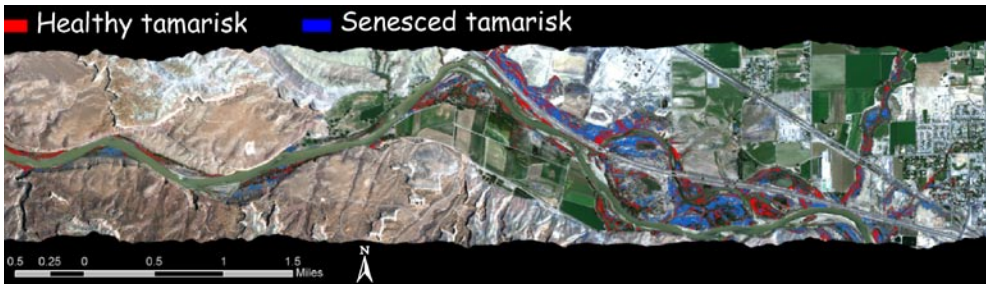

Figure 8—Classification of hyperspectral imagery along the Colorado River showing leaf-bearing tamarisk *(red pixels)* and dead tamarisk *(blue pixels)*.

identifying tamarisk. The CIR imagery was more difficult to use in the Feature Analyst classification process because it tended to either underclassify or overclassify tamarisk.

Analysts completed a field-based accuracy assessment for the hyperspectral data based on the procedure described in Fisk (2002). One hundred twenty accuracy-assessment sites were located in the Mack study area and 60 in the De Beque study area. When attempting to distinguish leaf-bearing tamarisk from dormant (senesced) plants and other cover types, the overall accuracy for the Mack study area was 71 percent. This increased to 75 percent if leaf-bearing and senesced classes were combined. At the De Beque study area, the overall accuracy for the combined tamarisk classes was 89 percent. These results verified that both digital-camera and hyperspectral imagery can be used to map tamarisk during the growing season. The digital-camera images captured smaller tamarisk bushes due to their greater spatial resolution. Although analysts used a subpixel unmixing procedure to classify the hyperspectral data, the accuracy of mixed pixels containing less than 70 percent tamarisk was low (less than 50 percent). Therefore, using hyperspectral imagery as an early detection tool will require more sophisticated analysis techniques.

References and Suggested Reading

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