Study 48

Remote Sensing Applications to Estimate Changes in Riparian Vegetation, San Joaquin River Restoration Program

Final
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER RESTORATION PROGRAM

November 2013

Establish Methodologies for the Use of Hyperspectral and LiDAR data to Map and Monitor Riparian Vegetation, San Joaquin River Restoration Program

Research Question:

How can hyperspectral and LiDAR data be used to estimate change to riparian vegetation resulting from SJRRP Interim and Restoration flows?

Research Strategy

<u>Goals and Objectives:</u> Test and establish remote-sensing-based classification methodologies using Hyperspectral imagery and laser imaging, detection and ranging (LiDAR) data to achieve the highest accuracies in mapping target riparian vegetation species occurrence and distribution. These results will be used for addressing future monitoring requirements to fulfill environmental commitments. The plant classification techniques developed could be applicable to other Reclamation river restoration projects as well.

<u>Study Design and Methods:</u> Hyperspectral imagery and LiDAR data will be acquired for the study area. Timing of this data acquisition will be based on an analysis of available existing SJRRP vegetation studies and plant phenology (e.g., flowering period) that would indicate the optimum acquisition date for discrimination of target native and invasive plant species in this area.

There are a large variety of classification approaches available. Recent studies in the California delta indicate that incorporating mulitiple methods in a decision tree approach can better account for variability in large datasets (Hestir, et al, 2008). Classification methodologies will be tested to establish which methods produce the most accurate results. Methods will include "hybrid" classification approaches to determine the optimal combination of inputs and classification strategies. Examples of these are:

1. Random Forest decision tree classifier (Breiman,L., 2001)
    a. Applied to Hyperspectral imagery in combination with LiDAR-derived inputs such as canopy height and/or vegetation density.
2. Object-based classifiers may also be used for evaluating results at both the pixel and object-based level.

Necessary ground validation data will be collected for testing and verifying classification methodology results.

<u>Reports/Publications (Deliverables):</u> Outreach to peers, stakeholders, resource managers, and facility managers will include presentation of progress and draft results at public SJRRP Restoration Goal Technical Feedback meetings, presentation/posters at conferences as opportunities become available, and submission of final report to the SJRRP Annual Technical Reporting process to document methods, results, costs and conclusions. A manuscript for submission to an open access peer-reviewed electronic journal, such as San Francisco Estuary and Watershed Science, will also be prepared.

Need and Benefit

The SJRRP began releasing Interim Flows from Friant Dam on October 1, 2009. These flows rewetted sections of the San Joaquin River channel that had been dry during non-flood operations for over 60 years. These dry areas and other river reaches used for water supply conveyance are included in a 153 mile section of the river known as the San Joaquin River Restoration Area.

In the SJRRP Programmatic Environmental Impact Statement/ Environmental Impact Report (PEIS/R) Reclamation committed to invasive vegetation monitoring and management through 2020 as a condition of releasing Interim and Restoration Flows, which have potential to spread invasive vegetation from upstream sites to newly wetted, unvegetated sites downstream. Reclamation entered into a grant with the San Joaquin River Parkway and Conservation Trust who began invasive vegetation monitoring and management activities in spring 2013. This agreement funds management actions for approximately 2-3 seasons. SJRRP needs to understand the extent and distribution of invasive vegetation in the Restoration Area and success of past invasive vegetation management on a Restoration Area-wide scale to determine if funding additional management is warranted.

The SJRRP PEIS/R analyzes all SJRRP channel/facility improvement actions on a program level and includes a Conservation Strategy intended to be incorporated into future site-specific project descriptions as a means of conserving species and other natural resources. The Conservation Strategy includes development of a Riparian Habitat Mitigation and Monitoring Plan (RHMMP) which will track development of riparian habitat in the Restoration Area over time. The RHMMP will include a credit system to quantify beneficial impacts of Restoration Flows to riparian habitat. The credits will then be available for use as mitigation for other site-specific construction actions undertaken by the SJRRP. The SJRRP is currently funding riparian vegetation mapping and monitoring through relatively conventional methods, but due to a variety of constraints such as property access, availability of ground-based resources, and budget, an effective means of mapping and monitoring riparian vegetation is needed to identify and map the occurrence and distribution of native and invasive riparian plant species.

Monitoring riparian vegetation at the species level to a spatial resolution that will meet project needs is often not realistic with traditional mapping approaches. New research is demonstrating that mapping and monitoring complex vegetation communities is improving through the use of hyperspectral imagery in combination with LiDAR data (Naidoo, L. (2012).). This study proposes to investigate and determine classification approaches using Hyperspectral imagery with LiDAR that will produce the highest vegetation map accuracies, and establish mapping methodologies for future monitoring requirements.

The proposed classification approach represents a technological advance to identify both desirable native and undesirable invasive vegetation at the species rather than aggregated “vegetation type or alliance” level. This tool will allow the SJRRP to more accurately map and quantify native riparian vegetation for mitigation credits as well as more precisely pin-point areas requiring invasive vegetation management and control, leading to program implementation and cost efficiencies.

Mission Responsibility

The work contained in this proposal supports Reclamation’s approaches to implementing the SJRRP and meeting environmental commitments as described in Need and Benefit.

People Involved

Principle Investigator- Erin Rice (Project Management role)

Jeff Milliken- Reclamation Remote Sensing Scientist

Funding Requests (tasks for FY14, Oct 1, 2013-Sep 30, 2014)

Total budget of tasks below is $385,000. SJRRP requests $192,500 in S&T funding.

Project Management: $10,000

Meetings, progress updates, milestone scheduling, project approach TM.

LiDAR Data Acquisition: $200,000

Hyperspectral Data Acquisition: $75,000

(SpecTIR bid from vendor UC Davis has used in the past).

Data processing: $80,000

UC Davis grad student 50% time for 9 months, 200 hours of Reclamation remote sensing scientist time for oversight, 10 days of field work, and CESU-approved indirect costs.

Reporting: $20,000

Preparing final project deliverable and journal manuscript.

Research Products

Reports/Publications (Deliverables): Outreach to peers, stakeholders, resource managers, and facility managers will include presenation of progress and draft results at public SJRRP Restoration Goal Technical Feedback meetings, presentation/posters at conferences as opportunities become available, and submission of final report to the SJRRP Annual Technical Reporting process to document methods, results, costs and conclusions.

A manuscript for submission to an open access peer-reviewed electronic journal, such as San Francisco Estuary and Watershed Science, will also be prepared.

References

Breiman, L. (2001). Random Forests. Machine Learning, 45, 5-32, 2001, Editor: Robert E. Schapire, Kluwer Academic Publishers, Netherlands.

Hestir, E., S. Khanna, et al. (2008). Identification of invasive vegetation using Hyperspectral remote sensing in the California Delta ecosystem. 112 (2008) 4034-4047, Remote Sensing of Environment, Elsevier, Inc.

Khanna S, Santos MJ and Ustin SL(2010c). Concurrent effects of natural disturbance and control of water hyacinth distribution in the Sacramento-San Joaquin Delta, Dissertation: Chapter 2, PhD Ecology, University of California, Davis, CA.

Naidoo, L., M. Cho, G. Asner (2012). Classificaiton of savanna tree species, in the Greater Kruger National Park region, by integrating Hyperspectral and LiDAR data in a Random Forest data mining environment. 69 (2012) 167-179, ISPRS Journal of Photogrammetry and Remote Sensing, Elsevier, Inc.

Santos, M.J., S. Khanna, et al. (2009). Use of Hyperspectral Remote Sensing to Evaluate Efficacy of Aquatic Plant Management in the Sacramento-San Joaquin River Delta, California. Invasive Plant Science and Management, 2:216-229.