Geospatial Analysis of the Pattern of Floodplain, Geomorphology, Land Use, and Riparian Vegetation in the Tuolumne River Watershed

Aldo Garcia
California State University, Stanislaus
USDA Internship: May 18, 2012 - May 18, 2013

Advisor Dr. Peggy Hauselt,
Department of Anthropology and Geography
California State University, Stanislaus

Report Submission: May 17, 2013
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>3</td>
</tr>
<tr>
<td>Project Objectives</td>
<td>3</td>
</tr>
<tr>
<td>Project Approach</td>
<td>4</td>
</tr>
<tr>
<td>Project Outcomes</td>
<td>6</td>
</tr>
<tr>
<td>Conclusion</td>
<td>7</td>
</tr>
<tr>
<td>Appendices</td>
<td>9</td>
</tr>
</tbody>
</table>
Executive Summary

This study focused on the Stanislaus, Tuolumne, and Merced rivers of the Central Sierra Nevada Watersheds (CSNW). Hydro-geomorphic data was collected to aid in the understanding of the effects of natural and human processes that affect the watersheds. Data was obtained from public data sets including national hydrographic, land use, land cover, digital elevation model, and soil data for the CSNW from various online databases. The data was processed using geospatial and hydrological tool sets in ESRI’s ArcGIS version 10. A series of maps were developed with the public data sets to identify the hydro-geomorphic characteristics of the CSNW. Soil samples and soil property data were also collected in the field at three sites. The series of maps and soil data may be useful for future studies.

Acknowledgements

This project was supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-38422-31204 from the U. S. Department of Agriculture (USDA) National Institute of Food and Agriculture. I would like to acknowledge my advisor Dr. Peggy Hauselt for her guidance throughout the internship, Oleta Piecuch for providing additional photos while conducting field work, and the Groveland Ranger District Office for meeting with the interns to discuss careers.

Project Objectives

Watersheds have experienced changes due to agriculture, dam construction, urban expansion, and other activities. Floodplains and riparian vegetation provide important roles for sediment transport, flood protection, bank stabilization, and biological habitats and can be affected by land use practices. Understanding land use patterns and the role of riparian
vegetation will aid in creating watershed management programs that seek equilibrium between urban needs and the dynamics of floodplain processes.

The first objective was to delineate the natural extent of the Tuolumne River watershed using geospatial technology based on public data sets including topographic, geomorphic, and soil data. The second objective was to interpret aerial photographs, analyze archival land use data, and classify multispectral satellite imagery to establish patterns of land use and riparian vegetation. This objective was not completed because we were unable to obtain LIDAR data for classification purposes. The third objective was to visit the watershed to verify the results of the satellite imagery classification and examine the land use and riparian vegetation patterns along the watershed. Field work included collecting hydrologic soil properties (infiltration, soil moisture, soil compaction, etc.) that have an impact on vegetation patterns. This objective was partially completed because we were unable to obtain LIDAR data for our study area to analyze.

The first project task included collecting and processing data covering the Tuolumne River watershed. Data included Digital Raster Graphics (DRG), a Digital Elevation Model (DEM), water, roads, and cities. The second task included generating Geographic Information Systems (GIS) layers including DRG’s, DEM, slope, aspect, water, roads, and cities. The third task included assisting other interns in measuring soil properties in the field including litter depth, compaction, and shear stress. The fourth task included assisting other interns collecting soil samples for laboratory analysis.

**Project Approach**

I created maps using ArcGIS version 10 software. Data was collected from various public databases online. Water data was uploaded from Cal-Atlas to produce a river layer that included the Stanislaus, Tuolumne, and Merced Rivers. The three rivers were selected by
attribute from the attribute table to create the river shapefile. The file was then clipped to a layer called water_bnd, which is a defined base layer of the CSNW sourced from the Fire and Resource Assessment Program data. Road and city data were also uploaded from Cal-Atlas to produce shapefiles in the same manner as the river shapefile. The layers were used to create a reference map of the CSNW (Figure 1).

DRG files were uploaded from Cal-Atlas as Geo TIFF images. The images were saved into a database and were used as base maps throughout the internship. Two DEM files in 90-meter resolution from the Shuttle Radar Topographic Mission (SRTM) were uploaded from the Consortium for Spatial Information (CGIAR-CSI) and the mosaic to new raster tool was used to create one DEM. The DEM was then clipped to a layer called water_bnd and a map was created (Figure 2). Surface toolsets in the spatial analyst were used on the DEM file to create a slope map (Figure 3) and an aspect map (Figure 4).

I also assisted other interns in conducting fieldwork in the Stanislaus National Forest. Site one was located off of Cherry Lake Road north of highway 120 (Figure 5). Four 10m² transects were measured and were labeled as quadrants A, B, C, and D (Figure 6). Flags were used to mark ten random points that were established in each quadrant where soil properties and samples were collected. A shear strength-measuring tool was used on the surface of the soil (Figure 7). The tool was placed on the surface of the soil and turned by hand with slight pressure until the soil broke loose. A dial on the top recorded the torque at which the soil broke loose.

A soil penetrometer was used to measure soil compaction (Figure 8). The penetrometer was pushed into the soil until a red tip was covered with soil. At this point, a white ring would be pushed down where a measurement would be taken of how compacted the soil was. Litter depth was measured using a standard ruler by measuring from the top of the ground litter to the
top of the soil. Soil cores were collected at each site. A soil corer was driven into the ground with a rubber mallet and the sample was placed into a plastic bag (Figure 9). Site two was located on Harden Flat Road south of highway 120 (Figure 10), and site three was located east of the Sweetwater campground north of highway 120 (Figure 11). Soil properties and samples were collected using the same procedures from above.

Various visits along the Tuolumne River were made to learn about the essential roles watersheds have on the natural ecosystem and human life. Visits along the river took place in different settings extending from the Sierras down the San Joaquin Valley and pictures documented various features of the watershed during the summer of 2012. I visited Hetch Hetchy Reservoir, Don Pedro Lake, the Middle Fork of the Tuolumne River, the Tuolumne River in the Sierra foothills and central valley, the terminus of the Tuolumne River, the Groveland Ranger District in the Stanislaus National Forest, and the 4th annual Water Resources and Policy Initiatives (WRPI) conference in Sacramento.

**Project Outcomes**

The maps produced provided an understanding of the CSNW watersheds. The reference map shows that there are two major cities within the watersheds, Modesto and Merced. Major highways can also be found along the rivers, which provide access to the upper watersheds. The DEM map shows the extent of the watersheds from the Sierras down to the San Joaquin Valley. The highest peaks in the watersheds are about 4,000 meters and water flows west to the central valley to near sea level. The slope map shows that the central valley is mostly flat and the steepest slopes are found along the river canyons. Slopes range from flat to about 75 degrees. The aspect map shows the Sierras having multiple down slope directions, and flat areas as bodies of water such as reservoirs in the mountains and foothills, and wetlands in the central valley.
The field visits throughout the Tuolumne River watershed also provided great insight on the importance of water for natural ecosystems and human uses. I learned about the human uses of the Tuolumne River including the Hetch Hetchy Reservoir, which provides drinking water for the San Francisco Bay Area (Figure 12). Power was also generated from the water that is gravity fed downstream from the O’Shaughnessy Dam (Figure 13). I also learned about Don Pedro Lake and the many human uses including agriculture, flood protection, and recreation (Figure 14). Hydroelectric power was also produce at the New Don Pedro Dam (Figure 15).

The Tuolumne River also has an important impact on ecosystems along the watershed. I learned about the various types of vegetation that can be found along the entire length of the Tuolumne River. Montane Hardwood-Conifer trees can be found along the Middle Fork of the Tuolumne River (Figure 16). Riparian vegetation can be found along the river in the Sierra foothills (Figure 17) and the central valley (Figure 18). The Tuolumne River eventually terminates at the San Joaquin River in the central valley (Figure 19).

Additional visits were made to aid in the understanding of watersheds. The Groveland Ranger District was visited where I discussed careers, and I learned about how GIS is incorporated and used in managing the forest. I also attended the 4th annual WRPI conference in Sacramento and learned about water related research projects and met with state agency leaders. I also plan to attend the 5th annual WRPI conference in Long Beach where I will present a poster with another intern.

**Conclusion**

This study examined the CSNW to gain an understanding of the relationship between the natural ecosystems and human uses of the watersheds. This was achieved by using publically available data online to examine land uses and the physical properties of the watersheds. The
data was used to create various maps that highlight characteristics of the watersheds including DEM, slope, and aspect. Soil samples and soil property data were also collected in the field to gain a better understanding of the Tuolumne River watershed. Field visits throughout the CSNW were conducted to gain a visual perspective of the dynamics of watersheds, and a ranger station and WRPI conference were visited to gain information about careers with the USDA.

This internship was related to my coursework and interest in Geography, more specifically Physical and California Geography, and Geospatial Technology. I was able to learn about and visualize the mix uses of the Tuolumne River watershed including the natural ecosystems, agriculture, urban, and recreation. I was able to conduct and enhance my field work abilities by acquiring skills in soil sampling and measuring of soil properties by using standard equipment. This was useful because I worked together with a team of interns to collect data and I gained a general understanding of basic sampling methods.

I also gained experience using GIS to create various maps and shapefiles. I learned to navigate publically available data online and obtained data to create maps and shapefiles for our study area. I also performed a basic analysis of a DEM file to create maps. Working with GIS has provided me with experience using various tools and I learned to research solutions for complications that arise during the map-making process. I believe I have attained valuable skills that I would like to apply in my future endeavors with the USDA.
Appendices

Figure 1. This is a reference map of the CSNW.
Figure 2. This is a DEM map produced with SRTM data in 90-meter resolution.
Figure 3. This is a slope map produced with the spatial analyst surface toolset.
Figure 4. This is an aspect map produced with the spatial analyst surface toolset.
Figure 5. This is site one and is located in the Stanislaus National Forest.

Figure 6. Four 10m² transects are measured to collect soil and vegetation data. Photo courtesy of Oleta Piecuch.
Figure 7. A shear strength measuring tool is used on the surface of the soil.

Figure 8. A soil penetrometer is used to measure soil compaction. Photo courtesy of Oleta Piecuch.
Figure 9. A soil corer and rubber mallet is used to collect soil samples.

Figure 10. This is site two and is located in the Stanislaus National Forest.
Figure 11. This is site three and is located in the Stanislaus National Forest.

Figure 12. This is Hetch Hetchy Reservoir on the Tuolumne River looking to the northeast.
Figure 13. This is O’Shaughnessy Dam located at Hetch Hetchy Reservoir.

Figure 14. This is the Don Pedro Lake on the Tuolumne River looking to the northwest.
Figure 15. This is the New Don Pedro Dam located at Don Pedro Lake.

Figure 16. This is the Middle Fork of the Tuolumne River looking west on Cherry Lake Road north of highway 120.
Figure 17. This is an example of riparian vegetation on the Tuolumne River at Robert’s Ferry Bridge south of highway 132.

Figure 18. This is the Tuolumne River looking west towards Modesto on the Mitchell Road Bridge.
Figure 19. The Tuolumne River terminates on the right and flows into the San Joaquin River on the left.