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Change Analysis of Land Use and Land Cover in the Chamokane Creek Basin, Washington, Using Satellite Remote Sensing

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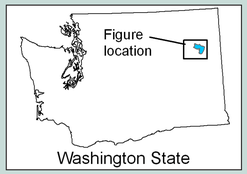
Introduction

The U.S. Geological Survey (USGS) is conducting a study to describe the groundwater and surface-water system of the Chamokane Creek basin, Washington, and to examine potential effects of increased groundwater use on water resources in the basin. Changes between historical and current land use and land cover (LULC) are an important component of this study. Satellite remote sensing can be extremely useful in providing data that are consistent and comparable, spatially defined, and that have the necessary level of detail for this study. This display describes the LULC change analysis process that will be undertaken for the Chamokane Creek basin study.



Study Area

Chamokane Creek basin is located in southern Stevens County in the northeastern part of Washington State (fig. 1). This 179-square mile area partially overlaps the eastern side of the Spokane Indian Reservation. Chamokane Creek (fig. 2) flows east through Camas Valley toward Springdale, Washington, where it then turns southeast and flows generally south through Chamokane Valley. It forms the eastern border of the Spokane Indian Reservation as it flows through Chamokane Valley and Walkers Prairie toward Ford, Washington.

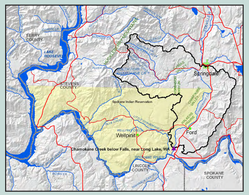


Figure 1. Chamokane Creek basin (black outline) in northeastern Washington.

Figure 2. Chamokane Falls.

Figure 3. Taking water-level measurements for Chamokane framework and model project.

USGS Chamokane Framework and Model

Residential development in the basin is expected to increase groundwater use, potentially affecting the streamflow of Chamokane Creek. The Spokane Tribe of Indians holds senior water rights on Chamokane Creek. All water rights for the Chamokane Creek basin were adjudicated in 1979; however, exempt groundwater use continues to increase with increasing population, subdivision, and development.

The U.S. Geological Survey is conducting a study in cooperation with the Bureau of Indian Affairs, the Spokane Tribe, and the Washington Department of Ecology to describe the groundwater and surface-water system of the basin and to examine the potential effects of increased groundwater use on water resources in the basin (fig. 3).

Relevance of LULC Data

Remotely-sensed satellite data can be used to determine LULC change in the Chamokane Creek basin.

With growing concern about development pressures on the groundwater system, it will be important to examine how and where residential development in the region has occurred. LULC data can be used to help quantify increases in residential development and describe the process of change by revealing which areas and land types have been most susceptible to residential development. Furthermore, LULC data need to be incorporated into the conceptual model of the basin's ground- and surface-water system to accurately describe historical and current hydrologic conditions. LULC can influence components of the hydrologic system, such as recharge and evapotranspiration rates. Finally, LULC data will be important for the calibrated ground water flow model that will be created to evaluate hydrologic responses to various stressors in the basin.

Although generalized LULC data is available through initiatives such as the Landscape Fire and Resource Management Planning Tools project (LANDFIRE), more precise data are needed for this study. Furthermore, these generalized, national land cover products usually do not provide data for the specific dates of interest.

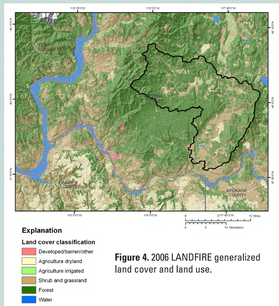


Figure 4. 2006 LANDFIRE generalized land cover and land use.

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Historical

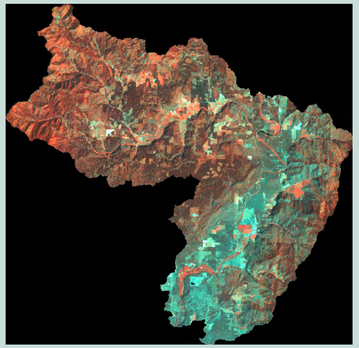

Figure 5a. July 1995 Landsat TM image (from USGS Global Visualization Viewer, path 43 row 27) clipped to Chamokane Creek basin study area. Transverse Mercator Projection, WGS 1984 UTM Zone 11, 30 meter resolution.

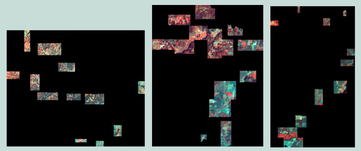

Figure 6a. Image blocks from 1995 Landsat TM image for unsupervised classification. Block themes from left to right: "forest," "agriculture" and "developed."

Figure 7a. Supervised training area for water in 1995 Landsat TM image.

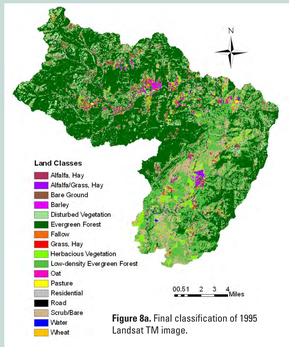

Figure 8a. Final classification of 1995 Landsat TM image.

Operational Sequence

Landsat Thematic Mapper (TM) data will be used for this study due to the availability of historical and continuous data. TM sensors on Landsat satellites have been collecting data since 1982. The TM sensor collects data in seven wavelength bands (six in the visible through mid-infrared regions of the electromagnetic spectrum and one thermal band). TM data have a pixel size of 30 meters (120 meters for the thermal band). Landsat TM data have been acquired from the U.S. Geological Survey Earth Resources Observation and Science Center (EROS). Although we are interested in LULC data at the time of adjudication (1979), high quality images with minimal cloud cover were not available until July 1984. For this analysis, LULC data from July 1984 will be compared to July 2008 data. Because 1984 data are still processing at EROS, we have displayed 1995 data here as an example, comparing these data to 2008 data (figs. 5a and 5b).

Although Multispectral Scanner (MSS) sensor data are available as far back as 1972, they have a much larger pixel size of 80 meters and are only available until 1992. The Chamokane Creek basin is still relatively undeveloped, and it is likely that LULC change between 1979 and 1984 was minimal. A change analysis using Landsat MSS data will be done to see if LULC change between these years was significant.

Landsat TM and MSS data for this study are radiometrically corrected and geometrically corrected using ground control points and elevation data.

Hybrid Classification

To classify LULC for the historical and current data, this analysis will use a hybrid approach to image classification using Earth Resouces Data Analysis Sytstem (ERDAS) IMAGINE software. The hybrid approach incorporates unsupervised (self organization of pixels) and supervised (user organization of pixels using training areas) classification into the process.

Unsupervised Classification

Three main "image blocks" are created from the original Landsat TM multispectral image to represent the three major thematic materials in the scene and best capture the spectral variation within each theme (figs. 6a and 6b). In this case, the themes are "forest," "agriculture," and "developed." Using an unsupervised classification, a signature file for each block is created. An Iterative Self-Organizing Data Analysis Technique (ISODATA) unsupervised clustering algorithm is run on each of the three blocks. A certain number of classes, or clusters, is entered into the program. Through an iterative process, the ISODATA algorithm then assigns each pixel to a cluster based on its spectral properties. At the end of the process, pixels in one cluster are more spectrally similar to each other than any other cluster. The algorithm determines a multi-spectral mean signature for each cluster. Each cluster class is given a name based on reflectance values, known features, and other external information.

Supervised Training

If more accurate data regarding land cover are available, these data can be used to create supervised training areas to assign a cluster signature to a known land-cover type in the image. Supervised training areas can be created from pixels of obvious or known features such as roads, water, and forest (fig. 7a) or from outside information such as the Washington State Department of Agriculture Crop Geodatabases (wsda; fig. 7b). For each block, the signature file from the unsupervised classification is edited to include spectral signature trainings for these known surface materials.

Final Classification

Once a spectral signature file for each image block is edited, all three files are merged into one master signature file. This file is then used to do a supervised classification on the entire image (figs. 8a and 8b). In the supervised classification, each pixel is assigned to one of the cluster signatures from the merged signature file based on a maximum likelihood classifier algorithm. Ground truthing in the study area will be needed to assess classification error. Historical aerial photographs can be used to assess classification error of 1984 data.

Change Analysis

After LULC for the historical and current images of the basin have been classified, a comparison can be done to examine which pixels had a change in classification since 1984 using ArcGIS software (fig. 9). This analysis will not only reveal the presence or absence of change, but also the specific transition that occurred between two classes. Finally, an accuracy assessment will be needed to determine how well this analysis was able to detect real change across the landscape. One simple way of doing this is to multiply the accuracy of the two classified images together to get the cumulative error.

The example below shows the process that will be undertaken for the LULC change analysis using the available 1995 data. The actual analysis will be done after the 1984 data have been received and field validation for the 2008 data is completed.

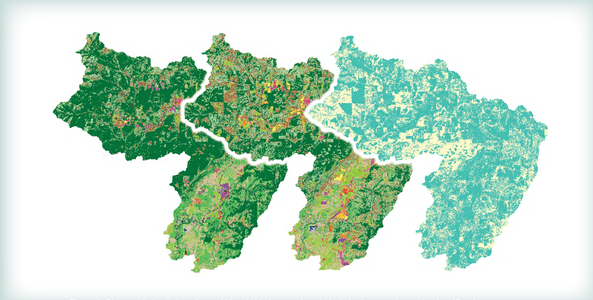

Figure 9. Changes in land class from 1995 to 2008. Aqua-colored pixels indicate a change in classification.

Current

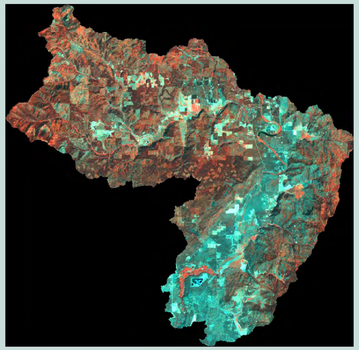

Figure 5b. July 2008 Landsat TM image (from USGS Global Visualization Viewer, path 43 row 27) clipped to Chamokane Creek basin study area. Transverse Mercator Projection, WGS 1984 UTM Zone 11, 30 meter resolution.

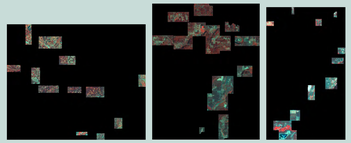

Figure 6b. Image blocks from 2008 Landsat TM image for unsupervised classification. Block themes from left to right: "forest," "agriculture" and "developed."

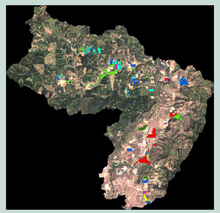

Figure 7b. Supervised training areas for various crop types in 2008 Landsat TM image using 2008 WSDA crop data for Stevens County.

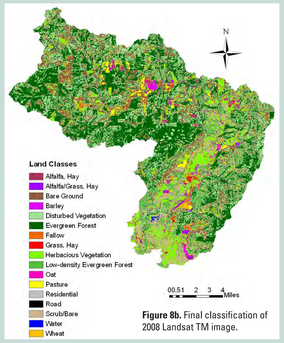

Figure 8b. Final classification of 2008 Landsat TM image.

U.S. Department of the Interior
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