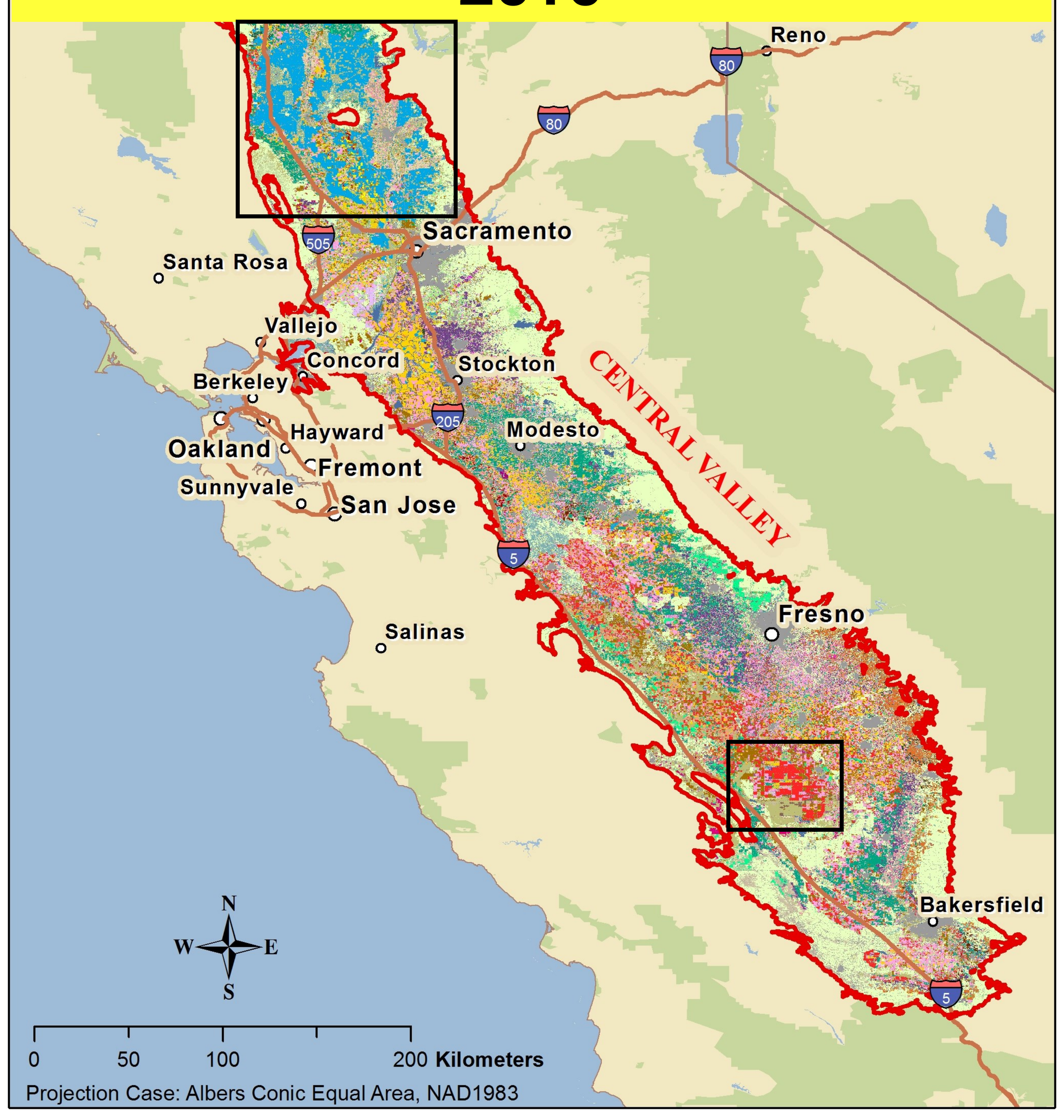
Water-Intensive Agriculture in California's Drought

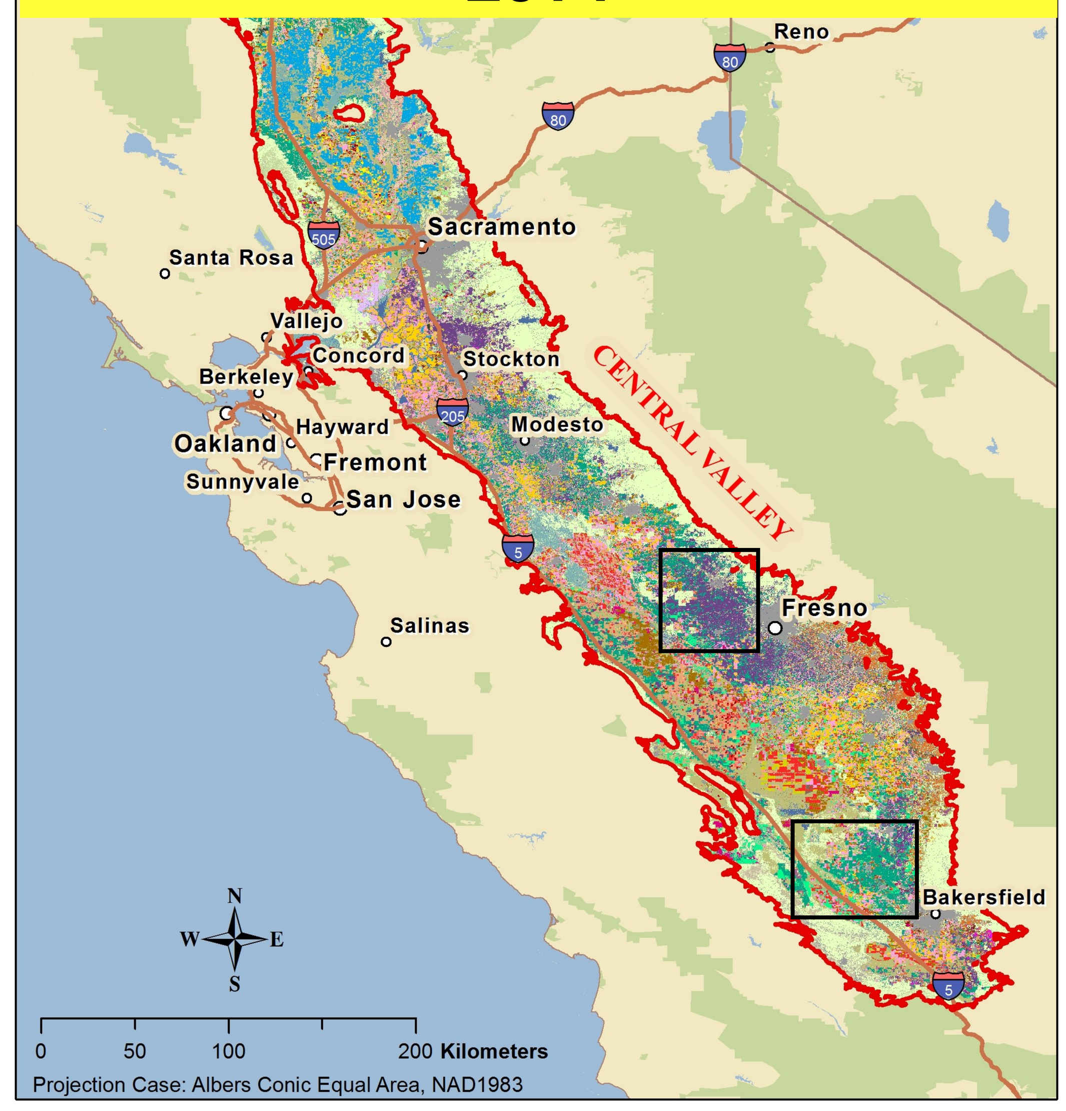
Anne Elise Stratton, Introduction to GIS, Tufts University, May 2015

2010



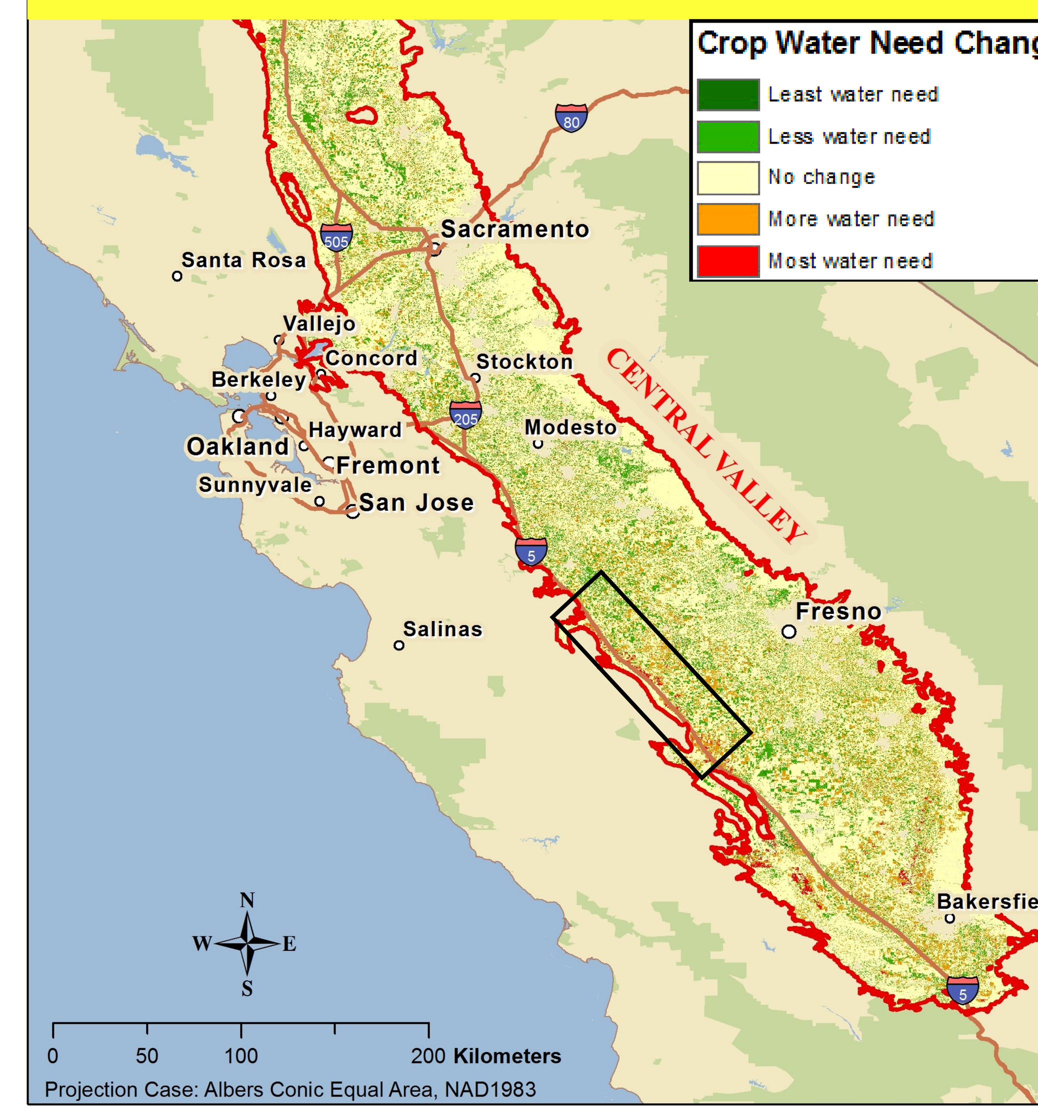
Crop Trends in California's Central Valley, 2010. The Central Valley, outlined here in red, spans the Sacramento, San Joaquin, and Tulare Lake groundwater basins defined by California's Department of Water Resources (an area of nearly 5 million hectares). It is California's principal area of fruit and vegetable production, and the crops produced within the valley are highly diverse and constantly changing. While the patterns of crop production depicted in this map resemble a patchwork quilt in many regards, there are regions dominated by the production of a single crop, such as the large blue swath of rice north of Sacramento and the cluster of red midway between Bakersfield and Fresno representing cotton. Both rice and cotton are water-intensive crops. This cropland dataset was collected by satellite imagery prior to the onset of California's current drought. In this analysis, I will use the 2010 dataset as a baseline for crop changes due to drought. Because data was collected by satellite, its representations are imperfect, particularly in areas with small plots of land containing various crops (ground resolution of 30 meters).

2014



Crop Trends in California's Central Valley, 2014. California's principal agricultural region has a semi-arid climate, and so farmers in the Valley rely on extensive irrigation systems and groundwater wells for watering. While the patterns of water-intensive rice and cotton production highlighted in the 2010 map seem to have eroded slightly in 2014 (Strom 2014), there are new crop trends in the southern part of the Central Valley. Grape production (in purple) has blossomed in the areas just outside Fresno, along with a new region of heavy almond production (in teal) to the northwest of Bakersfield. Interestingly, while grapes are a very low water-need crop, almonds require high water inputs for production, consuming 10% of California's water annually (Holthaus 2014). Data were collected at least three years after the onset of California's current drought. This indicates crop changes due to drought. When compared to the 2010 dataset, this map demonstrates spatial trends in crop production following drought in the Central Valley.

∆ 2010 - 2014



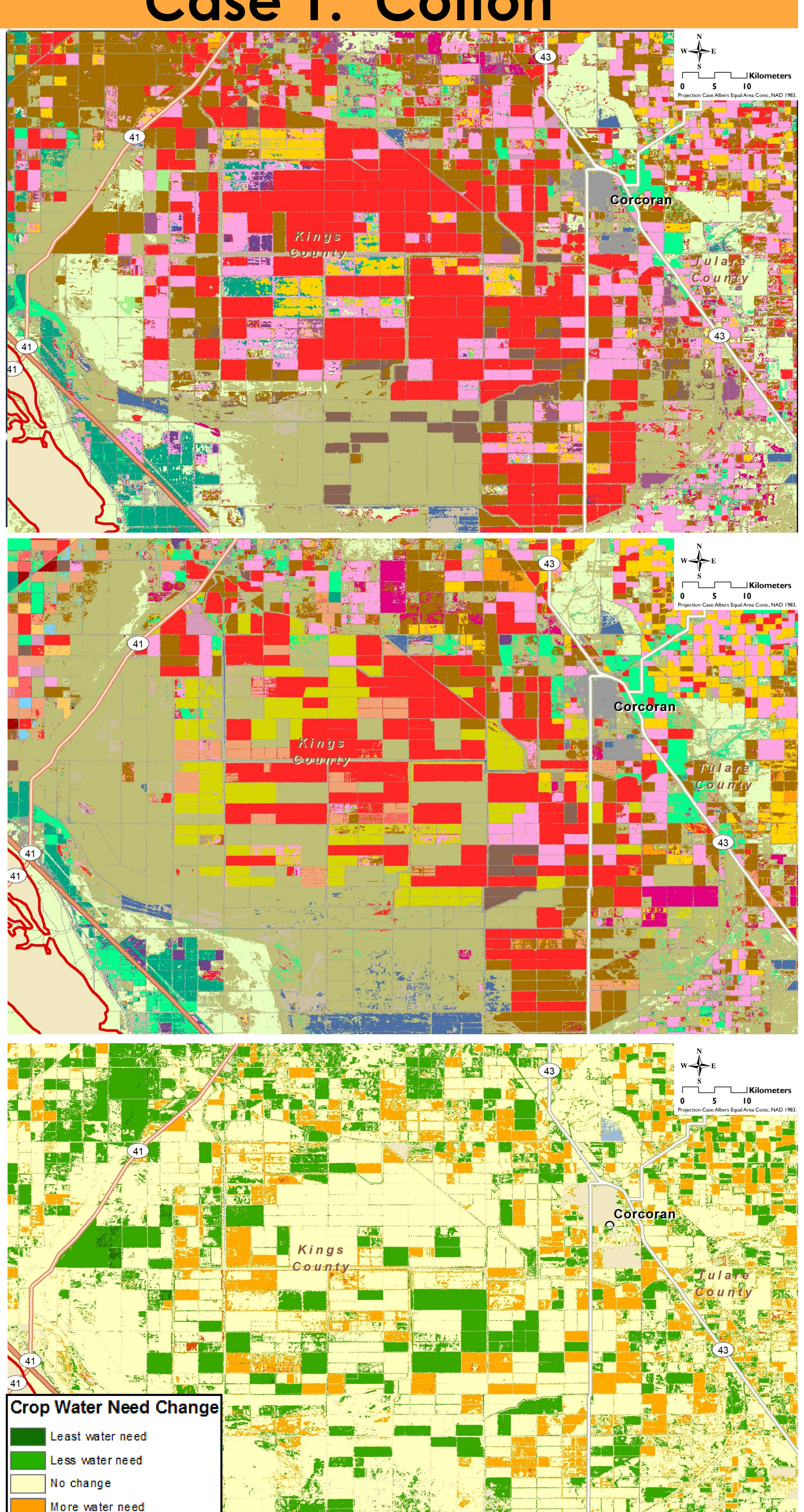
Crop Change by Water Need in California's Central Valley, 2010 – 2014. This map represents change in cropland use from 2010 to 2014 with colors ranging from dark green for a decrease in water need (from crops of high to low water need or to fallowed plots), to pale yellow for no change in crop, to dark red for an increase in crop water need (from fallow land or crops of low water need to high). This cropland raster dataset is a simplified attempt to quantify the amount of land converted to crops of higher or lower water need over the course of three years of drought. While a checkerboard of change is scattered throughout the state, there are some regions with a common pattern in crop change. One example is the area along Route 5, due west of Fresno, which was under extensive almond production in 2014 although it was mostly fallow land in 2010. According to my model, this change represents an increase in water need and is therefore shown in orange and red. Because I created this map from generalized water need data, representations of crop change and crop significance for water use are imperfect.

Case 1: Cotton

2010

2014

∆ 2010 - 2014



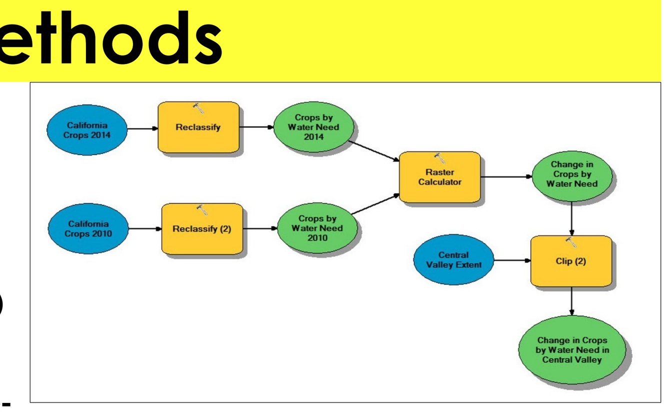
Methods

My completed model includes three principal geoprocessing procedures:

1) Reclassify, to categorize each crop type into one of three water need categories (high, low, or none/fallow) based on data from the FAO

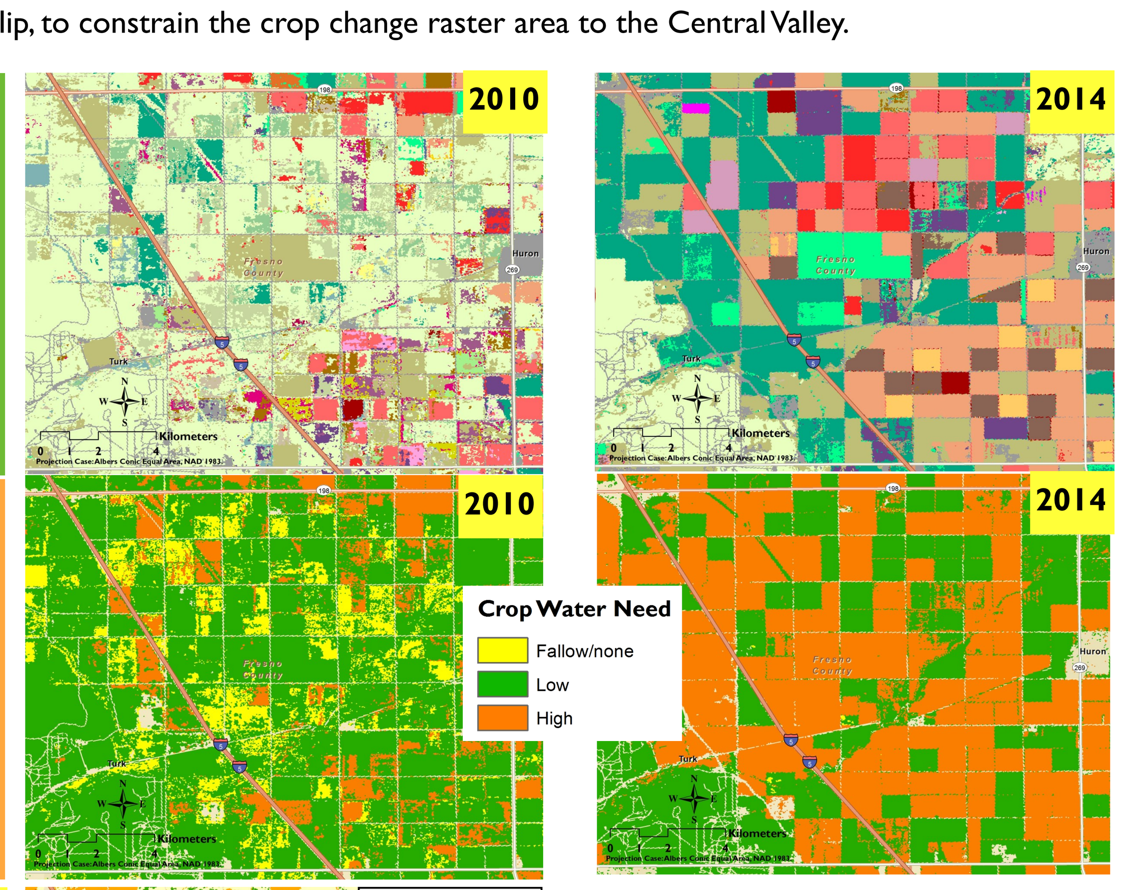
2) Raster Calculator, to subtract the reclassified 2010 data from 2014 data to create a crop change raster that represents the drought period

3) Clip, to constrain the crop change raster area to the Central Valley.

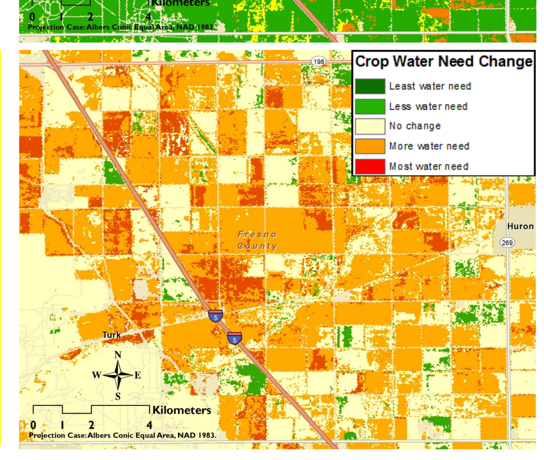


Crops

Reclassified Crops



Crop Change



The most important component of the model as it relates to representations of reality were the crop water-need categories (used to reclassify all the crops) from the FAO. These categories became the foundation of the model because they provided some credibility to the ranking of crops as high or low water-need.

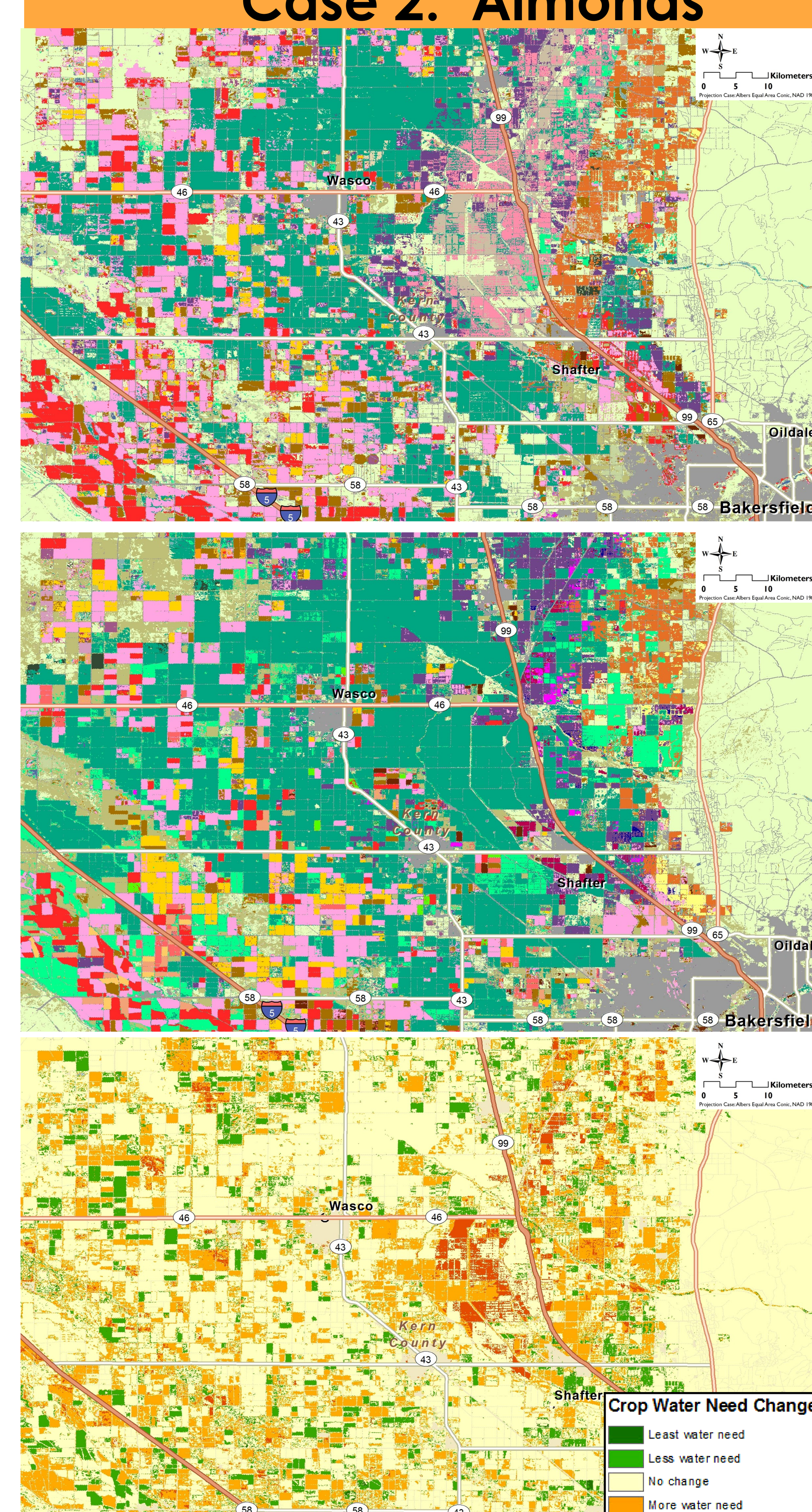
Without reclassifying each crop by high, low, or no water-need, the raster calculation would have been meaningless with regards to my question about the California drought. I did attempt to do the calculation before the reclassification in the early stages of my model, but the massive quantity of crop categories made the meaning of the output table difficult to identify beyond "0" meaning "no change." Reclassifying made the differences between the 2010 and 2014 datasets much simpler and more relatable to my question relating drought to crop choice.

Case 2: Almonds

2010

2014

∆ 2010 - 2014



Introduction

California's Central Valley is called the "salad bowl" of the United States due to its high fruit and vegetable production. The Central Valley's farmers rely on irrigation water to grow crops due to the semi-arid climate. Water has become increasingly scarce in the past four years due to drought. What percentage of agricultural land in the Central Valley shifted into the production of higher water need crops, lower water needs crops, or remained the same during the CA drought? It might be expected that farmers in the water-limited Central Valley would choose to plant more acreage with crops that require lower water inputs or to leave fields fallow rather than to plant crops with high water need. This is the hypothesis I tested with my model.

The answer to this question could be useful to policymakers who wonder whether farmers are adapting their crop choices to dwindling water supplies or if market incentives or other factors hold more sway over crop choice.

Bibliography

⇒ USGS, 2009, Alluvial Boundary of California's Central Valley; published by USGS, accessed April 24, 2015.

⇒ USDA, National Agricultural Statistics Service, 2010 California Cropland Data Layer, 2010; published by USDA Cropscape, accessed April 15, 2015.

⇒ USDA, National Agricultural Statistics Service, 2014 California Cropland Data Layer, 2014; published by USDA Cropscape, accessed April 15, 2015.

⇒ ESRI StreetMap, 2010.

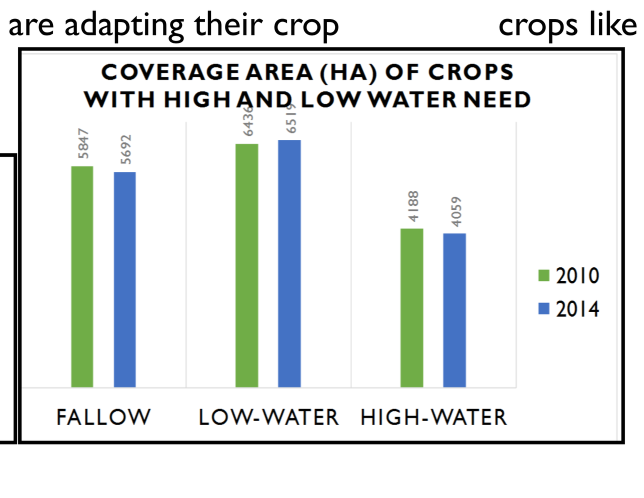
⇒ Food and Agriculture Organization and Natural Resources Management and Environment Department. 2015. Chapter 2: Crop Water Needs; published by FAO Corporate Document Repository, accessed April 24, 2015.

⇒ Holthaus, E. 14 May 2014. Ten Percent of California's Water Goes to Almond Farming. That's Nuts. *Slate*.

⇒ Strom, S. 20 April 2014. California's Thirsty Farmland. *New York Times*.

Discussion

Overall, the attribute table for my final change raster (the result of the model) indicated that 20% of Central Valley cropland use did not change from 2010 to 2014, 42% changed to crops with lower water needs, and 38% was converted to more water-intensive crop production. With this bird's-eye view of crop change, my data model shows that crop production did not shift dramatically toward water conserving crops due to the California drought. Rather, it appears that nearly as many farmers chose more water-intensive crops as chose water-conserving crops (see graph below). According to the *New York Times*, California cotton production declined by 35% from 2013 to 2014, while almond production has risen 44% since 2003 (Strom 2014). Despite their large water need, nuts and fruits can bring in ten times more earnings per acre than low-water vegetable crops like spinach, and this market incentive likely explains the increased plantings of water-intensive nuts (Holthaus 2014).



This analysis could benefit from quantifying the exact water needs of each type of crop and re-classifying each by a measurable amount of water rather than a simplified (high/low) category of water need. This would be a more specific approach. As my model stands now, it probably both under- and over-estimates water need depending on the crop. Almonds, for example, can be a very high water-need crop or an average water-need crop depending the environmental conditions, so by labeling them as a "high-need" crop I am generalizing several options into one category. Another strategy for analysis would be to incorporate related factors, such as climate impacts and crop growth stage, into the relationship between crop choice and water need. Farmers also plant multiple crops on the same land at different times of year; accounting for multi-cropping could improve the accuracy of my results.