LAND COVER CHANGE ANALYSIS IN THE STATE OF CALIFORNIA USING NLCD DATA

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ABSTRACT:

Land cover change is critical to be monitored as land cover change has significant impacts on flooding, ground water recharge, and urban air temperature. In this paper, key findings from a land cover change analysis study performed in the State of California are presented. National Land Cover Database (NLCD) data from the Multi-Resolution Land Characteristics Consortium (MRLC) was used for this study. Time series of NLCD data during the time period of 2001 through 2016 was used for the analysis. NLCD data processing was done in ArcMap 10.6.1. This paper includes the methodology in detail, and the results of the analysis. Results of the study indicate a significant increase in impervious surfaces, and a significant decrease in forest land cover.

1. INTRODUCTION

Urbanization has been accompanied by abundant increase of built surfaces, and decrease in vegetated surfaces (Kondoh and Nishiyama, 2000). Abundance of built surfaces has led to an increase in runoff (Ando et al., 1984; DeWalle et al., 2000).

Land Cover change analysis serves as a great means to understand impacts of urbanization, and provides an estimate of the percent increase or decrease in the areal extent of built surfaces and vegetated areas. The impacts of land cover changes include the following: reduced evapotranspiration due to decrease in vegetation (Peterson et al., 1995; Dow and DeWalle, 2000), increased urban air temperatures due to increase in built surfaces and decrease in vegetation (Landsberg, 1981; Akbari et al., 2001), formation of the urban heat island (UHI) (Oke, 1987; Grimmond and Oke, 1995). Increase in urban air temperature leads to an increase in energy usage for air-conditioning in warm summer months (Akbari et al., 2001).

Remote Sensing data is being increasingly used for land cover change monitoring due to the availability of time series of data. Landsat data and other regionally available remote sensing data has been used for LULC change analysis (Singh and Dubey, 2012; Bijender and Joginder, 2014; Nguyen et al., 2016; Utomo and Kurniawan, 2016; Wan et al., 2019).

In this paper, timer series of National Land Cover Database (NLCD) land cover data was used for the land cover change analysis in the State of California during the time period of 2001 through 2016. The organization of the paper is as follows: Section 2 focuses on the study area and data used, Section 3 focuses on the methodology, Section 4 focuses on the results and discussion, and Section 5 is the conclusion section of the paper.

2. STUDY AREA AND DATA

2.1 Study Area

State of California was used as the study area for the land cover change analysis. The area of State of California is 423,970 sq.km. There are 58 counties in the State of California. The case study area is shown in Figure 1.

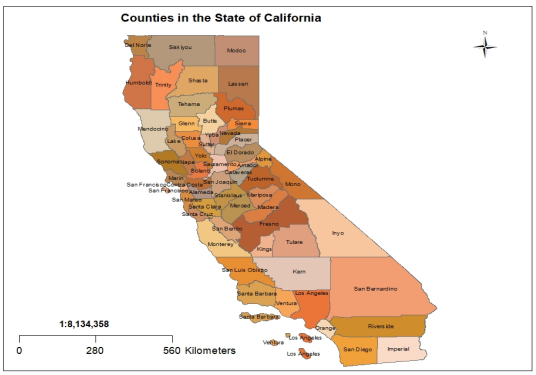


Figure 1. Study Area

2.2 Data Used

National Land Cover Database (NLCD) land cover data downloaded from the Multi- Resolution Land Characteristics Consortium Website was used for the land cover change analysis.

2.3 Time Period of Analysis

Land cover change analysis was performed for the time period of 2001 through 2016.

3. METHODOLOGY

NLCD data for Contiguous United States (CONUS) was downloaded from the Multi- Resolution Land Characteristics Consortium Website for the following years: 2001, 2004, 2006, 2008, 2011, 2013, 2016. This was the first step in the land cover change analysis.

NLCD data was processed in Esri ArcMap 10.6.1 for the land cover change analysis. A vital step in the land cover change analysis, was clipping the NLCD data to the extent of State of California. For the clipping process, Clip tool in ArcMap was used. State of California's boundary data was used as the clipping extent. To automate and batch process the time series of NLCD data (2001 through 2016), a model was created in Model Builder tool in ArcMap. The created model is shown in Figure 2.

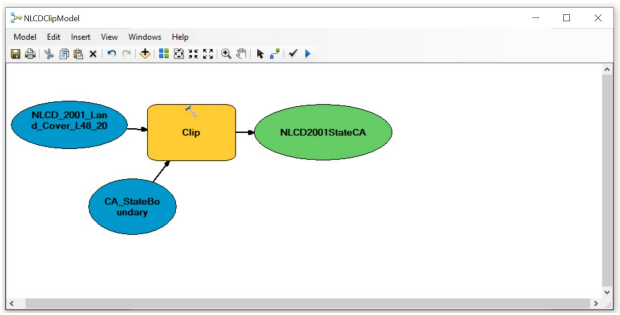


Figure 2. Land Cover Data Clip Model

Once the NLCD data for the years 2001, 2004, 2006, 2008, 2011, 2013, and 2016 were clipped to the study area extent, the area of each land cover type was computed. As the first step, an attribute field for area was added in the attribute table of the clipped NLCD time series data. This step is shown in Figure 3.

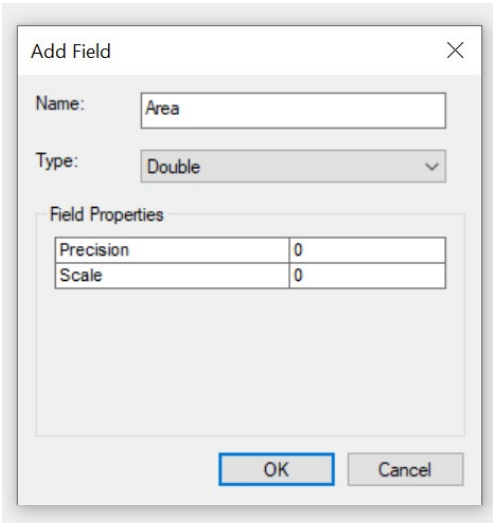


Figure 3. Adding the area field to the Attribute Table

Once the attribute field for area was added, the field calculator tool in ArcMap 10.6.1 was used for the area computation. The field calculator tool for computation of area is shown in Figure 4. Area was computed by multiplying the number of pixels in each cover category by the area of each pixel (30 m x 30 m) as the resolution of the NLCD data is 30-m. The area of each land cover category was computed using Equation 1.

$$Area = Count * 30 * 30 \quad (1)$$

where Area = Area of each land cover type (in square meters)

Count = Number of Pixels in each land cover type

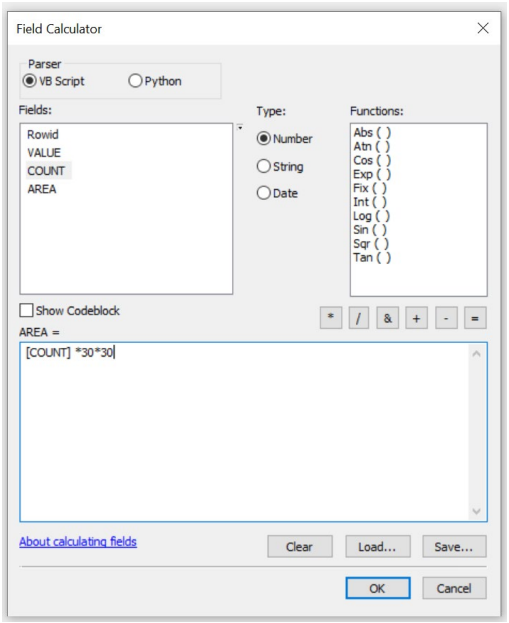
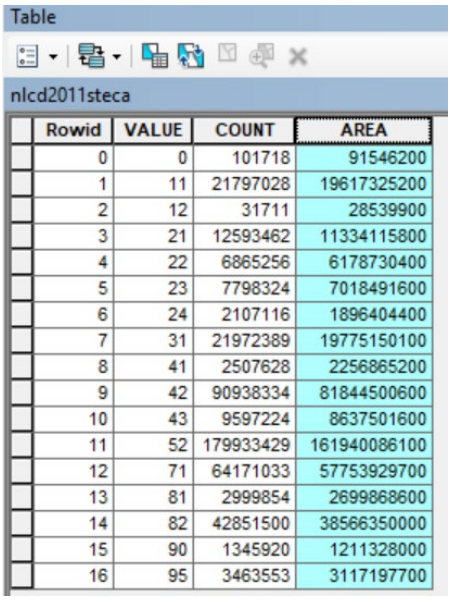


Figure 4. Area calculation using the Field Calculator

The area computed for each land cover category for NLCD 2011 data is shown in Figure 5.



Table

nlcd2011steca

Rowid	VALUE	COUNT	AREA
0	0	101718	91546200
1	11	21797028	19617325200
2	12	31711	28539900
3	21	12593462	11334115800
4	22	6865256	6178730400
5	23	7798324	7018491600
6	24	2107116	1896404400
7	31	21972389	19775150100
8	41	2507628	2256865200
9	42	90938334	81844500600
10	43	9597224	8637501600
11	52	179933429	161940086100
12	71	64171033	57753929700
13	81	2999854	2699868600
14	82	42851500	38566350000
15	90	1345920	1211328000
16	95	3463553	3117197700

Figure 5. Attribute Table of NLCD 2011 data

Following the methodology for area computation, the area of each land cover category was computed for the time series of NLCD data for the following years: 2001, 2004, 2006, 2008,

2011, 2013, and 2016. Further percent change analysis in the land cover categories was performed in Microsoft Excel.

4. RESULTS AND DISCUSSION

Results of the land cover change analysis during the time period of 2001 through 2016, show a significant increase in impervious surfaces through the increase in the following land cover categories: low-intensity developed, medium intensity developed, and high-intensity land cover categories. The overall increase in impervious surface from 2001 through 2016 is 33 %. The change in impervious surfaces from 2001 through 2016 is shown in Figure 6.

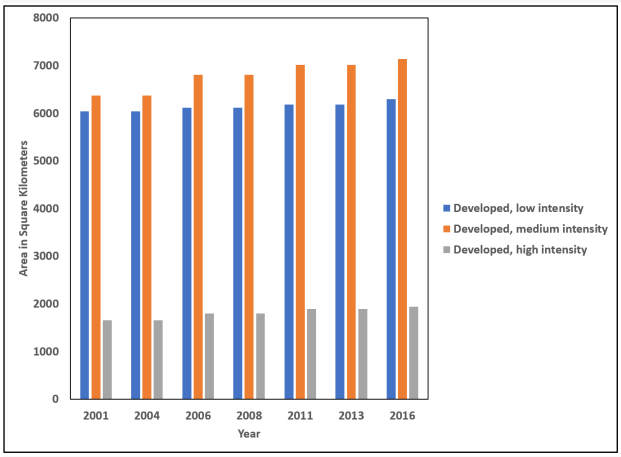


Figure 6. Impervious Surfaces Area from 2001 through 2016

The percent change in each land cover category from 2001 through 2016 is shown in Table 1. Negative values indicate a percent decrease in the area of the land cover, whereas positive values indicate percent increase in the area of the land cover.

Land Cover Category	Percent Increase/Decrease
Developed, open space	1.23
Developed, low intensity	4.20
Developed, medium intensity	11.98
Developed, high intensity	17.52
Barren land	0.95
Deciduous forest	-3.77
Evergreen forest	-7.43
Mixed forest	-12.14
Shrub/scrub	1.27
Grassland/Herbaceous	6.99
Pasture/Hay	-9.22
Cultivated Crops	2.31
Woody Wetlands	0.18
Emergent Herbaceous Wetlands	1.00

Table 1. Land Cover Change from 2001 through 2016

Percent change in land cover from 2001 through 2008 is shown in Table 2.

	Percent Increase/Decrease		
Land Cover Category	2001-2004	2004-2006	2006-2008
Developed, open space	0	0.43	0
Developed, low intensity	0	1.26	0
Developed, medium intensity	0	6.79	0
Developed, high intensity	0	9.00	0
Barren land	0.67	-1.06	0
Deciduous forest	-1.15	-0.23	0
Evergreen forest	-1.34	-0.38	0
Mixed forest	-2.81	-0.98	0
Shrub/scrub	-1.05	-0.22	0
Grassland/Herbaceous	5.92	-0.19	0
Pasture/Hay	-2.30	-2.88	0
Cultivated Crops	0.36	0.04	0
Woody Wetlands	0.54	-1.80	0
Emergent Herbaceous Wetlands	0.29	-3.41	0

Table 2. Land Cover Change from 2001 through 2008

Percent change in land cover from 2008 through 2016 is shown in Table 3.

	Percent Increase/Decrease		
Land Cover Category	2008-2011	2011-2013	2013-2016
Developed, open space	-0.14	0.00	0.94
Developed, low intensity	0.98	0.00	1.90
Developed, medium intensity	3.10	0.00	1.71
Developed, high intensity	5.28	0.00	2.41
Barren land	0.31	1.63	-0.58
Deciduous forest	-1.30	-0.05	-1.10
Evergreen forest	-2.19	-1.27	-2.47
Mixed forest	-5.95	-0.01	-2.90
Shrub/scrub	0.37	0.85	1.33
Grassland/Herbaceous	2.35	-0.24	-0.89
Pasture/Hay	-3.20	0.82	-1.98
Cultivated Crops	0.67	0.18	1.05
Woody Wetlands	0.30	1.83	-0.65
Emergent Herbaceous Wetlands	1.46	3.58	-0.78

Table 3. Land Cover Change from 2008 through 2016

5. CONCLUSION

The results of the land cover change analysis indicate an increase of 33% in impervious surfaces, a decrease of 24% in forest land cover, and a decrease of 9% in pasture land cover. Land Cover Changes are vital to be analyzed to devise urban development plans conducive to creating a sustainable environment. Future research will focus on modeling land cover changes impact on water demand and urban air temperature.

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