Journal of the Arkansas Academy of Science

Volume 66 Article 21

2012

Impervious Surface Area Change in Arkansas from 2001 to 2006

D. E. Long II
University of Arkansas at Monticello, longd@uamont.edu

R. C. Weih Jr.
University of Arkansas at Monticello

Impervious Surface Area Change in Arkansas from 2001 to 2006

D.E. Long II[1, 2] and R.C. Weih, Jr[1]

[1]*School of Forest Resources, University of Arkansas at Monticello, Monticello, AR 71655*

[2]Correspondence: longd@uamont.edu

Abstract

Impervious Surface Area (ISA) is a measurement used to determine stream quality as well as urban sprawl. ISA was calculated as part of the National Land Cover Dataset (NLCD) using Landsat imagery by the Multi-Resolution Land Characteristics Consortium (MRLC) in both 2001 and 2006. ISA for each of the 75 counties in Arkansas was taken from the NLCD for both 2001 and 2006. Using the ISA data, percent imperviousness was determined for each county in each time period as well as the difference between the two periods. These data were also compared to census projections for the two time periods as well as the difference between them. The differences between percent ISA change and census change were compared to determine consistency.

Introduction

Impervious Surface Area (ISA) is an important indicator for the extent of urban sprawl and developed land cover (Xian et al. 2011) as well as indicating changes in stream networks and water quality. Impervious surfaces include any surface that prevents water from being absorbed into the ground (Hebble et al. 2001). These surfaces can be either natural or manmade, but for the context of this paper we will be referring only to manmade surfaces. Examples of impervious surfaces include residential and commercial buildings, sidewalks, roads, and parking lots (Schueler 1994; Arnold and Gibbons 1996). Schueler (1994) found transportation components (roads, sidewalks, parking lots, etc.) account for 63-70% of total ISA. Monitoring change in ISA through time is important because as the percentage of impervious land area increases, runoff from rain events also increases. This in turn leads to stream degradation including widening and deepening of stream channels. Increased ISA is also associated with increased stream pollution from chemicals such as petroleum, antifreeze, and others, which are deposited on roads and parking lots by vehicles and transported into streams during rain events. As ISA grow, we also see an increase in heat islands which is a phenomenon of impervious surfaces causing higher temperatures when compared to the natural land cover.

The Multi-Resolution Land characteristics Consortium (MRLC) utilized Landsat imagery to complete an ISA map for the entire conterminous United States. This was part of a larger project to create a National Land Cover Database (NLCD). Both the NLCD and ISA datasets were created in 2001 and updated in 2006 (Homer 2007). Each dataset was created from 30X30 meter pixel Landsat imagery (see Figure 1). Each pixel was assigned a value between 0 and 100 indicating the percent of impervious land within that pixel (900 m^2). ISA values will continue to change as population growth and urban sprawl continue to increase. This paper aims to determine if changes in ISA values are consistent with changes in population through the same time frame. This will gave a baseline understanding of trends for future work to determine the accuracy of the ISA datasets.

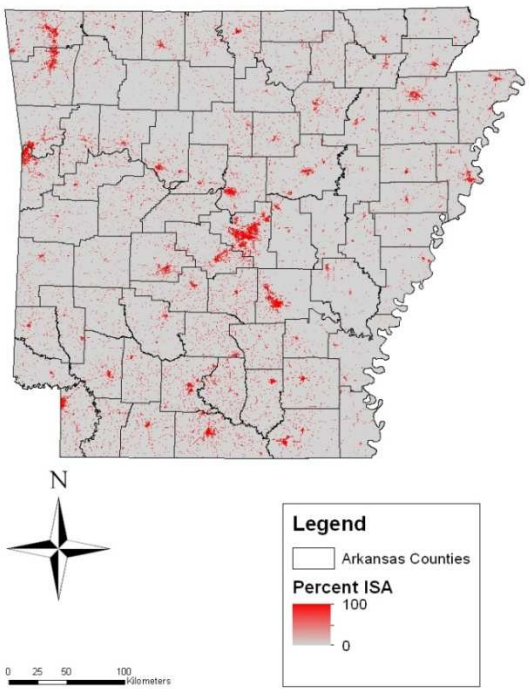

Figure 1: Impervious Surface Area in Arkansas (2006)

Methods

Datasets for ISA in both 2001 and 2006 were obtained from the MRLC (www.mrlc.gov) and subset to the area of Arkansas using ERSI's ArcMAP 10 Geographic Information System (GIS). Using a base map of the counties in Arkansas and utilizing model builder and Python in the GIS, each county was subset into its own file to determine the ISA within the individual counties for each time period.

ISA values for each county were calculated with Python in GIS by calculating the area (in hectares) that was covered by individual percentages (e.g., value 21% ISA in Pulaski covered 3.4 hectares, value 22% covered 4.6 hectares, etc.) and summed to get the total area for each county (Table1). The percent impervious was also determined by taking the number of cells for each value and dividing by the total number of cells within the county. These values were summed to obtain the percent impervious for the county. This was done for each time frame and used to find the difference between them. A Pearson Correlation was used to compare ISA and Census data. Census figures were used from Arkansas Hometown Locator to see how census changes related to changes in ISA (http://arkansas.hometownlocator.com/census/).

Table 1: ISA and Census Data for 2001 and 2006.

County	2001 ISA Hectares	2001 Population	2006 ISA Hectares	2006 Population	ISA Percent Change	Census Change	ISA Hectares Change
Arkansas	946	20,502	968	19,655	0.0001	-847	23
Ashley	3,339	23,823	3,350	22,515	<0.0001	-1,308	11
Baxter	1,711	38,417	1,735	41,155	0.0002	2,738	24
Benton	4,699	160,429	5,597	201,509	0.0039	41,080	898
Boone	1,555	34,253	1,564	35,959	0.0001	1,706	9
Bradley	1,939	12,487	1,949	11,986	0.0001	-501	11
Calhoun	2,241	5,580	2,242	5,526	<0.0001	-54	1
Carroll	1,263	25,678	1,263	27,083	<0.0001	1,405	1
Chicot	757	13,769	768	12,501	0.0001	-1,268	10
Clark	1,525	23,654	1,528	23,392	<0.0001	-262	3
Clay	763	17,256	767	16,315	<0.0001	-941	4
Cleburne	1,204	24,188	1,207	25,176	<0.0001	988	3
Cleveland	1,381	8,621	1,379	8,692	<0.0001	71	-2
Columbia	2,312	25,311	2,329	24,622	0.0001	-689	17
Conway	1,178	20,336	1,184	20,481	<0.0001	145	6
Craighead	2,703	83,274	2,887	89,669	0.0010	6,395	183
Crawford	2,128	54,100	2,164	58,077	0.0002	3,977	36
Crittenden	2,268	51,235	2,540	51,817	0.0016	582	271
Cross	843	19,469	855	18,911	0.0001	-558	13
Dallas	2,007	8,988	2,009	8,321	<0.0001	-667	2
Desha	775	14,993	779	14,016	<0.0001	-977	3
Drew	2,271	18,716	2,271	18,814	<0.0001	98	0
Faulkner	3,101	88,704	3,289	102,331	0.0011	13,627	188
Franklin	1,296	17,823	1,300	18,031	<0.0001	208	4
Fulton	709	11,602	710	11,643	<0.0001	41	1
Garland	3,334	89,311	3,400	95,492	0.0003	6,181	67
Grant	2,072	16,627	2,068	17,455	<0.0001	828	-3
Greene	1,158	37,807	1,205	39,907	0.0003	2,100	47

Table 1 *continued*: ISA and Census Data for 2001 and 2006.

County	2001 ISA Hectares	2001 Population	2006 ISA Hectares	2006 Population	ISA Percent Change	Census Change	ISA Hectares Change
Hempstead	1,800	23,310	1,805	23,169	<0.0001	-141	4
Hot Spring	2,031	30,325	2,051	31,580	0.0001	1,255	20
Howard	1,057	14,230	1,060	14,220	<0.0001	-10	4
Independence	1,863	34,162	1,873	34,377	<0.0001	215	10
Izard	916	13,199	914	13,138	<0.0001	-61	-1
Jackson	1,013	17,809	1,018	17,178	<0.0001	-631	5
Jefferson	5,309	83,442	5,313	80,405	<0.0001	-3,037	3
Johnson	1,337	22,932	1,343	24,295	<0.0001	1,363	6
Lafayette	1,262	8,349	1,263	7,754	<0.0001	-595	1
Lawrence	1,150	17,699	1,150	16,813	<0.0001	-886	0
Lee	401	12,354	410	10,941	0.0001	-1,413	9
Lincoln	876	14,433	875	13,833	<0.0001	-600	0
Little River	808	13,303	824	12,952	0.0001	-351	16
Logan	1,469	22,380	1,500	22,586	0.0002	206	31
Lonoke	1,496	53,907	1,543	61,940	0.0002	8,033	46
Madison	846	14,302	850	15,308	<0.0001	1,006	5
Marion	808	16,202	806	16,584	<0.0001	382	-2
Miller	3,064	40,637	3,266	42,812	0.0012	2,175	202
Mississippi	2,151	50,970	2,224	46,736	0.0003	-4,234	72
Montgomery	602	9,928	603	9,081	<0.0001	-93	2
Monroe	792	9,174	792	8,848	<0.0001	-1,080	1
Nevada	1,514	9,810	1,518	9,442	<0.0001	-368	3
Newton	494	8,523	498	8,377	<0.0001	-146	3
Ouachita	3,173	28,049	3,175	26,281	<0.0001	-1,768	2
Perry	691	10,300	691	10,237	<0.0001	-63	0
Phillips	827	25,661	838	22,458	0.0001	-3,203	10
Pike	918	11,224	920	10,814	<0.0001	-410	2
Poinsett	1,160	25,511	1,174	24,949	0.0001	-562	14
Polk	1,356	20,150	1,354	20,183	<0.0001	33	-2
Pope	2,277	54,934	2,295	58,397	0.0001	3,463	17
Prairie	494	9,499	495	8,876	<0.0001	-623	1
Pulaski	14,141	363,113	15,001	373,005	0.0041	9,892	860
Randolph	830	18,184	835	18,163	<0.0001	-21	5
Saline	3,380	84,763	3,597	92,696	0.0011	7,933	217
Scott	994	10,971	995	11,230	<0.0001	259	1
Searcy	586	8,216	588	8,025	<0.0001	-191	2
Sebastian	4,748	116,273	4,865	120,365	0.0008	4,092	117
Sevier	1,070	15,601	1,070	16,304	<0.0001	703	0
Sharp	946	17,289	947	17,814	<0.0001	525	1
St Francis	720	28,830	1,136	27,095	0.0023	-1,735	415

Table 1 *continued*: ISA and Census Data for 2001 and 2006.

County	2001 ISA Hectares	2001 Population	2006 ISA Hectares	2006 Population	ISA Percent Change	Census Change	ISA Hectares Change
Stone	1,118	11,449	725	11,987	-0.0021	538	-392
Union	5,202	45,047	5,212	43,460	<0.0001	-1,587	11
Van Buren	1,020	16,224	1,020	16,366	<0.0001	142	-1
Washington	4,743	163,229	5,151	190,581	0.0017	27,352	408
White	2,752	68,339	2,816	72,781	0.0002	4,442	64
Woodruff	462	8,681	462	7,875	<0.0001	-806	-1
Yell	1,371	21,198	1,373	21,735	<0.0001	537	2
Total	139,517	2,691,068	143,542	2,815,097	0.0202	124,029	4,026

Results and Discussion

The mean change in ISA per county between the years 2001 to 2006 was 0.0003% (53.68 Hectares). The change in ISA was variable among counties. Total population change across the state was 124,029 with a mean population change per county of 1,653.72. Lee County had the least ISA for 2001 and 2006. Pulaski County had the greatest ISA for 2001 and 2006.

On the state level the ISA area change and population changes are consistent with each other. As population increases, so does ISA. This is confirmed through a Pearson Correlation of 0.7262. Individual counties however seem to show some variation.

Some counties show an increase in population with a decrease in ISA. This could be attributed to imagery classification error between time frames. This is based on the apparent wandering of features such as individual roads between the 2001 and 2006 time frames (some roads shift 1 or 2 pixels between the 2001 and 2006 NLCD). ISA isn't expected to decrease over time as roads are seldom demolished without re-paving them and buildings generally aren't removed without building a new structure in its place. As roads account for up to 70% of all ISA (Schueler 1994), roads would have to be removed without replacing them in order to have any significant ISA reductions. One possible reason ISA would decrease over time, especially with increases in population over the same time frame, is changes in accuracy of Landsat measurement.

Another reason we would see negative change over this time period was error. This error could occur in measuring as well as error in representing ISA. To explore the possibilities of these errors, further research will be done to assess the accuracy of the NLCD ISA dataset at different scales.

Acknowledgments

We would like to thank Dr. Robert Kissell and Jay Guarneri for helping with the model for separating ISA by county. We would also like to thank the Arkansas Forest Resource Center for providing funds for this project.

References

Arnold CL and **CJ Gibbons**. 1996. Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62:243.

Hebble EE, **TN Carlson** and **K Daniel**. 2001. Impervious surface area and residential housing density: A satellite perspective. Geocarto International 16:13.

Homer C, **J Dewitz**, **J Fry**, **M Coan**, **N Hossain**, **C Larson**, **N Herold**, **A McKerrow**, **JN VanDriel** and **J Wickham**. 2007. Completion of the 2001 National Land Cover database for the conterminous United States. Photogrammetric Engineering & Remote Sensing 73:4.

Schueler TR. 1994. The importance of imperviousness. Watershed Protection Techniques 1:100.

Xian G, **C Homer**, **J Demitz**, **J Fry**, **N Hossain** and **J Wickham**. 2011 Change of impervious surface area between 2001 and 2006 in the conterminous United States. Photogrammetric Engineering & Remote Sensing 8:758-762.