Mapping the Distribution of Wood-Utilizing Industries in Arkansas Using Geographic Information Systems

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Abstract

Arkansas is endowed with vast forest resources, but the number of wood-utilizing industries is declining. A cartographic representation of the location of existing industries is needed to understand their spatial distribution trends and identify possible factors relating to their site preferences. We obtained coordinates of these industries from ZipList5 Geocode and overlaid them onto spatial data, including Land-Use/Land-Cover (LULC) raster data model, county- and city-limits vector data model, county-level population, and average house listing price in ArcMap. We used ArcGIS spatial analyst tools to reclassify and vectorize the LULC model based on timber supply potential and then categorized the subsectors of wood-utilizing industries based on their numeric and/or financial dominance. Spearman's nonparametric correlation showed that county-level counts of industries were not significantly related to population ($r = 0.193$, $P = 0.097$) and city limits ($r = 0.062$, $P = 0.600$) but were significantly related to timber supply area LULC type ($r = 0.284$, $P = 0.014$) and average house listing price ($r = 0.419$, $P < 0.0001$). This study provides spatially based knowledge about site-selection preferences for wood-utilizing industries, which is critical for potential investors, resource administrators, and wood-industry businesses in Arkansas.

The abundance of forest resources in Arkansas has made it possible to produce lumber, craft paper, fine paper, newsprint, chemicals, charcoal, and many other products. In 1998, one-sixth of all manufacturing jobs in Arkansas (i.e., 43,000 employees) were in forest harvesting and forest product manufacturing (Balogh 2008). The recent continuous decline in the number of wood-utilizing industries, however, has led not only to the loss of jobs but also to negative impacts on the motivation of forestland owners and timberland managers to commit more resources toward forest management as their merchandise faces dwindling patronage.

A detailed assessment of local demand and market competitiveness requires an understanding of both the number and geographic distribution of mills consuming each type of forest-derived raw material (Mendell 2008). Additionally, the location of wood-using facilities and productive timberlands are primary local factors for assessing timber markets (Mendell 2008). McCauley and Caulfield (1990) indicated that the important factors in the location selection for wood products industries are access to raw materials, ease of transportation, access to suitable manpower, factory capacity, cost of production, profitability, market observations, and investment requirements.

The wood-utilizing industry sector is unique in that it has many subsectors, including plymills, post/pole plants, chipmills, sawmills, and each subsector has a relatively unique set of location factors. For example, a sawmill may be more concerned about the supply of sawlogs in a chosen locality, whereas a kitchen cabinet manufacturer may be more concerned about access to markets (Fraser and Goode 1991). However, even though interplay of these factors often occurs, the preferences of wood industry entrepreneurs could become conflicting, and factors such as proximity to raw materials and to profitable markets could become irreconcilable. Given that state-wide universal factors (e.g., tax rate, government subsidies, and research and development) exist, the differential distribution of wood-utilizing industries across Arkansas might be better understood by assessing county-level variables including population (an index of manpower availability), extent of timber supply area (TSA; an indication of the availability of raw materials), average house listing price (an index of profitability and market performance), and city limits (an

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index of the infrastructure and land available for expansion of the industry). Analysis of the spatial distribution of existing industries with respect to these factors may facilitate the identification of potential investment locations, whereas evaluation of the significance of these variables might help forestland owners and managers to make management decisions that will strengthen the forest products industry.

Geographic Information Systems (GIS) is a versatile tool that has found immense application in solving spatial puzzles and illustrating spatial distributions. Application of GIS in studies focused on wood industries has been quite limited; however, it has been used to investigate the connection between timber supplies and sawmills in West Virginia by the network and suitability analysis approach (Harouff et al. 2008). The cost-effectiveness of GIS in analyzing and understanding resource distribution and utilization has made it an indispensable tool for better decision making. Therefore, the objectives for this study were to assess the spatial distribution of existing wood-utilizing industries in Arkansas and to evaluate the relationship of these industries' spatial distribution with population, city limits, availability of raw materials, and market performance.

Data and Methods

Information on existing Arkansas wood-utilizing industries (henceforth referred to as industries) was obtained from the 2008 Forest Industry Directory compiled by the Arkansas Forestry Commission (2008). The directory contains data on the size, capacity, ZIP code, phone number, mill type, major products, and equipment type of each industry. The latitude and longitude in decimal degrees of each industry were obtained from ZIPList5 Geocode (2007), which is a database for accurate and up-to-date information on ZIP codes in the United States. The 2005 vector data models for city limits and county boundaries and the 2006 Land-Use/Land-Cover (LULC) raster data models (30-m resolution) of Arkansas were obtained from the Arkansas Geostor database. The 2007 population estimates for each county in Arkansas were obtained from the Demographic Research database of the University of Arkansas at Little Rock Institute for Economic Advancement (Demographic Research 2008), and the average house listing prices for all counties were obtained from Trulia, Inc. (2008), which maintains a current database on the statistics and trends of the housing market.

The industry location coordinates were spatially projected as a point-shapefile layer in ArcMap 9.3 (Environmental Standards Research Institute 2009) with a Universal Transverse Mercator Zone 15N projection. We used the reclass tool in ArcGIS spatial analyst extension to reclassify and vectorize the Arkansas LULC raster data model, which initially contained 51 classifications, into urban, barren land, water, herbaceous, agricultural lands, and TSA. This process was carried out to merge all forestlands together, assign a unique TSA identity to them, and facilitate assessment of the distribution of industries on other major discrete categories of land-cover types. We spatially joined industry locations successively to the county layer, LULC layer, and city-limits layer to evaluate the number of industries in relation to each county, different LULC types, and city limits, respectively. A dummy field was created in their attribute table with a common designator of 1 to indicate the presence of industry and 0 to indicate otherwise. The spatially joined county-industry layer was summarized by the sum of industries (through the dummy designator) in each county, and the symbology was configured to show the general distribution of the industries. We then categorized and symbolized the most numerically and/or financially dominant subsectors of the industry, namely sawmills, plymills, pulp/paper mills, and furniture plants. Also, the spatially joined city-industry and LULC-industry layers were summarized by the sum of industries to evaluate the number of industries within city limits and in each LULC type, respectively.

The total of area of TSAs in each county was estimated by spatially joining the LULC layer to the county layer, recalculating the area of each vegetation polygon, and summarizing the county field based on the sum of TSAs within each county. This was repeated in the same manner for the city limits to assess the proportion of each county that is covered by the geometric extent of cities. We used Spearman's correlation in SAS 9.2 Windows Version (SAS Institute Inc. 2005) to assess the relationship between the number of existing industries and estimated county-level TSA percentages, city-limit percentages, population, and average house listing price.

Results and Discussion

At the time of this study, 382 industries were in existence across Arkansas. Nine counties did not have any industry, and only one county (Newton County) had more than 15 industries (Fig. 1). The general distribution pattern of these industries showed that the sawmill-based and sawmill-related industries were more concentrated in the northern part of the state, the furniture plants in the northwestern region, and the plywood plants in the southern region; the five existing papermills were located in the northcentral to the southern region of the state (Fig. 1). The cartographic layout of these key industries provided a clear visual representation of their distribution and showed the potential regions of the state where new industries can be sited, provided that other site-location factors (e.g., proximity to raw materials, profitable market, and availability of labor) are favorable.

Population and city limits

Population and city limits were not significantly related to the number of industries in each county ($P = 0.097$ and $P = 0.600$, respectively; Fig. 2; Table 1). The basic needs of any forest products industry include available supply of wood fiber, low-cost energy, adequately skilled and competitively priced labor, good transportation infrastructure, access to capital, low taxes on land and production instruments, and research and development (Vlosky 1997). However, because industries are often located relative to the optimum obtainable combination of these factors, higher priority is placed on indispensable factors such as proximity to the source of raw materials and profitable market. The increasing dependence of industries on automated process systems and sophisticated technologies might be adduced to the insignificance of population, whereas the level of infrastructure could be a dispensable factor amidst competing location-determinant factors. The occurrence of the highest number of wood industries in a low-population county (Fig. 1) might be because of good accessibility of a

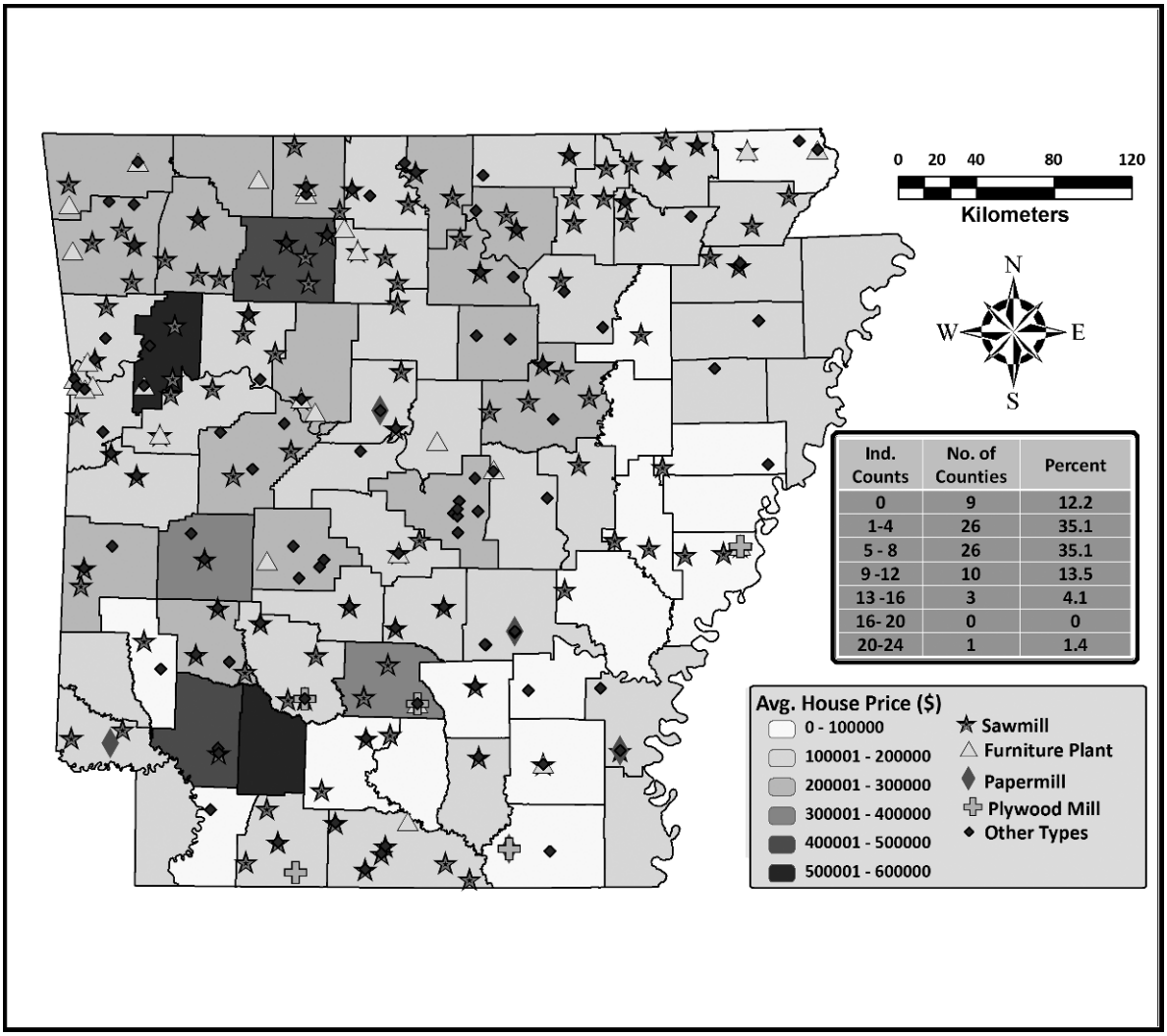

Figure 1.—Distribution of wood-utilizing industries in relation to average house listing price in Arkansas.

vast extent of TSAs, an adequate supply of cheaper energy from the TSAs, the potential availability of cheaper labor, and a more operation-tolerant environment, which cannot be obtained in highly populated counties. This is further evidenced by the output obtained from the spatial analysis of the distribution of the industries with respect to city limits, which indicated that only 80 (21%) of the Arkansas industries are located within city limits (Fig. 2).

LULC and average house listing price

Mapping of the distribution of existing industries with respect to the TSA LULC and the average house listing price shows that both factors were significantly related to ($P = 0.014$ and $P = < 0.001$, respectively) and positively correlated with ($r = 0.284$ and $r = 0.419$, respectively) the number of existing industries (Figs. 1 and 3; Table 1). This potentially indicates that the availability of raw materials and the market performance are related to site suitability for the industries. As Figure 3 shows, 49 and 27 percent of the industries are located on TSAs and agricultural lands, respectively. These findings are consistent with those in previous articles in which authors reported that industries are located in such a manner that they are proximate to the source of raw materials (McCauley and Caulfield 1990, Lin et al. 1996, Michael et al. 1998, Krajewski and Ritzman 1999). The significance of the relationship of TSA and average house listing price with the number of industries in each county indicated that the extent of raw materials and the market performance are key factors in the success of these industries.

The results obtained suggested that the recent decline in the number of existing industries in Arkansas might not be unconnected to the recent downturn in the housing market. Newton County, which has the highest number of existing industries, has one of the highest average house listing prices (Fig. 1). This lends credence to the result obtained from the regression analysis, which indicated that the spatial distribution of industries resonates with the market performance.

Conclusions

Mapping the distribution of the existing 382 wood-utilizing industries in Arkansas shows that only one county has more than 15 industries and that nine counties have no industry at all. Although these nine counties could be potential sites for investors because of lesser intra-industry competition, further evaluation of other location factors, such as proximity to consumers, availability of raw

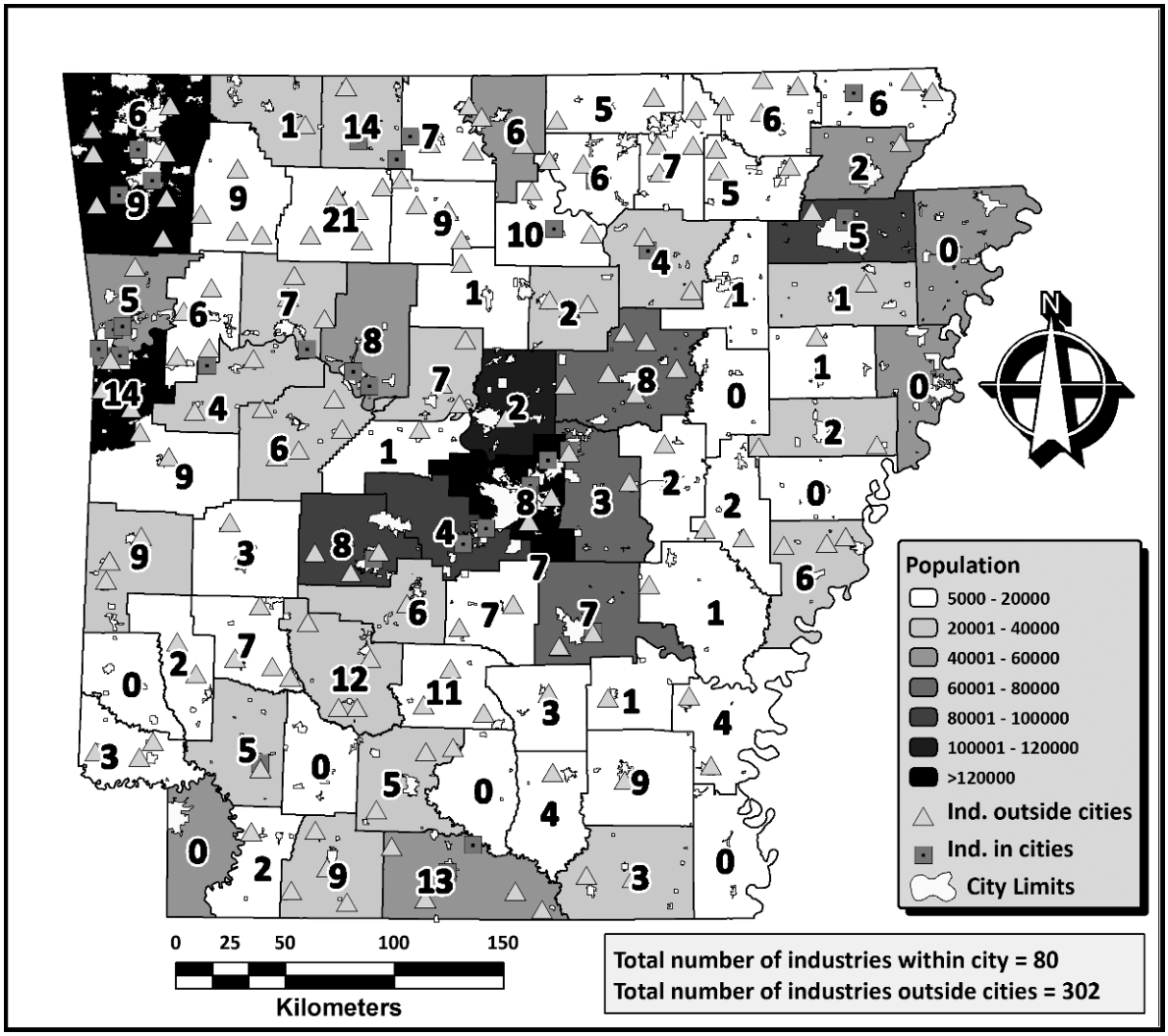

Figure 2.—Wood-utilizing industries in Arkansas in relation to city limits and population.

materials and labor, and conduciveness of the environment, will be needed to guide investors' decisions.

The extent of TSAs (an indication of the availability of raw materials) and average house listing price (an indication of market performance) are significantly and positively related to the distribution of wood-utilizing industries in Arkansas. The significant positive correlation of these two factors indicates that this sector has a greater potential to thrive if both of these factors are favorable (i.e., good TSA extent and strong market performance).

This study provides evidence-based insight about the unique dynamics of the wood-utilizing industries through spatial analysis of their distribution. Potential investors can make decisions more effectively based on empirical data about site selection factors, and potential raw/intermediate material suppliers can easily locate the closest industry to them. This provides a basis for tracking future changes and monitoring development of the wood-products industry in Arkansas.

Table 1.—Spearman correlation of individual county-level variables with number of existing industries.

Variable	*r*	*P*
City limit	0.062	0.600
Population	0.193	0.097
Avg. listing	0.419	<0.001[a]
TSA	0.284	0.014[a]

[a] Significant at $\alpha = 0.05$.

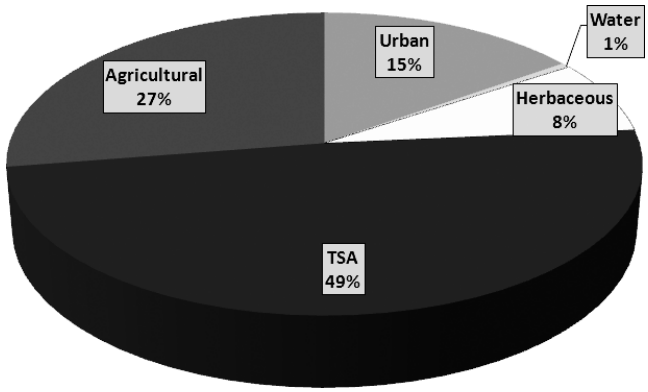

Figure 3.—LULC-based distribution of wood-utilizing industries in Arkansas.

Further studies are needed to understand specific factors driving the development of wood-utilizing industries in Arkansas, especially given the recent dwindling in their numbers. Arkansas has grown a vast stock of forest resources over the years; hence, understanding and creating conditions to enable the proliferation of wood-utilizing industries will be indispensable in earning good economic returns from the accumulated forest resources.

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