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Changes in Land Use, Forest Ownership, Parcel Size, and Fragmentation in Forests of the U.S. South

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ABSTRACT

Using U.S. Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) data, we examined changes in land use, ownership, parcel size, and parcel level in the U.S. South. Over a nominal 10-year period (2001 to 2011), 93.8 percent of the acreage did not change land use. Forest was the most common type and there was a small net gain of forested acreage. Of the forested acreage, 85.4 percent did not change ownership type. Families were the most common ownership type, and there was a small net loss of family-owned lands—primarily to corporate ownerships. Of family-owned forest acreage, 7.6 percent consisted of parcels that reduced in size by more than 100 acres, and 17.5 percent consisted of parcels that decreased in forest area density (i.e., became more fragmented). Increases in forest area density were more prevalent than fragmentation. In all States other than Arkansas, family forest acreage became on average more parcellated and less fragmented.

Keywords: Family forests, forest land use, forest ownership, fragmentation, parcellation.

INTRODUCTION

Forests are dynamic social-ecological systems that provide habitat for a wide variety of biota, as well as numerous ecosystem services that contribute to human well-being. In the U.S. South, forests are predominantly owned by private entities, with more than half owned by families and private individuals (Butler and others 2016). Private owners have the legal prerogative to harvest trees or otherwise manage their forest land. Their management decisions have a strong bearing on the future condition of the forest and the people and organisms who live there. In the U.S. South, family forest owners (FFOs, hereafter equivalent to "families") own their forest land for diverse reasons, with legacy, aesthetic enjoyment, and wildlife habitat being the three most commonly reported objectives in the region. Although < 30 percent of FFOs in the U.S. South identify timber or firewood production as an important management objective, tree cutting is very common, with 43.6 percent (SE = 2.6 percent) that report harvesting one or more timber products during their tenure (Butler and others 2016). Although timber harvest can and does alter the structure and function of forests, harvested forests will regenerate and, given enough time, ultimately can return to pre-harvest conditions. These include structural/functional conditions (Bormann and Likens 1979, Campbell and others 2007) and the capacity to provide ecosystem services (Caputo and others 2016). Compared to timber harvesting, broad changes in land use and land cover from forest to agriculture or developed land are generally thought to result in ecological and social changes that are both more permanent and of a greater magnitude (Thompson and others 2016).

A concept related to land use change is forest fragmentation. Fragmentation refers to a process whereby larger patches of contiguous forest are broken into smaller patches interspersed with patches of nonforest. Fragmentation leads to increased prevalence of forest edge and reduced prevalence of forest interior, resulting in marked changes in habitat quantity and quality for many species. Increased edge can lead to increased predation, changes in microclimate, reduced availability of resources, and overall reduction in fitness for interior species (Harper and others 2005, Laurance 2008, Murcia 1995, Radeloff and others 2005). Fragmentation occurs across a range of spatial scales, from fragmentation at the parcel level to landscape-scale fragmentation.

Ownership change and forest parcellation (the subdivision of parcels into a greater number of smaller parcels) are sociological phenomena that are widely believed to increase the likelihood of fragmentation and land use change (Riitters and Costanza 2018, Riitters and others 2012). As land is transferred from FFOs to other ownerships and as larger parcels are split into smaller parcels, the feasibility and profitability of timber production decreases (Haines and others 2011, Kilgore and Snyder 2016, L'Roe and Allred 2013, Wear and others 1999) and the likelihood of land becoming developed increases. Increases in developed land, along with associated increases in road density, are in turn associated with an increased likelihood of forest fragmentation (Riitters and others 2004) and possible further increases in the rate of parcellation. As yet, however, the causal mechanisms underlying these hypotheses remain largely unproven—in part because the collection of long-term data measuring temporal changes in ownership, land use, management, parcel size, and fragmentation simultaneously in landscapes dominated by private ownership has been relatively rare.

Thompson and Johnson (1996) and Thompson (1997, 1999) looked at parcel/tract size (hereafter parcel size) in three Southeastern States (Virginia, South Carolina, and Florida) using data from the U.S. Department of Agriculture (USDA) Forest Service, Forest Inventory and Analysis (FIA) program. They summarized parcel size in each State by ownership type, region, and forest type. They found statistically significant differences across many of these variables (e.g., smaller parcels in the Piedmont). They also found that management intensity was higher on bigger parcels in Florida and Virginia (although not in South Carolina), in some cases quite substantially.

Thompson and Johnson (1996) and Thompson (1997, 1999) did not, however, have the opportunity to look at change over time. Since these publications were published, FIA has continued to collect data in these three and other Southeastern States. With this analysis, we intend to make a first effort to characterize changes in land use, ownership, parcel size, and forest density over time across the U.S. Southeast.

METHODS

Data came from the USDA Forest Service Southern Research Station (SRS), FIA program. The FIA program serves as the official survey of U.S. forests, providing information on forest structure, composition, and general ownership patterns. The survey uses a stratified (by State) random sampling design (Bechtold and Patterson 2005). Individual States are divided into approximately 6,000-acre hexagons, within which a random point is selected. If a point is determined to be forested, a permanent sampling plot is established and ownership and inventory variables are measured. Plots are sub-divided into sub-plots and one or more conditions, defined by differences in ownership, land use, and certain forest attributes—forest type, stand size class, regeneration status, and tree density (USDA 2018). Plots are remeasured on a 5- to 7-year cycle in the Southern United States.

In this analysis, we looked at transitions in ownership and land use between 2 nominal years, 2001 (1998–2007 inclusive) and 2011 (2008–2017 inclusive). We identified those plots that were measured one or more times within each of the two windows in each State. For those plots that had more than one plot measurement within a given window, we selected the measurement that occurred closest to the nominal year (e.g., if a given plot was measured in 2010 and 2015, we selected the 2010 measurement and coded it with the nominal year 2011). For each plot, we analyzed the change at plot center (CONDITION = 1) between 2001 and 2011 in terms of broad land use and ownership categories (the variables COND_STATUS_CD and OWNCD in the FIA database, FIADB, as defined in Burrill and others 2017). Land use is determined for all plots in the FIA sample, whereas ownership is recorded for only those plots determined to be forest (USDA 2012, 2018). Therefore, we analyzed ownership change only for those plots that were forested in both 2001 and 2011. Plots that were identified as non-census water (COND_STATUS_CD=4) were excluded from the dataset, in order to ensure that all plots correspond to the total census area for each State (see below). Consequently, the term "water" in the text refers to Census water (COND_STATUS_CD=3) only.

It is important to note here that in using the first plot condition to characterize the entire plot, we have deliberately chosen to simplify a more complex sample design (Bechtold and Patterson 2005). Plots may and often do contain multiple conditions (30.9 percent of plots in the study area contain more than a single condition), and subsequent conditions often differ in attributes (land use and ownership) from the first condition. Importantly, however, there is no reason to suspect that these differences are non-random. Therefore, using this simplified dataset is expected to result in a sample in which the relative frequencies of plot attributes (land use, ownership, etc.) correspond to the true proportions of those attributes within a given State. In essence, by using only the first value for each plot, we transformed a more complex plot design to something akin to a simple random sample (SRS). A similar approach is taken to identify the sample for the FIA National Woodland Owner Survey (Butler and others, in preparation).

In addition to land use and ownership (which are standard variables across the United States), SRS FIA began in 1997 to collect two additional variables on inventory plots (Thompson and Johnson 1996), parcel size and forest area density (SRS_TRACT_TOTAL_ACRES and SRS_TRACT_PERCENT_FOREST as defined in USDA 2012). Forest area density is defined as the percent of the parcel that is forested, in terms of forest cover (USDA 2012). The primary data for making these measurements was acquired from municipal courthouses, including tax records and parcel maps, as well as aerial photographs and digital spatial layers, with measurements occasionally being made in the field (USDA 2012). Both of these variables were collected across all plots that were forested and privately owned, but only with high consistency across family forest ownerships. Therefore, our analysis of these variables was limited to those plots identified as family forests in both time periods. In this report, we interpret forest area density as a metric of forest fragmentation at the parcel scale.

In order to translate plot count into estimated acreage, expansion factors were created for each plot by dividing the total Census area (U.S. Census Bureau 2010) of the corresponding State by the total number of FIA plots (non-census water was again excluded) measured in that State in the FIA inventory year corresponding to the first time period for that plot (nominal year 2001). All analysis was conducted using R 3.5.1 (R Core Team 2018). Weighted means, standard errors, and weighted Pearson correlation

coefficients (using the plot-level expansion factors as weights) were calculated using the "survey" package (Lumley 2018).

RESULTS AND DISCUSSION

In total, 56,872 FIA plots were identified as having been remeasured in at least part of 12 Southern States (western Texas was excluded due to data availability) (fig. 1), out of 71,330 total plots (79.7 percent). These plots represent more than 369 million acres. Over the 10-year period from 2001 to 2011, the majority of acres (93.8 percent) did not change in terms of land use, with the bulk of these falling in the forest (55.5 percent of total acres) and nonforest (37.4 percent of total acres) land use categories (fig. 2). There was a small net transition towards a more forested condition in the region, with a net gain of 1.3 million acres from 2001 to 2011 (fig. 3). Among States, the net change ranged from a net loss of 0.3 million acres in Georgia to a net gain of 0.6 million acres in Louisiana.

Of the estimated 205 million acres that were forested in both 2001 and 2011, 85.4 percent did not change in terms of ownership type across the time period (fig. 4). Where ownership did change, changes from family to corporate (6.1 percent) and changes from corporate to family (4.0 percent) were most common. Family acreage declined within each of the 12 States, ranging from a net loss of 1.7 million acres in Alabama to a loss of 0.03 million acres in eastern Texas (fig. 5). Across all States, there was a net loss of family forest acreage amounting to an estimated 8 million acres. Land-use and ownership transition rates for each of the individual States are listed in supplementary tables 1 and 2.

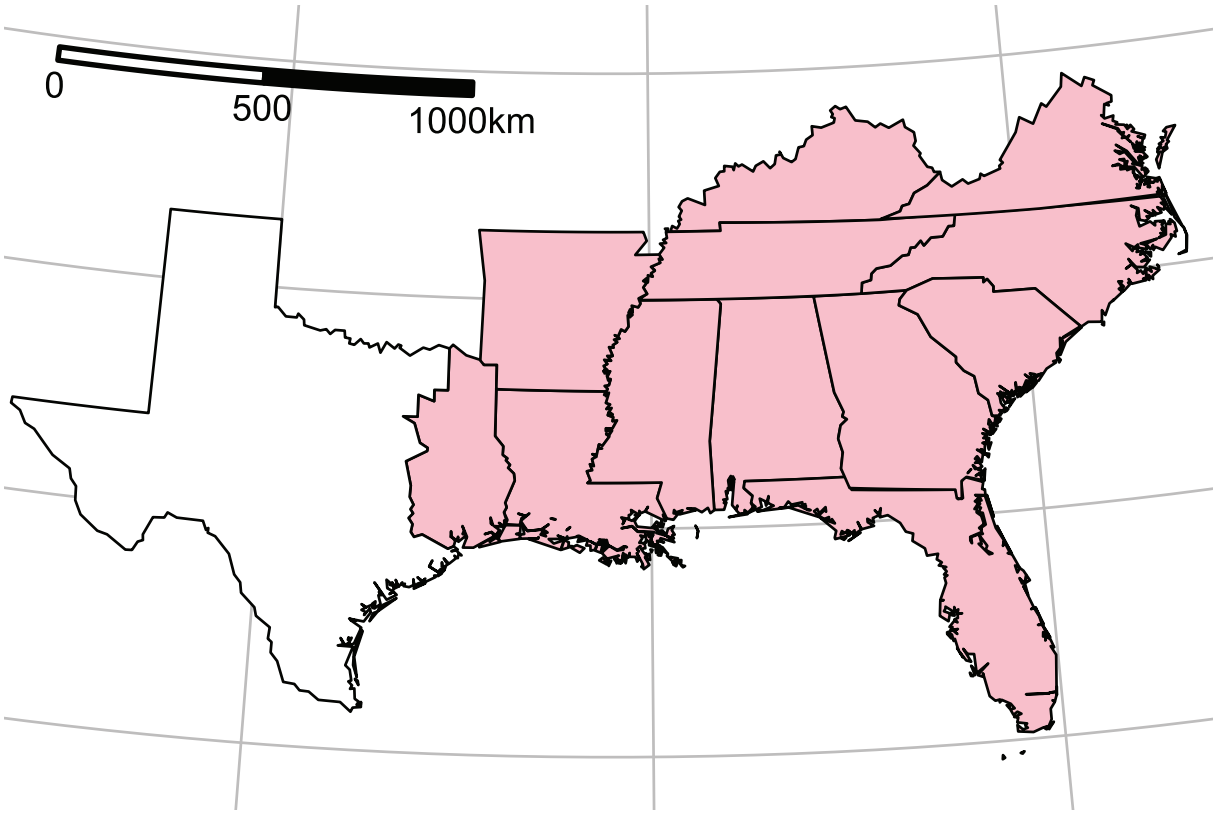

Figure 1—Entire and partial States in the Southern United States for which land use, ownership, parcel size, and forest area density data were available in 2 nominal years, 2001 (1998–2007) and 2011 (2008–2017). Map projected using Albers equal-area conic projection (EPSG:5071).

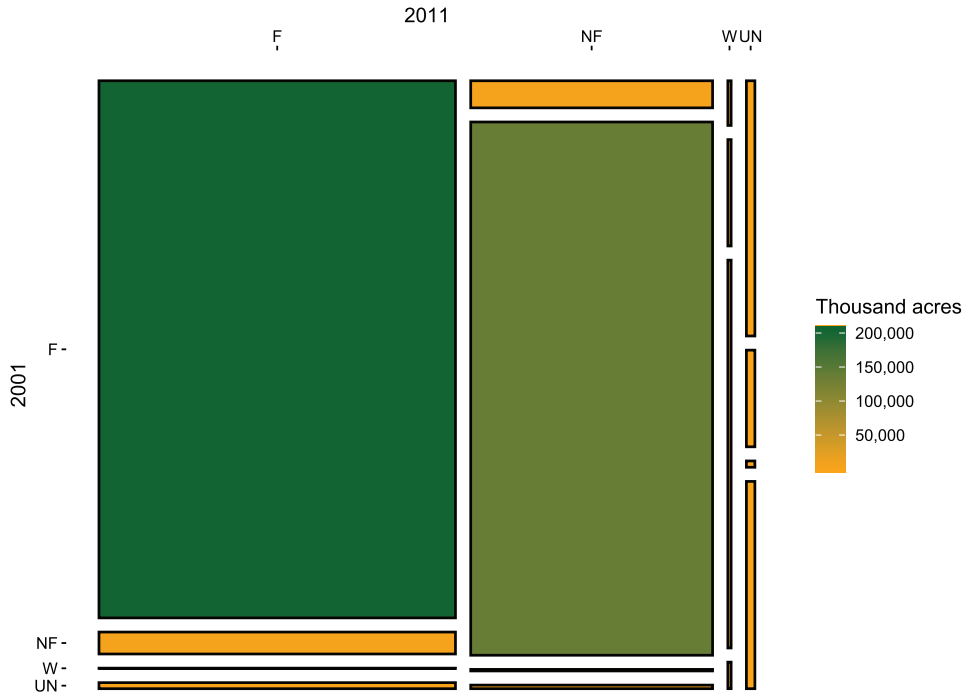

Figure 2—Land use transitions between 2001 and 2011 (nominal) for 12 entire and partial States in the U.S. South. Area of each cell is proportional to estimated acreage. Land use codes: F = forested, NF = nonforested, W = census water, UN = unknown.

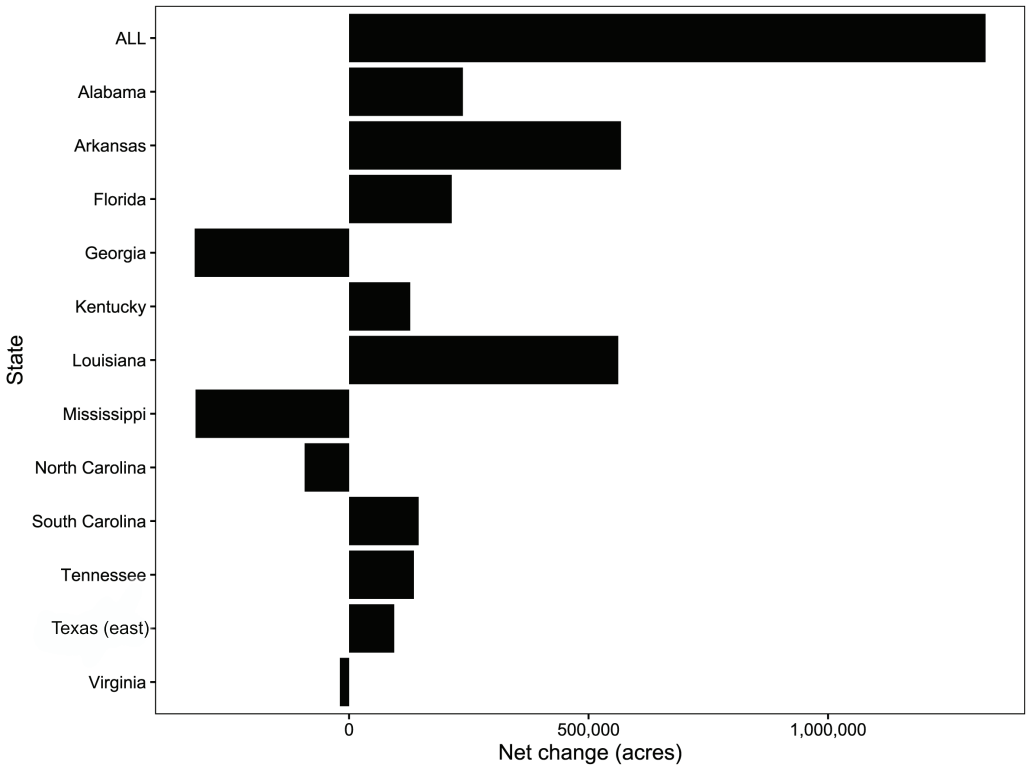

Figure 3—Net change in forested acreage between 2001 and 2011 (nominal) in 12 entire and partial States in the U.S. South.

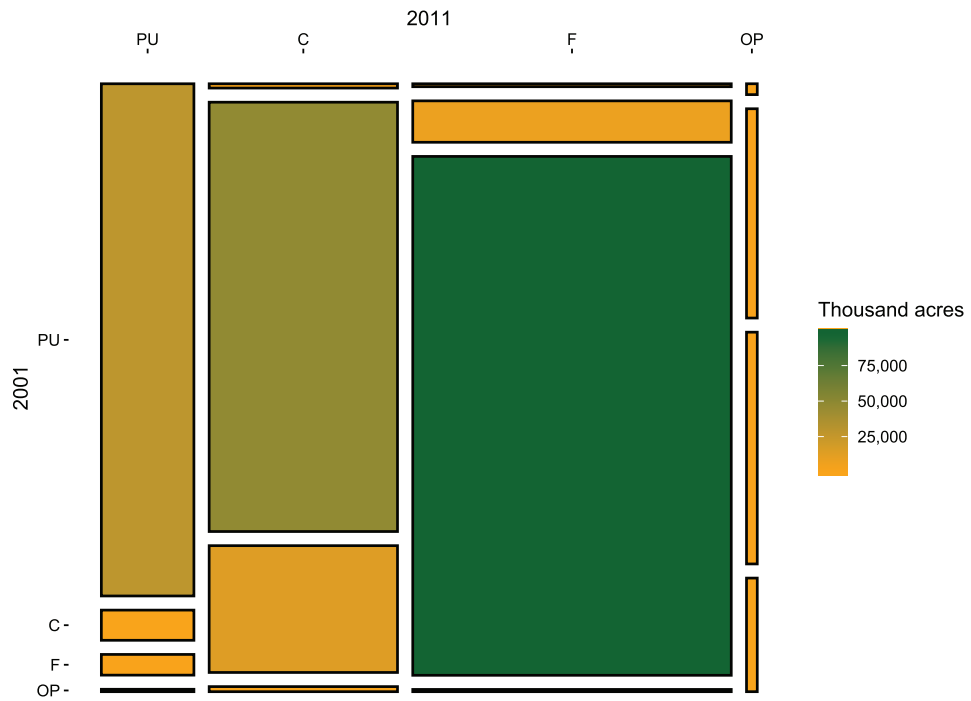

Figure 4—Ownership transitions between 2001 and 2011 (nominal) for forest land in 12 entire and partial States in the U.S. South. Area of each cell is proportional to estimated acreage of forest. Ownership codes: PU = public, C = corporate, F = family, OP = other private.

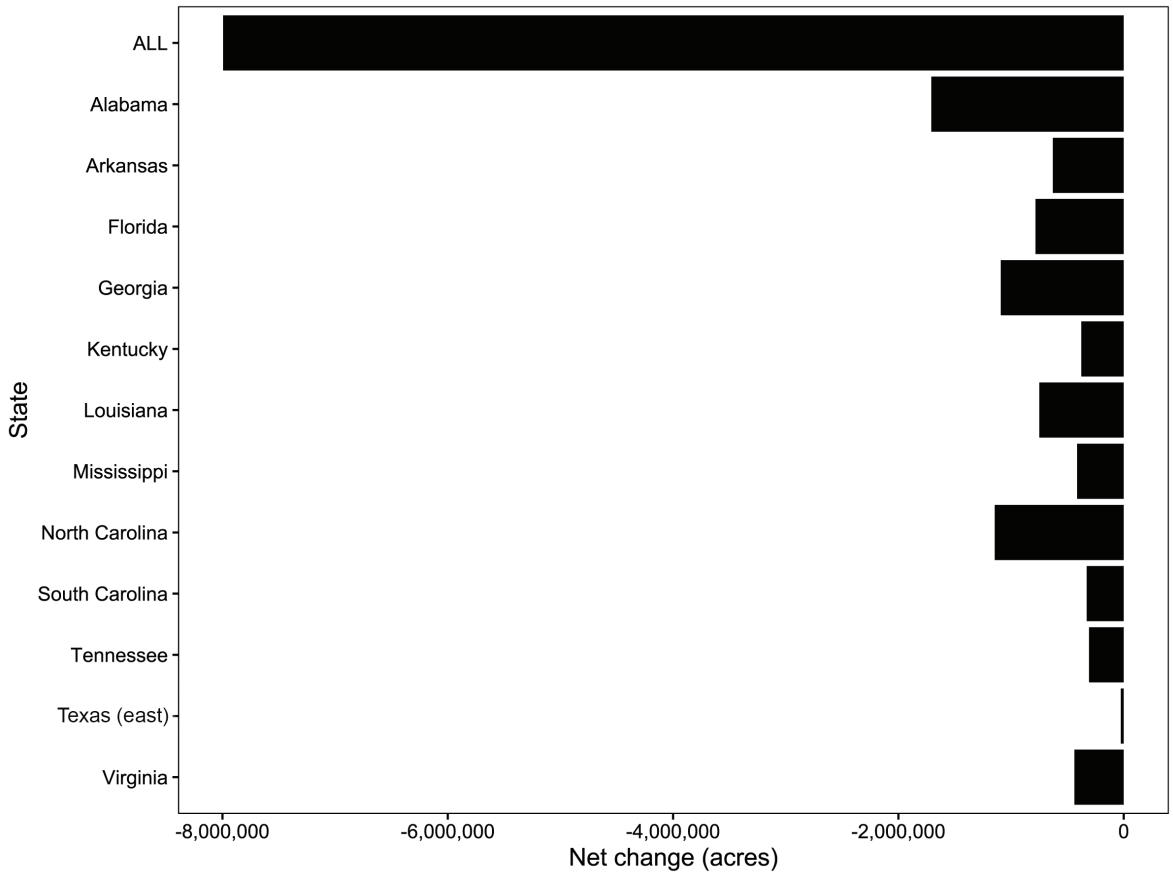

Figure 5—Net change in family forest acreage between 2001 and 2011 (nominal) in 12 entire and partial States in the U.S. South.

Of the 15,416 forested plots that were family-owned in 2001 and 2011, 99.9 percent (15,402 plots) of them had measured parcel size and forest percentage. These plots represent an estimated 98.2 million acres (~ 48 percent of land persisting as forest land from 2001–2011). Of these, 44.9 percent of acres consisted of parcels that changed in size by < 1 acre, and 88 percent of acres consisted of parcels that changed by < 100 acres over the 10 years (fig. 6). Of the acreage that changed in size by more than 100 acres, parcellation was more common than consolidation; 7.6 percent of acres consisted of parcels that became smaller during the 10-year period. Forest area density was unchanged (< 1 percent change) on 36.2 percent of acres and changed by < 10 percent on 60.2 percent of acres (fig. 7). It was more common for parcels to become more forested than otherwise; only 17.5 percent of acreage dropped in forest area density by more than 10 percent. The weighted mean change in acreage at the parcel level was -45.6 acres (SE = 11.7 acres); the mean change in forest area density was 1.9 percent (SE = 0.2 percent) (table 1). This varied among States, with parcels becoming larger and less forested in Arkansas and smaller and more forested in the other 11 States. The distributions of both parcel size and forest area density were skewed towards zero; the median unweighted change in both parcel size and forest area density was zero across all plots taken together as well as for each State considered individually. It is important to note here that our measure of forest area density is based on a measurement of land cover, not land use. Land cover is often a more conservative measure than land use (Drummond and Loveland 2010, Reams and others 2010) as it generally does not include recently cleared and regenerating forest land without significant canopy cover (e.g., clearcuts). It is likely that positive changes in forest area density in terms of land use would be even greater. The reasons for changes in parcel size and forest area density are varied and differ across the region; they include

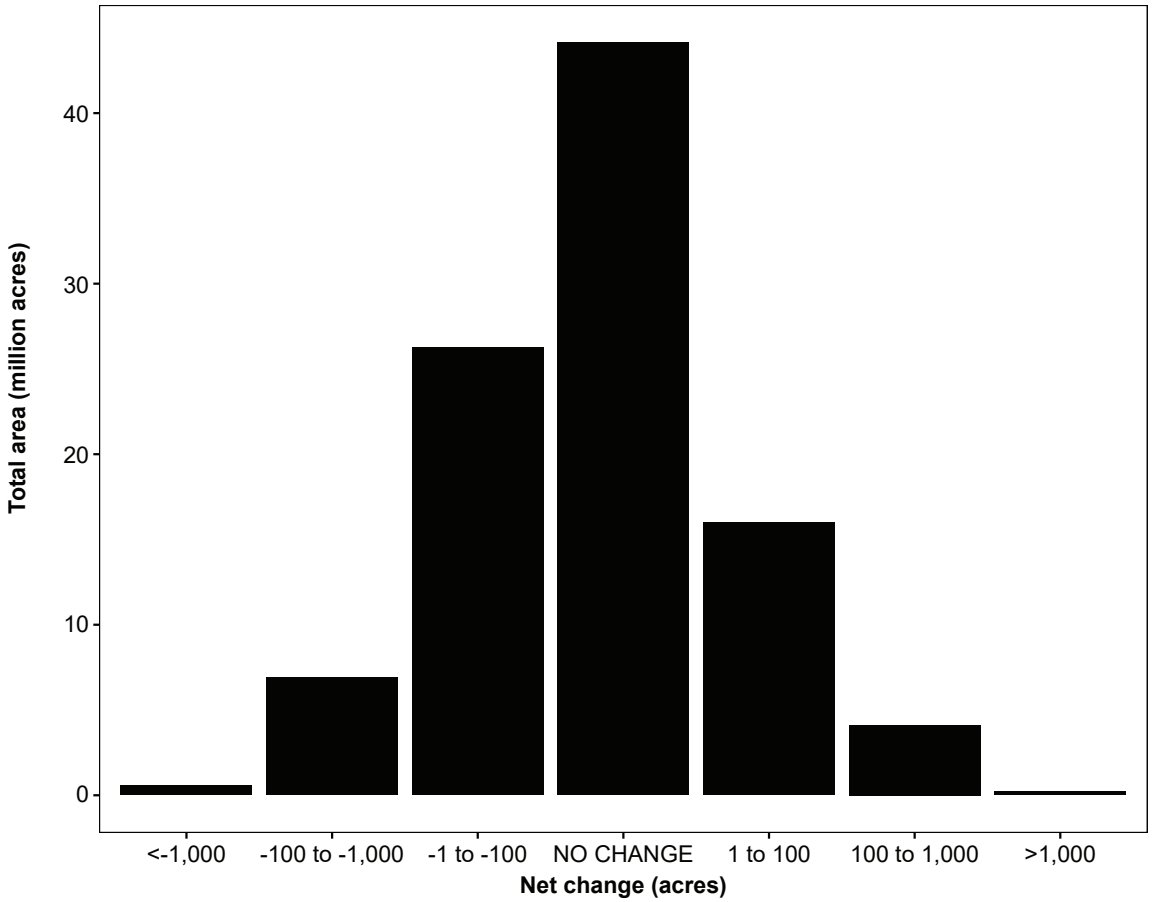

Figure 6—Change in parcel size between 2001 and 2011 (nominal) for family forest land in 12 entire and partial States in the U.S. South. NO CHANGE is equivalent to an absolute change of < 1 acre. Family forest land includes land that was in family ownership in both 2001 and 2011; it does not include land that transitioned out of forest use or family ownership during the study period.

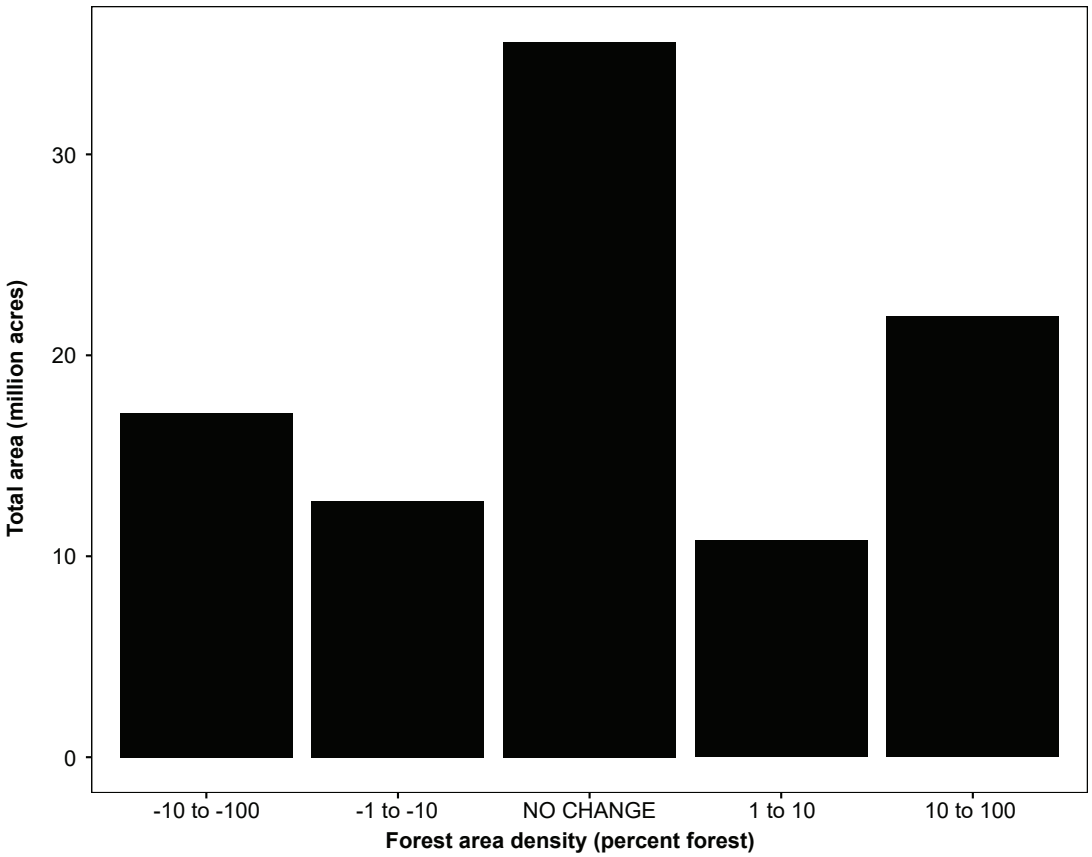

Figure 7—Change in percent forest between 2001 and 2011 (nominal) for family forest land in 12 entire and partial States in the U.S. South. NO CHANGE is equivalent to an absolute change of < 1 percent. Family forest land includes land that was in family ownership in both 2001 and 2011; it does not include land that transitioned out of forest use or family ownership during the study period.

Table 1—Change in parcel size and forest area density between 2001 and 2011 (nominal) for family forest land in 12 entire and partial States in the U.S. South

		Change in parcel size (acres)		Change in forest area density	
State	Total acres (family forest)	Weighted mean	SE	Weighted mean	SE
ALL	98,196,775	-45.59	11.66	1.85%	0.18%
Alabama	11,861,155	-11.55	2.13	3.67%	0.51%
Arkansas	7,587,847	0.21	2.69	-0.02%	0.67%
Florida	3,960,239	-21.82	7.05	0.05%	1.00%
Georgia	11,838,544	-23.33	6.73	2.37%	0.39%
Kentucky	8,043,211	-263.56	132.70	2.44%	0.70%
Louisiana	4,604,885	-98.84	45.41	2.11%	0.95%
Mississippi	10,839,777	-12.82	6.53	0.76%	0.48%
North Carolina	10,272,385	-33.30	12.62	1.02%	0.59%
South Carolina	6,441,954	-60.62	42.71	0.40%	0.68%
Tennessee	8,098,465	-32.32	10.91	1.35%	0.55%
Texas (east)	5,448,978	-26.81	16.94	2.73%	0.75%
Virginia	9,199,335	-13.51	5.40	3.70%	0.61%

SE=standard error.
Note: Family forest land includes land that was in family ownership in both 2001 and 2011; it does not include land that transitioned out of forest use or family ownership during the study period.

reasons such as changing land use, economics, and development patterns. Determining the prevailing reasons among these in a given State or location remains largely speculative.

The weighted Pearson correlation coefficient between changes in parcellation and changes in forest area density is small and statistically insignificant ($r = 0.009$, $P = 0.576$). This suggests that parcellation may not be directly related to fragmentation at the parcel scale, at least over a short period of time consisting of < 10 years. On the other hand, if, there is a substantial lag period between the two, there may very well be a relationship that would leave no signature in the current dataset. Similarly, even though parcellation may not be directly related to local fragmentation at the scale of an individual parcel, it may be related to landscape-scale fragmentation if the new parcels are disproportionately cleared, developed, or otherwise transitioned to nonforest. This may be true even if the remaining portion of the parcel becomes relatively more forested and if there is a region-wide net transition to greater forest cover (fig. 2). These cross-scale interactions—both temporal and spatial—are beyond the scope of the current analysis and will be the focus of future investigations.

CONCLUSIONS

Between 2001 and 2011, most land in the 12 Southern States did not change in terms of land use or forest ownership, with forested land being the largest category of land use and family forests being the predominant type of forest ownership. Within family-owned forest land, only 7.6 percent of acreage consisted of parcels that were reduced in size by more than 100 acres, and 17.5 percent consisted of parcels that were reduced by more than 10 percent in percent forest over a nominal period of 10 years. Although this suggests that the majority of acreage experienced no change, a smaller amount of change, or even change in the positive direction (parcel consolidation and/or afforestation), this still represents a non-trivial amount of change over a relatively short period of time. For example, if these rates were to be held constant, an area equivalent to 50 percent of all family forest acreage would be subject to substantial levels of parcellation (>100 acres) over an 80-year period. Granted, it is unlikely that parcellation processes will remain constant in terms of spatial or temporal intensity, but this gives one a general idea of the magnitude of parcellation processes. Across the entire region, parcellation and fragmentation do not correlate strongly, suggesting that parcellation may not be driving fragmentation in the short term at the level of the individual parcel. This is not to say, however, that the same is true across a longer term or over a wider spatial scale, particularly if there is a significant lag time (10 or more years) between parcellation and fragmentation. Additionally, localized effects of parcellation on fragmentation are possible or even likely, especially around urban areas or anywhere rural land is subject to greater levels of development pressure.

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Supplementary Table 1—Land use transitions between 2001 and 2011 (nominal) for 12 entire and partial States in the U.S. South

State	Land use, 2001	Land use, 2011	Estimated acreage	Percentage of acres in State
ALL	F	F	205,211,561	55.50%
ALL	NF	F	8,386,485	2.27%
ALL	W	F	139,946	0.04%
ALL	UN	F	2,311,237	0.63%
ALL	F	NF	7,022,338	1.90%
ALL	NF	NF	138,222,889	37.38%
ALL	W	NF	406,240	0.11%
ALL	UN	NF	930,654	0.25%
ALL	F	W	157,404	0.04%
ALL	NF	W	374,687	0.10%
ALL	W	W	1,366,022	0.37%
ALL	UN	W	93,546	0.03%
ALL	F	UN	2,328,965	0.63%
ALL	NF	UN	882,161	0.24%
ALL	W	UN	57,794	0.02%
ALL	UN	UN	1,891,290	0.51%
Alabama	F	F	22,297,432	66.46%
Alabama	NF	F	1,014,103	3.02%
Alabama	W	F	12,837	0.04%
Alabama	UN	F	134,786	0.40%
Alabama	F	NF	789,460	2.35%
Alabama	NF	NF	8,915,122	26.57%
Alabama	W	NF	6,418	0.02%
Alabama	UN	NF	25,673	0.08%
Alabama	F	W	6,418	0.02%
Alabama	NF	W	25,673	0.08%
Alabama	W	W	83,439	0.25%
Alabama	UN	W	6,418	0.02%
Alabama	F	UN	128,367	0.38%
Alabama	NF	UN	44,929	0.13%
Alabama	W	UN	0	0.00%
Alabama	UN	UN	57,765	0.17%
Arkansas	F	F	18,087,453	53.14%
Arkansas	NF	F	838,981	2.47%
Arkansas	W	F	6,169	0.02%
Arkansas	UN	F	222,083	0.65%
Arkansas	F	NF	357,801	1.05%
Arkansas	NF	NF	14,009,756	41.16%
Arkansas	W	NF	18,507	0.05%
Arkansas	UN	NF	74,028	0.22%
Arkansas	F	W	6,169	0.02%
Arkansas	NF	W	55,521	0.16%
Arkansas	W	W	86,366	0.25%
Arkansas	UN	W	0	0.00%
Arkansas	F	UN	135,718	0.40%
Arkansas	NF	UN	61,690	0.18%
Arkansas	W	UN	0	0.00%
Arkansas	UN	UN	74,028	0.22%
Florida	F	F	19,003,235	45.15%
Florida	NF	F	694,519	1.65%
Florida	W	F	44,331	0.11%
Florida	UN	F	458,087	1.09%
Florida	F	NF	613,246	1.46%
Florida	NF	NF	18,567,313	44.12%
Florida	W	NF	192,101	0.46%
Florida	UN	NF	487,641	1.16%
Florida	F	W	22,166	0.05%
Florida	NF	W	66,497	0.16%
Florida	W	W	177,324	0.42%
Florida	UN	W	7,389	0.02%
Florida	F	UN	347,260	0.83%
Florida	NF	UN	214,267	0.51%
Florida	W	UN	51,720	0.12%
Florida	UN	UN	1,137,830	2.70%
Georgia	F	F	24,427,068	64.23%
Georgia	NF	F	694,197	1.83%
Georgia	W	F	24,793	0.07%
Georgia	UN	F	130,162	0.34%
Georgia	F	NF	1,004,107	2.64%
Georgia	NF	NF	11,125,752	29.25%
Georgia	W	NF	18,595	0.05%
Georgia	UN	NF	49,586	0.13%
Georgia	F	W	30,991	0.08%
Georgia	NF	W	18,595	0.05%
Georgia	W	W	161,153	0.42%
Georgia	UN	W	0	0.00%
Georgia	F	UN	136,360	0.36%
Georgia	NF	UN	37,189	0.10%
Georgia	W	UN	0	0.00%
Georgia	UN	UN	173,549	0.46%
Kentucky	F	F	11,566,672	44.73%
Kentucky	NF	F	601,418	2.33%
Kentucky	W	F	6,075	0.02%
Kentucky	UN	F	242,997	0.94%

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Supplementary Table 1 (continued)—Land use transitions between 2001 and 2011 (nominal) for 12 entire and partial States in the U.S. South

State	Land use, 2001	Land use, 2011	Estimated acreage	Percentage of acres in State
Kentucky	F	NF	498,145	1.93%
Kentucky	NF	NF	12,411,088	47.99%
Kentucky	W	NF	18,225	0.07%
Kentucky	UN	NF	36,450	0.14%
Kentucky	F	W	6,075	0.02%
Kentucky	NF	W	48,599	0.19%
Kentucky	W	W	60,749	0.23%
Kentucky	UN	W	0	0.00%
Kentucky	F	UN	218,698	0.85%
Kentucky	NF	UN	42,525	0.16%
Kentucky	W	UN	6,075	0.02%
Kentucky	UN	UN	97,199	0.38%
Louisiana	F	F	16,124,904	48.10%
Louisiana	NF	F	1,092,685	3.26%
Louisiana	W	F	7,805	0.02%
Louisiana	UN	F	491,708	1.47%
Louisiana	F	NF	437,074	1.30%
Louisiana	NF	NF	14,134,656	42.17%
Louisiana	W	NF	39,024	0.12%
Louisiana	UN	NF	62,439	0.19%
Louisiana	F	W	23,415	0.07%
Louisiana	NF	W	78,049	0.23%
Louisiana	W	W	109,268	0.33%
Louisiana	UN	W	54,634	0.16%
Louisiana	F	UN	569,757	1.70%
Louisiana	NF	UN	179,512	0.54%
Louisiana	W	UN	0	0.00%
Louisiana	UN	UN	117,073	0.35%
Mississippi	F	F	19,133,008	61.73%
Mississippi	NF	F	283,635	0.92%
Mississippi	W	F	0	0.00%
Mississippi	UN	F	117,153	0.38%
Mississippi	F	NF	536,439	1.73%
Mississippi	NF	NF	10,334,168	33.34%
Mississippi	W	NF	24,664	0.08%
Mississippi	UN	NF	61,660	0.20%
Mississippi	F	W	24,664	0.08%
Mississippi	NF	W	6,166	0.02%
Mississippi	W	W	203,477	0.66%
Mississippi	UN	W	12,332	0.04%
Mississippi	F	UN	160,315	0.52%
Mississippi	NF	UN	18,498	0.06%
Mississippi	W	UN	0	0.00%
Mississippi	UN	UN	80,158	0.26%
North Carolina	F	F	19,690,945	57.17%
North Carolina	NF	F	688,356	2.00%
North Carolina	W	F	6,619	0.02%
North Carolina	UN	F	258,133	0.75%
North Carolina	F	NF	880,301	2.56%
North Carolina	NF	NF	12,436,734	36.11%
North Carolina	W	NF	19,856	0.06%
North Carolina	UN	NF	39,713	0.12%
North Carolina	F	W	0	0.00%
North Carolina	NF	W	6,619	0.02%
North Carolina	W	W	138,995	0.40%
North Carolina	UN	W	6,619	0.02%
North Carolina	F	UN	165,470	0.48%
North Carolina	NF	UN	46,332	0.13%
North Carolina	W	UN	0	0.00%
North Carolina	UN	UN	59,569	0.17%
South Carolina	F	F	13,243,546	64.62%
South Carolina	NF	F	542,613	2.65%
South Carolina	W	F	6,309	0.03%
South Carolina	UN	F	56,785	0.28%
South Carolina	F	NF	435,352	2.12%
South Carolina	NF	NF	6,006,601	29.31%
South Carolina	W	NF	12,619	0.06%
South Carolina	UN	NF	12,619	0.06%
South Carolina	F	W	0	0.00%
South Carolina	NF	W	12,619	0.06%
South Carolina	W	W	100,951	0.49%
South Carolina	UN	W	0	0.00%
South Carolina	F	UN	25,238	0.12%
South Carolina	NF	UN	31,547	0.15%
South Carolina	W	UN	0	0.00%
South Carolina	UN	UN	6,309	0.03%
Tennessee	F	F	13,212,314	48.98%
Tennessee	NF	F	800,000	2.97%
Tennessee	W	F	6,154	0.02%
Tennessee	UN	F	86,154	0.32%
Tennessee	F	NF	510,769	1.89%
Tennessee	NF	NF	11,821,544	43.83%

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Supplementary Table 1 (continued)—Land use transitions between 2001 and 2011 (nominal) for 12 entire and partial States in the U.S. South

State	Land use, 2001	Land use, 2011	Estimated acreage	Percentage of acres in State
Tennessee	W	NF	18,462	0.07%
Tennessee	UN	NF	43,077	0.16%
Tennessee	F	W	12,308	0.05%
Tennessee	NF	W	18,462	0.07%
Tennessee	W	W	80,000	0.30%
Tennessee	UN	W	6,154	0.02%
Tennessee	F	UN	233,846	0.87%
Tennessee	NF	UN	92,308	0.34%
Tennessee	W	UN	0	0.00%
Tennessee	UN	UN	30,769	0.11%
Texas (East)	F	F	11,828,116	52.76%
Texas (East)	NF	F	634,771	2.83%
Texas (East)	W	F	18,855	0.08%
Texas (East)	UN	F	106,843	0.48%
Texas (East)	F	NF	496,504	2.21%
Texas (East)	NF	NF	8,918,223	39.78%
Texas (East)	W	NF	31,424	0.14%
Texas (East)	UN	NF	31,424	0.14%
Texas (East)	F	W	18,855	0.08%
Texas (East)	NF	W	18,855	0.08%
Texas (East)	W	W	69,134	0.31%
Texas (East)	UN	W	0	0.00%
Texas (East)	F	UN	150,837	0.67%
Texas (East)	NF	UN	87,988	0.39%
Texas (East)	W	UN	0	0.00%
Texas (East)	UN	UN	6,285	0.03%
Virginia	F	F	16,596,869	60.63%
Virginia	NF	F	501,205	1.83%
Virginia	W	F	0	0.00%
Virginia	UN	F	6,344	0.02%
Virginia	F	NF	463,139	1.69%
Virginia	NF	NF	9,541,931	34.86%
Virginia	W	NF	6,344	0.02%
Virginia	UN	NF	6,344	0.02%
Virginia	F	W	6,344	0.02%
Virginia	NF	W	19,033	0.07%
Virginia	W	W	95,166	0.35%
Virginia	UN	W	0	0.00%
Virginia	F	UN	57,099	0.21%
Virginia	NF	UN	25,377	0.09%
Virginia	W	UN	0	0.00%
Virginia	UN	UN	50,755	0.19%

Land use codes: F = forested; NF = nonforested; W = census water; UN = unknown.

Supplementary Table 2—Ownership transitions between 2001 and 2011 (nominal) for forested acreage in 12 entire and partial States in the U.S. South

State	Ownership, 2001	Ownership, 2011	Estimated acreage	Percentage of acreage in State
ALL	PU	PU	28,197,325	13.74%
ALL	C	PU	1,662,040	0.81%
ALL	F	PU	1,139,362	0.56%
ALL	OP	PU	133,191	0.06%
ALL	PU	C	481,900	0.23%
ALL	C	C	48,087,583	23.43%
ALL	F	C	14,203,921	6.92%
ALL	OP	C	568,824	0.28%
ALL	PU	F	559,924	0.27%
ALL	C	F	7,846,884	3.82%
ALL	F	F	98,286,726	47.90%
ALL	OP	F	425,879	0.21%
ALL	PU	OP	69,490	0.03%
ALL	C	OP	1,338,910	0.65%
ALL	F	OP	1,482,766	0.72%
ALL	OP	OP	726,835	0.35%
Alabama	PU	PU	1,309,348	5.87%
Alabama	C	PU	102,694	0.46%
Alabama	F	PU	147,623	0.66%
Alabama	OP	PU	0	0.00%
Alabama	PU	C	57,765	0.26%
Alabama	C	C	5,153,954	23.11%
Alabama	F	C	2,438,982	10.94%
Alabama	OP	C	25,673	0.12%
Alabama	PU	F	25,673	0.12%
Alabama	C	F	969,174	4.35%
Alabama	F	F	11,861,155	53.20%
Alabama	OP	F	19,255	0.09%
Alabama	PU	OP	0	0.00%
Alabama	C	OP	51,347	0.23%
Alabama	F	OP	134,786	0.60%
Alabama	OP	OP	0	0.00%
Arkansas	PU	PU	3,485,474	19.27%
Arkansas	C	PU	55,521	0.31%
Arkansas	F	PU	43,183	0.24%
Arkansas	OP	PU	12,338	0.07%
Arkansas	PU	C	24,676	0.14%
Arkansas	C	C	4,676,088	25.85%
Arkansas	F	C	752,616	4.16%
Arkansas	OP	C	67,859	0.38%
Arkansas	PU	F	74,028	0.41%
Arkansas	C	F	425,660	2.35%
Arkansas	F	F	7,618,692	42.12%
Arkansas	OP	F	80,197	0.44%
Arkansas	PU	OP	12,338	0.07%
Arkansas	C	OP	215,914	1.19%
Arkansas	F	OP	413,322	2.29%
Arkansas	OP	OP	129,549	0.72%
Florida	PU	PU	5,785,200	30.44%
Florida	C	PU	332,483	1.75%
Florida	F	PU	140,382	0.74%
Florida	OP	PU	59,108	0.31%
Florida	PU	C	73,885	0.39%
Florida	C	C	6,627,489	34.88%
Florida	F	C	1,248,657	6.57%
Florida	OP	C	44,331	0.23%
Florida	PU	F	66,497	0.35%
Florida	C	F	546,749	2.88%
Florida	F	F	3,960,239	20.84%
Florida	OP	F	0	0.00%
Florida	PU	OP	0	0.00%
Florida	C	OP	7,389	0.04%
Florida	F	OP	7,389	0.04%
Florida	OP	OP	103,439	0.54%
Georgia	PU	PU	2,113,583	8.65%
Georgia	C	PU	173,549	0.71%
Georgia	F	PU	99,171	0.41%
Georgia	OP	PU	0	0.00%
Georgia	PU	C	37,189	0.15%
Georgia	C	C	6,266,371	25.65%
Georgia	F	C	2,169,367	8.88%
Georgia	OP	C	74,378	0.30%
Georgia	PU	F	43,387	0.18%
Georgia	C	F	1,214,845	4.97%
Georgia	F	F	11,857,138	48.54%
Georgia	OP	F	49,586	0.20%
Georgia	PU	OP	0	0.00%
Georgia	C	OP	192,144	0.79%
Georgia	F	OP	130,162	0.53%
Georgia	OP	OP	6,198	0.03%
Kentucky	PU	PU	1,214,987	10.50%
Kentucky	C	PU	60,749	0.53%

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Supplementary Table 2 (continued)—Ownership transitions between 2001 and 2011 (nominal) for forested acreage in 12 entire and partial States in the U.S. South

State	Ownership, 2001	Ownership, 2011	Estimated acreage	Percentage of acreage in State
Kentucky	F	PU	60,749	0.53%
Kentucky	OP	PU	0	0.00%
Kentucky	PU	C	18,225	0.16%
Kentucky	C	C	1,008,439	8.72%
Kentucky	F	C	668,243	5.78%
Kentucky	OP	C	18,225	0.16%
Kentucky	PU	F	78,974	0.68%
Kentucky	C	F	309,822	2.68%
Kentucky	F	F	8,043,211	69.54%
Kentucky	OP	F	6,075	0.05%
Kentucky	PU	OP	0	0.00%
Kentucky	C	OP	12,150	0.11%
Kentucky	F	OP	42,525	0.37%
Kentucky	OP	OP	24,300	0.21%
Louisiana	PU	PU	1,841,954	11.42%
Louisiana	C	PU	187,317	1.16%
Louisiana	F	PU	93,659	0.58%
Louisiana	OP	PU	23,415	0.15%
Louisiana	PU	C	85,854	0.53%
Louisiana	C	C	6,548,303	40.61%
Louisiana	F	C	1,545,368	9.58%
Louisiana	OP	C	70,244	0.44%
Louisiana	PU	F	54,634	0.34%
Louisiana	C	F	842,928	5.23%
Louisiana	F	F	4,620,495	28.65%
Louisiana	OP	F	78,049	0.48%
Louisiana	PU	OP	0	0.00%
Louisiana	C	OP	23,415	0.15%
Louisiana	F	OP	85,854	0.53%
Louisiana	OP	OP	23,415	0.15%
Mississippi	PU	PU	2,195,086	11.47%
Mississippi	C	PU	30,830	0.16%
Mississippi	F	PU	55,494	0.29%
Mississippi	OP	PU	6,166	0.03%
Mississippi	PU	C	49,328	0.26%
Mississippi	C	C	3,921,558	20.50%
Mississippi	F	C	554,937	2.90%
Mississippi	OP	C	141,817	0.74%
Mississippi	PU	F	24,664	0.13%
Mississippi	C	F	326,796	1.71%
Mississippi	F	F	10,839,777	56.65%
Mississippi	OP	F	92,490	0.48%
Mississippi	PU	OP	12,332	0.06%
Mississippi	C	OP	419,286	2.19%
Mississippi	F	OP	246,639	1.29%
Mississippi	OP	OP	215,809	1.13%
North Carolina	PU	PU	2,945,368	14.96%
North Carolina	C	PU	238,277	1.21%
North Carolina	F	PU	185,327	0.94%
North Carolina	OP	PU	19,856	0.10%
North Carolina	PU	C	52,950	0.27%
North Carolina	C	C	3,124,076	15.87%
North Carolina	F	C	1,641,464	8.34%
North Carolina	OP	C	6,619	0.03%
North Carolina	PU	F	72,807	0.37%
North Carolina	C	F	741,306	3.76%
North Carolina	F	F	10,272,385	52.17%
North Carolina	OP	F	6,619	0.03%
North Carolina	PU	OP	13,238	0.07%
North Carolina	C	OP	158,851	0.81%
North Carolina	F	OP	138,995	0.71%
North Carolina	OP	OP	72,807	0.37%
South Carolina	PU	PU	1,425,937	10.77%
South Carolina	C	PU	170,355	1.29%
South Carolina	F	PU	75,713	0.57%
South Carolina	OP	PU	0	0.00%
South Carolina	PU	C	25,238	0.19%
South Carolina	C	C	3,142,109	23.73%
South Carolina	F	C	984,275	7.43%
South Carolina	OP	C	25,238	0.19%
South Carolina	PU	F	25,238	0.19%
South Carolina	C	F	706,659	5.34%
South Carolina	F	F	6,448,263	48.69%
South Carolina	OP	F	31,547	0.24%
South Carolina	PU	OP	25,238	0.19%
South Carolina	C	OP	75,713	0.57%
South Carolina	F	OP	31,547	0.24%
South Carolina	OP	OP	50,476	0.38%
Tennessee	PU	PU	1,950,770	14.76%
Tennessee	C	PU	209,231	1.58%
Tennessee	F	PU	86,154	0.65%
Tennessee	OP	PU	12,308	0.09%

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Supplementary Table 2 (continued)—Ownership transitions between 2001 and 2011 (nominal) for forested acreage in 12 entire and partial States in the U.S. South

State	Ownership, 2001	Ownership, 2011	Estimated acreage	Percentage of acreage in State
Tennessee	PU	C	6,154	0.05%
Tennessee	C	C	1,452,308	10.99%
Tennessee	F	C	744,616	5.64%
Tennessee	OP	C	6,154	0.05%
Tennessee	PU	F	36,923	0.28%
Tennessee	C	F	492,308	3.73%
Tennessee	F	F	8,110,773	61.39%
Tennessee	OP	F	36,923	0.28%
Tennessee	PU	OP	0	0.00%
Tennessee	C	OP	18,462	0.14%
Tennessee	F	OP	43,077	0.33%
Tennessee	OP	OP	6,154	0.05%
Texas (East)	PU	PU	1,080,997	9.14%
Texas (East)	C	PU	50,279	0.43%
Texas (East)	F	PU	37,709	0.32%
Texas (East)	OP	PU	0	0.00%
Texas (East)	PU	C	12,570	0.11%
Texas (East)	C	C	4,003,459	33.85%
Texas (East)	F	C	402,231	3.40%
Texas (East)	OP	C	56,564	0.48%
Texas (East)	PU	F	0	0.00%
Texas (East)	C	F	483,935	4.09%
Texas (East)	F	F	5,455,263	46.12%
Texas (East)	OP	F	25,139	0.21%
Texas (East)	PU	OP	0	0.00%
Texas (East)	C	OP	75,418	0.64%
Texas (East)	F	OP	94,273	0.80%
Texas (East)	OP	OP	50,279	0.43%
Virginia	PU	PU	2,848,622	17.16%
Virginia	C	PU	50,755	0.31%
Virginia	F	PU	114,199	0.69%
Virginia	OP	PU	0	0.00%
Virginia	PU	C	38,066	0.23%
Virginia	C	C	2,163,430	13.04%
Virginia	F	C	1,053,165	6.35%
Virginia	OP	C	31,722	0.19%
Virginia	PU	F	57,099	0.34%
Virginia	C	F	786,702	4.74%
Virginia	F	F	9,199,335	55.43%
Virginia	OP	F	0	0.00%
Virginia	PU	OP	6,344	0.04%
Virginia	C	OP	88,821	0.54%
Virginia	F	OP	114,199	0.69%
Virginia	OP	OP	44,411	0.27%

Ownership codes: PU = public; C = corporate; F = family; OP = other private.

Caputo, Jesse; Butler, Brett; Brandeis, Thomas; Riitters, Kurt. 2020. Changes in land use, forest ownership, parcel size, and fragmentation in forests of the U.S. South. e-Res. Pap. SRS–63. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 16 p.

Using U.S. Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) data, we examined changes in land use, ownership, parcel size, and parcel level in the U.S. South. Over a nominal 10-year period (2001 to 2011), 93.8 percent of the acreage did not change land use. Forest was the most common type and there was a small net gain of forested acreage. Of the forested acreage, 85.4 percent did not change ownership type. Families were the most common ownership type, and there was a small net loss of family-owned lands—primarily to corporate ownerships. Of family-owned forest acreage, 7.6 percent consisted of parcels that reduced in size by more than 100 acres, and 17.5 percent consisted of parcels that decreased in forest area density (i.e., became more fragmented). Increases in forest area density were more prevalent than fragmentation. In all States other than Arkansas, family forest acreage became on average more parcellated and less fragmented.

Keywords: Family forests, forest land use, forest ownership, fragmentation, parcellation.

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