CHAPTER 7.

Detailed Assessment of the Decline of Core Forest in the Conterminous United States

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INTRODUCTION

Forest loss and fragmentation of the remainder threaten the sustainability of many ecological attributes and processes that depend on extensive forest cover. The direct loss of intact forest is an obvious threat; less obvious are the indirect threats posed by isolation and edge effects, which encompass a wide range of biotic and abiotic influences on remnant forest (Forman and Alexander 1998, Harper and others 2005, Laurance 2008, Murcia 1995, Ries and others 2004). Because fragmentation is a spatial process, monitoring the threats posed by forest fragmentation necessarily involves analysis of forest maps. The forest maps from the National Land Cover Database (NLCD) have proven useful for synoptic analyses because they provide consistent and complete coverage for the Nation. However, those synoptic analyses provide no details about the forest types or ownerships that are being fragmented. That information is important when considering conservation and restoration alternatives such as where to add or remove forest cover and whether the effort should be a public or private concern. A recent analysis of forest fragmentation trends using NLCD maps from 2001 and 2006 documented a decline in relatively intact forest in the conterminous United States (Riitters and Wickham 2012). The objective of this report is to reevaluate that decline in relation to forest types and ownerships by incorporating *in situ* data from the Forest Inventory and Analysis (FIA) databases.

METHODS

Briefly, we combined forest fragmentation data derived from the 2001 and 2006 NLCD land cover maps with field plot information from the FIA Program. We used the same general methods as have been applied in previous analyses (Riitters and others 2012). Here we extended those earlier analyses of forest-type fragmentation in the Eastern United States in 2001 by (a) evaluating trends from 2001 to 2006, (b) extending the geographic coverage to the conterminous United States, and (c) including forest ownership in addition to forest types.

Forest Inventory and Analysis Data

Bechtold and Patterson (2005) provide a detailed description of the FIA inventory, which may be summarized as follows. The FIA inventory uses a permanent, national, grid-based, equal-probability sample design across all land. Each sample location is determined to be either a forest land use ("forest land") or a nonforest land use. For those locations determined to be a forest land use, a field inventory plot is installed to collect additional information. A variety of site and vegetation measurements are taken on a cluster of four fixed-area subplots spanning approximately 0.4 ha, which may extend into more than one forest type and/or ownership class. FIA uses a poststratified estimator that accounts for different sampling intensities that arise because of intentional increases in sample size or unintentionally because of survey nonresponse. In effect, each plot has a weight

factor that accounts for those differences. In addition, each within-plot forest type and/or ownership is weighted by its relative area on the field plot. We refer to the within-plot differences as "partial plot" observations. The area estimates that we report were derived by combining the two weight factors (Bechtold and Patterson 2005).

We used forest land data from 140,584 plot or partial plot observations across the conterminous United States. The plots came from the same sample that was used in the most recent (as of 2012) FIA State report for each State. Unlike the NLCD data, for which observations were available for the years 2001 and 2006, only one date of observation was available during that time interval for each of the FIA plot locations. When combining FIA and NLCD data, it was assumed that the FIA observations represented both of the NLCD observations. Forest types and ownership classes were defined by FIA protocols (USDA Forest Service 2010). The original set of FIA plots represented approximately 275 million ha of forest land and 151 forest types. That sample was screened to eliminate observations of the nonstocked and unassigned types (19.6 million ha, 2 types); exotic types (0.8 million ha, 8 types); types with <50 000 ha each (0.3 million ha, 17 types); and woodland hardwood types (13.5 million ha, 6 types). The data carried into the analysis considered 118 forest types representing 240.5 million ha of forest land. The FIA ownership classes were condensed into four classes, called Federal, State and local government, corporate private, and noncorporate private.

National Land Cover Database Data

Fragmentation was measured using the 2001 and 2006 NLCD land cover maps (U.S. Geological Survey 2011a, 2011b). The NLCD maps identify 16 land cover types at a spatial resolution of 0.09 ha/pixel and a minimum mapping unit of 0.45 ha. The 16 NLCD land cover types were combined into 2 generalized land cover types called forest (including the NLCD deciduous forest, evergreen forest, mixed forest, and woody wetlands classes) and nonforest (including all other NLCD classes). Each inventory plot location was classified as "core" or "not core" by evaluating the NLCD forest data within a 4.41-ha (7 pixel by 7 pixel) neighborhood centered on the inventory plot center location (Riitters and others 2012). The "core" locations were those with 100-percent forest land cover in the 4.41-ha neighborhood, and the "not core" locations were those with <100-percent forest cover. That neighborhood size was large enough to reliably assess core status yet small enough to characterize fragmentation in the immediate vicinity of a field plot. Core (or not core) status was assigned to all of the plot (and partial plot) records for a given FIA plot location. In other words, core status was treated as a new plot-level attribute when using the FIA weight factors to summarize core status by forest types and owner classes.

RESULTS AND DISCUSSON

Of the 240.5 million ha of forest land in 2001 that was included in this study, the total core area was 98.4 million ha, or 41 percent of total

forest land area. Between 2001 and 2006, the gross gain of core forest was 1.2 million ha and the gross loss was 5.0 million ha. The net loss of 3.8 million ha, representing 3.9 percent of the core area in 2001, reduced total core area to 94.6 million ha (39 percent of total forest land area in 2006).

Changes in core area were driven primarily by forest cover changes on private lands (table 7.1). Because most of the total core area was privately owned, it is not surprising that most of the gains and losses of core occurred on private land. However, the changes on private land were not directly proportional to total core area. While 57 percent of the core area in 2001 was privately owned, private land accounted for more than 80 percent of the gross gains and losses and 78 percent of the net loss of core area. Changes in core area were larger on corporate private land than on noncorporate private land even though approximately two-thirds of private core area in 2001 was noncorporate private land.

Table 7.1—Core area and change from 2001 to 2006 by ownership class in the conterminous United States

(A) Core area and change[a]

Owner	2001	Gross loss	Gross gain	Net loss	2006
			million hectares		
State & local government	10.99	0.31	0.05	0.26	10.73
Corporate private	19.36	2.33	0.63	1.70	17.65
Noncorporate private	36.68	1.71	0.43	1.28	35.39
Federal	31.35	0.61	0.05	0.56	30.79
Total area	**98.38**	**4.96**	**1.15**	**3.81**	**94.57**

(B) Percent of total core area or total change area[b]

Owner	2001	Gross loss	Gross gain	Net loss	2006
			percent of total area from table 7.1A		
State & local government	11.2	6.3	4.5	6.9	11.3
Corporate private	19.7	47.0	54.3	44.7	18.7
Noncorporate private	37.3	34.5	37.2	33.7	37.4
Federal	31.9	12.2	3.9	14.7	32.6

[a] Columns may not sum to total area due to rounding.

[b] Due to rounding, columns may not sum to 100 percent, and individual percentages may be different than those calculated from raw hectare totals.

Public lands accounted for 43 percent of the core area in 2001, with Federal land contributing approximately three times more core area than State and local government land (table 7.1). Approximately 22 percent of the total net loss of core area occurred on public lands. Overall, the differences between the changes of core area on public and private lands resulted in a 1-percent increase in the overall share of total core area being located on public lands by 2006.

The total area of individual forest types ranged from 0.1 to 20.4 million ha, with average and median areas of 2.0 and 0.8 million ha, respectively. In 2001, the percentage of total forest type area that was core area ranged from 2 percent to 79 percent, with average and median area percentages of 38 percent and 36 percent, respectively. Just a few forest types dominated both total forest area and core area. Half (50.5 percent) of total forest area consisted of the 11 forest types with more than 5 million ha each. Those 11 forest types, along with 8 additional forest types with more than 1.5 million ha each of core area in 2001, accounted for 65 percent of total core area in 2001 (fig. 7.1). This report focuses on that group of 19 "dominant" forest

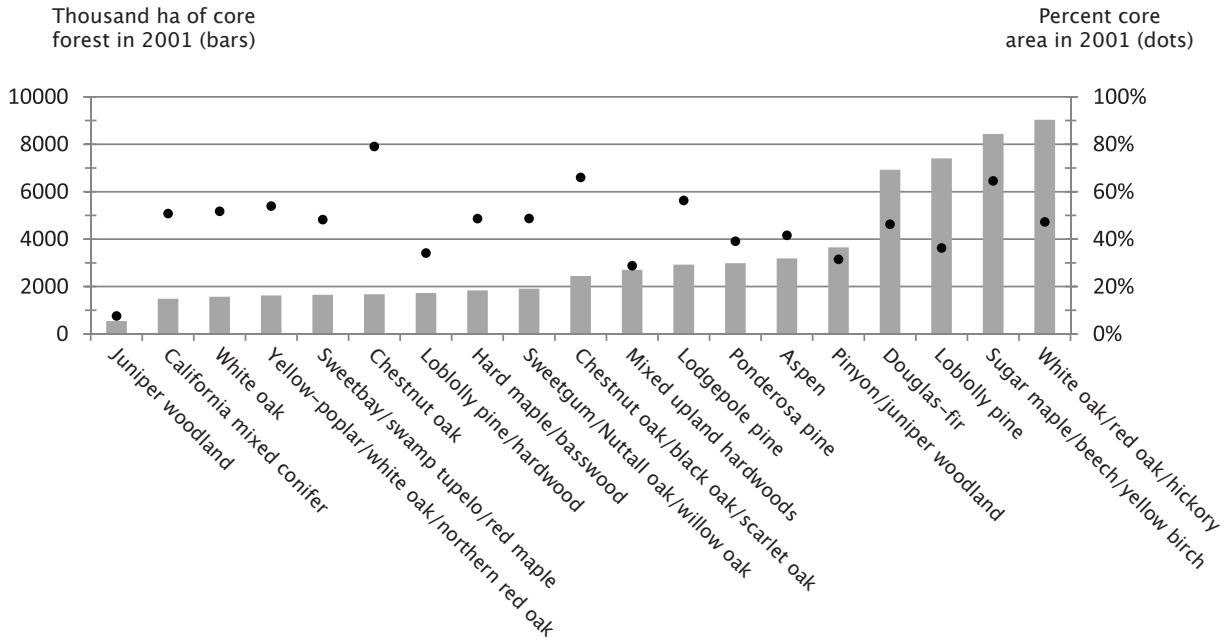

Figure 7.1—Core area and percentage of total area that was core in 2001 for the 19 forest types in the "dominant" group of forest types.

types because their dynamics dominated changes in total core area.

Most forest types exhibited a net loss of core area. Only 5 forest types had net gains (totaling only 5000 ha), and 19 forest types had no change in core area. Among the 94 forest types with a net loss, the percentage of core forest that was lost ranged from near 0 to 31 percent, and 35 forest types (including 5 in the "dominant" group) exhibited net losses larger than 5 percent. The net losses for the 19 forest types in the "dominant" group accounted for 66.7 percent of the total net loss of core area between 2001 and 2006 (fig. 7.2).

By 2006, the range of core area percentage among forest types was between 2 percent and 78 percent, and the 19 forest types in the "dominant" group still accounted for 65 percent of total core area. However, for most forest types, the percentage of total area that was core was lower in 2006 compared to 2001. As a result, the average and median percentages of core area both decreased by 2 percent, and the core area of many individual forest types decreased accordingly. The core areas in 2006 for the "dominant" group of forest types are shown for comparison in figure 7.3.

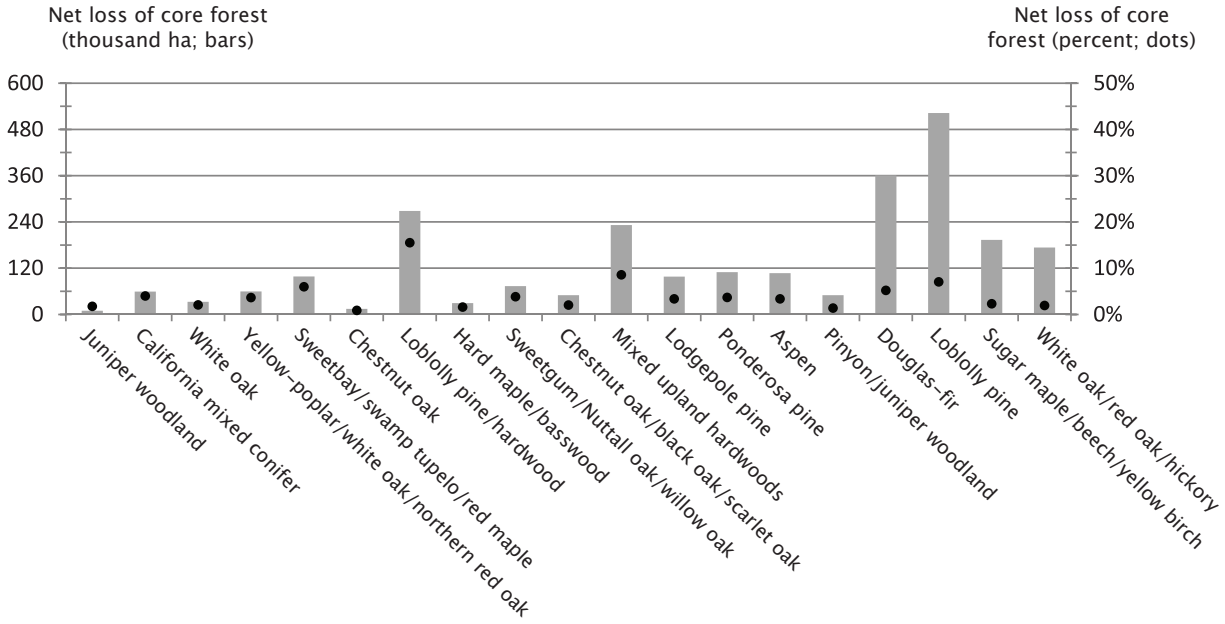

Figure 7.2—Net loss of core area and percentage of core area that was lost from 2001 to 2006 for the 19 forest types in the "dominant" group of forest types.

One approach to prioritizing conservation or restoration efforts is to identify the forest types and/or ownerships that have experienced large net losses (table 7.2) or large percentage reductions (table 7.3) of core area from 2001 to 2006. For example, public efforts could be directed at the giant chinkapin forest type because 71 percent of the remaining core area is on public land, while private efforts could be directed at the loblolly pine or gray birch forest types because 89 and 90 percent, respectively, of the remaining core area is on private lands (table 7.3). There may be particular concerns for the 5 forest types (slash pine, sweetgum/yellow-poplar, post oak/blackjack oak, western hemlock, and cherry/white ash/yellow-poplar) that were not in the "dominant" group of forest types but were among the top 20 in terms of net loss of core area (table 7.2). Similarly, there may also be particular concerns for the three forest types (loblolly pine/hardwood, mixed upland hardwoods, and loblolly pine) which are in the "dominant" group and experienced reductions of core area ranging from 7 percent to 16 percent (table 7.3).

Previous national studies of forest fragmentation had much lower thematic resolution than this study because they were based only on land cover data derived from synoptic mapping from Landsat satellites. By combining high thematic resolution data on forest communities obtained from field observations with satellite-based land cover

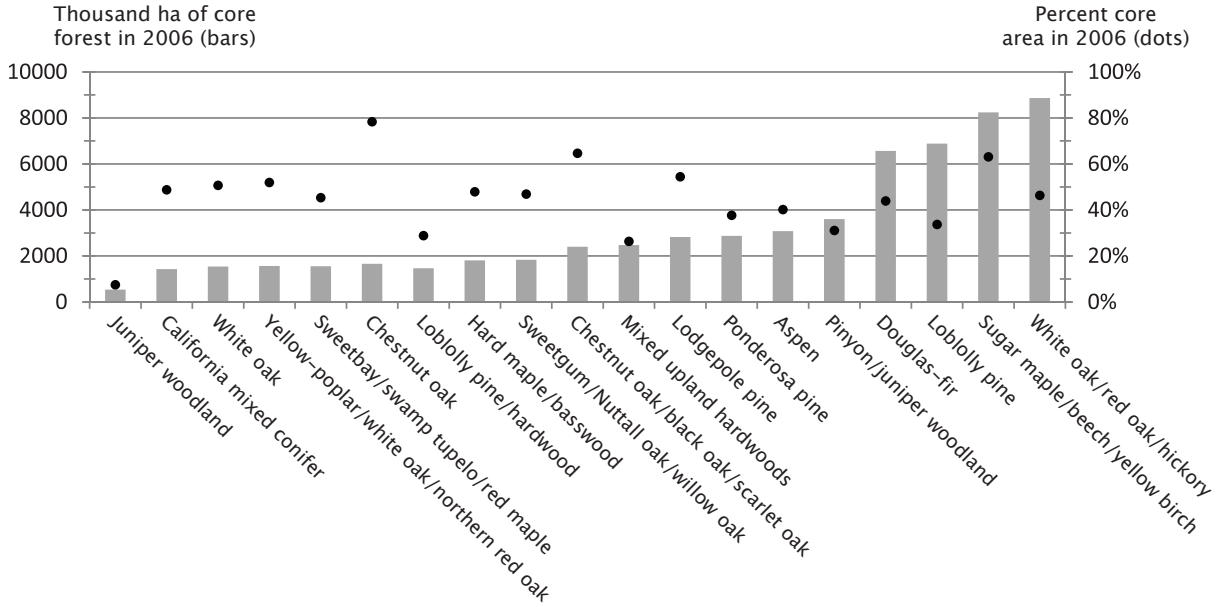

Figure 7.3—Core area and percentage of total area that was core in 2006 for the 19 forest types in the "dominant" group of forest types.

Table 7.2—The 20 forest types in the conterminous United States with the largest net losses of core area from 2001 to 2006

Forest type[a]	Net loss of core area	Share of 2006 core area in public ownership
	thousand ha	*percent*
Loblolly pine*	522	11.1
Douglas-fir*	361	75.2
Loblolly pine/hardwood*	269	12.0
Mixed upland hardwoods*	232	15.4
Sugar maple/beech/yellow birch*	193	30.0
White oak/red oak/hickory*	174	22.4
Ponderosa pine*	110	72.0
Aspen*	107	61.7
Slash pine	102	28.8
Sweetgum/yellow-poplar	100	13.0
Sweetbay/swamp tupelo/red maple*	99	27.6
Lodgepole pine*	98	95.0
Sweetgum/Nuttall oak/willow oak*	73	19.2
Post oak/blackjack oak	63	10.7
Yellow-poplar/white oak/northern red oak*	60	23.8
California mixed conifer*	59	76.1
Chestnut oak/black oak/scarlet oak*	50	37.8
Pinyon/juniper woodland*	50	86.5
Western hemlock	46	77.9
Cherry/white ash/yellow-poplar	43	15.9

[a] Asterisks indicate forest types included in the "dominant" group of forest types (see text for explanation).

Table 7.3—The 20 forest types in the conterminous United States with the largest percentage of core area loss from 2001 to 2006

Forest type[a]	Net loss of core area	Share of 2006 core area in public ownership
	percent	
Sitka spruce	31.3	36.7
Giant chinkapin	24.9	71.1
Loblolly pine/hardwood*	15.5	12.0
Oregon white oak	14.4	26.8
Longleaf pine/oak	14.3	50.3
Southern scrub oak	13.6	35.0
Sweetgum/yellow-poplar	11.9	13.0
Cottonwood	11.3	40.3
Bigleaf maple	10.7	42.3
Longleaf pine	9.7	56.5
Baldcypress/pondcypress	9.6	55.3
Sassafras/persimmon	8.8	19.1
Western larch	8.7	83.5
Mixed upland hardwoods*	8.6	15.4
Gray birch	8.4	10.2
Willow	8.4	46.7
Tanoak	8.3	38.1
Slash pine	7.6	28.8
Red alder	7.4	39.3
Loblolly pine*	7.1	11.1

[a] Asterisks indicate forest types included in the "dominant" group of forest types (see text for explanation).

data, we were able to substantially increase the thematic resolution of forest to determine which forest types and ownerships were experiencing more or less fragmentation. The lack of core forest in a relatively small (4.41-ha) neighborhood is a sensitive indicator of local fragmentation, and forest types or ownerships that are not fully forested over such small extents are also (by definition) not intact over larger extents. We expect that all estimates of percentage intact forest would be dramatically lower if larger neighborhood sizes (e.g., >10 ha) were tested (Riitters and others 2002).

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