Estimating Ownerships and Parcels of Nonindustrial Private Forestland in Massachusetts

David B. Kittredge, Anthony W. D'Amato, Paul Catanzaro, Jennifer Fish, and Brett Butler

ABSTRACT

Woodland ownership for three regions of Massachusetts is estimated using property tax assessor data. These data are nonspatially explicit and are based on commercial, industrial, residential, or other activity rather than actual land cover. A heuristic was used to aggregate similar parcels to provide an estimate of actual landownership. The estimated average statewide ownership is 17.9 ac, and when properties less than 10 ac are excluded, the average rises to 42.5 ac. The median ownership varies from east to west in the state across the spectrum of suburban development radiating from the metropolitan Boston area, with the median being 4.8, 7.8, and 8.6 ac in the eastern, central, and western part of the state, respectively. These results are compared with ownership estimates generated by the US Forest Service Forest Inventory and Analysis.

Keywords: nonindustrial private forest, parcelization, ownership, forest owners

It is estimated that nonindustrial private forest owners control nearly one-half of the forestland in the United States (i.e., 49%; Smith et al. 2004), with this percentage being even higher in the northeastern states (e.g., Massachusetts, 76%; Vermont, 78%; New York, 72%; Smith et al. 2004). The number of private owners is far from static, as land changes hands and often is divided into smaller parcels. It is estimated that average American woodland ownership will decline from a 1996 average of 25–17 ac by 2010 (Sampson and DeCoster 2000), and, likewise, the estimated number of American family forest owners increased by 11% from 1993 to 2003 (Butler and Leatherberry 2004). The overall statewide result of land changing hands and being divided can be an absolute forest loss of as much as 44 ac/day in densely populated states such as Massachusetts (MacConnell et al. 1991, Steel 1999, Alerich 2000). Indeed, the Chief of the US Forest Service has identified the loss of open space, referring primarily to the loss of private forestland, as one of the four principal threats to America's forests, and recent analysis identifies "forests on the edge" that are threatened by development (Stein et al. 2005).

In states where relatively small, private woodlands dominate the landscape, the continued provision of a wide array of environmental services depends on fully functioning ecosystems that span or are comprised of multiple ownerships. This places great importance on the future of these private woodlands and the decisions made by owners. Much has been written about the nonindustrial private forestland (NIPF) issue, in terms of better understanding owner behaviors and attitudes and program success (e.g., Snyder and Broderick 1992, Bliss et al. 1994, Bourke and Luloff 1994, Jones et al. 1995, Brunson et al. 1996, Rickenbach et al. 1998, Kittredge 2004, and Kendra and Hull 2005). Although this is vitally important, it is a daunting task, because the number of owners is so large and growing and the owners are changing.

The composite NIPF landscape is important for greater social benefits, and attitudinal research on owners provides insight into their motivations and potential successful programs, policies, and incentives. However, at the most fundamental level it is difficult to say just how many woodland owners there are in a state, average ownership size, and how those numbers change. The best estimates come from the US Forest Service Forest Inventory and Analysis (FIA) ownership surveys. Originally, estimates of the number of landowners and acres were part of a periodic survey of forest conditions. Changes in average ownership size and number of ownerships were derived, e.g., for 1973 (Kingsley 1976) and 1993 (Birch 1996), for Massachusetts. Recently, FIA changed to a continuous form of sampling to generate more frequent estimates.

The National Woodland Owner Survey (NWOS; part of FIA) bases a 2004 estimate of woodland owners in Massachusetts on mail-back and telephone survey responses gathered in 2002, 2003, and 2004. Estimates of the total area and number of private ownerships are 1,662,000 ac and 307,000 ownerships, with standard errors of 5.1 and 25.1%, respectively (Butler and Leatherberry 2005). These estimates are based on a total sample size of 48 ownerships statewide, and thus are less robust at finer scales (e.g., number of owners and area in the 1- to 9-ac class with standard errors of 28.3 and 28.4%, respectively). In contrast, FIA has produced impressively precise estimates of red oak sawtimber volume on Massachusetts timberland in 1998 (0.5% standard error), as well as the number of eastern white pine seedlings and saplings on timberland (2% standard error). Although less precise woodland owner and area estimates may be acceptable for certain general, statewide policy

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David Kittredge (dbk@nrc.umass.edu), Department of Natural Resources Conservation, University of Massachusetts–Amherst, Amherst, MA 01003, and Harvard Forest, Harvard University, Petersham, MA 01366. Anthony D'Amato (damato@umn.edu), Department of Forest Resources, University of Minnesota, 1530 Cleveland Ave. North, St. Paul, MN 55108. Paul Catanzaro (cat@umext.umass.edu), Department of Natural Resources Conservation, University of Massachusetts–Amherst, Amherst, MA 01003. Jennifer Fish (jennifer.fish@state.ma.us), Bureau of Forestry, Massachusetts Department of Conservation and Recreation, Boston, MA 02114. Brett Butler (bbutler01@fs.fed.us), US Forest Service, Northern Research Station, Holdsworth Hall, University of Massachusetts, Amherst, MA 01003. *This research was supported by the National Research Initiative of the USDA Cooperative State Research, Education, and Extension Service, Grant 2006-55101-16564, and by the Massachusetts Agriculture Experiment Station and UMass Extension. Comments from two anonymous reviewers and an Associate Editor greatly improved this article.*

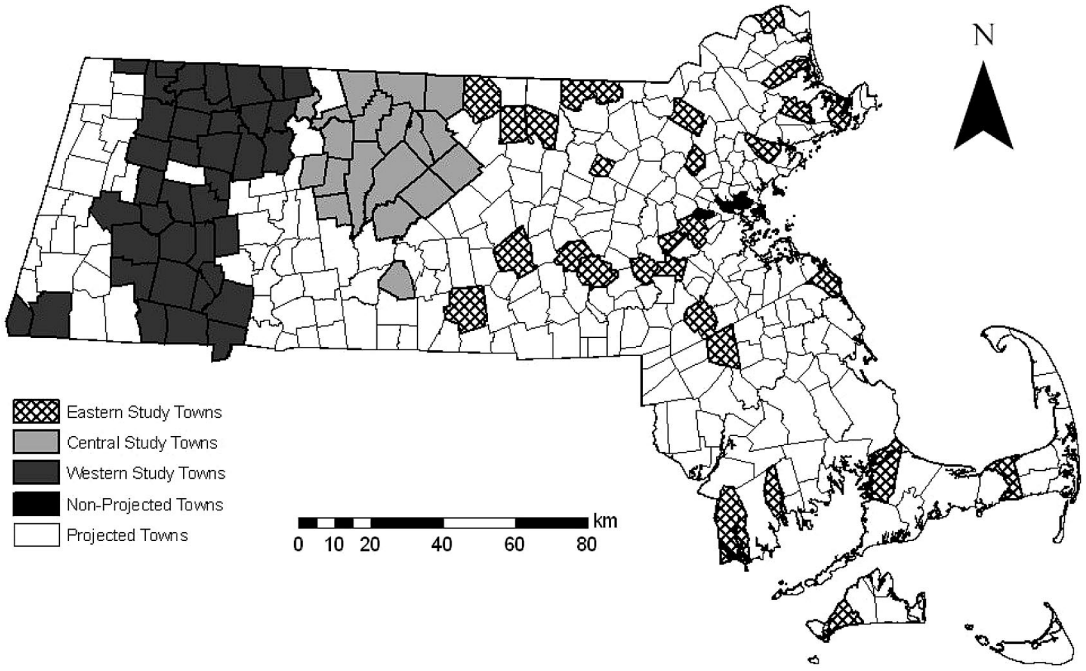

Figure 1. Distribution of the towns in Massachusetts (showing sampled towns, towns included in the projection using tax records, and excluded areas).

applications and trends, more precise estimates are necessary for monitoring changes in ownership size and number in different places within the state. These estimates would allow for an assessment of parcelization or landscape change over time. Moreover, improved estimates of the number of owners, the distribution of ownerships, and change in ownership represent important metrics in dynamic landscapes, as useful as traditional inventory information about physical and biological forest resources. As such, our specific objective was to generate alternate estimates of the number and extent of private woodland ownerships in Massachusetts and compare them with existing estimates generated by the FIA NWOS.

Methods

Local property tax records provide a useful source of data from which to estimate ownership size, number, and distribution. Property taxation is administered at the level of the individual town (n = 351 towns in Massachusetts) by assessors who periodically evaluate property to determine its value and hence the extent to which it will be taxed. We purchased property taxation records from a private service (The Warren Group, Boston, Massachusetts) for 88 Massachusetts towns in September 2005 (a total of 51,520 records for individual parcels of land of 3 acs or more). The cost of this data was $0.11 per parcel record, for a total of $ 4,227 (after we received a 25% academic discount). This represents a sample of 25% of all communities and 31.3% of all land in Massachusetts. Figure 1 shows the distribution of the towns in Massachusetts. It is important to note that the towns located in the central and western parts of the state were not selected randomly but were chosen as part of a different outreach/research project. As such, our extrapolations from this sample to the entire state were treated as an exploratory exercise on which future efforts using randomly selected towns could be based.

We purchased all data for parcels that were 3 ac and greater, under the assumption that smaller parcels would be primarily commercial or residential. Parcels that most likely did not include forestland were screened out by removing commercial and industrial properties from our data. In addition, we were solely interested in NIPFs; therefore, all public property was removed also. Parcels are coded solely by activity type (e.g., industrial, commercial, or public), so it was not possible to select only for forested parcels. Consequently, we only know in our analysis that we did not include developed land. Statewide land-use estimates indicate that most undeveloped land is forest (i.e., 80.9%), compared with a smaller fraction of open or agricultural land (MassGIS 1999). For our 88 sample towns, 83% of undeveloped land is forested. To develop the best estimate of forested ownerships, we adjusted our estimates of forestland by the factor of 80.9% to account for the fact that some of this undeveloped land may be open and not forested (e.g., cropland, pasture, open land, power lines, golf courses, orchards, and nurseries). Although we do not know with certainty that we only analyzed forested parcels, we know we did not analyze developed parcels, and the remaining majority of undeveloped land is forest.

Because of historic patterns of land use and division or aggregation over hundreds of years, a given family's ownership actually may be the composite of three, five, or more individual parcels. Thus, it would be erroneous to merely derive statistics on individual parcels, because, effectively, they may abut and be owned, managed, and treated in aggregate by one person or family. The parcel data we purchased were only marginally spatially explicit in that each parcel had a location (e.g., "Mill Street") but were not mapped. In recognition of this peculiarity of the data, we needed a heuristic that we could apply objectively to aggregate parcels to the best of our ability into our estimate of what we refer to as ownerships. We considered an ownership to be composed of parcels existing in the same town, with a location on the same road, and to be owned by people with the same last name and same mailing address, or different owner last names but with the same mailing address. Original parcel data were converted to our estimate of ownerships for each town by summing the acreage in each unique town, owner last name, location, and mailing address combination using the PROC MEANS function in SAS version 9.1 (SAS Institute 2005). The result of this process was

Table 1. Population density and percent forest cover for study towns and entire state of Massachusetts.

	Population density (people/mi^2)		Percent forest	
	Mean (SE)	Range	Mean (SE)	Range
Study towns (n = 88)	432.86 (94.10)	5.8–4403.5	67.7 (2.4)	3.5–93.8
Entire state (n = 351)	1059.3 (103.84)	0.7–17645.8	51.7 (1.2)	0.0–93.8

Source: Percent forest and population density data are from MassGIS (1999) and Massachusetts Department of Revenue (2005), respectively.

Table 2. Distribution of private forest parcels and ownerships by size class within the east, central, and west sample towns.

Size of forest landholdings (ac)	Number of parcels				Number of ownerships			
	East	Central	West	Total	East	Central	West	Total
3–9	10,474	6,303	10,753	27,530	9,071	5,067	8,461	22,599
10–49	3,060	3,393	6,163	12,616	2,827	2,808	5,154	10,789
50–99	325	614	1,375	2,314	340	624	1,299	2,263
100–499	103	197	584	884	134	246	722	1,102
500–999	0	6	12	18	2	7	13	22
1,000–4,999	0	0	1	1	0	2	1	3
Total	13,962	10,513	18,888	43,363	12,374	8,754	15,650	36,778

Table 3. Summary statistics for private forest parcels and ownerships within the east, central, and west study areas.

	Parcel acreage				Ownership acreage			
Study area	n	Mean (SE)	Median	Range	n	Mean (SE)	Median	Range
East	13,962	10.62 (0.17)	4.71	2.41–448.19	12,374	11.74 (0.21)	4.83	2.41–714.35
Central	10,513	17.28 (0.30)	7.28	2.41–809.00	8,754	20.19 (0.43)	7.79	2.41–1198.55
West	18,888	20.66 (0.27)	8.09	2.41–1382.04	15,650	24.36 (0.36)	8.58	2.41–1538.67

All parcel means and ownership means differ at $P = 0.01$.

exported as a new spreadsheet and the ownership heuristic was used to manually combine parcels (e.g., parcels with multiple entries under the same owner).

Once we generated a list of estimated ownerships for 88 towns, we expanded that to project what we believe to be the number of ownerships statewide. Our sample towns on average were 68.1% forested (ranging from 3.5 to 93.8%; standard error of 2.4%), and had a mean population density of 425.1 people/mi^2 (ranging from 5.8 to 4,403.5; standard error of 94.1; see Table 1 for a comparison of sample towns and the state). We did not expand our data to project ownerships throughout the entire state, because some of Massachusetts is heavily urbanized/suburbanized. Instead, we limited our projection to additional towns that fell within the percent forested and population density ranges of our sampled towns, resulting in ownership projections for 254 additional towns. Thus, we generated a projection of ownership for 342 towns, representing 97.5% of all towns and 99.4% of all land.

The projection of ownerships from our original 88-town database involved three main steps. First, the original 88-town database was divided into percentiles (using 5% increments) based on the number of forested acres in each respective town. Second, the median number of ownerships in each percentile was recorded due to skewed within percentile ownership distributions. Finally, each town without ownership data was assigned to a percentile (based on the number of forested acres) and assigned the median number of ownerships in that percentile as an estimate of the number of ownerships for that town.

Comparisons are made with estimates from the US Forest Service, FIA's NWOS. On an annual basis, the NWOS contacts approximately 6,500 private forest owners from across the country. These owners are selected randomly using an area-based sampling frame. This design requires the use of simple random sample estimation procedures to produce population-level estimates related to area of forestland and probability proportional to size estimation procedures to produce estimates related to numbers of owners. The NWOS uses a self-administered mail-based survey that follows the recommendations outlined by Dillman (2001). One hundred four Massachusetts family forest owners were asked to participate in the NWOS between 2002 and 2006. Of this group, 89 owners participated yielding an 85.5% response rate. For full details of the design, implementation, and analysis of the NWOS see Butler et al. (2005).

Results

Parcels versus Ownerships

Table 2 shows the estimated distribution of both parcels and ownerships by size class for the sample towns. Kolmogorov-Smirnov tests for goodness-of-fit indicated that the size class distributions of private forest parcels and ownerships differed significantly among the three study areas ($P < 0.0001$). Note that without our aggregation heuristic, we were dealing with a total of 43,363 individual private parcels in 88 towns, and the aggregation resulted in 36,778 ownerships (a change of 6,585 parcels, or a reduction of 15.2%). Our aggregation resulted in the median ownership being 2.5, 7.0, and 6.1% larger than the average parcel, in the east, central, and western area, respectively (Table 3).

Regional Differences

Mean parcel and ownership size were significantly different in the three different study areas within Massachusetts (Table 3). As one proceeds west and away from metropolitan Boston, median ownership size increases from 4.8 to 7.8 to 8.6 ac in our three sample regions. Similarly, the percentage of landowners with larger ownerships also increases in a similar manner (Figure 2). Of note is that the

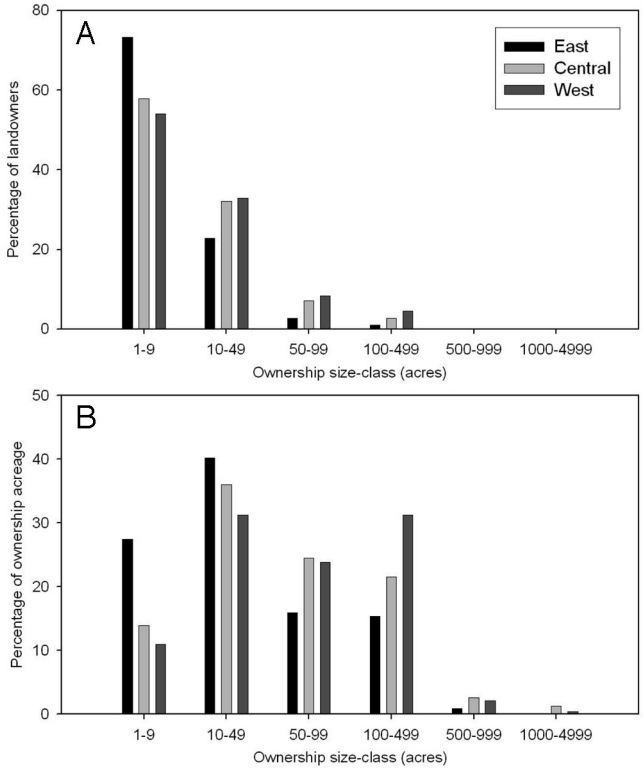

Figure 2. Distribution of the (a) percentage of private ownerships and (b) percentage of ownership acres by size class for the east, central, and west study areas (see Figure 1 for study area locations).

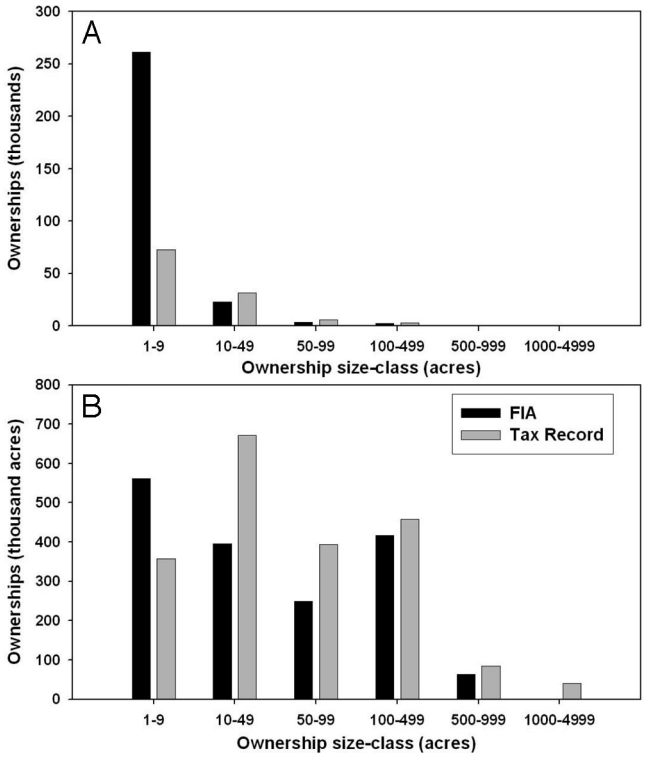

Figure 3. Distribution of FIA and tax record-based projections for private ownerships by size class in (a) thousands of ownerships and (b) thousands of acres (note that FIA counted ownerships down to 1 ac, whereas the tax record approach only counted 3 ac and larger).

median estimated ownership size for the central part of Massachusetts is still relatively large, despite that region being only a 1-hour commute from Boston itself and even closer to the suburban development that surrounds it. In addition, it is surprising that a few very large ownerships still remain in the East and central portions of the state (Figure 2).

Estimated Statewide Ownerships and Comparison with FIA Estimates

Table 4 shows the result of the projection or estimation of the number of ownerships statewide based on our 88-town sample. We estimate an average woodland ownership statewide of 17.9 ac, and when those smaller than 10 ac are excluded, an average ownership of 42.5 ac is seen. FIA NWOS, which includes owners with 1ac or more of forestland, estimates an overall average ownership size of 5.4 ac, and when those ownerships less than 10 ac are excluded, the average rises to 42.0 ac.

Overall, our approach estimates a total of 111,706 ownerships statewide (and 38,798 with more than 10 ac) in 2,004,325 ac. FIA estimates 307,000 ownerships statewide, with a much smaller number in properties greater than 10 ac (i.e., 28,000). The distribution of the estimated number of acres and ownerships by size class differed significantly between the FIA approach and our approach using tax records (Figure 3; Kolmogorov-Smirnov tests for goodness-of-fit, $P < 0.0001$). The large discrepancy in the 1- to 9-ac class between approaches is likely because of the fact that FIA includes ownerships as small as 1 ac, whereas we excluded any parcel from our analysis that was less than 3 ac. Interestingly, our approach estimates many more ownerships in the larger ownership size classes, despite using a similar approach to FIA NWOS estimates (i.e., estimating total forestland holdings versus parcels). Based on the small

Table 4. Estimated area and number of private forest ownerships and parcels in Massachusetts by size of forest landholdings, 2005, projected from an 88-town data set.

	Ownerships					Parcels				
Size of forest (ac)	Area (ac)	Percent of acreage	No. of ownerships	Percent of ownerships	N^a	Area (ac)	Percent of acreage	No. of parcels	Percent of parcels	n
3–9	356,640.1	17.8	72,908	64.6	22,599	401,918.4	20.1	84,151	66.0	27,530
10–49	671,809.1	33.5	31,509	27.9	10,789	771,472.4	38.5	35,440	27.8	12,616
50–99	393,185.8	19.6	5,507	4.9	2,263	390,265.3	19.5	5,673	4.5	2,314
100–499	458,157.6	22.9	2,727	2.4	1,102	345,932.3	17.3	2,078	1.6	884
500–999	84,986.9	4.2	131	0.1	22	85,062.3	4.2	130	0.1	18
1,000–4,999	39,545.5	2.0	22	<0.1	3	9,674.3	0.5	7	<0.1	1
5,000+	0	0	0	0	0	0	0	0	0	0
Total	2,004,325.0	100.0	111,706	100.0	36,778	2,004,325.0	100.0	127,478	100.0	43,363

[a]Number of ownership and parcel records, respectively, used in generating estimates.

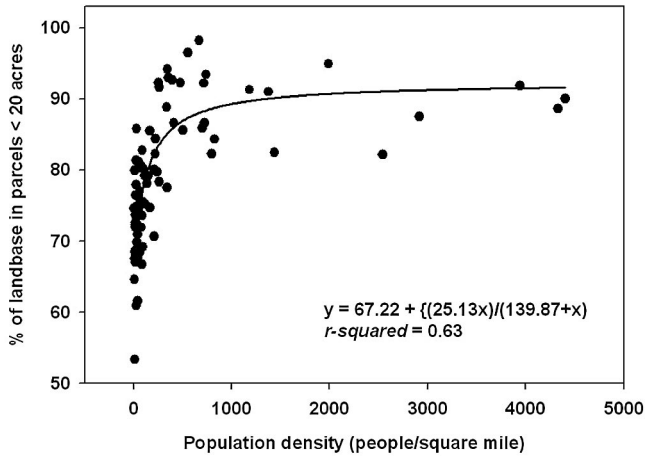

Figure 4. Relationship between population density and percentage of forest parcels less than 20 acs within a subsample of towns (n = 88) in Massachusetts.

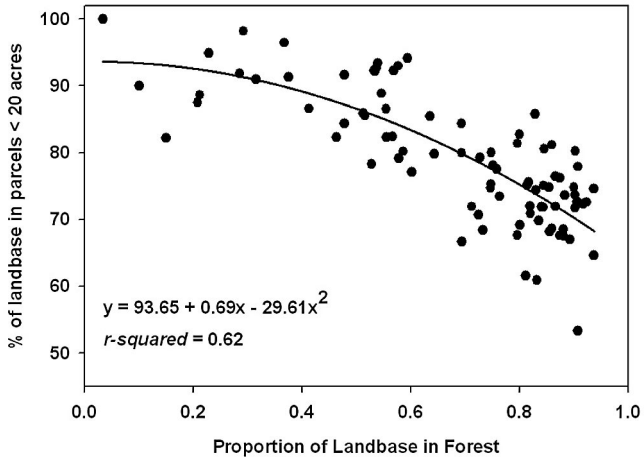

Figure 5. Relationship between proportion of land base in forest cover and proportion of forest parcels less than 20 ac within a subsample of towns (n = 88) in Massachusetts.

number of samples used for generating the FIA NWOS estimates (n = 89), as well as reported standard errors around FIA estimates at the level of individual size classes (e.g., standard errors for FIA NWOS 2006 family forest ownership acreages range from 26,494 to 64,093 ac), there is more variation associated with the FIA estimates.

Estimates of Parcelization with Respect to Population Density and Extent of Forest

We saw the original, nonaggregated parcel data from 88 towns as an opportunity to explore the degree of parcelization occurring in Massachusetts communities. As a proxy for or index of parcelization, we used the percent of a town's land that is in parcels smaller than 20 ac. This is a more meaningful indicator than the average parcel size, because that can be heavily skewed by many small observations. The proportion of a town's land in parcels smaller than 20 ac gives a good indication of the extent to which there is still land of sufficient size for management.

Using data from our regional 88-town sample, we modeled the percentage of a town's parcels less than 20 ac as a function of population density (Figure 4). As population density in a town exceeds 250–500/mi^2, the proportion of parcels less than 20 ac increases dramatically. Forest management on smaller parcels is unlikely because of economies of scale (e.g., Kittredge et al. 1996). Likewise, as towns lose forest cover because of land-use change, they are likely to have a larger percentage of their area be in parcels less than 20 ac (Figure 5).

Observations and Implications

Improved knowledge of ownership size distribution allows for better monitoring of trends of parcelization and landscape change. Our results show significant differences in ownership size by region and population density, implying the ability to identify the "sprawl front" or areas where parcelization is taking place, leading to a potential decline in the ability of woodland owners to practice forestry. For example, McDonald et al. (2006) analyzed timber harvest data in Massachusetts and identified a "strong negative correlation (r = −0.89) between the proportion of forest lost to land conversion and the proportion of forest harvested" silviculturally as part of a forest management system. Similarly, they determined that local road density is the most important overall predictor of harvest, with median home price also being important. Reduction in ownership size due to parcelization could result in properties that approach a size below which harvesting and forest management is impractical (e.g., Kittredge et al. 1996).

The differences between our estimates of ownership distributions and FIA NWOS estimates regarding the ownership acreages in the smallest (1–9 ac) and larger (more than 100 ac) size classes have important implications in assessing the degree of parcelization and, correspondingly, the amount of productive timberland on the landscape. Although the FIA approach was more effective at capturing those ownerships that were likely already subjected to parcelization (1–9 ac), our approach was more effective at identifying larger ownerships where forest management still is likely to occur (Kittredge et al. 1996). Because FIA estimates of total productive timberland in a state are made to the nearest acre, our results highlight that the effective amount of timberland in the nonindustrial private ownership category probably needs to be modified to address ownership patterns and sizes. One might argue that in our depiction of eastern Massachusetts (Figure 1), with an estimated median private ownership size of 4.8 ac (Table 3), there is very little effectively productive timberland. In contrast, there are over 107,000 ac of private forestland in ownerships greater than 100 ac within the 52 towns we sampled in the central and western portions of the state (Figure 2). As such, estimates of timberland in states with a high proportion of private ownership would be improved with information on ownership size and distribution. Without the ability to quantify woodland ownership by size and region, generous or optimistic estimates of timberland in a state may result.

An improved estimate of private ownership allows for a better ability to estimate program participation, success rates, and change over time. For example, it is estimated that there are 6,000 owners (340,000 ac) enrolled in the Massachusetts current-use property taxation program for private woodland owners, and compared with the total statewide estimated number of owners more than 10 ac from our projections (38,798), it represents an approximate participation rate of 15% of eligible owners and 21% of eligible NIPF land. FIA estimates approximately 29,000 owners with more than 10 ac, resulting in an estimated program enrollment rate of 21% of eligible owners and 29% of eligible land.

FIA reports that they invest approximately $1,000 in survey administration to generate data from which their Massachusetts woodland owner estimates are made. In contrast, we invested $ 4,227 to purchase parcel data for deriving our estimates. It could be argued that this study was overkill in terms of the number of observations, because useful estimates of private woodland ownership likely could be obtained with far fewer parcel records. For example, in an exercise to evaluate the influence of our nonrandom sample on our ownership estimates, we randomly selected 13 towns from each region and reran our projections. There were only negligible differences between our original projections using all 88 towns and this reanalysis using a random subsample of 39 towns (e.g., 111,706 versus 99,949 estimated ownerships projected from the 88 and 39 sample towns, respectively), suggesting that less expensive, equally useful estimates of private woodland ownership can be obtained from fewer parcel records. Moreover, the use of a random sampling scheme in obtaining these records will allow for unbiased extrapolation to statewide trends.

Clearly, our results do not obviate the need for and importance of the FIA's NWOS, because this program provides invaluable information on private woodland owner attitudes and behaviors that complement a more robust estimate of ownership numbers and size. As such, we see an excellent opportunity to correlate ongoing NWOS attitude/behavior results with an improved estimate of ownerships statewide and regionally within a state. We believe our estimates of ownerships based on tax records were relatively easy and inexpensive to develop and provide a basis for continued monitoring to provide future estimates of effective timberland and the outward expansion of the urban/rural interface. Notably, this approach allows for the collection of a complete census of ownerships, thus providing information on areas, such as larger forest ownerships, not entirely captured by the partial census used by the NWOS. As privately dominated forest landscapes continue to be subdivided and converted to nonforest use, accurate information on where this is occurring can focus land protection and woodland owner outreach to areas where they can be most effective and keep them from areas where the horse is out of the proverbial barn, and arborists, tree wardens, and urban foresters are more appropriate resource professionals.

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