



Research Paper

Parcel size related to household behaviors affecting carbon storage in exurban residential landscapes



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HIGHLIGHTS

- Cultural norms relate to how much of a parcel is intensively maintained.
- Parcels larger than 1.1 acre (0.45 ha) typically have a part that is less maintained.
- Smaller parcels are comprehensively maintained: this may affect carbon storage.
- Parcels larger than 0.5 acre (0.20 ha) have more mature trees and more trees planted.
- Adjacent property characteristics may affect small parcel land cover.

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ABSTRACT

We investigated whether exurban parcel size might be related to homeowners' behaviors that could affect carbon balance in residential landscapes. Based on data drawn from in-depth interviews and field surveys in 26 southeast Michigan exurban households, we conclude that an approximately 1-acre (0.45 ha) size may be a critical threshold for certain behaviors, such as leaving a portion of an exurban parcel in forest or old field or retaining leaf litter on the property. Tree planting is a relevant behavior that may increase when parcels are larger than 0.5 acres (0.20 ha). Yard style of adjacent properties also appears to be related to homeowners' landscape management behaviors: conventional turf-dominated yards prevail adjacent to parcels smaller than one-acre. We used our analysis of these data to develop an exurban homeowner typology to be employed in agent based models in which homeowners' behaviors that may affect carbon balance are linked to parcel size.

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1. Introduction

This paper reports our investigation of exurban homeowners' landscape care behaviors related to carbon storage in exurban residential landscapes, a pervasive, growing land use. Housing development is a primary cause of anthropogenic landscape change worldwide (Hammer, Stewart, Winkler, Radeloff, & Voss, 2004), and much of this is 'exurban' development – low-density settlements that are contiguous with urbanized areas but typically disconnected from government services of sanitary sewer and water

(An, Brown, Nassauer, & Low, 2011). Exurban residential landscape dynamics operate within coupled natural and human systems (CNHS) that affect ecosystem services at local scales and aggregate to affect global processes (Hammer et al., 2004; Liu et al., 2007; Radeloff, Hammer, & Stewart, 2005; Theobald, 2005), and household-scale mechanisms are core elements of these systems (Cook, Hall, & Larson, 2012; Fissore et al., 2011). The large parcel size that characterizes exurban landscapes creates a powerful legacy effect, ensuring that exurban households occupy disproportionately large areas of land, and Americans have repeatedly expressed a preference for living in large lot residential development (Alig, Kline, & Lichtenstein, 2004; Fernandez, Brown, Marans, & Nassauer, 2005; Talen, 2001). By 2001, about 4% of the land area of the coterminous US was in exurban development, which was the fastest growing land use, increasing fivefold in the last half of the 20th century (Brown, Johnson, Loveland, & Theobald, 2005; Heimlich &

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Anderson, 2001; Vesterby & Krupa, 2002). In the Upper Great Lakes Region alone metropolitan regions doubled in size over the last 20 years, despite relatively low population growth (Pijanowski & Robinson, 2011).

We investigated whether homeowner behaviors that could affect carbon storage might be related to parcel size, and whether some of these behaviors might be related to social norms, including expectations for neatness or for matching the yard style of nearby neighbors. Behaviors we explored include: managing part of the parcel to be less neat or untended, maintaining existing trees, including canopy trees in the mown part of the parcel, planting trees, and disposing of leaf litter. We also posited that other homeowner behaviors that could indirectly affect carbon storage by encouraging more woody vegetation might vary with parcel size. These were having an enclosed backyard, having a backyard that was not extremely neat, and enjoying viewing wildlife on the property. We also investigated the used of lawn fertilizer for a possible relationship with parcels' having higher proportions of turf.

Parcel size is driven by land use controls, perceived market demand, and land development decisions by regulators and developers (Vigmostad, 2004) as well as social norms (Grove et al., 2006; Harris et al., 2012; Nassauer, Wang, & Dayrell, 2009). In addition, homebuyers sort themselves within the residential real estate market according to their preferences and buying power. Regardless of sorting behavior, homebuyers who become homeowners change their parcels, managing vegetation and sometimes changing land cover.

Our study focused on exurban areas in 10 counties in southeast Michigan that vary in population density from urban to rural. The investigation we report here is part of a larger examination of exurban residential development, which links developer choices, homeowner behaviors, land markets, and the ecological dynamics of vegetation and soils to understand drivers of exurban landscape change related to landscape carbon balance.

Exurban areas and carbon storage. Exurban areas, characterized by relatively low population density and large parcel sizes, have been described as having particular ecological effects and associated ecosystem services based on land cover types and patterns (e.g., Brown, Pijanowski, & Duh, 2000), surface hydrology (e.g., Armstrong & Stedman, 2012; Groffman et al., 2003), and terrestrial habitat quality (e.g., Hansen et al., 2005). For example, exurban residential land use may enhance nutrient cycling and downstream hydrology compared with either agriculture or denser, more impervious urban land cover (Armstrong & Stedman, 2012; Nassauer, Allan, Johengen, Kosek, & Infante, 2004), and may increase forest cover on former cropland in some biomes (Brown et al., 2008).

Compared with cropland, forest and grassland sequester more carbon (Laganier, Angers, & Pare, 2009; Rhemtulla, Mladenoff, & Clayton, 2009). While carbon storage rates in urban forests may vary substantially from state to state (Nowak, Greenfield, Hoehn, & Lapoint, 2013), residential areas that have more forest (including canopied turf areas), as well as management that retains dead wood and leaf litter rather than burning or transporting it, may store more carbon than conventional turf-grass landscapes (Fissore et al., 2012; Milesi et al., 2005; Morris & Bagby, 2008).

Exurban land use and parcel size. Highly relevant to our investigation, Robinson (2012) found that, across the range of relatively large parcel sizes that characterize exurbia, the forested proportion of a parcel increased with parcel size. Using 10 m land cover and parcel data for three southeast Michigan townships, he found that mean patch size of forest or other "natural" area increased exponentially with increased parcel size. Large parcels with large proportions of forest were likely to be adjacent to similar parcels (Robinson, 2009), and as parcel size increased, connected habitat patch size increased. The proportion of the parcel in turf or impervious surfaces decreased with increased parcel size. Importantly,

Robinson (2012) suggested that this may occur because there are "limits to anthropogenic management of land within parcels with increasing size" (p. 95).

Other studies describe a relationship between parcel size and homeowner behavior. Vermont exurban homeowners' willingness to include forests on their properties was found to be partially dependent on parcel size (Erickson, Lovell, & Méndez, 2011). In southeast Michigan, small, private forest owners were found to take a 'hands-off' approach to forest management, allowing land to revert to forest near stream and field edges (Erickson, Ryan, & De Young, 2002).

Residential behaviors, demographics, and social norms. Homeowner behaviors that affect landscape carbon storage may be related to household demographic characteristics. A Baltimore, MD, study found that while demographic characteristics alone were not strongly related to land cover, combinations of demographic characteristics (e.g., family size, education, ethnicity, marriage), aggregated within US Census blocks, were related to proportion of forest or grass cover (Troy, Grove, O'Neil-Dunne, Pickett, & Cadenasso, 2007). They inferred that household land management decisions are influenced by a desire to assert influence within a group.

This is consistent with research demonstrating that residential landscape behaviors are significantly influenced by societal and community norms (Blaine, Clayton, Robbins, & Grewal, 2012; Lovejoy, Handy, & Mokhtarian, 2010; Nassauer et al., 2009). A homeowner's property is a means of self-presentation, and it is typically intended to be viewed by others (Nassauer, 1988). Physical evidence of landscape care is critical to self-presentation as a "good neighbor". It connotes civility or neighborliness, safety, and marketability or productivity. Widely recognized evidence of care in residential landscapes includes: mown turf, trimmed trees and hedges or neat rows, colorful flowers, and visible, crisp edges of different patch types (Nassauer, 2011). While excessive mowing, paving, irrigation, or application of herbicides or pesticides have well-known detrimental environmental effects, these behaviors are motivated in part by a desire to maintain a neat landscape appearance (Nassauer, 1997). Parts of residential landscapes that store more carbon than turf-grass alone (i.e., "brushy" areas, downed dead wood, small wetlands, remnant patches) often look less well-cared-for, and consequently may be removed to conform with neatness norms (Nassauer, 1995).

In exurban residential properties, front yards exhibit a higher level of tidiness, expressing care, than do backyards (Harris & Brown, 1996; Hess, 2008; Schroeder, 1993). Backyards may be more varied in their maintenance and usage, allowing more flexible, innovative, and personal design and maintenance choices (Larsen & Harlan, 2006; Quayle & van der Lieck, 1997).

Compared with broader cultural norms, neighborhood norms may more powerfully influence homeowner yard management. A southeast Michigan study found that the land cover in adjacent neighbors' front yards dramatically affected exurban homeowner preferences for their own front yards (Nassauer et al., 2009). Local area norms also were found to strongly affect preference for habitat of residential landscapes in Perth, AU (Kurz & Baudains, 2012), and group identity was found to affect neighborhood vegetative characteristics in Baltimore, MD (Boone, Cadenasso, Grove, Schwarz, & Buckley, 2010). Finally, a study in Ann Arbor, MI, found that certain front yard garden features were more likely to be observed if a nearby property had the same features (Hunter & Brown, 2012). These studies all suggest that neighborhood norms strongly influence homeowners' choices of land covers and management regimes.

Research in social psychology (Asch, 1951; Crutchfield, 1955) and economics (Bernheim, 1994; Bikhchandani, Hirshleifer, & Welch, 1992) concludes that individuals tend to adjust their

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