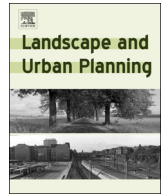




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Research Paper

## Household and block level influences on residential fertilizer use

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## ARTICLE INFO

## Keywords:

Landscape preferences  
Environmental behavior  
Fertilizer  
Nitrogen  
Urban ecology  
Residential lawns

## ABSTRACT

Urban and suburban lawns make up a large share of land use in the US. Maintaining lawns to fulfill aesthetic norms has environmental consequences. In this analysis, we examine household decisions to apply nitrogen-containing lawn fertilizer. Using survey data of 298 households in Nashville, Tennessee, we first examine the prevalence of fertilizer use and the rate of annual nitrogen applied. We find that the resulting distribution is skewed, with the top 20% of the sample applying 56% of the total share of nitrogen. In contrast to this subset of “intensive” fertilizers, 93% of households applied at or below levels recommended by landscaping professionals, challenging the assumption that the over-application of fertilizer is widespread. We employed multi-level modeling to examine the relative importance of household- and block-level characteristics on fertilizer use and the intensity of use. Consistent with prior work, we find that the desire for a green lawn is a significant predictor of fertilizer use. However, we also find that living on a wealthy block and living near others who value a green lawn independently predict fertilizer use. In addition, we observe that intensive fertilizing households tend to be less wealthy than others on their block, suggesting the possibility of an aspirational dimension to fertilizer use. Finally, we find evidence that environmental concern is associated with less intensive fertilizer use, suggesting that households may be willing to take some steps to mitigate the impact of their lawn care on the environment.

## 1. Introduction

Lawns take up more space in the United States than most staple crops (Milesi et al., 2005). Depending on how they are managed, lawns can provide some environmental benefits including carbon sequestration and the management of storm water runoff (Bandaranayake, Qian, Parton, Ojima, & Follett, 2003; Brabec, Schulte, & Richards, 2002; Milesi et al., 2005). Yet, maintaining turfgrass to fulfill today’s aesthetic norms often requires intensive irrigation, mowing, and the application of chemicals, which can result in a multitude of environmental impacts (Kjelgren, Rupp, & Kilgren, 2000; Priest, Williams, & Bridgman, 2000; Reid, Pollard, Sullivan, & Shaw, 2010).

In this analysis, we focus on the use of nitrogen-containing lawn fertilizer. Multiple studies have demonstrated a link between the use of fertilizer for lawn maintenance and subsequent eutrophication and pollution impacts on local water bodies (e.g., Barth, 1995; Frank, O’Reilly, Crum, & Calhoun, 2006; Guillard & Kopp, 2004; Lake, 2002; Shuman, 2002). Nitrate resulting from fertilizer contributes to algae blooms that can kill and displace aquatic wildlife (Anderson, 2007; Carpenter et al., 1998; Heisler et al., 2008). Over-fertilizing also

aggravates pest problems and accelerates the growth of grass, requiring more mowing and irrigation (Buss, 2007; UCIPM, 2016). Other analyses reveal the contribution of lawn fertilizer to greenhouse gas (GHG) emissions. The production of a typical nitrogen fertilizer product results in approximately 5.3–7.6 kg (kg) of carbon dioxide equivalents per kg of nitrogen produced (Wood & Cowie, 2004). Therefore, a standard 40-pound bag of lawn fertilizer comprised of 32% nitrogen produces 31–44 kg of carbon dioxide equivalents; roughly equal to driving an average passenger vehicle in the U.S. for over 70 miles (Environmental Protection Agency., 2016). Fertilized lawns are also net contributors to climate change through the direct emission of nitrous oxide, a powerful greenhouse gas (Gu, Crane, Hornberger, & Carrico, 2015).

Given these findings, the factors that motivate household-level lawn management decisions, and fertilizer use in particular, could provide important insights into how to reduce the environmental impacts of lawns. This is particularly true of those who over-fertilize. Not only are these individuals using a carbon-intensive product; but intensely managed lawns (involving above average use of fertilizer and irrigation) have a 70% higher global warming potential from direct emissions compared to lawns that are not fertilized or irrigated (Gu et al., 2015).

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<https://doi.org/10.1016/j.landurbplan.2018.05.008>

Received 24 March 2017; Received in revised form 30 April 2018; Accepted 7 May 2018  
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Furthermore, lawn management intensity has a nonlinear relationship with GHG emissions and diminishing returns on the productivity of the crop (Gu et al., 2015). Recognizing this, a number of government and industry outreach efforts have attempted to educate households regarding best practices in fertilizer use and other lawn management behaviors (Environmental Protection Agency., 2004; Frank, 2005; Southeast Oakland County Water Authority (SOCWA), 2011; USFWS., 2000); urging households to use the correct amount of fertilizer (USFWS, 2000), to pay close attention to package instructions (USFWS, 2000), or to hire a lawn care provider so as not to over-fertilize (University of Florida IFAS Extension, Florida-Friendly Landscaping Program, & Florida Department of Environmental Protection, 2015).

Despite the significant environmental repercussions of lawn care behavior, there is relatively little data regarding how much fertilizer households actually apply to their lawns (for exceptions, see Fissore et al., 2012; Fraser, Bazuin, Band, & Grove, 2013; Martini, Nelson, Hobbie, & Baker, 2013). Furthermore, we know little about the characteristics of households that apply fertilizer most intensively relative to their peers. This paper attempts to fill this gap by leveraging a unique data set that contains self-reported information about lawn management practices among households nested within neighborhoods in the Nashville metropolitan area. With these data, we can examine heterogeneity in fertilizer use and the intensity of use, as well as the household and neighborhood level correlates of these behaviors. More specifically, this paper addresses the following research questions:

- (1) What is the distribution of the amount of Nitrogen-containing fertilizer applied by households?
- (2) What is the relative importance of aesthetic preferences, environmental concern, and perceived neighborhood lawn care norms on a household's use of fertilizer and the intensity of fertilizer use?
- (3) After taking into account household level variables, to what extent do aesthetic preferences, environmental concern, and lawn care norms aggregated to the block level predict household fertilizer use and the intensity of fertilizer use?

### 1.1. Correlates of lawn fertilizer use

Research on lawn management behavior has revealed a multitude of factors that influence lawn care decisions. Individual aesthetic preferences, ease of maintenance, and income are often cited as driving forces behind household lawn care behavior (Fraser et al., 2013; Larson, Casagrande, Harlan, & Yabiku, 2009; Martin, Peterson, & Stabler, 2003; Templeton, Yoo, & Zilberman, 1999; Templeton, Zilberman, & Yoo, 1998). Many individuals enjoy lawn care as a hobby or creative outlet (Harris, Martin, Polsky, Denhardt, & Nehring, 2013). Other work has stressed the importance of the social context in which these decisions are made, with a focus on norms connected to social class and neighborhood etiquette (Fraser et al., 2013; Larson et al., 2009; Nassauer, Wang, & Dayrell, 2009; Robbins, 2007). To large segments of the American public, keeping a green, well-manicured lawn is understood as an act of stewardship towards one's neighborhood, family, and broader community. As argued by Robbins and colleagues, lawn care decisions should not be thought of as acts that simply satisfy individual preferences, but rather morally-significant behaviors that relate to one's position within a broader community context (Robbins, Polderman, & Birkenholtz, 2001; Robbins & Sharp, 2010). Larsen and Harlan (2006) have demonstrated that preferences for alternative lawn aesthetics are stratified along socioeconomic lines. More specifically, middle and high-income households prefer desert landscapes and low-income households prefer grass (Larsen & Harlan, 2006). Several studies have also shown a tendency for households to mimic the landscaping preferences and decisions of their nearby neighbors (Hunter & Brown, 2012; Julien & Zmyslony, 2001; Nassauer et al., 2009; Zmyslony & Gagnon, 1998, 2000), leading to the conclusion that neighborhood norms have a substantial impact on homeowner

preferences and behaviors related to lawn care.

Socioeconomic and peer influences on lawn care practices are well documented (as described above); however, we know relatively little about the influence of pro-environmental values on fertilizer use. Given the environmental impacts of fertilizer, the desire to maintain a green lawn may be in conflict with concerns about environmental protection. Prior research suggests that a majority of households believe that lawn fertilizer is harmful to the environment and to human health (Meyer, Behe, & Heilig, 2001). However, existing literature suggests that environmental concerns play a negligible role in lawn management decisions (Nielson & Smith, 2005; Yabiku, Casagrande, & Farley-Metzger, 2007). Researchers have speculated that this is due to the countervailing pressures to fulfill obligations to one's neighbors, overwhelming environmental concerns (Nielson & Smith, 2005). However, Suh and colleagues (2016) found that the perception that lawn fertilizer has a negative impact on the environment positively predicted the use of organic fertilizer. Although their analysis did not examine whether environmental perceptions predicted fertilizer use in general, this finding may suggest that some households take steps to mitigate environmental impacts by choosing products that they perceive to cause less environmental damage, even if not choosing to avoid the use of fertilizer altogether.

### 1.2. Research objectives & contributions to existing literature

The analyses presented below make several contributions to the existing literature. First, like other recent analyses, we examine the relative influence of aesthetic preferences, environmental concern, and neighborhood norms of lawn care on the decision to apply nitrogen-containing lawn fertilizer. We extend prior work by responding to appeals to consider the multi-scalar influences on lawn management decisions (Chowdhury, Larson, Grove, & Polsky, 2011; Cook, Hall, & Larson, 2012). As such, we measure these variables both at the household and block levels, allowing us to disentangle the relative importance of a household's preferences and beliefs from block-level norms surrounding those same preferences and beliefs.

We also advance existing literature by focusing not only on the decision to apply fertilizer, but also the intensity of fertilizer use. Other work suggests that the distribution of fertilizer application rates is skewed (Fissore et al., 2011, 2012). This, coupled with empirical evidence that intensely fertilized lawns have a disproportionate impact on environmental outcomes (Gu et al., 2015), suggests that the subset of households that fall at the high end of the distribution may deserve special attention. Recently, Martini and colleagues (2013) examined characteristics of households in Minneapolis/St. Paul that apply fertilizer as well as the characteristics of high fertilizing households. They found that high fertilizing households were better educated, more strongly believed that fertilizing produces an attractive lawn, and more strongly valued having an attractive property. They also found significant differences in fertilizer usage across communities, above and beyond these household level characteristics, suggesting contextual characteristics may also play a role in fertilizer use and intensity of use. However, an in-depth analysis of the community characteristics was beyond the scope of their analysis.

## 2. Methods

### 2.1. Overview of methodology and analyses

These data were collected as part of the Nashville Yard Project, an interdisciplinary study designed to examine the psychological, social, and institutional influences on lawn management behavior within the Richland Creek Watershed (*references omitted for double-blind review*). The Richland Creek Watershed covers 28.5 square miles of urban and suburban neighborhoods in the Nashville metropolitan area (see Fig. 1). The neighborhoods located within the watershed represent a diverse

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