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Analysis

Investigating the Impact of Agricultural Land Losses on Deforestation: Evidence From a Peri-urban Area in Canada

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ABSTRACT

Although deforestation has been studied extensively in tropical regions and developing countries, research focusing on developed countries in a peri-urban setting is scarce. This study helps to fill this gap in the literature by investigating the drivers of forest-to-agriculture conversion in one of the largest metropolitan areas and its surrounding peri-urban regions in Canada, focusing on the effect of farmland losses to development. A unique contribution of this study is that we take into account the heterogeneous forestland availability in the empirical investigation, which makes the estimation more realistic and accurate. Generalized spatial two-stage least square (GS2SLS) models are adopted to control for spillover effects from deforestation activities in neighboring areas and also to solve the potential endogeneity problem resulted from simultaneous land-use changes. Key findings include the following: agricultural land losses are an important driver for deforestation, and the magnitude of impact increases as the availability of forest-cover increases; population growth hinders the process of deforestation; high road density encourages forestland conversion to agriculture. Future policy-design shall find it helpful to incorporate the agricultural land expansion onto forestland due to land development when evaluating the social, economic, and environmental consequences of urbanization.

1. Introduction

Land use/land cover changes have drawn extensive research attention in past decades, especially in the field of deforestation (Brun et al., 2015; Meyfroidt and Lambin, 2011; Wheeler et al., 2013). The FAO Forest Resources Assessment reported an overall decline of forest both regionally and globally (FAO, 2006). A further study from Hansen et al. (2010) reported that the global rate of forest loss is currently 0.6% per year. Consequently, scholars have extensively investigated the ramifications of deforestation. For example, forest clearings were found to be major contributors to global climate change (Harris et al., 2012; Houghton, 2012), biodiversity reductions (Brooks et al., 2006; Wilcove et al., 2013) and degradation of ecosystem goods and services (Östlund et al., 2015; Schmitt et al., 2009).

Within deforestation studies, transitions and interactions between forest and agriculture have gained increasing attention (Agrawal et al., 2014; Munteanua et al., 2014). Gibbs et al. (2010) and Hosonuma et al. (2012) reported that more than 70% of deforestation could be attributed to agricultural land expansion. Managing agriculture-forest landscapes presents particular challenges to balance conservation and development (Newton et al., 2013). On the one hand, market forces and the need for increased food production to feed a growing population drive the process of agricultural land expansion (Verburg et al., 2014; Wassenaar et al., 2006), while rapid urban sprawl converts existing agricultural bases into developed uses (Jiang et al., 2012; Pandey and Seto, 2015). Although recent productivity advances have reduced the pace for agricultural land expansion, increases in crop and animal production are still driven by the increases in the land cultivated to a large extent (Rutton, 2002). This further triggers the transformation of forestland into agricultural uses. On the other hand, the general public and landowners have shown a strong preference for forest conservation in its ecosystem services and other environmental amenities through programs such as payments for ecosystem services (Alix-Garcia and Wolff, 2014). Addressing these challenges and conflicts requires considerable governance of the spatial configuration of agriculture-forest areas, and also needs in-depth investigations of what drives such land-use transitions and to what extent.

Over the decades, most attention on deforestation has been focused on tropical regions and developing countries (e.g., Brun et al., 2015; Li et al., 2015; Pfaff, 1999). Studies in developed countries, such as peri-urban areas where evident dynamics of agriculture-forest landscapes exist, are less explored. However, deforestation has become a pressing issue in these non-rural regions due to rapid urban encroachment onto agricultural land that largely triggers forestland transitions to agriculture (Cho et al., 2014). Indeed, mixed driving forces from both

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development and agricultural sectors present different and complicated phrases of forest transition in suburban areas (Drummond and Loveland, 2010; Jeon et al., 2014; MacDonald and Rudel, 2005; Rudel et al., 2005). Deforestation issues in an urban setting are of great importance and deserve more research attention. Besides the well-known environmental and ecological benefits such as the provision of wildlife habitats, biodiversity and improved air quality (Dwyer et al., 1992; Jose, 2009), urban forests offer extra social and economic benefits to urban dwellers and communities including the maintenance of enjoyable landscapes, and reduction of noise, pollution, and urban heat (Brack, 2002; Tyrvainen, 2001).

Different patterns and transitions of forest cover changes in both developing and developed countries contexts have been discussed (e.g., Jorgenson and Burns, 2007; Walker, 1993; Wolfersberger et al., 2015). Significant heterogeneity exists within the same context as well as between the two contexts (Krutilla et al., 1995; Southworth et al., 2012). For example, in many European countries, land-use planning solidifies the extent of forest-designated lands, whether public or private, so that urban development or agricultural expansion could only have a limited impact on forest (Mcgrath et al., 2015). For the New England areas in the U.S., a secondary phase of forest transition that involves a loss of forest driven by urban growth rather than agricultural expansion has been witnessed (MacDonald and Rudel, 2005; Jeon et al., 2014). Evidence also shows that tropical deforestation has been reduced in some developing countries, and these countries are experiencing the transition from net deforestation to net reforestation (Meyfroidt and Lambin, 2011; Meyfroidt et al., 2010). Literature also tends to investigate the deforestation issue in rural and non-rural settings based on various case studies (e.g., Cho et al., 2014; Deininger and Minten, 2002; Kuser, 2007; Nagendra, 2016).

Although a great deal of studies have investigated multiple factors contributing to deforestation given its complex process, the influence from agricultural land losses due to development that increasingly triggers deforestation in peri-urban areas was rarely explored. Incorporating this effect into the deforestation issue can assist policymakers in better understanding and quantifying the underlying driver of deforestation, and further, can provide empirical support to design more efficient and effective policy interventions.

The objective of this article is to examine the influence from agricultural land losses to development on deforestation. Our application is to the Alberta Capital Region in Canada, a peri-urban area where intensive urban encroachment onto agricultural land has occurred over the decade. This article makes several contributions to the current literature. First, we specifically quantify the impact of agricultural land losses to development on deforestation, in addition to other commonly examined drivers. Second, we take into account the availability of forestland in the empirical investigation and make the estimation more realistic and accurate. As will be shown in the results section, estimation obtained from the model without taking the availability into consideration could be misleading. Third, this research extends the study of peri-urban deforestation to a developed country which is still limited in the literature. Finally, we explore the spatial dependence of land use changes and adopt spatial regression models to draw efficient inferences. Results from this study can contribute to a better understanding of the peri-urban deforestation issue and also provide invaluable information to design policies to mitigate the forest-to-agriculture conversion and thus protect urban forestry.

2. Study Background

Located in the center of the prairie province Alberta in Canada, the Alberta Capital Region (ACR) is a conglomerate of municipalities surrounding the provincial capital city Edmonton (Fig. 1). The total area of ACR is approximately 1,255,000 ha. The ACR has experienced rapid economic growth and development over the decade. According to the 2011 Census, the ACR had a population of about 1.2 million, making it the sixth largest Census Metropolitan Area in Canada (CRB, 2015). During the period 2008–2013, the population in the ACR increased about 0.1 million with a growth rate of 8.6%. Such a rising trend is expected to continue over the forecast period with a net increase of over 620,000 residents by 2044 (CRB, 2015). Rapid population growth caused evident urban encroachment onto agricultural land in the ACR. It was reported that approximately 7.1% of agricultural land were converted to development in the ACR during 2000–2012 (ALI, 2014). Between 2000 and 2012, the ACR newly converted about 42,905 ha of land to developed uses; about 89.1% of the land converted to development came from the agricultural land base.[1]

Urban sprawl causes the loss of agricultural land surrounding Edmonton and further influences the local food production, and the power of developers' interest, both new industrial and residential development, continues to threaten the preservation of farmland in the Edmonton area. Unlike other provinces such as British Columbia, Quebec, and Ontario, there is no provincial-level legislative framework in Alberta for preserving prime farmland (Beckie et al., 2013). The power of development interests and the planning process itself have resulted in a land development plan that preserves little agricultural land and threatens the future of existing food production in the area (Smyth, 2015).

Alongside the increasing population and agricultural land losses to developed uses is the land transition from private forestland to agriculture. During the period 2000–2012, a total of approximately 36,000 ha forestland was cleared in the region. Detailed analyses showed that of all the conversions from forestland to non-forest uses, nearly 70% went to agriculture.[2] Despite the relatively small amount of forestry in the ACR compared to study areas in tropical regions, forestland in non-rural areas can generate special and substantial benefits for local residents and communities, as previously discussed. Urban forests not only mitigate flooding and improve air and water quality but also help create more aesthetically pleasing communities in urban or suburban areas by providing the environment amenities and other health benefits (Kuser, 2007). Two reports quantifying the economic values of urban forests in four cities across Canada (i.e., Toronto, Vancouver, Halifax, and Montreal) estimated that those forests were worth approximately $58 billion (Alexander and DePratto, 2014; Alexander and McDonald, 2014). The reports further estimated the significant economic returns on urban forests: for each dollar spent on maintenance, about $1.35 to $12.70 in benefits can be realized each year, depending on the city.

3. Econometric Models

Deforestation is caused by a complex interplay of different drivers, and there are two sets of variables generally used in the literature to act as proxies for the expected net returns/rents to agricultural and forest land uses (Li et al., 2015). The first set stems from the land's geophysical attributes such as topographic features (e.g., water availability), land quality and climate conditions like temperature and precipitation (Deininger and Minten, 2002; Pfaff et al., 2007; Wheeler et al., 2013). The second set represents socio-economic characteristics that often include the accessibility to markets or urban areas, infrastructure like network development, and population density or growth (Deininger and Minten, 2002; Li et al., 2015; Verburg et al., 2014).

Although deforestation decisions are usually made at the parcel level, not all variables influencing the expected returns to forest and agricultural land uses are observable at the same level. Rather, many variables of interest such as geographical and environmental factors often exist at the regional level (Angelsen and Kaimowitz, 1999; Pfaff, 1999; Pfaff et al., 2007). To address this issue, prior studies adapted the

[1] Source: Authors' compilation based on ALI (2014), page 79, Appendix 3: Landcover Change Matrix for the Capital Region of Alberta: 2000–2012.

[2] Source: Authors' compilation and analysis from land use and land cover data obtained from the Agriculture and Agri-Food Canada (AAFC).