Land Use Policy 59 (2016) 272–283

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Optimizing expenditures for agricultural land conservation: Spatially-explicit estimation of benefits, budgets, costs and targets

Haoluan Wang, Brent M. Swallow*

Department of Resource Economics and Environmental Sociology, University of Alberta, Edmonton, Alberta, Canada

ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form 20 June 2016
Accepted 26 July 2016
Available online 16 September 2016

Keywords:
Agricultural land conservation
Choice experiment
Spatially-explicit benefits
Cost-benefit analysis

ABSTRACT

This paper presents an empirical analysis of the optimal use of financial resources for agricultural land conservation in the Alberta Capital Region, Canada. All elements of the analysis are spatially explicit, including estimation of benefits and budgets from a choice experiment with Capital Region residents, assessed farmland value and list price data on conservation costs, and priority targets for conservation. The performance and efficiency of four targeting criteria are evaluated and compared for alternative budgets that are derived from the benefit study, applied to two sets of data on costs. The results show considerable interest in farmland conservation in the Alberta Capital Region: we estimate that a one-time increase in property taxes or rent that would generate $CAD 17.6 million would be acceptable to 75% of the population. Willingness to pay for conservation was highest for land used for commercial vegetable production, located near to primary highways and outside of city limits. However, the difference in willingness to pay to conserve such land generally does not offset the higher costs of that type of land, and efficient use of limited conservation funds would result in the targeting of lower-cost grazing lands located further from the main population centres. As expected, the branch-and-bound optimization (OPT) and benefit-cost ratio targeting (BCRT) provide more efficient use of conservation funds than either benefit targeting (BT) or cost targeting (CT).

1. Introduction

How to best utilize public funds to conserve environmental amenities has received increasing attention in economic analysis and public policy (Ando et al., 1998; Babcock et al., 1996). One strand of research explores how to allocate scarce conservation resources in the selection of sites for biological reserves (Polasky et al., 2001; Wilson et al., 2006), while another strand focuses on the conservation of land in agricultural uses, particularly through the purchase of agricultural conservation easements (ACEs). Mostly conducted in the United States, these studies show that the public has substantial willingness to pay (WTP) for ACEs and recognizes many environmental and other services resulting from these programs, such as improvements in water quality, scenic beauty and rural amenities (Duke et al., 2014; Lynch and Duke, 2007; Nickerson and Hellerstein, 2003; Yuan et al., 2015).

One of the first authors to discuss the economics of public investment in agricultural land preservation was Gardner (1977). Analysis of the benefits and costs of such investments is especially relevant when it comes to the use of agricultural conservation easements as an approach to conserving agricultural land (Duane, 2010). As these programs often involve the allocation of public funds collected through either specific taxes or general public funds (Land Trust Alliance 2004; Pidot, 2005), an appropriate objective is to maximize net public benefits subject to budget constraints (Kline and Wichelns, 1996; Poe, 1999).

Several targeting methods have been considered. Researchers initially emphasized the maximization of pure benefits of conservation programs, such as environmental amenities (Fooks and Messer, 2013; Messer, 2006). Because it ignores costs, this approach is unlikely to achieve efficient resource allocation. Techniques that integrate cost measures into priority setting have thus been developed and found to significantly increase efficiency and net public benefits (Balmford et al., 2000; Naidoo et al., 2006). Recent studies have used linear programming techniques such as the branch-and-bound optimization algorithm to take account of both benefits and costs (Kaiser and Messer, 2011; Messer, 2006).

The objective of this paper is to examine the optimal use of financial resources for agricultural land conservation for the case of the Alberta Capital Region in Canada. The paper largely follows the concepts and methods used by Duke et al. (2014) in their study of farmland conservation in the U.S. state of Delaware. The paper

* Corresponding author.
E-mail address: brent.swallow@ualberta.ca (B.M. Swallow).

http://dx.doi.org/10.1016/j.landusepol.2016.07.037
0264-8377/

makes several contributions to the current literature. First, we add to the relatively sparse literature on the use of targeting tools to quantify the efficiency of agricultural land conservation programs (see Duke et al., 2014, 2015). To our knowledge, this is the first such study in Canada or in a relatively land-abundant location such as the Canadian prairies. Second, while conservation preferences and benefits used in prior studies have been drawn from scoring or analytical hierarchy processes (e.g., Duke and Aull-Hyde, 2002; Messer, 2006; Messer and Allen, 2010) and conjoint analysis (e.g., Kline and Wichelns, 1996; Duke and Ilvento, 2004), few studies have used choice experiments to estimate nonmarket benefits (see Duke et al., 2014; Johnston and Duke, 2007). Through the attributes of our choice experiment, we have been able to generate a more thorough study of how the willingness to pay for agricultural land conservation varies across space. Third, while previous studies have used a single budget constraint (e.g., Duke et al., 2014, 2015), we consider alternative budgets that are consistent with different levels of agreement implied by the choice experiment. We also apply the optimization to two sets of spatially explicit cost data. Results drawn from this article can offer valuable empirical support for municipalities and conservation agencies to more effectively preserve agricultural land. The spatial approach employed in this article can also be further applied in other environmental valuation studies.

2. Study area and background

Located in the center of the Canadian prairie province, the Alberta Capital Region is a conglomerate of municipalities that surround Alberta's provincial Capital, Edmonton. The region covers approximately 3 million acres, which accounts for 1.9% of Alberta's land mass but holds 31.8% of Alberta's population (Capital Region Board, 2015). The area is an active agricultural region that contains some of the best farmland in the province. For example, there were a total of 2.2 million acres of farms or 4.4% of Alberta's total farm acreage in the region, which accounted for 4.6% of the province's total value of on-farm livestock and poultry in 2011 (Government of Alberta, 2012a).

Rapid population growth, a relatively diffuse employment pattern, and a lack of geographic barriers have resulted in relatively low population density and high conversion of land from agricultural to developed uses. In 2011 the Edmonton metropolitan area had an average population density of 123 persons/km^2, compared to 945/km^2 in Toronto and 238 in nearby Calgary (Statistics Canada, 2016). Between 2000 and 2012, about 95,000 acres of agricultural land was converted into developed land uses which represent a 4.3% loss of agricultural land base in the region, with the conversion mostly taken the form of suburban development on the periphery of the cities (Alberta Land Institute, 2014). Such conversions have brought substantial concerns to the provincial government and the Capital Region Board, and further led to the creation of the *Land-Use Framework* (LUF) in 2008 and the *Capital Region Land Use Plan* in 2009 to improve land-use planning. To help facilitate the efficient use of land and advance the goals outlined in the *LUF*, the Government of Alberta completed a review of tools in *Integrated Land Management Tools Compendium* (Government of Alberta, 2012b) and *Efficient Use of Land Implementation Tools Compendium* in 2014 (Government of Alberta, 2014). Both papers present potential tools for municipalities to achieve the outcome of efficient use of land strategies, including conservation easements.

3. Targeting methods

Prior studies have shown that targeting instruments can play a substantial role in optimally allocating a given budget allotted for conservation programs (Babcock et al., 1996, 1997). Several approaches have been proposed to evaluate and compare the relative efficiency of conservation programs in the literature, including benefit targeting (BT), cost targeting (CT), benefit-cost ratio targeting (BCRT), and optimization (OPT). Following Duke et al. (2014) and Messer and Allen (2010), we used all four targeting tools to comprehensively investigate the efficiency of different targeting adoptions in this article.

3.1. Benefit targeting (BT), cost targeting (CT) and benefit-cost ratio targeting (BCRT)

Benefit targeting (BT), as the name suggests, prioritizes lands that possess highest conservation benefits. This metric has been used in multiple studies regarding conservation efforts (Fooks and Messer, 2013; Messer, 2006). One advantage of this technique is that conservation agencies can easily target the lands they plan to acquire without having to consider cost information until the purchase stage. However, the downside is that such a selection outcome is likely to be cost-ineffective as it neglects costs (Duke et al., 2013). A parallel idea, cost targeting (CT), is when a conservation agency only considers conservation costs while ignoring the associated benefits. Specifically, it ranks programs solely by acquisition cost and selects the least expensive ones that can be afforded with a given budget (Ferraro, 2003). Benefit-cost ratio targeting (BCRT) selects programs with the highest benefit-cost ratios until the budget is fully spent. This approach ensures selection of programs with the highest benefit per dollar of cost, which typically generates greater cost-effectiveness than simple BT or CT (Babcock et al., 1996).

BT, CT and BCRT are all based on a sequential process. The selection is determined by ranking all available land parcels from highest to lowest based on benefits or benefit-cost ratios, lowest to highest for costs. One selects as many of the highest-ranked parcels as possible subject to a certain budget. For simplicity, we only explain the selection algorithm for BT in this paper. The algorithm holds for CT and BCRT, when benefits are replaced by costs and benefit-cost ratios, respectively. Assume an index for each land parcel, $i = 1, \ldots, j, \ldots, I$, where B_i, is the i^{th} parcel's benefit. B_i is then ranked from highest to lowest. The rank operator $R(B_1, \ldots, B_j \ldots, B_I)$ represents the rank of the all I parcels, where the land parcel with the highest benefit receives a rank of 1. The decision of whether a parcel is selected can be illustrated by a binary variable, $X_i = \{0, 1\}$, where $X_i = 1$ indicates that the i^{th} parcel is selected while $X_i = 0$ means that the i^{th} parcel is not selected. The selection of the i^{th} parcel is presented as follows,

$$X_i = 1 \; if \; C_i \le S - \sum_{1}^{i-1} C_j$$

$$X_i = 0 \; if C_i > S - \sum_{1}^{i-1} C_j$$

where C_i is the conservation costs of i^{th} land parcel and S is the budget constraint. According to the above iterative process, the selection continues until the financial resources are exhausted.

3.2. Optimization (OPT)

Although economists advocate BCRT because of its cost-effectiveness relative to BT and CT (Ferraro, 2003; Wu et al., 2001), true cost-effectiveness might not be achieved using BCRT for two reasons. First, cost is embedded as a benefit index in this measurement (Duke et al., 2013). Second, the sequenced targeting of