Ecological Economics 105 (2014) 319–329

Contents lists available at ScienceDirect

Ecological Economics

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

Analysis

Prioritizing payment for environmental services: Using nonmarket benefits and costs for optimal selection

Joshua M. Duke [a,*], Steven J. Dundas [a,1], Robert J. Johnston [b], Kent D. Messer [a]

[a] Department of Applied Economics and Statistics, University of Delaware, Newark, DE 19716, United States
[b] Department of Economics, Clark University, United States

ARTICLE INFO

Article history:
Received 23 October 2013
Received in revised form 6 May 2014
Accepted 17 June 2014
Available online 15 July 2014

Keywords:
Conservation easement
Prioritization
Benefit targeting
Cost targeting
Benefit–cost ratio targeting

ABSTRACT

This article provides a practical, applied analysis of optimal targeting in agricultural land preservation, comparing the performance of four alternative targeting strategies. Nonmarket benefit data and hedonic cost estimates are used for parcels in Sussex County, Delaware. The results show that branch-and-bound optimization (OPT) does not significantly outperform the much simpler benefit–cost ratio targeting (BCRT). However, significant losses of potential net benefits occur when applied methods overlook either benefits or costs. In this application, benefit targeting (BT) and cost targeting (CT) significantly underperform both OPT and BCRT, with BT underperforming all other methods.

1. Introduction

In his now classic article, Gardner (1977) clarified the economic rationale for public investment in land preservation. Among the justifications is the inability of the free market to allocate land efficiently in the presence of nonmarket amenities or benefits. Today, this argument is recognized to apply broadly to both conservation and preservation of natural and agricultural land uses, which deliver a host of public goods from environmental services. A large body of economic research assesses policies that ensure continued provision of these public goods; these include policies based on regulatory approaches and payments for environmental services (PES).

Several rich literatures inform the design of optimal preservation policy. For the most part these literatures have progressed independently, each offering unique insights into policy design. Yet the synergies that emerge when *combining* these insights often remain unexplored. This paper seeks to coordinate results from these multiple strands of the literature within a single application, demonstrating the policy guidance that is possible through such an integrated approach.

One branch of the literature, recently synthesized by Bergstrom and Ready (2009), quantifies the benefits of the environmental services of farmland protection so as to improve farmland preservation programs at the local, state, and national levels (Johnston and Bergstrom, 2011). The principal policy examined for agricultural land is the purchase of agricultural conservation easements (PACE). This literature shows that the public has substantial willingness to pay (WTP) for PACE and recognizes many environmental and other services resulting from these programs, such as water quality protection, habitat provision, and growth control (Duke and Aull-Hyde, 2002).

A much larger literature examines optimal conservation, including analyses of fiscal prudence and conservation targeting. Recent papers pose this in terms of the return on investment (ROI) in conservation (Murdoch et al., 2007; Withey et al., 2012). One consistent result of the targeting literature is that despite decades of research, the selection procedures of public and private entities rarely meet even minimal conditions for efficiency (Babcock et al., 1997; Duke et al., 2013; Ferraro, 2003; Messer and Allen, 2010; Ribaudo, 1986). This occurs even though, as Babcock et al. (1997) notes, it is often possible to realize efficiency gains—increasing benefits, reducing costs, or both—through relatively straightforward incorporation of economic intuition and methods into targeting strategies. As with other PES settings, agricultural land preservation decisions rarely incorporate systematic consideration of public benefits or preferences (Duke and Johnston, 2010).

Many papers in the targeting literature focus on designing new methods and assessing potential efficiency gains, with a subset also testing results with empirical data. For instance, this literature demonstrates that the incorporation of costs into preservation decisions can significantly improve efficiency (e.g., Ando et al., 1998; Balmford et al.,

* Corresponding author. Tel.: +1 302 831 1309.
E-mail addresses: duke@udel.edu (J.M. Duke), sjdundas@ncsu.edu (S.J. Dundas).
[1] Present address: Department of Economics, North Carolina State University, 4223-B Nelson Hall, Raleigh, NC 27695.

http://dx.doi.org/10.1016/j.ecolecon.2014.06.014
0921-8009/

2000; Naidoo et al., 2006; Polasky et al., 2001). Many studies examine optimal networks and connectivity (Hof and Flather, 1996; Williams et al., 2005). Other studies explicitly model other aspects of spatial conservation (Knight et al., 2009; Pfaff and Sanchez-Azofeifa, 2004). In addition, numerous studies develop optimal methods to deliver desired ecological measures such as population viability (Bode and Brennan, 2011) and averted species losses (Withey et al., 2012). A growing trend within this literature is to inform optimal conservation using empirical measures (for instance, Lewis et al., 2011). Several of these studies are integrated, including applications to carbon sequestration and species conservation in Oregon (Nelson et al., 2008) and biodiversity measures and land-use returns (Polasky et al, 2005, 2008).

Despite the insights that may be provided by purely theoretical analyses of optimal land conservation, applied studies using empirical economic measures are valuable for at least six reasons. First, Knight et al. (2007) have criticized the optimal conservation literature for not leading to sufficient implementation. Detailed applied studies, which are set in existing policy contexts, can show policy makers exactly how to implement optimal conservation and also estimate the potential efficiency gains.

Second, notwithstanding the research discussed above, there are comparatively few optimal conservation studies that incorporate empirical measures of economic benefits and costs. Although many studies incorporate benefit measures, these measures are frequently drawn from scoring, expert panels, or analytical hierarchy processes rather than methods that generate well-defined empirical measures of economic benefits and costs (e.g., Ferraro, 2003; Messer, 2006; Messer and Allen, 2010). Economic benefit measures are rarely available and expensive to collect. Using noneconomic benefit measures is probably an efficiency-enhancing step in most applied settings, but it does not guarantee optimality and can lead to perversities such as rank reversal (Duke et al., 2013). The economic-gold standard among these studies is the incorporation of economic benefit and cost measures (see an application to net benefit optimization through linear programming by Kaiser and Messer, 2011), yet these measures are not often available.

Third, the relative gains of efficient targeting within real-world settings are largely unknown.[2] This lack of knowledge about the substantive efficiency gains limits the ability of economists to promote improved targeting methods. Fourth, findings regarding the gains of efficient land conservation targeting will also inform future research. As the theoretical literature develops increasingly complex targeting strategies, accounting for more constraints and more synergies, it is important to assess whether these efforts enhance efficiency to a significant degree. Fifth, there are innumerable PES application areas, yet very few have examined land preservation. Moreover, although the targeting literature as a whole is extraordinarily large and rich, there are comparatively few agricultural land preservation studies (see Duane, 2010). This provides an important area in which economists can help inform the development of programs to enhance the efficient provision of environmental outcomes. Finally, applied targeting studies also help researchers recognize the struggles of applying "optimal policy" to a real word setting, as cautioned by Portney (2004). Often, the potential limitations of theoretical analyses only become evident during attempts to operationalize these models for real-world policy guidance.

This paper illustrates and compares the policy insights that may be gained through alternative, practical analyses that combine the theoretical insights of the optimal targeting literature with the empirical, welfare-theoretic data. Specifically, the analysis compares alternative targeting methods for land preservation that coordinate welfare-theoretic, empirical estimates of both preservation benefits and costs. The application illustrates empirical methods that both improve efficiency and could be readily applied by farmland preservation practitioners based on available data. Empirical data are used to estimate the relative efficiency of alternative methods for preservation targeting, including Benefit Targeting (BT), Cost Targeting (CT), Benefit–Cost Ratio Targeting (BCRT), and binary linear programming using the branch-and-bound optimization algorithm (OPT).

An application to agricultural land preservation in Delaware illustrates the relative performance of the four methods and the resulting efficiency gains. Unlike some prior analyses that are based on a more abstract "policy" context, this analysis is specifically designed to reflect the realistic context under which the state targets land for conservation, and the data sources they have available for this targeting. Among other insights, results of the analysis characterize the relative degree of efficiency that may be promoted through full- versus partial-information targeting methods in an actual empirical setting. Two of the illustrated methods can be applied when data on either benefits or costs (but not both) is unavailable. The remaining two require data on both benefits and costs. Model results show that applied targeting strategies that include benefits and costs jointly can dramatically improve the net benefits of land preservation efforts relative to strategies based solely on benefits or costs. However, more complex methods to optimize net benefits (OPT) do not necessarily outperform simpler decision rules (BCRT), and in some practical circumstances, they can lead to almost identical results. These results suggest that relatively simple decision rules can greatly enhance the efficiency of agricultural land preservation.

2. Background on Application Setting

Located in the mid-Atlantic of the United States, Delaware is the second smallest state, with a population of 907,135 in 2011 (U.S. Census Bureau, 2012). Between 2000 and 2010, the state population grew at a rate of 14.6%, which is approximately 50% faster than rest of the country (U.S. Census Bureau, 2012). New growth has been accommodated, in part, by converting agricultural lands to residential uses. According to a recent study by Awokuse et al. (2010), the total economic contribution of all categories of agriculture in Delaware was $7.95 billion in 2008, with the vast majority of this contribution being related to the poultry industry. Despite the state's small size, poultry producers in the state sold over 51 million broiler chickens in 2007 making Delaware 8th nationally in that category (NASS, 2010).

Delaware also has one of the largest and most successful agricultural land preservation programs in the U.S. Formed in 1991, the Delaware Agricultural Lands Preservation Foundation (DALPF) is a quasi-governmental organization that is administered by the State's Department of Agriculture staff under the guidance of an external advisory board. DALPF generally has acquired development rights easements on an annual basis through a reverse auction. Funding for DALPF comes not only from state taxpayers, but also includes local and federal matching dollars. Landowner participation in the program is voluntary. Landowners interested in selling their easements must first enroll in an agricultural preservation district (APD). By enrolling in an APD, landowners agree to not develop their land for at least 10 years and to use the land solely for agriculture and related uses. Landowners receive a variety of benefits from enrolling in an APD, including reduced property taxes, right-to-farm protection, and the right to sell an easement in the future. As of September 2013, landowners enrolled 166,241 acres (32% of the estimated 520,000 acres of agriculture in Delaware) in one of the 967 APD designated areas in the state. Of the APD, DALPF purchased easements on 754 properties with 110,954 acres (21.3% of the state agricultural land) for a cost of $198,780,209 (DDA, 2013). While the average per acre cost of these easements has been $1790 since the program began (not adjusted for inflation), the average cost per acre in the past five years has been 20% higher ($2159).

[2] Armsworth et al. (2012) is a notable exception. The authors empirically demonstrate that oversimplification of payment schemes (i.e., 'umbrella' payments) may result in substantial efficiency losses and that gains may be achieved through spatial targeting of payments for biodiversity production.