4. Farmland and forest conservation: evaluation of smart growth policies and tools

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INTRODUCTION

The preservation of open space, farmland, and critical environmental areas is one of the main smart growth principles. Land preservation efforts often use limited resources to target high priority areas to protect prime farmland, contiguous forests, and environmentally sensitive areas (e.g., wetlands). Open-space protection provides amenities to nearby residents that increase local property values and creates recreational opportunities that improve community quality of life. Additionally, farmland and forests provide myriad environmental benefits that are public goods, such as habitat for species, watershed protection for clean drinking water and reduced flooding, carbon sequestration, and reductions in air pollution and urban heat island effects. Yet these public goods are often underprovided from a societal perspective. These market failures motivate the need for land use policies and programs to manage development in rural regions to preserve open space, farmland, and forest resources.

Land preservation efforts predate the smart growth movement. At the federal level, the United States started creating national parks in the late nineteenth century and now has amassed 84 million acres under the National Park Service. The US Fish and Wildlife Service manages over 89 million acres, primarily to conserve plants and animals in wildlife refuges and other areas. Additionally, the US Forest Service and Bureau of Land Management manage about 193 million and 248 million acres, respectively, on federal lands that allow multiple uses such as recreation, grazing, timber harvesting, wildlife habitat, and other uses. These four federal agencies acquired the vast majority of their land holdings prior to 1990, with a substantial portion of this land concentrated in the 11 coterminous western states and Alaska (Vincent et al., 2017).

Meanwhile, local and state governments and land trusts have focused recent smart growth preservation efforts closer to cities and towns, emphasizing farmland and open space protection. In recent elections, voters have demonstrated strong support to fund open space protection. Between 1988 and 2019, 2,096 ballot initiatives passed at the local or state level that raised more than $80 billion for public land conservation. Land trusts in the non-governmental sector play a substantial role in land conservation, with 1,363 active land trusts in 2015 nationwide, up from 535 in 1984 (Chang, 2016). Land trusts have turned increasingly toward conservation easements, which permanently limit uses of land, due in part to lower acquisition costs compared with outright purchase (fee simple title). The impressive growth in conservation easements acquired by land trusts nationwide increased to 13.3 million acres in 2010 from about 0.8 million acres in 1990 (see Table 1 in Parker & Thurman, 2019). Additionally, land trusts purchased 7.6 million acres of land outright in 2010, representing more than a threefold increase from the 2.2 million acres held in 1990. Since the late 1970s, state and local government programs have also increased land conservation, with 28 state-level programs protecting almost three million acres and 95 local programs protecting more than one million acres (Farmland Information Center, 2018). Yet, despite the goal of smart growth advocates and planners to protect rural areas, sufficient funding does not exist to preserve all rural lands from development.

While the majority of people reside in urban and suburban areas (Nechyba & Walsh, 2004), exurban large-lot development (one acre or more per house) in particular has caused substantially more farmland and forest loss in the United States. According to Brown et al., (2005), the total amount of land area developed nationwide at urban densities (more than one house per acre) increased from less than 1 percent to about 2 percent between 1950 and 2000. During the same period, the total amount of exurban land (rural residential development between 1 and 40 acres per house) increased from approximately 5 percent to 25 percent. Approximately 31 million acres of farmland was lost to development between 1992 and 2012 nationwide, including 11 million acres of prime farmland (American Farmland Trust, 2018). Heimlich and Anderson (2001) characterize two distinct types of residential development that impact agricultural and rural lands. Urban and suburban development typically require municipal sewer service for higher density (more than one house per acre). Meanwhile, exurban development (less than one house per acre) is typically serviced by individual private septic systems, thereby allowing this large-lot development to leapfrog into rural regions well beyond sewer service areas and create noncontiguous areas of fragmented forest and farmland. Heimlich and Anderson (2001) demonstrate that almost 80 percent of acreage converted to residential development occurs outside urban areas, and 94 percent of this acreage is large-lot development at one acre or more. For this reason, it is imperative to understand the effectiveness of various land use policies and programs to manage both types of development, particularly approaches that address the more challenging and pervasive impacts from exurban large-lot development.

LAND PRESERVATION MECHANISMS AND OUTCOMES

In this section, we discuss four policy approaches used to achieve smart growth goals for land conservation—regulatory techniques, incentive-based policies, participatory preservation programs, and transfer of development rights (TDR) programs (Duke & Lynch, 2006). Regulatory techniques alter the location and density of allowable development within designated areas. Incentive-based policies adjust the price in the existing market structure to encourage certain land uses through tax or subsidy mechanisms. In participatory preservation programs, government agencies and land trusts may purchase land parcels outright or create easements to retire the development rights from willing landowners. Lastly, TDR programs have developers purchase and retire development rights from willing rural landowners, in exchange for the right to develop elsewhere at higher density than allowed under current zoning. To provide a framework for improving future policy implementation, we summarize recent research findings on the prevalence and effectiveness of these policies and their indirect and unintended consequences below. We focus on the rural impacts of such tools; Carruthers, Wei, and Wostenholme (Chapter 3) and Hanlon (Chapter 5) focus on the urban impacts.

Regulatory Approaches

Regulatory approaches have been used to meet smart growth objectives for land conservation because they have low budgetary costs to governments and allow for a higher degree of spatial contiguity of land preservation than voluntary programs alone. Since regulatory approaches apply to all landowners in a given designated area, these techniques can be used for reducing development and protecting productive farmland or forest resources in contiguous areas. Yet it can sometimes be difficult to gain adequate support in the political process, because of rural landowner opposition to placing new restrictions on property rights.

Zoning regulations have been one of the primary land use policies used to reduce farmland and forest conversion. Local governments implement zoning ordinances that specify allowable land uses and maximum density restrictions (housing units per acre). A major challenge when evaluating the effectiveness of zoning in reducing farmland conversion is that these regulations are not randomly assigned across the landscape. Empirical analysis often has factors unobserved by the researcher that affect the location of zoning designations and the probability of development. Failure to account for this relationship (known as endogeneity) can introduce bias into resulting estimations. Recent parcel-level models of residential land conversion have used quasi-experimental methods, including propensity score matching and difference-in-differences, to control for endogeneity in the evaluation of zoning policies. Butsic et al. (2011) analyzed the impact of agricultural zoning on residential land conversion in Columbia County, Wisconsin. If they assumed agricultural zoning is exogenous, they found zoning significantly reduced the probability of subdivision development. However, after correcting for the endogeneity of zoning using propensity score matching methods, they found zoning did not affect the probability of development. Similarly, after addressing the endogeneity of zoning using a difference-in-differences approach, Newburn and Ferris (2016) found that downzoning in Baltimore County, Maryland, did not significantly affect the probability of development. However, this rural downzoning did substantially reduce the density of development in areas designated for agricultural preservation. Other studies have similarly found that zoning regulations have significantly reduced the density of development in rural regions (McConnell et al., 2006b; Newburn & Berck, 2006).

Urban growth boundaries (UGBs) have been established in more than a hundred cities and counties in the United States (Staley et al., 1999). UGBs are spatially designated to control the expansion of urban development, while often aiming to preserve farmland and forest outside the boundary. Given that UGBs are also non-randomly designated, quasi-experimental methods are helpful to evaluate their effectiveness. Using a difference-in-differences hazard model, Cunningham (2007) found that the UGB adopted in the greater Seattle area lowered the likelihood of new housing outside the boundary by 28 to 39 percent. Applying similar methods, Dempsey and Plantinga (2013) focus on Oregon's UGBs and reveal that in many cities the effect of UGBs did constrain some, but not all, of the urban development with considerable variation across different cities. For more on Oregon UGBs, see Carruthers et al., Chapter 3 of this book.

An important issue is that UGBs may have different effects on different residential densities. However, residential land use change models are often specified using a binary dependent variable—develop or remain undeveloped (e.g., Cunningham, 2007; Dempsey & Plantinga, 2013). This binary specification implicitly assumes that growth management policies, such as UGBs, have the same effect on all residential density types. Allowing for multiple density classes, Newburn and Berck (2006) analyzed residential development in Sonoma County, California, where eight out of nine cities adopted UGBs. They found that suburban development (more than one house per acre) is largely constrained within UGBs. Basically, the UGBs primarily limit the extension of the municipal sewer service, which is required to develop at suburban densities. Meanwhile, exurban development (less than one house per acre) that relies on private septic systems is able to leapfrog into the rural region outside the UGBs. Newburn and Berck (2011) conducted policy simulations to further investigate the effect of UGBs versus expansion of municipal sewer service infrastructure in the same region, showing that UGBs are highly effective for managing suburban development but not exurban development.

UGBs may be viewed as an urban (but not exurban) containment strategy. Yet while the conventional view is that UGBs create a sharp perimeter between urban and rural lands, in which residential subdivision development is not allowed outside the boundary, exurban development is commonly found in rural areas outside of UGBs. For instance, Baltimore County, Maryland, established a UGB in 1967, which was highly effective in containing suburban development within the boundary. However, exurban large-lot development on septic systems continued unabated until Baltimore County enacted rural downzoning regulations a decade later in 1976 (Newburn & Ferris, 2016). Exurban development outside the UGB was only curtailed after the designation of agricultural zoning (one house per 50 acres). Similarly in Sonoma County, California, agricultural zoning was found to be the most effective approach to reduce exurban development (Newburn & Berck, 2006, 2011). It is important to consider effective tools for managing the threat of exurban development, which has been the leading cause of forest and farmland conversion in the United States (Brown et al., 2005; Heimlich & Anderson, 2001).

Incentive-based Approaches

Unlike regulatory methods that restrict allowable land uses or density, incentive-based policies utilize tax or subsidy mechanisms to alter the relative returns that landowners receive in order to encourage certain land uses. Some incentive-based approaches use the property tax system to decrease the tax burden for rural land uses, aiming to preserve agricultural and other rural resource uses in the face of increasing development pressures. As one of the oldest and most common incentive-based techniques, use-value assessment (UVA) determines the landowner property tax based on the existing use value in agriculture or forestry rather than the full market value. During the 1960s and 1970s, many state governments across the United States implemented UVA programs to preserve rural land uses; now almost every state has some form of UVA program for their resource lands.

According to Anderson and England (2015), this tax differential program amounts to tens of billions of dollars annually in foregone taxes and has been a poorly targeted policy instrument that often had a limited impact on the number of acres developed. These authors provide a detailed review with several criticisms of existing UVA programs nationwide and policy recommendations. First, many state programs have lax eligibility criteria for minimum parcel size or gross farm income, which may have the unintended consequence of lowering the cost for the formation of hobby farms and ranchettes. Land preservation efforts would be more efficient when using stricter size or income criteria targeted for operations primarily in agricultural or forestry use. Second, low penalties for early withdrawal may actually lower the cost for land speculators to hold land for future development. Third, voluntary enrollment is often poorly targeted, such that properties farther away from development pressures are more likely to participate. Despite being a pervasive strategy for land preservation, quasi-experimental analysis assessing the causal impact of UVA programs on farmland preservation has been limited to date. An exception is Butsic et al. (2011) who exploit the lotsize threshold in program eligibility using a regression discontinuity design. They found that the UVA program had a weak but significant effect on lowering the probability of subdivision development.

As a novel incentive-based smart growth policy initiative, Maryland's designated priority funding areas (PFAs) are intended to encourage growth in existing urban areas while indirectly reducing sprawl in rural areas. Carruthers et al (Chapter 3) describe PFAs as the quintessential smart growth instrument. Unlike UGBs' regulatory approach, PFAs aim to restrict state spending on growth-related infrastructure (e.g., sewer, water, roads) to areas designated for urban growth. In practice, local governments have established PFAs based on existing or planned municipal sewer and water service, as well as areas with buildout densities greater than 3.5 housing units per acre. Lewis et al. (2009) analyzed every parcel developed to single-family housing on less than 20 acres in size after development, including time periods before PFAs and after. They found that PFAs have had no significant effect on the trends in development patterns. Several reasons have been put forth, including: (1) state government spending represents a minor portion of the infrastructure spending compared with local government spending; (2) the state has not restricted spending to PFAs since as much as 29 percent of state funds went to projects outside PFAs; and (3) PFAs are not required to be integrated with the local comprehensive planning process (Howland & Sohn, 2007; Lewis et al., 2009).

Another important reason for the limited effectiveness is that PFAs are designated primarily based on existing and planned sewer service infrastructure, so while they may be helpful for containing suburban and urban development, similar to UGBs, PFAs do not directly inhibit exurban development on septic systems. Lewis et al. (2009) found that about three-quarters of the acreage converted in Maryland occurred outside the PFAs as exurban large-lot development. Specifically, the average lot size was approximately 0.25 acres inside PFAs and 2 acres outside PFAs, which both exhibited similar trends over time before and after PFA implementation (see Figure 7 and Table 4 in Lewis et al., 2009). Additionally, residential land-use change models have used a binary logit model specification to analyze the effect of PFAs (Hanlon et al., 2012; Shen & Zhang, 2007). Although these studies found that residential development is more likely to occur inside PFAs, this binary model is prone to aggregation bias because it implicitly assumes that PFAs have the same effect on a wide range of residential densities. As discussed earlier, a multinomial logit model that can accommodate multiple development types is needed to understand whether growth management policies, such as PFAs or UGBs, have different effects on different types of residential densities (Newburn & Berck, 2006, 2011). The trends in Lewis et al. (2009) clearly demonstrate that PFAs have had a limited effect on exurban development after PFAs were adopted in 1998. For more on Maryland's statewide program, see M. Bierbaum, Lewis, and Chapin's discussion in Chapter 2.

Participatory Approaches for Land Preservation

Participatory approaches for land preservation include when governments or non-governmental organizations enter the land market, either purchasing land outright or the development rights to land from willing landowners. The latter approach, often referred to as purchase of development rights (PDR) or purchase of agricultural conservation easements (PACE) programs, have gained in popularity because regulatory approaches have become more difficult to pass in some regions, and landowners seek compensation for restrictions to their land uses. Under PDR/PACE programs, the rights to convert a parcel up to its allowable zoned density are restricted, often in perpetuity, in exchange for a monetary payment or tax deduction benefits.

Evaluating these types of programs can be challenging because participation is voluntary, thereby leading to potential sample selection and endogeneity concerns. Moreover, PDR/PACE programs are often used in regions that have more development pressures and higher probability of farmland conversion. Quasi-experimental methods have allowed researchers to estimate causal impacts of these programs controlling for these challenges. Propensity score matching, for example, attempts to identify an appropriate control group with similar characteristics to compare to land use outcomes in the treatment group. Using this approach, Liu and Lynch (2011) found evidence in six Mid-Atlantic states that counties having a PDR program, on average, decreased the rate of farmland loss by 40 to 55 percent and decreased farmland acres lost by 375 to 550 acres per year. Nolte et al. (2019) similarly used propensity score matching to analyze the effectiveness of conservation easements in Massachusetts, finding that protected parcels had lower rates of forest loss and conversion to developed uses relative to counterfactual parcels without protection in the control group.

Land conservation programs often report their success based primarily on the number of acres protected, but other factors also matter. Programs that target additional factors can achieve greater benefits for the same budget. To improve targeting efficiency, Newburn et al. (2005) argue that land costs, environmental benefits, and the likelihood of future land-use conversion should be integrated into conservation planning when setting targeting priorities. As an example of this framework, Newburn et al. (2006) provide a spatially explicit parcel-level model to forecast the probability of future development and acquisition costs in Sonoma County, California, where the local government has operated a land acquisition program since 1990. To lower program costs, several PDR programs have implemented an auction mechanism to determine the compensation a landowner may receive for selling their development rights. Horowitz et al. (2009) found that, while an auction mechanism allows a PDR program to enroll more acres, it chooses the parcels as those "most on sale" rather than those with the highest benefits.

Federal and state tax credits have increased over time to incentivize landowners to place land under easements or sell their property outright. Parker and Thurman (2018) found that tax incentives for donating conservation easements have dramatically increased the amount of protected land. They argue, however, that these tax incentives often target the parcels with the highest tax deductions, instead of those with the highest benefit-cost ratios that would provide the most efficient outcomes for the public. Vercammen (2019) provided a theoretical model of a tax credit program for conservation easements and similarly found that the land with high environment value may have a smaller probability of being donated for an easement. The policy implication is that land trusts need to be discriminating when selecting donated parcels for conservation easements and should reject some parcels that provide low social or environmental benefits. But this is not always the case in practice, because land trusts often want to protect as much land as possible, particularly since taxpayers in general, not the land trusts, are those affected by the foregone taxes collected from donated easements.

Spatial contiguity of conserved land is a desirable goal and one to be targeted for several reasons. First, there are additional environmental and ecological benefits when land parcels are conserved in spatially contiguous patterns (Fooks et al., 2016). Second, conserving large contiguous tracts of land generally requires lower average conservation costs for acquisition and operation costs (Lynch & Lovell, 2003). Third, a critical mass of contiguous farms may be needed when economies of scale exist in support industries (Lynch & Carpenter, 2003) and to avoid conflicts with non-farm neighbors.

In practice, research has shown mixed results regarding the spatial contiguity of land through conservation programs. Many programs accept landowners voluntarily and do not have strong mechanisms nor the budget to enroll a large number of contiguous acres. Lynch and Musser (2001) found that preservation programs were less likely to enroll contiguous parcels and those most threatened by development pressure. Stoms et al. (2009) found little evidence of easements linking with other open spaces to achieve large contiguous blocks of protected areas in the San Francisco Bay Area. In an effort to avoid the scattershot of noncontiguous protected parcels in some prior programs, Maryland created the Rural Legacy Program as part of its smart growth legislation passed in 1997. Rural Legacy Areas (RLAs) strategically restricted program spending solely to designated priority areas so to protect rural areas in a contiguous area (Lewis & Knaap, 2012). Lynch and Liu (2007) found that RLAs positively impacted preserved acres as well as increasing the probability of preservation within them.

Land preservation programs may interact at a regional scale with one another through strategic spatial behaviors (Albers et al., 2008; Parker & Thurman, 2011), such as free-riding on another program's conservation efforts or working together (i.e., crowding in/out conservation effort). For example, Albers et al. (2008) explored spatial interactions of private land trusts and public conservation programs in California, Illinois, and Massachusetts and found some evidence that private land conservation is attracted to government open-space protection. Liu and Lynch (2009) found that parcels in designated RLAs were more attractive to other preservation programs; more preservation from other programs occurs in RLAs, thereby increasing contiguity of protected land.

Even if the land has been conserved, farmland owners may not find it viable to continue agricultural activities unless they are profitable. Most easements are negative in that they typically restrict certain developed uses rather than require the continuation of agricultural or other resource uses. Therefore, what types of farms are enrolled in preservation programs and the degree to which they remain active in farming remains an important question that deserves further attention. One benefit of PDR/PACE programs is the cash payments they provide farmland owners. If farmers use this money to invest in their business, this may boost their profits and sustain their farm activities especially if they were credit-constrained. In several states, numerous farmland owners said they sold their development rights in part to improve their business viability (Esseks et al., 2013). Lynch (2007) found that landowners of preserved farms were more likely to invest than those of unpreserved farms. Lynch and Lovell (2003) also found that preserved farms were more likely to grow crops, earn a higher percentage of family income from farming, have more acres, and have a child to take over the farm business. Gottlieb et al. (2015) found that owner-operators of preserved farmland tend to be more actively engaged in their farm businesses. Operators with higher farm sales had an increased probability of investing the easement money in their farm operations, which can increase the likelihood they will remain in business and thus enhance the preservation of farmland.

Transfers of Development Rights

TDR programs are a market-based approach for land preservation. Local zoning rules provide the basis for the development rights granted to each property. TDR programs set up a market between landowners and developers, whereby willing landowners sell their development rights for properties to be preserved (sending areas) and developers buy these rights to develop elsewhere (receiving areas) at higher density than current zoning. The TDR mechanism shares elements of two other approaches—the regulatory approach of zoning, which defines the number of allowable development rights, and the participatory approach of conservation easements. The attractiveness of TDR programs within smart growth planning is that developers pay the cost of land conservation instead of taxpayers via government expenditures. Pruetz and Standridge (2008) have identified 191 TDR programs that have preserved over 350,000 acres nationwide. However, most of these TDR programs have limited or no trading activity, and the largest five TDR programs represent about three quarters of this preserved acreage. TDR programs clearly have yet to deliver substantial land conservation, particularly compared with land trusts, which have preserved over 13.3 million acres in conservation easements in the United States (Parker & Thurman, 2019).

Although several factors explain the limited success of TDRs in various case studies, the lack of demand is perhaps the most critical issue in many TDR programs (Pruetz & Standridge, 2008; Walls & McConnell, 2007). The optimal density has to be constrained under the current baseline zoning in receiving areas so that developers will see a benefit from using TDRs. In other words, using TDRs reduces the average lot size in a residential subdivision, so developers need to believe that they can make higher profits selling the higher density project while covering the additional costs incurred for purchasing TDRs.

The location of receiving areas has been a key aspect of creating demand for TDR programs. Conventional TDR programs, aiming to transfer development from rural sending areas to urban receiving areas, have been the least successful (Linkous & Chapin, 2014). Despite the goal of many planners and smart-growth advocates to channel TDR use into higher density development within cities, towns, and other urban areas that have existing infrastructure, most of the TDR activity has occurred when receiving areas are designated in some portion of the rural region (Linkous & Chapin, 2014; Walls & McConnell, 2007).

McConnell et al. (2006a), for example, provide a detailed review of the TDR program in Calvert County, Maryland, that allowed flexibility for both urban and rural receiving areas. In this evaluation, the vast majority of TDR usage occurred in rural receiving areas, which had a baseline zoned density at one unit per five acres and allowable density with TDRs at one unit per two acres. A fundamental reason for higher TDR demand relates to the marginal value of additional yard space. When more than doubling the density with TDRs in rural areas, many residents are likely to find two-acre or five-acre lots to be a similar housing product. Hence, the willingness to pay for a larger lot without TDRs is not high enough to outbid the higher density project with TDRs. This is often not the case when doubling density within urban receiving areas, which may substantially impinge on the available yard space when comparing development options—single-family detached without TDRs versus single-family attached or multifamily dwellings with TDRs. Another important consideration, as explained in McConnell et al. (2006a), is that the receiving areas in Calvert County are only designated in a portion of the rural region. These rural community districts already had substantial rural residential development and limited potential for contiguous agricultural and forest lands. Sending areas were mainly prime farmland and resource areas, representing the county's designated priority preservation areas. This is essentially a mechanism to create clustered development at a landscape scale in the rural region. Sending areas had substantial farmland preservation. Meanwhile, rural receiving areas had a baseline zoning at one house per five acres with limited agricultural activity, and they were allowed to be denser rural residential areas than they would have been otherwise.

POLICY IMPLICATIONS FOR IMPROVING PROGRAM PERFORMANCE

Reframing Urban–Rural Planning

Smart growth programs often consider urban and rural areas, where urban areas are targeted for growth and rural areas are to be protected. Despite the goal of smart growth advocates to protect rural areas, there is typically not enough political will to downzone or allocate sufficient funding for the preservation of the entire rural area. Exurban large-lot development typically causes greater loss and fragmentation of farmland and forests than the expansion of urban and suburban areas. Policymakers need to recognize that rural areas are heterogeneous and to better understand how to manage exurban large-lot development on septic systems, which is more footloose than suburban development on contiguously expanding municipal sewer service lines.

We propose that future smart growth programs designate three main planning regions. The first region is comprised of existing and planned sewer service areas that are the locally designated growth areas for suburban and urban development. Infrastructure planning and growth management policies, such as UGBs, are effective for managing this type of growth. The second region is the designated priority preservation areas that are rural regions outside planned sewer service areas and dominated by contiguous prime farmland and environmentally sensitive forest lands and wetlands. Within these areas, policymakers can implement agricultural zoning as a primary tool, as well as targeting high benefit parcels with conservation easements and differential farmland taxation with stricter requirements for eligibility. Daniels

(1997) argues that, when politically feasible, agricultural zoning at a maximum of one housing unit per 25 acres is typically recommended to maintain intact farming and resource areas. The third region is the "sacrifice zones" in the rural regions outside planned sewer service zones that already have substantial existing large-lot development on septic systems or have been zoned for rural residential development allowing one to five acres per housing unit. The reality is that rural residential development rights have been granted historically for large swathes of the rural region due to prior zoning plans and existing large-lot development patterns. Land preservation is challenging in this region because it requires buying out these expensive development rights using participatory easement programs and often faces political opposition to further downzoning.

As a new generation of smart-growth legislation, Maryland's Sustainable Growth and Agricultural Preservation Act of 2012 reflects the three main planning regions outlined above (Maryland Department of Planning, 2012). This statewide legislation, also known as the septic law, directly aims to tackle the major threat of exurban large-lot development—in contrast to previous smart-growth tools such as PFAs that had limited effects on managing this type of rural land conversion (Lewis et al., 2009). Maryland's septic law specifies that existing and planned sewer service areas are the designated growth tiers for urban development. The rural region is divided into two categories. Priority preservation areas, designated by local county governments, are no longer allowed to have new major residential subdivisions on septic systems. Essentially, this is a new regulatory approach that restricts the number of development rights to a minor subdivision in designated priority preservation areas. The remainder of the rural region is not affected by the septic law (i.e., business as usual). That is, major residential subdivisions are allowed in accordance with existing zoning and other land-use regulations.

Planning in this latter rural region can be difficult because the default option is the continuation of low-density rural residential development filling in the historically granted development rights. Clustering requirements are an alternative option because this has the advantage of preserving a large parcel for farmland or open space, while forcing the allowable development rights onto smaller housing lots. Clustered subdivision development may nonetheless result in conflicts due to the close proximity of agricultural activities and new rural residential neighbors (e.g., drift from agricultural chemicals, nuisance smells from spreading manure, heavy farm machinery sharing rural roads). Depending on community goals, another option is to allow areas zoned for rural residential to become denser as sacrifice zones, in exchange for land preservation elsewhere. Rural residential zoned areas, for example, acted as receiving areas with the most TDR activity in Calvert County, Maryland, while the priority preservation areas were designated as sending areas to significantly preserve the agricultural and rural landscape (McConnell et al., 2006a).

Synergistic Policy Efforts for Land Preservation

Coordinating a variety of planning tools is helpful for achieving land preservation goals, especially through the collaboration between state and local governments. Attention should be paid to both direct and indirect interactions when multiple policies are adopted.

First, rural downzoning regulations can improve the effectiveness of participatory PDR programs. With rural downzoning, the government or land trusts will likely incur a lower cost to purchase land or conservation easements, such that more acreage can be preserved. Rural downzoning can also improve PDR program effectiveness to achieve spatial contiguity. Conservation easements create open-space amenities that may attract neighboring residential development, thereby potentially resulting in fragmented conservation and development outcomes. Agricultural zoning reduces this unintended spatial spillover effect since it lowers the development potential across the designated agricultural zoned areas. At the same time, PDR programs can improve the performance of rural agricultural zoning plans, particularly when the funding is targeted and restricted solely to priority areas. Lewis and Knaap (2012) indicate that RLAs are mainly designated in areas with agricultural protective zoning (less than one housing unit per 20 acres); therefore buying out the remaining development rights is more feasible in these priority areas with intact farmland, forests, and environmentally sensitive lands.

Second, multiple preservation programs that focus funding in the same targeted areas can have synergistic effects. Combining TDR and PDR programs, for instance, may have subtle and indirect interaction effects that may achieve better outcomes. One of the challenges in developing active markets for TDR programs is the uncertainty in prices for development rights, as well as high transaction costs for buyers and sellers to negotiate prices. McConnell et al. (2006a) show that TDR activity was initially limited at program inception and only increased after the county government introduced a PDR program. Basically, the PDR program set a floor price for selling development rights that was publicly shared. This price signal substantially reduced price uncertainty, spurring TDR activity between private developers and rural landowners. Local governments may also facilitate TDR activity through the establishment of a TDR bank. The bank can purchase TDRs from willing rural landowners in sending areas who cannot find private developers. This government purchase can help establish the stability of prices for TDRs and then inform potential developers of this option to purchase TDRs. The TDR bank creates an ongoing preservation revolving fund by buying TDRs, later selling them to private developers, and then using the proceeds to buy more TDRs. While uncommon to date, some of the most successful TDR programs in the United States have used them as a fundamental aspect to facilitate this market, including King County, Washington, and Palm Beach County, Florida (Pruetz & Standridge, 2008).

Third, the creation of a TDR program can make rural downzoning more politically feasible. Rural landowners often resist the designation of agricultural downzoning plans. This regulatory approach basically places new restrictions on private property owners without compensation that may invite political opposition or even legal challenges. The establishment of TDRs to sell can partially compensate rural landowners for the loss of land value that may result from agricultural downzoning, as was done for the rural downzoning and TDR program in Montgomery County, Maryland (Pruetz & Standridge, 2008; Walls & McConnell, 2007).

CONCLUSIONS AND FUTURE DIRECTIONS

Exurban large-lot development has been a greater cause of farmland and forest loss than the combined footprint of urban and suburban development in the United States (Heimlich & Anderson, 2001). Environmental impacts from exurban development on biodiversity are substantial due to the large extent and noncontiguous form of development, resulting in habitat loss and fragmentation and the introduction of invasive species (Hansen et al, 2005). Combating wildfire exacerbated by climate change is also made more difficult because of the widely dispersed low-density exurban development, particularly in the rural–urban interface across the western United States (Mann et al., 2014; Radeloff et al., 2018). Exurban homes in rural areas create challenges for forest management intervention strategies to mitigate wildfire risk, such as prescribed burns or letting natural fires burn to restore ecological processes to the landscape.

An empirical challenge in accurately estimating program effectiveness is that most land-use policy interventions are not randomly assigned across the landscape, and are thus subject to endogeneity that confounds estimation. Angrist and Pischke (2009) provide a thorough explanation of quasi-experimental techniques that can be used to address the endogeneity issue in program evaluation. As an example, propensity score matching attempts to emulate an experimental setup from observational data by comparing land-use outcomes in the treated group and outcomes for matched observations in the control group that are as similar as possible in terms of observable characteristics (Liu & Lynch, 2011; Nolte et al., 2019). The synthetic control method similarly generates a weighted average of untreated group outcomes to form a "synthetic" control unit that is similar to the treated group (Fang et al., 2019). The difference-in-differences approach accounts for the baseline differences in characteristics between the treated and untreated groups prior to the implementation of policy interventions (Cunningham, 2007; Newburn & Ferris, 2016). Regression discontinuity design aims to elicit the causal effects of interventions by comparing observations lying closely above and below a threshold in the program design (Butsic et al., 2011). These quasi-experimental techniques will hopefully become more widely used in the future to provide rigorous program evaluation for land use policies that aim to manage development and preserve rural areas.

While recent research has made significant advances in identifying issues and evaluating the effectiveness of smart growth programs aimed at land conservation, many challenges still exist and future research is needed. We identify several areas in particular where researchers should put further attention. First, more empirical analysis is needed on the effectiveness of UVAs to reduce the rate of farmland conversion. Many states have an agricultural property tax differential program that has enrolled a large portion of the existing farmland across the United States. Nonetheless, it is challenging to assess the effectiveness given the voluntary enrollment of landowners, and because states often implemented this tax program decades ago. Second, impact fee programs place charges on developers during the permit approval process for residential development. Prior studies have analyzed the effect of impact fees on the spatial location of housing in urban areas (Burge & Ihlanfeldt 2006; Burge et al., 2013). This research shows that impact fees can be used as an effective urban containment strategy, with the potential to limit development at the urban fringe and encourage development in the urban core. However, we could find no empirical analysis regarding the effect of impact fees on land conversion in rural areas. Third, analysis of post-preservation land use activities has received limited attention in the land preservation literature to date. A common critique is that land preservation programs should be judged not solely on the number of acres preserved since activities on protected land are heterogeneous. For instance, the degree to which landowners remain active in farming after preservation remains an important question that merits further investigation. Survey data asking farmers about post-preservation activities generally suffers from sample selection, and the analysis is often limited to cross-sectional data when longitudinal panel data would be more helpful to understand land-use dynamics (Gottlieb et al., 2015). With the increasing availability of high-resolution remote sensing data, researchers can take advantage of these technological advances in combination with survey data to monitor and evaluate land use activities on preserved land (see Goodspeed, Chapter 17).

Lastly, we argue that multiple policies may help create synergistic efforts for achieving smart growth goals for land preservation. Indeed many regions that are most active in land preservation are highly regulated landscapes with multiple intervention strategies. Yet these multiple policy approaches may interact in unexpected ways. Spatial spillovers and interdependencies of policies are important to consider. It has been challenging to identify the direct effect of policies using existing program evaluation techniques, let alone the indirect and unintended consequences of multiple interacting policies. Further theoretical modeling and careful empirical analysis is needed to advance our understanding on how the design of multiple policies can be improved to create more effective land preservation outcomes within smart growth programs.

REFERENCES

Albers, H. J., Ando, A. W., & Chen, X. (2008). Spatial-econometric analysis of attraction and repulsion of private conservation by public reserves. *Journal of Environmental Economics and Management*, 56, 33–49.

American Farmland Trust. (2018). *Farms under Threat: The State of America's Farmland*. Washington, DC: American Farmland Trust.

Anderson, J. E., & England, E. W. (2015). *Use-value Assessment of Rural Lands: Time for Reform?* Cambridge, MA: Lincoln Institute of Land Policy.
Angrist, J., & Pischke, J. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton, New Jersey. Princeton University Press.
Brown, D. G., Johnson, K. M., Loveland, T. R., & Theobald, D. M. (2005). Rural land use trends in the contemporaneous United States 1950–2000. *Ecological Applications*, 15(6), 1851–1863.
Burge, G., & Ihlanfeldt, K. (2006). Impact fees and single-family home construction. *Journal of Urban Economics*, 60, 284–306.
Burge, G. S., Trosper, T. L., Nelson, A. C., Juergensmeyer, J. C., & Nicholas, J. C. (2013). Can development impact fees help mitigate urban sprawl? *Journal of the American Planning Association*, 79(3), 235–248.
Butsic, V., Lewis, D. J., & Ludwig, L. (2011). An econometric analysis of land development with endogenous zoning. *Land Economics*, 87(3), 412–432.
Chang, K. (2016). *National Land Trust Census*. Washington, DC: Land Trust Alliance.
Cunningham, C. R. (2007). Growth controls, real options, and land development. *The Review of Economics and Statistics*, 89(2), 343–358.
Daniels, T. L. (1997). Where does cluster zoning fit in farmland protection? *Journal of the American Planning Association*, 63, 129–137.
Dempsey, J. A., & Plantinga, A. J. (2013). How well do urban growth boundaries contain development? Results for Oregon using a difference-in-difference estimator. *Regional Science and Urban* Economics, 43, 996–1007.
Duke, J. M., & Lynch, L. (2006). Four classes of farmland retention techniques: Comparative evaluation and property rights implications. *Land Economics*, 82(2), 189–213.
Esseks, J. D., Schilling, B. J., & Hahn, A. (2013). *Impacts of the Federal Farm and Ranch Lands Protection Program: An Assessment Based on Interviews with Participating Landowners*. Lincoln, NE: Center for Great Plains Studies, University of Nebraska, Lincoln.
Fang, L., Howland, M., Kim, J., Peng, Q., & Wu, J. (2019). Can transfer of development rights programs save farmland in metropolitan counties? *Growth and Change*, 50, 926–946.
Farmland Information Center. (2018). *2018 Status of State Purchase of Agricultural Conservation Easement Programs*. Northampton, MA: American Farmland Trust.
Fooks, J. R., Higgins, N., Messer, K. D., Duke, J. M., Hellerstein, D., & Lynch, L. (2016). Conserving spatially explicit benefits in ecosystem service markets: Experimental tests of network bonuses and spatial targeting. *American Journal of Agricultural Economics*, 98(2), 468–488.
Gottlieb, P. D., Schilling, B. J., Sullivan, K., Esseks, J. D., Lynch, L., & Duke, J. M. (2015). Are preserved farms actively engaged in agriculture and conservation? *Land Use Policy*, 45, 103–116.
Hanlon, B., Howland, M., & McGuire, M. P. (2012). Hotspots for growth: Does Maryland's Priority Funding Area program reduce sprawl? *Journal of the American Planning Association*, 78(3), 256–268.
Hansen, A., Knight, J., Marzluff, J. Powell, S., Brown, K., Gude, P. & Jones, K. (2005). Effects of exurban development on biodiversity: Patterns, mechanisms, and research needs. *Ecological Applications*, 15(6), 1893–1905.
Heimlich, R. E., & Anderson, W. D. (2001). *Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural Land*. Agricultural Economic Report No. 803. Washington, D.C.: U. S. Department of Agriculture, Economic Research Service.
Horowitz, J. K., Lynch, L., & Stocking, A. (2009). Competition-based environmental policy: An analysis of farmland preservation in Maryland. *Land Economics*, 85(4), 555–575.
Howland, M., & Sohn, J. (2007). Has Maryland's priority funding areas initiative constrained the expansion of water and sewer investments? *Land Use Policy*, 24(1), 175–186.

Lewis, R., & Knaap, G. (2012). Targeting spending for land conservation: An evaluation of Maryland's Rural Legacy Program. *Journal of the American Planning Association*, 78(1), 34–52.
Lewis, R., Knaap, G., & Sohn, J. (2009). Managing growth with Priority Funding Areas: A good idea whose time has yet to come. *Journal of the American Planning Association*, 75(4), 457–478.
Linkous, E. R., & Chapin, T. S. (2014). TDR program performance in Florida. *Journal of the American Planning Association*, 80(3), 253–267.
Liu, X., & Lynch, L. (2009). *Does Targeting a Designated Area Crowd Out the Other Preservation Programs' Efforts?* Agricultural and Applied Economics Association Annual Meeting, July 26–28, 2009, Milwaukee, Wisconsin.
Liu, X., & Lynch, L. (2011). Do agricultural land preservation programs reduce farmland loss? Evidence from a propensity score matching estimator. *Land Economics*, 87(2), 183–201.
Lynch, L. (2007). Economic benefits of farmland preservation. In C. T. F. de Brun (Ed.), *The Economic Benefits of Land Conservation* (pp. 13–23). The Trust for Public Land.
Lynch, L., & Carpenter, J. (2003). Is there evidence of a critical mass in the Mid-Atlantic agriculture sector between 1949 and 1997? *Agricultural and Resource Economics Review*, 32(1), 116–128.
Lynch, L., & Liu, X. (2007). Impact of designated preservation areas on rate of preservation and rate of conversion: Preliminary evidence. *American Journal of Agricultural Economics*, 89(5), 1205–1210.
Lynch, L., & Lovell, S. J. (2003). Combining spatial and survey data to explain participation in agricultural land preservation programs. *Land Economics*, 79(2), 259–276.
Lynch, L., & Musser, W. N. (2001). A relative efficiency analysis of farmland preservation programs. *Land Economics*, 77(4), 577–594.
Mann, M., Berck, P., Moritz, M., Batllori, E., Baldwin, J., Gately, C. & Cameron, D. (2014). Modeling residential development in California from 2000 to 2050: Integrating wildfire risk, wildland and agricultural encroachment. *Land Use Policy*, 41, 438–452.
Maryland Department of Planning. (2012). *Implementation Guidance for the Sustainable Growth and Agricultural Preservation Act of 2012*. Baltimore, MD: Maryland Department of Planning.
McConnell, V., Kopits, E., & Walls, M. (2006a). Using markets for land preservation: Results of a TDR program. *Journal of Environmental Planning and Management*, 49(5), 631–651.
McConnell, V., Walls, M., & Kopits, E. (2006b). Zoning, TDRs, and the density of development. *Journal of Urban Economics*, 59, 440–457.
Nechyba, T., & Walsh. R. (2004). Urban sprawl. *Journal of Economic Perspectives*, 18(4), 177–200.
Newburn, D. A., & Berck, P. (2006). Modeling suburban and rural-residential development beyond the urban fringe. *Land Economics*, 82(4), 481–499.
Newburn, D. A., & Berck, P. (2011). Growth management policies for exurban and suburban development: Theory and an application to Sonoma County, California. *Agricultural and Resource Economics Review*, 40(3), 375–392.
Newburn, D. A., Berck, P., & Merenlender, A. M. (2006). Habitat and open space at risk of land-use conversion: Targeting strategies for land conservation. *American Journal of Agricultural Economics*, 88(1), 28–42.
Newburn, D. A., & Ferris, J. S. (2016). The effect of downzoning for managing residential development and density. *Land Economics*, 92(2), 220–236.
Newburn, D. A., Reed, S., Berck, P., & Merenlender, A. M. (2005). Economics and land-use change in prioritizing private land conservation. *Conservation Biology*, 19, 1411–1420.
Nolte, C., Meyer, S. R., Sims, K. R. E., & Thompson, J. R. (2019). Voluntary, permanent land protection reduces forest loss and development in a rural-urban landscape. *Conservation Letters*, 12(6), e12649. https://conbio.onlinelibrary.wiley.com/doi/10.1111/conl.12649

Parker, D. P., & Thurman, W. N. (2011). Crowding out open space: the effects of federal land programs on private land trust conservation. *Land Economics*, 87(2), 202–222.

Parker, D. P., & Thurman, W. N. (2018). Tax incentives and the price of conservation. *Journal of the Association of Environmental and Resource Economists*, 5, 331–369.

Parker, D. P., & Thurman, W. N. (2019). Private land conservation and public policy: Land trusts, land owners, and conservation easements. *Annual Review of Resource Economics*, 11, 337–354.

Pruetz, R., & Standridge, N. (2008). What makes Transfer of Development Rights work?: Success factors from research and practice. *Journal of the American Planning Association*, 75(1), 78–87.

Radeloff, V., Helmers, D., Kramer, A., Mockrin, M., Alexandre, P., Bar-Massada, A., Butsic, V., Hawbaker, T., Martinuzzi, S., Syphard, A., & Stewart, S. (2018). Rapid growth of the US wildland-urban interface raises wildfire risk. *Proceedings of the National Academy of Sciences*, 115(13), 3314–3319.

Shen, Q., & Zhang, F. (2007). Land-use changes in a pro-smart-growth state: Maryland, USA. *Environment and Planning A*, 39, 1457–1477.

Staley, S. R., Edgens, J. D., & Mildner, G. C. S. (1999). *A Line in the Land: Urban-growth Boundaries, Smart Growth, and Housing Affordability*. Policy Study No. 263, Reason Public Policy Institute.

Stoms, D. M., Jantz, P. A., Davis, F. W., & DeAngelo, G. (2009). Strategic targeting of agricultural conservation easements as a growth management tool. *Land Use Policy*, 26, 1149–1161.

Vercammen, J. (2019). A welfare analysis of conservation easement tax credits. *Journal of the Association of Environmental and Resource Economists*, 6(1), 43–71.

Vincent, C., Hanson, L., & Argueta, C. (2017). *Federal Land Ownership: Overview and Data*. Report R42346, Congressional Research Service.

Walls, M. & McConnell, V. (2007). *Transfer of Development Rights in U.S. Communities: Evaluating Program Design, Implementation and Outcomes*. Washington, DC. Resources for the Future.