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Abstract

Fragmentation of agricultural land by urban sprawl affects both the agricultural production capacity of the land and its rural scenic quality. In order to assess the resulting fragmentation of the three most common types of agricultural land conservation tools in the United States, this study analyzes the spatial form of three land protection strategies: a purchase of development rights (PDR) program, a clustering program and a transfer of development rights program. By assessing a series of measures of success such as total acreage protected, size of parcels, contiguity and farming status, the study compares the effectiveness of programs that have been in place for approximately 20 years, analyzing the extent to which each program prevents or enhances fragmentation. The analysis shows that although the number of acres protected is an important factor in program success, the amount of protected land remaining in active farming is additionally influenced by any development rights that may remain with the land, the use of a variety of tools to reduce the likelihood of parcel isolation, and the adjacency and contiguity of protected parcels. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Urban sprawl, caused by the continued flight of homeowners out of cities to relatively inexpensive land and housing in the urban fringe, has placed a tremendous pressure on farmland resources in the United States (Heimlich and Brooks, 1989). With the fragmentation of farms in the urban fringe has come a loss of the traditional farming economic base, and a change in the character and visual quality of rural communities (Heimlich, 1989; Lapping et al., 1989). To combat this loss and fragmentation of farmland, many communities in urbanizing areas of the United States

are adopting a variety of tools to protect farms, farmland and the rural landscape. The primary responses by communities have been two-pronged: governmental or non-profit agencies purchase significant tracts of land, and local governments impose zoning and other regulatory requirements on the development of the land (American Farmland Trust, 1997). While analysis of the numbers of acres protected by each type of tool has been completed in the past, the varying effects on fragmentation of these regulatory and acquisition programs have not been analyzed or compared (Daniels, 1997).

The issues for farmland fragmentation are two-fold. First, there is the issue of regional fragmentation: the erosion of the farmland base leading to a loss of sufficient farm support operations and facilities, which raise operating costs (Lapping, 1979; Pfeffer and

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Lapping, 1995). Second is the issue of parcel fragmentation:

“Development in rural/urban fringe areas creates other farm management problems. Without strict zoning regulations farmland often becomes parceled as entire farms or parts of farms are sold to developers. This parcelization of farmlands leads to a “checkerboard distribution of farmlands, i.e. many noncontiguous fields. Farming such scattered plots is problematic. For example, field surveillance to monitor crop growth and pest populations is difficult, as is the movement of farm equipment because of transportation problems. Under these conditions consolidation of landholdings to achieve efficient scales of operation is nearly impossible.” (Pfeffer and Lapping, 1995, p. 85)

This study examines the use of the three dominant land conservation tools used in the urban fringe and urbanizing rural areas—transfer of development rights, purchase of development rights (PDR) and cluster development—to determine the effect of each type of program on fragmentation of agricultural land. The following analysis provides a brief description of each land preservation program, a history of the program in each community and then the results of the spatial analysis conducted for the targeted agricultural land.

2. A description of the programs reviewed

Three communities were chosen in the eastern United States as case studies for analysis: Montgomery County, Maryland, and the towns of Riverhead and Southampton on Long Island, in New York state. These communities were chosen based upon three primary factors which affect the ability to assess the long-term effects of a land protection strategy. First, all three have had active farmland preservation strategies and tools in place for approximately 20 years, a sufficient period of time to develop a clear analysis of the impact of the tools on the farmland resource. Secondly, while all three communities use a variety of land conservation tools, each community's strategy relies significantly on one tool as the major leader in protection efforts: Montgomery County, Maryland relies primarily on transfer of development rights;

Riverhead, New York on PDR; and Southampton, New York on cluster development. Thirdly, all three communities have active farming economies located in or on the fringe of major metropolitan areas, therefore, each farmland protection strategy and its tools must deal with significant development pressures.

2.1. *Transfer of development rights in Montgomery County, Maryland*

A transfer of development rights (TDR) program is typically a broadly applied, regional program which defines an area to be protected from development (sending area) and an area where development will be allowed to occur (receiving area). Since the program allows landowners to transfer the rights to develop one parcel of land to another parcel of land, the parcel from which the development rights are being transferred can no longer be developed, or developed only in a limited way.

In theory, a TDR program that is mandatory in the sending area should result in a low rate of farmland fragmentation. Since all of the parcels in the sending area transfer development rights outside of the area, little to no fragmentation should result. Thus, TDR programs have been touted as a primary tool for protecting agricultural land (Lapping et al., 1989; Merriam, 1978).

In 1980, Montgomery County became one of the first municipalities in the nation to adopt a countywide TDR program for agriculture preservation through its 1980 master plan (M-NCPPC, 1980). The county articulated a number of public policies underlying the TDR program, among them: a desire to control public costs associated with sprawl by channeling growth to existing population centers and setting aside lands for agriculture preservation; a goal of ensuring the continued viability of farming for regional food supplies; and a desire to maintain rural open space and the rural character of the area (M-NCPPC, 1980).

The county delineated an agricultural reserve (the sending area) of approximately 96,000 acres in the northern portion of the County. The extent of the agricultural reserve was based on soil quality, existing agricultural use, amount of existing development, size of farm parcels, and the threat of projected future development (M-NCPPC, 1980) with the goal of preserving a “critical mass” of farmland. Within the

boundaries of the reserve, the TDR program was mandatory, and created easement restrictions on property from which development rights were transferred. In establishing the program, the county allowed landowners to sell development rights at the rate of one development unit per 5 acres, but decreased the allowable building density in the sending area to 1 unit per 25 acres (Montgomery County Code, 1997, Article 28, Section 59-C-9.6). The county allotted one development right for every 5 acres of land (no fractional development rights) regardless of the quality of land, proximity to existing development, or other factors. Once a landowner transferred the development rights, the county acquired a permanent easement on the land, limiting residential development and restricting that parcel to agricultural uses except for the residual 1 unit per 25 acres which the landowner retained (M-NCPPC, 1980).

The county created approximately 15,000 development rights on land within the Agriculture Reserve. As of 1997, 6629 development rights had been removed from the underlying parcels and 5123 transferred to receiving areas (leaving 1506 development rights that had been removed, but not transferred). Approximately 2170 development rights remain attached to the underlying land in the form of small, pre-existing parcels or the 1 unit per 25 acres underlying right the county permits for actual development in the area.

Today the county's active farms are primarily located in the northern portion of the county, in the agricultural reserve. Agricultural production remains a strong segment of the economy in Montgomery County, with approximately US\$ 28.6 million of agricultural products produced in 1997, up from US\$ 27.7 million in 1992 (US Census, 1997). Crops, including field and nursery crops, are the major agricultural land use with a value of almost US\$ 20 million in 1997 (US Census, 1997). Field analysis indicates that these crops are predominantly cereal and grain crops, with nursery and row crops composing a minor portion of the production. Livestock production, although still a strong component of the agricultural economy, is valued just under US\$ 9 million (US Census, 1997).

Of the approximately 96,000 acres that make up the agricultural reserve in Montgomery County, 30,062 acres are protected under the TDR program, alongside an additional 15,000 acres of public lands and 9058

acres of land protected under the county's other four preservation tools (see Fig. 1). Judging from these figures, the TDR program has been the most aggressive in terms of preserving the farmland base in the county and provides a point of comparison for the predominant PDR program in Riverhead and the Southampton cluster development program.

2.2. Purchase of development rights in the town of Riverhead, New York

A PDR program typically uses public funds—tax revenues or municipal or state bonds—to fund the purchase and retirement of development rights on agricultural land. They are a commonly used farmland preservation tool, and are touted as being highly efficient at farmland retention (Lapping et al., 1989), equitable for landowners (Daniels, 1991), and generally a permanent preservation solution (Daniels, 1991). Since the tool is voluntary on the part of the landowner, a PDR program does not hold the inherent protection against fragmentation of a TDR program. In addition, the tool's most often cited drawback is its expense (Daniels, 1991; American Farmland Trust, 1997; Nelson, 1994), therefore, its potential to avoid fragmentation is tied to the amount of public funds that are available for development rights purchase.

The town of Riverhead is an historic agricultural community on the eastern end of Long Island. Riverhead has abundant, high quality agricultural soils and is one of the most important agricultural areas in New York state. However, thus far, Riverhead has experienced only a fraction of the tourism and resulting resort economy that has come to define Southampton, located on its southeastern border. Of Riverhead's more than 46,000 acres, and 16,862 acres are in agricultural use, although only 14,584 acres are zoned for agriculture. Approximately 12,300 acres, or 84% of the agricultural zone, are currently engaged in agricultural production, while the remainder are engaged in other uses such as golf courses, camps and private hunting reserves.

Riverhead's agricultural economy is focused primarily on row crops and nurseries. Of the total land in agricultural production, 1970 acres are in nursery production, 1924 in potatoes, 3211 in row crops and 1610 in sod. According to the 1997 census for the

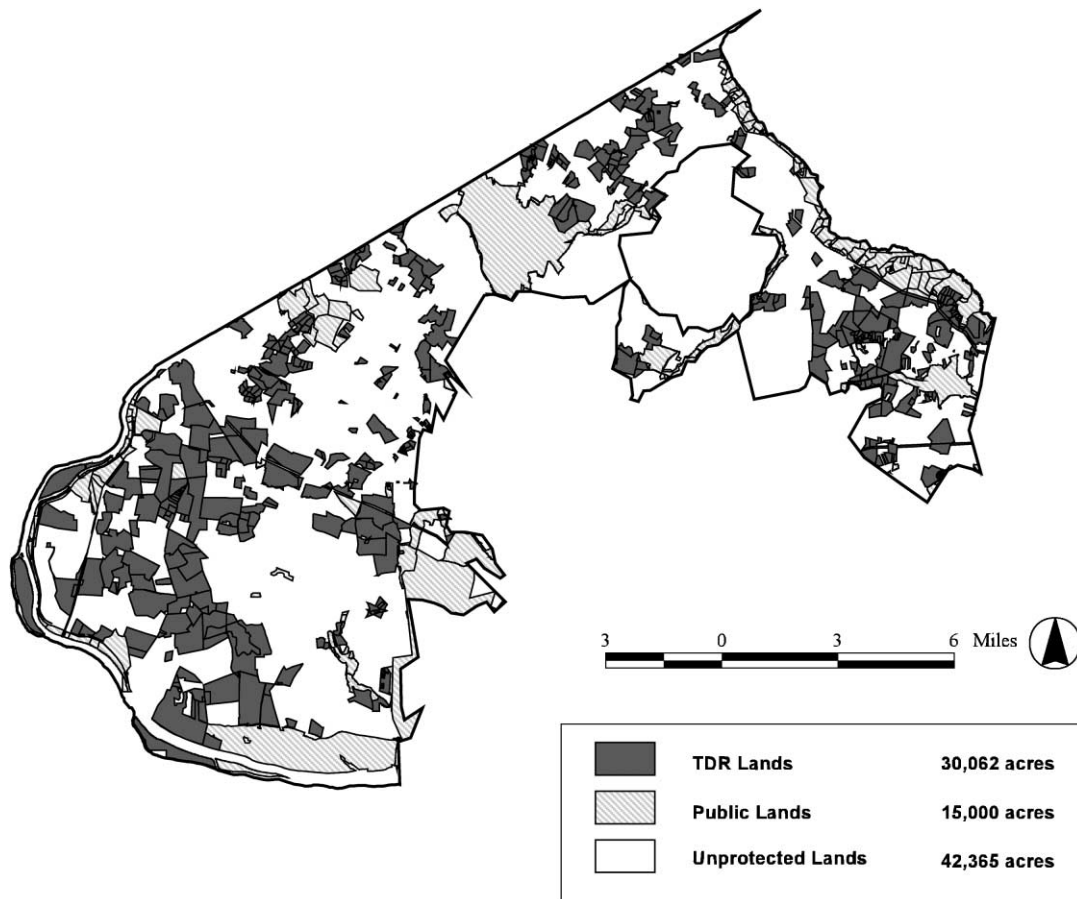


Fig. 1. Montgomery County's agricultural reserve area showing protected and unprotected lands.

entire area of Suffolk County, the agricultural economy relies on crop production, which includes potatoes, vegetables and orchards. The number of farms producing livestock is very small, producing only US\$ 12 million compared to the US\$ 155 million produced by crops (including nursery and greenhouse crops).

Unlike its neighbor Southampton, Riverhead depends primarily upon the Suffolk County PDR program to preserve agricultural land (see Fig. 2). Though Riverhead has established a town PDR program, the town has only purchased the development rights on two agricultural parcels. By contrast, the county PDR program has purchased the development rights on 70 parcels, preserving 3889 acres to the 61.5 acres preserved through the town program. Other tools have not been used effectively in Riverhead's strategy

to add to the protected pool of farmland. Local land trusts have not been active in Riverhead in the purchase of farmland or farmland development rights as they have in Southampton. While, the town has a transfer of development rights program on the books, it is not mandatory in the sending area, and the town has only designated a very small receiving zone, resulting in the lack of use of this tool.

The county PDR program, one of the nation's first PDR program, was implemented in 1977 (American Farmland Trust, 1997). According to the Suffolk County Planning Department, between 1977 and 1996, US\$ 40 million was spent to fund the acquisition of development rights, preserving over 7000 acres of land in the county. Another US\$ 9 million was spent in conjunction with partnerships between Suffolk County, town governments and non-profits to purchase



Fig. 2. The town of Riverhead showing extent of agricultural land, along with county PDR parcels.

development rights and conservation easements (Suffolk County Planning Department, 2000). The amount of land preserved in Riverhead by the county PDR program represents more than half of the total land preserved in the county through the program.

The county program used five factors in determining where to buy development rights: soils, current land use, contiguity of farmland, development pressure and the price of land (Suffolk County, 1996). Highest priority for acquisition was given to land in designated county Agricultural Districts, parcels over 10 acres in size and those with high-quality agricultural soils. In addition, parcels under consideration for purchase must have been engaged in active farming for at least 2 years prior to purchase.

2.3. Cluster program in Southampton, New York

In contrast to the regional focus and planning inherent in transfer and PDR programs, cluster development programs typically deal with development on

a site by site basis. While cluster programs may be mandated in a prescribed geographical area, development and preservation decisions are made on an individual site basis, providing the opportunity for significantly more fragmentation than in transfer or purchase programs, a tendency noted in previous reviews (Arendt, 1997; American Farmland Trust, 1997). Cluster programs work with the underlying zoning density, reducing minimum lot sizes and requiring that a portion of the site remain as open space. Obviously, the percentage of open space required to be set aside in any cluster program is a major determining factor in the overall effectiveness of that program, as is whether the program is mandatory or voluntary, and the degree of discretion granted to the statutory review body. In terms of the potential for fragmentation, the question of whether protected open space on adjacent clusters is contiguous is critical.

Fragmentation of the remaining open space into a patchwork that has limited use as agricultural land or

habitat is also a critical issue (Whyte, 1964; Arendt et al., 1994; Dramstad et al., 1996). Although, it is a very popular tool, clustering is not regarded by farmland protection advocates as a front-line means to protect agricultural land bases (Arendt, 1997; American Farmland Trust, 1997). Previous reviews have suggested that clustering may be better designed for preserving niche farms on the urban fringe that produce high-value specialty crops for sale to urban areas (Arendt, 1997) and as a means to protect rural character and scenic quality (Daniels, 1997; Arendt, 1991), even though clustering may produce development results that are visually and functionally incompatible with surrounding land uses (Arendt, 1991).

The town of Southampton, located on the eastern end of Long Island, has been an agricultural community since its settlement in the late 1600s. By the 1970s, tourism and second home development were beginning to fragment the existing farming areas. Mandated in the 1970 master plan for the town, residential clustering was adopted in 1979 and substantially revised in the early 1980s. The town defined an agricultural overlay district, that coincided with the concentrations of agricultural land in the town and prime agricultural soils. By mandating the use of planned residential development (PRD) subdivisions within the agricultural overlay district, the town granted the planning board the discretion to require that a subdivision cluster the development units on the portion of the parcel containing the least productive soils. The percentage of open space to be set aside in

Table 1

Prime agricultural soil preservation guidelines in the town of Southampton for the various development densities allowed in the agricultural overlay zone (Town of Southampton, 1989)

Zone	Minimum lot size requirements	Required percentage of prime soil preservation (%)
R-10	0.23 ac	35
R-15	0.34 ac	35
R-20	0.46 ac	35
R-40, CR-40	0.92 ac	35
R-60, CR-60	1.37 ac	35
CR-80, R-80	1.84 ac	50
CR-120, R-120	2.75 ac	65
CR-200	4.59 ac	65

the subdivision was governed by a sliding scale based on the minimum lot size of the underlying zoning (see Table 1).

Despite intense development pressure, farming continues in the town. Paradoxically perhaps, the most important farming areas are also located in the areas of highest land value located in the southeastern portion of the town adjacent to the prime beaches, comprising the highly desirable resort hamlets of Sagaponack, Bridgehampton and Water Mill. Cropping patterns provide evidence of the shift from traditional farming to metropolitan niche farming: row crops, particularly potatoes are being edged out by truck farming and nurseries as the predominant agricultural products.

Land in the agricultural overlay zone in the town of Southampton is protected under three different

Table 2

A breakdown of protected land by acres in the agricultural overlay zone, town of Southampton

Land type or protection tool	Total acres	Percent of total area	Average parcel size (acres)
Total land in farming use	6397.1	48.8	11.0
Total protected	2274.6	17.8	18.5
Subdivision reserve areas	755.7	5.8	13.7
County PDR	669.4	5.1	30.4
Town PDR	757.1	5.8	30.3
Local land trusts	149.1	1.1	3.4
Unprotected	4122.5	31.0	8.2
Total land not in farming use	6704.2	51.1	—
Protected	97.8	0.9	8.9
Developed and vacant land	6575.6	50.0	1.7
Public land	30.8	0.2	1.6
Total agricultural overlay	13101.3	100	—

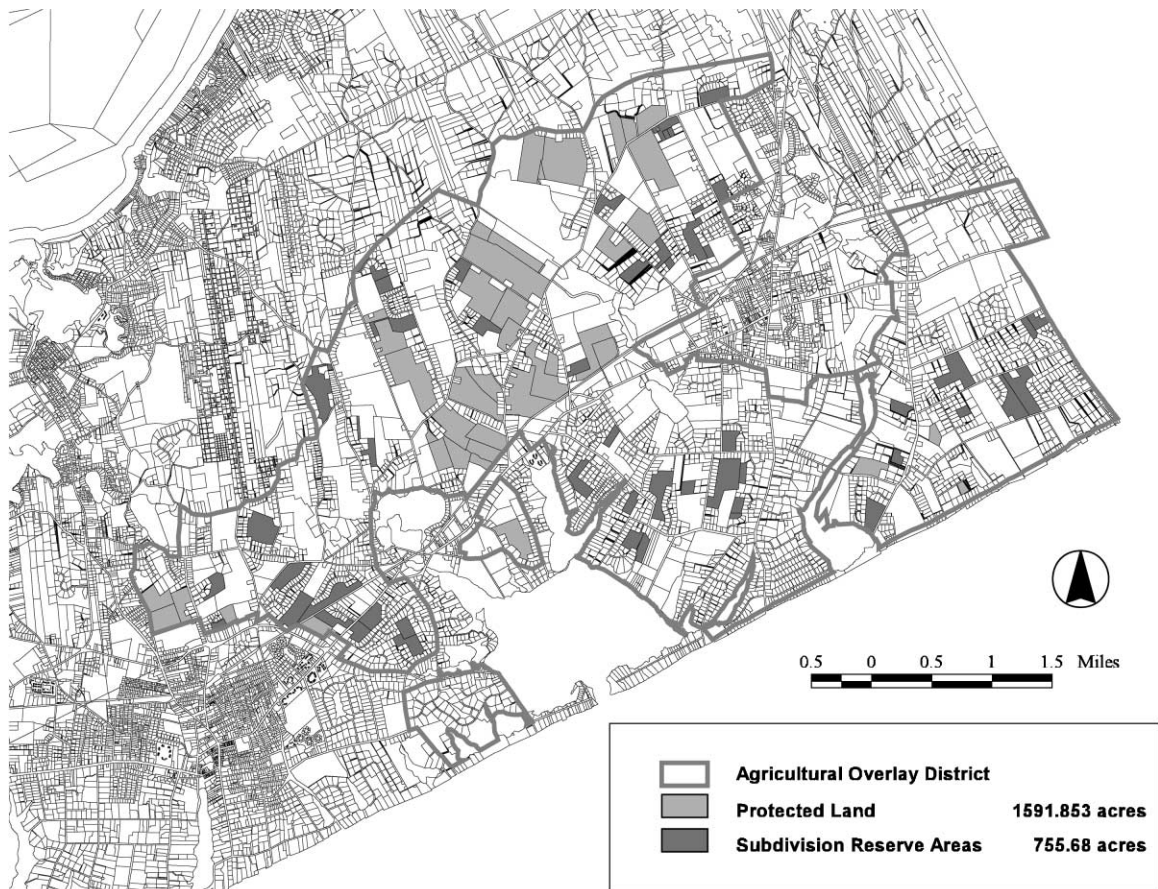


Fig. 3. The agricultural overlay zone in the eastern portion of the town of Southampton showing protected land and subdivision reserve areas.

tools: planned residential development (cluster), county and town PDR, and local land trusts. As of 1997, total preserved land accounted for 18% (2372 acres) of the total land acreage within the agricultural overlay, while unprotected land accounted for 4123 acres, or 31%. The remaining 6576 acres (50%) were developed (see Fig. 3 and Table 2).

3. The effects of the three programs on resource fragmentation

In order to compare the effect of the land protection tools and programs on fragmentation of the farmland resource, each major tool was analyzed according to the two major issues of fragmentation: (1) the erosion of the farmland base leading to a loss of sufficient farm

support operations and facilities; and (2) the issue of parcel fragmentation. These two issues give rise to three measures or indicators of fragmentation in the resource, described below.

First, to assess the issue of the erosion of the farmland base, the total number of acres protected by the program was determined according to each of its associated tools. In order to allow the comparison of programs with widely differing amounts of resource land, this number was compared to the total number of acres of targeted land, giving a relative percentage of land protected.

Second, to assess the issue of parcel fragmentation, two measures were analyzed: parcel size and parcel contiguity. The average protected parcel size was assessed as a key indicator of the continued viability of the protected parcels for farming. Parcel size is an

indicator for large-scale, traditional farming enterprises, and is often relied upon as an indicator of fragmentation and degradation of the resource (Daniels, 1997; Gerard, 1984). However, in metropolitan fringe areas, there is some indication that parcel size may not be as important an indicator of continued farm production, due to a change in focus from field crops to high yield specialty crops (Pfeffer and Lapping, 1995; Scarfo, 1990).

Contiguity, or the degree to which the protected parcels connect to other protected parcels, creating a large agglomeration of land available for farming (Lapping et al., 1989) is a key measure of fragmentation. Other reviewers have noted that isolated farm parcels that are not contiguous with other farmed parcels often experience negative impacts such as complaints from neighbors and lack of support that negatively affect farming operations (Bryant and Johnston, 1992; Scarfo, 1990) in addition to the management issues associated with farming isolated parcels of land.

Finally, to test the effects of fragmentation on active farming, all protected lands for the three major tools were checked for active farming status through a field inventory conducted during the summer of 1999.

3.1. Regional fragmentation: total acreage protected

The three tools show a wide variety in the total number of acres protected over the lifetime of the program (see Table 3). However, since the total acreage targeted for protection in each jurisdiction varies so dramatically, the percent of the total acreage protected and the average acres protected per year provide a clearer indication of the preservation potential of each program.

In these respects, the TDR and PDR programs are the clear forerunners, protecting 31 and 23% of their

respective land areas over the life of the program (see Table 3). However, when comparing the average acres protected per year, the TDR program at 1768 acres to the PDR program's 195 acres illustrates the TDR program's potential to protect large acreages of farmland. The cost of acquiring the development rights to large amounts of farmland (to acquire the amount of farmland preserved under Montgomery County's TDR program would require an almost 10-fold increase over the Riverhead totals) could make the goal of preservation almost prohibitive. It is interesting to note that in Montgomery County, an additional 10% of the land base (9058 acres) above that protected by TDR has been protected through the use of state and county PDR programs. The failure of clustering to protect a significant amount of the farmland base is underscored by the small amount (6%) protected in the Southampton program.

3.2. Parcel fragmentation

3.2.1. Size of parcels

Parcel sizes vary widely under the three tools, again with the TDR and PDR programs showing the most congruency. The greatest difference between these two tools is in the size of unprotected parcels, which in Montgomery County was 47.7 acres and in Riverhead, 28.5 acres. This reflects the fact that the PDR program has targeted the largest parcels for protection, leaving many of the smaller parcels for either future protection or development.

Pre-protection parcel sizes are relevant to the analysis only in terms of comparison between the cluster program and the other two programs. In Southampton, pre-protection parcel sizes ranged from the smallest at 6.6 acres to the largest at 71 acres. The mean pre-development or pre-protection parcel size was 37 acres, compared to 74.1 in Montgomery County

Table 3

Comparison of land protection achieved in acres for the three preservation programs: transfer of development rights, PDR and cluster

Program	Date of program inception	Total acreage targeted for protection ^a	Protected acreage ^b	Percent of total acreage protected (%)	Average acres protected per year
TDR, Montgomery County	1980	96485	30062	31	1768
PDR, Riverhead	1977	16862	3889	23	195
Cluster, Southampton	1979	13093	771	6	41

^a Acreage contained within the target protection zone.

^b Acreage permanently protected by the program: TDR by 1997, PDR by 1999; cluster by 1998.

Table 4

Comparison of parcel sizes across the three programs: transfer of development rights, PDR and cluster

Program	Affected parcel size		Unprotected parcel size ^a (mean acres)
	Pre-development or protection (mean acres)	Protected (mean acres)	
TDR, Montgomery County	74.1	74.1	11.3
PDR, Riverhead	51.1	51.1	37.5
Cluster, Southampton	37.0	13.7	8.5

^a Parcels in agricultural use.

(50% larger) and 51.1 acres in Riverhead (28% larger). In Southampton, the relatively small pre-development parcel size exacerbated the results of the mean protected development parcel. At 13.7 acres, the mean protected development parcel was less than half the size of the original parcel (see Table 4). Loss of parcel size is an inherent result of the clustering tool since only a portion of the affected parcel is protected from development, while in TDR and PDR, the entire affected parcel is protected.

3.2.2. Contiguity

Contiguity with other protected land can be an important factor in the long-term farming status of a particular parcel of land. In addition to the measure of adjacency of protected land is the question of how the tools and coordinated farmland protection strategies achieved an aggregation of protected parcels across the targeted protection area. Two measures are key: adjacency of a protected parcel with another protected parcel, and secondly, the extent to which

those protected parcels form a large mass of contiguous protected land. In assessing the results of the aggregations, the key factor is the average size of the resulting aggregations (see Table 5) and the overall percentage of protected land that remains isolated from other protected land (see Table 6).

In reviewing the adjacency of protected parcels in the three programs, the TDR and PDR showed the strongest results, with 91 and 75% of parcels adjacent to other protected parcels under the same program (see Table 7). In Southampton, only 36% of the protected parcels were adjacent to other subdivision reserve areas, and 46% were adjacent to only unprotected parcels. This result illustrates the failure of discretionary review to ensure contiguous protected land in a cluster program. Exacerbating the issue of adjacency in Southampton, 17% of the protected parcels (8 of the 47 subdivision reserve areas) were completely surrounded by residential subdivisions.

Due to its large target protection area, Montgomery County's TDR program produced the largest aggrega-

Table 5

Aggregations of protected land achieved by the various tools and three preservation strategies of the study sites

Program	Percent of aggregations	Total acres	Average percent of parcels	Mean size of aggregation in acres	Maximum acres of aggregation	Minimum acres of aggregation
Montgomery County						
TDR	59	27406.2	10.0	464.5	11675.1	3.9
PDR	20	7758.8	6.25	387.9	2183.0	48.8
TDR and PDR	59	36963.1	12.7	626.5	14906.7	3.9
Riverhead						
PDR	12	2952.3	4.0	246.0	857.0	21.7
Southampton						
Cluster	18	275.9	2	30.7	56.7	9.7
PDR and land trust	75	1165.5	4.4	68.6	261.9	4.7
Cluster, PDR and land trust	27	1606.7	3.8	54.2	142.8	4.7

Table 6

Relative area of the protected parcels that were aggregated and isolated by the tools used in the three study sites

Program	Percent of parcels	Total acres	Mean size of parcels (in acres)	Percent of protected area by tool
Montgomery County				
TDR				
Aggregated	593	27406.2	46.2	91
Isolated	50	2655.6	53.1	8
Total	643	30061.8	–	100
PDR				
Aggregated	125	7758.8	62.1	86
Isolated	18	1299.6	72.2	14
Total	143	9058.4	–	100
Riverhead				
PDR				
Aggregated	48	2952.3	61.5	75
Isolated	22	981.1	44.6	25
Total	70	3933.4	–	100
Southampton				
Cluster				
Aggregated	18	275.9	15.3	36
Isolated	30	496.9	16.6	64
Total	48	772.8	–	100
PDR and land trust				
Aggregated	75	1165.5	15.6	88
Isolated	8	161.5	20.3	12
Total	83	1327.0	–	100

tions of protected land. However, it is clear from Table 6 that the farmland protection strategies that use more than one tool—Montgomery County and Southampton—achieve a positive effect in protected land aggregation. In Southampton, aggregations of protected land increased in total acreage almost six-fold, while the average aggregation size increased by 43%. Montgomery County's aggregation size increased by 25%.

When looking at the effects of the individual tools (Table 7), the TDR program showed a positive effect on fragmentation, resulting in the aggregation of 91% of the parcels into protected areas with an average size of 465 acres. The PDR programs also fared well, aggregating 86% of the total protected land area in Montgomery County, 75% in Riverhead, and 88% of the PDR and land trust parcels in Southampton. The parcel aggregations in Montgomery County and

Table 7

Breakdown of percentage of parcels contiguous with other protected parcels or unprotected land in agriculture

Program	Contiguous with other protected parcels ^a		Contiguous with only unprotected parcels (%)
	Same program (%)	Other programs (%)	
TDR, Montgomery County	92	2	7
PDR, Riverhead	78	–	20
Cluster, Southampton	38	19	46

^a A parcel may be contiguous with more than one type of protected parcel.

Table 8
Breakdown of programs detailing accessibility of preserved lands

Program	Accessible by (percent of parcels)		
	Road (%)	Protected (mean acres) (%)	Unprotected land in farm use (%)
TDR, Montgomery County	88	60	2
PDR, Riverhead	66	43	7
Cluster, Southampton	67	15	17

Riverhead communities averaged 387 and 246 acres, respectively.

The cluster program in Southampton did not fare as well. Of the protected parcels, 64% were isolated, with an average protected aggregation of only 30 acres. The additive effect of other tools in reducing fragmentation is particularly obvious here, since the average aggregation size rose to 54.2 acres with the addition of county and town owned PDR parcels and acquisitions by local land trusts.

3.3. Farming status

In order to test the effects of fragmentation on active farming, all protected lands for the three major tools were checked for active farming status. Farming status was determined for Montgomery County from tax

parcel information with field checks. In Riverhead and Southampton, status was based solely on field observations.

All three farmland preservation tools showed high rates of active agricultural use. In Riverhead, 97% of PDR protected land were in active farm use (see Table 8). Parcel size had a direct effect on the agricultural status of land in Riverhead. Analysis of the parcels identified that 40% of parcels under 5 acres were actively farmed, 92% of parcels between 10 and 25 acres were actively farmed and 96% of parcels larger than 25 acres were actively farmed; there are no PDR parcels between 5 and 10 acres. This analysis indicates that in Riverhead parcel size is factor in agricultural status: the larger the preserved parcel, the greater the likelihood it remains in agricultural use (Tables 9 and 10).

Table 9
Comparison of lands in active farm use

Program	Protected land in active farm use			Not in active farm use mean parcel size (acres)
	Acres	Percent (%)	Mean parcel size	
TDR, Montgomery County	24641	82	77.7	16.6
PDR, Riverhead	3786	97	59.2	32.6
Cluster, Southampton	709	92	13.7	8.9

Table 10
Summary comparison of land protection for the three programs^a

Program	Total acres protected	Percent of land base protected (%)	Average protected parcel size (acres)	Percent of protected parcels in active agriculture (%)	Percent of protected land in aggregations (%)
TDR, Montgomery County	30062	31	74.1	82	91
PDR, Riverhead	3889	23	51.1	97	75
Cluster, Southampton	771	6	13.7	92	36

^a In the TDR program, the land parcel retains development rights at the rate of 1 unit per 25 acres after transfer.

In Southampton, 92% of all subdivision reserve areas were actively farmed. For the purposes of this study, land in agricultural production includes equestrian land (153 acres), land used by commercial nurseries and orchards (45 acres), and farmland producing row or specialty crops (511 acres). The status of two SRA parcels (11.5 acres) was undeterminable due to the visual and/or physical inaccessibility of the lots from public property. It is important to note that in addition to equestrian uses, several of the subdivision reserve areas were used as wildflower meadows, both of which take land out of traditional agriculture. Riding arenas and academies, while popular, have a high ratio of built structures and impervious surfaces, therefore, these uses do not preserve the prime agricultural soils as intended by the goals of the program.

In Southampton, larger parcels are more likely to be farmed than smaller parcels. Half of parcels under 5 acres were actively farmed; 91% of parcels 5–10 acres in size were actively farmed; 79% of parcels 10–20 acres were actively farmed; and 100% of parcels larger than 20 acres were actively farmed. One explanation for the dip in percentage of parcels actively farmed in the 10–20 acres category is that 10 acres may be too large to be leased for efficient truck farming and 20 acres too small to support efficient row crop production.

The analysis of active farming status in Montgomery County indicates one flaw of TDR program as applied in the county. While 82% of the protected land continues in agricultural use, it is the lowest percentage of the three programs. Part of the reason for this can be found in the mean parcel size of land not in active farm use, 16.6 acres. This supports the finding that the remaining development right of 1 unit per 25 acres encourages the creation of smaller parcels that have a residential function.

4. Conclusions

Avoiding fragmentation—the isolation of farmland parcels—is a key aspect of any farmland preservation strategy. Therefore, it is critical to understand the triggers and the effects of fragmentation inherent in any farmland preservation strategy. The results of this initial investigation into the spatial forms produced by

three farmland preservation programs identify several key triggers of fragmentation.

At the regional level, when looking strictly at the numbers of acres of farmland protected by the three programs, transfer of development rights appears to be the most successful agricultural land protection method. Montgomery County's transfer of development rights program resulted in a higher rate of land conservation than either of the other two programs—31% of the land base from transfer of development rights in Montgomery County, compared to 23% from PDR in Riverhead and 6% for Southampton's cluster program. The most significant weakness in the cluster program is the issue of preservation of the agricultural land base: only 6% of the original agricultural land base has been protected through the use of clustering, and only an average of 36% of an original parcel is protected under the requirements of the program. Thus, the effect of the cluster program is increasing fragmentation and loss of the land base.

However, the number of acres protected provides only an initial indication of the success of any of the three programs in avoiding land fragmentation. The success or failure of each program is clarified by the amount of protected land that continues to remain in active farming. The PDR program resulted in 97% of the preserved parcels in active agricultural production, compared to 82% for the transfer of development rights program. This is due at least in part to the remaining development rights in the transfer program (at the rate of 1 unit per 25 acres) that allow for further subdivision of the land into residential estates, a popular commodity in the metropolitan real estate market. Even in Southampton, where the parcel sizes are much smaller, the active agricultural use is 92%, underscoring the importance of severing all future development rights from the protected parcel.

As important to the issue of fragmentation is the question of how the farmland preservation programs achieve contiguous blocks of protected farmland. Again, the transfer of development rights program in Montgomery County is the most successful in achieving large contiguous blocks. However, the results also underscore the importance of developing a coordinated strategy utilizing a variety of farmland protection tools. Two of the case studies, Montgomery County and Southampton, which used a variety of tools for protecting farmland showed both a dramatic

increase in size of protected areas and reduction of protected parcel isolation when all of the farmland protection tools are included in the analysis. Meanwhile, Riverhead did not have a variety of active tools. While the PDR program in Riverhead used adjacency in its selection criteria, isolated parcels remained a problem in the program.

Further, research and comparison between programs is certainly needed, however, this analysis illustrates key criteria for effectively reducing fragmentation in a farmland protection strategy. First, an emphasis on protecting large parcels is critical to reducing fragmentation as much as possible during the protection process. Secondly, using adjacency and contiguity criteria in making preservation decisions improves the ability to protect large contiguous blocks of land and are key in ensuring that farming can continue effectively in the targeted area. In this respect, severing all development rights from the land will ensure the continued viability of farming, lessening the potential of conversion to residential uses. In cluster programs, effectiveness is also influenced by the amount of review discretion granted to the site plan approval board, and the threshold of open space protection required in the ordinance. Finally, the analysis and comparison of the three land preservation strategies reinforces the importance of utilizing and coordinating a variety of protection tools to achieve optimum protection of the land base.

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References

- American Farmland Trust, 1997. *Saving American Farmland: What Works*. American Farmland Trust, Washington, DC.
- Arendt, R., 1991. Cluster Development: A Profitable Way to Save Open Space. *Land Development*: 26–30.
- Arendt, R., 1997. Basing cluster techniques on development densities appropriate to the area. *J. Am. Plann. Assoc.* 63 (1), 137.
- Arendt, R., Brabec, E.A., Dodson, H., Reid, C., Yaro, R.D., 1994. *Rural by design: maintaining small town character*. American Planning Association, Chicago.
- Bryant, C., Johnston, T., 1992. *Agriculture in the City's Countryside*. Belhaven Press, London.
- Daniels, T.L., 1991. The purchase of development rights: preserving agricultural land and open space. *J. Am. Plann. Assoc.* 57, 421–431.
- Daniels, T.L., 1997. Where does cluster zoning fit in farmland protection? *J. Am. Plann. Assoc.* 63, 129–137.
- Dramstad, W.E., Olson, J.D., Forman, R.T.T., 1996. *Landscape ecology principles in landscape architecture and land-use planning*. Harvard University Graduate School of Design, Island Press, and the American Society of Landscape Architects, Boston, MA.
- Gerard, J., 1984. *Criteria for Agricultural Land Protection, Land Saving Action*. Island Press, Covelo, CA.
- Heimlich, R.E., 1989. Metropolitan agriculture: farming in the city's shadow. *J. Am. Plann. Assoc.* 55, 457–466.
- Heimlich, R.E., Brooks D.H., 1989. *Metropolitan growth and agriculture: farming in the city's shadow*. Resources and Technology Division, Economic Research Service, US Department of Agriculture. *Agricultural Economic Report* no. 619.
- Lapping, M., 1979. Underpinnings for an agricultural land reformation strategy. *J. Soil Water Conserv.* 34 (3), 124–126.
- Lapping, M.B., Daniels, T.L., Keller, J.K., 1989. *Rural Planning and Development in the United States*. Guilford Press.
- Maryland-National Capital Park and Planning Commission, 1980. *Functional Master Plan for the Preservation of Agriculture and Rural Open Space in Montgomery County*. Maryland-National Capital Park and Planning Commission, Silver Spring, Maryland.
- Merriam, D.H., 1978. Making TDR work. *NC Law Rev.* 56, 77–139.
- Montgomery County Code, 1997. *Montgomery County Code*. American Legal Publishing Corporation, Cincinnati.
- Nelson, A.C., 1994. Preserving prime farmland in the face of urbanization: lessons from Oregon. *J. Am. Plann. Assoc.* 58, 467–488.
- Pfeffer, M.J., Lapping, M.B., 1995. Prospects for a sustainable agriculture in the northeast's rural/urban fringe. *Res. Rural Sociol. Dev.* 6, 67–93.
- Scarfo, R.A., 1990. *Cultivating Agriculture: A Report of Current Trends and Future Viability of Farming in Maryland's Metropolitan Fringe*. Maryland Office of Planning and The University of Maryland, College Park.
- Suffolk County, 1996. *Suffolk County Agricultural Protection Plan*. Suffolk County, New York.
- Suffolk County Planning Department, 2000. http://co.suffolk.ny.us/planning/acq_progrs.html.
- Town of Southampton, 1989. *Code of the Town of Southampton*. General Code Publishers Corp., Rochester, New York.
- US Census, 1997. *Census of Agriculture*.
- Whyte, W.H., 1964. *Cluster Development*. American Conservation Association, New York.

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