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Abstract: Conservation development has become a widely accepted residential development option in suburban areas in Pennsylvania. As an alternative to conventional, sprawl settlement patterns, conservation development is touted as a land development form that can more effectively preserve natural resources at both the site level and over a region. Based on a sample of completed conservation developments in Chester County, Pennsylvania, this research empirically assesses the outcome of these projects in regard to preservation of selected natural features. The features that are tested include steep slopes, woodlands and open space. The results indicate that conservation development is more effective at preserving open space and moderate and steep slopes than woodlands. The findings have implications for the design of effective regulations of conservation development to better preserve all natural features.

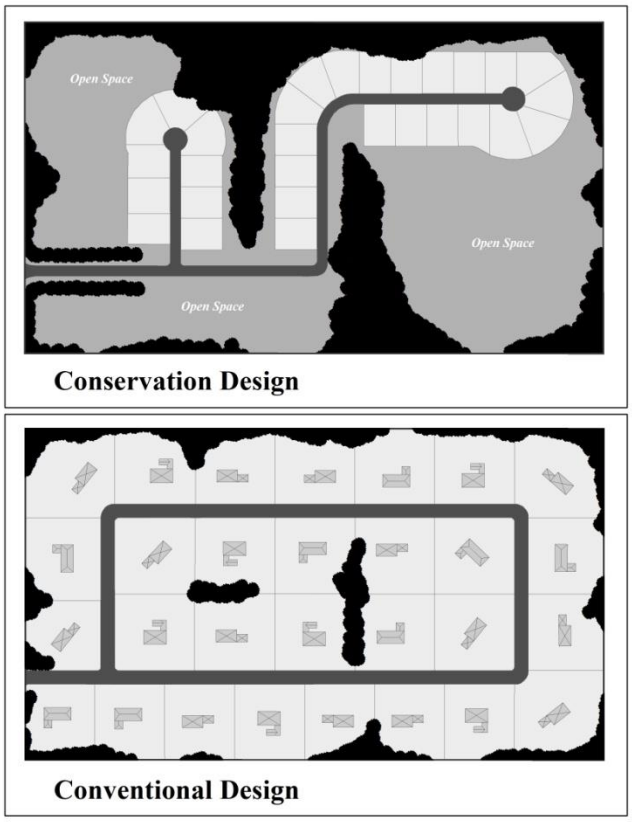
INTRODUCTION

Residential development is a pervasive presence in the suburban landscape. In suburban Philadelphia, residential development accounts for 25% of all land use (DVRPC, 2008). While the recent world financial crisis has slowed the pace of homebuilding, trends in suburban development are expected to continue in the future. The main forces driving suburban trends are demographic in nature, including overall population growth and new household formation, combined with trends towards increasing land consumption per household. Additionally, advances in high speed travel and telecommunications technology continue to create decentralizing forces in metropolitan areas (Heimlich and Anderson 2001). Land development creates a number of ecological impacts. Conventional suburban land development disturbs natural resources, fragments habitat systems, degrades water resources and diminishes the landscape aesthetic (Radeloff et al 2005). Left unchecked, conventional development can quickly degrade the system of unprotected lands and to reduce the ecological quality of protected areas (Ewing et al. 2005).

Conservation development has been used to manage suburban growth throughout the United States since the early 1990s. Sometimes called cluster development or open space design, conservation development is a design approach to land development that seeks to balance residential development with the preservation of environmentally sensitive resources, historic resources, or other unique features of the land being developed. Conservation development emerged as an alternative to conventional suburban low-density development on large lots that permeates the suburban landscape (Milder, 2007). Arendt (1996) provides the standard description of the purpose and the form of conservation development. A conservation subdivision is a residential development that clusters residential units on lots that are smaller than typically permitted and protects a large area or areas of the site as undisturbed land (see Figure 1). The land that, under a conventional design, would have been divided among larger individual lots is consolidated into areas of common shared open space for the benefit of residents of the community. By linking conserved lands over a larger area, conservation development is said to reduce the damaging effects of new suburban development over a larger region (Chester County, 2002).

Conservation developments are often built above the maximum density permitted for conventional development. In the early 2000s, conservation development remained a relatively small niche activity compared to conventional development, accounting for approximately 2.5% of total US real estate development (McMahon and Pawlukiewicz 2002). In recent years it has become a more common development form in rapidly growing suburban areas.

Figure 1. Conservation v. Conventional Development



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Much of the literature on conservation development is normative or theoretical in nature. The land use planning literature promotes conservation development as one of a number of tools to balance open space and natural resource preservation with the need for housing (Arendt, 1996). Natural features such as woodland areas, wetlands, riparian habitats, slope, and open space are said to be better protected with conservation development than with conventional development. However, to date, here has been relatively limited effort to empirically assess the effectiveness of conservation development in meeting planning goals, particularly with respect to preserving sensitive natural resources. The purpose of this research study is to fill in part of this analytical gap

by providing an empirical assessment of the natural preservation outcomes of recent conservation development projects.

Conservation development is implemented through zoning and subdivision ordinances and other land development regulations that specify design elements of the development such as density, minimum lot size, area and bulk standards, as well as disturbance limits on selected sensitive natural resources. For this research, geographic information systems (GIS) is used to measure pre- and post-development conditions of natural features over a sample of residential cluster developments. The observed disturbance to a selection of natural features is compared to the permitted disturbances as indicated in the municipal zoning ordinances that govern each of the properties. The analysis assesses the extent to which planning objectives for preservation are met. Findings have important implications for the efficacy of cluster development patterns in preserving natural resources and implications for the design of effective regulations.

LITERATURE REVIEW

New residential development in the metropolitan fringes inevitably disturbs valuable natural resources such as woodlands, slopes, wetlands, floodplain, riparian features and other natural elements that are unique to an area. Conservation development is promoted as a means to accommodate residential development while simultaneously preserving natural features, rural character and wildlife habitat (Austin, 2003). The primary purpose of conservation development is to identify and preserve natural resources and conservation areas from development. During the subdivision design process, these areas are identified and protected from development. Typically those that

are the most fragile and generally not buildable such as very steep slopes, wetlands and floodplain are considered *primary* conservation areas. *Secondary* conservation areas are then identified and typically include such places as woodlands, areas with historic and cultural resources, wildlife habitat and productive farmland. Lots are designed to position homes in areas that will have the least disturbance on the conservation resource areas. Early forms of clustering were concerned with maximizing the overall amount of preserved land, with little regard to the quality of the natural resources (Whyte 1968). More recent efforts at open space conservation design encourages a clustering pattern that focuses on the quality of land preserved as well as the amount (Arendt, 1996, 1999).

Conservation developments make use of natural resources by incorporating views as well as passive and active recreation uses such as trails and common open space which are managed by a homeowner's association (HOA) or other entity. Regulations typically require that 40 to 60 percent of the original parcel be protected from development, with priority given to areas with natural resources. Conservation easements are used to protect preserved lands from future development. Research has found that HOA management goals for common open space typically favor recreational use, aesthetic qualities, and privacy elements, over its use for natural resource conservation (Austin and Kaplan 2003).

There is a relatively sparse academic literature that evaluates the effectiveness of conservation development in meeting planning objectives. Investigating a variety of projects that incorporate conservation and development projects, Margoluis and Salafsky (1998) found that there are no uniform methods for assessing the success of conservation initiatives that are consistent across different contexts. A small number of studies have

looked at socio-economic aspects of conservation development. Mohamed (2006) evaluated price and economic efficiency characteristics and found that lots in conservation subdivisions sell at a premium over lots in conventional suburban developments. His study also found that developers spend less per unit on infrastructure. Investigating the social and educational aspects of conservation subdivisions Austin and Kaplan (2003) and (Kaplan 2003) found that the shared open space areas posed challenges for residents. Proper stewardship of open spaces required knowledge and skills that sometimes were not available in a community as well as the necessity for public participation and social engagement. Residents typically need outside expertise and resources to organize and effectively manage the community's natural resources.

While a number of studies have projected environmental benefits of conservation development (City of Olympia 1996, Milder 2007), there has been little effort to assess the natural features preservation results of conservation developments. In a recent empirical study of a sample of clustered housing communities in Colorado, Lenth et. al. (2006) found that the clustered communities were not significantly different from nearby conventional housing developments in regard to the conservation of bird, mammal, and native plant species.

Regulating Natural Features

Local land-use regulation, because it is too fragmentary and weak, has generally been found to be ineffective in achieving significant conservation in areas that are developing rapidly (Beatley 2000). In Pennsylvania, regulation over disturbance of natural features is largely vested in the local municipalities. Local governments have to

comply with federal and state regulations regarding disturbance to primary resource areas including wetlands, critical wildlife habitat, and floodplain, but are empowered to create their own standards in regard to disturbance of woodlands, riparian buffers, prime soils and open space conservation. Through zoning regulations, municipalities specify limits to the disturbance of natural features in a development plan including disturbance to floodplain, wetlands, steep slopes, riparian buffers, and woodlands. With conservation subdivision, developers are typically provided incentives in the form of higher site densities in return for more protection of natural features.

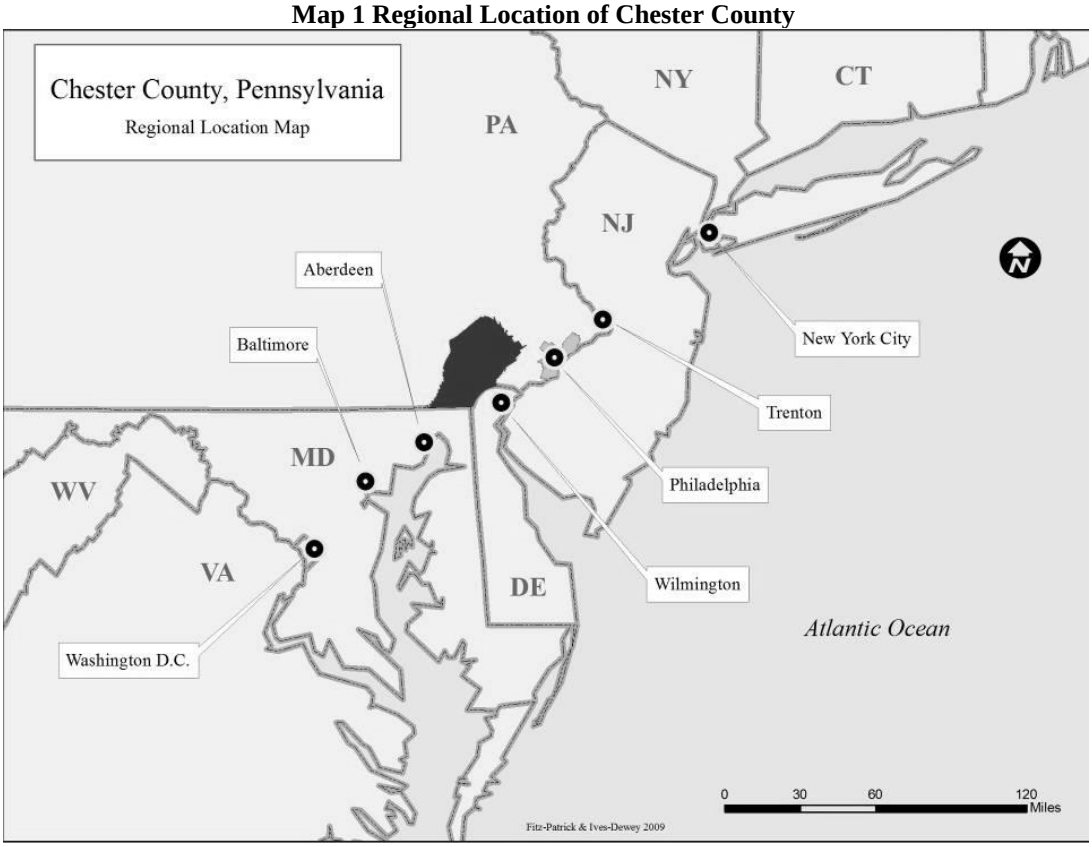
There is little consistency among local municipalities in regard to permitted disturbance limits across the spectrum of natural resources. There is greater consistency in the regulation of primary resource protection features such as flood plain, wetlands and steep slopes. Most ordinances impose stringent standards in limiting disturbance to these features, reflecting federal and state regulation that imposes strict disturbance limits. For secondary resource features, such as riparian buffers, moderate slopes, and woodlands, local communities have the authority to establish their own standards over permitted disturbance and ordinances vary widely.

The first generation of conservation development communities now exists in Pennsylvania. The purpose of this study is to empirically assess the effectiveness of conservation development in meeting goals related to the preservation of natural resources.

STUDY AREA

The study area for this research is Chester County, Pennsylvania. Chester County, a suburban county in the Philadelphia metropolitan region, is one of the fastest growing counties in the state. Chester County was one of the three counties created by William Penn in 1682. Situated between Philadelphia to the east and Wilmington, Delaware to the south, the county offers an easy commute to these two large metropolitan areas (see Map 1).

Map 1 Regional Location of Chester County



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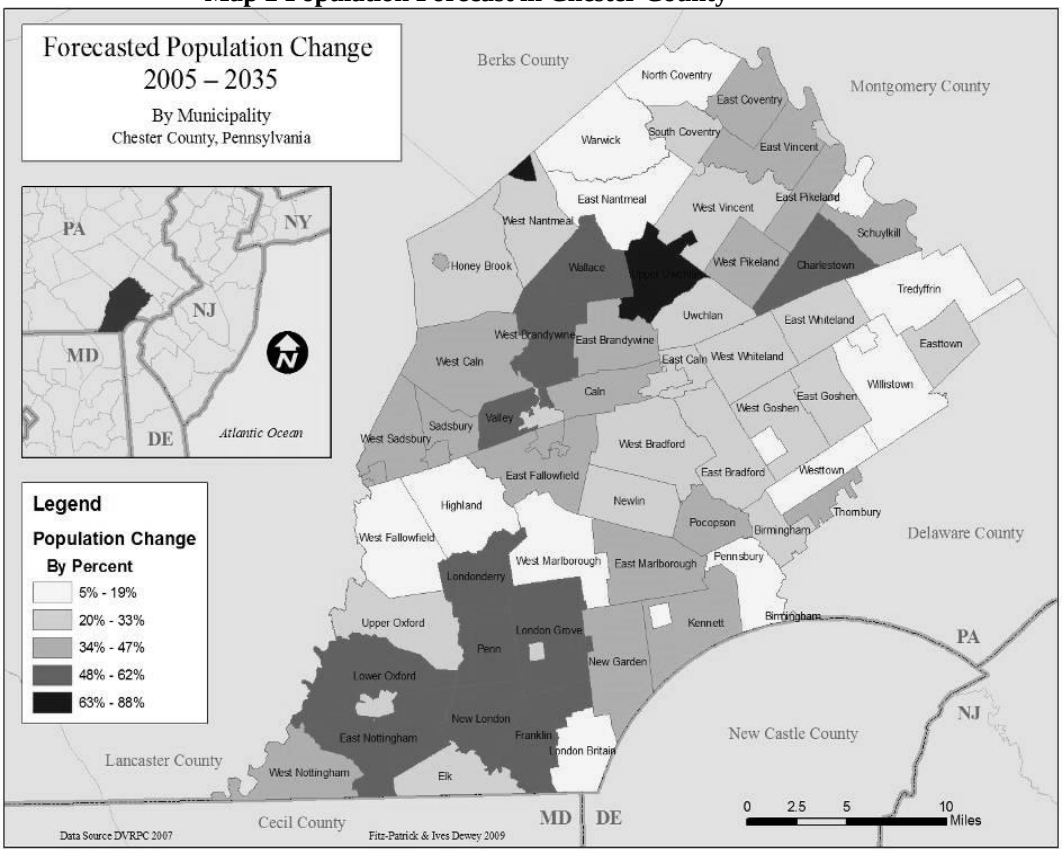
Census data from 2000 indicate that the county experienced a 15.17% (376,396 to 433,501) increase in population between 1990 and 2000. According to the American Community Survey, 2003-2007, Chester County had 479,000 people in 2007,

representing a 10.5% increase from 2000. Map 2. Population Change in Chester County shows the forecasted population change between 2005 and 2035. Every township and borough in the county is expected to experience positive growth with more than half the municipalities projected to grow 34% or more. With an almost certain increase in population in the decades to come, it is important to identify which development methods are effective at managing growth in a sustainable manner.

Map 2 Population Forecast in Chester County



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Pennsylvania's governing structure over land use is a major impediment to effective regional planning in the state. Most powers of land use planning in Pennsylvania, including zoning and subdivision, are vested in local municipalities. The county operates in largely an advisory capacity in providing resources to help local

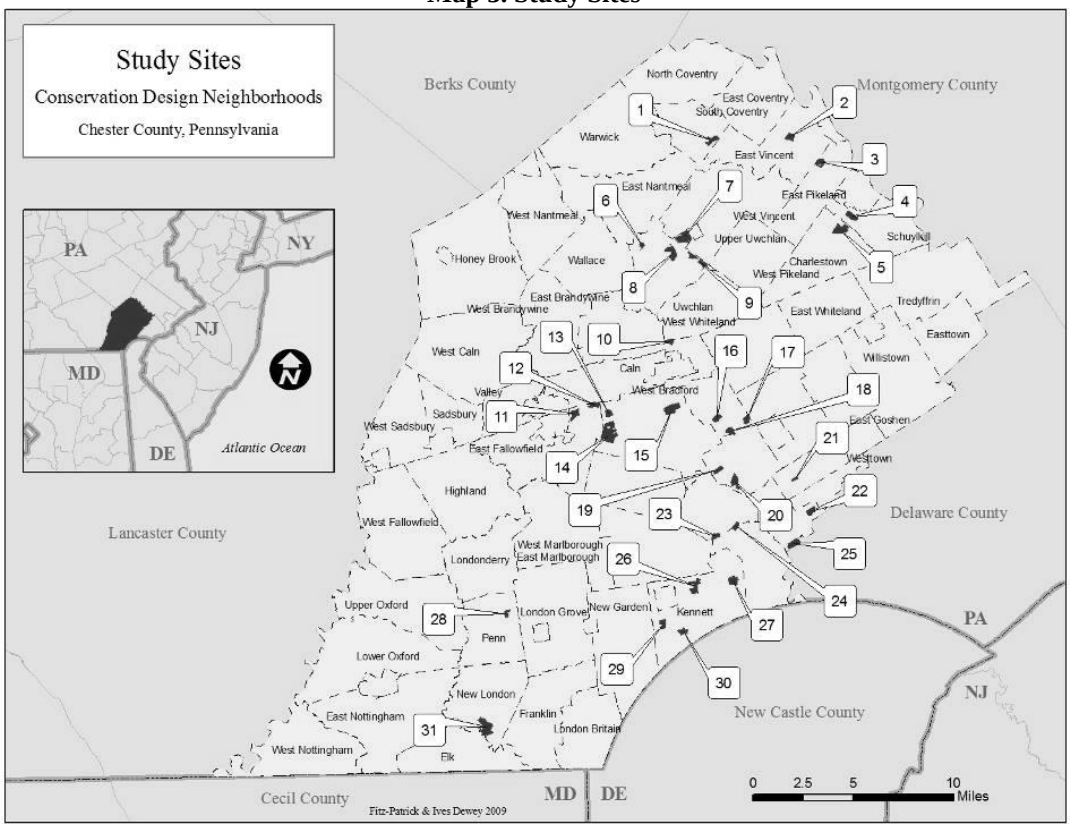
governments plan better. Chester County has been an active proponent of conservation development, particularly through the efforts of the Chester County Planning Commission. Conservation development was promoted by the County as one of a number of planning tools to guide growth in a way that complements the existing rural character of the county and to conserve natural resources. A guide prepared in 2003 (Chester County Planning Commission, 2003) provides municipal guidelines for promoting conservation development through examples of successful conservation subdivisions in the county. A number of townships in Chester County adopted conservation development ordinances through the late 1990s early 2000s. Today, most municipalities in the county have implemented some form of conservation development in their zoning regulations. Typically offered as a development option that required conditional use approval, in some townships, conservation design was made the "by-right" alternative to development. That is, conservation design is specified in the zoning ordinance as the permitted form of development. Other forms, such as conventional development patterns require a conditional use or a special exception and additional layers of regulatory review.

METHODOLOGY

A sample of conservation developments was selected for the analysis. Thirty-one (31) sites were identified, each of which represents a conservation subdivision development that had been completely build out. The study sites are located in 17 different municipalities distributed throughout Chester County (see Map 3). There are no sites located in the western edge of the county. While many of these western townships have conservation development ordinances, there are no completed conservation

development projects. The eastern edge of the county was also not represented in the sample. This area of the township was largely developed prior to the advent of conservation development within the county.

Map 3. Study Sites



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GIS was used to identify and quantify certain attributes of the developments. Using ArcGIS (version 9.3) data were collected for the County and the individual sites. General information was gathered for each of the selected developments, including total area (in acres) and the density of development (number of housing units per acre). Impact to natural features was determined by analyzing aerial images of each site. Pre-development and post-development aerials were analyzed to determine the impact to certain selected natural features between the pre- and post-development states. The pre-

development aerial was from 1990, which preceded development on any of the parcels. The post-development aerial was from 2007, a time after the development of each of the tracts was completed.

Observed Disturbance

For each site, the total amount of disturbance between the pre-development and post-development periods was obtained for each of the following natural features: open space, woodlands, severe slopes, and moderate slopes. Each of these features is described in this section.

Common open space

To qualify under the local zoning ordinance as a conservation development, a minimum amount of the tract has to be preserved as open space. Often referred to as common open space, these areas provide passive an active recreation for community residents. The amount of required common open space varies, but is typically in the range of 30-70% of the parcel. Using GIS, common open space for both the pre-development and the post-development states was determined by identifying areas of contiguous undisturbed area on the parcel. An area had to be a minimum of one undisturbed acre to be counted as common open space.

Steep slopes

Municipalities have different disturbance limits for different categories of steep slopes. Most ordinances classify slopes as either moderate slopes or severe slopes. Moderate slopes are typically in the range of 15-25% grade. Steep slopes are those that exceed a 25% grade. The disturbance limits on moderate slopes is typically more

permissive than the allowed disturbances on severe steep slopes. Using GIS, steep slopes were identified by analyzing contour lines for each of the site.

Woodlands

Each site had a considerable amount of wooded area in its predevelopment state. Using GIS, measurements were taken from the aerial images of the amount of woodland that existed in the pre-development state and the remaining woodland in the post-development state. The criteria for what constituted a woodland was a contiguous wooded area of one-quarter acre or more. Individual trees or small outcroppings were not counted as woodlands.

Permitted Disturbance

The observed disturbance of natural features was compared with the permitted disturbance of those features. Permitted disturbances were determined by reviewing the applicable sections of the zoning ordinances that governed each study site. Disturbance to natural features is regulated in most cases by zoning. Each municipality sets its own standards for permitted disturbance. The zoning ordinances specified, typically in percentage terms, the amount of each of the natural features – open space, woodlands and slopes – that could be disturbed in the final development. Using the analytical method described below, the observed disturbances from the completed developments were compared to the permitted disturbances for each of the natural features.

Statistical Analysis

The data were analyzed using a Wilcoxon Matched-Pairs Signed-Rank test. The Wilcoxon test is a non-parametric, statistical hypothesis test which can be used to compare two related samples. The test requires an interval level of measurement, but it

does not require a normal distribution of the measurements. The distribution of the data was tested for normality using a Shapiro-Wilkes test (the Kolmogorov-Smirnov is an alternative test for normality, but the data set, with 31 observations, was too small). The data were found to not be normally distributed.

The null hypothesis is that there is no significant difference between the medians of the two samples. That is, there is no significant difference between the observed amount of disturbance of a particular feature and the permitted disturbance of that feature as determined by the ordinances. The test was run on four separate types of natural features: common open space, woodlands, severe slopes and moderate slopes. The alternate hypothesis is that there is a difference between the medians of the two samples. The significance level was set at .025, since it is a two-tailed test.

RESULTS

Table 1 shows the observed amount of disturbance, in percentages, for the four types of natural features. There is a wide range of observed disturbance amounts for each of the four natural features. Woodlands had a median disturbance of 36.16%, with a maximum of nearly 87% and a minimum of approximately 8.43%. The median disturbance of common open space was 54.62%, with a high of over 97% and a low of approximately 14%. Disturbance to moderate slopes also showed a large range with a high of 93.59% and a low of 21.07%, and a median of 21.07%. Disturbance to steep slopes showed the lowest range with a high of 48% and a low of 0%. The median disturbance to steep slopes was 0%.

Table 1. Observed Disturbance Summary Statistics

Natural Resource	Median Disturbance Level	Maximum Disturbance Level	Minimum Disturbance Level
Woodland	36.16%	86.79%	8.43%
Open Space	54.62%	97.15%	13.71%
Moderate Slope	21.07%	93.59%	0.0%
Steep Slope	0.0%	48.00%	0.0%

n = 31

For each study site, the permitted amount of disturbance was identified for each natural feature. There is a wide variation in permitted disturbances of natural features. Table 2 summarizes the observations over each of the natural features. Once again, the data show a wide range of permitted disturbance levels. In the case of woodlands, the median permitted disturbance was 25%. However, the range of permitted disturbance varied from a low of 5% permitted disturbance to a high of 75% disturbance. Permitted disturbance of open space ranged from a low of 30% to a high of 70%, with a median of 50%. Permitted disturbance of moderate slopes shows the highest range with a high of 100% (virtually no protection of moderate slopes) and a low of 5%. The median permitted disturbance of moderate slopes is 15%. The strictest regulations are those that govern steep slopes, where the median permitted disturbance is 0% with a low of 0% and a high of 20%.

Table 2. Permitted Disturbance from Zoning Summary Statistics

Natural Resource	Median Disturbance Level	Maximum Disturbance Level	Minimum Disturbance Level
Woodland	25%	75%	5%
Open Space	50%	70%	30%

Moderate Slope	15%	100%	5%
Steep Slope	0%	20%	0%

n = 31

Significance Test

To determine if there is a statistically significance difference between the observed disturbances and the permitted disturbance limits specified in the zoning ordinances, a Wilcoxon matched-pairs signed-rank test was run to compare the means of the observed disturbances with the permitted disturbances for each of the four types of natural features. The results are reported in Table 3.

Table 3. Wilcoxon Matched-Pairs Signed-Rank Test Results

Natural Resource	z-value	Sig. (2-tailed)
Woodland	-2.371	.018
Open Space	-1.842	.065
Moderate Slope	-0.745	.456
Steep Slope	-1.087	.277

n = 31

These results indicate that there is no statistically significant difference between observed and permitted disturbances for moderate slopes or steep slopes. The observed disturbance of these features is not significantly different from the permitted disturbances as prescribed by the zoning regulations. The results also indicate that there is no statistically significant difference between observed and permitted disturbance of open space, although the significance value (0.065) is closer to 0.025. Still, for this variable the null hypothesis that there is a difference between permitted and observed disturbance of open space can not be rejected.

The results indicate that there is a statistically significant difference between the observed and permitted woodland disturbances. This finding suggests that the actual

disturbances are not consistent with the specifications of the ordinances. In 25 of the 31 cases, the amount of disturbed woodlands exceeded the permitted disturbance amounts. The median observed disturbance of woodlands (36.16%) is higher than the median permitted disturbance for woodlands (25%).

DISCUSSION AND IMPLICATIONS

The findings of this study are mixed and have important implications for the effective design of regulatory mechanisms to support conservation subdivision initiatives. The results of the analysis suggest that municipalities are doing an effective job at regulating the disturbance of some natural features, but not all. Zoning and subdivision are the strongest regulatory mechanisms that local municipalities have to preserve natural resources. Primary conservation areas such as wetlands, floodplain and steep slopes are generally well-protected in ordinances with strict limits over their disturbance. While the analysis did not evaluate wetlands and floodplain, it did find that steep slopes are being appropriately regulated. The results also suggest that regulatory protections over common open space are consistent with the objectives of conservation subdivision, as the observed disturbance to these resources is consistent with prescribed disturbance levels.

The statistically significant difference between the permitted and observed disturbances of woodlands indicates that actual woodland disturbance is not consistent with the specifications of the ordinances. This suggests that zoning is not as effective in regulating disturbance of woodlands. Preservation of woodlands is an important component of conservation development. Woodlands are valuable to a township for both aesthetic and functional purposes. Aesthetically, the rural character of a low density

suburb is largely due to the presence of woodlands, hedgerows and other significant vegetation. Functionally, vegetation helps to dissipate rainfall and prevent erosion and thereby provides soil stability. When significant stands of trees and shrubs are left undisturbed, wildlife habitat is provided. Protection of specimen vegetation such as heritage trees is common. Protection of woodlands and hedgerows from alteration is less common.

In order to effectively accomplish preservation of this resource, there needs to be more effective regulation that can appropriately specify and effectively enforce woodland disturbance. A review of the ordinances governing each of the observed developments indicates a general lack of consistency and clarity in regulating woodland disturbance. While some townships are highly precise in regard to what woodlands can be disturbed and how they can be disturbed, other ordinances are quite vague or do not address the preservation of woodlands at all. This is an important area for future research.

CONCLUSION

With an almost certain increase in population in the decades to come, it is important to identify which development methods are effective at managing growth in a sustainable manner. Conservation subdivision has received a tremendous amount of attention and implementation as a tool to preserve natural resources. While conservation subdivision is in principle a planning approach that has the potential to guide growth in a way that preserves natural resources, the findings of this study suggest that in order to be effective, land use regulations, particularly zoning, have to be rigorous with clearly prescribed standards that are consistent with conservation development objectives.

Without an effective regulatory mechanism, resource protection consistent with the goals of conservation subdivision will be difficult to achieve. The findings indicate that those natural resources, notably steep slopes and common open space that are rigorously regulated are successfully protected with conservation design. However, woodlands are not afforded the same regulatory backing and therefore are not as consistently protected.

From a research standpoint, more empirical analysis is needed to assess the conservation outcomes of cluster and conservation design development approaches. Future studies need to consider additional characteristics of these developments such as the size or scale of the projects, elements of form or design, geographic features, and economic elements. Testing over these parameters can help further an understanding of the factors that promote or undermine conservation effectiveness. The findings of this study also indicate that additional work is also needed to determine how to best integrate conservation development into land use regulation to ensure that this tool is implemented properly to contribute to large-scale conservation and development objectives. Effective regulatory design is one of the best ways by which a community can ensure that conservation goals promoted by conservation development can be achieved.

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