Analyzing conservation-siting decisions and spillover effects in North Carolina

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Table of Contents

Executive Summary

Land conservation is used to protect a variety of vulnerable ecosystem services and land uses in the United States and around the world. As of 2019, 12% of the total land in the US was protected for conservation by private actors and public agencies. Strategies to select land for conservation consider a host of factors – the benefits protected by conserving land, the cost of implementing conservation, and the risk of future development if land remains unprotected.

The two main tools used to conserve land are fee-simple acquisitions through which conservation actors purchase land, and conservations easements through which conservation actors enter into land-use agreements with landowners. These two tools differ in the kinds of benefits they can conserve, their costs of implementation and their ability to reduce future development risk. These differences may lead conservation actors to use fee-simple purchases and easements to protect different kinds of lands. The implementation of these tools may also have differing impacts on neighboring land values, posing a threat to future conservation of surrounding lands. In this study I used data on conserved lands in Durham County, North Carolina to understand how fee-simple acquisitions and conservation easements are used to conserved different types of lands and what their differing spillover effects are on surrounding land prices.

The *Introduction* section provides context for our study by explaining the importance of land conservation and the mechanisms through which land is conserved in the United States. It also summarizes the hypotheses of our study. The *Theory* section elaborates on these hypotheses by outlining the rationale behind the use of fee-simple purchases and conservation easements to conserve different types of lands and their differing spillover effects. It describes how conservation actors may use the two tools to maximize the benefits of land conservation while minimizing the costs of implementation and the risks of future land conversion. The study predicts that fee-simple purchases would be used to protected land parcels with higher ecological value, higher costs of conservation, and higher risks of future development as compared to easements. It also discusses the reasons behind positive spillover effects of using fee-simple purchases and conservation easements to protect land.

The *Material & Methods* section provides an overview of Durham County, the data, and the methods used to answer our research questions. It provides a summary of land conservation in the county including the distribution of conserved land between the two main tools used, the different kinds of conservation actors and different levels of protection. The section presents the data used and compiled from different sources and the methods of statistical analysis used. The study uses logistic regression

analysis to analyze how different benefits, costs and development risks influence the use of the two tools and a matched Ordinary Least Squares (OLS) analysis to analyze the different spillover effects.

The *Results* section provides summary statistics for the data being analyzed and summarizes the results of the analysis. The *Discussion* section discusses the results in the context of our hypotheses and limitations of the study. The study finds that land parcels conserved through fee-simple purchases have higher conservation priority, higher land value and are closer to urban areas as compared to parcels conserved through conservation easements. The study also finds that vacant parcels are sold for higher prices when they are closer to fee-simple purchases than conservation easements. While our statistical analysis alone is not able to confirm our hypothesis, they do provide some evidence in favor of it. The study calls for similar research with sufficient geographical and temporal variation to understand important differences in the impact of fee-simple purchases and conservation easements.

Introduction

Land conservation, the practice of taking land out of production or limiting its use to practices that sustain ecosystem services, is a critical part of ecosystem conservation. Increasing urbanization and land conversion for human use have increased pressure on natural lands and habitats. Over 2 million acres of land are converted for development use in the United States annually (Reeves et al. 2018). With the impending climate crisis that threatens the balance of ecosystems, there is a growing need to preserve undeveloped environments that provide important services like carbon sequestration, water filtration, habitat for threatened species, open space for recreation etc.

Creation of protected areas has long been considered essential for both wildlife conservation and prevention of climate change. There is scientific support for the need to preserve land and reduce anthropogenic disturbances in natural landscapes to prevent a rise of 2 degrees Celsius in global temperatures (Waite 2019). The UN Convention on Biological Diversity, signed by 196 nation parties, aimed to set aside 17% of lands and 10% of oceans for conservation by 2020 to reduce the speed at which species are nearing extinction (UN Convention on Biological Diversity 2018). As of 2019, 15% of land and 7% of the global seas have been protected for conservation. Recently, the U.S. Congress enacted the John D. Dingell, Jr. Conservation, Management, and Recreation Act with strong bipartisan support. The Act authorized long term funding for public land and water conservation in the US signaling that both democratic and republican legislators recognized an urgent need for such conservation interventions (Davenport 2019).

This Act is important for land conservation in the United States, which is largely a public undertaking. As of 2019, 12% of the total land in the U.S., approximately 2.8 million acres, was protected for conservation (Richards 2018). Of this protected land, 97% is protected by federal, state and local governments and only 3% is protected by private actors (Richards 2018). Public land conservation has been instituted through various laws and mechanisms. The largest driver of land conservation is the Land and Water Conservation Fund, a program that directs offshore drilling revenue into onshore conservation projects like national parks and other public lands (“LWCF Overview” 2015). The fund, which was established by Congress in 1964, has extended over $3.9 billion in state grants for the protection of over 2.37 million acres (“Land and Water Conservation Fund” 2015).

Although public lands dominate land conservation in terms of quantity of land protected, private land conservation is incredibly valuable in terms of the quality of land protected. Private lands provide habitat for 95% of the federally threatened or endangered flora and fauna listed and 19% of these species only survive on private lands (Merenlender et al. 2004). Since federal and state governments are well-

positioned to acquire large tracts of land at a time, in general, they often focus their efforts in more rural areas where demand for land and land prices are low (Baldwin and Leonard 2015). Some studies have found that local governments and private land conservation agencies like land trusts and NGOs tend to work on smaller scales and focus on protecting more vulnerable land in areas of high demand like the outskirts of cities (Rissman and Merenlender 2008).

Despite these differences, public and private land conservation primarily happens through two main mechanisms – fee-simple acquisition/purchase and conservation easements. Agencies use fee-simple acquisition when they purchase the title to the land parcel at its total market value. Acquired through this purchase, the government or land trust becomes the landowner and regulates the current and future use of the land (Merenlender et al. 2004). Conservation easements regulate the use of the land in a similar way but maintain original ownership of the land. Conservation easements are voluntary legal agreements that restrict how a parcel of land can be used (Merenlender et al. 2004). A landowner may either donate or sell the rights to place an easement on the land parcel to the government or conservation actor, who become the easement holders. Unlike fee-simple acquisition, conservation easements allow the landowners to continue their use of the land, subject to certain restrictions agreed upon in the contract. The easement holders are usually responsible for monitoring and enforcing easement specifications. Easements are often perpetual i.e. all future land use, even after resale, must abide by the easement contract.

Despite scientific consensus on the need for land conservation, the strategy for selecting land for conservation and creating management plans is complex and contentious. Lands differ in the types of benefits they provide, how much they cost and how likely they are to be converted to other land uses. While some land parcels may act as important habitats for vulnerable species, others may be key parts of a wetland system. When deciding which land parcel to conserve, both public and private actors must compare lands and rank them according to their specific conservation priorities. In such site selection exercises, agencies' budgets are a limiting factor (Messer and Allen 2018). Even if governments and land trusts want to protect multiple land parcels, they may not have the required finances to do so. Thus, the cost of land conservation must play a role in the site prioritization process. Furthermore, the threat of development and conversion varies from parcel to parcel and conservation actors should ideally consider the risk of future development when making investment decisions to guarantee long term benefits.

Since fee-simple acquisitions and easements differ in their implementation costs, the kind of activities they allow on the land, and thus the kind of ecological value they can protect, conservation entities may use them on different kinds of parcels. Easements have become more popular as a conservation tool in the recent decades due to concerns about rising land prices and exclusion of local

community interests in land conservation (Merenlender et al. 2004). As easements are more widely implemented, it is important to analyze to what extent fees and easements protect lands that are not only ecologically valuable but are also at a risk of being degraded.

Siting of fee-simple purchases and easements may also have spillover effects on surrounding land prices that could endanger future land conservation. Land conservation creates benefits and amenities for surrounding communities by providing scenic open spaces, recreational activities, and access to clean air and water (Brander and Koetse 2011). As people choose to shift closer to conserved land to enjoy these benefits, the demand for land increases, capitalizing these benefits into higher real estate prices. Real estate prices may be even higher if people perceive that tools like easements create permanently conserved lands and prevent future land use that could be undesirable or costly to community members in anyway. While higher land prices may generate greater tax revenue, they may also make future conservation of surrounding land parcels more costly leading to a fragmented landscape with pockets of conserved land in a sea of developed land (Armsworth et al. 2006). An analysis of how real estate prices respond differently to lands conserved using fee-simple purchases and conservation easements would help understand how these tools may be deployed to complement each other and create corridors of conserved land.

In this paper, I analyzed the kinds of lands conserved using fee-simple acquisitions versus conservation easements and how these two tools affected land prices around the conserved land parcels in Durham County, North Carolina. I sought to understand whether conservation actors use fee-simple acquisitions and conservation easements to conserve different types of lands or if the two tools act as substitutes. I also explored whether the implementation of a fee-simple acquisition has a greater impact on neighboring land values than conservation easements. If fee-simple parcels are sited in higher risk areas and further increase surrounding land values, it may lead to conservation of isolated land parcels and perhaps conservation easements and fee-simple parcels may be used together to conserve more contiguous lands.

Theory

Siting land conservation

The process of conserving land involves decisionmaking by conservation entities as well as owners of land parcels. Land is conserved when an organization decides they want to conserve a parcel of land and the landowner agrees to the terms and conditions of the conservation tool being implemented.

Site selection or prioritization is the process through which conservation agencies select and rank order the land parcels they want to conserve. Since agencies have different priorities and resources, their strategies for site selection may vary. The most common method for selecting and prioritizing land parcels is the traditional Benefit Targeting approach. This strategy only considers the conservation benefits of land parcels when prioritizing them for protection without comparing costs and future development risks of the land parcel options (Messer and Allen 2018). A second strategy an agency may use is to consider both ecological value i.e. benefits of the land parcel as well as the overall cost of conservation. Such an approach would try to choose a portfolio of land parcels that maximizes the benefits per unit cost of conserving land (Newburn, Berck, and Merenlender 2006). For example, an agency may choose to forego protecting a highly valuable land parcel if the cost of conserving it is high rendering the benefits per unit cost low. The third strategy that agencies can employ is considering the expected benefits and costs of land conservation over time. Such an approach considers the risk of future land conversion and the counter-factual scenario to model the expected benefits of conserving a land parcel. In such a case, a land parcel with high ecological value but with low risks of conversion to other land uses may have lower expected benefits than a land parcel with moderate ecological value but high risk of conversion (Newburn, Berck, and Merenlender 2006).

Since fee-simple acquisitions and conservation easements differ in the type of resources required for their implementation and the level of protection they provide, conservation agencies may deploy them in different ways. In general, conservation actors would prefer to use conservation easements over fee-simple purchases since easements only require the purchase of development rights while fee-simple purchases require the purchase of the entire land parcel. However, in cases where the land parcel has a high development risk, the value of the development rights makes up a greater proportion of the overall land value such that purchase of the easement would be akin to purchasing the entire land parcel. Hence conservation actors would be likely to ease land with lower development risk, where development rights only make up a small portion of the total land value, and purchase land with higher development risk, where development rights make up most of the land value. From a benefits perspective, fee-simple purchases allow for better land management and would be preferred either when the conservation value is very high and requires specific management practices or when the land has a high development potential, which may reduce the landowner's inclination to maintain the property for conservation.

From the landowner's perspective, considerations of future development potential of their land, current livelihood concerns, and a desire to conserve their land would dictate conservation decisions. Landowners who own land that has a low risk of being converted for more intense uses may be more likely to conserve their land. The sale of the land or easement could provide a higher income than the

future development of the parcel. In such cases, land conservation would be more common on land with lower risk of development, further away from urban areas. Additionally, landowners who want to continue to use their land but would also like additional income may opt to sell the easement on their land parcel. Such decisionmaking would make easements more common on land with lower biodiversity value in addition to low development risk.

In summary, fee-acquisition and conservation easements may be sited in the following ways based on the following considerations:

1. Ecological value – Fee-simple purchases are used on land with higher ecological value while conservation easements are used on land with lower ecological value because the former tool allows for better management.
2. Conservation costs and development risk –Fee-simple purchases are used on higher value land with higher development potential as compared to conservation easements because purchase of development rights would make up a larger portion of land value.

Davies, Kareiva, and Armsworth (2010) found that although fee-simple acquisitions tend to be more expensive on a cost per hectare basis, conservation easements tend to be applied to larger tracts of land and thus make up a larger portion of agencies' costs. Rissman and Merenlender (2008) also found that fee-simple properties were more likely to be sited in urban areas than conservation easements in their analysis of land conservation in San Francisco Bay Area.

Impact on neighboring land prices

Conserved land offers several amenities like cleaner air and water, scenic views etc. to communities that live near it and can result in an increase in the value of surrounding lands. Surrounding land values may increase by a greater level if the conserved land is under fee-simple purchase and is likely to protect higher biodiversity value while preventing intensive activities like logging. Furthermore, if fee-simple purchases are sited on land with a higher risk of conversion, the perceived impact of a fee-simple purchase on protection of ecological benefits may be greater than that of conservation easements. This may result in greater increases in surrounding land values for fee-simple purchases compared to conservation easements. On the other hand, since easements can permanently conserve land parcels unlike fee-simple purchased lands, which can be sold for future development, lands under easements may result in larger increases in land prices as compared to lands acquired through fee-simple acquisition.

Studies that explore the differential impact of fee-simple acquisition and conservation easements on surrounding land prices have come to different conclusions. Chamblee et al. (2011) analyzed the

impact of fee-simple acquisition versus conservation easements on vacant land parcel values in Buncombe County, NC to find that fee-simple purchased parcels resulted in greater increases in land values as compared to easements. On the other hand, Mittal (2014) and Geoghegan (2002) found that open space lands with a permanent conservation contract in the form of easements resulted in higher increases in surrounding land values than mixed bag open spaces like forests that may be conserved using other tools like fee-simple acquisition.

Materials & Methods

Study Area

This analysis used data on land parcels and land conservation in Durham County, North Carolina. The county is in Central North Carolina and covers an area of 772 km^2. Its population is estimated at just over 300,000 people, most of whom reside in the city of Durham, making it the sixth most populous county in the state (City of Durham n.d.; U.S. Census Bureau 2010). Durham County has a significant amount of land under both natural forest cover and urban development making it an ideal county to study conservation siting and its spillover effects. According to the 2016 National Land Use Land Cover Data, most of the county is classified as forest land (46%) followed by developed land (35%) and agricultural land (8%) ("National Land Cover Database" 2019).

Of the total land in the county, 158.49 km^2 (20.5%) is under conservation by both public and private entities. Federal government conserves half of this land through the US Army Corp of Engineers and the Natural Resources Conservation Service of the USDA. The remaining land is conserved by the state government (22%), private entities like land trusts (19%), and the local government (9%) (North Carolina Natural Heritage Program 2019a).

Both public and private entities primarily use fee-simple purchases to conserve land for both conservation and extractive activities. Land under fee-simple conservation makes up 90% of the total land under conservation while the remaining falls under conservation easements and mixed protection agreements (North Carolina Natural Heritage Program 2019a). The conserved area is managed for conservation to varying degrees and is classified into Gap Statuses based on these management practices. According to the United States Geological Survey, Status 1 lands are permanently protected in their natural state and are managed by allowing/mimicking natural disturbance activities, Status 2 lands are similar to Status 1 lands but allow management practices detrimental to natural communities like suppression of natural disturbances, and Status 3 lands are permanently protected in their natural state for a majority of their area but also allow extractive activities like logging and mining (Prior-Magee,

Johnson, and Croft 2020). A majority (89.5%) of the conserved land in Durham County is classified as Status 3 land followed by Status 2 (8%) and Status 1 (2%). Status 3 land makes up a 100% of the land that is conserved by the federal and local government and a bulk (78%) of state-conserved land as well. Private entities primarily conserved land categorized as Status 2 (61%) followed by Status 3 (37%) and Status 1 (0.03%). Finally, Status 1 and Status 3 lands are conserved primarily through fee-simple purchases while Status 2 lands are almost equally distributed between easements and fee-simple acquisitions.

Data Sources

Data on land conservation in North Carolina was available from the Managed Areas Database created by the North Carolina Natural Heritage Program. The database contained geospatial data on land parcels that have been conserved in North Carolina by both private and public actors along with information on conservation ownership, conservation tools used, and the conservation gap statuses of the conserved parcels (North Carolina Natural Heritage Program 2019a). I also used the National Conservation Easement Database to supplement the Managed Area dataset with additional information on conservation easements such as the date when the easement was established (Ducks Unlimited and The Trust for Public Land 2016). I used these data on conserved land parcels to calculate the percentages of conserved land around each vacant land parcel in the county.

Data on all land parcels in the county was extracted from the Durham County land parcels dataset compiled by the Integrated Cadastral Data Exchange project and hosted by the North Carolina OneMap initiative (Brown 2016). The dataset included spatial information about the land parcels and parcel characteristics such as current land use, presence of structures on the land and most recent date of sale. Most recent date of sale served as the date of conservation for land parcels under fee-simple conservation. I also extracted the year of sale to serve as a control for time trends in real estate prices. Most recent sale price for each land parcel was found in the Durham County tax parcel dataset (Durham County Tax Administration 2019).

The conservation benefit of each land parcel may be gauged by multiple criteria. I used the Biodiversity and Wildlife Habitat Assessment map created by the North Carolina Natural Heritage Program to assign conservation value to each land parcel in the study area (North Carolina Natural Heritage Program 2019b). The Biodiversity and Wildlife Habitat Assessment map is a raster file that ranks the North Carolina landscape based on multiple ecological criteria like ecosystem services, terrestrial habitat and land connectivity. While the benefits considered by land trusts and government

bodies may vary depending on their priority, such a map ranking the entire landscape based on different ecological values could capture most of the benefits considered by conservation agencies.

I used elevation data from the Digital Elevation Model (DEM) raster for North Carolina hosted on the North Carolina OneMap platform (NC Floodplain Mapping Program 2019a; 2019b). I used the same DEM to extract slope values in degrees. I used the Web Soil Survey data for Durham County, collected and hosted by the National Resources Conservation Service at the USDA, to summarize the development limitation on each land parcel (National Cooperative Soil Survey 2019). The Web Soil Survey categorizes soils as very limited, somewhat limited and not limited based on the ability of the soil to accommodate structures like dwellings with basements, dwellings without basements, and small commercial buildings. Depending on the land parcel's soil type, I assigned the most limiting rank for development. Distance to nearest urban center and distance from Interstate Highways, U.S. Routes, and State Routes were calculated using the city boundaries and state road network maps created by the North Carolina Department of Transportation (NC Department of Transportation 2019a; 2019b). Finally, I used geospatial Land Use Land Cover (LULC) data from the 2016 National Land Cover Database, compiled by the Multi-Resolution Land Characteristics Consortium of federal agencies, to calculate percentage of developed impervious area within a 1 km radius of each land parcel ("National Land Cover Database" 2019).

Analysis

To analyze how ecological value, cost of conservation and future development risk influenced the siting of conservation easements vs fee-simple acquisitions, the analysis was limited to the 274 land parcels that were conserved between 2000 and 2019, when both tools were being implemented, in Durham County. I divided the sample further to analyze the use of easements vs. fee-simple purchases inside city limits (N = 131) and outside city limits (N = 143). I selected 13 covariates, compared means using t-tests, and calculated Pearson's correlations to check for collinearity among the covariates (Pearson 1895) (Table 1). Since the data sample for parcels inside and outside the city contained a small proportion of conservation easements, I used a Firth's Penalized-Likelihood Regression method to analyze changes in the binary response variable *Constool* (Zorn 2005). I calculated Variance Inflation Factors to select variables and reduce multicollinearity in the regression.

I expected conservation easements to be sited in regions with lower biodiversity ranks as compared to fee-simple purchases. I expected easements to be sited on parcels with lower land value and lower future risk of development, as compared to parcels with fee-simple purchases. This means I expected easements to be sited on lands at higher elevations, higher slopes, further away from road

networks, with greater soil development limitation, with less impervious land and more conserved land around them. Finally, for land parcels outside the city limits, I expected conservation easements to be more prevalent further away from city limits as compared to fee-simple purchases.

To analyze the differential impact of conservation easements and fee-simple purchases on surrounding land values, I used Propensity Score Matching followed by an Ordinary Least Squares (OLS) regression model (Austin 2011). I used the propensity score matching method to identify 72 land parcels that had equal probabilities of being eased based on the benefits they protect, their land values and their risk of future development. I then identified 2,550 vacant land parcels in Durham County that were sold after the closest of the matched parcels had been conserved. I used 12 covariates in the analysis, compared means using t-tests, and checked for multicollinearity through Pearson's correlations (Pearson 1895). I used a stepdown procedure based on the Akaike Information Criterion to obtain the most parsimonious final model (Burnham and Anderson 2002).

I expected parcels at a lower risk of future development i.e. parcels at higher elevations, higher slopes, further away from the city, further away from road networks, with higher soil development limitations, with less impervious land in the surrounding region to have lower sale prices. I also expected parcels that were further away from conserved parcels and with less conserved land in the surrounding region to have lower sale prices. On the other hand, I expected parcels close to land that was under fee-simple conservation as opposed to easement and was more highly protected to have a higher sale price.

Results

Siting land conservation

Of the 274 conserved land parcels, 241 were under fee-simple conservation while 33 were under conservation easements. Within Durham city limits, an average conserved land parcel covered an area of 0.13 km^2 (SD = 0.30 km^2) at an elevation of 315.5 meters (SD = 63.10 meters) and a slope of 6.73 degrees (SD = 4.93 degrees). Conserved land parcels were, on average, 3.65 km from Interstate Highways, 2.42 km from US Routes and 2.49 km from State Routes. They were surrounded by 9.04 % of impervious land and 34.45 % of conserved land within a 1 km radius. The parcels had a mean biodiversity and wildlife assessment rank of 5.04. Outside Durham city limits, the average conserved land parcel covered an area of 0.19 km^2 (SD = 0.60 km^2) at an elevation of 344.5 meters (SD = 85.52 meters) and a slope of 8.26 degrees (SD = 5.46 degrees). The parcels were 6.99 km from Interstate Highways, 3.93 km from US Routes, and 4.14 km from State Routes on average. They were surrounded by an average of 2.98 % of impervious land and 44.12 % of conserved land within a 1km radius and had a mean biodiversity rank of 5.78.

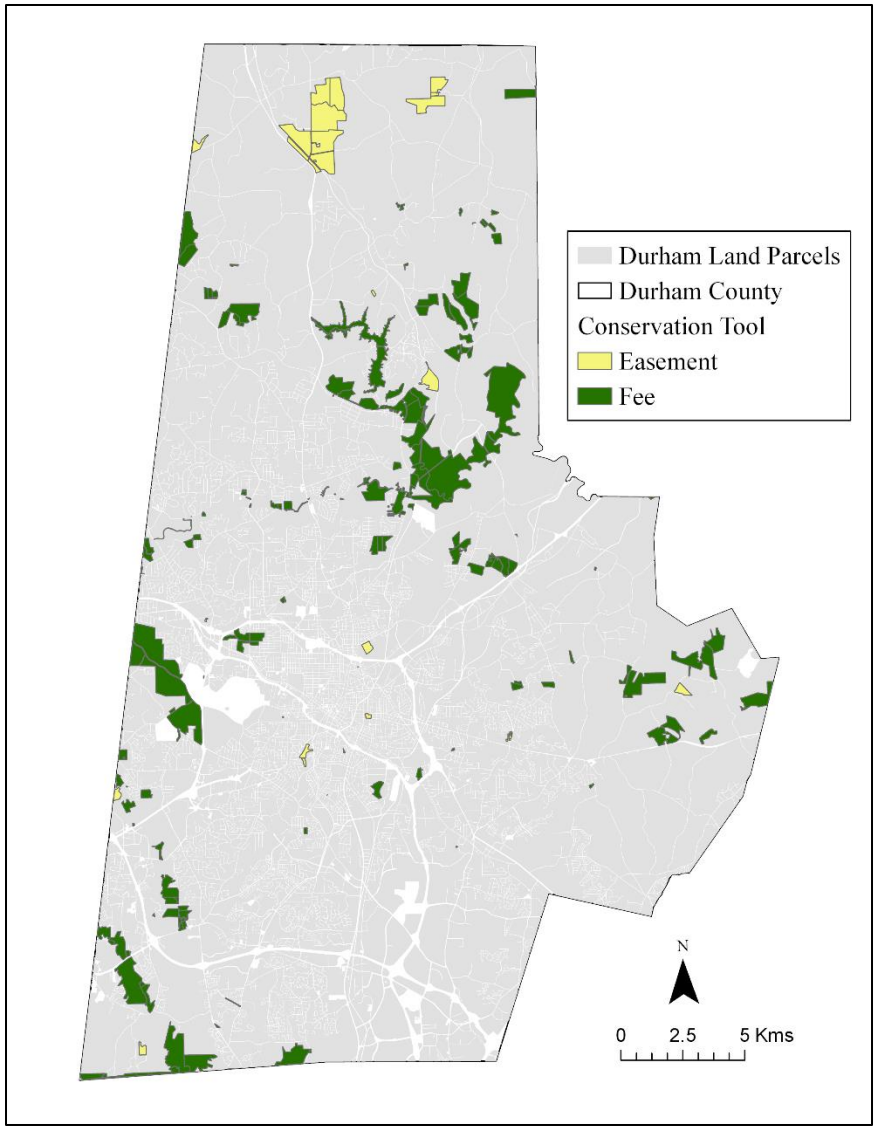

Figure 1: 274 conserved land parcels in Durham County, North Carolina

Using t-tests, I found that fee-simple parcels differed from conservation easements in statistically significant ways. Parcels under fee-simple conservation had a higher land value per m^2 ($t(53) = 2.58$, $p < 0.05$), were closer to the city ($t(33) = -3.13$, $p < 0.01$), were at lower elevations ($t(36) = -2.26$, $p < 0.05$), were at steeper slopes ($t(44) = 2.30$, $p < 0.05$), had less impervious land around them ($t(37) = -2.39$, $p < 0.05$) and had a higher biodiversity rank compared to conservation easements ($t(49) = 7.04$, $p < 0.01$; Figure 2).

Within Durham city limits, I found that land parcels that that were further away from Interstate Highways and were conserved more recently were more likely to be under conservation easements than

fee-simple conservation (Table 3). On the other hand, land parcels that were closer to state routes were more likely to be under fee-simple conservation than easements holding all other factors constant (Table 3). I did not find any other factors of statistical significance in the model.

Outside Durham city limits, I found that land parcels that were more recently conserved were more likely to be under conservation easements than fee-simple conservation (Table 3). I did not find any other factors of statistical significance in the model.

Spillover effects

The 2,550 vacant land parcels included in our analysis were sold for a mean price of 1,092.81 USD per m^2. The parcels were situated 0.41 km (SD = 1.41 km) from Durham City Boundaries at an elevation of 373.9 meters (SD = 64.53 m) and a slope of 7.08 degrees (SD = 3.61 degrees). On average, 17.04% of the land within 1 km of each vacant land parcel was impervious while only 7.70% of the land was conserved. The land parcels were at a mean distance of 4.07 km from Interstate Highways, 2.22 km from US Routes, and 1.78 km from State Routes.

The nearest conserved parcel was under fee-simple conservation for 1,616 vacant parcels and under conservation easements for 934 vacant parcels. The mean distance between vacant land parcel and the nearest conserved land parcel was 1.84 km (SD = 1.57 km). Most of the vacant parcels were closest to land conserved by Local Government (985), followed by State Government (889), Private entities (518), and Federal government (158). The vacant parcels were mostly near conservation classified as Status 3 followed by Status 2 and Status 1. A t-test comparison revealed that vacant lands sold near fee-simple conservation sold for significantly higher prices than parcels sold near conservation easements ($t(1452) = 16.379$, $p < 0.01$; Figure 3).

According to my analysis, higher priced vacant lands were closer to Durham city, closer to Interstate Highways and State routes, at higher elevations, in regions with greater impervious land, and in regions with more land under conservation (Table 4). Vacant land sale prices also increased with increased distance from the closest conserved land parcel. Finally, sale prices were higher for vacant lands that were close to land conserved by the federal government compared to lands conserved by private actors or state and local governments. I did not find any other factors of statistical significance.

Discussion

Through my analysis, I found that fee-simple parcels were associated with higher ecological value but that the ecological value was not a significant predictor of the kind of tool used to conserve land. Among all the parcels conserved in Durham County, we found that parcels that were classified as

Status 1 were only protected via fee-simple purchases. Since Status 1 parcels do not allow any interference with natural ecological processes including disturbance activities, fee-simple purchases that give conservation actors complete control over the land parcel would be more useful as a conservation tool. This was supported by the finding that fee-simple parcels had a significantly higher biodiversity rank than eased parcels. Despite the positive association between biodiversity rank and fee-simple purchases, the regression analysis did not find biodiversity rank to be a significant predictor for the kind of conservation tool used on the conserved parcel.

Although fee-simple parcels were associated with higher risk of development, the development indicators did not serve as significant predictors for the kind of conservation implemented. Comparing fee-simple parcels to conservation easements, I found that fee-simple purchased parcels had higher land values and were closer to urban areas suggesting they conserved land at a higher risk of development compared to easements. Fee-simple purchased parcels also had a higher percentage of conserved land around it suggesting fee-simple purchases were used to create large contiguous portions of conserved land. Despite finding statistically significant differences in proxies for cost and development, the regression analysis failed to support our hypothesis. While we found that fee-simple purchases were closer to Interstate highways and thus may have a higher likelihood of being developed in the future, there was no statistically significant difference between fee-simple purchases and easements for other development indicators. The lack of statistically significant results may be attributed to our small sample in terms of conservation easements and geography. Easements made up only a small percentage of the parcels considered for analysis (12%) and such a small sample may not be enough to study differences between fee-simple acquisitions and easements. Furthermore, our analysis was limited to Durham County, 38% of which is already urban. There may not be enough variation in land values and development risks across the county to estimate the influence of these factors in the use of the two tools.

To understand the differential effects of fee-simple purchases and easements on surrounding land prices, we analyzed 2,550 parcels but did not find evidence for differential impact. Although we found that vacant lands close to fee-simple purchased parcels had higher sale prices per m^2 than conservation easements, the conservation tool dropped from the regression when I controlled for other characteristics of the conserved parcels. Higher sale prices were associated with a higher distance from the conserved land parcel suggesting that either conservation reduces sale prices, contrary to our predictions, or that conservation occurs in regions with lower land values. Chamblee (2011) found a similar result in their study of spillover effects of land conservation in Buncombe County, NC where land conservation was more likely to be sited on lower value land parcels, especially in areas with higher land values. Unexpectedly, our analysis found that higher sale prices were associated with federally conserved land

despite the federal government conserving Status 3 lands that allow for more extractive activities and undesirable land uses.

This preliminary analysis of land conservation in Durham County revealed that fee-simple acquisitions are being sited on land with higher ecological value and on parcels that have a higher risk of urban development than conservation easements. Since fee-simple purchases may be sited on higher value land, we also found sale prices for neighboring vacant parcels to be higher near fee-simple acquisitions than easements. This indicates that conservation actors do use these two tools to conserve different kinds of land and there may be a complementarity where lands that may not be at immediate risk of conversion but have moderate conservation value can be better protected through easements than an expensive tool like fee-simple purchase. Finally, we found that fee-simple purchases were surrounded by more land conservation than easements suggesting that either the spillover effects of conservation are not enough to deter future conservation around the parcel or conservation actors choose to purchase multiple parcels at the same time. If the former is true, that reduces the risk of creating fragmented landscapes but if the latter is true, then the risk remains and may be higher in areas where local conservation actors do not have enough funds to purchase multiple sites at once. Hence, a similar study over a larger geographic and temporal scale is required to understand how and why land conservation strategies are implemented and their effects on future conservation.

Limitations

The results from this study are limited due to the small geographic sample and limited variation in the data. Our analysis to understand how fee-simple and conservation easements were sited used 274 parcels however only 33 parcels were conservation easements. Furthermore, both analyses were limited to Durham County which is very urban and does not present enough variation in land prices and risks of development to statistically differentiate conservation siting decisions and differential spillover effects. Finally, our study was limited by data availability. We eliminated land parcels that were duplicated in their tax parcel numbers or geometry. We also eliminated land parcels that lacked data on important model attributes such as land value and conservation ownership in the case of conserved parcels, and sale price and sale date in the case of vacant parcels. Our study was not able to control for any selection biases that may have been introduced as a result of such sample selection.

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Tables

Table 1: Descriptive statistics and model covariates to analyze the siting of conservation easements and fee-simple lands in Durham County

Variable	Definition		Inside City Limits				Outside City Limits			
			N	Mean	Standard Deviation	Range	N	Mean	Standard Deviation	Range
Constool	Tool used on nearest conserved parcel	Fee-simple (0)	120	NA	NA	NA	121	NA	NA	NA
		Easement (1)	11	NA	NA	NA	22	NA	NA	NA
Lndvl_2	Value of land parcel per m^2 (USD)		131	8.63	14.82	0-93.56	143	3.66	4.32	0-25.39
city_dist	Distance to closest urban center (Km)		NA	NA	NA	NA	143	1.97	2.56	0-10.42
Elev	Elevation (meters)		131	315.5	63.10	227-519	143	344.5	85.52	215-570
slope	Slope (degrees)		131	6.73	4.93	0-24.59	143	8.26	5.46	0-27.17
imperv	Percentage of impervious land within 1km of the land parcel (%)		131	9.04	8.04	0.13-37.73	143	2.98	4.24	0-17.58
Perc_cons	Percentage of conserved land within 1km of the land parcel (%)		131	34.45	18.75	0.44-71.73	143	44.12	24.86	0.60-98.91
Dist_1	Distance to closest Interstate Highway (Km)		131	3.65	2.77	0.028-10.37	143	6.99	4.24	0.032-18.06
Dist_2	Distance to closest US Route road (Km)		131	2.42	1.73	0.006-9.97	143	3.93	2.04	0.01-10.03
Dist_3	Distance to closest State Route (Km)		131	2.49	2.13	0.009-6.28	143	4.14	2.72	0.015-9.99
Area_m2	Area of land parcel (Km^2)		131	0.13	0.30	0.00-1.68	143	0.19	0.60	0.00-6.63
biod	Biodiversity value of parcel		131	5.04	4.14	(-1)-10	143	5.78	3.91	(-1)-10
devlim	Development limitation on the land parcel due to soil type	Very Limited (1)	102	NA	NA	NA	100	NA	NA	NA
		Somewhat Limited (2)	8	NA	NA	NA	15	NA	NA	NA
		Not Limited (3)	21	NA	NA	NA	28	NA	NA	NA
consyear	Year of conservation		131	NA	NA	2000-2019	143	NA	NA	2000-2018

Table 2: Descriptive statistics and model covariates to analyze the effect of conservation on vacant land parcel sale prices in Durham County

Variable	Definition		N	Mean	Standard Deviation	Range
Ln_saleprice	Natural Log of sale price per m^2 (USD)		2550	3.97	2.48	(-4.16)-12.53
city_dist	Distance to closest urban center (Km)		2550	0.41	1.41	0-10.92
Elev	Elevation (meters)		2550	373.9	64.53	242-658
slope	Slope (degrees)		2550	7.08	3.61	0-30.27
imperv	Percentage of impervious land within 1km of the land parcel (%)		2550	17.04	12.80	0.08-57.17
Perc_cons	Percentage of conserved land within 1km of the land parcel (%)		2550	7.70	13.50	0-76.96
Dist_1	Distance to closest Interstate Highway (Km)		2550	4.07	3.14	0.025-19.54
Dist_2	Distance to closest U.S. Route (Km)		2550	2.22	2.12	0.0045-10.29
Dist_3	Distance to closest State Route (Km)		2550	1.78	1.97	0.0064-10.06
Dist_cons	Distance to nearest conserved parcel (Km)		2550	1.84	1.57	0.00-10.15
consarea	Area of conserved land parcel (Km^2)		2550	0.06	0.13	0.00-1.29
Constool	Tool used on nearest conserved parcel	Fee-simple (0)	1616	NA	NA	NA
		Easement (1)	934	NA	NA	NA
consownr	Ownership of nearest conserved parcel	Federal (1)	158	NA	NA	NA
		State (2)	889	NA	NA	NA
		Local Government (3)	985	NA	NA	NA
		Private (4)	518	NA	NA	NA
consstat	Conservation status of nearest conserved parcel	Status 1 (1)	161	NA	NA	NA
		Status 2 (2)	1145	NA	NA	NA
		Status 3 (3)	1244	NA	NA	NA

Table 3: Firth's Penalized-Likelihood Logistic Regression results

Impact on the probability of conservation easement vs fee-simple purchase		
	Dependent Variable Logit(Easement=1)	
	Inside city limits	Outside city limits
Area of land parcel (m^2)	0.0000 (0.0000)	0.0000 (0.0000)
Land Value (USD per m^2)	-0.01175 (0.01744)	-0.02628 (0.04488)
Elevation (m)	-0.00585 (0.00520)	
Slope (Degrees)	-0.01077 (0.05073)	-0.01092 (0.03945)
Distance from city (m)		0.00011 (0.00010)
Distance from Interstate Highways (m)	0.00006 ** (0.00011)	
Distance from US Routes (m)	-0.00004 (0.00019)	-0.00004 (0.00010)
Distance from State Routes (m)	-0.00005 * (0.00016)	-0.00001 (0.00008)
Percentage of impervious land within 1km radius	0.00069 (0.05444)	0.04628 (0.06572)
Percentage of conserved land within 1km radius	-0.02624 (0.02049)	-0.00068 (0.01051)
Biodiversity Rank	-0.03638 (0.08414)	-0.02021 (0.05530)
Development Limitation – Somewhat Limited	-0.08940 (0.99084)	-0.07828 (0.70024)
Development Limitation – Not Limited	0.40887 (0.78727)	-0.01432 (0.52338)
Year of Conservation	0.01268 *** (0.05734)	0.00963 *** (0.04498)
Constant	-20.78125 *** (114.929)	-18.43750 *** (90.5493)
Observations	131	143
Likelihood Ratio Test	9.07 (df = 13)	159.7754 *** (df = 12)

Table 4: Ordinary Least Squares Regression results

Impact on vacant land sale prices	
	Dependent Variable Log(Vacant Sale Price)
Distance to City (m)	-0.0001 *** (0.0001)
Distance to Interstate Highways (m)	-0.0001 *** (0.00003)
Distance to US Routes (m)	-0.00004 (0.00003)
Distance to State Routes (m)	-0.0001 *** (0.00003)
Elevation (m)	0.003 *** (0.001)
Percentage of impervious land within 1km radius	0.049 *** (0.005)
Percentage of conserved land within 1km radius	0.019 *** (0.004)
Distance to closest conserved land parcel (m)	0.0003 *** (0.00004)
Parcel conserved by State Government	-1.918 *** (0.231)
Parcel conserved by Local Government	-1.380 *** (0.232)
Parcel conserved by Private NGO/Land Trust	-1.152 *** (0.245)
Constant	3.701 *** (0.424)
Observations	2,550
R^2	0.186
Adjusted R^2	0.183
Residual Std. Error	2.241 (df = 2538)
F Statistic	52.859^{***} (df = 11; 2538)
Note:	$^{*}p^{**}p^{***}p<0.01$

Figures

Figure 2: Comparison of means for 6 covariates between fee-simple acquisitions and conservation easements in Durham County

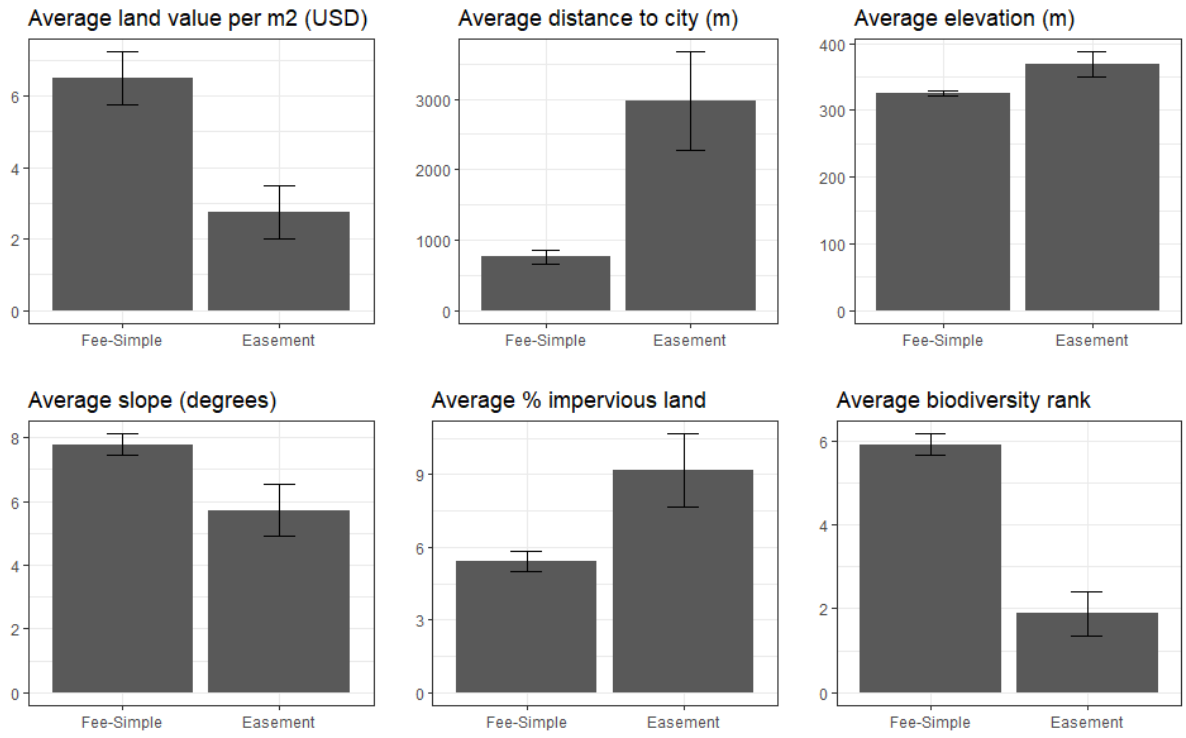

Figure 3: Comparison of log of sale prices of vacant lands close to fee-simple acquisitions and conservation easements in Durham County (N = 2,550)