Effects of Conservation Area Proximity and Size on Municipal Ballot Measures in the Eastern United States

Master's Project by Will Baughman and Griffin Bird

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Executive Summary

In recent decades, conservation ballot measures have been one of the principal means of conserving land in the United States. Recent research suggests that public support for these measures is significantly influenced by the characteristics of existing conservation areas, like land use designations. No studies thus far have investigated the impacts of existing conservation area size and proximity to municipalities on municipal conservation referendum success. We hypothesized that these variables would be negatively and positively correlated with referendum success, respectively, while state, time period, and additional socioeconomic and demographic variables would not be correlated with referendum success.

Our hypotheses were tested using a multiple logistic regression model and multiple linear regression model, yielding results that suggests negative correlations between referendum success and particular time periods, as well as positive correlation with certain socioeconomic and demographic variables, but no correlation with conservation area size or proximity. These results suggest that the physical conservation area characteristics assessed do not have the potential to influence referendum success, however our models have limited explanatory power and further study is needed to clarify this relationship.

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Introduction

As communities across the United States grow and change, they face a myriad of challenges – maintaining adequate housing stock, attracting new or better employment opportunities, providing public services to a changing population. Land conservation is certainly among these challenges. Communities must decide, often in the face of increasing development and population growth, where and how to establish conservation areas. For our purposes, conservation areas are protected parcels of terrestrial open space that preserve the natural environment, biodiversity, cultural heritage, and/or provide aesthetic and recreational opportunities.[1,2] Several policy tools are available to make conservation decisions at the municipal level, like conservation easements and ballot measures or referendums.

Conservation referendums, that is ballot measures that raise public funds for conservation, are important policy tools for communities across the country (Myers, 1999; Szabo, 2009). In 2020 alone voters across the United States approved nearly $3.7 billion in funding for land conservation, parks, habitat protection, and climate resilience through referendums (Trust for Public Land, 2020). Since 1988, conservation referendums have consistently approved millions, and frequently billions, of dollars for conservation projects annually, as shown in Figure 1.

[1] Per the United States Forest Service, open space refers to any open, undeveloped piece of land. This includes natural areas, grasslands, stream and river corridors, parks, etc (U.S. Forest Service, n.d.).
[2] We are using the term "conservation area" as this most aptly describes the areas contained within USGS' Protected Area Database, open spaces that have been protected (USGS, 2022).

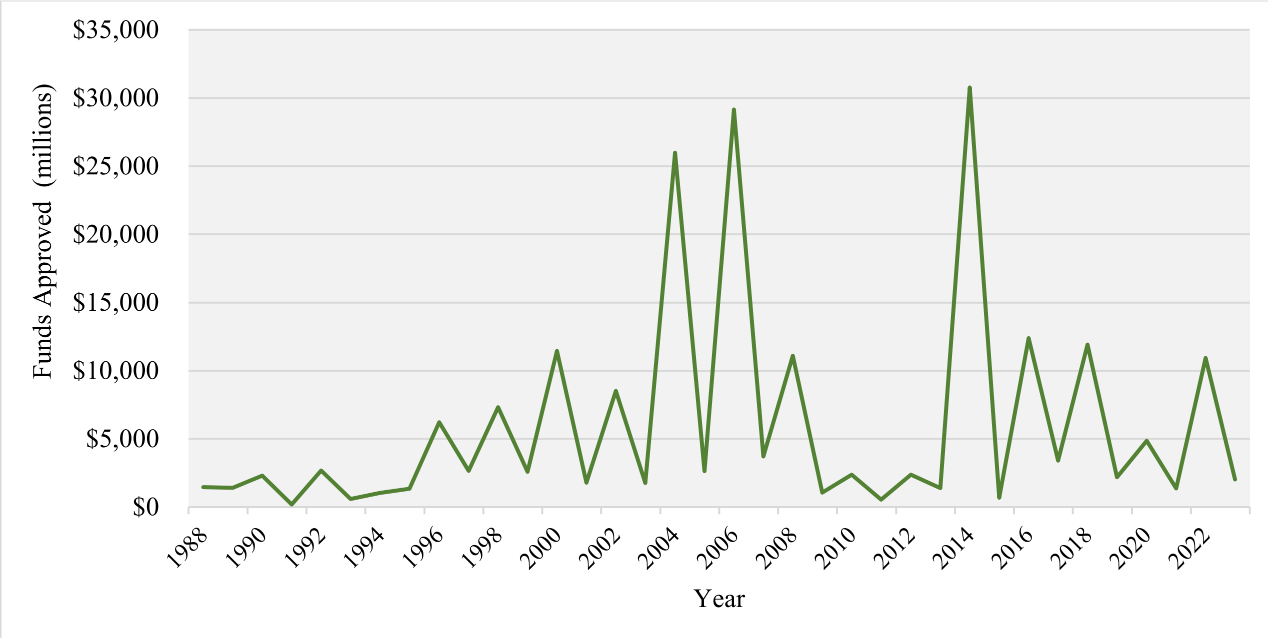

Figure 1. Total funds approved via conservation referendums in the United States, 1988 - 2023[3]

Referendums are attractive vehicles for conservation proposals as they provide relatively high policy durability, allow for direct democratic participation, and can bypass gridlocked legislatures (León-Moreta, 2021). Perhaps their most attractive aspect, conservation referendums are often successful. A study found that between 1996 and 2004 open space conservation referendums at the local, county, and state levels had a 77% passage rate (Szabo, 2009). However, conservation referendums are not always successful, see Figure 2, and are not used evenly across the United States (Kotchen & Powers, 2006; Szabo, 2009; Trust for Public Land, n.d.).

[3] Data from the Trust for Public Land's LandVote database, available at https://tpl.quickbase.com/db/bbqna2qct?a=dbpage&pageID=8.

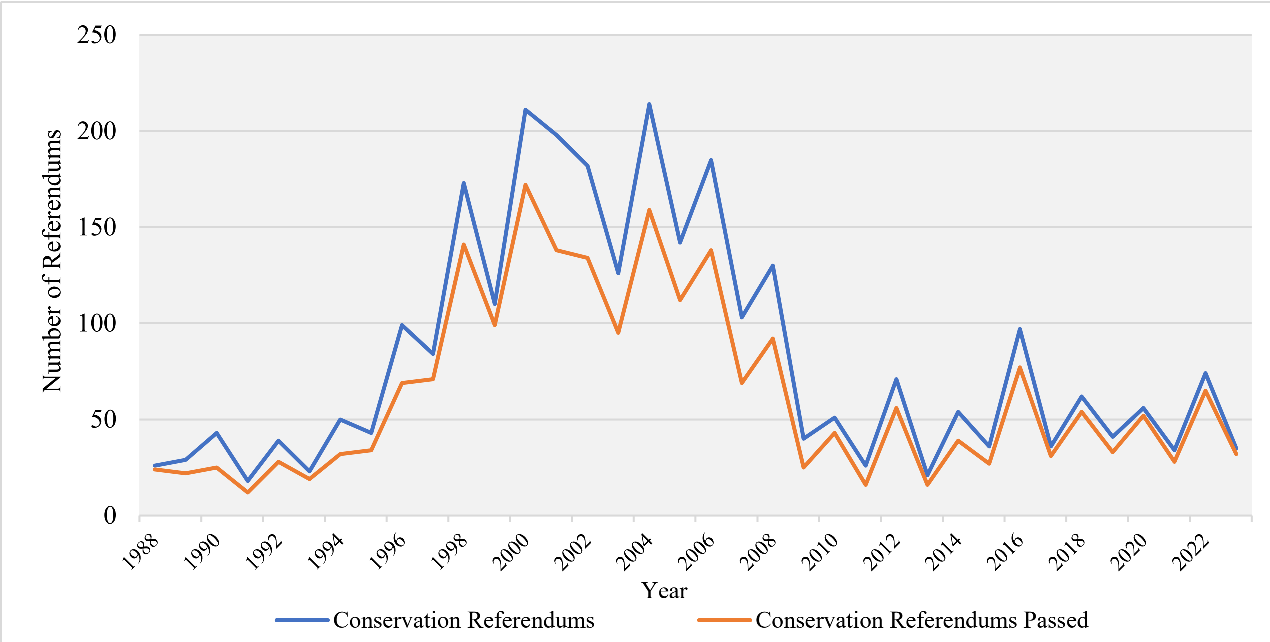

Figure 2. Conservation referendums in the United States, 1988 - 2023[4]

A great deal of scholarship has sought to understand which factors influence the success of conservation ballot measures. Many conservation referendum studies have focused on the impacts of socioeconomic and demographic factors of the voting community. Other studies have focused on how the proportion of conservation areas within a community and their land use characteristics impact referendum outcomes. However, there is a gap in the existing scholarship regarding the impacts of the physical characteristics of existing conservation areas. Specifically, how existing conservation area size and proximity to a nearby municipality can influence municipal referendum outcomes.

Identifying how physical conservation area characteristics – specifically the size of existing conservation areas and their proximity to nearby municipalities – can influence referendums will have significant implications for communities, elected officials, and conservation advocates. We are motivated to pursue this question as recent studies have found

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[4] Data from the Trust for Public Land's LandVote database, available at https://tpl.quickbase.com/db/bbqna2qct?a=dbpage&pageID=8.

that the land use characteristics of existing open space influences referendum success, and that living closer to a potential wolf restoration site was associated with lower support for a wolf reintroduction referendum (Ditmer et al., 2022; Hawkins & Chia-Yuan, 2018). Our findings could help policymakers and community members gauge whether a referendum is a suitable vehicle for their conservation goals given the existing conservation context in their community. Thus, our master's project seeks to answer the following questions: Does a municipality's proximity to large conservation areas impact conservation referendum success? For which distances between municipalities and conservation areas is the relationship significant? For which protected area sizes is the relationship significant?

Literature Review

The relationships between various socioeconomic factors and the success of conservation referendums have been investigated extensively. Across multiple studies, higher education attainment, wealth, population growth, and low unemployment have consistently shown positive associations with municipal conservation referendum passage (Heintzelman, Walsh, & Grzeskowiak, 2013; Kotchen & Powers, 2006; Kroetz et al., 2014; León-Moreta, 2021; Nelson, Uwasu & Polasky, 2007).

Recent scholarship has explored the relationships between biodiversity, political dynamics, and conservation ballot measures. For instance, Kroetz et al. (2014) found that counties that held at least one successful conservation ballot referendum contained more federally endangered and imperiled species than would be expected of a random sample. A 2017 study found that interest group coalitions are positively associated with conservation referendum passage during non-presidential election years when referendum stakes are high, and the referendum goals are diverse (Lowry & Scott Krummenacher, 2017).

Other studies have explored the relationships between changes in existing open space and conservation referendums, at times with conflicting results. An analysis of municipalities in New Jersey and Massachusetts found that the odds of approving a conservation referendum decreased as open space loss increased (Kotchen & Powers, 2006). However, the same study also found that in Massachusetts, more open space within a jurisdiction tends to increase voter support for referendums (Kotchen & Powers, 2006).

Similarly conflicting results come from studies of existing open space land use characteristics and conservation referendums. A 2018 study of Rhode Island voting districts found that a higher percentage of existing open space devoted to habitat conservation and resource management is associated with lower environmental bond support (Hawkins & Chia-Yuan, 2018). However, this study also reported significant positive associations between the percentage of publicly accessible and recreational existing open space and environmental bond support (Hawkins & Chia-Yuan, 2018). A 2019 study by Dr. Agustín León-Moreta found that as the utilization of conservation easements – private landowners dedicating their land for permanent conservation – increases, the likelihood of a conservation referendum occurring decreases and the likelihood of passage decreases. Dr. León-Moreta hypothesized that this inverse relationship was observed because conservation easements are an effective private substitute for conservation ballot measures (Agustín León-Moreta, 2021).

Our research focuses on examining the relationship between the size of existing conservation areas, their proximity to municipalities, and the success of conservation referendums. While previous studies have investigated how different characteristics of open space affect referendum outcomes, we were unable to identify any studies that focused on open space or conservation area size and proximity during our literature review. Previous scholarship has posited that easements serve as a substitute for conservation areas, it's possible that a similar substitution effect could occur when a municipality already has a sufficient supply of existing conservation areas. Our findings will provide insight as to the potential substitution impact of ample conservation area supply and provide a valuable addition to the conservation referendum literature.

Pre-Analysis Hypotheses

Our hypotheses are:

1. As the distance between the nearest existing conservation area and a municipality increases, the likelihood of conservation referendum passage will increase.
2. As the size of the nearest existing conservation area increases, the likelihood of conservation referendum passage will decrease.

Methods

Data Description

The data employed in this analysis were taken from the Trust for Public Land's LandVote ("LandVote") database, the United States Geological Survey's Protected Area Database ("PAD-US"), and the US Census Bureau's 2010 American Community Survey ("ACS"). The LandVote database tracks two major types of conservation ballot measures, "pay as you go" measures and bond measures, since 1988 for all US states (Trust for Public Land, n.d.). For each tracked ballot measure, LandVote provides information on the date the ballot measure was held, whether it passed, the margin by which it passed or failed, the amount of funding at stake, the objective of the ballot measure, along with other information. LandVote data is available for download as a CSV file.[5]

The PAD-US database is a geospatial inventory of marine and terrestrial protected areas held by public agencies and non-profits in US states and territories (USGS, 2022). PAD-US contains six feature classes of protected area boundaries: fee, easements, designation, marine, proclamations, and combined (fee, easement, and designation boundaries combined). All PAD-US feature classes provide protected area boundary polygons, area, ownership and management information, data sources, IUCN categories, GAP status codes, public access status, and other information. The PAD-US database is maintained in a projected coordinate system, USA Contiguous Albers Equal Area Conic USGS version. Our analysis employed PAD-US version 3.0, which was released in July 2022.[6]

The 2010 ACS was used to source the key socioeconomic data used in the analysis: the number of owned and rented housing units, the percentage of individuals with bachelor's degrees, total population size, the percentage of the non-white population, median age, and annual median income (U.S. Census Bureau, 2010).[7] All socioeconomic data were collected at the county subdivision level, allowing for alignment with the geospatial and referendum data.

Geospatial Analysis

Fee, easement, and designation boundaries from PAD-US were employed in our analysis as they represent existing terrestrial conservation area boundaries. Proclamation boundaries were excluded from our analysis as they do not necessarily represent existing conservation areas,

[5] LandVote conservation ballot measure data is available at https://tpl.quickbase.com/db/bbqna2qct?a=dbpage&pageID=8.
[6] PAD-US protected area boundary data is available at https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download.
[7] ACS socioeconomic data is available at https://www.census.gov/programs-surveys/acs/data.html.

instead they can outline pre-approved future acquisition areas. Filters were applied to all boundary feature classes as listed in Table 1.

Table 1. Filters applied to PAD-US feature classes

Feature Class Attribute	Filter Applied
State Name	= CT, DE, D.C., FL, GA, ME, MD, MA, NH, NJ, NY, NC, PA, RI, SC, VT, VA, WV
GIS Acres	>= 50
Public Access	= Open Access, Unknown

The analysis focuses on eastern states as they contain a diverse mix of federal, state, and local conservation areas. Filters were applied based on minimum conservation area size and public access criteria to ensure that the conservation areas included in our sample were both accessible to the public and sufficiently large to attract visitors.

Filters were applied to LandVote ballot measure data from 1988 to 2023 as listed in Table 2.

Table 2. Filters applied to LandVote data

Column	Filter Applied
State Name	= CT, DE, D.C., FL, GA, ME, MD, MA, NH, NJ, NY, NC, PA, RI, SC, VT, VA, WV
Date	From 2000-01-01 to 2020-12-31
Jurisdiction Type	= Municipal

We limited our study period to the last twenty years to ensure that our findings are based on recent ballot measures. Additionally, this study period takes advantage of LandVote's improvements in data accuracy post-1996 (Trust for Public Land, n.d.). We are focusing on municipalities as they are the units of study often employed in conservation referendum studies and enable us to generate conservation area proximity values easily.

The “Jurisdiction Name” and “State” columns in the LandVote dataframe were joined into a new column, “Locations”, for geocoding. Geocoding was performed using ArcGIS World Geocoder, this provided a point for each municipality in the filtered LandVote dataframe. ArcGIS’ Near tool was used to calculate the distance in miles from each municipality point to the nearest edge of the closest protected area polygon. Distances from the Near analysis results were added to the municipality points’ attribute table. The PAD-US boundary information was also joined to the municipality points via a field join. A spatial join was conducted between the municipality points and a shapefile of all US counties, aggregated using US Census Bureau TIGER shapefiles, to add county names to the attribute table. The final municipality points attribute table was exported to an Excel file, which was subsequently converted to a CSV file.

Summary statistics of conservation area size and proximity used in our analysis are provided below in Table 3.

Table 3. Summary statistics for conservation area proximity and area variables[8]

Boundary Types	Variable	N	Median	Min/Max	Standard Deviation
Fee + Easement + Designation	Proximity (miles)	1160	0.02	0/115.05	3.38
	Size (acres)	1160	142	50/172435	7636.30

Statistical Analysis

Following CSV conversion, the data were read into R, and subsequently analyzed, using the RStudio integrated development environment. To facilitate statistical analysis, the categorical variable “Year” was made numerical, while the categorical variable “Status” was converted into

[8] The number of observations for both proximity and size were reduced slightly (N = 946) in the statistical models due to limited availability of socioeconomic and demographic data.

a binary dummy variable, "Results." The numerical variable "Year" was then used to create the categorical "YearGroup" variable, with three levels reflecting non-overlapping 7-year time periods: 2000-2006, 2007-2013, and 2014-2020. Given the relatively small amounts of data collected in certain years, the use of 7-year blocks was considered a better approach for evaluating temporal influences compared to directly using the "Year" variable. Overall, there were far more successful referendum results, 709, than unsuccessful results, 237. For our study period a majority of conservation referendums occurred prior to 2010, as shown in Figure 3.

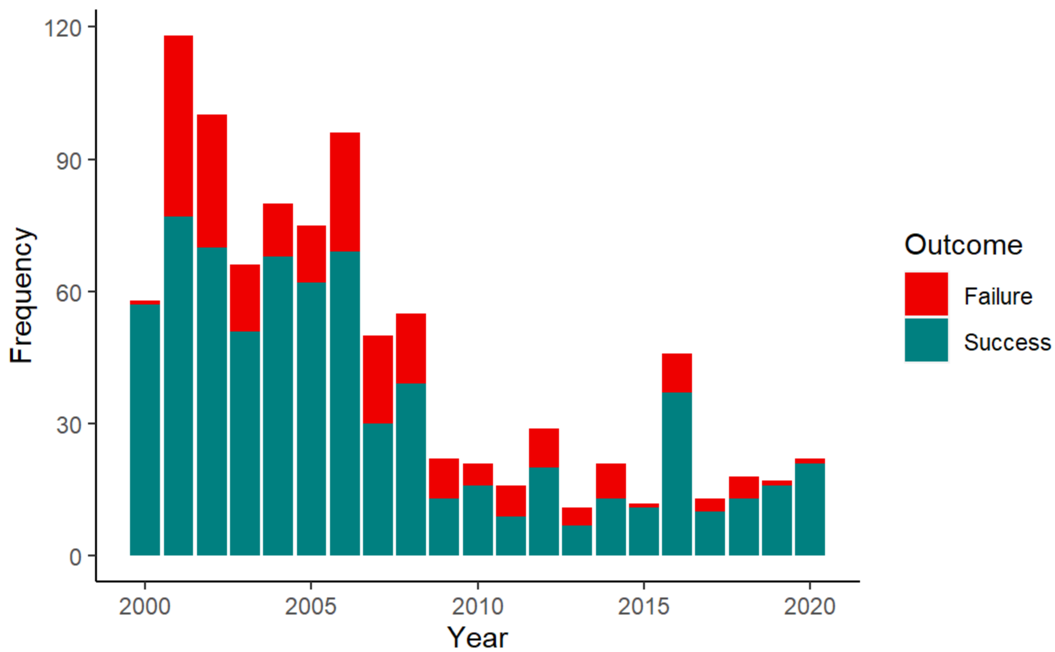

Figure 3. Distribution of dataset referendum outcomes by year, 2000 - 2020[9]

Given the need to assess the influence of multiple numerical and categorical variables on referendum probability, multiple logistic regression and multiple linear regression were selected as the primary statistical analysis methods. The variables "Result" and "PercentApproval" served as the dependent variables in the logistic and linear regressions, respectively, while "NEAR_DIST," "Population," "RentingPercent," "BachelorsPercent," "Income," "GIS.Acres,"

[9] Data from the Trust for Public Land's LandVote database, available at https://tpl.quickbase.com/db/bbqna2qct?a=dbpage&pageID=8.

“YearGroup,” “Age,” “MinorityPercent,” and “Massachusetts” served as the independent variables, description are provided in Table 4.

Table 4. List of variables used in the analyses

Variable Name	Description
Result	Binary dummy variable representing referendum success (1) or failure (0)
PercentApproval	Percentage of conservation referendum participants voting in favor of the measure
NEAR_DIST	Distance, in miles, from a referendum holding municipality to the nearest conservation area boundary
GIS.Acres	Total size, in acres, of a given conservation area
RentingPercent	Percentage of rented housing units, reported from 0-1
BachelorsPercent	Percentage of residents with a bachelor’s degree
MinorityPercent	Percentage of non-white residents
Population	Total population size
YearGroup	The time period (2000-2006, 2007-2013, 2014-2020) in which a referendum was held
Age	Median age
Income	Annual median income
Massachusetts	Whether a referendum was held in Massachusetts

Prior to the analysis, a scatterplot matrix was created to check the extent of linear correlation between the response and independent variables; a lack of linear correlation was assessed as present in “GIS.Acres”, “NEAR_DIST”, and “Population”, and as a result these variables were log-transformed. Following the creation of a multiple logistic regression model, the McFadden R2 index was performed to identify the model fit. Likewise, for the multiple linear regression model, Breusch-Pagan and VIF tests were performed to assess the extent of heteroskedasticity and multicollinearity, respectively. A residuals vs fitted values scatterplot was created to identify non-linearity and the presence of outliers, while a histogram of residuals was used to assess their normality.

Table 5. Summary statistics for demographic and socioeconomic variables for successful conservation referendums

Variable	N	Median	Min/Max	Standard Deviation
BachelorsPercent	946	25%	5.4%/44%	7.5%
RentingPercent	946	17%	2%/75%	12.9%
MinorityPercent	946	8%	0%/96%	11%
Population	946	12597	198/602609	45640
Age	946	42.2	21/66	5.32
Income ($)	946	81937	31948/223088	26365
PercentApproval	946	64%	50%/93%	9%

Table 6. Summary statistics for demographic and socioeconomic variables for unsuccessful conservation referendums

Variable	N	Median	Min/Max	Standard Deviation
BachelorsPercent	946	24%	7.1%/43%	7.1%
RentingPercent	946	17%	2.8%/65%	12.5%
MinorityPercent	946	8%	0.5%/54%	10.4%
Population	946	12642	423/602609	52993
Age	946	41.7	21/62	4.49
Income ($)	946	81176	36202/175399	25806
PercentApproval	946	44%	19%/65%	6%

Results

Informed by prior research, we hypothesized that there would be statistically significant positive and negative relationships between public support for conservation ballot measures and conservation area size and municipal proximity, respectively. To test our hypothesis, we performed linear and logistic regressions, adding socioeconomic explanatory variables to increase the explanatory power of our models. In the logistic regression analysis, level two of the "YearGroup" variable had a statistically significant p-value of 0.002, while level one of the "Massachusetts" variable had a p-value of <0.001 (Table 7). All other explanatory variables included in the model had p-values that exceeded the 0.05 threshold, suggesting a lack of statistical significance (Table 7). A subsequent McFadden R2 index analysis produced a psuedo-R2 value of 0.0539, suggesting that the model's explanatory power is very limited.

Table 7. Summary table of multiple logistic regression results

	Odds Ratios	Std. Error	Z-Value	P-Value
Intercept	0.89	1.16	-0.09	0.928
Log.NEAR_DIST	0.89	0.07	-1.55	0.122
Log.Population	1.00	0.08	-0.01	0.992
Log.GIS.acres	0.98	0.06	-0.38	0.705
Age	1.02	0.02	1.06	0.290
Minority%	0.35	0.31	-1.17	0.242
Bachelors%	8.61	13.48	1.37	0.169
Renting%	3.24	3.10	1.23	0.220
Income	1.00	0.00	-0.47	0.639
YearGroup2	0.56	0.10	-3.14	**0.002**
YearGroup3	1.37	0.33	1.32	0.186
Massachusetts1	*0.37*	*0.06*	*-5.96*	***<0.001***
Observations	946			
R^2 Tjur	0.059			
Wald Chi-Squared Test (YearGroup & Mass.)	P = 0.0022	df = 3	$X^2 = 14.6$	

The results of the multiple logistic regression analysis suggest that referendum year and state have the potential to significantly affect referendum success. Conservation referendums held in Massachusetts appear to be less likely to succeed than those held in other states; a similar trend is evident with year group 2, where referendum success in the period 2007-2013 seems to be less likely relative to 2000-2006. Although the p-value for the distance variable was relatively low, it was still above 0.05, suggesting no significant correlation with referendum passage (Table 7). A subsequent Wald test performed on the factor “YearGroup” and “Massachusetts1” variables further suggests that they are significant (Table 7).

The initial multiple linear regression analysis yielded statistically significant p-values for median age, bachelor’s degree percentage, “YearGroup2,” and “Massachusetts1.” Analysis of a subsequent Breusch-Pagan test, VIF test, residuals vs. fitted values scatterplot, and residual histogram suggested that the model was in alignment with the key assumptions of non-multicollinearity, linearity, and normality of residuals, but not homoeskedasticity. Further analysis of the residuals vs. fitted values scatterplot suggested significant clustering by state, with Massachusetts’ residuals largely isolated from those of other states (Figure 1A). As a result, standard errors clustered according to state were applied to the multiple linear regression model, producing significant p-values for age, bachelor’s degree percentage, and “Massachusetts1” (Table 8). The model had an adjusted R2 value of 0.10, suggesting limited explanatory power (Table 8).

Table 8. Summary table of multiple linear regression results with clustered standard errors

	Estimate	Std. Error	T Statistic	P-Value
Intercept	4.1411e-01	0.0583	7.1062	<0.0002e-8
Log.NEAR_DIST	-3.4987e-03	0.0041	-0.8611	0.3894
Log.Population	0.0063	0.0045	1.3894	0.1651
Log.GIS.acres	0.0010	0.0040	0.2363	0.8132
Age	0.0027	0.0009	2.8842	**0.0040**
Minority%	-0.0611	0.0625	-0.9769	0.3289
Bachelors%	0.18896	0.0456	4.1434	**0.0037e-2**
Renting%	0.0683	0.0397	1.5273	0.1270
Income	-0.0256	0.0003e-3	-1.6691	0.0954
YearGroup2	-0.0256	0.0178	-1.4368	0.1511
YearGroup3	0.0095	0.0062	1.5170	0.1296
Massachusetts1	-0.0082	0.0212	-3.8814	**0.0001**
Observations	946			
R^2	*0.10*			

The final multiple linear regression analysis suggests that median age, the percentage of the population with bachelor's degrees, and state have the potential to influence referendum percent approval. Except for "Massachusetts", each significant variable was positively correlated with referendum percent approval.

Discussion

Conservation referendums are important policy tools for communities across the United States (Myers, 1999; Szabo, 2009; Trust for Public Land, 2020). Prior research has explored how community socioeconomic and demographic factors, ecological factors, political factors, land use characteristics, and open space growth or depletion rates impact conservation referendum outcomes (Heintzelman, Walsh, & Grzeskowiak, 2013; Kotchen & Powers, 2006; Kroetz et al., 2014; León-Moreta, 2021; Lowry & Scott Krummenacher, 2017; Nelson, Uwasu & Polasky, 2007). To date, no studies have explored how existing conservation area size and proximity to a municipality influence referendum outcomes. Investigating these potential relationships could provide valuable information to communities considering a conservation referendum.

The combined results of both regressions suggest that demographic, temporal, and geographic factors have the potential to influence the likelihood of conservation referendum passage and rates of public support. The multiple logistic regression model points to the influence of time period and state, while the multiple linear regression model suggests that age, education, and state are relevant. While somewhat aligned with the pooled time-series analysis performed by Dr. León-Moreta (2021), which found a positive correlation between educational attainment and referendum support, as well as significant influence from year effects, our analysis' results differ in that age is also positively correlated with support.

The lack of support for conservation referendums in the period 2007-2013 may reflect lessened interest in conservation spending following the 2007-2008 financial crisis, as well as shifting public priorities in the face of terrorism and overseas military interventions. This finding aligns with national conservation referendum funding data, depicted in Figure 1, which shows a decline in funding in this period. The increasing political polarization of the discourse surrounding conservation may play a role as well. In the case of median age, the results may reflect greater financial stability among those 65 and older, as well as more regular use of public outdoor spaces through activities such as hiking and birding. Those with bachelor's degrees may be more aware of the value of ecosystem services, increasing the likelihood of support for conservation referendums. The significant negative correlation between municipalities in Massachusetts and referendum support, finally, may reflect the exceptionally large number of referendums held in the state, potentially suggesting an oversaturation of conservation ballot measures. Interestingly, this finding conflicts with a the Kotchen & Powers (2006) finding that within Massachusetts, more open space within a jurisdiction tends to increase voter support for referendums.

While significantly different, the two models are not necessarily incongruent. The logistic model measured simple referendum success, whereas the linear model dealt with the percentage of public support regardless of referendum passage. The linear model's finer scale of analysis may reveal more subtle influences on the percentage of support, even in cases where the referendums failed to pass.

Although both models meet all key assumptions, there are significant potential concerns with the data used. Because the date of current boundary establishment is not available for most conservation areas, rendering cross-checking with referendum years impossible, geospatial data are not guaranteed to reflect a given conservation area's boundaries at the time of an associated referendum. Given the age of most of the conservation areas featured, however, it is probable that the vast majority of PAD-US data closely reflect conservation area boundaries at the times of associated referendums. Likewise, 2010 ACS data were used for socioeconomic variables, potentially obscuring change in these metrics from 2000-2020. Within the model itself, the low R2 values suggests a risk of omitted variable bias. Given the complexity of public opinion on conservation ballot measures, as well as their longstanding use within geographically and demographically diverse communities across the United States, it is likely that a large number of geospatial, socioeconomic, and demographic variables influence referendum results.

Conclusion

Ultimately, our results did not support our pre-analysis hypotheses and were not entirely congruent with previous research. Neither conservation area size nor proximity to a municipality showed a statistically significant relationship with referendum outcomes. While some socioeconomic variables did display such relationships, this result may be a product of the more restricted scope of our analysis relative to other studies, the inclusion of different geospatial and socioeconomic variables, or differences in the time period assessed. Additionally, our attempt at representing the proximity of conservation areas to nearby municipalities may have been too simple. Still, our results suggest that there may be significant value in conservation attitude surveys targeting Massachusetts and other Northeast states, helping to elucidate why this region boasts so many ballot measures.

Future research could include additional explanatory variables when considering the impact of conservation area size and proximity on referendums. For instance, the type of landcover within a conservation area, the presence of trails or recreational equipment within a conservation area, or a measure of political affiliation for the referendum holding municipality. Additionally, the are other ways to attempt to represent the proximity of conservation areas to a municipality – you could average distance of the three, five, or ten conservation areas closest to a municipality. It's possible that this Nth nearest neighbor approach could provide a more accurate representation of how near conservation areas are to a given municipality. Lastly, future researchers could employ a spatial lag or spatial error model that would account for the spatial autocorrelation of conservation referendums.

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Appendix

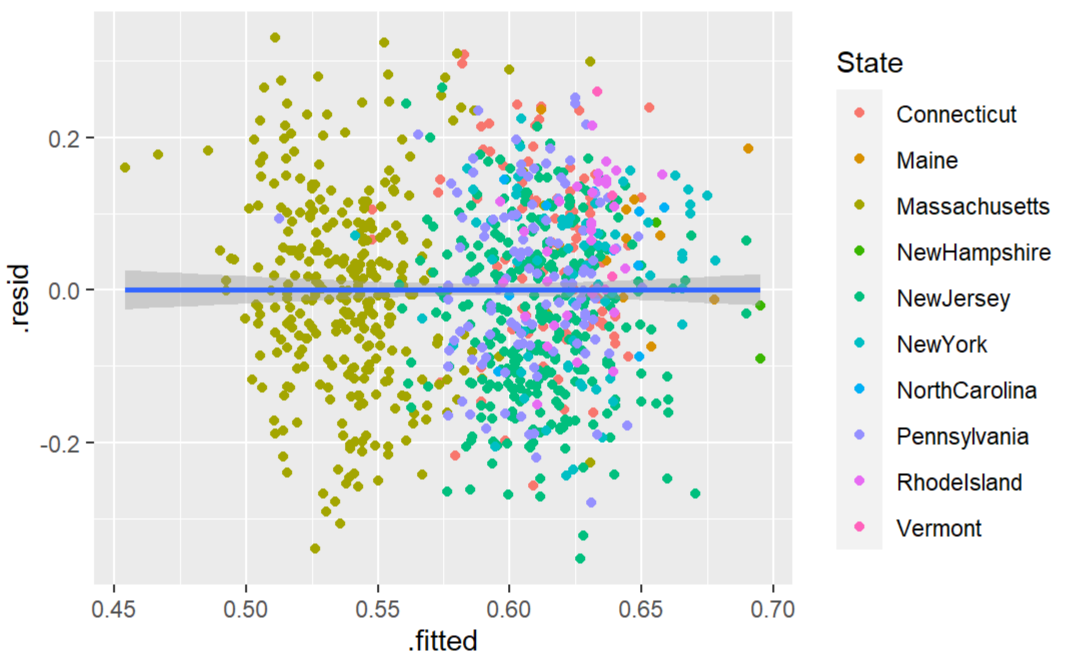

Figure 1A. Residuals vs. fitted values scatterplot for the original linear regression model.