Spatial Distribution of Conservation Easements in the United States: Drivers and Implications

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Problem Statement

- Conservation easements are legal agreements between land owners and qualified conservation organizations, such as land trusts, that restrict the activities that may take place on a property in order to protect its significant agricultural, scenic, ecological, and/or historic resources in perpetuity (Byers and Marchetti 2005).
- Conservation easements are an important tool to help protect productive agricultural land, valuable wildlife habitat, scenic open spaces, and historical sites from residential and urban development (Anella and Wright 2004).
- Increasing use of conservation easements could mitigate open space fragmentation and promote more sustainable urban planning.
- However, our understanding of where conservation easements occur in the United States and why is limited, hampering the ability of land trusts to better target specific groups of people for the purpose of establishing new conservation easements.

Objectives

- Characterize the current spatial distribution of conservation easements in the United States (U.S.).
- Explain the current spatial distribution of conservation easements.
- Predict the current spatial distribution of conservation easements.

Methods

- Acquired data for conservation easements (dependent variable) and 91 potential explanatory variables representing human and environmental conditions.
- Used Moran's I and Local Moran's I to characterize spatial autocorrelation in conservation easement data.
- Transformed variables to normality and standardized variables to mean of 9 and standard deviation of 1.
- Removed variables with $p < 0.25$ in univariate linear regressions.
- Removed collinear variables that seemed the least relevant using Pearson's correlation coefficients ($r^2 > 0.7$) and variance inflation factors (VIF > 7.5).
- Final variables were selected using exploratory regression (maximize r^2, minimize AICc, maximize p, minimize VIF, no spatial autocorrelation in residuals).
- Used ordinary least squares (OLS) regression and geographically weighted regression (GWR) to determine the relative importance of each of the remaining independent variables in explaining conservation easements and to predict conservation easements across space.

References

- Anella, A., and J. B. Wright. 2004. Saving the ranch: conservation easement design in the American West. Washington, DC: Island Press.
- Byers, E., and P. K. Marchetti. 2005. The conservation easement handbook. Washington DC: Odyssey Press, Inc.

Acknowledgments

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Results

- The percentage of land under conservation easements by land trusts varies across the U.S. (Figure 1).
- Several northeastern states have by far the highest percentage, followed by select Rocky Mountain and East Coast states, and California.
- The states with the lowest percentage are concentrated in the Great Basin, the Great Plains, and the Upper Midwest.

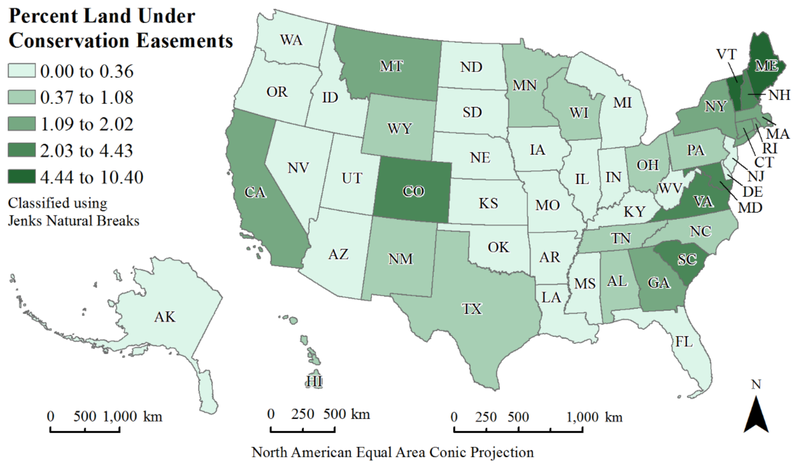

Figure 1: Percent of state land under easement by land trusts across the United States in 2015.

- Moran's *I* was 0.383 ($p < 0.001$, $z = 5.152$), suggesting global spatial autocorrelation in the conservation easement data.
- Statistically significant ($p < 0.05$) local spatial autocorrelation occurred in three geographical areas: high-high clustering in three northeastern states (ME, MA, NH), low-low clustering in four upper midwestern states (IL, IA, MN, MO), and high-low clustering in CA (Figure 2).

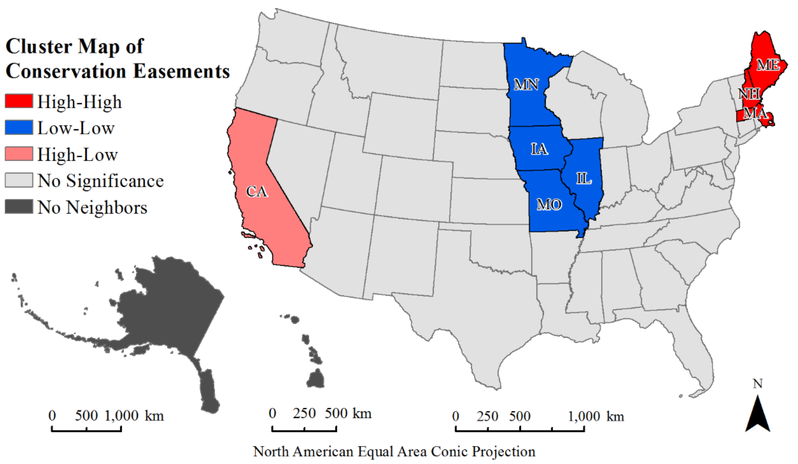

Figure 2: Spatial clustering in the conservation easement data according to local Moran's I.

Results

- OLS suggests that four predictors (Table 1) explain 51% of the variance in percentage of land under conservation easements by land trusts (Adj $R^2 = 0.51$, $F(4,45) = 13.71$, $p < 0.001$).

Table 1: Explained variance in conservation easements using OLS.

Dependent variable: percent of state land under easement by land trusts			
Independent variable	Coefficient	Standard Error	Significance
Number of active land trusts	+ 0.319	0.131	$p < 0.05$
Percent conservative	- 0.320	0.129	$p < 0.05$
Percent grassland	+ 0.307	0.126	$p < 0.05$
Percent forest land	+0.566	0.123	$p < 0.01$

- Using GWR, the same four predictors explain 56% of the variance in percentage of land under conservation easements by land trusts (Adj $R^2 = 0.561$).
- Coefficients of the predictors in GWR varied greatly across space: number of active land trusts (0.154 to 0.558), percent conservative (-0.621 to -0.016), percent grassland (0.161 to 0.870), percent forest (0.456 to 0.661).
- The mean standard deviation of GWR residuals was 0.87 for states in which conservation easements were underpredicted and 0.72 for states in which they were overpredicted, suggesting good model fit across much of the U.S..
- Though not included in the final OLS and GWR models, numerous other predictors were statistically significant in univariate linear regressions (Table 2).

Table 2: Selected other statistically significant ($p < 0.05$) human and environmental explanatory variables.

Positive Relationship	Negative Relationship
Percent population 18 or older ($r^2 = 0.21$)	Percent population under 18 ($r^2 = 0.16$)
Percent urban area ($r^2 = 0.16$)	Mean precipitation seasonality ($r^2 = 0.16$)
Percent population 18 or older ($r^2 = 0.15$)	Percent cropland ($r^2 = 0.13$)
Percent with higher education ($r^2 = 0.14$)	Percent liberal ($r^2 = 0.11$)
Percent democratic ($r^2 = 0.13$)	Mean annual temperature range ($r^2 = 0.10$)

Discussion and Conclusion

- A notable portion of the variance in the percentage of land under conservation easements by land trusts remains unexplained (~ 44%), most likely due to missing explanatory variables (e.g., cultural norms and values) and our analysis at a fairly coarse spatial scale (i.e., state level).
- However, our data reveal that political leaning, land cover, population age, education, and climate are strong predictors for the current distribution of conservation easements across most of the U.S. The most likely states with much of the land in conservation easements are currently those that are democratic leaning and have a high percentage of grassland, forest, and/or urban land; an older population; a higher education; and less variability in precipitation and temperature throughout the year. The reverse is true for states with a low percentage of land in conservation easements.
- Given this information, land trusts can focus their efforts on informing aging, conservative populations about the many benefits of conservation easements, including forever protecting land from development and substantial tax breaks.