What Drives Voluntary Preservation? Significant Natural Heritage Areas in North Carolina

Carol Mansfield
Subhrendu K. Pattanayak
William McDow (Duke University)

Working Paper 00_02 September 2000

RTI INTERNATIONAL

RTI International's* Environment and Natural Resource Economics Program circulates these working papers to convey information and entertain discussion. The papers may not have undergone formal peer review. Contact Subhrendu Pattanayak (subrendu@rti.org) if you have any questions or concerns. <www.rti.org/enrepaper/>

*RTI International is a trade name of Research Triangle Institute.

What Drives Voluntary Preservation? Significant Natural Heritage Areas in North Carolina

Carol Mansfield
Subhrendu K. Pattanayak
William McDow (Duke University)

Keywords: natural heritage program, conservation economics, GIS, probit models

ABSTRACT

Rapid conversion of natural ecosystems and consequent biodiversity loss are potentially fraying the very fabric of life. Will individuals, corporations, and quasi-public institutions voluntarily preserve ecologically significant land? The ascendancy of voluntary programs in the policy arsenal of U.S. federal agencies might suggest an answer in the affirmative. Moreover, at least in the U.S. the strength of the current economy, against a backdrop of shrinking government, can create expectations of voluntary preservation of significant natural habitat to stem the tide of biodiversity loss. A reasoned answer, however, would depend on our understanding of what drives preservation by individuals and institutions. Unfortunately, the economic logic behind voluntary corporate environmentalism is still immature, and the scant empirical literature focuses on emissions into the air and water and not on ecological amenities such as ecosystems, species, and habitats. This paper investigates the determinants of voluntary ecological preservation using a unique data set from North Carolina, the state with the second highest rate of land use change in the U.S. between the early 1980s and early 1990s. Using the literature on joint production of forest outputs, land use change, and voluntary environmentalism as a point of departure, we tell a supply side story to conceptualize the problem of ecological preservation. Our empirical models show that a variety of forces influence the decision to enter into management agreements for the protection of ecologically significant natural sites. The ecological rareness of the site positively influences the likelihood of preservation across all models. Distance to highways and cities and the size of the preserved area also influence the preservation choice. Our proxies for socio-economic drivers signal the mixed influence of the opportunity costs and ecological benefits of preservation. We find some evidence of political activity influencing conservation choices. Furthermore, our results demonstrate differences between classes of landowners that influence the probability of protection. We conclude with some methodological and policy lessons.

INTRODUCTION: WHAT DRIVES VOLUNTARY PRESERVATION?

Rapid conversion of natural ecosystems and consequent biodiversity loss are potentially fraying the very fabric of life. Will individuals, corporations, and quasi-public institutions voluntarily preserve ecologically significant land? The ascendancy of voluntary programs in the policy arsenal of U.S. federal agencies might suggest an answer in the affirmative. A reasoned answer, however, would depend on our understanding of what drives preservation by individuals and institutions. Unfortunately, the economic logic behind voluntary environmentalism is still immature, and the scant empirical literature focuses on emissions into the air and water and not on ecological amenities such as ecosystems, species, and habitats (for example, see Lyons and Maxwell, 1999). This paper investigates the determinants of ecological preservation using a unique data set from North Carolina, the state with the second highest rate of land use change in the U.S. between the early 1980s and early 1990s.

Restricting land use for the purpose of preserving habitat for plants and animals is politically controversial. For example, attempts to regulate land use through the Endangered Species Act have generated lawsuits and attempts by some members of Congress to fight any measures designed to protect habitat. Voluntary programs for habitat preservation, along with privately funded efforts to purchase land such as land trusts, have the potential to provide preservation in a politically acceptable method. Very little is known about why and how individuals and institutions participate in voluntary environmental programs. By closely scrutinizing participation in voluntary protection efforts in North Carolina, our research yields insights for the design of future voluntary programs by agencies such as the Environmental Protection Agency. Before turning to the specifics of our approach, we briefly summarize the relevant literature, beginning with studies on voluntary environmentalism.

To counter concerns about regulatory cost-effectiveness, federal agencies such as the EPA have sought out additional instruments to achieve their objectives. Key to this thinking is that voluntary programs can play an important complementary role with traditional regulatory instruments in securing the environmental goals of the U.S. Programs such as the 33/50, Green Lights, Project XL, and the Common Sense Initiative where corporations voluntarily undertake environmental cleanup and protection efforts offer firms flexibility in achieving environmental objectives, while potentially lowering costs to regulators. These programs are part of a broader federal public–private partnership as articulated by Vice-President Gore’s campaign to “reinvent government.” Empirical research on the best known and most carefully studied voluntary program, the 33/50 Program, has focused on the influence of consumers, shareholders, regulators, and communities on firms’ participation decision (Arora and Cason, 1995; Brunnermeier and Cohen, 1996). The development of corporate environmentalism theory and empirical assessment of environmental performance has progressed slowly. Importantly, almost none of this research has assessed private preservation of ecological amenities and prevention of irreversible processes such as biodiversity and habitat loss.

Beyond the voluntary compliance studies, research on land use change and landowner decision-making also offer insights for models of voluntary ecological preservation. One set of studies includes empirical analyses of landuse change that have focused primarily on suburban landuse dynamics in the U.S. (Bockstael, 1996; Bell and Bockstael, 1999) and tropical deforestation (Cropper et al., 1999; Pfaff, 1999). These studies have framed their empirical questions on a model of profit maximization by individual land owner-managers. Location variables such as distance to cities and roads have significant statistical explanatory power and have been shown to accelerate development and deforestation by increasing the net income. Demographic factors such as population density have also been important determinants of landuse change. Press (1998) has examined preservation of open space by county governments to develop theory of the "policy capacity" of the local government, measured as the "community's ability to engage in collective action that secures environmental public goods and services (p. 37)". Using a data set from California, he finds wide variation in the level of open space protection across counties, but a low level of correlation between the amount of open space and income at the county level. Instead he suggests that other environmental policy outcomes such as the size of the parks and resources budget, water conservation and recycling proxy for the activism of the county government.

A second body of work uses a Fisherian utility maximization framework as a starting point to evaluate timber supply in the light of amenity and other considerations by forest owner-managers (Binkley, 1981).[1] Ecological preservation of habitats and ecosystem functions could certainly be included in the non-timber considerations of these models. In this framework, a representative private landowner is assumed to maximize utility by consuming goods and amenities, where utility is separable over time and commodity space, and is subject to an income and a production constraint. The technical production constraint links the landowner's scarce inputs, e.g., land or capital, to multiple products, timber, and amenity. Amenity is conceptualized as self-produced output that is proxied by some measure of forest condition; most timber supply studies do not estimate amenity services. Survey data are typically used to estimate the timber supply model with some indirect accommodations for amenity services. The primary contribution of this body of work is the recognition of the role of owner characteristics on timber supply because of nontimber amenities, uncertainty in prices and interest rates, imperfect capital markets, and forest taxation.

In our paper, we build on these areas of research to define a model of ecological preservation. We propose to use a unique set of ecological, economic, institutional, and demographic data from North Carolina to investigate the role of individuals, institutions, and governments in preserving significant natural heritage sites (ecologically significant land). While these results are important to North Carolina, they will also be of interest throughout the U.S. because of the

[1] By "Fisherian," we mean a construct that allows the analyst to conceive of decision-makers separating their periodic production and consumption decisions. Production over time is organized to maximize the present value of the utility of consumption over time.

similarity of institutions across all 50 states, the standardization of the ecological data, and the problem of ecosystem preservation across the U.S. North Carolina provides an appropriate laboratory for study not only because of the rate of land use change in the state, but because the North Carolina Natural Heritage Program (NHP) has collected detailed data on the ecological characteristics, ownership, and management of significant natural heritage areas. The NHP facilitates preservation through voluntary technical assistance programs such as the registry of natural areas (RHA) and the dedicated state nature preserves (DNP).

In section II of the paper, we describe the Significant Natural Heritage Areas data set. With the data constraints in mind, in section III we formulate a stylized model of the preservation choice, describe our empirical strategy for implementing it and discuss the intuition behind our choice of variables. The results and discussions are presented in sections IV and V.

THE SIGNIFICANT NATURAL HERITAGE AREAS PROGRAM

The primary source of our data is the North Carolina Natural Heritage Program (NHP), which in conjunction with The Nature Conservancy (TNC), maintains a database of significant natural heritage areas (SNHAs) for the state as required by the 1985 Nature Preserves Act. Sites are identified through statewide inventories of natural areas, and the list includes all properties identified as ecologically significant, whether they are protected or unprotected sites. Figure 1 maps the location of the SNHAs relative to interstate highways and cities with populations over 50,000 in North Carolina. According to the NHP, “The sites included on this list are the best known representatives of the natural diversity of the state and therefore have priority for protection” (NHP, 2000). Sites are defined along ecological boundaries, so a single SNHA may encompass land belonging to multiple owners.

The SNHA list is contained in two databases: site basic records (SBR) and managed area basic records (MBR). An SBR exists for each SNHA and contains information on the owner(s), location of the site, ecological ranking, and notes on the protection status. The SNHAs range in size from less than 5 acres to 276,715 acres. The MBR contains information on sites that are managed for protection in some fashion, including the name of the manager, the type of protection arrangement, and date of protection. Unlike SBRs, MBRs are defined by who manages the area rather than by ecological boundaries, and the manager may be different than the owner. Thus, if an SNHA contains several tracts of land under different ownership, one of these owners may enter into a management agreement while the others do not. While 84 percent of the sites in this database incorporate land owned by a single landowner, the remaining 16 percent contain multiple tracts of land under different ownership.

Landowners that elect to preserve their land demonstrate a willingness to exceed the regulations that govern land use in North Carolina. The state government provides technical assistance in the form of information about the ecological characteristics of the land and advice on how to manage the land for the benefit of the ecological characteristics. The most popular method of protection, a registered heritage area (RHA), offers the lowest level of protection for a site. The NHP together with the landowner agree on a management plan for the site and the landowners agree to notify the NHP of any planned activities that run counter to the management plan to provide the NHP with the opportunity to contribute input. Any landowner, including Federal, state, and private can register their land. More than 75 percent of the sites enrolled in one of the protection programs are enrolled in the RHA. Beyond the registry, all types of landowners can also commit their land to legally binding preservation through vehicles such as the DNP. The legally binding preservation options offer tax incentives to the landowners.

The NHP ranks each SNHA by ecological significance into categories based on its national, statewide, and regional significance. The ecological rank of the site reflects the number and rareness of the elemental occurrences (EOs) on the site; the elements can be plants and animals. The EOs are also ranked according to their rareness on a national, statewide, or regional scale, and the SBR also includes information on the EOs on each site. In ranking both the sites and the EOs, the NHP has focused on the rareness of entire natural communities in addition to individual elements, the threats to the site (e.g., from development), and the viability of the resource. In Table 1, Column 2 lists the number of sites in the SBR database for each level of ecological ranking (where 4 implies the highest ecological ranking or rarest community). The percentage in parentheses is the fraction of sites protected in some form. Columns 3 through 7 present the number of SNHAs in each category for SNHAs with only one owner by several ownership types. Over 90 percent of the single-owner federal sites have some sort of protection; however, only one-third of the privately owned sites with a single owner are managed for protection.

TO PRESERVE OR NOT TO PRESERVE: TOWARDS A EMPIRICAL MODEL OF VOLUNTARY ECOLOGICAL PRESERVATION

Using the literature on joint production of forest outputs, land use change, and voluntary environmentalism as a point of departure, in this paper we tell a supply side story to conceptualize the problem of ecological preservation. These studies show that we can study preservation of biodiversity, species habitat, and ecosystem functions by extending the neoclassical theory of profit-maximizing firms to incorporate multiple objectives. Thus, a stylized characterization of our anticipated model is described in Eq. (1):

$$\mathrm{Max}_P W\,(E\pi \mid \Omega, X, G). \tag{1}$$

Owner-managers will choose a vector of production or management inputs P, including preservation behavior to maximize objectives W. The objective is a function of expected land value, $E\pi$, that is mediated by the ecological condition (Ω), socio-economic drivers (X), and institutional and political influences (G). The land owners/managers' chosen dimension/type of land preservation, P^*, will correspondingly be conditioned by Ω, X, and G. It is in this sense that we conceive of land preservation as derived demand and P* is a welfare maximizing choice. This relationship is described in Equation [2].

$$P^* = P^* (\Omega, X, G) \tag{2}$$

For an empirical model based on the SNHA data set, consider the choice facing a site owner-manager when deciding whether to preserve her site *i* under an NHP program such as RHA. This participation decision clearly depends on the site's net value with and without participation ($E\pi_{i,}*$). This net value is given by

$$E\pi_i^* = \alpha_1\Omega_{i,} + \alpha_2 X_{i,} + \alpha_3 G_i + e_i \tag{3}$$

where e_i is a random disturbance and Ω_i, X_i, and G_i are as defined above. Note that while $E\pi_i^*$ is not directly observable, the owner-manager's decision outcome is. Let P_i be an indicator of whether site *i* is enrolled in a protection program or not. Then

$$P_i = 0 \text{ if } E\pi_i^* \le 0 \text{ and } P_i = 1 \text{ if } E\pi_i^* > 0. \tag{4}$$

The structural relationship presented above can be estimated using a probit model (Maddala, 1983). Our measure of protection is whether an MBR exists for the site. Because MBRs are only created when a preservation agreement is reached, the existence of a managed area record for a site implies management for protection of a portion of the site or the entire site. Consequently it offers the most reliable indicator of the existence of some preservation plan. As discussed above this protection ranges from non-binding voluntary agreements to legal contracts.

The exogenous variables in the probit model will include the variables described in Table 2. We measure the ecological significance of a site by its ecological rank and the number of element occurrences, both contained in the SBR data from the NHP. We expect these variables to be positively correlated with the preservation choice because the owner-manager of more ecologically sensitive land will be subject to more external public and internal personal pressure to preserve. We also include the total acres of the site, although the sign of this variable is unclear. Larger sites will potentially be more valuable in development, but larger sites may also be more valuable for preservation because they offer more protection for the EOs located on the site and may be less susceptible to disturbances from development on adjacent land or a form of 'ecologies of scope'.

We use several county level demographic variables to proxy for socio-economic drivers of land use change, X. Because the demographic variables are only a proxy, they do not offer a clean interpretation. Rapid development and growth in income, population and land values mean more competition for undeveloped land and a greater opportunity cost for preservation. However, development also puts unprotected natural communities at greater risk than similar communities in counties that are not developing. Faced with greater threats, pressure to preserve may increase. Growth in income and development may also provide more resources for preservation activities at the local level, and potentially may proxy for changing preferences for open space and environmental protection as development changes the landscape. The specific county-level demographic variables to measure growth include the change in median income between 1979 and 1995, the change in agricultural land prices between 1992 and 1995, and the change in population density between 1985 and 1995. In addition, the SNHA data, including the boundaries, are contained in a geographic information system (GIS) providing a computerized map of the sites that can be overlaid with other data to create spatial variables. We used this mapping system to create two variables related to the distance of the site to the nearest city of 50,000 or greater and the nearest interstate highway. To the extent that these variables proxy for development pressure from nearby cities and access to markets for timber and agricultural products, increasing distance will imply a decreasing benefits from development and a higher probability of protection. In addition, if a site crosses county boundaries, the map was used to calculate the area of the site in each county. The county specific location and acreage was used to assign socio-economic and political variables for each site. If a site spanned several counties, the variables for each site are a weighted average of the variables for each of the counties, where the weights are the percentage of the site that is located in each county.

Finally, we include institutional and political variables. In our data set, land is managed by private and public owners, including individuals, colleges, NGOs, states, and the federal government. Our model of the preservation decision fits private landowners most obviously, but the behavior of the government and institutional landowners provides an instructive comparison. In general, one might expect that government and institutional landowners would have been less influenced by local economic conditions and have more latitude to focus on ecological consequences. Of course some institutional landowners in the NHP data set such as The Nature Conservancy and the Audubon Society are dedicated to ecological preservation, but in order to purchase land they must take into account local land prices.

Political support for the environment or a high level of “policy capacity” to undertake innovative policies may create favorable opportunities for land preservation in a county (Press (1987)). A high level of environmental activity in a county should have two effects: greater pressure on landowners to protect sites and lower the transaction costs for taking a protection action. We use an index of the environmental voting records of the state senators (in 1995) and representatives from the county (in 1997) calculated by the North Carolina League of Conservation Voters as the first proxy for political support. Voting districts cross county lines, so for the county voting index we calculated the average of the environmental voting index for all the senators and representatives whose districts included a particular county. These two averages were then added together to form the county environmental voting. The second measure of political support is the change in the parks and natural resources budgets for each county from 1981 to 1991 as a percentage of total general revenue. The sum of the budgets for the Parks and Recreation Department and the Natural Resources Departments were added together and divided by the total general revenue for both 1981 and 1991. Third, the acreage of state and Federal Park land is calculated from our GIS database to proxy for another governmental influence on private behavior. The sign on this variable is unclear. A large federal or state presence in the county could provide technical assistance and information to landowners and exert pressure on them to preserve. Alternatively, the federal and state investments in protection could crowd out private initiatives.

WHAT DRIVES VOLUNTARY SNHA PRESERVATION? PROBIT RESULTS

Table 3 presents the results from a probit model predicting the existence of an MBR for the full data set of SNHAs. We see that the coefficients on ecological rareness and elemental occurrences are positive and significant as expected. Clearly ecology is a significant influence on entering into a protection agreement. We also find that distance to highways has a positive influence on preservation, similar to other authors studying development and deforestation. As suspected, our economic variables present a mixed signal: increasing median income reduces the likelihood of protection, while increasing population density and land values increase the likelihood. Factors such as income, population pressures and land values will increase the demand for land and thus the cost of protection. However, these factors also indicate increased threats to ecologically sensitive land and heighten the urgency for protection. Furthermore, as development increases the demand for open space should also increase. These results may reflect the interplay between these two conflicting forces.

Of the two county level political factors, the voting record of the state senators and representatives is significant—but has a negative coefficient. This may indicate a backlash against what might be viewed as excessive protection for example in counties with large, protected, Federal sites. Alternatively, counties without large Federally protected sites may be more concerned about the environment. The change in the county's natural resource budget, however, is insignificant.

In this model we include a series of dummy variables breaking down the impact of different institutional owners on the protection of single-owner sites and a variable for the number of owners. The dummies for the various institutional owners provide a sense of the differences between owner categories. Compared to land with multiple owners, solely managed federal, state and NGO owned land are more likely to be managed for protection, while privately owned land is less likely to be preserved. Compared to SNHAs with multiple owners, a sole owner may be more likely to protect her land because the transactions and administration costs of management are lower. This factor may be confounded by the fact that more owners may raise the possibility of preservation, since any one of them could enter into a preservation agreement with NHP. Indeed, we find a positive coefficient on the number of owners variable.

In Table 4, we more closely examine sites with single owners who are private (column [2]) and Federal (column [3])—the two extremes on the ownership spectrum. The privately owned sites make up the largest number of single owner sites. The result for these sites shows a combination of influences. The ecological ranking of the site is positive, as is the total acres of the site. Because a managed area does not need to cover the entire site, larger sites offer more opportunities for protection. Elemental occurrence is not significant, perhaps because of high collinearity with ecological rareness. Returning to the importance of socio-economic factors in the decision to protect a site, for private owners being close to a city or in a county with rising median income results in less protection. Both of these variables can reflect increased demand for land and increased value of land. As seen in Table 4, increasing population density leads to a greater probability of protection—potentially a response to increasing ecological threats. We also included the acreage of Federal and State parkland in the county. The positive and significant coefficient suggests that the parkland has positive spillover effects for protection. This could be due to the availability of technical assistance and management advice or from greater pressure from government landowners in the same county to protect.

The federally owned sites provide an interesting comparison. We find that the ecological rareness of the site is positive and significant, as is distance to highways. However, sites located closer to cities are more likely to be protected. For Federally protected sites that are recreation areas, sites that are closer to cities may receive a larger number of visitors and thus there would be greater public pressure for protection. Interestingly, none of the county level demographic variables are significant. This suggests that federal protection may be a consequence of a regulatory process detached from local economic considerations. As in the full sample case, our political proxy, the voting record of the state senators and representatives is negative and significant. This may indicate a backlash against environmental regulation in counties with large, protected, Federal sites. Alternatively, counties without large Federally protected sites may be more concerned about the environment. As a closing caveat for our regression based empirics, we recognize that the use of county level data to proxy several economic and political drivers is far from ideal because it restricts the confidence with which we can identify causality. Nevertheless, we believe this approach represents an important first step in model building.[2]

DISCUSSION

The strength of the current U.S. economy, against a backdrop of shrinking government, can create expectations of voluntary preservation of significant natural habitat to stem the tide of biodiversity loss. In this paper we use a unique data set from North Carolina to examine the determinants of voluntary ecological preservation by public and private individuals and institutions. We model the preservation decision as a function of ecological, socio-economic, and political factors and use GIS to overlay the various data themes.

An economically efficient land preservation strategy balances the ecological value of the site to society and the opportunity cost of preserving the site in terms of forgone development and

[2] See Deaton (1997) for a discussion of the general uses of regression for model building.

timber sales. One would expect landowners who are concerned about biodiversity, such as some government agencies and private organizations including land trusts, to place more emphasis on the ecological characteristics of the land. Private landowners who are dependent on the land for income, such as timber companies, may undervalue the public good environmental benefits from protection.

We find that a variety of forces influence the decision to enter into management agreements for the protection of ecologically significant natural sites. The ecological rareness of the site positively influences the likelihood of preservation across all models. Supporting evidence from other studies of development and deforestation, distance to highways and cities affects the decision to protect land. Our proxies for socio-economic drivers signal the mixed influence of the opportunity costs and ecological benefits of preservation. We find some evidence of political activity influencing conservation choices. Furthermore, our results demonstrate differences between classes of landowners with regards to the probability of protection. While Federal sites appear to be protected on the basis of ecological characteristics almost exclusively, privately owned sites are sensitive to local economic and demographic conditions as well.

In sum, this study provides a conceptual and empirical framework for evaluating determinants of ecological preservation. Our use of an ecological rareness variable (from field biologists) illustrates the application of new and improved measures to evaluate ecological influences of preservation. From a methodological perspective, our site variables (ecological rareness and distance) are statistically robust and significant, whereas our county-level proxies offer mixed signals. This suggests that the degree of resolution might effect statistical performance and economic inference. Further research is needed to determine the efficiency versus bias tradeoff that can be attributed to 'ecological inference or aggregation' problems of this nature (King, 1993). The issue of interactions between various preservationists also needs further empirical research even though our analysis of single owner sites indicate that the existence of Federal and State parkland may increase private protection actions. The complexity of interactions among preservationists cannot be captured by analysis of single owner sites. While this paper provides evidence regarding factors that influence land protection, it does not provide an analysis of the optimal level of land preservation. Further research is needed on whether land preservation efforts by different landowners in North Carolina are optimal. Determining the relative optimal weights for various ecological and socio-economic factors, through non-market valuation methods, could be a starting point for such research.

From a policy perspective, the performance of our ecological variable suggests that provision of information to landowners on the ecological quality of lands could increase preservation. The performances of our socio-economic variables also suggest that economic incentives such as subsidies used to reduce erosive farming under the Conservation Reserve Program could increase preservation by private owner-managers. Furthermore, as in studies of tropical deforestation, road building appears to increase the probability that land is developed. Finally, while the end product from this research can help various federal agencies understand the determinants of voluntary environmentalism, this type of research generates as a positive externality, a spatially explicit mix of economic, ecological, and institutional data, that can significantly supplement conservation effort.

ACKNOWLEDGEMENTS

We would like to thank the North Carolina Natural Heritage Program, in particular Linda Pearsall and John Finnegan, for their assistance in providing the data for this project and answering all our questions about the program. We would also like to thank Dr. Patrick Halpin and Jill Ozarki for their help creating the GIS and Census data.

REFERENCES

Arora, S., and T. Cason, 1995. “An Experiment in Voluntary Environmental Regulation: Participation in EPA’s 33/50 Program.” *Journal of Environmental Economics and Management* 28:271-286.

Bell, K. and N. Bockstael, 2000. “Applying the Generalized Method of Moments Estimator to Spatial Problems Involving Micro-Level Data,” *Review of Economics and Statistics* 82 (1): 72-82.

Binkley, C, 1981. *Timber Supply from Nonindustrial Forests: A Microeconomic Analysis of Landowner Behavior.* Yale University Press, New Haven.

Bockstael, N., 1996. Modeling Economics and Ecology: The Importance of a Spatial Perspective. *American Journal of Agricultural Economics*. 78: 1168-1180.

Brunnermeier, S., and M.A. Cohen, 1996. “The Impact of Voluntary Environmental Program Participation on Firm Market Value: A Switching Regression Model.” Vanderbilt University Working Paper.

Cropper, M., C. Griffiths, and M. Mani, 1999. “Roads, Population Pressures and Deforestation in Thailand, 1976-1989,” *Land Economics*, vol. 75(1), 58-74.

Deaton, A., 1997. *The Analysis of Household Surveys: A Micro-econometric Approach to Development Policy.* Johns Hopkins University Press. 479 p.

King, G., 1997. *A Solution to the Ecological Inference Problem: Reconstructing Individual Behavior from Aggregate Data*. Princeton: Princeton University Press. 346 p.

Lyon, T., and J. Maxwell, 1999. “Voluntary Approaches to Environmental Regulation: A Survey.” In *Environmental Economics: Past, Present, and Future*, M. Franzini and A. Nicita (eds). Aldershot, Hampshire: Ashgate Publishing Ltd.

Maddala, G, 1983. *Limited Dependent and Qualitative Variables in Econometrics.* New York: Cambridge University Press.

Natural Heritage Program (NHP), 2000. “North Carolina Natural Heritage Programs.” Available from <http://ils.unc.edu/parkproject/nhp/index.html/>.

Pfaff, A., 1999. “What Drives Deforestation in the Brazilian Amazon?” *Journal of Environmental Economics and Management*, vol. 37(1), 26-44.

Press, D., 1998. “Local Environmental Policy Capacity: A Framework for Research,” *Natural Resources Journal*, vol. 38, 29-52.

Table 1. Ecological Rank of Sites, Ownership and Preservation

Ecological Rank	Total Number of Sites (% preserved)	Sites with a Single Owner (% preserved)				
		Federal	State	Private	College	NGO
4 (highest quality)	302 (65%)	69 (93%)	38 (55%)	67 (31%)	0	2 (100%)
3	536 (55%)	101 (91%)	68 (69%)	227 (19%)	6 (67%)	10 (100%)
2	669 (30%)	116 (79%)	46 (67%)	405 (7%)	12 (25%)	3 (0%)
1 (lowest quality)	272 (17%)	30 (50%)	14 (50%)	131 (2%)	6 (17%)	3 (100%)

Table 2. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Std. Dev.
Dependent Variable			
MBR	=1 if managed area record exists for a site	0.45	0.50
Ecological Variables			
Ecol Rank	Ecological ranking of site (4=highest, 1=lowest)	2.59	0.84
Number of EOs	Number of element occurrences (plants or animals)	6.69	8.45
Total acres	Total acres of site	1598	85550
Socio-Economic Variables			
Dist to highway	Minimum distance from edge of site to nearest city of population 50,000 or greater	181482	155877
Dist to city	Minimum distance from edge of site to interstate highway	144860	133835
Ch pop density	Change in population density of county between 1985 – 1995	19.05	36.74
Ch land value	Change in agricultural land values in county between 1992 – 1995	482.64	478.23
Ch median income	Change in median income of county between 1979-1995	16666	3288
Political/Institutional Variables			
Ch nat res budget	Change in sum of natural resources and parks budgets for county as percentage of general revenue between 1981-1991	0.51	1.65
Vote record	Sum of average environmental voting records of state senators (for 1995) and state representatives (for 1997) from a county	124.69	21.04
Acres of park land	Acres of Federal and State park land in county	3004.00	8590.00
Federal owner	Partial or complete Federal ownership of site	0.28	
State owner	Partial or complete State ownership of site	0.16	
Private owner	Partial or complete private ownership of site, individual or business	0.63	
College owner	Partial or complete college or university ownership of site	0.02	
NGO owner	Partial or complete NGO ownership of site	0.05	
Single Fed	Single, Federal owner of site	0.21	
Single State	Single, State owner of site	0.09	
Single Private	Single, private owner of site	0.48	
Single College	Single, college or university owner of site	0.01	
Single NGO	Single, NGO owner of site	0.01	
Number of owners	Number of owners for site	1.19	0.48
N Obs	Number of observations (SNHAs)	1358	

Table 3. What Drives SNHA Preservation? Probit Model Coefficients and (Standard Errors)

Variables	Estimated Coefficient	Standard Errors
Ecol Rank	0.32**	0.06
Number of EOs	0.20**	0.008
Dist to highway	1.21e-06**	5.48e-07
Dist to city	4.37e-07	4.58e-07
Total acres	8.67e-06	1.54e-05
Ch median income	-0.00005**	0.00002
Ch pop density	0.004*	0.002
Ch land value	0.0003**	0.0001
Ch nat res budget	0.02	0.03
Vote record	-0.004**	0.002
Single Fed	0.95**	0.21
Single State	0.45**	0.23
Single college	-0.04	0.37
Single NGO	0.87**	0.44
Single Private	-1.30**	0.20
Number of owners	0.65**	0.18
Number of observations	1358	
Pseudo R^2	0.46	
Log Likelihood	-503.76	

* statistically significant at the 10% level
** statistically significant at the 5% level
Dependent Variable: Managed Area Basic Record exists for SNHA

Table 4. What Drives SNHA Preservation? Single Owner Sites Probit Model Coefficients and (Standard Errors)

Variables	Private	Federal
Ecol rank	0.45** (0.11)	0.32** (0.15)
Number of EO's	0.018 (0.013)	0.01 (0.02)
Dist to highway	-5.16e-07 (8.72e-07)	4.28e-06** (1.41e-06)
Dist to city	1.62e-06** (6.65e-07)	-2.54e-06* (1.28e-06)
Total acres	0.00007** (0.00003)	3.55e-06 (1.81e-05)
Ch median income	-0.0001** (0.00004)	0.000026 (0.000058)
Ch pop density	0.009** (0.003)	0.003 (0.006)
Ch land value	0.0003 (0.0002)	0.0002 (0.0002)
Ch nat res budget	-0.03 (0.06)	0.02 (0.08)
Vote record	-0.005 (0.004)	-0.017** (0.005)
Acres of park land	0.00002* (0.00001)	
N obs	656	282
Pseudo R^2	0.14	0.16
LL	190.20	-103.63

* statistically significant at the 10% level
** statistically significant at the 5% level

Dependent Variable: Managed Area Basic Record exists for SNHA