LETTER

State-level variation in conservation investment by a major nongovernmental organization

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Abstract

Few empirical studies examine how conservation organizations distribute the resources that they have available for habitat conservation, despite numerous theoretical studies that recommend how these resources should be directed. Here we examine the distribution of conservation investments made over 49 years by a major conservation nongovernmental organization (NGO), The Nature Conservancy (TNC). We measured the level of conservation effort across U.S. states by the area protected and the upfront cost of protection, accounting for easements and land acquisitions. While correlated, we show that two measures of conservation effort (area and amount invested) cannot be used as reliable proxies for one another. The distributions of both measures of conservation effort are explained by combinations of one biological (species richness) and three socioeconomic (land price, rate of development and action of other NGOs) factors, revealing a generally strategic pattern of investment by TNC. Finally, we identify examples of underinvestment in particular states by TNC.

Introduction

Habitat destruction threatens biodiversity at all levels, from ecosystems to individuals (WWF 2004; Hoekstra *et al*. 2005; Ricketts *et al*. 2005; Pimm *et al*. 2006). Over one quarter of the earth is cultivated and 20% to 50% of habitat in over half of 14 terrestrial biomes has been converted to human use (MEA 2005). In the United States, over 8,000 km^2 of open land per year is developed (LTA 2004). As such, habitat protection is imperative to securing the future of biodiversity. With limited budgets to support habitat protection, the conservation community is under pressure to allocate efficiently what resource is available. The institutions that protect land are both public and private, with nongovernmental organizations (NGOs), such as private land trusts, playing an increasing role, because they are less subject to the political winds of government and can often serve as agile catalysts for subsequent public investment.

Here we examine the distribution of investment in habitat conservation in the United States by a major conservation NGO, The Nature Conservancy (TNC). Although public-protected areas (including national parks, designated wilderness areas, national wildlife refuges, Indian reservations, and county parks) cover 5% (over 400,000 km^2) of the coterminous United States (Scott *et al*. 2001), these are often poorly sited for biodiversity (60% of them cover high elevations and/or poor quality soils), with most not originally being designated for their biological importance (Scott *et al*. 2001; Hansen & Rotella 2002). Moreover, in the United States at least two-thirds of species listed under the U.S. Endangered Species Act have more than 60% of their range on nonfederal lands (Bean & Wilcove 1997; Groves *et al*. 2002). As such, additional habitat conservation efforts are needed outside of the existing public-protected area network. An important contribution to habitat conservation comes from the growing land trust movement. Land trusts are nonprofit organizations that are actively engaged in land conservation (Albers & Ando 2003; Merenlender *et al*. 2004). The latest census by the Land Trust Alliance (LTA) included more than 1,650 local and state land trusts in the

United States that together had protected almost five million hectares of land (LTA 2005). Some of the biggest players in habitat conservation, such as TNC, are not included in these figures. We know of no published studies documenting the combined spending on habitat conservation accounted for by the land trust movement. Indeed, there are few studies looking at the spending profiles of any conservation NGOs (but see Halpern *et al*. 2006).

The lack of clear measurements of habitat conservation activity has not impeded the proliferation of theoretical studies into how conservation efforts should be targeted. Recent theory emphasizes that alongside biological value, accounting for social and economic factors in priority setting can improve effectiveness (O'Connor *et al*. 2003; Armsworth *et al*. 2006; Knight & Cowling 2007). Conservation theory will have a greater impact if it more accurately reflects the choices and constraints that practitioners face in decision making.

In this article, we examine spatial patterns of conservation investments by land trusts. We focus on land deals in the coterminous United States that were made over 49 years by TNC, which is the largest land trust in operation. The advantage of using only TNC projects, rather than including conservation projects by other land trusts as well, is that TNC projects represent a homogeneous sample of conservation efforts, all following the same method and all representing the same biological objectives and mission. The spatial and temporal extent of the data set is unrivalled.

Methods

Scale of analysis

TNC operates as an international organization, with major land transactions requiring Board approval. This means that there is the opportunity for governance to shape the distribution of resources and investment among different states within the coterminous United States. All of our analyses are at the state level—with each of 48 different states representing a sample with attributes that include biological, investment, and socioeconomic factors for that state. Similar analyses could and should be pursued at different scales, but states are a natural starting point for us for three reasons. First, state tax and land zoning policy will influence conservation, and biodiversity data are readily available at the state level. Second, TNC records all transactions and financial dealings at the state level. And third, the full extent of the data set that we analyze is only currently available at this spatial resolution. Therefore, studying conservation allocation decisions at a finer spatial resolution, while informative, would necessarily provide an incomplete picture of the allocation decisions that TNC faces. By focusing on the state level, our study nests between studies of conservation allocation decisions at whole country or ecoregion scales (O'Connor *et al*. 2003; Kareiva & Marvier 2003; Halpern *et al*. 2006; Bode *et al*. 2008) and more localized studies of allocation decisions within a particular state that focus on county-level spending patterns (Underwood *et al*. 2008).

Data set

We analyzed conservation easement and fee simple land transactions by TNC across 48 contiguous states between 1954 and 2003. In fee simple transactions, TNC acquires land outright. However, TNC only acquires some property rights with a conservation easement, such as the right to subdivide and develop a property; the remaining rights remain with the original landowner (Dana & Ramsey 1989). We measured conservation investment using two response variables: total area protected (*Hectares*) and the overall acquisition cost involved in protecting that area (*Dollars*). Dollar values were converted to 2003 equivalents accounting for inflation (CPI 2006). Fully donated deals appear in the area total only; those for water rights appear strictly under the financial heading.

Predictor variables

We selected seven biological and socioeconomic variables that could potentially contribute to predicting the spatial distribution of TNC investments (Table 1). First, we included state area and species richness (*Spp. richness*) within a state. Socioeconomic variables included the rate of change in number of households (*Households*) between 1960 and 2000, as a proxy for land threat; the average market value of agricultural land between 1974 and 2000 (*Cost*) as an estimate of land cost (USDA 2000—U.S. Census of Agriculture, 2002); the area protected by other land trusts (*LTA*); and overall donations to TNC across states (*Donors*). To proxy for state-level variation in donations, we used data on grant income to TNC from charitable foundations between 1999 and 2004. Finally, we considered whether a passive accumulation model could explain variation in investment patterns. For example, the first deal for New York was in 1956 while the first in Louisiana took place in 1986. The passive accumulation hypothesis included the date of the first deal (*Date*).

Analyses

Variables were transformed to meet assumptions of normality. When suitable a log transformation was used,

Table 1 Predictor variables tested to explain the spatial distribution of investments by The Nature Conservancy

Predictor	Source	Additional comments
State area	US Census Bureau (2000)	
Spp. richness	NatureServe (2006)	National distribution of all native terrestrial vertebrates, invertebrates and plants
Cost	US Census of Agriculture (2002)	Average land market value (1974–2000); proxy for land cost
Households	US Census Bureau (2000)	Rate of change in number of households (1960–2000); proxy for land threat
Donors	GuideStar (2006)	Donations from independent charities given to The Nature Conservancy of $500 or more from 1999 to 2005
LTA	Land Trust Alliance (2003)	Total area protected by other land trusts
Date	TNC database	Date of first deal made by The Nature Conservancy

and when this was not suitable, a more flexible Box-Cox transformation was applied (Krebs 1999). All analyses were performed using the transformed data.

Our statistical analyses treat states as independent samples. In order to check the validity of this assumption, we checked for spatial dependency in the response variables in two ways: centroid and adjacent autocorrelation. The former assigned the two response variables to state centroids. Spatial correlograms using Morans I (1950) revealed no autocorrelation in either response variable. For adjacent autocorrelation, we tested the correlation between adjoining pairs of states (one lag only) and used bootstrapping to test for spatial dependence. In both cases (i.e., for Hectares and Dollars), we ran a permutation test with 150 randomizations to calculate the probability of observing the correlation that we found between neighboring states for both Hectares and Dollars if no spatial signal was present. While some spatial autocorrelation was present in both response variables ($P = 0.03$ for Hectares and $P = 0.03$ for Dollars), the association between response variables in neighboring states was very weak ($R^2 = 0.03$ for Hectares and $R^2 = 0.02$ for Dollars). Given these low values we decided that spatial dependency was minimal and not likely to influence patterns found in subsequent analyses. Therefore, we used aspatial models.

We first correlated hectares and dollars in order to assess whether these are complementary metrics of conservation effort. We then constructed multiple regression models to assess the association between conservation effort and biological and socioeconomic variables. Prior to running multiple regressions we investigated if there was evidence of collinearity between predictor variables (Quinn & Keough 2002). In all cases tolerance levels were sufficiently high (i.e., >0.1) for collinearity to be of limited concern. We adopted the information theoretic approach to model simplification. For the two response variables we constructed all possible models given the set of predictor variables. The model with the smallest Akaike Information Criteria (AIC) value was considered the most parsimonious model. Following standard procedures, we calculated model weights, which indicate the probability that the model is true given that truth is in the model set (Link & Barker 2006). Following Johnson & Omland (2004), we then constructed the 95% confidence set of models, that is, the smallest number of models whose cumulative weights summed to 0.95. We calculated model averages across the 95% confidence set for both hectares and dollars. We assessed the explanatory power of each predictor using partial r^2 values.

Results

In total, over 3.4 million hectares of habitat was protected at an upfront cost of more than US$5.8 billion. Conservation easements protected 37% of this area and accounted for 15% of overall expenditure. The remainder was protected through fee simple acquisition.

There is large-scale spatial heterogeneity in the distribution of overall investments across the United States (Figure 1A–D). Some states received substantial levels of investment for Hectares and Dollars (e.g., California and Texas; Figure 2), whereas others received little (e.g., Iowa and North Dakota; Figure 2). Some states have little area protected relative to the financial outlay (e.g., Massachusetts; Figure 2), while in others a large area was protected relatively cheaply (e.g., New Mexico; Figure 2). The median of the two investment metrics was 30,000 hectares and US$77 million. California and New York received the highest levels of financial investment. Maine had the largest area protected (>500 thousand hectares), with a substantial fraction accounted for by two large sets of easement transactions toward the end of the study period.

The spatial distribution of Hectares and Dollars across states is strongly correlated (Figure 2; $R^2 = 0.38$, $P < 0.0001$). However, much of the variance remains

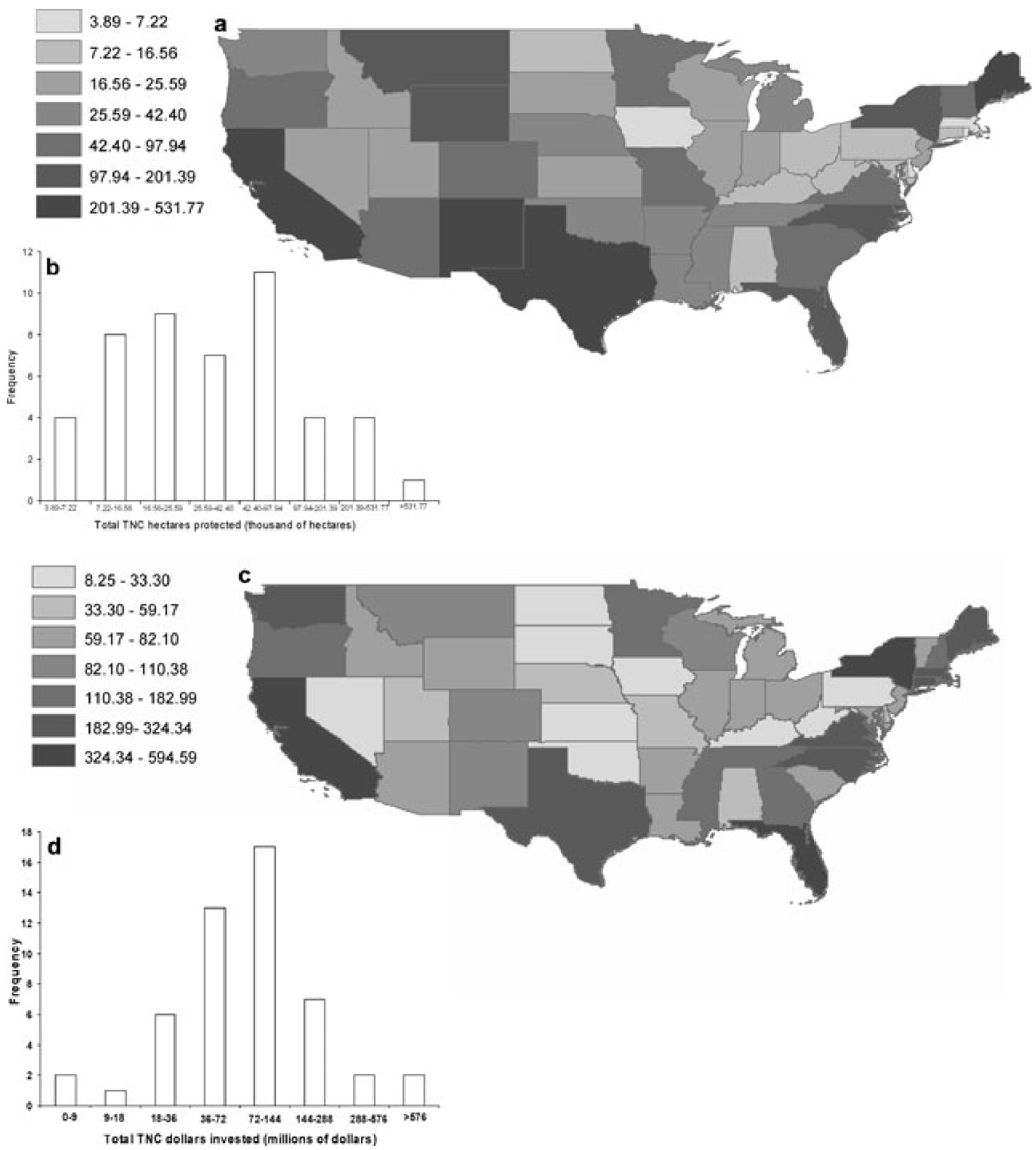

Figure 1 Spatial distribution of (a) total hectares protected (thousands of hectares) and (c) total dollars invested (millions of dollars) by The Nature Conservancy throughout the coterminous states between 1954 and 2003. Frequency distribution of (b) total hectares protected and (d) total dollars invested.

unexplained, suggesting that the two metrics of habitat conservation effort are not complementary.

Six models were included in the 95% confidence set for models describing the area protected by TNC (Table 2). The model averaged total r^2 was 0.53. The model averaged partial r^2 values were greatest for cost (partial $R^2 = 0.20$) and the area protected by other land trusts (partial $R^2 = 0.19$). The cost of land was negatively related to the overall area protected by TNC (model average: slope = –0.70), and the area of habitat protected by other land trusts was positively related to the area protected by TNC (model average: slope = 0.34). In addition, species richness, the rate of change in the number of households and state area appeared in models within the 95% confidence set, but had less predictive capacity.

When considering the financial investment by TNC to protect habitat in different states, seven models were included in the 95% confidence set (Table 3). The model averaged total r^2 was 0.52. Species richness (slope = 0.99, model averaged partial $R^2 = 0.10$) and the area protected by other land trusts (slope = 0.22, model averaged partial $R^2 = 0.15$) had the greatest predictive capacity. The rate

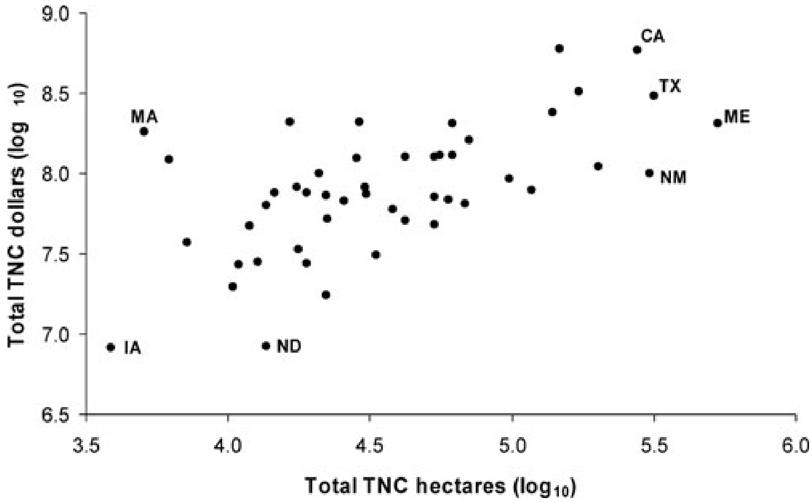

Figure 2 Correlation between total hectares protected and dollars invested by The Nature Conservancy ($n = 48$; $P < 0.0001$; $R^2 = 0.38$). Some states (e.g., CA, TX) received large amounts of investment whether measured in area or spending; some (e.g., IA, ND) received little investment using either metric; some had a small area protected at high cost (e.g., MA), while others had a large area protected relatively cheaply (e.g., NM).

of change of the number of households and the cost of land also appeared in models within the 95% confidence set. In contrast to the models for the area protected by TNC, the cost of land is related positively to the amount invested in habitat protection, that is, more money is invested in states where land is expensive (Table 3).

Discussion

Most past analyses exploring the allocation of conservation effort have concentrated on the area protected (Hansen & Rotella 2002; Yuan-Farrell *et al*. 2005; Kiesecker *et al*. 2007; Rissman *et al*. 2007). Only a few studies examine conservation spending (Halpern *et al*. 2006; Lerner *et al*. 2007; Underwood *et al*. 2008), and ours is the first to look simultaneously at both measures of conservation effort by a major conservation NGO. The overall area protected is correlated with overall spending, but much variation remains unexplained (Figure 2). Our results suggest some commonality in the factors important in shaping TNC's conservation investment profile when measured by area protected and financial outlay (Tables 2 and 3). However, the relative importance of different factors for predicting each measure of conservation effort changes. For example, species richness has greater predictive capacity when considering financial investments by TNC than when considering the area of land protected. Also, the direction of some relationships changes when comparing models predicting the amount invested and the area protected. For example, states where land is expensive received greater financial investment, but still had a smaller area protected. Taken together, these results suggest a richer understanding of conservation effort stands to be gained by analyzing investment strategies along both dimensions (area and dollars invested).

Table 2 The 95% confidence set of models of spatial variation in hectares protected by The Nature Conservancy in the United States at the state level ($n = 48$). Parameter estimates are provided ± 1 SE. The model average across the 95% confidence set is also given (shaded)

	Parameter estimates					Partial r^2							
Model	Spp. richness	Cost	LTA	Households	State area	Spp. richness	Cost	LTA	Households	State area	Model r^2	AIC	Model wt
1	1.09 ± 0.47	−0.61 ± 0.16	0.32 ± 0.08	–	–	0.06	0.16	0.17	–	–	0.53	50.70	0.45
2	–	−0.85 ± 0.16	0.35 ± 0.08	0.32 ± 0.12	–	–	0.31	0.22	0.07	–	0.54	52.06	0.23
3	0.26 ± 0.85	−0.80 ± 0.22	0.34 ± 0.08	0.27 ± 0.23	–	0.00	0.13	0.18	0.01	–	0.54	52.46	0.19
4	–	−0.74 ± 0.16	0.40 ± 0.07	–	–	–	0.25	0.31	–	–	0.47	54.16	0.08
5	–	–	0.33 ± 0.07	–	0.00003 ± 0.000006	–	–	0.23	–	0.28	0.50	58.47	0.009
6	1.87 ± 0.49	−0.43 ± 0.18	–	–	–	0.08	0.2	–	–	–	0.36	59.13	0.007
Model average	0.57	−0.70	0.34	0.13	0.0000003	0.03	0.20	0.19	0.02	0.003	0.53		

Table 3 The 95% confidence set of models of spatial variation in dollars invested by The Nature Conservancy in the United States at the state level ($n = 48$). Parameter estimates are provided ± 1 SE. The model average across the 95% confidence set is also given (shaded)

	Parameter estimates				Partial r^2						
Model	Spp.richness	Cost	LTA	Households	Spp.richness	Cost	LTA	Households	Model r^2	AIC	Model wt
1	1.51 ± 0.38	0.35 ± 0.13	0.22 ± 0.07	–	0.17	0.08	0.12	–	0.55	31.37	0.39
2	–	–	0.27 ± 0.06	0.38 ± 0.10	–	–	0.20	0.15	0.51	32.83	0.19
3	0.46 ± 0.50	–	0.26 ± 0.06	0.29 ± 0.14	0.01	–	0.17	0.05	0.52	33.53	0.13
4	1.18 ± 0.38	–	0.27 ± 0.06	–	0.11	–	0.19	–	0.47	33.85	0.11
5	1.22 ± 0.69	0.28 ± 0.18	0.09 ± 0.18	0.22 ± 0.06	0.04	0.03	0.12	0.00	0.55	34.67	0.07
6	2.04 ± 0.38	0.48 ± 0.14	–	–	0.37	0.15	–	–	0.43	35.95	0.04
7	–	0.06 ± 0.13	0.27 ± 0.06	0.36 ± 0.10	–	0.00	0.19	0.13	0.51	36.85	0.02
Model average	0.99	0.18	0.22	0.14	0.10	0.04	0.15	0.04	0.52		

Past habitat conservation strategies have been suggested to be largely opportunistic (Ando *et al*. 1998; Scott *et al*. 2001). However, our analyses suggest a generally strategic signal in TNC's investment portfolio. In combinations, four factors (species richness, land cost, rate of development and the action of other land trusts) offered a good fit to the data ($R^2 = 0.53$ for area protected and $R^2 = 0.52$ for dollars invested). While state area also appears in the 95% confidence set of models for predicting the area protected, its predictive capacity is small (partial $R^2 = 0.003$). If investments had been opportunistic (as the term opportunism has typically been applied in the conservation planning literature, e.g., Margules & Pressey (2000)), we would expect investments to have been disproportionately allocated to inexpensive areas or for all predictor variables to have weak predictive capacity. There was no evidence for either of these patterns in TNC's investment actions.

The area protected by other land trusts was an important predictor of TNC's investment profile for both Hectares and Dollars. This could indicate a signal of cooperation and communication between land trusts (Albers & Ando 2003). However, we suspect that the relationship is not causal but instead symptomatic of the legal and cultural factors that vary across states, rendering some more suitable for conservation than others. Such factors would include variations in state tax laws that affect donations (particularly of land) to organizations like TNC (see Parker 2003), as well as variations in the funds available to local and state conservation agencies that result from both variations in the local tax base and voter preferences for conservation. Variations in public funding available for conservation could be important to TNC and other land trusts, because public agencies often partner in and part-fund land conservation deals. A final possibility is that there is some redundancy; some of the area protected by TNC may also appear in the Land Trust Census because TNC commonly pass stewardship responsibilities on to other organizations, including local land trusts.

We expected variation across TNC's donors to predict where TNC allocate investments but found little evidence for this when controlling for confounding effects of other factors. The Donor field that we used in the analysis only covers recent donations from grant-giving bodies to TNC, (also see above comments regarding other types of donation, the Online Supplementary Material for additional relevant results, and the recent study by Zavaleta *et al*. 2008). The grant-giving bodies did not appear to bias their donations toward the TNC chapter covering the state where the grantor was registered for income tax purposes. Only 25% of donations to TNC from charitable foundations were given to the TNC chapter covering the foundation's home state. We also found no evidence for a passive accumulation model.

Over the 49-year period of the study, TNC's expenditure on land transactions has continued to grow. As the organization has grown, it has become able to undertake occasionally very large land transactions. Such deals have the potential to introduce a sampling artifact based on which time period is chosen for study when trying to obtain an overall picture of conservation investment patterns. By aggregating data over an unusually long time period and including well over 10,000 different land deals, we have attempted to minimize such sampling effects. Even then, the very large area of Maine protected over the study period was accounted for, in part, by two sets of easement transactions in 2001 and 2003. Very large, one-off investments in habitat conservation like this, introduce a particular set of problems to conservation planning (Armsworth *et al*. 2006) and future studies that focused exclusively on these large deals may be well warranted, because they have continued to be important after 2003 (Kareiva, unpublished data).

While we have emphasized evidence of some strategic signal in the TNC data, it is important to note examples of over- and under-investment. For example, expenditure in Maine was seven times greater than that in Alabama, which has 64% more species than Maine. However, claiming underinvestment simply because of lack of spending relative to the biological diversity in a state is ill advised, because multiple factors contribute to conservation allocation decisions (Kareiva & Marvier 2003). We suspect most examples of underinvestment represent poorer states, presumably with reduced fundraising and donor resources. Indeed, a simple correlation shows that the wealth of a state (as measured by GSP) is positively correlated with the money donated to TNC by grant-making agencies within that state ($R^2 = 0.56$). Although it is common to treat conservation decisions as unconstrained, the reality is that poorer regions may have less money for conservation. The central challenge for conservation, one that applies much more broadly than among U.S. states, may well not be the design of ever more theoretically deft decision-support algorithms, but mechanisms for transferring funds from wealthy regions with little biodiversity to poor regions rich in biodiversity.

An important role that conservation planning theories can play is to help the conservation community distil out generalizable lessons from across a range of case studies, such as the one that we present, to help inform conservation practice elsewhere. Here we focused on the most common question posed in conservation planning papers, namely, how conservation organizations allocate resources across different locations and which biological, social, and economic factors they respond to when doing so. If it is not grounded in case studies like this, conservation planning theory risks becoming an abstract, largely academic, endeavor (Knight & Cowling 2007). Therefore, we would welcome further case studies reviewing past conservation investments in contrasting contexts, perhaps in the developing world, on which such a grounding of conservation theory can be based.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1 Additional predictor variables (see Methods; Table 1) used in bivariate regressions. These were excluded for multiple regression models after checking for collinearity.

Table S2 Bivariate regressions between ten predictor variables and total hectares protected by The Nature Conservancy (n = 48), including slope parameters ±1 standard error [SE].

Table S3 Bivariate regressions between the ten predictor variables identified and the total dollars invested by The Nature Conservancy (n = 48) including slope parameters ± 1 standard error [SE].

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