Conservation Biology

Contributed Paper

The value of flexibility in conservation financing

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Abstract: *Land-acquisition strategies employed by conservation organizations vary in their flexibility. Conservation-planning theory largely fails to reflect this by presenting models that are either extremely inflexible—parcel acquisitions are irreversible and budgets are fixed—or extremely flexible—previously acquired parcels can readily be sold. This latter approach, the selling of protected areas, is infeasible or problematic in many situations. We considered the value to conservation organizations of increasing the flexibility of their land-acquisition strategies through their approach to financing deals. Specifically, we modeled 2 acquisition-financing methods commonly used by conservation organizations: borrowing and budget carry-over. Using simulated data, we compared results from these models with those from an inflexible fixed-budget model and an extremely flexible selling model in which previous acquisitions could be sold to fund new acquisitions. We then examined 3 case studies of how conservation organizations use borrowing and budget carry-over in practice. Model comparisons showed that borrowing and budget carry-over always returned considerably higher rewards than the fixed-budget model. How they performed relative to the selling model depended on the relative conservation value of past acquisitions. Both the models and case studies showed that incorporating flexibility through borrowing or budget carry-over gives conservation organizations the ability to purchase parcels of higher conservation value than when budgets are fixed without the problems associated with the selling of protected areas.*

Keywords: conservation finance, conservation planning, land conservation, option value, protected areas, stochastic dynamic programming

El Valor de la Flexibilidad dentro del Financiamiento para la Conservación

Resumen: *Las estrategias de adquisición de tierras empleadas por las organizaciones de conservación varían en su flexibilidad. La teoría para la planificación de la conservación fracasa enormemente en la representación de esto ya que presenta modelos que son extremadamente inflexibles – la adquisición de lotes es irreversible y los presupuestos están fijados – o extremadamente flexibles – los lotes adquiridos previamente pueden venderse de inmediato. Esta estrategia previa, la venta de áreas protegidas, es inviable o problemática en muchas situaciones. Consideramos el valor que tiene para las organizaciones de conservación incrementar la flexibilidad de sus estrategias de adquisición de suelo a través de su estrategia para los acuerdos de financiamiento. En específico, modelamos dos métodos de adquisición-financiamiento utilizados comúnmente por las organizaciones de conservación: el préstamo y el arrastre del presupuesto. Con el uso de datos simulados comparamos los resultados de estos modelos con aquellos de un modelo inflexible con presupuesto fijo y de un modelo extremadamente flexible de ventas, en el cual las adquisiciones previas podían venderse para financiar nuevas adquisiciones. Después examinamos tres estudios de caso sobre cómo las organizaciones de la conservación utilizan el préstamo y el remanente del presupuesto en la práctica. La comparación entre los modelos mostró que el préstamo y el remanente del presupuesto siempre devolvían recompensas considerablemente más altas que el modelo con el presupuesto fijo. Su desempeño en relación con el modelo de ventas dependió del valor de conservación relativo de las adquisiciones previas. Tanto los modelos como los estudios de caso mostraron que incorporar la flexibilidad por medio del préstamo o el arrastre del presupuesto otorga a las organizaciones de conservación la habilidad de comprar lotes con un*

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valor más alto de conservación que cuando los presupuestos están fijados y sin los problemas asociados con la venta de áreas protegidas.

Palabras Clave: áreas protegidas, financiamiento de la conservación, planificación de la conservación, programación estocástica dinámica, suelo de conservación, valor de opción

Introduction

Habitat destruction, degradation, and fragmentation are leading drivers of declines in biodiversity and ecosystem-service provision (Millennium Ecosystem Assessment 2005; Butchart et al. 2011). In response, many public agencies and nonprofit organizations pursue land acquisition programs to expand protected-area networks (Land Trust Alliance 2011; Fishburn et al. 2013). These organizations increasingly rely on systematic conservation planning to identify target areas for conservation (e.g., particular watersheds or forest blocks) (Groves et al. 2002; Amundsen 2011). However, the transition from identifying target areas to deciding whether or not to acquire a particular parcel of land is complex (Pressey et al. 2013).

Decisions over whether to acquire specific parcels often share certain characteristics. For example, conservation organizations must make acquisition decisions regarding parcels that vary in economic cost and ecological value. Further, particular parcels are in general only available for acquisition for a narrow window of time before they are purchased by competing buyers, often for purposes other than conservation. Deciding to acquire a parcel means the organization commits resources that will then be unavailable to acquire other parcels. And, when deciding whether to acquire a parcel, the organization will be uncertain about which other parcels will become available later. Conservation organizations must therefore balance the imperative of protecting available parcels immediately against the risk of committing resources and being unable to act should parcels of higher conservation value become available (Meir et al. 2004; McDonald-Madden et al. 2008).

Conservation-planning theory provides recommendations concerning how organizations can balance benefits, costs, and risks when evaluating a potential acquisition. Analyses focused on decisions over time often make similar assumptions about the land-acquisition process (e.g., Costello & Polasky 2004; Meir et al. 2004; Tóth et al. 2011). For example, many investigators assume that an organization with a fixed budget decides which parcel or parcels to purchase during some predefined funding period (but see Drechsler & Wätzold [2007] and Alagador et al. [2016]). Many also assume acquisitions are irreversible—parcels once acquired remain indefinitely within the network of protected areas.

Some predictions from these studies can be understood through the concept of quasi-option value (Arrow & Fisher 1974) and option-value economic theory more generally (McDonald & Siegel 1986; Dixit & Pindyck 1994). *Quasi-option value* can be defined as the value of delaying an irreversible investment while uncertainty about alternatives is resolved. With respect to conservation planning, delaying the purchase of a parcel can be beneficial if information will be revealed about the availability and conservation value of other parcels. Early in the funding period, a conservation organization may therefore wait rather than commit funding to a medium-value parcel. As the end of the funding period approaches, and the imperative to use available funds increases, parcels of progressively lower conservation value become acceptable acquisitions (McDonald-Madden et al. 2008).

The optimality of this wait-and-see approach is a consequence of the assumption that conservation acquisitions represent irreversible resource commitments. Thus, some authors suggest that conservation effectiveness could be increased if organizations were able to sell or abandon previously acquired parcels of low conservation value (e.g., Strange et al. 2006; Fuller et al. 2010; Alagador et al. 2016). This would then release resources to protect parcels of higher value if they became available. However, some practitioners question the feasibility and desirability of employing such swapping strategies when managing protected-area networks (e.g., Lemieux & Scott 2011; Mascia & Pailler 2011; Bernard et al. 2014). Indeed, the funding provided to conservation organizations is often given with the requirement that parcels be protected permanently, such that resale to nonconservation buyers is not an option (although a limited number of conservation approaches, such as conservation easements, can include the option of area release [Rissman et al. 2015]).

Conservation-planning theory therefore offers 2 extremes of flexibility in parcel-acquisition strategies: very inflexible, where acquisitions are irreversible and budgets are fixed, and very flexible, where parcels can be sold. Left unconsidered is the value of increasing a conservation organization's flexibility through its financing strategy. Typically, conservation-planning theory presents a simple financing model in which a single conservation organization acquires a parcel and has all the required funding in hand. In reality, however, the practice of financing conservation land deals can be considerably more complex. A common approach involves an organization receiving short-term bridge financing from another organization to acquire an otherwise unaffordable parcel.

Bridge financing of this type has been applied widely in the United States. For example, in a 2013 survey of 248 land trusts, The Conservation Fund, an organization that provides loans to other conservation organizations across the United States, found that 50% used bridge financing to facilitate acquisitions (O.M. Amundsen, personal communication). Loans of this type expand the set of parcels available to a conservation organization and increase its flexibility to manage uncertainty over parcel availability.

The degree to which an organization is able to manage its funds also influences its flexibility. In particular, an organization that imposes a strict use-it-or-lose-it rule over the funding available for conservation each financial period, such as a government agency bound by an annual appropriations process, has limited flexibility over its acquisition choices. In contrast, an organization, such as a nonprofit, which is able to carry over unused funds in a given year by, for example, moving them into financial reserves, retains more flexibility over how it sequences land acquisitions.

We considered the value of increasing the flexibility of a conservation organization's financing structure through borrowing and budget carry-over. We first defined simple theoretical models to compare the cost-effectiveness and parcel-acquisition strategies of these financing approaches with those of the 2 extremes that have characterized the relevant conservation planning theory to date: irreversible acquisitions with a fixed budget and fully reversible acquisitions in which parcels can be sold. Our primary aim in these analyses was to provide a simple, general-purpose modeling framework through which we could begin to explore the richness of conservation financing approaches and what they might offer organizations. We then examined some of the complexities of real-world applications in case studies of 3 prominent conservation organizations—The Nature Conservancy and Scenic Hudson in the United States and the Royal Society for the Protection of Birds in the United Kingdom—that use flexible financing approaches in their land acquisition programs.

Methods

Modeling Framework

We modeled the problem where a conservation organization acquires land parcels over time. The objective of the acquisitions is to maximize expected conservation rewards at the end of the overall funding period. The organization receives an annual land acquisition budget. Each month a single parcel becomes available for purchase, and the organization must decide whether or not to buy it. If a parcel is not bought, then it is assumed to be no longer available.

Parcels vary in conservation value, and there are many ways we could have represented this. For example, we could have accounted for complementarity in the sets of species found on different parcels (e.g., Church et al. 1996; Costello & Polasky 2004; Meir et al. 2004) or considered the contribution of different parcels to metapopulation dynamics (e.g., Nicholson et al. 2006; Kites & Merenlender 2013). Although interesting in their own right, we believe such factors are not required to illustrate how flexible financing strategies can change a conservation organization's approach to land acquisitions. As such, we opted for a simpler conservation reward function in which the value of a parcel does not depend on which other parcels are also protected.

For each parcel-acquisition model, we solved the following optimization problem:

$$R_t\ (\mathbf{x_t}) = \max_{\mathbf{y_t}\, \in\, X(\mathbf{x_t})} \left\{ r_t\left(\mathbf{x_t},\ \mathbf{y_t}\right) + \mathrm{E}\left[R_{t+1}\left(m_t\left(\mathbf{x_t}, \mathbf{y_t}, \varepsilon_{t+1}\right)\right)\ \mid \mathbf{x_t}, \mathbf{y_t}\right]\right\}, \quad (1)$$

where R is the optimal reward that can be achieved in time t while in state $\mathbf{x_t}$; $\mathbf{y_t}$ is the chosen action that maximizes the current reward (r_t) plus the expected value of the optimal reward from the following period; and m_t is the state transition function. State transitions have a Markovian structure (i.e., they do not depend on the history of transitions) and are determined by the chosen action and ε_{t+1}, the model's random component, which occurs after the decision has been made in time t. Equation (1) defines a recursive algorithm solved by backward induction (e.g., Costello & Polasky 2004).

In our models, the random component determines the cost and conservation status of parcels that will become available for purchase in the future. All our models have at least 3 state variables: the cost of the available parcel, $C = \{c \mid c = 1, 2, \ldots, i\}$, its conservation status, $S = \{s \mid s = 1, 2, \ldots, j\}$, and the conservation organization's budget, $B = \{b \mid b = 0, 1, \ldots, k, \ldots, l\}$, where k is the annual budget. The probability of a parcel becoming available in cost state c is independent of any other factor and has a binomial distribution. The probability of a parcel becoming available in status state s is conditional on the cost state and also has a binomial distribution. In other words, the probability that a parcel will become available in state (c, s) is $f_c(c)f_s(s \mid c)$, where

$$f_c\ (c) = \binom{i-1}{c-1} p^{c-1}\left(1-p\right)^{i-c} \quad (2)$$

and

$$f_s\ \left(s \mid c\right) = \binom{j-1}{s-1} g(c)^{s-1}\left(1-g\left(c\right)\right)^{j-s}. \quad (3)$$

In Eqs. (2) and (3), respectively, p and $g(c)$ are the underlying Bernoulli trial probabilities of the associated binomial distribution (Supporting Information).

To compare the effectiveness of the acquisition models over a range of conservation planning scenarios, we assumed the conservation value of a parcel in status s was $v(s) = s^z$, where $z > 0$. We also assumed in Eq. (3) that g is linearly increasing in c; specifically, $g(c) = c(i-1)/i^2$. This means that on average more expensive parcels have higher conservation status, but that low cost/high conservation status and high cost/low conservation status parcels can become available. Taken together, these assumptions meant that for $z = 1$ the expected conservation value of a parcel is linearly proportional to its cost (proportionality constant $= \sum_{s \in S} s f_S(s|1)$). For $z > 1$, expensive parcels have proportionally greater expected conservation value than cheap parcels. While for $z<1$, expensive parcels have proportionately lower expected conservation value than cheap parcels. We summarized in Results cases where $z > 1$, which we think is more realistic and represents a number of meaningful conservation situations. For example, it could represent a situation where the conservation reward function is the overall area covered by acquired parcels and parcel costs show economies of scale with area (Kim et al. 2014). Alternatively, it could represent a situation where costs scale linearly with area and the conservation value of protecting a large parcel is proportionally greater than protecting a small parcel. Such a scenario could result from large parcels supporting species that have extended home ranges or that are sensitive to edge effects (e.g., Laurance 2008). Cases where $z \leq 1$ are discussed in the Supporting Information.

Parcel-Acquisition Models

We investigated 4 parcel-acquisition models: irreversible acquisitions with a fixed budget, fully reversible acquisitions, irreversible acquisitions with budget carry-over, and irreversible acquisitions with borrowing.

For irreversible acquisitions with a fixed budget (hereafter fixed-budget model), once parcels are acquired they cannot be sold. Parcels that become available at a cost greater than the current budget cannot be bought irrespective of their conservation value. And, any funds remaining at the end of the year are lost, meaning the conservation organization begins each year with a budget equal to k. This is the least flexible model we considered.

In the fully reversible model (hereafter selling model), when a parcel becomes available at a cost greater than the current budget, the organization can purchase it by selling previously acquired parcels. This is the most flexible model we considered.

We used these first 2 models as benchmarks to examine what increasing flexibility through financing strategies might offer. Therefore, in this selling model, we wanted to delineate an upper bound on the increase in conservation effectiveness achieved by allowing parcels to be sold. To do so, we assumed that the conservation organization can immediately find buyers for parcels that it chooses to sell (e.g., Strange et al. 2006) and that the organization has a large set of previously acquired parcels and can sell 1 to obtain the required amount of additional funding. The overall conservation value that follows from the purchase of a parcel in state (b, c, s) in this model is

$$v(s) = \begin{cases} s^z, & if\ c \leq b \\ s^z - \alpha \sum_{\beta \in S} \beta^z f_S(\beta \mid c-b), & if\ c > b \end{cases}. \quad (4)$$

This reward structure means if the organization purchases a parcel that costs no more than the available budget, it simply gains the newly acquired parcel's conservation value, but if the organization purchases a parcel costing $c - b$ more than its available budget, alongside gaining the conservation value of the new acquisition, it loses α times the expected conservation value of a parcel costing $c - b$. Small or large values of α mean previously acquired parcels are on average of relatively low or high conservation value, respectively, given how much they cost. In essence, α indicates how discerning the conservation organization was in their previous acquisitions. As in the fixed-budget model, we assumed that any funds remaining at the end of the year are lost.

In our 2 flexible financing models, we assumed that acquisitions remain irreversible, as in the fixed-budget model, but we increased the conservation organization's flexibility through its financing strategy. First, we considered a budget carry-over model in which the organization can save a proportion of its budget in 1 year to increase it the following year. We investigated various limits for the amount that could be carried-over, up to the conservation organization's annual budget. This allows the organization to acquire parcels costing up to twice its annual budget. In these first 3 models, the cost of the available parcel, its conservation status, and the conservation organization's budget are the state variables.

In the second flexible financing model, we considered an extension of the fixed-budget model that incorporates a borrowing mechanism: The conservation organization can borrow up to a fixed proportion of its annual budget in any year. We considered borrowing limits up to the organization's annual budget (meaning, again, that parcels up to twice the annual budget could be purchased). The debt currently held by the organization enters this model as a state variable, in addition to those for the cost of the available parcel, its conservation status, and the available budget. To keep the model simple, the conservation organization makes a debt repayment relative to the level of debt held at the beginning of the year (Supporting Information).

Analyses

We first investigate the relative effectiveness of the 4 acquisition models over 20 years of investment decisions.

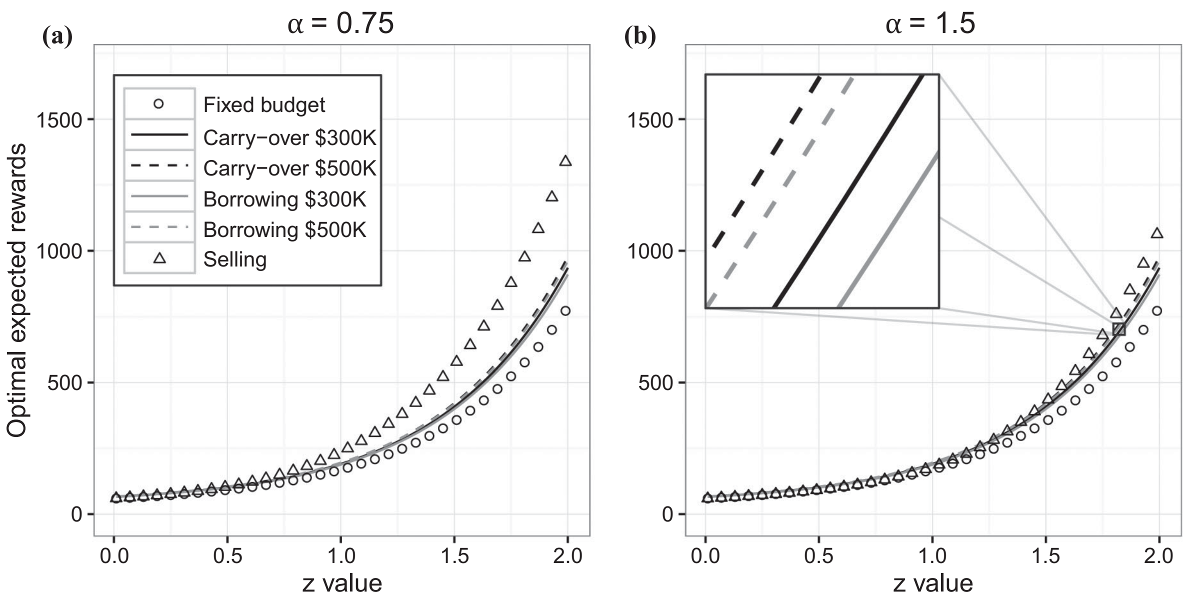

Figure 1. Optimal expected conservation rewards from 20 years of land acquisitions in the 4 acquisition models (irreversible acquisitions with a fixed budget, reversible acquisitions [selling], irreversible acquisitions with borrowing, and irreversible acquisitions with budget carry-over) with (a) α (which defines the conservation value of previously acquired parcels) set to 0.75 (i.e., past acquisitions were relatively opportunistic) and (b) α set to 1.5 (i.e., past acquisitions were strategically targeted). In the budget carry-over and borrowing models, we set 2 different carry-over and borrowing limits of $300,000 and $500,000.

We then examine the average characteristics of the parcels purchased according to each model's optimal acquisition strategy. This was achieved by randomly sampling the parcel cost and conservation-status distributions (Eqs. (2) & (3)) to simulate 20 years of investment decisions and repeating the process 1000 times (Supporting Information). Finally, we briefly outline the full optimal acquisition strategy for each model.

The results we present are for a land-acquisition scenario with the following properties: the conservation organization receives an annual budget of $500,000, discretized over integer states 0–5 (0–10 in the carry-over model); debt states are discretized over states 0–5; parcel costs range from $100,000 to $1,000,000, discretized over states 1–10; and the conservation status of parcels is discretized over states 1–10. We also assumed that parcel costs are positively skewed by setting $p = 0.2$ in Eq. (2) (Supporting Information).

Results

Expected Conservation Rewards

The higher the relative expected conservation value of protecting a more expensive parcel (larger z values), the more important financial flexibility was in determining the overall impact of the land acquisitions (Figs. 1a & 1b). The importance of flexibility also depended heavily on the distribution of parcel costs. Specifically, the relative performance of the more flexible models increased as high cost parcels, which have higher expected conservation value, became more likely to come on the market (i.e., as the parcel cost distribution moved from a positive to negative skew) (Supporting Information).

The effectiveness of the selling model depended crucially on the conservation value of previously acquired parcels (α). For example, when $z = 2$ and the conservation value of sold properties was 0.75 of what would be expected given their cost, suggesting past acquisitions were opportunistically acquired rather than strategically targeted, selling returned conservation rewards 67% greater than the next best model, which was the budget carry-over model with the maximum carry-over limit (Fig. 1a). When sold parcels were 1.5 times the expected conservation value for their cost (past acquisitions were targeted), that advantage fell to 11% (Fig. 1b). Indeed, when the conservation organization's previously acquired parcels were >1.8 times the expected conservation value for their cost, the selling model was less cost-effective than either of the more flexible financing models (Supporting Information). (As an illustration, the α value of optimal acquisitions made with the budget carry-over models ranged from 1.98 to 2.23. This suggests flexible financing models may be the most cost-effective

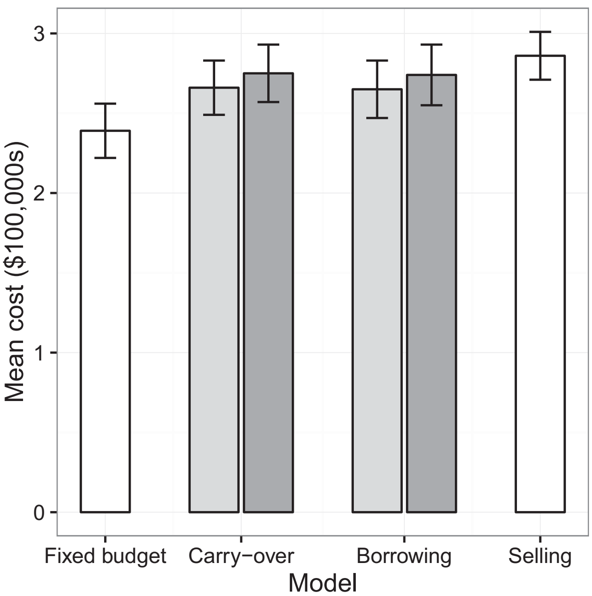

Figure 2. The total mean cost of parcels purchased by the conservation organization for the 4 acquisition models (x-axis categories defined in the legend of Fig. 1) (error bars, 1 SD; light gray, carry-over and borrowing limit $300,000; dark gray, carry-over and borrowing limit $500,000). In the selling model, α (which defines the conservation value of previously acquired parcels) was set to 0.75.

approach even if past targeting was not fully optimized.)

The more flexible financing models always returned higher rewards than the fixed-budget model. They also performed approximately equally well over both the range of z and the distributions of parcel costs. Fundamentally, these 2 financing models were very similar, in that they both allowed for parcels costing more than annual budget to be purchased, up to a maximum cost of $k(1 + x)$, where x is the proportion of the budget that can be carried over or borrowed.

Parcel-Acquisition Strategies

Results are presented for $z = 2$, $\alpha = 0.75$, and the positively skewed distribution of parcel costs detailed above.

Increasing the conservation organization's flexibility increased the average cost of parcels purchased (Fig. 2). When previously acquired parcels could be sold, on average the conservation organization made purchases that were 1.2 times more expensive than in the fixed-budget model. Consequently, the conservation organization secured parcels of substantially higher conservation value. For example, in the borrowing and budget carry-over models, the average conservation value of acquisitions was approximately one-third higher than those purchased with the fixed-budget model (Supporting Information). This purchasing behavior explains the results shown in Fig. 1: The models that offered the conservation organization greater flexibility allowed for parcels of higher conservation value to be purchased, which in turn resulted in greater expected rewards at the end of the overall funding period.

The average cost and conservation value of acquired parcels was determined by the underlying optimal state- and time-dependent decisions of the conservation organization. These are documented more fully in the Supporting Information. Briefly, with the fixed-budget model, the conservation organization only purchased parcels of high conservation value relative to cost early in the year, in line with quasi-option value theory. As the year progressed, the organization became increasingly accepting of lower quality parcels. By the end of the year, the organization purchased any available parcel within its budget to avoid losing unspent funds.

In the selling model, the organization also acquired parcels of high value relative to cost early in the year. This included selling previously acquired parcels to finance acquisitions costing more than the available budget if the available parcel was of sufficiently high conservation value (Supporting Information). But, as in the fixed-budget model, the quality of parcels that were acceptable for purchase decreased as the year progressed. This culminated in any parcel that returned a reward greater than 0, which included any parcel within the organization's remaining budget, being purchased at the end of the year.

The optimal acquisition strategy for the budget carry-over and borrowing models was broadly similar (Supporting Information). As with the other 2 models, available parcels were rejected early in the year unless they were of high conservation value. As the year progressed, parcels of lower value became acceptable. However, these effects were attenuated in the budget carry-over and borrowing models relative to the other models: many of the low-quality parcels that could have been purchased were rejected toward the end of the year. Because the conservation organization had more control over future budgets in these models, it no longer faced an imperative to use all of its funds, and in the process acquire parcels of low conservation value, before the beginning of the year.

The Nature Conservancy Case Study

The Nature Conservancy (TNC) is a land trust and the largest U.S. nonprofit conservation organization (Armsworth et al. 2012). For this case study, we reviewed how TNC uses borrowing to increase its financial flexibility. The organization is structured hierarchically with semiautonomous state chapters operating under an international executive and board. When seeking to fund an acquisition, a state chapter can apply to TNC's Land Preservation Fund (LPF) for an internal loan to help meet the costs involved. The state chapter raises funds after the acquisition is made to repay the loan.

We examined financial plans for a sample of 183 land acquisitions made by TNC in the central and southern Appalachian Mountains (U.S.A.) from 2000 to 2009. Acquisitions for which an LPF loan was used had a significantly higher average total cost than those that did not (Supporting Information). This indicated loans of this sort allowed state chapters to make acquisitions that they otherwise could not afford, a result consistent with the findings from our borrowing model (Fig. 2 & Supporting Information).

Various details of TNC's land transactions also support assumptions of our models. The cost of their land acquisitions varied greatly, and costs were positively skewed (Davies et al. 2010). Moreover, acquisition costs for the Appalachian land deals in our sample showed economies of scale with area (Kim et al. 2014). This economy of scale in acquisition costs alone would equate to a z value of approximately 1.2 if the conservation value of protecting different parcels in the region was similar per hectare.

Even though the LPF increased the financial flexibility of state chapters, we found evidence that suggests there are some limitations on the scope of this flexibility. Specifically, when analyzing data on all fee simple and easement acquisitions made by TNC in the contiguous United States between 2000 and 2009, we found a significant increase in acquisition activity in the final quarter of the year. On average, over twice as many transactions were completed in the last quarter than in any other quarter (Supporting Information). This spike in spending may indicate that state chapters face some imperative to conclude deals at the end of year, something also evident in the optimal acquisition strategies of our borrowing model (Supporting Information). However, this spike could also be driven by supply-side dynamics, such as seller-initiated deals being completed at the end of the year for tax purposes.

Scenic Hudson Case Study

Scenic Hudson is a regional land trust in New York, (U.S.A.), which has contributed to the conservation of over 12,500 ha of land in the Hudson River Valley. To finance land acquisitions, Scenic Hudson achieves financial flexibility through a range of mechanisms, including loans, bridge financing, and multiorganization partnerships. Scenic Hudson also strategically manages its endowments in order to finance large acquisitions of particular conservation interest. After completing such deals, it uses future donations to replenish available capital or rebuild its endowments. Managing endowments this way is analogous to budget carry-over in that funds are held in reserve to support the acquisition of priority purchases that would otherwise be too expensive. Moreover, if Scenic Hudson believes a priority parcel may come on the market, the organization may forego smaller deals in the interim to position itself to move quickly if the opportunity arises, which accords with the strategy that emerges from the dynamic solutions of our model (Supporting Information). Having this flexibility in place has served the organization well. For example, during the 2007–2009 recession, when many other land trusts were struggling (Larson et al. 2014), Scenic Hudson was able to accelerate its land acquisition efforts to exploit sudden decreases in real-estate prices and pursue properties that it could not afford previously.

All else being equal, Scenic Hudson also exhibited a strong preference for larger parcels (i.e., $z > 1$). This stems, in part, from the fixed costs associated with a transaction, limiting the number it can complete per year. Scenic Hudson also closed an increased number of deals toward the end of the year. However, this was not driven by any spending imperative. Rather, it was driven by external factors, such as uncertainty over whether the U.S. Congress would renew tax incentives that land trusts rely on to solicit donations in the subsequent year.

Royal Society for the Protection of Birds Case Study

The Royal Society for the Protection of Birds (RSPB) is a conservation nonprofit organization that owns or manages 151,000 ha of protected land throughout the United Kingdom. The RSPB is currently undertaking an ambitious plan to double its land holdings in the first 3 decades of this century. In pursuing this goal, the organization preferentially acquires larger tracts of land, partly because it expects such sites to have proportionately greater ecological value than smaller parcels. However, RSPB has found that large parcels in priority areas rarely become available for acquisition (i.e., the parcel cost distribution is positively skewed, in line with our modeling assumption). Consequently, RSPB often constructs large protected areas piecemeal through the purchase of multiple smaller sites in the same locality, acquiring large land parcels of high ecological value if and when they become available. This acquisition portfolio—a high ratio of small to large purchases—mirrors that which emerges from our flexible financing models (Supporting Information).

Flexible financing arrangements have been keys to RSPB's ability to pursue the type of large conservation projects it favors. For example, the organization runs 2 distinct budgeting structures. For many expenditure types, budgeting is done annually, with the requirement that funds are used within the financial year. But large projects, which regularly take several years to complete, are funded with separate budget lines designed to match project lifetimes. This split budgeting model is functionally similar to our carry-over model. In addition, the organization has been exploring the potential of bridge financing to gain the type of flexibility described by our borrowing model.

The RSPB also uses a third mechanism to acquire parcels. For large land deals, RSPB commonly secures option agreements with landowners under which they acquire the right to buy properties within some defined period. The use of an option agreement ensures that properties remain available while the organization tries to obtain sufficient financing and other support to complete the transaction. Although we did not model this type of arrangement, it emphasizes that there are other means through which conservation organizations are able to increase financial flexibility without retiring previously protected areas.

Discussion

In a bid to inform land-protection efforts, researchers have developed tools to help conservation organizations prioritize acquisitions. Most dynamic site-selection studies assume that organizations have fixed budgets and a requirement to use all available funds in each budget period. These assumptions drive the recommendations that emerge from the analyses. In response, some researchers have suggested that greater effectiveness could be achieved if organizations were free to sell or abandon previously protected parcels, a recommendation at which many organizations justifiably balk. We suggest that both sets of assumptions are too extreme. Our case study descriptions illustrate that organizations have moved beyond the assumptions of the fixed-budget-type models and developed a host of strategies to increase their flexibility. Our modeling results show that such flexibility allows organizations to recoup substantial proportions, if not all, of the efficiency gains that led to appeals for the swapping of reserves in the first place.

We captured variation in the current conservation value of previously acquired parcels in our selling model through the α parameter. Small values of this parameter conform to scenarios in which the conservation value of previously protected areas is low. Such situations can emerge when, for example, current conservation priorities diverge from those prevalent in the past (e.g., away from the protection of wilderness to a focus on representativeness [Margules & Pressey 2000]), where new types of opportunities for land protection become available (Meyer et al. 2014) or where climate and other environmental changes diminish the ecological worth of protected areas (e.g., Alagador et al. 2014; Rissman et al. 2015). In cases such as these, we found that a selling strategy was more cost-effective than the other approaches to land acquisition we investigated. However, given that the selling of protected areas is infeasible in many contexts, future studies may fare better by helping conservation organizations find ways to increase their flexibility that recognize the existing institutional and regulatory constraints under which they operate (Armsworth et al. 2015). Our financing models provide examples of such approaches. These models returned higher conservation rewards than fixed-budget models irrespective of past conservation actions (indeed higher than the selling model when currently held sites are of high conservation value), and, as our case studies demonstrate, organizations are actively exploring their possibilities.

Moreover, borrowing and budget carry-over strategies illustrate only 2 ways organizations can overcome the limitations of fixed-budget models. Conservation organizations also use other strategies to improve the effectiveness of their land-acquisition programs. The use of option agreements by RSPB is an example. Also, none of the organizations we considered wait passively for priority parcels to become available. Rather, they build relationships with private landowners to encourage the sale or transfer of properties to conservation organizations in an orderly manner. Future theoretical work could explore the relative merits of these strategies and the circumstances in which they operate best. The effectiveness of budget carry-over and borrowing approaches to land acquisition in contexts other than those we modeled offers another avenue for future research. This could include the incorporation of nonstationary effects (e.g., time-dependent changes in conservation opportunities [Meyer et al. 2014]), more complex benefit functions (e.g., nonlinear benefit aggregation over time and space [Church et al. 1996]), or parcel-cost interdependencies across acquisitions (e.g., localized cost feedbacks [Armsworth et al. 2006; Tóth et al. 2011]).

A recurring criticism of conservation planning research is that there is a marked gap between analyses and the practice of land protection (Prendergast et al. 1999; Knight et al. 2008). This gap is evident in many dynamic site-selection studies, where assumptions often fail to align with conservation realities and where recommendations often have little impact on the ground. The case studies presented here illustrate that conservation organizations have been developing creative mechanisms to increase the effectiveness of their biodiversity conservation efforts. To ensure the continuing success of systematic conservation planning approaches, a greater appreciation of this creativity and the factors that spur it is necessary.

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Supporting Information

Results for alternative parcel-cost distributions and the dynamic parcel-acquisition strategies are available online (Appendix S1). The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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