Efficient routes to land conservation given risk of covenant failure

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Abstract

Conservation initiatives to protect valued species communities in human-dominated landscapes face challenges linked to their potential costs. Conservation covenants on private land may represent a cost-effective alternative to land purchase, although many questions on the long-term monitoring and enforcement costs of covenants and the risk of violation or legal challenges remain unquantified. We explore the cost-effectiveness of conservation covenants, defined here as the fraction of the high-biodiversity landscape potentially protected via investment in covenants versus land purchase. We show that covenant violation and dispute rates substantially affect the estimated long-term cost-effectiveness of a covenant versus land purchase strategy. Our results suggest the long-term cost-effectiveness of conservation covenants may outperform land purchase as a strategy to protect biodiversity as long as disputes and legal challenges are low, but point to a critical need for monitoring data to reduce uncertainty and maximize conservation investment cost-effectiveness.

INTRODUCTION

Despite an urgent need to develop mechanisms to promote biodiversity conservation (Bayon and Jenkins, 2010; Estes et al., 2011), developing such mechanisms in human-dominated landscapes primarily under private ownership is particularly challenging (Naidoo et al., 2006; Wunder, 2007). One potentially cost-effective route to conservation in such areas may be to promote private land conservation covenants or easements that prohibit land use changes likely to reduce conservation values in exchange for monetary or other compensation (Knight et al., 2011; Merenlender et al., 2004). Advantages of covenants include their low initial cost compared to land purchase (Pence et al., 2003) and their ability to facilitate voluntary conservation with landowners wishing to retain title (Knight et al., 2010). Covenants have thus gained global attention as conservation tools (Fishburn et al., 2009; Gordon et al., 2011).

However, few studies identify the conditions likely to affect the cost-effectiveness of covenant versus land purchase strategies for biodiversity conservation (Armsworth and Sanchirico, 2008; Fishburn et al., 2009). For example, because no systematic studies of the long-term costs of monitoring, enforcing or defending covenants against legal challenges exist, it is possible that existing comparisons of land purchase versus covenant approaches to conservation overestimate the cost-effectiveness of covenants (e.g. Copeland et al., 2013; Morzaria-Luna et al., 2014). These uncertainties may therefore represent substantial financial risk to covenant holders and negatively affect long-term success in conservation if left unaddressed (Byers et al., 2005; Knight et al., 2010; Rissman and Butsic, 2011). Although some land trusts have begun developing strategies to address potential financial risk in future (Land Trust Alliance, 2009), detailed studies of these potential challenges are lacking. It also remains unknown whether covenants offer similar levels of biodiversity protection as compared to land purchase (Fishburn et al., 2009; Merenlender et al., 2004), despite that an increased demand for covenants, often without proportional increases in funding, is underway (Fitzsimons and Carr, 2014). These uncertainties highlight the critical need for the development of theoretical frameworks capable of evaluating the cost-effectiveness of biodiversity conservation via the establishment of conservation covenants versus fee simple land purchase.

We developed a simple theoretical framework for simulating conservation outcomes to help define and elucidate the uncertainties above, using detailed data on biodiversity and property values to compare the total cost and effectiveness of land purchase versus conservation covenants as strategies to restore critically endangered Old Forest and Savannah habitats and bird communities of the Georgia Basin of northwestern North America, where <20% of the threatened landscape is owned by governments, and only 9% has been allocated to conservation. Specifically, we asked two questions about the long-term (100 year) cost and biodiversity value of covenant versus land purchase strategies: 1) how might dispute rate influence the cost-effectiveness of conservation covenants as compared to land purchase? 2) Assuming that violations reduce the area of covenants allocated to conservation, what is the total area of the high-biodiversity landscape protected over the long-term given investment in covenants versus land purchase? To answer these questions we used detailed distribution maps for 47 bird species and expert elicitation to map high-biodiversity landscapes in the region, and detailed assessment data to represent land cost. We then contrasted land purchase scenarios developed by Schuster et al. (2014) to maximize biodiversity conservation to parallel scenarios that substituted covenants for land purchase under a range of assumptions about dispute rate and cost from the literature and local practitioners. Our approach offers a new theoretical framework for evaluating land acquisition strategies for biodiversity conservation and highlights a critical need for empirical analyses to estimate the total costs of long-term monitoring and the potential costs and expected rate of legal challenges.

MATERIALS AND METHODS

Ethics Statement

Permits or permission for the use of bird point count locations were obtained from Parks Canada (locations in National Park Reserves), private land owners (locations on private land), or did not require specific permission as they occurred on public right of ways (e.g., roadsides, regional parks). As private land owners did not want their information posted publically please contact the authors for contact details. The field studies did not involve endangered or protected species. This study did not require approval from an Animal Care and Use Committee because it was a non-invasive observational field study, and did not involve the capture and handling of wild animals.

Study region

We studied a 2520 km^2 portion of the Coastal Douglas Fir (CDF) ecological zone of the Georgia Basin of British Columbia (BC), Canada (Appendix S1 in Supporting Information). The CDF includes a critically endangered but diverse suite of old forest and savannah plant and animal communities endemic to the region, but ≥ 60% has been converted to human use (Austin et al., 2008) and ≤ 0.3% of historic old forests (>250 years) (MES, 2008) and ≤ 10% of oak woodlands extant prior to European contact remain (Lea, 2006).

Land purchase cost scenario

We built on Schuster et al. (2014) to identify conservation networks based on fee-simple land purchase and designed to maximize avian biodiversity in Old Forest and Savannah habitats. To do so, we developed distribution models for 47 birds based on 25 remote-sensed predictor variables and incorporating imperfect detectability (Mackenzie et al., 2002) to create composite community scores (Schuster and Arcese, 2013). We then combined Old Forest and Savannah community scores to create a beta-diversity metric to identify heterogeneous landscapes likely to maximize the occurrence of both target communities. Cadastral data was used to identify properties and 2012 assessments to represent property cost. We then used the systematic reserve design software Marxan (Ball et al., 2009) to prioritize properties (n = 193,623) by the beta-diversity metric for inclusion in conservation networks to protect 20% of the total beta-diversity scores (Schuster et al., 2014). We retained 100 Marxan solutions to estimate variability in spatial network configuration and cost.

Covenant cost metrics and assumptions

All properties selected in land purchase Marxan solutions were also used as candidates for covenants under the assumption of willing owners in both cases. We did not estimate change in land value given covenants as there is no clear consensus on its magnitude or direction (Anderson and Weinhold, 2008). Covenant costs used here reflect experience at The Nature

Trust of British Columbia (http://www.naturetrust.bc.ca/) and Islands Trust Fund (http://www.islandstrustfund.bc.ca/) following examples in literature (Main et al., 1999; Parker, 2004). We compiled estimates of fixed covenant costs including: legal, financial advice, registration and endowment fees, as well as scalable costs of property surveys and appraisal (Table 1). Land managers also identified reoccurring costs of annual monitoring and staff time to address land owner requests (Table 1). All costs were estimated in present day Canadian dollars, because the alternative of using discount rates equal to the inflation rate for costs incurred over time and reporting in future dollar values, has been shown to be highly sensitive to the discount rate chosen, leading to substantial uncertainties about future dollar amounts (Arrow et al., 2013).

Conservation covenant scenarios

We calculated the cost-effectiveness of alternate scenarios as the fraction of the high-biodiversity landscape protected, divided by the total reserve network cost for each scenario (Wilson et al., 2007) and then standardized this value by the cost of land purchase for comparisons. We followed Rissman & Butsic (2011) to estimate the distribution of dispute costs and fitted a cost profile bound between \$1000 and \$400,000 following the power function $\text{cost}[\$] = 4845.78 * \text{disputes}^{-0.701}$. We also explored cost profiles including dispute costs over \$400k using a truncated normal distribution with mean of \$400k, SE of \$1M, and 1% probability of those costs arising but found similar results, and thus restricted our analysis to published values. To find the covenant dispute rate that caused the cost effectiveness of land purchase to exceed that of covenants, we used dispute rates of 0.028, 0.28 and 2.8% of covenants per year. Rissman & Butsic (2011) surveyed 205 land trusts to report that they experienced about 2.8 disputes per year, but because they did not record the total number of covenants represented we could not estimate dispute rates precisely.

In each year of simulation, covenants suffered disputes at rates assumed above and, given a dispute, were assigned a randomly drawn dispute cost that contributed to the total cost of covenant scenarios. To quantify the effect of disputes on biodiversity values we assumed that biodiversity loss followed the same distribution as dispute cost, bounded between 0 and 100%, which was then used to reduce the disputed covenant's beta diversity metric. In the absence of empirical study, we also relaxed that assumption by allowing variation in biodiversity loss to follow a normal distribution around the estimate (SD=5% of total biodiversity loss possible). All analyses were conducted using R v.3.0.2 and the analysis script can be found in Appendix S1.

RESULTS

Given a goal of protecting 20% of the high-biodiversity landscape, land purchase scenarios protected a mean of 370 km^2 (range = 365-374 km^2) at a mean cost of $457M (range = $441 – 470M) (Figure 1a). In comparison, the cost of an equivalent area under conservation covenants averaged $43.9M in year 1 (range = $42.6 – 45.0 M) and $162M cumulatively to year 100 (range = $157 – 166M; Figure 1a), representing a 65% reduction in cost compared to land purchase. Including dispute rates of 0.028 and 0.28% increased long term costs in covenant scenarios by 2 and 23%, respectively (Figure 1a). However, with 2.8% of covenants experiencing disputes annually, network cost increased up to 400% (mean = $546M, range = $524 – 570 M), exceeding the cost of land purchase (Figure 1a).

Baseline scenarios in the absence of disputes aimed to protect 20% of the high-biodiversity landscape. However, under the assumption that disputes cause biodiversity loss, a dispute rate of 0.028% reduced the area effectively conserved after 100 years by 0.75% (range = 0.11 – 1.49%) compared to baseline (Figure 1b). In contrast, an intermediate dispute rate (0.28%) returned a mean reduction of 7.31% (range = 5.25 – 9.25%), and a high dispute rate (2.8%) returned a mean reduction of 53.62% (range = 49.33 – 57.7%; Figure 1b).

Given our results above, the cost-effectiveness of conservation covenant versus land purchase scenarios was 2.1 – 2.8 times higher after 100 years (Figure 2). However, assuming a high annual dispute rate of 2.8% drove the cost-effectiveness of covenant scenarios below that of land purchase within 50 years, and was only 39% as cost-efficient as land purchase after 100 years (Figure 2).

DISCUSSION

We show that covenant violations and disputes can substantially affect the long-term cost-effectiveness of conservation strategies that employ covenants and land purchase to protect high-biodiversity landscapes. In particular, land purchase outperformed covenants as a cost-effective approach to protection when dispute rates were high, in part because disputes may also reduce the level of biodiversity protection (Figure 1b). These results point to critical uncertainties about the cost-effectiveness of conservation covenants and the potential liabilities to covenant holders. In contrast, the low initial cost of covenants vs land purchase suggests that as long as disputes are rare, conservation covenants are likely to outperform land purchase in terms of their cost-effectiveness of biodiversity conservation (Figure 2). We now develop these points in light of literature on land acquisition and conservation covenants and point out several remaining uncertainties.

Covenant dispute rate

We found that the cost-effectiveness of covenants versus purchases in land conservation depend on covenant dispute rate (Figure 2). This indicates that minimizing dispute rates should be a key goal of organizations that use covenants to maximize biodiversity conservation. However, the paucity of published data on the frequency and cost of disputes (Byers et al., 2005; Rissman and Butsic, 2011) points to an urgent need to formalize the experience of conservation organizations and historically-drafted covenants, identify potential pitfalls and reduce dispute rates in future. Anecdotal evidence suggests that dispute rate increases with the number of successive owners of covenanted properties. If true, this implies that some existing covenants include unrecognized risk to holders that should be remedied before ownership is transferred.

Dispute costs

We adopted a dispute cost profile based on a survey of 205 land trusts, but including substantial uncertainty and a maximum dispute cost of $400k (Rissman and Butsic, 2011), but are aware of examples with a potential for much higher costs. Although we used an inverse dispute cost profile in our simulations, the risk of very large costs remains an uncertainty faced by all covenant holders. Thus, additional empirical data are critically needed to characterize cost profiles sufficiently to facilitate realistic economic analyses of alternate strategies (Boyd et al., 2000; Game et al., 2013). Although more complex cost profiles can be imagined, they remain highly speculative in the absence of data, and our results suggest that modest variation around the upper end of dispute costs had little influence on our results.

Biodiversity loss and covenant dispute

The potential for biodiversity loss via covenant violation also remains unquantified in detail, based on existing literature. However, we found that even at intermediate dispute rates, the area of the high-biodiversity landscape conserved declined by >7% after 100 years (Figure 2). At higher dispute rates over half of the originally covenanted landscape was lost under the assumption that disputes involve land conversion and the loss of protected elements or site integrity (Smith, 2009). Although our assumption that biodiversity loss and dispute cost vary directly is simplistic, and not yet tested with empirical data, we suggest it is a reasonable initial assumption given that covenant violations often involve land clearing, road building or new structures likely to reduce the integrity of high-biodiversity habitats. Our results therefore emphasize that covenant disputes may add management costs and also fail to prevent biodiversity loss, and make it clear that these potential costs must be considered when comparing biodiversity conservation strategies.

Conclusion

Our results suggest that over the long-term, the cost-effectiveness of conservation covenants may outperform land purchase as a strategy to protect or restore critical habitat, as long as the rate of disputes and legal challenges to covenants remain low. We identify several actions that could improve the reliability of comparisons of the cost-effectiveness of land purchase and covenants as approaches to biodiversity protection, including obtaining better quantitative data on: i) covenant dispute rates and cost profiles over time, and ii) biodiversity loss given a dispute. Our findings are general and thus should apply to areas with similar patterns of private ownership and human impact as occurs in the Georgia Basin of western North America, which is currently subject to very high development pressures and land and/or opportunity costs of conservation.

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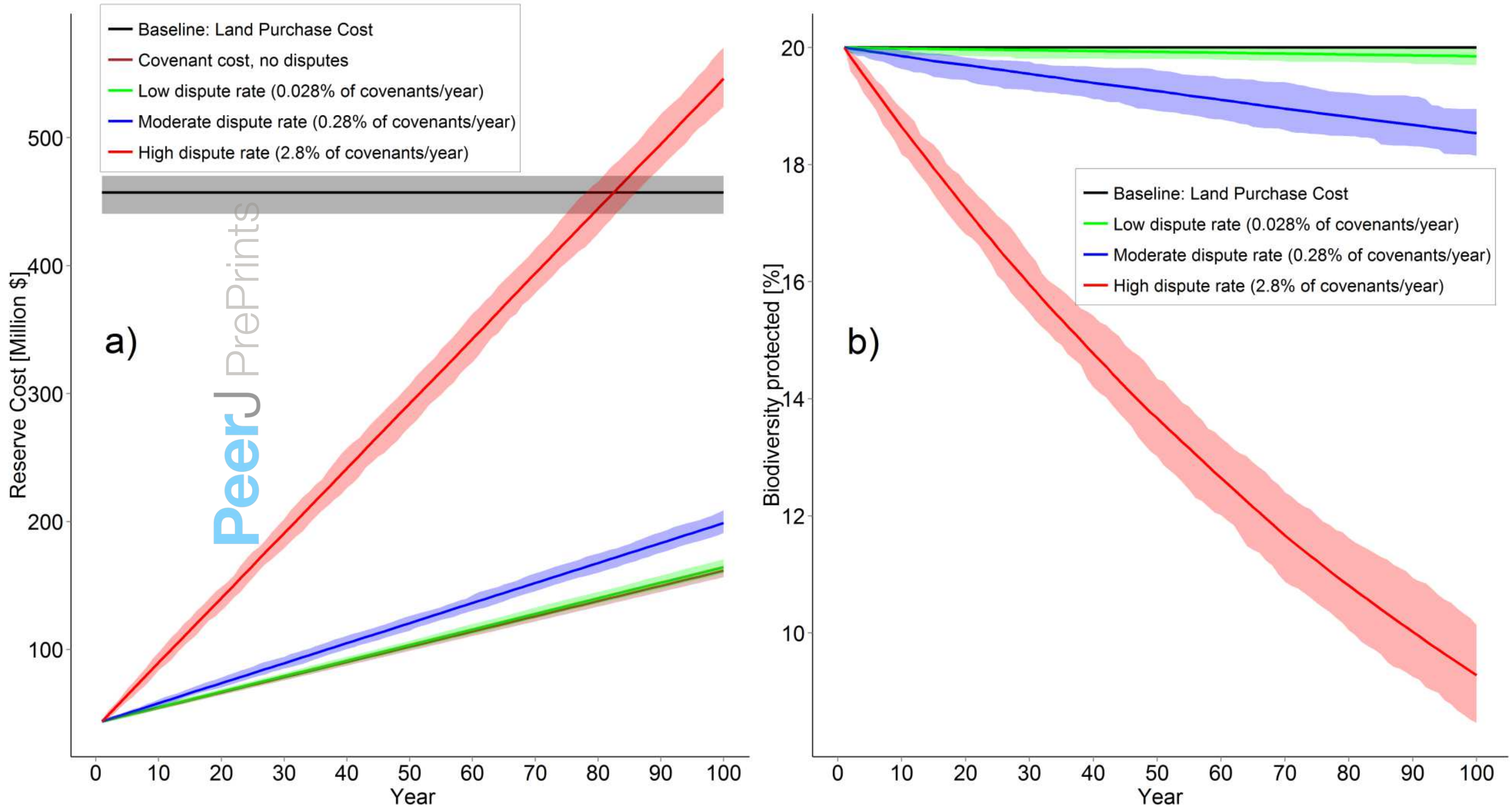
Table 1: Covenant cost estimates from The Nature Trust of British Columbia and Islands Trust Fund. All variable costs follow a saturating curve in the form of: cost = Intercept + Slope * ln(covenant size [acres]), with the constraint that the cost could not be below 'minimum cost'.

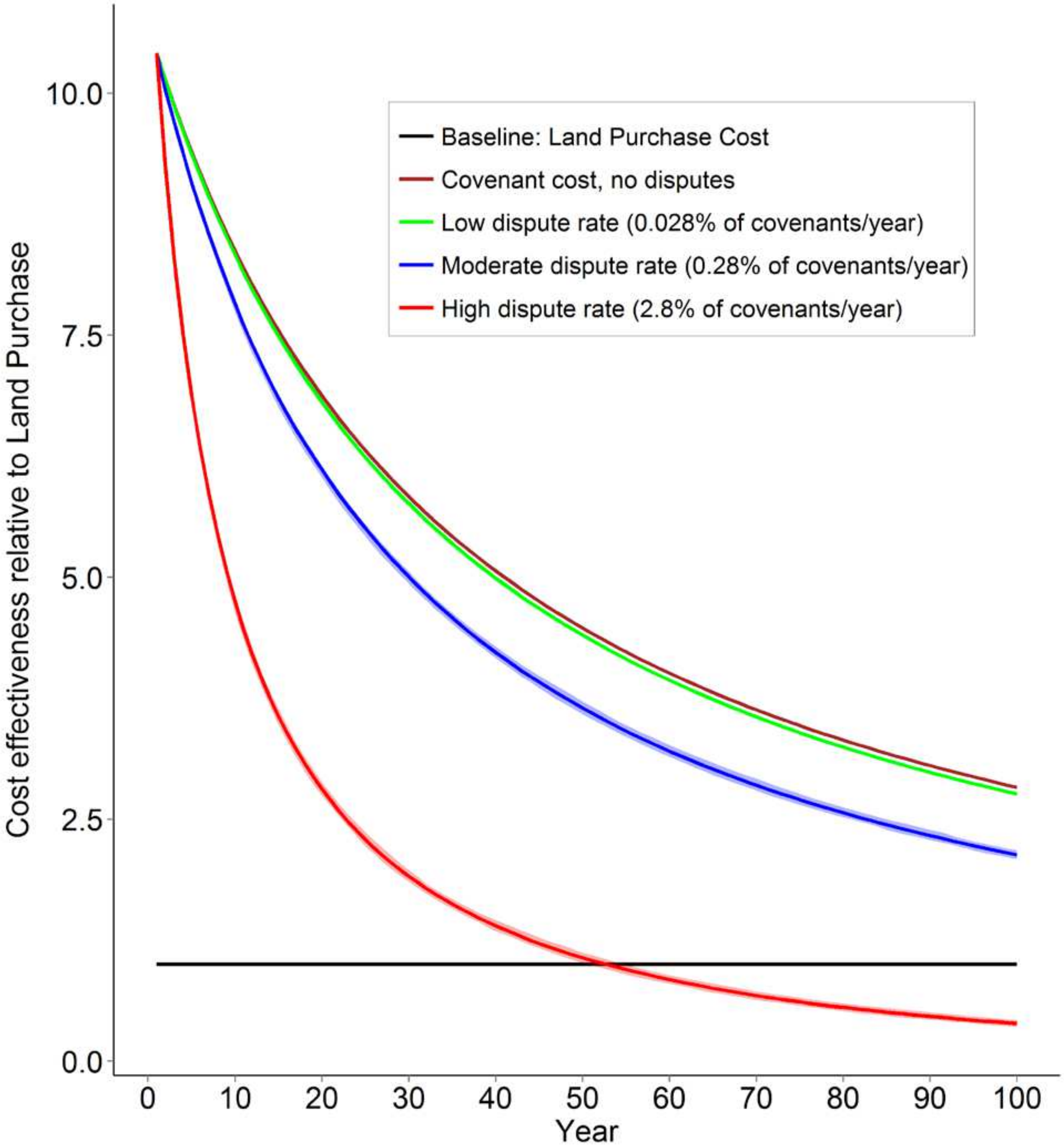
	Cost [$]
Fixed costs	
Land owner	
legal cost	300
financial advice	300
Covenant registration	200
Endowment	10000
Covenant holder	
legal cost	4000
Variable costs	
Ecological baseline survey	
minimum cost	1000
Intercept	2185
Slope	1957
Appraisal	
minimum cost	1500
Intercept	0
Slope	1957
Land survey	
minimum cost	1000
Intercept	300
Slope	1957
Reoccurring costs [yearly]	
Covenant monitoring	760
Staff cost to reply to Land owner request	152

Figures legends:

Figure 1: a) Conservation network cost comparison between land acquisition and conservation covenants of varying dispute rates. b) Biodiversity loss of varying covenant dispute rates in conservation networks and an initial 20% protection level of current biodiversity in the CDF ecological zone. Solid lines represent mean values for each approach, and the corresponding ribbons show minimum and maximum values for the 100 Marxan solutions.

Figure 2: Long term cost effectiveness defined as rate of biodiversity protected divided by the reserve network cost. Values are relative to the baseline land purchase scenario. Solid lines represent mean values for each scenario, and the corresponding ribbons show minimum and maximum values for the 100 Marxan solutions.


a)
Reserve Cost [Million $]
Year
Baseline: Land Purchase Cost
Covenant cost, no disputes
Low dispute rate (0.028% of covenants/year)
Moderate dispute rate (0.28% of covenants/year)
High dispute rate (2.8% of covenants/year)
b)
Biodiversity protected [%]
Year
Baseline: Land Purchase Cost
Low dispute rate (0.028% of covenants/year)
Moderate dispute rate (0.28% of covenants/year)
High dispute rate (2.8% of covenants/year)


Cost effectiveness relative to Land Purchase
10.0
7.5
5.0
2.5
0.0
0
10
20
30
40
50
60
70
80
90
100
Year
Baseline: Land Purchase Cost
Covenant cost, no disputes
Low dispute rate (0.028% of covenants/year)
Moderate dispute rate (0.28% of covenants/year)
High dispute rate (2.8% of covenants/year)

Supporting Information

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

Appendix S1. A figure of the Georgia Basin of British Columbia, Canada, highlighting the study region as well as the R script that we used for our analysis and simulations.

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